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Puget Sound Clean Air Agency

Working together for clean air

Analysis of Sand Point Wind Profiler and RASS system

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Sand Point Profiler Site

Project Details and Goals

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- **Details**
  - **Vaisala 915 MHz radar wind profiler and RASS at Sand Point**
  - **Virtual temperature and wind data from 2001-2007 on disk**
  - **Data is consensus averaged every half hour**

- **Goals**
  - **Quality control**
  - **Wind and virtual temperature climatology's**
  - **Apply to air quality: Temperature inversion analysis**
  - **Use signal to noise ratio (SNR) to determine boundary layer heights and document precipitation**

Project Results

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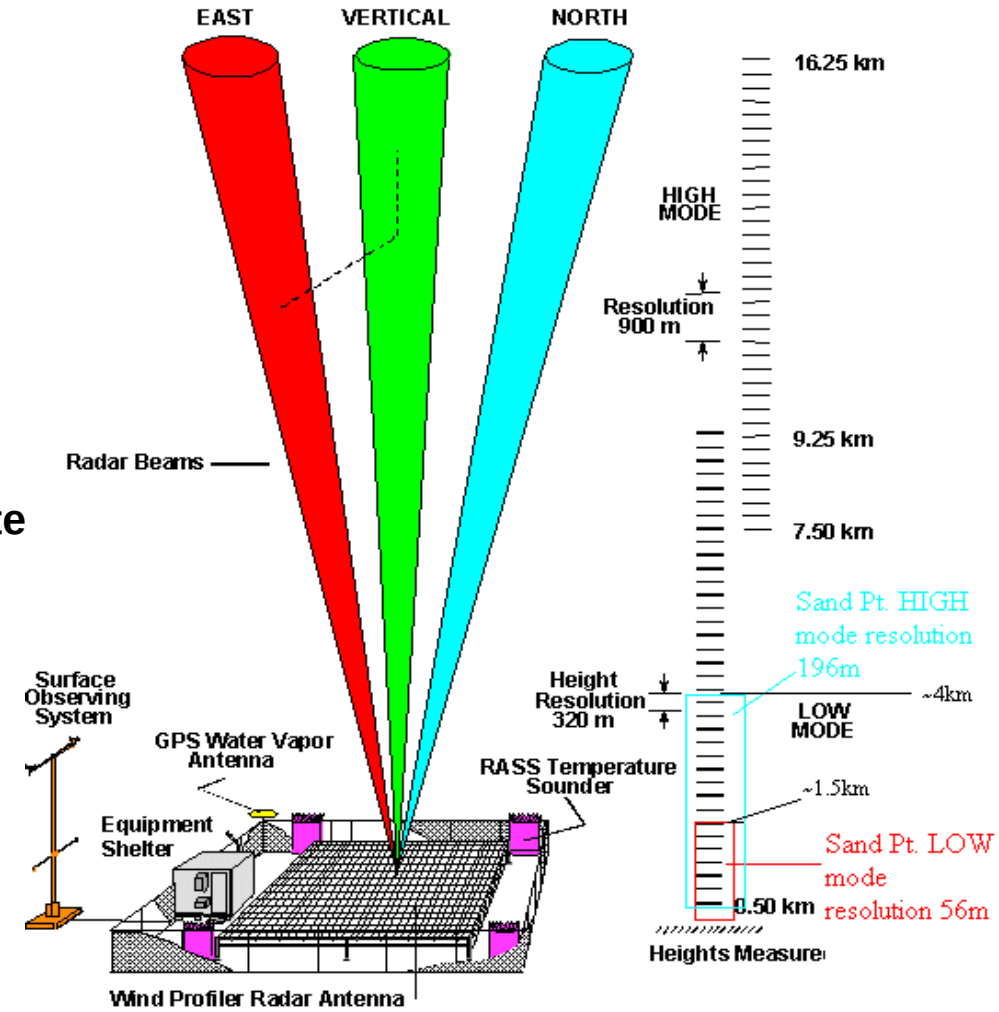
- **Quality control: wind unfolding**
- **Five year mean profiles of temperature and wind**
- **Climatology's to be inserted into the trend graphing and wind rose tools at pscleanair.org**
- **Analysis of burn ban events, identification of burn ban conditions and inversions**
- **SNR visualization**

NPN Profilers vs. profiler at Sand Point

- **The profiler at Sand Point is a boundary layer profiler**
  - **Higher resolution & lower upper bound have implications for implementing the unfolding algorithm used by the NPN.**
  - **25 gates in the low mode**
  - **12 or (less often) 22 gates in the high mode depending on the date the data is from.**



http://www.profiler.noaa.gov/npn/aboutProfilerData.jsp

Wind Folding/Aliasing

- **Wind folding occurs when the radial velocity exceeds the Nyquist velocity (AKA full scale Doppler velocity AKA unambiguous velocity) and often makes the wind appear to suddenly and drastically change direction.**
  - **Inconsistent data from important high wind periods**
- **Miller et al. (1994) describe an algorithm to unfold profiler winds by using a median check on the radial velocities**
  - **If the measured velocity (Vm) plus or minus two times the Nyquist velocity is closer to the median than the measured velocity, it is folded**
  - **The median (Vmed) is taken from the seven gates immediately above (high mode) or immediately below (low mode).**
  - **If it is folded, the measured velocity is replaced by the true velocity (Vt)**

