



## Winter Woodsmoke Forecasting in the Puget Sound



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2020 AirQuest Annual Meeting

June 10, 2020



*Clean, healthy air  
for everyone, everywhere,  
all the time.*

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# Forecasting Objectives and Paradigm

## 1. Comply with Federal and State law

- Prevent violations of the NAAQS
  - ▲ Tacoma in Nonattainment
  - ▲ Darrington, Marysville fairly close (at risk)
- Enforce state law regarding restrictions on burning
  - ▲ Stage 1 and Stage 2 trigger levels and timeframe

## 2. Protect public health

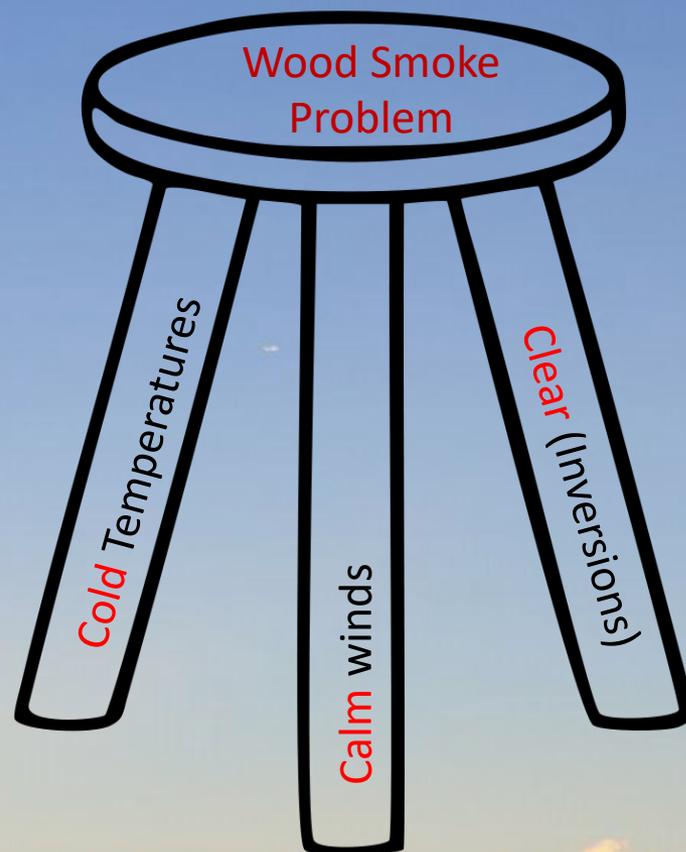
- Prevent levels from exceeding Agency and Ecology goals
- Inform public
  - ▲ Voluntarily & required emissions restrictions
  - ▲ Reduce exposure

# Winter Fine PM

- Residential wood burning major source, some contribution from vehicles, sporadic outdoor burning
- Radiatively driven surface inversion is main factor, need: **Cold, Calm, Clear:**
- **Cold:**
  - causes heating need and more burning
  - also typically occurs with clear skies
  - at surface causes inversion and poor mixing
- **Calm:**
  - light winds, so poor mixing,
  - enable surface cooling
- **Clear:**
  - allows for radiative cooling at surface
  - allows inversion profile to set up

# RESIDENTIAL WOOD SMOKE FACTORS

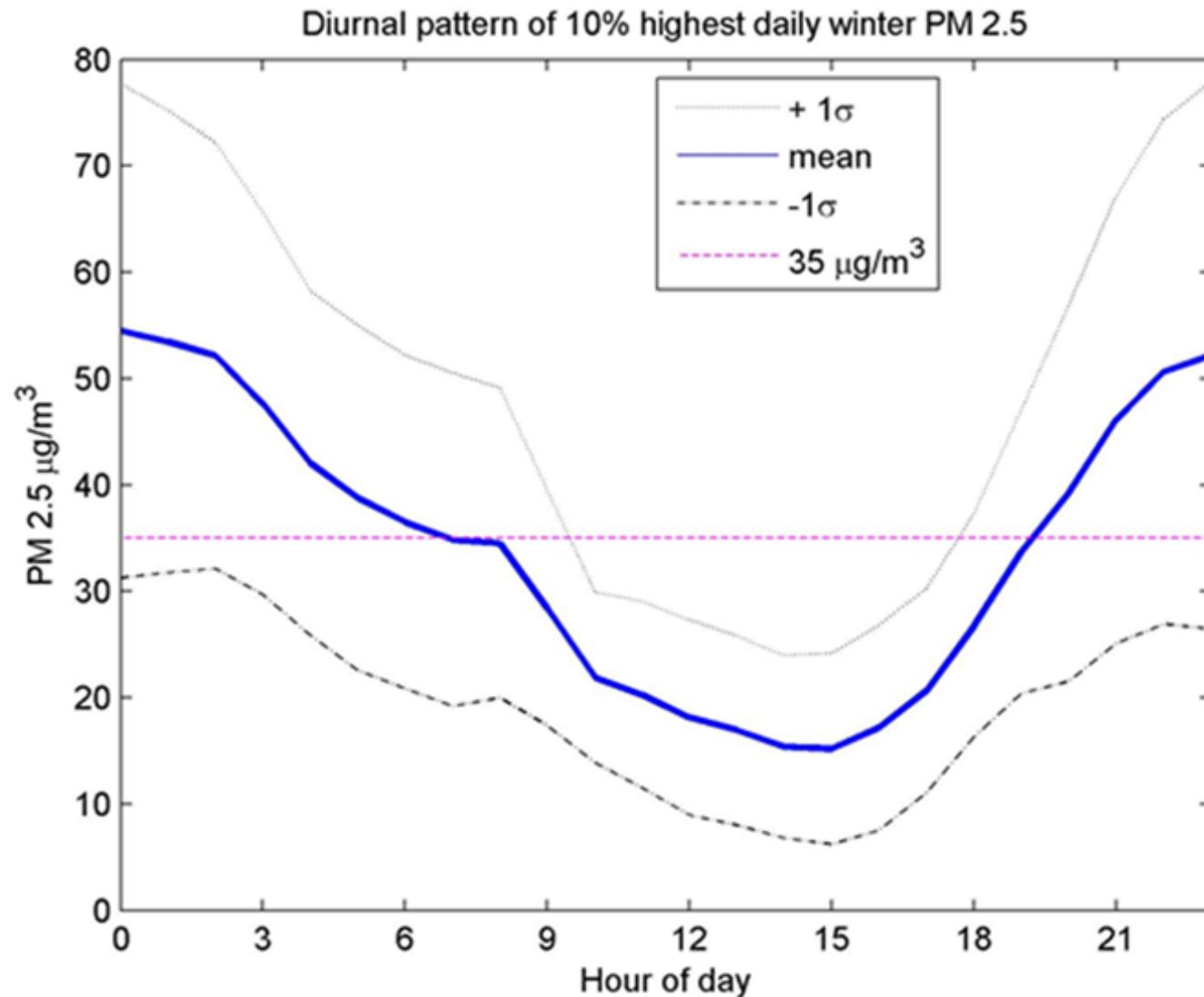
- Meteorology (**Cold, Calm, Clear**):
  - Temperatures  $< 40^{\circ}\text{F}$
  - Wind speeds  $< 2$  mph
  - Temperature inversions  $> 0.5^{\circ}$
- Emissions
  - Human behavior
  - Weekends and holidays higher
  - UW Huskies and Seahawks games
  - Available wood vs natural gas
  - Stove population density



