NEIL ABERCROMBIE
GOVERNOR OF HAWAII

LINDA ROSEN, M.D., M.P.H.
DIRECTOR OF HEALTH

**STATE OF HAWAII**
**DEPARTMENT OF HEALTH**
P.O. Box 3378
HONOLULU, HAWAII 96801-3378

In reply, please refer to:
File:

14-496M&A CAB

July 1, 2014

Ms. Meredith Kurpius
Manager
Air Quality Analysis Office (AIR-7)
U.S. EPA, Region IX
75 Hawthorne Street
San Francisco, California 94105

Dear Ms. Kurpius:

SUBJECT: Documentation for Natural Event Excluded Data for the 2011, 2012, and 2013 Exceedances of the Annual PM2.5 National Ambient Air Quality Standards (NAAQS)

In the calendar years 2011, 2012 and 2013, there were exceedances of the Annual $PM_{2.5}$ NAAQS at the Kona air monitoring station on the Island of Hawaii. A final report demonstrating that the 2011-2012 exceedances were caused by naturally occurring volcanic emissions was submitted to the U.S. Environmental Protection Agency (EPA) on December 11, 2013.

Attached is the addendum to the 2011-2012 final report providing additional supporting information. Also attached is the final report demonstrating that the 2013 exceedance was caused by naturally occurring volcanic emissions. Pursuant to 40 CFR 50.14, *Treatment of air quality monitoring data influenced by exceptional events*, the state is requesting EPA concurrence with the exclusion of the $PM_{2.5}$ exceedances due to the emissions from the Kilauea volcano.

Included in Attachment C of these final reports are the affidavits of the public notice through the three (3) local newspapers. The reports were placed on the Department of Health, Clean Air Branch (DOH-CAB), website and made available at the DOH-CAB offices in Honolulu, Hilo, and Kona for public review for a period of thirty (30) days ending June 30, 2014. No comments were received from the public regarding the reports.

If there are any questions concerning the attached, please contact Ms. Lisa Young of my staff at (808) 586-4200.

Sincerely,

NOLAN S. HIRAI, P.E.
Manager, Clean Air Branch

GW:rkb
Attachment

c: Dena Vallano, Technical Support Office (AIR-7), U.S. EPA, Region IX
Gwen Yoshimura, Air Division, Air Quality Analysis Office (AIR-7), U.S. EPA, Region IX
Carol Bohnenkamp, Air Division, Air Quality Analysis Office (AIR-7), U.S. EPA, Region IX
Rynda Kay, Air Division, Rules Office (AIR-4), U.S. EPA, Region IX

RECEIVED
JUL 02 2014

State of Hawaii
Department of Health
Clean Air Branch

# Documentation for Natural Events Excluded Data
# Kona Air Monitoring Station, AQS ID 15-001-1012
# 2011-2012 $PM_{2.5}$ Exceedances

## Addendum to the Final Report
## May 2014

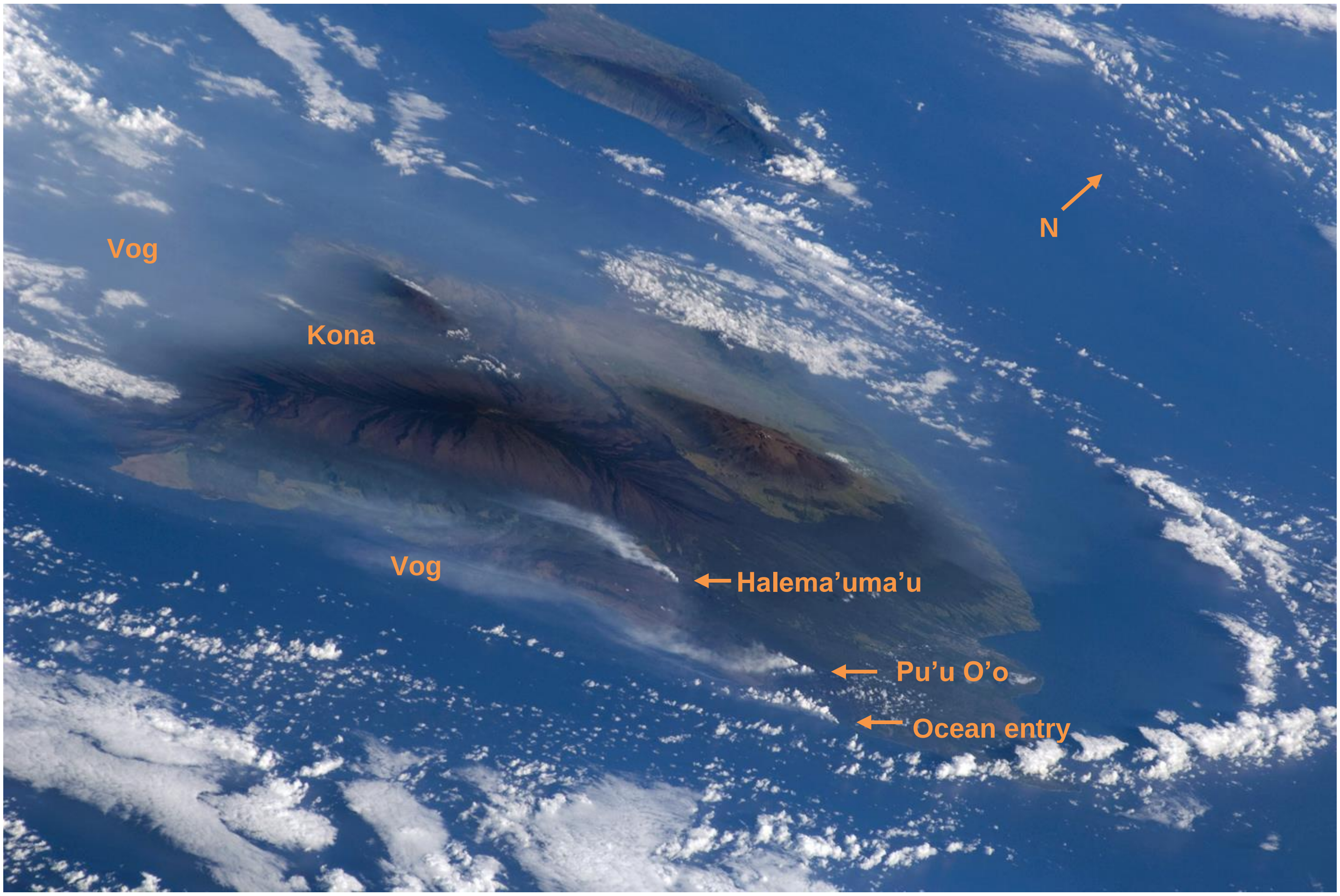


Image by crew of Space Shuttle Atlantis, May 13, 2009

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# Introduction

During 2011 and 2012, the Kona air monitoring station recorded annual average particulate matter less than or equal to 2.5 micrometers in diameter ($PM_{2.5}$) concentrations of 12.1 $\mu g/m^3$ and 16.2 $\mu g/m^3$, respectively. These values exceed the annual $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS) of 12 $\mu g/m^3$.

**This addendum is to supplement the original document dated December 2013, and is solely to demonstrate that these exceedances at the Kona station, and Kona station alone**, were caused by naturally occurring volcanic emissions, were not reasonably controllable or preventable, were associated with measured concentrations in excess of normal historical fluctuations, and would not have occurred "but-for" the volcanic emissions and, therefore, are Exceptional Events as defined by the U.S. Environmental Protection Agency's (EPA) Exceptional Events Rule (EER).

Section 6 of the original document is to be replaced in its entirety with the new Section 6 provided in this addendum, which better summarizes the demonstration, showing a clear causal relationship between the natural event and the exceedances, and concludes that these exceedances would not have occurred "but-for" the continuing natural event.

Appendix C in this addendum includes the affidavits of publication in three local newspapers notifying the public of the availability for inspection of this addendum to the original document. The three newspapers are the Honolulu Star-Advertiser (State-wide distribution), the Hawaii Tribune-Herald (East Hawaii newspaper distribution) and the West Hawaii Today (West Hawaii newspaper distribution). No public comments were received.

Appendix D in this addendum is to be added to the original document and includes additional supporting information for the ambient air monitoring stations mentioned in the original document.

Appendix E in this addendum includes full size copies of the figures in Section 3 of the original document, provided for more legible and discernable figures. It also includes select revised figures from Appendix A of the original document that needed minor corrections. A table listing the corrections is provided at the beginning of the appendix. Sample "legend" pages are also provided in this appendix to help identify and explain the different chart headings.

## Table of Contents



Cover graphic illustrates the volcanic emission plumes (vog) from the Halema'uma'u and Pu'u O'o vents and the lava ocean entry point being blown to the southern end of Hawaii Island then travelling up to the Kona coast during predominant trade wind regime.

## Section 6. "But-for" Analysis/Conclusions

The $PM_{2.5}$ exceedances of the annual monitored $PM_{2.5}$ concentrations in 2011 and 2012, satisfy the criteria of the EER, which states that in order to justify the exclusion of air quality monitoring data, evidence must be provided for the following elements:

- The event satisfies the criteria set forth in 40 CFR 50.1(j) that
  a. The event affected air quality,
  b. The event was not reasonably controllable or preventable, and
  c. The event was  caused by human activity unlikely to recur in a particular location or was a natural event;

- There is a clear causal relationship between the measurement(s) under consideration and the event;

- The event is associated with a measured concentration(s) in excess of normal historical fluctuations; and

- There would have been no exceedance or violation but for the event.

### 6.1 Affects Air Quality

As stated in the preamble to the EER, the event in question is considered to have affected air quality if it can be shown that there is a clear causal relationship between the monitored exceedance and the event, and that the event is associated with a measured concentration in excess of normal historical fluctuations.  Given the information presented in Sections 2, 3, 4, and 5, we can reasonably conclude that the event in question affected air quality.

### 6.2 Not Reasonably Controllable or Preventable

Section 50.1(j) of 40 CFR Part 50 requires that an event must be "not reasonably controllable or preventable" in order to be defined as an exceptional event.  This requirement is met by demonstrating that despite reasonable control measures in place for anthropogenic sources operating within the Kona area, continuous volcanic emissions overwhelmed all reasonably available controls (Section 4, pages 43-53).

The $PM_{2.5}$ exceedances discussed in this report were caused by the naturally occurring eruptions from Kilauea volcano that emitted extremely large quantities of $SO_2$ which transformed to sulfates on the pathway of transport into the Kona area.  The transport path and magnitude of $SO_2$ emissions associated with the volcanic eruptions provide strong evidence that the exceedance of the annual monitored $PM_{2.5}$ concentrations in 2011 and 2012 at the Kona air monitoring station were not reasonably controllable or preventable.

6.3 Natural Event

As discussed above, the exceedance of the annual monitored $PM_{2.5}$ concentrations in 2011 and 2012 was shown to be caused by transport of volcanic emissions into the Kona area. Also, contributing anthropogenic emissions in the Kona area were reasonably controlled and significantly lower in magnitude than those from the volcano. The event therefore qualifies as a natural event.

6.4 Clear Causal Relationship

The following points demonstrate that the high $PM_{2.5}$ concentrations were caused by volcanic emissions:

- According to the USGS, $SO_2$ released from the volcano creates vog when $SO_2$ reacts chemically with sunlight, oxygen, dust particles, and moisture in the air to form sulfate aerosols (fine particles and droplets) (Section 2, page 10).

- The USGS indicates that trade winds blow the vog from its main source on the volcano to the southwest, where wind patterns send it up the Kona coast. Also, the vog becomes trapped along the Kona coast by daytime (onshore) and nighttime (offshore) breezes (Section 2, page 5 and Section 3, pages 15-16 and 27-35).

- Air monitoring data for 2011 and 2012 in Tables 3-2 and 3-3 of Section 3 show a decrease in annual $SO_2$ concentration from Pahala to Ocean View stations and a further decrease from Ocean View to Kona stations while there is an increase in annual $PM_{2.5}$ concentration from Kona to Ocean View stations and an additional increase from Ocean View to Pahala stations. This is consistent with what would be expected as $SO_2$ is converted to sulfates in the wake of the volcano's plume as it drifts from Pahala-to-Ocean View-to-Kona. This demonstrates a clear causal link between $SO_2$ released by the volcano, the time necessary to form sulfates in the presence of sunlight and atmospheric constituents, the volcanic plume transport path, and monitored concentrations (Section 3, pages 20-21).

- Similar concentration versus time plots of air quality data from the Kona and Ocean View air monitoring stations indicate a large regional source is affecting air quality at the monitoring sites. The Kilauea volcano is a large regional source that is not reasonably controllable or preventable and overwhelms the quantity of emissions from anthropogenic sources (Section 3, pages 21-27 and Section 4, page 48).

- Emissions of $PM_{2.5}$ and $PM_{2.5}$ precursors of $NO_2$ and $SO_2$ from anthropogenic sources in the Kona area are only 1% of the total emissions (anthropogenic $PM_{2.5}$, $NO_2$, and $SO_2$ + volcanic $SO_2$). These anthropogenic sources are also scattered in location on the island. Therefore, anthropogenic sources cannot be the cause of correlation in pollutant concentrations measured at the Kona and

Ocean View air monitoring sites. The air pollution control measures for permitted sources are adequate and should be considered reasonable for minimizing primary and secondary $PM_{2.5}$ (Section 4, pages 50-53).

- Table 4-1 from Section 4, shows a higher annual $PM_{2.5}$ concentration measured at the Kona air monitoring station in 2012 than in 2011. The higher 2012 concentration is likely attributed to larger $SO_2$ emissions from the volcano's Halema'uma'u vent that were 71,584 tons per year higher in 2012 than in 2011. In 2012, the $SO_2$ emissions from the Halema'uma'u vent were also 146,518 tons per year higher than those from the Pu'uO'o vent. As stated in a previous evaluation, the Halema'uma'u vent, being situated at a higher elevation and further inland, appears to have a greater impact on the more populated areas of the island than the Pu'u O'o vent, which is situated at a lower elevation and closer to the coast. This would indicate a clear causal connection between the quantity of emissions released from the Halema'uma'u vent and annual $PM_{2.5}$ exceedances measured in 2012 from the Kona air monitoring station (Section 4, pages 43-54).

## 6.5 Historical Norm

Concentrations of $SO_2$ in excess of historical fluctuations were measured after the Halema'uma'u vent opened in 2008. Air monitoring data in Figure 5-1 of Section 5 shows that increased $SO_2$ concentrations at the Kona, Hilo, and Pahala are associated with the opening of the Halema'uma'u vent. Considering the transport path and magnitude of $SO_2$ emissions associated with the volcano plume, there would have been no exceedances of the annual $PM_{2.5}$ standard but for the naturally occurring and ongoing eruption of Kilauea volcano. This demonstrates an event that is associated with a measured concentration in excess of normal fluctuations (Section 5, page 54).

## 6.6 But For

On the basis of the weight of evidence described above, the exceedance of the federal annual $PM_{2.5}$ standard in 2011 and 2012, in the Kona area would not have occurred but for the continuous volcanic emissions from Kilauea volcano and transport of sulfate aerosols (fine particles and droplets) to the Kona area.

# APPENDIX C

Public Review Documentation

# AFFIDAVIT OF PUBLICATION

**IN THE MATTER OF**
Public Notice Docket No. 14-CA-PA-12

STATE OF HAWAII }
} SS.
City and County of Honolulu }

**Doc. Date:** MAY 30 201_ **# Pages:** 1

**Notary Name:** Patricia K. Reese First Judicial **Circuit**

**Doc. Description:** Affidavit of Publication

Notary Signature MAY 30 2014 Date

PATRICIA K. REESE NOTARY PUBLIC Comm. No. 86-467 STATE OF HAWAII

Julie Clark being duly sworn, deposes and says that she is a clerk, duly authorized to execute this affidavit of Oahu Publications, Inc. publisher of The Honolulu Star-Advertiser and MidWeek, that said newspapers are newspapers of general circulation in the State of Hawaii, and that the attached notice is true notice as was published in the aforementioned newspapers as follows:

Honolulu Star-Advertiser 1 times on:
05/30/2014

Midweek Wed. 0 times on:

_______ times on:

And that affiant is not a party to or in any way interested in the above entitled matter.

Julie Clark

Subscribed to and sworn before me this 30th day of May A.D. 2014

Patricia K. Reese, Notary Public of the First Judicial Circuit, State of Hawaii

My commission expires: Oct 07 2014

Ad # 0000633400

PATRICIA K. REESE NOTARY PUBLIC Comm. No. 86-467 STATE OF HAWAII

SP.NO.: ____________ L.N.

**PUBLIC NOTICE**

The Department of Health, State of Hawaii, is notifying all interested persons of the report, "Documentation for Natural Event Excluded Data." Pursuant to 40 CFR 50.14, this report describes the treatment of air quality monitoring data influenced by natural events.

The report is available for public review during regular office hours, Monday through Friday, 7:45 a.m. to 4:15 p.m., at the following locations:

Oahu:
- Clean Air Branch, Department of Health
  919 Ala Moana Blvd., Room 203, Honolulu, Oahu 96814

Hawaii:
- Hawaii District Health Office, Department of Health
  1582 Kamehameha Ave., Hilo, Hawaii
- Clean Air Branch - Kona, Keakealani Building, Department of Health
  79-1020 Haukapila Street, Room 113, Kealakekua, Hawaii

The report is also available on the Clean Air Branch, Department of Health website at http://health.hawaii.gov/cab. Interested persons may submit written comments addressed to the Department of Health at the above address on Oahu, and must be postmarked or received by June 30, 2014. For additional information, contact Ms. Lisa Young of the Clean Air Branch in Honolulu at (808) 586-4200.
(SA633400 5/30/14)

# AFFIDAVIT OF PUBLICATION

State of Hawaii )
) SS:
County of Hawaii )

M. R. Chavez, being first duly sworn, deposes and says:

1. That she is the Classified Accountant of WEST HAWAII TODAY, a newspaper published in the City of Kailua-Kona, State of Hawaii.

2. That "**PUBLIC NOTICE** The Department of Health, State of Hawaii, is notifying all interested persons of the report, "Documentation for Natural Event Excluded Data." Pursuant to" of which a clipping from the newspaper is attached hereto, was published in said newspaper on the following date(s) May 30, 2014 (etc.)

M. R. Chavez

Subscribed and sworn to before me
This 30th day of May, 2014

Henriann P. Kahananui

Notary Public, Third Circuit,
State of Hawaii

HENRIANN P. KAHANANUI NOTARY Comm. No. 11-188 PUBLIC STATE OF HAWAII

Henriann P. Kahananui

My Commission expires: June 6, 2015
# Page(s): 1

**PUBLIC NOTICE**

The Department of Health, State of Hawaii, is notifying all interested persons of the report, "Documentation for Natural Event Excluded Data." Pursuant to 40 CFR 50.14, this report describes the treatment of air quality monitoring data influenced by natural events.

The report is available for public review during regular office hours, Monday through Friday, 7:45 a.m. to 4:15 p.m., at the following locations:

Oahu:
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Hawaii:
- Hawaii District Health Office, Department of Health
  1582 Kamehameha Ave., Hilo, Hawaii
- Clean Air Branch – Kona, Keakealani Building, Department of Health
  79-1020 Haukapila Street, Room 113, Kealakekua, Hawaii

The report is also available on the Clean Air Branch, Department of Health website at http://health.hawaii.gov/cab. Interested persons may submit written comments addressed to the Department of Health at the above address on Oahu, and must be postmarked or received by June 30, 2014. For additional information, contact Ms. Lisa Young of the Clean Air Branch in Honolulu at (808) 586-4200.

(No. 199094-West Hawaii Today: May 30, 2014)

# AFFIDAVIT OF PUBLICATION

State of Hawaii )
) SS:
County of Hawaii )

LEILANI K. R. HIGAKI, being first duly sworn, deposes and says:

1. That she is the BUSINESS MANAGER of HAWAII TRIBUNE-HERALD, a newspaper published in the City of HILO, State of Hawaii.

2. That the " PUBLIC NOTICE..."Documentation for Natural Event Excluded Data."...etc.
".

of which a clipping from the newspaper as published is attached hereto, was published in said newspaper on the following date(s)
May 30, 2014, (etc.).
199872

Leilani K R Higaki

Subscribed and sworn to before me

this 16th day of June, 2014.

Danette K Koochi

DANETTE K. KOOCHI
**Notary Public, Third Circuit, State of Hawaii**
My commission expires March 23, 2018

DANETTE K. KOOCHI
NOTARY PUBLIC
Comm. No. 14-82
STATE OF HAWAII

Page(s): 1

## PUBLIC N[illegible]

The Department of H[illegible]lth, S[illegible]waii, is notifying all interested persons o[illegible]cumentation for Natural Event Excluded D[illegible]ant to 40 CFR 50.1[illegible] this report describes the trea[illegible]f air quality monitoring data influenced by [illegible]l events.

The report is available for public r[illegible]iew during regular office hours, Monday through Frid[illegible]y, 7:45 a.m. to 4:15 p.m. at the following locations:

Oahu:

- Clean Air Branch, Department of Health
  919 Ala Moana Blvd., Room 203, Honolulu, Oahu 96814

Hawaii:

- Hawaii District Health Office, Department of Health
  1582 Kamehameha Ave., Hilo, Hawaii
- Clean Air Branch – Kona, Keakealani Building, Department of Health
  79-1020 Haukapila Street, Room 113, Kealakekua, Hawaii

The report is also available on the Clean Air Branch, Department of Health website at http://health.hawaii.gov/cab. Interested persons may submit written comments addressed to the Department of Health at the above address on Oahu, and must be postmarked or received by June 30, 2014. For additional information, contact Ms. Lisa Young of the Clean Air Branch in Honolulu at (808) 586-4200.

(HT99872 Hawaii Tribune-Herald: May 30, 2014)

# APPENDIX D

## Appendix D

## Detailed Site Information for Monitoring Stations Referenced in the 2012 and 2013 Hawaii Exceptional Events Demonstration Packages

The State of Hawaii Department of Health (DOH) plans, operates and maintains the statewide ambient air quality monitoring network. Data from the following monitoring stations were used in the Exceptional Events Demonstration document: Kona (AQS 150011012), Ocean View (AQS 150012020), and Pahala (AQS 150012016). The following tables include detailed descriptions and site information such as location, traffic, probe siting, monitor information and adherence to quality assurance requirements for each of these stations. The tables were taken from the State of Hawaii 2013 Annual Network Plan. For further information and to view the entire plan, go to http://health.hawaii.gov/cab, click on the *2013 Air Monitoring Network Plan* under *Reports*.

# APPENDIX D

| (KN) KONA | | | |
|---|---|---|---|
| AQS: 150011012 | Type: SLAMS ($SO_2$)<br>SPMS ($PM_{2.5}$) | County: Hawaii | MSA: Not in a MSA |
| Address:81-1043 Konawaena School Rd., Kona, HI 96750 | | | |
| Latitude: 19.50978 Longitude: -155.91342 | | | Elevation: 517.2 m MSL |
| Location Description:<br>This station is located on the upper campus of Konawaena High School. It was established to measure impacts from volcanic emissions. The station has been operating at this site since 2005. | | | |

| Type of Roadway | Konawaena School Rd. | Mamalahoa Hwy. |
|---|---|---|
| Freeway | | |
| Major Street or Highway | | X |
| Local Street or Road | X | |
| Distance from air intake (m) | 17 | 702 |
| Direction from air inlet | N | W |
| Composition of roadway | asphalt | asphalt |
| Number of traffic lanes | 1 | 2 |
| Average daily traffic | 500 [2] | 15,503 (2006)[1] |
| Average vehicle speed (est. mph) | 10 | 55 |
| Traffic one way or two | 2 | 2 |
| Street parking? | No | No |

[1] Source: State of Hawaii Department of Transportation
[2] Estimated only, no data available. This is a road used for school access only and station is at the top of the road where there would be less ingress/egress.

| KN MONITOR INFORMATION | N/A = Not Applicable | | | | |
|---|---|---|---|---|---|
| | $PM_{2.5}$ | $SO_2$ | WS | WD | AT |
| POC/FRM or FEM | 1/FEM | 1/FEM | Info only | Info only | Info only |
| Type of Monitor | SPM | SLAMS | N/A | N/A | N/A |
| Parameter Code | 88101 | 42401 | Not entered | Not entered | Not entered |
| Manufacturer | Met-One | TECO | RM Young | RM Young | RM Young |
| Model No. | BAM1020 | 43C | 05103VP | 05103VP | 41342VC |
| AQS Method Code | 170 | 060 | Not entered | Not entered | Not entered |
| Parameter start date | 3/15/2008 | 9/13/2005 | 9/13/2005 | 9/13/2005 | 9/13/2005 |
| Frequency | continuous | continuous | continuous | continuous | continuous |
| Probe material | N/A | Glass | N/A | N/A | N/A |
| Residence Time (sec) | N/A | 17.55 | N/A | N/A | N/A |

# APPENDIX D

## KN Kona continued

| PROBE SITING | | |
|---|---|---|
| **(N/A = Not applicable)** | **$PM_{2.5}$** | **$SO_2$** |
| Location of probe | Top of shelter | Top of shelter |
| Shelter dimensions | | |
| Height (m) | 3 | 3 |
| Width (m) | 2.4 | 2.4 |
| Depth (m) | 5 | 5 |
| Horizontal distance from supporting structure (m) | N/A | N/A |
| Vertical distance above supporting structure (m) | 1 | 1.09 |
| Height of probe above ground (m) | 4 | 4 |
| Distance (m) & direction from nearest tree(s) | 38 NE | 38 NE |
| Horizontal distance from edge of nearest traffic lane (m) | 30 N | 30 N |
| Horizontal distance from nearest parking lot (m) | N/A | N/A |
| Distance & direction from obstructions on roof (m) | None | None |
| Distance & direction from possible obstructions not on roof (m) | 21 SSW | 21 SSW |
| Height of nearest possible obstacle (m) | 9 | 9 |
| Distance & direction from furnace or incineration flues (m) | None | None |
| Unrestricted airflow | 360° | 360° |
| Located in paved or vegetative ground? | vegetative | vegetative |

| SITE REPRESENTATIVENESS | | |
|---|---|---|
| | **$PM_{2.5}$** | **$SO_2$** |
| Spatial scale | Neighborhood | Neighborhood |
| Applicable NAAQS averaging times | 24-hr; annual | 1-hr; 3-hr; 24-hr; annual |
| Sampling season | 12-months | 12-months |
| Site type [1] | 3 | 3 |
| Purpose of Monitor [2] | 1, 4 | 1, 2, 4 |
| Suitable for comparison against the annual $PM_{2.5}$ NAAQS? | Yes | |

[1]Site Types:
1) located to determine the highest concentrations;
2) located to measure typical concentrations in areas of high population density;
3) located to determine the impact of significant sources or source categories on air quality;
4) located to determine general background concentration levels;
5) located to determine extent of regional pollutant transport among populated areas and in support of secondary standards;
6) located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts

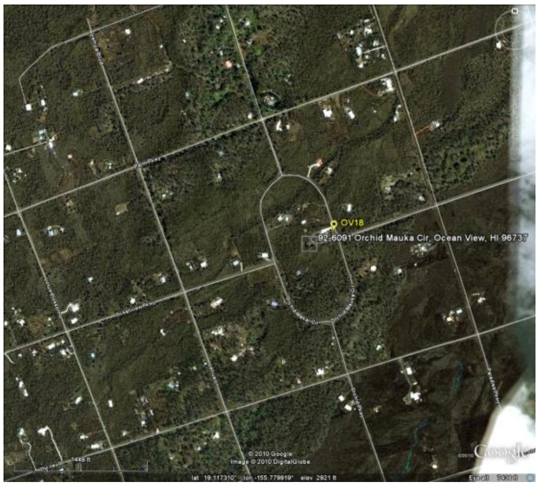
[2] Purposes:
1) Provide air pollution data to the general public in a timely manner;
2) Support compliance with ambient air quality standards;
3) Support emissions strategy development and track trends in air pollution abatement control measures;
4) Support for air pollution research

| DATA QUALITY | | |
|---|---|---|
| | **Date or Frequency** | **Result** |
| Last PEP | 3/17/11 | Did not receive results from EPA |
| Last NPAP | 3/17/11 | Did not receive results from EPA |
| Date of last annual independent performance audit (CAB) | 9/25/13 | $PM_{2.5}$ and $SO_2$ passed. |
| Frequency of flow rate audits (automated PM) | Monthly | |
| Dates of last two semi-annual flow rate audits (PM) | 5/9/12, 11/27/12 | Passed, Passed |
| Precision & Accuracy submitted to AQS | Quarterly | |
| Frequency of 1-pt. QC check for gases | Weekly | |
| Frequency of multipoint gas calibration | 60 days | |
| Annual data certification submitted | Annually by 5/1 | submitted on: 5/15/13 |

| REASONS FOR INVALID OR MISSING DATA; OTHER SITE CHANGES and Notes | |
|---|---|
| Invalid or Missing Data (<75% data): | $PM_{2.5}$ 11/9-11/16/12: 71% Obs. Maintenance/Routine repairs. |
| Changes planned in the next 18 months: | Pending EPA approval, collocate a $PM_{2.5}$ FEM |

# APPENDIX D

| (OV) OCEAN VIEW | | | |
|---|---|---|---|
| AQS: 150012020 | Type: SPMS | County: Hawaii | MSA: Not in a MSA |
| Address:92-6091 Orchid Mauka Circle, Ocean View, HI 96737 | | | |
| Latitude: 19.11756 | Longitude: -155.77814 | | Elevation: 862.6 m MSL |
| Location Description: This station established in 2010 is located on the grounds of the Ocean View Fire Station. During normal trade-winds, volcanic emissions are carried into this residential/agricultural community. | | | |




| Type of Roadway | Orchid Mauka Circ. |
|---|---|
| Freeway | |
| Major Street or Highway | |
| Local Street or Road | X |
| Distance from air intake (m) | 13.6 |
| Direction from air inlet | ENE |
| Composition of roadway | asphalt |
| Number of traffic lanes | 2 |
| Average daily traffic | < 3,000 [1] |
| Average vehicle speed (est. mph) | 25 |
| Traffic one way or two | 2 |
| Street parking? | No |
| [1] Estimated only, local residential street, no data available | |

| OV MONITOR INFORMATION | N/A = Not Applicable | | | |
|---|---|---|---|---|
| | $PM_{2.5}$ | $SO_2$ | WS | WD |
| POC/FRM or FEM | 1/FEM | 1/FEM | Info only | Info only |
| Type of Monitor | SPM | SPM | N/A | N/A |
| Parameter Code | 88101 | 42401 | Not entered | Not entered |
| Manufacturer | Met-One | TECO | RM Young | RM Young |
| Model No. | BAM1020 | 43i | 05103VP | 05103VP |
| AQS Method Code | 170 | 060 | Not entered | Not entered |
| Parameter start date | 4/1/2010 | 4/1/2010 | 4/1/2010 | 4/1/2010 |
| Frequency | continuous | continuous | continuous | continuous |
| Probe material | N/A | Glass | N/A | N/A |
| Residence Time (sec) | N/A | 18.34 | N/A | N/A |

## OV Ocean View continued

| PROBE SITING | | |
|---|---|---|
| (N/A = Not applicable) | $PM_{2.5}$ | $SO_2$ |
| Location of probe | Top of shelter | Top of shelter |
| Shelter dimensions | | |
| Height (m) | 3 | 3 |
| Width (m) | 2.4 | 2.4 |
| Depth (m) | 5 | 5 |
| Horizontal distance from supporting structure (m) | N/A | N/A |
| Vertical distance above supporting structure (m) | 1.1 | 1 |
| Height of probe above ground (m) | 4.1 | 4 |
| Distance (m) & direction from nearest tree(s) | 7 ENE | 7 ENE |
| Horizontal distance from edge of nearest traffic lane (m) | 13.6 | 13.6 |
| Horizontal distance from nearest parking lot (m) | 6.4 | 6.4 |
| Distance & direction from obstructions on roof (m) | None | None |
| Distance & direction from possible obstructions not on roof (m) | None | None |
| Height of nearest possible obstruction (m) | N/A | N/A |
| Distance & direction from furnace or incineration flues (m) | None | None |
| Unrestricted airflow | 360° | 360° |
| Located in paved or vegetative ground? | vegetative | vegetative |

| SITE REPRESENTATIVENESS | | |
|---|---|---|
| | $PM_{2.5}$ | $SO_2$ |
| Spatial scale | Middle | Neighborhood |
| Applicable NAAQS averaging times | 24-hr; annual | 1-hr; 3-hr; 24-hr; annual |
| Sampling season | 12-months | 12-months |
| Site type [1] | 3, 6 | 3, 6 |
| Purpose of Monitor [2] | 1 | 1 |
| Suitable for comparison against the annual $PM_{2.5}$ NAAQS? | Yes | |

[1]Site Types:
1) located to determine the highest concentrations;
2) located to measure typical concentrations in areas of high population density;
3) located to determine the impact of significant sources or source categories on air quality;
4) located to determine general background concentration levels;
5) located to determine extent of regional pollutant transport among populated areas and in support of secondary standards;
6) located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts

[2] Purposes:
1) Provide air pollution data to the general public in a timely manner;
2) Support compliance with ambient air quality standards;
3) Support emissions strategy development and track trends in air pollution abatement control measures;
4) Support for air pollution research

| DATA QUALITY | | |
|---|---|---|
| | Date or Frequency | Result |
| Last PEP | 2/9/12 | Did not receive results from EPA |
| Last NPAP | 2/9/12 | Passed |
| Date of last annual independent performance audit (CAB) | 9/19/12 | Passed with the following note: $SO_2$ audit pts. 2, 3, & 10: >10% (warning level) |
| Frequency of flow rate audits (automated PM) | Monthly | |
| Dates of last two semi-annual flow rate audits (PM) | 5/9/12, 11/1/12 | Passed, Passed |
| Precision & Accuracy submitted to AQS | Quarterly | |
| Frequency of 1-pt. QC check for gases | Weekly | |
| Frequency of multipoint gas calibration | 60 days | |
| Annual data certification submitted | Annually by 5/1 | submitted on: 5/15/13 |
| **REASONS FOR INVALID OR MISSING DATA; OTHER SITE CHANGES and Notes** | | |
| Invalid or Missing Data (<75% data): | None | |
| Changes planned in the next 18 months: | None | |

# APPENDIX D

| (PA) PAHALA | | | |
|---|---|---|---|
| AQS: 150012016 | Type: SPMS | County: Hawaii | MSA: Not in a MSA |
| Address:96-3150 Pikake St., Pahala, HI 96777 | | | |
| Latitude: 19.2039 Longitude: -155.48018 | | Elevation: 320 m MSL | |
| Location Description: This station is located on the grounds of the Ka'u High/Pahala Elementary School. During normal trade-winds, volcanic emissions are carried into this rural community. The station began operating in 2007. | | | |


| Type of Roadway | Puahala | Pumeli |
|---|---|---|
| Freeway | | |
| Major Street or Highway | | |
| Local Street or Road | X | X |
| Distance from air intake (m) | 226 | 61 |
| Direction from air inlet | E | N |
| Composition of roadway | Asphalt | Asphalt |
| Number of traffic lanes | 2 | 2 |
| Average daily traffic | < 3,000 [1] | < 3,000 [1] |
| Average vehicle speed (est. mph) | 25 mph | 25 mph |
| Traffic one way or two | 2 | 2 |
| Street parking? | No | No |
| [1] Estimated only, no data available. Local roads for a community with a 2010 population of about 1,400 | | |

| PA MONITOR INFORMATION | N/A = Not Applicable | | | |
|---|---|---|---|---|
| | $PM_{2.5}$ | $SO_2$ | WS | WD |
| POC/FRM or FEM | 1/FEM | 1/FEM | Info only | Info only |
| Type of Monitor | SPM | SPM | N/A | N/A |
| Parameter Code | 88101 | 42401 | Not entered | Not entered |
| Manufacturer | Met-One | TECO | RM Young | RM Young |
| Model No. | BAM1020 | 43i | 05103VP | 05103VP |
| AQS Method Code | 170 | 060 | Not entered | Not entered |
| Parameter start date | 4/11/2008 | 8/10/2007 | 8/10/2007 | 8/10/2007 |
| Frequency | continuous | continuous | continuous | continuous |
| Probe material | N/A | Glass | N/A | N/A |
| Residence Time (sec) | N/A | 18.22 | N/A | N/A |

# APPENDIX D

## PA Pahala continued

| PROBE SITING | | |
|---|---|---|
| **(N/A = Not applicable)** | **$PM_{2.5}$** | **$SO_2$** |
| Location of probe | Top of shelter | Top of shelter |
| Shelter dimensions | | |
| Height (m) | 2.4 | 2.4 |
| Width (m) | 2.4 | 2.4 |
| Depth (m) | 6 | 6 |
| Horizontal distance from supporting structure (m) | N/A | N/A |
| Vertical distance above supporting structure (m) | 1 | 1 |
| Height of probe above ground (m) | 3.4 | 3.4 |
| Distance (m) & direction from nearest tree(s) | 11 N | 11 N |
| Horizontal distance from edge of nearest traffic lane (m) | 48 S | 48 S |
| Horizontal distance from nearest parking lot (m) | 73 S | 73 S |
| Distance & direction from obstructions on roof (m) | None | None |
| Distance & direction from possible obstructions not on roof (m) | None | None |
| Height of nearest possible obstruction (m) | N/A | N/A |
| Distance & direction from furnace or incineration flues (m) | None | None |
| Unrestricted airflow | 360° | 360° |
| Located in paved or vegetative ground? | vegetative | vegetative |

| SITE REPRESENTATIVENESS | | |
|---|---|---|
| | **$PM_{2.5}$** | **$SO_2$** |
| Spatial scale | Neighborhood | Neighborhood |
| Applicable NAAQS averaging times | 24-hr; annual | 1-hr; 3-hr; 24-hr; annual |
| Sampling season | 12-months | 12-months |
| Site type [1] | 3 | 3 |
| Purpose of Monitor [2] | 1, 4 | 1, 4 |
| Suitable for comparison against the annual $PM_{2.5}$ NAAQS? | Yes | |

[1]Site Types:
1) located to determine the highest concentrations;
2) located to measure typical concentrations in areas of high population density;
3) located to determine the impact of significant sources or source categories on air quality;
4) located to determine general background concentration levels;
5) located to determine extent of regional pollutant transport among populated areas and in support of secondary standards;
6) located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts

[2] Purposes:
1) Provide air pollution data to the general public in a timely manner;
2) Support compliance with ambient air quality standards;
3) Support emissions strategy development and track trends in air pollution abatement control measures;
4) Support for air pollution research

| DATA QUALITY | | |
|---|---|---|
| | **Date or Frequency** | **Result** |
| Last PEP | 3/17/11 | Did not receive results from EPA |
| Last NPAP | 7/29/08 | Passed |
| Date of last annual independent performance audit (CAB) | 9/20/12 | $PM_{2.5}$ and $SO_2$ passed. |
| Frequency of flow rate audits (automated PM) | Monthly | |
| Dates of last two semi-annual flow rate audits (PM) | 5/2/12, 11/1/12 | Passed, Passed |
| Precision & Accuracy submitted to AQS | Quarterly | |
| Frequency of 1-pt. QC check for gases | Weekly | |
| Frequency of multipoint gas calibration | 60 days | |
| Annual data certification submitted | Annually by 5/1 | submitted on: 5/15/13 |

| REASONS FOR INVALID OR MISSING DATA; OTHER SITE CHANGES and Notes | |
|---|---|
| Invalid or Missing Data (<75% data): | None |
| Changes planned in the next 18 months: | None |

# APPENDIX E

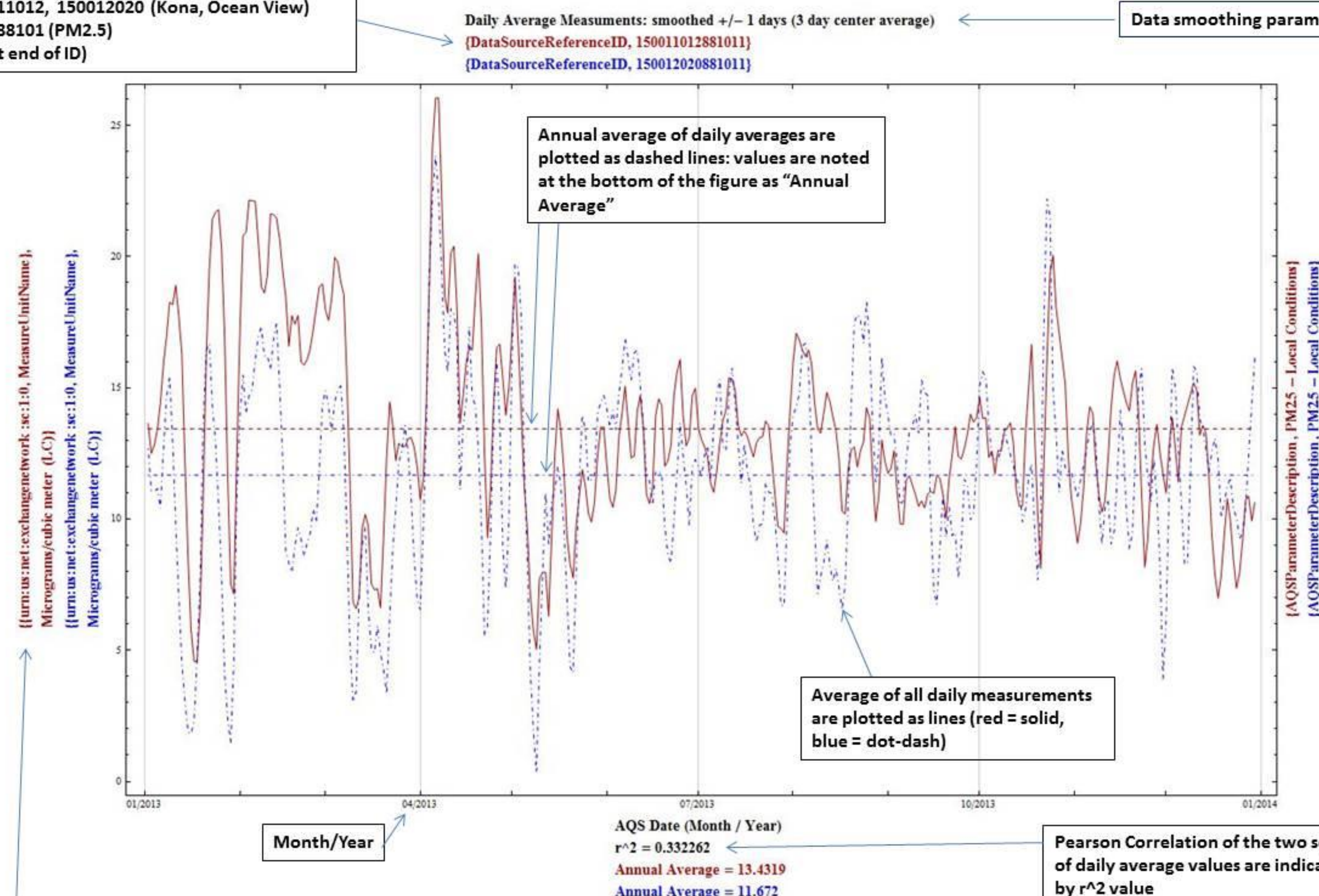
| Figure No. | Title | Revised | Revised due to Plotting Error | Comment |
|---|---|---|---|---|
| Figure 3-2. | 2011 Time History of Kona (red) and Ocean View (blue, dot-dash) PM2.5 Concentrations | Yes | No | Ocean View plots now use blue, dot-dash lines |
| Figure 3-3. | 2011 Time History of Kona (red) and Ocean View (blue, dot-dash) normalized PM2.5 Concentrations | Yes | No | Ocean View plots now use blue, dot-dash lines |
| Figure 3-4. | 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) PM2.5 Concentrations | Yes | No | Ocean View plots now use blue, dot-dash lines |
| Figure 3-5. | Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized PM2.5 Concentrations | Yes | No | Ocean View plots now use blue, dot-dash lines |
| Figure 3-6. | 2011 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized SO2 Concentrations | Yes | No | Ocean View plots now use blue, dot-dash lines |
| Figure 3-7. | 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized SO2 Concentrations | Yes | No | Ocean View plots now use blue, dot-dash lines |
| Figure 3-8. | Kona Area AN155 Windrose Plots for 2011 (left) and 2012 (right) | Yes | Yes | Data records erroneously dropped from plotted datasets; for 2011, only 4568 of the 4721 records were plotted; for 2012, only 6414 of the 6493 records were plotted. |
| Figure 3-9. | 2012 Kamuela (PHMU)(left) & Keaumo (KKUH1)(right) Windrose | No | No | None |
| Figure 3-10 | 2012 Kaunakakai, Molokai Airport (PHMK)(left) & Kaneohe, Marine Corps Air Station (PHNG)(right) Windrose | No | No | None |
| Figure 3-11. | 2012 Waikoloa (WKVH1)(left) & Kaupulehu Lava Flow (KPLH1)(right) Windrose | No | No | None |
| Figure 3-12. | 2012 PTA Range 17 (left) & Hilo International Airport (right) Windrose | No | No | None |
| Figure 3-13. | 2012 Pahala (AN157)(left) and Ocean View (AN738)(right) Windrose | Yes | Yes | Data records erroneously dropped from plotted datasets; for 2011, only 7853 of the 7938 records were plotted; for 2012, only 7704 of the 7787 records were plotted. |
| Figure 3-14. | 2011 Time History of Kona (red) PM2.5 Concentrations with Flagged Days (green) | No | No | None |
| Figure 3-15. | Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized PM2.5 Concentrations with Flagged Days (vertical broken lines) | Yes | No | Ocean View plots now use blue, dot-dash lines |
| Figure 3-16. | 2011 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized SO2 Concentrations with Flagged Days (vertical broken lines) | Yes | No | Ocean View plots now use blue, dot-dash lines |
| Figure 3-17. | 2012 Time History of Kona (red) PM2.5 Concentrations with Flagged Days (green) | No | No | None |
| Figure 3-18. | 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized PM2.5 Concentrations with Flagged Days (vertical broken lines) | Yes | No | Ocean View plots now use blue, dot-dash lines |
| Figure 3-19. | 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized SO2 Concentrations with Flagged Days (vertical broken lines) | Yes | No | Ocean View plots now use blue, dot-dash lines |
| Figure A-14. | 2011 Time History of Kona (red) and Ocean View (blue, dot-dash) PM2.5 Concentrations (unsmoothed data) | Yes | No | None |
| Figure A-15. | 2012 Time History of Kona (red) and Ocean View (blue,dot-dash) PM2.5 Concentrations (unsmoothed data) | Yes | No | None |
| Figure A-16. | 2011 Kona (AN155) Windrose - Morning Hours | Yes | No | Plotted Windroses are correct; However, for each hourly plot, the "Number of Datasets" reported included records with blank wind directions |
| Figure A-17. | 2011 Kona (AN155) Windrose - Evening Hours | Yes | No | Plotted Windroses are correct; However, for each hourly plot, the "Number of Datasets" reported included records with blank wind directions |
| Figure A-20. | 2011 Kona (AN155) PM2.5 Pollution Time History by Wind Quadrant | Yes | Yes | Data records erroneously dropped from plotted datasets |
| Figure A-21. | 2012 Kona (AN155) PM2.5 Pollution Time History by Wind Quadrant | Yes | Yes | Data records erroneously dropped from plotted datasets |
| Figure A-24. | 2012 Wailoloa (WKVH1) Windrose - Morning Hours | Yes | No | Plotted Windroses are correct; However, for each hourly plot, the "Number of Datasets" reported included records with blank wind directions |
| Figure A-25. | 2012 Wailoloa (WKVH1) Windrose - Evening Hours | Yes | No | Plotted Windroses are correct; However, for each hourly plot, the "Number of Datasets" reported included records with blank wind directions |
| Figure A-26. | 2012 Kaupulehu Lava Flow (KPLH1) - Morning Hours | Yes | No | Plotted Windroses are correct; However, for each hourly plot, the "Number of Datasets" reported included records with blank wind directions |
| Figure A-27. | 2012 Kaupulehu Lava Flow (KPLH1) - Evening Hours | Yes | No | Plotted Windroses are correct; However, for each hourly plot, the "Number of Datasets" reported included records with blank wind directions |
| Figure A-28. | 2012 PTA Range 17 (PTRH1) Windrose - Morning Hours | Yes | No | Plotted Windroses are correct; However, for each hourly plot, the "Number of Datasets" reported included records with blank wind directions |
| Figure A-29. | 2012 PTA Range 17 (PTRH1) Windrose - Evening Hours | Yes | No | Plotted Windroses are correct; However, for each hourly plot, the "Number of Datasets" reported included records with blank wind directions |
| Figure A-30. | 2012 Hilo International Airport (PHTO) Windrose - Morning Hours | Yes | No | Plotted Windroses are correct; However, for each hourly plot, the "Number of Datasets" reported included records with blank wind directions |
| Figure A-31. | 2012 Hilo International Airport (PHTO) Windrose - Evening Hours | Yes | No | Plotted Windroses are correct; However, for each hourly plot, the "Number of Datasets" reported included records with blank wind directions |
| Figure A-32. | 2012 Pahala (AN157) Windrose - Morning Hours | Yes | No | Plotted Windroses are correct; However, for each hourly plot, the "Number of Datasets" reported included records with blank wind directions |
| Figure A-33. | 2012 Pahala (AN157) Windrose - Evening Hours | Yes | No | Plotted Windroses are correct; However, for each hourly plot, the "Number of Datasets" reported included records with blank wind directions |
| Figure A-34. | 2012 Ocean View (AN738) Windrose - Morning Hours | Yes | No | Plotted Windroses are correct; However, for each hourly plot, the "Number of Datasets" reported included records with blank wind directions |
| Figure A-35. | 2012 Ocean View (AN738) Windrose - Evening Hours | Yes | No | Plotted Windroses are correct; However, for each hourly plot, the "Number of Datasets" reported included records with blank wind directions |

# Legend for Time History Figures

DataSourceReferenceID = AQS Data Mart XML tag for Monitoring Site and Pollutant (numerical ID)

Sites = 150011012, 150012020 (Kona, Ocean View)
Pollutant = 88101 (PM2.5)
Other = 1 (at end of ID)

Data smoothing parameter




Annual average of daily averages are plotted as dashed lines: values are noted at the bottom of the figure as "Annual Average"

AQSParameterDescription = AQS Data Mart XML tag for Pollutant (Text ID)

Pollutant = PM2.5 (local conditions)

Average of all daily measurements are plotted as lines (red = solid, blue = dot-dash)

Month/Year

Pearson Correlation of the two sets of daily average values are indicated by r^2 value

{urn:us:net:exchangenetwork :sc:1:0, MeasurementUnitName} = AQS Data Mart XML tag for reported measurement unit (Text ID)

Measurement Unit = Micrograms/cubic meter (LC)

Annual average of daily averages
Units match "Measurement Unit" given on the left side of plot

**APPENDIX E**

# Legend for Wind Rose Figures

Data file name = AN155y2013.xls
Meso West Monitor ID = AN155
Data year = 2013

Data Selection for Plot
Year of Data Selected: "-2013" means 2013
Hours Selected: "All Hours" means all hours of day
("1" = 1 AM, "13" = 1PM)

**AN155y2013.xls–2013: All Hours**

**Data Info: Windrose**

**Number of Datasets = 8092**

"Number of Datasets" are the number of data records that have a valid value in the designated data column (in this case the Direction column)

**... first dataset (below); Direction = DRCT °**

Direction = "XXXX" indicates the column header value being plotted for the Wind Rose

Dataset column header and first valid data record. Note that the first column header ("ID = AN155") is repeated in the last column. This was done because the Meso West date/time format (in the last column) needed to be changed to that given in the first column for more efficient data processing. The repetition ensured that the date/time reformatting could be more easily checked for accuracy. It also ensured that the correct time zone (Hawaii Standard Time) was used for the hourly Wind Rose plots.

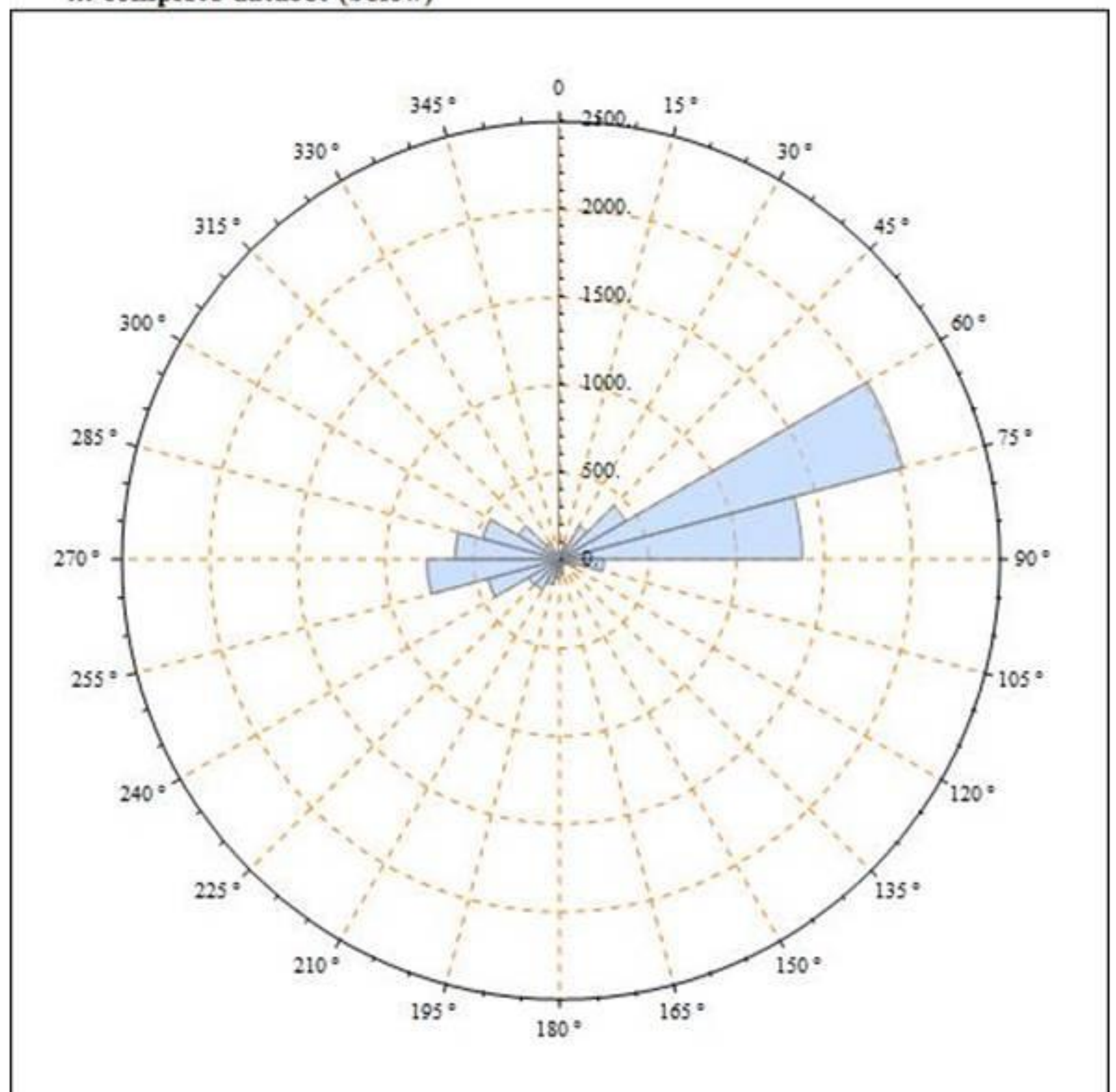
Date/time format in first column = {Year, Month, Day, Hour, Minute, Second}

When "All Hours" are not selected, only data records with the "Hour" selected are plotted.

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 0, 0, 0.} | 2.2 | 75. | N/A | 1–1–2013 0:00 HST |

Indicates the Time Zone associated with the Meso West dataset

**... complete dataset (below)**



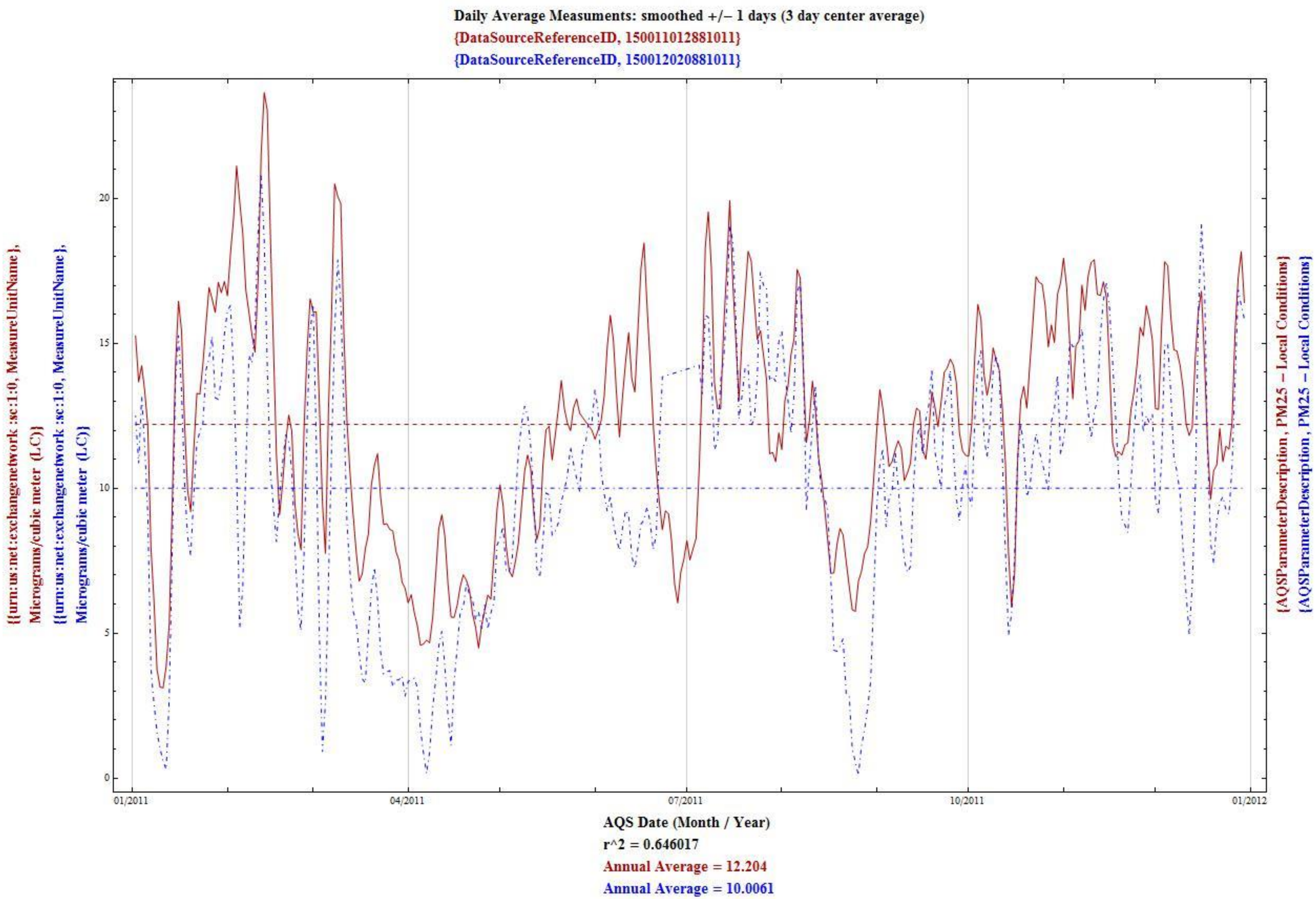



**Figure 3-2.** 2011 Time History of Kona (red) and Ocean View (blue, dot-dash) $PM_{2.5}$ Concentrations

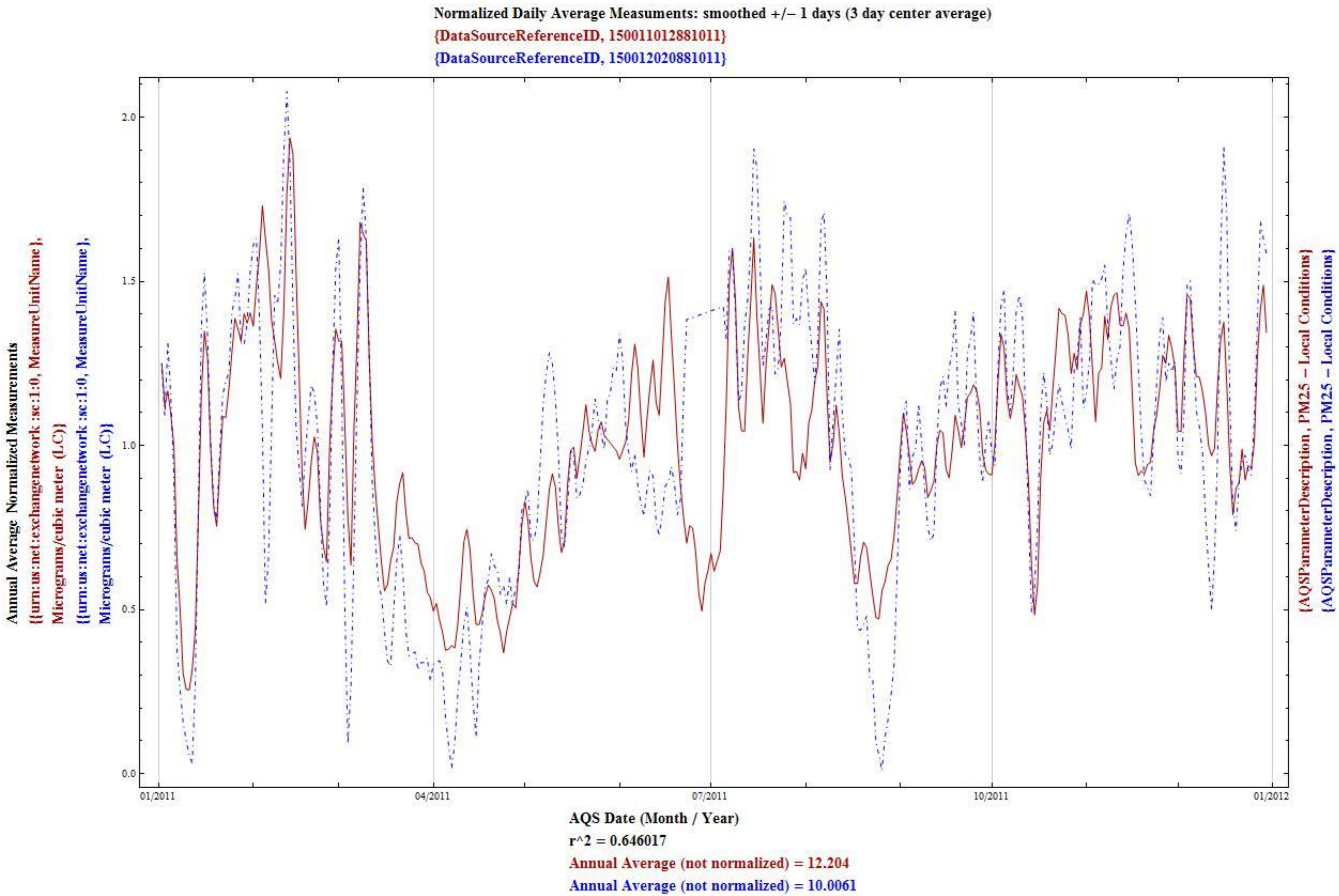



**Figure 3-3.** 2011 Time History of Kona (red) and Ocean View (blue, dot-dash) normalized $PM_{2.5}$ Concentrations

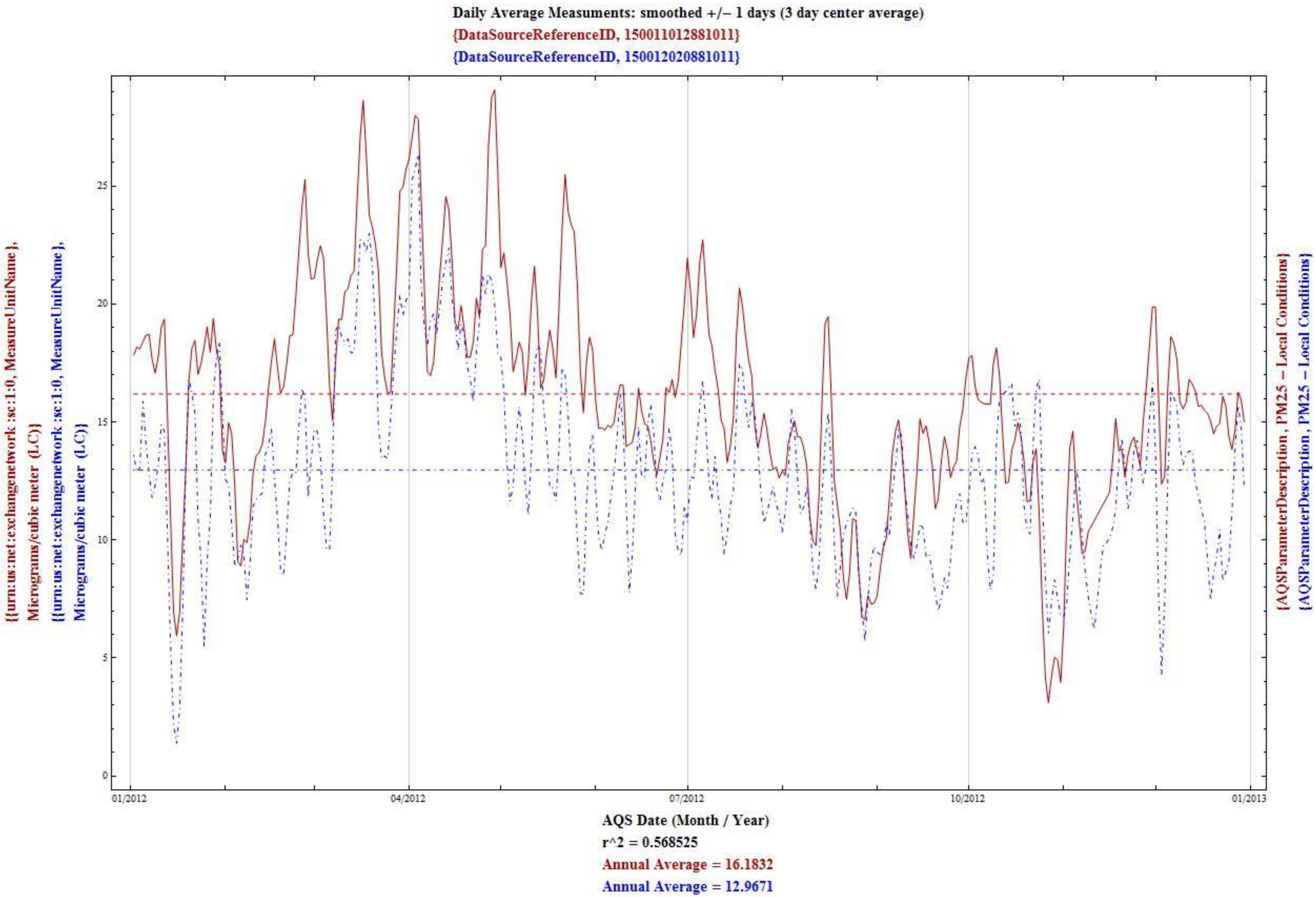



**Figure 3-4.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) $PM_{2.5}$ Concentrations

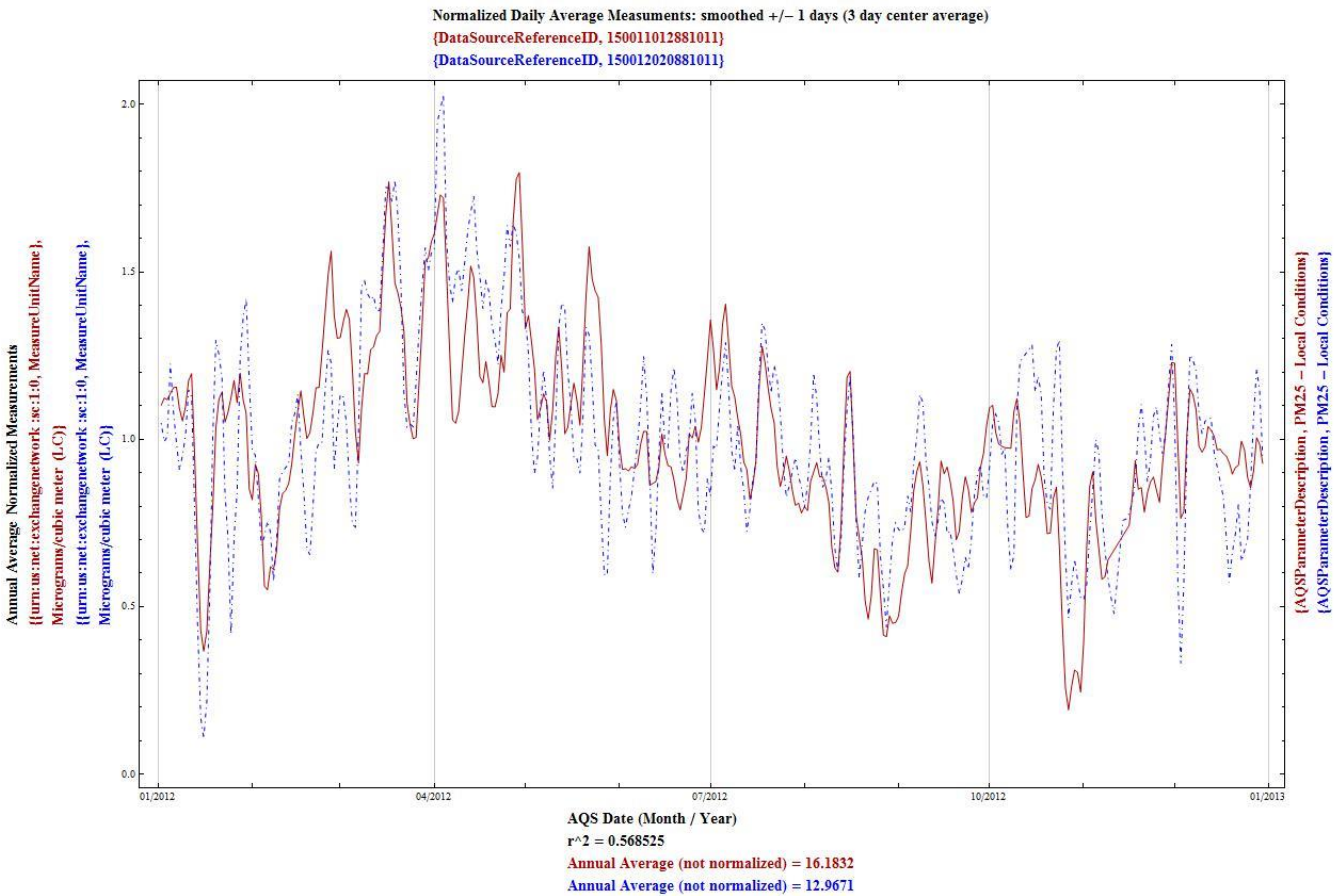



**Figure 3-5.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $PM_{2.5}$ Concentrations

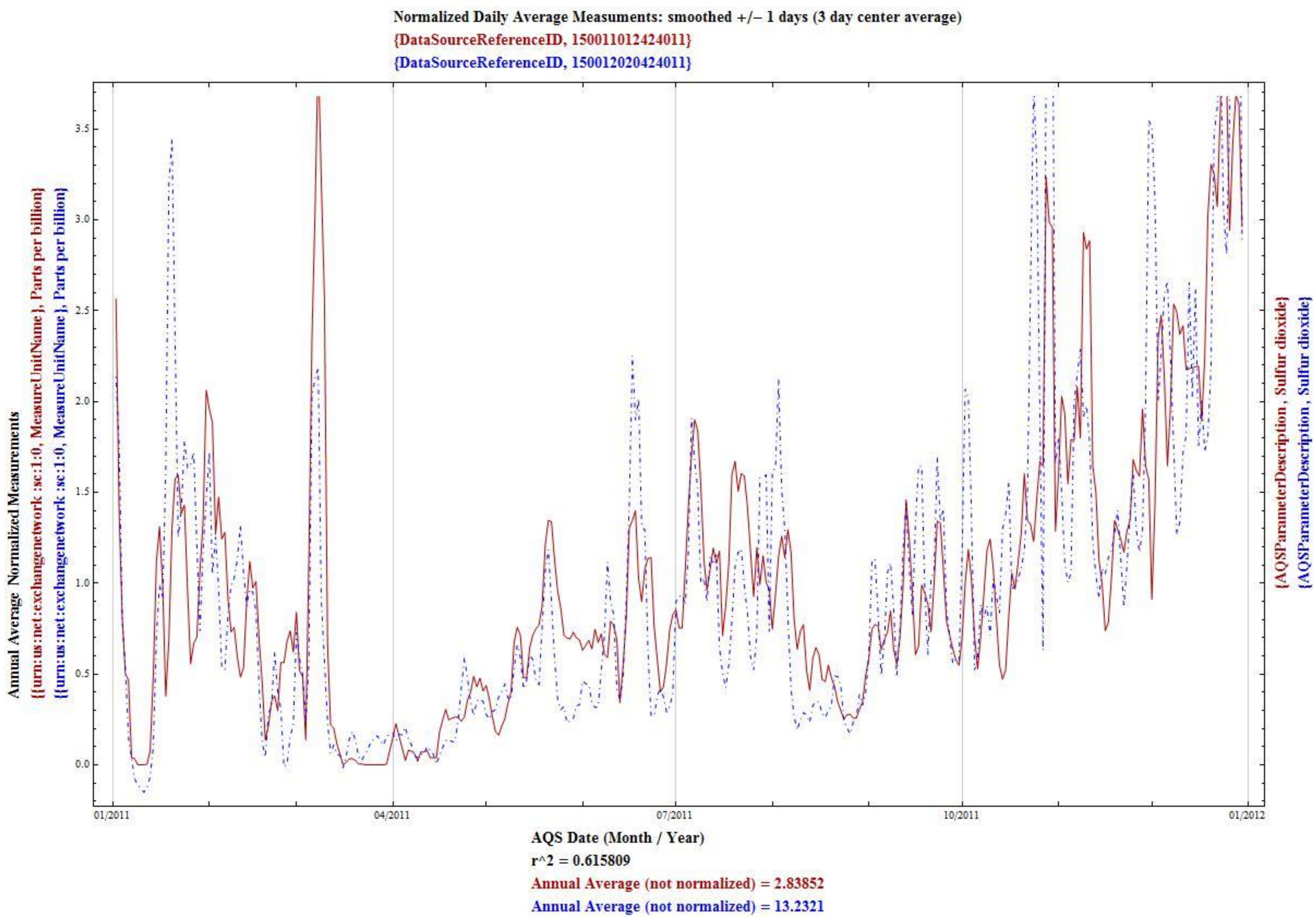



**Figure 3-6.** 2011 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $SO_2$ Concentrations

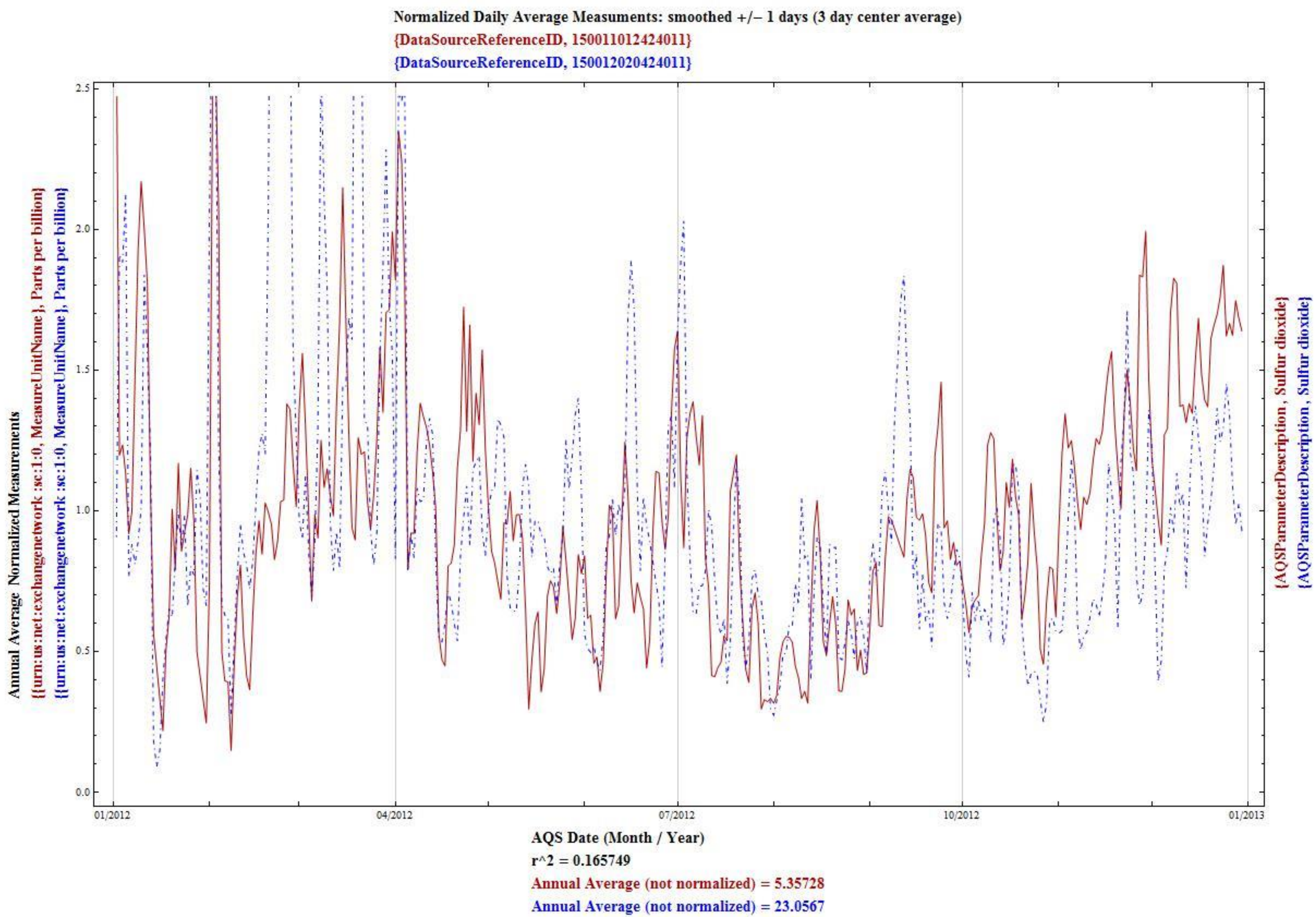



**Figure 3-7.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $SO_2$ Concentrations

**AN155y2011.xls–2011: All Hours**

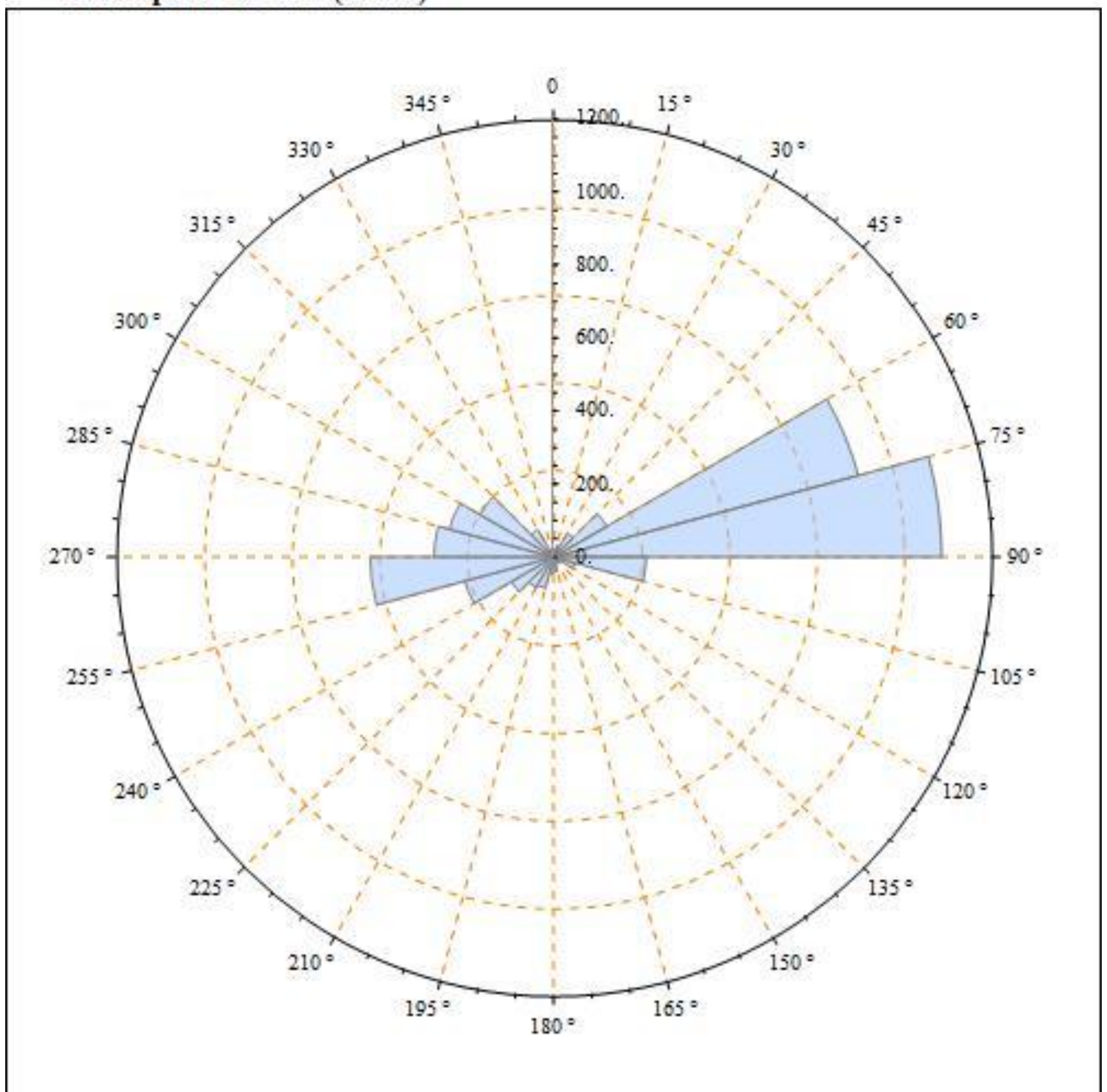
**Data Info: Windrose**

**Number of Datasets = 4721**

**... first dataset (below); Direction = DRCT °**

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2011, 1, 1, 0, 0, 0.} | 1.7 | 68. | OK | 1–1–2011 0:00 HST |

**... complete dataset (below)**




**AN155y2012.xls–2012: All Hours**

**Data Info: Windrose**

**Number of Datasets = 6493**

**... first dataset (below); Direction = DRCT °**

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2012, 1, 1, 1, 0, 0.} | 2.1 | 81. | N/A | 1–1–2012 1:00 HST |

**... complete dataset (below)**

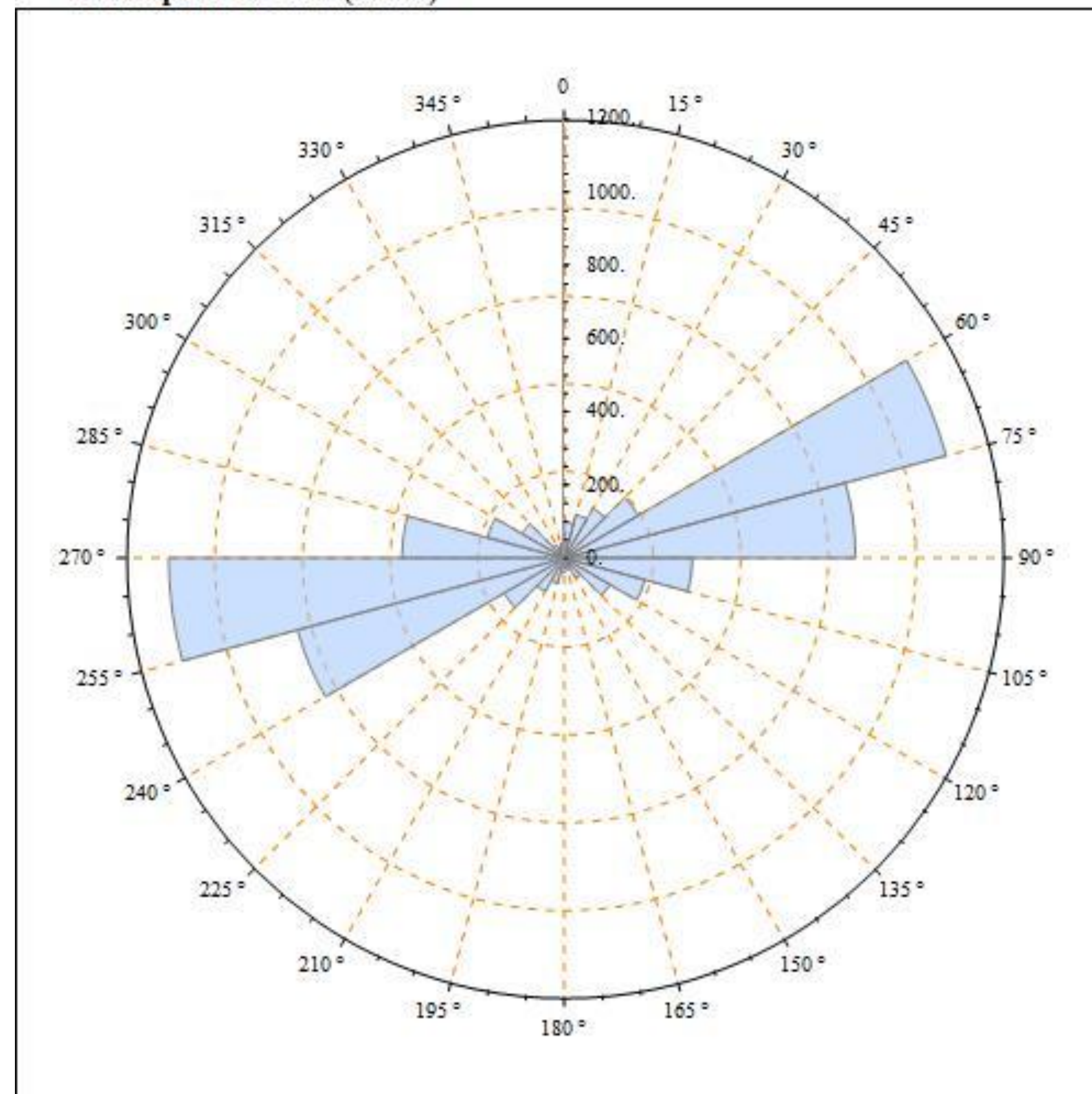



**Figure 3-8.** Kona Area AN155 Windrose Plots for 2011 (left) and 2012 (right)

PHMUy2012.xls–2012: All Hours

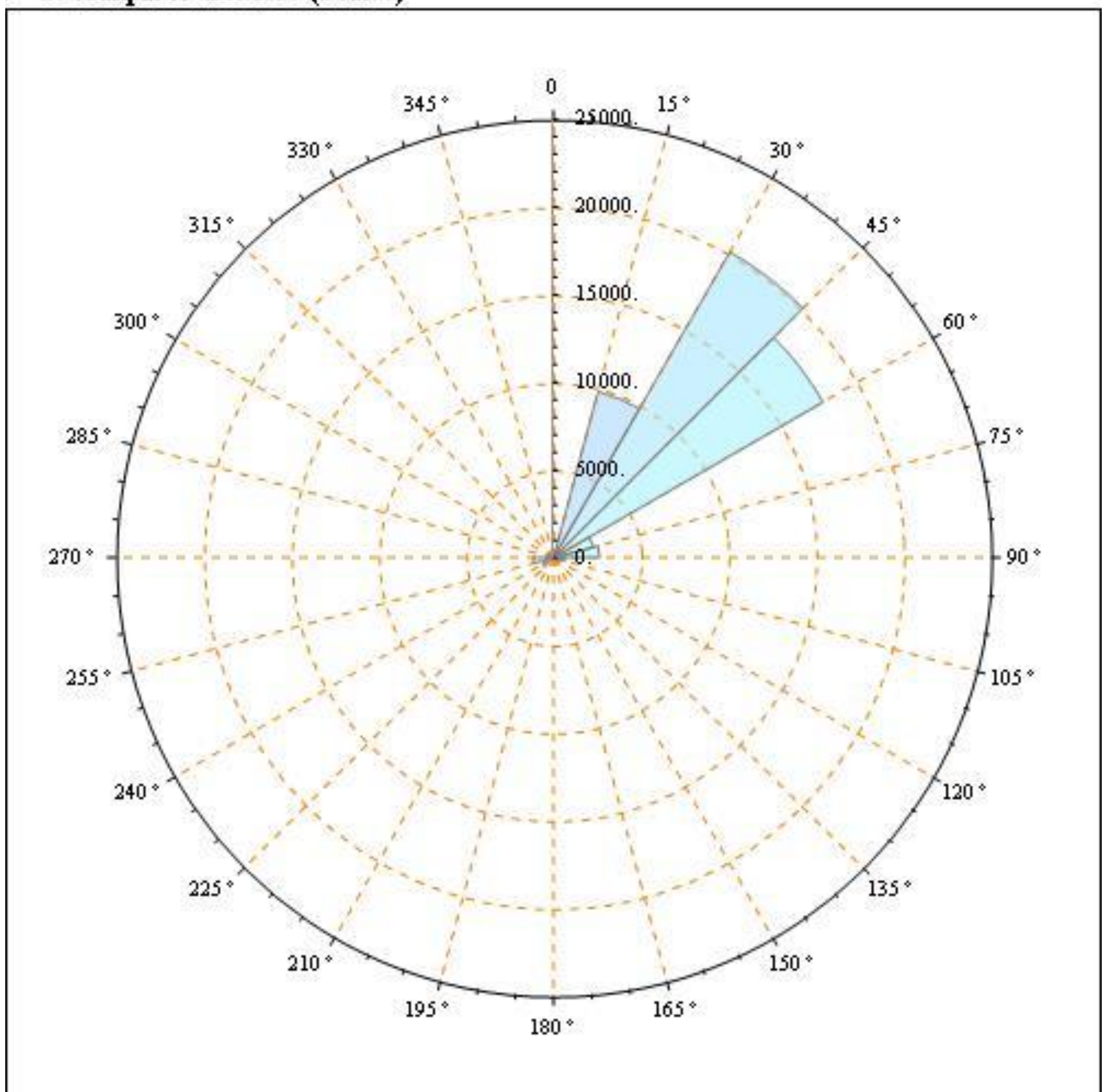
Data Info: Windrose

Number of Datasets = 58199

... first dataset (below); Direction = DRCT °

| ID = PHMU | SKNT m/s | DRCT ° | QFLG | ID = PHMU |
|---|---|---|---|---|
| {2012, 5, 9, 15, 34, 0.} | 7.2 | 30. | OK | 5–9–2012 15:34 HST |

... complete dataset (below)




KKUH1y2012.xls–2012: All Hours

Data Info: Windrose

Number of Datasets = 8413

... first dataset (below); Direction = DRCT °

| ID = KKUH1 | SKNT m/s | DRCT ° | QFLG | ID = KKUH1 |
|---|---|---|---|---|
| {2012, 1, 1, 0, 34, 0.} | 2.2 | 310. | OK | 1–1–2012 0:34 HST |

... complete dataset (below)

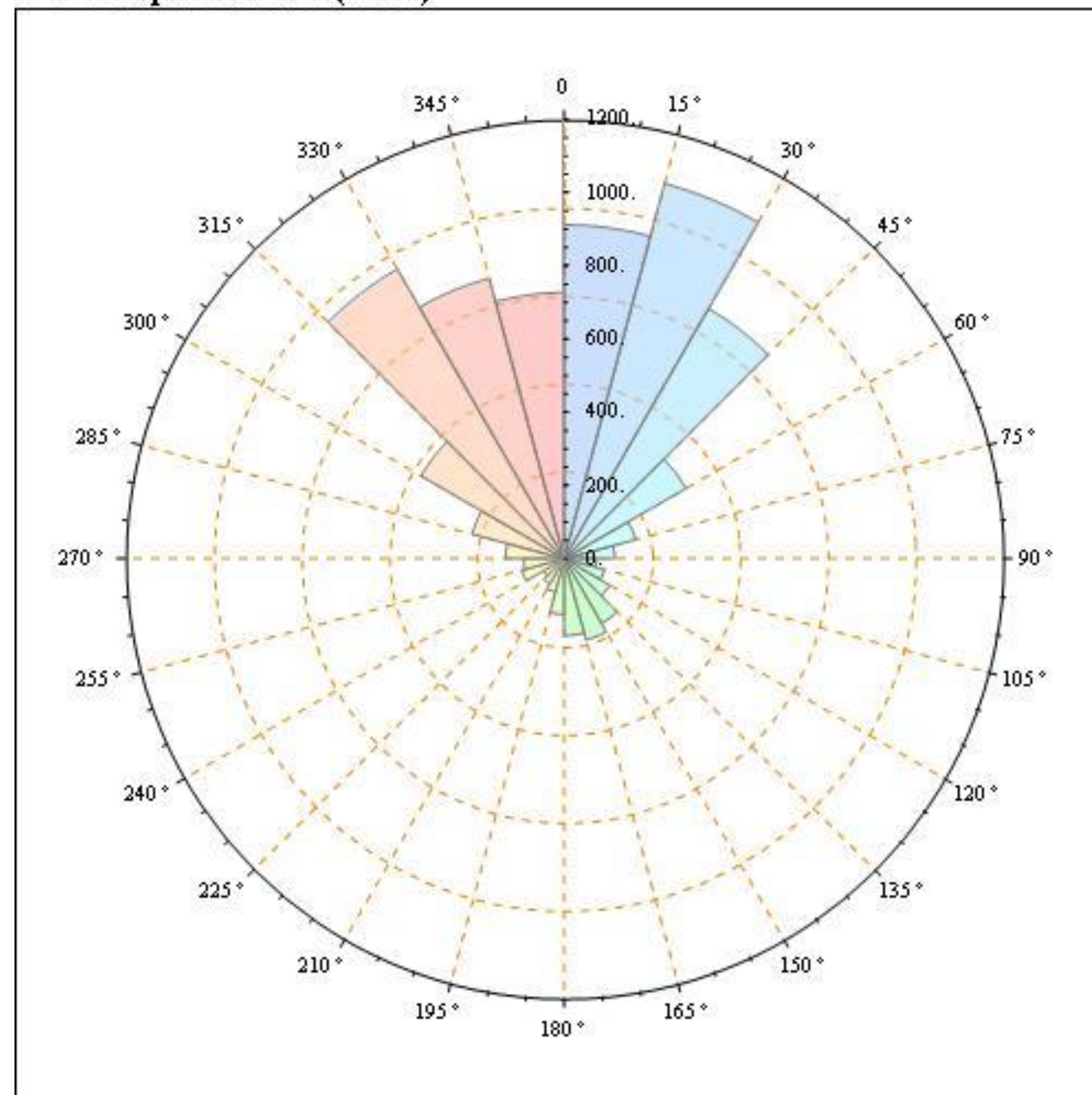



**Figure 3-9.** 2012 Kamuela (PHMU)(left) & Keaumo (KKUH1)(right) Windrose

PHMKy2012.xls–2012: All Hours

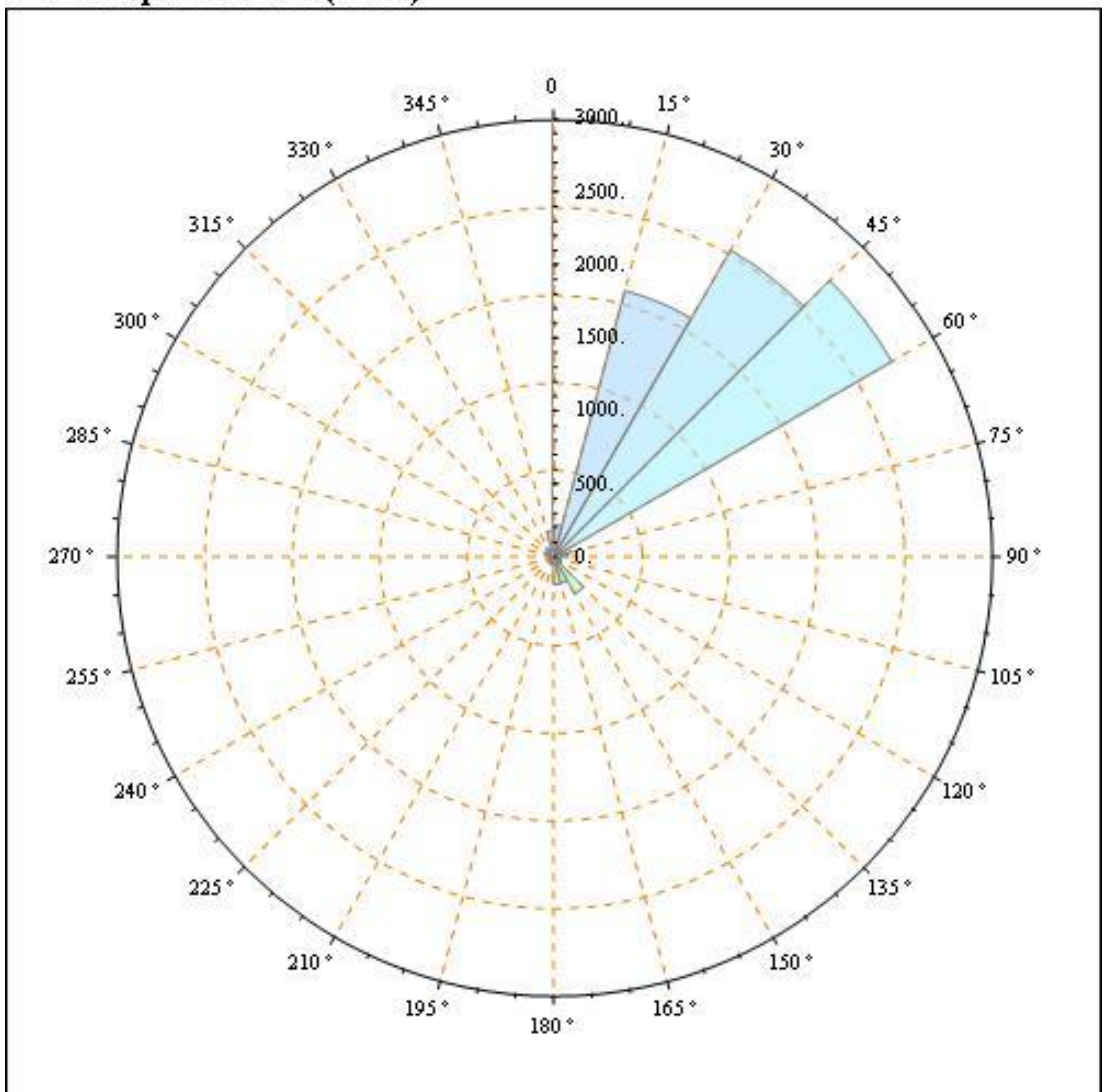
Data Info: Windrose

Number of Datasets = 8835

... first dataset (below); Direction = DRCT °

| ID = PHMK | SKNT m/s | DRCT ° | QFLG | ID = PHMK |
|---|---|---|---|---|
| {2012, 1, 1, 0, 54, 0.} | 2.6 | 30. | OK | 1–1–2012 0:54 HST |

... complete dataset (below)




PHNGy2012.xls–2012: All Hours

Data Info: Windrose

Number of Datasets = 9721

... first dataset (below); Direction = DRCT °

| ID = PHNG | SKNT m/s | DRCT ° | QFLG | ID = PHNG |
|---|---|---|---|---|
| {2012, 1, 1, 5, 38, 0.} | 2.1 | 50. | OK | 1–1–2012 5:38 HST |

... complete dataset (below)

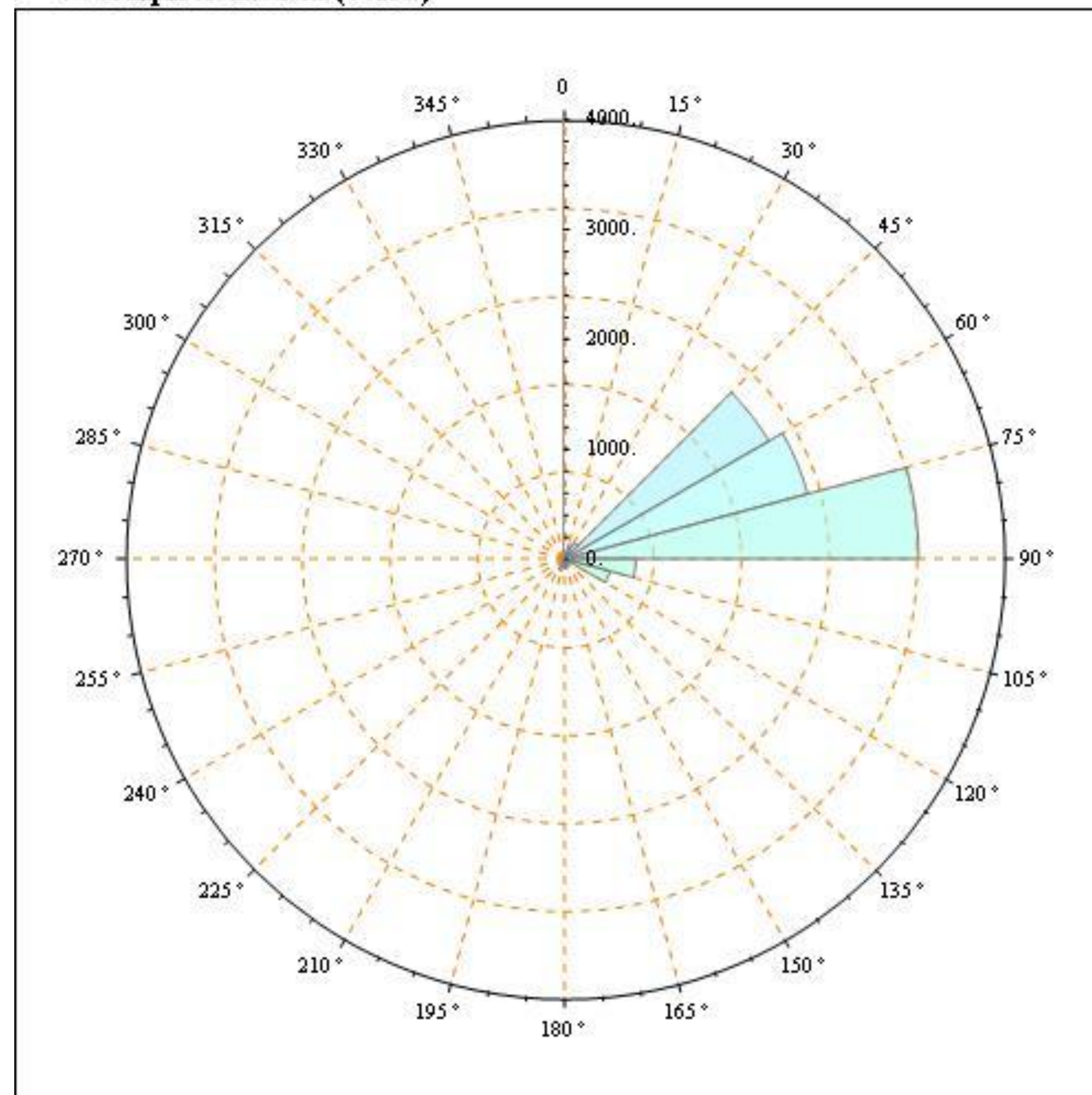



**Figure 3-10.** 2012 Kaunakakai, Molokai Airport (PHMK)(left) & Kaneohe, Marine Corps Air Station (PHNG)(right) Windrose

WKVH1y2012.xls–2012: All Hours

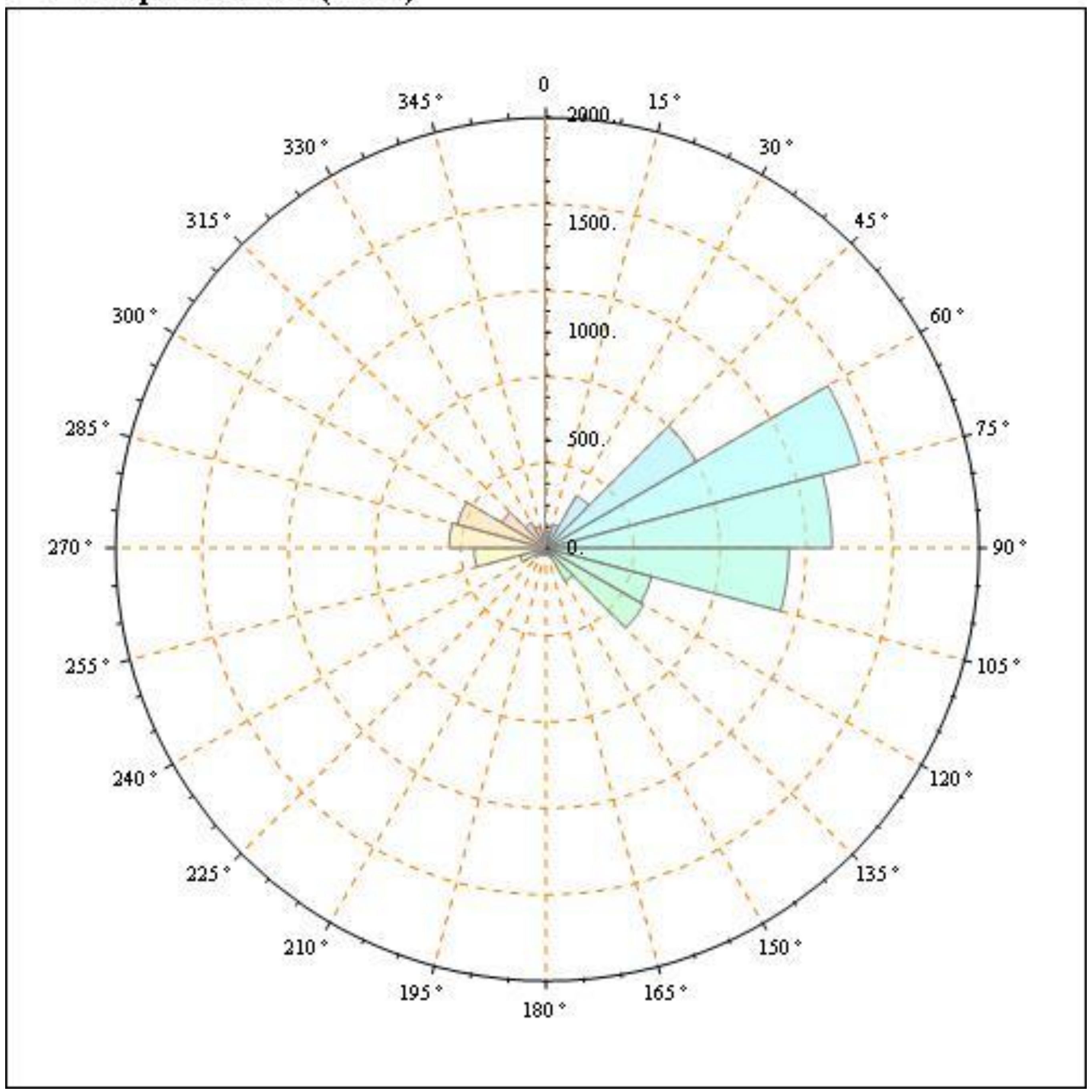
Data Info: Windrose

Number of Datasets = 8552

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 0, 35, 0.} | 5.8 | 64. | OK | 1–1–2012 0:35 HST |

... complete dataset (below)




KPLH1y2012.xls–2012: All Hours

Data Info: Windrose

Number of Datasets = 7067

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 0, 36, 0.} | 3.6 | 156. | OK | 1–1–2012 0:36 HST |

... complete dataset (below)

