Hawaiian Electric Company

Field Campaign Report

Appendix I1-2 to Wind HUI Initiative 1

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Appendix to Final Technical Report
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Appendix I1-2: Field Campaign Report

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Appendix I1-2 to Wind HUI DOE/EE0001379-2

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1. INTRODUCTION

As part of the WindNET project on the Big Island of Hawaii, AWS Truepower (AWST) conducted a field campaign to assess the viability of deploying a network of monitoring systems to aid in local wind energy forecasting. The data provided at these monitoring locations, which were strategically placed around the Big Island of Hawaii based upon results from the Oahu Wind Integration and Transmission Study (OWITS) observational targeting study (Figure 1), provided predictive indicators for improving wind forecasts and developing responsive strategies for managing real-time, wind-related system events.

The goal of the field campaign was to make measurements from a network of monitoring devices that could improve 1- to 3-hour ahead forecasts for the Apollo wind farm.

2. TIME PERIOD

The Big Island WindNET field deployment project began July 2010 and ended October 2011. A total of four meteorological instruments were selected and deployed on the Big Island in areas identified by a previous study as being highly sensitive for forecasting for the Apollo Wind Farm. Table 1 shows the locations of the instruments and the deployment dates for each location.

Table 1: Instrumentation summary for the WindNET field campaign.

Site	Instrumentation	Deployment Date	Period of Record As of 31 August 2011
Bruns' residence	Radiometrics MP3000-A Radiometer	4 August 2010	50 weeks*
Naalehu communication site	ART VT-1 Sodar	20 September 2010	46.5 weeks
Punaluu substation (decommissioned 5 August 2011)	ART VT-1 Sodar	25 July 2010	51 weeks
South Point	ART VT-1 Sodar	10 November 2010	39 weeks

*Radiometer was unavailable from 1 October through 21 October due to a hardware failure.

3. LOGISTICAL EXPERIENCE OPERATING A DIVERSE SENSOR NETWORK

3.1 Sodar Siting Considerations

Sodar (sonic detection and ranging) operates by emitting acoustic pulses – beeps or chirps – into the atmosphere and recording the frequency shift of those sounds reflected back to the unit by atmospheric turbulence. Due to the nature of this technology's operation certain atmospheric and/or operating environment conditions can affect instrument performance. As such, siting considerations were taken into account for deployment and operation of these devices, particularly in developed areas.

Very dry or very noisy conditions, for example, will tend to limit the maximum achievable altitude performance. A sodar should be located at a site that is representative of the prevailing wind conditions for the area of interest, similar to the way in which meteorological masts are sited. The sodar should be placed on firm and level ground, and should be anchored if there is a risk of toppling due to high winds. Sodar siting must also take into account unwanted sources of ambient noise, fixed echoes, and sources of electrical noise, which can deteriorate data quality. To avoid echo interference, the sodar must have a clear view of the sky in two 45 degree angles off horizontal that are 90 degrees apart.

3.1.1 Acoustic Noise (passive and active)

When siting a sodar system, consideration should be given to the location and spatial distribution of all potential acoustic sources and scatterers. Acoustic noise (active noise) can interfere with sodar measurements by presenting false signals near the sodars acoustic frequency or by causing a degradation of the signal-to-noise ratio (SNR), which results in degraded altitude performance. Active noise sources can include machinery such as generators or air conditioners, insects and birds, and even the wind itself blowing through and around trees or guy wires.

3.1.2 Electronic Noise

Input signals should be examined for the presence of radio frequency interference (RFI) or other electronic noise produced by power supplies, inverters, communication equipment, fans, radio towers, high voltage power lines, etc.

3.1.3 Public Annoyance

The ongoing beeping or chirping of a sodar can be an annoyance to people living nearby. If a sodar is going to be operating 24 hours a day for some period of time, it is best to site it far enough from residences so as to minimize this annoyance. It is recommended that the sodar not be sited closer than about 500 m from populated areas.

3.2 Radiometer Siting Considerations:

The radiometer utilizes a microwave beam to measure the atmospheric temperature profile. The primary siting consideration was a clear view of the sky across its intended viewing area. The radiometer needs to be located on a flat stable location, preferably away from large sources of dust, as this can increase the frequency of maintenance visits. The unit needs to be within 30 meters of a 120V AC power source and as far away from residences as possible to avoid disturbing people as a result of the noise of the unit’s cooling fan. Due to the need of regular site visits to clean air filters and other parts of the radiometer, a local contact for maintenance needs to be established.