# Synoptics for Winter Fine PM Exceedances

- Typically occurs under ridge closer to center line, to the east side, NOT at the top
  - farther east tends windier
  - farther west more moisture
- May also have subsidence inversion well above the ground, usually has little impact
- During day is heating of surface, so no inversion, PM concentration drops
- After sunset, outgoing radiation dominates, inversion sets up

# Tacoma South L Diurnal Pattern



# Winter Fine PM Forecasting (1)

- Look at GFS for 2-7 days ahead (500 mb)
- Look at WRF 36km 500mb heights for synoptic overview
- Check NWS for ridging and discussion of stagnation
- Check UW WRF 4km surface for stagnant patterns, usually need region wide prediction of  $< 3$  mph with clear skies
- Check ventilation indices, AIRPACT, SAQM

# Winter Fine PM Forecasting (2)

- Look at current PM levels, above/below expectation?
- Low clouds almost always prevent surface inversion, high thin clouds can, but definitely not safe to assume
- Rain does scrub some PM, but rate is varied, usually are enough winds that there is mixing within a few hours (mostly just inhibits inversion formation)
- Arriving cold fronts always clean the air out within a few hours, but sometimes the forecast arrival time is off by 3-6 hours

Back

Model Guidance

Home

Un-Zoom Page Help Product Description

Start

Rock

< Prev

Next >

[< First

Last >]