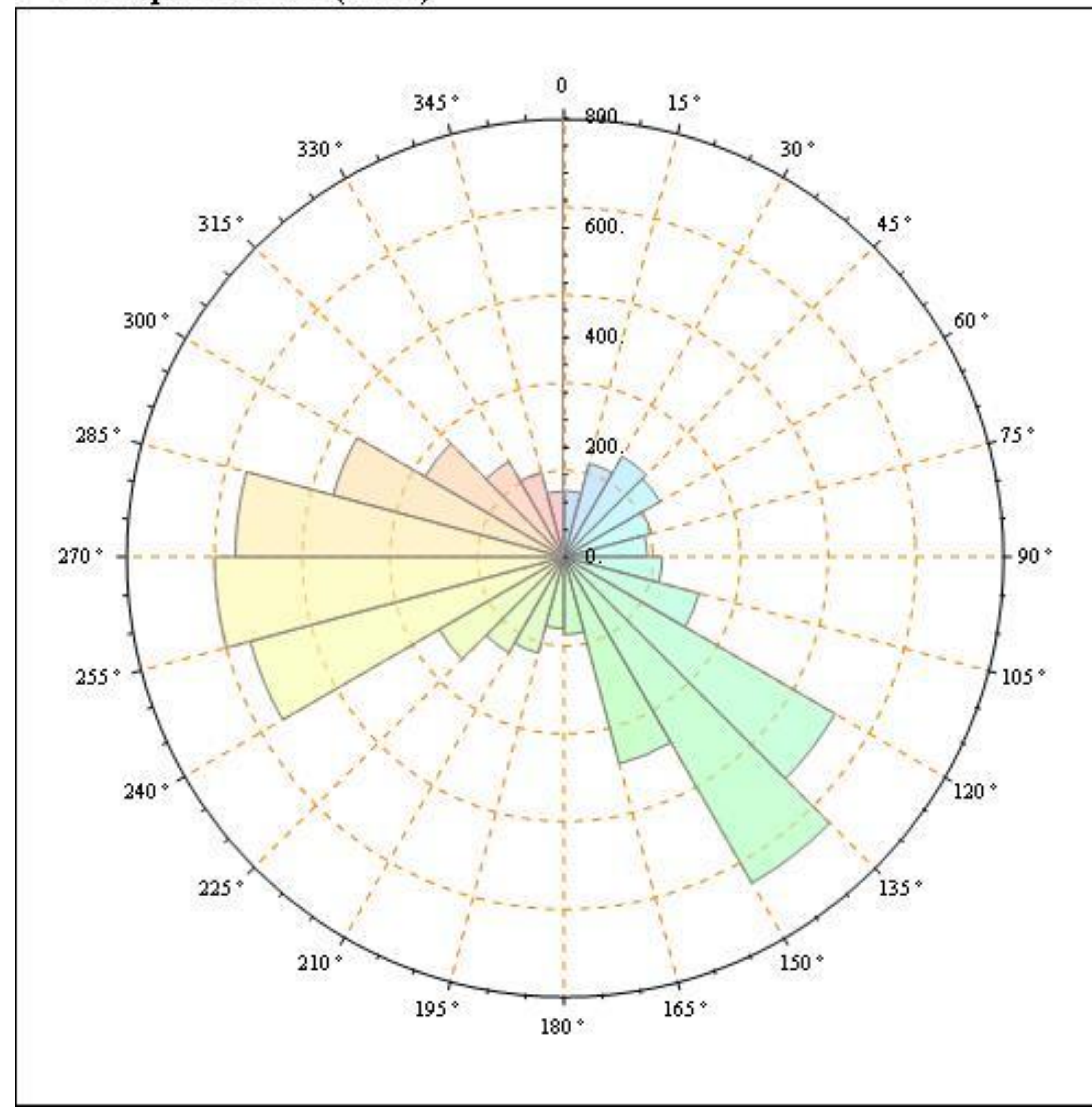



**Figure 3-11.** 2012 Waikoloa (WKVH1)(left) & Kaupulehu Lava Flow (KPLH1)(right) Windrose

PTRH1y2012.xls–2012: All Hours

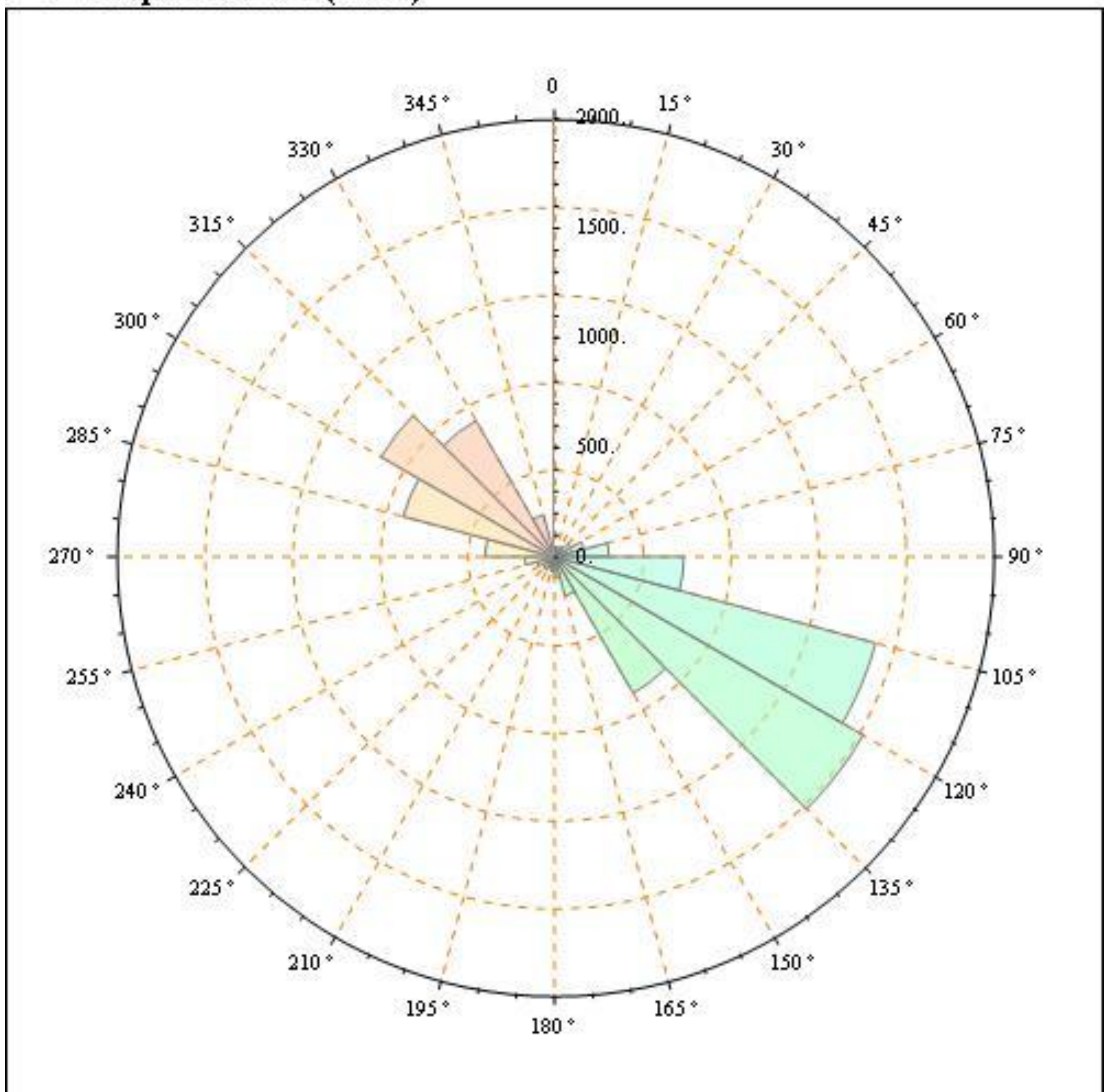
Data Info: Windrose

Number of Datasets = 8734

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 0, 49, 0.} | 2.7 | 101. | OK | 1–1–2012 0:49 HST |

... complete dataset (below)




PHTOy2012.xls–2012: All Hours

Data Info: Windrose

Number of Datasets = 10784

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 0, 19, 0.} | 2.1 | 290. | OK | 1–1–2012 0:19 HST |

... complete dataset (below)

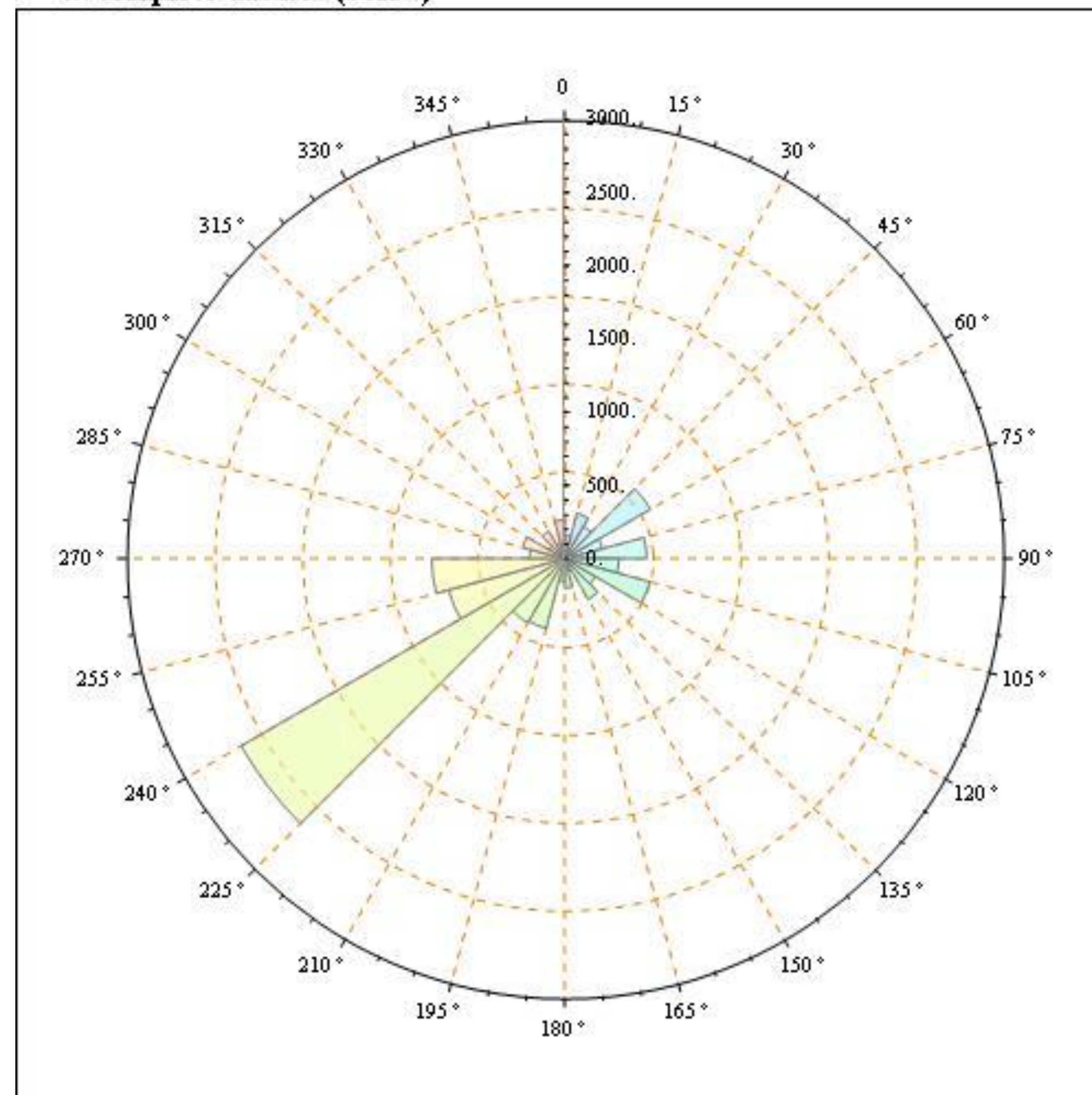



**Figure 3-12.** 2012 PTA Range 17 (left) & Hilo International Airport (right) Windrose

**AN157y2012.xls–2012: All Hours**

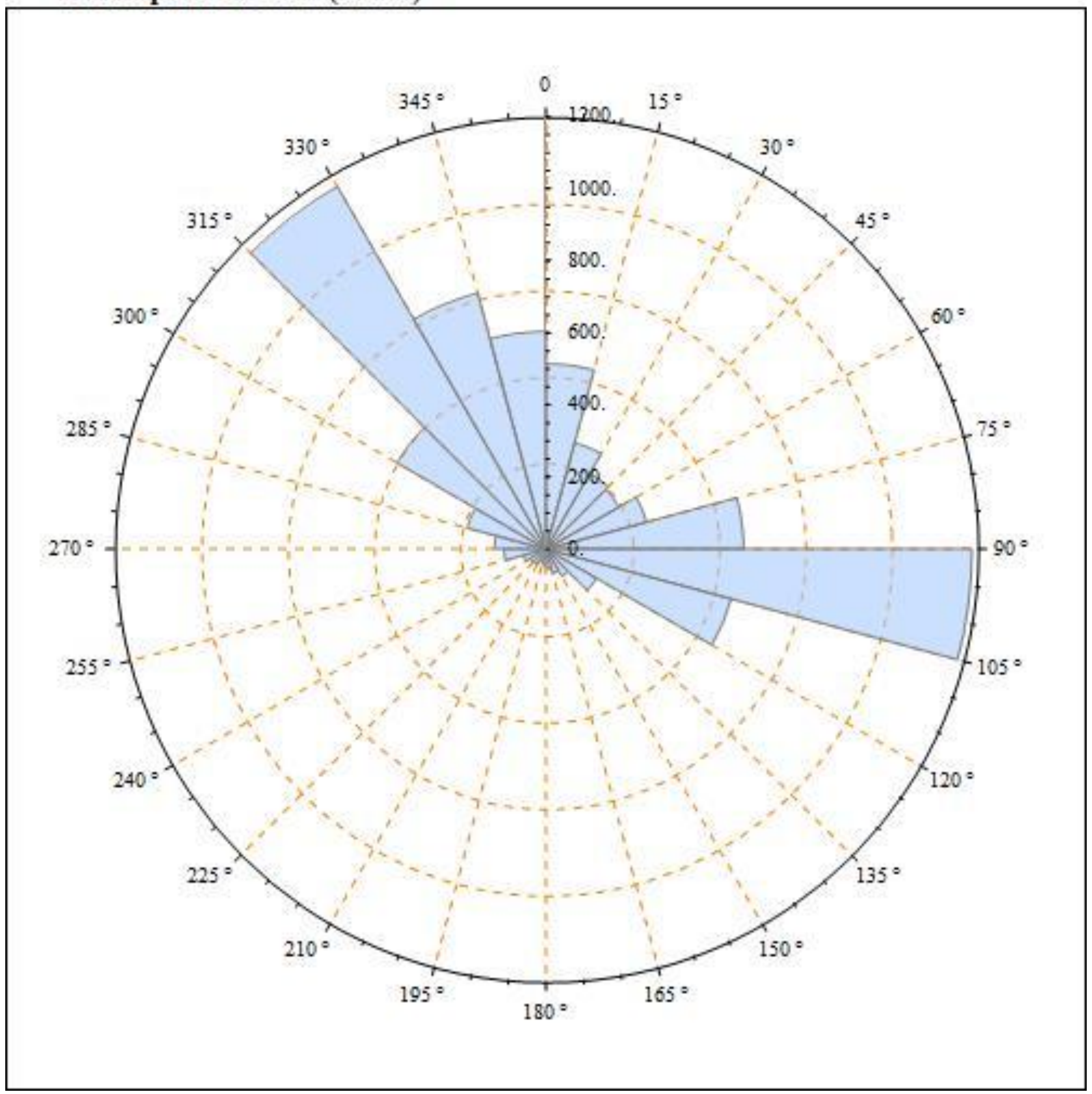
Data Info: Windrose

Number of Datasets = 7938

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 1, 0, 0.} | 1.7 | 314. | OK | 1–1–2012 1:00 HST |

... complete dataset (below)




**AN738y2012.xls–2012: All Hours**

Data Info: Windrose

Number of Datasets = 7787

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 1, 0, 0.} | 2.1 | 7. | N/A | 1–1–2012 1:00 HST |

... complete dataset (below)

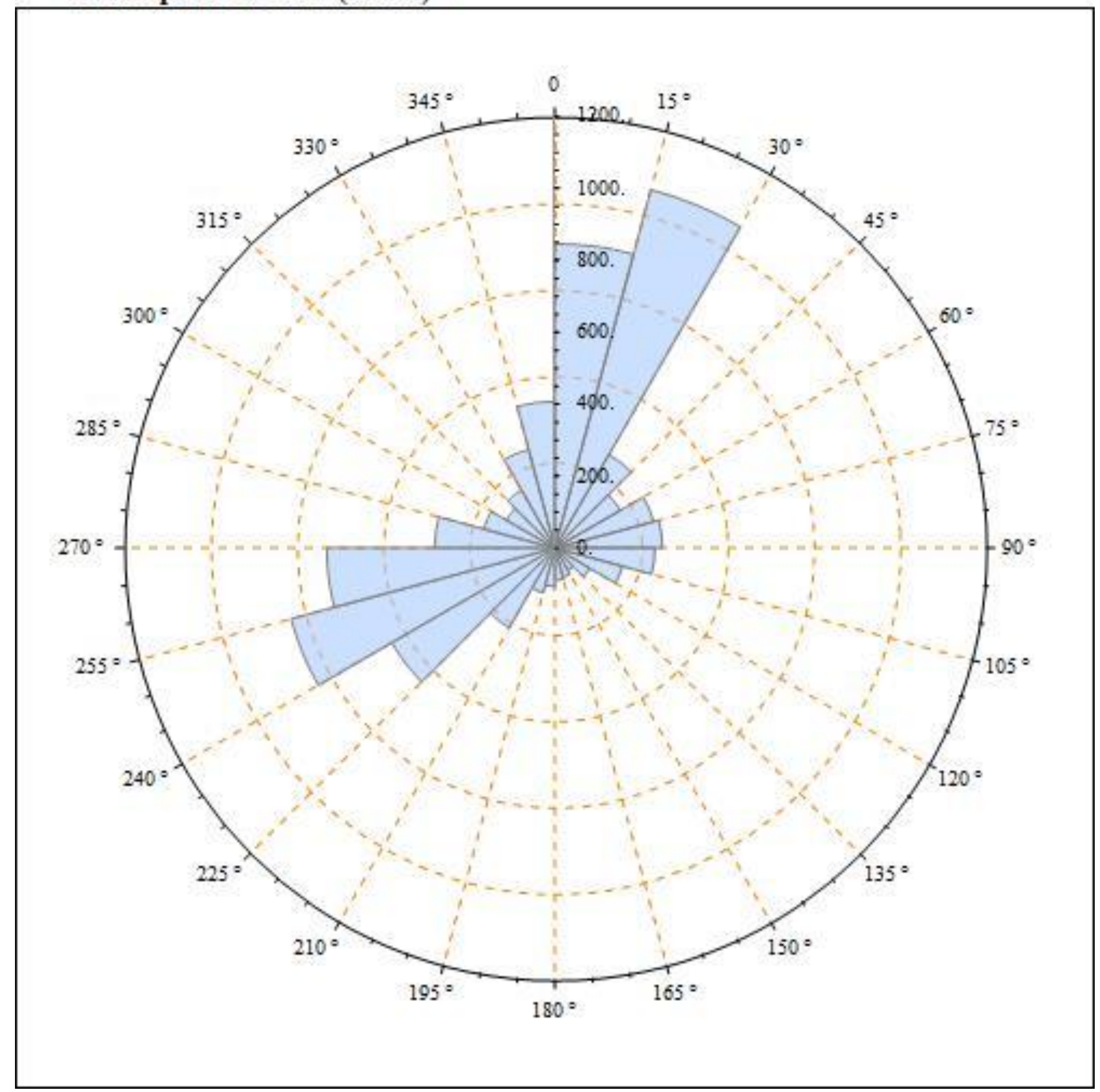



**Figure 3-13.** 2012 Pahala (AN157)(left) and Ocean View (AN738)(right) Windrose

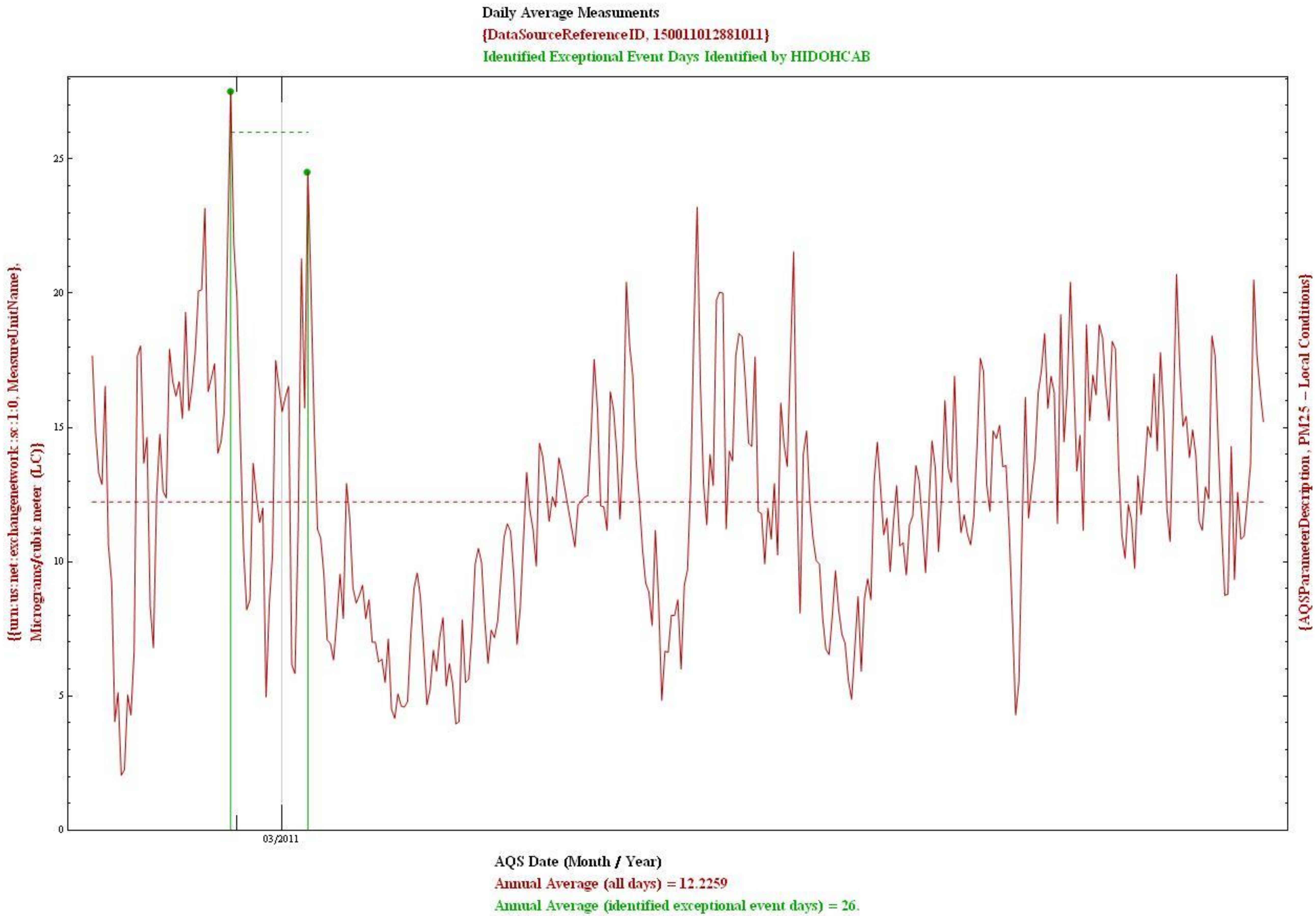



**Figure 3-14.** 2011 Time History of Kona (red) $PM_{2.5}$ Concentrations with Flagged Days (green)

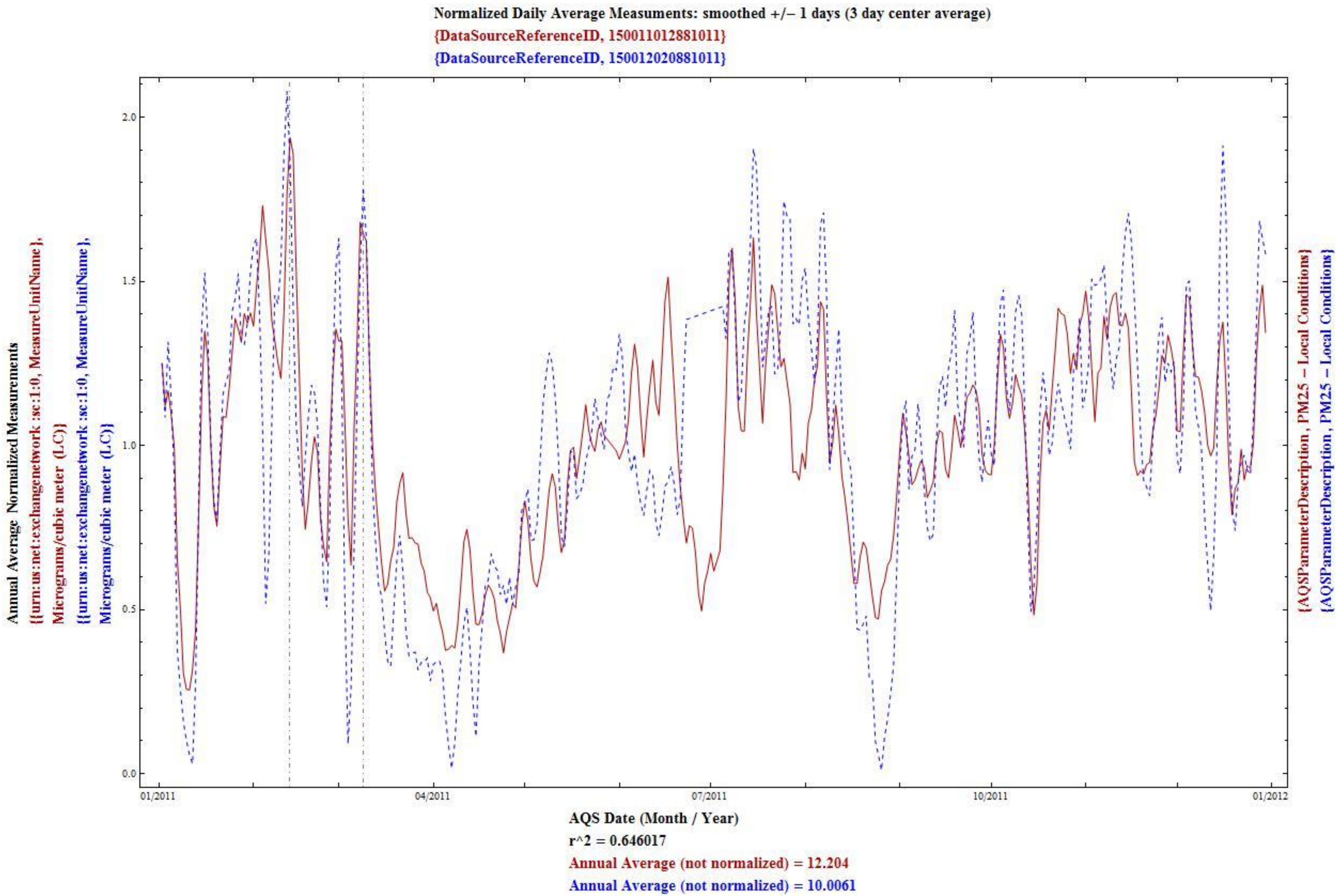



**Figure 3-15.** Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $PM_{2.5}$ Concentrations with Flagged Days (vertical broken lines)

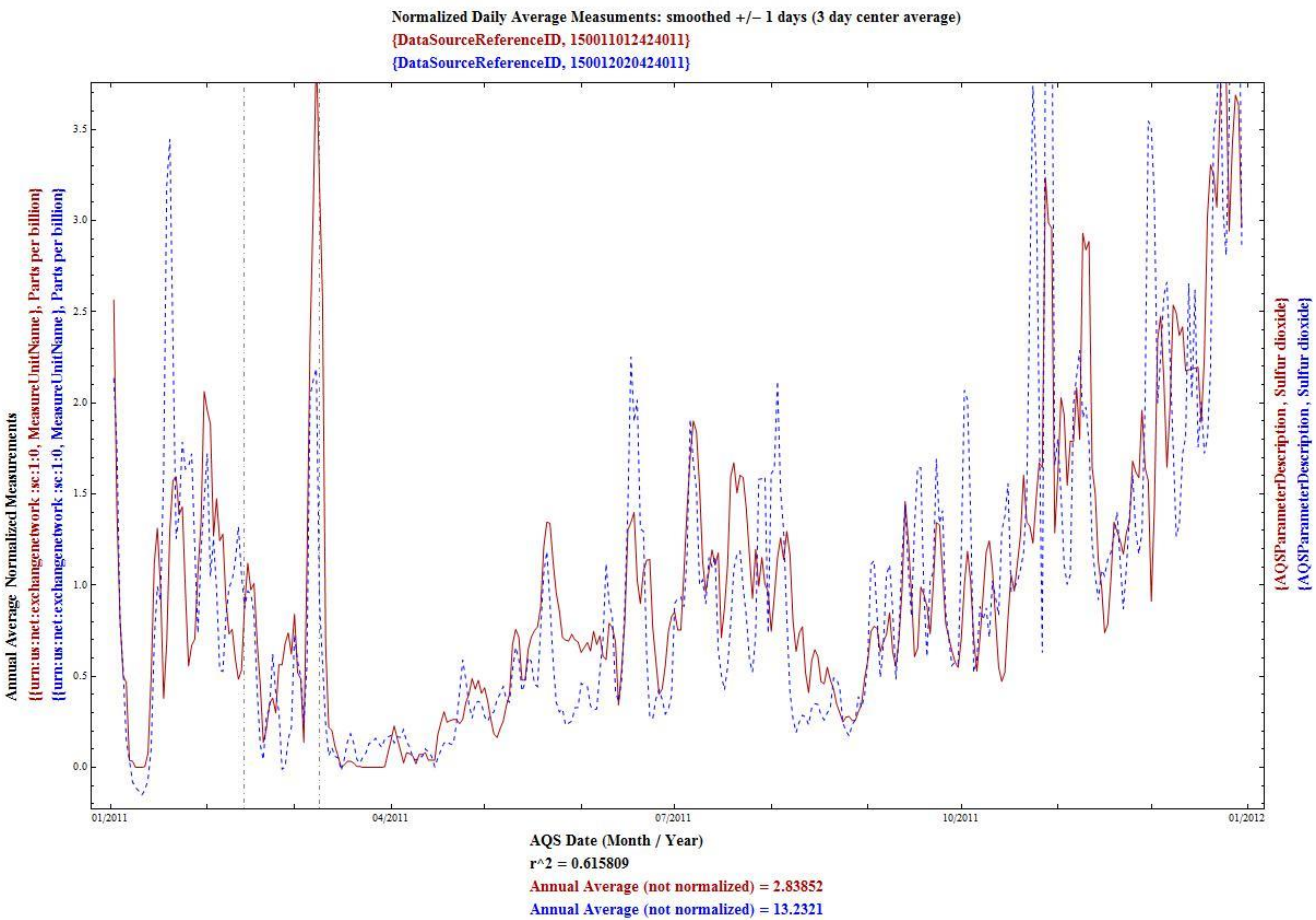



**Figure 3-16.** 2011 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $SO_2$ Concentrations with Flagged Days (vertical broken lines)

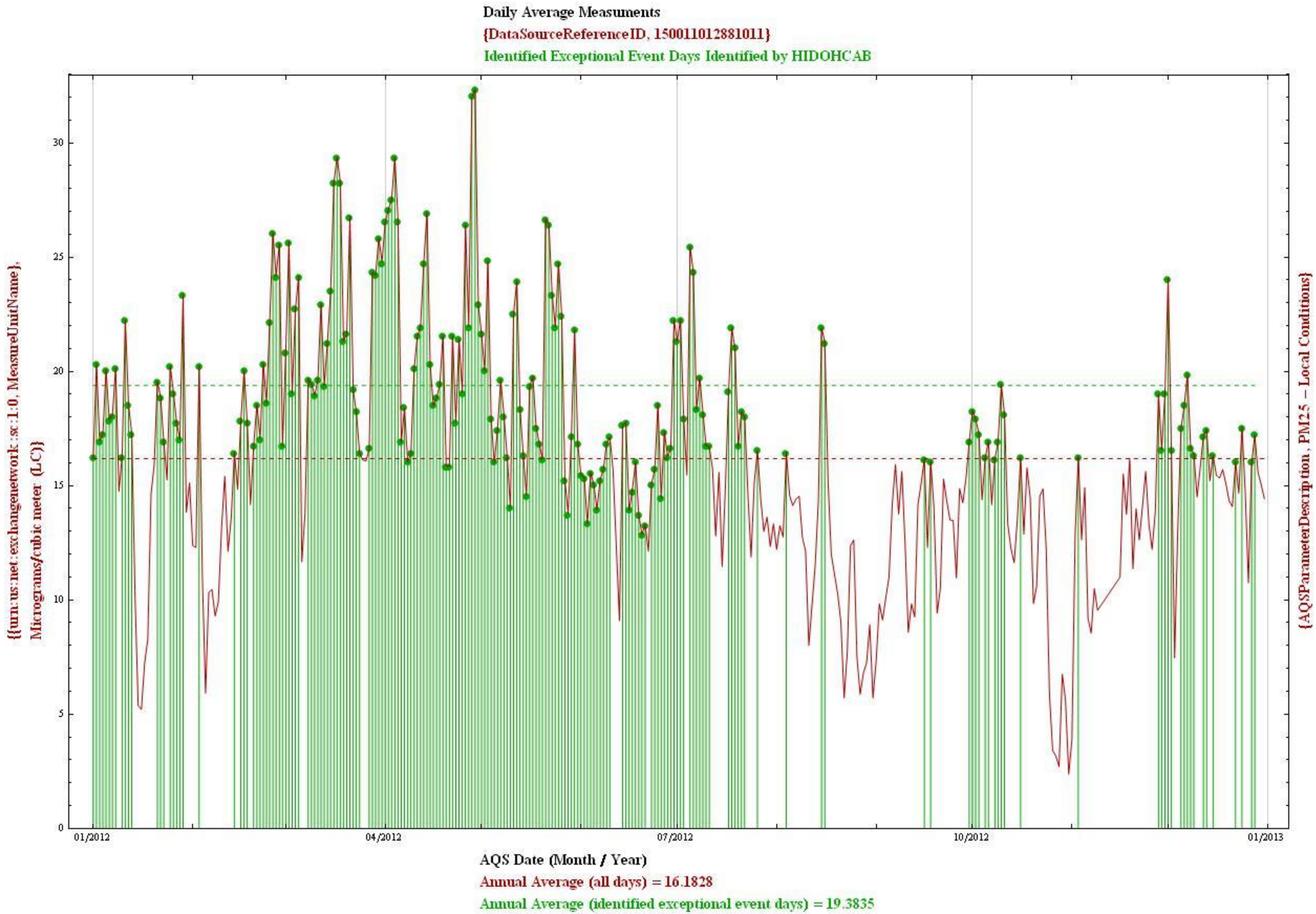



**Figure 3-17.** 2012 Time History of Kona (red) $PM_{2.5}$ Concentrations with Flagged Days (green)

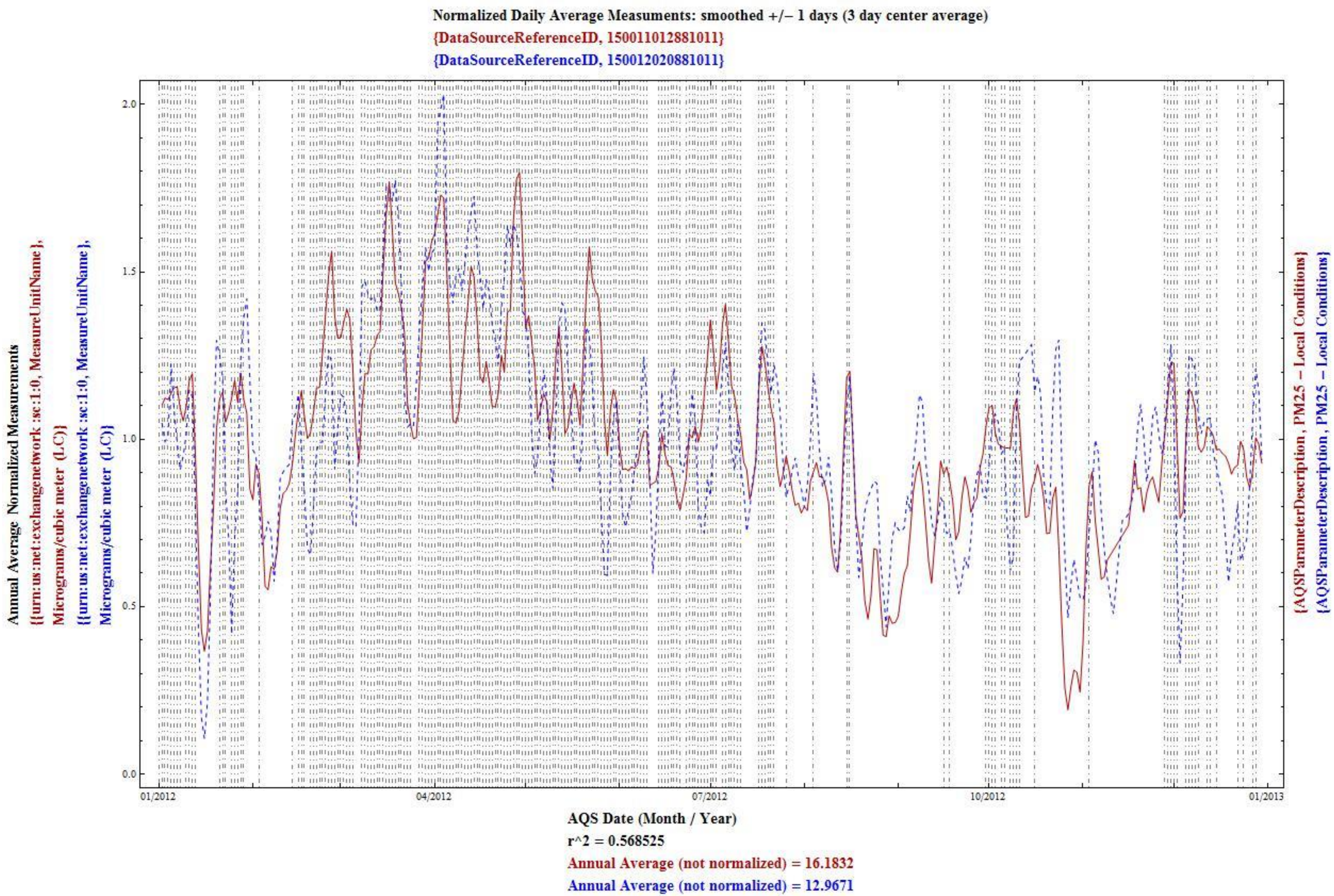



**Figure 3-18.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $PM_{2.5}$ Concentrations with Flagged Days (vertical broken lines)

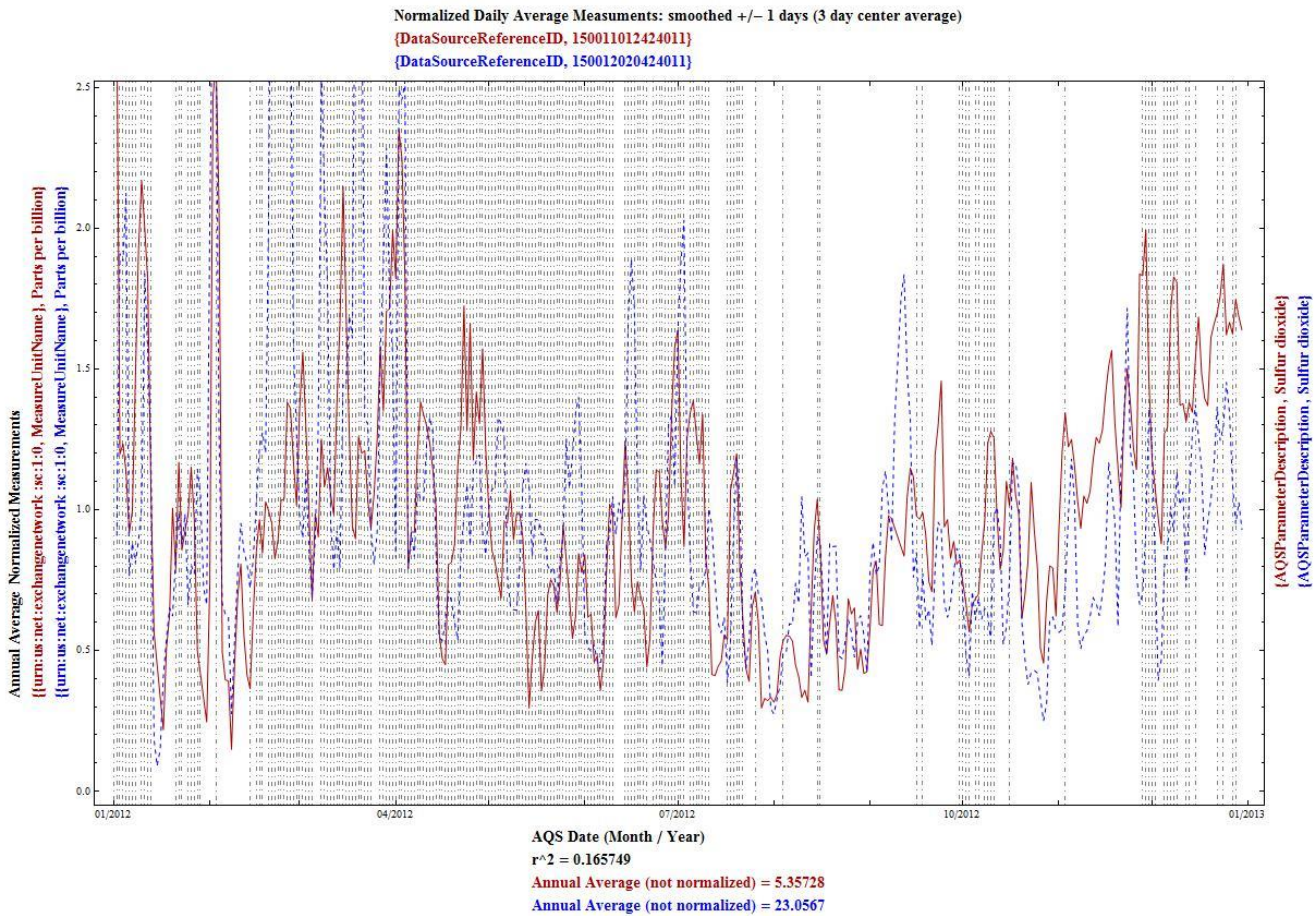



**Figure 3-19.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $SO_2$ Concentrations with Flagged Days (vertical broken lines)

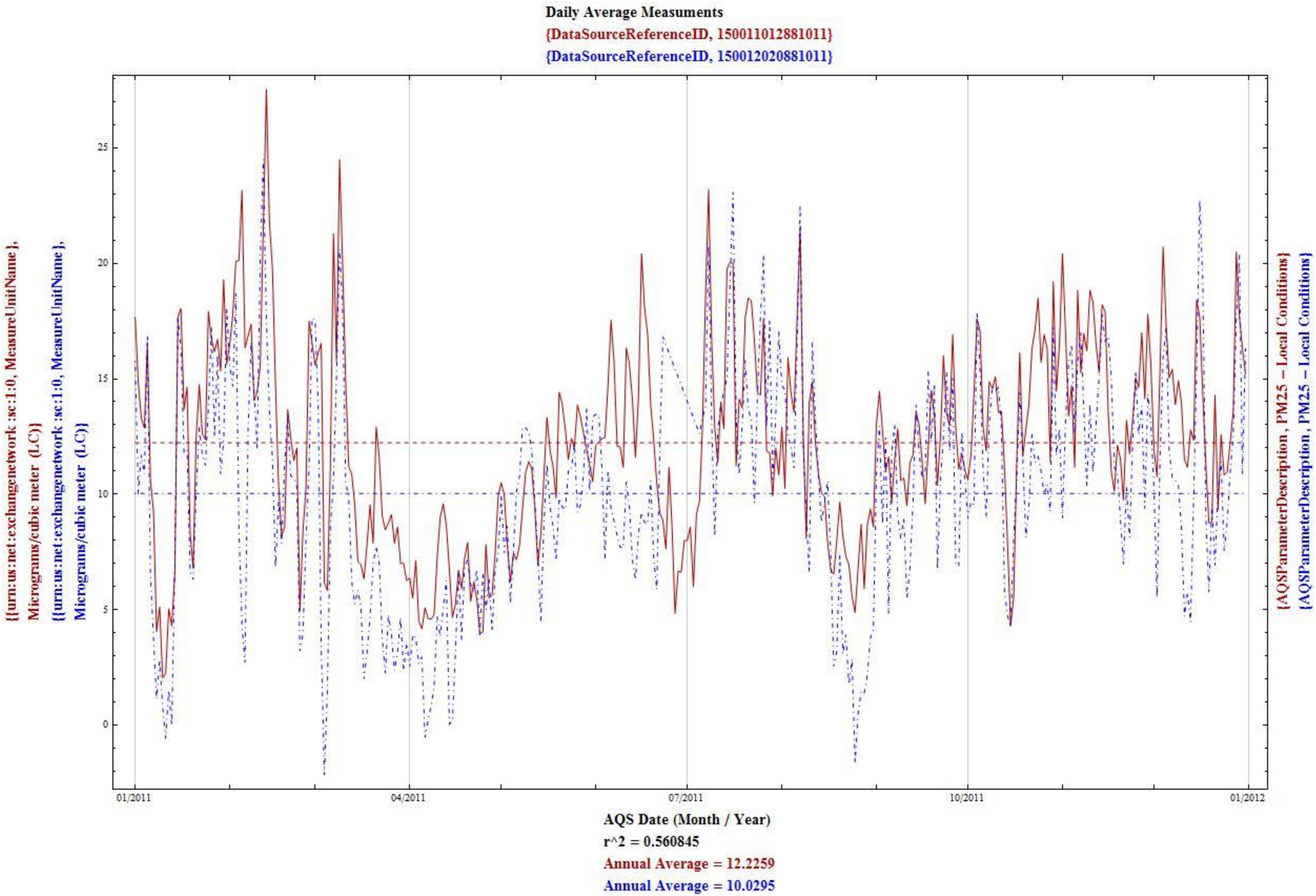



**Figure A-14.** 2011 Time History of Kona (red) and Ocean View (blue, dot-dash) $PM_{2.5}$ Concentrations (unsmoothed data)

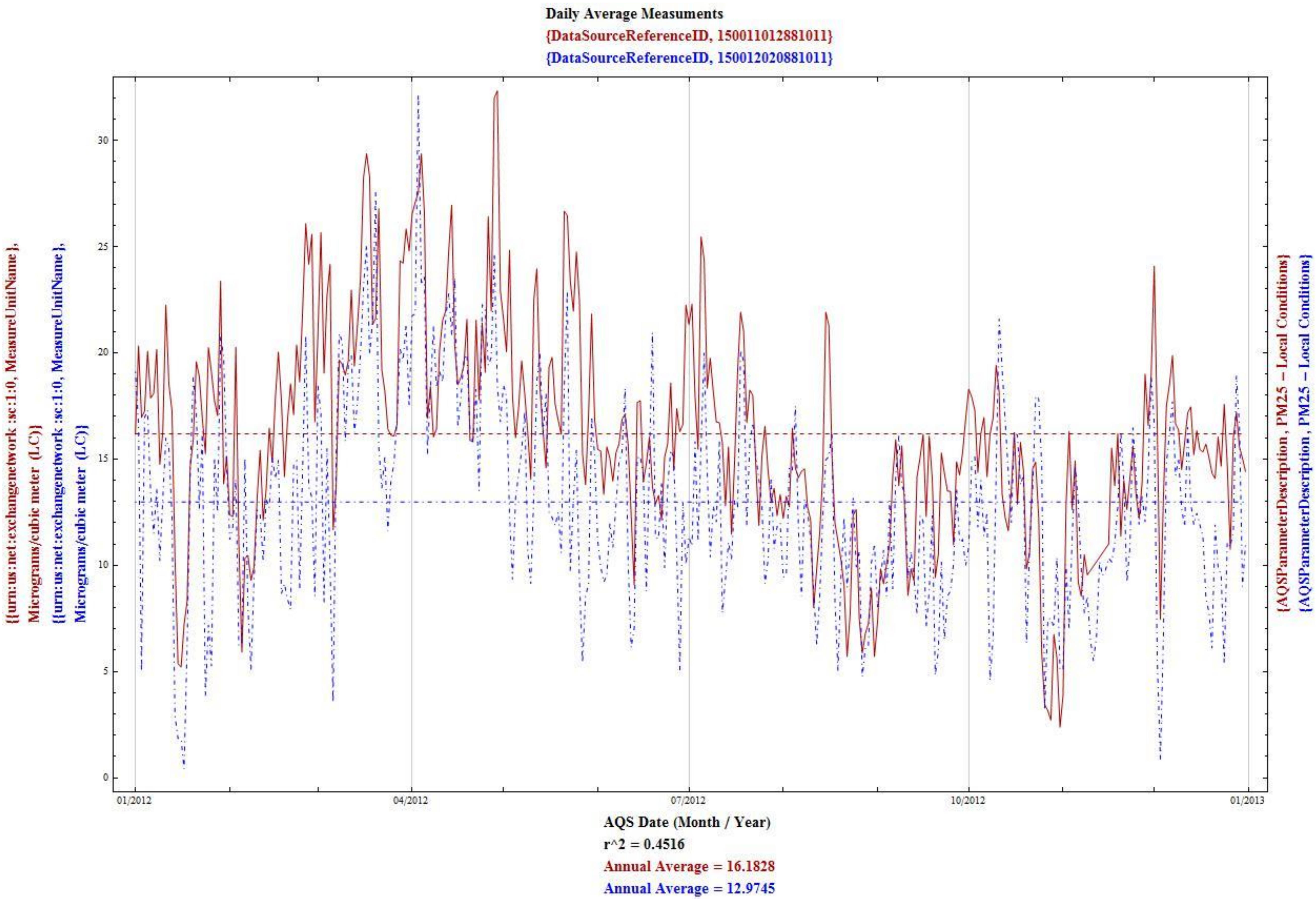



**Figure A-15.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) $PM_{2.5}$ Concentrations (unsmoothed data)

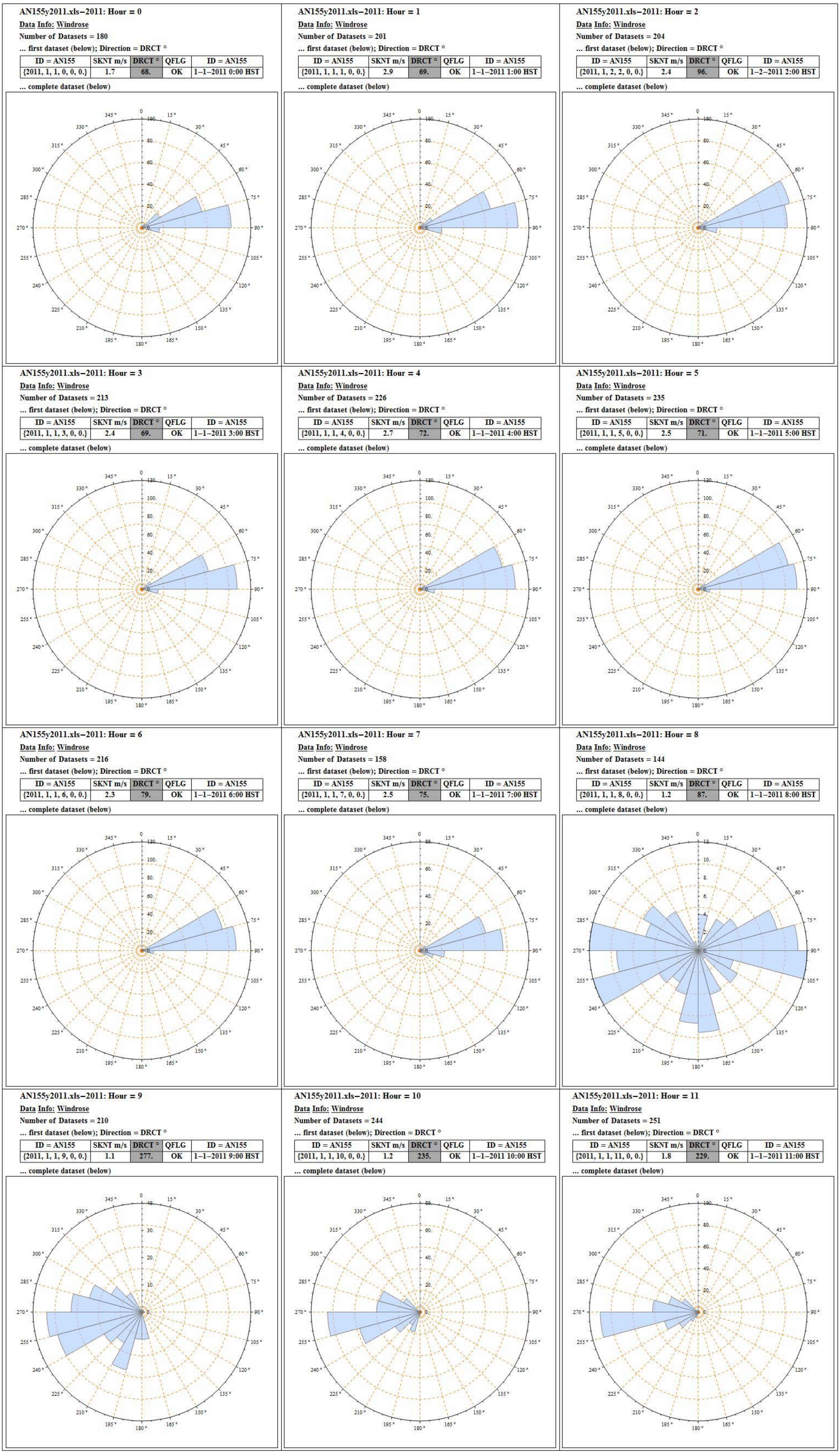
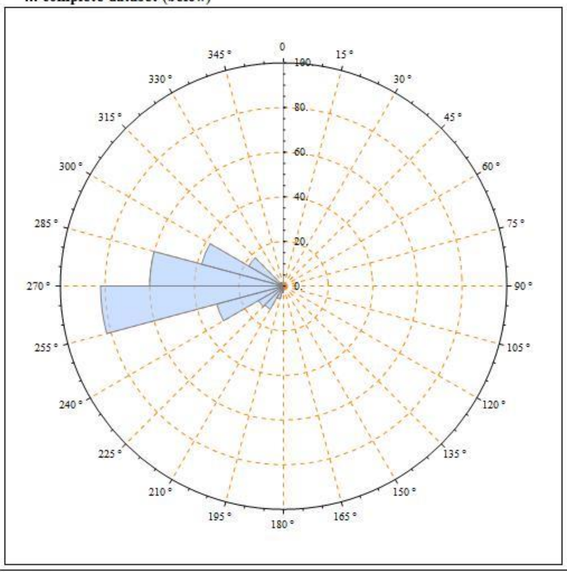



**Figure A-16.** 2011 Kona (AN155) Windrose - Morning Hours

**AN155y2011.xls–2011: Hour = 12**
Data Info: Windrose
Number of Datasets = 266
... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2011, 1, 1, 12, 0, 0.} | 2. | 213. | OK | 1–1–2011 12:00 HST |

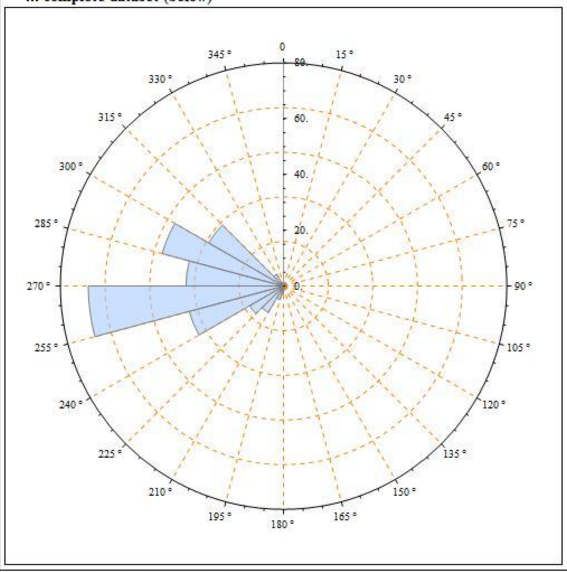
... complete dataset (below)



**AN155y2011.xls–2011: Hour = 13**
Data Info: Windrose
Number of Datasets = 257
... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2011, 1, 1, 13, 0, 0.} | 1.7 | 218. | OK | 1–1–2011 13:00 HST |

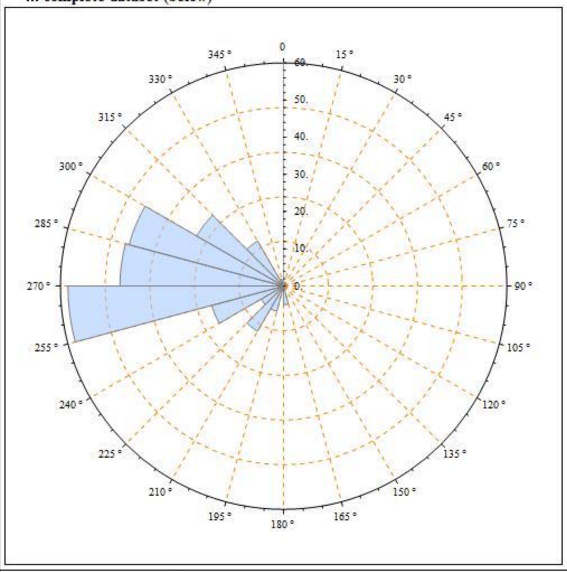
... complete dataset (below)



**AN155y2011.xls–2011: Hour = 14**
Data Info: Windrose
Number of Datasets = 245
... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2011, 1, 1, 14, 0, 0.} | 1.9 | 211. | OK | 1–1–2011 14:00 HST |

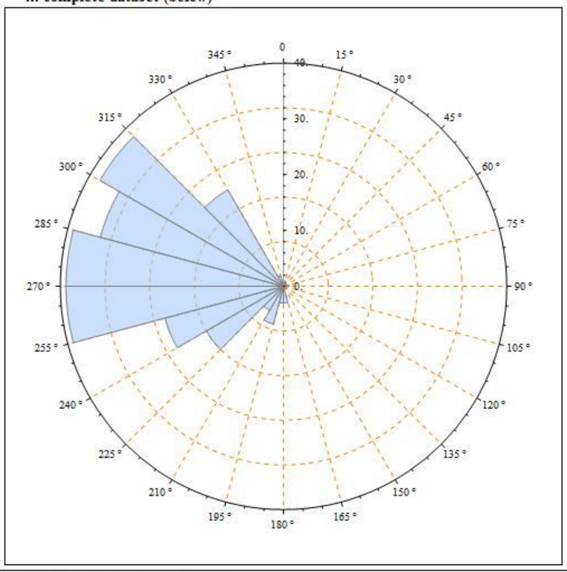
... complete dataset (below)



**AN155y2011.xls–2011: Hour = 15**
Data Info: Windrose
Number of Datasets = 231
... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2011, 1, 2, 15, 0, 0.} | 1.6 | 267. | OK | 1–2–2011 15:00 HST |

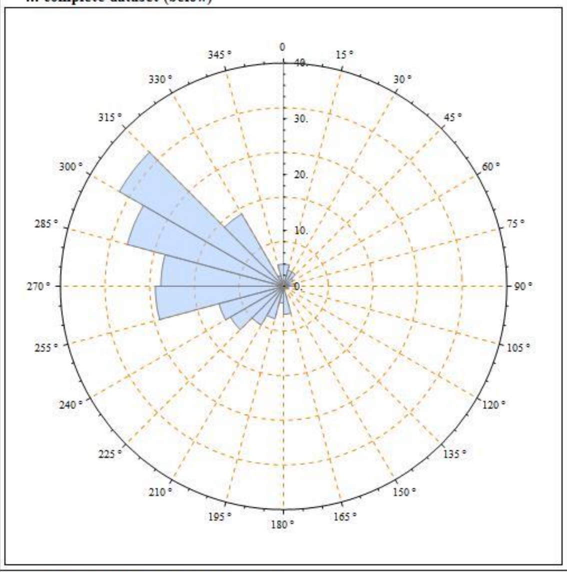
... complete dataset (below)



**AN155y2011.xls–2011: Hour = 16**
Data Info: Windrose
Number of Datasets = 190
... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2011, 1, 1, 16, 0, 0.} | 1.2 | 272. | OK | 1–1–2011 16:00 HST |

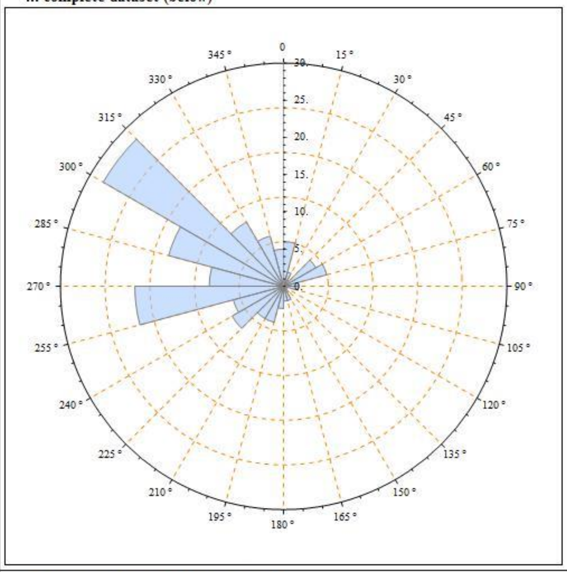
... complete dataset (below)



**AN155y2011.xls–2011: Hour = 17**
Data Info: Windrose
Number of Datasets = 153
... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2011, 1, 1, 17, 0, 0.} | 0.8 | 9. | OK | 1–1–2011 17:00 HST |

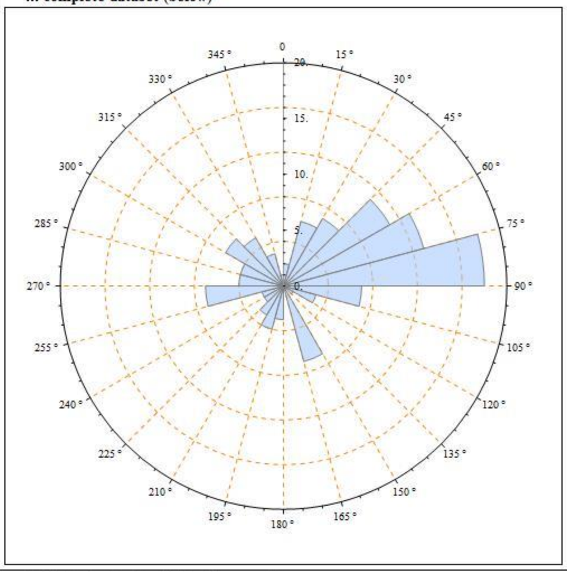
... complete dataset (below)



**AN155y2011.xls–2011: Hour = 18**
Data Info: Windrose
Number of Datasets = 119
... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2011, 1, 1, 18, 0, 0.} | 1.4 | 36. | OK | 1–1–2011 18:00 HST |

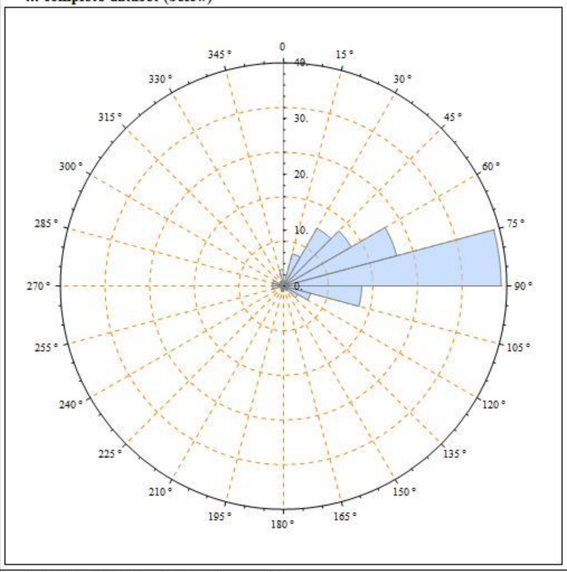
... complete dataset (below)



**AN155y2011.xls–2011: Hour = 19**
Data Info: Windrose
Number of Datasets = 129
... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2011, 1, 1, 19, 0, 0.} | 1.9 | 43. | OK | 1–1–2011 19:00 HST |

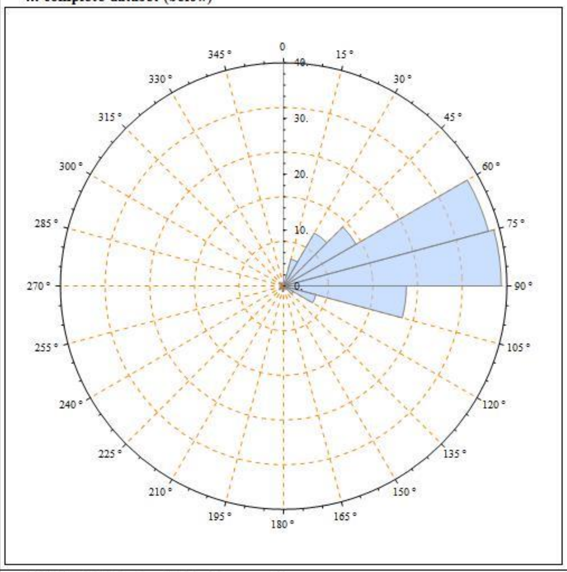
... complete dataset (below)



**AN155y2011.xls–2011: Hour = 20**
Data Info: Windrose
Number of Datasets = 141
... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2011, 1, 1, 20, 0, 0.} | 2. | 38. | OK | 1–1–2011 20:00 HST |

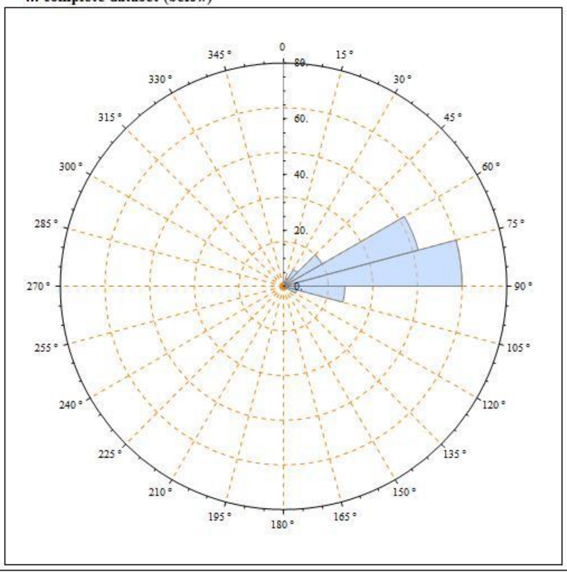
... complete dataset (below)



**AN155y2011.xls–2011: Hour = 21**
Data Info: Windrose
Number of Datasets = 168
... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2011, 1, 1, 21, 0, 0.} | 2.2 | 36. | OK | 1–1–2011 21:00 HST |

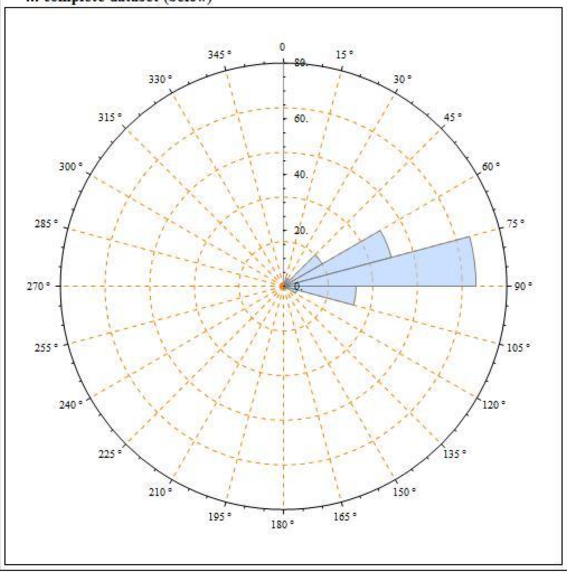
... complete dataset (below)



**AN155y2011.xls–2011: Hour = 22**
Data Info: Windrose
Number of Datasets = 164
... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2011, 1, 1, 22, 0, 0.} | 1.8 | 33. | OK | 1–1–2011 22:00 HST |

... complete dataset (below)



**AN155y2011.xls–2011: Hour = 23**
Data Info: Windrose
Number of Datasets = 176
... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2011, 1, 1, 23, 0, 0.} | 1.9 | 72. | OK | 1–1–2011 23:00 HST |

... complete dataset (below)

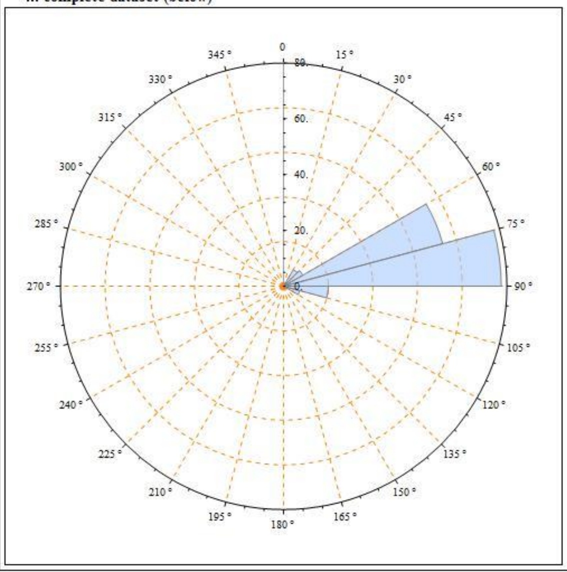


**Figure A-17.** 2011 Kona (AN155) Windrose - Evening Hours

Data year: 2011
{AQS File: AQDM_RR_248385.xml, ID: 150011012881011, Lat: 19.5098, Long: −155.913, Elev: 517 Meters, Pollutant: PM2.5 – Local Conditions (Micrograms/cubic meter (LC)), # Records: 8555}
{Meso West File: AN155y2011.xls, ID = AN155, Data Info: {SKNT m/s, DRCT °}, # Records: {4726, 4}}
{# Matching Records: 4582, # Unmatched AQS Records: 3973, Total # AQS Records: 8555}
{{DRCT: 0.–45., DRCT: 315.–360.}, {DRCT: 45.–135.}, {DRCT: 135.–225.}, {DRCT: 225.–315.}}
{{SKNT: 0.–0.5}, {SKNT: 0.5–7.}, {SKNT: 7.–100.}}

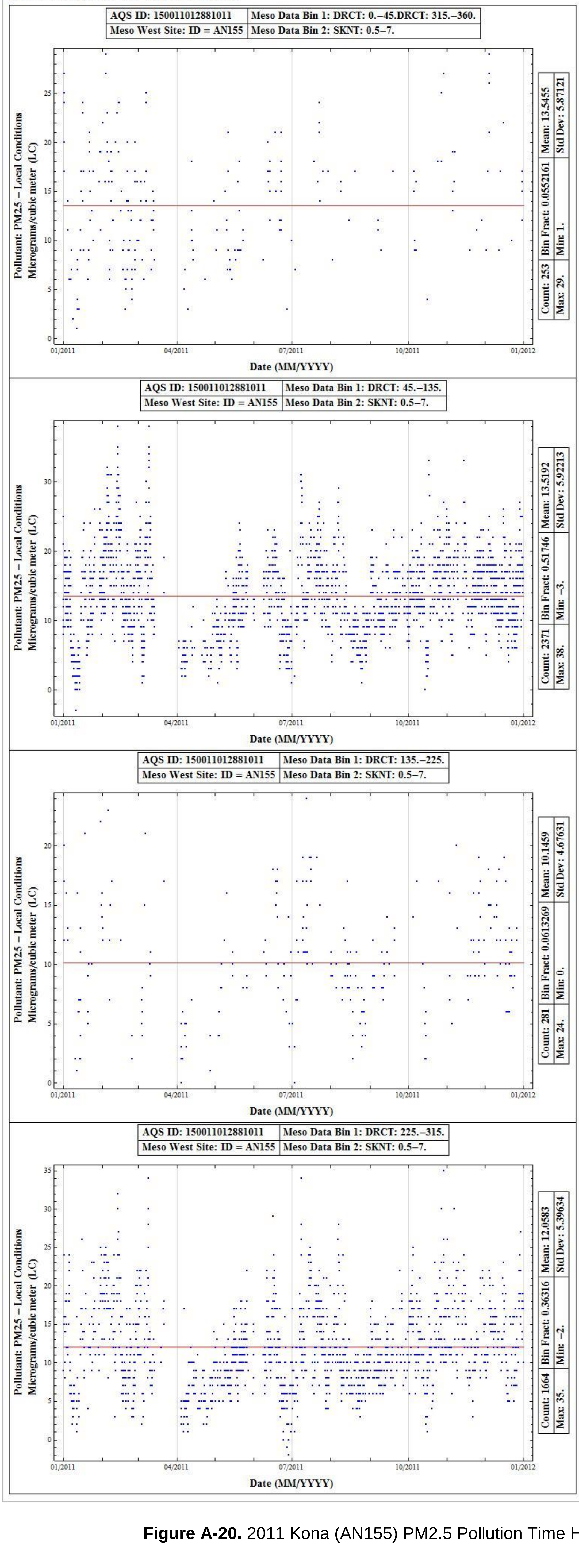



**Figure A-20.** 2011 Kona (AN155) PM2.5 Pollution Time History by Wind Quadrant

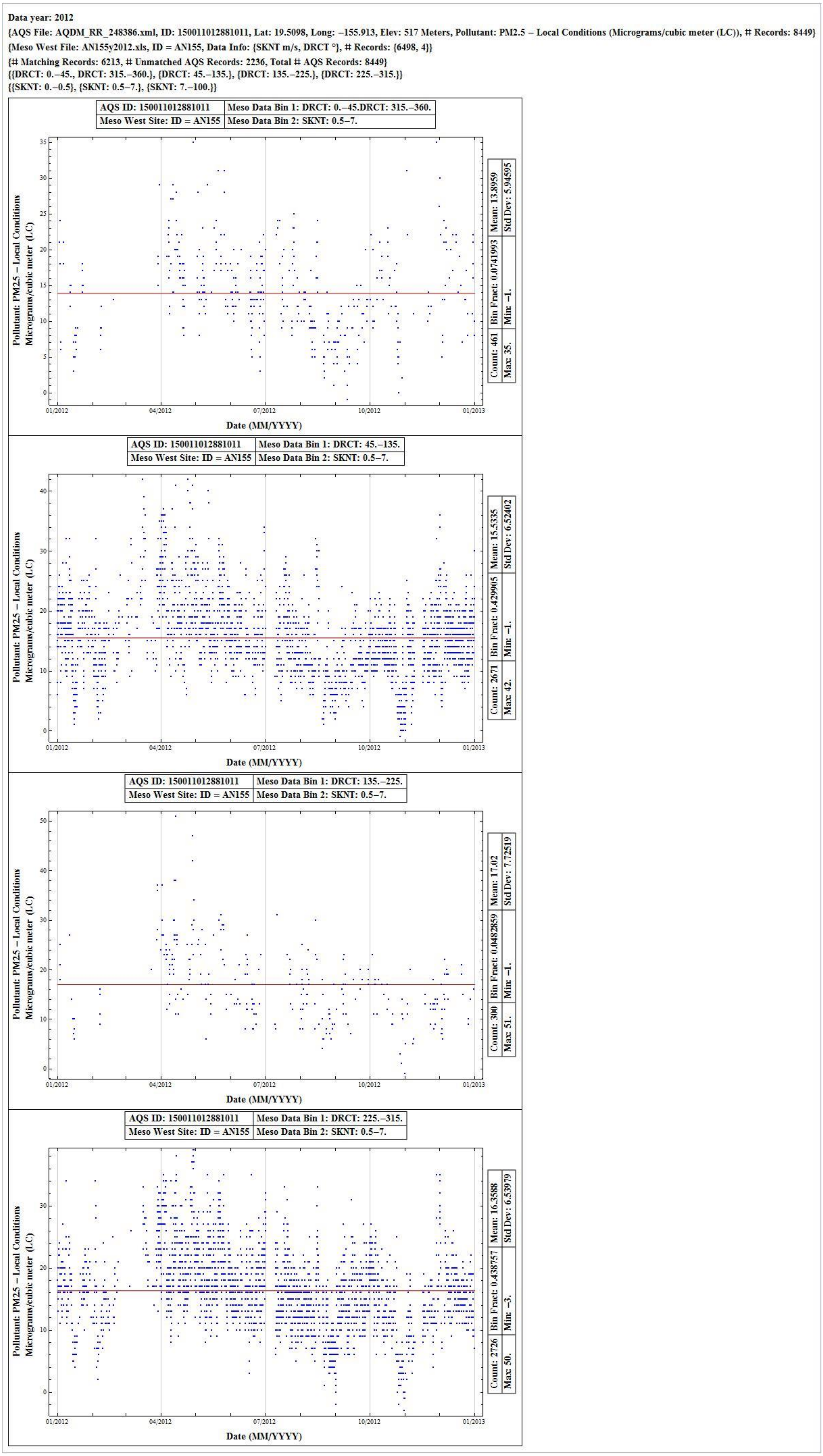



**Figure A-21.** 2012 Kona (AN155) PM2.5 Pollution Time History by Wind Quadrant

**WKVH1y2012.xls−2012: Hour = 0**

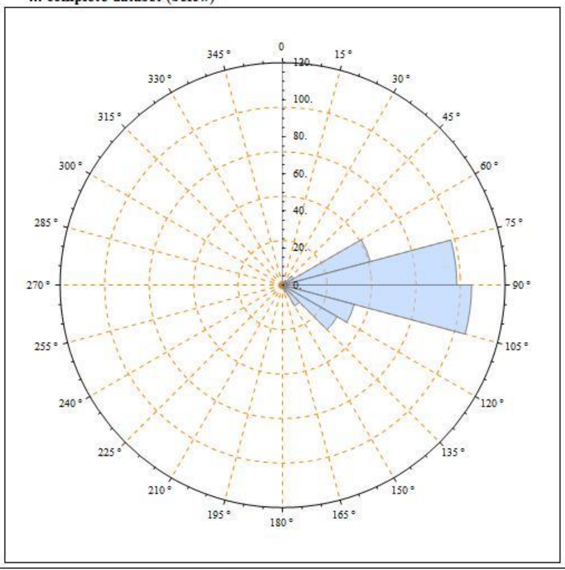
Data Info: Windrose

Number of Datasets = 353

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 0, 35, 0.} | 5.8 | 64. | OK | 1–1–2012 0:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 1**

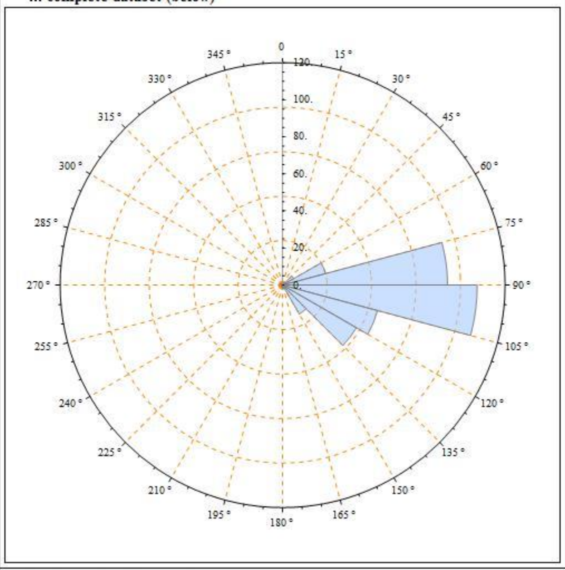
Data Info: Windrose

Number of Datasets = 350

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 1, 35, 0.} | 2.7 | 87. | OK | 1–1–2012 1:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 2**

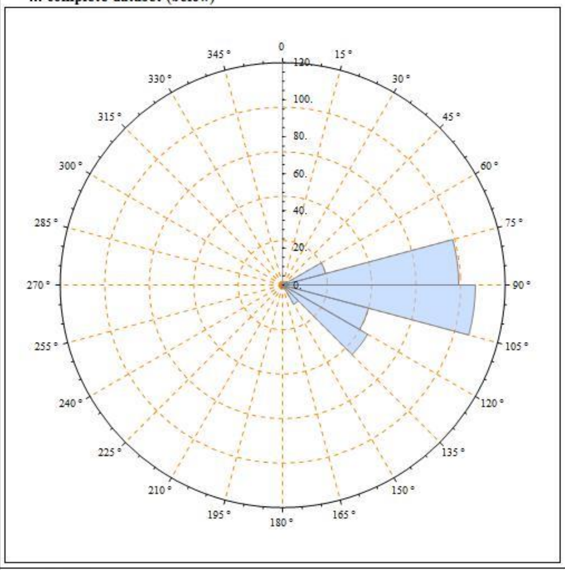
Data Info: Windrose

Number of Datasets = 346

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 4, 2, 35, 0.} | 3.6 | 123. | OK | 1–4–2012 2:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 3**

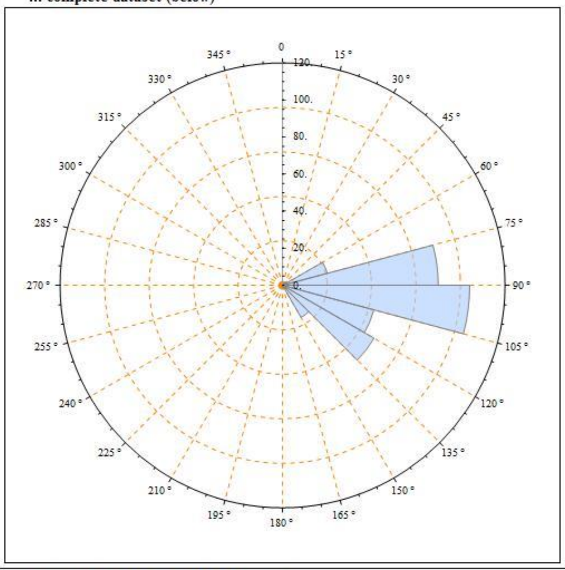
Data Info: Windrose

Number of Datasets = 344

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 3, 3, 35, 0.} | 2.2 | 136. | OK | 1–3–2012 3:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 4**

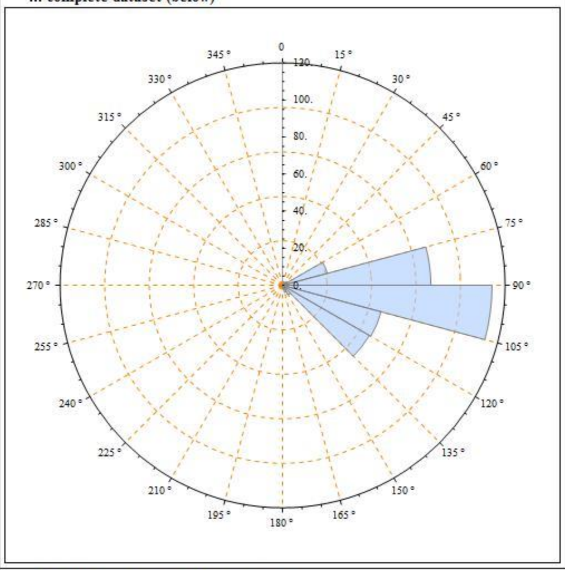
Data Info: Windrose

Number of Datasets = 343

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 3, 4, 35, 0.} | 2.7 | 132. | OK | 1–3–2012 4:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 5**

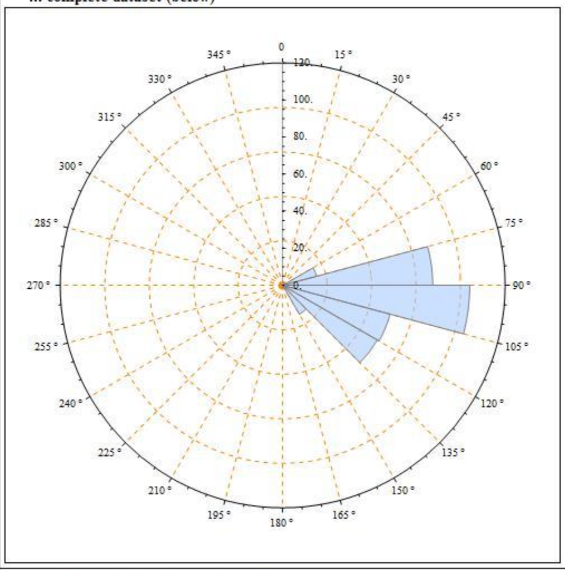
Data Info: Windrose

Number of Datasets = 342

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 3, 5, 35, 0.} | 3.6 | 91. | OK | 1–3–2012 5:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 6**

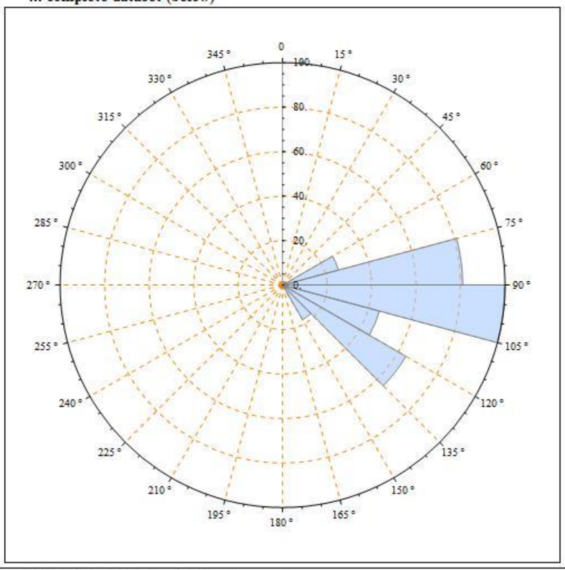
Data Info: Windrose

Number of Datasets = 340

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 3, 6, 35, 0.} | 4.5 | 100. | OK | 1–3–2012 6:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 7**

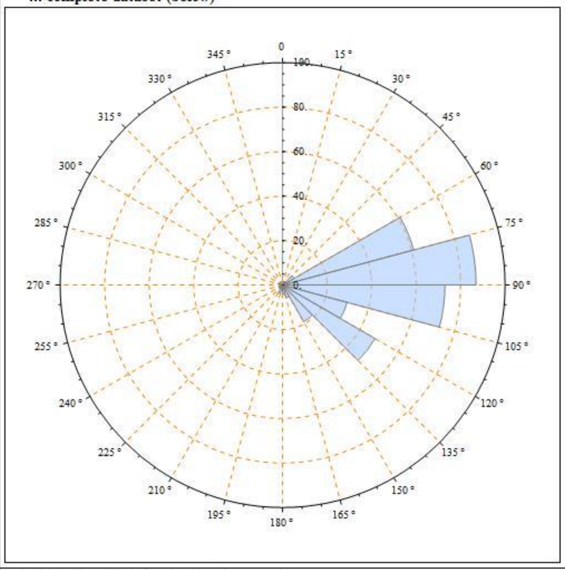
Data Info: Windrose

Number of Datasets = 348

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 3, 7, 35, 0.} | 2.7 | 132. | OK | 1–3–2012 7:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 8**

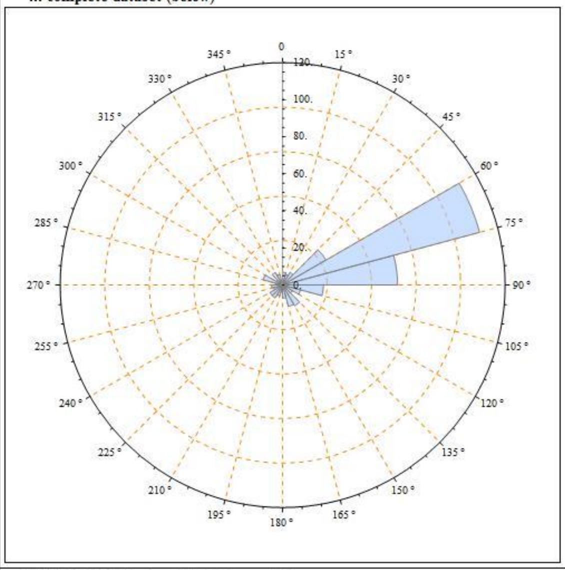
Data Info: Windrose

Number of Datasets = 363

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 8, 35, 0.} | 2.2 | 40. | OK | 1–1–2012 8:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 9**

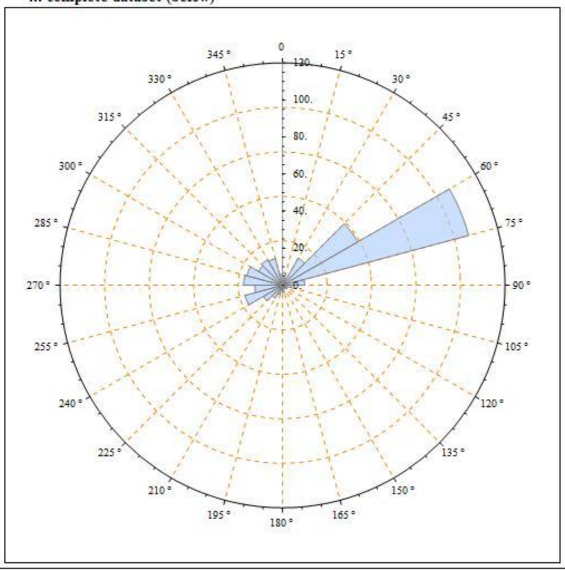
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 9, 35, 0.} | 1.3 | 24. | OK | 1–1–2012 9:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 10**

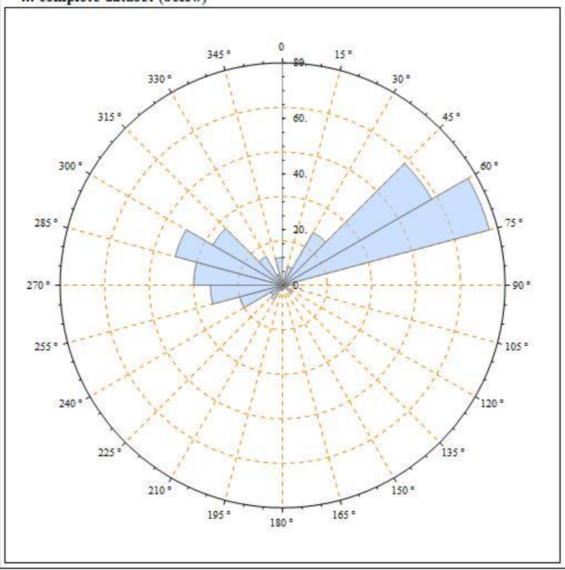
Data Info: Windrose

Number of Datasets = 365

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 10, 35, 0.} | 1.3 | 289. | OK | 1–1–2012 10:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 11**

Data Info: Windrose

Number of Datasets = 363

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 11, 35, 0.} | 3.6 | 301. | OK | 1–1–2012 11:35 HST |

... complete dataset (below)

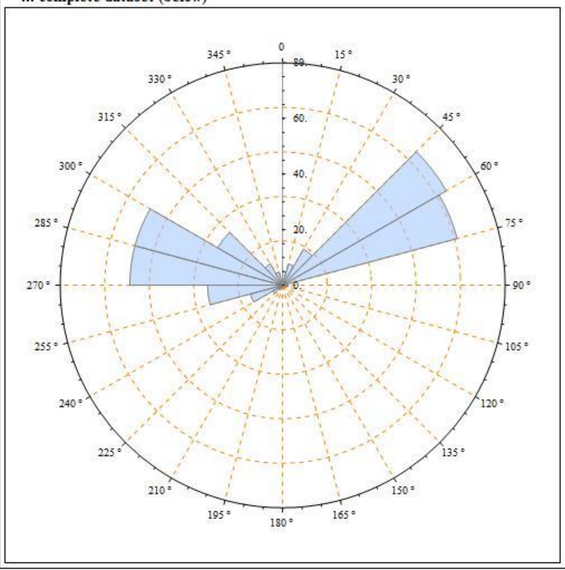


**Figure A-24**. 2012 Wailoloa (WKVH1) Windrose - Morning Hours

**WKVH1y2012.xls−2012: Hour = 12**

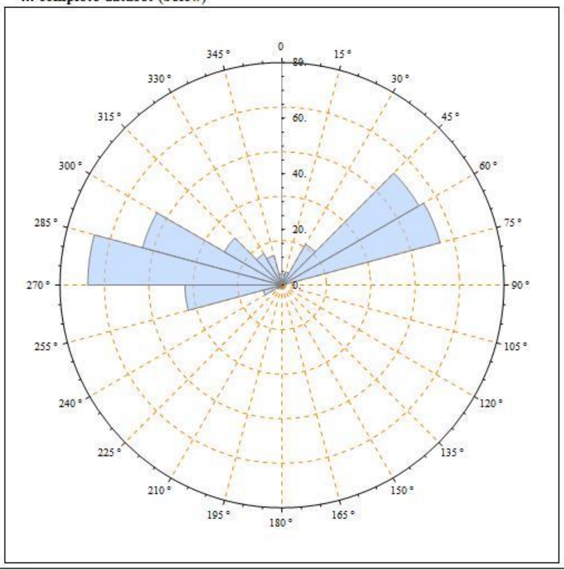
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 12, 35, 0.} | 4. | 296. | OK | 1–1–2012 12:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 13**

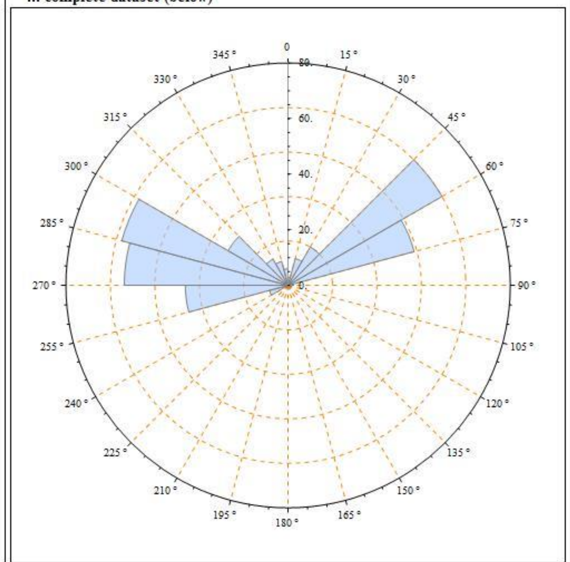
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 13, 35, 0.} | 3.6 | 279. | OK | 1–1–2012 13:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 14**

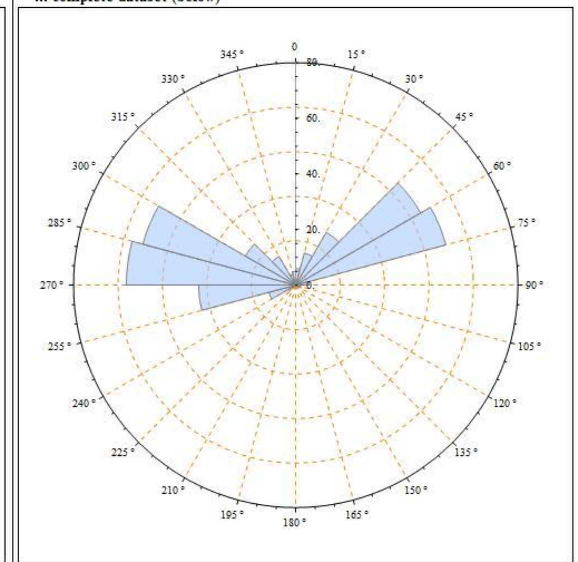
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 14, 35, 0.} | 3.6 | 254. | OK | 1–1–2012 14:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 15**

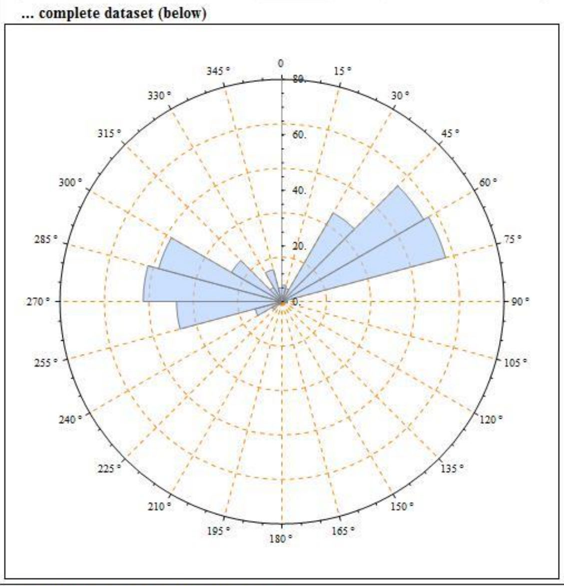
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 15, 35, 0.} | 3.6 | 297. | OK | 1–1–2012 15:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 16**

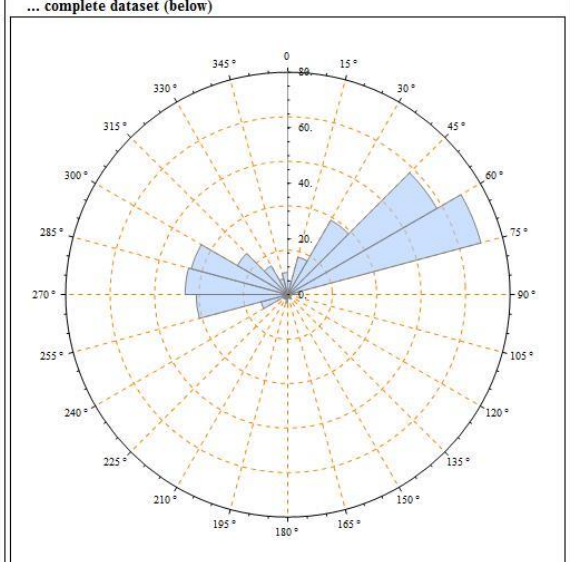
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 16, 35, 0.} | 3.1 | 280. | OK | 1–1–2012 16:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 17**

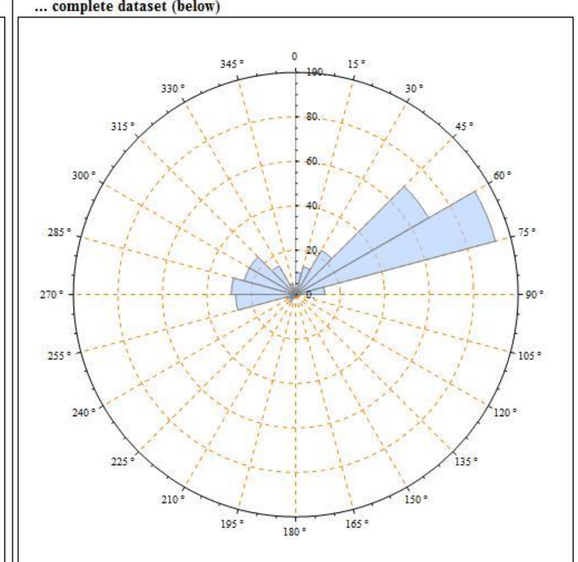
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 17, 35, 0.} | 0.9 | 214. | OK | 1–1–2012 17:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 18**

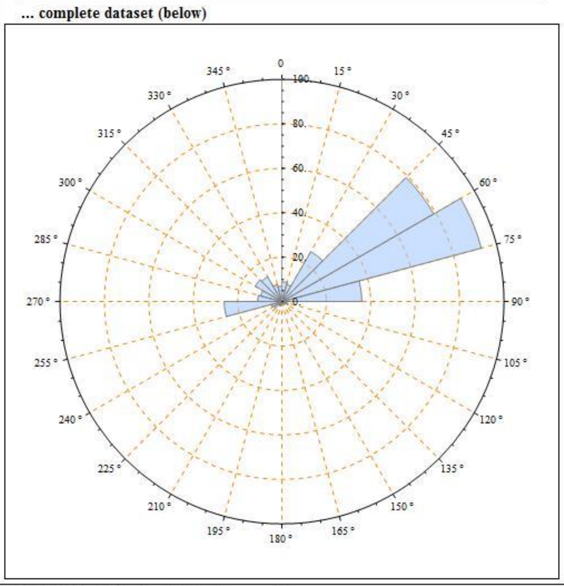
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 18, 35, 0.} | 4. | 86. | OK | 1–1–2012 18:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 19**

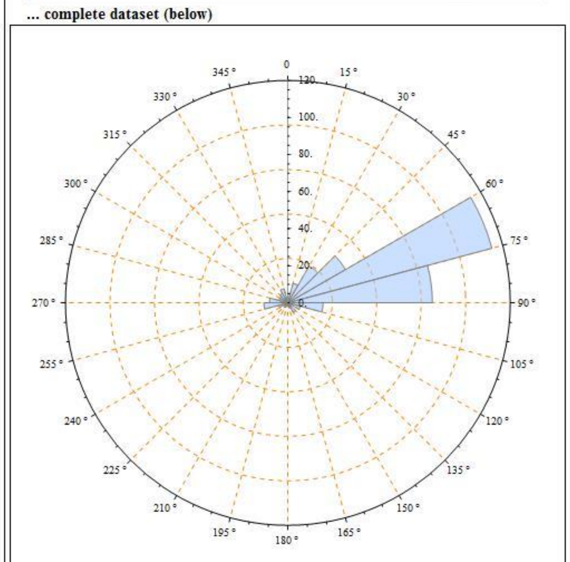
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 19, 35, 0.} | 4.9 | 93. | OK | 1–1–2012 19:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 20**

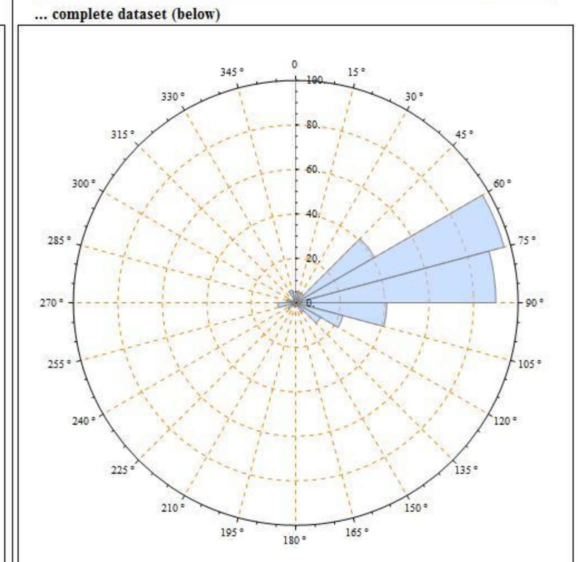
Data Info: Windrose

Number of Datasets = 363

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 20, 35, 0.} | 5.8 | 87. | OK | 1–1–2012 20:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 21**

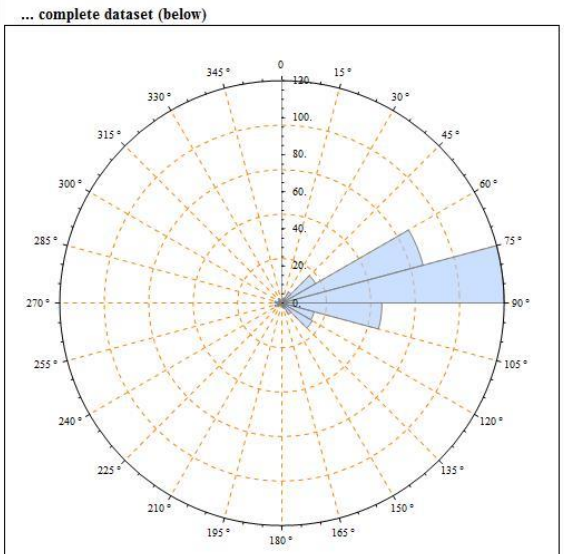
Data Info: Windrose

Number of Datasets = 353

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 21, 35, 0.} | 4.5 | 89. | OK | 1–1–2012 21:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 22**

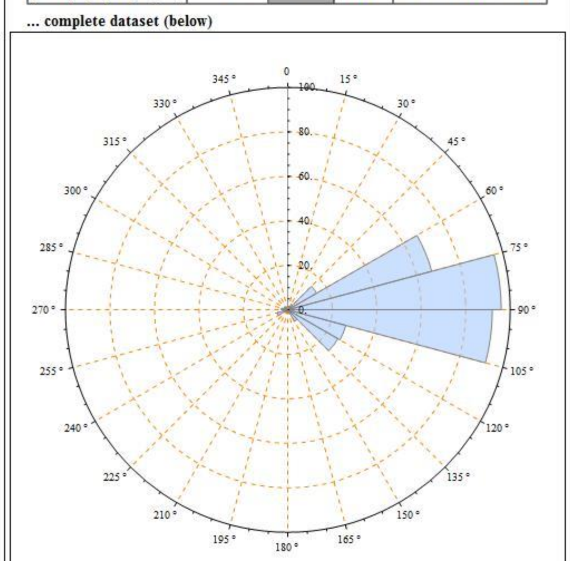
Data Info: Windrose

Number of Datasets = 354

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 22, 35, 0.} | 4.9 | 90. | OK | 1–1–2012 22:35 HST |

... complete dataset (below)



**WKVH1y2012.xls−2012: Hour = 23**

Data Info: Windrose

Number of Datasets = 355

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 23, 35, 0.} | 2.2 | 117. | OK | 1–1–2012 23:35 HST |

... complete dataset (below)

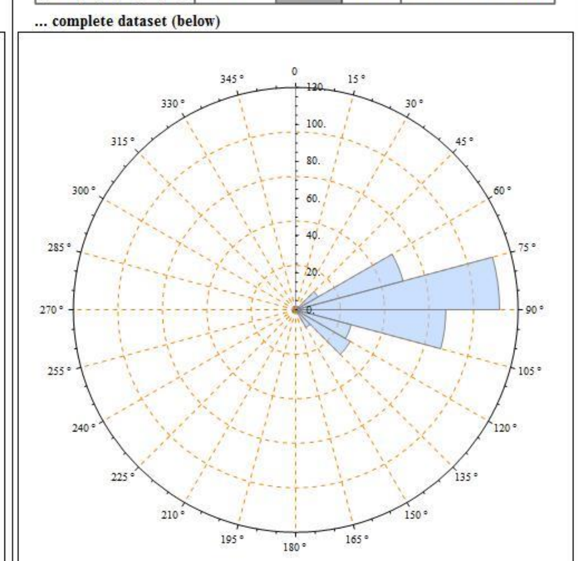


**Figure A-25.** 2012 Wailoloa (WKVH1) Windrose - Evening Hours

**KPLH1y2012.xls–2012: Hour = 0**

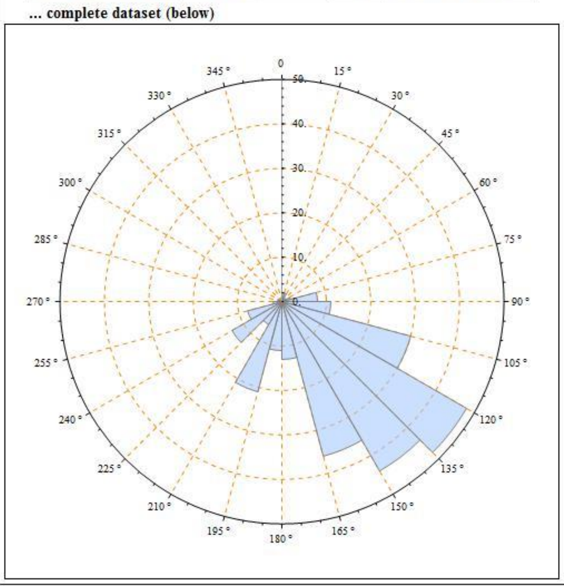
Data Info: Windrose

Number of Datasets = 260

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 0, 36, 0.} | 3.6 | 156. | OK | 1–1–2012 0:36 HST |

... complete dataset (below)



**KPLH1y2012.xls–2012: Hour = 1**

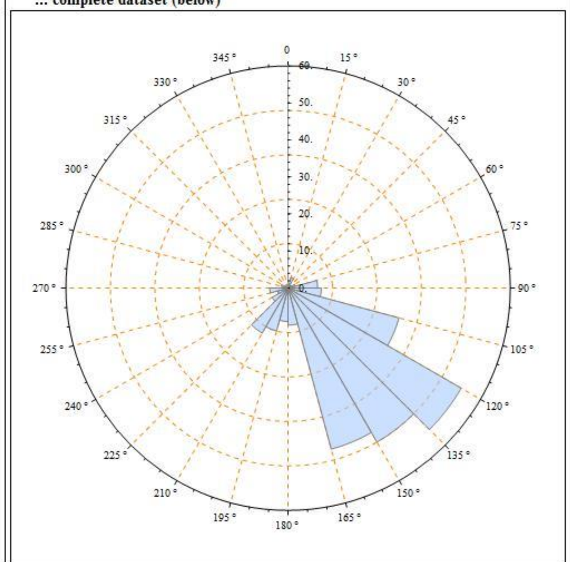
Data Info: Windrose

Number of Datasets = 262

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 1, 36, 0.} | 3.1 | 131. | OK | 1–1–2012 1:36 HST |

... complete dataset (below)



**KPLH1y2012.xls–2012: Hour = 2**

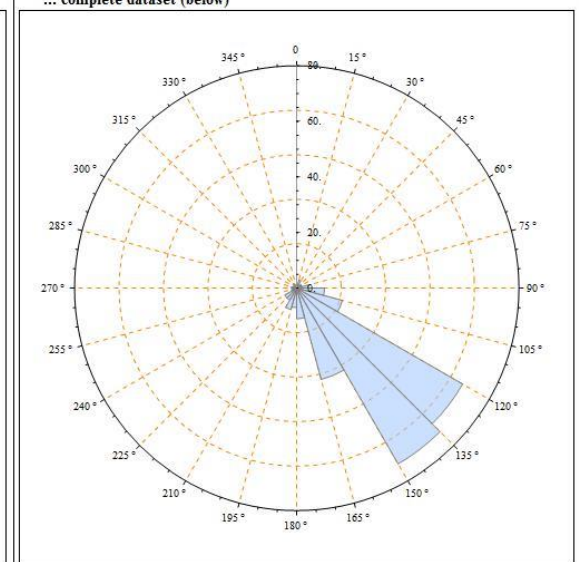
Data Info: Windrose

Number of Datasets = 258

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 2, 36, 0.} | 2.7 | 94. | OK | 1–1–2012 2:36 HST |

... complete dataset (below)



**KPLH1y2012.xls–2012: Hour = 3**

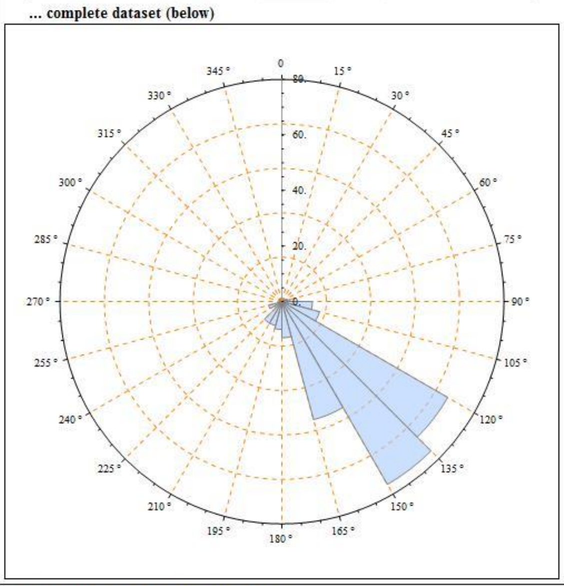
Data Info: Windrose

Number of Datasets = 271

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 3, 36, 0.} | 3.1 | 126. | OK | 1–1–2012 3:36 HST |

... complete dataset (below)



**KPLH1y2012.xls–2012: Hour = 4**

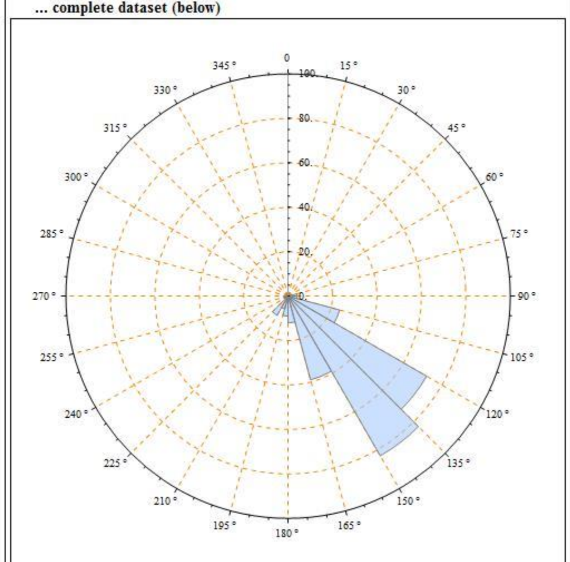
Data Info: Windrose

Number of Datasets = 274

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 4, 36, 0.} | 3.6 | 142. | OK | 1–1–2012 4:36 HST |

... complete dataset (below)



**KPLH1y2012.xls–2012: Hour = 5**

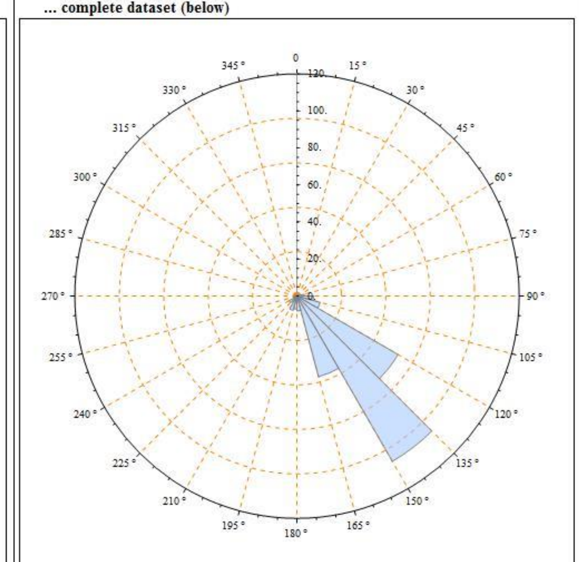
Data Info: Windrose

Number of Datasets = 273

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 5, 36, 0.} | 3.1 | 133. | OK | 1–1–2012 5:36 HST |

... complete dataset (below)