3.3 Available Land Locations/Lease Negotiations:

The ideal locations for field equipment deployment are utility-owned properties with security fencing and on-site power. When suitable utility-owned locations cannot be identified, alternate locations need to be found. In the case of WindNET, only one sodar could be located at a utility substation (Punaluu). The radiometer was sited at a HELCO employee’s property in the vicinity of the original preferred site and a lease agreement was drafted to provide maintenance funds for the equipment and power usage. Lease agreements also had to be created for the sodars located at South Point and Naalehu Communication Site. Delays in the equipment deployment schedule were related to negotiations with landowners at these sites. Sodars located at Naalehu and South Point were within cattle pastures, requiring the installation of cattle fencing around the equipment to protect it from cattle rubbing against it or chewing through cables.

3.4 Power and Communications Requirements:

At locations without on-site power availability, solar panels and batteries had to be added to sodar equipment to provide a power source. Sodars draw about 40 watts of power per unit. Two sodars were equipped with solar power systems (Naalehu and South Point) while Punaluu was able to connect to the on-site power supply. Monitoring of sodar data revealed sodars occasionally shutting down and maintenance checks had to be done to ensure solar panels and batteries were functioning correctly. Solar panels and battery chargers had to be replaced several months into the deployment. The sodar with on-site power at Punaluu also had a battery charger replaced.

All equipment transmitted data over cellular phone connections. Sodar systems all used consumer-grade cellular data cards for communications. In areas where cell coverage was inadequate, additional antennae were added to boost the signal. Data was emailed to AWST once each day at midnight. The radiometer is typically installed at sites where the system laptop can be connected to a local network through an Ethernet connection. The manufacturer had less experience with the use of a wireless communications system to access the unit, retrieve data, etc., but this type of communication protocol is necessary in more remote locations. The radiometer data was manually downloaded on a weekly basis.

3.5 Security

Depending upon the deployment location, monitoring devices may need to be secured within fencing to deter vandals and access by livestock. In environments where animals such as cattle or horses can approach the device (e.g. at Naalehu and South Point), temporary fencing was used to keep animals from damaging the instrumentation. At sites prone to vandalism, or where the unit is clearly visible and likely to attract attention, a fence of at least six feet tall, preferably topped with barbed wire, is recommended. The Punaluu site was within an electric substation. This provided good security but required special training for entering the substation and required the technician to be accompanied by a utility employee on each visit.

4. SENSOR SELECTION

The selection of equipment for the measurement campaign was driven by the capabilities of the device to measure wind speed and temperature profiles, expected power consumption, permitting requirements, siting constraints, data accuracy and equipment availability. Although meteorological towers were considered for the study, they were not utilized primarily due to scheduling implications associated with the permitting process. In addition, the high cost to purchase/lease lidar units as well as their high power requirements did not make them a viable option for this campaign.

For low-level wind measurements (30 to 200 m including hub height winds near 70 m), sodar units were chosen due to the low power requirements, cost, accuracy considerations and availability. A microwave radiometer was chosen for collection of temperature profile data for its sensing range (up to 10 km) and available lease options.

4.1 Punaluu Substation – Sodar

The Punaluu substation is located on the southeastern part of the island at an elevation of 120 m and is 1.5 km from the coast and 27 km in the prevailing upwind direction from the Apollo wind farm (Figure 2). This site is under control of HELCO, has power available onsite, and an existing security fence around the perimeter of the facility. The equipment located at this site was an ART VT-1 sodar system. The sodar measured wind speed and wind direction data between approximately 30 m and 200 m above ground level (AGL). A temperature/relative humidity sensor was also set up at the site to collect surface temperature and relative humidity data at a height of 2 m. Measurements from a noise test revealed that the substation equipment and nearby highway traffic did not significantly interfere with sodar operation.

