PENNSTATE

Analysis of Visible Transmissometer Data in the Coastal Surf Zone

by

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Abstract

Introduction. A visible transmissometer was designed and constructed at Penn State by the authors. During April 1997, this instrument was used to take transmittance data at the Scripps Institution of Oceanography, as part of the Navy's Electro-Optical Propagation Assessment in the Coastal Environment (EOPACE) program. The goal of EOPACE is to improve the understanding of surf-generated aerosols and of electro-optical propagation in coastal regions.

Hardware. A feedback-controlled constant current source drives a halogen bulb, which serves as the white light source (approximated by a 3000K black body). The light is then mechanically chopped and filtered to eliminate near-IR, and is collimated by the source telescope. A receiving telescope collects some of the light at the far end of the optical path, focusing it through a second IR blocking filter onto a blue-enhanced silicon detector. The received signal is then amplified by the receiver and extracted from DC and noise by the lock-in amplifier. The lock-in uses a reference signal from the chopper to perform this extraction, so a coax cable runs from the source to the receiver. The lock-in then digitizes the signal and transmits it to the computer via RS-232 serial interface. The computer processes and stores the data (2 samples per second) using LabView software.

System layout. The diagram shows the locations of the source and receiver units during the intensive operating period (IOP). The 264m optical path included the entire surf zone. Note that the elevations shown are approximate maximum distances above the ocean surface (based on mean lower low tide), and the distances were less during most of the IOP.

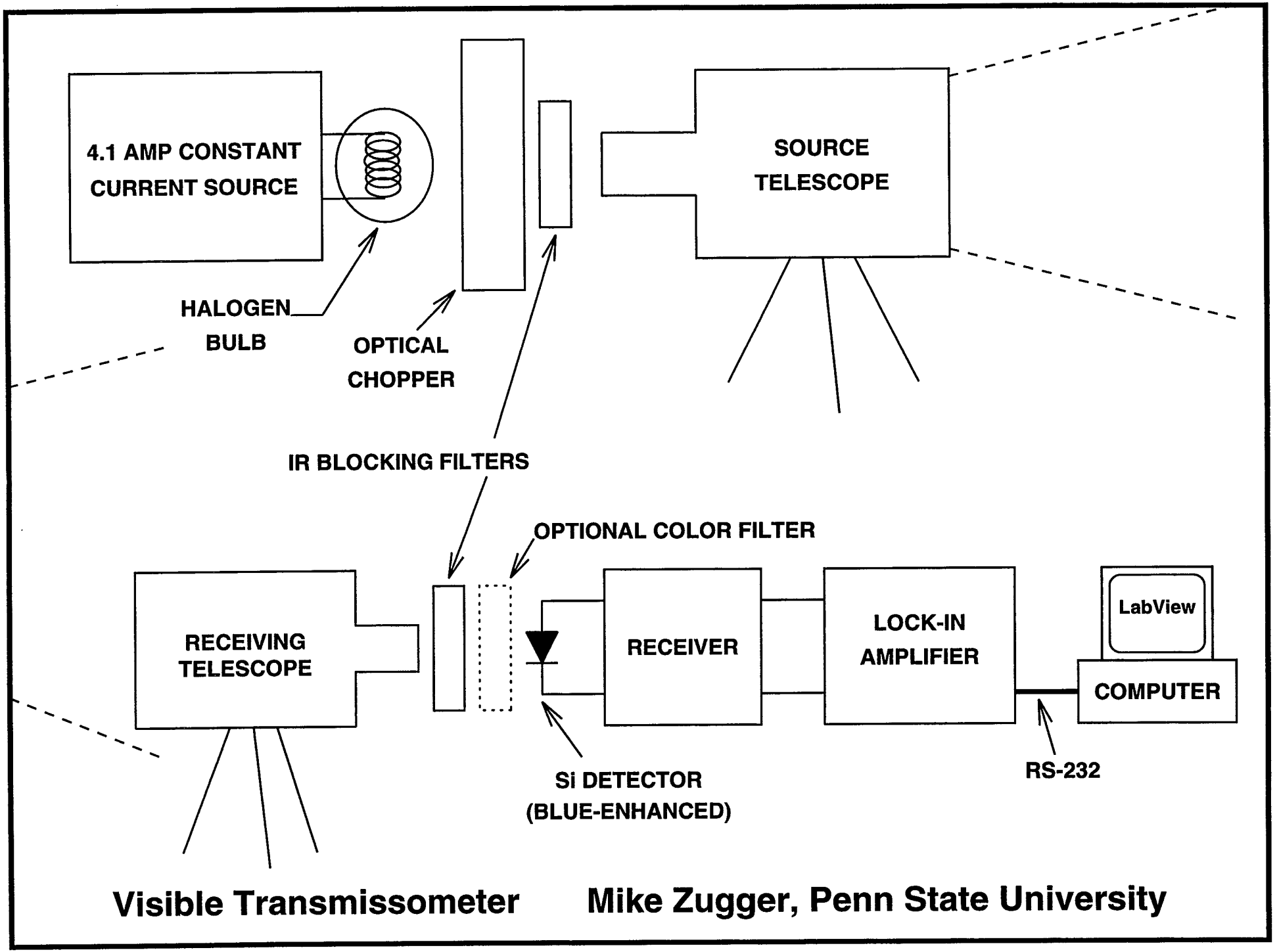
Data analysis. The next viewgraph is an example of the raw data obtained from the instrument. This graph shows the data taken on April 7 between 1:36am and midnight. The vertical axis is the signal level in volts, and the horizontal axis is arbitrary data point number (0 to 163,000). Note that there are many "dropouts" in the data; these were caused by interference picked up by the 350m coax cable. By taking the maximum of ten consecutive points (5 seconds), then averaging twelve consecutive maxima, most of the dropouts were eliminated.

A wide variety of meteorological data during the IOP was provided by Scripps and NRad, including air, sea surface, and bottom temperatures, relative humidity, wind speed and direction, wave height and period, tides, and barometric pressure. Data from a vertical array of temperature sensors was also available from another Penn State experiment. These parameters were compared with the transmittance data in an attempt to find a correlation. The best correlation found was with wind speed and direction. On April 7 and 8, a moderately strong west wind (10-15 knots) was present during much of the daylight hours, and correlates with the times of low transmittance. On April 5, data collection began at about 2pm, and transmittance remained roughly constant through the remainder of the day. On this day, the wind speed was only about 7 to 8 knots. It is

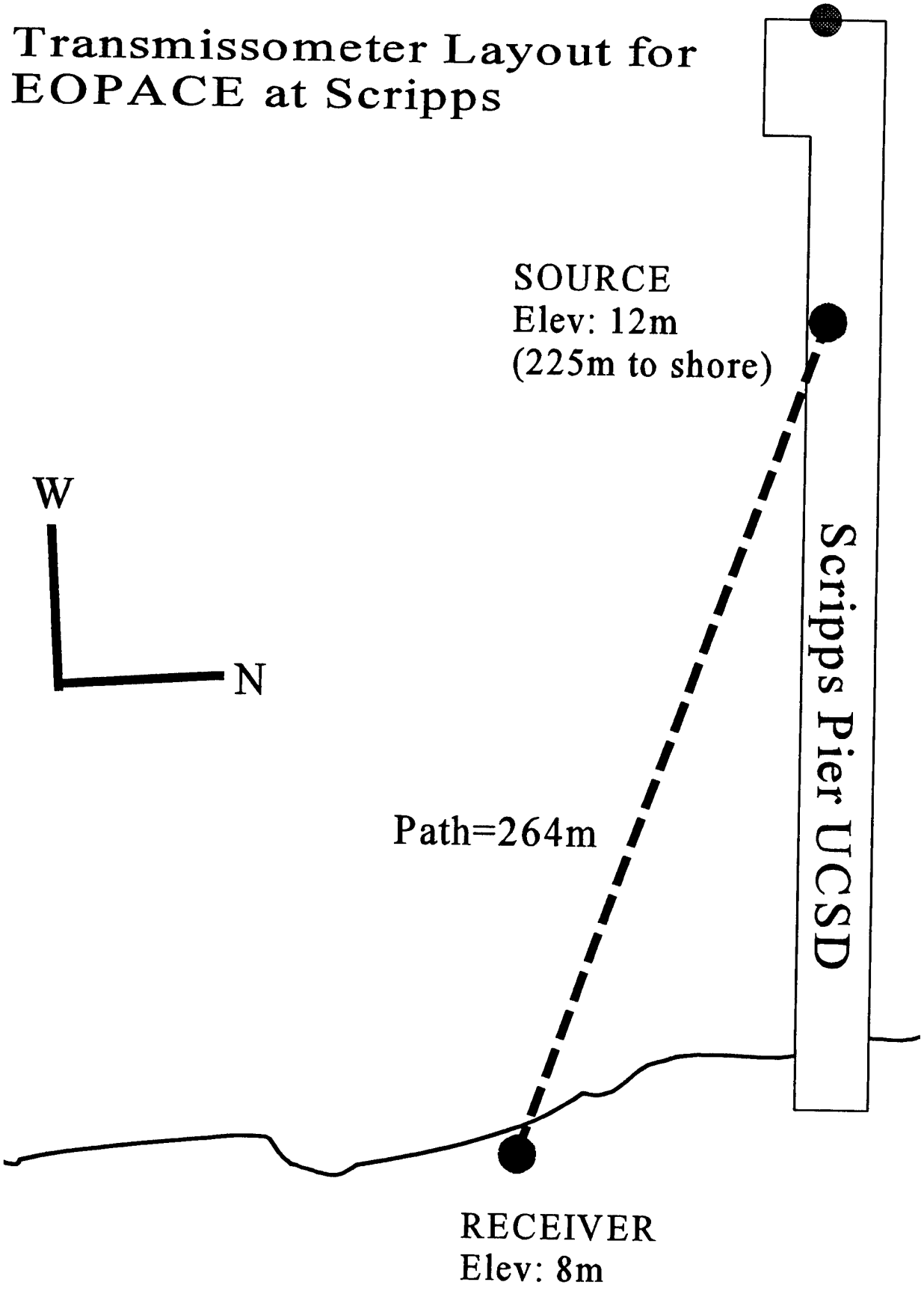
theorized that the west wind is either bringing in aerosols from the open ocean, or affecting the surf plumes in such a way as to reduce transmittance.