**KPLH1y2012.xls–2012: Hour = 6**

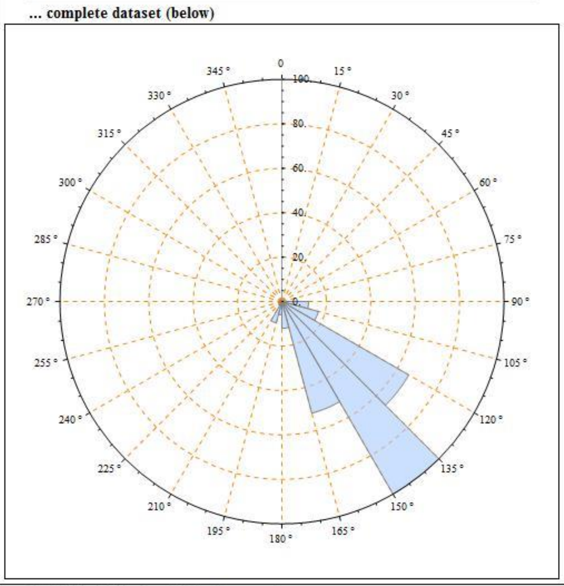
Data Info: Windrose

Number of Datasets = 283

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 6, 36, 0.} | 2.7 | 141. | OK | 1–1–2012 6:36 HST |

... complete dataset (below)



**KPLH1y2012.xls–2012: Hour = 7**

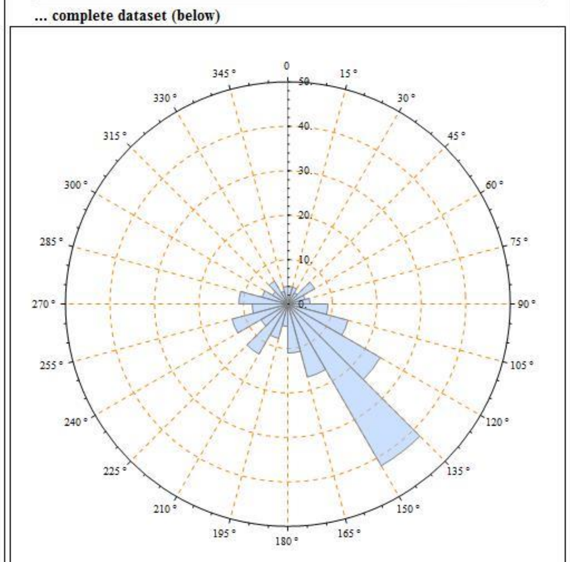
Data Info: Windrose

Number of Datasets = 232

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 7, 36, 0.} | 2.2 | 122. | OK | 1–1–2012 7:36 HST |

... complete dataset (below)



**KPLH1y2012.xls–2012: Hour = 8**

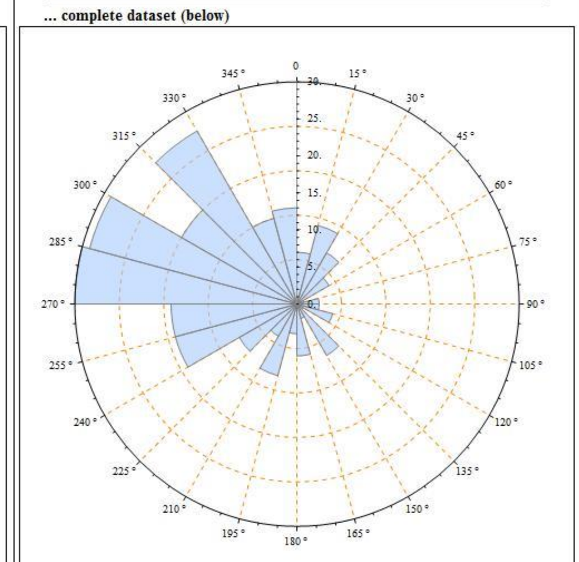
Data Info: Windrose

Number of Datasets = 252

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 8, 36, 0.} | 1.8 | 59. | OK | 1–1–2012 8:36 HST |

... complete dataset (below)



**KPLH1y2012.xls–2012: Hour = 9**

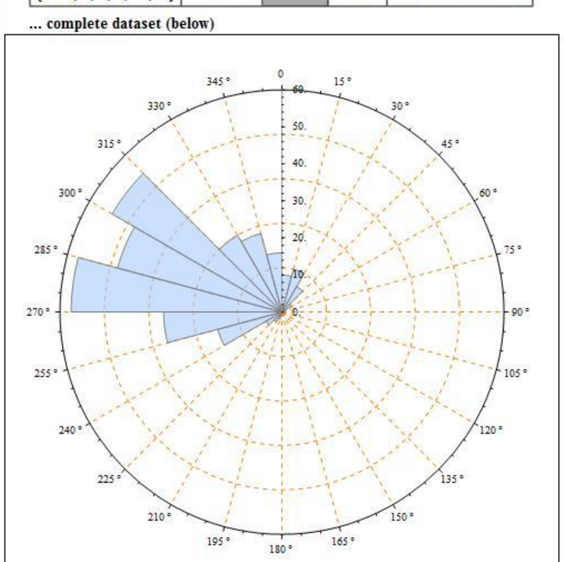
Data Info: Windrose

Number of Datasets = 312

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 9, 36, 0.} | 1.3 | 27. | OK | 1–1–2012 9:36 HST |

... complete dataset (below)



**KPLH1y2012.xls–2012: Hour = 10**

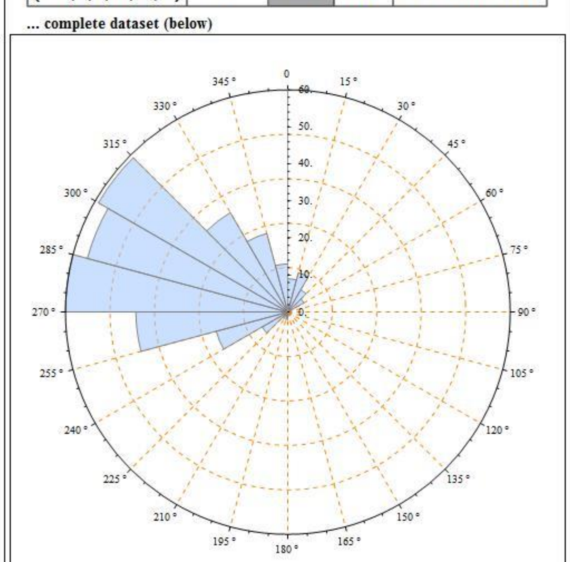
Data Info: Windrose

Number of Datasets = 346

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 10, 36, 0.} | 2.2 | 299. | OK | 1–1–2012 10:36 HST |

... complete dataset (below)



**KPLH1y2012.xls–2012: Hour = 11**

Data Info: Windrose

Number of Datasets = 355

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 11, 36, 0.} | 3.1 | 278. | OK | 1–1–2012 11:36 HST |

... complete dataset (below)

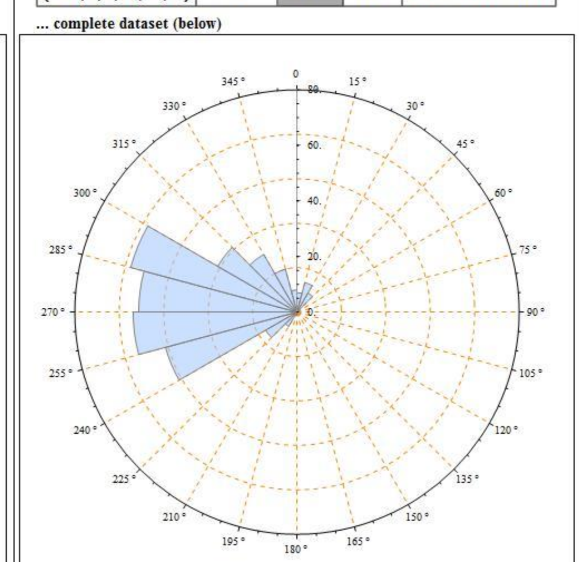


**Figure A-26.** 2012 Kaupulehu Lava Flow (KPLH1) - Morning Hours


**Figure A-27.** 2012 Kaupulehu Lava Flow (KPLH1) - Evening Hours

**PTRH1y2011.xls–2011: Hour = 0**

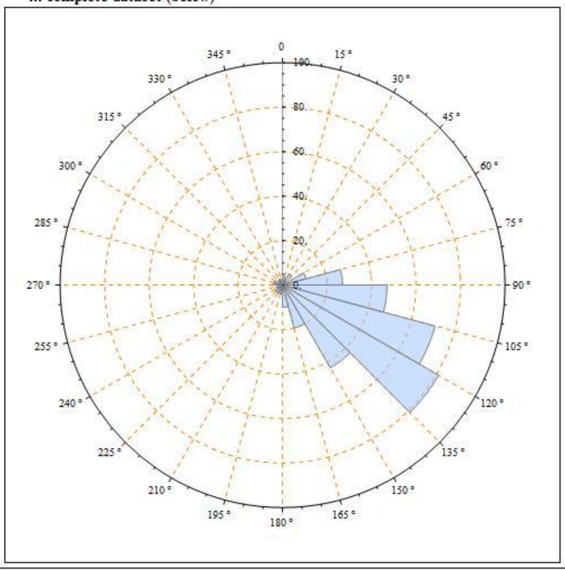
Data Info: Windrose

Number of Datasets = 361

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 0, 49, 0.} | 0.9 | 34. | OK | 1–1–2011 0:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 1**

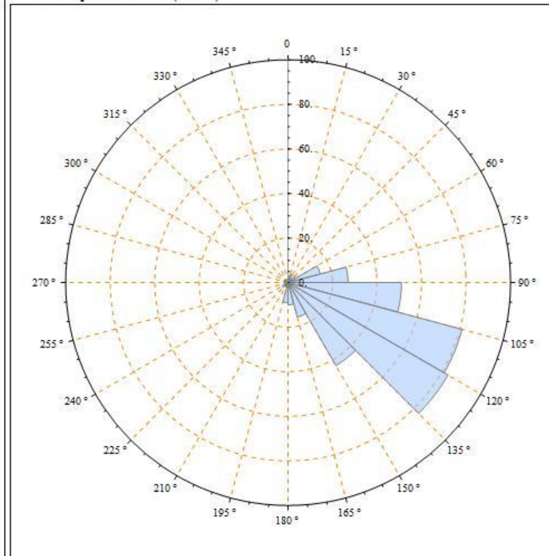
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 1, 49, 0.} | 1.3 | 119. | OK | 1–1–2011 1:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 2**

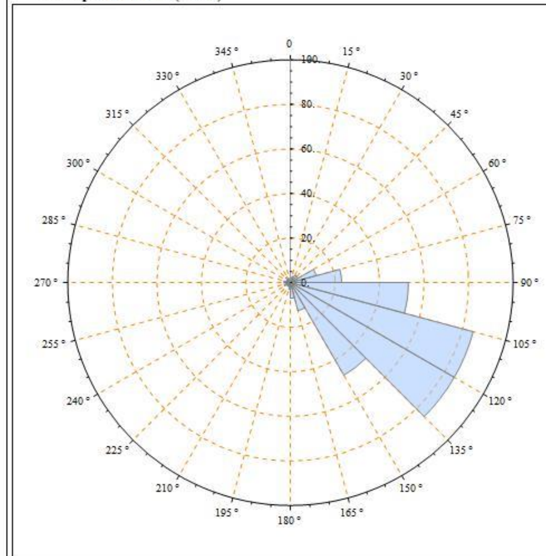
Data Info: Windrose

Number of Datasets = 360

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 2, 49, 0.} | 3.1 | 112. | OK | 1–1–2011 2:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 3**

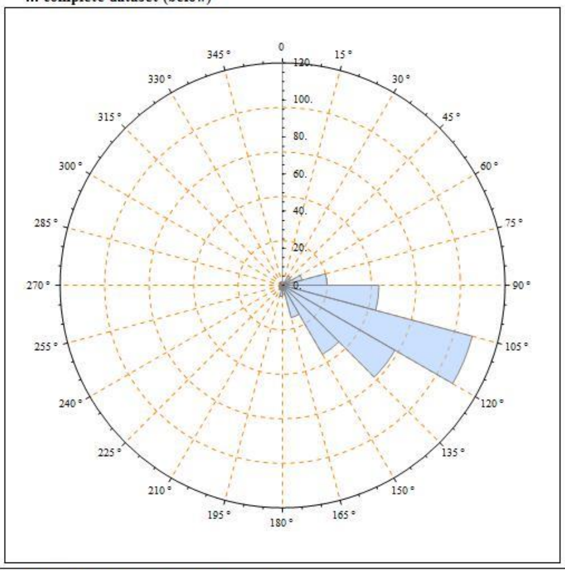
Data Info: Windrose

Number of Datasets = 361

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 3, 49, 0.} | 3.1 | 107. | Caution | 1–1–2011 3:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 4**

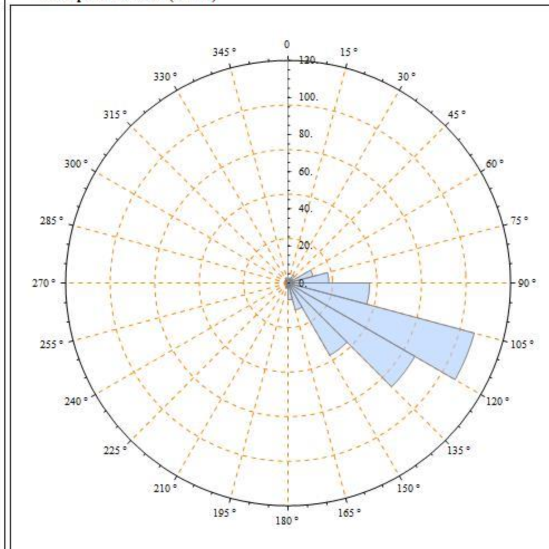
Data Info: Windrose

Number of Datasets = 361

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 4, 49, 0.} | 1.3 | 132. | Caution | 1–1–2011 4:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 5**

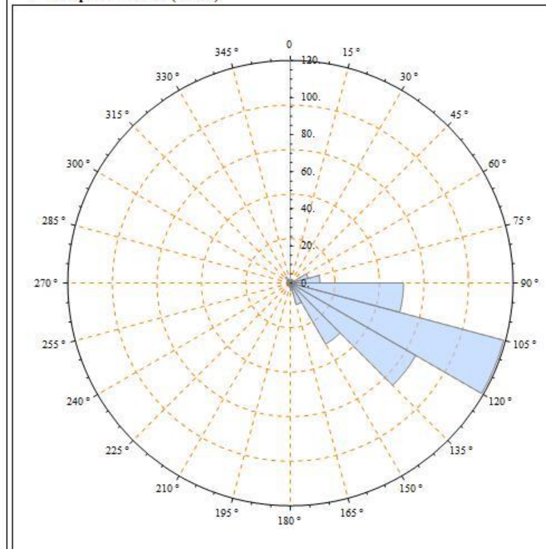
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 5, 49, 0.} | 3.6 | 109. | Caution | 1–1–2011 5:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 6**

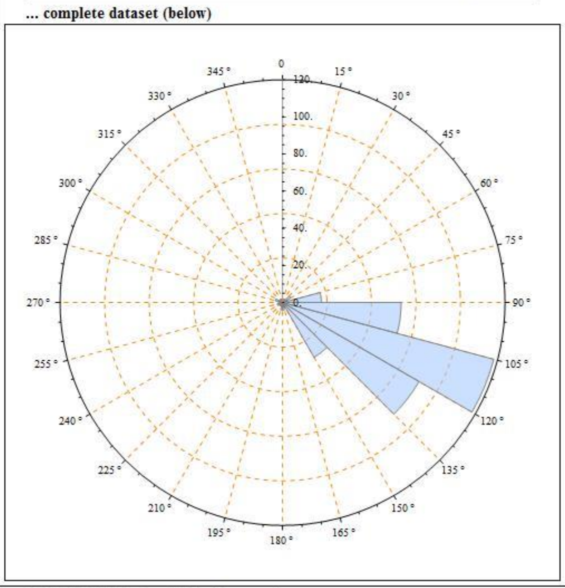
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 6, 49, 0.} | 3.6 | 115. | Caution | 1–1–2011 6:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 7**

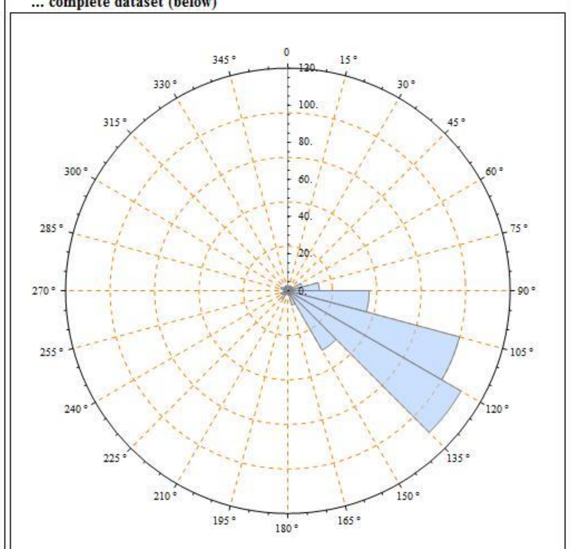
Data Info: Windrose

Number of Datasets = 361

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 7, 49, 0.} | 3.1 | 125. | Caution | 1–1–2011 7:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 8**

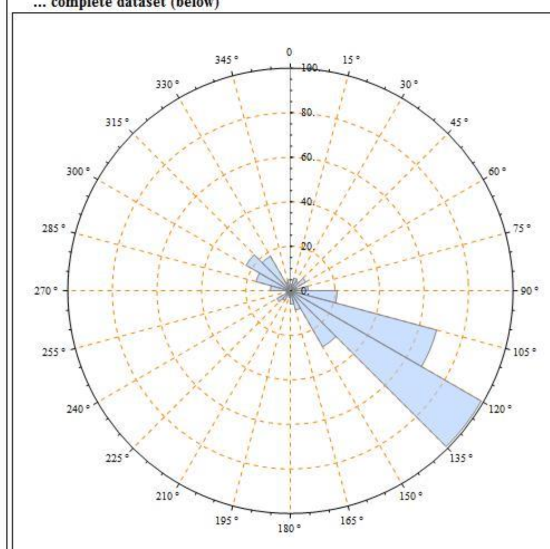
Data Info: Windrose

Number of Datasets = 360

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 8, 49, 0.} | 3.1 | 109. | Caution | 1–1–2011 8:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 9**

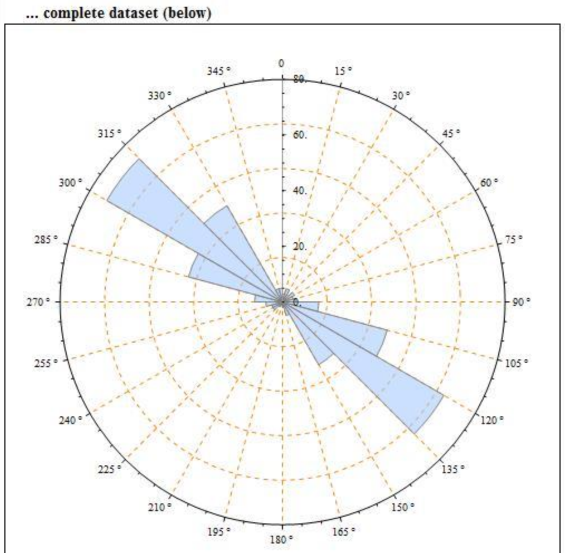
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 9, 49, 0.} | 0.9 | 340. | Caution | 1–1–2011 9:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 10**

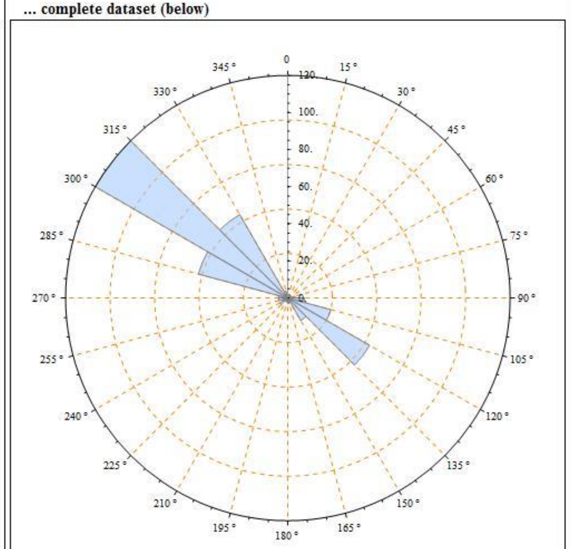
Data Info: Windrose

Number of Datasets = 363

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 10, 49, 0.} | 4. | 310. | Caution | 1–1–2011 10:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 11**

Data Info: Windrose

Number of Datasets = 361

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 11, 49, 0.} | 4.9 | 321. | Caution | 1–1–2011 11:49 HST |

... complete dataset (below)

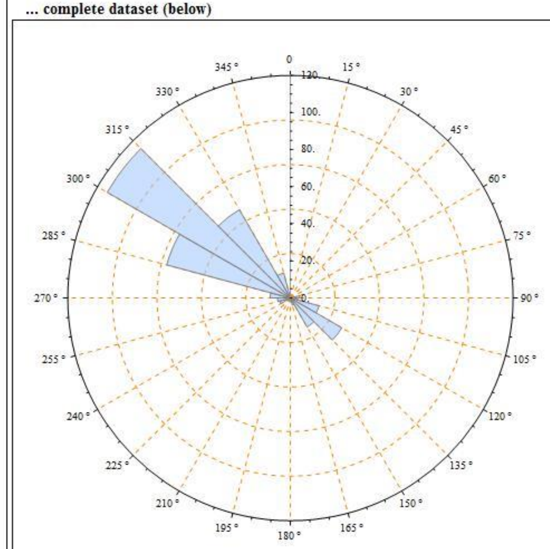


**Figure A-28.** 2012 PTA Range 17 (PTRH1) Windrose - Morning Hours

**PTRH1y2011.xls–2011: Hour = 12**

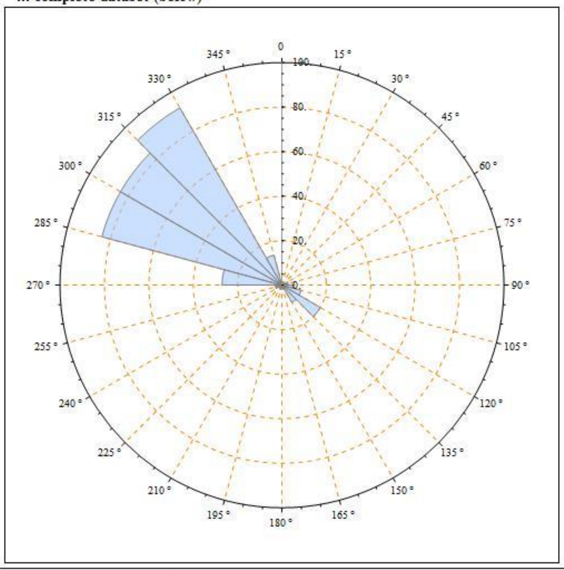
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 12, 49, 0.} | 4.9 | 293. | Caution | 1–1–2011 12:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 13**

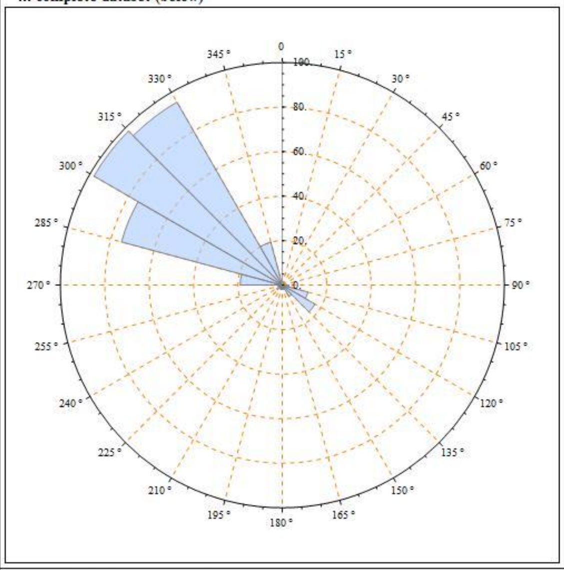
Data Info: Windrose

Number of Datasets = 361

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 13, 49, 0.} | 5.4 | 317. | Caution | 1–1–2011 13:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 14**

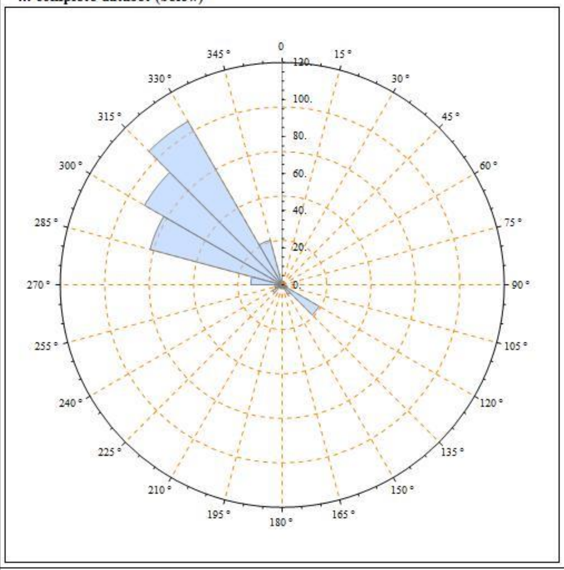
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 14, 49, 0.} | 4. | 315. | Caution | 1–1–2011 14:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 15**

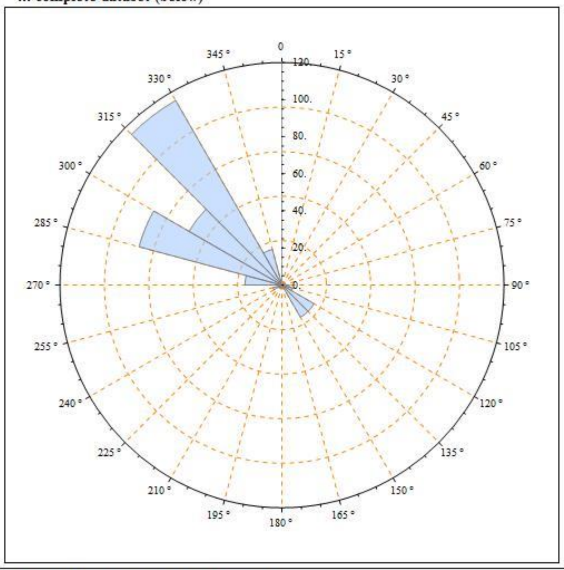
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 15, 49, 0.} | 4.5 | 304. | Caution | 1–1–2011 15:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 16**

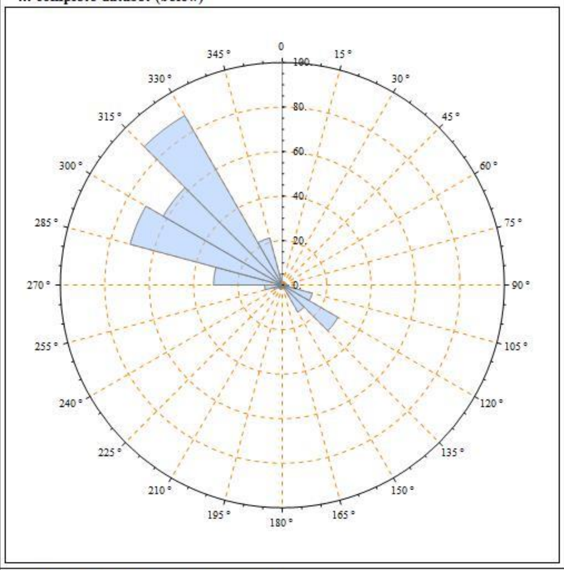
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 16, 49, 0.} | 3.1 | 285. | Caution | 1–1–2011 16:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 17**

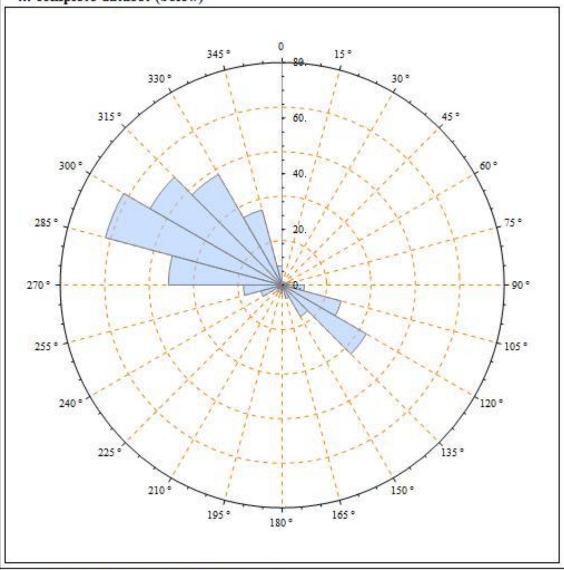
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 17, 49, 0.} | 4.9 | 123. | Caution | 1–1–2011 17:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 18**

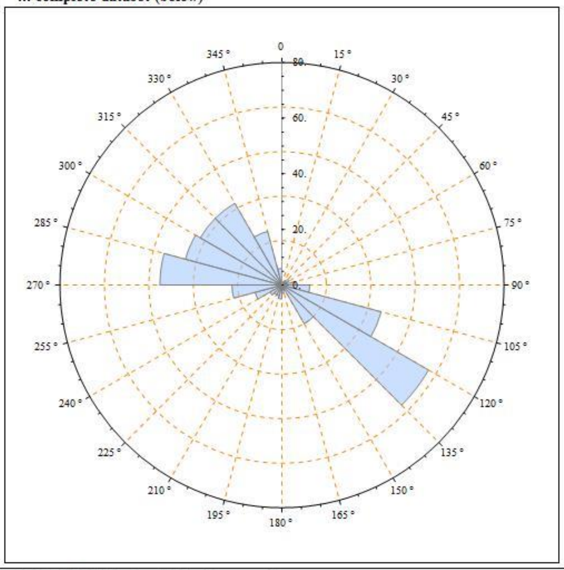
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 18, 49, 0.} | 4.5 | 111. | Caution | 1–1–2011 18:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 19**

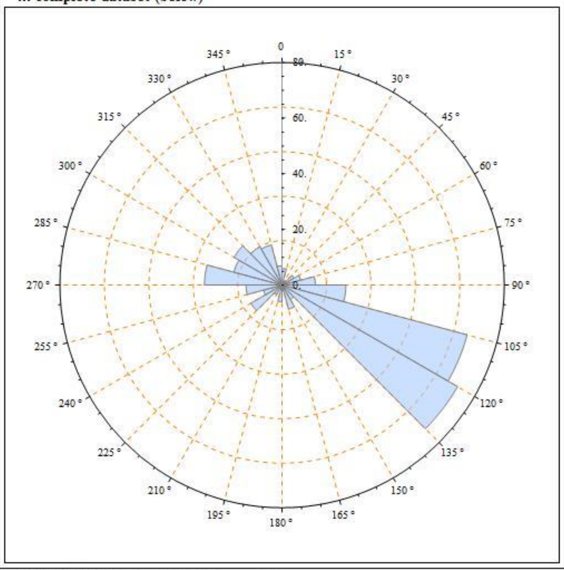
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 19, 49, 0.} | 4.5 | 125. | Caution | 1–1–2011 19:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 20**

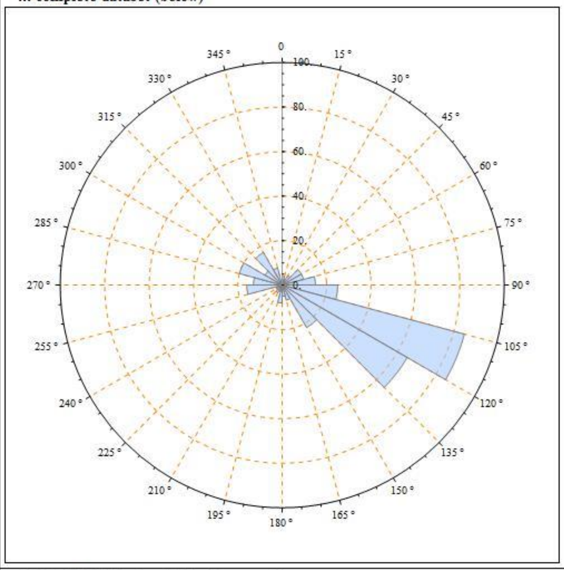
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 20, 49, 0.} | 2.7 | 35. | Caution | 1–1–2011 20:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 21**

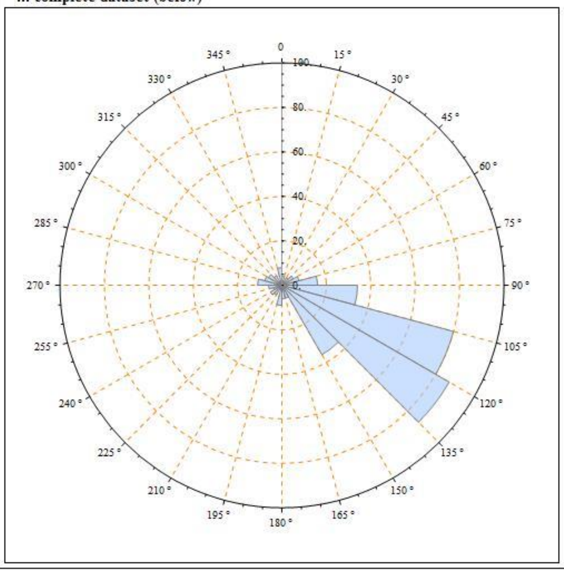
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 21, 49, 0.} | 1.3 | 32. | Caution | 1–1–2011 21:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 22**

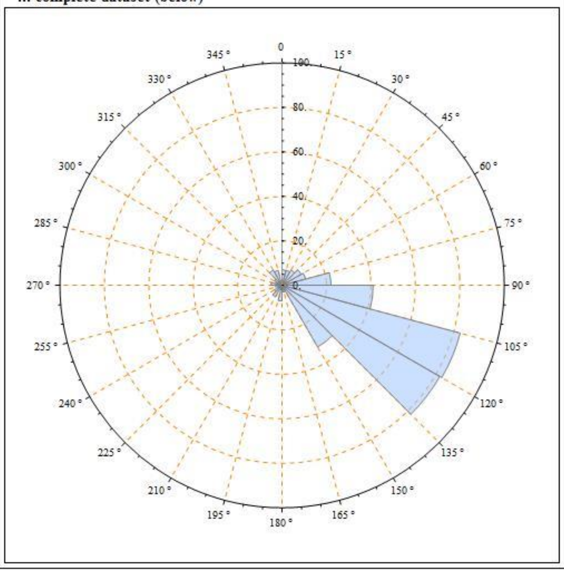
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 22, 49, 0.} | 4.5 | 82. | Caution | 1–1–2011 22:49 HST |

... complete dataset (below)



**PTRH1y2011.xls–2011: Hour = 23**

Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2011, 1, 1, 23, 49, 0.} | 3.1 | 67. | OK | 1–1–2011 23:49 HST |

... complete dataset (below)

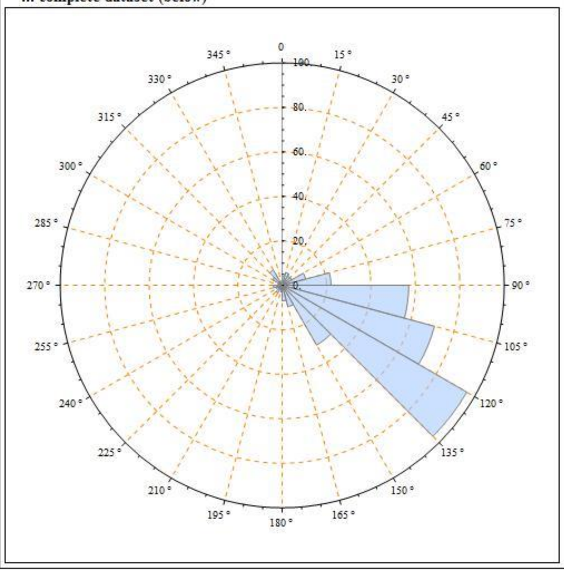


**Figure A-29.** 2012 PTA Range 17 (PTRH1) Windrose - Evening Hours

**PHTOy2012.xls–2012: Hour = 0**

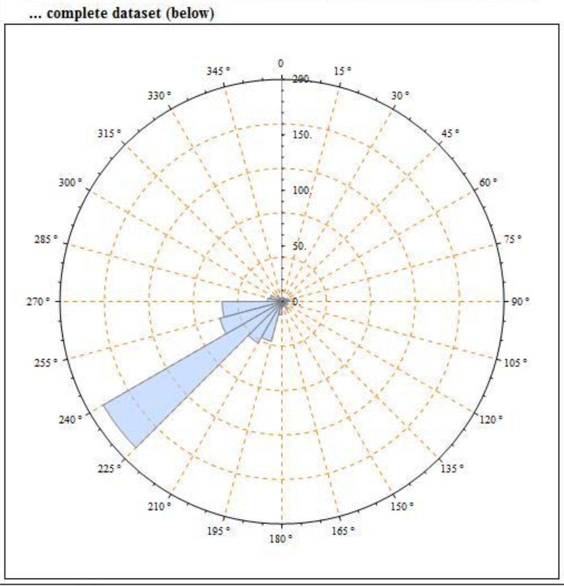
Data Info: Windrose

Number of Datasets = 475

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 0, 19, 0.} | 2.1 | 290. | OK | 1–1–2012 0:19 HST |

... complete dataset (below)



**PHTOy2012.xls–2012: Hour = 1**

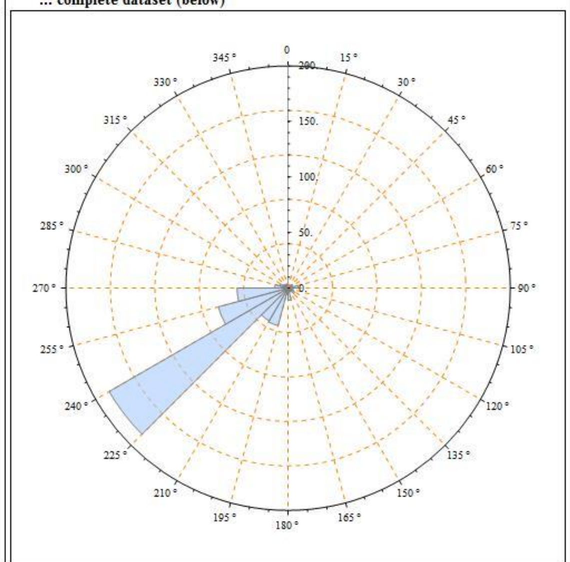
Data Info: Windrose

Number of Datasets = 455

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 1, 2, 0.} | 2.6 | 270. | OK | 1–1–2012 1:02 HST |

... complete dataset (below)



**PHTOy2012.xls–2012: Hour = 2**

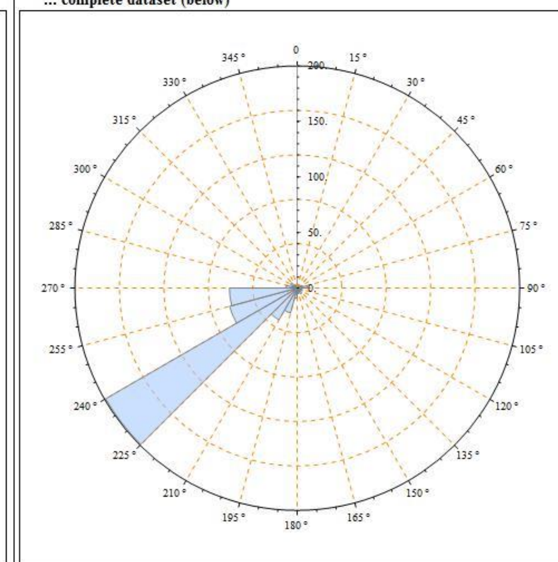
Data Info: Windrose

Number of Datasets = 457

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 2, 11, 0.} | 2.6 | 240. | OK | 1–1–2012 2:11 HST |

... complete dataset (below)



**PHTOy2012.xls–2012: Hour = 3**

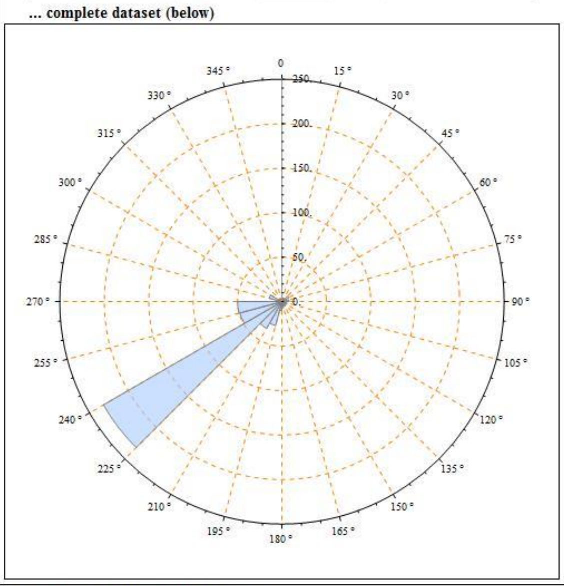
Data Info: Windrose

Number of Datasets = 485

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 3, 28, 0.} | 3.1 | 240. | OK | 1–1–2012 3:28 HST |

... complete dataset (below)



**PHTOy2012.xls–2012: Hour = 4**

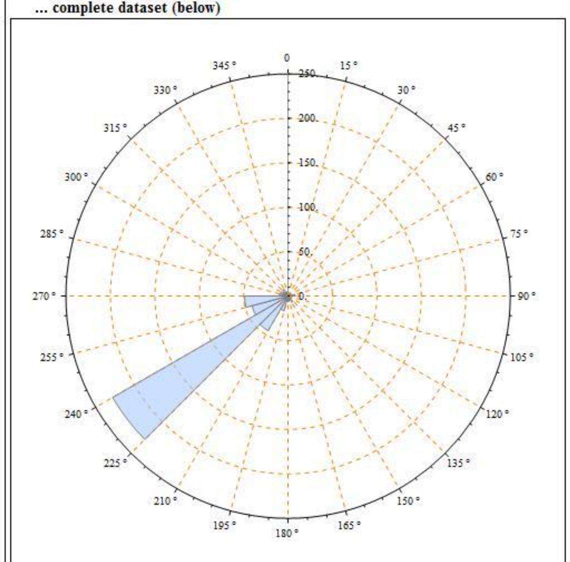
Data Info: Windrose

Number of Datasets = 467

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 4, 53, 0.} | 3.1 | 240. | OK | 1–1–2012 4:53 HST |

... complete dataset (below)



**PHTOy2012.xls–2012: Hour = 5**

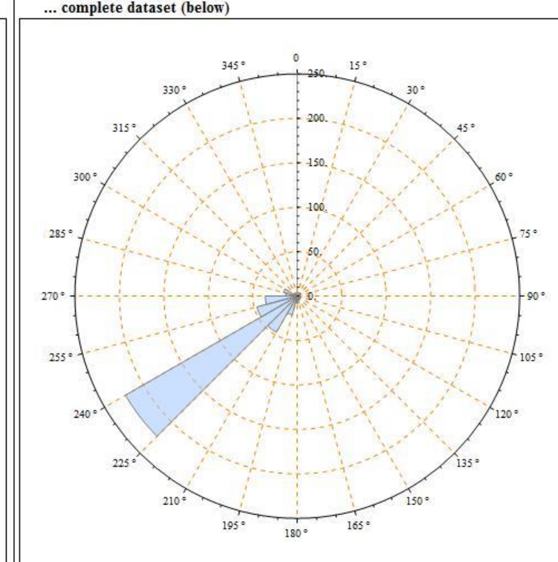
Data Info: Windrose

Number of Datasets = 460

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 5, 53, 0.} | 2.1 | 230. | OK | 1–1–2012 5:53 HST |

... complete dataset (below)



**PHTOy2012.xls–2012: Hour = 6**

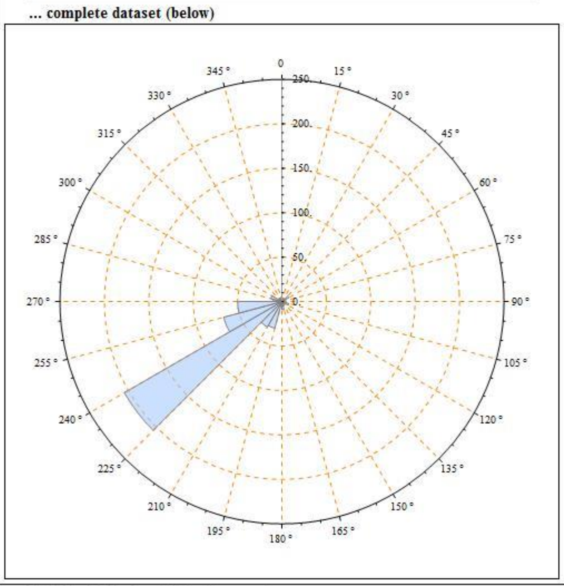
Data Info: Windrose

Number of Datasets = 476

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 6, 53, 0.} | 2.1 | 230. | OK | 1–1–2012 6:53 HST |

... complete dataset (below)



**PHTOy2012.xls–2012: Hour = 7**

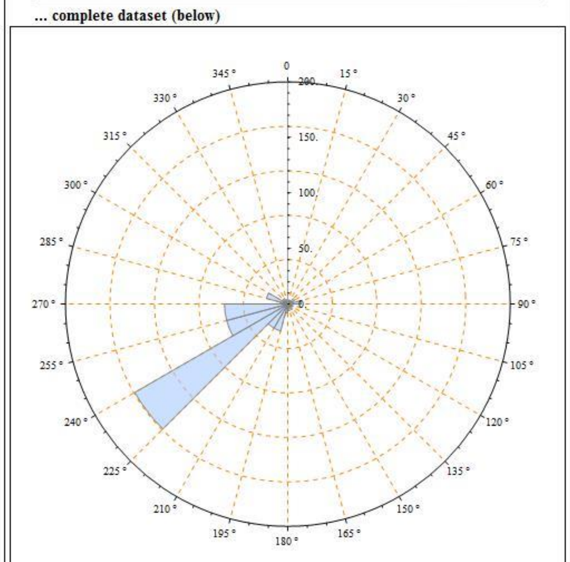
Data Info: Windrose

Number of Datasets = 433

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 7, 53, 0.} | 1.5 | 210. | OK | 1–1–2012 7:53 HST |

... complete dataset (below)



**PHTOy2012.xls–2012: Hour = 8**

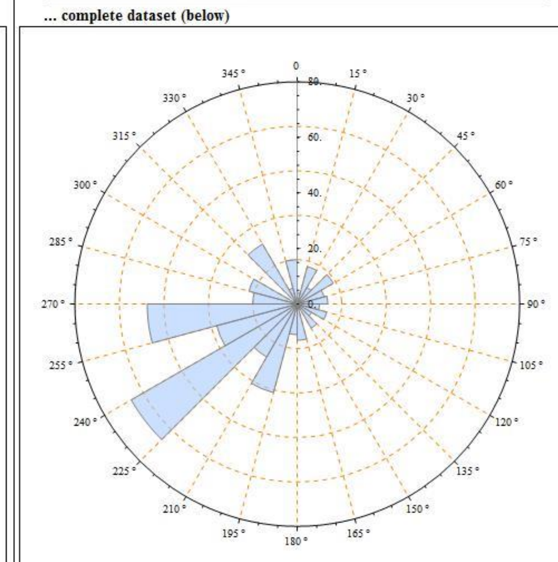
Data Info: Windrose

Number of Datasets = 412

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 4, 8, 53, 0.} | 3.1 | 220. | OK | 1–4–2012 8:53 HST |

... complete dataset (below)



**PHTOy2012.xls–2012: Hour = 9**

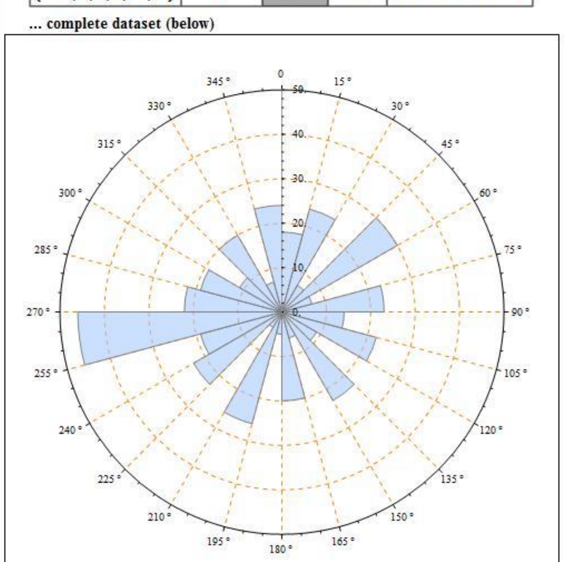
Data Info: Windrose

Number of Datasets = 429

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 2, 9, 53, 0.} | 4.1 | 140. | OK | 1–2–2012 9:53 HST |

... complete dataset (below)



**PHTOy2012.xls–2012: Hour = 10**

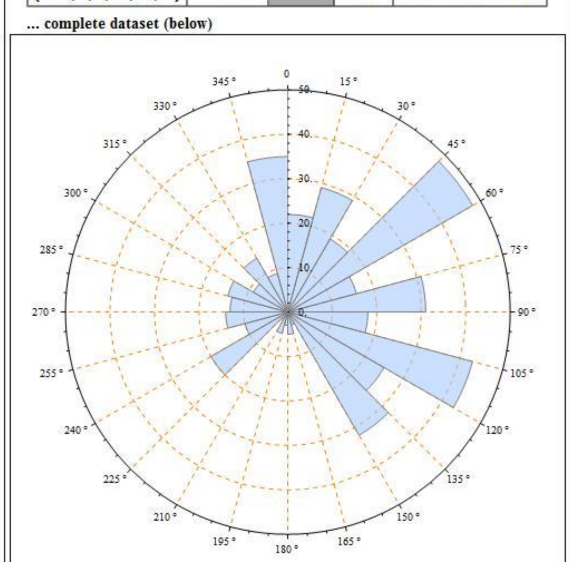
Data Info: Windrose

Number of Datasets = 439

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 10, 53, 0.} | 2.6 | 50. | OK | 1–1–2012 10:53 HST |

... complete dataset (below)



**PHTOy2012.xls–2012: Hour = 11**

Data Info: Windrose

Number of Datasets = 465

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 2, 11, 53, 0.} | 5.1 | 140. | OK | 1–2–2012 11:53 HST |

... complete dataset (below)

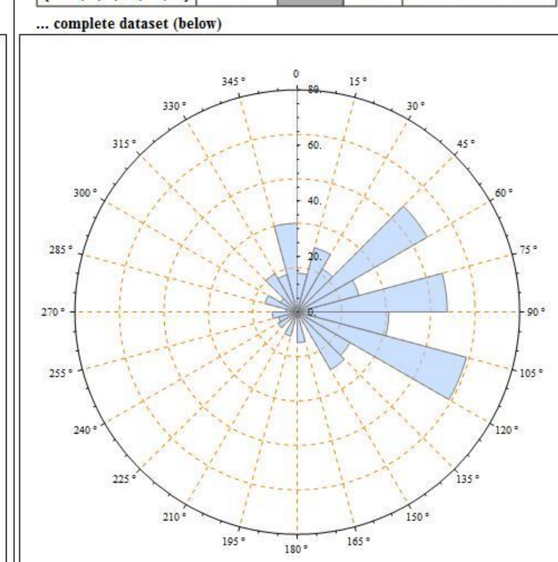


**Figure A-30.** 2012 Hilo International Airport (PHTO) Windrose - Morning Hours

## APPENDIX E

**PHTOy2012.xls−2012: Hour = 12**

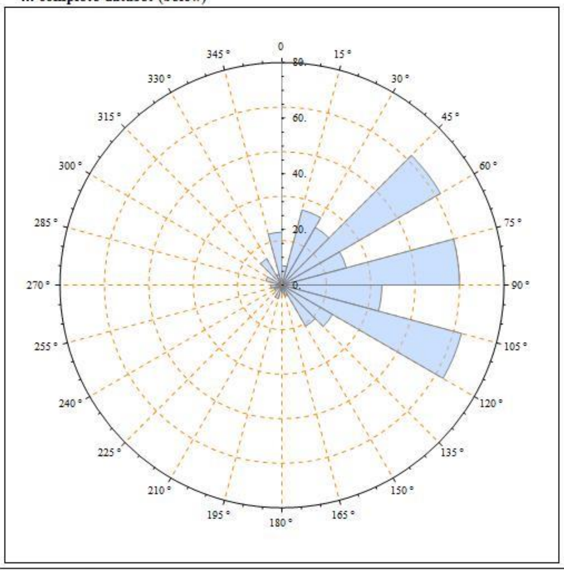
Data Info: Windrose

Number of Datasets = 421

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 12, 53, 0.} | 4.1 | 100. | OK | 1−1−2012 12:53 HST |

... complete dataset (below)



**PHTOy2012.xls−2012: Hour = 13**

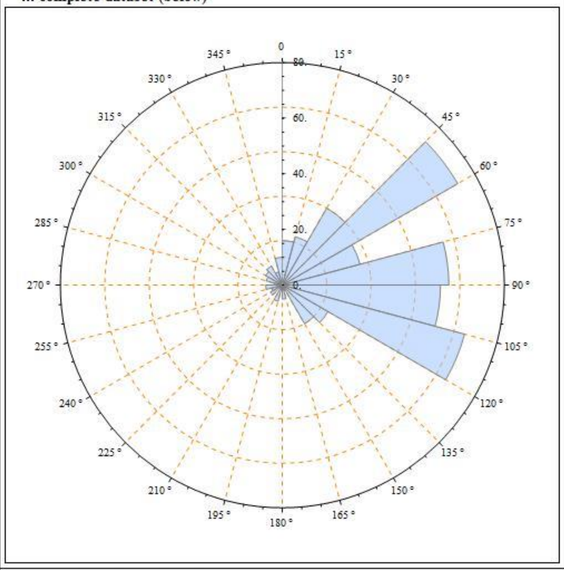
Data Info: Windrose

Number of Datasets = 457

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 13, 53, 0.} | 4.1 | 50. | OK | 1−1−2012 13:53 HST |

... complete dataset (below)



**PHTOy2012.xls−2012: Hour = 14**

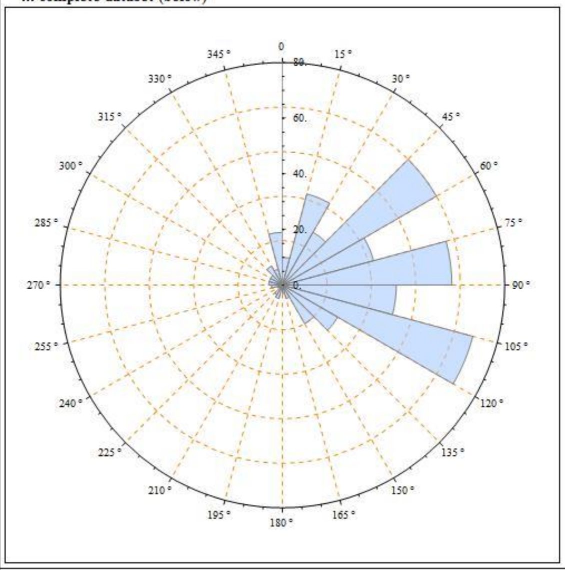
Data Info: Windrose

Number of Datasets = 449

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 14, 43, 0.} | 2.6 | 80. | OK | 1−1−2012 14:43 HST |

... complete dataset (below)



**PHTOy2012.xls−2012: Hour = 15**

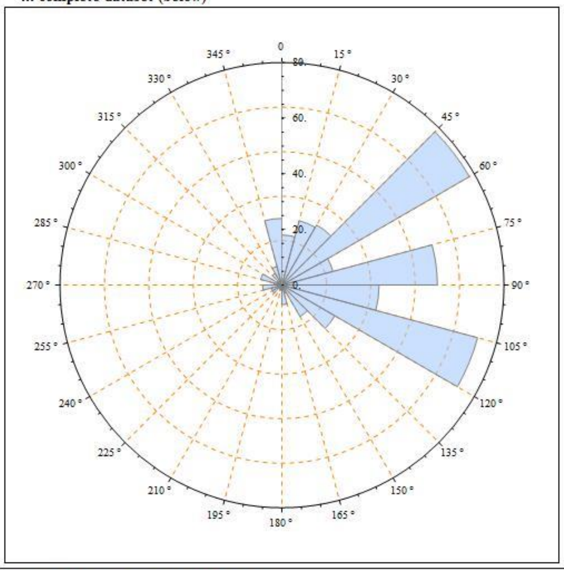
Data Info: Windrose

Number of Datasets = 441

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 15, 10, 0.} | 3.6 | 70. | OK | 1−1−2012 15:10 HST |

... complete dataset (below)



**PHTOy2012.xls−2012: Hour = 16**

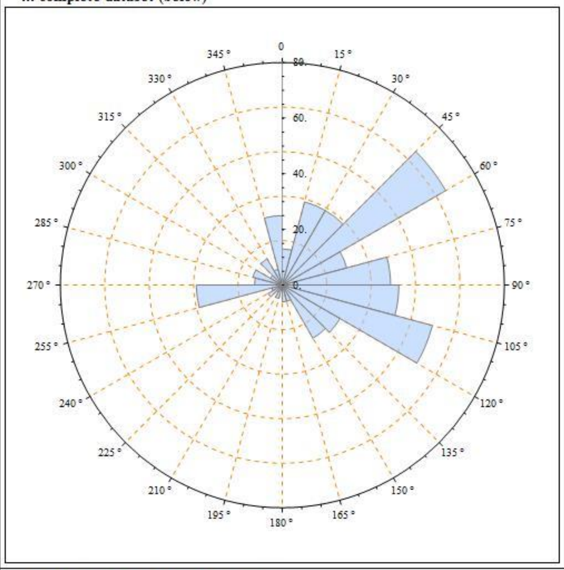
Data Info: Windrose

Number of Datasets = 481

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 16, 36, 0.} | 2.6 | 120. | OK | 1−1−2012 16:36 HST |

... complete dataset (below)



**PHTOy2012.xls−2012: Hour = 17**

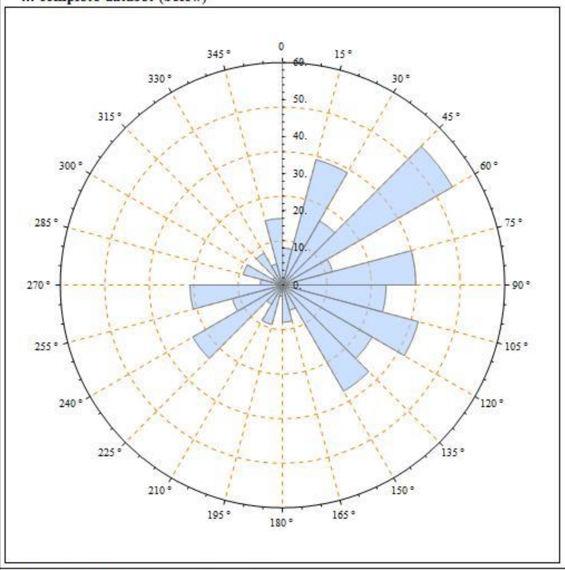
Data Info: Windrose

Number of Datasets = 453

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 17, 53, 0.} | 1.5 | 230. | OK | 1−1−2012 17:53 HST |

... complete dataset (below)



**PHTOy2012.xls−2012: Hour = 18**

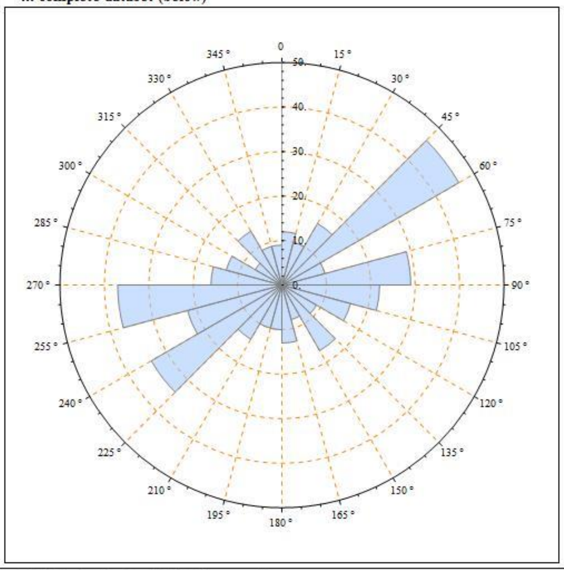
Data Info: Windrose

Number of Datasets = 403

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 18, 53, 0.} | 2.1 | 240. | OK | 1−1−2012 18:53 HST |

... complete dataset (below)



**PHTOy2012.xls−2012: Hour = 19**

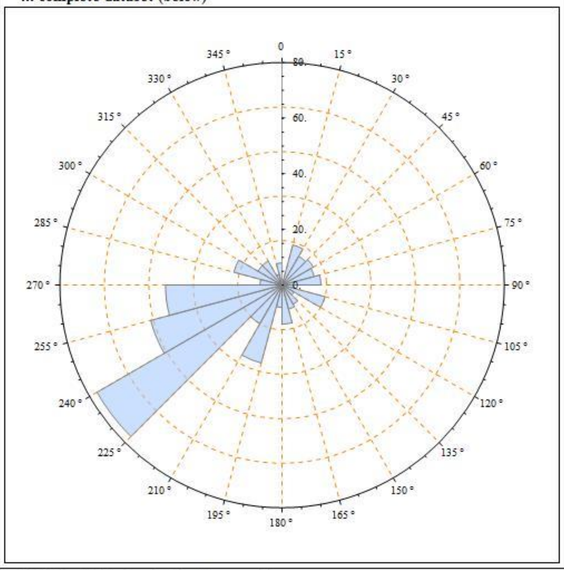
Data Info: Windrose

Number of Datasets = 403

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 19, 53, 0.} | 1.5 | 230. | OK | 1−1−2012 19:53 HST |

... complete dataset (below)



**PHTOy2012.xls−2012: Hour = 20**

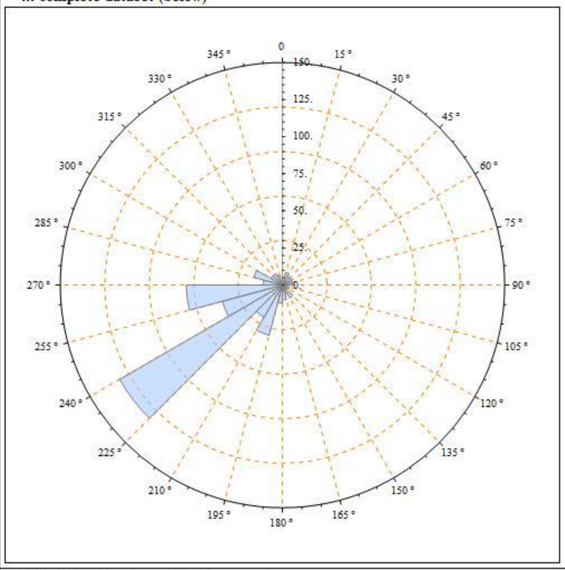
Data Info: Windrose

Number of Datasets = 441

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 20, 53, 0.} | 2.6 | 230. | OK | 1−1−2012 20:53 HST |

... complete dataset (below)



**PHTOy2012.xls−2012: Hour = 21**

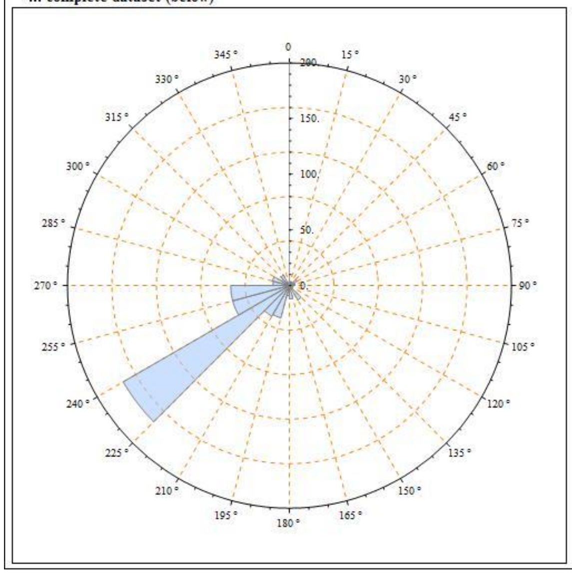
Data Info: Windrose

Number of Datasets = 462

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 21, 53, 0.} | 1.5 | 240. | OK | 1−1−2012 21:53 HST |

... complete dataset (below)



**PHTOy2012.xls−2012: Hour = 22**

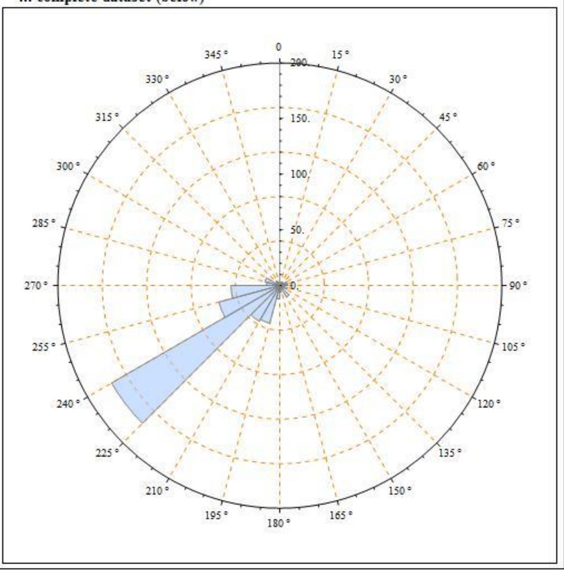
Data Info: Windrose

Number of Datasets = 452

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 22, 53, 0.} | 1.5 | 210. | OK | 1−1−2012 22:53 HST |

... complete dataset (below)



**PHTOy2012.xls−2012: Hour = 23**

Data Info: Windrose

Number of Datasets = 468

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 23, 53, 0.} | 2.1 | 220. | OK | 1−1−2012 23:53 HST |

... complete dataset (below)

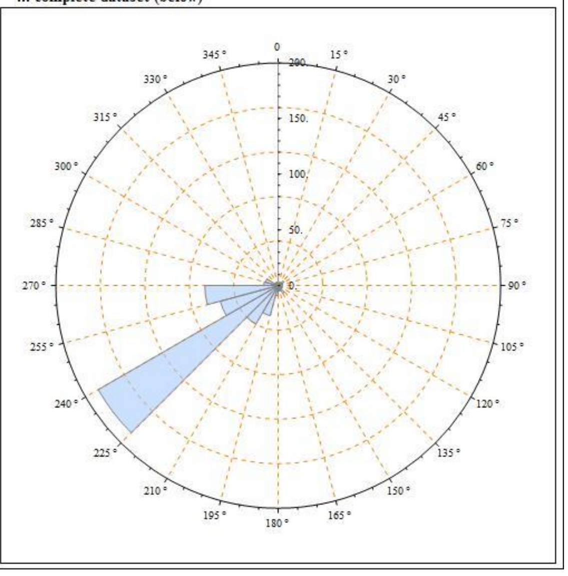


**Figure A-31.** 2012 Hilo International Airport (PHTO) Windrose - Evening Hours

## APPENDIX E

**AN157y2012.xls–2012: Hour = 0**

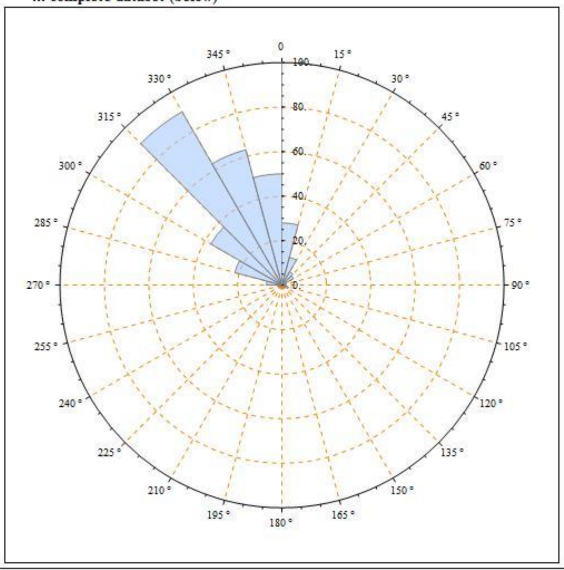
**Data Info: Windrose**

**Number of Datasets = 333**

**... first dataset (below); Direction = DRCT °**

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 2, 0, 0, 0.} | 1.7 | 313. | OK | 1–2–2012 0:00 HST |

**... complete dataset (below)**



**AN157y2012.xls–2012: Hour = 1**

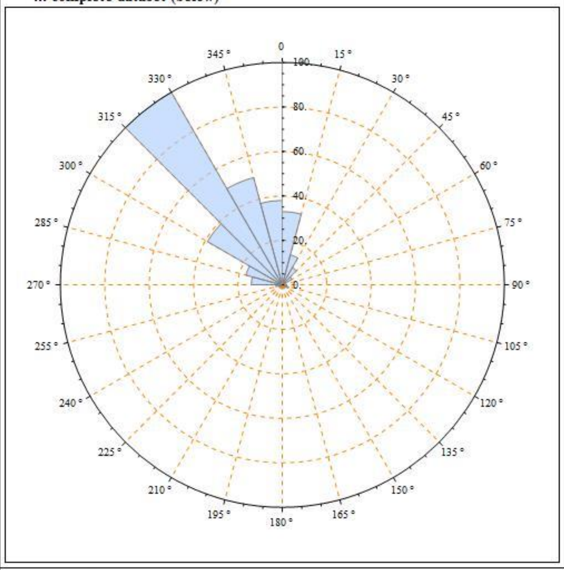
**Data Info: Windrose**

**Number of Datasets = 331**

**... first dataset (below); Direction = DRCT °**

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 1, 0, 0.} | 1.7 | 314. | OK | 1–1–2012 1:00 HST |

**... complete dataset (below)**



**AN157y2012.xls–2012: Hour = 2**

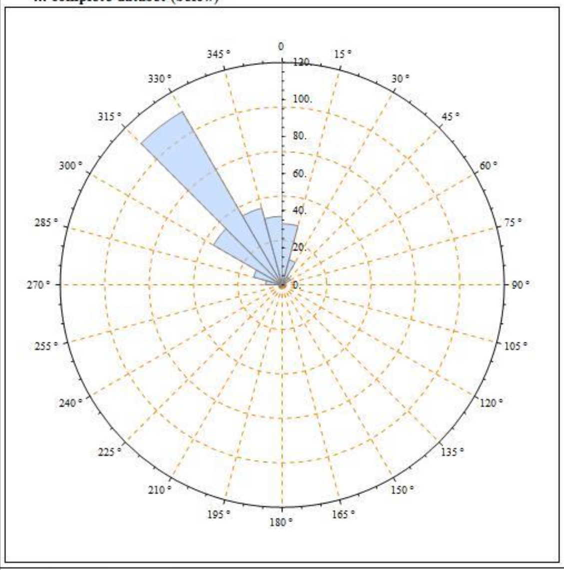
**Data Info: Windrose**

**Number of Datasets = 325**

**... first dataset (below); Direction = DRCT °**

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 2, 0, 0.} | 1.9 | 317. | OK | 1–1–2012 2:00 HST |

**... complete dataset (below)**



**AN157y2012.xls–2012: Hour = 3**

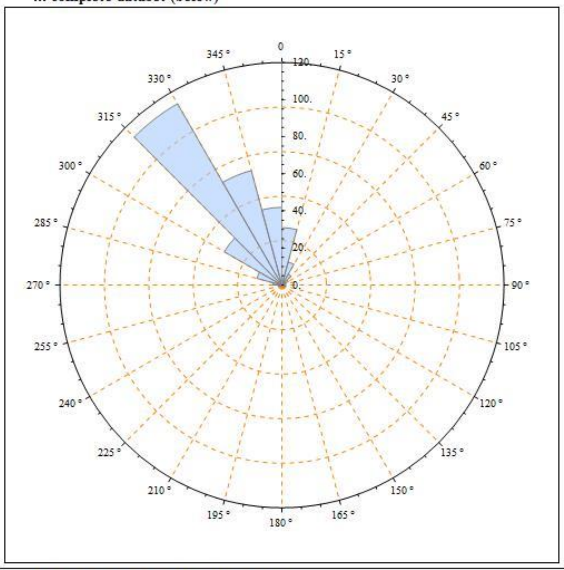
**Data Info: Windrose**

**Number of Datasets = 340**

**... first dataset (below); Direction = DRCT °**

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 3, 0, 0.} | 2. | 319. | OK | 1–1–2012 3:00 HST |

**... complete dataset (below)**



**AN157y2012.xls–2012: Hour = 4**

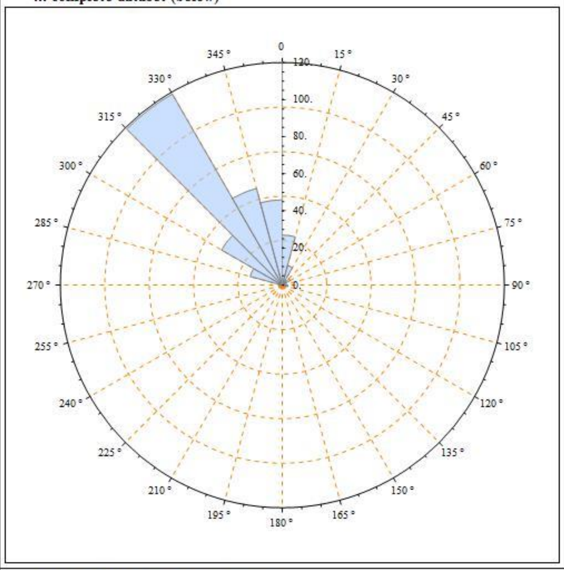
**Data Info: Windrose**

**Number of Datasets = 332**

**... first dataset (below); Direction = DRCT °**

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 4, 0, 0.} | 2.5 | 334. | OK | 1–1–2012 4:00 HST |

**... complete dataset (below)**



**AN157y2012.xls–2012: Hour = 5**

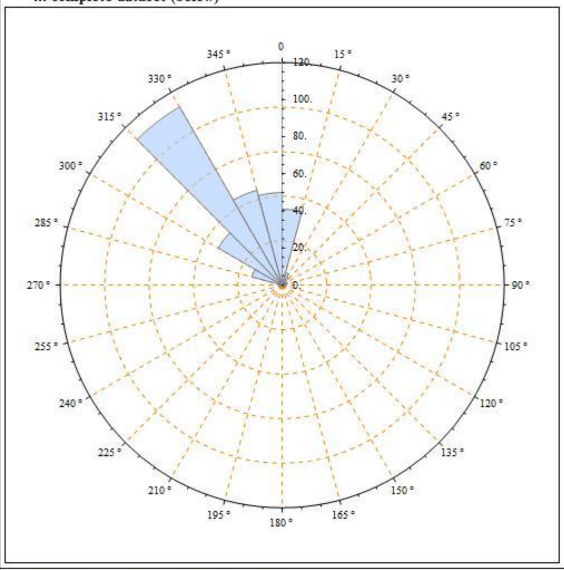
**Data Info: Windrose**

**Number of Datasets = 338**

**... first dataset (below); Direction = DRCT °**

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 5, 0, 0.} | 2.1 | 326. | OK | 1–1–2012 5:00 HST |

**... complete dataset (below)**



**AN157y2012.xls–2012: Hour = 6**

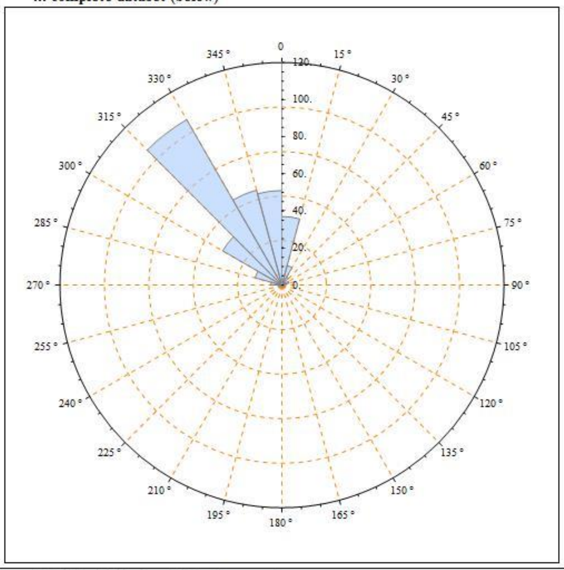
**Data Info: Windrose**

**Number of Datasets = 333**

**... first dataset (below); Direction = DRCT °**

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 6, 0, 0.} | 2.6 | 319. | OK | 1–1–2012 6:00 HST |

**... complete dataset (below)**



**AN157y2012.xls–2012: Hour = 7**

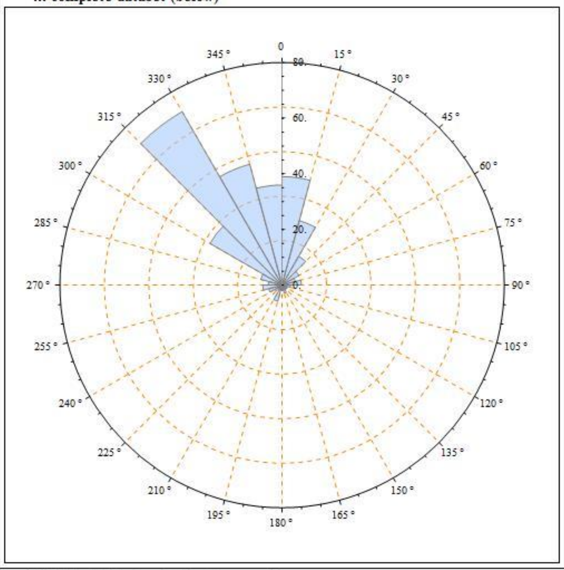
**Data Info: Windrose**

**Number of Datasets = 329**

**... first dataset (below); Direction = DRCT °**

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 7, 0, 0.} | 1.3 | 315. | OK | 1–1–2012 7:00 HST |

**... complete dataset (below)**



**AN157y2012.xls–2012: Hour = 8**

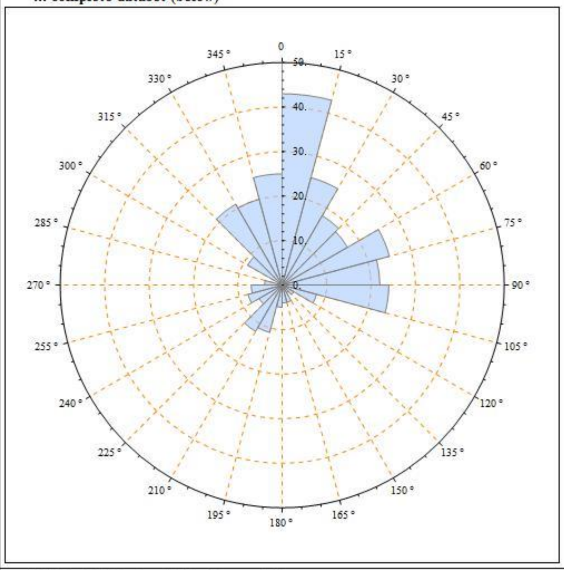
**Data Info: Windrose**

**Number of Datasets = 324**

**... first dataset (below); Direction = DRCT °**

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 8, 0, 0.} | 0.5 | 173. | OK | 1–1–2012 8:00 HST |

**... complete dataset (below)**



**AN157y2012.xls–2012: Hour = 9**

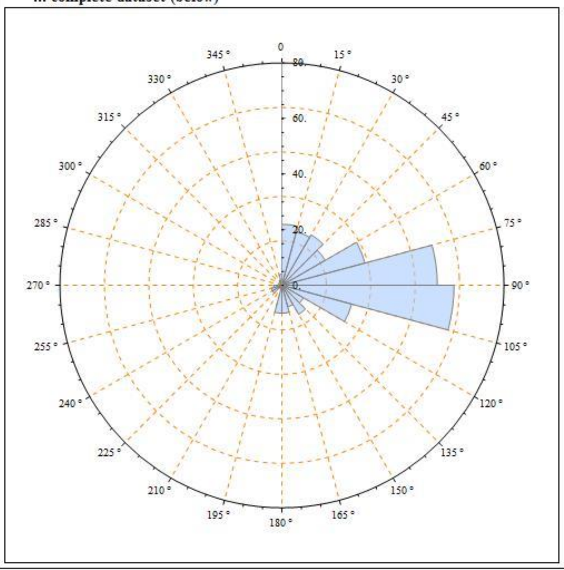
**Data Info: Windrose**

**Number of Datasets = 324**

**... first dataset (below); Direction = DRCT °**

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 9, 0, 0.} | 1. | 124. | OK | 1–1–2012 9:00 HST |

**... complete dataset (below)**



**AN157y2012.xls–2012: Hour = 10**

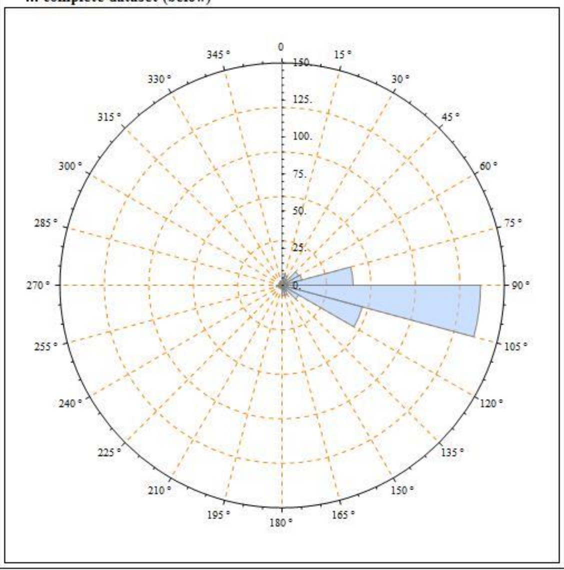
**Data Info: Windrose**

**Number of Datasets = 336**

**... first dataset (below); Direction = DRCT °**

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 10, 0, 0.} | 2.2 | 107. | OK | 1–1–2012 10:00 HST |

**... complete dataset (below)**



**AN157y2012.xls–2012: Hour = 11**

**Data Info: Windrose**

**Number of Datasets = 328**

**... first dataset (below); Direction = DRCT °**

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 11, 0, 0.} | 3.1 | 111. | OK | 1–1–2012 11:00 HST |

**... complete dataset (below)**

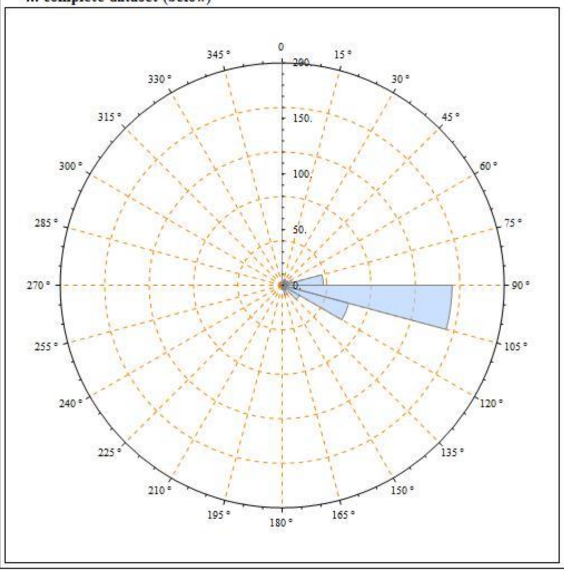


**Figure A-32.** 2012 Pahala (AN157) Windrose - Morning Hours

**AN157y2012.xls–2012: Hour = 12**

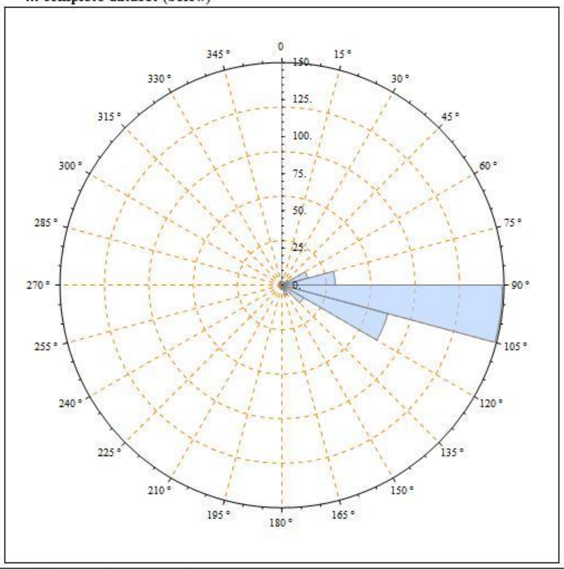
Data Info: Windrose

Number of Datasets = 335

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 12, 0, 0.} | 3.6 | 112. | OK | 1–1–2012 12:00 HST |

... complete dataset (below)



**AN157y2012.xls–2012: Hour = 13**

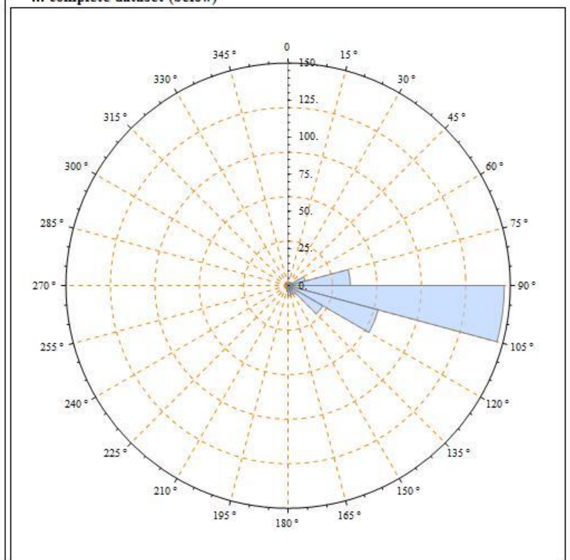
Data Info: Windrose

Number of Datasets = 331

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 2, 13, 0, 0.} | 2.3 | 125. | OK | 1–2–2012 13:00 HST |

... complete dataset (below)



**AN157y2012.xls–2012: Hour = 14**

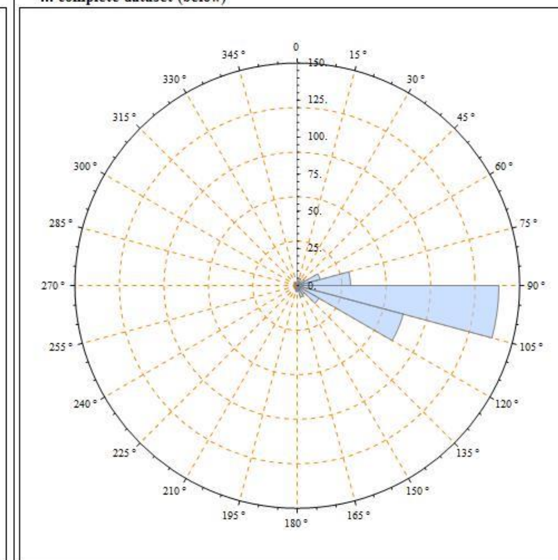
Data Info: Windrose

Number of Datasets = 333

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 14, 0, 0.} | 2.3 | 99. | OK | 1–1–2012 14:00 HST |

... complete dataset (below)



**AN157y2012.xls–2012: Hour = 15**

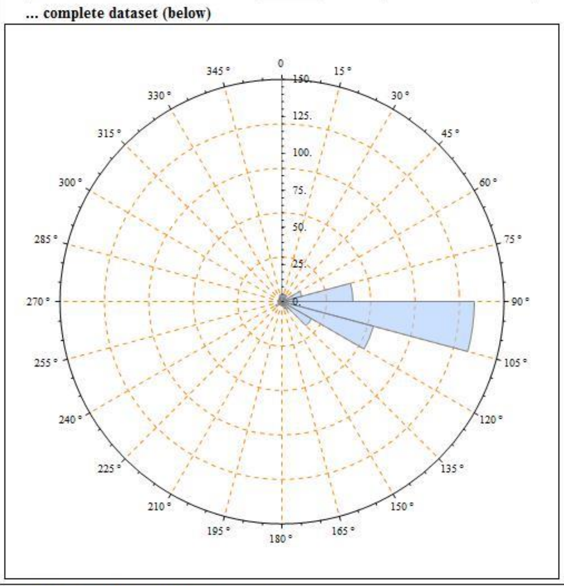
Data Info: Windrose

Number of Datasets = 336

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 15, 0, 0.} | 2. | 98. | OK | 1–1–2012 15:00 HST |

... complete dataset (below)



**AN157y2012.xls–2012: Hour = 16**

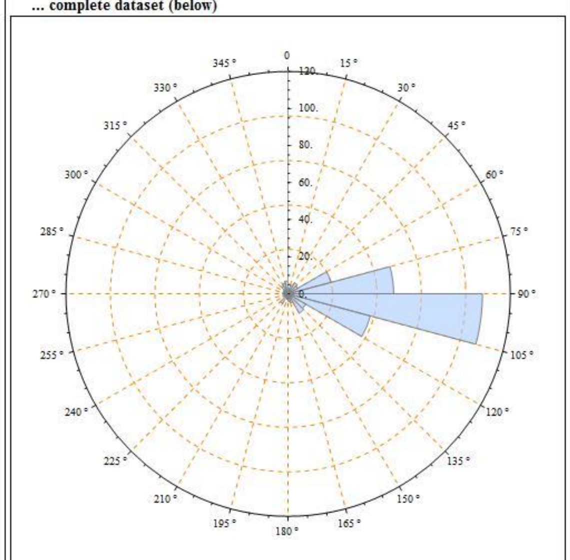
Data Info: Windrose

Number of Datasets = 327

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 16, 0, 0.} | 1.6 | 97. | OK | 1–1–2012 16:00 HST |

... complete dataset (below)



**AN157y2012.xls–2012: Hour = 17**

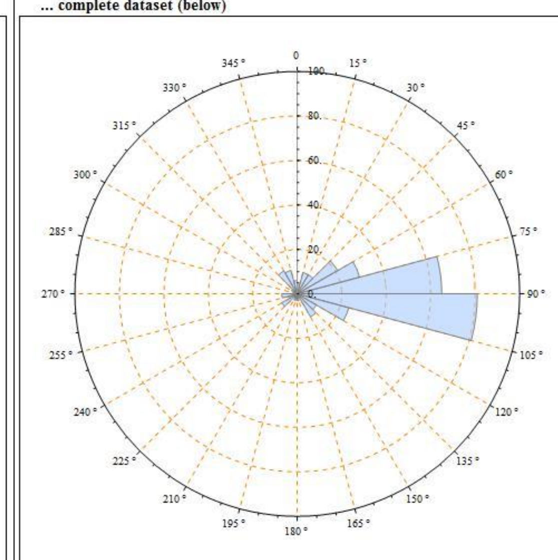
Data Info: Windrose

Number of Datasets = 331

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 17, 0, 0.} | 0.9 | 82. | OK | 1–1–2012 17:00 HST |

... complete dataset (below)



**AN157y2012.xls–2012: Hour = 18**

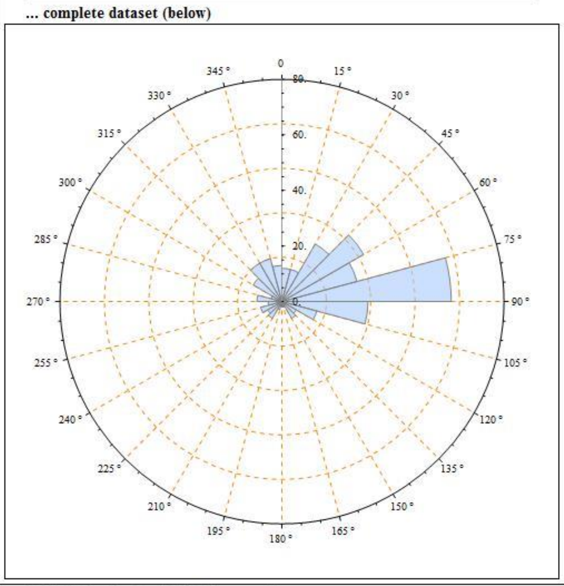
Data Info: Windrose

Number of Datasets = 332

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 2, 18, 0, 0.} | 1.1 | 114. | OK | 1–2–2012 18:00 HST |

... complete dataset (below)



**AN157y2012.xls–2012: Hour = 19**

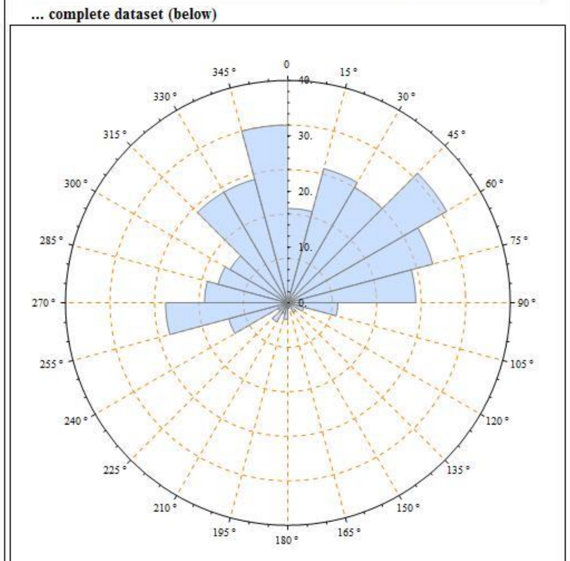
Data Info: Windrose

Number of Datasets = 326

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 19, 0, 0.} | 0.7 | 251. | OK | 1–1–2012 19:00 HST |

... complete dataset (below)



**AN157y2012.xls–2012: Hour = 20**

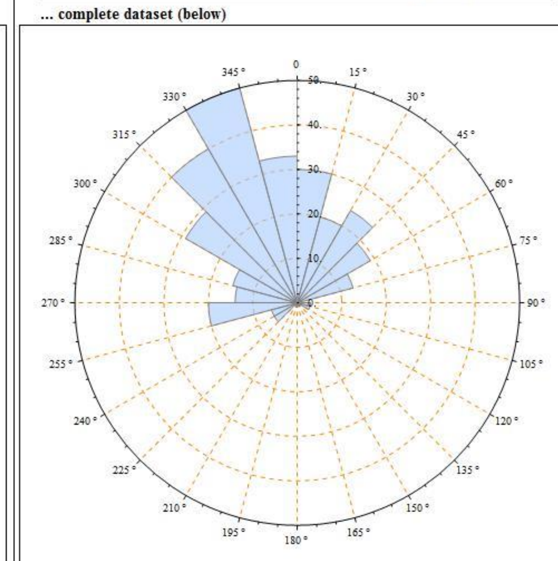
Data Info: Windrose

Number of Datasets = 328

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 20, 0, 0.} | 0.6 | 293. | OK | 1–1–2012 20:00 HST |

... complete dataset (below)



**AN157y2012.xls–2012: Hour = 21**

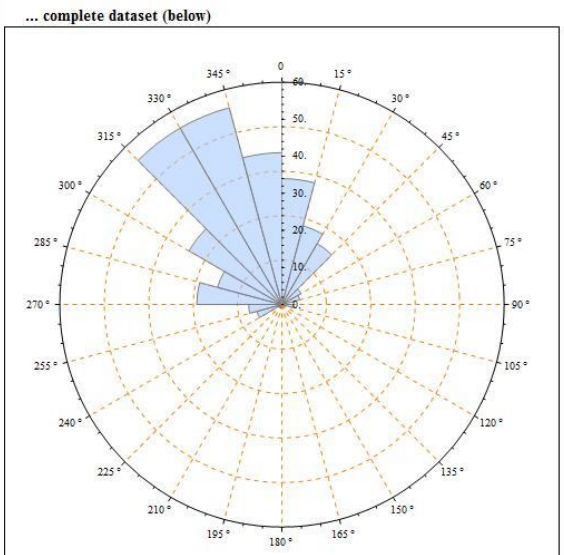
Data Info: Windrose

Number of Datasets = 329

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 21, 0, 0.} | 1.6 | 323. | OK | 1–1–2012 21:00 HST |

... complete dataset (below)



**AN157y2012.xls–2012: Hour = 22**

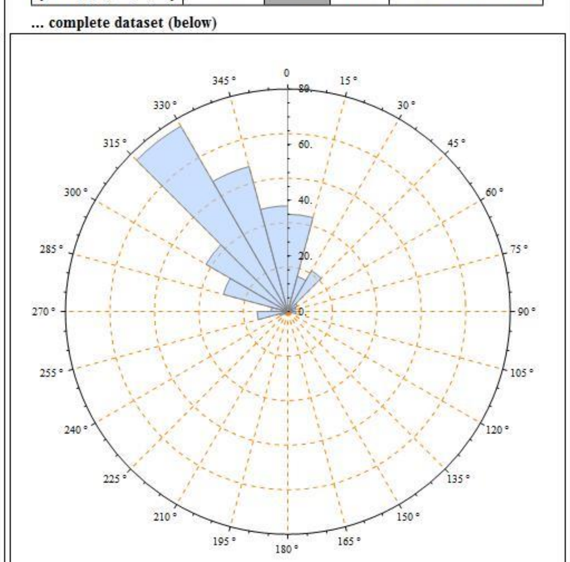
Data Info: Windrose

Number of Datasets = 324

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 22, 0, 0.} | 2. | 334. | OK | 1–1–2012 22:00 HST |

... complete dataset (below)



**AN157y2012.xls–2012: Hour = 23**

Data Info: Windrose

Number of Datasets = 333

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT m/s | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2012, 1, 1, 23, 0, 0.} | 1.9 | 319. | OK | 1–1–2012 23:00 HST |

... complete dataset (below)

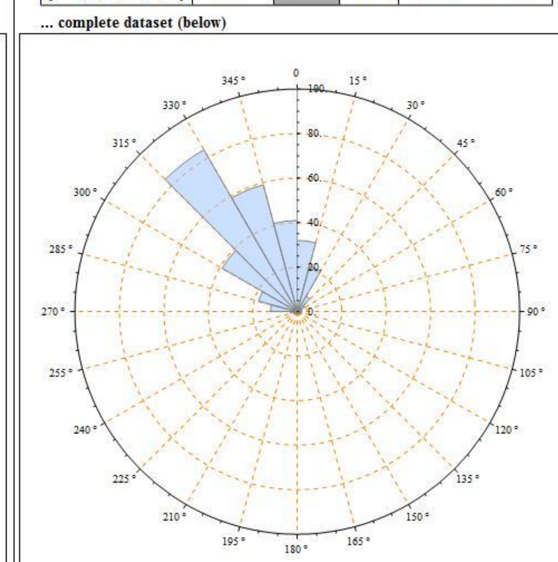


**Figure A-33.** 2012 Pahala (AN157) Windrose - Evening Hours

**AN738y2012.xls–2012: Hour = 0**

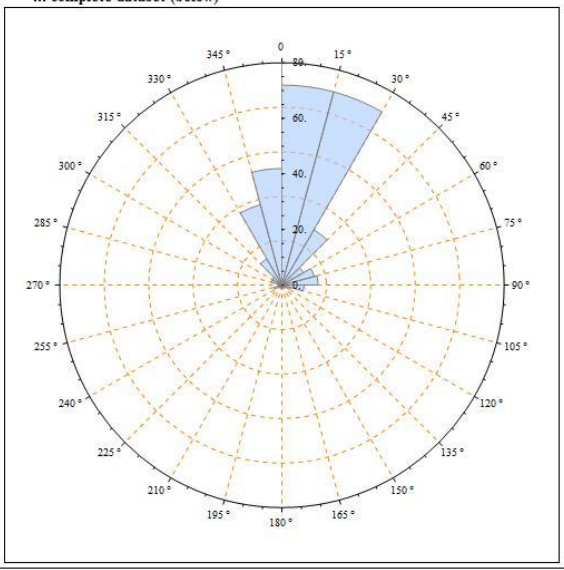
Data Info: Windrose

Number of Datasets = 314

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 2, 0, 0, 0.} | 2.2 | 16. | N/A | 1–2–2012 0:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 1**

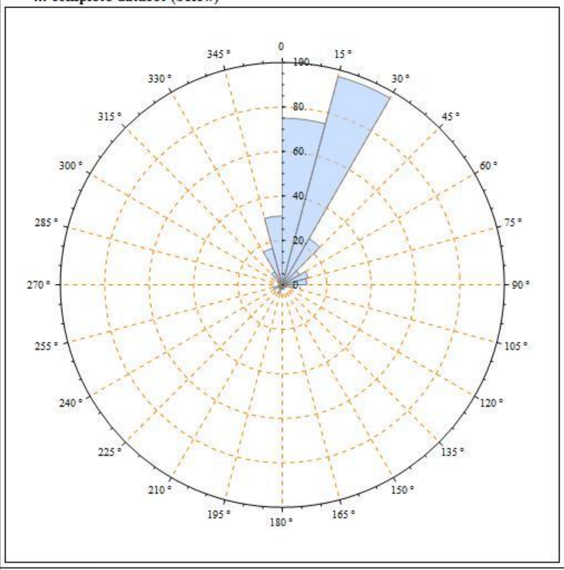
Data Info: Windrose

Number of Datasets = 309

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 1, 0, 0.} | 2.1 | 7. | N/A | 1–1–2012 1:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 2**

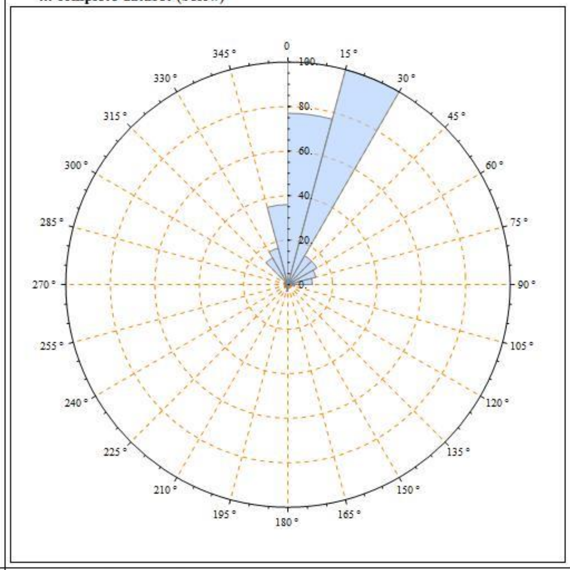
Data Info: Windrose

Number of Datasets = 312

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 2, 0, 0.} | 1.3 | 25. | N/A | 1–1–2012 2:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 3**

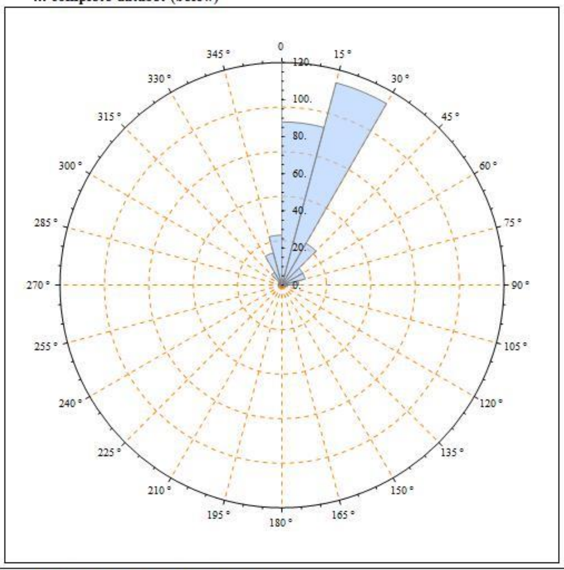
Data Info: Windrose

Number of Datasets = 329

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 3, 0, 0.} | 0.6 | 39. | N/A | 1–1–2012 3:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 4**

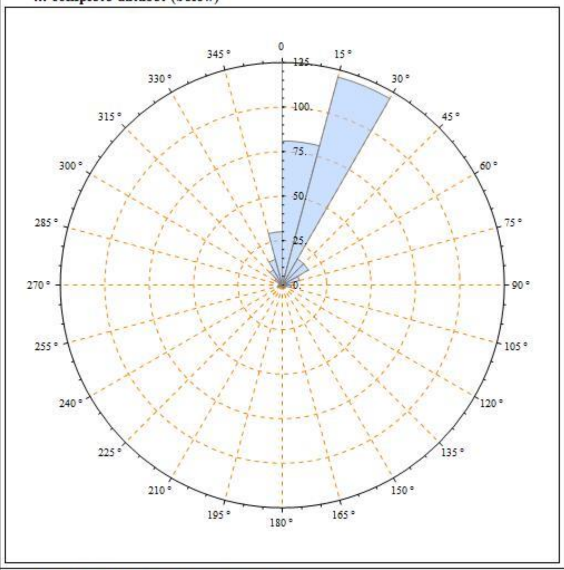
Data Info: Windrose

Number of Datasets = 326

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 4, 0, 0.} | 2.1 | 18. | N/A | 1–1–2012 4:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 5**

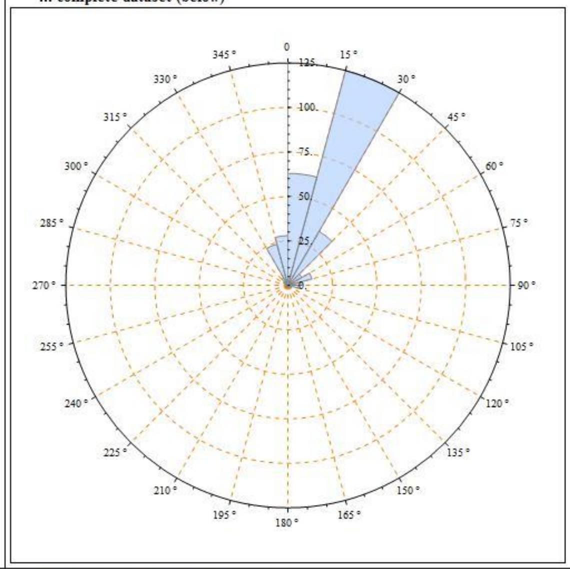
Data Info: Windrose

Number of Datasets = 331

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 5, 0, 0.} | 2.2 | 14. | N/A | 1–1–2012 5:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 6**

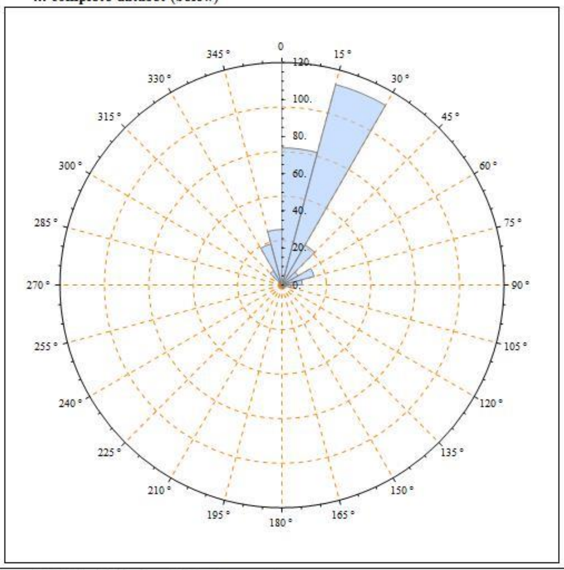
Data Info: Windrose

Number of Datasets = 327

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 6, 0, 0.} | 1.9 | 21. | N/A | 1–1–2012 6:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 7**

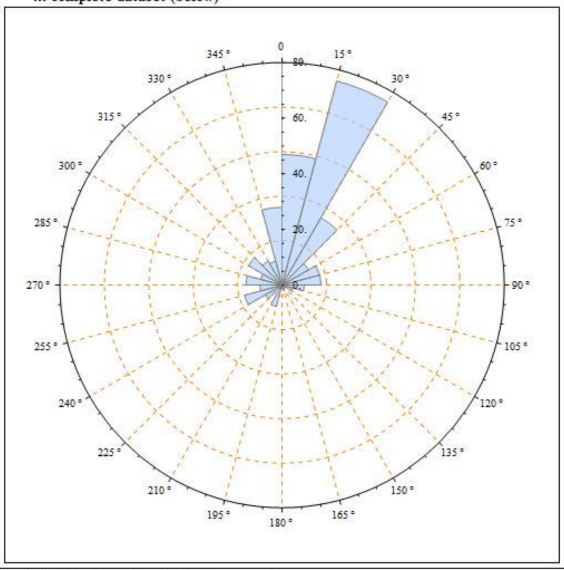
Data Info: Windrose

Number of Datasets = 327

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 7, 0, 0.} | 1.4 | 23. | N/A | 1–1–2012 7:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 8**

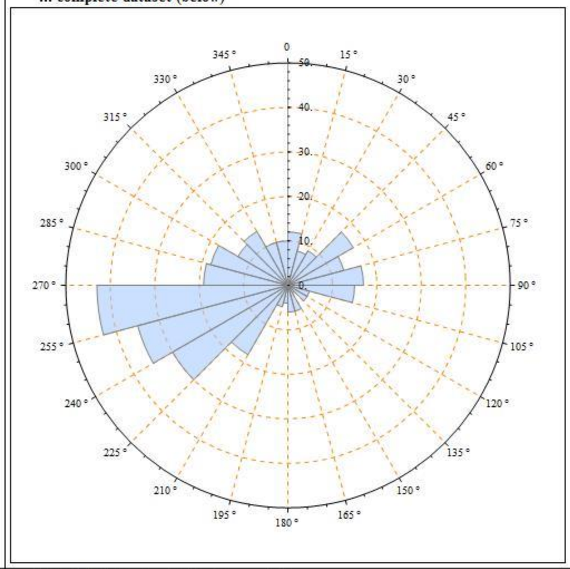
Data Info: Windrose

Number of Datasets = 334

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 8, 0, 0.} | 0.8 | 267. | N/A | 1–1–2012 8:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 9**

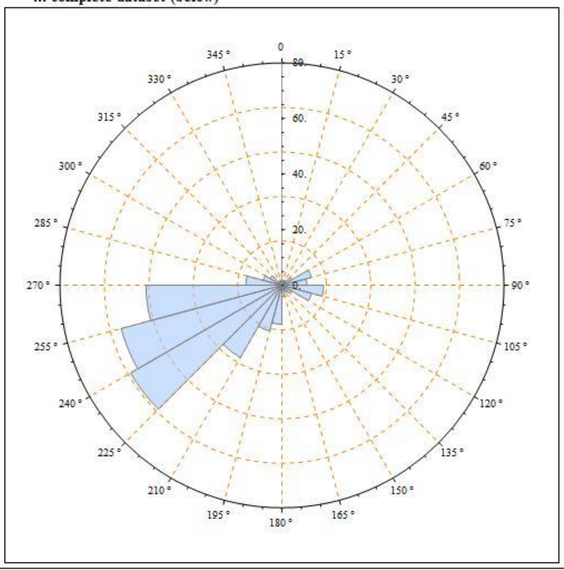
Data Info: Windrose

Number of Datasets = 329

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 9, 0, 0.} | 1.1 | 234. | N/A | 1–1–2012 9:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 10**

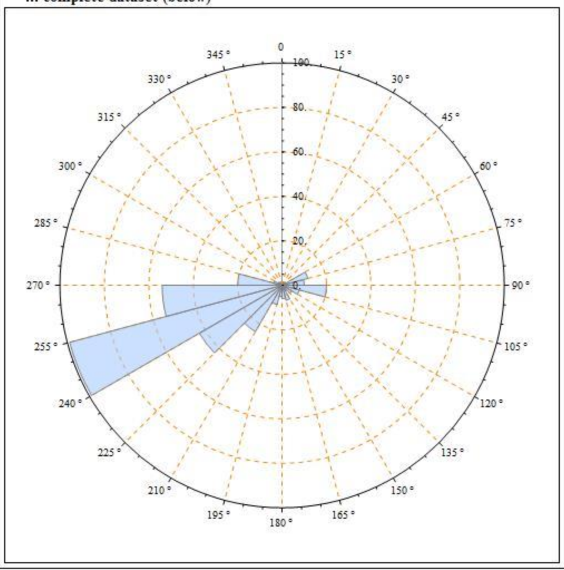
Data Info: Windrose

Number of Datasets = 338

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 10, 0, 0.} | 1.5 | 223. | N/A | 1–1–2012 10:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 11**

Data Info: Windrose

Number of Datasets = 331

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 11, 0, 0.} | 1.6 | 234. | N/A | 1–1–2012 11:00 HST |