4.2 Naalehu Communications Site – Sodar

The Naalehu communications site is located southwest of the Punaluu substation at an elevation of 190 m (Figure 3). It is located 2 km from the southeast coast of the Big Island and 13 km in the prevailing upwind direction from the Apollo wind farm. The Naalehu communications site itself was not used due to concerns about the tall communications towers interfering with the sodar measurements. Rather, a location in a cattle pasture approximately 100 m from the communications towers was used. A trailer-mounted ART VT-1 sodar system equipped with solar power was located at this site. The sodar measured wind speed and wind direction data between approximately 30 m and 200 m AGL. A temperature/relative humidity sensor was also set up at the site to collect surface temperature and relative humidity data at a height of 3 m. This unit was also equipped with an anemometer/wind vane mounted on a 6-m mast for comparison with the sodar.

4.3 South Point Site – Sodar

The South Point site is the closest site to the Apollo wind farm. It is located at an elevation of 100 m and is approximately 500 m from the southwest coast of the Big Island and 6 km from the Apollo Wind Farm (Figure 4). An ART VT-1 sodar was deployed at this location. The sodar measured wind speed and wind direction data between approximately 30 m and 200 m AGL. A temperature/relative humidity sensor was also set up at the site to collect surface temperature and relative humidity data at a height of 3 m, and an anemometer/wind vane collected wind data at a height of 6 m.

4.4 Bruns Residence – Radiometer

The location originally identified for the radiometer during the field visit was the Kua'o Ka La Charter School. However, this facility did not have grid power and there was insufficient capacity on their existing solar-powered generation system for the radiometer. After further investigation, it was determined that providing a stand-alone power supply at this site would be too costly given the budget constraints of the project. Therefore, an alternative location with access to grid power was selected adjacent to a private residence owned by a HELCO employee, Mr. Christopher Bruns. The site is located on the eastern tip of the Big Island at an elevation of 61 m (Figure 5). It is 800 m from the coast and approximately 93 km northeast of the Apollo wind farm. A Radiometrics MP-3000A microwave radiometer leased from the Radiometric Corporation was located at this site.

5. DATA

5.1 Sodar and Radiometer Data

Sample Sodar and Radiometer Data from 04 April 2011 are shown in Figure 6. The missing data in the sodar wind speed and direction is due to rain contamination on that day.

6. ENCOUNTERED PROBLEMS

Shortly after deployment in Naalehu, a malfunctioning air card (digital cellular modem) resulted in a loss of communication with one of the sodar units. A new air card was installed on 2 October 2010 and the communications problems were resolved. On 11 October, Mr. Neal discovered that the sodars' Data

Acquisition System (DAS) was malfunctioning. A replacement DAS was installed 7 November at the same time fencing was erected to keep livestock from accessing the equipment.

At the Naalehu site, the rocky soil conditions made it difficult to install the grounding rods and anchors for the sodar unit. Following the deployment of the sodar unit, an earth drill was used on a subsequent site visit to install two grounding rods (a typical eight foot grounding rod was cut in half and wired together), as well as the sodar unit's four anchors. (Same was done at South Point.) Regular maintenance was performed on all three sodars monthly by Mr. Neal.

Communications issues required the data to be stored locally on the radiometer laptop until connectivity could be restored in mid-September. Manual downloads of the data were conducted on a weekly basis. The radiometer experienced an equipment failure and was sent back to Radiometrics for repair on 7 October 2010. The unit was repaired, tested, recalibrated, and then sent back to Hawaii where it was received by Mr. Neal then redeployed on 21 October 2010.

A wireless air card was installed in the radiometer laptop to provide remote access to the unit. It was necessary to get a static IP address assigned to the air card, as opposed to the dynamic IP addresses that air cards are allocated by default. This process can take about one to two weeks and costs approximately $500, though these parameters likely vary by carrier. The static IP address is necessary because accessing the unit involves logging into the radiometer through a web-based portal through static IP address of the air card. The static IP address also allows users to Remote Desktop into the radiometer laptop as well for control and display of data. Given the relatively poor cellular coverage at the site, an external directional antenna and amplifier were used to supplement the air card's standard antenna.

Power Supply

The power requirements for the radiometer unit were a significant driver in the selection of the radiometer site. The initial plan was to use a stand-alone solar or solar/wind hybrid power supply for the radiometer and its ancillary equipment. A semi-portable rack-mounted solar system and battery bank, both designed for five days of autonomous operation (i.e. without additional generation) was estimated to cost approximately $27,000 for a 250-watt system including shipping and installation. In addition, the site itself would need to be graded in preparation for the installation. While this type of power supply could provide maximum flexibility in siting the unit, the cost was too large relative to the project budget. For this reason, an alternative location with grid power was ultimately selected for the measurement campaign.