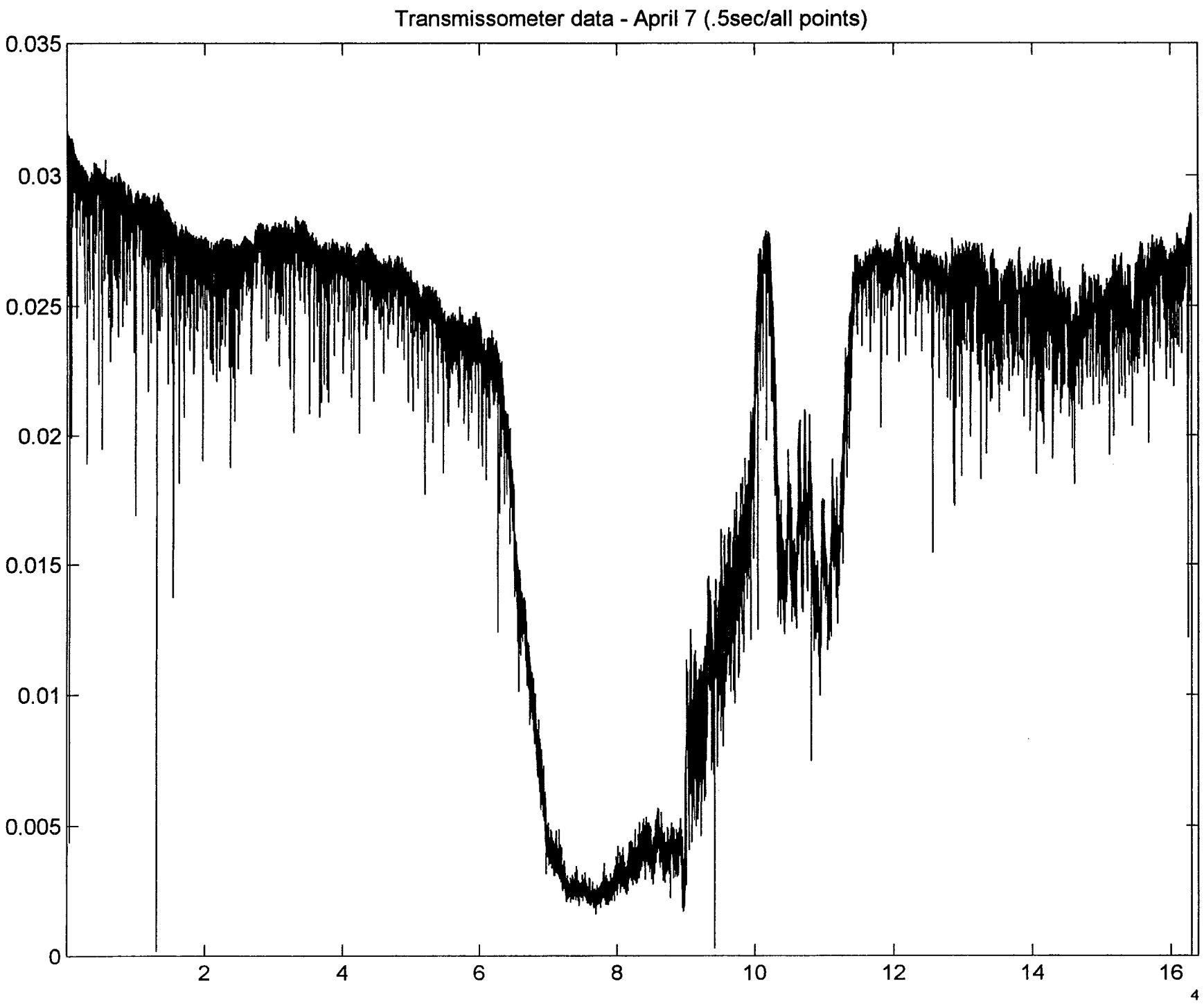
Preliminary modeling (MODTRAN). The predicted transmission versus wavelength curves for the 264km path were plotted using four standard MODTRAN aerosol models: Rural 23km Visibility, Rural 5km Visibility, Maritime 23km Visibility, and Navy Maritime 23km Visibility. Next, the combined spectral responses of the detector and the two IR-block filters were entered into the filter function associated with MODTRAN. The "Filter Function Input" viewgraph shows the resulting wavelength weighting curve. The black body input was set to 3000K for the halogen bulb. Finally, the filter function was applied to the four models, yielding predicted transmittances of 82.9%, 95.9%, 95.7%, and 98.4%, respectively. Returning to the data, when the voltage-to-transmittance conversion is applied, it is seen that the measured transmittance for the 57 hours of data falls predominantly at about 65% and about 7%.

Future work. Additional transmittance data and improved understanding of surf plumes will be required in order to better understand and predict surf zone transmittance. Comparison of data from this visible transmissometer with the NRad infrared transmissometer (also operated during this EOPACE IOP) may also provide some insights.


4.1 AMP CONSTANT
CURRENT SOURCE
HALOGEN
BULB
OPTICAL
CHOPPER
SOURCE
TELESCOPE
IR BLOCKING FILTERS
OPTIONAL COLOR FILTER
RECEIVING
TELESCOPE
RECEIVER
LOCK-IN
AMPLIFIER
LabView
COMPUTER
Si DETECTOR
(BLUE-ENHANCED)
RS-232
Visible Transmissometer
Mike Zugger, Penn State University

Transmissometer Layout for EOPACE at Scripps




Transmissometer data - April 7 (.5sec/all points)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
2
4
6
8
10
12
14
16