$$\hat{n} = \frac{\left(V_{med} - V_m\right)}{2V_{nyq}}$$

$$n = \begin{cases} 1, \hat{n} > .5 \\ -1, \hat{n} \le -.5 \\ 0, otherwise \end{cases}$$

$$V_t = V_m + 2nV_{nyq}$$

Applying Unfolding to the Profiler at Sand Point

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- **Slight changes have to be made to have an appropriate algorithm**
  - **Since the high mode has fewer gates than NPN profilers, take the median of 5 gates instead of 7**
  - **Because the high mode ends lower in the atmosphere, take the median of the gates immediately below the measured value that are less likely to be folded, instead of immediately above.**
- **Once unfolded, the data can be put into a useful format**
  - **Wind rose and trend graphing tools on pscleanair.org will make this data easily visualized and available to the Clean Air Agency and the public.**
  - **Virtual temperature data from the RASS is also be available.**

Before and After Unfolding

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Seattle 915/RASS
WINDS rev 4.1
47.70 -122.20 11
06 02 04 01 37 02 480
23 3 12
05:07 (2.0) 05:07 (2.0) 05:07 (1.5)
132 132 84 84 2800 2800 41 41
15.1 15.1 1 3300 3300 12 12 2800 2800
216 90.0 216 69.1 306 69.1

HT	SPD	DIR	Radials...								
0.322	20.7	177	-0.0	5.7	-4.7	7	7	7	10	5	6
0.715	23.6	184	-0.0	7.1	-4.5	7	5	5	6	2	5
1.107	9999	999	-0.2	9.4	-3.8	7	4	7	4	0	3
1.499	30.3	202	-0.2	10.3	-2.9	6	7	7	4	-2	1
1.892	33.3	211	0.1	11.9	-0.9	6	6	6	13	-1	2
2.284	34.4	212	1.2	13.3	0.2	6	6	6	22	9	14
2.676	44.8	44	1.4	-14.5	-1.0	5	6	5	22	16	21
3.069	41.4	50	1.0	-13.4	-2.7	6	7	6	20	15	21
3.461	9999	999	0.8	15.0	-4.3	7	3	7	18	14	18
3.854	39.0	191	0.7	13.3	-5.3	7	7	7	15	13	16
4.246	35.1	185	0.8	11.5	-5.7	7	6	7	13	11	13
4.638	33.4	183	0.8	10.8	-5.7	7	5	7	10	9	11

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Products

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- **Wind Roses**
  - **Low and high mode**
  - **Interactive**
- **Profiler and RASS database**
  - **Excel**
- **Mean virtual temperature profiles**
- **Inversion Profiles**

Wind Rose – An Interactive Tool

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Home > About Air Quality > Air Quality Data & Reports > **Wind Rose Aloft**