While the use of diesel generators was considered to power the radiometer unit, they were not selected for a number of reasons: 1) the duration of the campaign would require that any generator system be refueled and maintained regularly, 2) the noise and exhausted emitted by a generator can be a siting issue in populated areas, and 3) the expected cost of a power supply system that consisted of an generator, charge controller and battery array was too high. If a stand-alone power supply were to be considered for future deployments, one possible option to minimize power requirements, aside from reducing the power requirements of the radiometer itself, would be to select a laptop with low power consumption.

7. SUMMARY

Meteorological equipment was deployed in four locations across the Big Island of Hawaii between July 2010 and October 2011. Data from these sensors was used to assess the value of increased observations on wind forecasting for the Apollo Wind Farm. Issues encountered during the field deployment included finding appropriate sites, negotiating land leases, power needs of the equipment and communications issues. Apart from the equipment failure of the radiometer in October, all four sensors collected data regularly over a 40-50 week period (periods of record differed due to varying deployment dates).

FIGURES

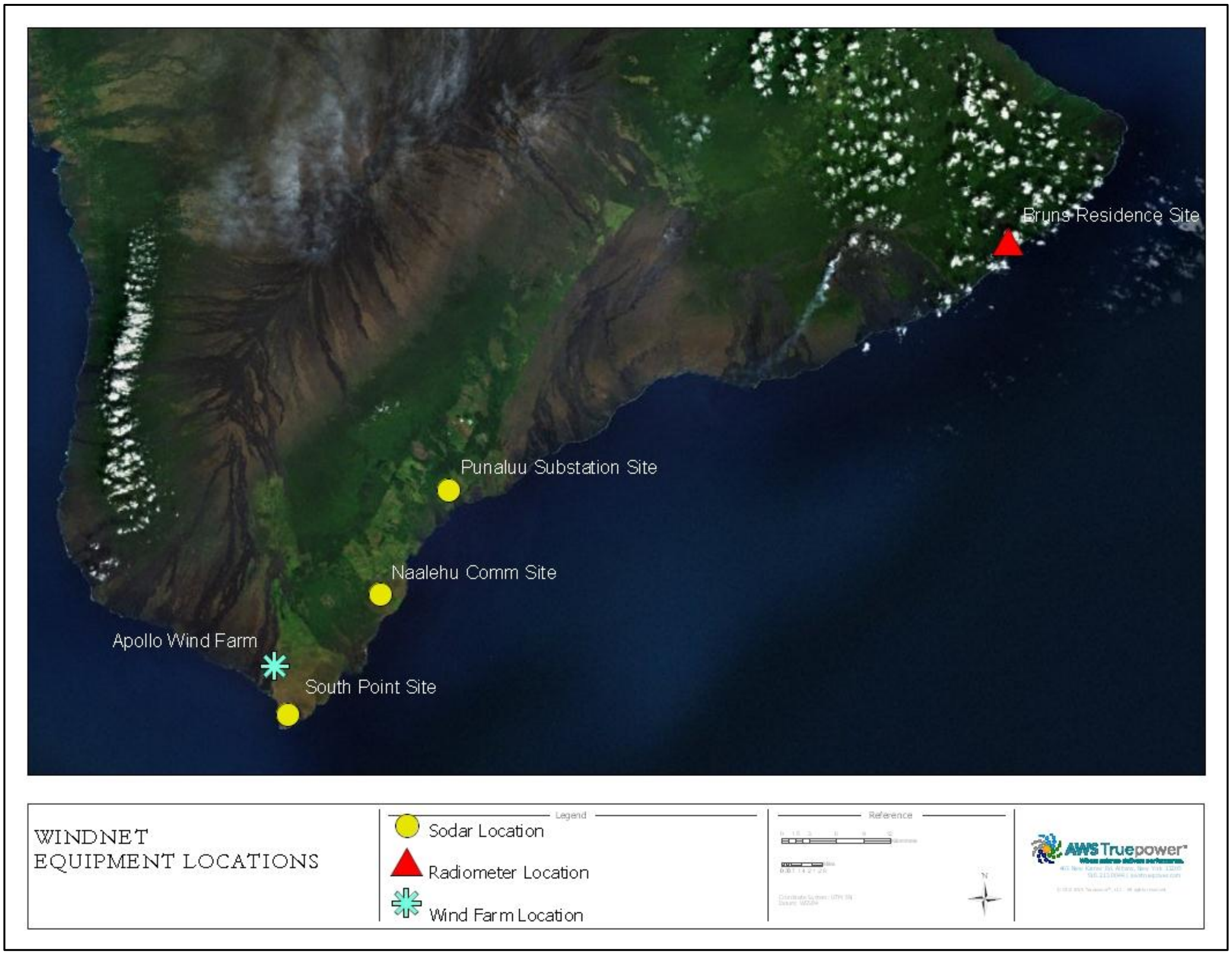

Figure 1. Final equipment locations on the Big Island.

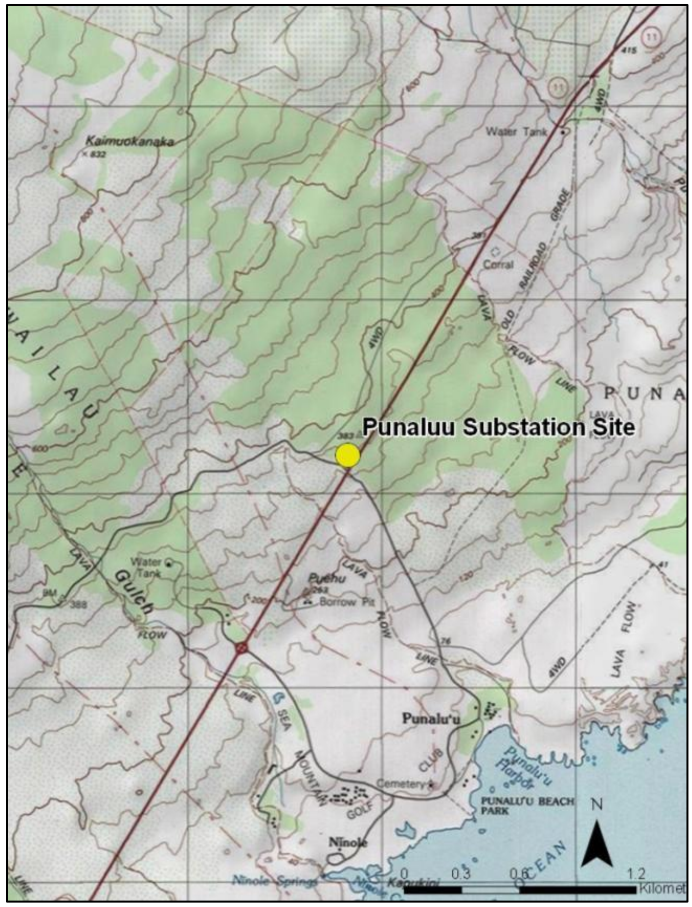
Punaluu Substation Site
Kaimuokanaka
Water Tank
Corral
PUNA
Water Tank
Gulch
Puahu
Borrow Pit
Punalu'u
Cemetery
PUNALU'U BEACH PARK
Ninole
Ninole Springs
N
0
0.3
0.6
1.2
Kilomet

Figure 2: Punaluu sodar site and installations.

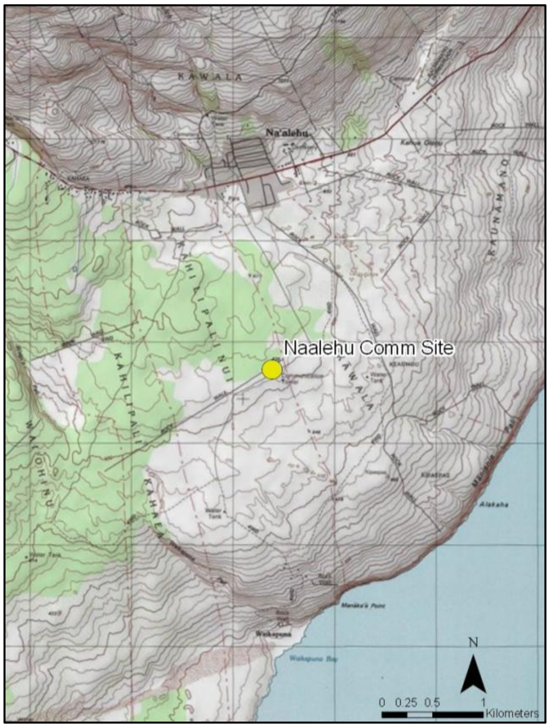

Figure 3: Naalehu sodar site and nearby communication towers.