Slower

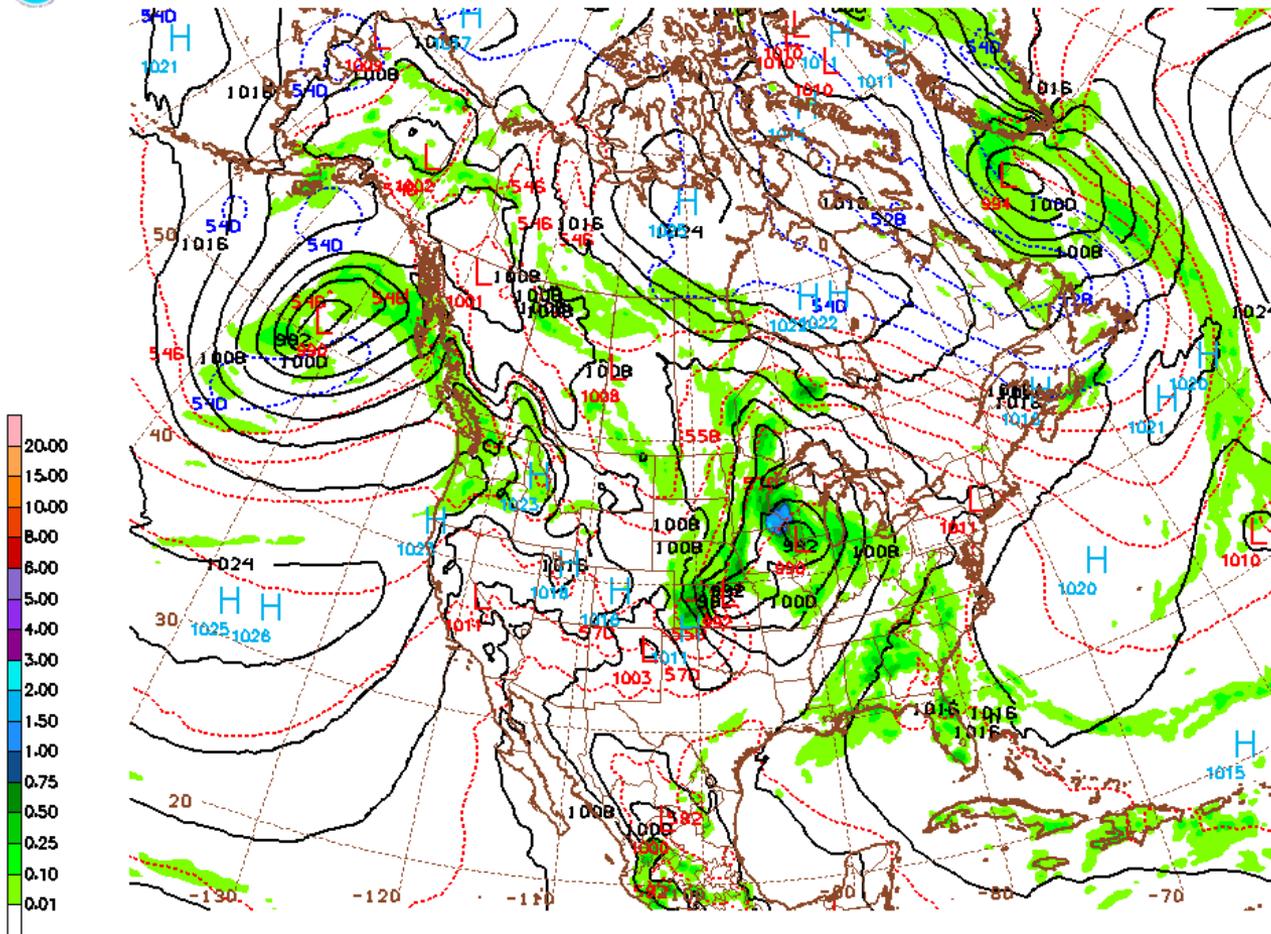
Faster

View Image

13 of 73



06/09/20 12UTC 12HR FCST VALID WED 06/10/20 00UTC NOAA/NWS/NCEP



WED 200610/0000V012 GFS EMSL(4MB), 03HR PCPN (IN), 1000-500MB THICKNESS

UW WRF-GFS 36km Domain

Init: 12 UTC Tue 24 Dec 13

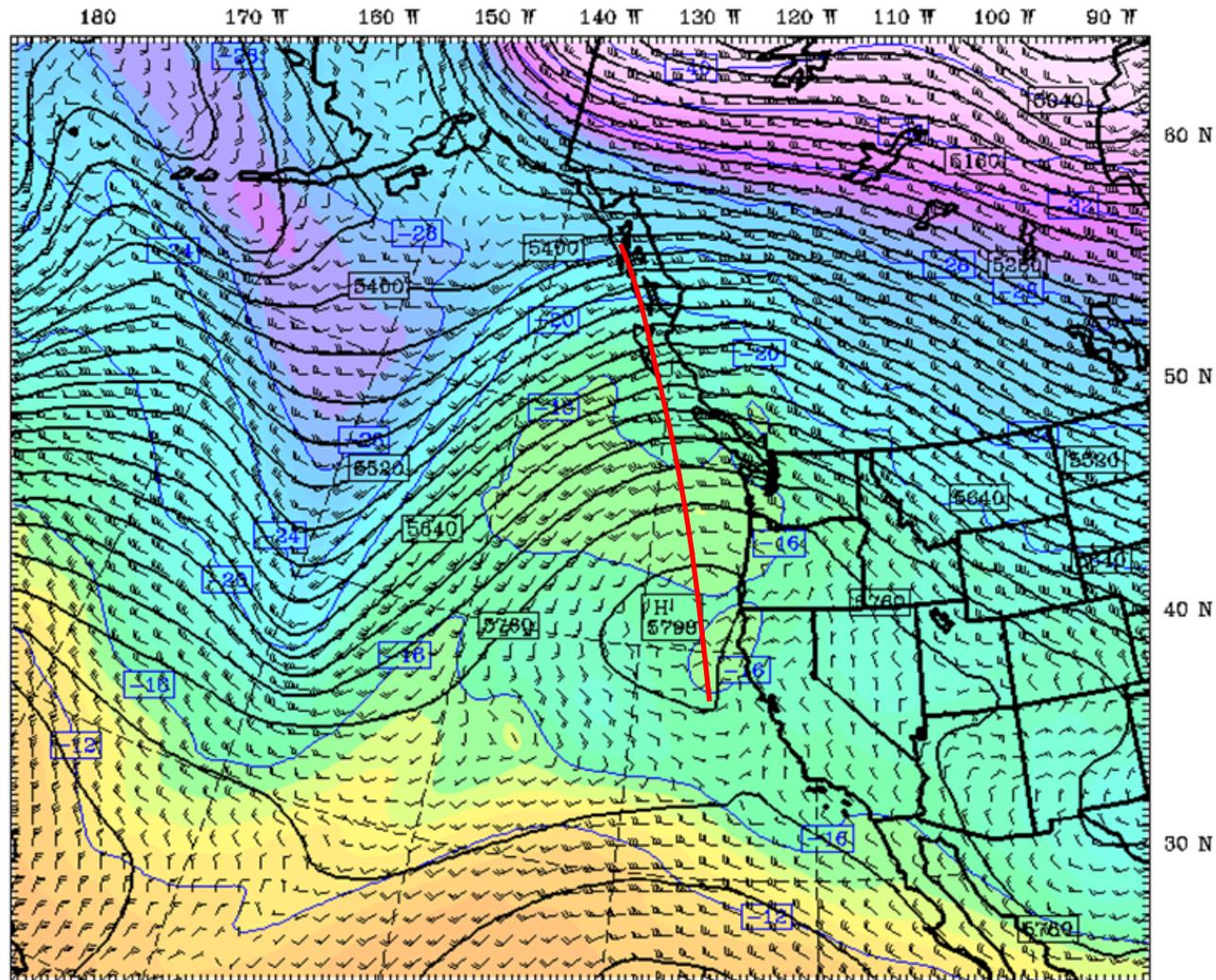
Fcst: 45 h

Valid: 09 UTC Thu 26 Dec 13 (01 PST Thu 26 Dec 13)

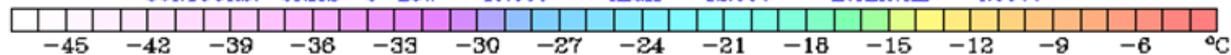
Temperature at 500mb (°C)

Geopotential Height at 500mb (m)

Wind at 500mb (full barb = 10kts)



CONTOURS: UNITS=m LOW= 5010.0 HIGH= 5850.0 INTERVAL= 30.000  
 CONTOURS: UNITS=°C LOW= -40.000 HIGH= -12.000 INTERVAL= 4.0000



Model Info: V3.5 SAS Sch YSU PBL Thompson Noah LSM 36 km, 37 levels, 216 sec  
 LW: RRTM SW: RRTMG DIFF: simple KM: 2D Smagor