... complete dataset (below)

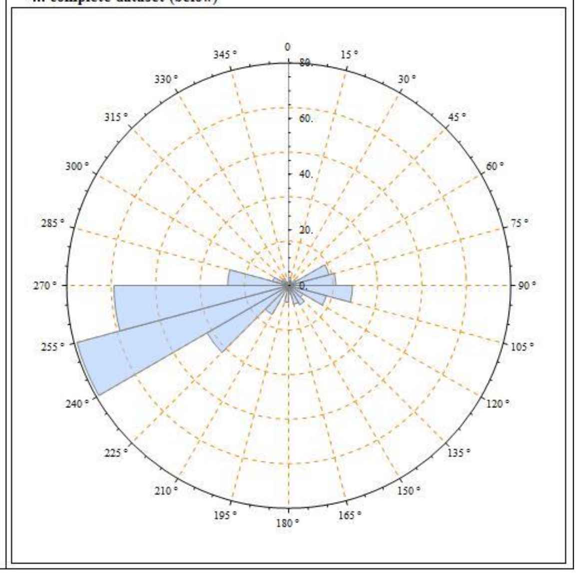


**Figure A-34.** 2012 Ocean View (AN738) Windrose - Morning Hours

# APPENDIX E

**AN738y2012.xls–2012: Hour = 12**

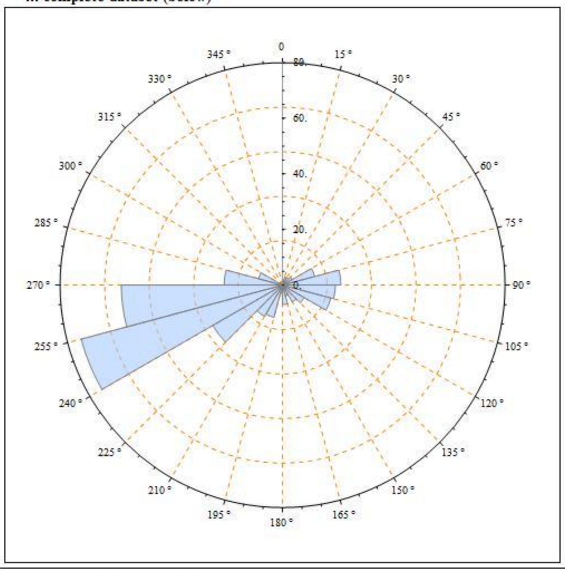
Data Info: Windrose

Number of Datasets = 331

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 12, 0, 0.} | 1.3 | 253. | N/A | 1–1–2012 12:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 13**

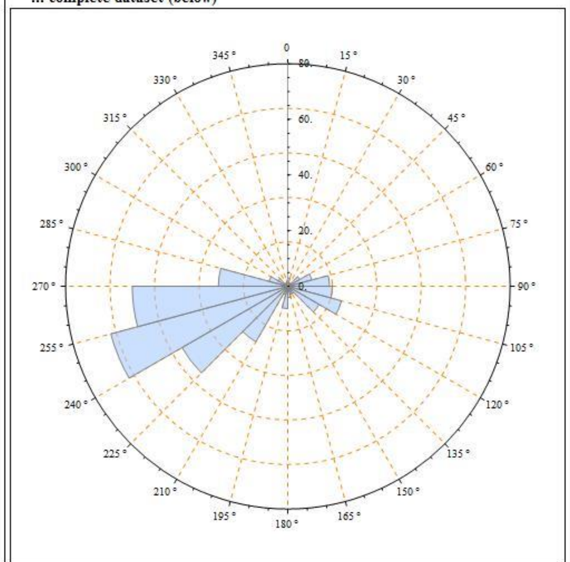
Data Info: Windrose

Number of Datasets = 332

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 2, 13, 0, 0.} | 1.7 | 253. | N/A | 1–2–2012 13:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 14**

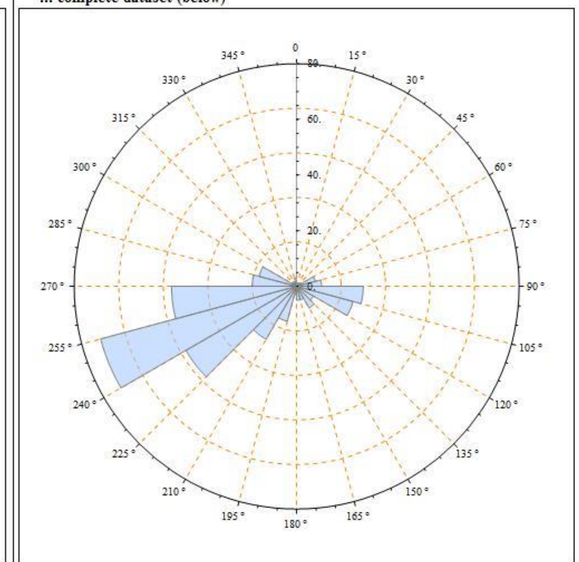
Data Info: Windrose

Number of Datasets = 331

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 14, 0, 0.} | 1.3 | 230. | N/A | 1–1–2012 14:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 15**

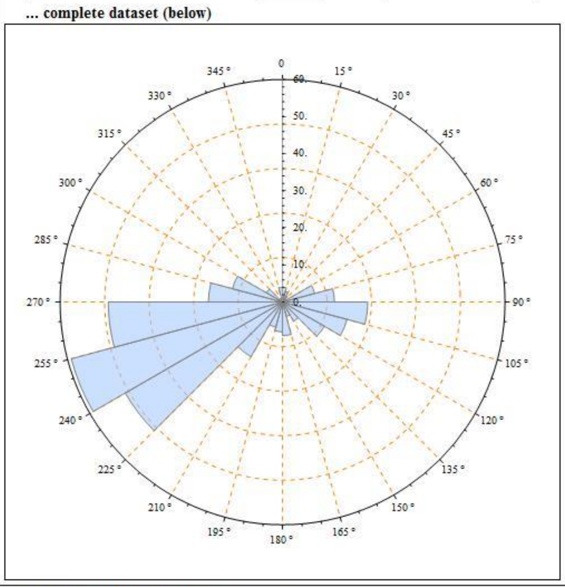
Data Info: Windrose

Number of Datasets = 337

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 15, 0, 0.} | 1.7 | 178. | N/A | 1–1–2012 15:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 16**

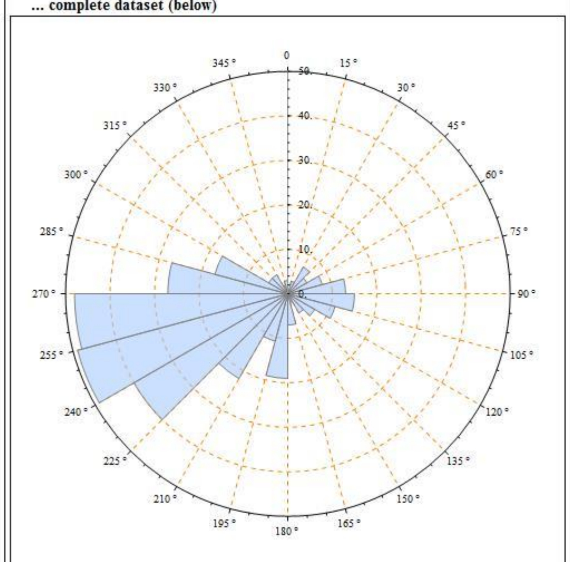
Data Info: Windrose

Number of Datasets = 331

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 16, 0, 0.} | 1.7 | 213. | N/A | 1–1–2012 16:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 17**

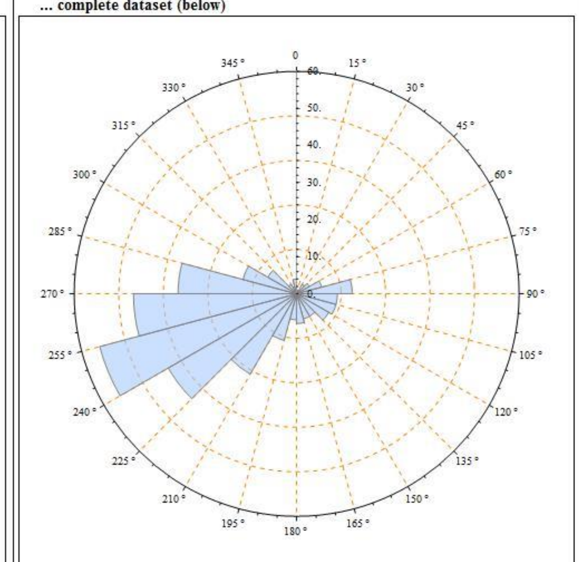
Data Info: Windrose

Number of Datasets = 334

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 17, 0, 0.} | 0.9 | 211. | N/A | 1–1–2012 17:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 18**

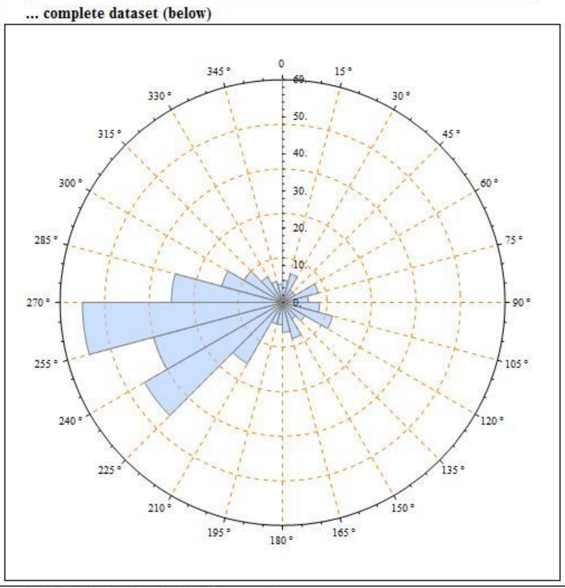
Data Info: Windrose

Number of Datasets = 335

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 18, 0, 0.} | 0.7 | 235. | N/A | 1–1–2012 18:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 19**

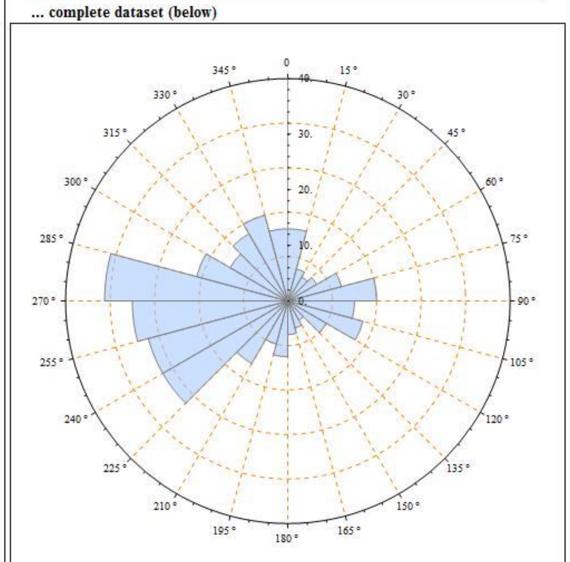
Data Info: Windrose

Number of Datasets = 321

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 19, 0, 0.} | 0.5 | 276. | N/A | 1–1–2012 19:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 20**

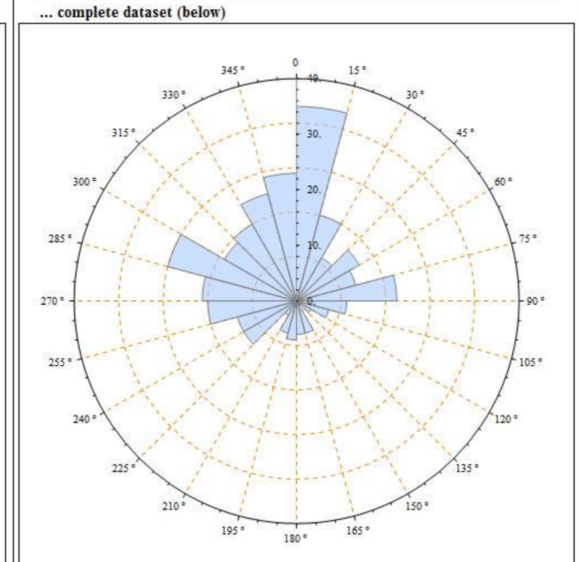
Data Info: Windrose

Number of Datasets = 302

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 20, 0, 0.} | 1.5 | 12. | N/A | 1–1–2012 20:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 21**

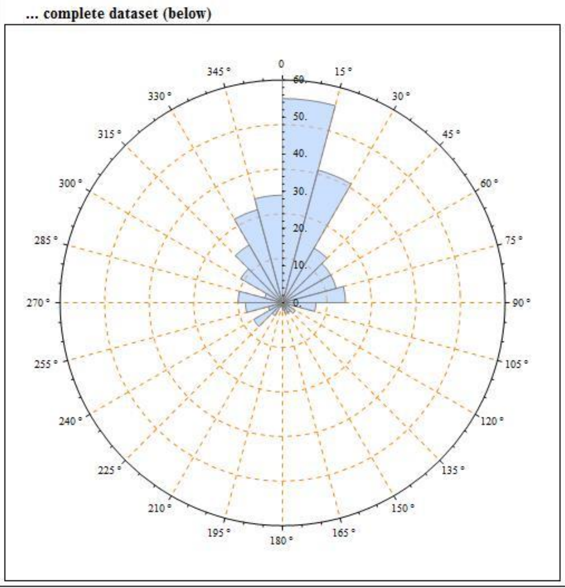
Data Info: Windrose

Number of Datasets = 310

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 21, 0, 0.} | 1.3 | 356. | N/A | 1–1–2012 21:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 22**

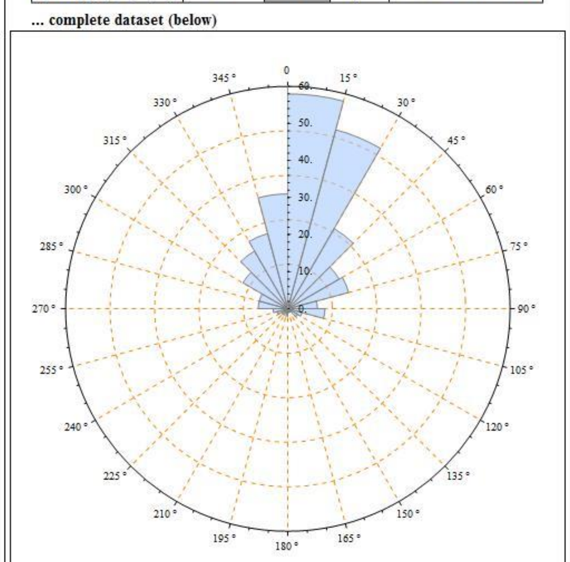
Data Info: Windrose

Number of Datasets = 308

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 22, 0, 0.} | 1.3 | 18. | N/A | 1–1–2012 22:00 HST |

... complete dataset (below)



**AN738y2012.xls–2012: Hour = 23**

Data Info: Windrose

Number of Datasets = 308

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT m/s | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2012, 1, 1, 23, 0, 0.} | 1.9 | 16. | N/A | 1–1–2012 23:00 HST |

... complete dataset (below)

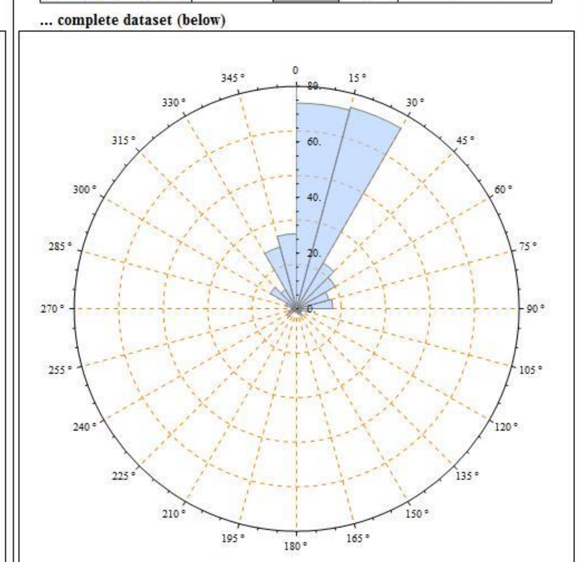


**Figure A-35.** 2012 Ocean View (AN738) Windrose - Evening Hours

State of Hawaii
Department of Health
Clean Air Branch

# Documentation for Natural Events Excluded Data
# Kona Air Monitoring Station, AQS ID 15-001-1012
# 2013 $PM_{2.5}$ Exceedance

## Final Report
## June 2014

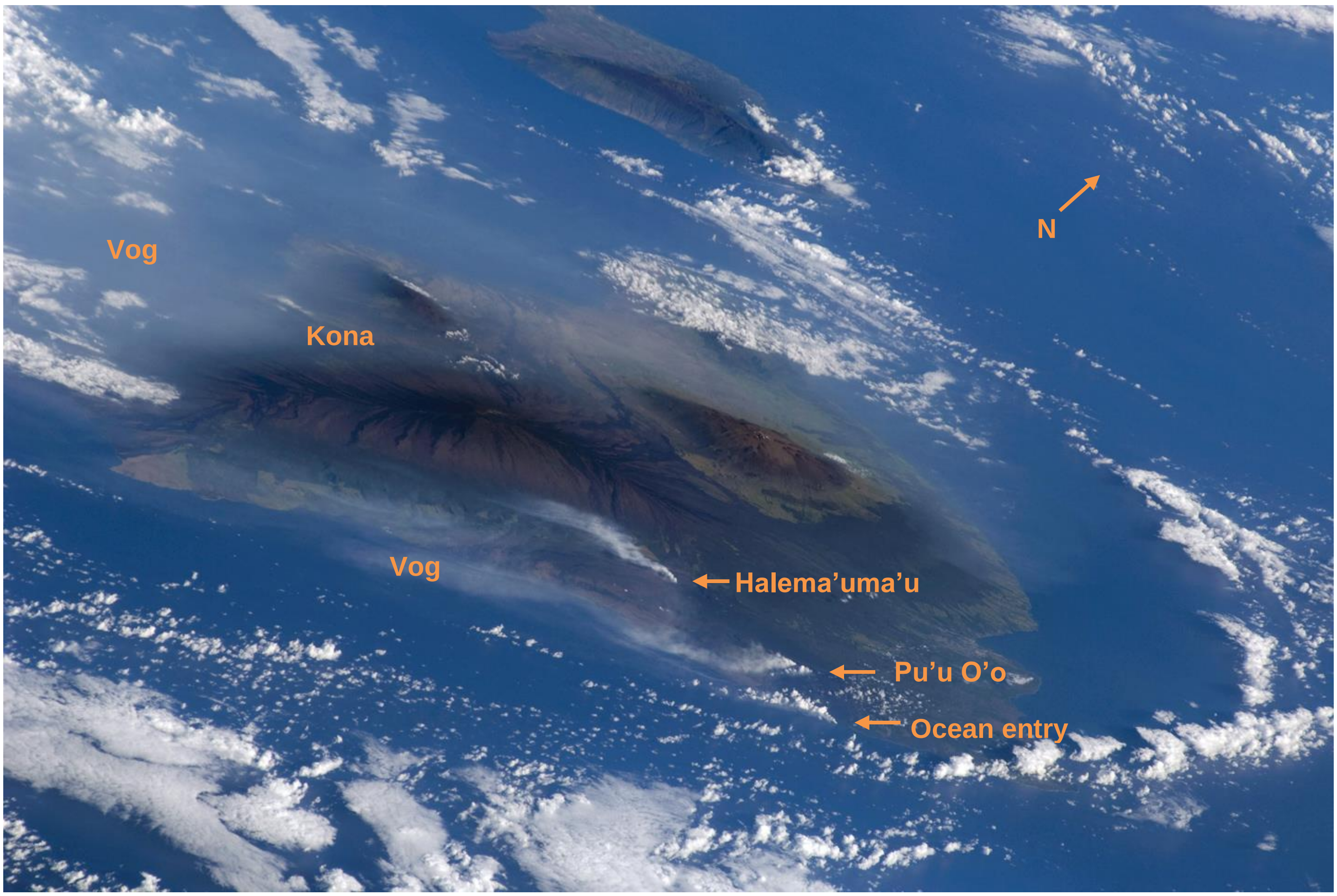



Image by crew of Space Shuttle Atlantis, May 13, 2009

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## Introduction

During 2013, the Kona air monitoring station recorded annual average particulate matter less than or equal to 2.5 micrometers in diameter ($PM_{2.5}$) concentration of 13.3 µg/$m^3$. This value exceeds the annual $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS) of 12 µg/$m^3$.

**This report is solely to demonstrate that this exceedance at the Kona station, and Kona station alone**, was caused by naturally occurring volcanic emissions, was not reasonably controllable or preventable, was associated with measured concentrations in excess of normal historical fluctuations, and would not have occurred "but-for" the volcanic emissions and, therefore, is an Exceptional Event as defined by the U.S. Environmental Protection Agency's (EPA) Exceptional Events Rule (EER).

Table I-1 below is a summary of the flagged $PM_{2.5}$ data for 2013. A table with a complete listing all the dates that were flagged is included in Appendix B. While Table I-1 reports all 2013 24-hour $PM_{2.5}$ flagged data, we are only requesting that flagged values in Quarter 1 and Quarter 2 of 2013 be considered at this time.

| **Kona (AQS ID 150011012): 2013 24-hr $PM_{2.5}$ Flagged Data** | | | |
|---|---|---|---|
| Year | Quarter | Date Range | Number of Flagged Days |
| 2013 | 1 | January 1 to March 31 | 66 |
| 2013 | 2 | April 1 to June 30 | 56 |
| 2013 | 3 | July 1 to September 30 | 54 |
| 2013 | 4 | October 1 to December 28 | 39 |

**Table I-1.** Summary of Flagged Days in 2013

There were no exceedances of the 24-hour $PM_{2.5}$ NAAQS of 35 µg/$m^3$ at the Kona station in 2013.

Section 1 of this report provides a summary of the exceptional events rules and requirements and details how those rules are met within the report.

Section 2 of this report introduces the conceptual model of the volcanic event that occurred during 2013, providing a background narrative of the natural event and an explanation that it affected air quality. Section 2 also provides evidence that the exceedances were due to a natural event.

Section 3 of this report establishes a clear causal relationship between the natural event and the exceedance of the annual $PM_{2.5}$ standard at the monitoring station. This section also discusses how sulfur dioxide ($SO_2$) gas from the volcano turns into sulfate particles as it travels to the Kona coast.

Section 4 of this report provides information on existing anthropogenic sources in the Kona area and the emissions control measures required of these sources. It demonstrates that despite the regulation of these man-made sources, the exceedance was not reasonably controllable or preventable.

Section 5 of this report provides information which help illustrate that the exceptional event produced $PM_{2.5}$ concentrations in excess of normal historical fluctuations.

Section 6 of this report summarizes the demonstration, showing a clear causal relationship between the natural event and the exceedance, and concludes that this exceedance would not have occurred “but-for” the continuing natural event.

Appendix A of this report includes additional figures with supporting information.

Appendix B of this report includes a table with a complete listing all the dates that were flagged.

Appendix C of this report includes the affidavits of publication in three local newspapers notifying the public of the availability for inspection of this document. The three newspapers are the Honolulu Star-Advertiser (State-wide distribution), the Hawaii Tribune-Herald (East Hawaii newspaper distribution) and the West Hawaii Today (West Hawaii newspaper distribution). No public comments were received.

Appendix D of this report includes additional supporting information for the ambient air monitoring stations mentioned in this report.

Appendix E of this report includes full size copies of the figures in Section 3 of this document, provided for more legible and discernable figures. Sample “legend” pages are also provided in this appendix to help identify and explain the different chart headings.

## Table of Contents



Cover graphic illustrates the volcanic emission plumes (vog) from the Halema'uma'u and Pu'u O'o vents and the lava ocean entry point being blown to the southern end of Hawaii Island then travelling up to the Kona coast during predominant trade wind regime.

## List of Figures

## List of Tables

## List of Acronyms and Definitions

| | |
|---|---|
| QS | Air Quality System |
| ASAS | Air Surveillance and Analysis Section (State of Hawaii, Department of Health) |
| BACT | Best Available Control Technology |
| CEMS | Continuous Emissions Monitoring System |
| CFR | Code of Federal Regulations |
| COMS | Continuous Opacity Monitoring System |
| DOH-CAB | Department of Health Clean Air Branch (State of Hawaii) |
| EPA | United States Environmental Protection Agency |
| HAR | Hawaii Administrative Rules |
| HAVO | Hawaii Volcano Observatory |
| HAVO OB | Hawaii Volcano Observatory Kilauea Observatory |
| HAVO VC | Hawaii Volcano Observatory Kilauea Visitor's Center |
| hp | Horsepower |
| Kona winds | This refers to periods of light, variable to southerly winds that typically occur when a subtropical ridge rests over the state. |
| kW | Kilowatt |
| MMBtu/hr | One million British Thermal Units per hour |
| MW | Megawatt |
| NAAQS | National Ambient Air Quality Standards |
| NEI | National Emissions Inventory |
| $NO_2$ | Nitrogen Dioxide |
| NESHAPS | National Emissions Standards for Hazardous Air Pollutants |
| NPS | National Park Service |
| NSPS | New Source Performance Standards |
| Particulate Matter | A mixture in the air of very small particles and liquid droplets. This includes "fine particles" 2.5 micrometers or less in diameter and "coarse particles" greater than 2.5 micrometers but less than 10 micrometers in diameter. |
| $PM_{2.5}$ | Particulate matter less than or equal to 2.5 micrometers in diameter |
| ppb | parts per billion |
| PSD | Prevention of Significant Deterioration |
| SCR | Selective Catalytic Reduction |
| $SO_2$ | Sulfur dioxide gas |
| TPH | Tons per hour |
| TPY | Tons per year |
| Trade winds | Refers to the predominant winds in the state of Hawaii which is from the east/northeasterly direction. |
| USGS | United States Geological Survey |
| $\mu g/m^3$ | micrograms per cubic meter |
| Vog | This is a local term that refers to "volcanic smog" or a hazy air pollution condition attributed to the active volcano. |

## Section 1. Exceptional Event Rule (EER) Requirements

Technical and procedural requirements are contained within the EER and must be met in order for EPA to concur with the flagged air monitoring data. This section of the report details the Hawaii Department of Health, Clean Air Branch's (DOH-CAB) effort to address those requirements as required by 40 CFR 50.14 (*Treatment of Air Quality Monitoring Data Influenced by Exceptional Events*).

### 1.1 Procedural Requirements

***Public notification that event was occurring (40 CFR 50.14 (c)(1(i))***
Immediate public notification of NAAQS exceedances is provided on the DOH-CAB website at http://health.hawaii.gov/cab/notification-of-exceedance-of-a-national-ambient-air-quality-standard. Notification of the 2013 exceedance of the annual $PM_{2.5}$ NAAQS was posted once the data was validated.

***Place informational flag on data in AQS (40 CFR 50.14 (c)(2(ii))***
The Department of Health Laboratory Division, Air Surveillance and Analysis Section (ASAS), submits the data into the EPA's Air Quality System (AQS), the official repository of ambient air quality data. A preliminary flag is submitted for data collected that may be influenced by exceptional events.

***Notify EPA of intent to flag through submission of initial event description by July 1 of calendar year following event (40 CFR 50.14 (c)(2(iii))***
This report is our initial event description. All data has been flagged in AQS.

***Document that the public comment process was followed for event documentation (40 CFR 50.14 (c)(3(iv))***
This report will be placed on the DOH-CAB website as well as be available at the DOH-CAB offices in Honolulu, Hilo and Kona for public review for a period of thirty (30) days beginning May 30, 2014 and ending June 30, 2014.

***Submit demonstration supporting exceptional event flag (40 CFR 50.14 (a)(1-2))***
The deadline for the submittal of this demonstration package is July 1, 2014. DOH-CAB will submit this document to EPA Region IX by the deadline. Any significant comments received during the public comment period along with DOH-CAB's corresponding responses will be forwarded to EPA. Affidavits of the public notice through the three local newspapers will be submitted to EPA once they are available.

### 1.2 Documentation Requirements

Pursuant to 40 Code of Federal Regulations (CFR) Part 50.14(c)(3)(iii) of the Exceptional Event Rule (EER), the following six elements must be addressed when requesting the EPA exclude event-related concentrations from regulatory requirements:

1) The event affected air quality;
2) The event was not reasonably controllable or preventable;
3) The event was caused by human activity that is unlikely to recur at a particular location, or was a natural event;
4) There exists a clear causal relationship between the specific event and the monitored concentration;
5) The event is associated with a measured concentration in excess of normal historical fluctuations including background; and
6) There would have been no exceedances or violation but for the event.

Section 2 of this report introduces the conceptual model of the volcanic event that occurred during 2013, providing a background narrative of the natural event and an explanation that it “affected air quality”. Section 2 also provides evidence that the exceedance was due to a natural event.

Section 4 of this report provides information on existing anthropogenic sources in the Kona area and the emissions control measures required of these sources. It demonstrates that despite the regulation of these man-made sources, the exceedance was “not reasonably controllable or preventable”.

Section 3 of this report establishes a “clear causal relationship” between the natural event and the exceedance of the annual $PM_{2.5}$ standard at the monitoring station. This section also discusses how sulfur dioxide ($SO_2$) gas from the volcano turns into sulfate particles as it travels to the Kona coast. The evidence in this section also confirms that the event in question both affected air quality and was the result of a “natural event”.

Section 5 of this report provides information which help illustrate that the exceptional event produced $PM_{2.5}$ concentrations in excess of normal historical fluctuations.

Section 6 of this report summarizes the demonstration, showing a clear causal relationship between the natural event and the exceedance, and concludes that this exceedance would not have occurred “but-for” the continuing natural event.

## Section 2. Conceptual Model

The purpose of this section is to introduce a conceptual model describing how $SO_2$ emissions emanating from the Kilauea volcano are transported by prevailing winds around the southern end of the island toward Kona, are transformed enroute to sulfate $PM_{2.5}$ aerosol, then are caught in the wake of the island in a land-sea breeze circulation causing exceedances of the annual $PM_{2.5}$ standard at the Kona air station. We note, the background narrative presented here also applies to the 2011-2012 exceptional events documented in the "Documentation for Natural Events Excluded Data, Kona Air Monitoring Station, AQS ID 15-001-1012, 2011-2012 $PM_{2.5}$ Exceedances" submitted to EPA on December 12, 2013, and should be considered as supplemental information to that report.

This section includes the following:

- Details of the Kona air monitoring station,
- A description of the topography and climate of Hawaii, including a discussion of the prevailing wind patterns that allow for the efficient transport of Kilauea influenced air masses to Kona
- A discussion of the transformation of $SO_2$ to sulfate $PM_{2.5}$
- A summary of additional analysis presented in this document

### 2.1 Kona Air Monitoring Station

The Kona air station (AQS 15-001-1012) is located on the upper campus of Konawaena High School, at 81-1043 Konawaena School Road, in Kailua-Kona, on the Island of Hawaii (Latitude: 19.50978, Longitude: -155.91342). The photos below in Figure 2-1 show the station and the surrounding view from the station.

The station is at 517.2 meters (~1,697 feet) elevation on the lower slopes of Mauna Loa and approximately 2.6 miles inland from the west coast of the island. The site has been collecting continuous measurements of $PM_{2.5}$ and $SO_2$ starting in 3/15/2008 and 9/13/2005, respectively. Continuous measurements of wind speed, wind direction, and ambient temperature are recorded for informational purposes.

Northwest North Northeast

West Station East

Southwest South Southeast

**Figure 2-1.** Kona Air Station Photos

Figure 2-2 below is a satellite image taken from Google Earth of the Kona air station and the surrounding area. The image shows that the surrounding area is a mix of residential lots, agricultural lots, small business, forests, and grasslands.

The closest emission source, Captain Cook Coffee Company, is approximately 1.7 miles away from the Kona station. The permitted equipment at this facility consists of two (2) 20 hp Coffee Bean Peelers, and has the maximum potential emissions of 2.2 TPY of $PM_{2.5}$, and 0.0 TPY of $NO_2$ and $SO_2$.

In this document we also make use of $SO_2$ and $PM_{2.5}$ measurements at the Ocean View and Pahala air stations (See Figure 2-6). Ocean View is located 28 miles south of the Kona station; Pahala is located 35.5 miles southeast of the Kona station. For more detailed information on these air stations, please see Appendix D and the State of Hawaii's 2014 Air Monitoring Network plan available at our CAB website http://health.hawaii.gov/cab/files/2013/05/Air_Monitoring_Network_Plan_2014.pdf.


**Figure 2-2.** Google Earth Photo of Kona Air Station

## 2.2 Topography and Climate of Hawaii

There are six major populated islands in the state of Hawaii with Kauai being geologically the oldest and Hawaii the youngest. It is the only state that is surrounded by ocean. The islands are actually the summit regions of a long range of undersea volcanic mountains with the largest peaks being Mauna Loa, and Mauna Kea on the island of Hawaii both rising over 13,000 feet above sea level.

Situated in the tropics, there are generally two recognized “seasons”: summer, which extends from May to September and winter from October to April. Hawaii has a temperate climate with a relatively small annual temperature variation with the coldest and warmest months usually occurring in February and August, respectively. Rainfall is influenced by the mountainous nature of the islands with the highest amounts being recorded on the lower flanks of the large peaks of Haleakala, Mauna Loa and Mauna Kea normally during the winter months. There is a large difference in average rainfall amounts between the east side of the island of Hawaii (Hilo) and the west side (Kona). The average rainfall amount from 2000 to 2011 for the Hilo side of the island was 114 inches, while the Kona side averaged 9 inches for the same period (ref. State of Hawaii 2012 Data Book).

The northeasterly trade winds are the predominant wind regime for the islands. These winds are produced by an area of high pressure called the Pacific High which is at its northern most position in summer. Therefore, during May to September, the trades predominate about 80 to 95 percent of the time and diminish when they move south with the sun during the winter months. Additionally, subtropical cyclones, often called Kona lows or Kona storms, occur more often in the winter months. The term Kona is used to describe these storms due to the replacement of the normal northeast trade winds with southerly winds.

The average wind speeds are highest during the trade wind months of May to September and decrease from October to April. When the trade winds are stronger, they prevail over most of the lowlands. However, in some areas such as the Kona coast and the Kihei area on Maui local sea and land breezes may actually be strengthened by the trade winds.

Figure 2-3 below shows that the prevailing trade winds from the northeast usually travel over the island of Hawaii and then wrap around the south point of the island up to the Kona coast. A diurnal pattern of land-sea breezes occurs along the Kona coast. During Kona or southerly winds, the wind travels from the south of the island towards the eastern coast of the island.

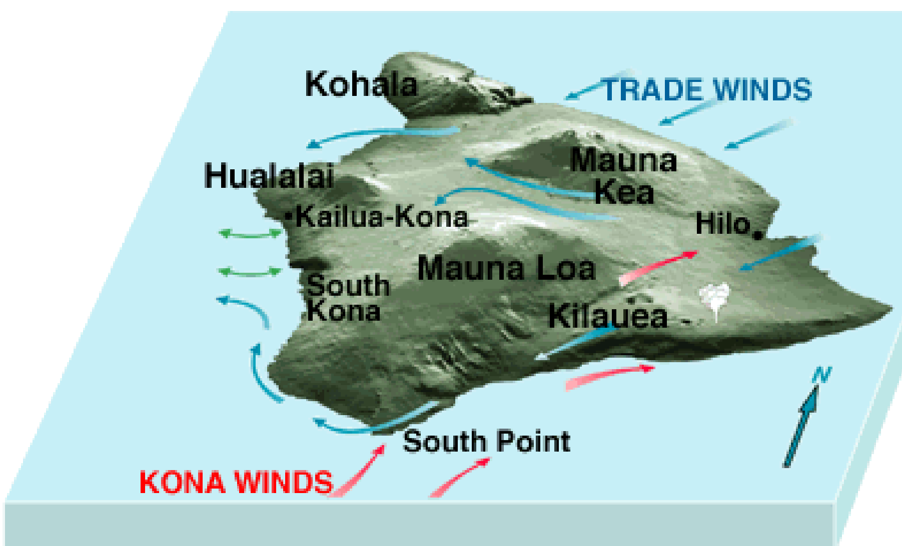



**Figure 2-3.** Hawaii Island Wind Patterns (courtesy USGS).

The transport path for $SO_2$ released by the volcano, as shown by monitored concentrations and discussed in Section 3.2, is consistent with what would be expected based on wind patterns for the island. Prevailing trade winds from the northeast transport volcanic emissions over the island, around the South Point, and then up the Kona coast. Figures 2-4 and 2-5 show how different weather/wind conditions can affect plume behavior. During typical trade wind days, the plume can be seen blowing in the southwesterly direction. During calm winds or Kona wind days, the vent emissions can be seen fumigating the summit and surrounding area. In Section 3, additional information is provided on this transport pathway as well as the diurnal wind pattern that trap pollutants in the Kona area.

**Figure 2-4.** View of Halema’uma’u crater and emission plume looking southeast from the Jagger Museum on trade wind day (taken by DOH staff)

**Figure 2-5.** View of Halema’uma’u crater and emission plume looking south from the Visitor Center on Kona wind day (taken by DOH staff)

The Kilauea volcano is situated on the southeastern part of the island of Hawaii. Halema'uma'u crater is located at the summit of Kilauea at an elevation of 4,091 feet (1,247 meters) and Pu'u O'o crater is located in the east rift zone at an elevation of 2,290 feet (698 meters). Halema'uma'u is located approximately 10 miles inland while Pu'u O'o is located approximately 6 miles inland.

Figure 2-6 is a topographical map of the Big Island showing the locations of the two vents, the ambient air stations operated by DOH, and the location of large emission sources that include five power plants. Figure 2-7 is a topographical map of the main Hawaiian Islands with information on Meso West and NPS locations. Figure 2-8 is a map of the Hawaiian Islands showing the population bases.

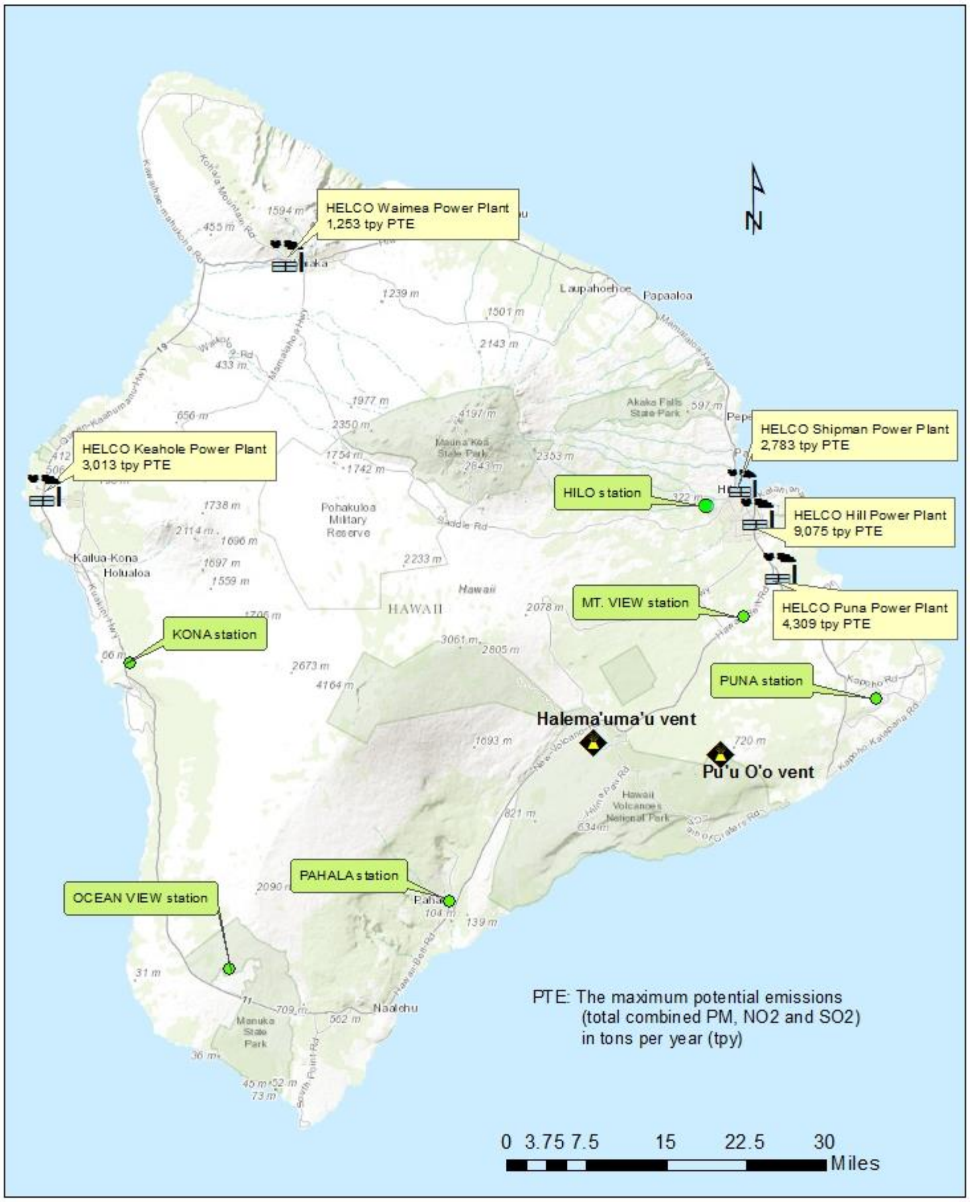



**Figure 2-6.** Hawaii Island Topographical Map.

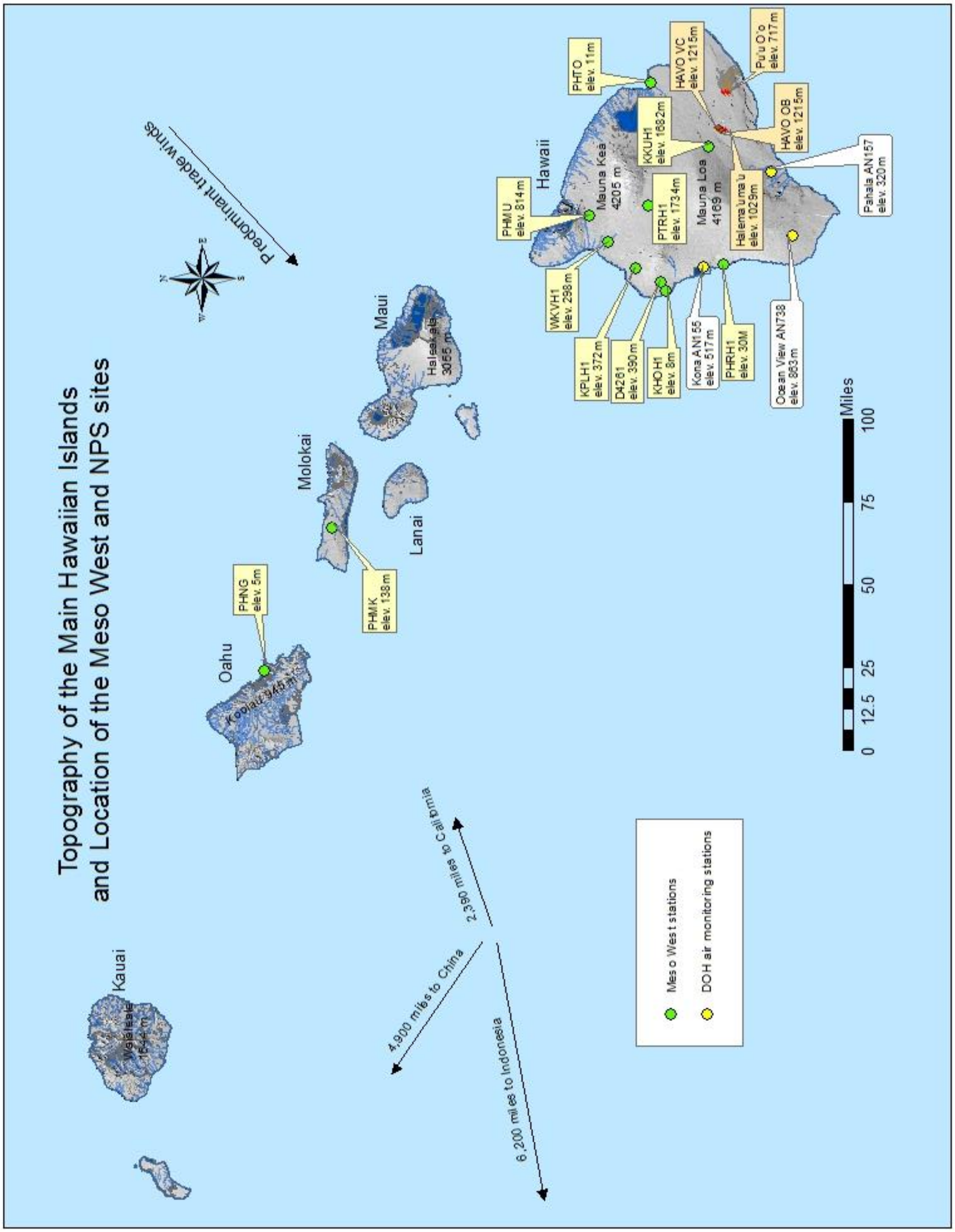



**Figure 2-7.** Hawaiian Islands Topographical Map.

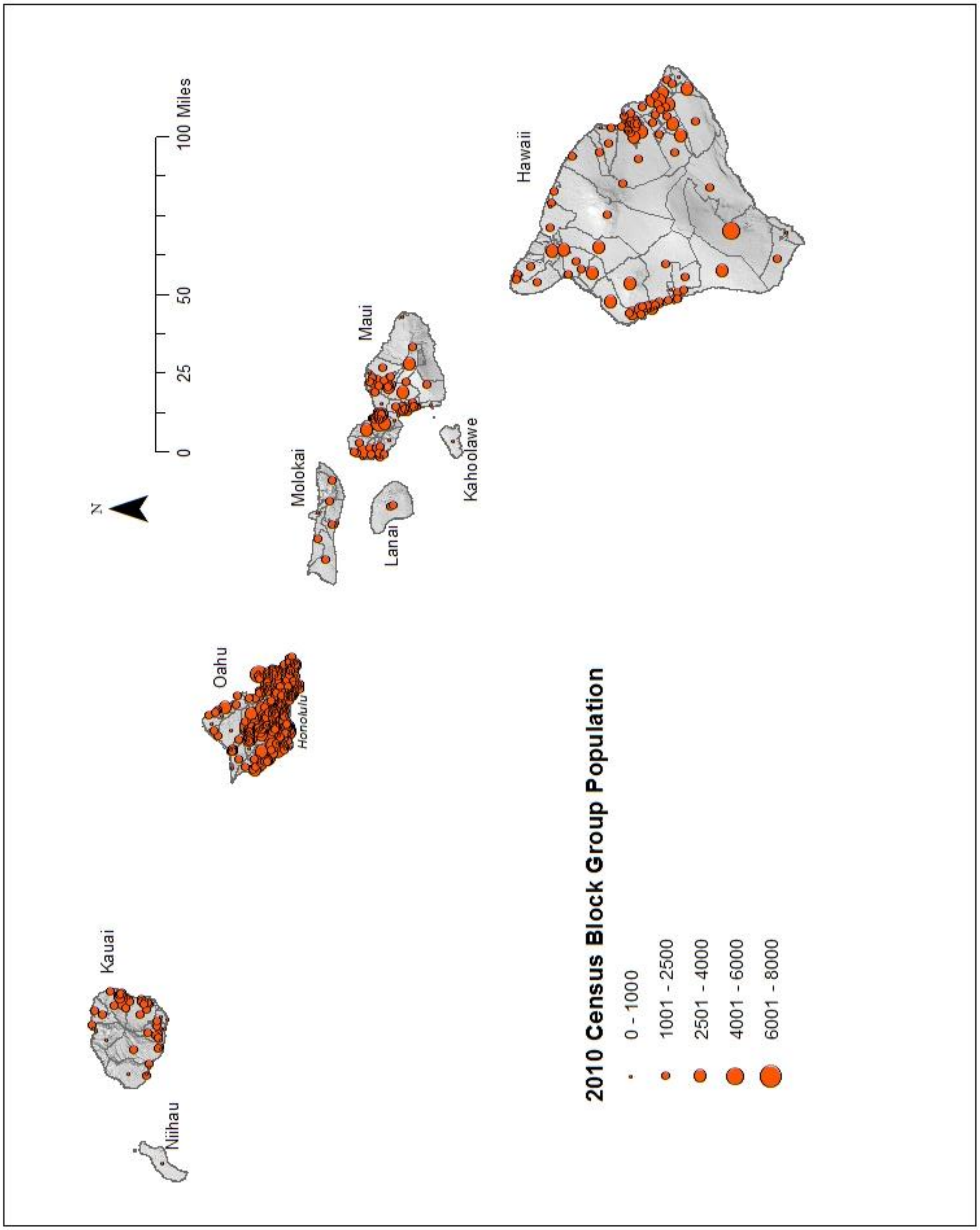



**Figure 2-8.** Hawaiian Islands Population Map.

## 2.3 Transformation of $SO_2$ to Sulfates ($PM_{2.5}$)

Volcanic emissions consist primarily of water vapor, carbon dioxide and $SO_2$. The volcano releases minimal direct primary $PM_{2.5}$ emissions. The $SO_2$ released from the Kilauea volcano creates vog when $SO_2$ reacts chemically with sunlight and constituents in the air to form secondary sulfate aerosols. Effects from vog are evident from annual $PM_{2.5}$ concentration exceedances measured at the Kona air monitoring station as well as the effects on visibility around the Big Island and on other islands hundreds of miles away from the Kilauea volcano.

As the $SO_2$ gas travels around the southern end of the island, it interacts with other atmospheric constituents to form particulates that affect communities farther away from the vents, such as Kona. When the winds shift to a southerly direction, the volcanic emissions, mainly as $SO_2$ gas, are carried to towns northeast of the volcano, such as Mountain View and Hilo. Figure 2-9 is a satellite image that depicts this phenomenon.

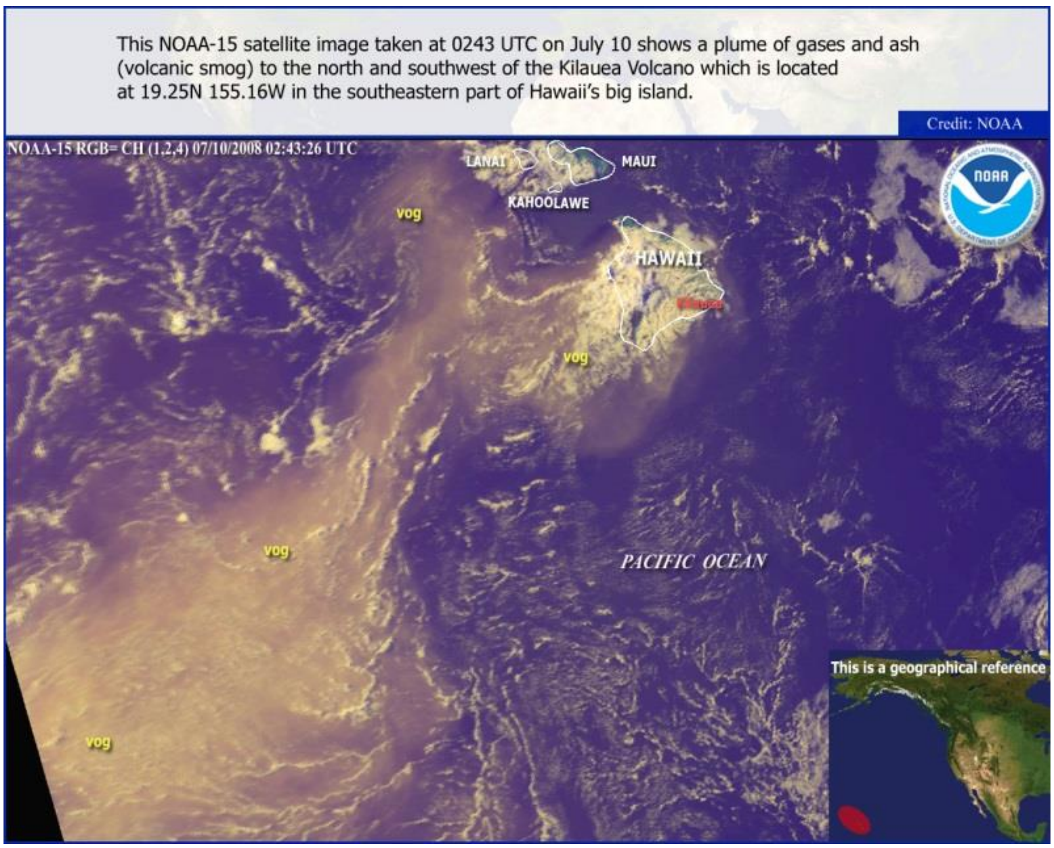



**Figure 2-9.** Satellite Image of Vog (courtesy NOAA).

The transformation of $SO_2$ from the Kilauea volcano into aerosol particles, of which $PM_{2.5}$ is a subset, is discussed in Ref. 7. The reference notes that $SO_2$ is depleted from the air by deposition (dry or wet) in the boundary layer or through chemical reaction to sulphuric acid ($H_2SO_4$). It notes that for the time period from 2007-2012, Kilauea $SO_2$ persists in the environment in the range of 16 to 57 hours, and states: "lifetimes are highest in summer when cloud cover is smallest, and shorter for higher cloud fractions in spring and autumn".  It further states: "On average, we find a mean $SO_2$ lifetime of 1.56 days, which is consistent with previous studies."

Figures 2-10 to 2-12 are from a PowerPoint presentation provided by Rudolf B. Husar, Professor and Director, Center for Air Pollution Impact and Trend Analysis (CAPITA), Washington University.  The figures show satellite measurements of $NO_2$ and $SO_2$ from the Ozone Monitoring Instrument (OMI) aboard the Eos Aura satellite and aerosol optical depth (AOD), an indicator of the amount of aerosol present, from the moderate resolution imaging spectroradiometer (MODIS) instrument aboard the Aqua and Terra satellites for June – August averaged over 2004-2010.  The figures show elevated concentrations of $SO_2$ emissions emanating from the Kilauea volcano and high AOD downwind to the south and west peaking off shore of the Kona area.  Conversely, $NO_2$, a marker of many anthropogenic emissions, is low over the entire Island of Hawaii, suggesting anthropogenic emissions are not likely to be the major source of this $PM_{2.5}$.

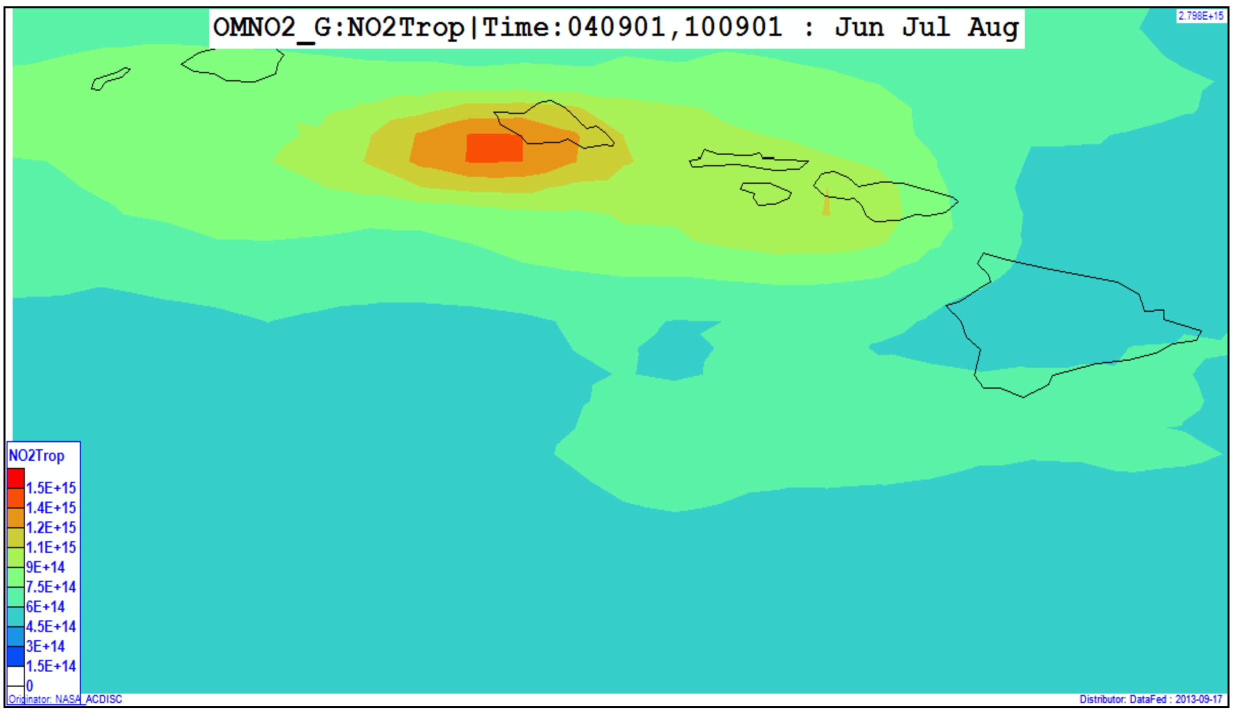


**Figure 2-10.** OMI Satellite Measurements of Columnar $NO_2$ Average, 2004-2010

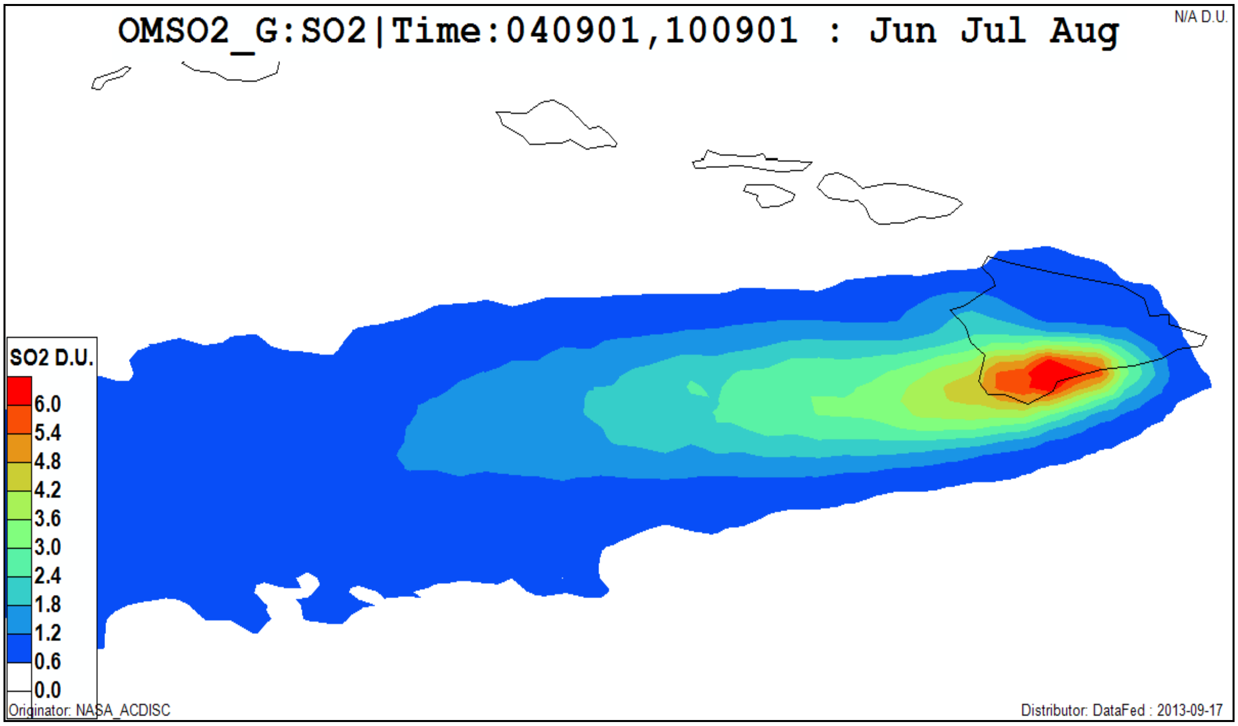



**Figure 2-11.** OMI Satellite Columnar $SO_2$ Average, 2004-2010

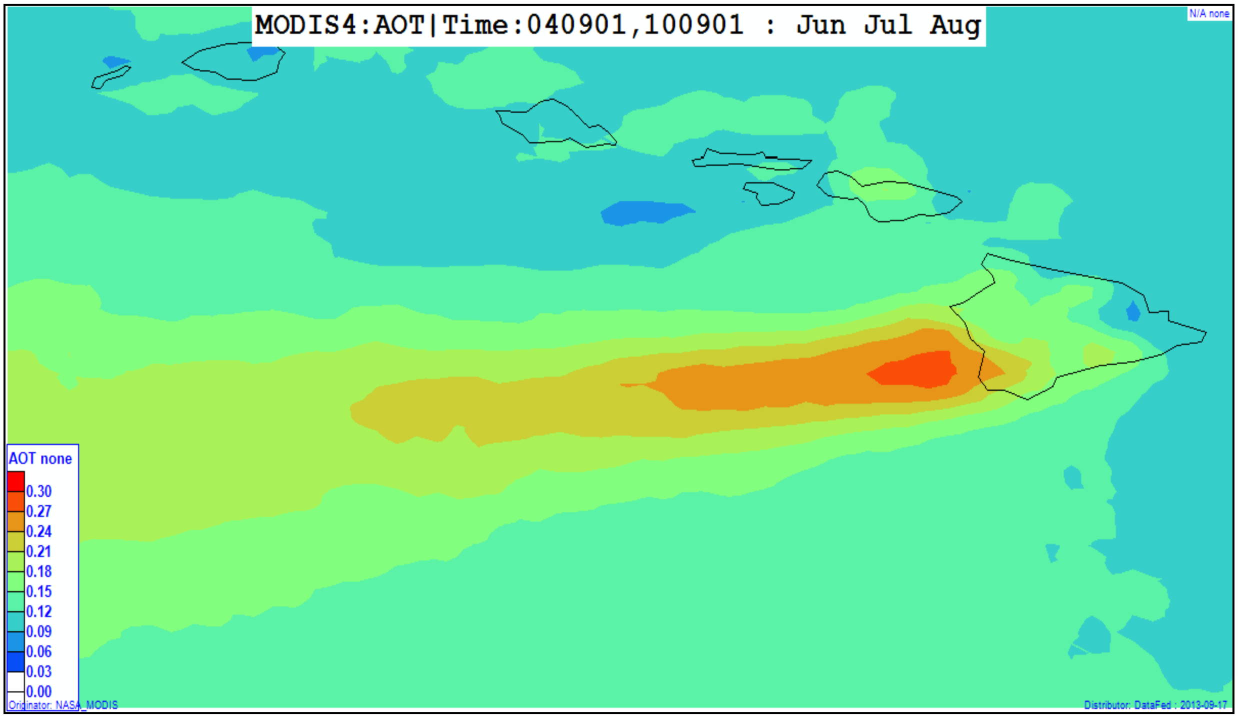



**Figure 2-12.** MODIS Satellite Measurements of Volcano Aerosol (Sulfate) Seasonal Averages of AOD, 2004-2010

## 2.4 Kilauea $SO_2$ Emissions

The Kilauea volcano on the island of Hawaii has been erupting almost continuously since1983 typically emitting approximately 2,000 tons of $SO_2$ per day. The $SO_2$ is currently being emitted from two vents located at the Halemaʻumaʻu and Puʻu Oʻo craters. Prior to December 2007, approximately 200 tons of $SO_2$ came from the Halemaʻumaʻu vent and 1,800 tons came from the Puʻu Oʻo vent. In late December 2007, the $SO_2$ emission rate began to increase; and on March 13, 2008, a new gas vent at Halemaʻumaʻu increased the amount of $SO_2$ from this location ten-fold, from 200 to 2,000 tons per day.

Figure 2-13 below represents the emissions in tons per year from the Kilauea volcano at the Halema'uma'u and Pu'u O'o (East Rift Zone) vents. This data was provided by the United States Geological Survey (USGS), who provides periodic updates of final emissions estimates; the most recent report (Ref. 4) includes data through 2010. A different data set was used to calculate the emissions from 2011-2013.

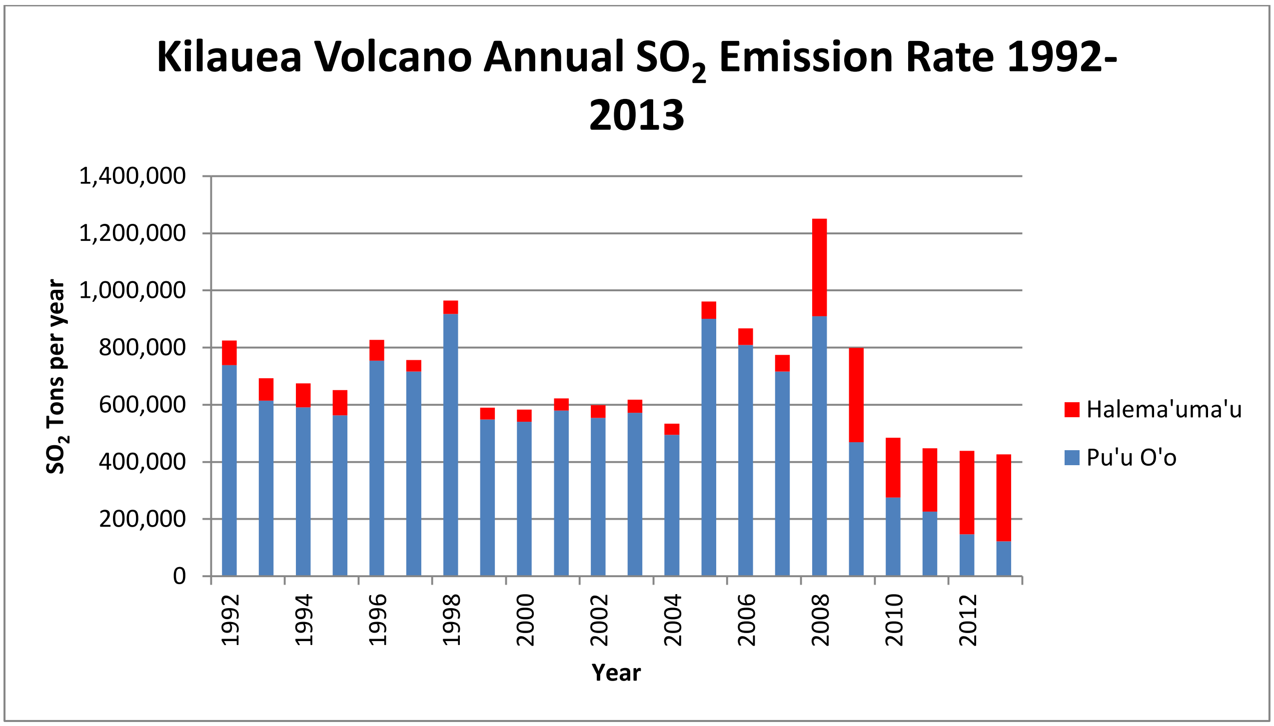



**Figure 2-13.** Kilauea Volcano Annual $SO_2$ Emission Rates 1992-2013

Figure 2-14 below represents the emissions in average tons per day from the Kilauea volcano at the Halema'uma'u and Pu'u O'o (East Rift Zone) vents. This is calculated by taking the annual $SO_2$ emission rate and dividing by the number of days in the year.

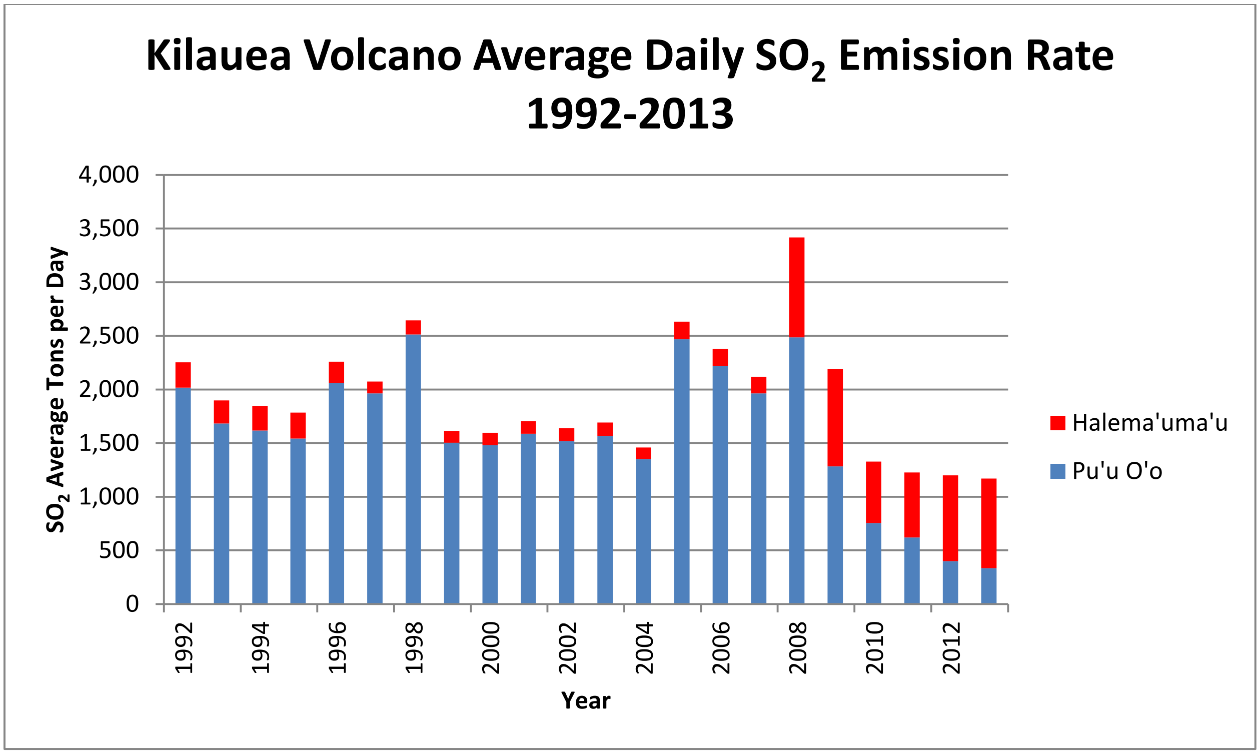



**Figure 2-14.** Kilauea Volcano Average Daily $SO_2$ Emission Rates 1992-2013

Figure 2-15 shows the average daily output of $SO_2$ in 2013 as gathered from the Hawaii Volcanoes Observatory Daily Updates. Preliminary emissions estimates are provided in the updates for both Halema'uma'u and Pu'u O'o. The daily averages for each month were derived by totaling the daily output from each vent for each month, and dividing the total by the number of days in the month.

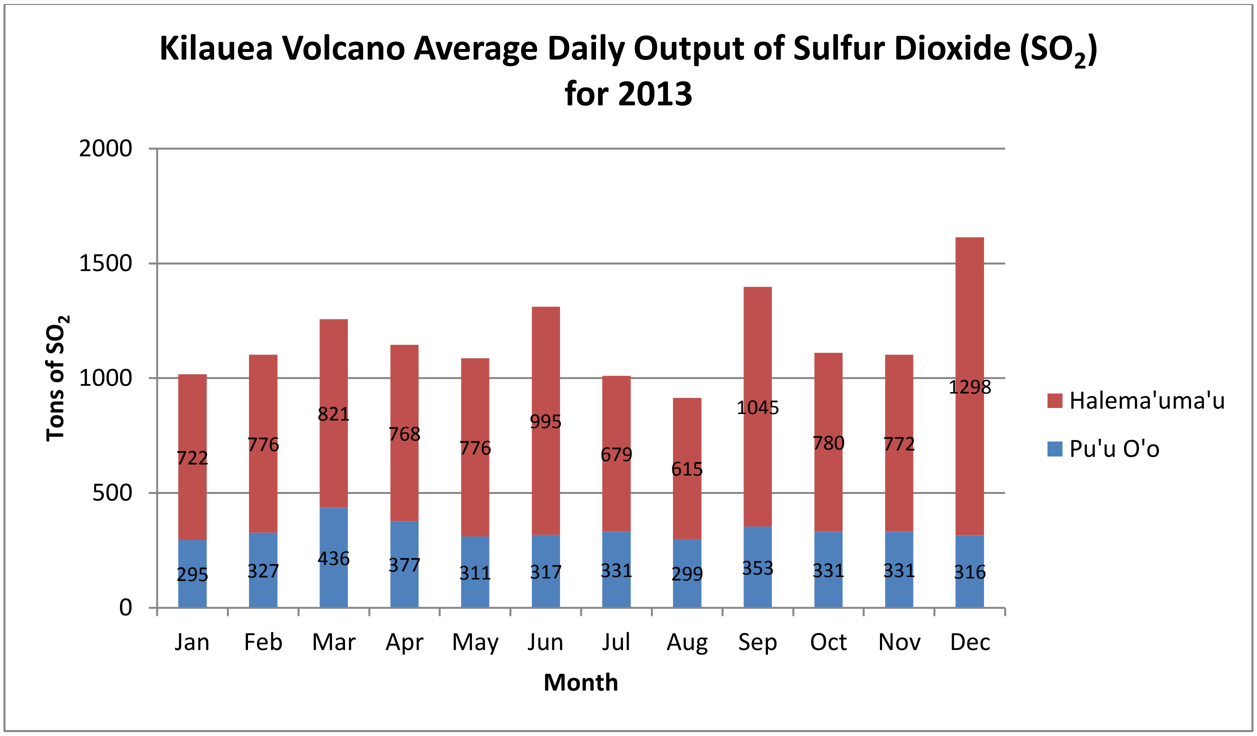



**Figure 2-15.** Kilauea Volcano Average Daily Output of Sulfur Dioxide ($SO_2$) for 2013

As discussed further in Section 3.1, emissions from the Halema'uma'u vent were found to have a greater impact on air quality in Kona than those from the Pu'u O'o vent. Because the Halema'uma'u vent is located at a higher elevation (1,247 m vs 698 m at Pu'u O'o) and more inland, volcanic emissions would tend to drift more over the island than out to the ocean. Conversely, trade winds would tend to push volcanic emissions from the Pu'u O'o vent more over the ocean because this vent is located at a lower elevation and closer to the coast.

During 2011, 2012 and 2013, the Kona air monitoring station recorded annual average $PM_{2.5}$ concentrations of 12.1 µg/$m^3$, 16.2 µg/$m^3$, and 13.3 µg/$m^3$, respectively. Here, we flag 2 days in 2011, 200 days in 2012, and 215 days in 2013 as exceptional events to be excluded. In section 3.1.B, we show the higher annual $PM_{2.5}$ concentrations recorded and increased flagged days at the Kona air monitoring station in 2012 and 2013 are likely the result of a much greater release of $SO_2$ from the Halema'uma'u vent in 2012 and 2013 than in 2011. In 2012 and 2013, the respective release of $SO_2$ from the Halema'uma'u vent was 71,584 tons per year and 83,219 tons per year greater than what it released in 2011. The release of $SO_2$ from the Halema'uma'u vent in was also 146,518 tons per year and 182,018 tons per year greater than that released from the Pu'u O'o vent in 2012 and 2013, respectively. This correlates to the premise that the Halema'uma'u vent has a greater impact on the Kona air monitoring station than the Pu'u O'o vent.

## 2.5 Summary

Prevailing trade winds from the northeast usually travel over the island, wrap around South Point, and then travel up the Kona coast.

In Section 3.2, we show time series plots of 3-day centered average $PM_{2.5}$ and $SO_2$ concentration measurements from the Kona and Ocean View air monitoring stations. The concentrations are well correlated between the two stations over the 2011, 2012, and 2013 time frames. The results indicate a large regional source, whose emissions follow a southerly path over the two monitors, is affecting the air quality at both the monitoring sites. The Kilauea volcano is a large regional source that is not reasonably controllable or preventable, releases gases that follow a southerly path over the two monitors, and is the most likely source of emissions responsible for this correlation.

Figures 2-11 and 2-12 show the trajectory of aerosols created from gases released by the Kilauea volcano. As further support for this transport/transformation pathway following a trajectory around the southern edge of the island, air monitoring data for 2011, 2012, and 2013 show a decrease in annual $SO_2$ concentration from the Pahala to the Ocean View stations and a further decrease from the Ocean View to Kona stations while there is an increase in annual $PM_{2.5}$ concentration from Kona to the Ocean View stations and an additional increase from the Ocean View to Pahala stations. This supports the assertion that $SO_2$ is being converted to sulfates in the wake of the volcano's plume as it drifts along a transport path from Pahala-to-Ocean View-to-Kona. The transport path for $SO_2$ released by the volcano is consistent with what would be expected based on prevailing wind patterns for the island (Figure 2-3). As discussed in Section 3.1.A and 3.2.E, when the air mass reaches Kona, it is trapped in the prevailing land-sea breeze and stagnant conditions governing the region, further reacting to create more sulfate aerosol.

Large point emissions from sources located on the Hilo side of the Big Island (Figure 2-6) would rarely follow the identical transport path as emissions from either the Halema'uma'u or Pu'u O'o craters. At minimum, a northeast trade wind would be required for emissions from sources located in Hilo to follow the same transport path as that for the Halema'uma'u and Pu'u O'o vents. Although the Hawaiian Islands are dominated by northeast trade winds, the winds in the Hilo area are heavily influenced by Mauna Kea and Mauna Loa, due to diurnal valley flow dynamics, producing a dominant southerly wind flow. Therefore, we conclude emissions from the Hilo side of the island are not responsible for exceedances at Kona.

In section 4, we show local emissions near Kona are not responsible for exceedances at the Kona station. We show emissions from the volcano are considerably higher than those from anthropogenic sources in Kona. The $SO_2$ emissions from the volcano were as high as 447,566 tons, 438,958 tons and 426,728 per year for 2011, 2012 and 2013, respectively. A comparison of volcano emissions to those from significant anthropogenic sources in Kona found that $PM_{2.5}$ and $PM_{2.5}$ precursors of $NO_2$ and $SO_2$ are only 1% of the total emissions (anthropogenic $PM_{2.5}$, $NO_2$, and $SO_2$ + volcanic $SO_2$).

This shows that Kilauea volcano is the primary source contributing to annual $PM_{2.5}$ concentration exceedances, and do not consider them here.

We further show that air pollution control measures provided by regulations that apply to anthropogenic sources in the Kona area, including the HAR, PSD/BACT, NSPS, and NESHAP, are adequate and should be considered reasonable for minimizing $PM_{2.5}$ and $PM_{2.5}$ precursors from permitted sources. Please refer to Section 4.12 for the applicable regulations. As stated in Section 4.13, Title V sources, which include all large facilities in the Kona area, are inspected each year and minor sources are inspected every three to five years to ensure equipment is operated within the terms of the permits. Also, complaints are investigated that involve both Title V and minor sources.

In Section 5 we examine the change in $SO_2$ concentrations before and after the new gas vent at Halema'uma'u opened which illustrates the increased impact of Kilauea emissions on Kona since 2008, putting these emissions in a historical context.

In section 6, we summarize how the above analysis shows that the exceedances flagged here would not have occurred but-for the naturally occurring and ongoing eruption of the Kilauea volcano and summarize how the requirements of the Exceptional Events rule have been met.

## 2.6 Hawaii Island Attainment Status

The Big Island of Hawaii attainment/non-attainment status is currently unclassifiable for $PM_{2.5}$, $NO_2$ and $SO_2$ due to the Kilauea volcano.

## Section 3. Causal Relationship

The primary purpose of this effort is to analyze $PM_{2.5}$ monitoring data sets from the Kona monitor on the island of Hawaii with respect to the significant volcanic emissions from the Kilauea volcano. This work is intended to provide supporting documentation for the exclusion of datasets under the Exceptional Events Rule (EER). To accomplish this:

- Volcanic $SO_2$ emission information from the United States Geological Survey (USGS) and $SO_2$ and $PM_{2.5}$ pollutant and wind monitoring data from the United States National Parks Service (NPS) were examined (Ref. 9);
- $SO_2$, $PM_{2.5}$, and wind monitoring data sets from the United States Environmental Protection Agency (EPA; Ref. 10) and University of Utah MesoWest (MesoWest) were analyzed (Ref. 11);
- Additional relevant wind monitoring data was examined with respect to potential pollutant transport paths; and
- The proposed exceptional event days for Kona were examined relative to relevant monitoring data.

The vent from Halema'uma'u, located at a higher elevation and further inland, appears to have a greater impact on the more populated areas of the island than the Pu'u O'o vent, which is situated at a lower elevation and closer to the coast. The prevailing trades would tend to push the plume from Pu'u O'o out more over the ocean while the plume from Halema'uma'u would be blown more directly to the town of Pahala and Ocean View, and subsequently up the Kona coast. During days with southerly winds, the Kona area clears up as the plume from Halema'uma'u would be blown more directly to Hilo and Mountain View.

During Kona or southerly winds, the vog from Kilauea travels up to the other islands in the chain. The DOH-CAB monitors the weather forecasts for these Kona wind days as the vog creates widespread haze (see Figure 3-1) and elevated $PM_{2.5}$ levels can be seen at the stations on Maui, Oahu, and/or Kauai. To date, the vog has not resulted in $PM_{2.5}$ exceedances on these islands. However, on such days, the DOH-CAB often declares a "no-burn" period for agricultural burning on these islands as well as for the east side of Hawaii Island in order to protect human health and prevent additional particulate pollution. Historically, the majority of no-burn days occur during the winter months, when Kona winds are more likely to occur.

The analysis shows that high $PM_{2.5}$ concentrations measured at the Kona air monitoring station are the result of $SO_2$ released from the volcano's Halema'uma'u and Pu'u O'o vents (Figure 2-6). $SO_2$ transported from north of Kona would have the $SO_2$ decreasing from Kona, through Ocean View, and on to Pahala. $PM_{2.5}$ would grow from Kona to Pahala; neither of these is the case. A very large $PM_{2.5}$ north of Kona would not explain the increasing $SO_2$ concentrations monitored as the postulated pollutant is transported from Kona, to Ocean View, and to Pahala.

The elevated Halema'uma'u (summit) emissions after 2007 shown in Figures 2-13, 2-14, and 2-15 are consistent with the USGS observations (Ref. 1, 3, and 4). If there was a potentially large $SO_2$ emission source other than the volcano upwind of Pahala, it would be a second candidate for causal analysis. However, as shown in Figure 2-6, there is no such source.

The diurnal nature of the winds at Kona, Ocean View, and Pahala provides the coupling between the elevated aerosol concentrations that are observed by satellite observations (e.g. Figure 2-9) and $PM_{2.5}$ and $SO_2$ concentrations measured at the sites. The good correspondence between time histories of $PM_{2.5}$ and $SO_2$ concentrations measured at Kona and Ocean View for 2013 is consistent with this transport.

These examinations of pollutant and wind monitoring data indicate that $SO_2$ emissions from the Kilauea volcano are the cause for the elevated levels of $PM_{2.5}$ at the Kona monitoring site.

**Figure 3-1.** Honolulu on a Hazy Kona Wind Day (taken by DOH staff)

## 3.1 Volcanic emissions and pollutant monitoring data from the Kilauea Volcano

### 3.1.A Overview

The magnitude of $SO_2$ emissions from the Kilauea volcano on the island of Hawaii is well documented, as is the impact on the Hawaiian Islands. The USGS noted in 2012 that $SO_2$ plumes from both major Kilauea volcano emission vents, Pu'u 'O'o (rift zone) and Halema'uma'u (summit), significantly impact the Kona area, stating (Ref. 1):

"Unfortunately, both plumes eventually reach the west side of Hawai`i Island in a "double whammy" of combined effects, resulting in an especially dense and nearly constant haze of vog along the Kona coast."

The use of the term "nearly constant haze of vog" is consistent with the nearly constant elevated level of $PM_{2.5}$ and $SO_2$ measured at the Kona monitoring station; monitoring site location and general information available at reference 2. The USGS noted the direct relationship between Kilauea $SO_2$ emissions and elevated levels of $SO_2$ and sulfate particles at Kona in their March 7, 1997 "Hawaii Volcano Observatory, Volcano Watch" webpage stating (Ref. 3):

"This 90% decrease in released $SO_2$ gas from Kilauea is very good news for Kona residents, for it means that there is simply much less gas to be blown by the prevailing trade winds from degassing sources on Kilauea around South Point, and up along the Kona coast, where it is trapped by the onshore-offshore daily wind regime. On this journey, there is also less gas to react chemically with sunlight, oxygen, dust and water to form the sulfuric acid and other sulfate particles that cause the visible pollution that had become so ubiquitous for Kona residents and visitors."

In 2008, the USGS discussed the connection between elevated $SO_2$ emissions from the Halema`uma`u vent and $PM_{2.5}$ exceedances around Kona and Pahala (Ref. 4); this would also include the Ocean View area. Key conditions and observations described by USGS in the article were:

"During prevailing trade winds, the east rift gas plume is generally blown out to sea, where it is dispersed and diluted before being carried back onshore to impact downwind communities. The Halema`uma`u plume remains onshore and is generally blown through the Ka`u desert to directly affect downwind communities."

"Since the new activity at Halema`uma`u began, the EPA standards for $SO_2$ have been exceeded on numerous occasions in Pahala, and for particulate matter they have been exceeded in both Pahala and Kona. The Pahala air quality monitoring station, which was installed in August 2007, only measured exceedance of $SO_2$ standards after the opening of the Halema`uma`u vent in March 2008." (See Figure 2-13)

To further examine the link between the volcano and Kona $PM_{2.5}$ measurements, the $SO_2$ emission time history was examined. The USGS monitors $SO_2$ emissions from Kilauea vents at the rift zone and summit and reports preliminary values at their "Recent Kilauea Status Reports, Updates, and Information Releases" webpage (Ref.3). While these values are preliminary, the USGS provides periodic updates of final emissions estimates, the most recent of which includes data from 2007 through 2010. This latest report (Ref. 6) includes one reference that estimates Kilauea's 2007-2010 $SO_2$ average of 751,000 tonnes per year (approximately 828,000 TPY), and notes that this is approximately 6% of the global volcanic $SO_2$ emissions. In addition to providing the total emissions, the report also documents the time history of relative emission from the summit and rift zone from 2000 through the end of 2010, showing the shift in emissions from being dominated by the rift zone through 2007, to a more even division in 2009, with somewhat greater emissions from the summit into 2010 (see Figure 31 of Ref. 6).

The NPS monitors $SO_2$ and $PM_{2.5}$ levels, along with weather information within the Kilauea National Park from the Hawaii Volcanoes National Park - Visitor Center and Hawaii Volcanoes National Park - Observatory, located near and to the northeast and northwest of the summit vent (See Figure A-1).

3.1.B USGS $SO_2$ Emissions Estimates & NPS Pollutant and Wind data

Quantifying volcano emissions between 2011 and 2013 shows $SO_2$ increasing at the summit (Halema'uma'u) vent and decreasing at the rift zone (Pu'u O'o) vent (Tables 3-1a and 3-1b). The Halema'uma'u vent emissions increase by approximately 32% to 37% and Pu'u O'o vent emissions decrease by 35% to 46%. The ton per day $SO_2$ from the volcano vents result in total combined annual $SO_2$ emissions of 447,566 TPY, 438,958 TPY, and 426,728 TPY for 2011, 2012, and 2013, respectively. The increase in $SO_2$ emissions from the summit of Kilauea is noteworthy since, consistent with the USGS web posting (Ref. 4) discussed previously, it would indicate an expectation for increased $SO_2$ and particulate levels at the Pahala, Ocean View, and Kona areas for 2012 and 2013 relative to 2011.

| Source | 2011 Daily Average $SO_2$ | | 2012 Daily Average $SO_2$ | | % Change from 2011 to 2012 |
|---|---|---|---|---|---|
| | Tons/day | Tonnes/day | Tons/day | Tonnes/day | |
| Halema'uma'u Vent | 606 | 550 | 802 | 728 | 32% |
| Pu'u O'o Vent | 620 | 562 | 401 | 364 | -35% |
| Total-→ | 1,226 | 1,112 | 1,203 | 1,092 | -3% |

**Table 3-1a.** 2011-2012 USGS (Ref. 5) preliminary $SO_2$ emissions data quantified by DOH

| Source | 2011 Daily Average $SO_2$ | | 2013 Daily Average $SO_2$ | | % Change from 2011 to 2013 |
|---|---|---|---|---|---|
| | Tons/day | Tonnes/day | Tons/day | Tonnes/day | |
| Halema'uma'u Vent | 606 | 550 | 833 | 756 | 37% |
| Pu'u O'o Vent | 620 | 562 | 335 | 304 | -46% |
| Total-→ | 1,226 | 1,112 | 1,168 | 1,060 | -9% |

**Table 3-1b.** 2011- 2013 USGS (Ref. 5) preliminary $SO_2$ emissions data quantified by DOH

Recent satellite based Kilauea $SO_2$ emission estimates indicate emission levels for March through November 2008 are about 3 times larger than those previously estimated by the USGS using ground based measurements (Ref. 7). The USGS is reviewing these preliminary Kilauea $SO_2$ emission estimates, as well as values in prior published reports (e.g. Ref. 6), for possible revision. Changes in the USGS ground based measurement methods are also being developed to improve measurement accuracy and address the estimate differences reported in Reference 7. The emission levels after revision are currently expected to result in day to day variations that will appear similar to those previously published, but with larger values overall (Ref. 8).

3.1.C Discussion

While the USGS $SO_2$ emissions estimates for 2011, 2012, and 2013 are preliminary, and may be revised upward by USGS, they provide an indication of the magnitude of the total emissions as well as relative emissions associated with the summit and rift zone. Based on the 2008 USGS assessment (Ref. 4), the growth in Kilauea summit $SO_2$ emissions from 2011 to 2012, is consistent with the increase in $SO_2$ and particulate levels at Kona, Ocean View, and Pahala between 2011 and 2012. It is also consistent with the increase in $SO_2$ and particulate levels at Kona, Ocean View, and Pahala between 2011 and 2013.

3.2 Pollutant monitoring data from Kona, Ocean View, and Pahala

3.2.A Overview

The locations of DOH-CAB pollutant and weather monitors at Kona, Ocean View, and Pahala are shown in Figure 2-6. $PM_{2.5}$ and $SO_2$ monitoring data from these monitors were downloaded from the EPA AQS Data Mart (Ref. 10). The AQS designations for the Kona, Ocean View, and Pahala monitors are 150011012, 150012020, and 150012016, respectively. The AQS designation for the $PM_{2.5}$ and $SO_2$ pollutants are 88101 and 42401, respectively; there is an extra "1" at the end of the AQS ID number for datasets downloaded from the AQS Data Mart Data (e.g. the Kona $PM_{2.5}$ ID number is 150011012881011). For each monitoring site and pollutant, pollutant concentrations are nominally reported hourly. The measurement units for $PM_{2.5}$ and $SO_2$ are in µg/m$^3$ and ppb, respectively. Wind direction data associated with these three monitors, as well as for other relevant monitors, was obtained from the University of Utah MesoWest website (Ref. 11). The weather monitors associated with the Kona, Ocean View, and Pahala pollutant monitoring sites are identified by MesoWest as AN155, AN738, and AN157, respectively.

It is important to note that the annual average values presented throughout Section 3.2 were calculated by averaging all daily values based on all hourly data downloaded from the AQS Data Mart for both $PM_{2.5}$ and $SO_2$. This calculation method was used to produce a value for normalizing individual datasets, and will not produce the exact results reported in the Introduction (e.g. 13.3 µg/m$^3$ for 2013 Kona $PM_{2.5}$). However, for the purpose of normalizing the downloaded AQS dataset, it is an appropriate methodology and result. The calculations were made using heritage subroutines and limited time and the risk of introducing errors made revisions very unwise considering that the calculation results were used only for this section's visualization and trend establishment purposes.

3.2.B Annual Average for Normalization of $PM_{2.5}$ and $SO_2$ Pollutant Concentrations

Annual average $PM_{2.5}$ and $SO_2$ concentration levels from the Kona, Ocean View, and Pahala monitoring sites were calculated for dataset normalization purposes with data from the EPA AQS Data Mart. For all datasets, the nominal hourly measurement values were averaged for each day, and annual averages were calculated by averaging the daily values for a given calendar year.  Negative concentration values were included in the averaging process.  The annual average $PM_{2.5}$ and $SO_2$ concentrations, as well as the percent concentration increases between 2011, 2012, and 2013 (using 2011 as the baseline) are shown in Tables 3-2 and 3-3, respectively; where table numbers with an “a” compare 2011 to 2012, and table numbers with a “b” compare 2011 to 2013.

As indicated in Table 3-2a, all monitoring sites show $PM_{2.5}$ pollutant concentration increases between 2011 and 2012.  These results, when coupled with the 2008 USGS web posting (Ref. 4), are consistent with the estimated 32% increase in $SO_2$ emissions from the Kilauea summit shown in Table 3-1a.  Compared to Table 3-2a, Table 3-2b shows smaller percentage increases in $PM_{2.5}$ pollutant concentration between 2011 and 2013 for Kona and Ocean View, and decrease for Pahala.  $SO_2$ emissions from the Kilauea summit increased by approximately 37% between 2011 and 2013 (Table 3-1b). While there is a decrease in annual average $PM_{2.5}$ pollutant concentration at Pahala between 2011 and 2013 while Kilauea summit $SO_2$ emissions increase, the complexity of the chemical transformation from $SO_2$ into $PM_{2.5}$ and variations in transport are very probable explanations.

The effect of the chemical transformation from $SO_2$ into $PM_{2.5}$ as the prevailing winds carry the pollutants from Pahala, to Ocean View, and finally up to Kona is discussed in the 1997 USGS web posting (Ref. 3).   For all years, the annual average $PM_{2.5}$ concentrations increase from the smallest values at Pahala, to Ocean View, and finally at the Kona site (Table 3-2a and Table 3-2b).  Likewise, the annual average $SO_2$ concentrations decrease from the largest values at Pahala, to Ocean View, and the Kona site (Table 3-3a and Table 3-3b).

| | 2011 Annual Ave | 2012 Annual Ave | 2011 to 2012 |
|---|---|---|---|
| Monitor | PM2.5 (µg/m^3) | PM2.5 (µg/m^3) | % change |
| Kona | 12.23 | 16.18 | 32% |
| Ocean View | 10.03 | 12.97 | 29% |
| Pahala | 6.18 | 7.59 | 23% |

**Table 3-2a.** 2011 & 2012 AQS Data Mart Hourly $PM_{2.5}$ Data: Annual Averages

| | 2011 Annual Ave | 2013 Annual Ave | 2011 to 2013 |
|---|---|---|---|
| Monitor | PM2.5 (µg/m^3) | PM2.5 (µg/m^3) | % change |
| Kona | 12.23 | 13.43 | 10% |
| Ocean View | 10.03 | 11.7 | 17% |
| Pahala | 6.18 | 5.43 | -12% |

**Table 3-2b.** 2011 & 2013 AQS Data Mart Hourly $PM_{2.5}$ Data: Annual Averages

| | 2011 Annual Ave | 2012 Annual Ave | 2011 to 2012 |
|---|---|---|---|
| **Monitor** | **SO2 (ppb)** | **SO2 (ppb)** | **% change** |
| **Kona** | 2.88 | 5.36 | 86% |
| **Ocean View** | 13.38 | 23.06 | 72% |
| **Pahala** | 33.64 | 52.16 | 55% |

**Table 3-3a.** 2011 & 2012 AQS Data Mart Hourly $SO_2$ Data: Annual Averages

| | 2011 Annual Ave | 2013 Annual Ave | 2011 to 2013 |
|---|---|---|---|
| **Monitor** | **SO2 (ppb)** | **SO2 (ppb)** | **% change** |
| **Kona** | 2.88 | 4.82 | 67% |
| **Ocean View** | 13.38 | 14.18 | 6% |
| **Pahala** | 33.64 | 29.75 | -12% |

**Table 3-3b.** 2011 & 2013 AQS Data Mart Hourly $SO_2$ Data: Annual Averages

While a range of sources may have had a similar level of change between years, the very large nature of the Kilauea source and associated regional impact is unique. With the possible exception of 2013 Pahala data, annual average concentration levels are consistent with the annual average $SO_2$ emissions from the Kilauea summit, the expected pollutant transport path, and the expected chemical transformation process.

3.2.C 2012 $PM_{2.5}$ and $SO_2$ Pollutant Concentrations at Kona & Ocean View

The USGS well outlines the expected transport path for pollutants originating from the Kilauea volcano (Refs. 2, 3, 4), and the annual average pollutant levels are consistent with this description. However, it was recognized that additional confirmation of the linkage between volcanic emissions and monitoring levels could potentially be gleaned from the pollutant time histories measured at the Kona, Ocean View, and Pahala monitoring sites. The linkage between Kona and Ocean View datasets, particularly for the $PM_{2.5}$ pollutant, are very evident from a casual comparison of the plotted time histories (Figure 3-2). The $PM_{2.5}$ concentration peaks and valleys are seen to match quite well throughout 2012.

Note that the time histories presented in this section plot the average of the three daily average values for normalization, centered on the middle (second) day. This smoothing was performed to represent time lag associated with pollutant transport between Ocean View and Kona, as well as provide some smoothing of the large short scale concentration variations that are characteristic of these datasets. The degree of smoothing, plus and minus one day about the center point, is also consistent with the estimated $SO_2$ average lifetime of 1.56 days discussed in Section 2.3 (Ref. 7).

While a comparison of pollutant transport time between the Kilauea summit and Kona monitoring station with the $SO_2$ average lifetime discussed above could be performed, it seems that this can efficiently and sufficiently be accomplished by inference.

- USGS references discussed in 3.1.A identify the elevated $PM_{2.5}$ and $SO_2$ at Kona as due to Kilauea volcano and we have vog impacts on the island of Oahu.
- Satellite imagery shows the presence of dominant island scale impacts from the volcano.
- $SO_2$ concentration measurements at Pahala, Ocean View, and Kona show annual average $SO_2$ decreasing from Pahala to Kona & $PM_{2.5}$ increasing from Pahala to Kona.
- Tables 3-2 a/b show about a doubling in $PM_{2.5}$ from Pahala to Kona.
- Tables 3-3 a/b show about an order of magnitude decrease in $SO_2$ between Pahala and Kona.
- There are good correlations between "unsmoothed" Kona and Ocean View $PM_{2.5}$ datasets for 2012 & 2013 (Figures A-10 & A-11).
- The normalized $SO_2$ time histories for Kona and Ocean are shown to correspond well for 2012 and 2013 (Figures 3-6 and 3-7, respectively).

Overall, the items above indicate that the volcano is the $SO_2$/$PM_{2.5}$ source and the $SO_2$ is significantly diminished enough between Pahala and Kona so that the transit time between the sites is consistent with the $SO_2$ average lifetime. While time accurate pollutant transport calculations could be made to estimate transport time, mesoscale wind data would need to be obtained, the effort would be very computationally intensive, and the result would provide minimal additional useful information. While monitoring site wind data could be relatively easily analyzed to determine mean speeds, it seems that such results would provide minimal additional value compared to the persistent and very compelling satellite images that demonstrate the presence of island scale volcanic plumes.

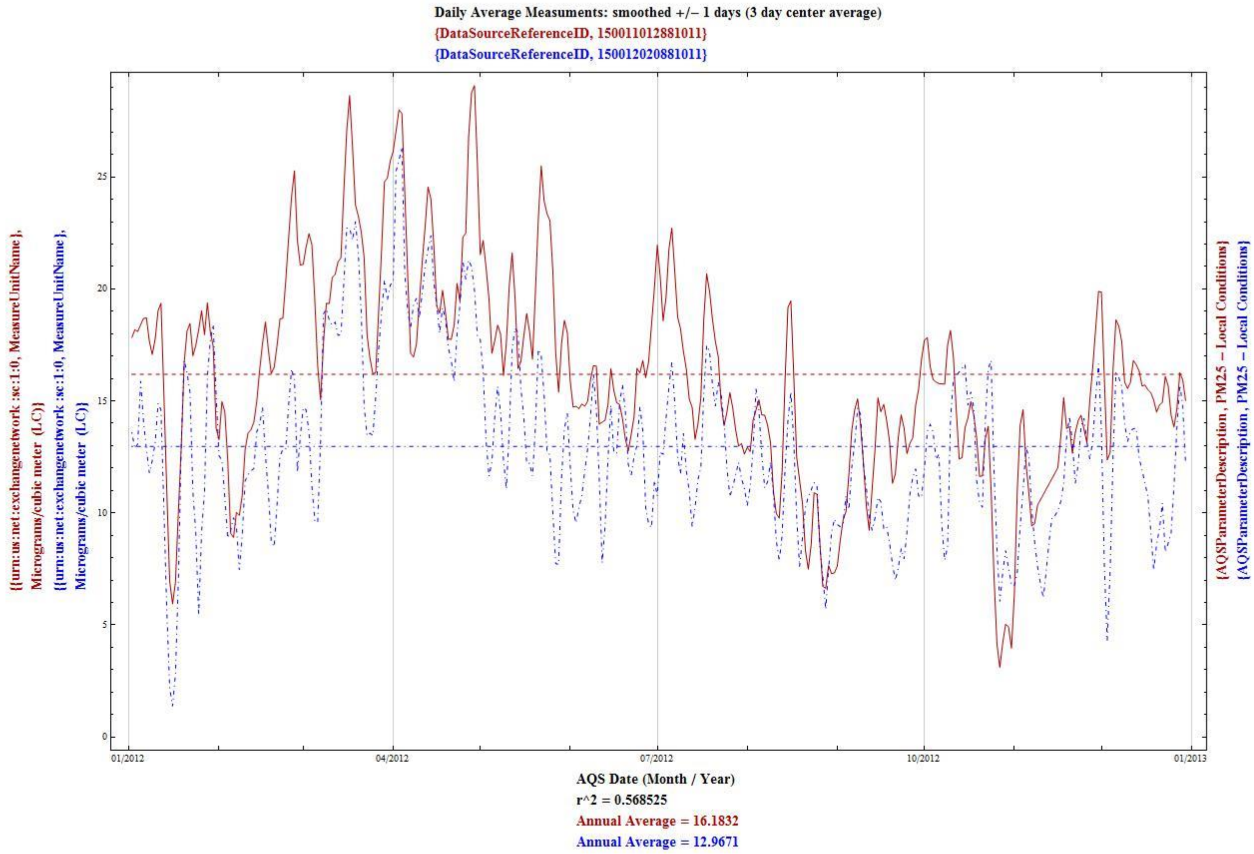



**Figure 3-2.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) $PM_{2.5}$ Concentrations

For comparison, the plot without smoothing is shown in Figure A-2. In both figures, the Pearson correlation ($r^2$ ; Ref. 12), a quantitative indication of how well the two concentration time histories match, are given below the "AQS Date (Month / Year)" label and are seen to be similar; approximately 0.57 for the smoothed case shown in Figure 3-2 versus approximate 0.45 without smoothing (Fig. A-2); an $r^2$ value of one is the maximum correlation value. The annual average values are calculated using the daily values used for plotting. Because the smoothing weights the concentration values for the first and last data values at half the value as the remaining 363 for calendar year 2012, the annual average values are seen to be very slightly different between the smoothed and unsmoothed plots (e.g. 16.1832 $\mu g/m^3$ for 2012 Kona with smoothing versus 16.1828 $\mu g/m^3$, the value given in Figure A-2, without smoothing).

At the bottom of Figure 3-2, the annual average $PM_{2.5}$ concentrations for Kona and Ocean View are shown. The Kona concentration is seen to be approximately 25% larger than for Ocean View. The time histories for Kona and Ocean View show the Kona $PM_{2.5}$ concentrations are generally slightly higher than those at Ocean View. This is consistent with the USGS description of the expected transport path of Kilauea volcano $SO_2$ and its chemical conversion into sulfate particulates. In an attempt to better visualize the correspondence between the pollutant concentrations at the monitoring sites, their time histories were normalized with respect to their annual averages.

In Figure 3-3, for example, Kona $PM_{2.5}$ concentrations throughout 2012 were divided by the annual average of the daily $PM_{2.5}$ concentrations (after smoothing), and likewise for Ocean View $PM_{2.5}$ concentrations. Through normalization, the relative similarities and differences in the two time histories appear easier to identify. Because the annual averages for the two sites differ by only about 25%, Figures 3-2 and 3-3 appear quite similar.

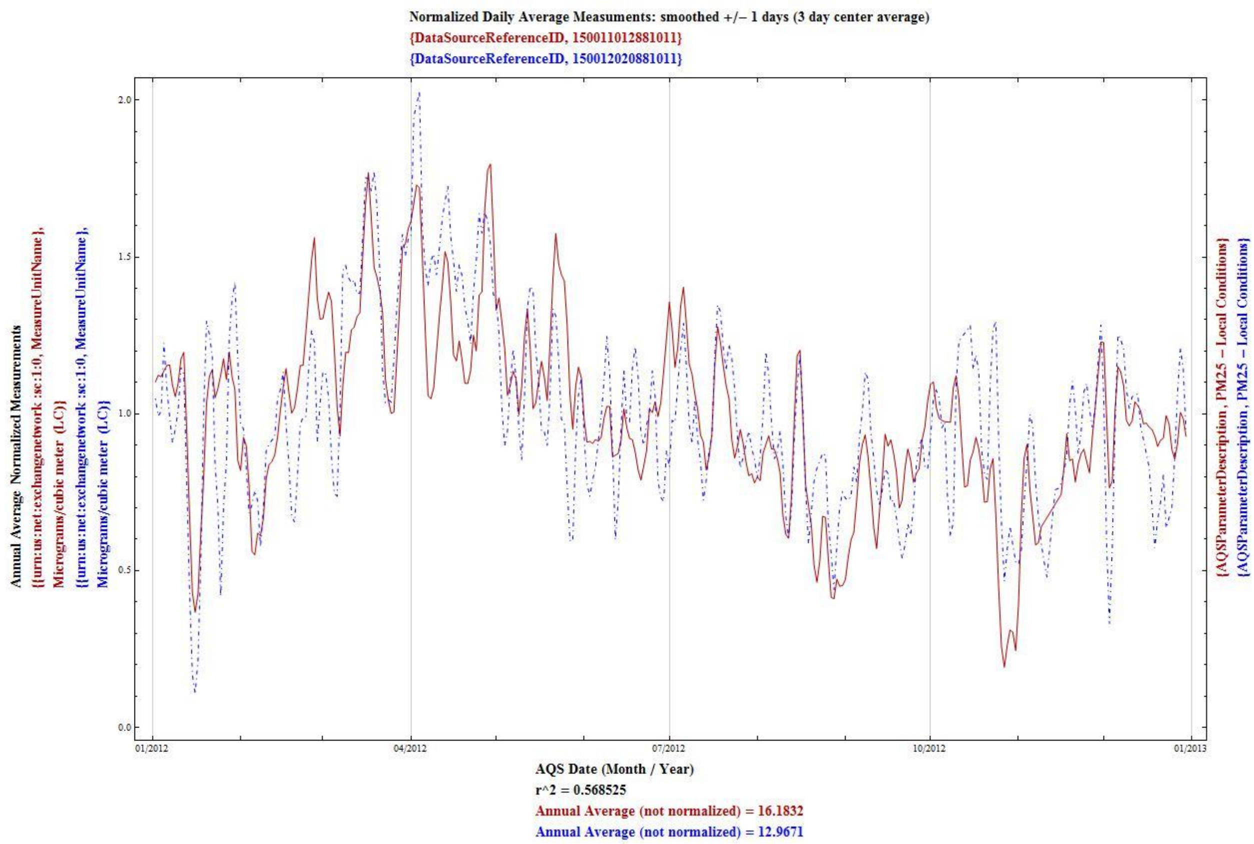



**Figure 3-3.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $PM_{2.5}$ Concentrations

However, Figure 3-3 does assist in showing that the $PM_{2.5}$ concentration time histories at Kona and Ocean View correspond well. It should be noted that correlation values ($r^2$) shown in the two figures are identical. This is a feature of the Pearson correlation algorithm, which remains unchanged if one or both datasets are multiplied by a constant.

The good correspondence between the Kona and Ocean View $PM_{2.5}$ time histories though 2012 is continued in 2013. Figure 3-4 shows the smoothed concentrations for 2013; the unsmoothed plot is shown in Figure A-3, and is seen to be similar. As would be expected from the increased $SO_2$ emissions from the Kilauea summit, the annual average of the $PM_{2.5}$ concentrations at both sites are greater in 2013 than in 2011. The correlation value ($r^2$) associated with 2013 is somewhat smaller in 2013 than in 2012, approximately 0.33 versus 0.57.

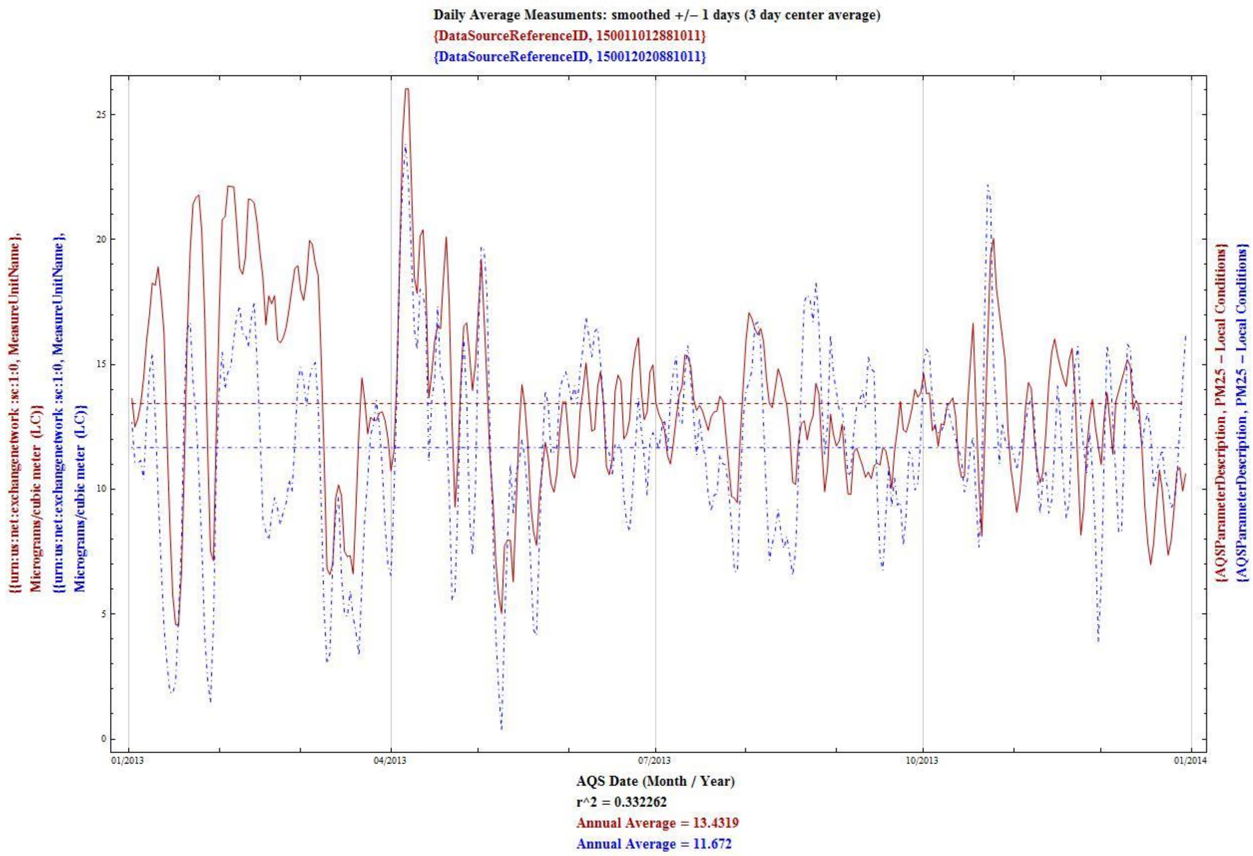



**Figure 3-4.** 2013 Time History of Kona (red) and Ocean View (blue, dot-dash) $PM_{2.5}$ Concentrations

While the seasonal $PM_{2.5}$ concentration highs and lows are noticeably different between 2012 and 2013, this is to be expected considering the coupling of Kilauea $SO_2$ emissions variability winds.