Wind Rose Aloft

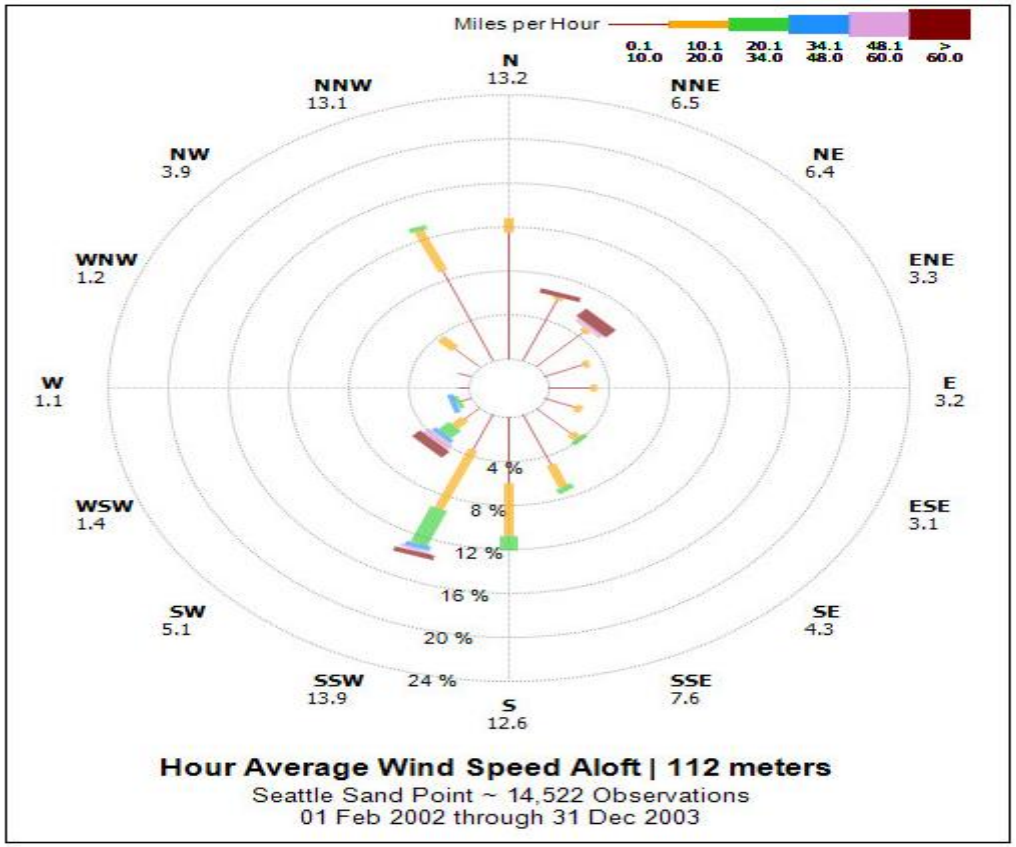
Start Date 2/1/2002

End Date 12/31/2003

Mode
- (•) Low
- ( ) High

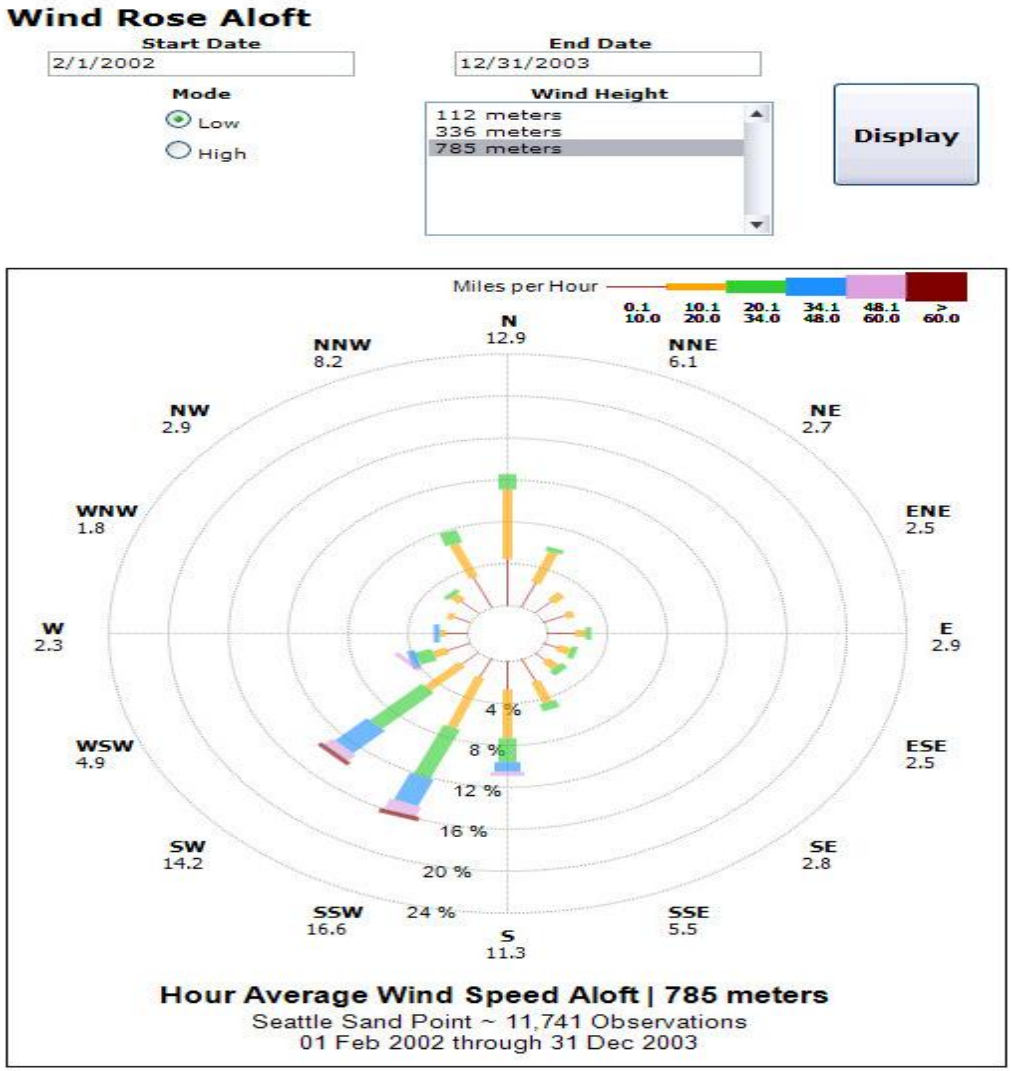
Wind Height
- 112 meters
- 336 meters
- 785 meters