UW WRF-GFS 4km Domain

Init: 12 UTC Wed 25 Dec 13

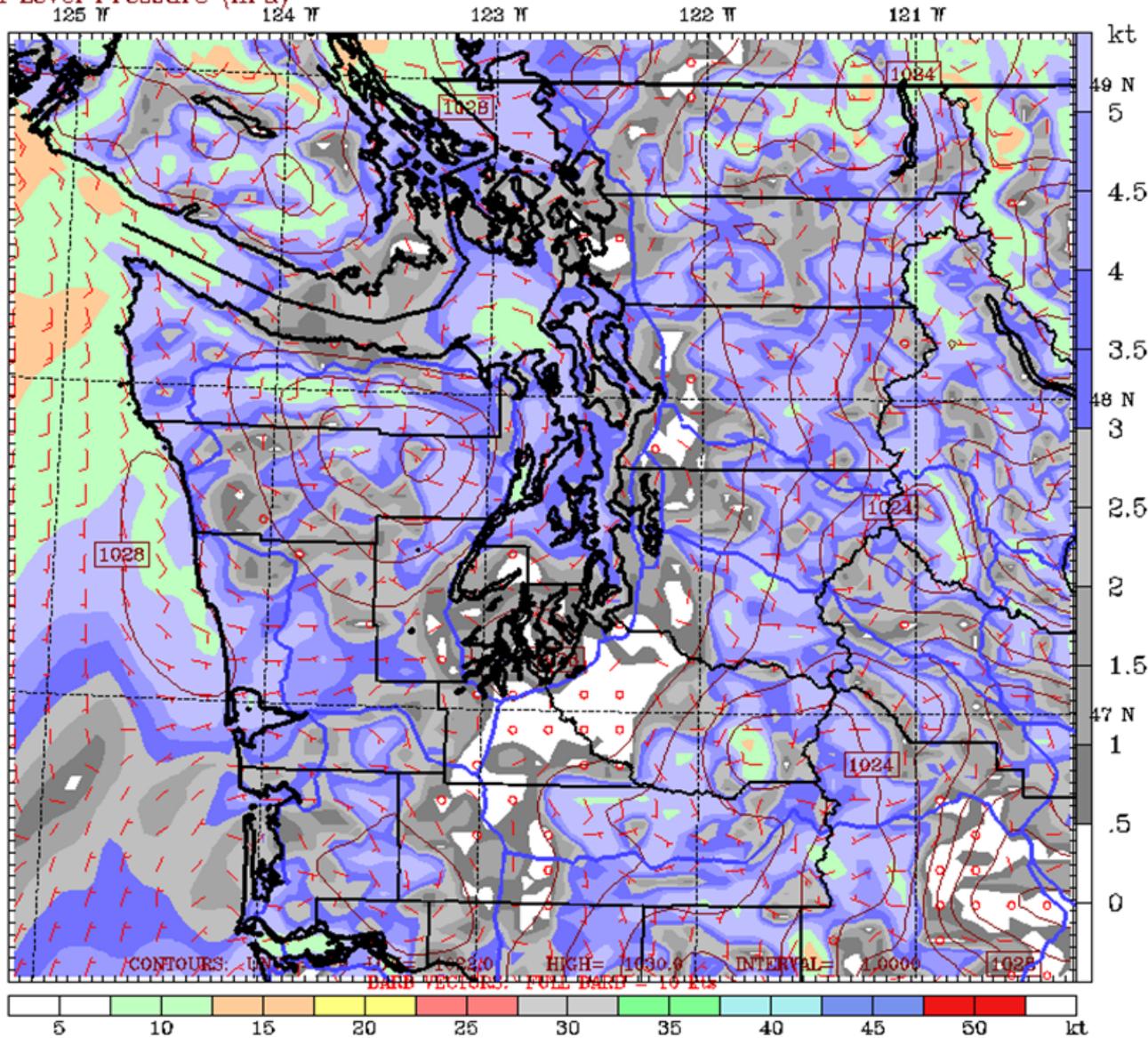
Fcst: 18 h

Valid: 06 UTC Thu 26 Dec 13 (22 PST Wed 25 Dec 13)

10m Wind Speed (knots)

Wind at 10m (full barb = 10kts)

Sea Level Pressure (hPa)



Model Info: V3.5

SAS Sch YSU PBL Thompson Noah LSM 4.0 km, 37 levels, 24 sec

LW: RRTM SW: RRTMG DIFF: simple KM: 2D Smagor

06/03/2020 + -  
 06/09/2020 + -  
**USER GUIDE**  
 Highest PS Wood Smo...  
 GO

+ New Series  
 - Remove All Series  
 Refresh Session  
 Collapse All

**Lake Forest Park - Pm25Neph**

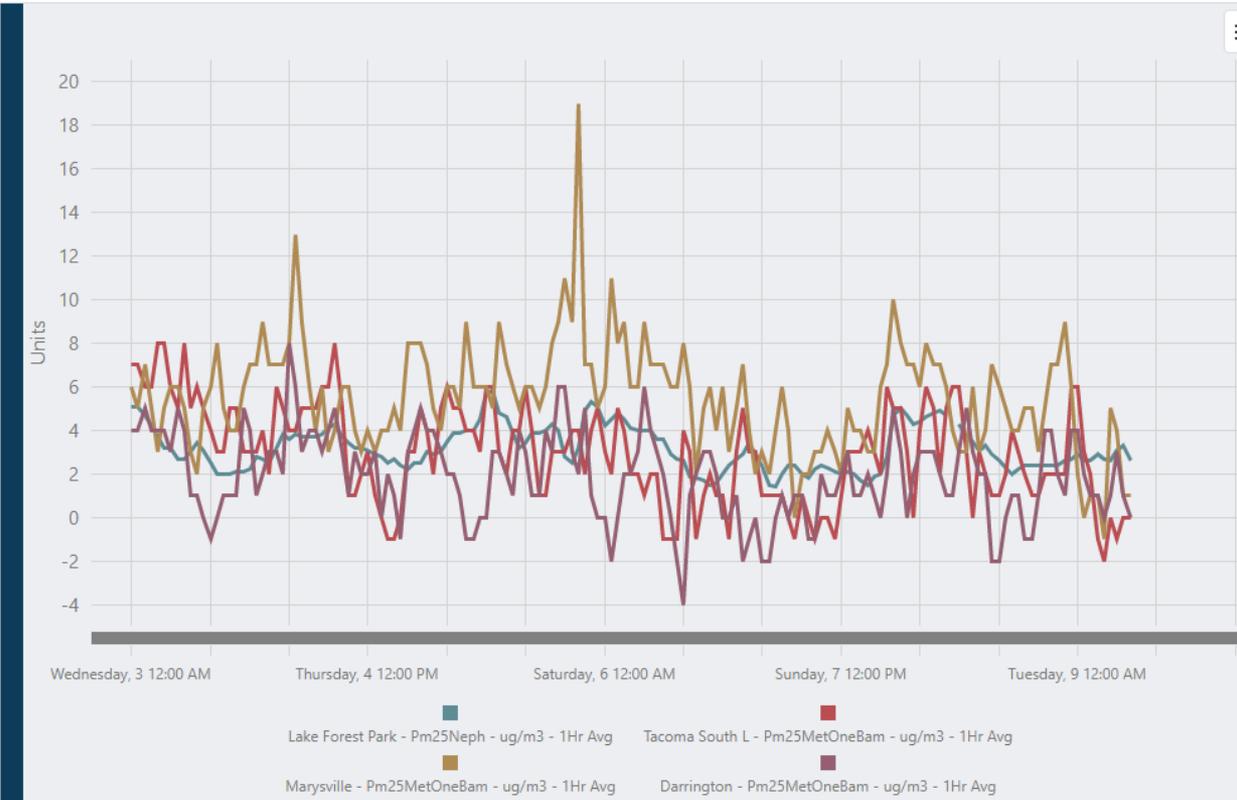
Lake Forest Park  
 Pm2.5 Nephelometer  
 1-Hour Average v(7)  
 Calculation...