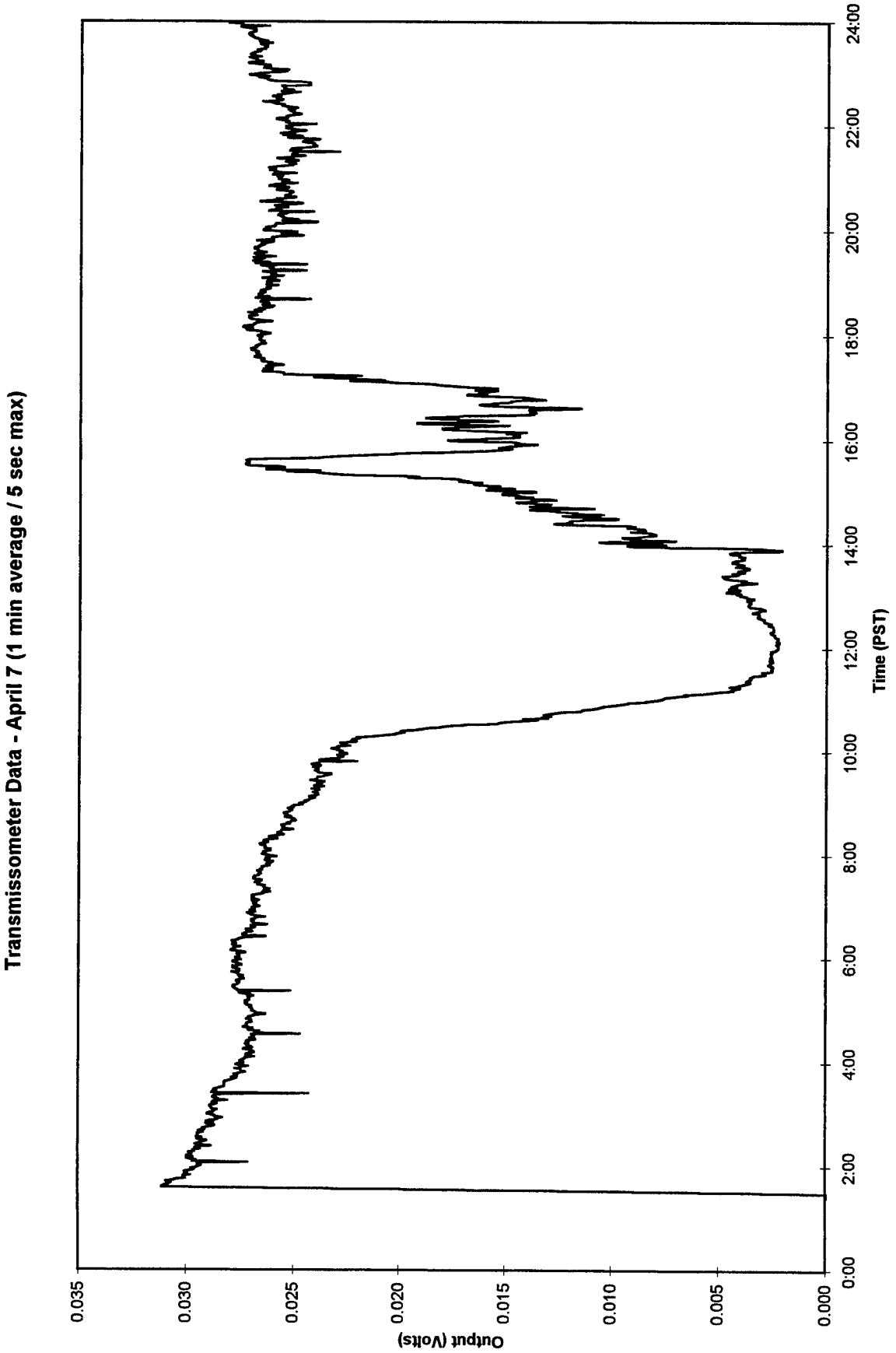
Meteorological Data Available

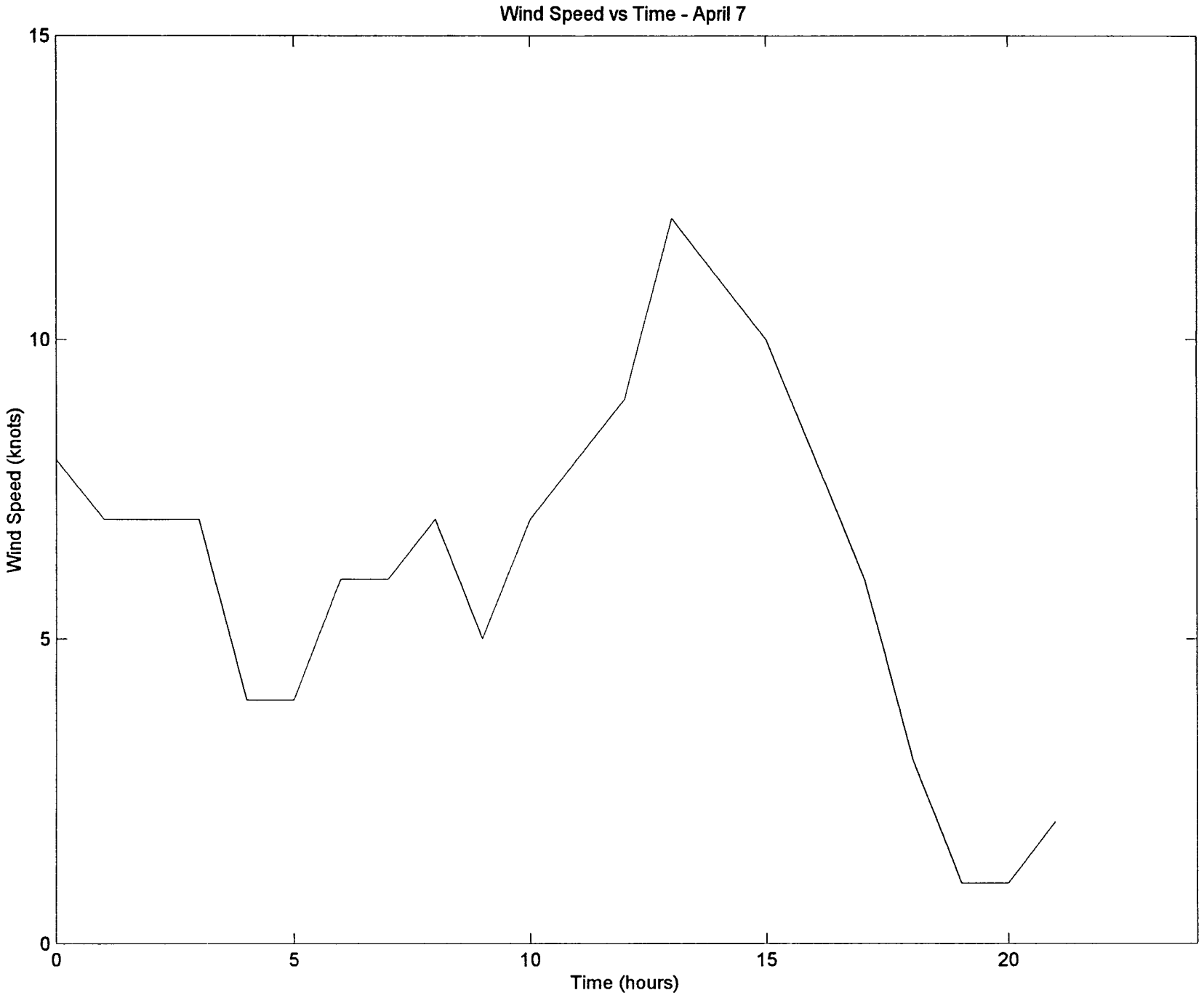
Scripps

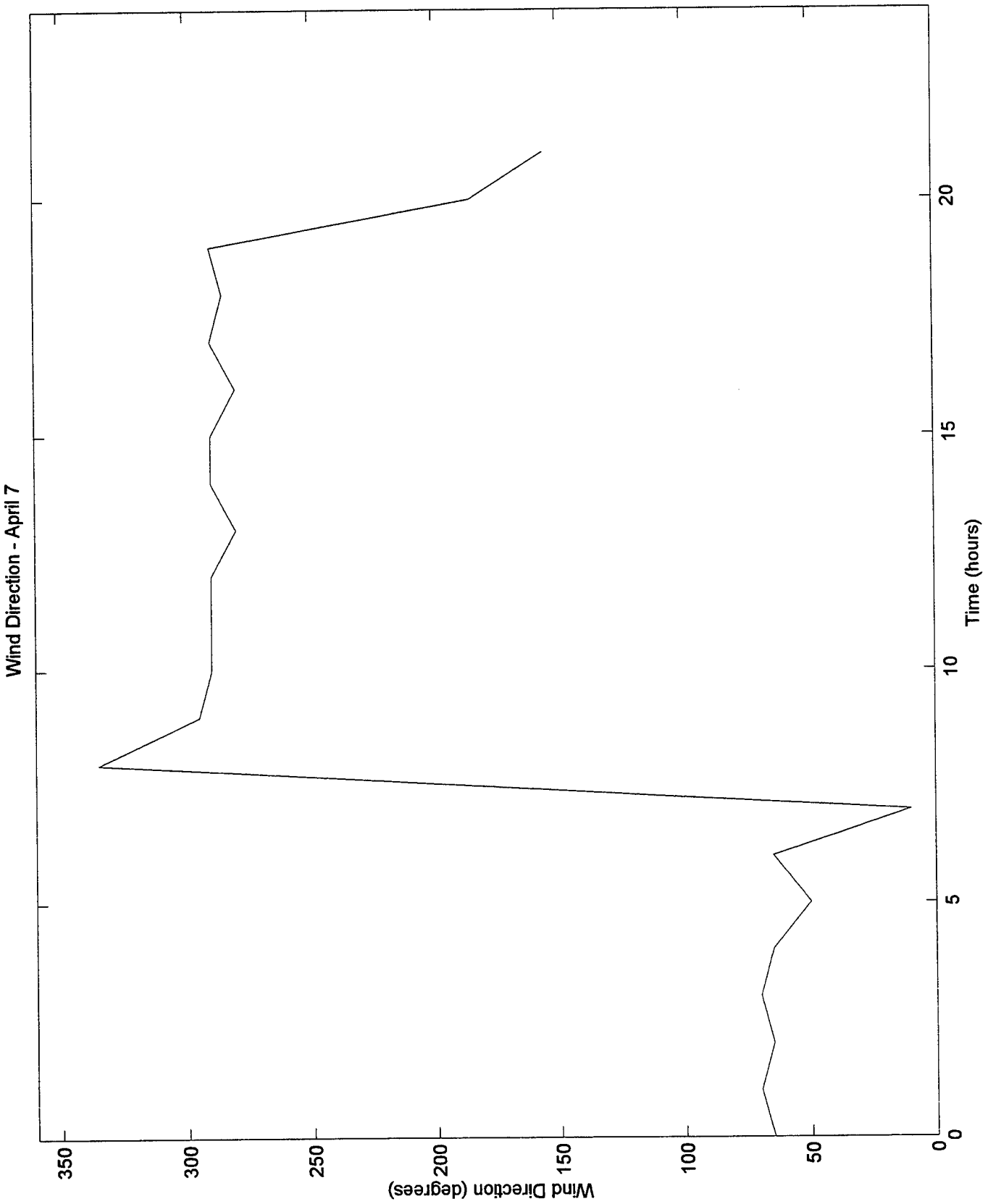
- Air Temperature
- Relative Humidity
- Wind Speed & Direction
- Bottom Water Temp
- Wave Height & Period
- Barometric Pressure
- Radiation (PAR)
- Tides