The normalized 2013 $PM_{2.5}$ time histories for Kona and Ocean View are shown in Figure 3-5. This normalized plot indicates where numerous $PM_{2.5}$ concentration peaks at Ocean View appear less prominent at Kona. There are very few instances where $PM_{2.5}$ concentration peaks occur at Kona which are not evident at Ocean View.

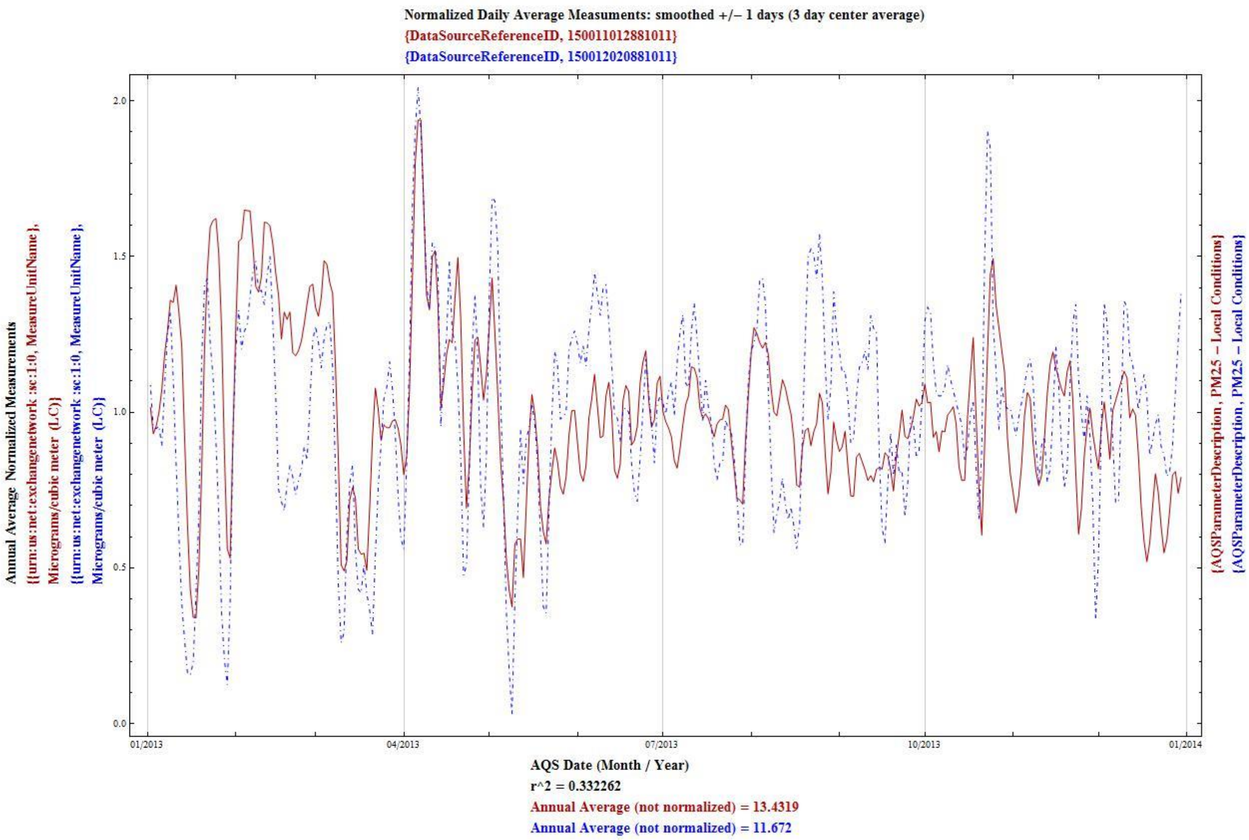



**Figure 3-5.** 2013 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $PM_{2.5}$ Concentrations

The very large $SO_2$ emissions from the Kilauea volcano would be expected to follow a similar path to Kona as particulates. To examine this assertion, the correspondence between the time histories of $SO_2$ concentrations at Kona and Ocean View is presented for 2012 and 2013 in Figures 3-6 and 3-7, respectively. These figures include the same temporal smoothing (3 day center average) and normalization that were used in Figures 3-3 and 3-5.

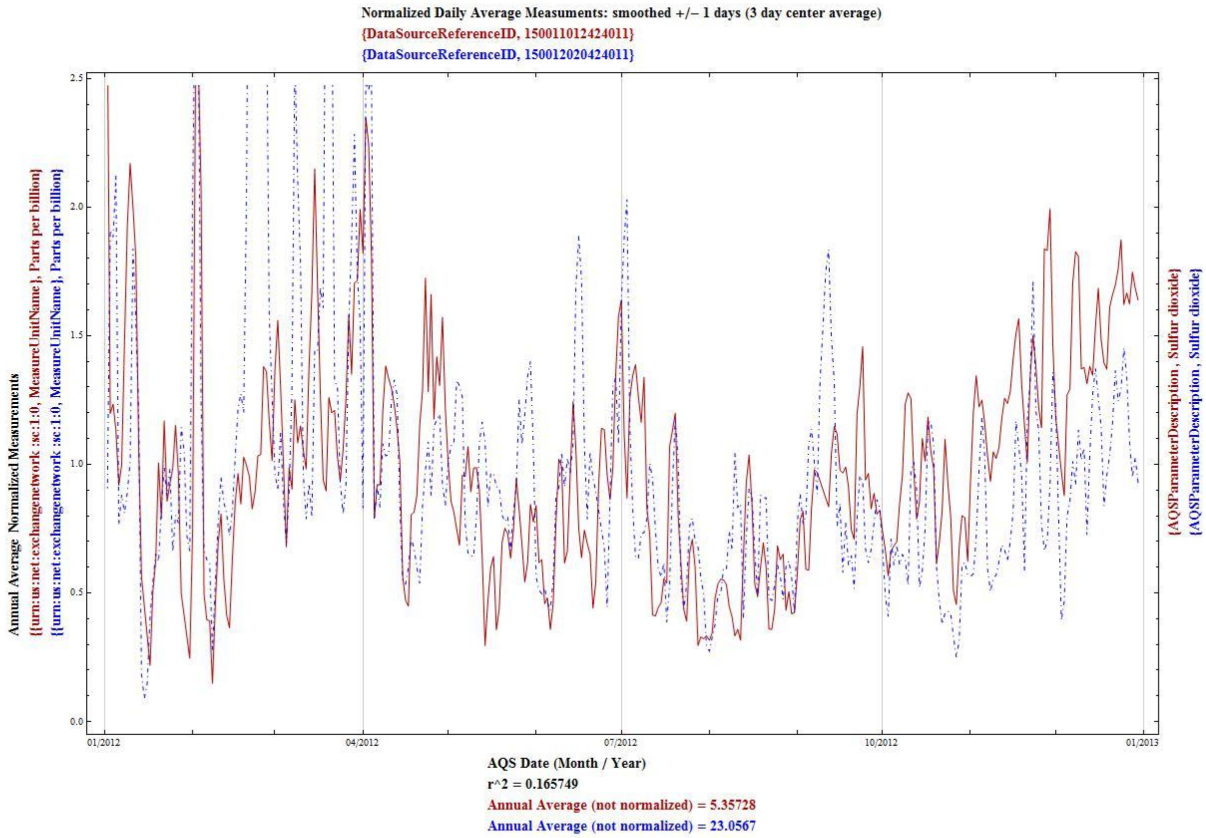



**Figure 3-6.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $SO_2$ Concentrations

For 2012, the time histories of normalized $SO_2$ concentrations at Kona and Ocean View are seen to correspond similarly well as those seen for $PM_{2.5}$; the correlation value ($r^2$) is approximately 0.17. The seasonal trends in the $SO_2$ concentration time histories are seen to correspond well. Kona has an annual average of approximately 5.4 ppb compared to Ocean View's value of approximately 23.1 ppb. For 2013, the annual average $SO_2$ concentrations at both sites are similar (4.8 ppb for Kona, 29.8 ppb for Ocean View), as is the correlation value of approximately 0.24. The seasonal trends appear to be similar in 2013, as are many of the concentration peaks and valleys. As with the 2012 dataset, there are several large concentration peaks in the 2013 Ocean View dataset that appear to be proportionally less prominent by the time they reach Kona. While it is unknown if these differences result from spatial inhomogeneities in the volcanic plume, time dependent changes in the chemical conversion rate of $SO_2$, or some other reason, the $SO_2$ concentration data appears consistent with the transport of a large pollutant plume from the Kilauea volcano.

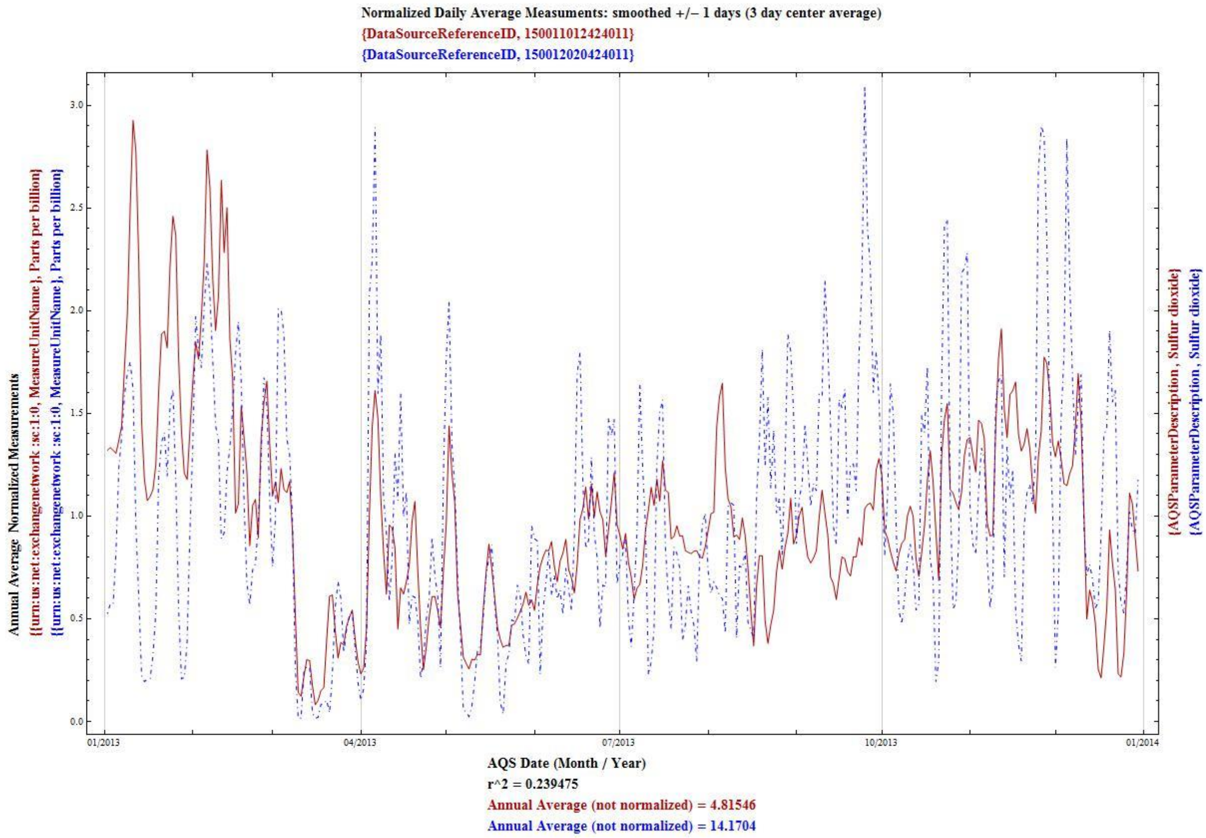



**Figure 3-7.** 2013 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $SO_2$ Concentrations

The 1997 USGS webpage (Ref. 3) described the Kona pollutants of volcanic origin being "trapped by the onshore-offshore daily wind regime". This description was evaluated. Hourly monitored $PM_{2.5}$ pollutant concentrations for 2012 and 2013 were combined with hourly wind direction data from the collocated AN155 monitor. Hourly wind direction data was also examined. During the review of hourly wind data from the AN155 monitor, it was noted that the wind rose for AN155 had an increased frequency of wind approaching from the west (Figure 3-8). This issue had previously been noted in an October 2012 memo (Ref. 9) which identified that "Kona - Wind direction sensor, all readings were approximately 180 degrees off". An examination of the 2013 AN155 wind direct data showed the consistent diurnal wind pattern indicated in the USGS document.

**AN155y2012.xls–2012: All Hours**

Data Info: Windrose

Number of Datasets = 6493

... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2012, 1, 1, 1, 0, 0.} | 2.1 | 81. | N/A | 1–1–2012 1:00 HST |

... complete dataset (below)

**AN155y2013.xls–2013: All Hours**

Data Info: Windrose

Number of Datasets = 8092

... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 0, 0, 0.} | 2.2 | 75. | N/A | 1–1–2013 0:00 HST |

... complete dataset (below)

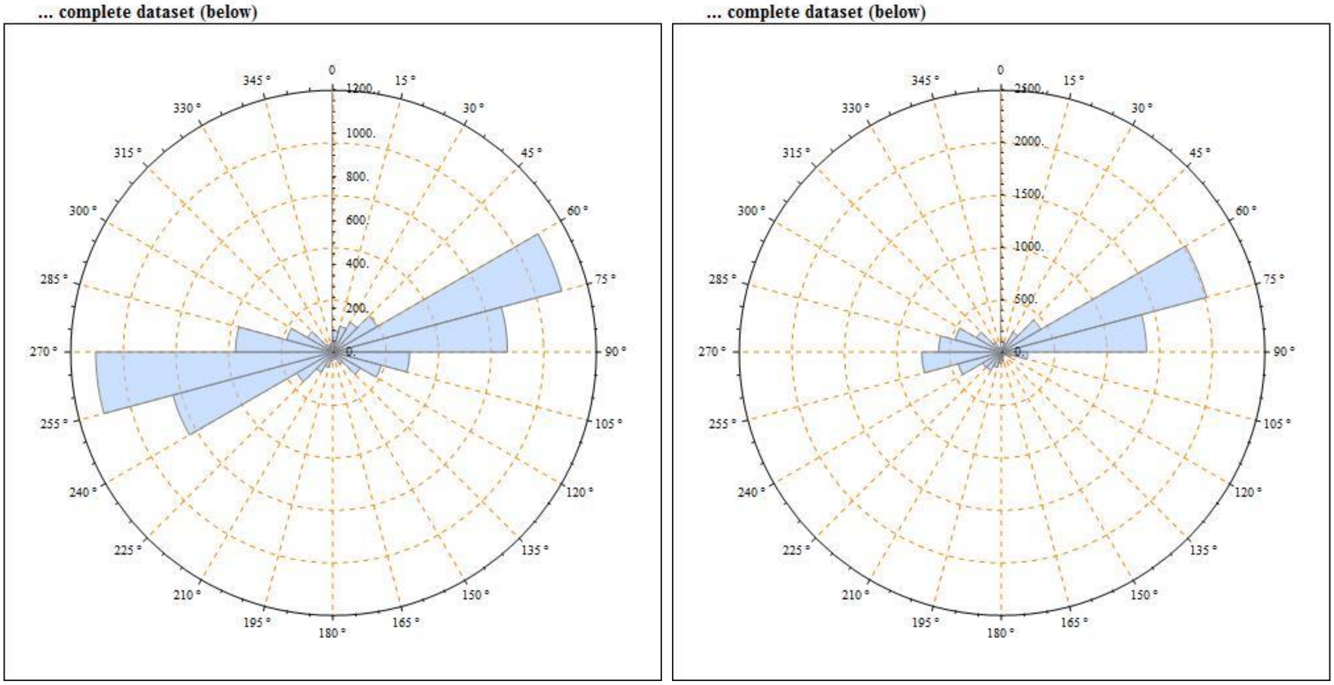



**Figure 3-8.** Kona Area AN155 Wind Rose for 2012 (left) and 2013 (right)

In Figure A-4, the wind rose plots for the 12 morning hours are presented in 12 plots. The hours begin in the upper left and advance from left to right, beginning at midnight (hour 0) through 2 AM (hour 2) in the top row, with each of the subsequent rows continuing the pattern; times are given in Hawaii Standard Time (HST). In Figure A-5, the wind roses for the twelve (12) evening hours are presented in twelve (12) plots. The morning hours through about 7 AM were dominated by winds approaching from the east (inland).

The 8 AM hour showed winds from both the east and west directions. Beginning in the 9 AM hour and extending through 5 PM, winds approached from the west (offshore). From 6 PM through the 11 PM hour, winds again approached from the east (inland). This diurnal pattern was not reflected in the 2012 dataset. The reason for this difference in the 2013 and 2012 datasets is illustrated in Figures A-6 and A-7 which show the 2012 hourly wind directions as a function of the date. Consistent with the DOH memo, the dominant wind direct associated with each hour is seen to change by about 180 degrees during the middle months of 2012.

With the wind data quality for 2013 confirmed, and the problem with the 2012 dataset understood, hourly wind data and hourly $PM_{2.5}$ concentration for Kona were combined. The hourly pollutant concentrations were binned according to matching hourly wind directions into four 90 degree quadrants. Each quadrant was centered about the four compass points. Figure A-8 shows the individual 2013 hourly $PM_{2.5}$ concentration measurements associated with winds approaching from the north, east, south, and west (from top to bottom in the figure). The average concentrations associated with the primary directions of approach are about 13.3 $\mu g/m^3$ from the west (offshore, 34% of winds) and 13.7 $\mu g/m^3$ from the east (onshore, 52% of winds); the values associated with the less frequent approaches from the north and south were 14.2 $\mu g/m^3$ (6.4% of winds) and 11.4 $\mu g/m^3$ (6.9% of winds), respectively. The relatively small difference between the average 2013 $PM_{2.5}$ concentrations approaching from onshore versus offshore is consistent with the USGS description of pollutants trapped by the local wind pattern.

The 2012 hourly $PM_{2.5}$ and wind datasets were plotted without attempting to correct for the know issue with the wind direction. Figure A-9 shows the result of this combining of the two datasets. While an accurate correction of the wind direction could have been made based on the prevailing diurnal wind pattern, it was felt that the significance of this effort would have been negligible for the purposes of this effort. By visual inspection, the east approaching and west approaching data values for the middle of 2012 do not appear to be significantly different. Without correction, the average $PM_{2.5}$ concentration for winds approaching from the west (offshore) is about 16.4 $\mu g/m^3$ versus 15.5 $\mu g/m^3$ from the east (onshore); the values associated with the less frequent approaches from the north and south were 13.9 $\mu g/m^3$ and 17.0 $\mu g/m^3$, respectively. As with 2013, the relatively small difference between the average 2012 $PM_{2.5}$ concentrations approaching from onshore versus offshore is consistent with the USGS description of Kilauea pollutants trapped by the local wind pattern.

3.2.D Seasonal $PM_{2.5}$ and $SO_2$ Correlations at Kona, Ocean View and Pahala

An examination of the effect of seasonality has on the correlation between $PM_{2.5}$ and $SO_2$ concentrations at Kona, Ocean View, and Pahala for 2011 and 2012 was made. Each year was divided into four quarters, each three months in length, beginning with January. The results are shown for 2012 and 2013 in Figures A-10 and A-11, respectively; note that these correlation calculations were made with the "unsmoothed" AQS datasets. The following observations were noted:

For 2012 Kona and Ocean View $PM_{2.5}$, the first quarter of the year had the best correlation (0.483). For 2013, the second quarter correlation value (0.589) was slightly larger than the first quarter (0.467). For 2012, the second and third quarters were equal (0.384) and a fair amount less than the first quarter (0.483).

For 2013 Ocean View and Pahala $PM_{2.5}$, the first and second quarters had the best correlations (0.132 and 0.185, respectively). For 2012, the first and fourth quarter values of 0.117 and 0.133, respectively.

2013 Kona $SO_2$ correlated best with Kona $PM_{2.5}$ during the first and second quarters with values of 0.458 and 0.533, respectively. 2012 Kona $SO_2$ correlated best with Ocean View $PM_{2.5}$ during the second quarter with a value of 0.202. 2013 Kona $SO_2$

correlated best with Ocean View $SO_2$ during the first and second quarters (0.324 and 0.354, respectively). Generally, 2012 Kona $SO_2$ correlations had lower values than in 2013.

2013 Pahala $SO_2$ correlated best with Ocean View $SO_2$ in the first and third quarters, with values of 0.395 and 0.167, respectively. For 2012, Pahala $SO_2$ correlated best with the first, third and fourth quarters of Pahala $PM_{2.5}$, with values of 0.426, 0.219, and 0.207, respectively.

While these observations by quarter help to illustrate the linkages between the Kona, Ocean View, and Pahala $SO_2$ and $PM_{2.5}$ datasets, it appears that the normalized time-history plots (e.g. Figure 3-3) provide better, though qualitative, illustration of transport and chemical conversion process that links these sites.

### 3.2.E Additional Relevant Wind Data

The wind patterns associated with the island of Hawaii were discussed previously in Section 2.2 and illustrated in Figure 2-3. In this section, additional wind direction monitoring data from the Meso West website will be presented and discussed with respect to candidate pollutant transport pathways and source locations. 2012 data is presented, but 2011 data was also examined and is consistent with the 2012 data. The locations and elevations of the monitors are presented in Figure 2-7.

While diurnal wind patterns dominate the Kona monitoring site, trade winds can be seen to be predominant at higher elevations on the island of Hawaii (Fig. 3-9). In addition to the previously discussed HAVO VC and HAVO OB sites near the Kilauea summit vent, the Kamuela monitor (PHMU) is situated in the northern part of Hawaii at an elevation of 814 meters. Winds from the north are also predominant for the Keaumo monitor located on the eastern side of Mauna Loa at an elevation of 1,682 meters.

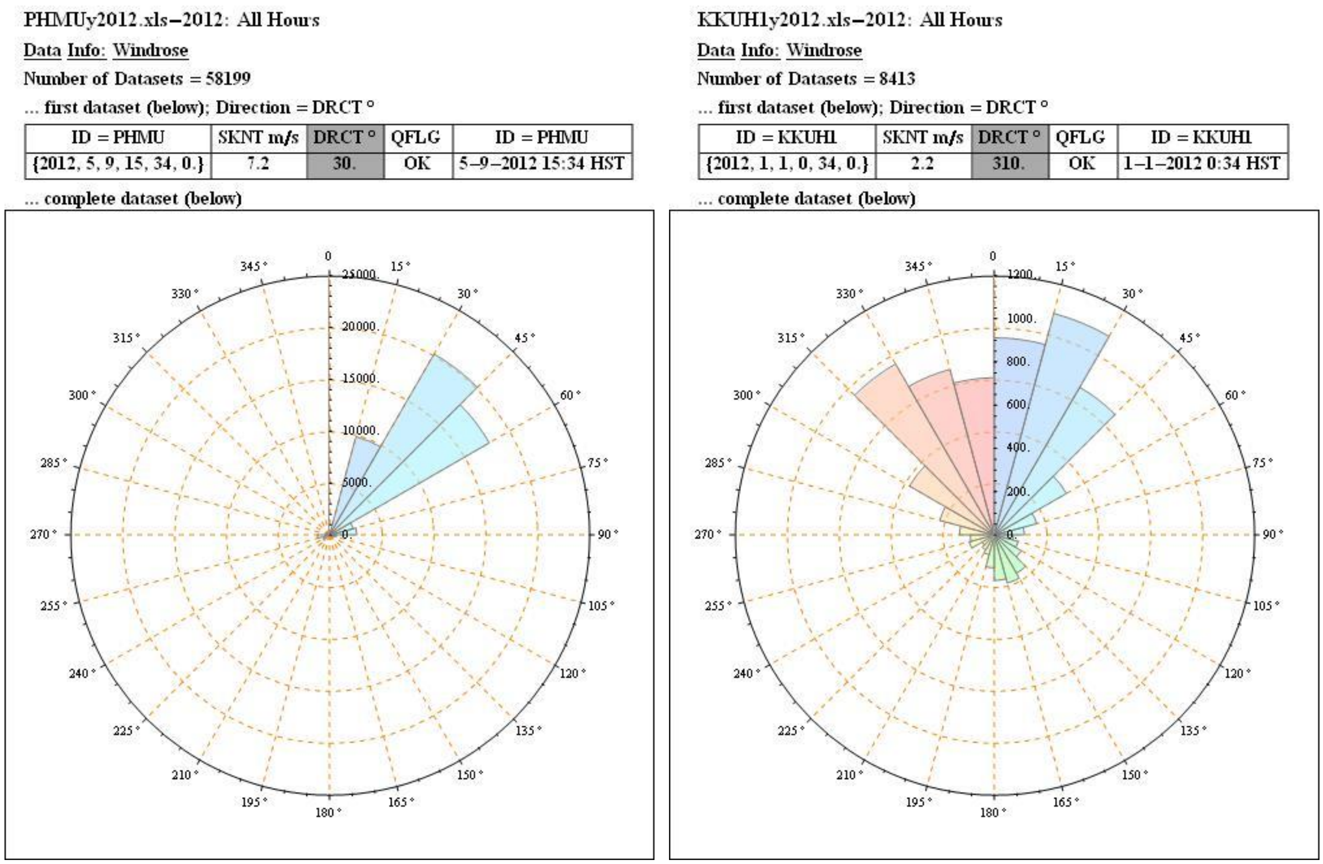



**Figure 3-9.** 2012 Kamuela (PHMU)(left) & Keaumo (KKUH1)(right) Wind Rose

The predominance of trade winds can also be seen at lower elevations when the impact of local mountains are small, such as for the Kaunakakai, Molokai Airport (PHMK, 138 meter elevation) and Kaneohe Marine Corps Air Station (PHNG, 5 meter elevation) data sets shown in Figure 3-10. The PHMK and PHNG monitors are located on the islands Molokai and Oahu, respectively.

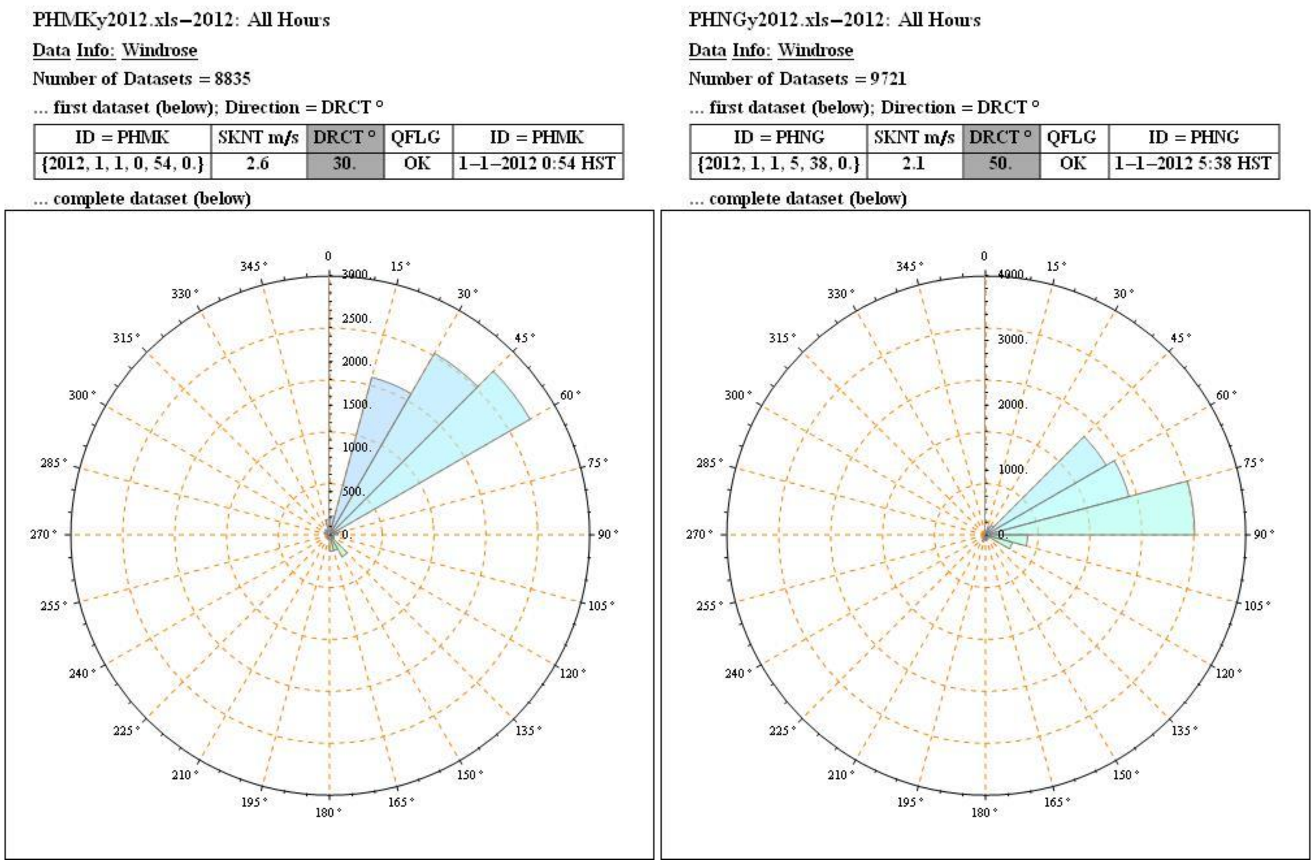



**Figure 3-10.** 2012 Kaunakakai, Molokai Airport (PHMK)(left) & Kaneohe, Marine Corps Air Station (PHNG)(right) Wind Rose

In the region north of Kona shown in Figure 2-3, the winds are seen to travel largely from east to west. That figure is consistent with the wind data from the Waikoloa monitor (WKVH1) (Fig. 3-11, left side). Hourly wind rose plots are included in Appendix A (Fig. A-12 & A-13) and show the diurnal pattern of the wind for this monitor, with the dominant flow path being from the east. The Kaupulehu Lava Flow (KPLH1) monitor is also north of the Kona monitor, and like the Waikoloa monitor, is near the western coast. The winds associated with KPLH1 come mostly from the west and also the southeast (Fig. 3-12, right side). The diurnal wind pattern can be seen in the hourly wind rose plots (Fig. A-14 & A-15).

WKVH1y2012.xls–2012: All Hours

Data Info: Windrose

Number of Datasets = 8552

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 0, 35, 0.} | 5.8 | 64. | OK | 1–1–2012 0:35 HST |

... complete dataset (below)

KPLH1y2012.xls–2012: All Hours

Data Info: Windrose

Number of Datasets = 7067

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 0, 36, 0.} | 3.6 | 156. | OK | 1–1–2012 0:36 HST |

... complete dataset (below)

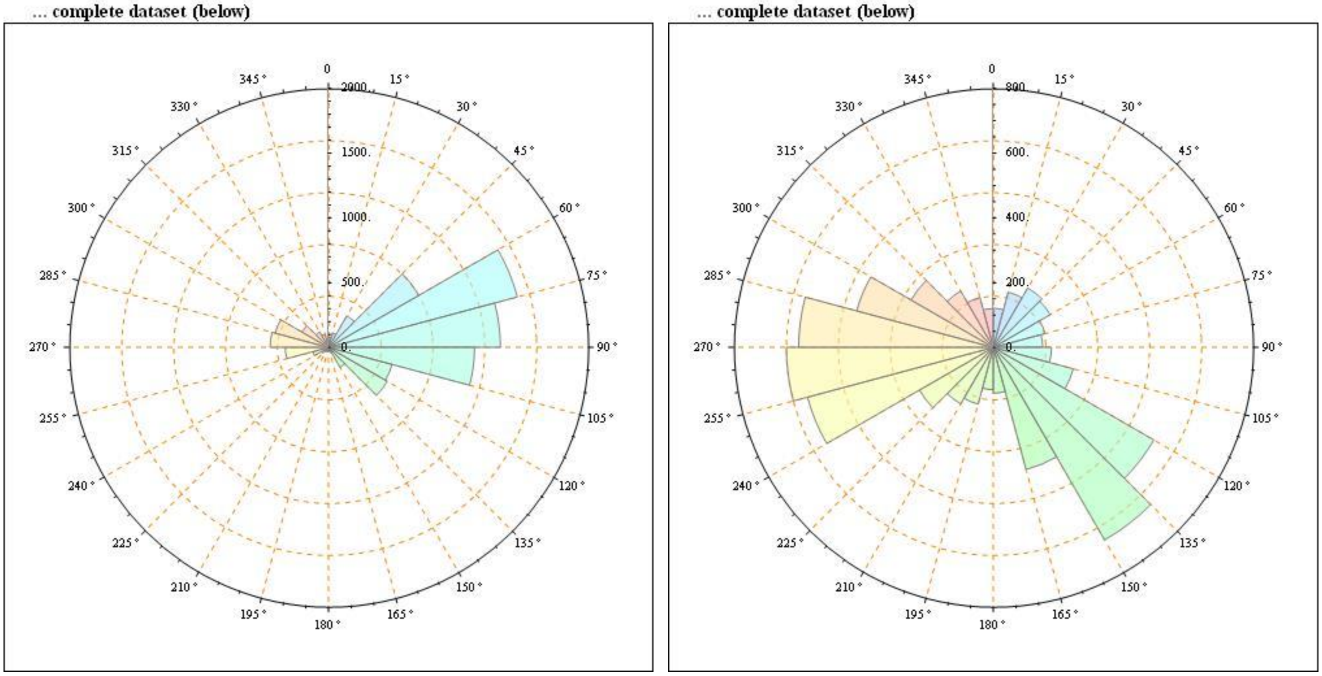



**Figure 3-11.** 2012 Waikoloa (WKVH1)(left) & Kaupulehu Lava Flow (KPLH1)(right) Wind Rose

Nearer to the center of the island, wind direction data from the PTA Range 17 monitor (PTRH1) was examined for consistency with Figure 2-3. The wind rose plot shows the predominant winds are from the southeast, with some from the northwest (Fig 3-12, left). The daytime diurnal winds coming from the western coast would seem to be a likely explanation for the winds from the northwest, with nighttime and morning winds coming from the southeast (Fig. A-16 & A-17).

The Hilo International Airport (PHTO) winds are seen to be dominated by winds from the southwest, as indicated by the red arrow approaching Hilo in Figure 2-3. However, while the red "KONA WINDS" designation in Figure 2-3 relates to the less frequent Kona winds, the wind rose for PHTO (Fig 3-12, right) is based on year round data. The predominance of winds from the southwest is shown to be associated with a diurnal wind pattern (Fig. A-18 & A-19). Other than the late morning and early afternoon, the winds are predominantly from the southwest.

PTRH1y2012.xls−2012: All Hours

Data Info: Windrose

Number of Datasets = 8734

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 0, 49, 0.} | 2.7 | 101. | OK | 1–1–2012 0:49 HST |

... complete dataset (below)

PHTOy2012.xls−2012: All Hours

Data Info: Windrose

Number of Datasets = 10784

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 0, 19, 0.} | 2.1 | 290. | OK | 1–1–2012 0:19 HST |

... complete dataset (below)

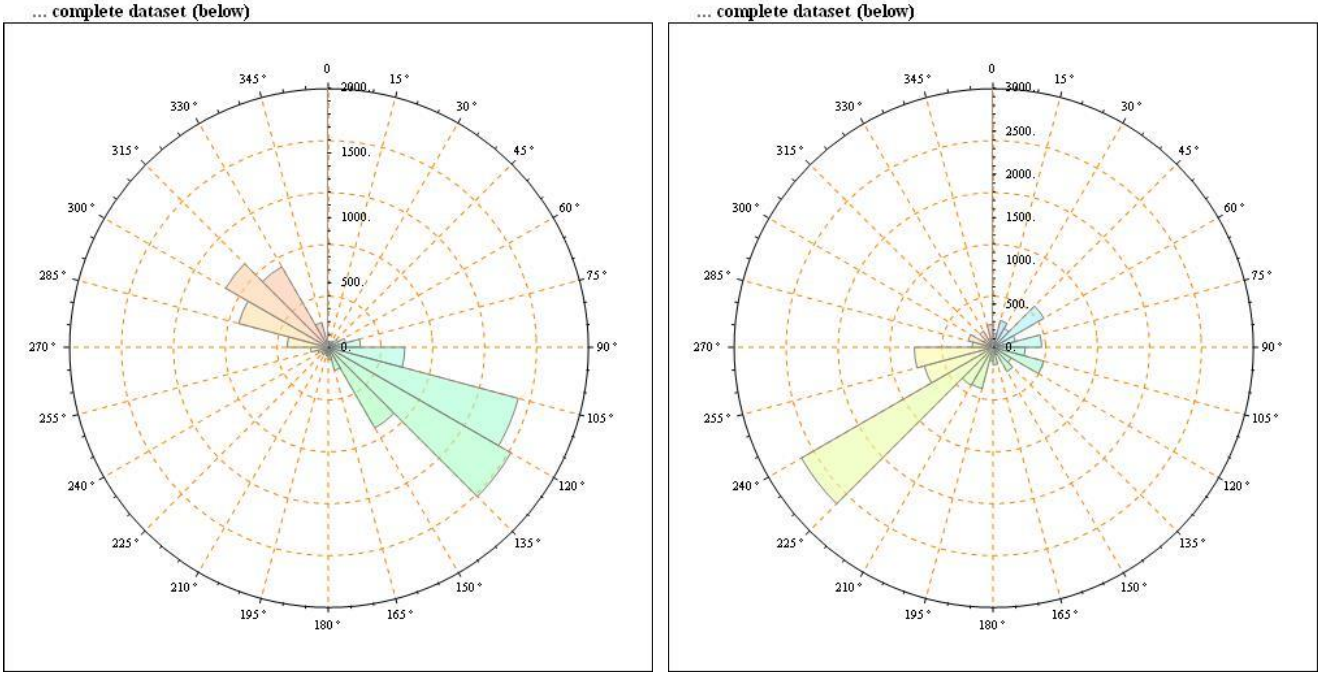



**Figure 3-12.** 2012 PTA Range 17 (left) & Hilo International Airport (right) Wind Rose

2013 annual wind roses for Pahala (AN157) and Ocean View (AN738) monitors show relatively even distributions of winds from two directions each. For Pahala (Fig. 3-13, left), winds arrive from the northwest and the east. For Ocean View, winds arrive from the northeast and the southwest. The diurnal nature of the winds can be seen in Fig A-20 and A-21 for Pahala, and Fig A-22 and A-23 for Ocean View. In both cases, morning and evening winds arrive from the direction of the mountain, and daytime winds arrive from the direct of the ocean.

In section 3.2.B, the presence of diurnal winds at the Kona (AN155) monitor was discussed. The wind data presented in this section shows that diurnal wind patterns dominate in many areas, including those near the Ocean View (AN738) and Pahala (AN157) monitors. This diurnal pattern will couple with the bulk transport of pollutants from the Kilauea summit, around the bottom of the island, and up the western coast as described by the USGS (Ref. 3, 4).

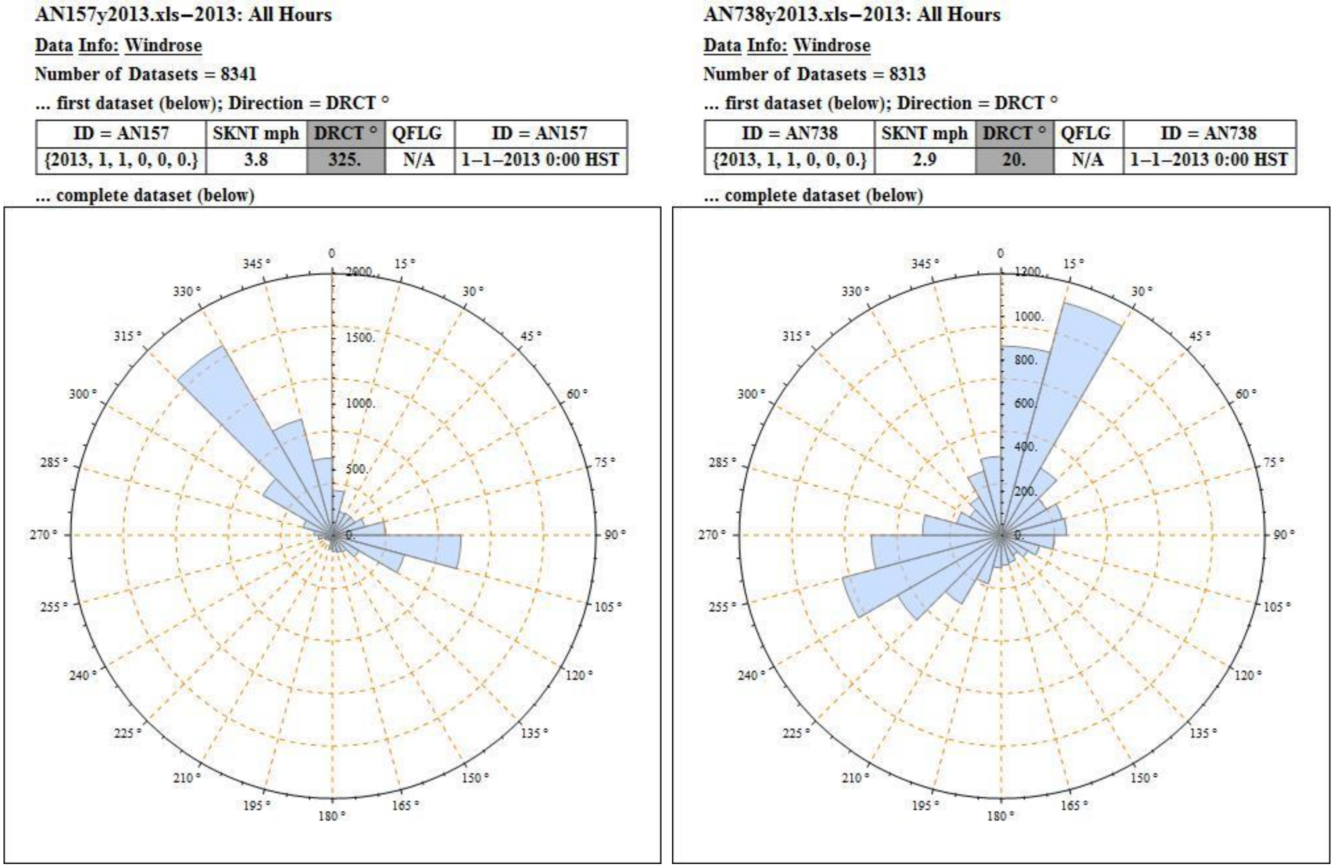
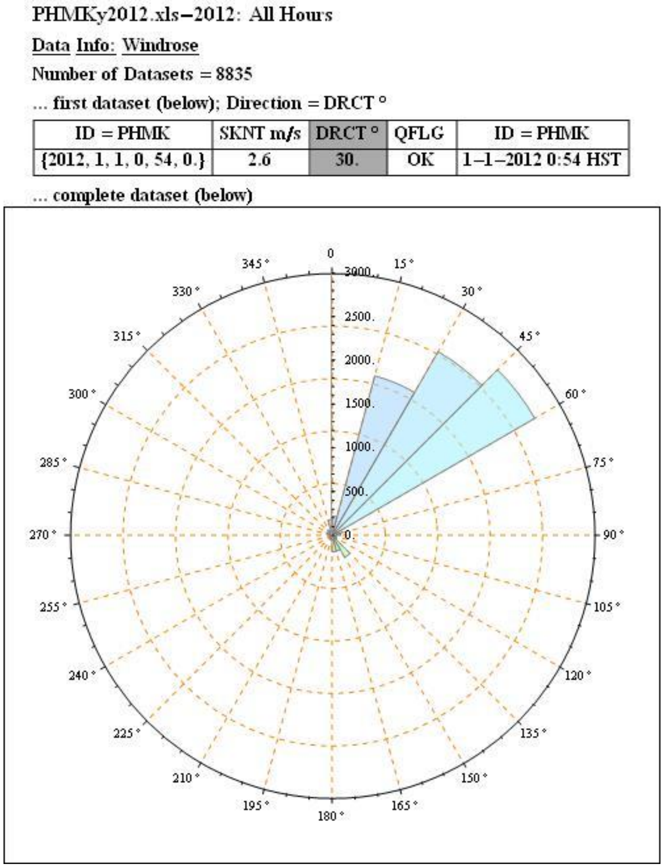



**Figure 3-13.** 2013 Pahala (AN157)(left) and Ocean View (AN738)(right) Wind Rose

Considering the wind data discussed in this section the following observations are noted:

As indicated in Figure 3-9 and 3-10, the predominance of trade winds is such that it seems unlikely that the occasional Kona winds would impact the analysis of seasonal average concentrations. Based on the $SO_2$ chemical transformation description given in reference 7, it seems much more likely that seasonal weather conditions such as cloud cover, humidity, and precipitation would have a much great influence on $SO_2$ and $PM_{2.5}$ concentration variability.

The predominance of winds from the southwest monitored in the Hilo area reduce the likelihood that pollutants originating in Hilo would impact the pollutant levels measured by the Kona monitor.



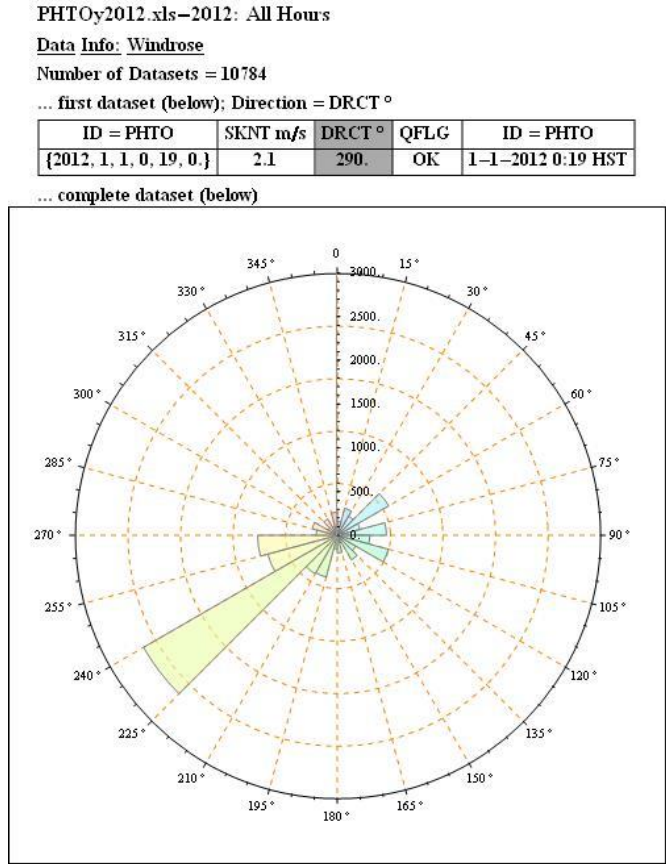




**Figure 3-14.** 2012 Kaunakakai, Molokai Airport (PHMK) (left) & Hilo International Airport (right) Wind Rose

The wind roses from Molokai Airport and Hilo International Airport in Figure 3-14 show that emissions from sources in Hilo would rarely follow the identical transport path as emissions from the volcano. At a minimum, a northeast trade wind would be required for emissions from Hilo to follow the same transport path as that for the Halema'uma'u and Pu'u O'o vents. Although the Hawaiian Islands are dominated by northeast trade winds, the winds in the Hilo area are heavily influenced by Mauna Kea and Mauna Loa, producing a dominant southerly wind (wind blows from south to north). Figure 3-14 (left) illustrates a dominant northeast trade wind (wind blows from northeast to southwest) from a meteorological site at Molokai Airport. The Molokai Airport site is not influenced by high mountain ranges like Hilo. In contrast, Figure 3-14 (right) illustrates the dominant southerly wind flow at the Hilo International Airport due to the diurnal heating and cooling effects of Mauna Kea and Mauna Loa. Also, Figure A-17 shows hourly wind roses at Hilo International Airport. During the day, warm air flows upslope along the valley between Mauna Kea and Mauna Loa leading to a westerly flow at Hilo. In the evening/night, cold air flows down the valley leading to a more southerly flow at Hilo (also see topography in Figure 2-3). These valley slope dynamics typically preclude the emissions from the Hilo area following the same transport path as Kilauea volcanic emissions.

### 3.2.F Discussion

Examinations of pollutant and wind monitoring data indicate that $SO_2$ emissions from the Kilauea volcano are the cause for the elevated levels of $PM_{2.5}$ at the Kona monitoring site.

The magnitude of the Kilauea volcano $SO_2$ emissions is well documented. The elevated Halema'uma'u (summit) emissions after 2007 shown in Figures 2-13, 2-14, and 2-15 are consistent with the USGS observations (Ref. 1, 3, and 4).

Pollutant monitoring data from Kona, Ocean View, and Pahala shows decreasing $SO_2$ concentrations (and increasing $PM_{2.5}$) as prevailing coastal winds travel clockwise from Pahala, to Ocean View, and up to Kona. The monitoring data is consistent with the Kilauea volcano $SO_2$ transport and chemical conversion process described in references 3, 4, and 7, and discussed in Section 2-3.

If $PM_{2.5}$ exceedances were due to sources in North Kona, one would expect the $SO_2$ transported from north of Kona to decrease from Kona, through Ocean View, and on to Pahala. It would also be expected that $PM_{2.5}$ would increase from Kona to Pahala. Neither of these is the case. A very large $PM_{2.5}$ concentration north of Kona does not explain the increasing $SO_2$ concentrations measured as the postulated pollutant is transported from Kona to Ocean View and to Pahala.

The diurnal nature of the winds at Kona, Ocean View, and Pahala provide the coupling between the elevated aerosol shown-by satellite AOD (e.g. Figure 2-9) and $PM_{2.5}$ and $SO_2$ concentrations measured at the air monitoring sites. The good correspondence between time histories of $PM_{2.5}$ and $SO_2$ concentrations measured at Kona and Ocean View for both 2012 and 2013 is consistent with this transport.

Wind barbs and topography for the Hawaiian Islands were examined to determine an air monitoring site that could serve as a surrogate for what the Kona monitor might read if the volcano was not present. No air monitoring sites were found with similar topographical and wind influences as those affecting the Kona area. However, except for the Kona station, all other state monitoring sites show compliance with the annual concentration standard for $PM_{2.5}$. The other monitoring locations include sites in and around Campbell Industrial Park (CIP) on Oahu with larger anthropogenic sources than those in Kona. This is evident when comparing Table 3-4 emissions from some of the larger sources in the CIP area to emissions in Table 4-9 from sources in Kona. Also, satellite OMI measurements of $NO_2$ in Figure 2-10 show much higher $NO_2$ in the vicinity of Oahu than over the entire Island of Hawaii. Although, monitoring stations on Oahu are not a direct comparison to the Kona station, these stations could provide a baseline for gauging worst-case $PM_{2.5}$ impacts from local anthropogenic sources in Kona. If the CIP monitoring station (Kapolei monitor, AQS ID 150030010) was used as a surrogate, annual $PM_{2.5}$ impacts associated with anthropogenic sources in Kona would be 5.2 µg /$m^3$, 7.0 µg /$m^3$, and 2.8 µg /$m^3$ for 2011, 2012, and 2013, respectively. These impacts are well within the 12 µg/$m^3$ annual ambient air quality standard for $PM_{2.5}$.

| LARGE CIP SOURCE EMISSIONS (EXAMPLES) | | | | |
|---|---|---|---|---|
| Source | Major Equipment | Emissions (TPY)[a] | | |
| | | $PM_{10}$ | $NO_2$ | $SO_2$ |
| Chevron Refinery | Boilers, Cogeneration Turbines, Furnaces, and Fluidized Catalytic Cracker | 220 | 2,501 | 6,736 |
| Hawaii Independent Energy Refinery | Heaters, Boilers, Cogeneration Turbine, Flare, and Incinerators | 259 | 2,475 | 2,629 |
| AES Hawaii, Inc. | Two Fluidized Bed Steam Boilers | 141[b] | 1,038 | 2,830 |
| Hawaii Electric Company Kahe Generating Station | Six Boilers and Black Start Diesel Engine Generators | 2,871 | 21,730 | 15,204 |
| H-POWER Refuse Derived Fuel (RDF) and Mass-Burn Facilities | Two RDF Boilers and One Mass-Burn Boiler | 167 | 1,702 | 351 |

a: Maximum potential emissions.
b: Assumed PM = $PM_{10}$.

**Table 3-4.** Examples of Large Stationary Source Emissions in CIP

## 3.3 Examination of Proposed Kona Exceptional Events Days

### 3.3.A Overview

The DOH identified days during 2012 and 2013 that are flagged for exclusion from the Kona dataset (see Appendix B). In 2012, there are 200 flagged days. In 2013 there are 215 flagged days. In this section, the flagged days are presented with respect to annual $PM_{2.5}$ time histories (unsmoothed) at Kona and normalized $PM_{2.5}$ and $SO_2$ concentrations at Kona and Ocean View. The purpose of these comparisons is to illustrate the appropriateness of flagging these days.

### 3.3.B 2012 Flagged Days

The daily average $PM_{2.5}$ concentrations for 2012 are indicated in red on Figure 3-15.

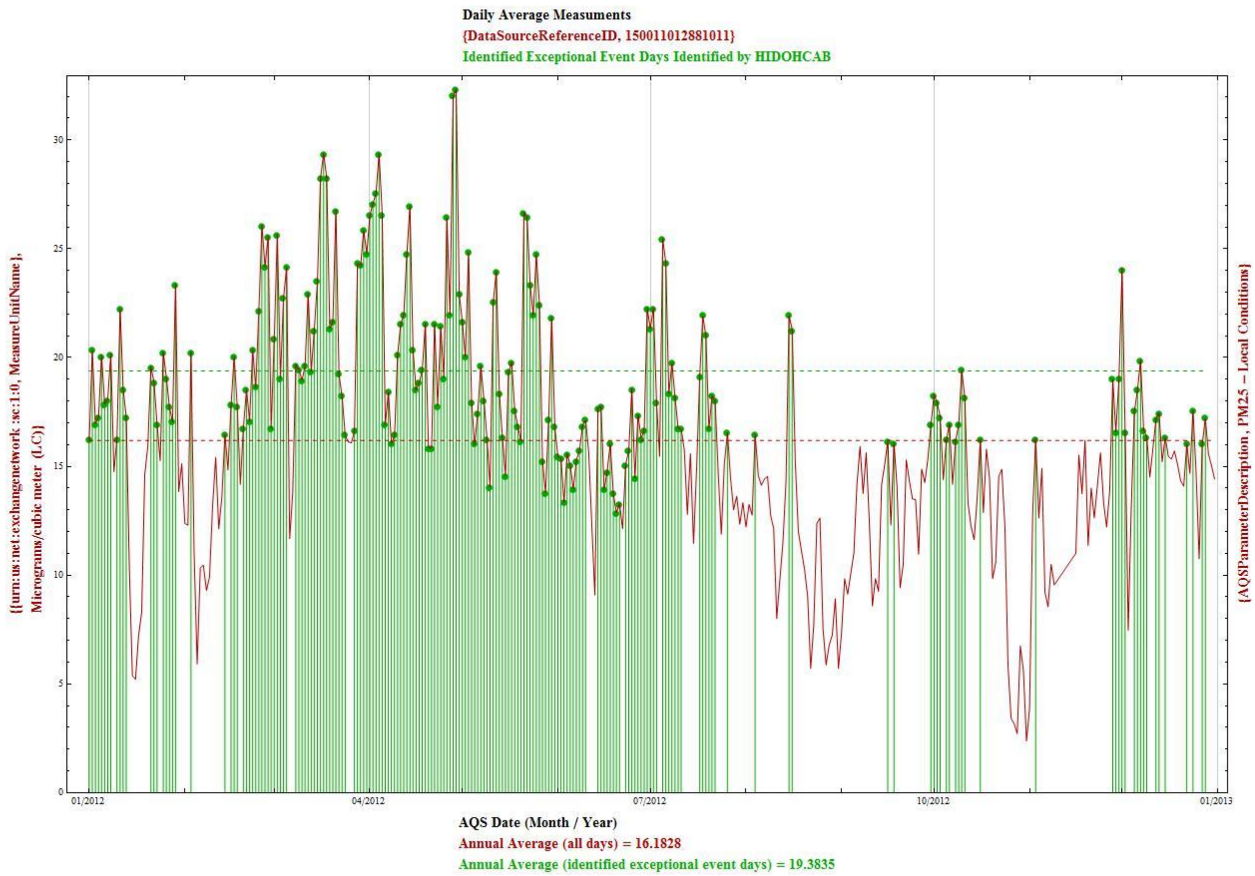



**Figure 3-15.** 2012 Time History of Kona (red) $PM_{2.5}$ Concentrations with Flagged Days (green)

The flagged days and measurement values are indicated by the green vertical lines and green dots. The average $PM_{2.5}$ concentration used for normalization purposes of the flagged days is 19.4 µg/m$^3$ versus the annual average of all days (before flagging) of approximately 16.2 µg/m$^3$. The linkages discussed in Section 3.2.F between volcanic emissions, the pollutant transport path/chemical conversion process, and the monitored concentration levels establish the causal link between elevated $PM_{2.5}$ concentrations and the Kilauea volcano.

As indicated in Figure 3-16, the flagged days occur during peak periods of $PM_{2.5}$ concentration (smoothed using 3 day center average, then normalized) at the Kona and Ocean View monitors.

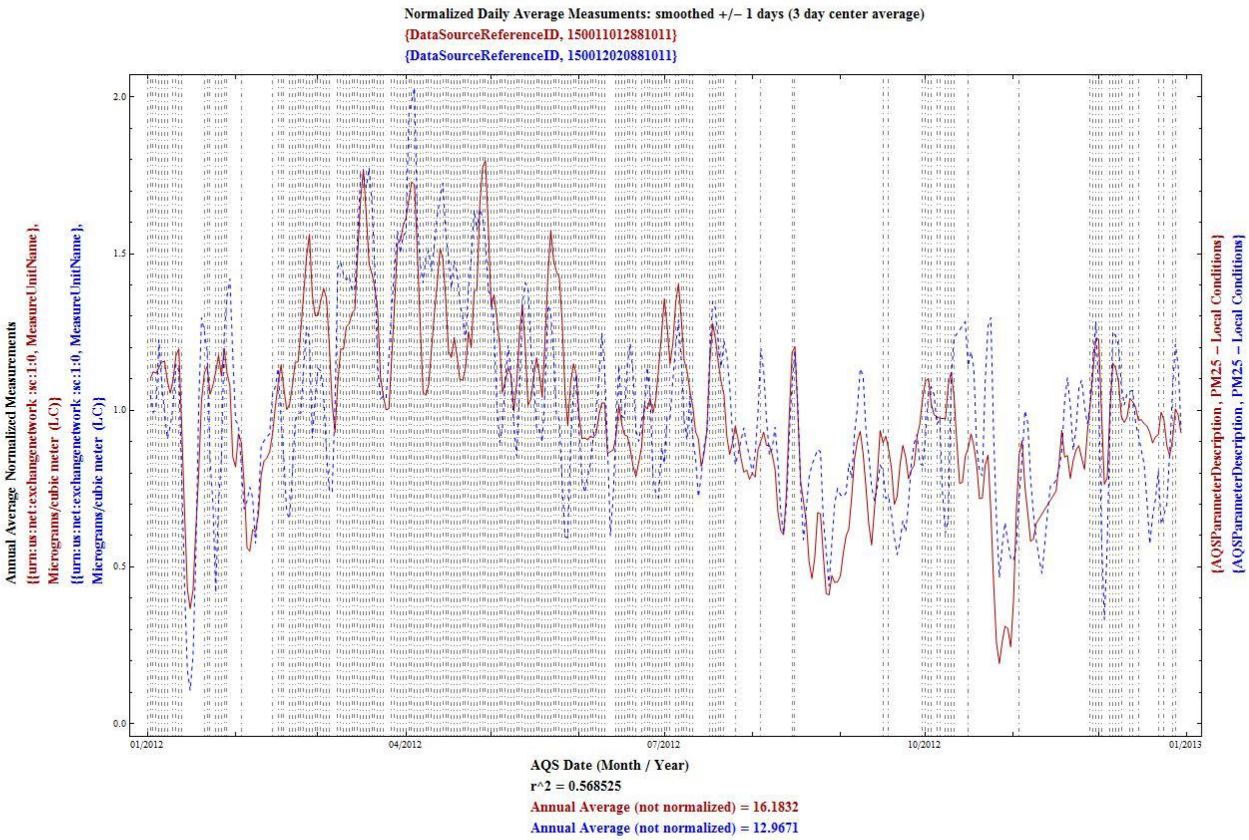



**Figure 3-16.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $PM_{2.5}$ Concentrations with Flagged Days (vertical broken lines)

Figure 3-17 presents the normalized $SO_2$ concentration data (smoothed using 3 day center average) for Kona and Ocean View with respect to the flagged days. Flagged days also generally occur during elevated $SO_2$ concentration at both monitoring sites.

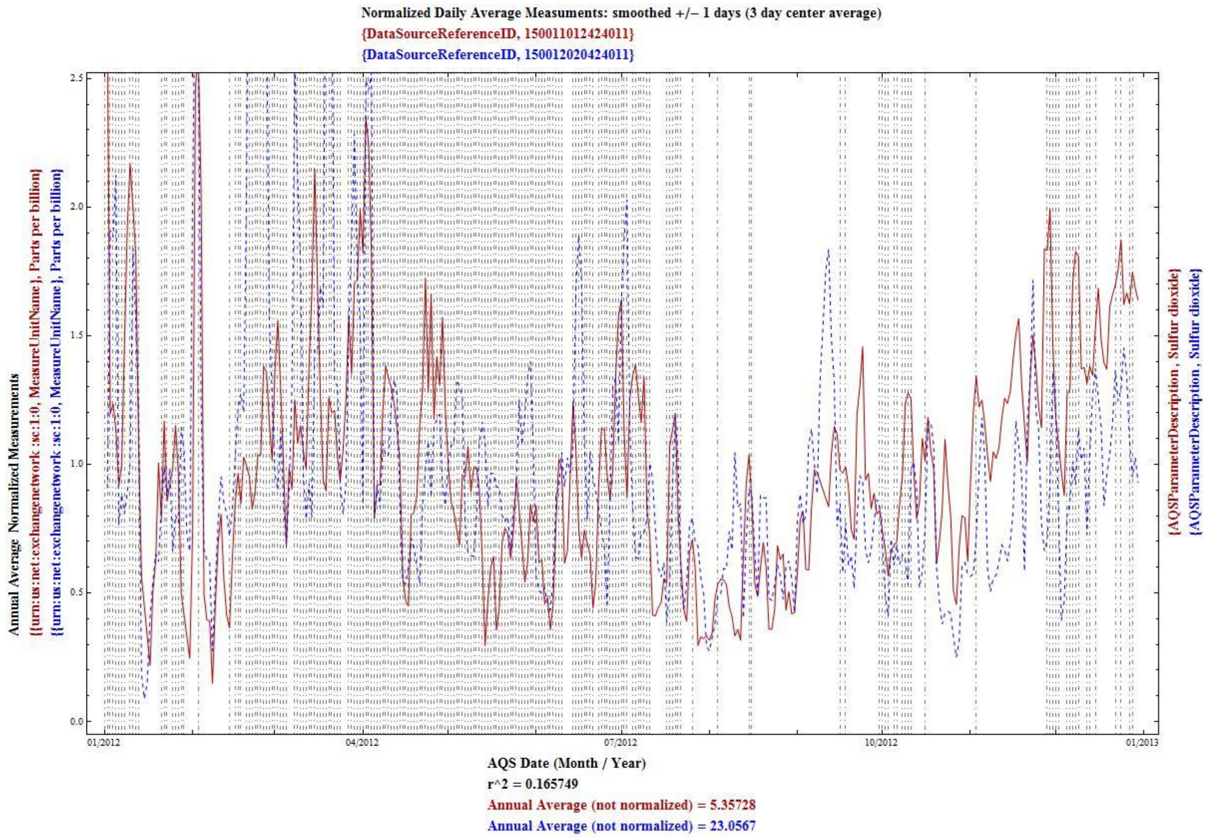



**Figure 3-17.** 2012 Time History of Kona (red) and Ocean View (blue) Normalized $SO_2$ Concentrations with Flagged Days (vertical broken lines)

The time history data presented in Figures 3-16 and 3-17 clearly indicates that $PM_{2.5}$ and $SO_2$ pollutant levels at Kona and Ocean View are strongly linked, and that linkage is due to the large $SO_2$ emissions from the Kilauea volcano. The data indicates that pollutant levels are elevated throughout most of the year only because of those volcanic emissions.

3.3.C 2013 Flagged Days

The daily average $PM_{2.5}$ concentrations for 2013 are indicated in red on Figure 3-18. The flagged days and measurement values are indicated by the green vertical lines and green dots. The average $PM_{2.5}$ concentration of the flagged days is 15.9 µg/m$^3$ versus the annual average of all days (before flagging, used for normalization purposes) of approximately 13.4 µg/m$^3$. For 2013, 215 days are flagged. The large number of flagged days is a direct result of the significant and persistent impact that Kilauea $SO_2$ emissions have on the Kona area. Note that because these time-history comparisons used all available hourly monitoring data from the AQS Data Mart, there are a few instances of elevated daily average $PM_{2.5}$ indicated by the “red” line that have insufficient hourly data to be considered valid days.

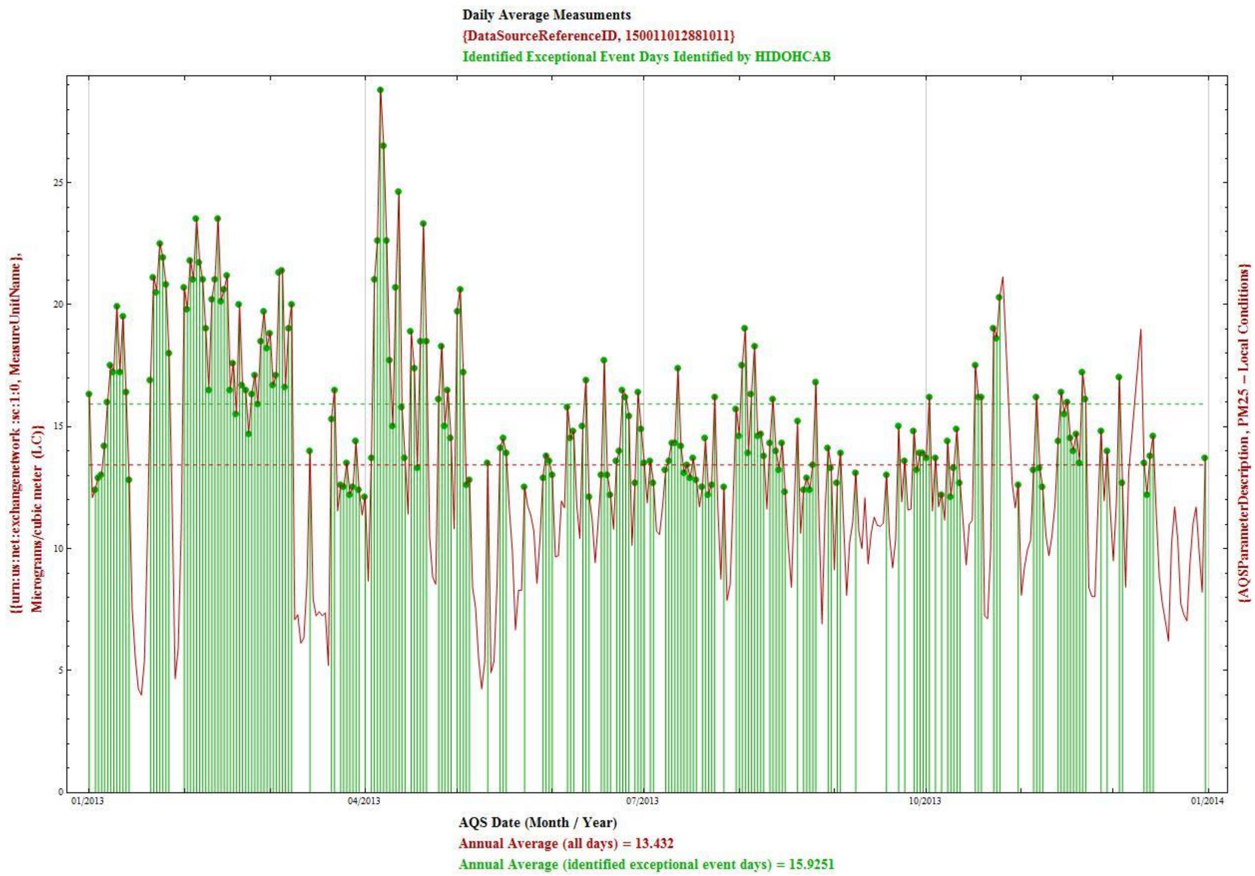



**Figure 3-18.** 2013 Time History of Kona (red) $PM_{2.5}$ Concentrations with Flagged Days (green)

As indicated in Figure 3-19, the flagged days occur during periods of elevated $PM_{2.5}$ concentration (smoothed using 3 day center average, then normalized) at the Kona and Ocean View monitors.

Figure 3-20 presents the normalized $SO_2$ concentration data (smoothed using 3 day center average) for Kona and Ocean View with respect to the flagged days. While the correlation between the $SO_2$ concentration levels at the two sites is not as strong for $SO_2$ as $PM_{2.5}$, the seasonal trend is evident. As is the case with 2012, the 2013 data indicates that pollutant levels are elevated throughout most of the year only because of volcanic emissions from Kilauea.

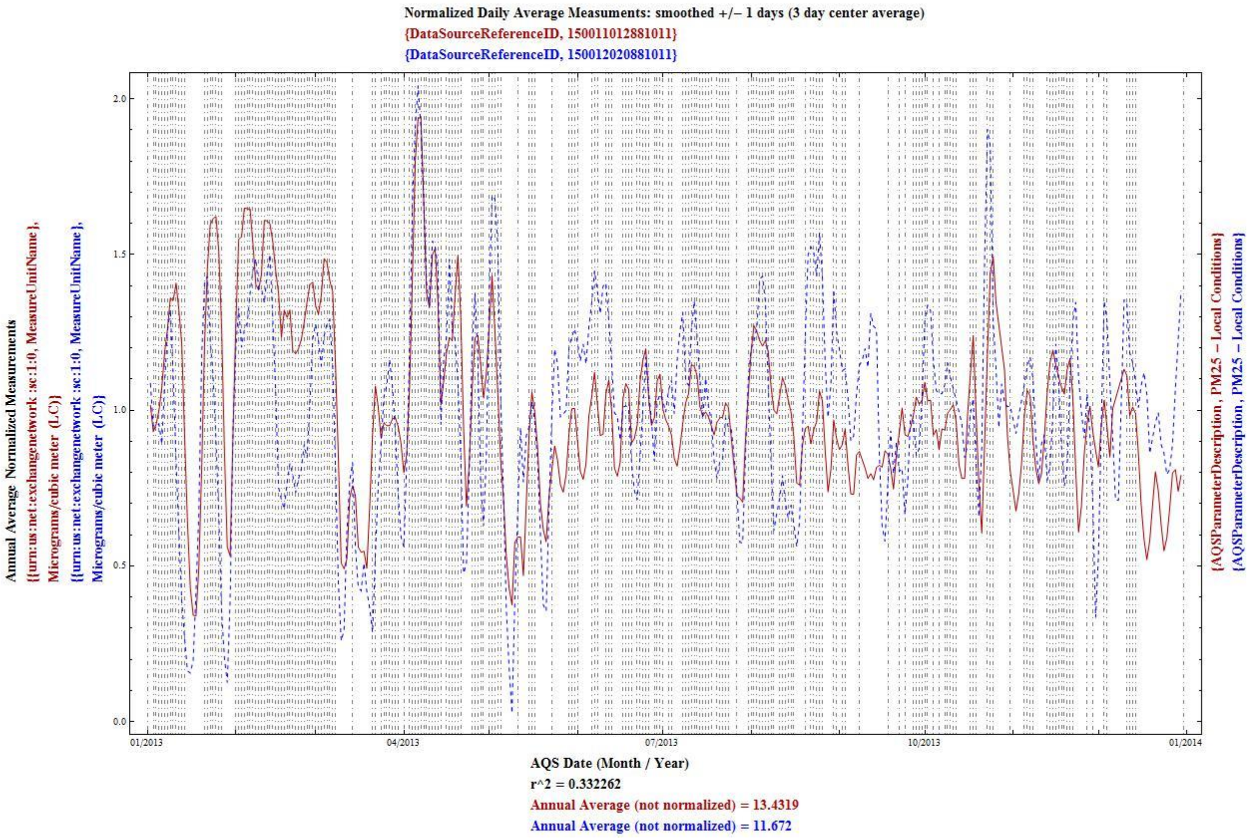



**Figure 3-19.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $PM_{2.5}$ Concentrations with Flagged Days (vertical broken lines)

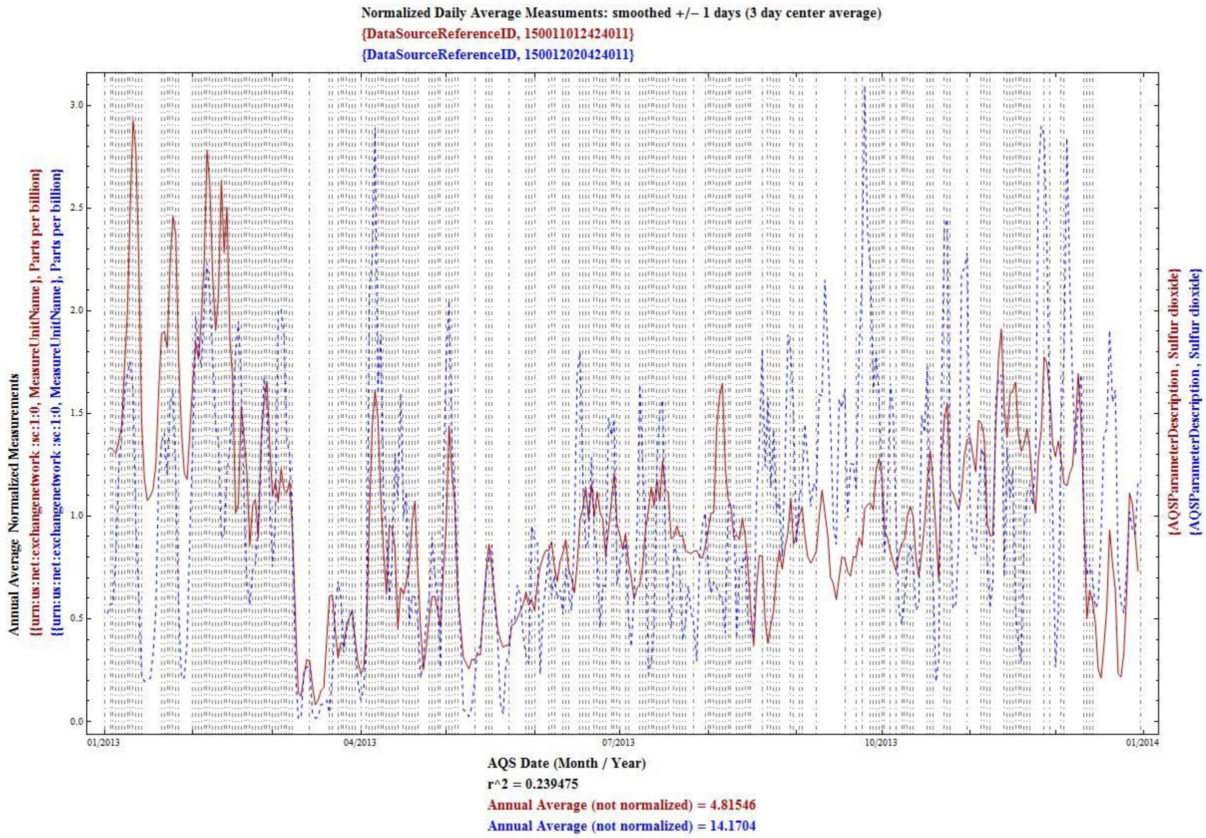



**Figure 3-20.** 2013 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $SO_2$ Concentrations with Flagged Days (vertical broken lines)

### 3.3.D Conclusion

The USGS descriptions of the significant impact on the Kona area, as well as the southern region of Hawaii, of the very large $SO_2$ emissions from the Kilauea volcano are consistent with the observed monitoring data for 2012 and 2013. The time histories of $PM_{2.5}$ concentrations from the Kona and Ocean View monitors indicate a large pollutant plume of common origin impacting both sites. The relative magnitudes of $PM_{2.5}$ and $SO_2$ measured at Kona, Ocean View, and Pahala are consistent with the transport path described by the USGS. The hourly $PM_{2.5}$ concentrations at Kona, when coupled with local wind data, present no indication of any local source significantly impacting the measurements. As such, the Kilauea volcano is the only source that could reasonably be considered responsible for the highly elevated levels of $PM_{2.5}$ measured by the Kona monitor. The data and associated analysis fully supports the proposed flagged days from the 2012 and 2013 data sets.

## Section 4. Not Reasonably Controllable or Preventable

The ongoing release of $SO_2$ from Kilauea volcano is the primary source contributing to the annual $PM_{2.5}$ concentration exceedance measured at the Kona air monitoring station in 2013. Anthropogenic emissions in the Kona area are significantly lower in comparison to those from the volcano. Control and inspection measures for $PM_{2.5}$ and $PM_{2.5}$ precursors of $NO_2$ and $SO_2$ from permitted sources in the Kona area are considered reasonable for minimizing emissions.

Emissions were quantified from sources in the Kona area to provide information for this exceptional event demonstration to address the exceedance of the 12 $\mu g/m^3$ annual NAAQS for $PM_{2.5}$. The annual $PM_{2.5}$ concentration exceedance being addressed was recorded at the Kona air quality monitoring station for 2013. Table 4-1 below provides information on the air quality exceedance:

| **KONA AIR MONITORING STATION, AQS ID 15-001-1012** | | |
|---|---|---|
| Year | Annual $PM_{2.5}$ NAAQS ($\mu g/m^3$) | Annual Concentration Measured ($\mu g/m^3$) |
| 2013 | 12 | 13.3 |

**Table 4-1.** NAAQS Concentration

Although Hilo has large sources that include electric power plants with combined potential emissions of PM, $NO_2$, and $SO_2$ ranging from 2,083 TPY to 4,309 TPY (see Figure 2-6), emissions from these sources were not considered a significant factor in contributing to $PM_{2.5}$ concentration exceedances at the Kona air monitoring station. As indicated in Section 3.2.E (Figure 3-14, page 42), emissions from sources in Hilo would rarely follow the same transport path as emissions from the volcano. Due to the effects of Mauna Kea and Mauna Loa, a dominant southerly wind flow exists in Hilo that reduces the likelihood of pollutants from Hilo impacting the Kona area. Therefore, emissions from Hilo sources were not included in this section for comparison to $SO_2$ emissions from Kilauea volcano.

### 4.1 Pollutant Emissions

Emissions were quantified among significant sources in the Kona area for comparison to $SO_2$ emissions from Kilauea volcano. The TPY maximum potential emissions of $PM_{2.5}$ and $PM_{2.5}$ precursors of $NO_2$ and $SO_2$ were quantified from stationary and temporary permitted sources. Actual $PM_{2.5}$, $NO_2$, and $SO_2$ emissions from Kona International Airport were added to the total anthropogenic emissions. The anthropogenic sources emit $PM_{2.5}$, $NO_2$, and $SO_2$ from fuel burning equipment. Anthropogenic emissions also include fugitive dust from vehicle travel on unpaved roads and plant processing (crushing and screening of aggregate, grinding of green waste, and asphalt production).

## 4.2 Stationary Sources

There are a number of permitted stationary sources operating in Kona. The Keahole Power Plant is the largest stationary source that includes three (3) combustion turbine generators; its location is identified on the map from Figure 2-6. The remaining facilities are smaller sources of emissions. Stationary sources operating in the Kona area are listed in the table 4-2:

| STATIONARY SOURCES | | | | | |
|---|---|---|---|---|---|
| No. | Facility | Type | Equipment | Distance From Kona Station (miles) | Distance From Ocean View Station (miles) |
| 1 | BRE/Waikoloa, LLC | Resort | Two 5.07 MMBtu/hr Boilers | 27.90 | 55.43 |
| 2 | Waste Management of Hawaii, Inc. | Aggregate Processing | 340 TPH Crushing Plant and 275 TPH Screening Plant | 26.11 | 53.37 |
| 3 | Captain Cook Coffee Company, Ltd. | Wholesale Coffee | Two 20 hp Coffee Bean Peelers | 1.69 | 30.11 |
| 4[a] | Hawaiian Electric Light Company | Electric Generation | Two 20 MW Combustion Turbine generators, Three 2.5 MW Diesel Engine Generators, and One 500 kW Black Start Diesel Engine Generator | 17.06 | 45.32 |
| 5[a] | Hawaiian Electric Light company | Electric Generation | One 18 MW Combustion Turbine Generator | 17.33 | 45.66 |
| 6 | Hawaiian Electric Light Company | Electric Generation | One 1.5 MW Diesel Engine Generator | 4.76 | 32.79 |
| 7 | Grace Pacific, LLC | Asphalt Plant | 325 TPH Asphalt Plant | 13.82 | 41.99 |
| 8 | Jas W. Glover, Ltd. | Concrete Batching | 150 $yd^3$/hr Concrete Batch Plant | 13.55 | 41.92 |
| 9 | West Hawaii Concrete | Concrete Batching | 150 $yd^3$/hr Concrete Batch Plant | 14.80 | 42.93 |
| 10 | Cremation Services of West Hawaii | Funeral Service | 150 lb/hr Pathological Waste Incinerator | 14.65 | 43.13 |
| 11 | A Hui Hou Funeral and Tribute Service | Funeral Service | 150 lb/hr Human Crematory Unit | 38.42 | 10.22 |

a: Nos. 4 and 5 designate equipment servicing one facility at the same location. There are two permits for equipment at this one facility. These permits are currently being consolidated into one permit.

**Table 4-2.** Stationary Sources

## 4.3 Temporary Sources

A majority of temporary permit sources in the Kona area emitting $PM_{2.5}$ and $PM_{2.5}$ precursors are crushing and screening plants that move from one site to another. Other temporary sources include various portable asphalt plants, a water well drilling rig, and a green waste processing facility. The temporary sources may operate outside Kona or on other islands. Temporary sources on outer islands may also relocate to Kona. Each temporary source must submit a Change of Location Request that requires the Department's approval prior to relocating equipment.  Table 4-3 summarizes information for temporary sources:

| TEMPORARY SOURCES | | |
|---|---|---|
| Facility | Type | Equipment |
| Various<br>Arrow of Oregon/Hawaiian, LLC<br>(random representative company) | Aggregate Processing | Various Equipment<br>Arrow of Oregon/Hawaiian, LLC has a 300 TPH Impact Plant, 400 TPH Impact Plant, and 500 TPH Screening Plant |
| Black Maui Rose, LLC | Asphalt Plant | 300 TPH Portable Asphalt Plant |
| Road and Highway Builders, LLC | Asphalt Plant | 400 TPH Portable Asphalt Plant |
| Keauhou Kona Construction Cor. | Asphalt Plant | 120 TPH Portable Asphalt Plant |
| Water Resources International, Inc. | Water Well Drilling | Two 300 hp Diesel Engines,  One 400 hp Diesel Engine, and Two 665 hp Diesel Engines |
| Menehune Green, LLC dba Hawaiian Earth Products | Green Waste Processing | 69 TPH Horizontal Grinder with 765 hp Diesel Engine |

**Table 4-3.** Temporary Sources

## 4.4 Kona International Airport

The Kona International Airport is another source of primary and secondary $PM_{2.5}$ emissions in the Kona area.  Currently, there are no permitted sources at the airport. Mobile sources, such as aircraft, and portable ground support equipment for servicing and starting aircraft are exempt from air permit requirements.  Table 4-4 below lists information for the airport.

| KONA INTERNATIONAL AIRPORT | | |
|---|---|---|
| Source | Distance From Kona Station (miles) | Distance From Ocean View  Station (miles) |
| Kona International Airport Various | 18.2 | 46.7 |

**Table 4-4.** Kona International Airport

## 4.5 Kilauea Volcano

Kilauea Volcano is an extremely large source of $SO_2$ emissions that affect the Kona area.  As indicated by U.S. Geological Survey (USGS), the $SO_2$ emitted from the volcano interacts chemically with atmospheric moisture, oxygen, dust, and sunlight to produce vog.  Table 4-5 below lists information for Kilauea volcano.

| KILAUEA VOLCANO | | |
|---|---|---|
| Source | Distance From Kona Station (miles) | Distance From Ocean View Station (miles) |
| Halema'uma'u Vent | 42.2 | 38.0 |
| Pu'u O'o Vent | 53.5 | 47.9 |

**Table 4-5.** Kilauea Volcano

4.6 Stationary Source Emissions

Maximum potential $PM_{2.5}$, $NO_2$, and $SO_2$ emissions from permitted stationary sources, assuming controls and permit limits, are shown in Table 4-6.

| STATIONARY SOURCE EMISSIONS | | | | | |
|---|---|---|---|---|---|
| No. | Facility | Equipment | Total Combined Emissions (TPY) | | |
| | | | $PM_{2.5}$ | $NO_2$ | $SO_2$ |
| 1 | BRE/Waikoloa, LLC | Two 5.07 MMBtu/hr Boilers | 0.01 | 3.2 | 0.4 |
| 2 | Waste Management of Hawaii, Inc. | 340 TPH Crushing Plant and 275 TPH Screening Plant | 1.2 | 6.6 | 1.9 |
| 3 | Captain Cook Coffee Company, Ltd. | Two 20 hp Coffee Bean Peelers | 2.2 | 0 | 0 |
| 4 | Hawaiian Electric Light Company | Two 20 MW Combustion Turbine Generators, Three 2.5 MW Diesel Engine Generators[b], and One 500 kW Black Start Diesel Engine Generator | 221.8[a] | 983.5 | 1,067.6 |
| 5 | Hawaiian Electric Light company | One 18 MW Combustion Turbine Generators | 87.6[a] | 170.8 | 481.8 |
| 6 | Hawaiian Electric Light Company | One 1.5 MW Diesel Engine Generator | 1.8 | 99.1 | 0.1 |
| 7 | Grace Pacific, LLC | 325 TPH Asphalt Plant | 1.4 | 21.8 | 4.6 |
| 8 | Jas W. Glover, Ltd. | 150 $yd^3$/hr Concrete Batch Plant | 29.4 | 10.4 | 3.2 |
| 9 | West Hawaii Concrete | 150 $yd^3$/hr Concrete Batch Plant | 13.3 | 0 | 0 |
| 10 | Cremation Services of West Hawaii | Two 150 lb/hr Pathological Waste Incinerators | 0.8[c] | 2.8 | 1.2 |
| 11 | A Hui Hou Funeral and Tribute Service | One 150 lb/hr Human Crematory Unit | 0.1 | 1.2 | 0.7 |
| | | Total → | 359.6 | 1,299.4 | 1,561.5 |

a: $PM_{2.5}$ emissions based on data for $PM_{10}$.
b: Two of three 2.5 MW diesel engine generators can operate 8,760 hr/yr. The third 2.5 MW diesel engine generator is limited to 70,000 gal/yr fuel consumption.
c: $PM_{2.5}$ emissions based on data for PM.

**Table 4-6.** Stationary Source Emissions

4.7 Temporary Source Emissions

Maximum potential $PM_{2.5}$, $NO_2$, and $SO_2$ emissions, assuming controls and permit limits, are listed in Table 4-7 for temporary permitted sources that would typically operate in the Kona area.

| TEMPORARY SOURCE EMISSIONS | | | | | |
|---|---|---|---|---|---|
| Source | Typical Number of Plants | Equipment | Total Emissions (TPY) | | |
| | | | $PM_{2.5}$ | $NO_2$ | $SO_2$ |
| Various | 20 | Various Equipment Arrow of Oregon/Hawaiian, LLC has a 300 TPH Impact Plant, 400 TPH Impact Plant, and 500 TPH Screening Plant | 46.0[a] | 456.0[a] | 82.0[a] |
| Asphalt Production Plants | 3 | 300 TPH Portable Asphalt Plant 400 TPH Portable Asphalt Plant 120 TPH Portable Asphalt Plant | 27.9 | 104.0 | 50.1 |
| Well Drilling Rig with Diesel Engines | 1 | Two 300 hp Diesel Engines, One 400 hp Diesel Engine, and Two 665 hp Diesel Engines | 2.1[b] | 39.2 | 0.1 |
| Green Waste Grinder and Diesel Engine | 1 | 69 TPH Horizontal Grinder with 765 hp Diesel Engine | 1.1 | 44.7 | 0.1 |
| | | Total→ | 77.1 | 643.9 | 132.3 |

a. Based on emissions from Arrow of Oregon/Hawaiian LLC (CSP No. 0738-01-CT) as a random representative source. Emissions from this facility were multiplied by 20 to approximate total combined emissions from all twenty (20) of the crushing and screening plants.

b. $PM_{2.5}$ emissions are based on emission estimates for $PM_{10}$.

**Table 4-7.** Temporary Source Emissions

## 4.8 Kona International Airport Emissions

Table 4-8 shows estimated actual emissions of $PM_{2.5}$, $NO_2$, and $SO_2$ from the Kona International Airport. Emissions were based on information from the National Emissions Inventory (NEI) for year 2011. The NEI data is not available for 2013.

| KONA INTERNATIONA AIRPORT EMISSIONS | | | | |
|---|---|---|---|---|
| Source | Equipment | Emissions (TPY)[a] | | |
| | | $PM_{2.5}$ | $NO_2$ | $SO_2$ |
| Kona International Airport | Various | 11.6 | 226.7 | 27.2 |

a: Based on NEI data for 2011.

**Table 4-8.** Kona International Airport Emissions

## 4.9 Anthropogenic Emissions

Total anthropogenic emissions of $PM_{2.5}$, $NO_2$, and $SO_2$ from significant sources in the Kona area are shown in Table 4-9.

| ANTHROPOGENIC EMISSIONS | | | |
|---|---|---|---|
| Source | Emissions (TPY) | | |
| | $PM_{2.5}$ | $NO_2$ | $SO_2$ |
| Stationary Permitted Sources | 359.6 | 1,299.4 | 1,561.5 |
| Temporary Permitted Sources | 77.1 | 643.9 | 132.3 |
| Kona International Airport | 11.6 | 226.7 | 27.2 |
| Total→ | 448.3 | 2,170.0 | 1,721.0 |

**Table 4-9.** Anthropogenic Emissions

## 4.10 Kilauea Volcano Emissions

As indicated by USGS, Kilauea volcano emits about 2,000 tons of $SO_2$ gas each day during periods of sustained eruption. Emissions of $SO_2$ from Kilauea Volcano were quantified for 2013, based on information provided by the USGS - HAVO. Table 4-10 provides emissions from the volcano.

| KILAUEA VOLCANO EMISSIONS | | |
|---|---|---|
| Source | Short Tons per Year | Metric Tons per Year |
| | 2013 | 2013 |
| Halema'uma'u Vent | 304,373 | 276,125 |
| Pu'u O'o Vent | 122,355 | 111,000 |
| Total→ | 426,728 | 387,125 |

**Table 4-10.** Kilauea Volcano Emissions

## 4.11 Anthropogenic and Volcanic Emissions

Figure 4-1 provides a comparison between $PM_{2.5}$, $NO_2$, and $SO_2$ emissions from anthropogenic sources and $SO_2$ emissions from the volcano in 2013.

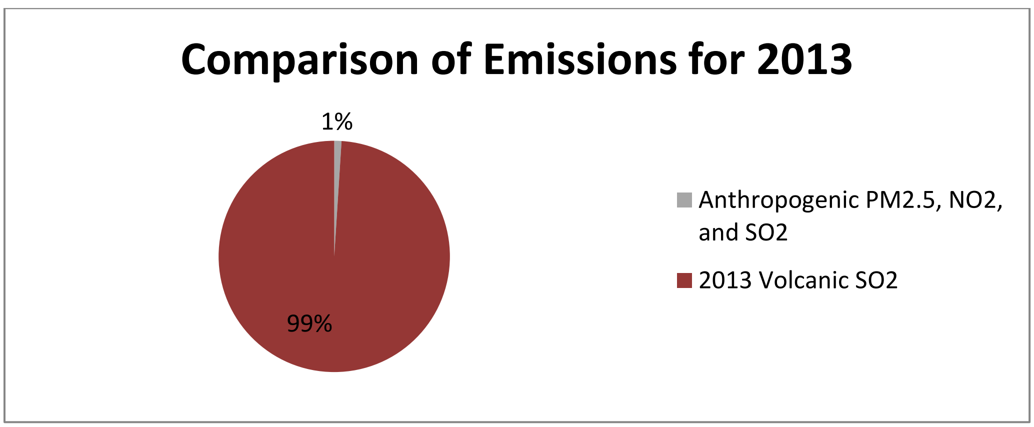



**Figure 4-1.** Comparison of Emissions for 2013

## 4.12 Regulatory Measures and Air Pollution Controls

The Department of Health is responsible for implementing measures specified in the applicable regulations to control pollutants from stationary and temporary sources. Requirements from the following regulations are incorporated into permits of facilities in the Kona area according to the applicable source category:

1) Hawaii Administrative Rules (HAR);
2) PSD/BACT, §52.21;
3) 40 CFR Part 60, Subpart OOO, NSPS, Standards of Performance for Nonmetallic Mineral Processing Plants;
4) 40 CFR Part 60, Subpart I, NSPS, Standards of Performance for Hot Mix Asphalt Facilities;

5) 40 CFR Part 60, Subpart GG, NSPS, Standards of Performance for Stationary Gas Turbines; and
6) 40 CFR Part 63, Subpart ZZZZ, NESHAP for Stationary Reciprocating Internal Combustion Engines.

Table 4-11summarizes regulations that apply to sources in the Kona area that provide control requirements to minimize $PM_{2.5}$ and $PM_{2.5}$ precursors of $NO_2$ and $SO_2$.

| No. | Source | Regulation(s) | Regulatory Measures for PM2.5, $NO_2$, and $SO_2$ |
|---|---|---|---|
| 1 | BRE/Waikoloa, LLC[a,b]<br>Two 5.07 MMBtu/hr Boilers | HAR | Provides stack opacity standards. |
| 2 | Waste Management of Hawaii, Inc.[a]<br>Crushing and & Screening Plant | HAR | Provides standards for stack opacity and visible emissions of fugitive dust from and beyond property. |
| 3 | Captain Cook Coffee Company, Ltd. Two Coffee Bean Peelers | HAR | Provides stack opacity standards. |
| 4 | Hawaiian Electric Light Company[a]<br>Two 20 MW Combustion Turbine Generators, Three 2.5 MW Diesel Engine Generators, and One 500 kW Black Start Diesel Engine Generator | HAR<br>Subpart ZZZZ<br><br><br><br>Subpart GG<br>PSD | Provides stack opacity standards.<br>Specifies ultra-low sulfur fuel for diesel engine generators. Requires particulate control measures for engine crankcase.<br><br>Specifies $NO_2$ controls.<br>Provides combustion turbine BACT emission limits for PM, $NO_2$, and $SO_2$ among other pollutants.<br>Provides diesel engine generator BACT emission limit for $NO_2$.<br><br>Continuous emission monitoring systems (CEMS) for combustion turbine $NO_2$ limit as well as other pollutant emission limits.<br>Continuous opacity monitor system (COMS) for combustion turbine opacity.<br><br>Monthly visible emission evaluations performed for diesel engine generator stack opacity.<br><br>Performance testing conducted at least every two years to determine compliance with combustion turbine BACT limits. |
| 5 | Hawaiian Electric Light Company[a]<br>One 18 MW Combustion Turbine Generator | HAR<br>Subpart GG<br>PSD | Provides stack opacity standards.<br>Specifies $NO_2$ controls.<br><br>Provides combustion turbine BACT emission limits for PM, $NO_2$, and $SO_2$ among other pollutants.<br><br>CEMS for combustion turbine $NO_2$ limit as well as other pollutant emission limits.<br>COMS for combustion turbine opacity.<br>Performance testing at least every two years for BACT emission limits. |

| No. | Source | Regulation(s) | Regulatory Measures for PM2.5, $NO_2$, and $SO_2$ |
|---|---|---|---|
| 6 | Hawaiian Electric Light Company[a]<br>One 1.5 MW Diesel Engine Generator | HAR<br>Subpart ZZZZ | Provides opacity standards.<br>Specifies ultra-low sulfur fuel for the diesel engine generator. Requires particulate control measures for engine crankcase. |
| 7 | Grace Pacific, LLC[a]<br>325 TPH Asphalt Plant | HAR<br><br><br>Subpart ZZZZ<br><br><br><br>Subpart I | Provides standards for stack opacity and visible emissions of fugitive dust from and beyond the property.<br>Specifies ultra-low sulfur fuel for diesel engine generator. Requires particulate control measures for engine crankcase.<br>Provides opacity and particulate emissions standards for drum mixer dryer.<br>Monthly visible emissions evaluations for stack opacity.<br>Performance testing of drum mixer dryer at least every two years for particulate matter emission limit and opacity. |
| 8 | Jas W. Glover[a]<br>150 $yd^3$/hr Concrete Batch Plant | HAR | Provides standard for visible emissions of fugitive dust from and beyond the property. |
| 9 | West Hawaii Concrete[a]<br>150 $yd^3$/hr Concrete Batch Plant | HAR | Provides standard for fugitive dust from and beyond the property. |
| 10 | Cremation Services of West Hawaii[a] - 150 $yd^3$/hr Pathological Waste Incinerator | HAR | Provides stack opacity standards. |
| 11 | A Hui Hou Funeral and Tribute Service[a] - 150 $yd^3$/hr Crematory | HAR | Provides stack opacity standards. |
| ---- | Arrow of Oregon/Hawaiian, LLC[c,d,e]<br>(random representative company)<br><br>Crushing and Screening Equipment | HAR<br><br><br>Subpart OOO | Provides standards for stack opacity and visible emissions of fugitive dust from and beyond property.<br>Provides fugitive dust opacity standards.<br>Monthly visible emissions evaluations for fugitive emissions and stack opacity.<br>Performance testing at least every two years for fugitive dust opacity limits. |
| ----- | Black Maui Rose, LLC[c]<br>Road and Highway Builders, LLC[c]<br>Keauhou Kona Construction Corporation[c]<br><br>Portable Asphalt Plants | HAR<br><br><br>Subpart I | Provides standards for stack opacity and visible emissions of fugitive dust from and beyond the property.<br>Provides particulate emission limit and opacity standards for drum mixer dryer.<br>Monthly visible emissions evaluations for stack opacity.<br>Performance testing at least every two years for drum mixer dryers for opacity and particulate matter emission limits. |
| ----- | Water Resources International, Inc.[c]<br>Temporary Water Well Drilling Rig with Portable Diesel Engine Gen. | HAR | Provides stack opacity standards. |
| ----- | Menehune Green, LLC dba Hawaiian Earth Products[c]<br>Portable Green Waste Grinder | HAR | Provides standards for stack opacity and visible emissions of fugitive dust from and beyond the property. |

a. Stationary source.
b. Subpart JJJJJJ, NESHAP for Area Sources: Industrial Commercial, and Institutional Boilers will apply in 2014 that will require biennial boiler tune ups.

c. Temporary source.
d. Temporary sources consist of 19 covered sources and 1 noncovered source.
e. Covered sources are subject to both HAR and Subpart OOO. Noncovered source is only subject to requirements from HAR.

**Table 4-11.** Regulatory Measures for Anthropogenic Sources

Table 4-12 summarizes control measures utilized by sources in the Kona area to minimize $PM_{2.5}$ and $PM_{2.5}$ precursors of $NO_2$ and $SO_2$.

| No. | Source | Air Pollution Control Measures |
|---|---|---|
| 1 | BRE/Waikoloa, LLC[a]<br>Two 5.07 MMBtu/hr Boilers | Proper maintenance and operation for stack opacity. |
| 2 | Waste Management of Hawaii, Inc.[a]<br>Crushing and & Screening Plant | Wet suppression methods for fugitive dust.<br>Proper maintenance and operation for stack opacity. |
| 3 | Captain Cook Coffee Company, Ltd.[a]<br>Two Coffee Bean Peelers | Cyclone dust collector for peelers to control particulate and for opacity.<br>Proper maintenance and operation for stack opacity. |
| 4 | Hawaiian Electric Light Company[a]<br>Two 20 MW Combustion Turbine Generators, Three 2.5 MW Diesel Engine Generators, and One 500 kW Black Start Diesel Engine Generator | Selective catalytic reduction (SCR) and water injection for combustion turbine to control $NO_2$.<br>Burning ultra-low sulfur fuel to minimize $SO_2$ from diesel engine generators.<br>Crankcase filtration systems for diesel engine generators to control particulate.<br>Proper equipment maintenance & operation for opacity. |
| 5 | Hawaiian Electric Light Company[a]<br>One 18 MW Combustion Turbine Generator | Water injection system for combustion turbine to control $NO_2$. Proper maintenance & operation for stack opacity. |
| 6 | Hawaiian Electric Light Company[a]<br>One 1.5 MW Diesel Engine Generator | Ultra-low sulfur fuel fired by unit to minimize $SO_2$.<br>Crankcase filtration system for engine to minimize particulate emissions |
| 7 | Grace Pacific, LLC[a]<br>325 TPH Asphalt Plant | Wet suppression methods for fugitive dust.<br>Baghouse for drum mixer dryers to control particulate for opacity and particulate matter emission limits.<br>Proper maintenance and operation for stack opacity. |
| 8 | Jas W. Glover[a]<br>150 $yd^3$/hr Concrete Batch Plant | Wet suppression measures for fugitive dust.<br>Baghouses for transit mix truck and cement silo loading. |
| 9 | West Hawaii Concrete[a]<br>150 $yd^3$/hr Concrete Batch Plant | Wet suppression measures for fugitive dust.<br>Baghouses for transit mix truck and cement silo loading. |
| 10 | Cremation Services of West Hawaii[a]<br>150 $yd^3$/hr Pathological Waste Incinerator | Wet suppression measures for fugitive dust.<br>Baghouses for transit mix truck and cement silo loading. |
| 11 | A Hui Hou Funeral and Tribute Service[a]<br>150 $yd^3$/hr Crematory | Secondary chamber to reduce particulate.<br>Proper maintenance and secondary chamber for stack opacity. Visual alarm if opacity exceeds 10%. |
| ---- | Arrow of Oregon/Hawaiian, LLC[b]<br>(random representative company)<br>Crushing and Screening Equipment | Wet suppression measures for fugitive dust.<br>Proper maintenance and operation for stack opacity. |
| ----- | Black Maui Rose, LLC[b]<br>Road and Highway Builders, LLC[b]<br>Keauhou Kona Construction Corporation[b]<br>Portable Asphalt Plants | Wet suppression methods for fugitive dust.<br>Baghouses to control particulate from drum mixer dryers for opacity and particulate matter emissions limit.<br>Proper maintenance and operation for stack opacity. |
| ----- | Water Resources International, Inc.[b]<br>Temporary Water Well Drilling Rig with Portable Diesel Engine Generators | Proper maintenance and operation for stack opacity. |
| ----- | Menehune Green, LLC dba Hawaiian Earth Products[b]<br>Portable Green Waste Grinder | Wet suppression methods for fugitive dust.<br>Proper maintenance and operation for stack opacity. |

a. Stationary source.
b. Temporary source.

**Table 4-12.** Air Pollution Control Measures for Anthropogenic Sources

## 4.13 Inspections

Permitted sources found in Tables 4-2 and 4-3 are regularly inspected to ensure compliance with applicable requirements. Title V sources are inspected each year and minor sources are inspected at least every three (3) to five (5) years. Complaints are also investigated that may involve either Title V or minor sources.

Inspection reports and correspondence were reviewed from 2011 to 2013 for the sources found in Tables 4-2 and 4-3. The review found no indication of source noncompliance with standards involving $PM_{2.5}$ (including fugitive dust), $NO_{2,}$ and $SO_2$ emissions.

## Section 5. Historical Norm

Prior to the opening of the new vent at Halema'uma'u, there was no $PM_{2.5}$ monitoring being conducted at the Kona station, nor at any of the other air monitoring stations on the Big Island. The earliest $PM_{2.5}$ monitoring began at the Kona station in March 2008, Pahala in April 2008, and Hilo in May 2008, necessitated by the increase of volcanic emissions and concern for public health and safety. Since no $PM_{2.5}$ data is available prior to 2008, there is no possible way to show that "the exceptional event is associated with a measured $PM_{2.5}$ concentration in excess of normal historical fluctuations."

However, historical $SO_2$ monitoring data is available for the Kona and Hilo stations beginning in 2000. Sampling for $SO_2$ at the Pahala station began on August 10, 2007. Figure 5-1 below shows the annual average of measured $SO_2$ at the three stations. The chart shows an increase in measured $SO_2$ at the three stations beginning 2008, coinciding with the March 18, 2008 Halema'uma'u event. As shown in Figure 5-1, the average $SO_2$ concentrations at the Kona and Hilo monitors were 0.0035 and 0.0030 ppm for 2000-2007 (pre Halema'uma'u event), as compared with 0.0053 and 0.0043 ppm for 2009-2013 respectively. As explained in previous sections of this report, the increased $SO_2$ emissions correlate with the increase in measured $PM_{2.5}$ concentrations.

Taking into consideration the correlation between $SO_2$ emissions and measured $PM_{2.5}$ concentrations, the information presented in this chart show that "the exceptional event is associated with a measured concentration in excess of normal historical fluctuations."

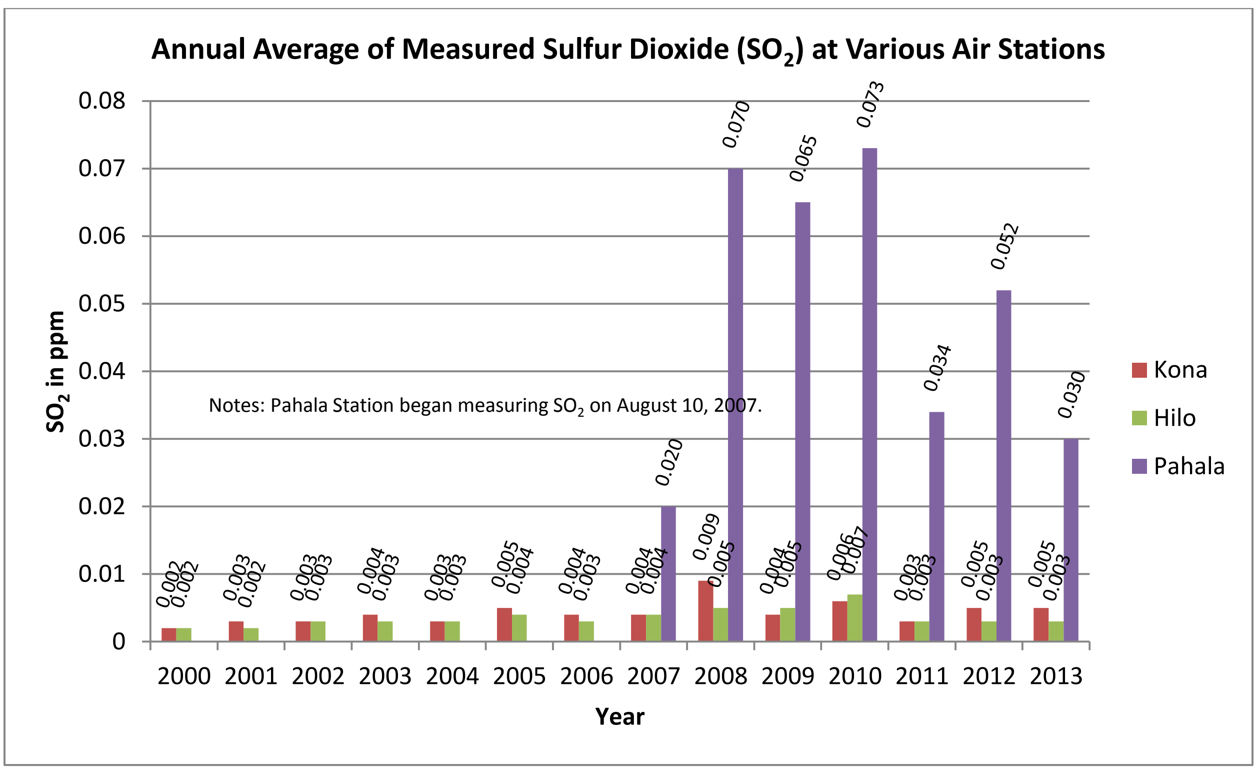



**Figure 5-1.** Annual Average of Measured $SO_2$ at Various Air Stations

To further emphasize $SO_2$ concentrations in excess of normal historical fluctuations, Figures 5-2 and 5-3 provide a cumulative distribution of 1-hr $SO_2$ measured at the Kona Station for the 0-100 and 75-100 percentile ranges, respectively. Daily 1-hr $SO_2$ concentrations were plotted with data recorded both before and after the Halema'uma'u vent opened in 2008. The plots show that there are much higher daily 1-hr $SO_2$ concentrations in the 90 to 100 percentile range after the Halema'uma'u vent opened in 2008.