Display

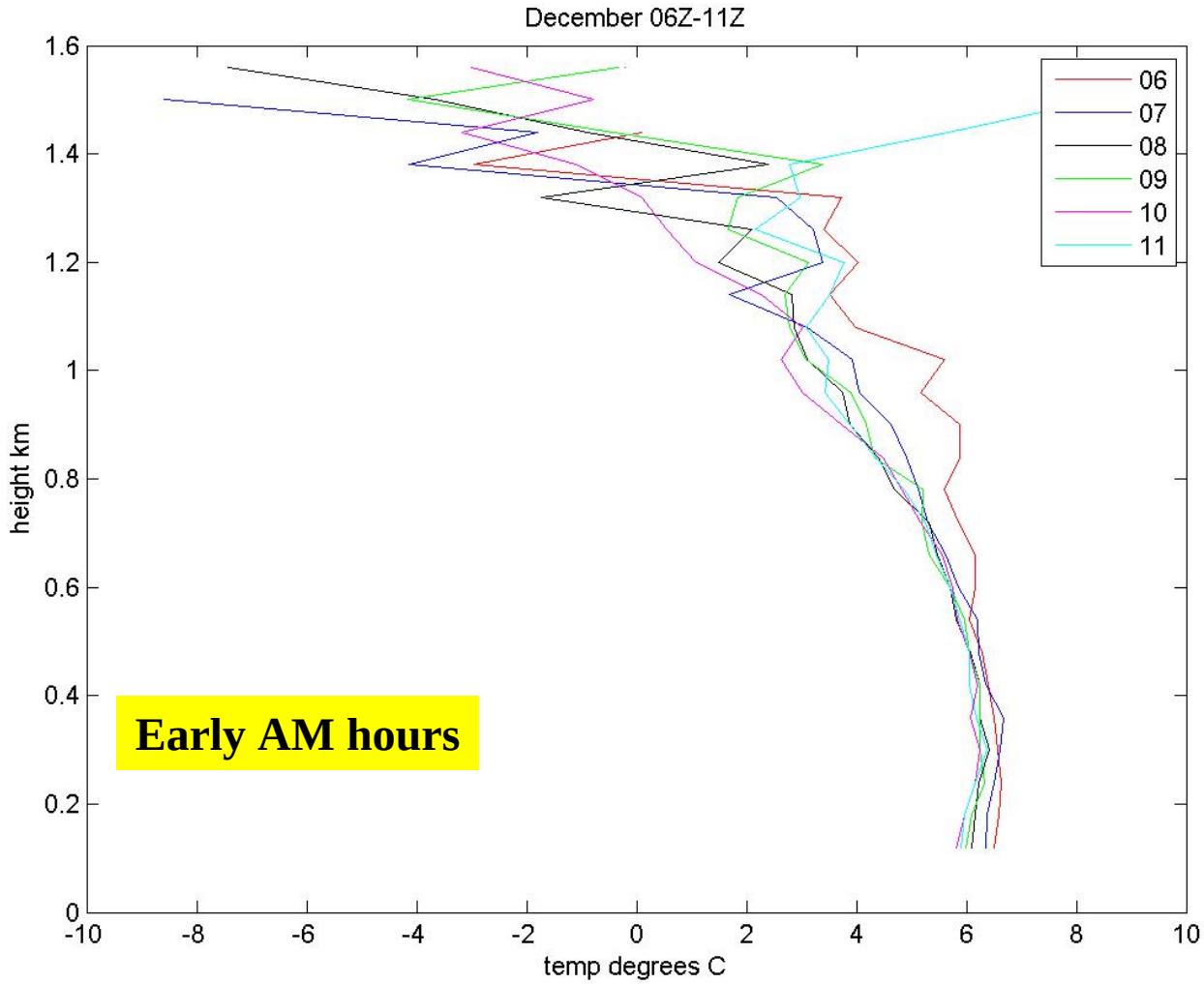


Hour Average Wind Speed Aloft | 112 meters
Seattle Sand Point ~ 14,522 Observations
01 Feb 2002 through 31 Dec 2003