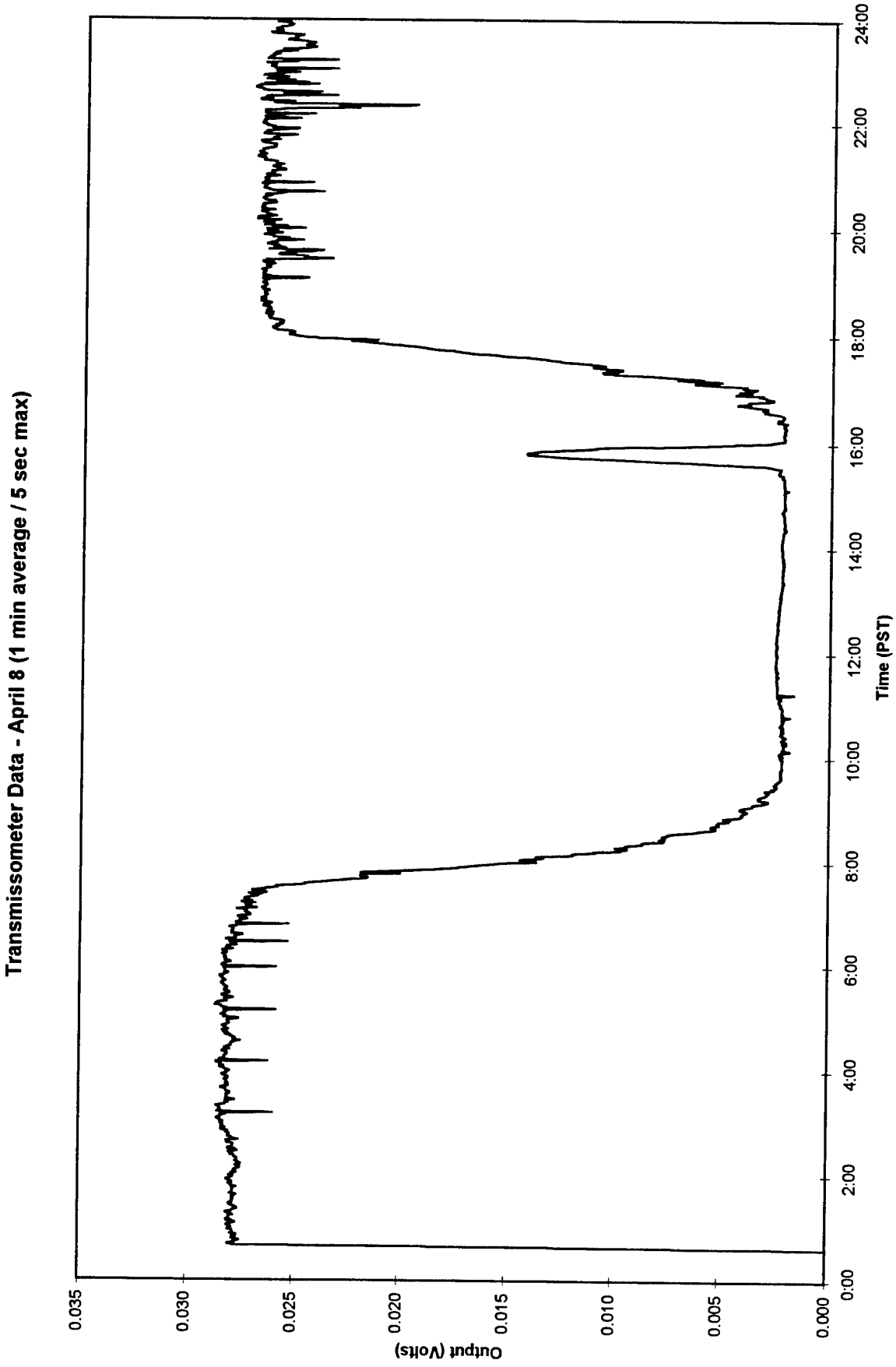
NRad

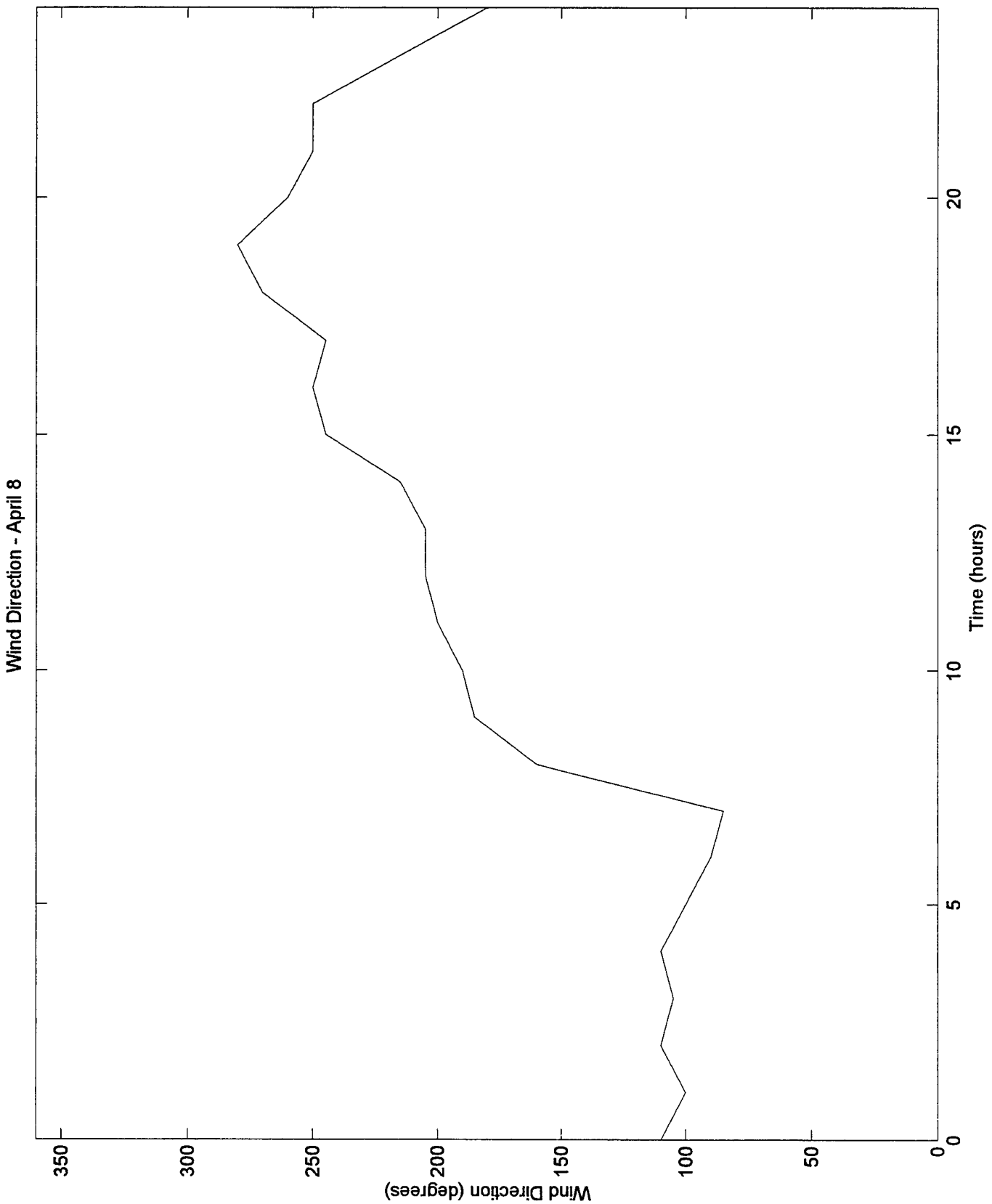
- Air Temperature
- Relative Humidity
- Wind Speed
- Sea Surface Temp
- Wave Height
- Condensation Nuclei