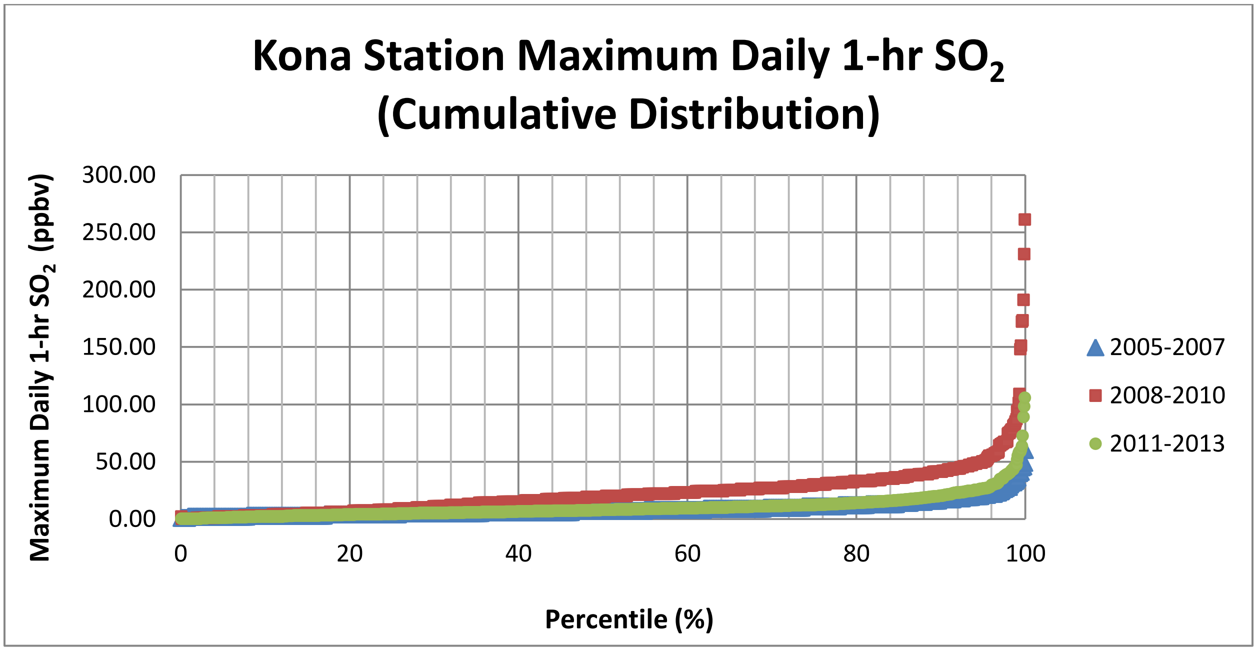



**Figure 5-2.** Kona Station Maximum Daily 1-hr $SO_2$ (0-100%)

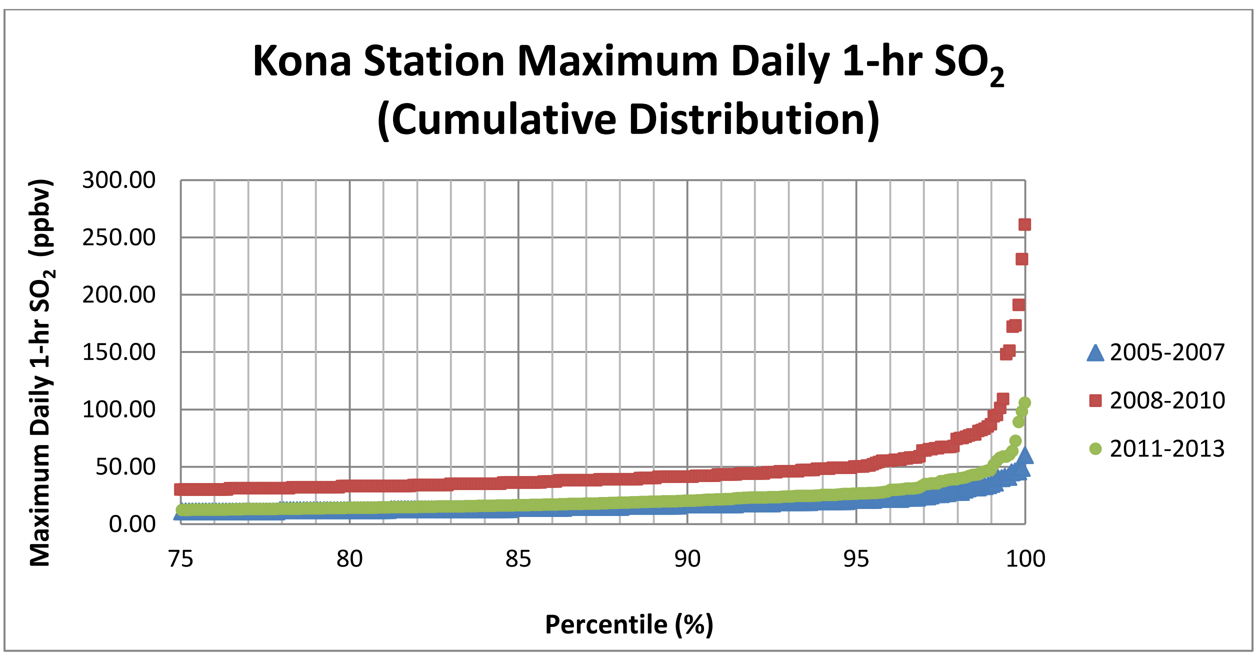



**Figure 5-3.** Kona Station Maximum Daily 1-hr $SO_2$ (75-100%)

## Section 6. "But-for" Analysis/Conclusions

The $PM_{2.5}$ exceedance of the annual monitored $PM_{2.5}$ concentration in 2013, satisfy the criteria of the EER, which states that in order to justify the exclusion of air quality monitoring data, evidence must be provided for the following elements:

- The event satisfies the criteria set forth in 40 CFR 50.1(j) that
    a. The event affected air quality,
    b. The event was not reasonably controllable or preventable, and
    c. The event was caused by human activity unlikely to recur in a particular location or was a natural event;

- There is a clear causal relationship between the measurement(s) under consideration and the event;

- The event is associated with a measured concentration(s) in excess of normal historical fluctuations; and

- There would have been no exceedance or violation but for the event.

### 6.1 Affects Air Quality

As stated in the preamble to the EER, the event in question is considered to have affected air quality if it can be shown that there is a clear causal relationship between the monitored exceedance and the event, and that the event is associated with a measured concentration in excess of normal historical fluctuations. Given the information presented in Sections 2, 3, 4, and 5, we can reasonably conclude that the event in question affected air quality.

### 6.2 Not Reasonably Controllable or Preventable

Section 50.1(j) of 40 CFR Part 50 requires that an event must be "not reasonably controllable or preventable" in order to be defined as an exceptional event. This requirement is met by demonstrating that despite reasonable control and inspection measures in place for anthropogenic sources operating within the Kona area, continuous volcanic emissions overwhelmed all reasonably available controls (Section 4, pages 50-59).

The $PM_{2.5}$ exceedance discussed in this report was caused by the naturally occurring eruptions from Kilauea volcano that emitted extremely large quantities of $SO_2$ which transformed to sulfates on the pathway of transport into the Kona area. The transport path and magnitude of $SO_2$ emissions associated with the volcanic eruptions provide strong evidence that the exceedance of the annual monitored $PM_{2.5}$ concentration in 2013 at the Kona air monitoring station was not reasonably controllable or preventable.

6.3 Natural Event

As discussed above, the exceedance of the annual monitored $PM_{2.5}$ concentrations in 2013 was shown to be caused by transport of volcanic emissions into the Kona area. Also, contributing anthropogenic emissions in the Kona area were reasonably controlled and significantly lower in magnitude than those from the volcano. The event therefore qualifies as a natural event.

6.4 Clear Causal Relationship

The following points demonstrate that the high $PM_{2.5}$ concentrations were caused by volcanic emissions:

- According to the USGS, $SO_2$ released from the volcano creates vog when $SO_2$ reacts chemically with sunlight, oxygen, dust particles, and moisture in the air to form sulfate aerosols (fine particles) (Section 2, page 12).

- The USGS indicates that trade winds blow the vog from its main source on the volcano to the southwest, where wind patterns send it up the Kona coast. Also, the vog becomes trapped along the Kona coast by daytime (onshore) and nighttime (offshore) breezes (Section 2, page 6 and Section 3, pages 20-21 and 33-43).

- Air monitoring data for 2013 in Tables 3-2a and b and 3-3a and b of Section 3 show a decrease in annual $SO_2$ concentration from Pahala to Ocean View stations and a further decrease from Ocean View to Kona stations while there is an increase in annual $PM_{2.5}$ concentration from Kona to Ocean View stations and an additional increase from Ocean View to Pahala stations. This is consistent with what would be expected as $SO_2$ is converted to sulfates in the wake of the volcano's plume as it drifts from Pahala-to-Ocean View-to-Kona. This demonstrates a clear causal link between $SO_2$ released by the volcano, the time necessary to form sulfates in the presence of sunlight and atmospheric constituents, the volcanic plume transport path, and monitored concentrations (Section 3, pages 24-26).

- Similar concentration versus time plots of air quality data from the Kona and Ocean View air monitoring stations indicate a large regional source is affecting air quality at the monitoring sites. The Kilauea volcano is a large regional source that is not reasonably controllable or preventable and overwhelms the quantity of emissions from anthropogenic sources (Section 3, pages 26-33 and Section 4, page 55).

- Emissions of $PM_{2.5}$ and $PM_{2.5}$ precursors of $NO_2$ and $SO_2$ from anthropogenic sources in the Kona area are only 1% of the total emissions (anthropogenic $PM_{2.5}$, $NO_2$, and $SO_2$ + volcanic $SO_2$). These anthropogenic sources are also scattered in location on the island. Therefore, anthropogenic sources cannot be the cause of correlation in pollutant concentrations measured at the Kona and Ocean View air monitoring sites. The air pollution control and inspection measures for permitted sources are adequate and should be considered reasonable for minimizing primary and secondary $PM_{2.5}$ (Section 4, pages 55-59).

- Satellite OMI measurements of $NO_2$ that is high around Oahu and low over the entire Island of Hawaii indicate anthropogenic emissions are not the primary source of $PM_{2.5}$ that caused exceedances at the Kona air monitoring station.

- Table 4-1 from Section 4, shows a higher annual $PM_{2.5}$ concentration measured at the Kona air monitoring station in 2012 and 2013 than in 2011. The higher concentration measured in 2012 and 2013 is likely attributed to larger $SO_2$ emissions from the volcano's Halema'uma'u vent.

- The Halema'uma'u vent, being situated at a higher elevation and further inland, appears to have a greater impact on the more populated areas of the island than the Pu'u O'o vent, which is situated at a lower elevation and closer to the coast. This would indicate a clear causal connection between the quantity of emissions released from the Halema'uma'u vent and annual $PM_{2.5}$ exceedances measured in 2013 from the Kona air monitoring station (Section 4, page 55).

- Although Hilo has large sources that include power plants, emissions from the Hilo area would rarely follow the same transport path as emissions from the volcano. Due to the topographic effects of Mauna Kea and Mauna Loa, a dominant southerly flow exists that reduces the likelihood of pollutants from Hilo impacting the Kona area (Section 3.2.E, page 42).

- Due to the unique topography of the Big Island, no other monitor exists that could serve as a surrogate with like topography and meteorology for what the Kona monitor might read if the volcano was not present. We note however, that except for the Kona station, all other state monitoring sites show compliance with the annual standard for $PM_{2.5}$. The Campbell Industrial Park monitor (Kapolei monitor AQS ID 150030010) on Oahu, with larger nearby anthropogenic sources than the Kona monitor, measure annual $PM_{2.5}$ concentrations of 5.2, 7.0, and 2.8 $\mu g/m^3$ for 2011, 2012, and 2013 respectively (Section 3.2.F, page 43).

## 6.5 Historical Norm

Concentrations of $SO_2$ in excess of historical fluctuations were measured after the Halema'uma'u vent opened in 2008. Air monitoring data in Figures 5-1 through 5-3 of Section 5 show increased $SO_2$ concentrations associated with the opening of the Halema'uma'u vent. Considering the transport path and magnitude of $SO_2$ emissions associated with the volcano plume, there would have been no exceedances of the annual $PM_{2.5}$ standard but for the naturally occurring and ongoing eruption of Kilauea volcano.  This demonstrates an event that is associated with a measured concentration in excess of normal fluctuations (Section 5, pages 60 and 61).

## 6.6 But For

On the basis of the weight of evidence described above, the exceedance of the federal annual $PM_{2.5}$ standard in 2013, in the Kona area would not have occurred but for the continuous volcanic emissions from Kilauea volcano and transport of sulfate aerosols (fine particles) to the Kona area.

References:

1. United States Geological Survey, Hawaiian Volcano Observatory, "Volcanic Hazards, Frequently Asked Questions about Air Quality in Hawai`i", Updated: 18 December 2012; http://hvo.wr.usgs.gov/hazards/FAQ_$SO_2$-Vog-Ash/P1.html

2. State of Hawaii, Department of Health Environmental Management Division, Clean Air Branch and State Laboratories Division, Air Surveillance and Analysis Section, "State of Hawaii 2013 Air Monitoring Network Plan", Submitted to the U.S. EPA Region 9: July, 1, 2013; http://health.hawaii.gov/cab/files/2013/05/Air_Monitoring_Network_Plan_2013.pdf

3. United States Geological Survey, Hawaiian Volcano Observatory, "Volcano Watch, Kilauea sulfur dioxide emissions down by 90% ", March 7, 1997; http://hvo.wr.usgs.gov/volcanowatch/archive/1997/97_03_07.html

4. United States Geological Survey, Hawaiian Volcano Observatory, "Volcano Watch, In every volcanic paradise, a little vog must fall ", August 14, 2008; http://hvo.wr.usgs.gov/volcanowatch/archive/2008/08_08_14.html

5. United States Geological Survey, Hawaiian Volcano Observatory, "Recent Kilauea Status Reports, Updates, and Information Releases, HAWAIIAN VOLCANO OBSERVATORY DAILY UPDATE"; http://hvo.wr.usgs.gov/hazards/FAQ_$SO_2$-Vog-Ash/P1.html

6. T. Elias and A.J. Sutton, United States Geological Survey, "Sulfur Dioxide Emission Rates from Kilauea Volcano, Hawai‘i, 2007–2010."  ; http://pubs.usgs.gov/of/2012/1107/

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10. United States Environmental Protection Agency, Technology Transfer Network (TTN), Air Quality System (AQS) Data Mart, Direct Interface; http://www.epa.gov/ttn/airs/aqsdatamart/access/interface.htm

11. University of Utah, MesoWest, Weather Observations;  http://mesowest.utah.edu/

12. Wikipedia, "Pearson product-moment correlation coefficient"; http://en.wikipedia.org/wiki/Pearson_product-moment_correlation_coefficient

13. Hawaii, Department of Health, Clean Air Branch, "Clean Air Branch (CAB) 2012 Performance Audit Data - Hilo, Kona, Mountain View, Pahala, Puna E., and Waikoloa Monitoring Stations", October 18, 2012, 12-850M&A CAB.

## Appendix A

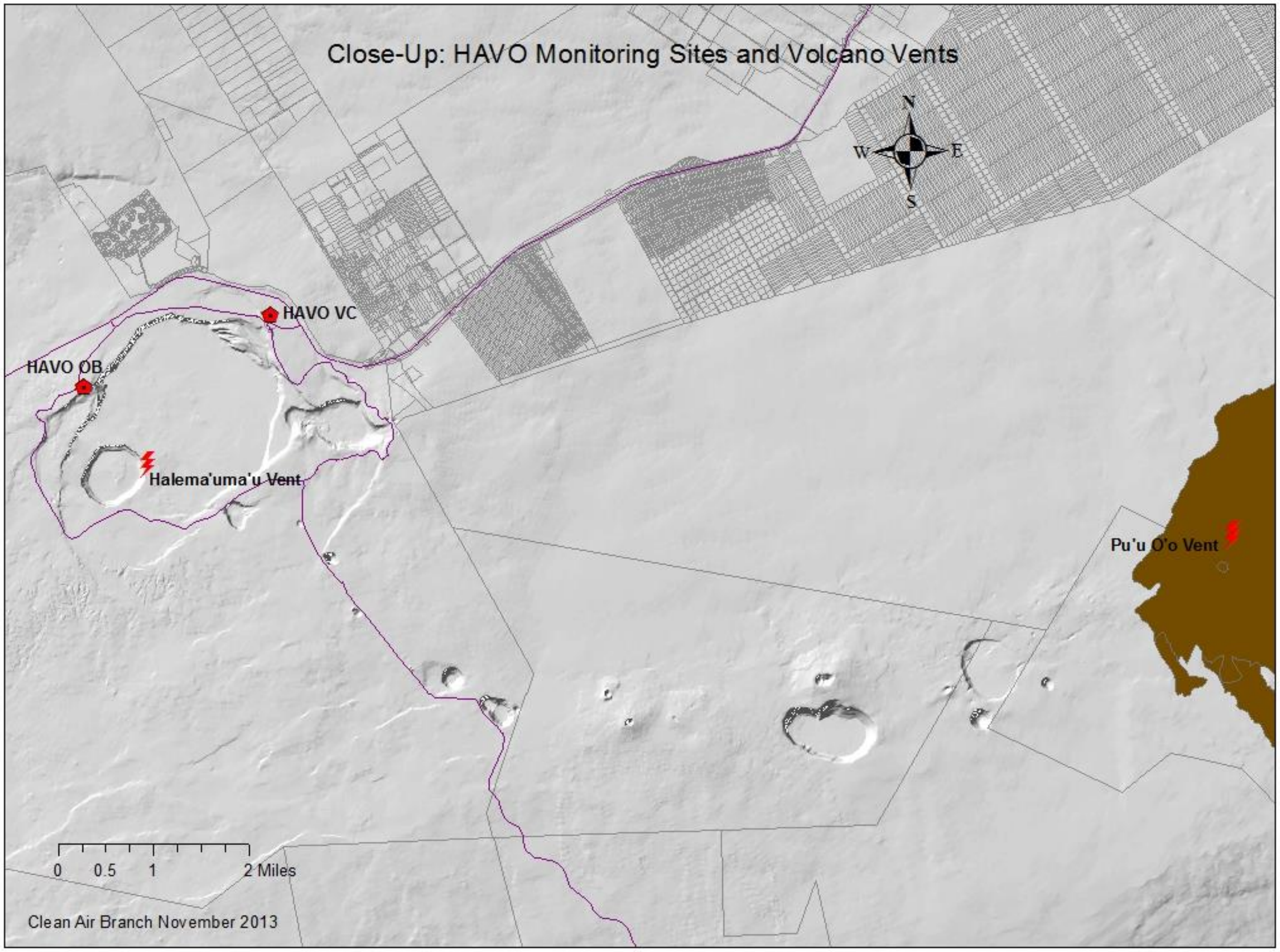



**Figure A-1.** Hawaii Volcanoes (HAVO) Monitoring Sites and Kilauea Volcano Vent

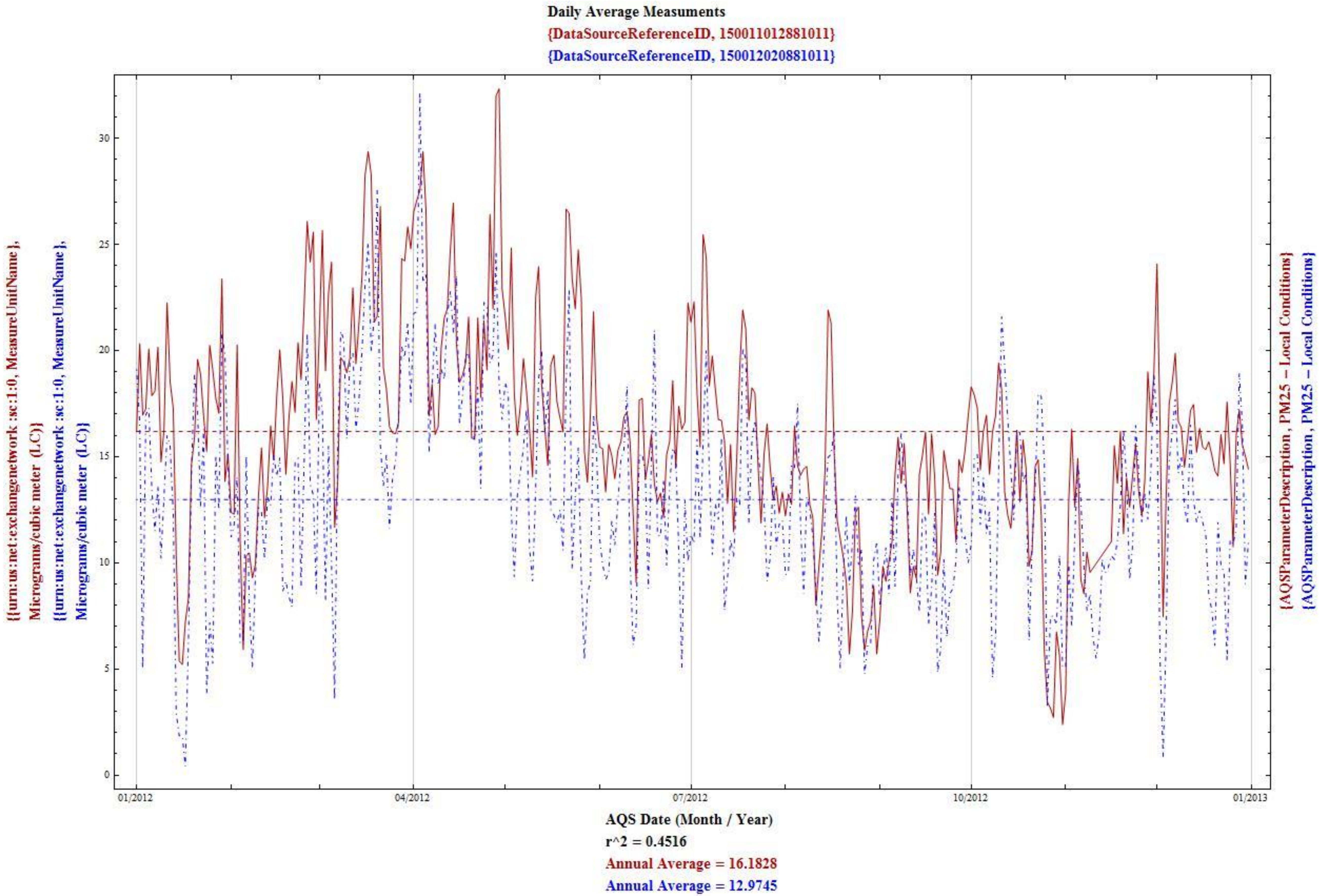



**Figure A-2.** 2012 Time History of Kona (red) and Ocean View (blue) $PM_{2.5}$ Concentrations (unsmoothed data)

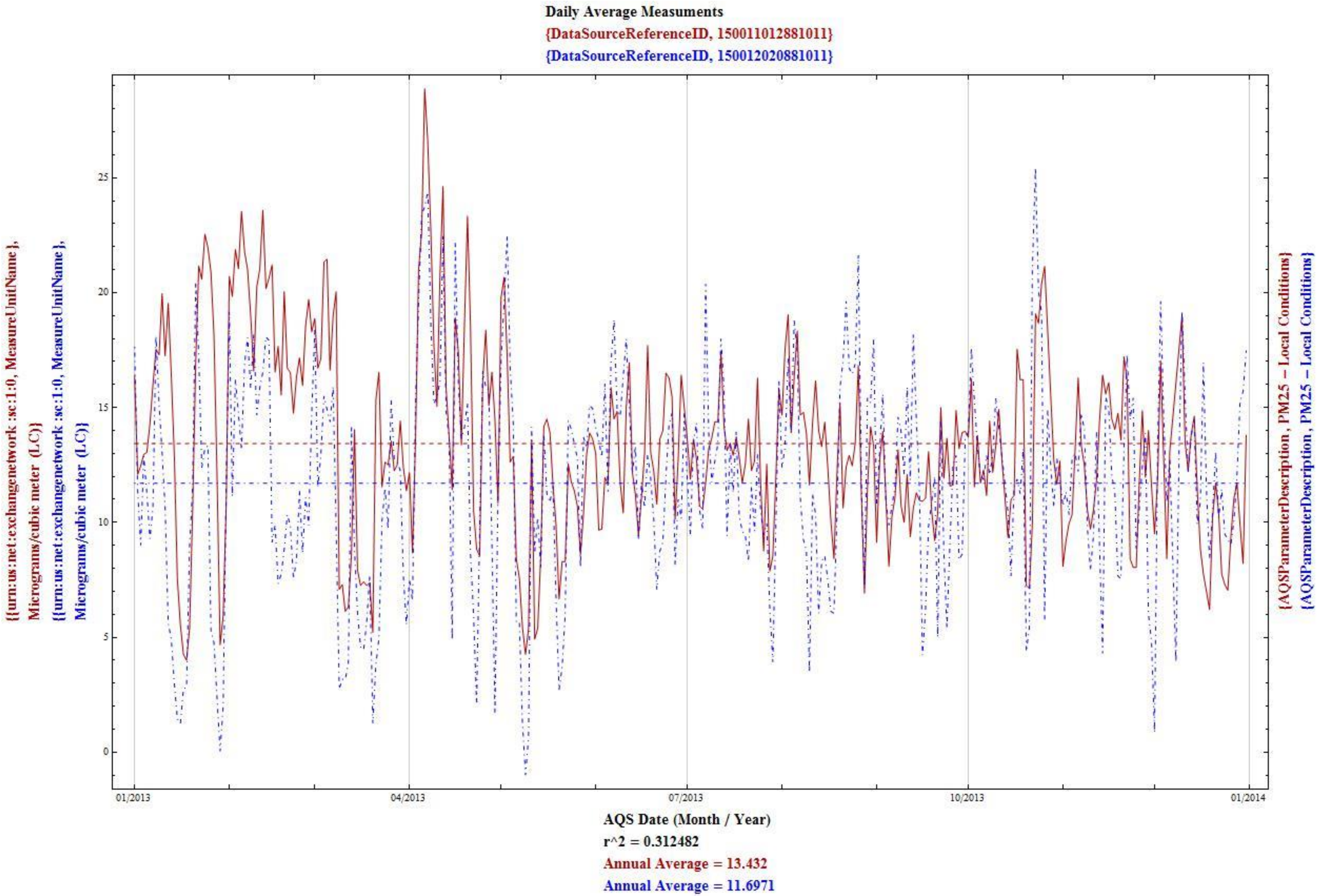



**Figure A-3.** 2013 Time History of Kona (red) and Ocean View (blue) $PM_{2.5}$ Concentrations (unsmoothed data)

AN155y2013.xls–2013: Hour = 0

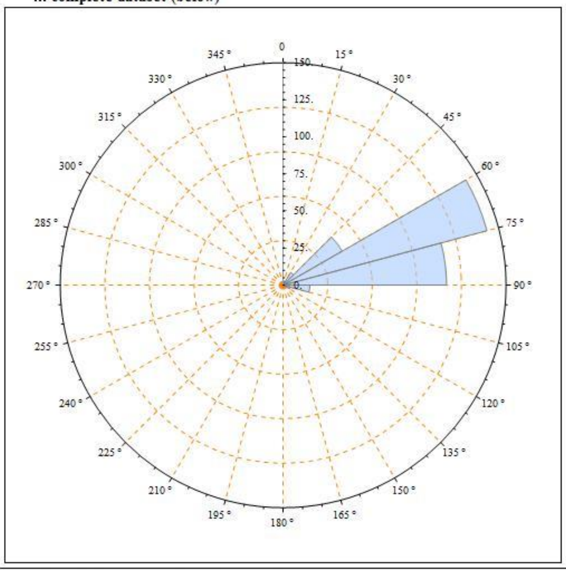
Data Info: Windrose

Number of Datasets = 338

... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 0, 0, 0.} | 2.2 | 75. | N/A | 1–1–2013 0:00 HST |

... complete dataset (below)



AN155y2013.xls–2013: Hour = 1

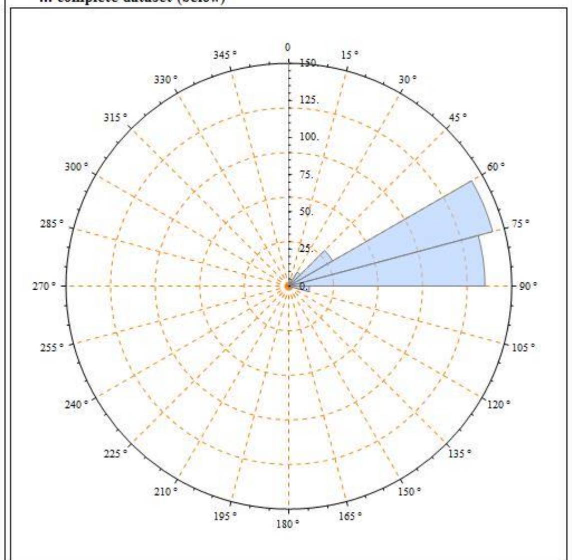
Data Info: Windrose

Number of Datasets = 342

... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 1, 0, 0.} | 2.5 | 78. | N/A | 1–1–2013 1:00 HST |

... complete dataset (below)



AN155y2013.xls–2013: Hour = 2

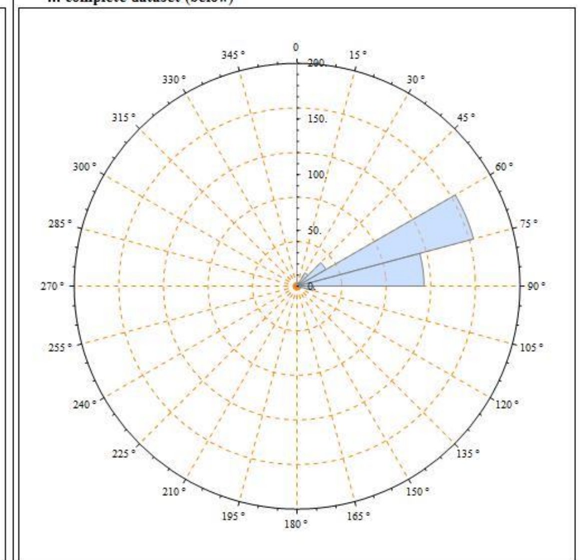
Data Info: Windrose

Number of Datasets = 344

... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 2, 0, 0.} | 2. | 76. | N/A | 1–1–2013 2:00 HST |

... complete dataset (below)



AN155y2013.xls–2013: Hour = 3

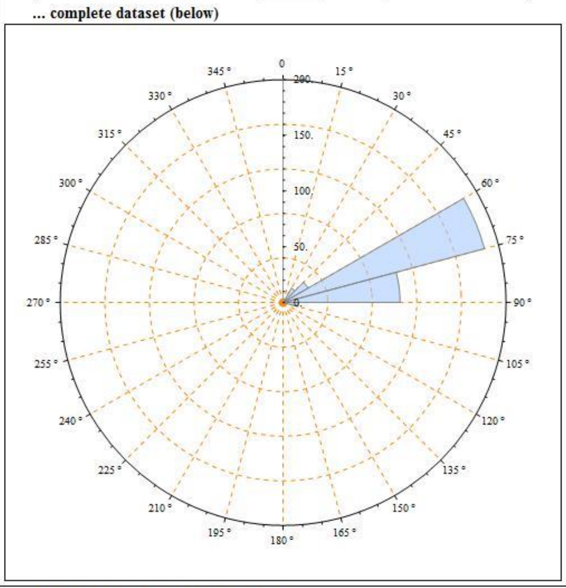
Data Info: Windrose

Number of Datasets = 349

... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 3, 0, 0.} | 2.3 | 74. | N/A | 1–1–2013 3:00 HST |

... complete dataset (below)



AN155y2013.xls–2013: Hour = 4

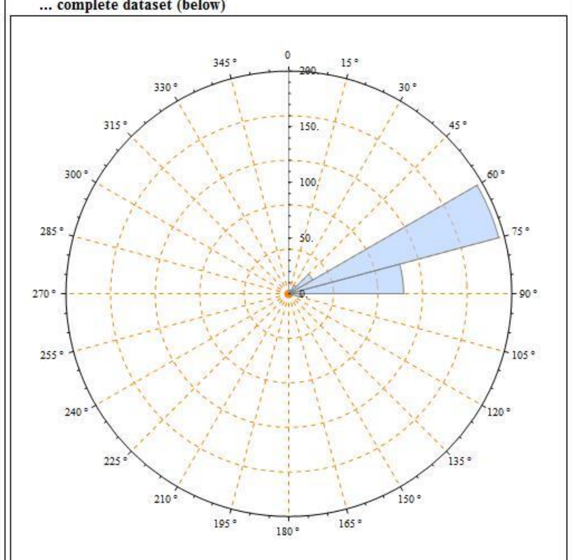
Data Info: Windrose

Number of Datasets = 347

... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 4, 0, 0.} | 2.1 | 68. | N/A | 1–1–2013 4:00 HST |

... complete dataset (below)



AN155y2013.xls–2013: Hour = 5

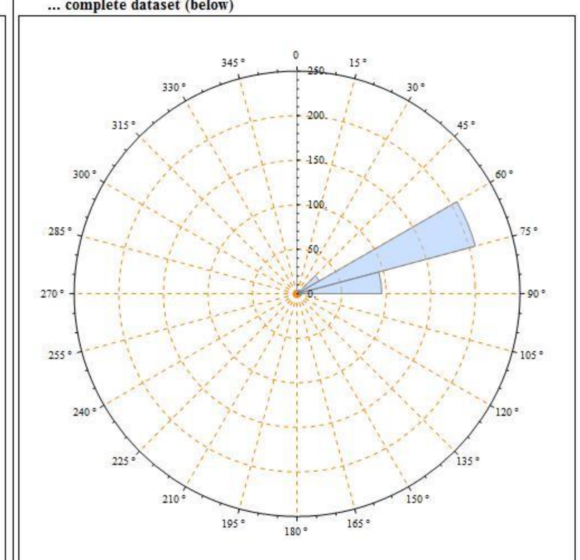
Data Info: Windrose

Number of Datasets = 345

... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 5, 0, 0.} | 2.3 | 71. | N/A | 1–1–2013 5:00 HST |

... complete dataset (below)



AN155y2013.xls–2013: Hour = 6

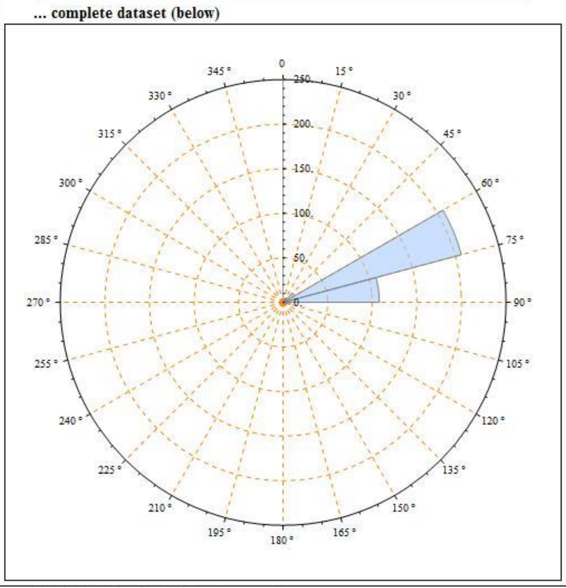
Data Info: Windrose

Number of Datasets = 347

... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 6, 0, 0.} | 2.4 | 70. | N/A | 1–1–2013 6:00 HST |

... complete dataset (below)



AN155y2013.xls–2013: Hour = 7

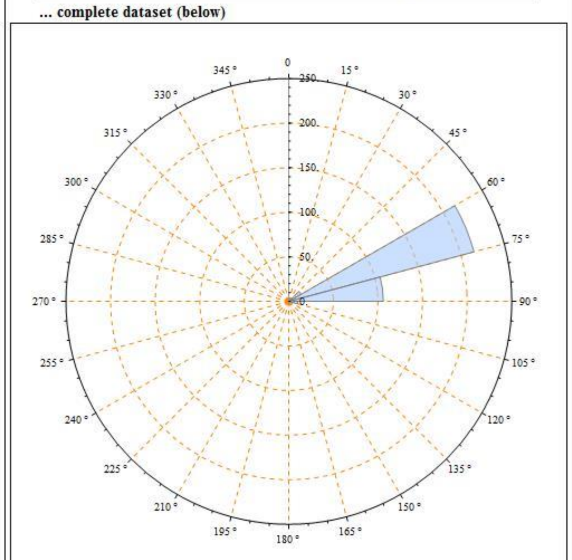
Data Info: Windrose

Number of Datasets = 354

... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 7, 0, 0.} | 2.1 | 69. | N/A | 1–1–2013 7:00 HST |

... complete dataset (below)



AN155y2013.xls–2013: Hour = 8

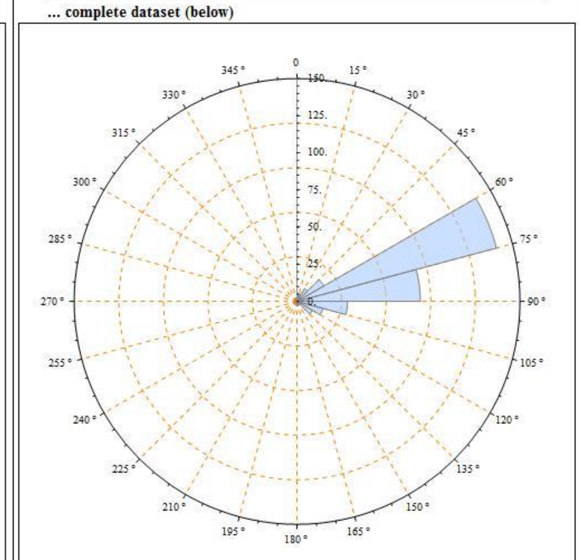
Data Info: Windrose

Number of Datasets = 342

... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 8, 0, 0.} | 2.1 | 73. | N/A | 1–1–2013 8:00 HST |

... complete dataset (below)



AN155y2013.xls–2013: Hour = 9

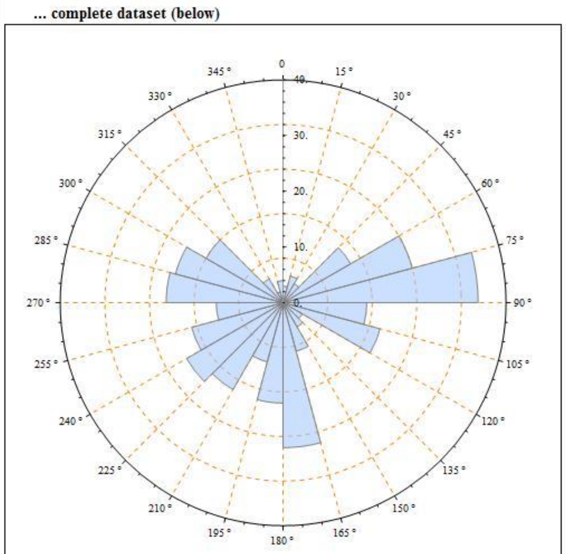
Data Info: Windrose

Number of Datasets = 326

... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 9, 0, 0.} | 0.8 | 77. | N/A | 1–1–2013 9:00 HST |

... complete dataset (below)



AN155y2013.xls–2013: Hour = 10

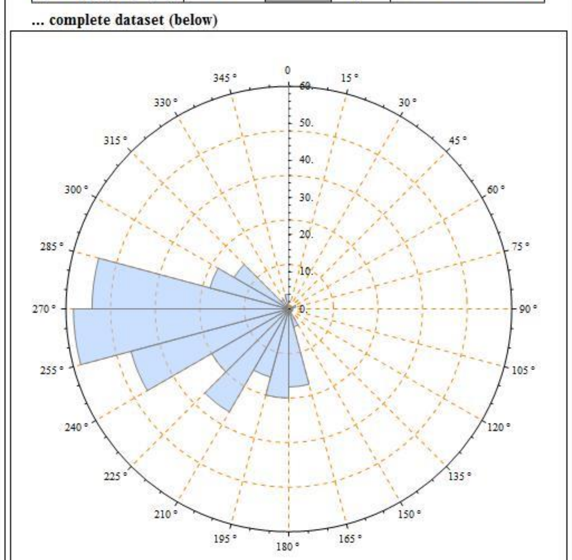
Data Info: Windrose

Number of Datasets = 332

... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 2, 10, 0, 0.} | 1.1 | 306. | N/A | 1–2–2013 10:00 HST |

... complete dataset (below)



AN155y2013.xls–2013: Hour = 11

Data Info: Windrose

Number of Datasets = 345

... first dataset (below); Direction = DRCT °

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 11, 0, 0.} | 1.6 | 243. | N/A | 1–1–2013 11:00 HST |

... complete dataset (below)

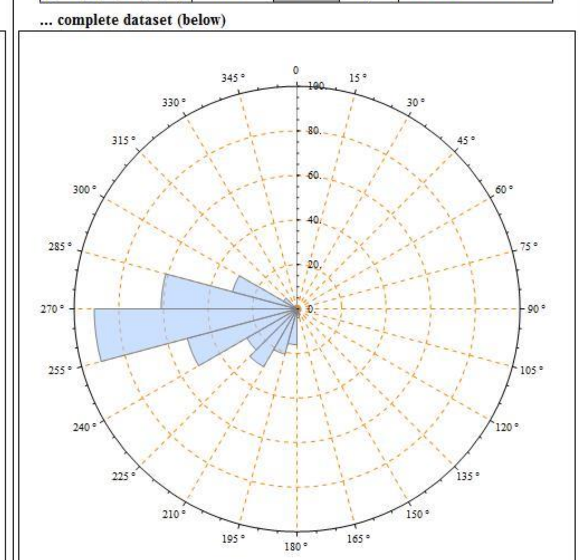


**Figure A-4.** 2013 Kona (AN155) Wind Rose - Morning Hours

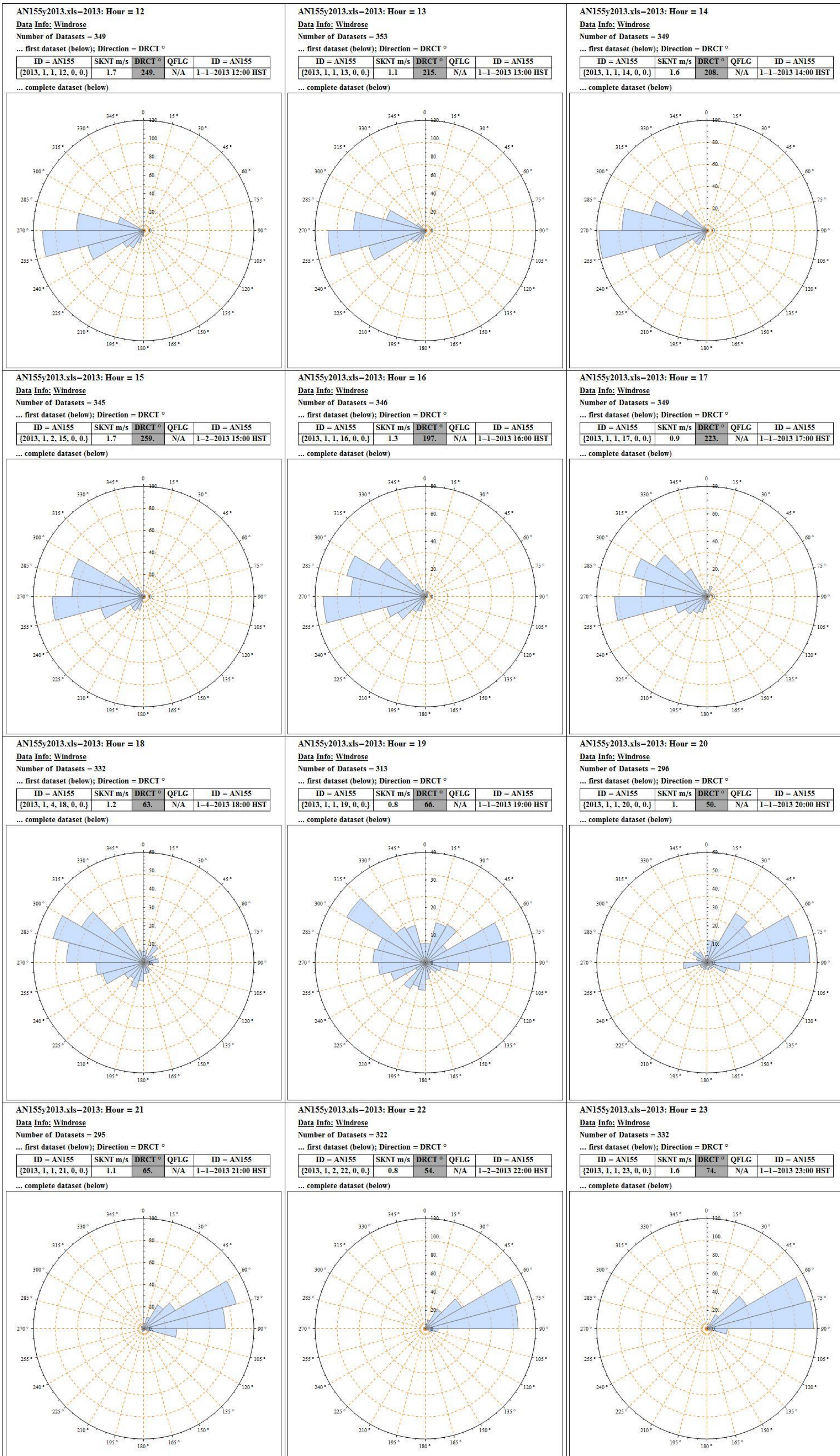



**Figure A-5.** 2013 Kona (AN155) Wind Rose - Evening Hours

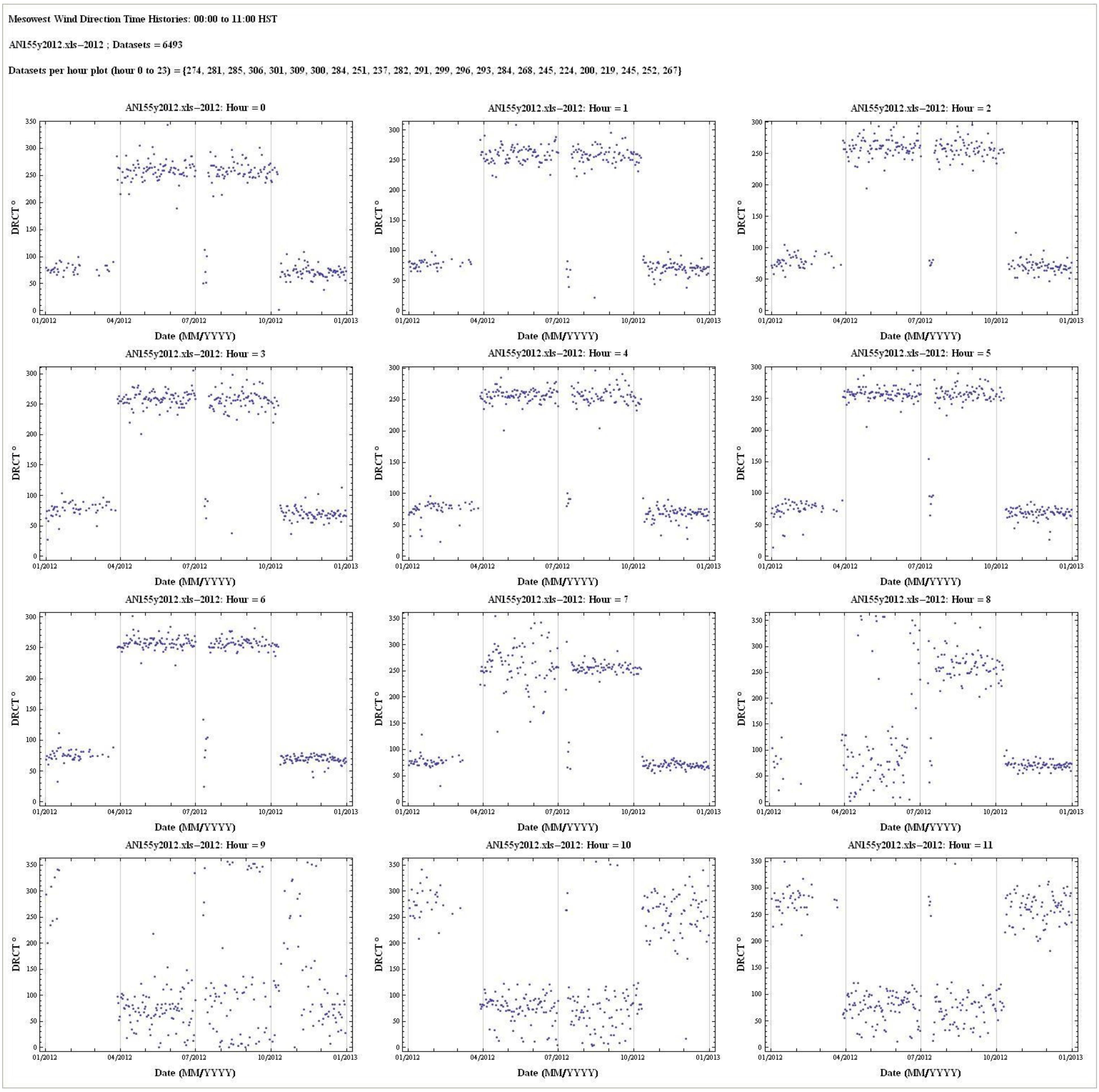



**Figure A-6.** 2012 Kona (AN155) Wind Direction Time History - Morning Hours

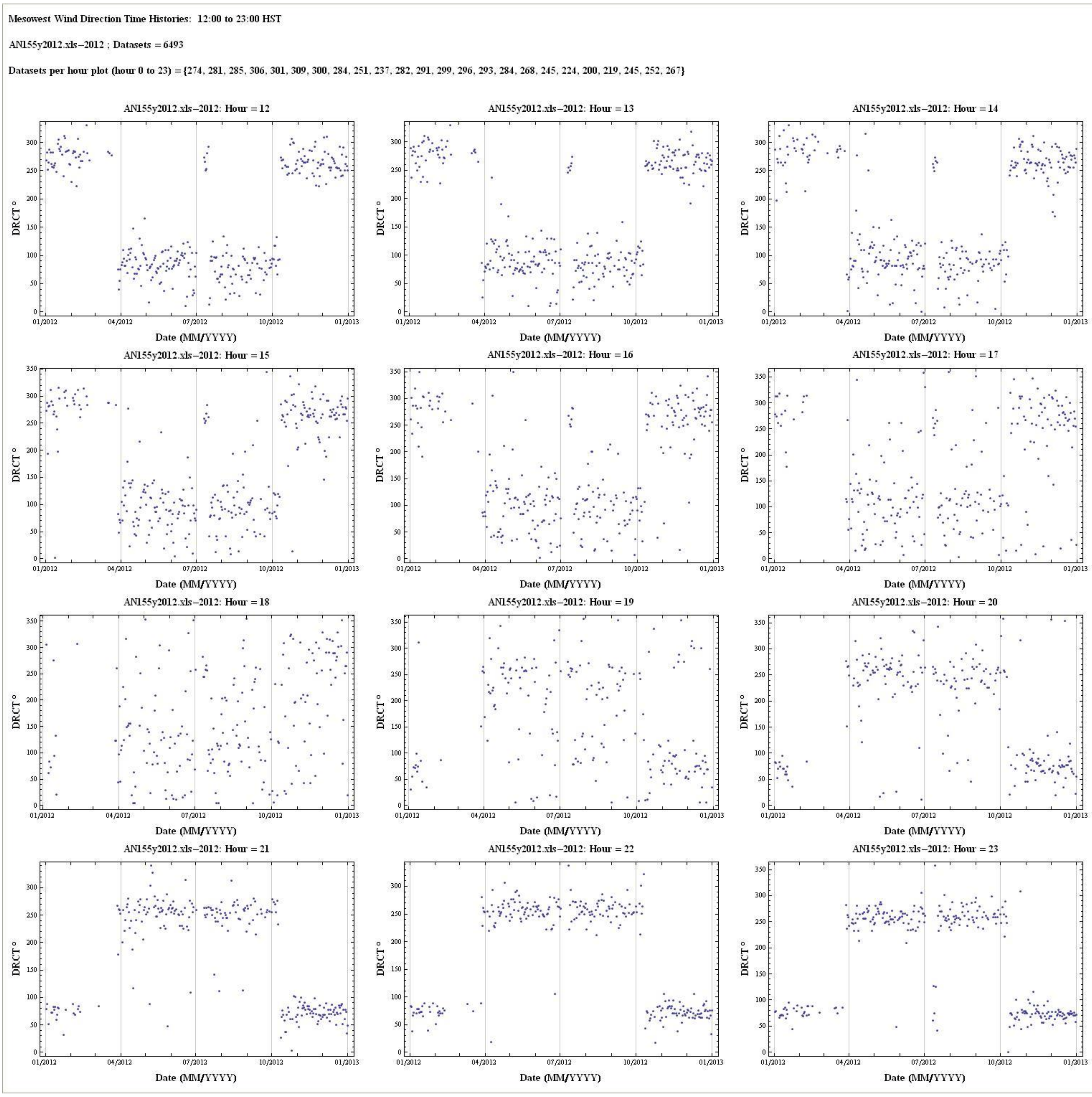



**Figure A-7.** 2012 Kona (AN155) Wind Direction Time History - Evening Hours

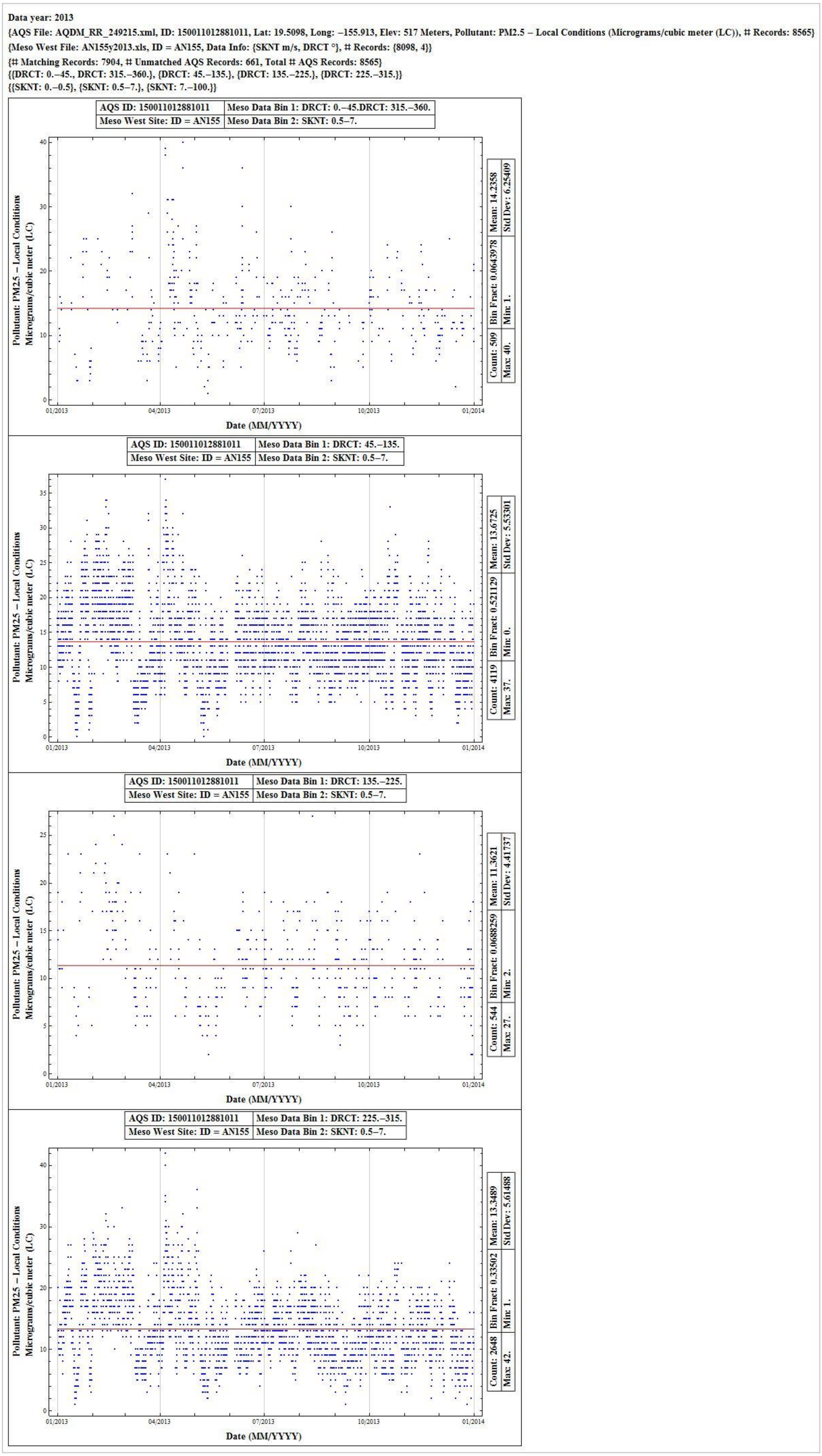



**Figure A-8.** 2013 Kona (AN155) $PM_{2.5}$ Pollution Time History by Wind Quadrant

Data year: 2012
{AQS File: AQDM_RR_248386.xml, ID: 150011012881011, Lat: 19.5098, Long: −155.913, Elev: 517 Meters, Pollutant: PM2.5 − Local Conditions (Micrograms/cubic meter (LC)), # Records: 8449}
{Meso West File: AN155y2012.xls, ID = AN155, Data Info: {SKNT m/s, DRCT °}, # Records: 6498}
{# Matching Records: 6134, # Unmatched AQS Records: 2315, Total # AQS Records: 8449}
{{DRCT: 0.−45., DRCT: 315.−360.}, {DRCT: 45.−135.}, {DRCT: 135.−225.}, {DRCT: 225.−315.}}
{{SKNT: 0.−0.5}, {SKNT: 0.5−7.}, {SKNT: 7.−100.}}

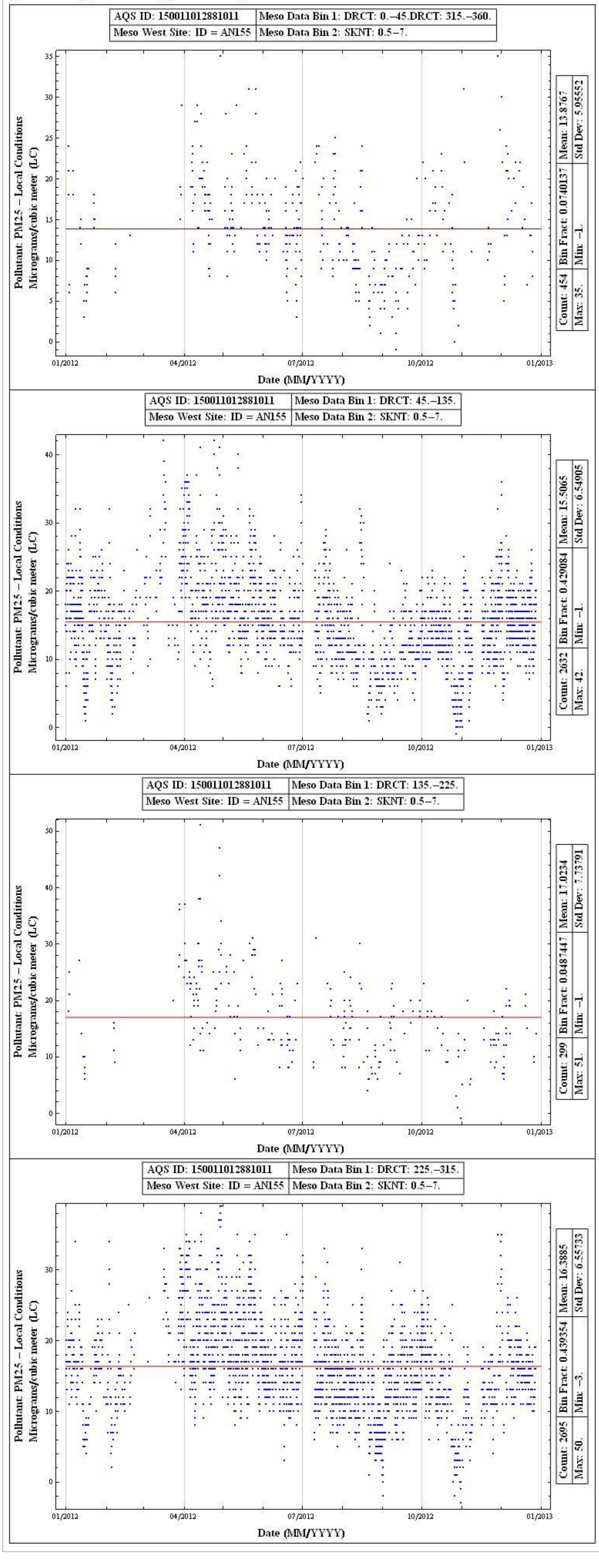



**Figure A-9.** 2012 Kona (AN155) $PM_{2.5}$ Pollution Time History by Wind Quadrant

| Annual & Quart r^2: 2012 | Kona PM2.5 | | | Ocean View PM2.5 | | | Pahala PM2.5 | | | Kona SO2 | | | Ocean View SO2 | | | Pahala SO2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AQS Ref ID | 150011012881011 | | | 150012020881011 | | | 150012016881011 | | | 150011012424011 | | | 150012020424011 | | | 150012016424011 | | |
| Average Type | Annual AveQtr | Quarterly r^2 | #pts | Annual AveQtr | Quarterly r^2 | #pts | Annual AveQtr | Quarterly r^2 | #pts | Annual AveQtr | Quarterly r^2 | #pts | Annual AveQtr | Quarterly r^2 | #pts | Annual AveQtr | Quarterly r^2 | #pts |
| | | 1. | 91 | | 0.483 | 91 | | 0.006 | 91 | | 0.136 | 87 | | 0.109 | 91 | | 0.071 | 91 |
| Kona PM2.5 | 1. | 1. | 90 | 0.452 | 0.384 | 90 | 0.011 | 0.006 | 90 | 0.15 | 0.242 | 90 | 0.08 | 0.018 | 90 | 0.022 | 0. | 90 |
| 150011012881011 | 1. | 1. | 91 | 0.379 | 0.384 | 91 | 0.017 | 0. | 91 | 0.225 | 0.252 | 88 | 0.055 | 0.012 | 91 | 0.019 | 0.002 | 91 |
| | | 1. | 86 | | 0.264 | 82 | | 0.055 | 83 | | 0.271 | 85 | | 0.081 | 85 | | 0.003 | 86 |
| | | 0.483 | 91 | | 1. | 91 | | 0.117 | 91 | | 0.127 | 87 | | 0.184 | 91 | | 0.125 | 91 |
| Ocean View PM2.5 | 0.452 | 0.384 | 90 | 1. | 1. | 91 | 0.057 | 0.019 | 91 | 0.085 | 0.202 | 91 | 0.101 | 0.064 | 91 | 0.039 | 0. | 91 |
| 150012020881011 | 0.379 | 0.384 | 91 | 1. | 1. | 92 | 0.068 | 0.005 | 92 | 0.098 | 0.015 | 89 | 0.078 | 0.001 | 92 | 0.035 | 0.003 | 92 |
| | | 0.264 | 82 | | 1. | 88 | | 0.133 | 85 | | 0.046 | 87 | | 0.061 | 88 | | 0.012 | 88 |
| | | 0.006 | 91 | | 0.117 | 91 | | 1. | 91 | | 0.007 | 87 | | 0.003 | 91 | | 0.426 | 91 |
| Pahala PM2.5 | 0.011 | 0.006 | 90 | 0.057 | 0.019 | 91 | 1. | 1. | 91 | 0.001 | 0. | 91 | 0.003 | 0. | 91 | 0.054 | 0.001 | 91 |
| 150012016881011 | 0.017 | 0. | 91 | 0.068 | 0.005 | 92 | 1. | 1. | 92 | 0.005 | 0.006 | 89 | 0.018 | 0.003 | 92 | 0.213 | 0.219 | 92 |
| | | 0.055 | 83 | | 0.133 | 85 | | 1. | 89 | | 0.009 | 88 | | 0.065 | 88 | | 0.207 | 89 |
| | | 0.136 | 87 | | 0.127 | 87 | | 0.007 | 87 | | 1. | 87 | | 0.052 | 87 | | 0.011 | 87 |
| Kona SO2 | 0.15 | 0.242 | 90 | 0.085 | 0.202 | 91 | 0.001 | 0. | 91 | 1. | 1. | 91 | 0.089 | 0.159 | 91 | 0.024 | 0.004 | 91 |
| 150011012424011 | 0.225 | 0.252 | 88 | 0.098 | 0.015 | 89 | 0.005 | 0.006 | 89 | 1. | 1. | 89 | 0.106 | 0.07 | 89 | 0.02 | 0.026 | 89 |
| | | 0.271 | 85 | | 0.046 | 87 | | 0.009 | 88 | | 1. | 91 | | 0.145 | 90 | | 0.041 | 91 |
| | | 0.109 | 91 | | 0.184 | 91 | | 0.003 | 91 | | 0.052 | 87 | | 1. | 91 | | 0.002 | 91 |
| Ocean View SO2 | 0.08 | 0.018 | 90 | 0.101 | 0.064 | 91 | 0.003 | 0. | 91 | 0.089 | 0.159 | 91 | 1. | 1. | 91 | 0.022 | 0.011 | 91 |
| 150012020424011 | 0.055 | 0.012 | 91 | 0.078 | 0.001 | 92 | 0.018 | 0.003 | 92 | 0.106 | 0.07 | 89 | 1. | 1. | 92 | 0.044 | 0.093 | 92 |
| | | 0.081 | 85 | | 0.061 | 88 | | 0.065 | 88 | | 0.145 | 90 | | 1. | 91 | | 0.069 | 91 |
| | | 0.071 | 91 | | 0.125 | 91 | | 0.426 | 91 | | 0.011 | 87 | | 0.002 | 91 | | 1. | 91 |
| Pahala SO2 | 0.022 | 0. | 90 | 0.039 | 0. | 91 | 0.054 | 0.001 | 91 | 0.024 | 0.004 | 91 | 0.022 | 0.011 | 91 | 1. | 1. | 91 |
| 150012016424011 | 0.019 | 0.002 | 91 | 0.035 | 0.003 | 92 | 0.213 | 0.219 | 92 | 0.02 | 0.026 | 89 | 0.044 | 0.093 | 92 | 1. | 1. | 92 |
| | | 0.003 | 86 | | 0.012 | 88 | | 0.207 | 89 | | 0.041 | 91 | | 0.069 | 91 | | 1. | 92 |

**Figure A-10.** 2012 Kona (AN155), Ocean View (AN738), and Pahala (AN157) Annual and Seasonal (Quarterly) Correlations for $SO_2$ and $PM_{2.5}$

| Annual & Quart r^2: 2013 | Kona PM2.5 | | | Ocean View PM2.5 | | | Pahala PM2.5 | | | Kona SO2 | | | Ocean View SO2 | | | Pahala SO2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AQS Ref ID | 150011012881011 | | | 150012020881011 | | | 150012016881011 | | | 150011012424011 | | | 150012020424011 | | | 150012016424011 | | |
| Average Type | Annual AveQtr | Quarterly r^2 | #pts | Annual AveQtr | Quarterly r^2 | #pts | Annual AveQtr | Quarterly r^2 | #pts | Annual AveQtr | Quarterly r^2 | #pts | Annual AveQtr | Quarterly r^2 | #pts | Annual AveQtr | Quarterly r^2 | #pts |
| | | 1. | 90 | | 0.467 | 90 | | 0.005 | 90 | | 0.458 | 90 | | 0.437 | 90 | | 0.271 | 90 |
| Kona PM2.5 | 1. | 1. | 91 | 0.312 | 0.589 | 91 | 0.015 | 0.153 | 91 | 0.36 | 0.533 | 91 | 0.088 | 0.202 | 91 | 0.119 | 0.196 | 91 |
| 150011012881011 | 1. | 1. | 92 | 0.35 | 0.201 | 92 | 0.041 | 0.001 | 91 | 0.368 | 0.239 | 92 | 0.166 | 0.008 | 92 | 0.117 | 0.001 | 91 |
| | | 1. | 87 | | 0.142 | 84 | | 0.006 | 84 | | 0.242 | 87 | | 0.014 | 87 | | 0. | 87 |
| | | 0.467 | 90 | | 1. | 90 | | 0.132 | 90 | | 0.2 | 90 | | 0.358 | 90 | | 0.262 | 90 |
| Ocean View PM2.5 | 0.312 | 0.589 | 91 | 1. | 1. | 91 | 0.122 | 0.185 | 91 | 0.083 | 0.392 | 91 | 0.122 | 0.241 | 91 | 0.086 | 0.3 | 91 |
| 150012020881011 | 0.35 | 0.201 | 92 | 1. | 1. | 92 | 0.132 | 0.063 | 91 | 0.165 | 0.046 | 92 | 0.168 | 0. | 92 | 0.155 | 0.011 | 91 |
| | | 0.142 | 84 | | 1. | 89 | | 0.15 | 86 | | 0.022 | 89 | | 0.072 | 89 | | 0.045 | 89 |
| | | 0.005 | 90 | | 0.132 | 90 | | 1. | 90 | | 0. | 90 | | 0.044 | 90 | | 0.117 | 90 |
| Pahala PM2.5 | 0.015 | 0.153 | 91 | 0.122 | 0.185 | 91 | 1. | 1. | 91 | 0.002 | 0.04 | 91 | 0.022 | 0.065 | 91 | 0.098 | 0.142 | 91 |
| 150012016881011 | 0.041 | 0.001 | 91 | 0.132 | 0.063 | 91 | 1. | 1. | 91 | 0.017 | 0.027 | 91 | 0.039 | 0.047 | 91 | 0.13 | 0.221 | 91 |
| | | 0.006 | 84 | | 0.15 | 86 | | 1. | 89 | | 0.001 | 89 | | 0.002 | 89 | | 0.041 | 89 |
| | | 0.458 | 90 | | 0.2 | 90 | | 0. | 90 | | 1. | 90 | | 0.324 | 90 | | 0.102 | 90 |
| Kona SO2 | 0.36 | 0.533 | 91 | 0.083 | 0.392 | 91 | 0.002 | 0.04 | 91 | 1. | 1. | 91 | 0.184 | 0.354 | 91 | 0.107 | 0.251 | 91 |
| 150011012424011 | 0.368 | 0.239 | 92 | 0.165 | 0.046 | 92 | 0.017 | 0.027 | 91 | 1. | 1. | 92 | 0.227 | 0.034 | 92 | 0.092 | 0.004 | 91 |
| | | 0.242 | 87 | | 0.022 | 89 | | 0.001 | 89 | | 1. | 92 | | 0.197 | 92 | | 0.011 | 92 |
| | | 0.437 | 90 | | 0.358 | 90 | | 0.044 | 90 | | 0.324 | 90 | | 1. | 90 | | 0.395 | 90 |
| Ocean View SO2 | 0.088 | 0.202 | 91 | 0.122 | 0.241 | 91 | 0.022 | 0.065 | 91 | 0.184 | 0.354 | 91 | 1. | 1. | 91 | 0.148 | 0.074 | 91 |
| 150012020424011 | 0.166 | 0.008 | 92 | 0.168 | 0. | 92 | 0.039 | 0.047 | 91 | 0.227 | 0.034 | 92 | 1. | 1. | 92 | 0.177 | 0.167 | 91 |
| | | 0.014 | 87 | | 0.072 | 89 | | 0.002 | 89 | | 0.197 | 92 | | 1. | 92 | | 0.072 | 92 |
| | | 0.271 | 90 | | 0.262 | 90 | | 0.117 | 90 | | 0.102 | 90 | | 0.395 | 90 | | 1. | 90 |
| Pahala SO2 | 0.119 | 0.196 | 91 | 0.086 | 0.3 | 91 | 0.098 | 0.142 | 91 | 0.107 | 0.251 | 91 | 0.148 | 0.074 | 91 | 1. | 1. | 91 |
| 150012016424011 | 0.117 | 0.001 | 91 | 0.155 | 0.011 | 91 | 0.13 | 0.221 | 91 | 0.092 | 0.004 | 91 | 0.177 | 0.167 | 91 | 1. | 1. | 91 |
| | | 0. | 87 | | 0.045 | 89 | | 0.041 | 89 | | 0.011 | 92 | | 0.072 | 92 | | 1. | 92 |

**Figure A-11.** 2013 Kona (AN155), Ocean View (AN738), and Pahala (AN157) Annual and Seasonal (Quarterly) Correlations for $SO_2$ and $PM_{2.5}$

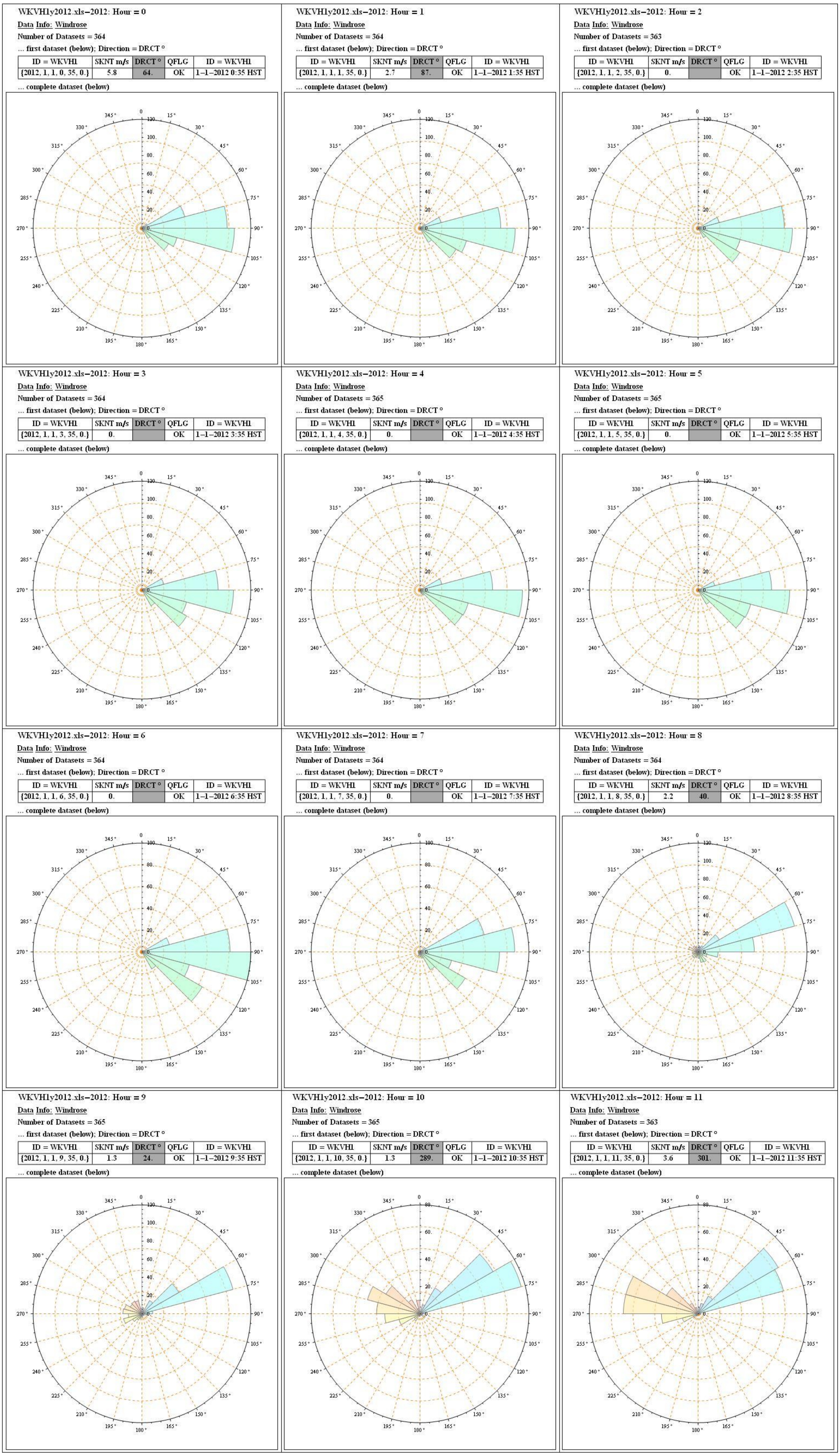



**Figure A-12.** 2012 Waikoloa (WKVH1) Wind Rose - Morning Hours

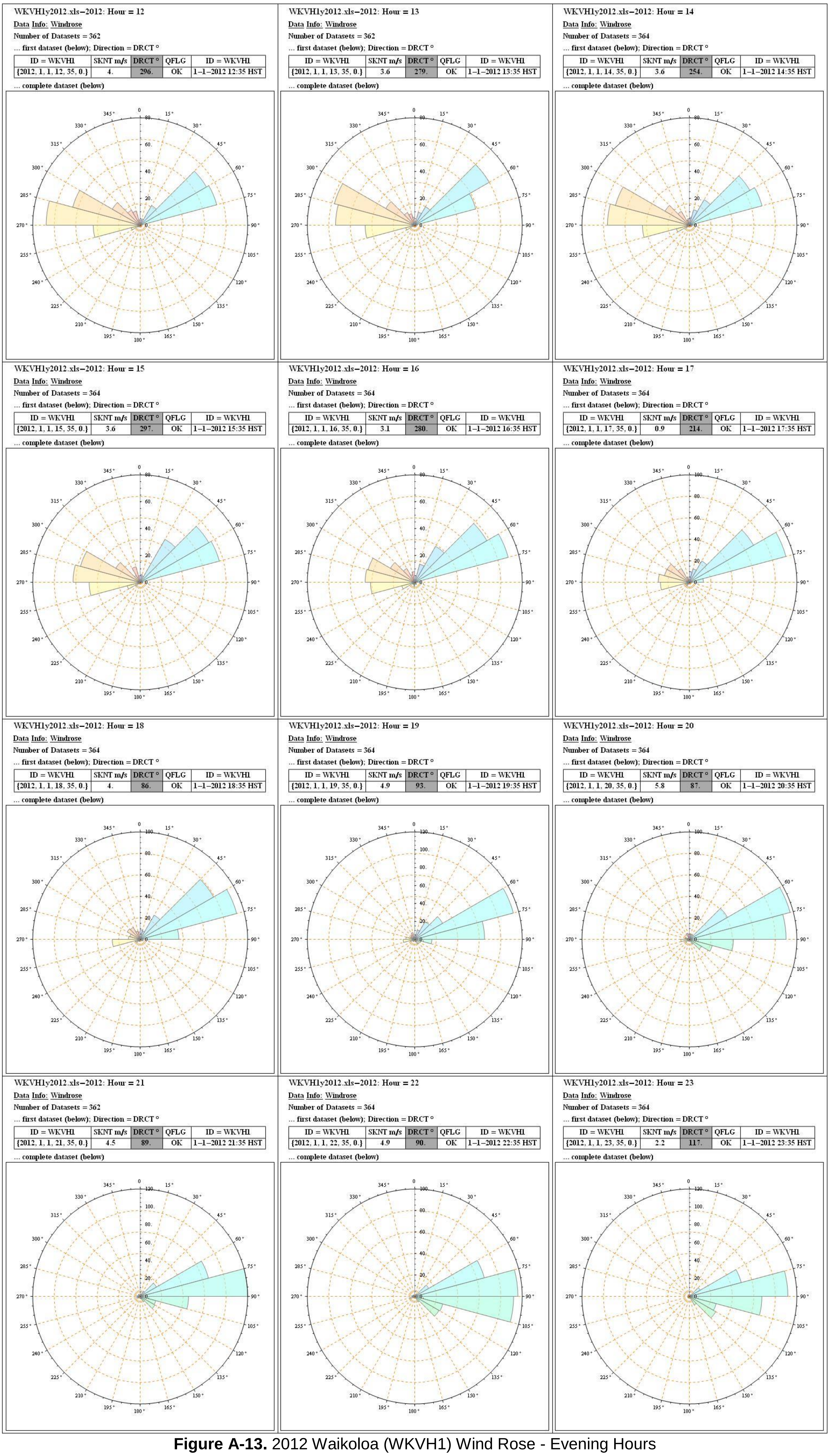



**Figure A-13.** 2012 Waikoloa (WKVH1) Wind Rose - Evening Hours

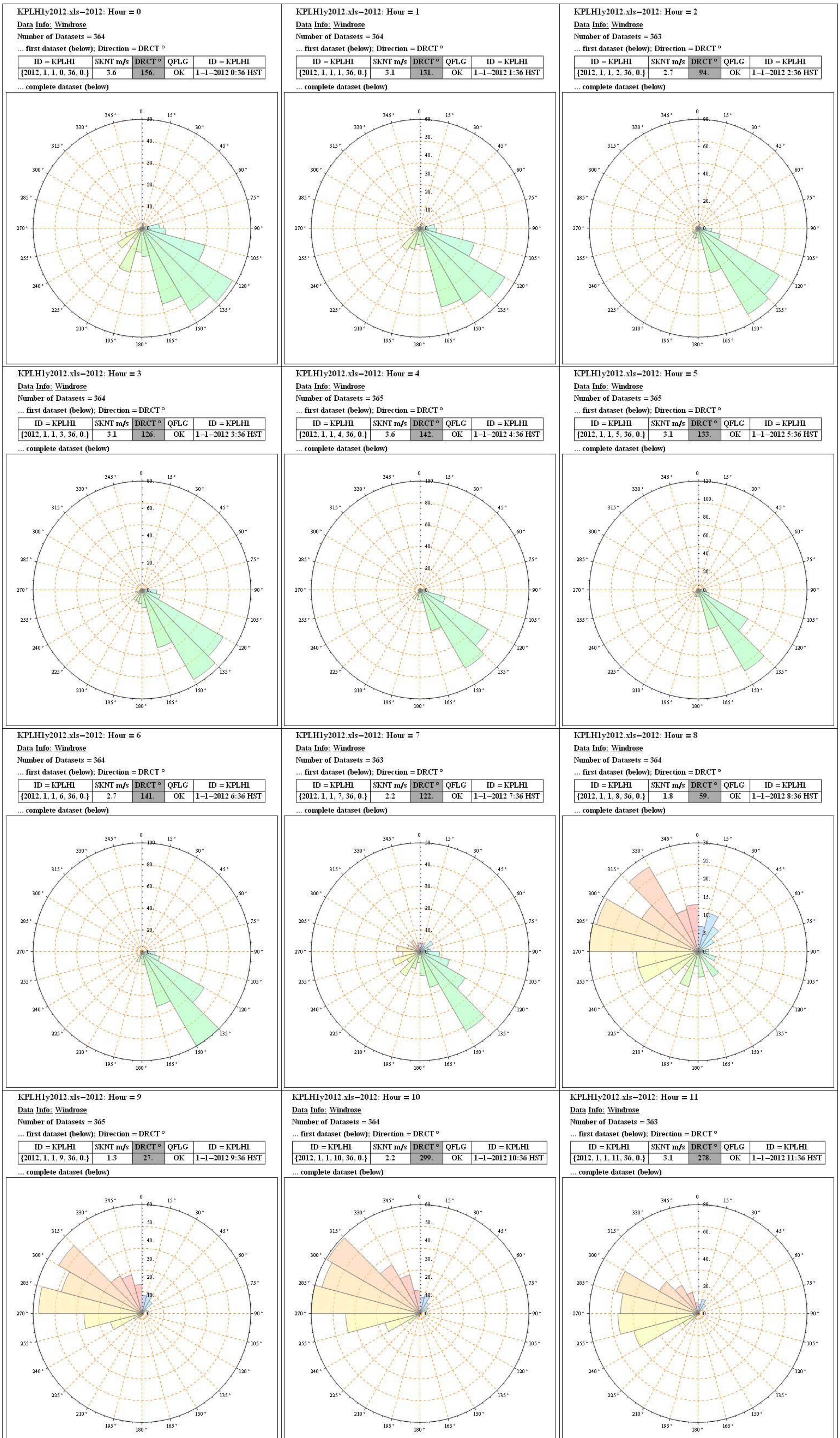



**Figure A-14.** 2012 Kaupulehu Lava Flow (KPLH1) - Morning Hours

KPLH1y2012.xls−2012: Hour = 12

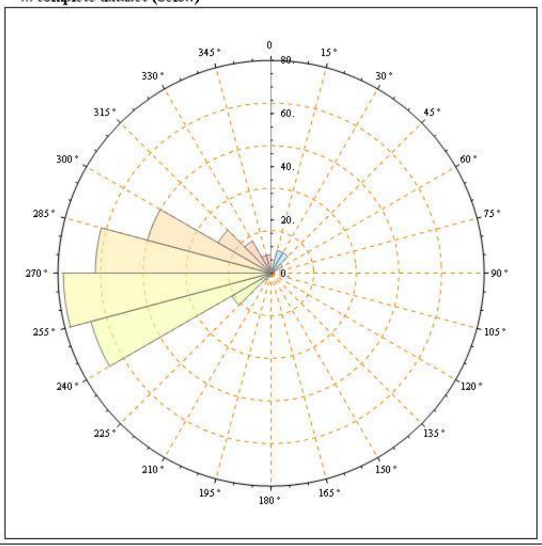
Data Info: Windrose

Number of Datasets = 362

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 12, 36, 0.} | 5.4 | 272. | OK | 1–1–2012 12:36 HST |

... complete dataset (below)




KPLH1y2012.xls−2012: Hour = 13

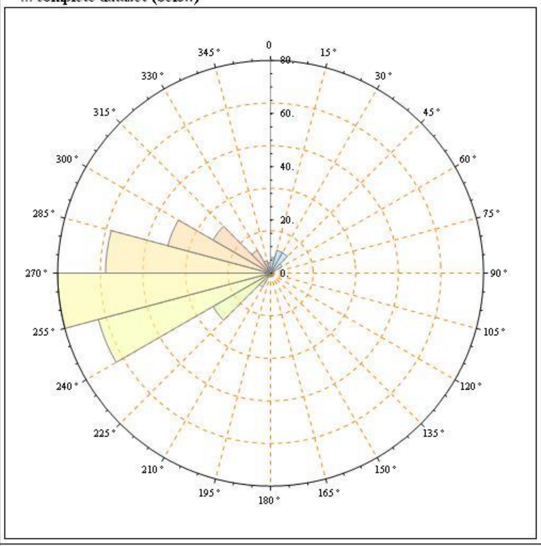
Data Info: Windrose

Number of Datasets = 363

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 13, 36, 0.} | 4.5 | 255. | OK | 1–1–2012 13:36 HST |

... complete dataset (below)




KPLH1y2012.xls−2012: Hour = 14

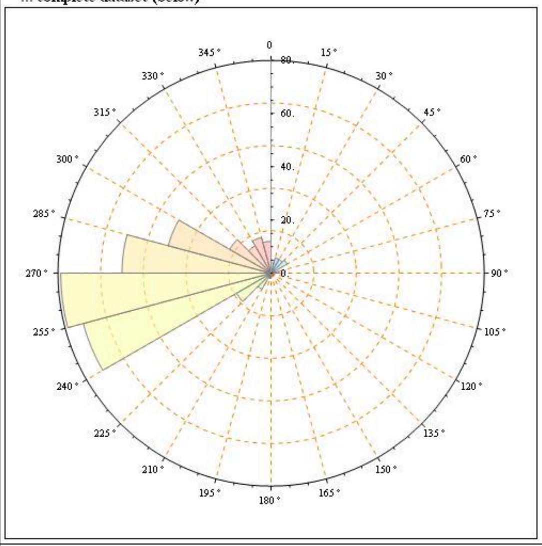
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 14, 36, 0.} | 5.4 | 258. | OK | 1–1–2012 14:36 HST |

... complete dataset (below)




KPLH1y2012.xls−2012: Hour = 15

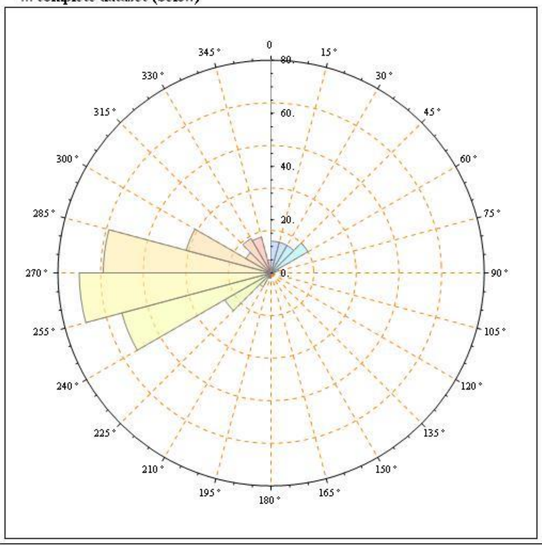
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 15, 36, 0.} | 4.5 | 258. | OK | 1–1–2012 15:36 HST |

... complete dataset (below)




KPLH1y2012.xls−2012: Hour = 16

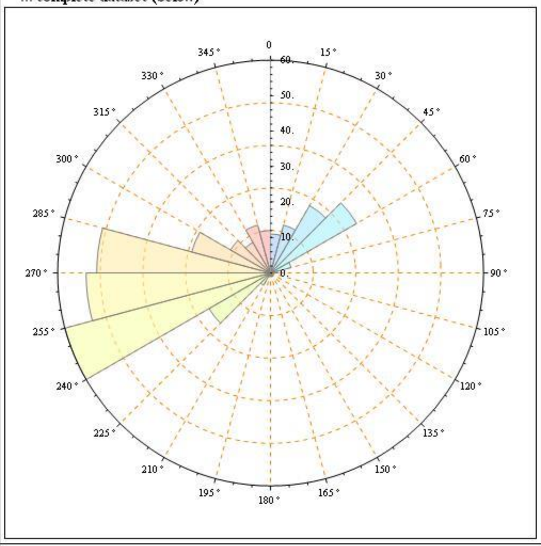
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 16, 36, 0.} | 4.5 | 265. | OK | 1–1–2012 16:36 HST |

... complete dataset (below)




KPLH1y2012.xls−2012: Hour = 17

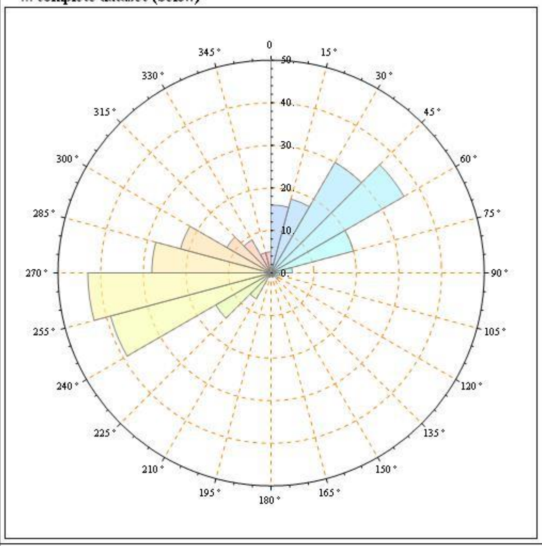
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 17, 36, 0.} | 4.5 | 273. | OK | 1–1–2012 17:36 HST |

... complete dataset (below)




KPLH1y2012.xls−2012: Hour = 18

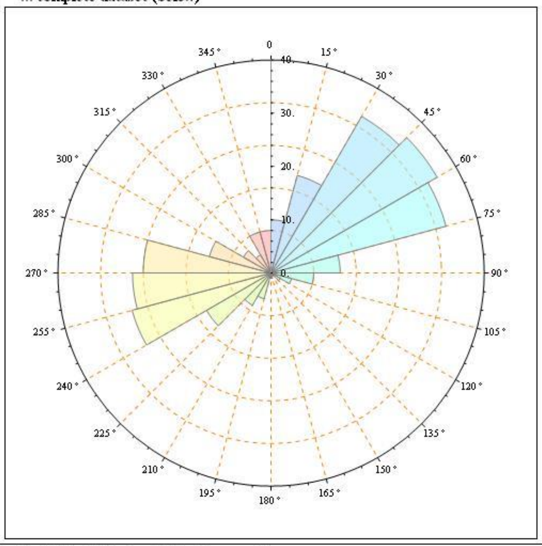
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 18, 36, 0.} | 1.8 | 256. | OK | 1–1–2012 18:36 HST |

... complete dataset (below)




KPLH1y2012.xls−2012: Hour = 19

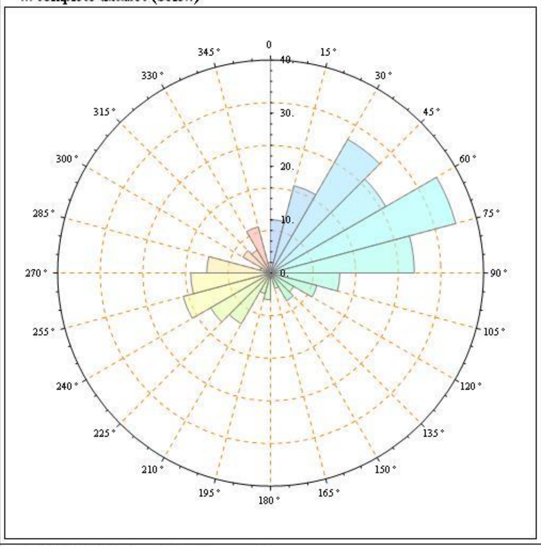
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 19, 36, 0.} | 2.7 | 67. | OK | 1–1–2012 19:36 HST |

... complete dataset (below)




KPLH1y2012.xls−2012: Hour = 20

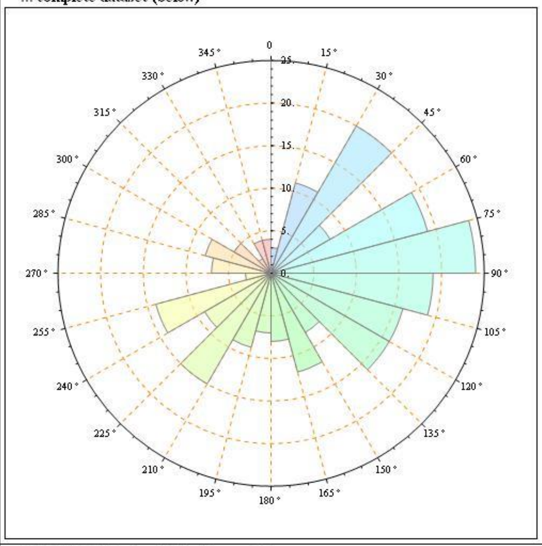
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 20, 36, 0.} | 2.2 | 135. | OK | 1–1–2012 20:36 HST |

... complete dataset (below)




KPLH1y2012.xls−2012: Hour = 21

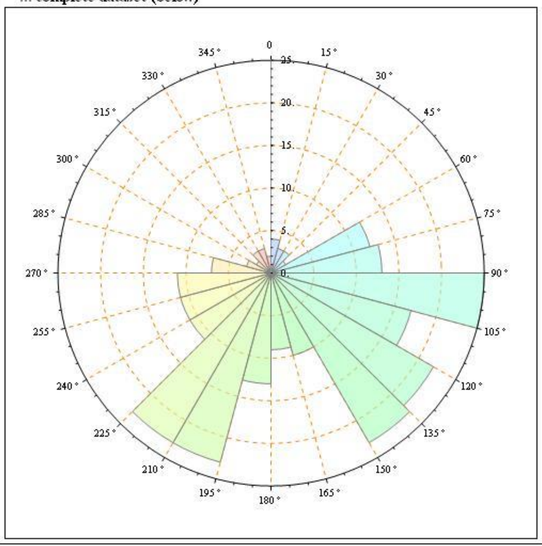
Data Info: Windrose

Number of Datasets = 361

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 21, 36, 0.} | 2.2 | 204. | OK | 1–1–2012 21:36 HST |

... complete dataset (below)




KPLH1y2012.xls−2012: Hour = 22

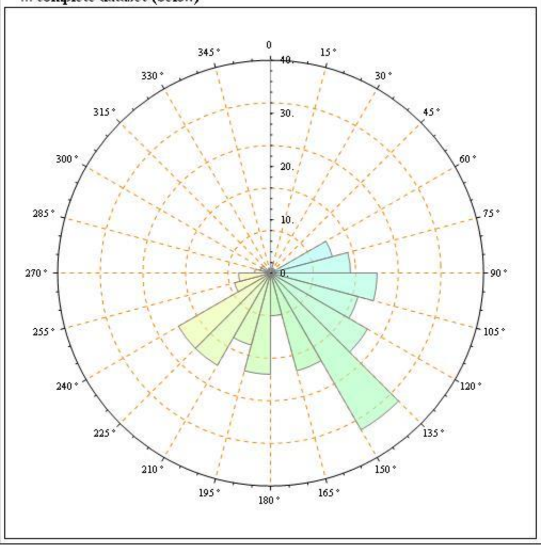
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 22, 36, 0.} | 1.3 | 146. | OK | 1–1–2012 22:36 HST |

... complete dataset (below)




KPLH1y2012.xls−2012: Hour = 23

Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 23, 36, 0.} | 1.8 | 122. | OK | 1–1–2012 23:36 HST |

... complete dataset (below)

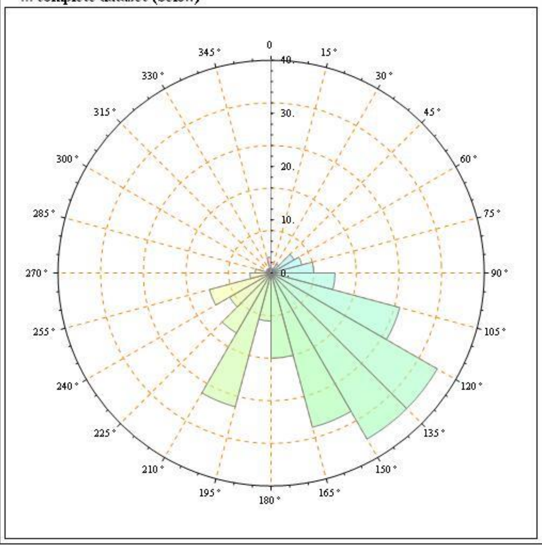



**Figure A-15.** 2012 Kaupulehu Lava Flow (KPLH1) - Evening Hours


**Figure A-16.** 2012 PTA Range 17 (PTRH1) Wind Rose - Morning Hours

PTRH1y2012.xls−2012: Hour = 12

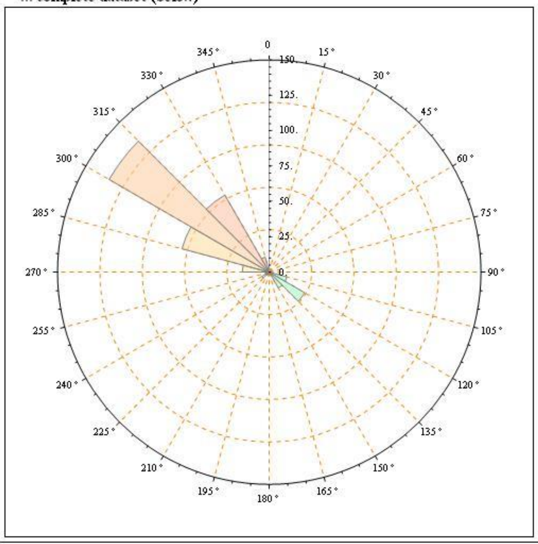
Data Info: Windrose

Number of Datasets = 363

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 12, 49, 0.} | 5.4 | 311. | OK | 1−1−2012 12:49 HST |

... complete dataset (below)




PTRH1y2012.xls−2012: Hour = 13

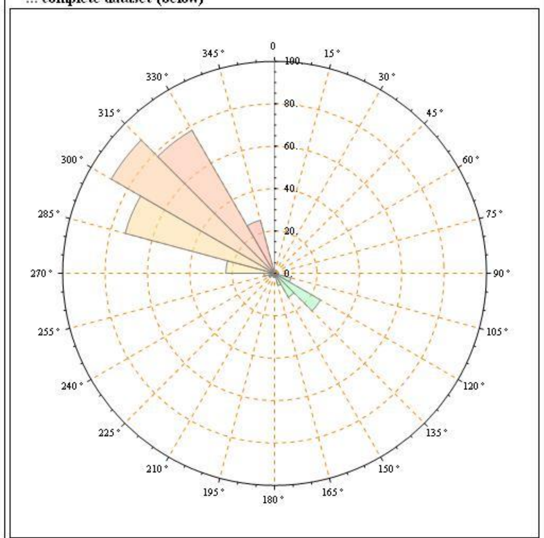
Data Info: Windrose

Number of Datasets = 363

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 13, 49, 0.} | 4.5 | 307. | OK | 1−1−2012 13:49 HST |

... complete dataset (below)




PTRH1y2012.xls−2012: Hour = 14

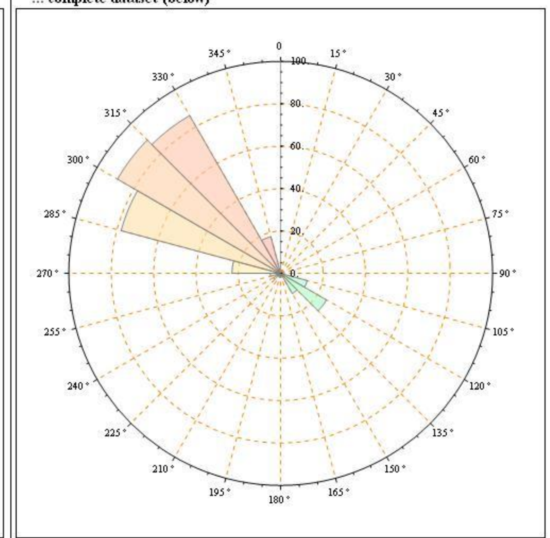
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 14, 49, 0.} | 4.5 | 294. | OK | 1−1−2012 14:49 HST |

... complete dataset (below)




PTRH1y2012.xls−2012: Hour = 15

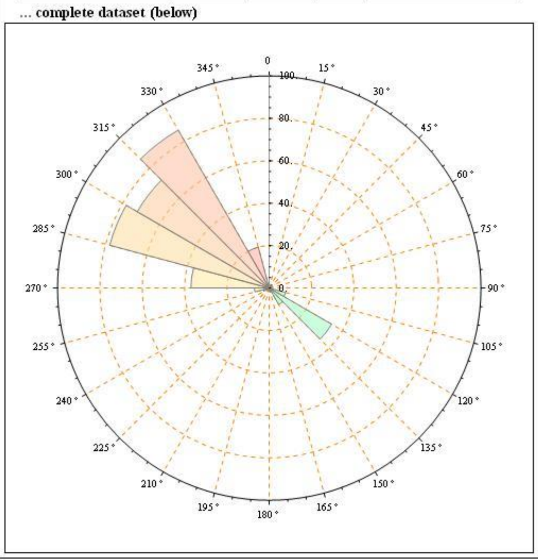
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 15, 49, 0.} | 4. | 285. | OK | 1−1−2012 15:49 HST |

... complete dataset (below)




PTRH1y2012.xls−2012: Hour = 16

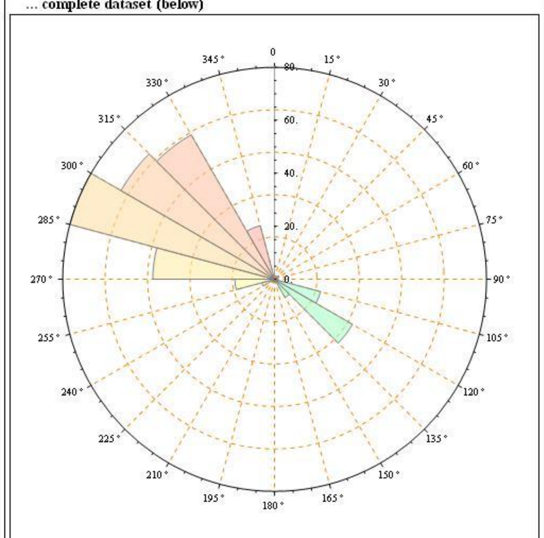
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 16, 49, 0.} | 3.1 | 336. | OK | 1−1−2012 16:49 HST |

... complete dataset (below)




PTRH1y2012.xls−2012: Hour = 17

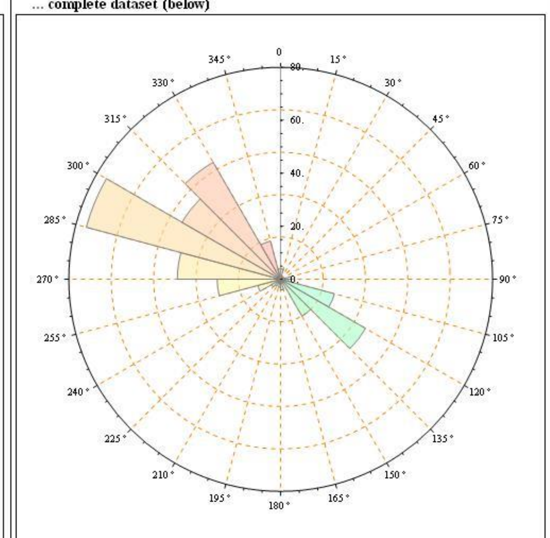
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 17, 49, 0.} | 2.2 | 331. | OK | 1−1−2012 17:49 HST |

... complete dataset (below)




PTRH1y2012.xls−2012: Hour = 18

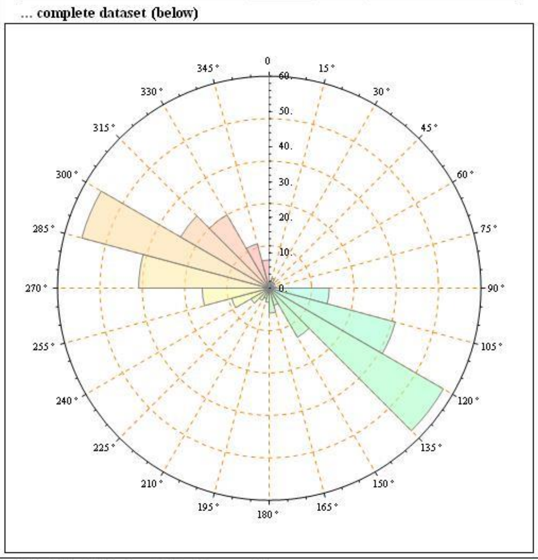
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 18, 49, 0.} | 0.9 | 340. | OK | 1−1−2012 18:49 HST |

... complete dataset (below)




PTRH1y2012.xls−2012: Hour = 19

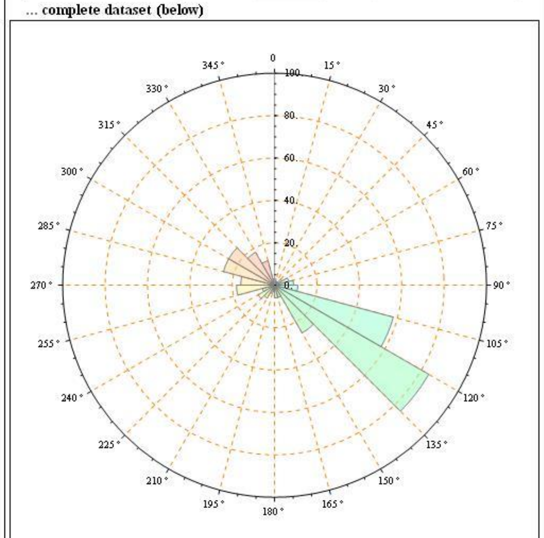
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 19, 49, 0.} | 1.3 | 20. | OK | 1−1−2012 19:49 HST |

... complete dataset (below)




PTRH1y2012.xls−2012: Hour = 20

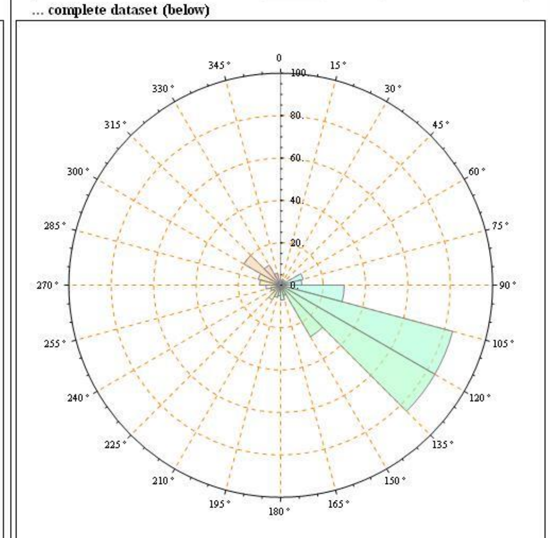
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 20, 49, 0.} | 2.7 | 116. | OK | 1−1−2012 20:49 HST |

... complete dataset (below)




PTRH1y2012.xls−2012: Hour = 21

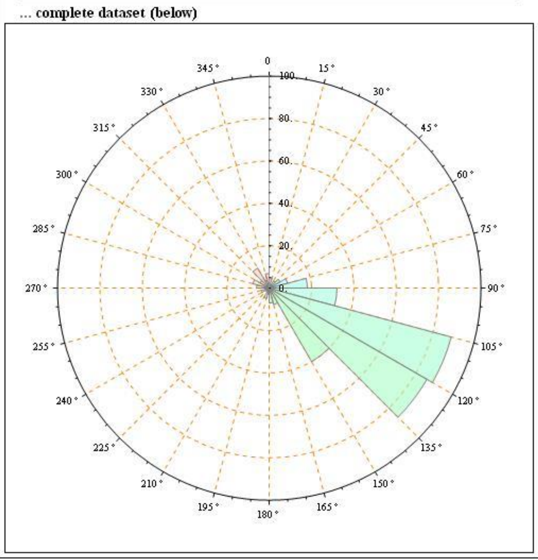
Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 21, 49, 0.} | 1.8 | 90. | OK | 1−1−2012 21:49 HST |

... complete dataset (below)




PTRH1y2012.xls−2012: Hour = 22

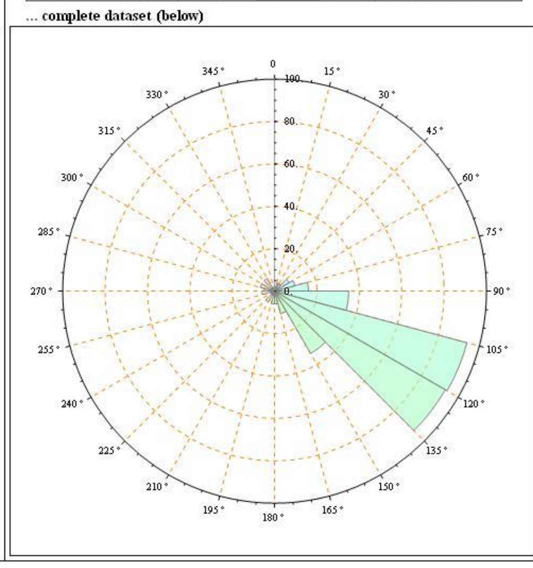
Data Info: Windrose

Number of Datasets = 363

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 22, 49, 0.} | 2.2 | 118. | OK | 1−1−2012 22:49 HST |

... complete dataset (below)




PTRH1y2012.xls−2012: Hour = 23

Data Info: Windrose

Number of Datasets = 364

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 23, 49, 0.} | 2.2 | 133. | OK | 1−1−2012 23:49 HST |

... complete dataset (below)

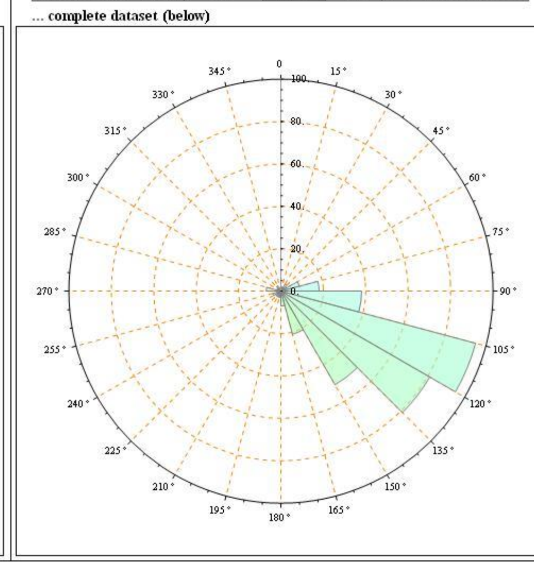



**Figure A-17.** 2012 PTA Range 17 (PTRH1) Wind Rose - Evening Hours

PHTOy2012.xls–2012: Hour = 0

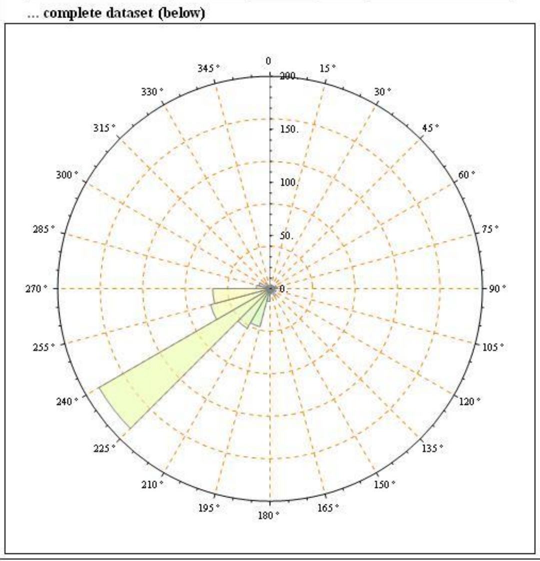
Data Info: Windrose

Number of Datasets = 598

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 0, 12, 0.} | 0. | | OK | 1–1–2012 0:12 HST |

... complete dataset (below)