Wind Rose – 785 m



Five Year Mean Temperature Profiles



Five Year Mean Wind Profile-Knots

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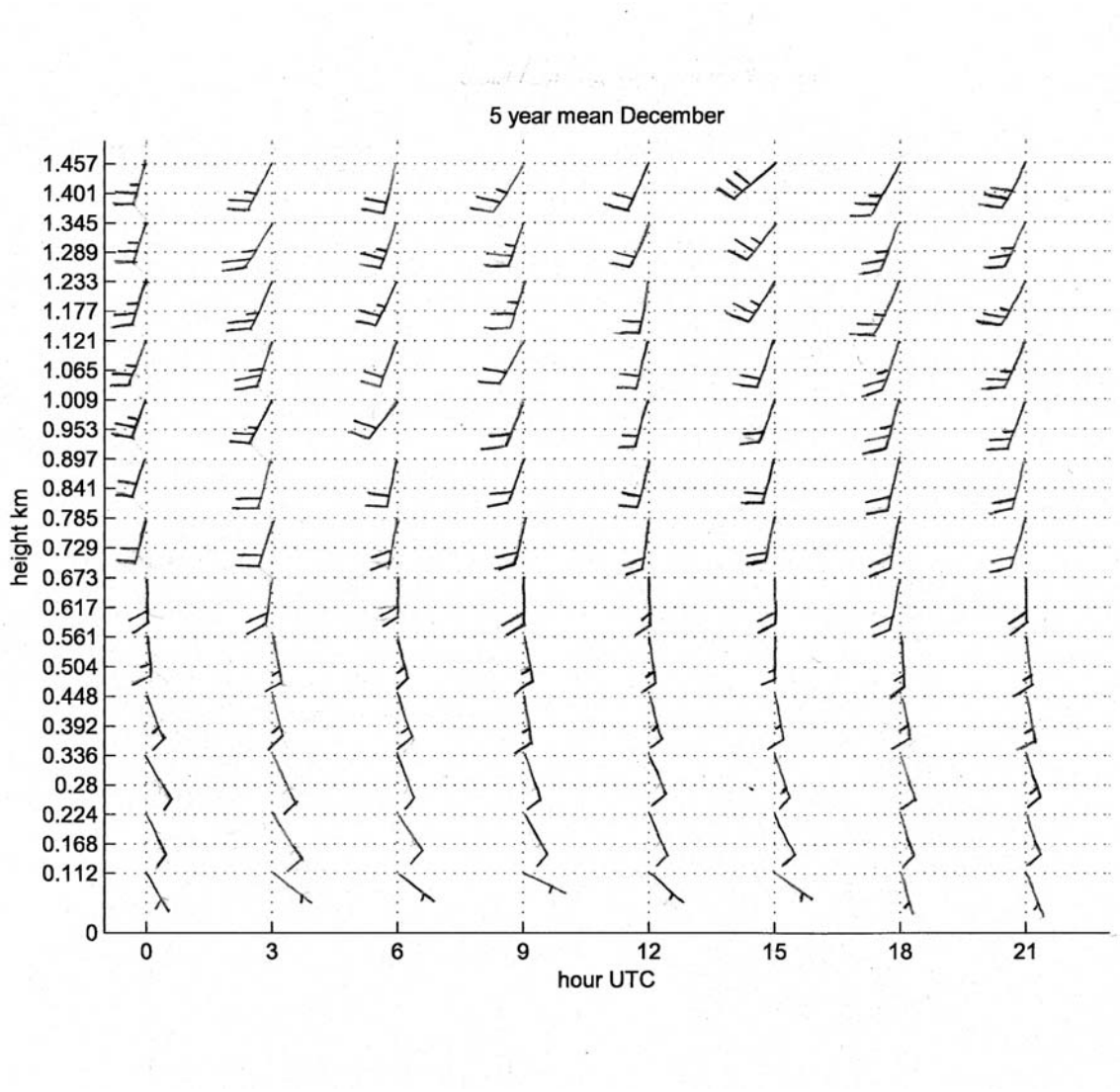