**Tacoma South L - Pm25MetOneBam**

Tacoma South L  
 Pm2.5 MetOne Bam  
 1-Hour Average v(7)  
 Calculation...

**Marysville - Pm25MetOneBam**

Marysville  
 Pm2.5 MetOne Bam  
 1-Hour Average v(7)  
 Calculation...



pscleanair.org  
 Puget Sound Clean Air Agency

Chart Options

scale (0 for auto) 0 max +- min  
 +-  
**Legend**  
 On

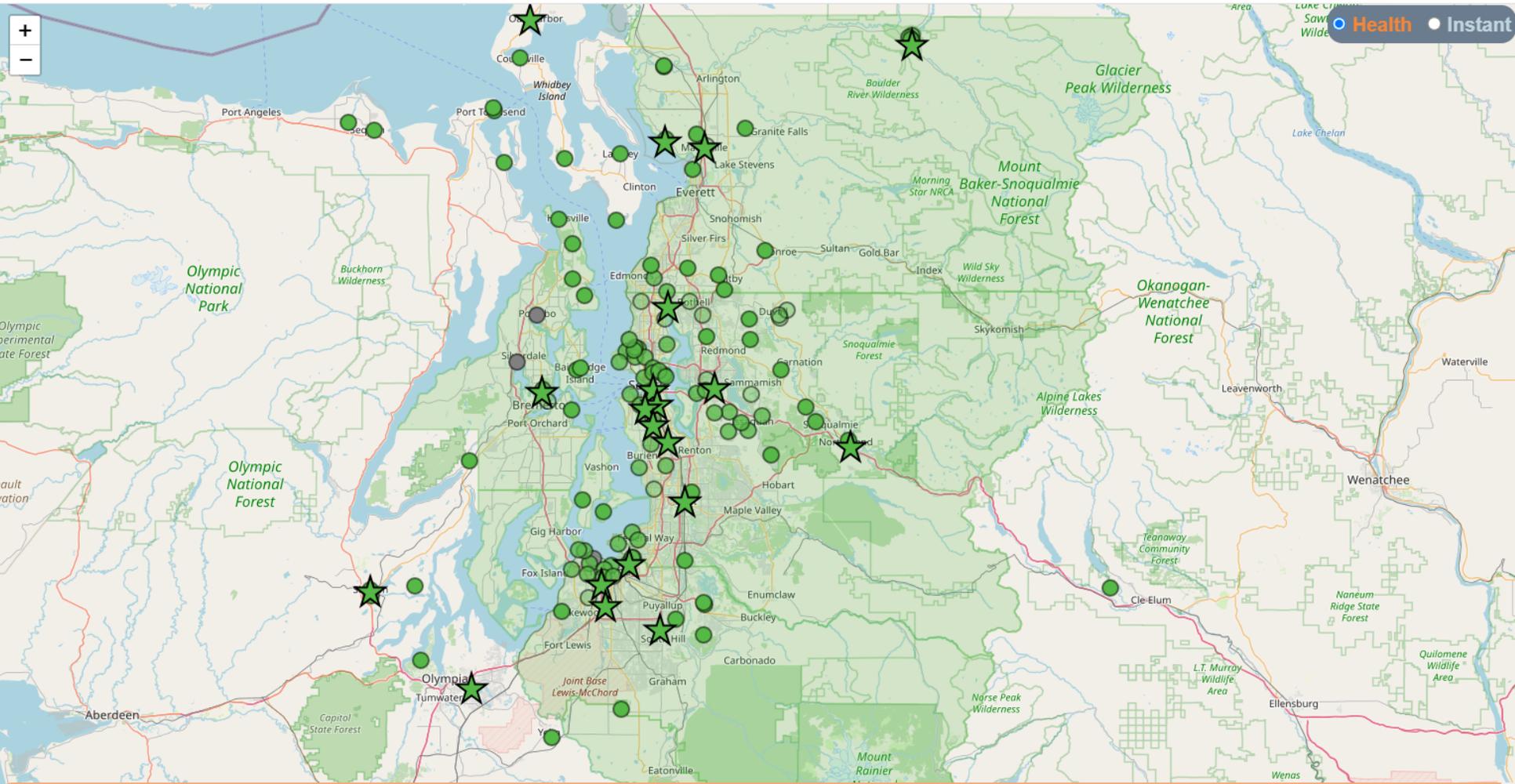
**AQI Shading**  
 Particulate  Off  
 Ozone  Off  
 NOx  Off

Data Downloads  
 XML CSV  
 Final validation of PSCAA site data may take up to 2 months

- Other...
- Add all...
- Aberdeen
- Anacortes
- Anacortes-O Ave
- Bellevue SE 12th
- Bellingham
- Bremerton Spruce
- Burbank
- Chehalis
- Chelan Woodin Av
- Cheney Tumbull
- Other...
- Add all...
- Barometric Pressure
- Carbon Monoxide (Trace CO)
- Light Scatter eco\_9003\_2
- Light Scatter eco\_aur
- Light Scatter eco\_aur2
- Light Scatter rr
- Nitric Oxide (NO)
- Nitric Oxide (Trace NO)
- Nitrogen Dioxide (NO2)
- Nitrogen Oxides (NOx)

Location	Quantity	
Darrington	Pm2.5 MetOne Bam	<a href="#">top values</a> <a href="#">standard stats</a> <a href="#">delete</a> ...
Marysville	Pm2.5 MetOne Bam	<a href="#">top values</a> <a href="#">standard stats</a> <a href="#">delete</a> ...
Tacoma South L	Pm2.5 MetOne Bam	<a href="#">top values</a> <a href="#">standard stats</a> <a href="#">delete</a> ...
Lake Forest Park	Pm2.5 Nephelometer	<a href="#">top values</a> <a href="#">standard stats</a> <a href="#">delete</a> ...