Figure 4: South Point sodar site.

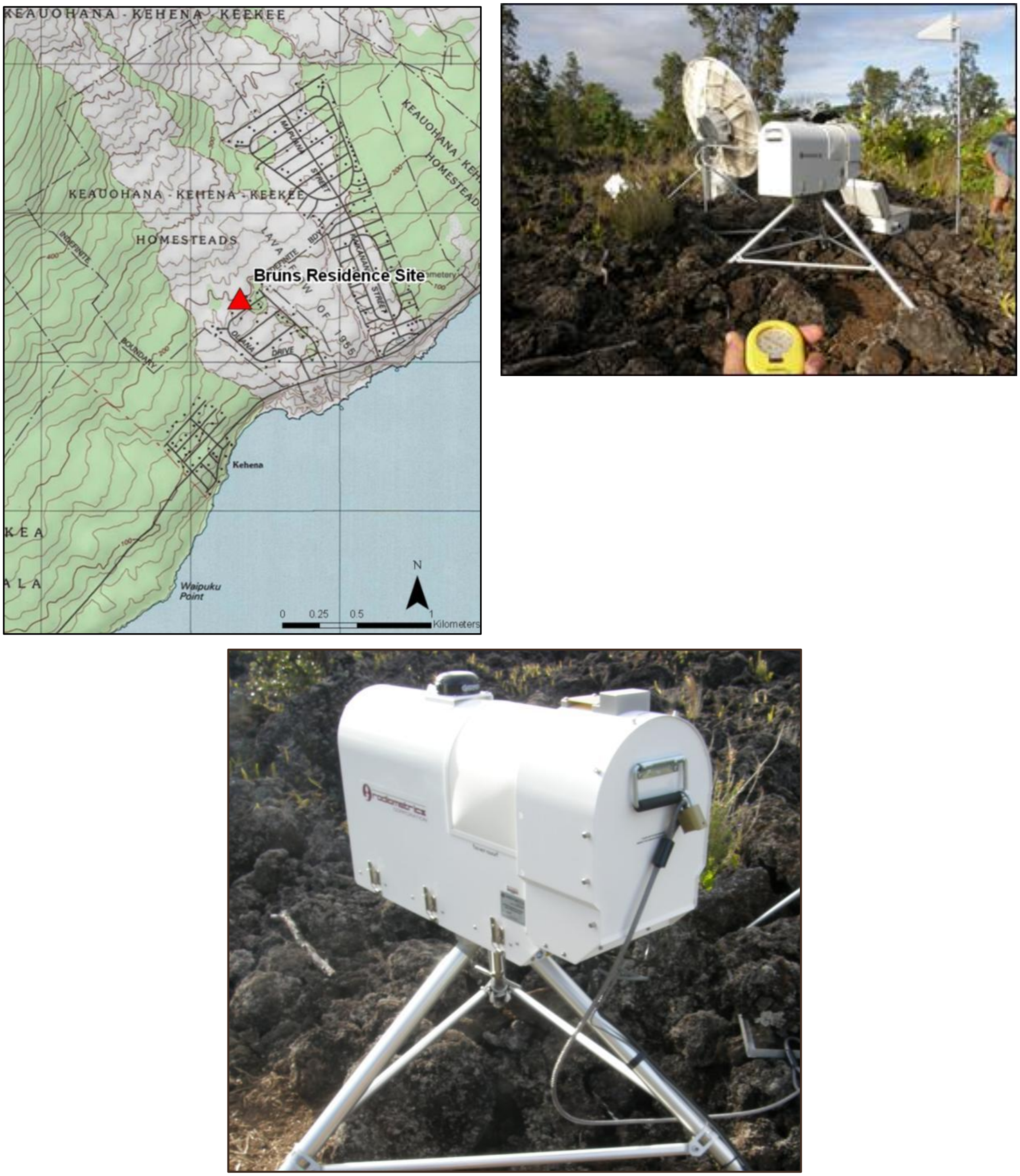

Figure 5: Radiometer site.