Finding Temperature Inversions

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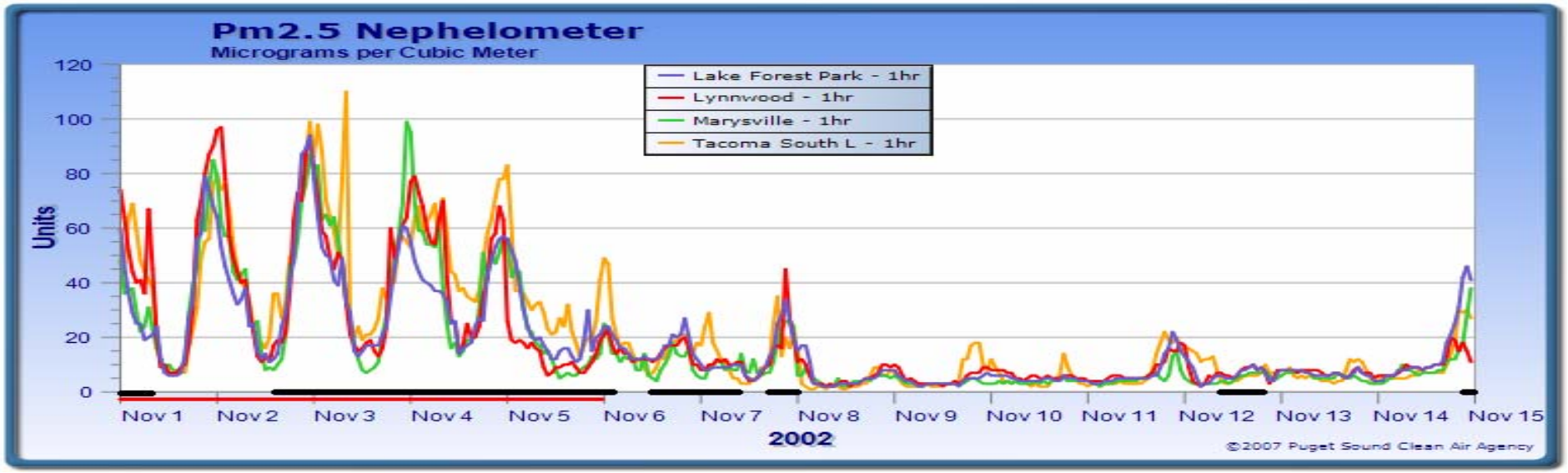
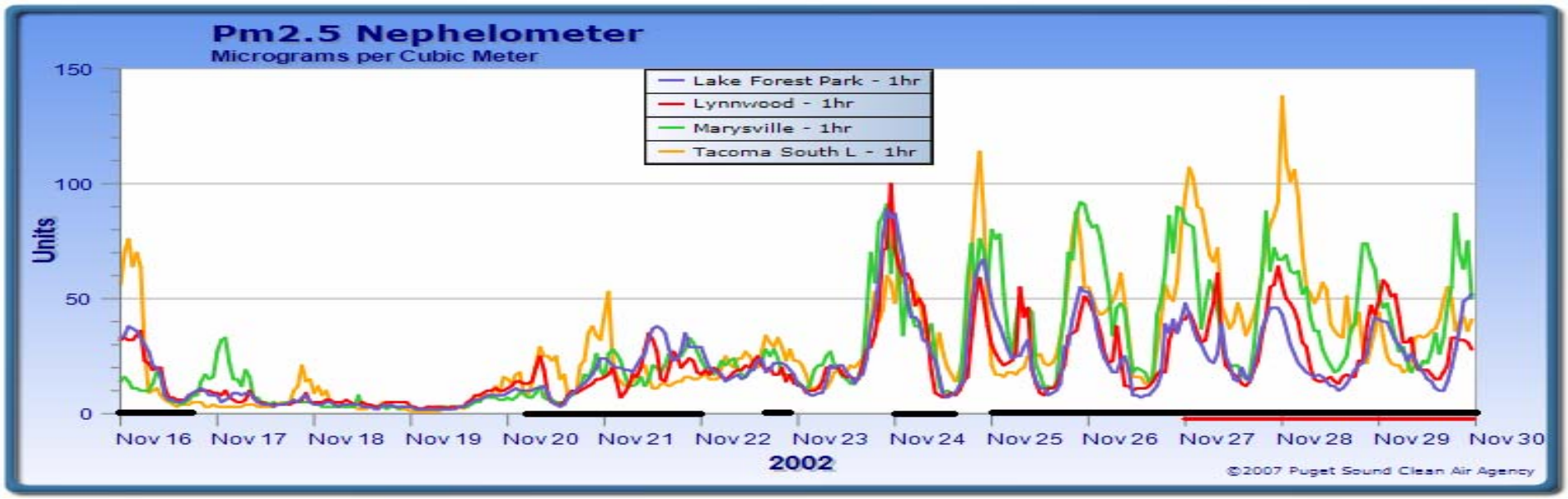
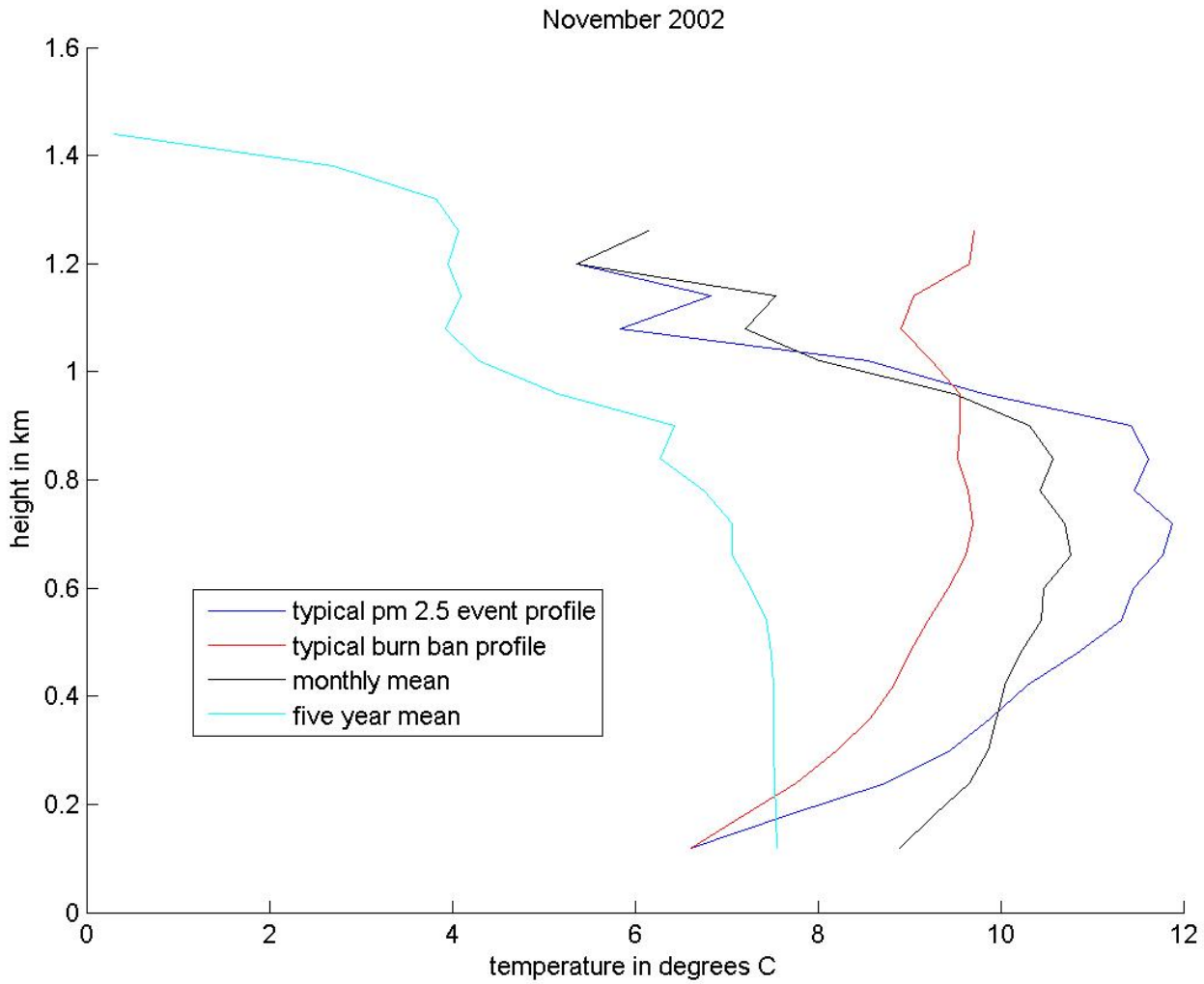
- **Instead of looking for plain inversions, look for conditions that look like burn bans**
  - **Take known burn ban periods and find the typical profile and lapse rates for every hour.**
  - **Compare profiles to these typical burn ban profiles and pick the ones that are similar, or even more inverted.**
  - **When checked with pm 2.5 measurements, a good indicator of inversions, this method picks periods of high pm 2.5 *whether there was a burn ban or not.***
  - **Most useful for finding periods that threatened air quality.**