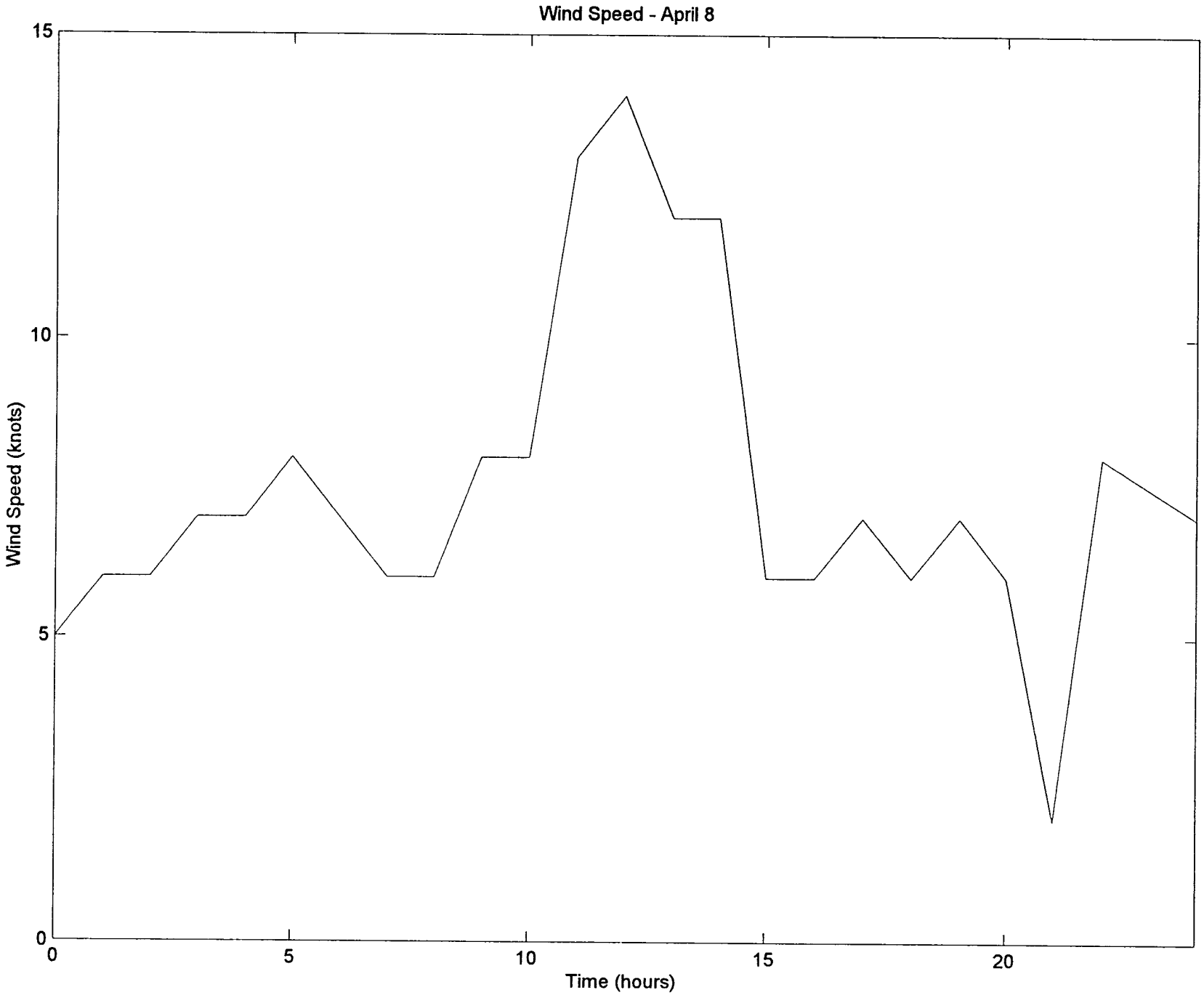

Transmissometer Data - April 7 (1 min average / 5 sec max)
Output (Volts)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
24:00
Time (PST)