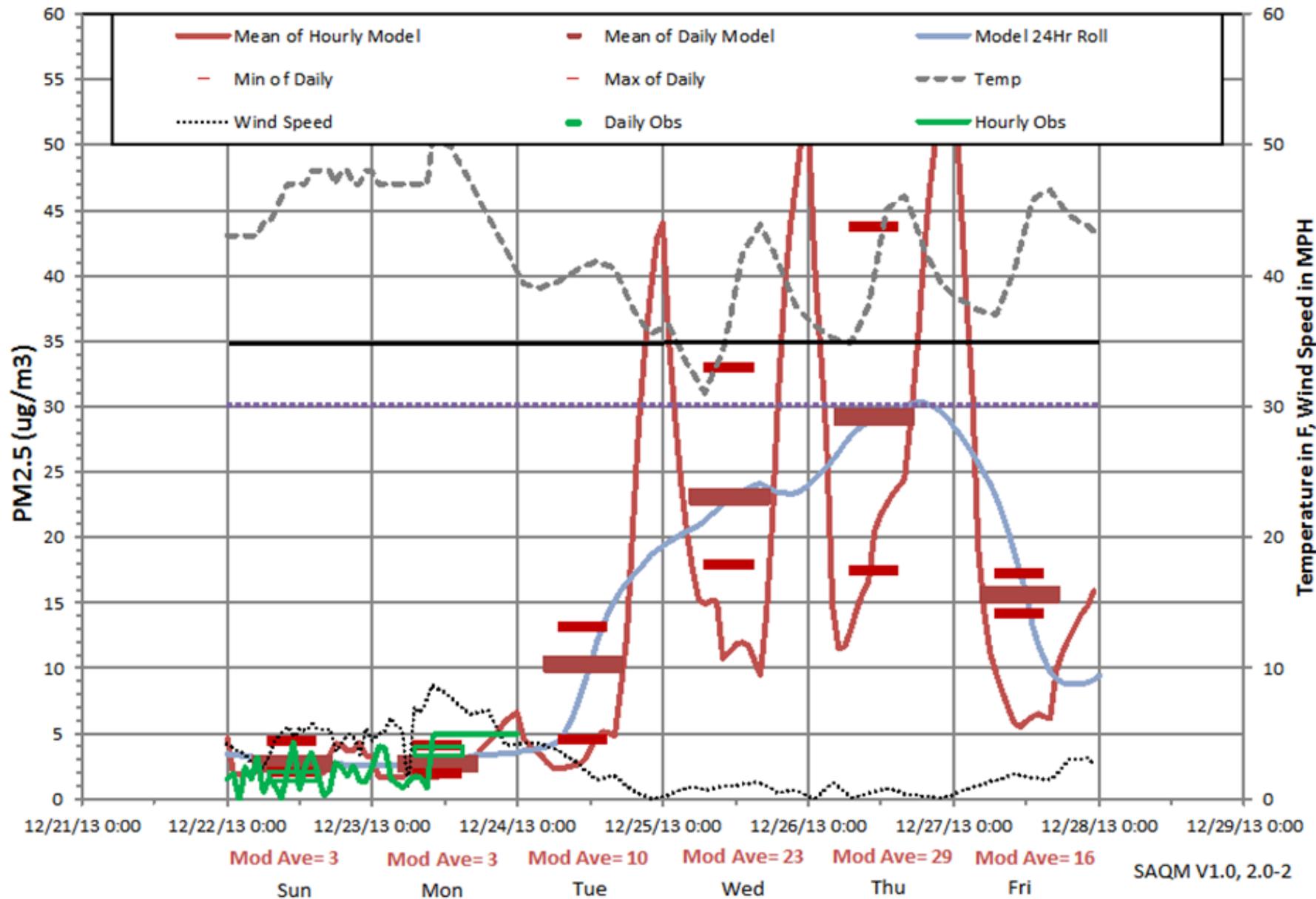
Add Series



<b>Health View</b>	<b>Site Marker</b>	<b>Site Color</b>	<b>How To Use This Map</b>
24-hr particle pollution	★ Agency Monitor	● Good	Click on a circle or star to see pollution for that site.
	○ Purple Air Sensor	● Moderate	Then click on the Impact tab for activity suggestions.
		● Unhealthy for sensitive groups	To see current pollution levels click on Instant in the top right.
		● Unhealthy for everyone	<a href="#">Want to learn more?</a>
		● No data	

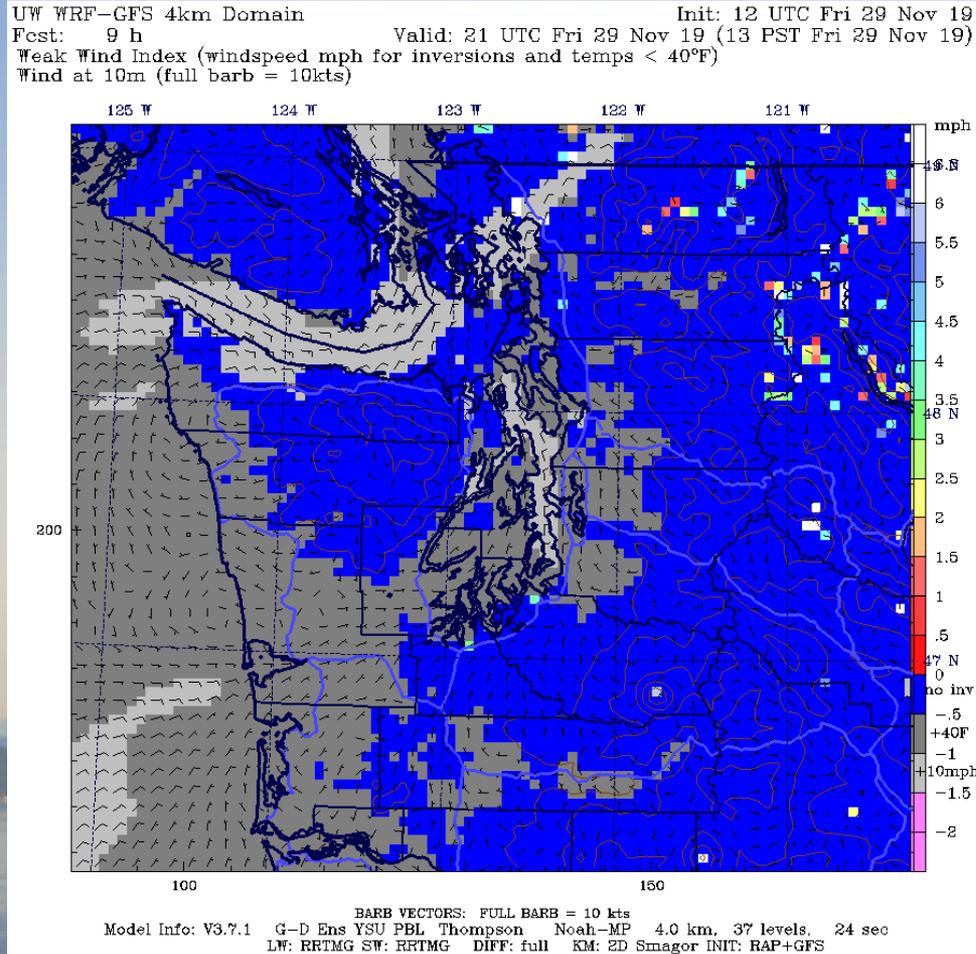
# Tacoma - Statistical Air Quality Model using WRF