PHTOy2012.xls–2012: Hour = 1

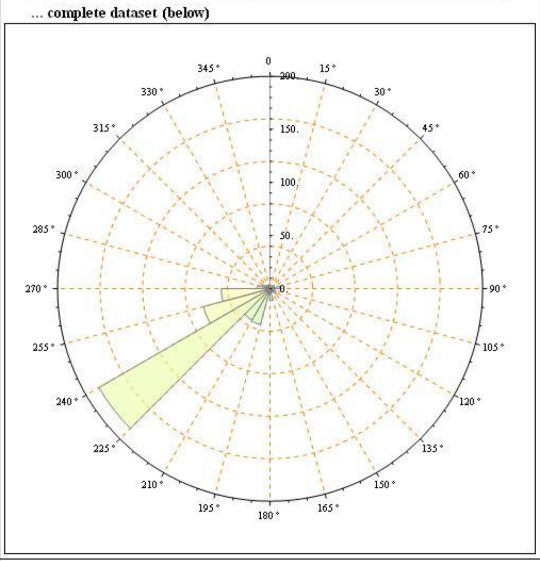
Data Info: Windrose

Number of Datasets = 563

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 1, 2, 0.} | 2.6 | 270. | OK | 1–1–2012 1:02 HST |

... complete dataset (below)



PHTOy2012.xls–2012: Hour = 2

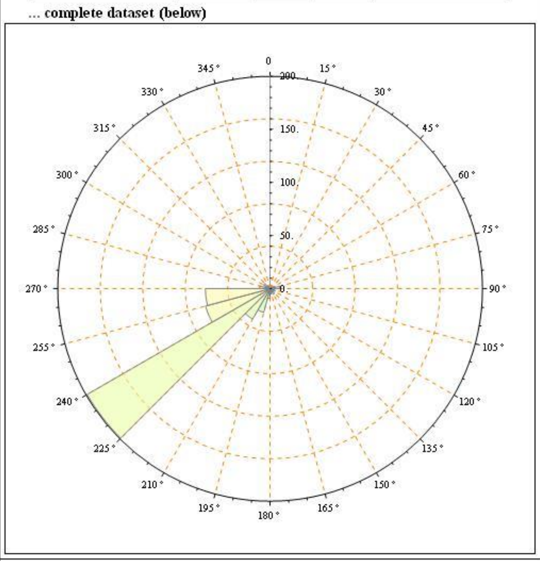
Data Info: Windrose

Number of Datasets = 564

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 2, 11, 0.} | 2.6 | 240. | OK | 1–1–2012 2:11 HST |

... complete dataset (below)



PHTOy2012.xls–2012: Hour = 3

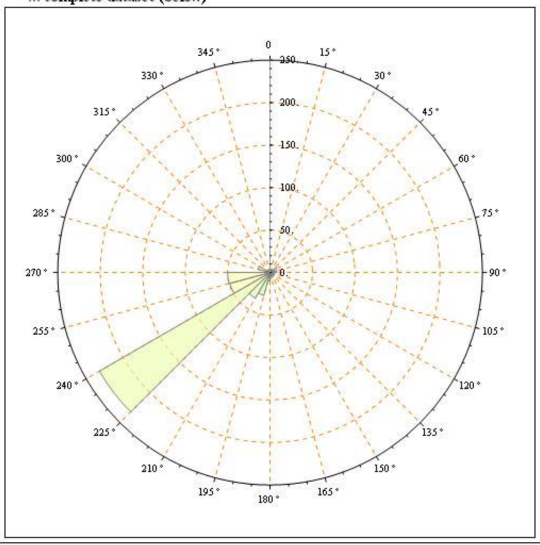
Data Info: Windrose

Number of Datasets = 576

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 3, 28, 0.} | 3.1 | 240. | OK | 1–1–2012 3:28 HST |

... complete dataset (below)



PHTOy2012.xls–2012: Hour = 4

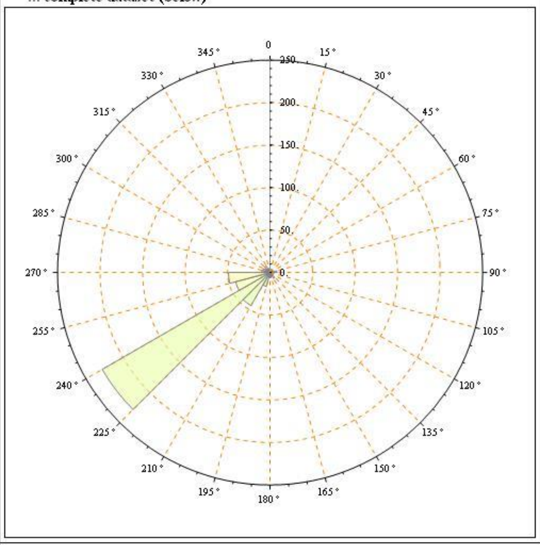
Data Info: Windrose

Number of Datasets = 561

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 4, 53, 0.} | 3.1 | 240. | OK | 1–1–2012 4:53 HST |

... complete dataset (below)



PHTOy2012.xls–2012: Hour = 5

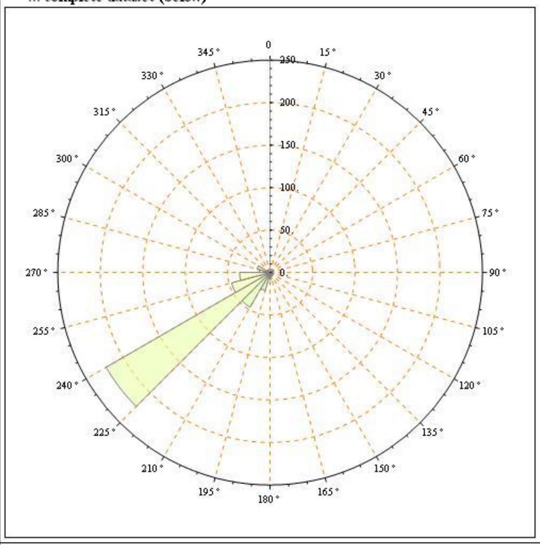
Data Info: Windrose

Number of Datasets = 538

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 5, 53, 0.} | 2.1 | 230. | OK | 1–1–2012 5:53 HST |

... complete dataset (below)



PHTOy2012.xls–2012: Hour = 6

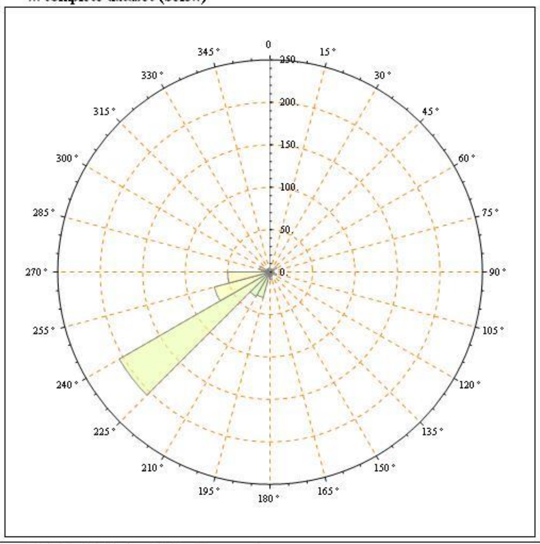
Data Info: Windrose

Number of Datasets = 575

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 6, 53, 0.} | 2.1 | 230. | OK | 1–1–2012 6:53 HST |

... complete dataset (below)



PHTOy2012.xls–2012: Hour = 7

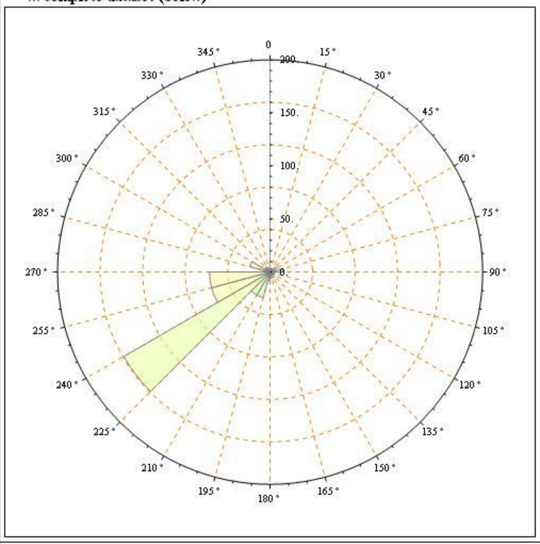
Data Info: Windrose

Number of Datasets = 541

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 7, 53, 0.} | 1.5 | 210. | OK | 1–1–2012 7:53 HST |

... complete dataset (below)



PHTOy2012.xls–2012: Hour = 8

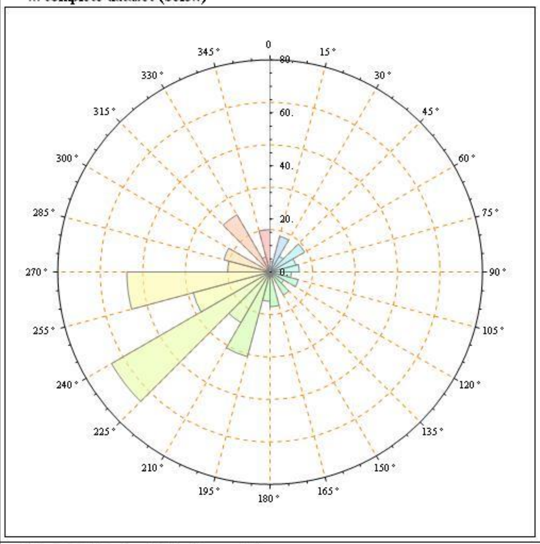
Data Info: Windrose

Number of Datasets = 516

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 8, 53, 0.} | 0. | | OK | 1–1–2012 8:53 HST |

... complete dataset (below)



PHTOy2012.xls–2012: Hour = 9

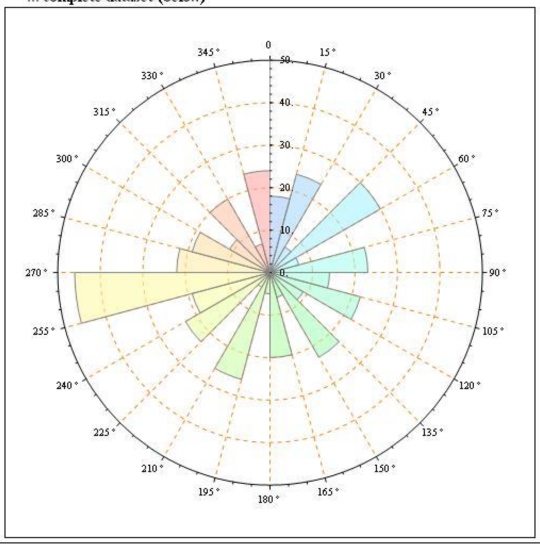
Data Info: Windrose

Number of Datasets = 538

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 9, 53, 0.} | 0. | | OK | 1–1–2012 9:53 HST |

... complete dataset (below)



PHTOy2012.xls–2012: Hour = 10

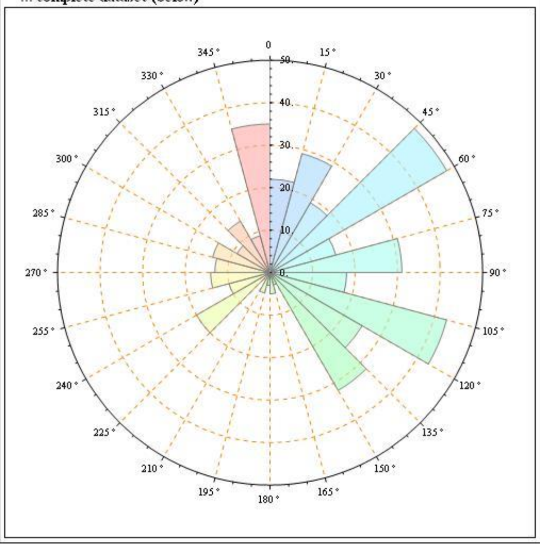
Data Info: Windrose

Number of Datasets = 523

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 10, 53, 0.} | 2.6 | 50. | OK | 1–1–2012 10:53 HST |

... complete dataset (below)



PHTOy2012.xls–2012: Hour = 11

Data Info: Windrose

Number of Datasets = 531

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 11, 53, 0.} | 0. | | OK | 1–1–2012 11:53 HST |

... complete dataset (below)

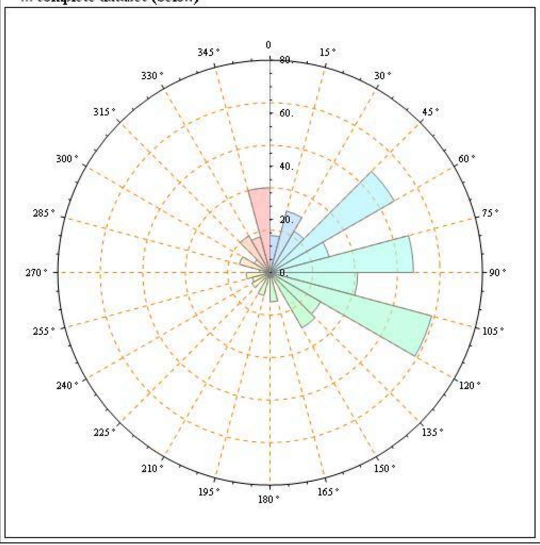
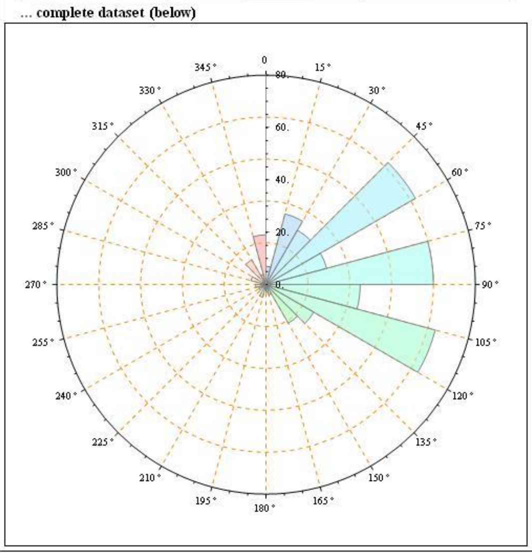


**Figure A-18.** 2012 Hilo International Airport (PHTO) Wind Rose - Morning Hours

PHTOy2012.xls–2012: Hour = 12
Data Info: Windrose
Number of Datasets = 489
... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 12, 53, 0.} | 4.1 | 100. | OK | 1–1–2012 12:53 HST |

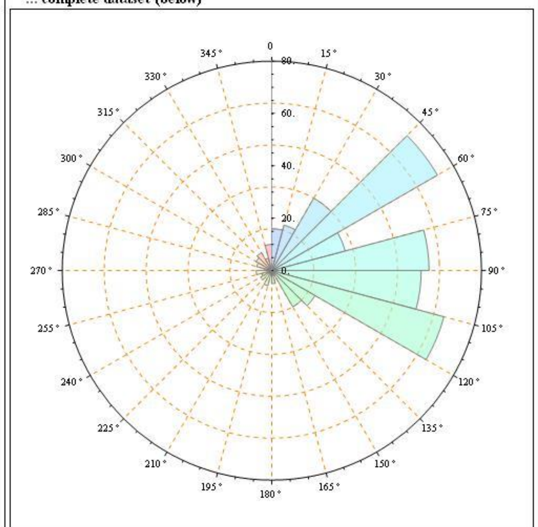
... complete dataset (below)



PHTOy2012.xls–2012: Hour = 13
Data Info: Windrose
Number of Datasets = 501
... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 13, 53, 0.} | 4.1 | 50. | OK | 1–1–2012 13:53 HST |

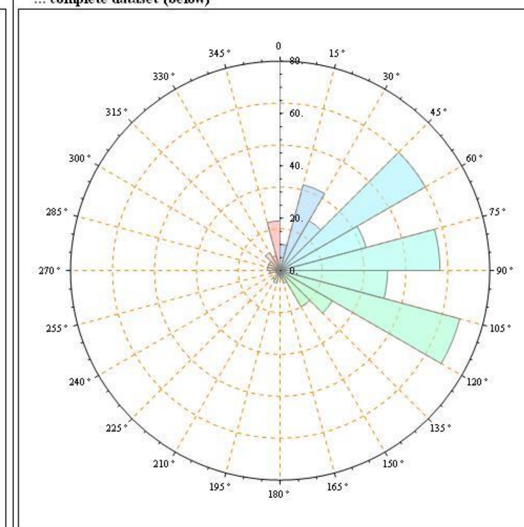
... complete dataset (below)



PHTOy2012.xls–2012: Hour = 14
Data Info: Windrose
Number of Datasets = 491
... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 14, 43, 0.} | 2.6 | 80. | OK | 1–1–2012 14:43 HST |

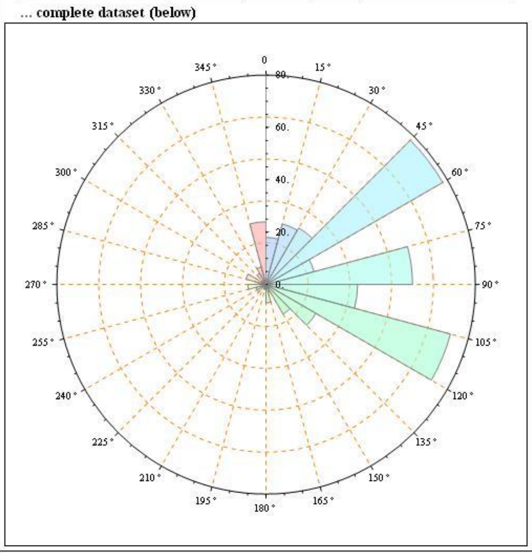
... complete dataset (below)



PHTOy2012.xls–2012: Hour = 15
Data Info: Windrose
Number of Datasets = 475
... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 15, 10, 0.} | 3.6 | 70. | OK | 1–1–2012 15:10 HST |

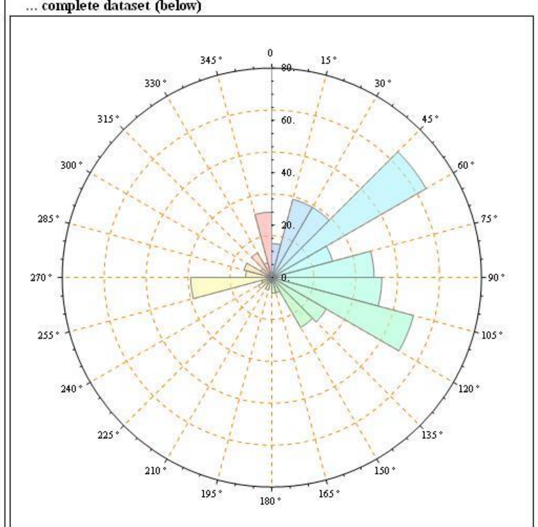
... complete dataset (below)



PHTOy2012.xls–2012: Hour = 16
Data Info: Windrose
Number of Datasets = 538
... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 16, 16, 0.} | 0. | | OK | 1–1–2012 16:16 HST |

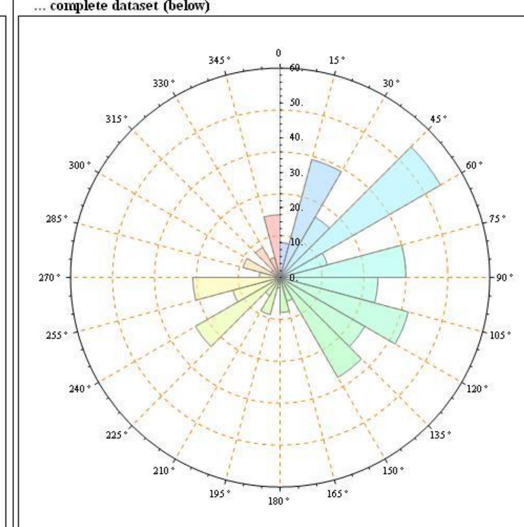
... complete dataset (below)



PHTOy2012.xls–2012: Hour = 17
Data Info: Windrose
Number of Datasets = 534
... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 17, 53, 0.} | 1.5 | 230. | OK | 1–1–2012 17:53 HST |

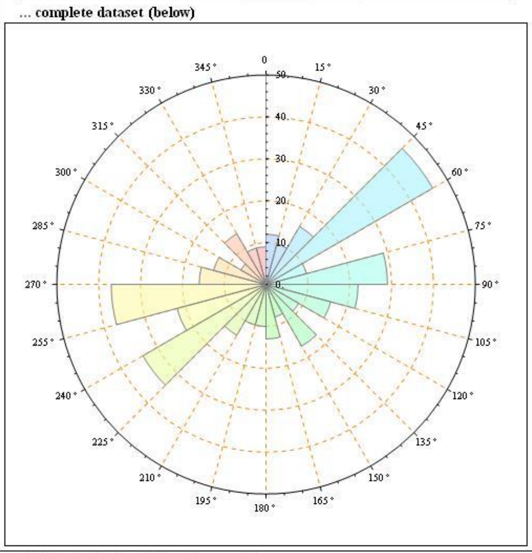
... complete dataset (below)



PHTOy2012.xls–2012: Hour = 18
Data Info: Windrose
Number of Datasets = 536
... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 18, 53, 0.} | 2.1 | 240. | OK | 1–1–2012 18:53 HST |

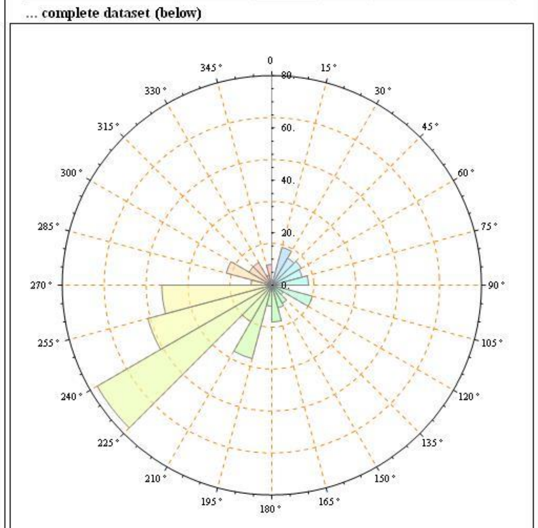
... complete dataset (below)



PHTOy2012.xls–2012: Hour = 19
Data Info: Windrose
Number of Datasets = 540
... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 19, 53, 0.} | 1.5 | 230. | OK | 1–1–2012 19:53 HST |

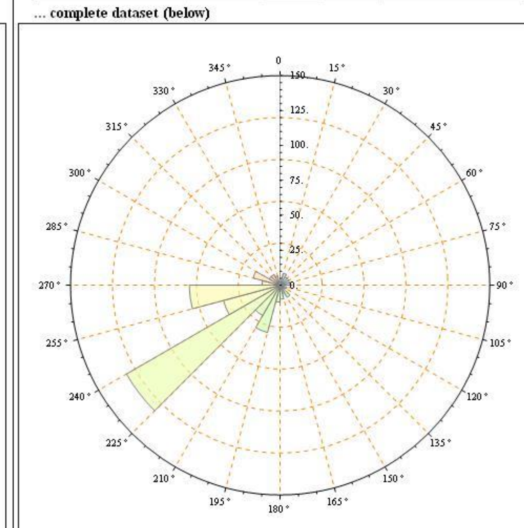
... complete dataset (below)



PHTOy2012.xls–2012: Hour = 20
Data Info: Windrose
Number of Datasets = 574
... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 20, 53, 0.} | 2.6 | 230. | OK | 1–1–2012 20:53 HST |

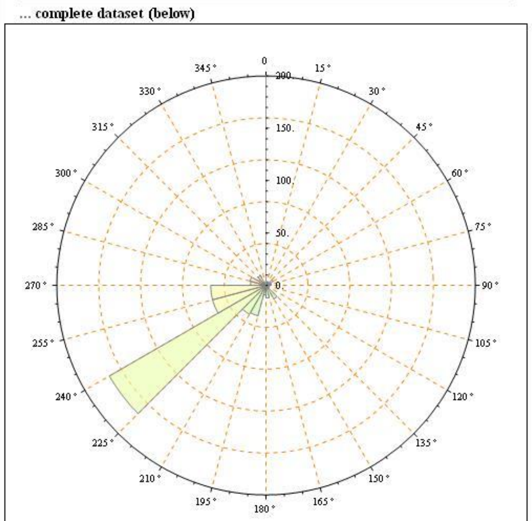
... complete dataset (below)



PHTOy2012.xls–2012: Hour = 21
Data Info: Windrose
Number of Datasets = 593
... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 21, 53, 0.} | 1.5 | 240. | OK | 1–1–2012 21:53 HST |

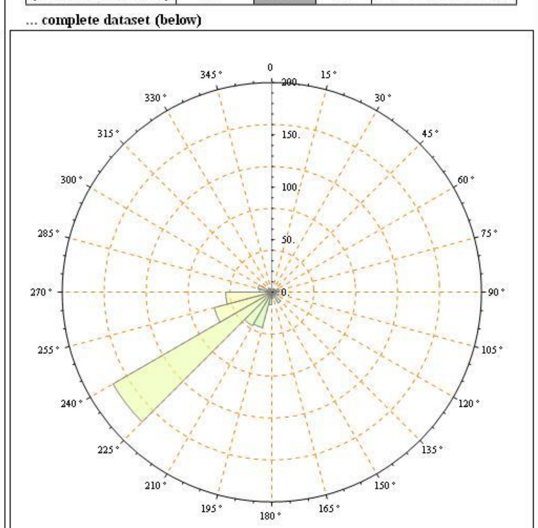
... complete dataset (below)



PHTOy2012.xls–2012: Hour = 22
Data Info: Windrose
Number of Datasets = 579
... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 22, 53, 0.} | 1.5 | 210. | OK | 1–1–2012 22:53 HST |

... complete dataset (below)



PHTOy2012.xls–2012: Hour = 23
Data Info: Windrose
Number of Datasets = 570
... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 23, 53, 0.} | 2.1 | 220. | OK | 1–1–2012 23:53 HST |

... complete dataset (below)

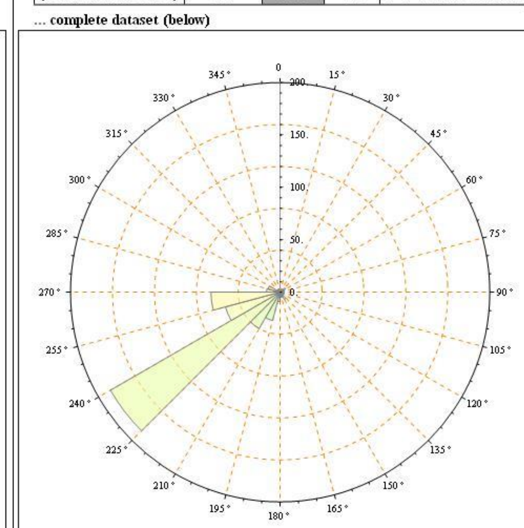


**Figure A-19.** 2012 Hilo International Airport (PHTO) Wind Rose - Evening Hours

AN157y2013.xls–2013: Hour = 0

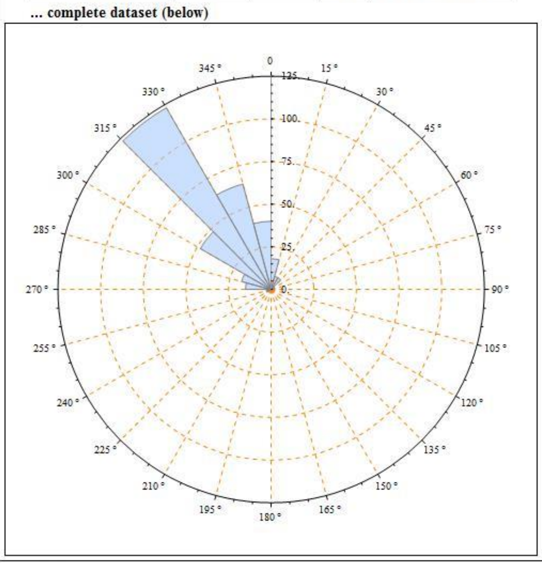
Data Info: Windrose

Number of Datasets = 351

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT mph | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2013, 1, 1, 0, 0, 0.} | 3.8 | 325. | N/A | 1–1–2013 0:00 HST |

... complete dataset (below)



AN157y2013.xls–2013: Hour = 1

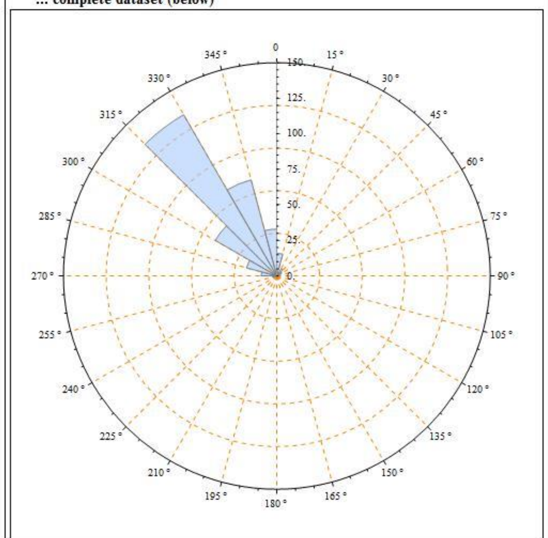
Data Info: Windrose

Number of Datasets = 350

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT mph | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2013, 1, 1, 1, 0, 0.} | 4.5 | 325. | N/A | 1–1–2013 1:00 HST |

... complete dataset (below)



AN157y2013.xls–2013: Hour = 2

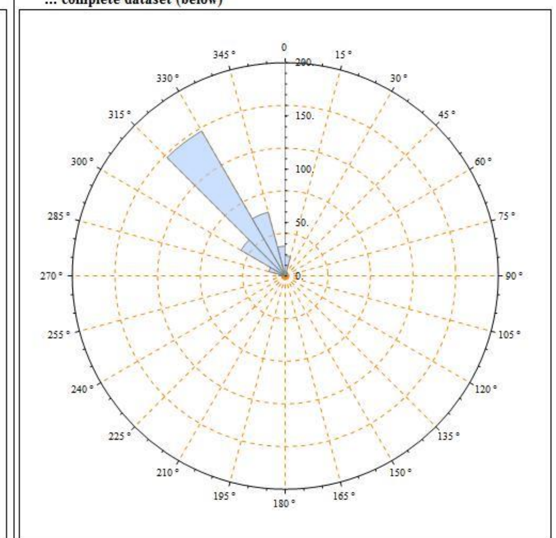
Data Info: Windrose

Number of Datasets = 348

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT mph | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2013, 1, 1, 2, 0, 0.} | 3.3 | 316. | N/A | 1–1–2013 2:00 HST |

... complete dataset (below)



AN157y2013.xls–2013: Hour = 3

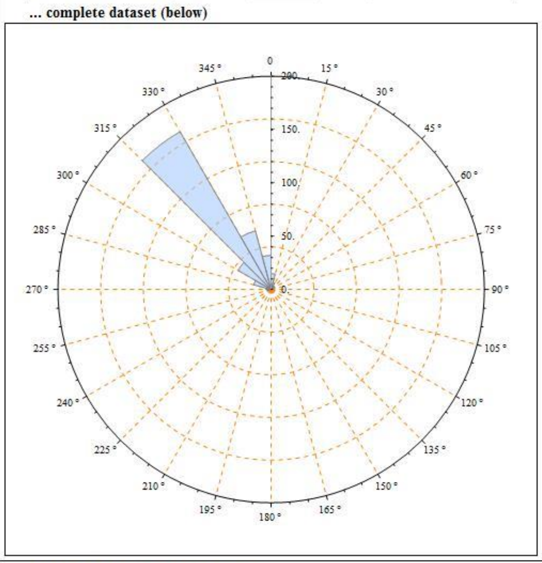
Data Info: Windrose

Number of Datasets = 352

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT mph | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2013, 1, 1, 3, 0, 0.} | 4.7 | 324. | N/A | 1–1–2013 3:00 HST |

... complete dataset (below)



AN157y2013.xls–2013: Hour = 4

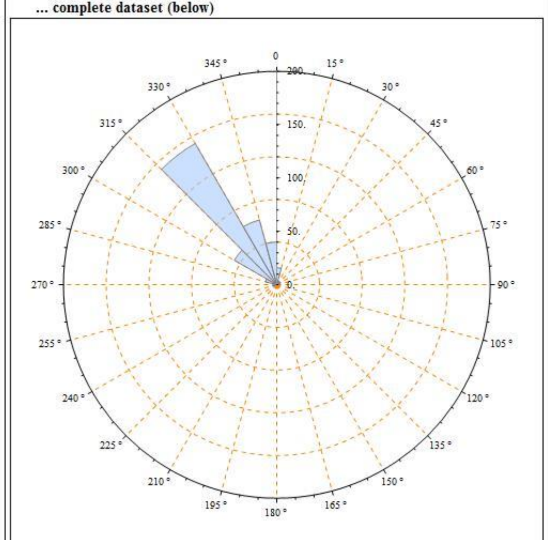
Data Info: Windrose

Number of Datasets = 349

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT mph | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2013, 1, 1, 4, 0, 0.} | 5.1 | 322. | N/A | 1–1–2013 4:00 HST |

... complete dataset (below)



AN157y2013.xls–2013: Hour = 5

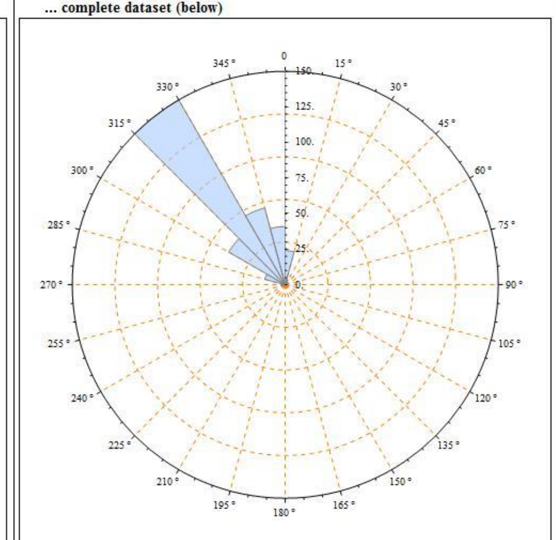
Data Info: Windrose

Number of Datasets = 348

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT mph | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2013, 1, 1, 5, 0, 0.} | 5.1 | 317. | N/A | 1–1–2013 5:00 HST |

... complete dataset (below)



AN157y2013.xls–2013: Hour = 6

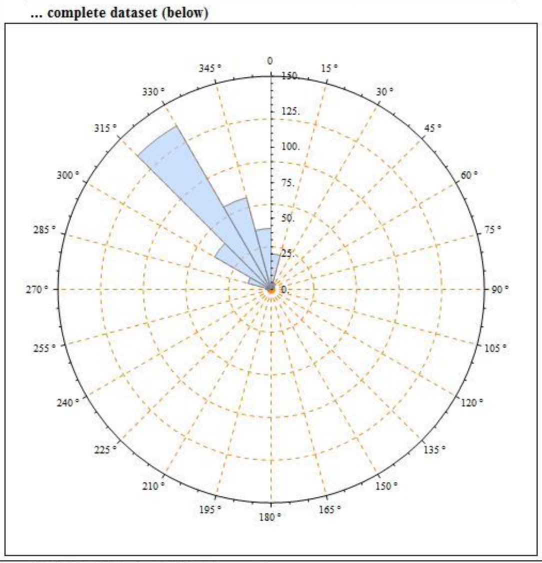
Data Info: Windrose

Number of Datasets = 350

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT mph | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2013, 1, 1, 6, 0, 0.} | 4.7 | 315. | N/A | 1–1–2013 6:00 HST |

... complete dataset (below)



AN157y2013.xls–2013: Hour = 7

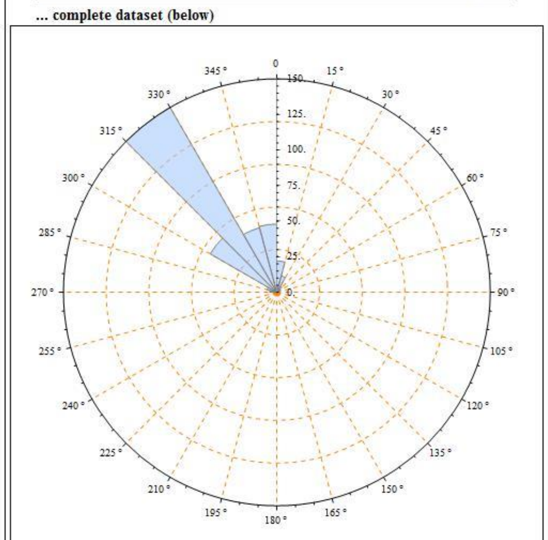
Data Info: Windrose

Number of Datasets = 355

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT mph | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2013, 1, 1, 7, 0, 0.} | 4.9 | 323. | N/A | 1–1–2013 7:00 HST |

... complete dataset (below)



AN157y2013.xls–2013: Hour = 8

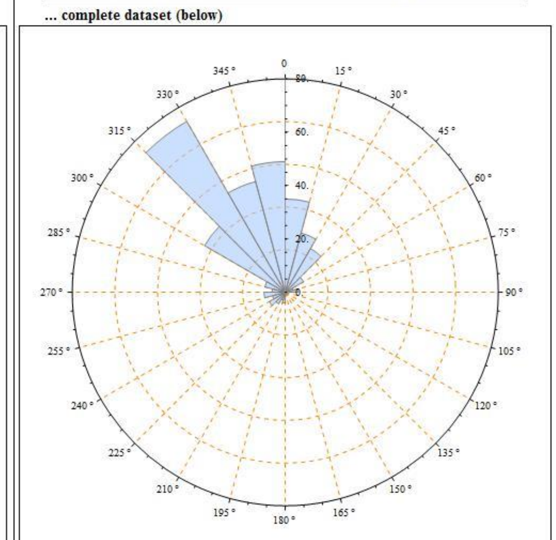
Data Info: Windrose

Number of Datasets = 341

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT mph | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2013, 1, 1, 8, 0, 0.} | 3.6 | 312. | N/A | 1–1–2013 8:00 HST |

... complete dataset (below)



AN157y2013.xls–2013: Hour = 9

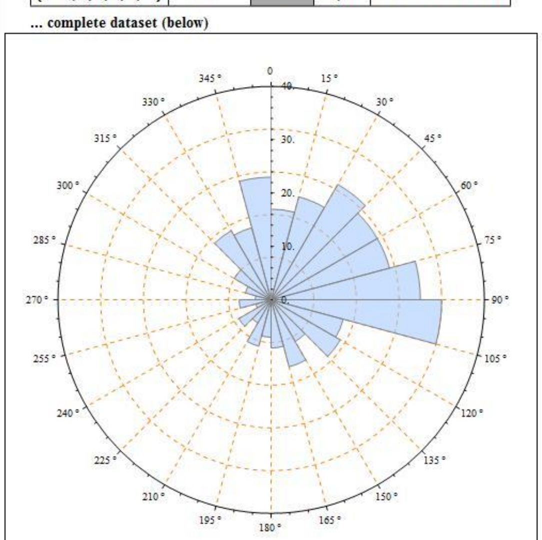
Data Info: Windrose

Number of Datasets = 333

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT mph | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2013, 1, 1, 9, 0, 0.} | 1.8 | 35. | N/A | 1–1–2013 9:00 HST |

... complete dataset (below)



AN157y2013.xls–2013: Hour = 10

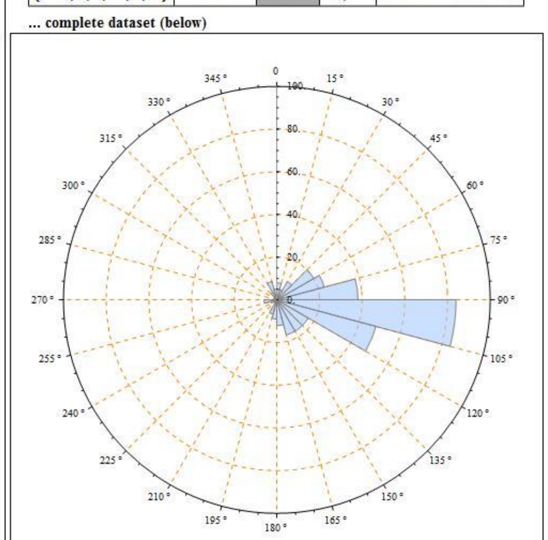
Data Info: Windrose

Number of Datasets = 344

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT mph | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2013, 1, 1, 10, 0, 0.} | 2.5 | 41. | N/A | 1–1–2013 10:00 HST |

... complete dataset (below)



AN157y2013.xls–2013: Hour = 11

Data Info: Windrose

Number of Datasets = 346

... first dataset (below); Direction = DRCT °

| ID = AN157 | SKNT mph | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2013, 1, 1, 11, 0, 0.} | 2.2 | 50. | N/A | 1–1–2013 11:00 HST |

... complete dataset (below)

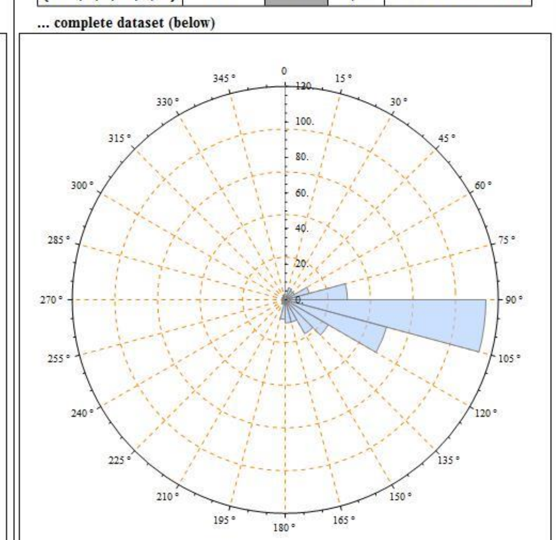


**Figure A-20.** 2013 Pahala (AN157) Wind Rose - Morning Hours

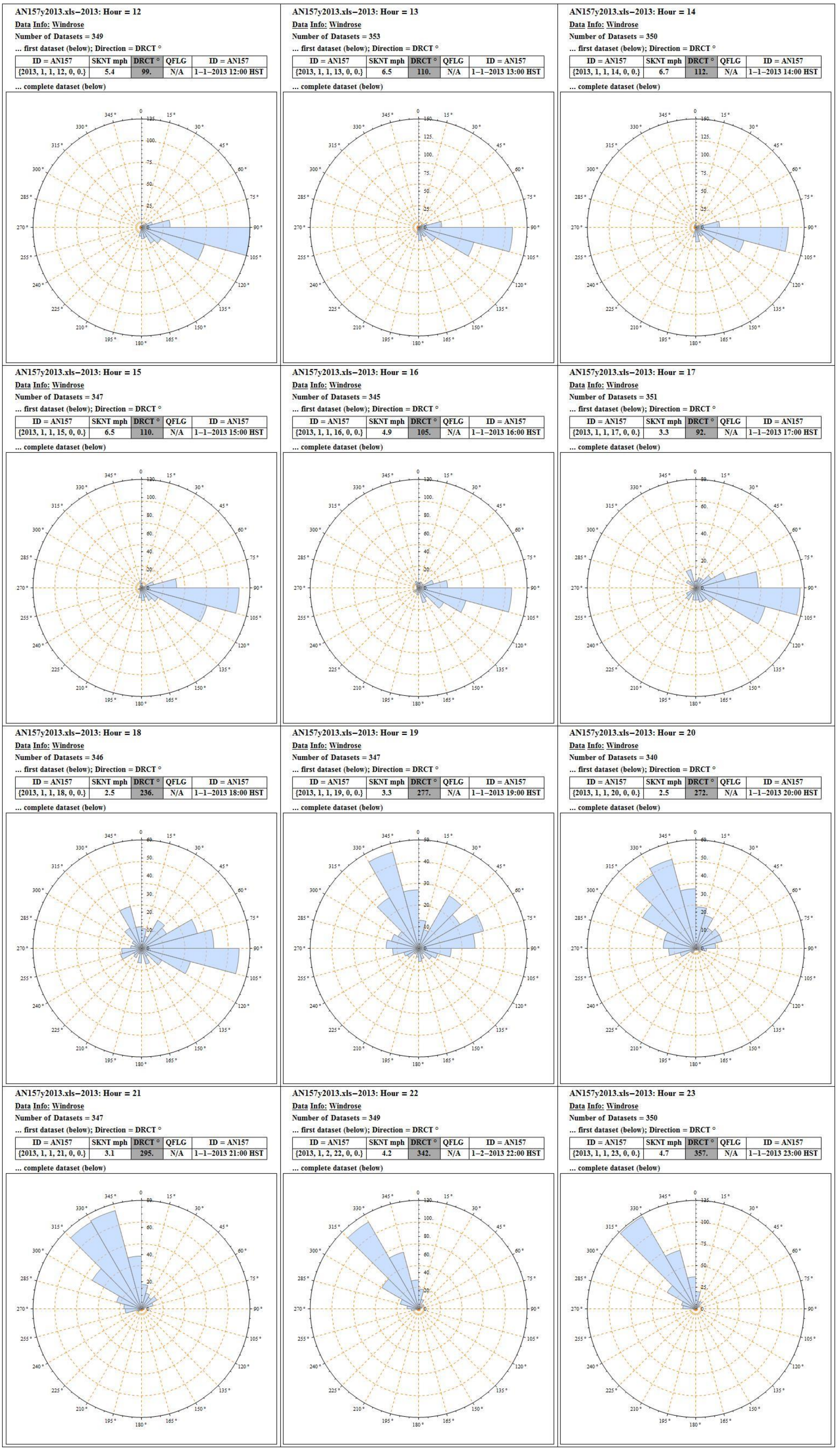



**Figure A-21.** 2013 Pahala (AN157) Wind Rose - Evening Hours

**AN738y2013.xls−2013: Hour = 0**

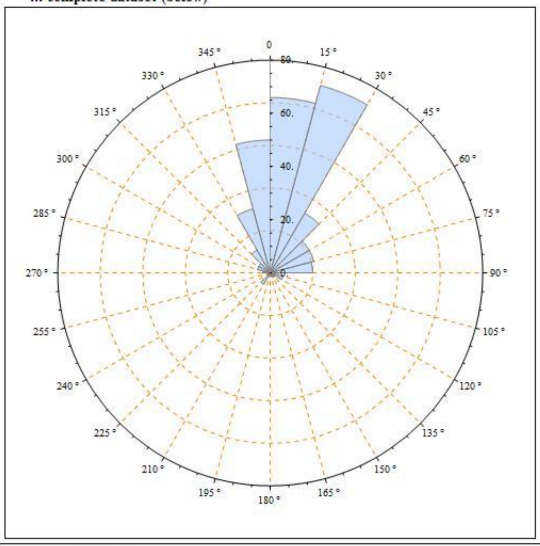
Data Info: Windrose

Number of Datasets = 334

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 0, 0, 0.} | 2.9 | 20. | N/A | 1−1−2013 0:00 HST |

... complete dataset (below)




**AN738y2013.xls−2013: Hour = 1**

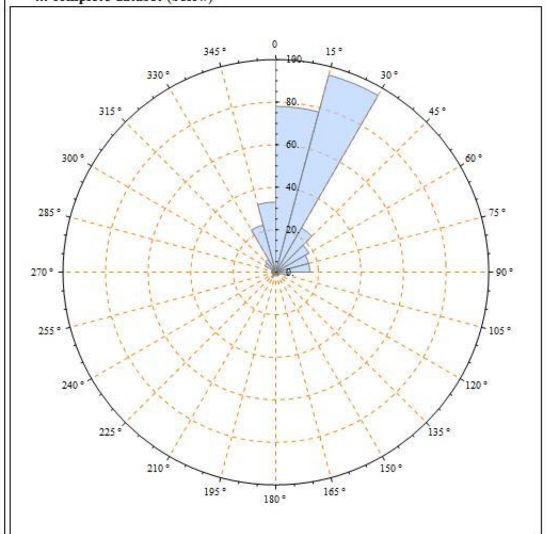
Data Info: Windrose

Number of Datasets = 338

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 1, 0, 0.} | 3.8 | 14. | N/A | 1−1−2013 1:00 HST |

... complete dataset (below)




**AN738y2013.xls−2013: Hour = 2**

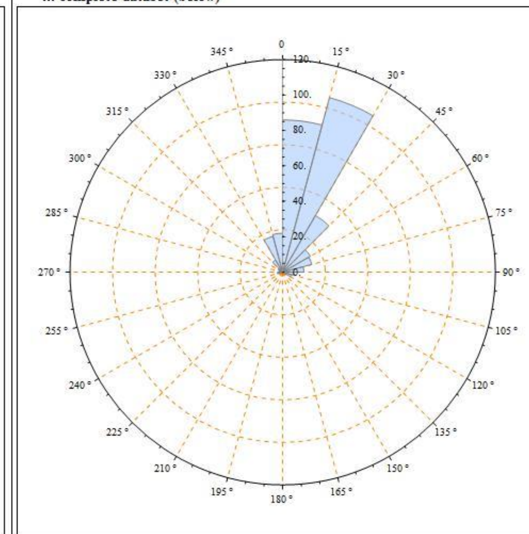
Data Info: Windrose

Number of Datasets = 343

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 2, 0, 0.} | 2.7 | 344. | N/A | 1−1−2013 2:00 HST |

... complete dataset (below)




**AN738y2013.xls−2013: Hour = 3**

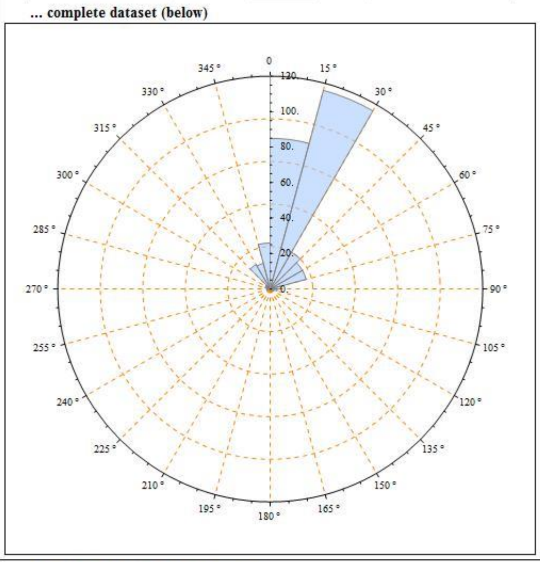
Data Info: Windrose

Number of Datasets = 346

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 3, 0, 0.} | 3.6 | 15. | N/A | 1−1−2013 3:00 HST |

... complete dataset (below)




**AN738y2013.xls−2013: Hour = 4**

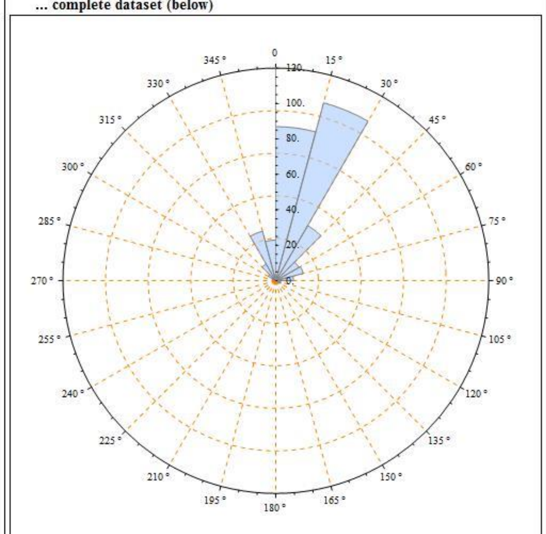
Data Info: Windrose

Number of Datasets = 342

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 4, 0, 0.} | 5.1 | 23. | N/A | 1−1−2013 4:00 HST |

... complete dataset (below)




**AN738y2013.xls−2013: Hour = 5**

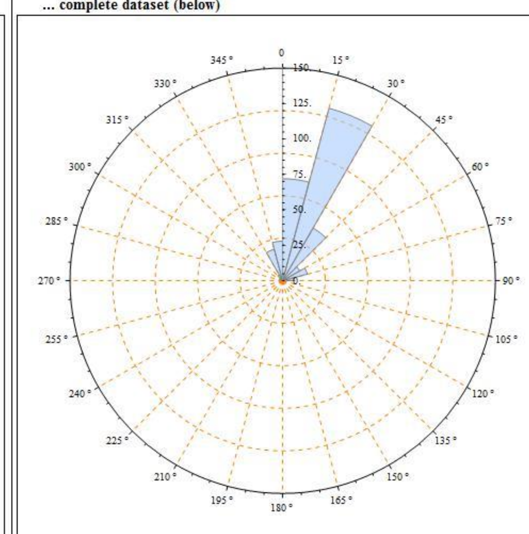
Data Info: Windrose

Number of Datasets = 342

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 5, 0, 0.} | 4. | 16. | N/A | 1−1−2013 5:00 HST |

... complete dataset (below)




**AN738y2013.xls−2013: Hour = 6**

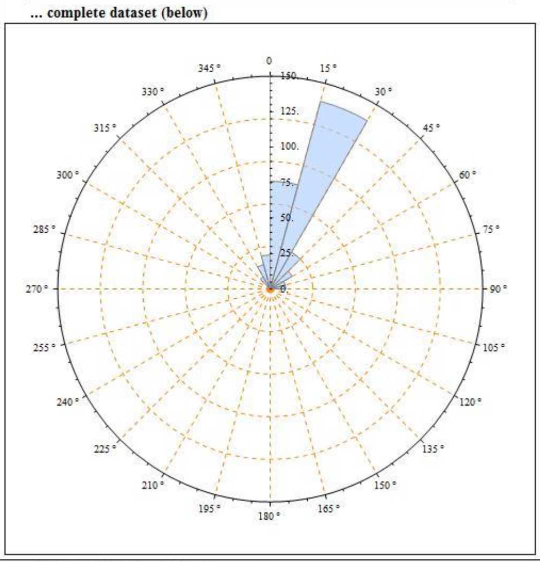
Data Info: Windrose

Number of Datasets = 338

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 6, 0, 0.} | 5.4 | 20. | N/A | 1−1−2013 6:00 HST |

... complete dataset (below)




**AN738y2013.xls−2013: Hour = 7**

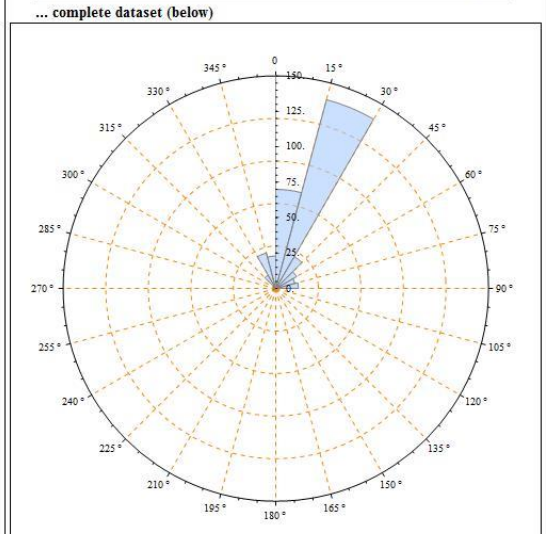
Data Info: Windrose

Number of Datasets = 349

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 7, 0, 0.} | 3.1 | 28. | N/A | 1−1−2013 7:00 HST |

... complete dataset (below)




**AN738y2013.xls−2013: Hour = 8**

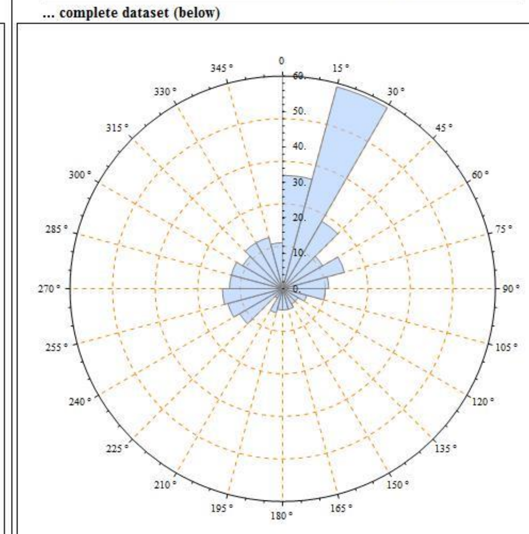
Data Info: Windrose

Number of Datasets = 347

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 8, 0, 0.} | 3.3 | 13. | N/A | 1−1−2013 8:00 HST |

... complete dataset (below)




**AN738y2013.xls−2013: Hour = 9**

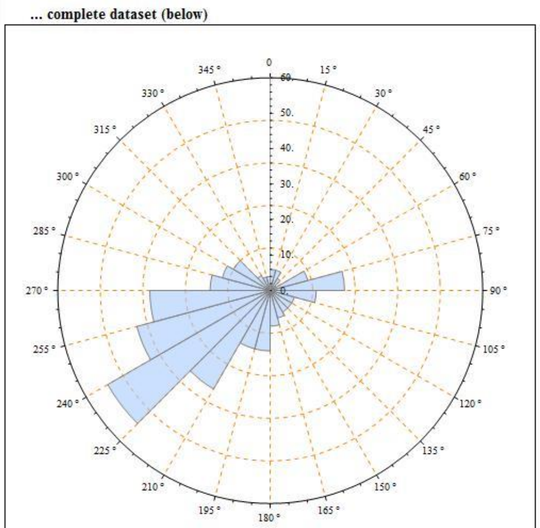
Data Info: Windrose

Number of Datasets = 350

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 9, 0, 0.} | 1.8 | 229. | N/A | 1−1−2013 9:00 HST |

... complete dataset (below)




**AN738y2013.xls−2013: Hour = 10**

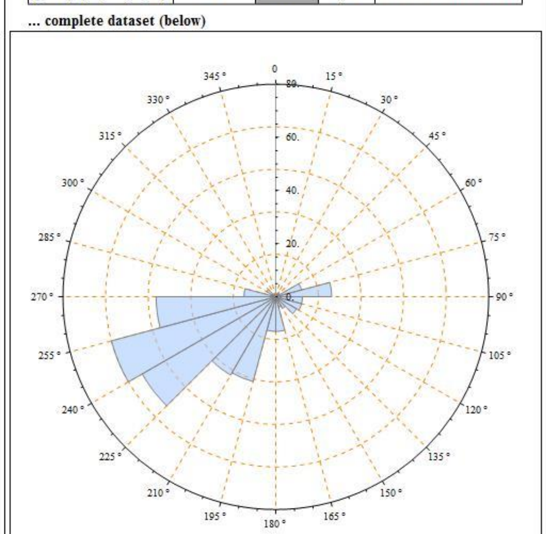
Data Info: Windrose

Number of Datasets = 352

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 10, 0, 0.} | 2.2 | 254. | N/A | 1−1−2013 10:00 HST |

... complete dataset (below)




**AN738y2013.xls−2013: Hour = 11**

Data Info: Windrose

Number of Datasets = 352

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 11, 0, 0.} | 4.5 | 260. | N/A | 1−1−2013 11:00 HST |

... complete dataset (below)

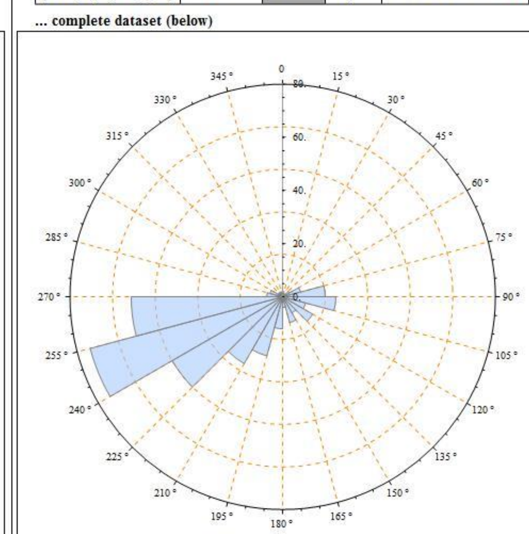



**Figure A-22.** 2013 Ocean View (AN738) Wind Rose - Morning Hours

AN738y2013.xls−2013: Hour = 12

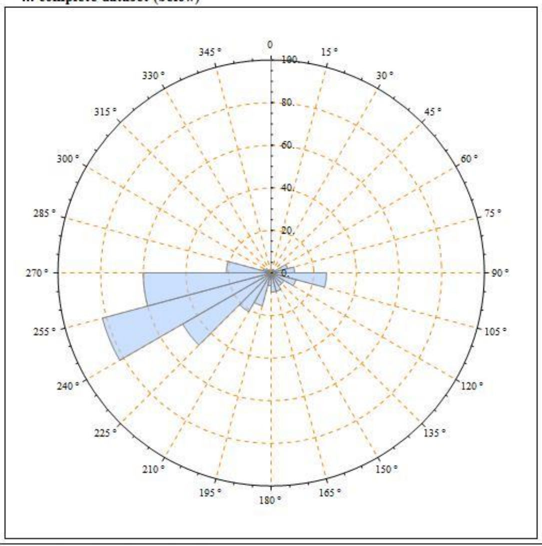
Data Info: Windrose

Number of Datasets = 355

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 12, 0, 0.} | 5.4 | 231. | N/A | 1–1–2013 12:00 HST |

... complete dataset (below)



AN738y2013.xls−2013: Hour = 13

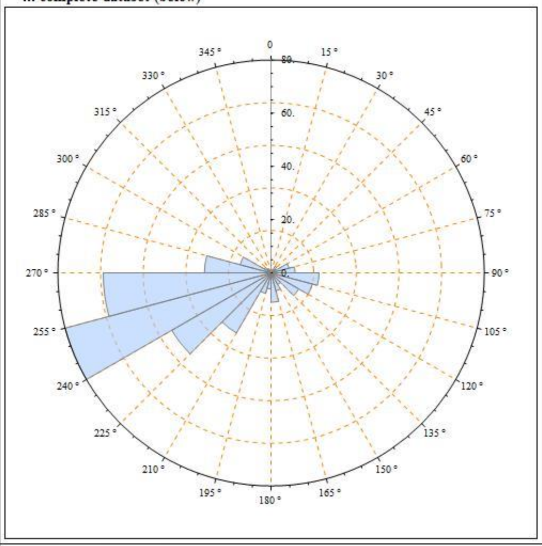
Data Info: Windrose

Number of Datasets = 359

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 13, 0, 0.} | 4.2 | 250. | N/A | 1–1–2013 13:00 HST |

... complete dataset (below)



AN738y2013.xls−2013: Hour = 14

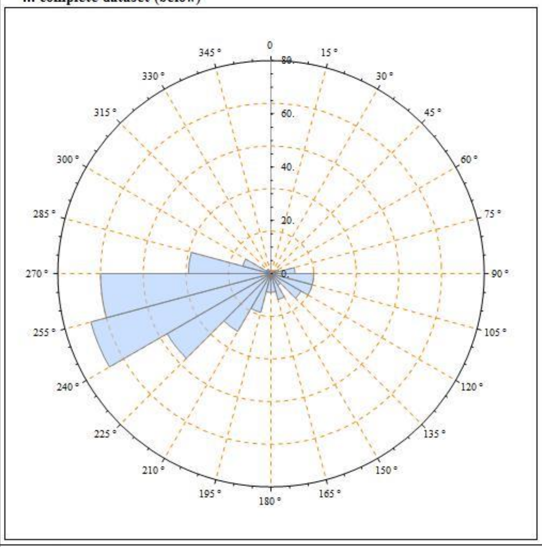
Data Info: Windrose

Number of Datasets = 354

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 14, 0, 0.} | 3.6 | 233. | N/A | 1–1–2013 14:00 HST |

... complete dataset (below)



AN738y2013.xls−2013: Hour = 15

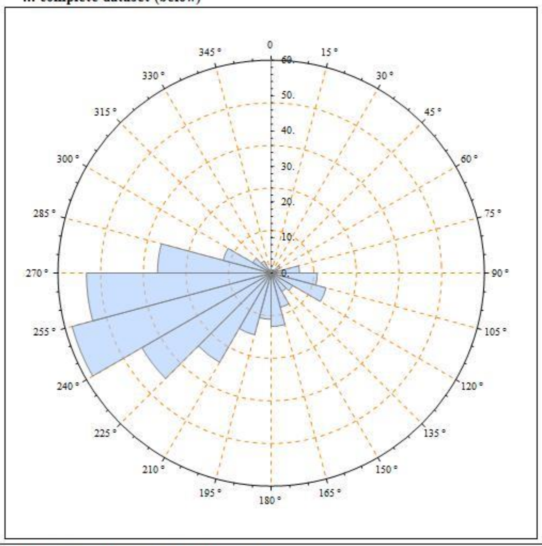
Data Info: Windrose

Number of Datasets = 350

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 15, 0, 0.} | 3.8 | 226. | N/A | 1–1–2013 15:00 HST |

... complete dataset (below)



AN738y2013.xls−2013: Hour = 16

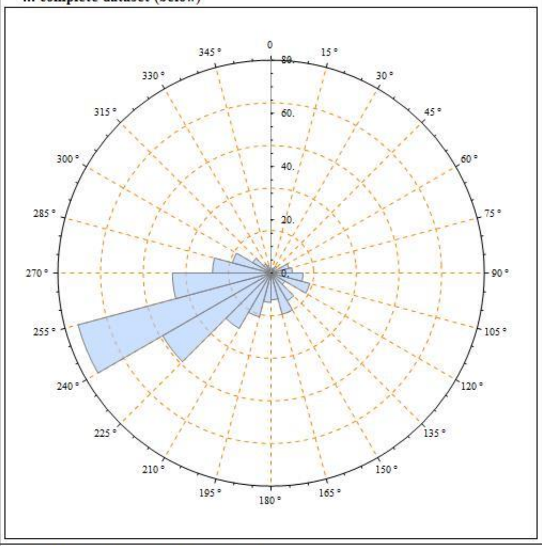
Data Info: Windrose

Number of Datasets = 355

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 16, 0, 0.} | 3.6 | 268. | N/A | 1–1–2013 16:00 HST |

... complete dataset (below)



AN738y2013.xls−2013: Hour = 17

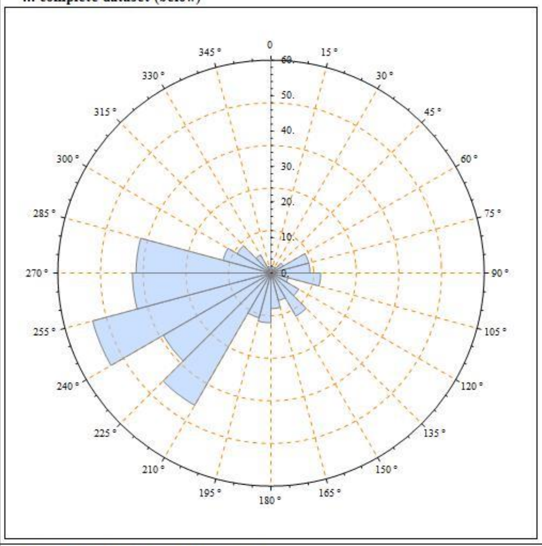
Data Info: Windrose

Number of Datasets = 359

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 17, 0, 0.} | 3.1 | 287. | N/A | 1–1–2013 17:00 HST |

... complete dataset (below)



AN738y2013.xls−2013: Hour = 18

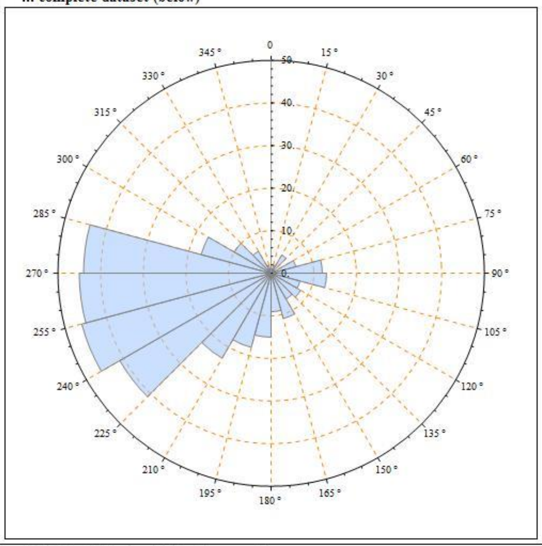
Data Info: Windrose

Number of Datasets = 350

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 18, 0, 0.} | 2.2 | 227. | N/A | 1–1–2013 18:00 HST |

... complete dataset (below)



AN738y2013.xls−2013: Hour = 19

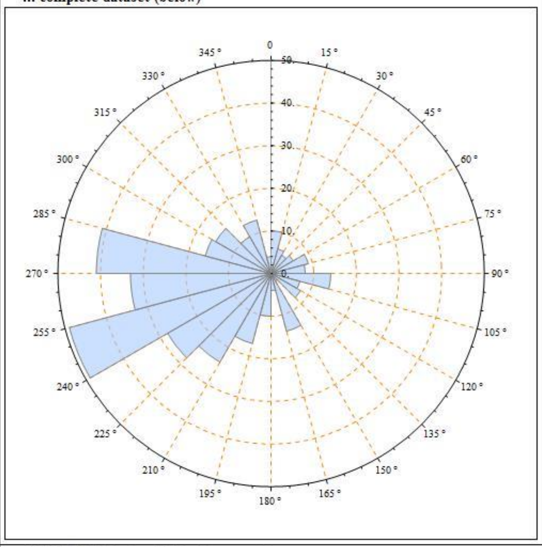
Data Info: Windrose

Number of Datasets = 353

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 19, 0, 0.} | 0.7 | 238. | N/A | 1–1–2013 19:00 HST |

... complete dataset (below)



AN738y2013.xls−2013: Hour = 20

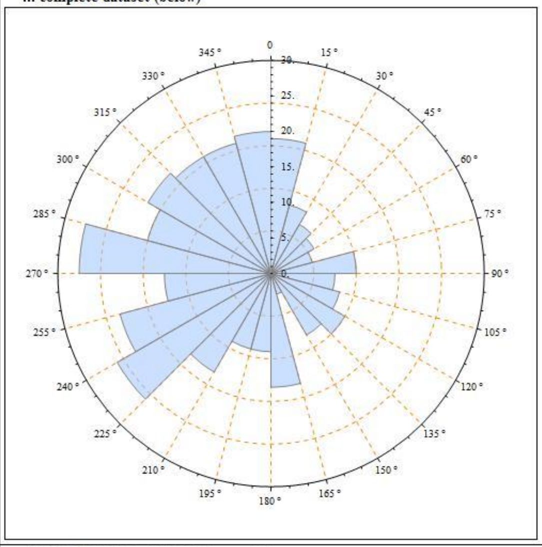
Data Info: Windrose

Number of Datasets = 345

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 2, 20, 0, 0.} | 1.8 | 338. | N/A | 1–2–2013 20:00 HST |

... complete dataset (below)



AN738y2013.xls−2013: Hour = 21

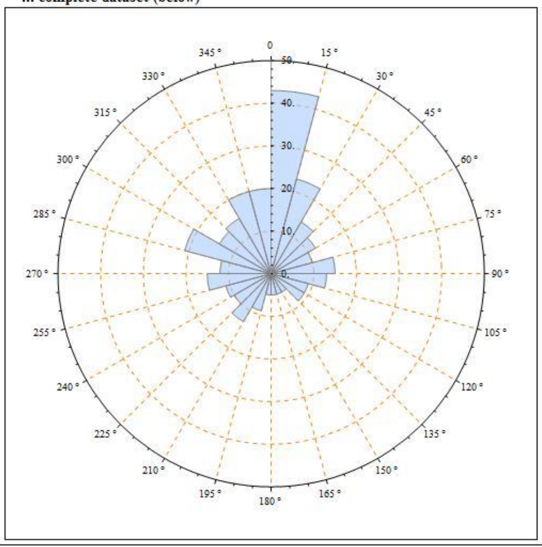
Data Info: Windrose

Number of Datasets = 328

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 21, 0, 0.} | 2.7 | 23. | N/A | 1–1–2013 21:00 HST |

... complete dataset (below)



AN738y2013.xls−2013: Hour = 22

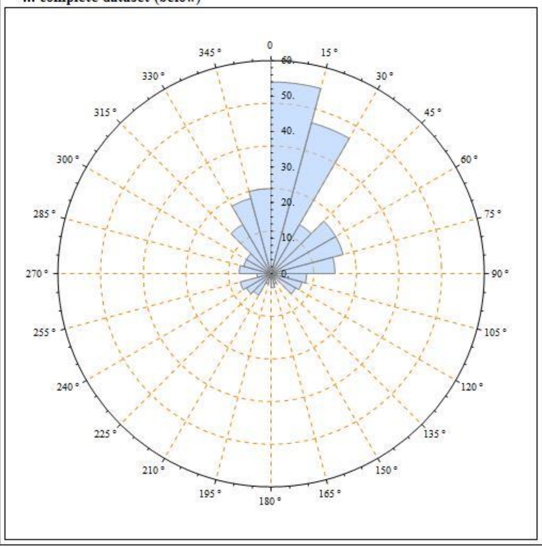
Data Info: Windrose

Number of Datasets = 329

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 2, 22, 0, 0.} | 1.8 | 2. | N/A | 1–2–2013 22:00 HST |

... complete dataset (below)



AN738y2013.xls−2013: Hour = 23

Data Info: Windrose

Number of Datasets = 343

... first dataset (below); Direction = DRCT °

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 23, 0, 0.} | 4.7 | 21. | N/A | 1–1–2013 23:00 HST |

... complete dataset (below)

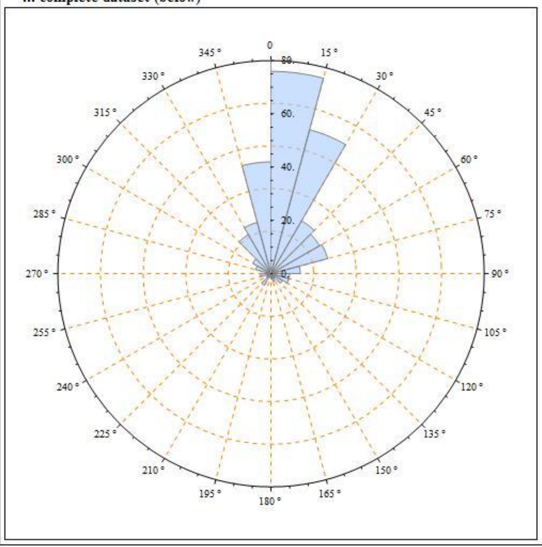


**Figure A-23. 2013** Ocean View (AN738) Wind Rose - Evening Hours

Appendix B

| KONA (KN) 150011012: 2013 24-hr $PM_{2.5}$ Flagged Data >12.04 ug/$m^3$ | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2013 | | | | | | | |
| Q1 | µg/$m^3$ | Q1 (cont'd) | µg/$m^3$ | Q2 | µg/$m^3$ | Q2 (cont'd) | µg/$m^3$ |
| 1/1/2013 | 16.3 | 3/7/2013 | 19.0 | 4/1/2013 | 12.1 | 6/29/2013 | 16.4 |
| 1/3/2013 | 12.4 | 3/8/2013 | 20.0 | 4/3/2013 | 13.7 | 6/30/2013 | 14.9 |
| 1/4/2013 | 12.9 | 3/14/2013 | 14.0 | 4/4/2013 | 21 | | |
| 1/5/2013 | 13.0 | 3/21/2013 | 15.3 | 4/5/2013 | 22.6 | | |
| 1/6/2013 | 14.2 | 3/22/2013 | 16.5 | 4/6/2013 | 28.8 | | |
| 1/7/2013 | 16.0 | 3/24/2013 | 12.6 | 4/7/2013 | 26.5 | | |
| 1/8/2013 | 17.5 | 3/25/2013 | 12.5 | 4/8/2013 | 22.6 | | |
| 1/9/2013 | 17.2 | 3/26/2013 | 13.5 | 4/9/2013 | 17.7 | | |
| 1/10/2013 | 19.9 | 3/27/2013 | 12.2 | 4/10/2013 | 15 | | |
| 1/11/2013 | 17.2 | 3/28/2013 | 12.5 | 4/11/2013 | 20.7 | | |
| 1/12/2013 | 19.5 | 3/29/2013 | 14.4 | 4/12/2013 | 24.6 | | |
| 1/13/2013 | 16.4 | 3/30/2013 | 12.4 | 4/13/2013 | 15.8 | | |
| 1/14/2013 | 12.8 | | | 4/14/2013 | 13.7 | | |
| 1/21/2013 | 16.9 | | | 4/16/2013 | 18.9 | | |
| 1/22/2013 | 21.1 | | | 4/17/2013 | 17.4 | | |
| 1/23/2013 | 20.5 | | | 4/18/2013 | 13.3 | | |
| 1/24/2013 | 22.5 | | | 4/19/2013 | 18.5 | | |
| 1/25/2013 | 21.9 | | | 4/20/2013 | 23.3 | | |
| 1/26/2013 | 20.8 | | | 4/21/2013 | 18.5 | | |
| 1/27/2013 | 18.0 | | | 4/25/2013 | 16.1 | | |
| 2/1/2013 | 20.7 | | | 4/26/2013 | 18.3 | | |
| 2/2/2013 | 19.8 | | | 4/27/2013 | 15 | | |
| 2/3/2013 | 21.8 | | | 4/28/2013 | 16.5 | | |
| 2/4/2013 | 21.0 | | | 4/29/2013 | 14.5 | | |
| 2/5/2013 | 23.5 | | | 5/1/2013 | 19.7 | | |
| 2/6/2013 | 21.7 | | | 5/2/2013 | 20.6 | | |
| 2/7/2013 | 21.0 | | | 5/3/2013 | 17.2 | | |
| 2/8/2013 | 19.0 | | | 5/4/2013 | 12.6 | | |
| 2/9/2013 | 16.5 | | | 5/5/2013 | 12.8 | | |
| 2/10/2013 | 20.2 | | | 5/11/2013 | 13.5 | | |
| 2/11/2013 | 21.0 | | | 5/15/2013 | 14.1 | | |
| 2/12/2013 | 23.5 | | | 5/16/2013 | 14.5 | | |
| 2/13/2013 | 20.1 | | | 5/17/2013 | 13.9 | | |
| 2/14/2013 | 20.6 | | | 5/23/2013 | 12.5 | | |
| 2/15/2013 | 21.2 | | | 5/29/2013 | 12.9 | | |
| 2/16/2013 | 16.5 | | | 5/30/2013 | 13.8 | | |
| 2/17/2013 | 17.6 | | | 5/31/2013 | 13.6 | | |
| 2/18/2013 | 15.5 | | | 6/1/2013 | 13 | | |
| 2/19/2013 | 20.0 | | | 6/6/2013 | 15.8 | | |
| 2/20/2013 | 16.7 | | | 6/7/2013 | 14.5 | | |
| 2/21/2013 | 16.5 | | | 6/8/2013 | 14.8 | | |
| 2/22/2013 | 14.7 | | | 6/11/2013 | 15 | | |
| 2/23/2013 | 16.3 | | | 6/12/2013 | 16.9 | | |
| 2/24/2013 | 17.1 | | | 6/13/2013 | 12.1 | | |
| 2/25/2013 | 15.9 | | | 6/17/2013 | 13 | | |
| 2/26/2013 | 18.5 | | | 6/18/2013 | 17.7 | | |
| 2/27/2013 | 19.7 | | | 6/19/2013 | 13 | | |
| 2/28/2013 | 18.2 | | | 6/20/2013 | 12.2 | | |
| 3/1/2013 | 18.8 | | | 6/22/2013 | 13.6 | | |
| 3/2/2013 | 16.7 | | | 6/23/2013 | 14 | | |
| 3/3/2013 | 17.1 | | | 6/24/2013 | 16.5 | | |
| 3/4/2013 | 21.3 | | | 6/25/2013 | 16.2 | | |
| 3/5/2013 | 21.4 | | | 6/26/2013 | 15.4 | | |
| 3/6/2013 | 16.6 | | | 6/28/2013 | 12.7 | | |

# Appendix B

| KONA (KN) 150011012: 2013 24-hr $PM_{2.5}$ Flagged Data >12.04 ug/m$^3$ | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2013 | | | | | | | |
| Q3 | µg/m$^3$ | | | Q4 | µg/m$^3$ | | |
| 7/1/2013 | 13.5 | | | 10/1/2013 | 13.7 | | |
| 7/3/2013 | 13.6 | | | 10/2/2013 | 16.2 | | |
| 7/4/2013 | 12.7 | | | 10/4/2013 | 13.7 | | |
| 7/8/2013 | 13.2 | | | 10/6/2013 | 12.2 | | |
| 7/9/2013 | 13.6 | | | 10/8/2013 | 14.4 | | |
| 7/10/2013 | 14.3 | | | 10/9/2013 | 12.1 | | |
| 7/11/2013 | 14.3 | | | 10/10/2013 | 13.3 | | |
| 7/12/2013 | 17.4 | | | 10/11/2013 | 14.9 | | |
| 7/13/2013 | 14.2 | | | 10/12/2013 | 12.7 | | |
| 7/14/2013 | 13.1 | | | 10/17/2013 | 17.5 | | |
| 7/15/2013 | 13.4 | | | 10/18/2013 | 16.2 | | |
| 7/16/2013 | 12.9 | | | 10/19/2013 | 16.2 | | |
| 7/17/2013 | 13.7 | | | 10/23/2013 | 19 | | |
| 7/18/2013 | 12.8 | | | 10/24/2013 | 18.6 | | |
| 7/20/2013 | 12.5 | | | 10/25/2013 | 20.3 | | |
| 7/21/2013 | 14.5 | | | 10/31/2013 | 12.6 | | |
| 7/22/2013 | 12.2 | | | 11/5/2013 | 13.2 | | |
| 7/23/2013 | 12.6 | | | 11/6/2013 | 16.2 | | |
| 7/24/2013 | 16.2 | | | 11/7/2013 | 13.3 | | |
| 7/27/2013 | 12.5 | | | 11/8/2013 | 12.5 | | |
| 7/31/2013 | 15.7 | | | 11/13/2013 | 14.4 | | |
| 8/1/2013 | 14.6 | | | 11/14/2013 | 16.4 | | |
| 8/2/2013 | 17.5 | | | 11/15/2013 | 15.5 | | |
| 8/3/2013 | 19 | | | 11/16/2013 | 16 | | |
| 8/4/2013 | 13.9 | | | 11/17/2013 | 14.5 | | |
| 8/5/2013 | 16.3 | | | 11/18/2013 | 14 | | |
| 8/6/2013 | 18.3 | | | 11/19/2013 | 14.7 | | |
| 8/7/2013 | 14.6 | | | 11/20/2013 | 13.5 | | |
| 8/8/2013 | 14.7 | | | 11/21/2013 | 17.2 | | |
| 8/9/2013 | 13.8 | | | 11/22/2013 | 16.1 | | |
| 8/11/2013 | 14.3 | | | 11/27/2013 | 14.8 | | |
| 8/12/2013 | 16.1 | | | 11/29/2013 | 14 | | |
| 8/13/2013 | 14 | | | 12/3/2013 | 17 | | |
| 8/14/2013 | 13.2 | | | 12/4/2013 | 12.7 | | |
| 8/15/2013 | 14.3 | | | 12/11/2013 | 13.5 | | |
| 8/16/2013 | 12.3 | | | 12/12/2013 | 12.2 | | |
| 8/20/2013 | 15.2 | | | 12/13/2013 | 13.8 | | |
| 8/22/2013 | 12.4 | | | 12/14/2013 | 14.6 | | |
| 8/23/2013 | 12.9 | | | 12/31/2013 | 13.7 | | |
| 8/24/2013 | 12.4 | | | | | | |
| 8/25/2013 | 13.4 | | | | | | |
| 8/26/2013 | 16.8 | | | | | | |
| 8/30/2013 | 14.1 | | | | | | |
| 8/31/2013 | 13.3 | | | | | | |
| 9/2/2013 | 12.7 | | | | | | |
| 9/3/2013 | 13.9 | | | | | | |
| 9/8/2013 | 13.1 | | | | | | |
| 9/18/2013 | 13 | | | | | | |
| 9/22/2013 | 15 | | | | | | |
| 9/24/2013 | 13.6 | | | | | | |
| 9/27/2013 | 14.8 | | | | | | |
| 9/28/2013 | 13.2 | | | | | | |
| 9/29/2013 | 13.9 | | | | | | |
| 9/30/2013 | 13.9 | | | | | | |

# APPENDIX C

Public Review Documentation

## AFFIDAVIT OF PUBLICATION

**IN THE MATTER OF**
Public Notice Docket No. 14-CA-PA-12

STATE OF HAWAII } SS.
City and County of Honolulu }

**Doc. Date:** MAY 30 201_ **# Pages:** 1
**Notary Name:** Patricia K. Reese First Judicial **Circuit**
**Doc. Description:** Affidavit of Publication

MAY 30 2014

Notary Signature Date

PATRICIA K. REESE NOTARY PUBLIC Comm. No. 86-467 STATE OF HAWAII

Julie Clark being duly sworn, deposes and says that she is a clerk, duly authorized to execute this affidavit of Oahu Publications, Inc. publisher of The Honolulu Star-Advertiser and MidWeek, that said newspapers are newspapers of general circulation in the State of Hawaii, and that the attached notice is true notice as was published in the aforementioned newspapers as follows:

Honolulu Star-Advertiser 1 times on:
05/30/2014

Midweek Wed. 0 times on:

_______ times on:

And that affiant is not a party to or in any way interested in the above entitled matter.

Julie Clark

Subscribed to and sworn before me this 30th day of May A.D. 2014

Patricia K. Reese, Notary Public of the First Judicial Circuit, State of Hawaii
My commission expires: Oct 07 2014

Ad # 0000633400

PUBLIC NOTICE

The Department of Health, State of Hawaii, is notifying all interested persons of the report, "Documentation for Natural Event Excluded Data." Pursuant to 40 CFR 50.14, this report describes the treatment of air quality monitoring data influenced by natural events.

The report is available for public review during regular office hours, Monday through Friday, 7:45 a.m. to 4:15 p.m., at the following locations:

Oahu:
- Clean Air Branch, Department of Health
919 Ala Moana Blvd., Room 203, Honolulu, Oahu 96814

Hawaii:
- Hawaii District Health Office, Department of Health
1582 Kamehameha Ave., Hilo, Hawaii
- Clean Air Branch - Kona, Keakealani Building, Department of Health
79-1020 Haukapila Street, Room 113, Kealakekua, Hawaii

The report is also available on the Clean Air Branch, Department of Health website at http://health.hawaii.gov/cab. Interested persons may submit written comments addressed to the Department of Health at the above address on Oahu, and must be postmarked or received by June 30, 2014. For additional information, contact Ms. Lisa Young of the Clean Air Branch in Honolulu at (808) 586-4200.
(SA633400 5/30/14)

PATRICIA K. REESE NOTARY PUBLIC Comm. No. 86-467 STATE OF HAWAII

SP.NO.: ____________ L.N.

# AFFIDAVIT OF PUBLICATION

State of Hawaii )
) SS:
County of Hawaii )

M. R. Chavez, being first duly sworn, deposes and says:

1. That she is the Classified Accountant of WEST HAWAII TODAY, a newspaper published in the City of Kailua-Kona, State of Hawaii.

2. That "**PUBLIC NOTICE** The Department of Health, State of Hawaii, is notifying all interested persons of the report, "Documentation for Natural Event Excluded Data." Pursuant to" of which a clipping from the newspaper is attached hereto, was published in said newspaper on the following date(s) May 30, 2014 (etc.)

[signature]

Subscribed and sworn to before me
This 30th day of May, 2014

[signature]

Notary Public, Third Circuit,
State of Hawaii

HENRIANN P. KAHANANUI
NOTARY
Comm. No. 11-188
PUBLIC
STATE OF HAWAII

Henriann P. Kahananui

My Commission expires: June 6, 2015
# Page(s): 1

**PUBLIC NOTICE**

The Department of Health, State of Hawaii, is notifying all interested persons of the report, "Documentation for Natural Event Excluded Data." Pursuant to 40 CFR 50.14, this report describes the treatment of air quality monitoring data influenced by natural events.

The report is available for public review during regular office hours, Monday through Friday, 7:45 a.m. to 4:15 p.m., at the following locations:

Oahu:
- Clean Air Branch, Department of Health
  919 Ala Moana Blvd., Room 203, Honolulu, Oahu 96814

Hawaii:
- Hawaii District Health Office, Department of Health
  1582 Kamehameha Ave., Hilo, Hawaii
- Clean Air Branch – Kona, Keakealani Building, Department of Health
  79-1020 Haukapila Street, Room 113, Kealakekua, Hawaii

The report is also available on the Clean Air Branch, Department of Health website at http://health.hawaii.gov/cab. Interested persons may submit written comments addressed to the Department of Health at the above address on Oahu, and must be postmarked or received by June 30, 2014. For additional information, contact Ms. Lisa Young of the Clean Air Branch in Honolulu at (808) 586-4200.

(No. 199094-West Hawaii Today: May 30, 2014)

# AFFIDAVIT OF PUBLICATION

State of Hawaii )
) SS:
County of Hawaii )

LEILANI K. R. HIGAKI, being first duly sworn, deposes and says:

1. That she is the BUSINESS MANAGER of HAWAII TRIBUNE-HERALD, a newspaper published in the City of HILO, State of Hawaii.

2. That the " PUBLIC NOTICE..."Documentation for Natural Event Excluded Data."...etc. ".

of which a clipping from the newspaper as published is attached hereto, was published in said newspaper on the following date(s) May 30, 2014, (etc.).

199872

Leilani K R Higaki

Subscribed and sworn to before me

this 16th day of June, 2014.

Danette K Koochi

DANETTE K. KOOCHI

**Notary Public, Third Circuit, State of Hawaii**

My commission expires March 23, 2018

DANETTE K. KOOCHI NOTARY PUBLIC Comm. No. 14-82 STATE OF HAWAII

Page(s): 1

## PUBLIC NOTICE

The Department of Health, State of Hawaii, is notifying all interested persons of the report [illegible] documentation for Natural Event Excluded Data [illegible] pursuant to 40 CFR 50.14; this report describes the treatment of air quality monitoring data influenced by natural events.

The report is available for public review during regular office hours, Monday through Friday, 7:45 a.m. to 4:15 p.m. at the following locations:

Oahu:

- Clean Air Branch, Department of Health
  919 Ala Moana Blvd., Room 203, Honolulu, Oahu 96814

Hawaii:

- Hawaii District Health Office, Department of Health
  1582 Kamehameha Ave., Hilo, Hawaii
- Clean Air Branch – Kona, Keakealani Building, Department of Health
  79-1020 Haukapila Street, Room 113, Kealakekua, Hawaii

The report is also available on the Clean Air Branch, Department of Health website at http://health.hawaii.gov/cab/. Interested persons may submit written comments addressed to the Department of Health at the above address on Oahu, and must be postmarked or received by June 30, 2014. For additional information, contact Ms. Lisa Young of the Clean Air Branch in Honolulu at (808) 586-4200.

(199872 Hawaii Tribune-Herald: May 30, 2014)

# APPENDIX D

## Appendix D

### Detailed Site Information for Monitoring Stations Referenced in the 2012 and 2013 Hawaii Exceptional Events Demonstration Packages

The State of Hawaii Department of Health (DOH) plans, operates and maintains the statewide ambient air quality monitoring network. Data from the following monitoring stations were used in the Exceptional Events Demonstration document: Kona (AQS 150011012), Ocean View (AQS 150012020), and Pahala (AQS 150012016). The following tables include detailed descriptions and site information such as location, traffic, probe siting, monitor information and adherence to quality assurance requirements for each of these stations. The tables were taken from the State of Hawaii 2013 Annual Network Plan. For further information and to view the entire plan, go to http://health.hawaii.gov/cab, click on the *2013 Air Monitoring Network Plan* under *Reports*.

# APPENDIX D

| (KN) KONA | | | |
|---|---|---|---|
| AQS: 150011012 | Type: SLAMS ($SO_2$)<br>SPMS ($PM_{2.5}$) | County: Hawaii | MSA: Not in a MSA |
| Address: 81-1043 Konawaena School Rd., Kona, HI 96750 | | | |
| Latitude: 19.50978 | Longitude: -155.91342 | | Elevation: 517.2 m MSL |
| Location Description:<br>This station is located on the upper campus of Konawaena High School. It was established to measure impacts from volcanic emissions. The station has been operating at this site since 2005. | | | |

| Type of Roadway | Konawaena School Rd. | Mamalahoa Hwy. |
|---|---|---|
| Freeway | | |
| Major Street or Highway | | X |
| Local Street or Road | X | |
| Distance from air intake (m) | 17 | 702 |
| Direction from air inlet | N | W |
| Composition of roadway | asphalt | asphalt |
| Number of traffic lanes | 1 | 2 |
| Average daily traffic | 500 [2] | 15,503 (2006)[1] |
| Average vehicle speed (est. mph) | 10 | 55 |
| Traffic one way or two | 2 | 2 |
| Street parking? | No | No |

[1] Source: State of Hawaii Department of Transportation
[2] Estimated only, no data available. This is a road used for school access only and station is at the top of the road where there would be less ingress/egress.

| KN MONITOR INFORMATION | N/A = Not Applicable | | | | |
|---|---|---|---|---|---|
| | $PM_{2.5}$ | $SO_2$ | WS | WD | AT |
| POC/FRM or FEM | 1/FEM | 1/FEM | Info only | Info only | Info only |
| Type of Monitor | SPM | SLAMS | N/A | N/A | N/A |
| Parameter Code | 88101 | 42401 | Not entered | Not entered | Not entered |
| Manufacturer | Met-One | TECO | RM Young | RM Young | RM Young |
| Model No. | BAM1020 | 43C | 05103VP | 05103VP | 41342VC |
| AQS Method Code | 170 | 060 | Not entered | Not entered | Not entered |
| Parameter start date | 3/15/2008 | 9/13/2005 | 9/13/2005 | 9/13/2005 | 9/13/2005 |
| Frequency | continuous | continuous | continuous | continuous | continuous |
| Probe material | N/A | Glass | N/A | N/A | N/A |
| Residence Time (sec) | N/A | 17.55 | N/A | N/A | N/A |

### KN Kona continued

| PROBE SITING | | |
|---|---|---|
| (N/A = Not applicable) | $PM_{2.5}$ | $SO_2$ |
| Location of probe | Top of shelter | Top of shelter |
| Shelter dimensions | | |
| Height (m) | 3 | 3 |
| Width (m) | 2.4 | 2.4 |
| Depth (m) | 5 | 5 |
| Horizontal distance from supporting structure (m) | N/A | N/A |
| Vertical distance above supporting structure (m) | 1 | 1.09 |
| Height of probe above ground (m) | 4 | 4 |
| Distance (m) & direction from nearest tree(s) | 38 NE | 38 NE |
| Horizontal distance from edge of nearest traffic lane (m) | 30 N | 30 N |
| Horizontal distance from nearest parking lot (m) | N/A | N/A |
| Distance & direction from obstructions on roof (m) | None | None |
| Distance & direction from possible obstructions not on roof (m) | 21 SSW | 21 SSW |
| Height of nearest possible obstacle (m) | 9 | 9 |
| Distance & direction from furnace or incineration flues (m) | None | None |
| Unrestricted airflow | 360° | 360° |
| Located in paved or vegetative ground? | vegetative | vegetative |

| SITE REPRESENTATIVENESS | | |
|---|---|---|
| | $PM_{2.5}$ | $SO_2$ |
| Spatial scale | Neighborhood | Neighborhood |
| Applicable NAAQS averaging times | 24-hr; annual | 1-hr; 3-hr; 24-hr; annual |
| Sampling season | 12-months | 12-months |
| Site type [1] | 3 | 3 |
| Purpose of Monitor [2] | 1, 4 | 1, 2, 4 |
| Suitable for comparison against the annual $PM_{2.5}$ NAAQS? | Yes | |

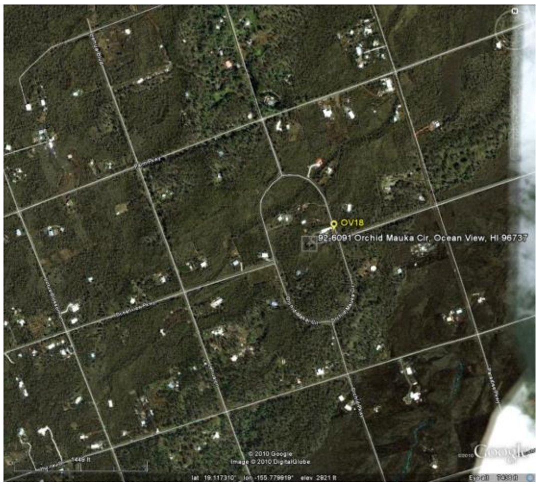
[1]Site Types:
1) located to determine the highest concentrations;
2) located to measure typical concentrations in areas of high population density;
3) located to determine the impact of significant sources or source categories on air quality;
4) located to determine general background concentration levels;
5) located to determine extent of regional pollutant transport among populated areas and in support of secondary standards;
6) located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts

[2] Purposes:
1) Provide air pollution data to the general public in a timely manner;
2) Support compliance with ambient air quality standards;
3) Support emissions strategy development and track trends in air pollution abatement control measures;
4) Support for air pollution research

| DATA QUALITY | | |
|---|---|---|
| | Date or Frequency | Result |
| Last PEP | 3/17/11 | Did not receive results from EPA |
| Last NPAP | 3/17/11 | Did not receive results from EPA |
| Date of last annual independent performance audit (CAB) | 9/25/13 | $PM_{2.5}$ and $SO_2$ passed. |
| Frequency of flow rate audits (automated PM) | Monthly | |
| Dates of last two semi-annual flow rate audits (PM) | 5/9/12, 11/27/12 | Passed, Passed |
| Precision & Accuracy submitted to AQS | Quarterly | |
| Frequency of 1-pt. QC check for gases | Weekly | |
| Frequency of multipoint gas calibration | 60 days | |
| Annual data certification submitted | Annually by 5/1 | submitted on: 5/15/13 |
| **REASONS FOR INVALID OR MISSING DATA; OTHER SITE CHANGES and Notes** | | |
| Invalid or Missing Data (<75% data): | $PM_{2.5}$ 11/9-11/16/12: 71% Obs. Maintenance/Routine repairs. | |
| Changes planned in the next 18 months: | Pending EPA approval, collocate a $PM_{2.5}$ FEM | |

# APPENDIX D

| (OV) OCEAN VIEW | | | |
|---|---|---|---|
| AQS: 150012020 | Type: SPMS | County: Hawaii | MSA: Not in a MSA |
| Address:92-6091 Orchid Mauka Circle, Ocean View, HI 96737 | | | |
| Latitude: 19.11756 | Longitude: -155.77814 | | Elevation: 862.6 m MSL |
| Location Description:<br>This station established in 2010 is located on the grounds of the Ocean View Fire Station. During normal trade-winds, volcanic emissions are carried into this residential/agricultural community. | | | |




| Type of Roadway | Orchid Mauka Circ. |
|---|---|
| Freeway | |
| Major Street or Highway | |
| Local Street or Road | X |
| Distance from air intake (m) | 13.6 |
| Direction from air inlet | ENE |
| Composition of roadway | asphalt |
| Number of traffic lanes | 2 |
| Average daily traffic | < 3,000 [1] |
| Average vehicle speed (est. mph) | 25 |
| Traffic one way or two | 2 |
| Street parking? | No |
| [1] Estimated only, local residential street, no data available | |

| OV MONITOR INFORMATION N/A = Not Applicable | | | | |
|---|---|---|---|---|
| | $PM_{2.5}$ | $SO_2$ | WS | WD |
| POC/FRM or FEM | 1/FEM | 1/FEM | Info only | Info only |
| Type of Monitor | SPM | SPM | N/A | N/A |
| Parameter Code | 88101 | 42401 | Not entered | Not entered |
| Manufacturer | Met-One | TECO | RM Young | RM Young |
| Model No. | BAM1020 | 43i | 05103VP | 05103VP |
| AQS Method Code | 170 | 060 | Not entered | Not entered |
| Parameter start date | 4/1/2010 | 4/1/2010 | 4/1/2010 | 4/1/2010 |
| Frequency | continuous | continuous | continuous | continuous |
| Probe material | N/A | Glass | N/A | N/A |
| Residence Time (sec) | N/A | 18.34 | N/A | N/A |

## OV Ocean View continued

| PROBE SITING | | |
|---|---|---|
| **(N/A = Not applicable)** | **$PM_{2.5}$** | **$SO_2$** |
| Location of probe | Top of shelter | Top of shelter |
| Shelter dimensions | | |
| Height (m) | 3 | 3 |
| Width (m) | 2.4 | 2.4 |
| Depth (m) | 5 | 5 |
| Horizontal distance from supporting structure (m) | N/A | N/A |
| Vertical distance above supporting structure (m) | 1.1 | 1 |
| Height of probe above ground (m) | 4.1 | 4 |
| Distance (m) & direction from nearest tree(s) | 7 ENE | 7 ENE |
| Horizontal distance from edge of nearest traffic lane (m) | 13.6 | 13.6 |
| Horizontal distance from nearest parking lot (m) | 6.4 | 6.4 |
| Distance & direction from obstructions on roof (m) | None | None |
| Distance & direction from possible obstructions not on roof (m) | None | None |
| Height of nearest possible obstruction (m) | N/A | N/A |
| Distance & direction from furnace or incineration flues (m) | None | None |
| Unrestricted airflow | 360° | 360° |
| Located in paved or vegetative ground? | vegetative | vegetative |

| SITE REPRESENTATIVENESS | | |
|---|---|---|
| | **$PM_{2.5}$** | **$SO_2$** |
| Spatial scale | Middle | Neighborhood |
| Applicable NAAQS averaging times | 24-hr; annual | 1-hr; 3-hr; 24-hr; annual |
| Sampling season | 12-months | 12-months |
| Site type [1] | 3, 6 | 3, 6 |
| Purpose of Monitor [2] | 1 | 1 |
| Suitable for comparison against the annual $PM_{2.5}$ NAAQS? | Yes | |

[1]Site Types:
1) located to determine the highest concentrations;
2) located to measure typical concentrations in areas of high population density;
3) located to determine the impact of significant sources or source categories on air quality;
4) located to determine general background concentration levels;
5) located to determine extent of regional pollutant transport among populated areas and in support of secondary standards;
6) located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts

[2] Purposes:
1) Provide air pollution data to the general public in a timely manner;
2) Support compliance with ambient air quality standards;
3) Support emissions strategy development and track trends in air pollution abatement control measures;
4) Support for air pollution research

| DATA QUALITY | | |
|---|---|---|
| | **Date or Frequency** | **Result** |
| Last PEP | 2/9/12 | Did not receive results from EPA |
| Last NPAP | 2/9/12 | Passed |
| Date of last annual independent performance audit (CAB) | 9/19/12 | Passed with the following note:<br>$SO_2$ audit pts. 2, 3, & 10: >10% (warning level) |
| Frequency of flow rate audits (automated PM) | Monthly | |
| Dates of last two semi-annual flow rate audits (PM) | 5/9/12, 11/1/12 | Passed, Passed |
| Precision & Accuracy submitted to AQS | Quarterly | |
| Frequency of 1-pt. QC check for gases | Weekly | |
| Frequency of multipoint gas calibration | 60 days | |
| Annual data certification submitted | Annually by 5/1 | submitted on: 5/15/13 |
| **REASONS FOR INVALID OR MISSING DATA; OTHER SITE CHANGES and Notes** | | |
| Invalid or Missing Data (<75% data): | None | |
| Changes planned in the next 18 months: | None | |

# APPENDIX D

| (PA) PAHALA | | | |
|---|---|---|---|
| AQS: 150012016 | Type: SPMS | County: Hawaii | MSA: Not in a MSA |
| Address: 96-3150 Pikake St., Pahala, HI 96777 | | | |
| Latitude: 19.2039 | Longitude: -155.48018 | Elevation: 320 m MSL | |
| Location Description: This station is located on the grounds of the Ka'u High/Pahala Elementary School. During normal trade-winds, volcanic emissions are carried into this rural community. The station began operating in 2007. | | | |


| Type of Roadway | Puahala | Pumeli |
|---|---|---|
| Freeway | | |
| Major Street or Highway | | |
| Local Street or Road | X | X |
| Distance from air intake (m) | 226 | 61 |
| Direction from air inlet | E | N |
| Composition of roadway | Asphalt | Asphalt |
| Number of traffic lanes | 2 | 2 |
| Average daily traffic | < 3,000 [1] | < 3,000 [1] |
| Average vehicle speed (est. mph) | 25 mph | 25 mph |
| Traffic one way or two | 2 | 2 |
| Street parking? | No | No |

[1] Estimated only, no data available. Local roads for a community with a 2010 population of about 1,400

| PA MONITOR INFORMATION | N/A = Not Applicable | | | |
|---|---|---|---|---|
| | $PM_{2.5}$ | $SO_2$ | WS | WD |
| POC/FRM or FEM | 1/FEM | 1/FEM | Info only | Info only |
| Type of Monitor | SPM | SPM | N/A | N/A |
| Parameter Code | 88101 | 42401 | Not entered | Not entered |
| Manufacturer | Met-One | TECO | RM Young | RM Young |
| Model No. | BAM1020 | 43i | 05103VP | 05103VP |
| AQS Method Code | 170 | 060 | Not entered | Not entered |
| Parameter start date | 4/11/2008 | 8/10/2007 | 8/10/2007 | 8/10/2007 |
| Frequency | continuous | continuous | continuous | continuous |
| Probe material | N/A | Glass | N/A | N/A |
| Residence Time (sec) | N/A | 18.22 | N/A | N/A |

# APPENDIX D

## PA Pahala continued

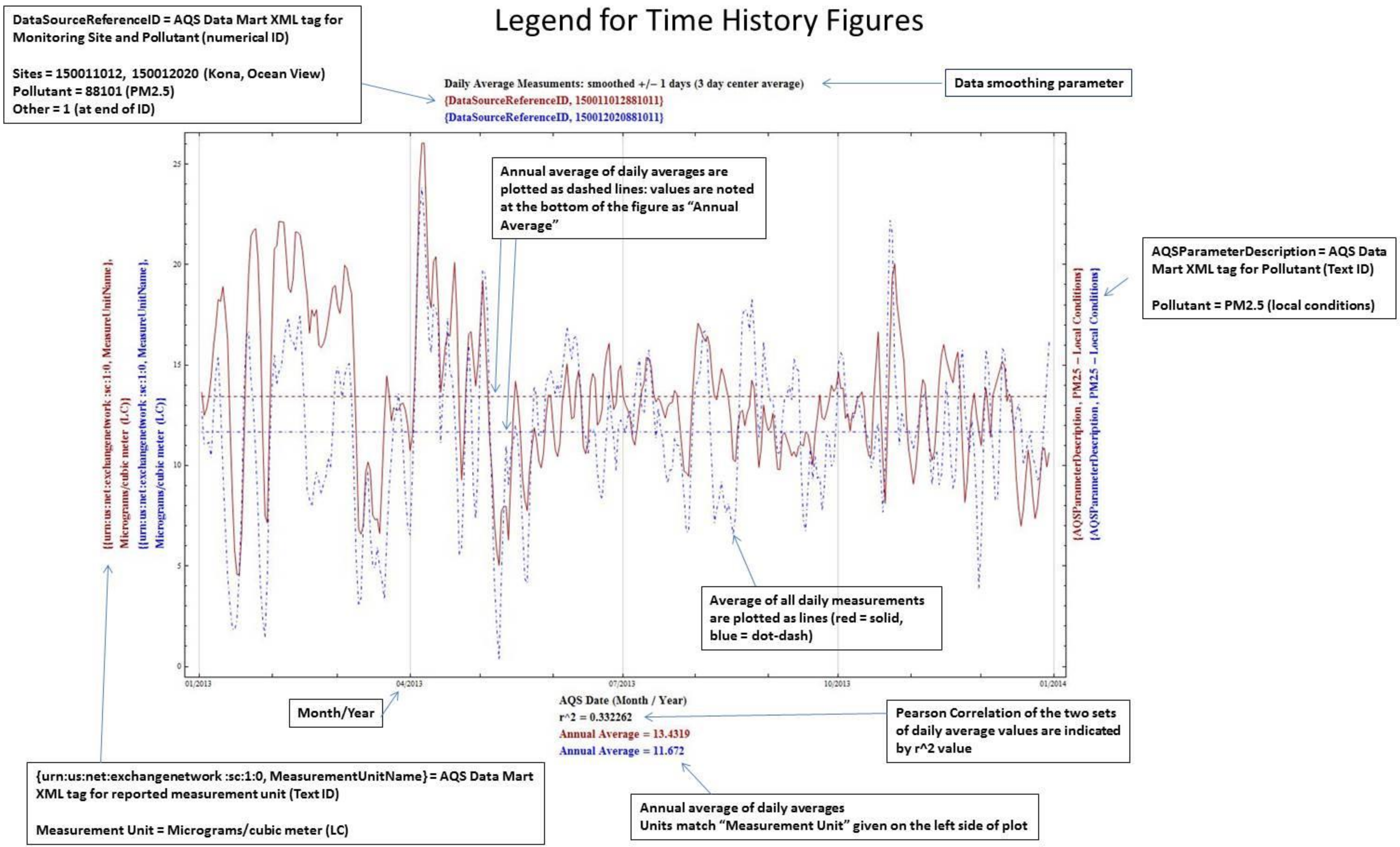
| PROBE SITING | | |
|---|---|---|
| **(N/A = Not applicable)** | **$PM_{2.5}$** | **$SO_2$** |
| Location of probe | Top of shelter | Top of shelter |
| Shelter dimensions | | |
| Height (m) | 2.4 | 2.4 |
| Width (m) | 2.4 | 2.4 |
| Depth (m) | 6 | 6 |
| Horizontal distance from supporting structure (m) | N/A | N/A |
| Vertical distance above supporting structure (m) | 1 | 1 |
| Height of probe above ground (m) | 3.4 | 3.4 |
| Distance (m) & direction from nearest tree(s) | 11 N | 11 N |
| Horizontal distance from edge of nearest traffic lane (m) | 48 S | 48 S |
| Horizontal distance from nearest parking lot (m) | 73 S | 73 S |
| Distance & direction from obstructions on roof (m) | None | None |
| Distance & direction from possible obstructions not on roof (m) | None | None |
| Height of nearest possible obstruction (m) | N/A | N/A |
| Distance & direction from furnace or incineration flues (m) | None | None |
| Unrestricted airflow | 360° | 360° |
| Located in paved or vegetative ground? | vegetative | vegetative |

| SITE REPRESENTATIVENESS | | |
|---|---|---|
| | **$PM_{2.5}$** | **$SO_2$** |
| Spatial scale | Neighborhood | Neighborhood |
| Applicable NAAQS averaging times | 24-hr; annual | 1-hr; 3-hr; 24-hr; annual |
| Sampling season | 12-months | 12-months |
| Site type [1] | 3 | 3 |
| Purpose of Monitor [2] | 1, 4 | 1, 4 |
| Suitable for comparison against the annual $PM_{2.5}$ NAAQS? | Yes | |

[1]Site Types:
1) located to determine the highest concentrations;
2) located to measure typical concentrations in areas of high population density;
3) located to determine the impact of significant sources or source categories on air quality;
4) located to determine general background concentration levels;
5) located to determine extent of regional pollutant transport among populated areas and in support of secondary standards;
6) located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts

[2] Purposes:
1) Provide air pollution data to the general public in a timely manner;
2) Support compliance with ambient air quality standards;
3) Support emissions strategy development and track trends in air pollution abatement control measures;
4) Support for air pollution research

| DATA QUALITY | | |
|---|---|---|
| | **Date or Frequency** | **Result** |
| Last PEP | 3/17/11 | Did not receive results from EPA |
| Last NPAP | 7/29/08 | Passed |
| Date of last annual independent performance audit (CAB) | 9/20/12 | $PM_{2.5}$ and $SO_2$ passed. |
| Frequency of flow rate audits (automated PM) | Monthly | |
| Dates of last two semi-annual flow rate audits (PM) | 5/2/12, 11/1/12 | Passed, Passed |
| Precision & Accuracy submitted to AQS | Quarterly | |
| Frequency of 1-pt. QC check for gases | Weekly | |
| Frequency of multipoint gas calibration | 60 days | |
| Annual data certification submitted | Annually by 5/1 | submitted on: 5/15/13 |
| **REASONS FOR INVALID OR MISSING DATA; OTHER SITE CHANGES and Notes** | | |
| Invalid or Missing Data (<75% data): | None | |
| Changes planned in the next 18 months: | None | |


Legend for Time History Figures
DataSourceReferenceID = AQS Data Mart XML tag for Monitoring Site and Pollutant (numerical ID)
Sites = 150011012, 150012020 (Kona, Ocean View)
Pollutant = 88101 (PM2.5)
Other = 1 (at end of ID)
Daily Average Measuments: smoothed +/– 1 days (3 day center average)
{DataSourceReferenceID, 150011012881011}
{DataSourceReferenceID, 150012020881011}
Data smoothing parameter
Annual average of daily averages are plotted as dashed lines: values are noted at the bottom of the figure as "Annual Average"
AQSParameterDescription = AQS Data Mart XML tag for Pollutant (Text ID)
Pollutant = PM2.5 (local conditions)
{urn:us:net:exchangenetwork:sc:1:0, MeasurementUnitName}, Micrograms/cubic meter (LC)}
{urn:us:net:exchangenetwork:sc:1:0, MeasurementUnitName}, Micrograms/cubic meter (LC)}
{AQSParameterDescription, PM2.5 – Local Conditions}
{AQSParameterDescription, PM2.5 – Local Conditions}
Average of all daily measurements are plotted as lines (red = solid, blue = dot-dash)
01/2013
04/2013
07/2013
10/2013
01/2014
AQS Date (Month / Year)
r^2 = 0.332262
Annual Average = 13.4319
Annual Average = 11.672
Month/Year
Pearson Correlation of the two sets of daily average values are indicated by r^2 value
{urn:us:net:exchangenetwork :sc:1:0, MeasurementUnitName} = AQS Data Mart XML tag for reported measurement unit (Text ID)
Measurement Unit = Micrograms/cubic meter (LC)
Annual average of daily averages
Units match "Measurement Unit" given on the left side of plot

# Legend for Wind Rose Figures

Data Selection for Plot
Year of Data Selected: "-2013" means 2013
Hours Selected: "All Hours" means all hours of day
("1" = 1 AM, "13" = 1PM)

Data file name = AN155y2013.xls
Meso West Monitor ID = AN155
Data year = 2013

**AN155y2013.xls–2013: All Hours**

**Data Info: Windrose**

**Number of Datasets = 8092**

"Number of Datasets" are the number of data records that have a valid value in the designated data column (in this case the Direction column)

**... first dataset (below); Direction = DRCT °**

Direction = "XXXX" indicates the column header value being plotted for the Wind Rose

Dataset column header and first valid data record. Note that the first column header ("ID = AN155") is repeated in the last column. This was done because the Meso West date/time format (in the last column) needed to be changed to that given in the first column for more efficient data processing. The repetition ensured that the date/time reformatting could be more easily checked for accuracy. It also ensured that the correct time zone (Hawaii Standard Time) was used for the hourly Wind Rose plots.