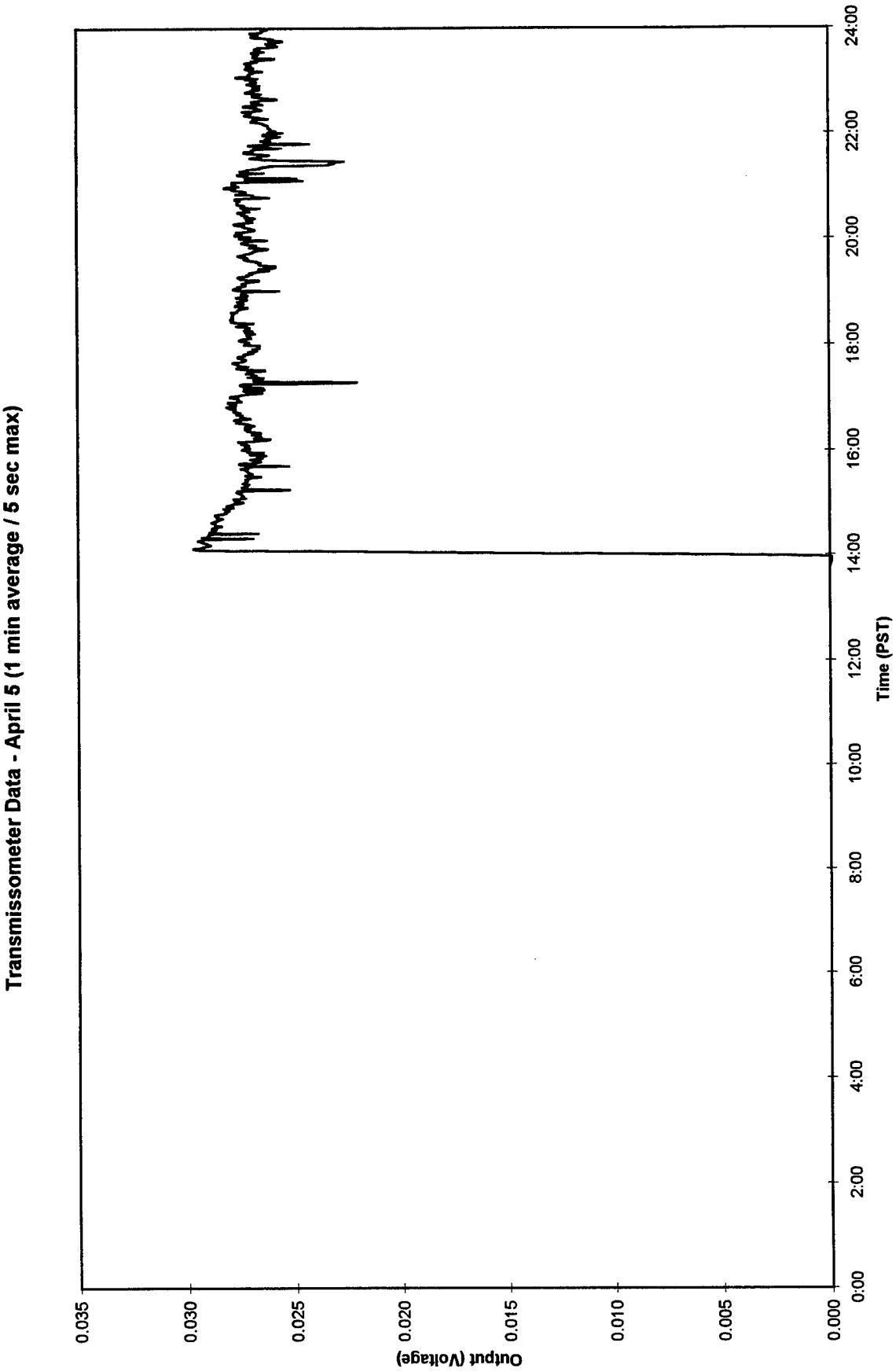

Wind Speed vs Time - April 7
Wind Speed (knots)
Time (hours)
0
5
10
15
20

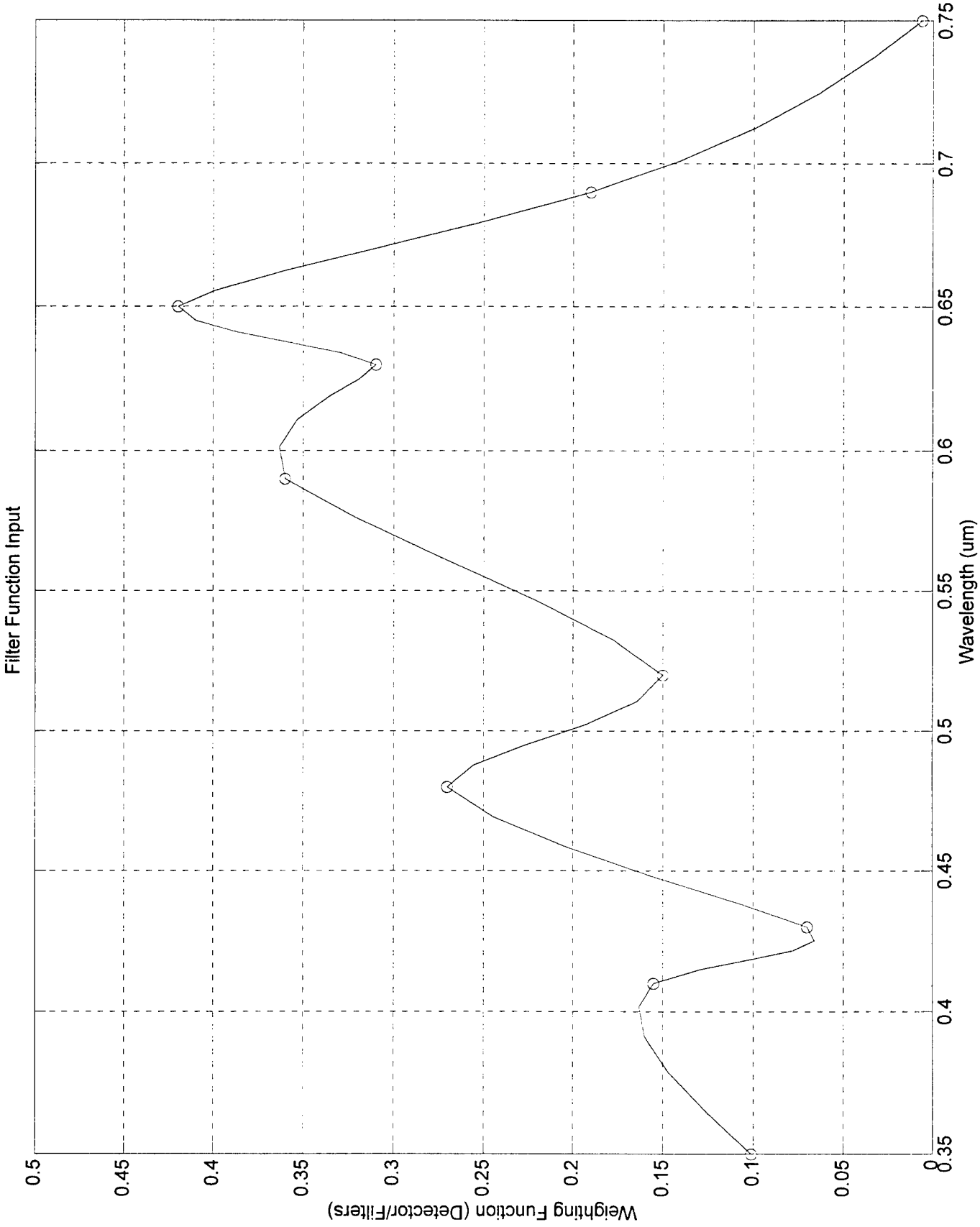

Wind Direction - April 7
Wind Direction (degrees)
Time (hours)
350
300
250
200
150
100
50
0
5
10
15
20

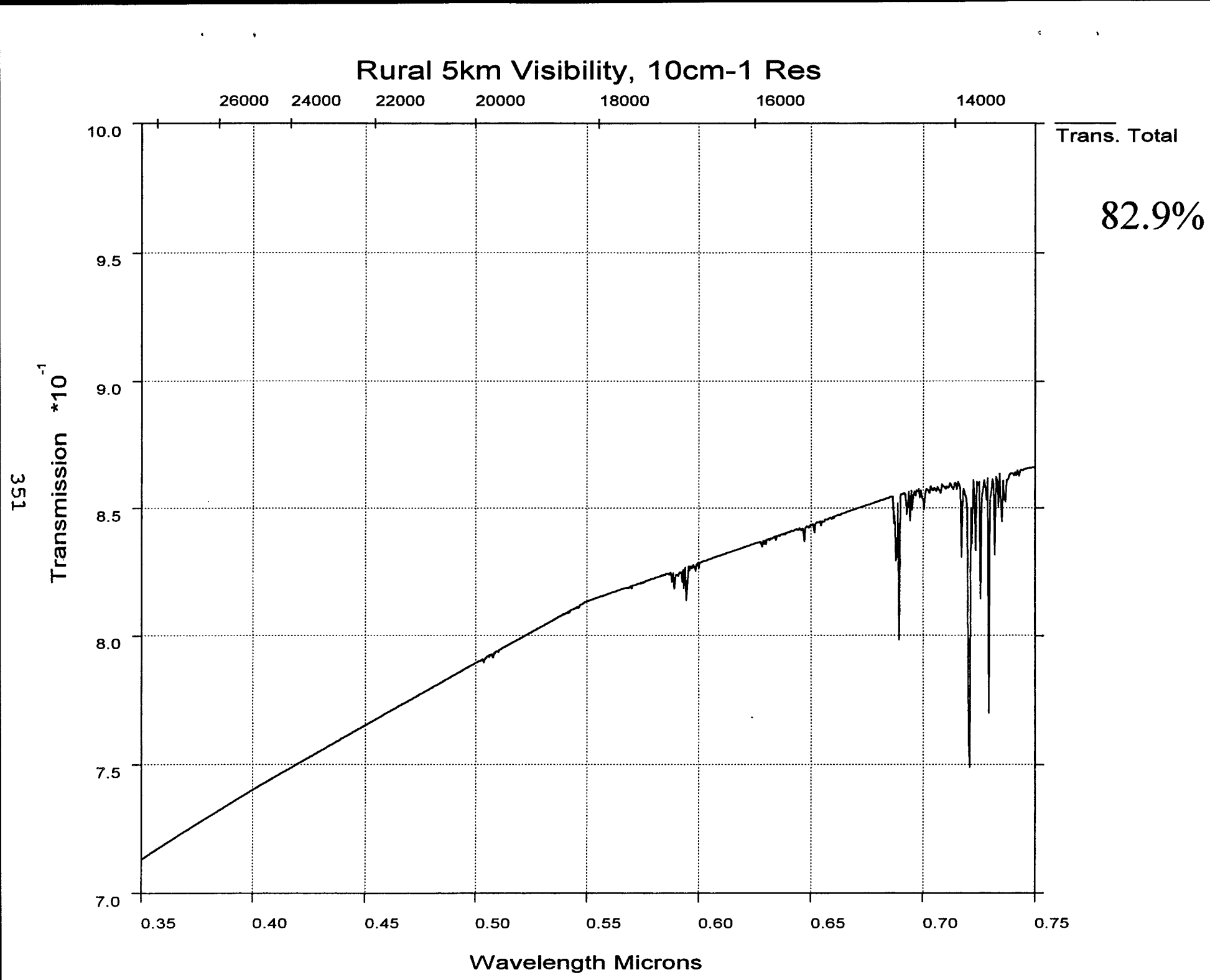

Transmissometer Data - April 8 (1 min average / 5 sec max)
Output (Volts)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
24:00
Time (PST)