November 2002

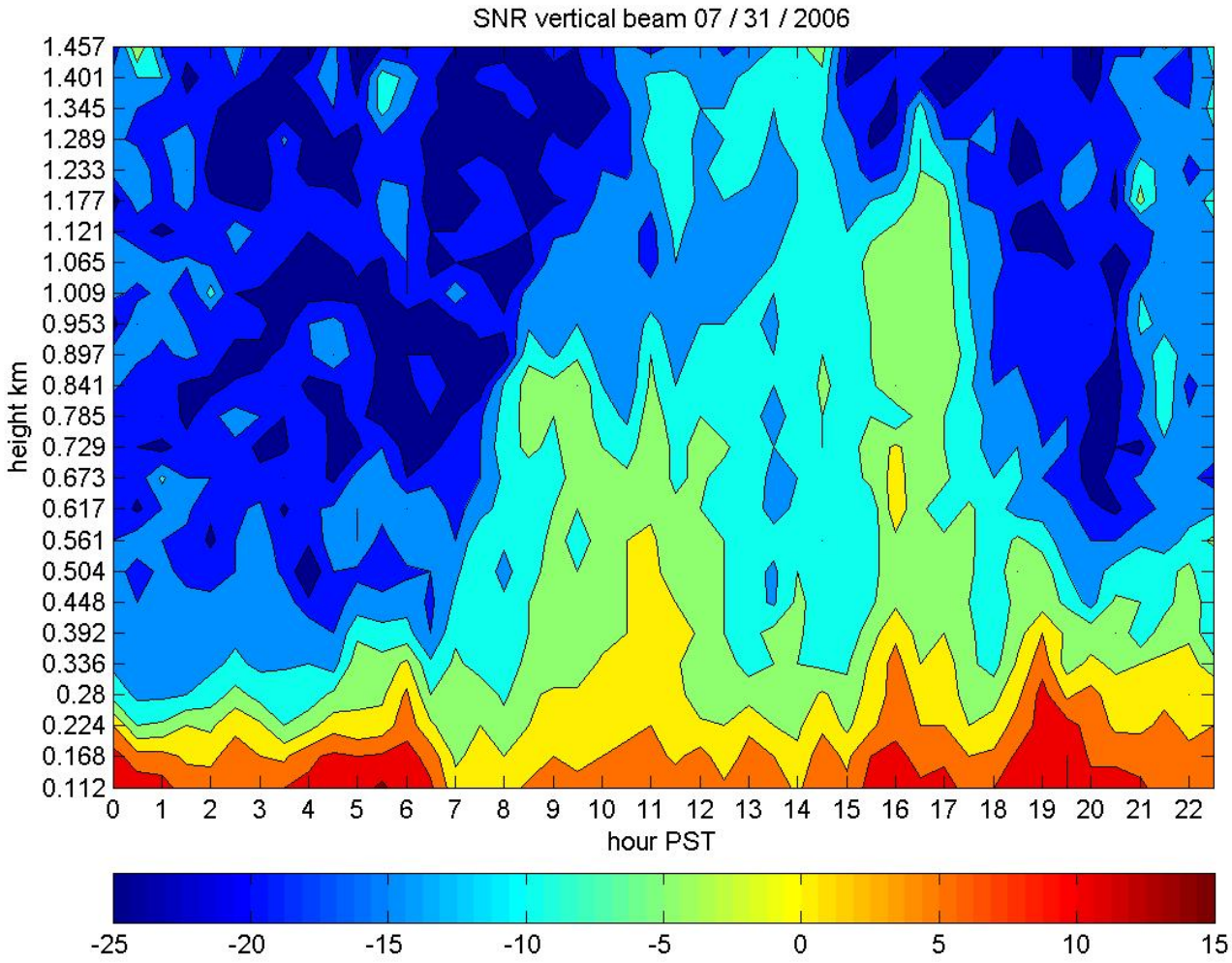




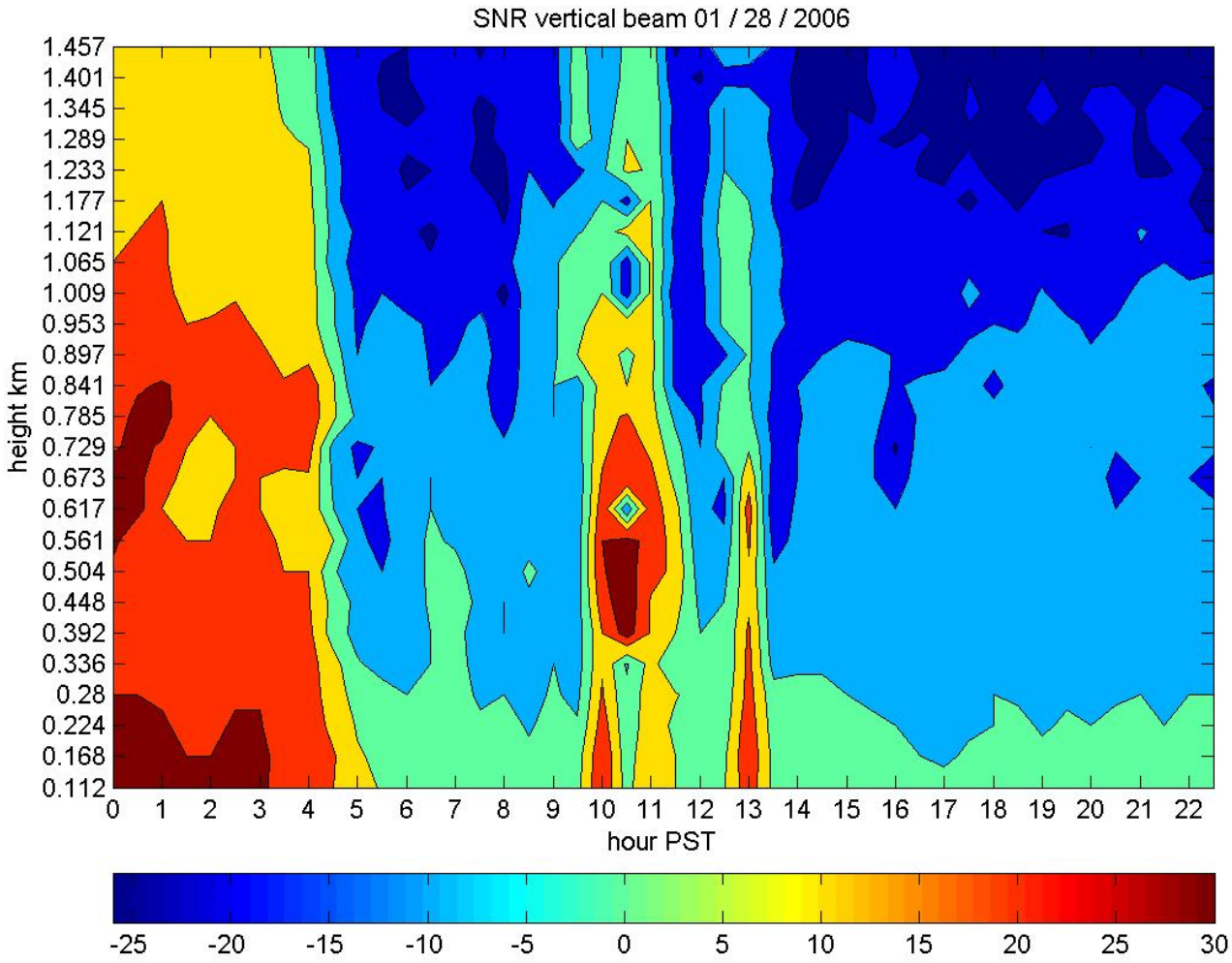
A Different View



Signal to Noise Ratio – warm and clear



Signal to Noise Ratio – cloudy and rainy



What's Left To Do

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- **Storing and maintaining a database of unfolded winds**
- **Continued quality control for issues besides wind folding**
- **Making the data available, especially on the UW's time series/animation tools, as well as the Clean Air Agency's website.**
- **Checking and comparing the inversion analysis to the MM5 output.**
- **SNR analysis to identify the boundary layer and periods of precipitation.**
- **Continued restoration of old profiler data.**

Acknowledgements

- **Thanks to: Mike Gilroy, the Technical Services Dept. and everyone at the Puget Sound Clean Air Agency**
- **Prof. Cliff Mass, Neal Johnson and Mark Albright at the University of Washington Dept. of Atmospheric Science**
- **Resources:**
  - ***An Unfolding Algorithm for Profiler Winds*, Miller et al. (1994), Journal of Atmospheric and Ocean Tech.**
  - ***Radar Wind Profiler Radial Velocity: A Comparison with Doppler Lidar*, Cohn & Goodrich (2002).**