calculation date and time: 23-Dec-13 11:21

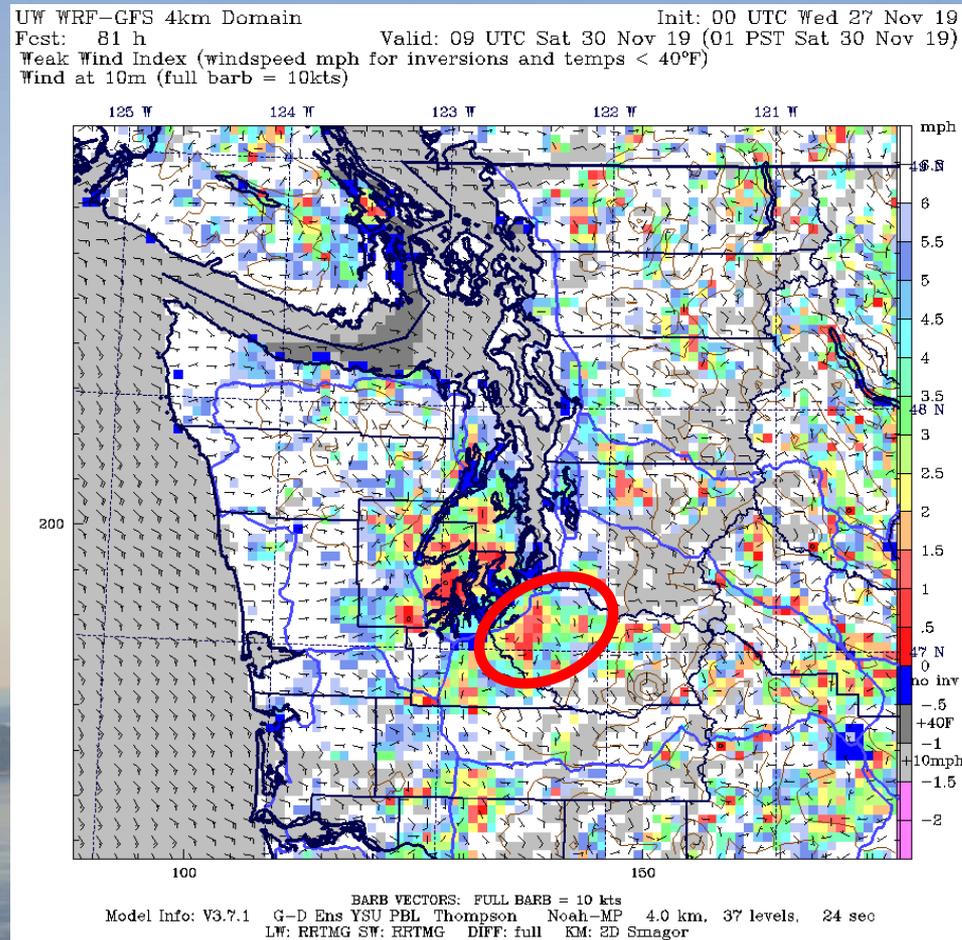




# Weak Wind Index: No Inversion

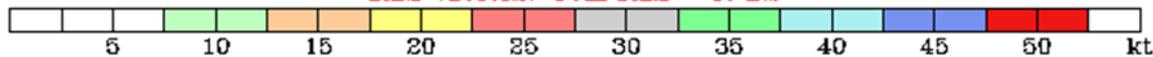