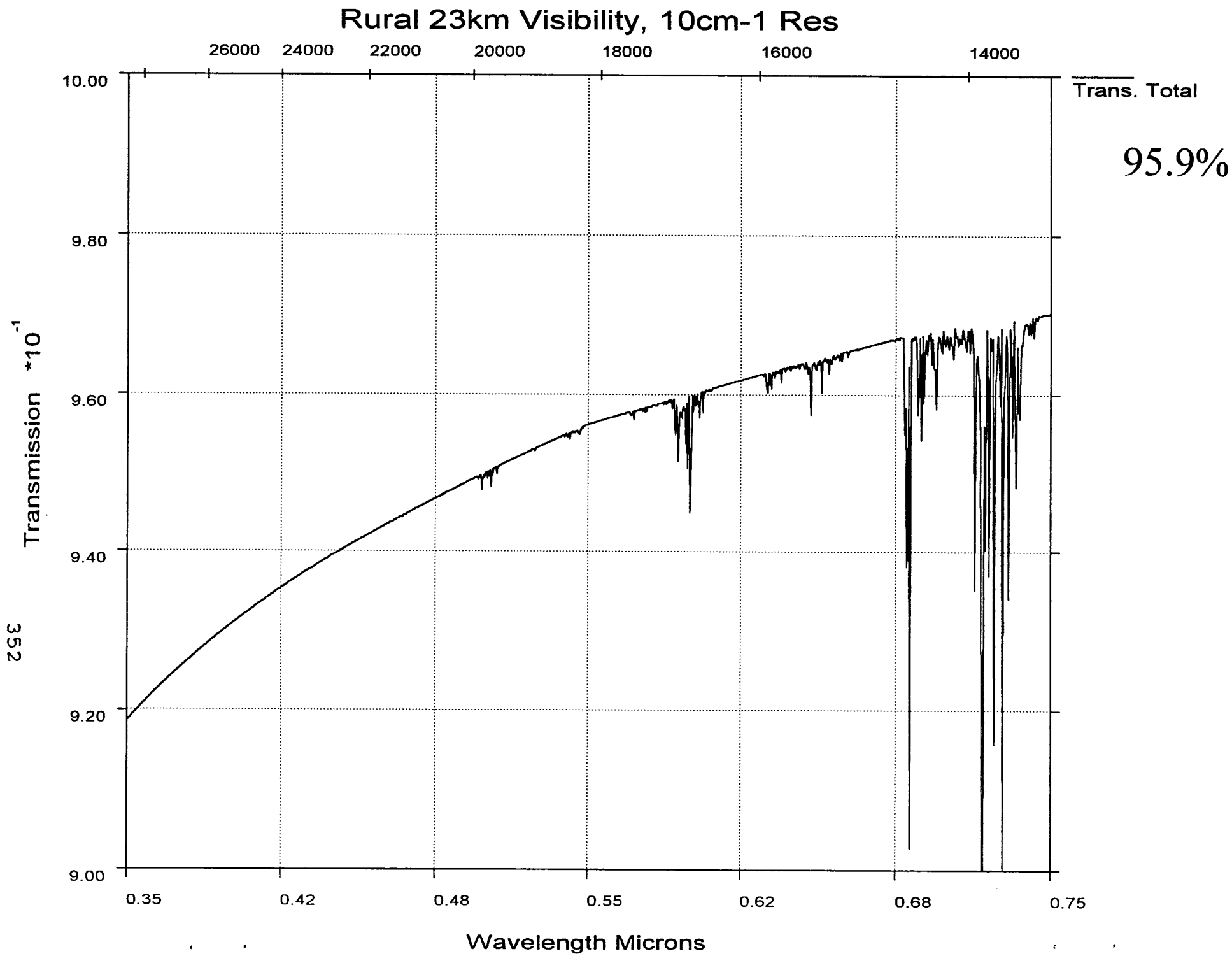

Wind Direction - April 8
Wind Direction (degrees)
Time (hours)
0
50
100
150
200
250
300
350
0
5
10
15
20