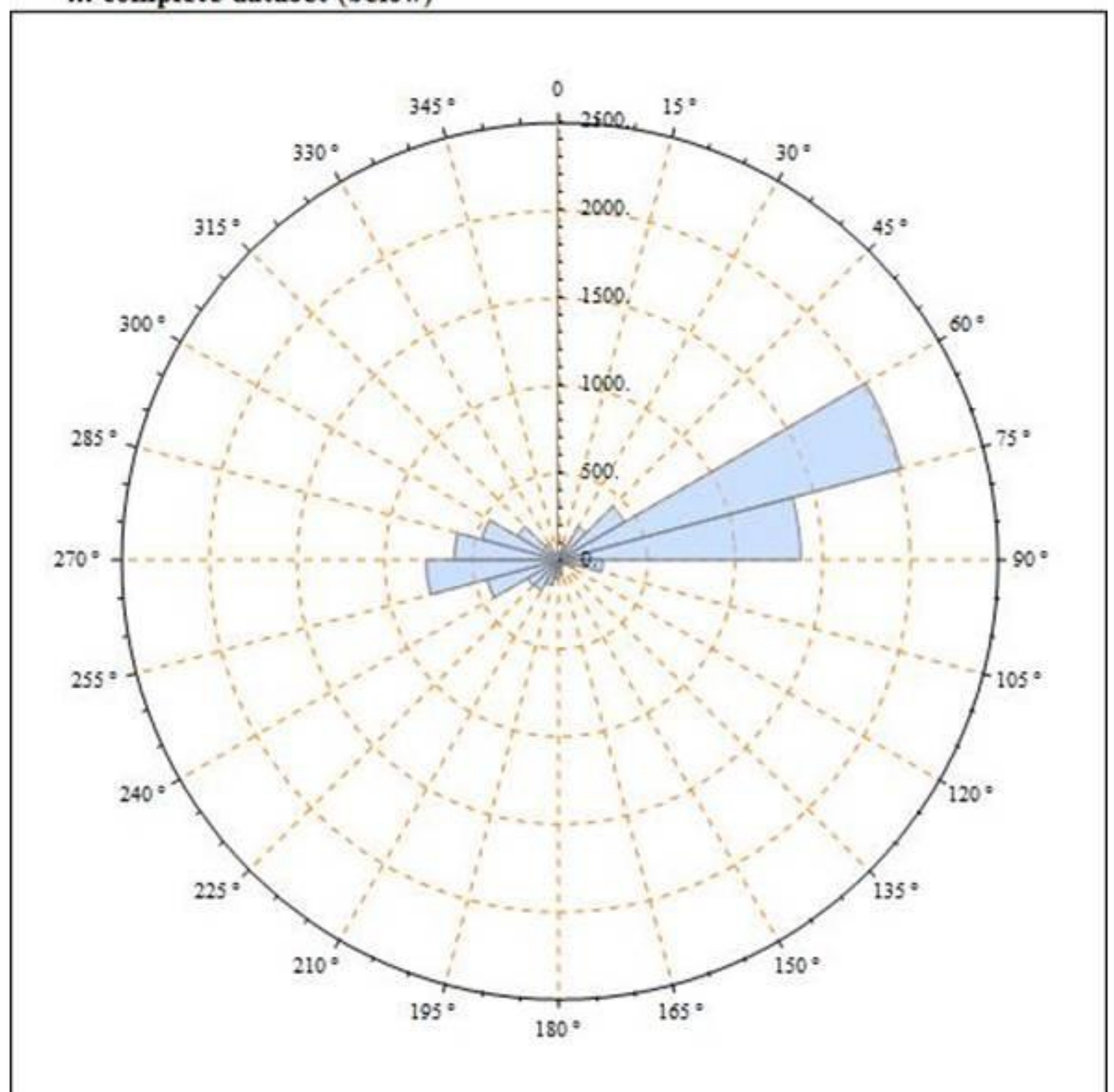
Date/time format in first column = {Year, Month, Day, Hour, Minute, Second}

When "All Hours" are not selected, only data records with the "Hour" selected are plotted.

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 0, 0, 0.} | 2.2 | 75. | N/A | 1–1–2013 0:00 HST |

Indicates the Time Zone associated with the Meso West dataset

**... complete dataset (below)**



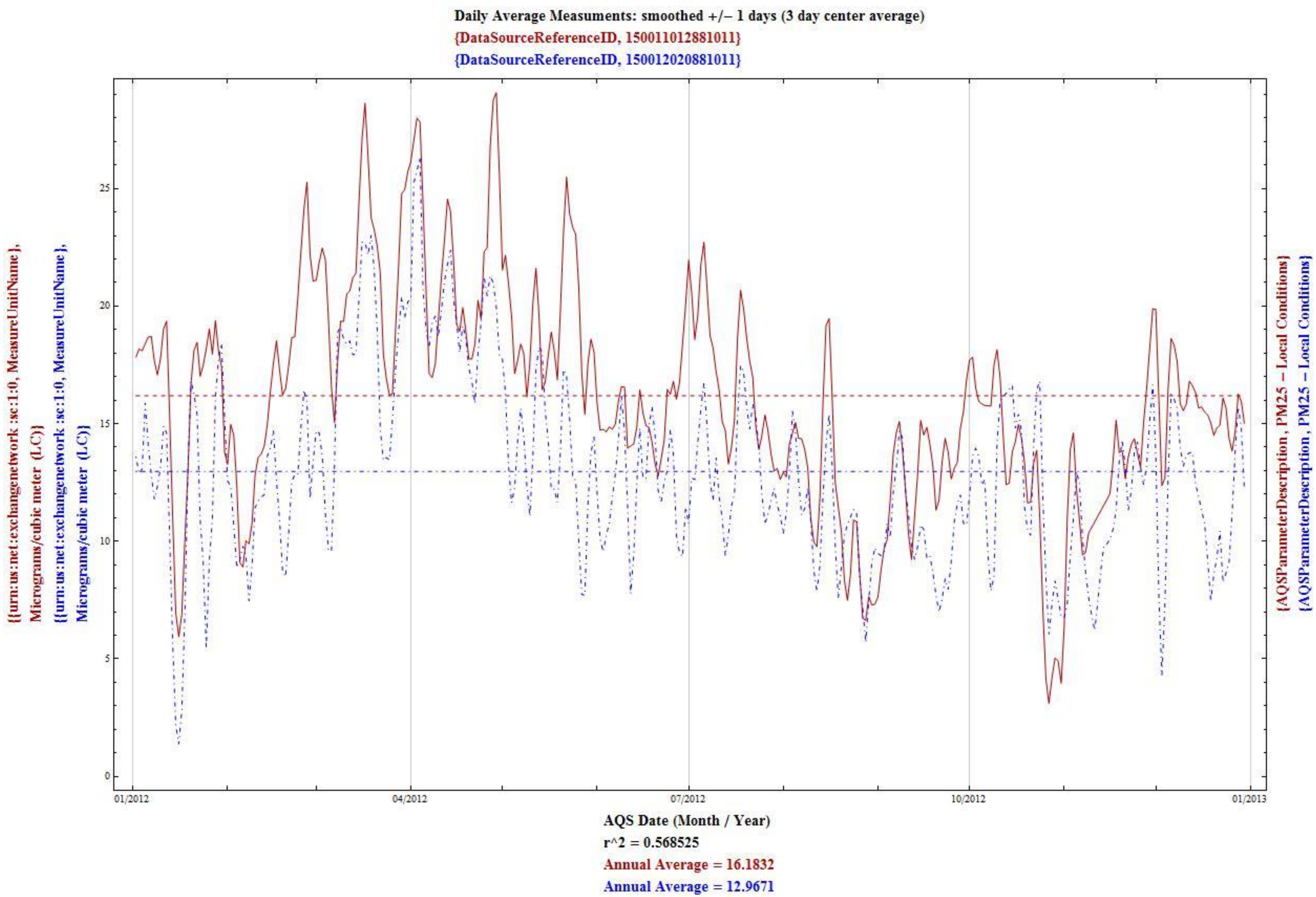



**Figure 3-2.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) $PM_{2.5}$ Concentrations

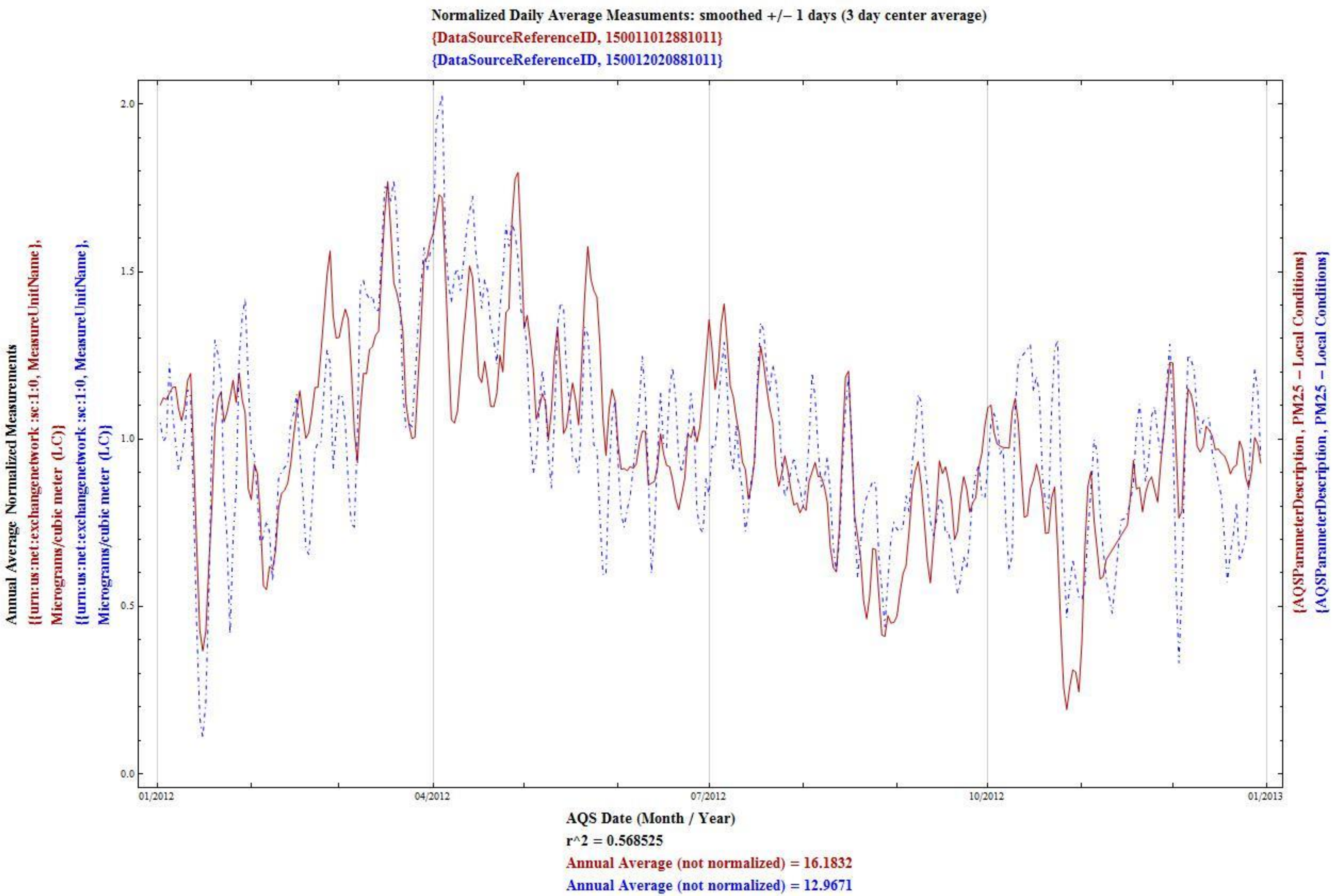



**Figure 3-3.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) normalized $PM_{2.5}$ Concentrations

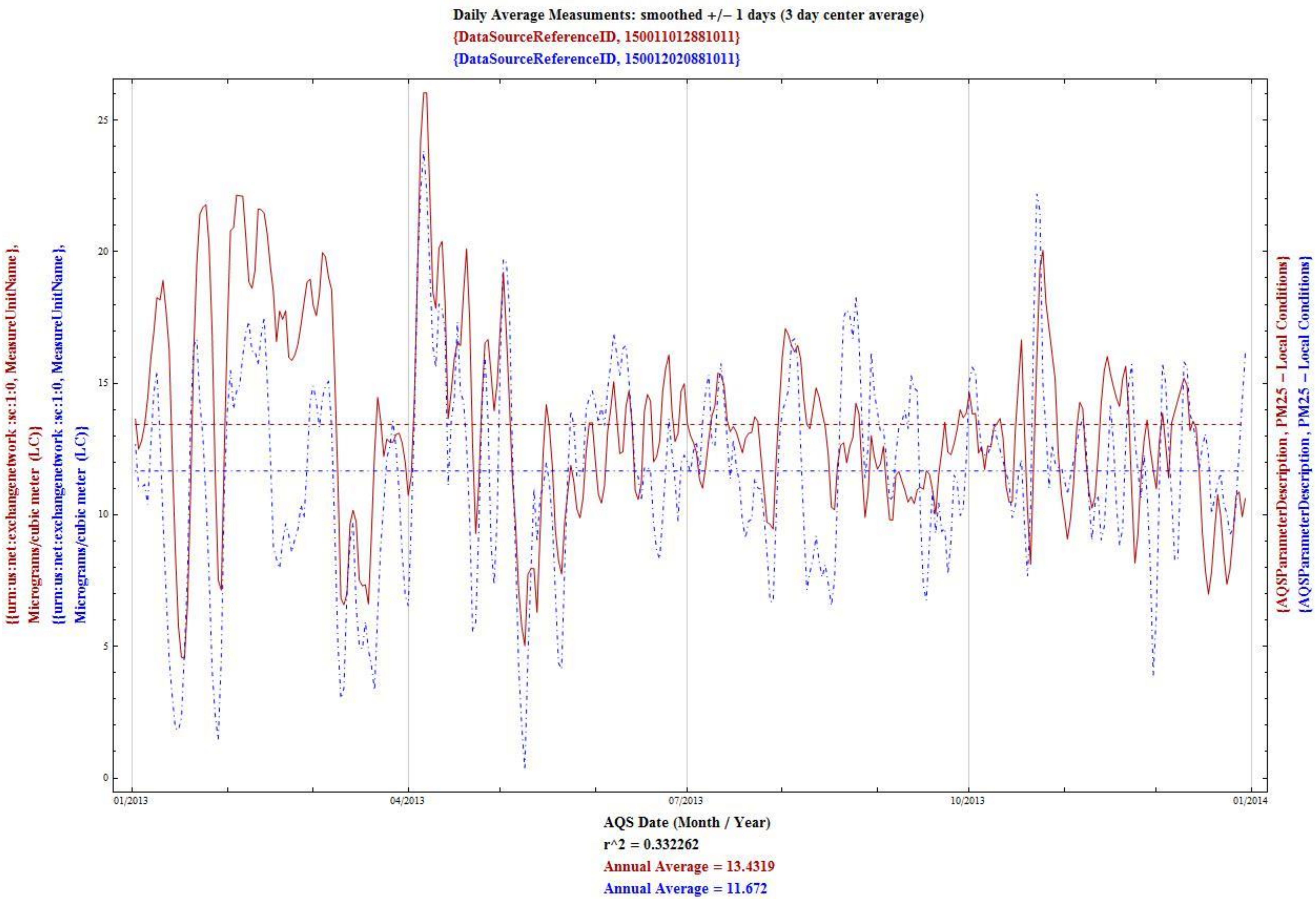



**Figure 3-4.** 2013 Time History of Kona (red) and Ocean View (blue, dot-dash) $PM_{2.5}$ Concentrations

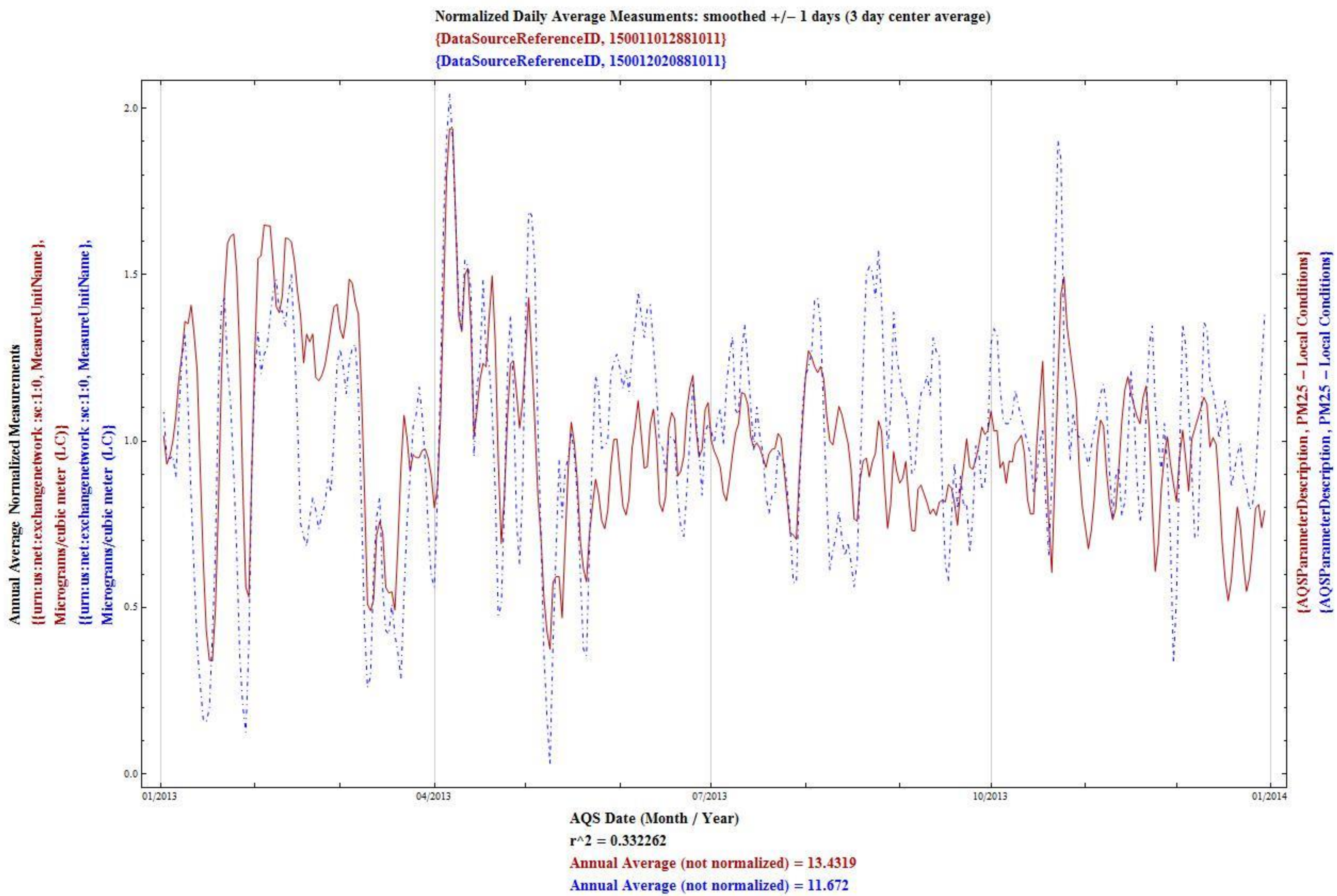



**Figure 3-5.** 2013 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $PM_{2.5}$ Concentrations

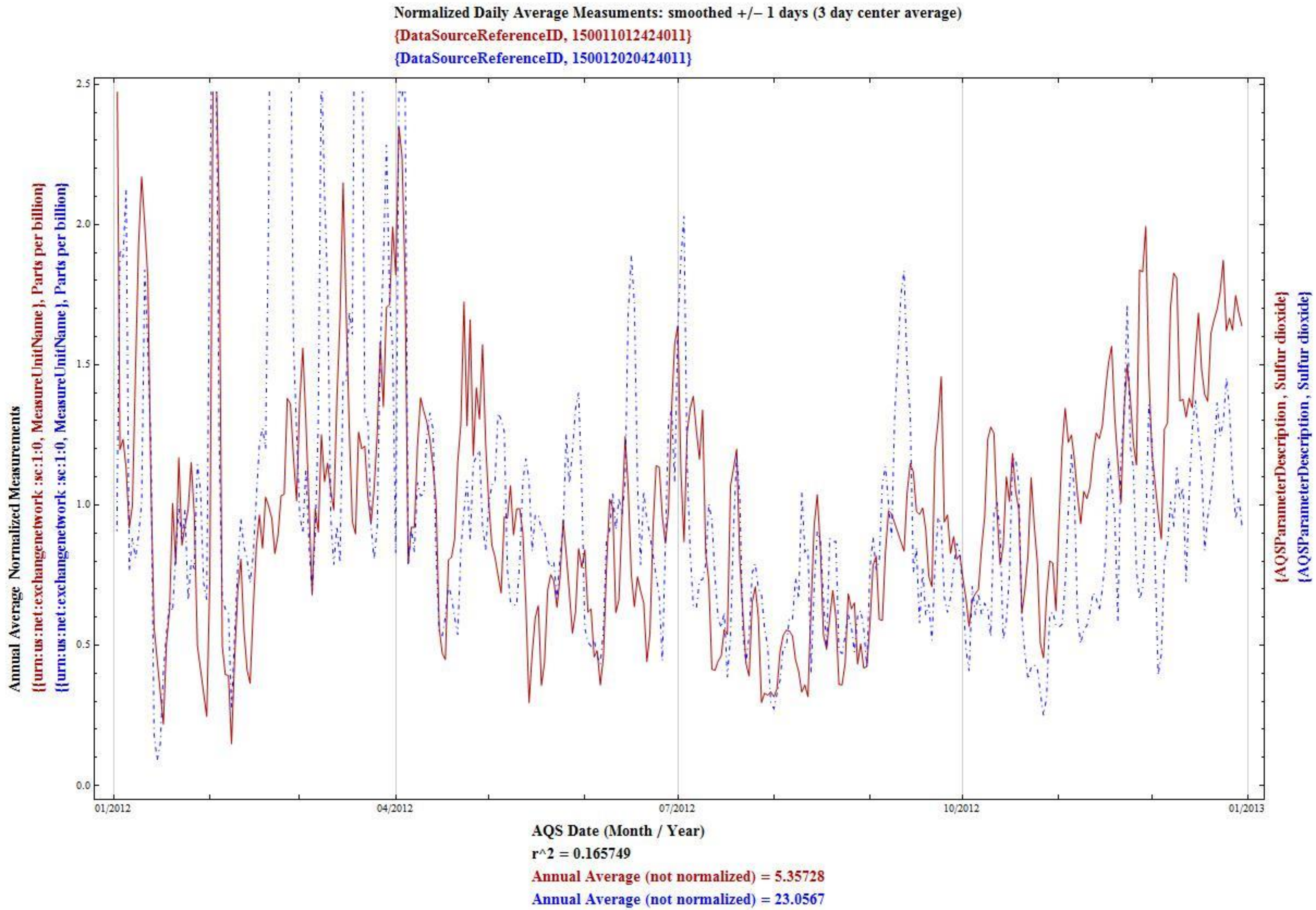



**Figure 3-6.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $SO_2$ Concentrations

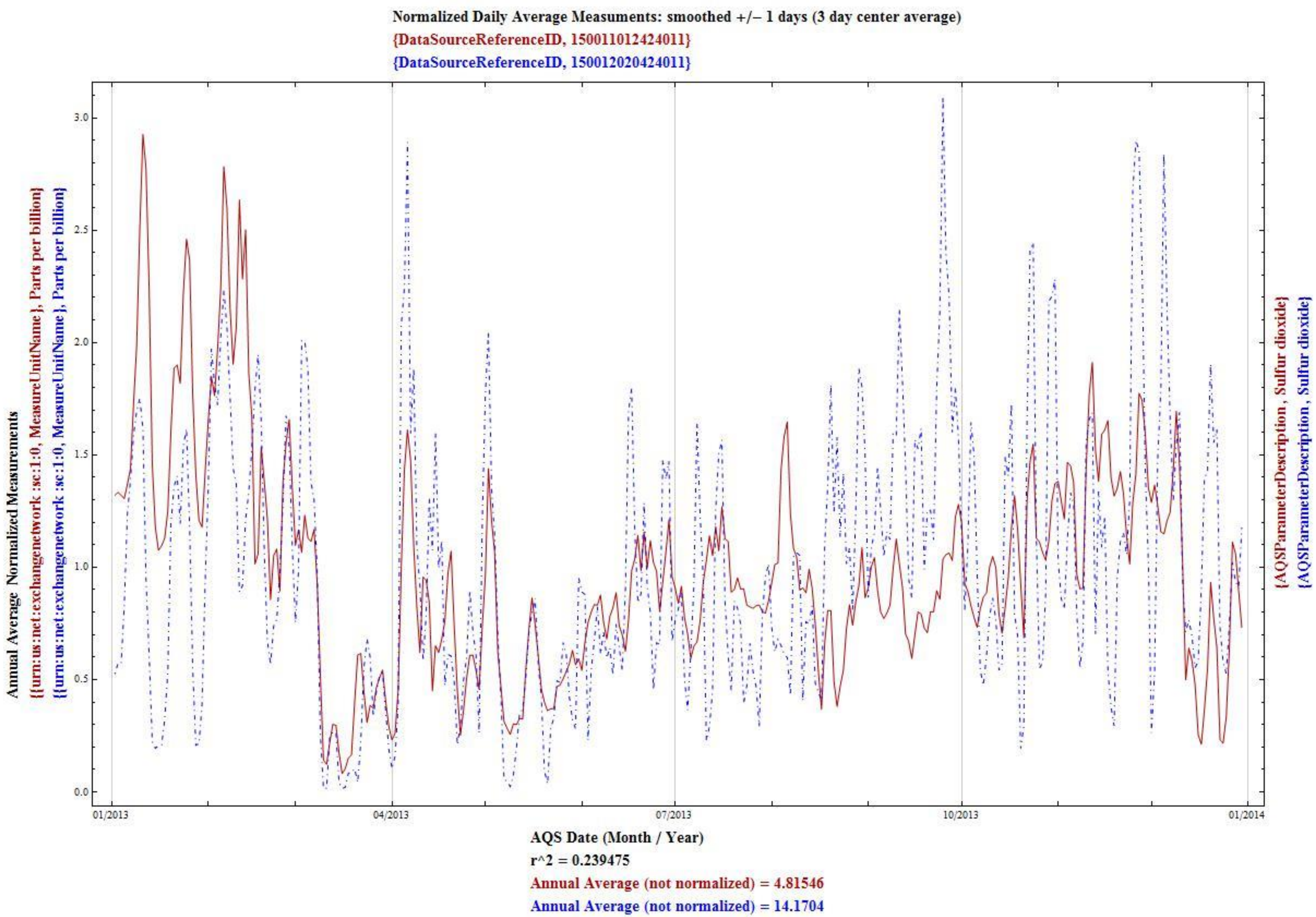



**Figure 3-7.** 2013 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $SO_2$ Concentrations

**AN155y2012.xls–2012: All Hours**

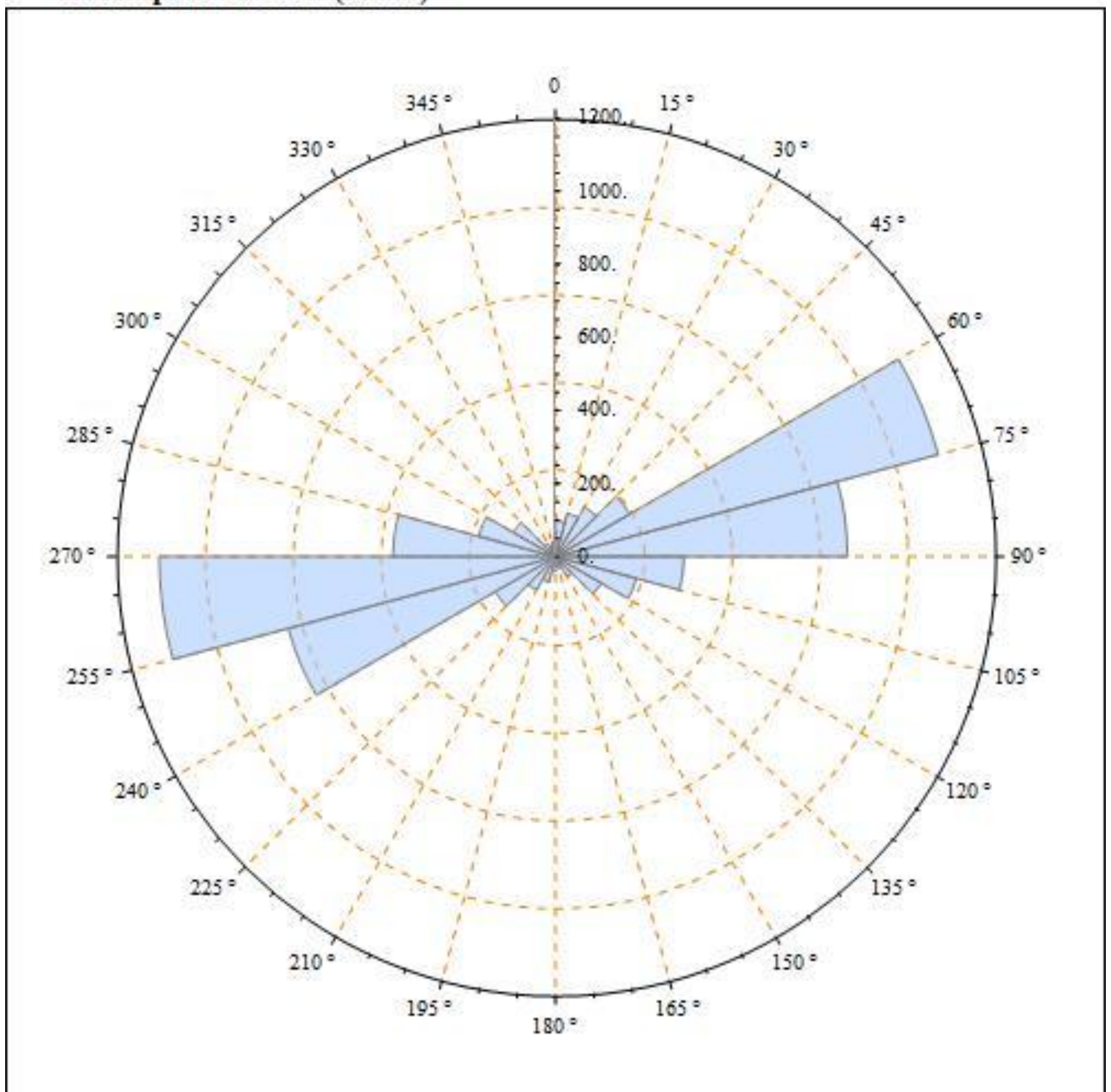
**Data Info: Windrose**

**Number of Datasets = 6493**

**... first dataset (below); Direction = DRCT °**

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2012, 1, 1, 1, 0, 0.} | 2.1 | 81. | N/A | 1–1–2012 1:00 HST |

**... complete dataset (below)**




**AN155y2013.xls–2013: All Hours**

**Data Info: Windrose**

**Number of Datasets = 8092**

**... first dataset (below); Direction = DRCT °**

| ID = AN155 | SKNT m/s | DRCT ° | QFLG | ID = AN155 |
|---|---|---|---|---|
| {2013, 1, 1, 0, 0, 0.} | 2.2 | 75. | N/A | 1–1–2013 0:00 HST |

**... complete dataset (below)**

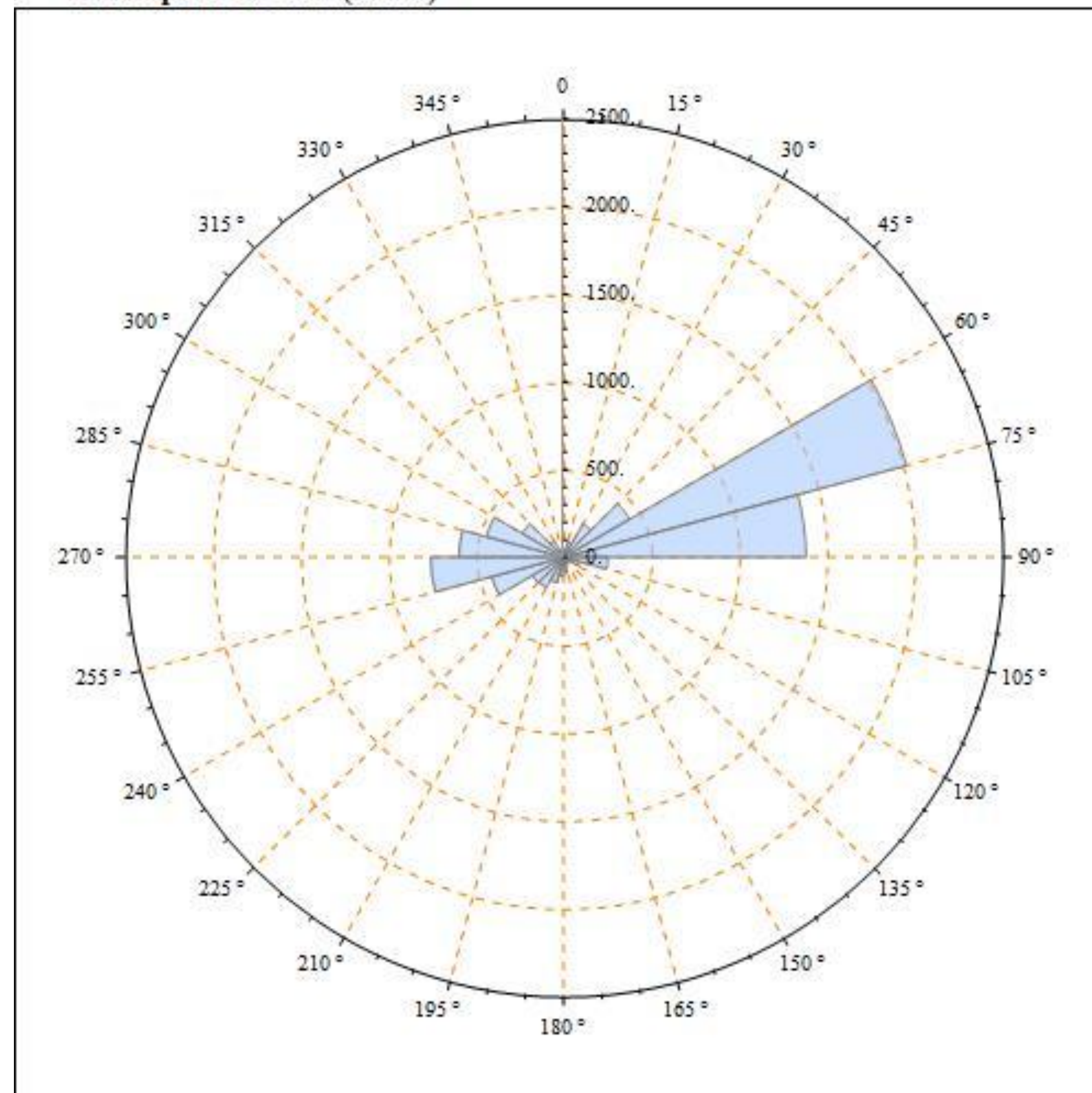



**Figure 3-8.** Kona Area AN155 Wind Rose Plots for 2012 (left) and 2013 (right)

PHMUy2012.xls–2012: All Hours

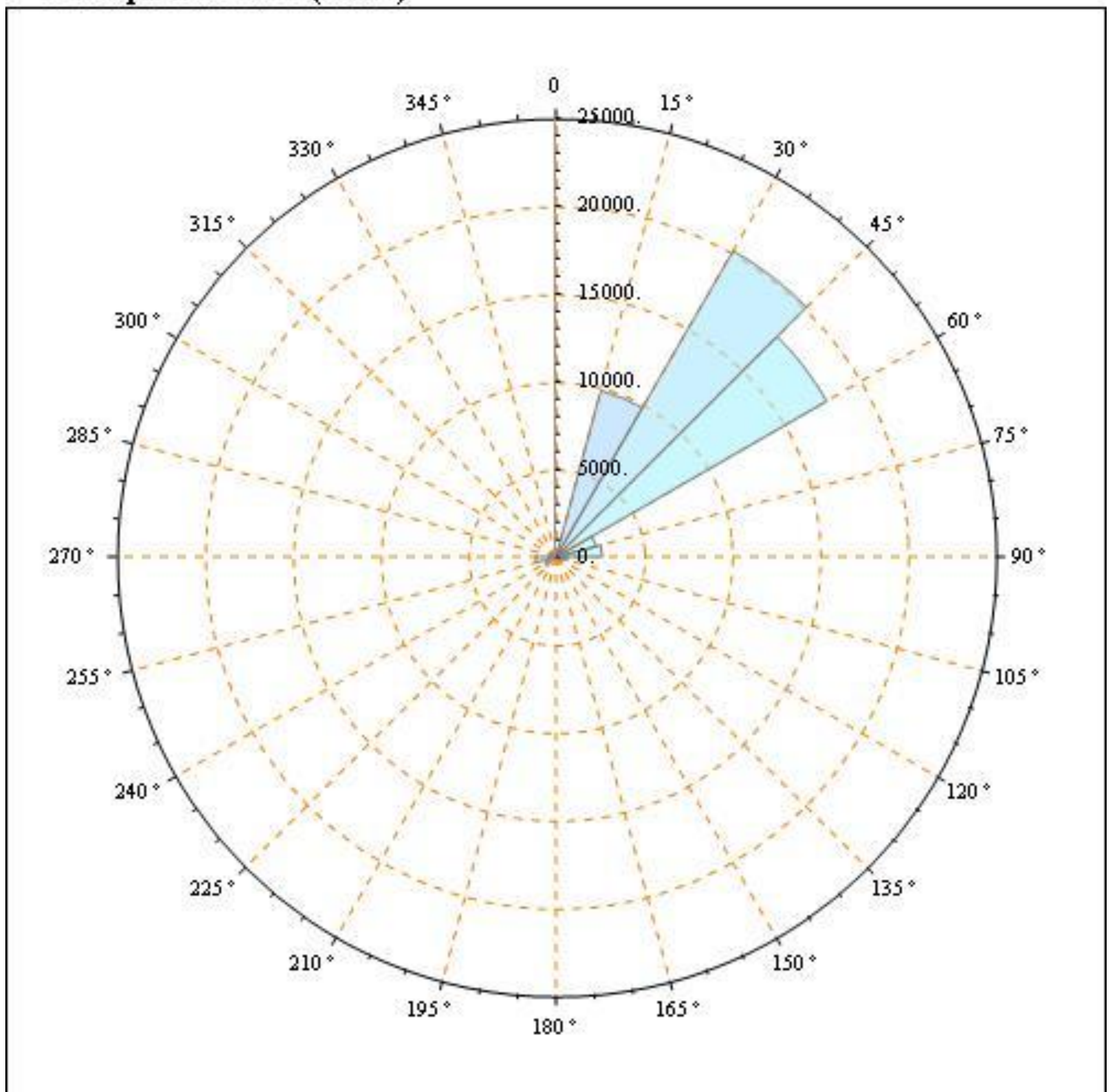
Data Info: Windrose

Number of Datasets = 58199

... first dataset (below); Direction = DRCT °

| ID = PHMU | SKNT m/s | DRCT ° | QFLG | ID = PHMU |
|---|---|---|---|---|
| {2012, 5, 9, 15, 34, 0.} | 7.2 | 30. | OK | 5–9–2012 15:34 HST |

... complete dataset (below)




KKUH1y2012.xls–2012: All Hours

Data Info: Windrose

Number of Datasets = 8413

... first dataset (below); Direction = DRCT °

| ID = KKUH1 | SKNT m/s | DRCT ° | QFLG | ID = KKUH1 |
|---|---|---|---|---|
| {2012, 1, 1, 0, 34, 0.} | 2.2 | 310. | OK | 1–1–2012 0:34 HST |

... complete dataset (below)

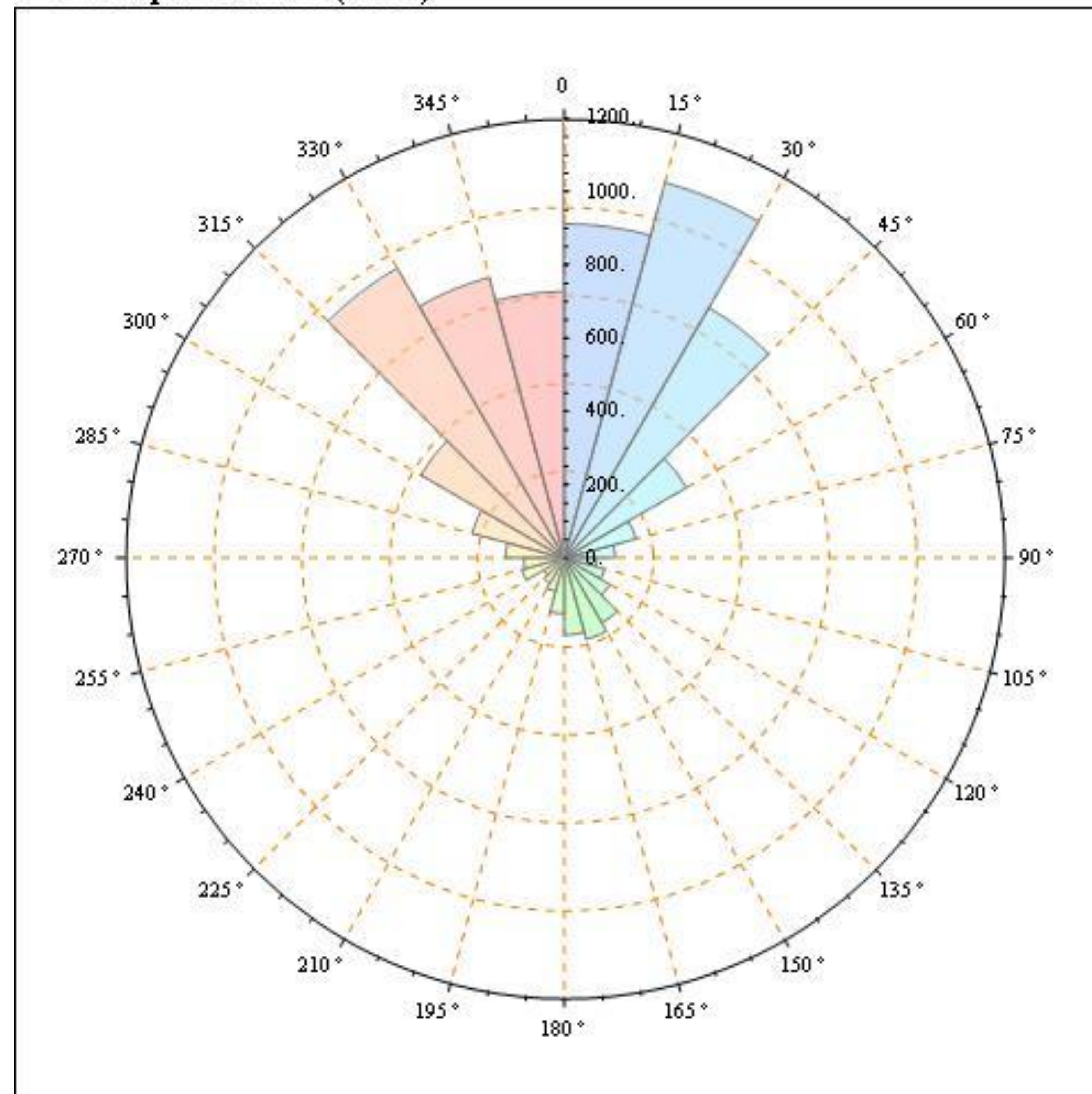



**Figure 3-9.** 2012 Kamuela (PHMU)(left) & Keaumo (KKUH1)(right) Wind Rose

PHMKy2012.xls–2012: All Hours

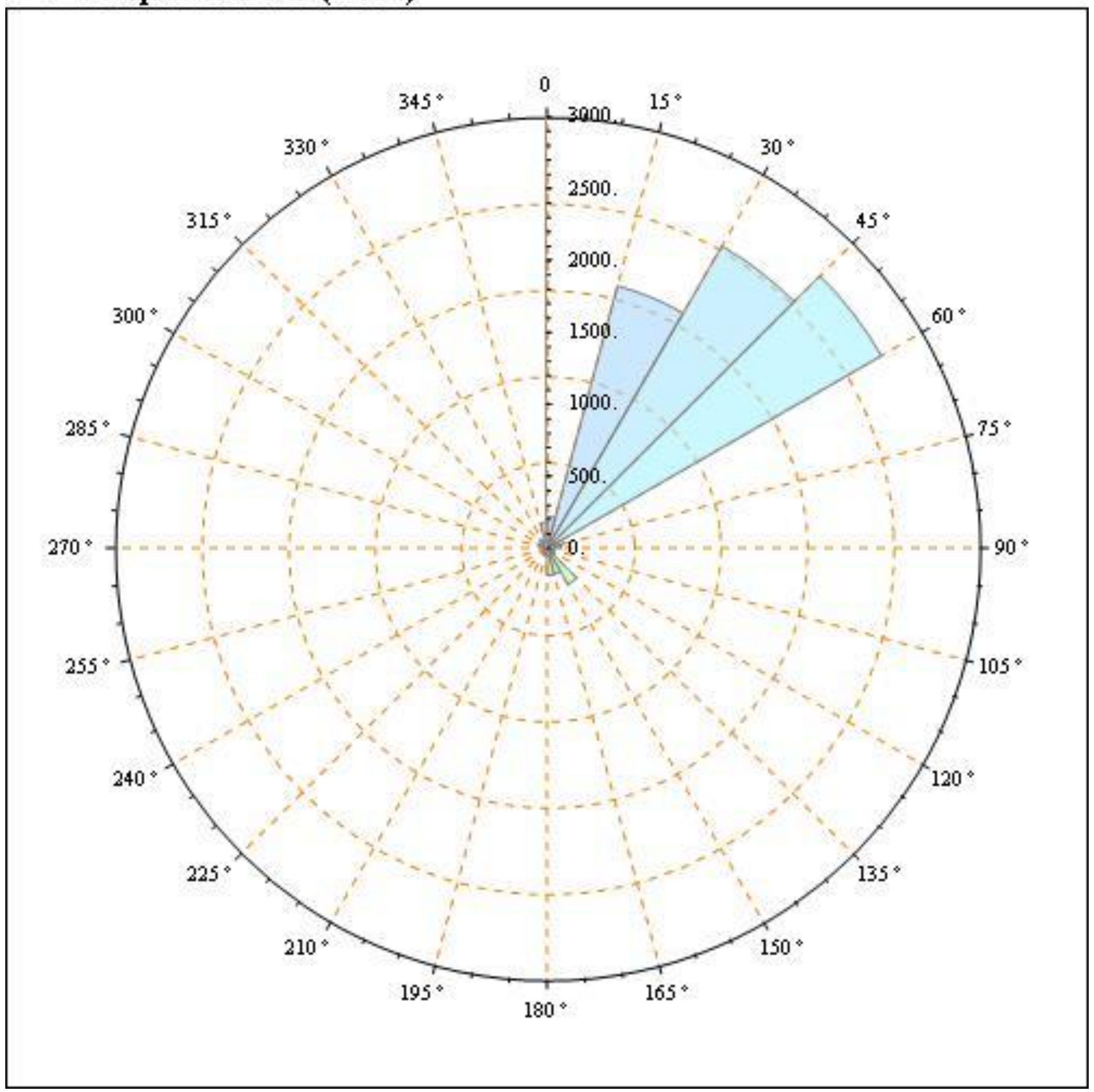
Data Info: Windrose

Number of Datasets = 8835

... first dataset (below); Direction = DRCT °

| ID = PHMK | SKNT m/s | DRCT ° | QFLG | ID = PHMK |
|---|---|---|---|---|
| {2012, 1, 1, 0, 54, 0.} | 2.6 | 30. | OK | 1–1–2012 0:54 HST |

... complete dataset (below)




PHNGy2012.xls–2012: All Hours

Data Info: Windrose

Number of Datasets = 9721

... first dataset (below); Direction = DRCT °

| ID = PHNG | SKNT m/s | DRCT ° | QFLG | ID = PHNG |
|---|---|---|---|---|
| {2012, 1, 1, 5, 38, 0.} | 2.1 | 50. | OK | 1–1–2012 5:38 HST |

... complete dataset (below)

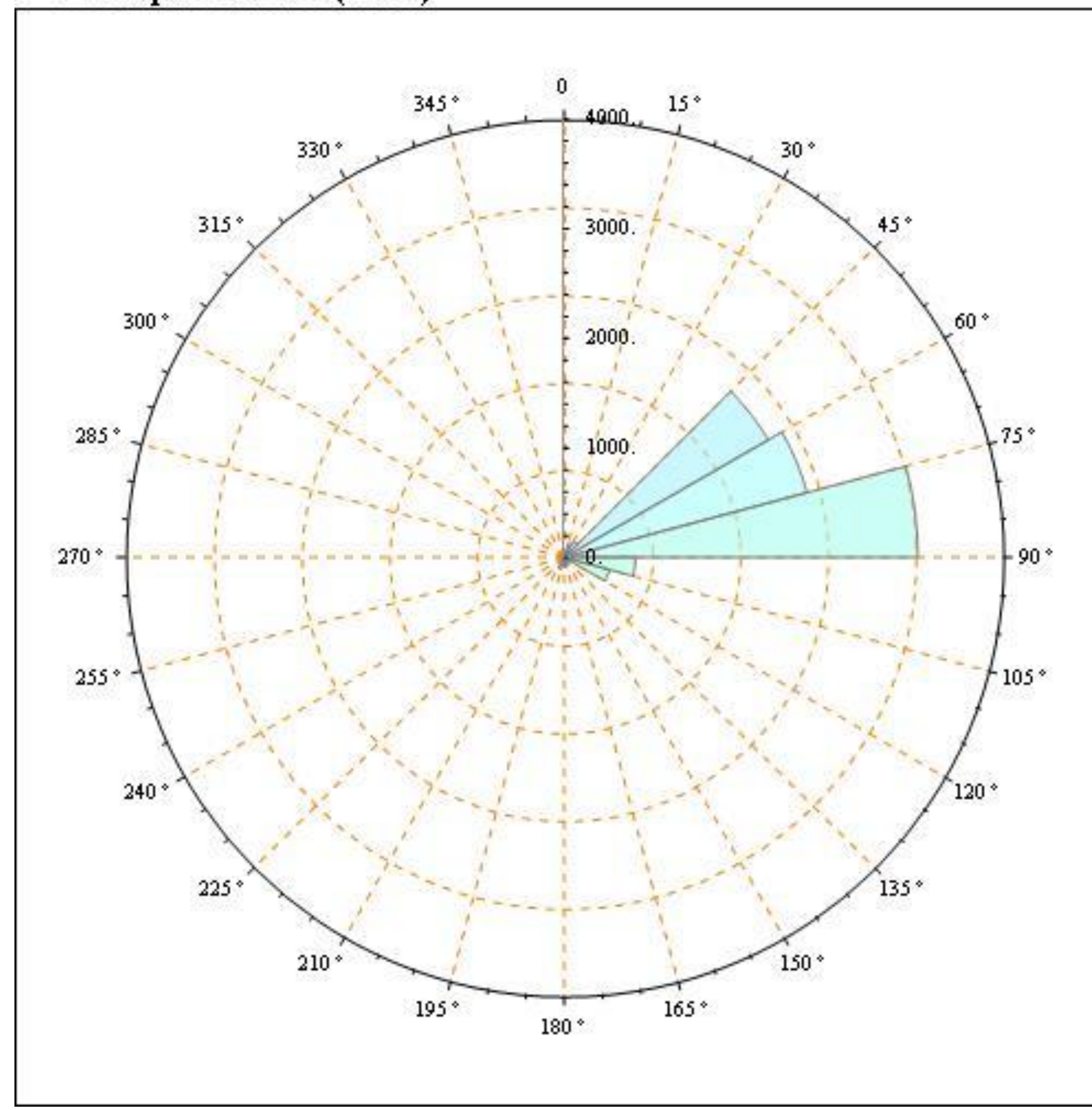



**Figure 3-10.** 2012 Kaunakakai, Molokai Airport (PHMK)(left) & Kaneohe, Marine Corps Air Station (PHNG)(right) Wind Rose

WKVH1y2012.xls–2012: All Hours

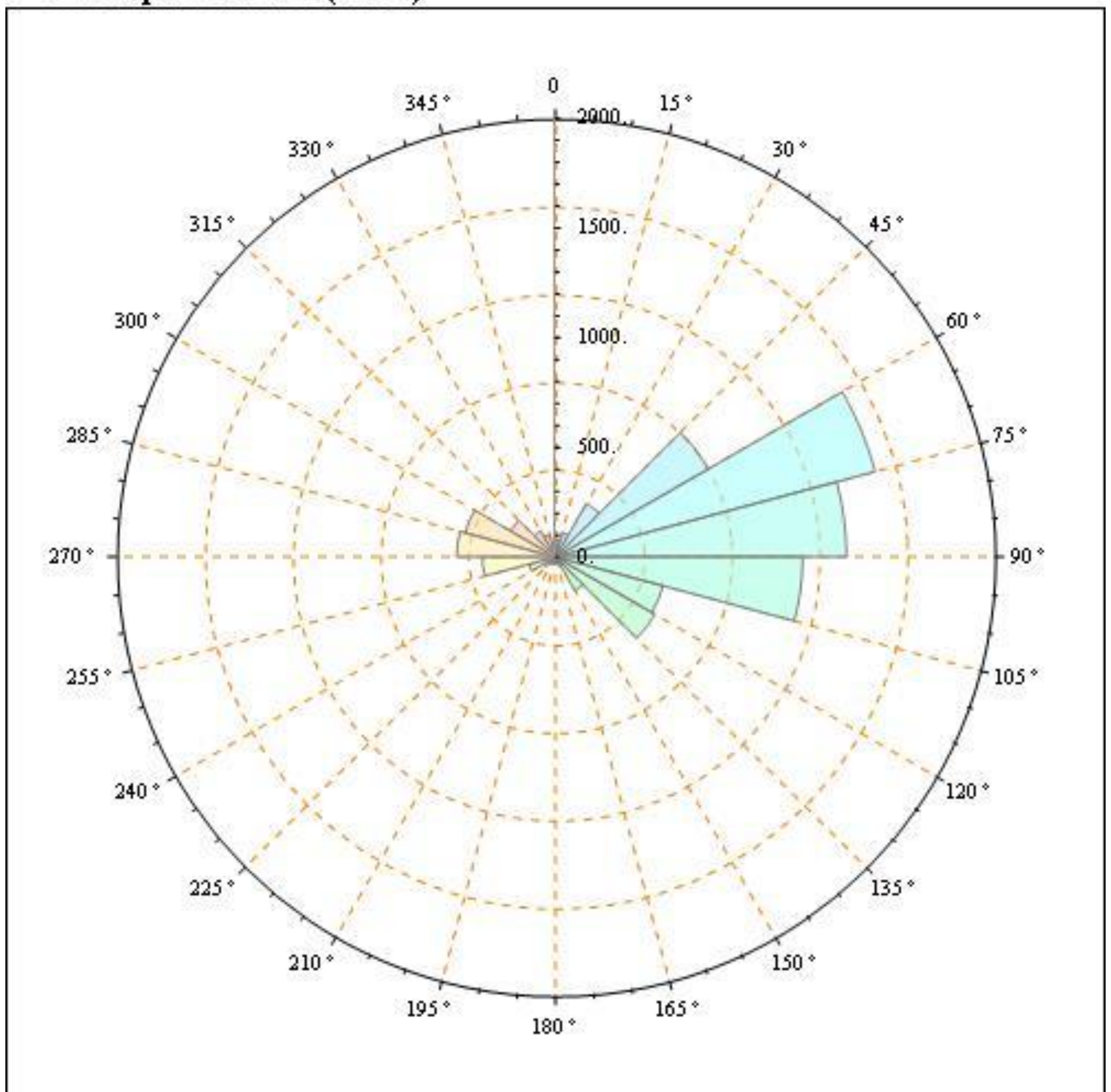
Data Info: Windrose

Number of Datasets = 8552

... first dataset (below); Direction = DRCT °

| ID = WKVH1 | SKNT m/s | DRCT ° | QFLG | ID = WKVH1 |
|---|---|---|---|---|
| {2012, 1, 1, 0, 35, 0.} | 5.8 | 64. | OK | 1–1–2012 0:35 HST |

... complete dataset (below)




KPLH1y2012.xls–2012: All Hours

Data Info: Windrose

Number of Datasets = 7067

... first dataset (below); Direction = DRCT °

| ID = KPLH1 | SKNT m/s | DRCT ° | QFLG | ID = KPLH1 |
|---|---|---|---|---|
| {2012, 1, 1, 0, 36, 0.} | 3.6 | 156. | OK | 1–1–2012 0:36 HST |

... complete dataset (below)

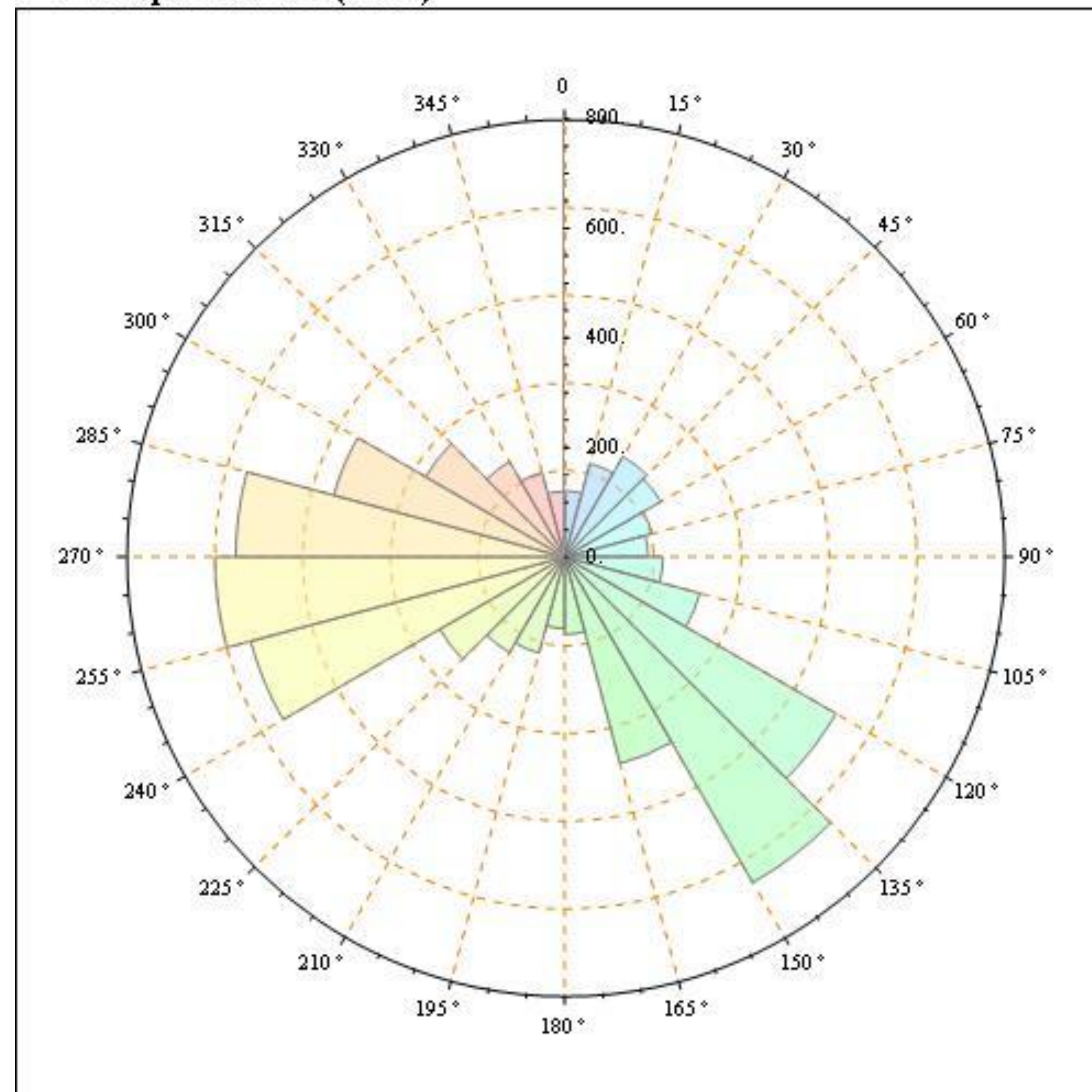



**Figure 3-11.** 2012 Waikoloa (WKVH1)(left) & Kaupulehu Lava Flow (KPLH1)(right) Wind Rose

PTRH1y2012.xls–2012: All Hours

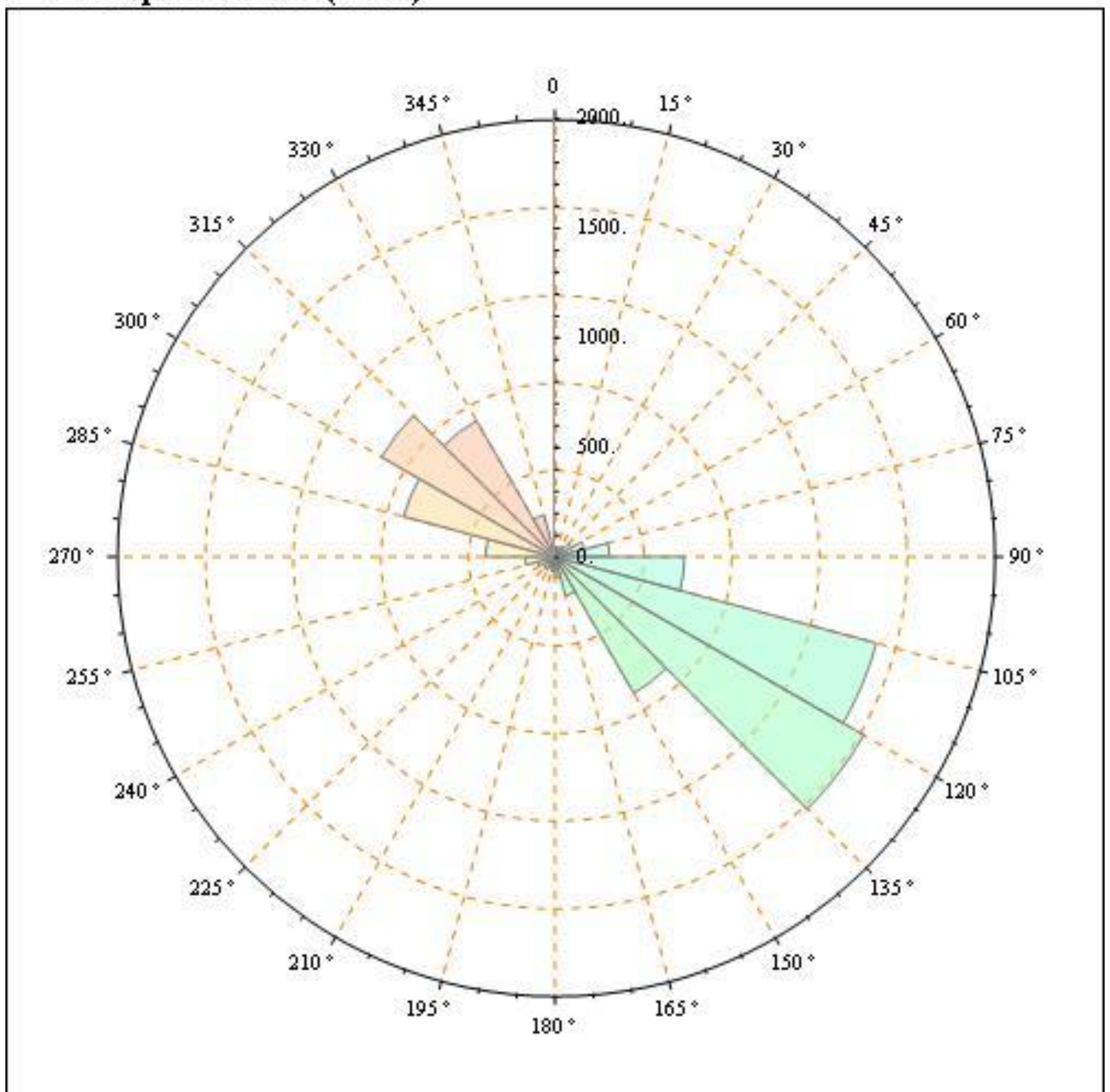
Data Info: Windrose

Number of Datasets = 8734

... first dataset (below); Direction = DRCT °

| ID = PTRH1 | SKNT m/s | DRCT ° | QFLG | ID = PTRH1 |
|---|---|---|---|---|
| {2012, 1, 1, 0, 49, 0.} | 2.7 | 101. | OK | 1–1–2012 0:49 HST |

... complete dataset (below)




PHTOy2012.xls–2012: All Hours

Data Info: Windrose

Number of Datasets = 10784

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 0, 19, 0.} | 2.1 | 290. | OK | 1–1–2012 0:19 HST |

... complete dataset (below)

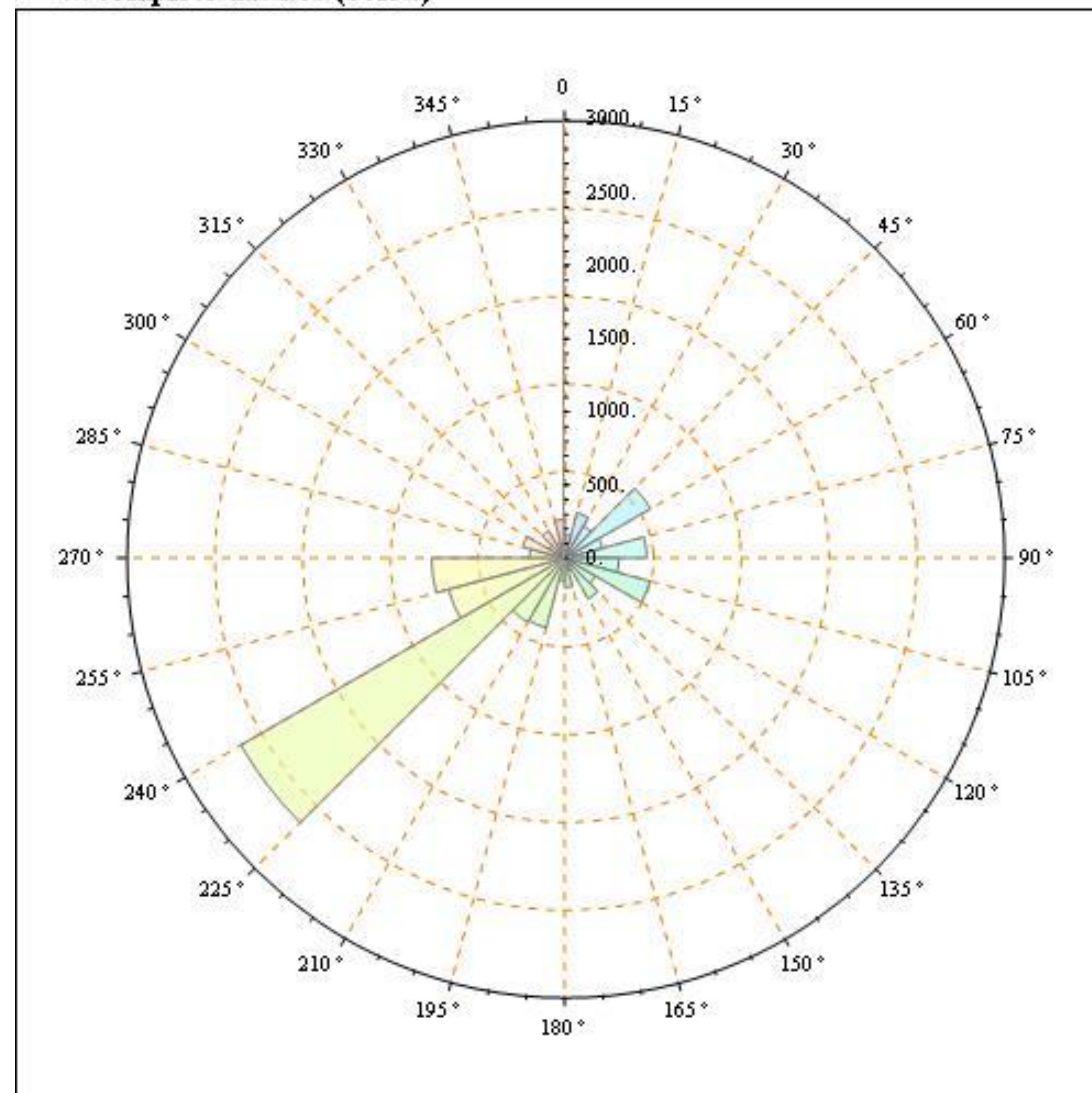



**Figure 3-12.** 2012 PTA Range 17 (left) & Hilo International Airport (right) Wind Rose

**AN157y2013.xls–2013: All Hours**

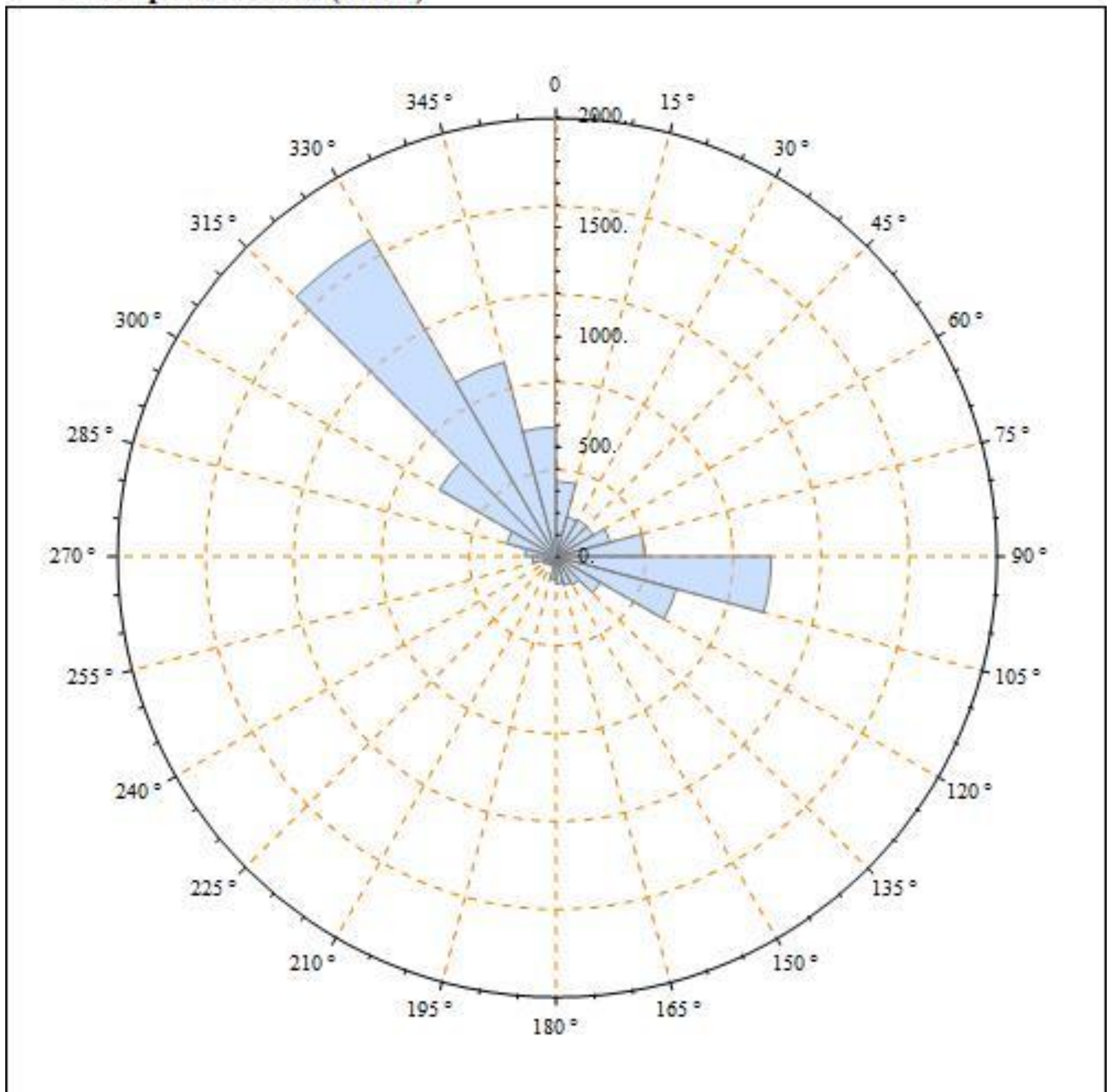
**Data Info: Windrose**

**Number of Datasets = 8341**

**... first dataset (below); Direction = DRCT °**

| ID = AN157 | SKNT mph | DRCT ° | QFLG | ID = AN157 |
|---|---|---|---|---|
| {2013, 1, 1, 0, 0, 0.} | 3.8 | 325. | N/A | 1–1–2013 0:00 HST |

**... complete dataset (below)**




**AN738y2013.xls–2013: All Hours**

**Data Info: Windrose**

**Number of Datasets = 8313**

**... first dataset (below); Direction = DRCT °**

| ID = AN738 | SKNT mph | DRCT ° | QFLG | ID = AN738 |
|---|---|---|---|---|
| {2013, 1, 1, 0, 0, 0.} | 2.9 | 20. | N/A | 1–1–2013 0:00 HST |

**... complete dataset (below)**

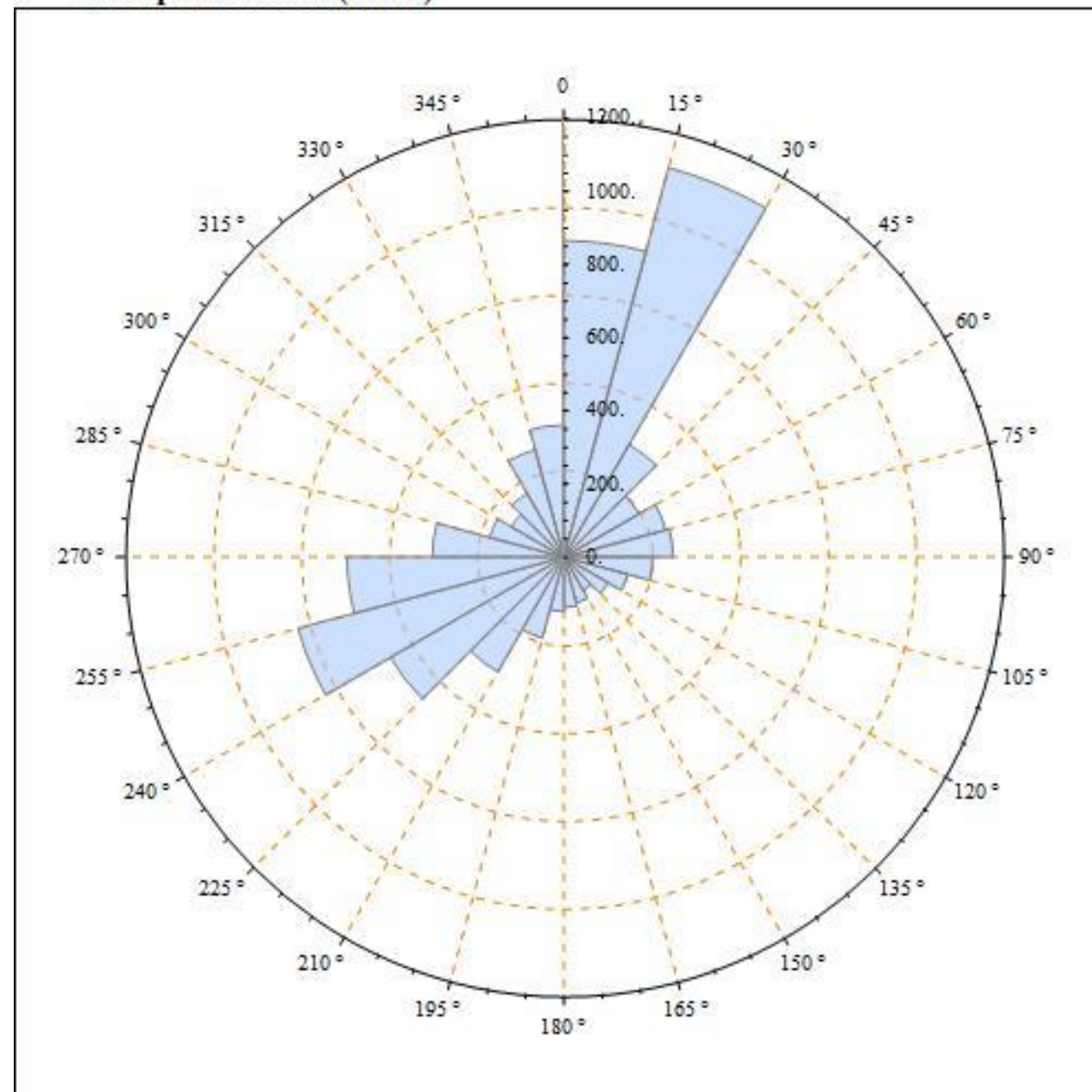



**Figure 3-13.** 2013 Pahala (AN157)(left) and Ocean View (AN738)(right) Wind Rose

PHMKy2012.xls–2012: All Hours

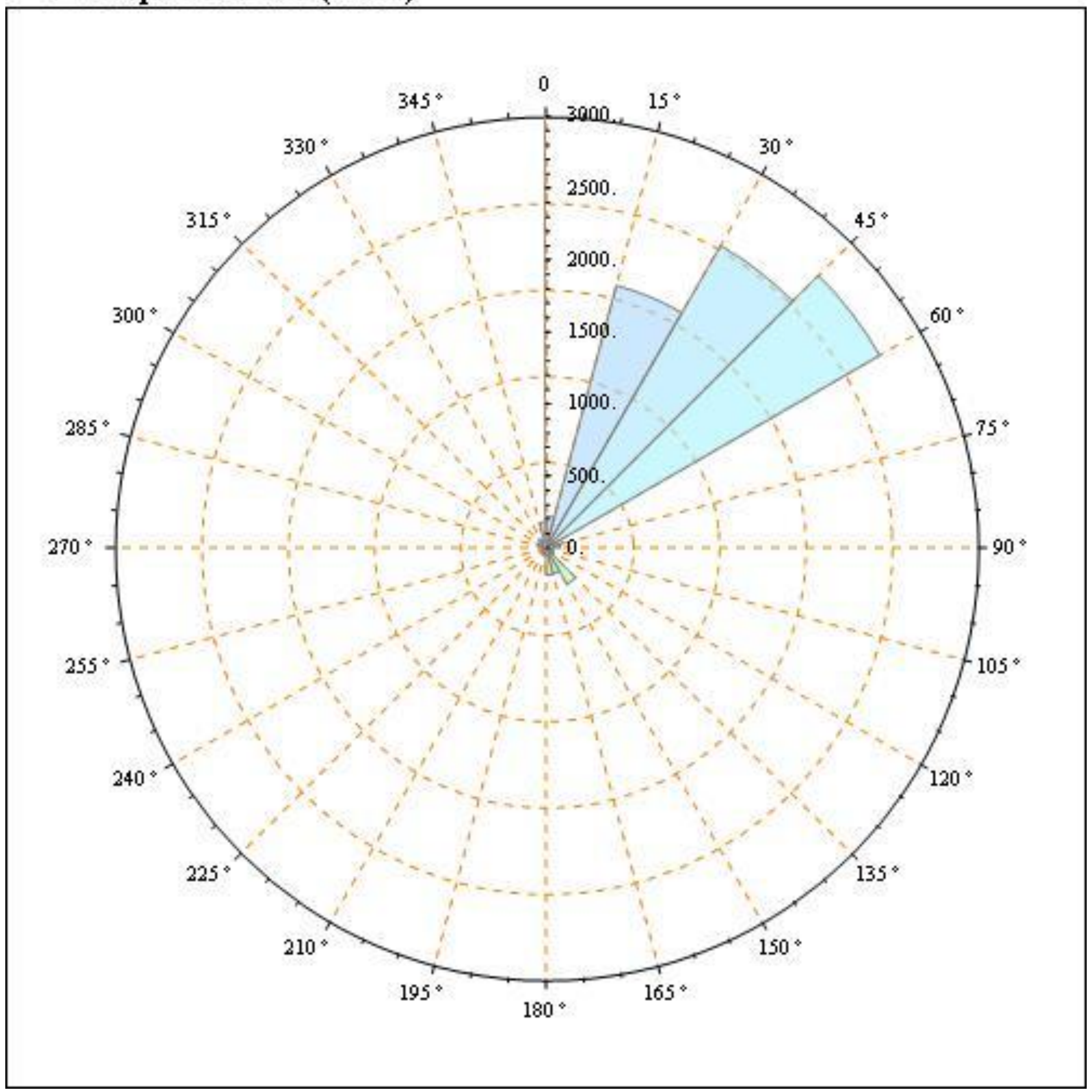
Data Info: Windrose

Number of Datasets = 8835

... first dataset (below); Direction = DRCT °

| ID = PHMK | SKNT m/s | DRCT ° | QFLG | ID = PHMK |
|---|---|---|---|---|
| {2012, 1, 1, 0, 54, 0.} | 2.6 | 30. | OK | 1–1–2012 0:54 HST |

... complete dataset (below)




PHTOy2012.xls–2012: All Hours

Data Info: Windrose

Number of Datasets = 10784

... first dataset (below); Direction = DRCT °

| ID = PHTO | SKNT m/s | DRCT ° | QFLG | ID = PHTO |
|---|---|---|---|---|
| {2012, 1, 1, 0, 19, 0.} | 2.1 | 290. | OK | 1–1–2012 0:19 HST |

... complete dataset (below)

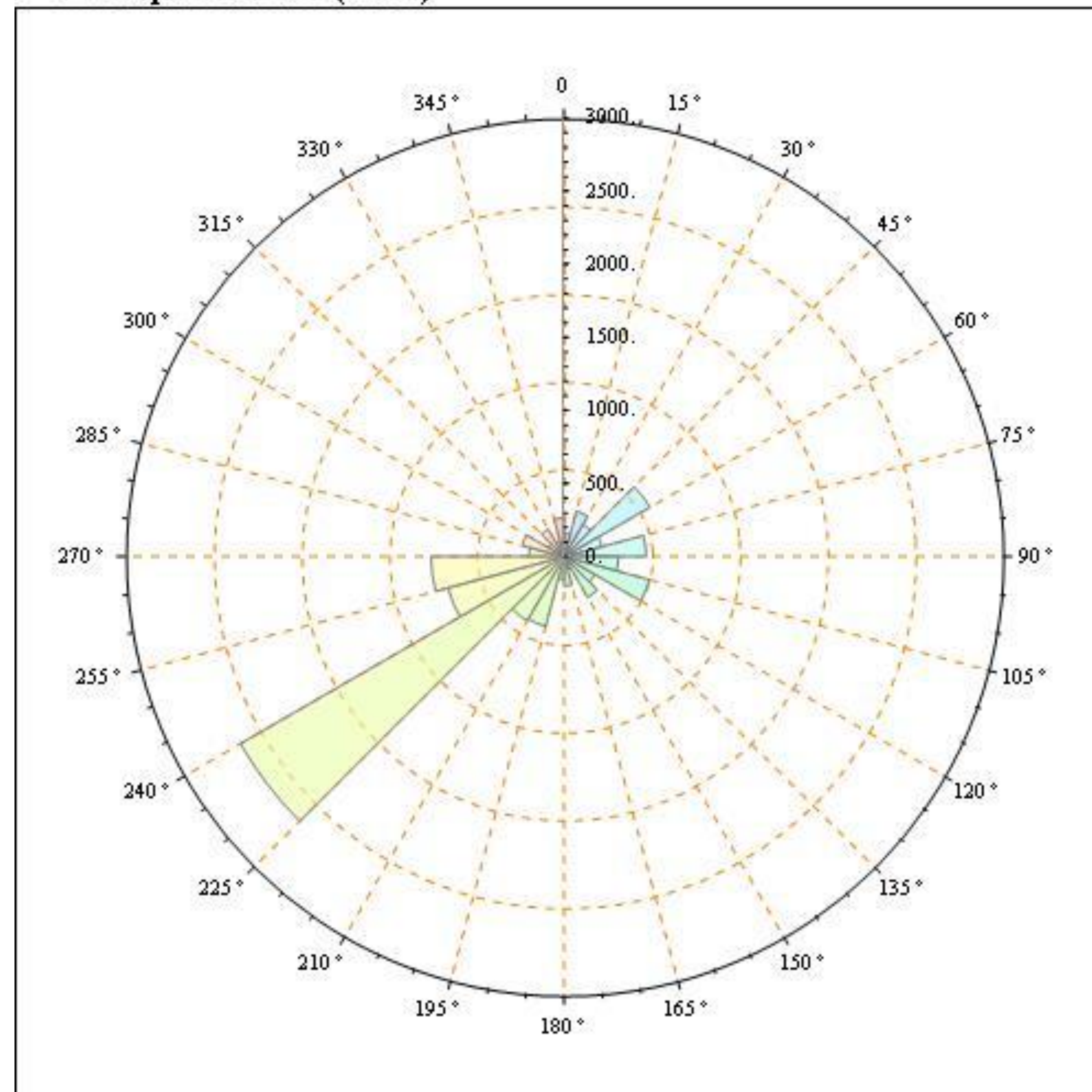



**Figure 3-14.** 2012 Kaunakakai, Molokai Airport (PHMK) (left) & Hilo International Airport (right) Wind Rose

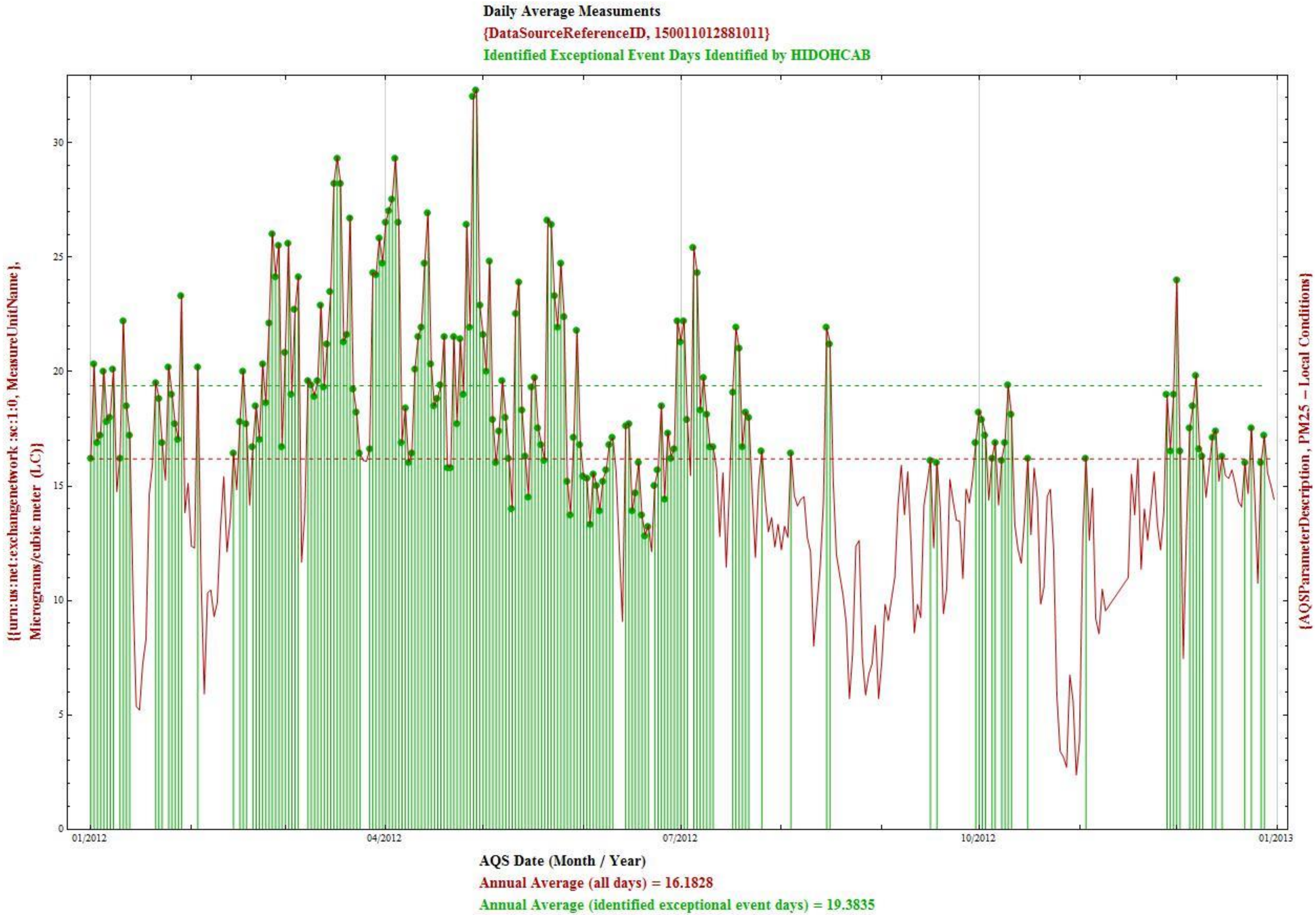



**Figure 3-15.** 2012 Time History of Kona (red) $PM_{2.5}$ Concentrations with Flagged Days (green)

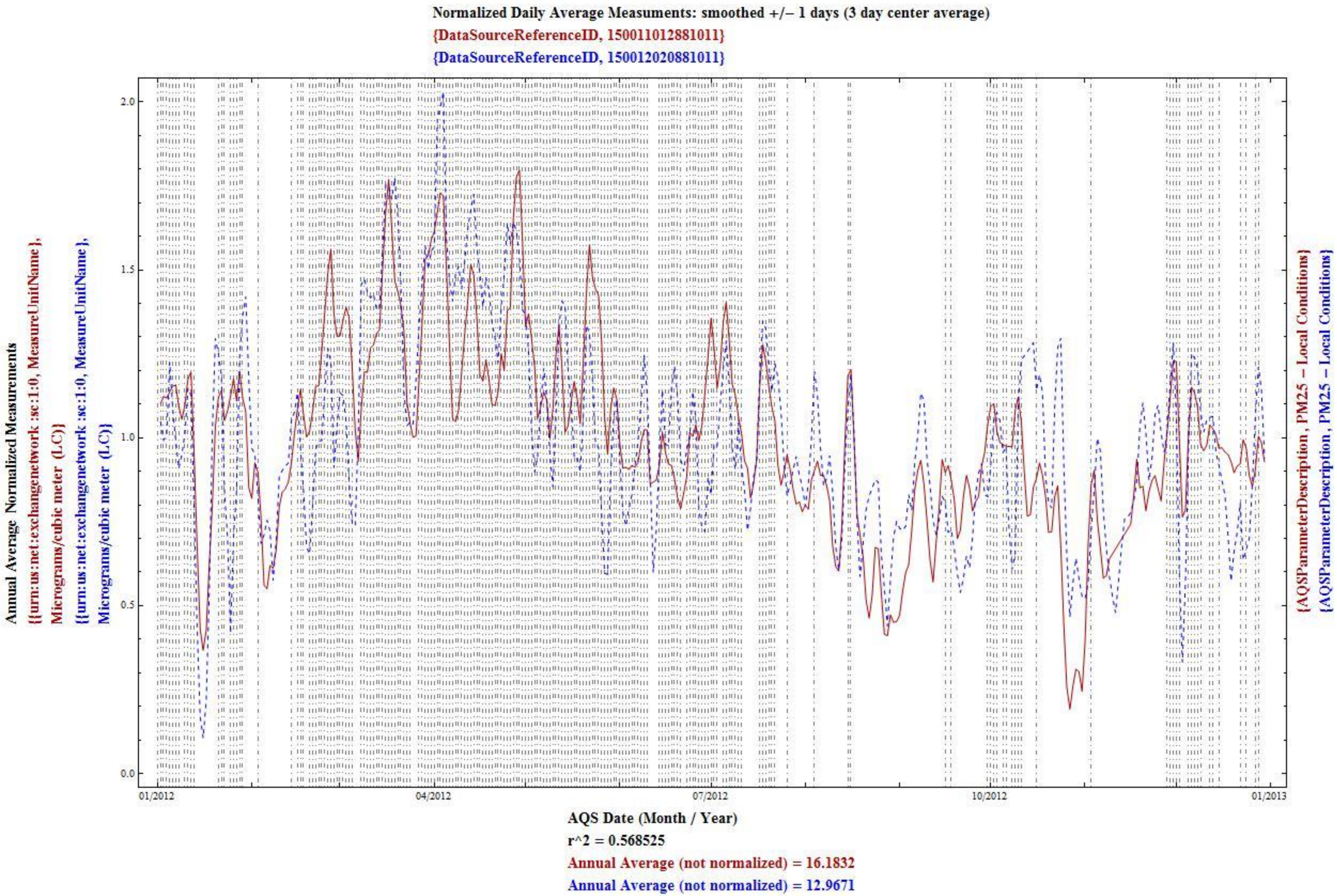



**Figure 3-16.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $PM_{2.5}$ Concentrations with Flagged Days (vertical broken lines)

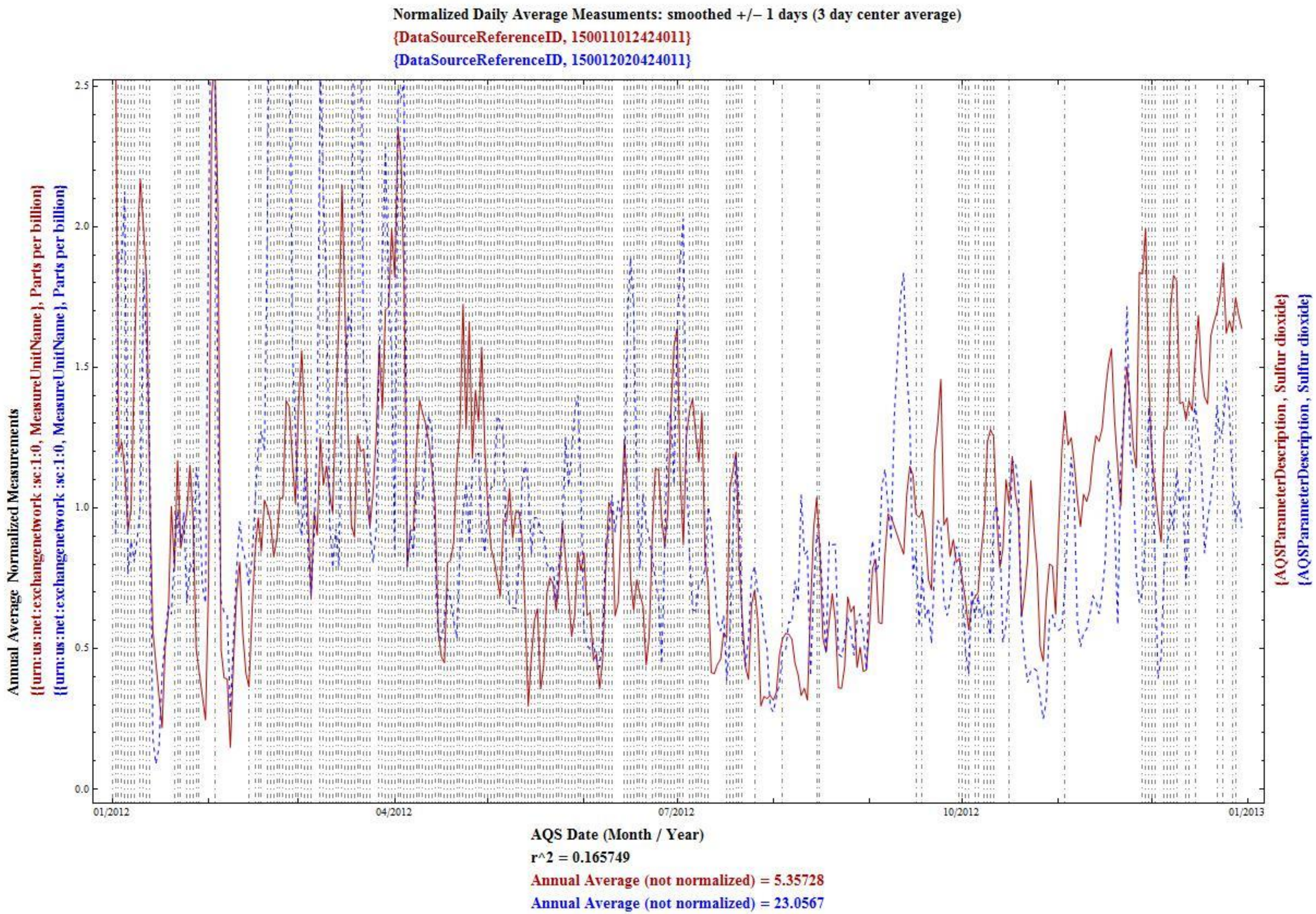



**Figure 3-17.** 2012 Time History of Kona (red) and Ocean View (blue) Normalized $SO_2$ Concentrations with Flagged Days (vertical broken lines)

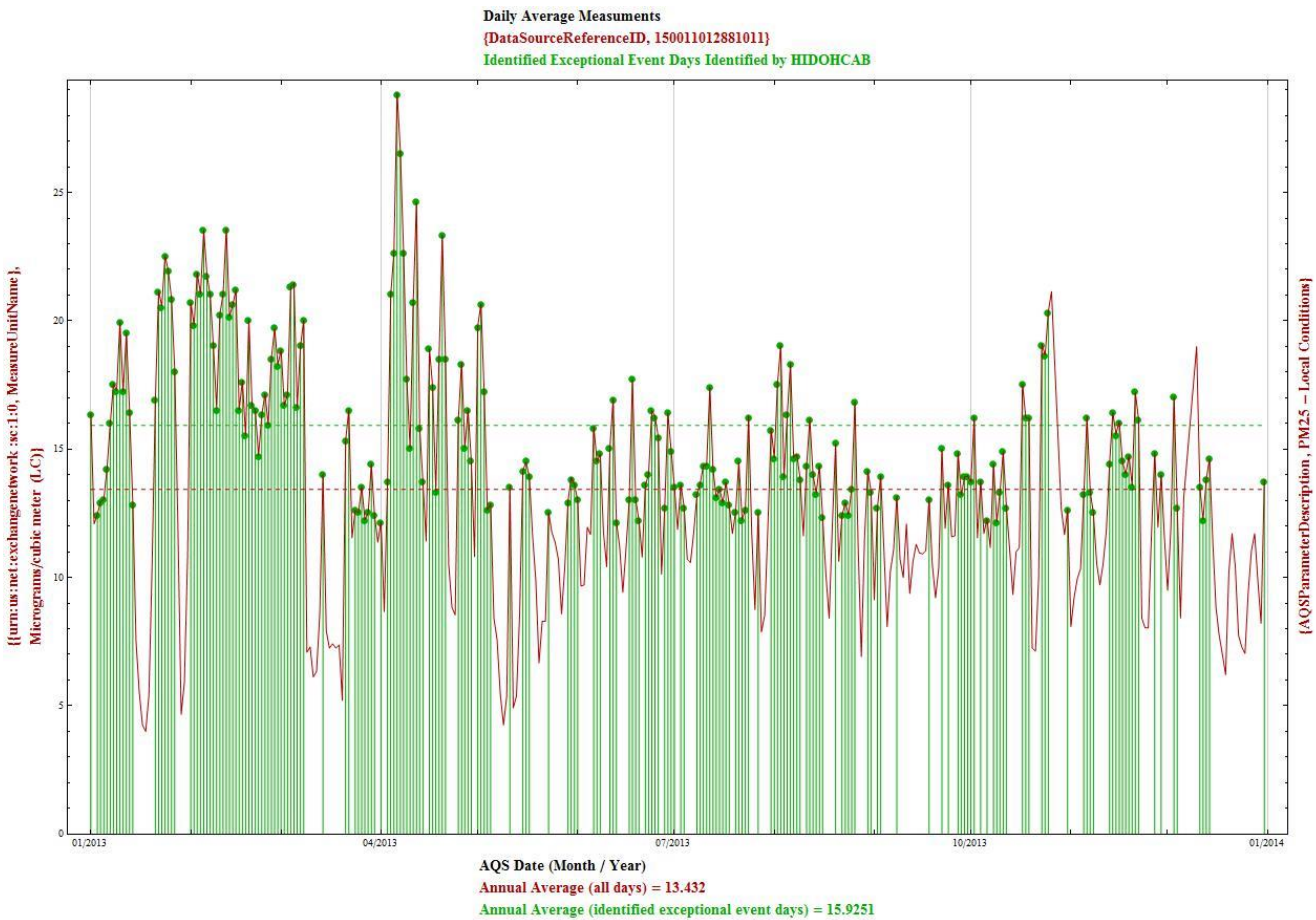



**Figure 3-18.** 2013 Time History of Kona (red) $PM_{2.5}$ Concentrations with Flagged Days (green)

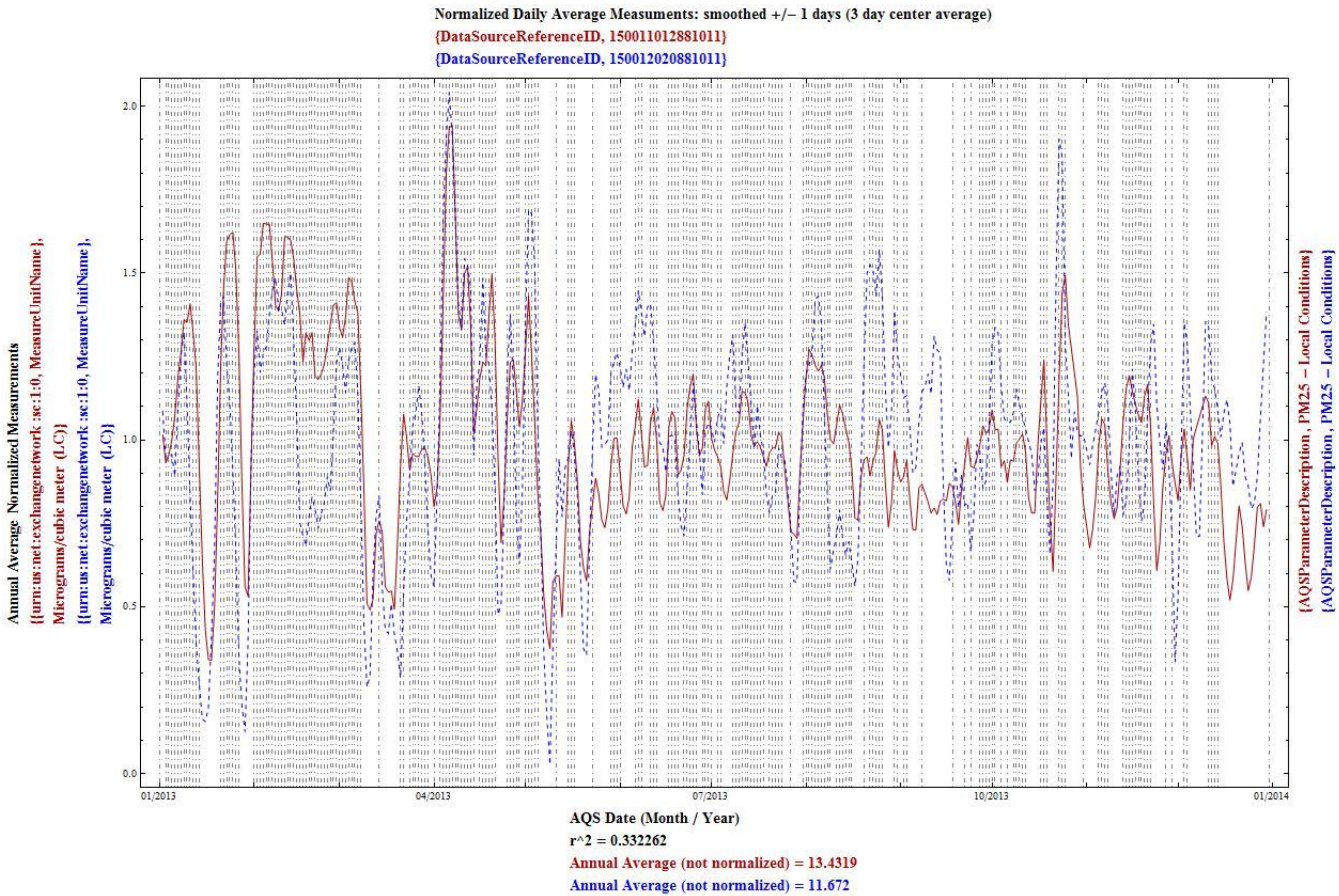



**Figure 3-19.** 2012 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $PM_{2.5}$ Concentrations with Flagged Days (vertical broken lines)

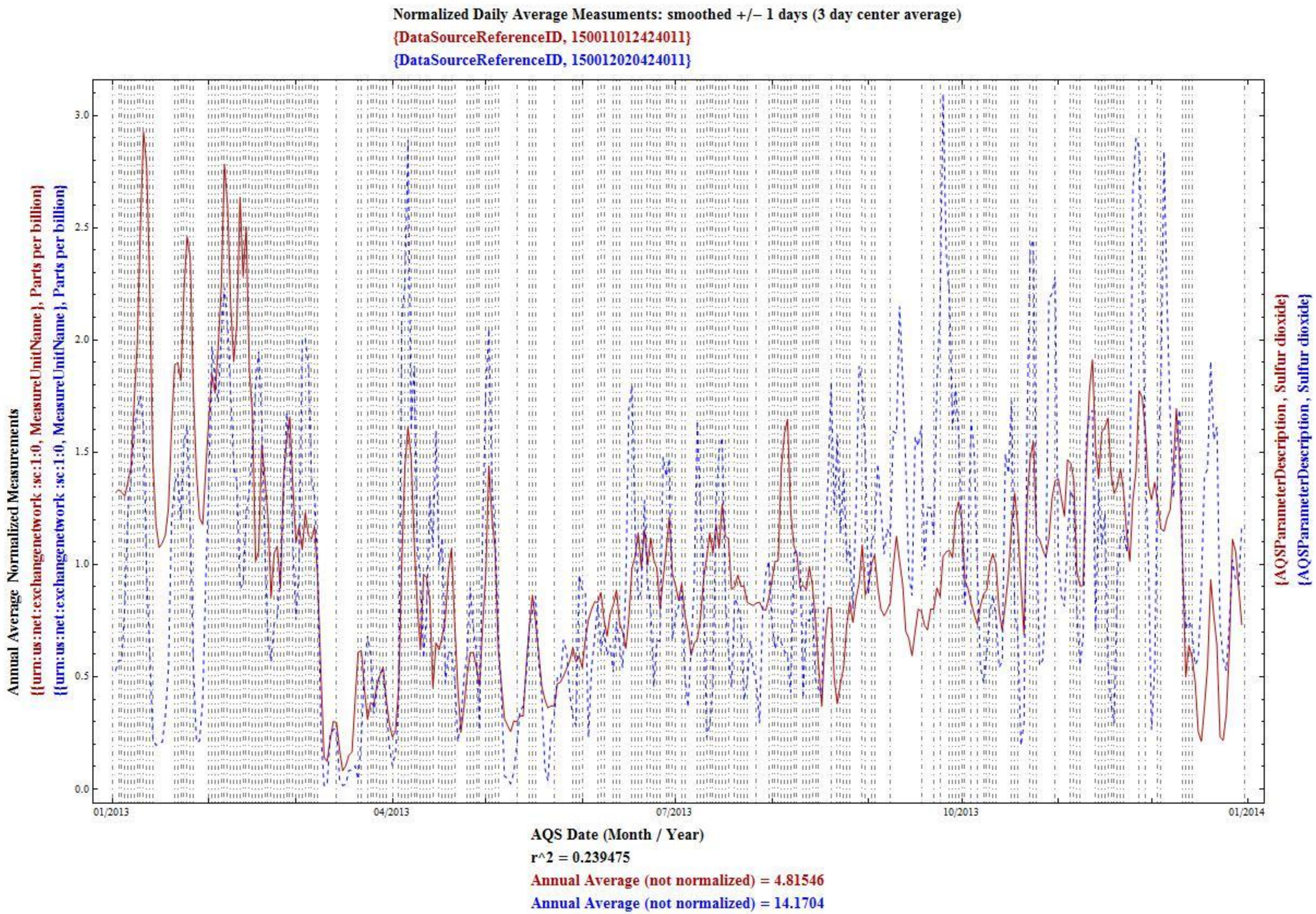



**Figure 3-20.** 2013 Time History of Kona (red) and Ocean View (blue, dot-dash) Normalized $SO_2$ Concentrations with Flagged Days (vertical broken lines)