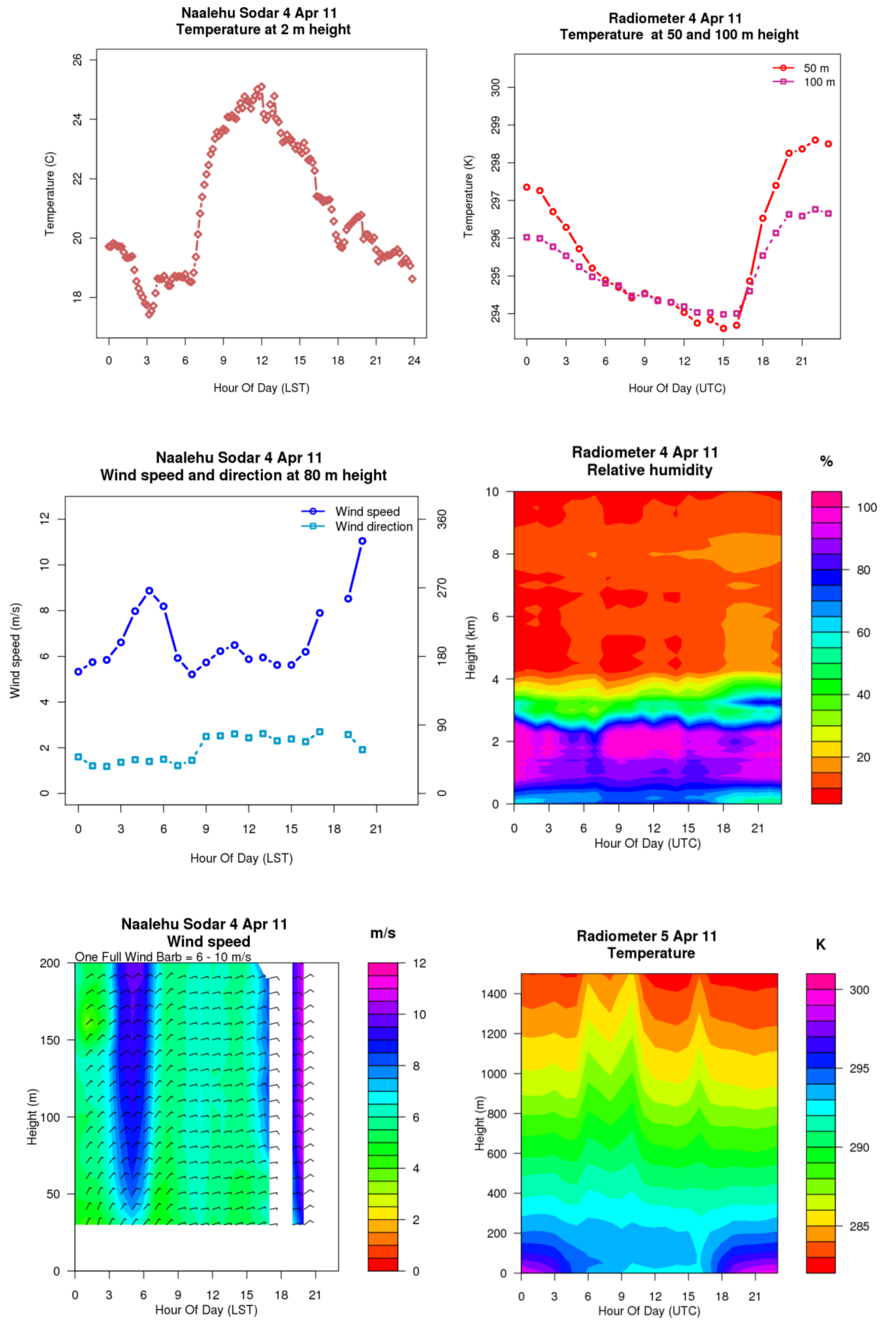

Figure 6: Sample Sodar and Radiometer Data from 04 April 2011.