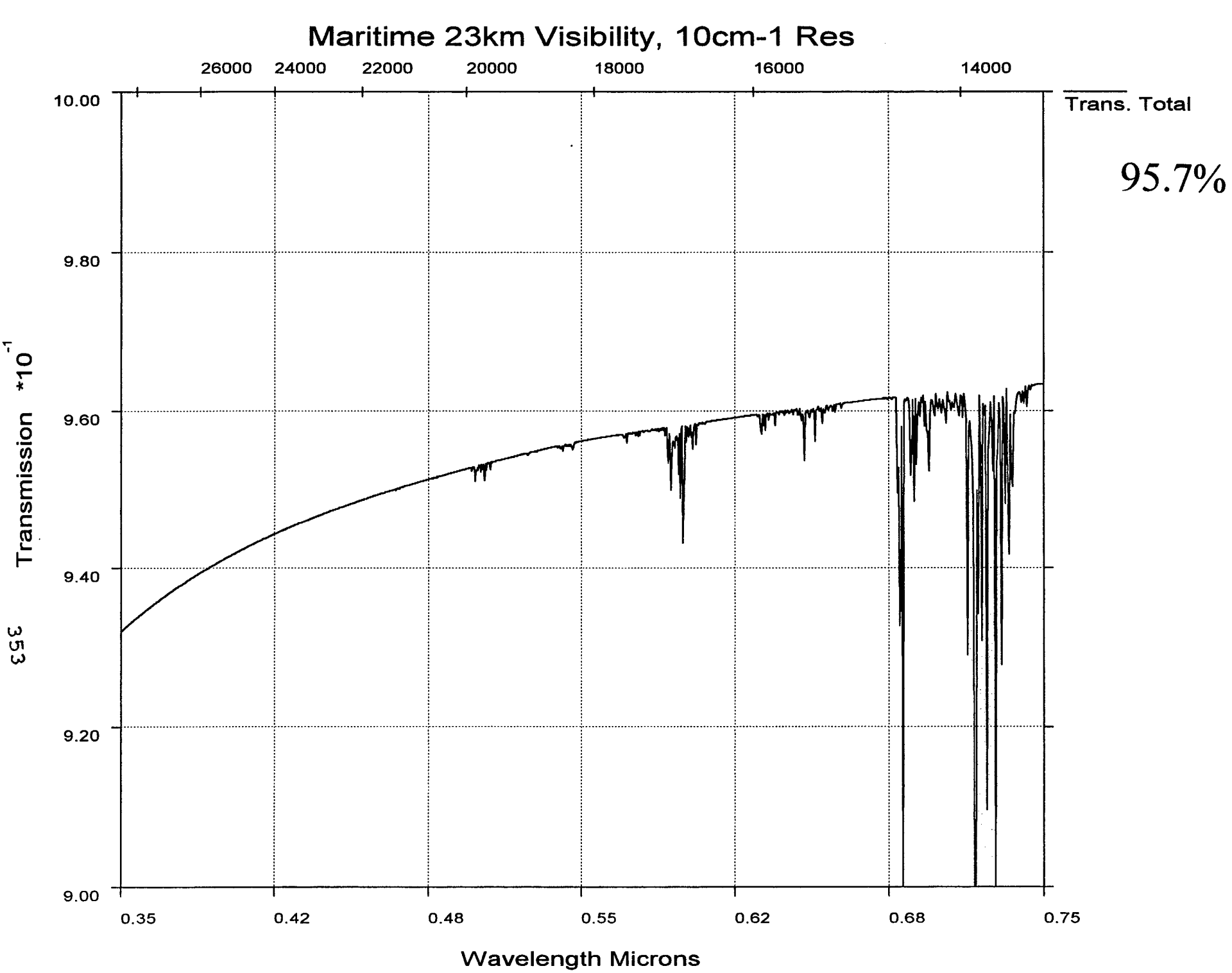

Wind Speed - April 8
Wind Speed (knots)
Time (hours)
0
5
10
15
20

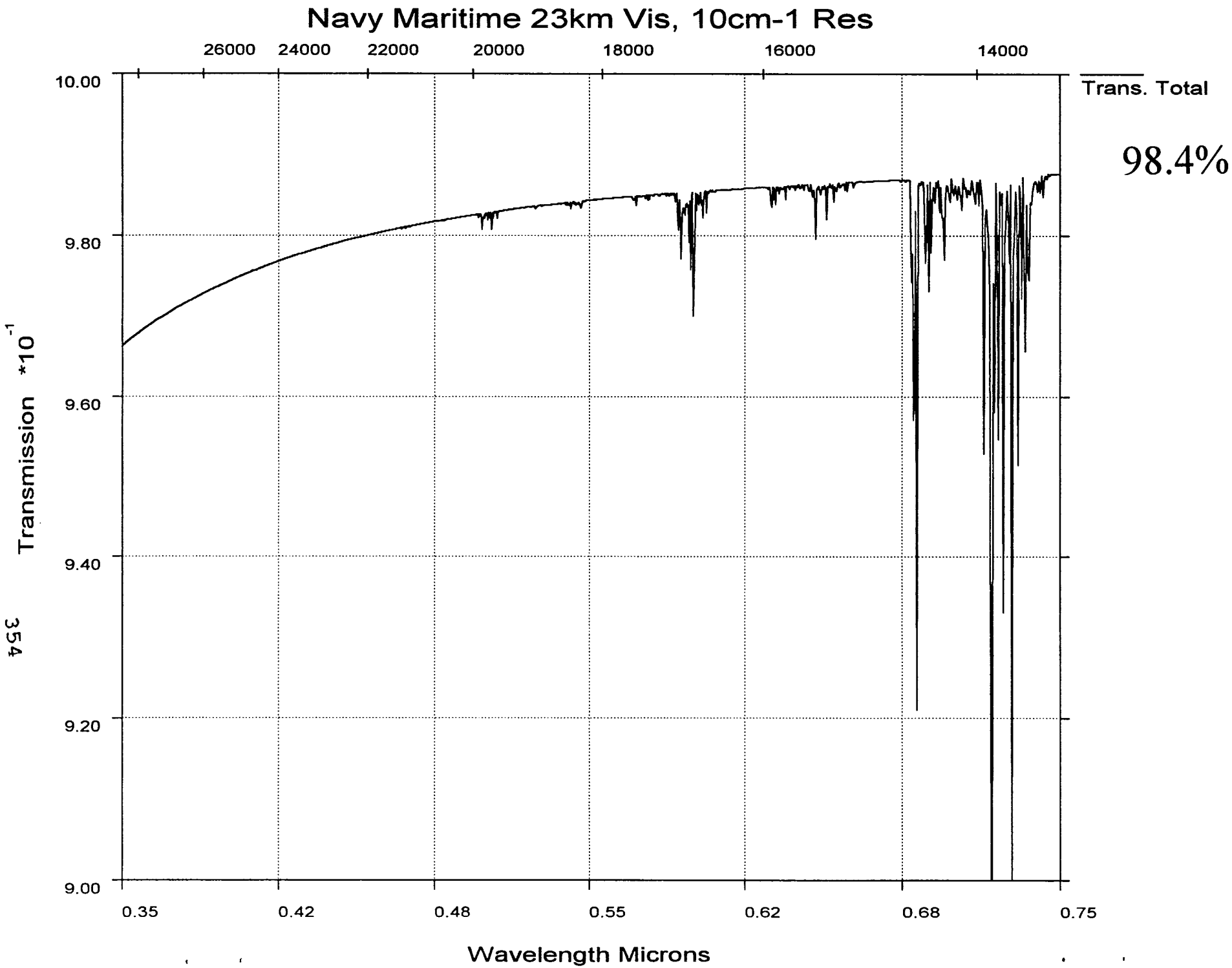

Transmissometer Data - April 5 (1 min average / 5 sec max)
Output (Voltage)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
24:00
Time (PST)


Filter Function Input
Weighting Function (Detector/Filters)
Wavelength (um)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75


Rural 5km Visibility, 10cm-1 Res
26000
24000
22000
20000
18000
16000
14000
10.0
9.5
9.0
8.5
8.0
7.5
7.0
Transmission *10-1
0.35
0.40
0.45
0.50
0.55
0.60
0.65
0.70
0.75
Wavelength Microns
Trans. Total
82.9%

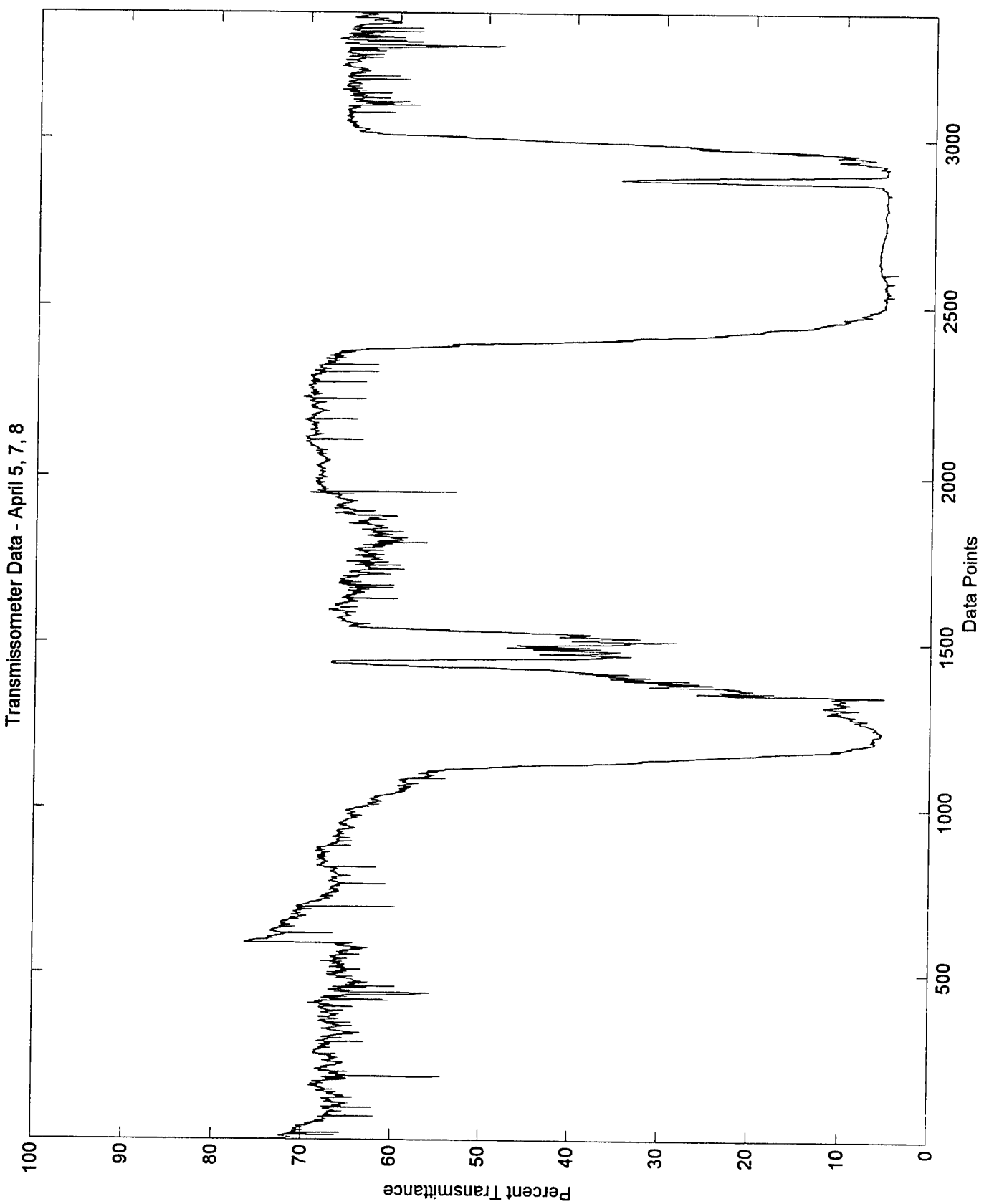

Rural 23km Visibility, 10cm-1 Res
26000
24000
22000
20000
18000
16000
14000
10.00
9.80
9.60
9.40
9.20
9.00
Transmission *10-1
0.35
0.42
0.48
0.55
0.62
0.68
0.75
Wavelength Microns
Trans. Total
95.9%


Maritime 23km Visibility, 10cm-1 Res
26000
24000
22000
20000
18000
16000
14000
10.00
9.80
9.60
9.40
9.20
9.00
Transmission *10-1
353
0.35
0.42
0.48
0.55
0.62
0.68
0.75
Wavelength Microns
Trans. Total
95.7%


Navy Maritime 23km Vis, 10cm-1 Res
26000
24000
22000
20000
18000
16000
14000
10.00
9.80
9.60
9.40
9.20
9.00
Transmission *10^-1
0.35
0.42
0.48
0.55
0.62
0.68
0.75
Wavelength Microns
Trans. Total
98.4%

Predicted Transmittances for Standard Models

Rural 5km Visibility	82.9%
Rural 23km Visibility	95.9%
Maritime 23km Visibility	95.7%
Navy Maritime 23km Visibility	98.4%


Transmissometer Data - April 5, 7, 8
Percent Transmittance
Data Points
100
90
80
70
60
50
40
30
20
10
0
500
1000
1500
2000
2500
3000

Conclusions

- Transmissometer data correlates with wind
- Standard aerosol models predict higher transmission - model surf plume effects

Future Work

- Verify calibration
- Hardware enhancements
- Comparison with NRad IR transmissometer
- Meteo data correlation
- Custom aerosol modeling

Contributors

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