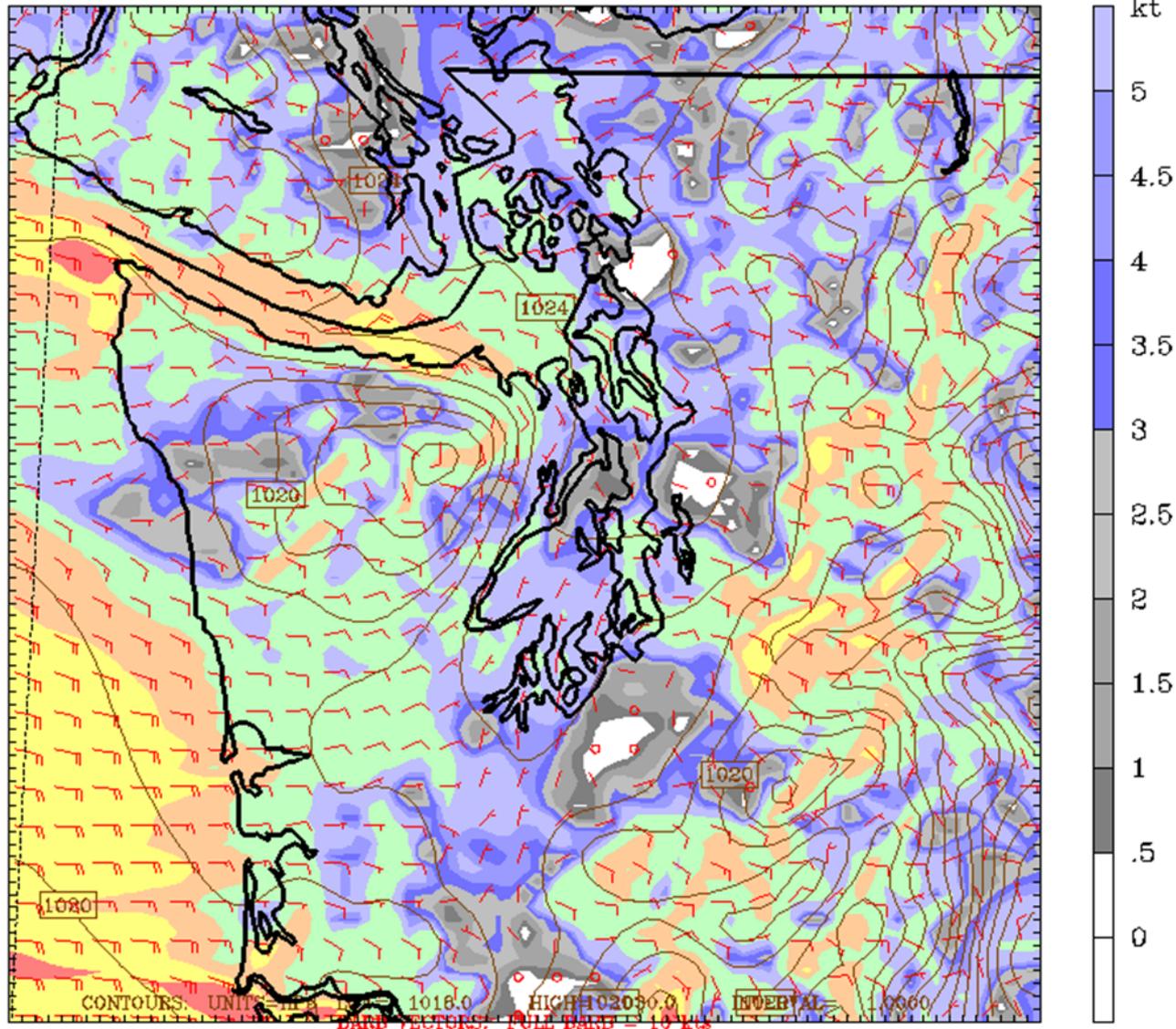


# Weak Wind Index: Cold, Calm, Inversion

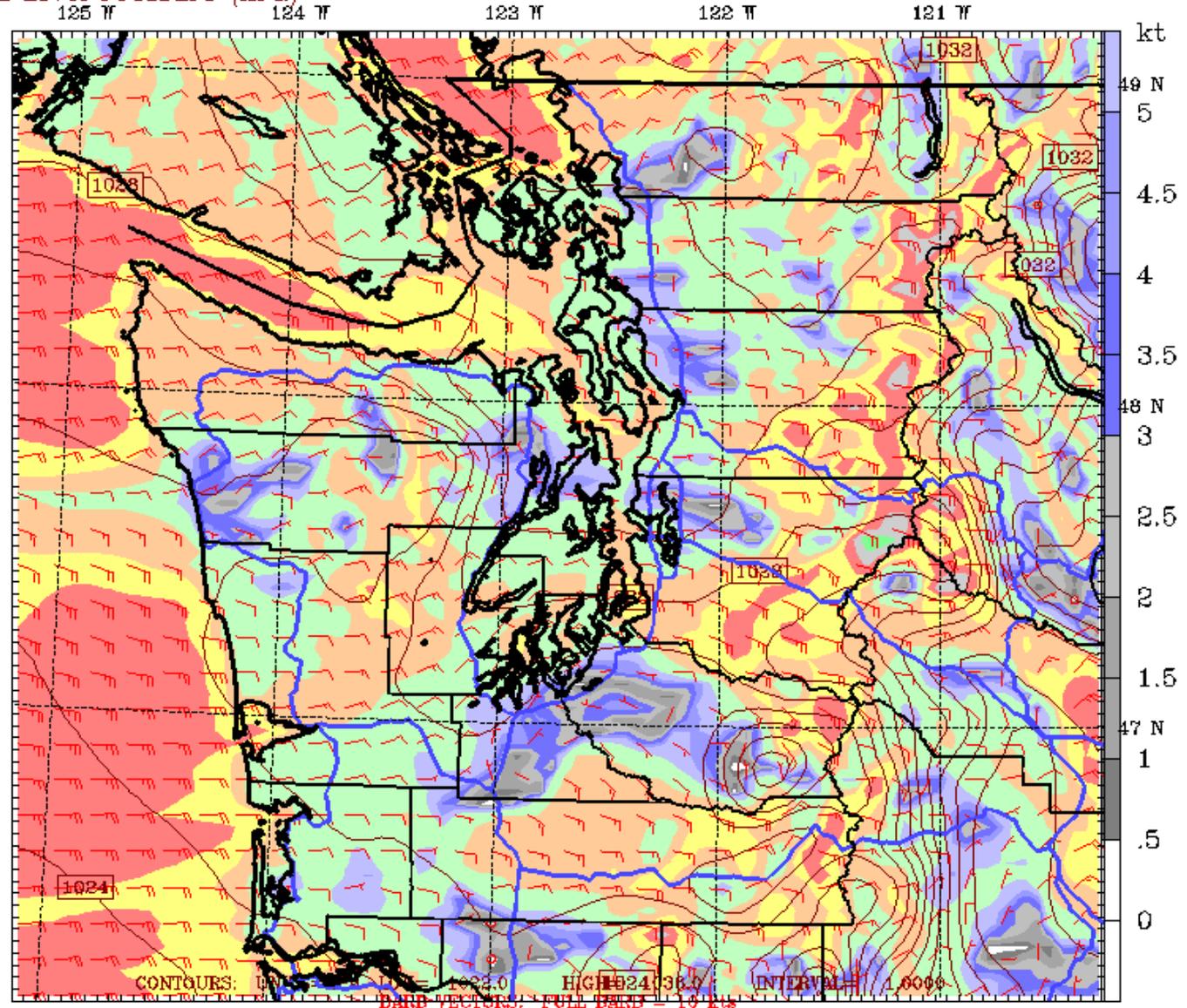


# Other forecasting considerations

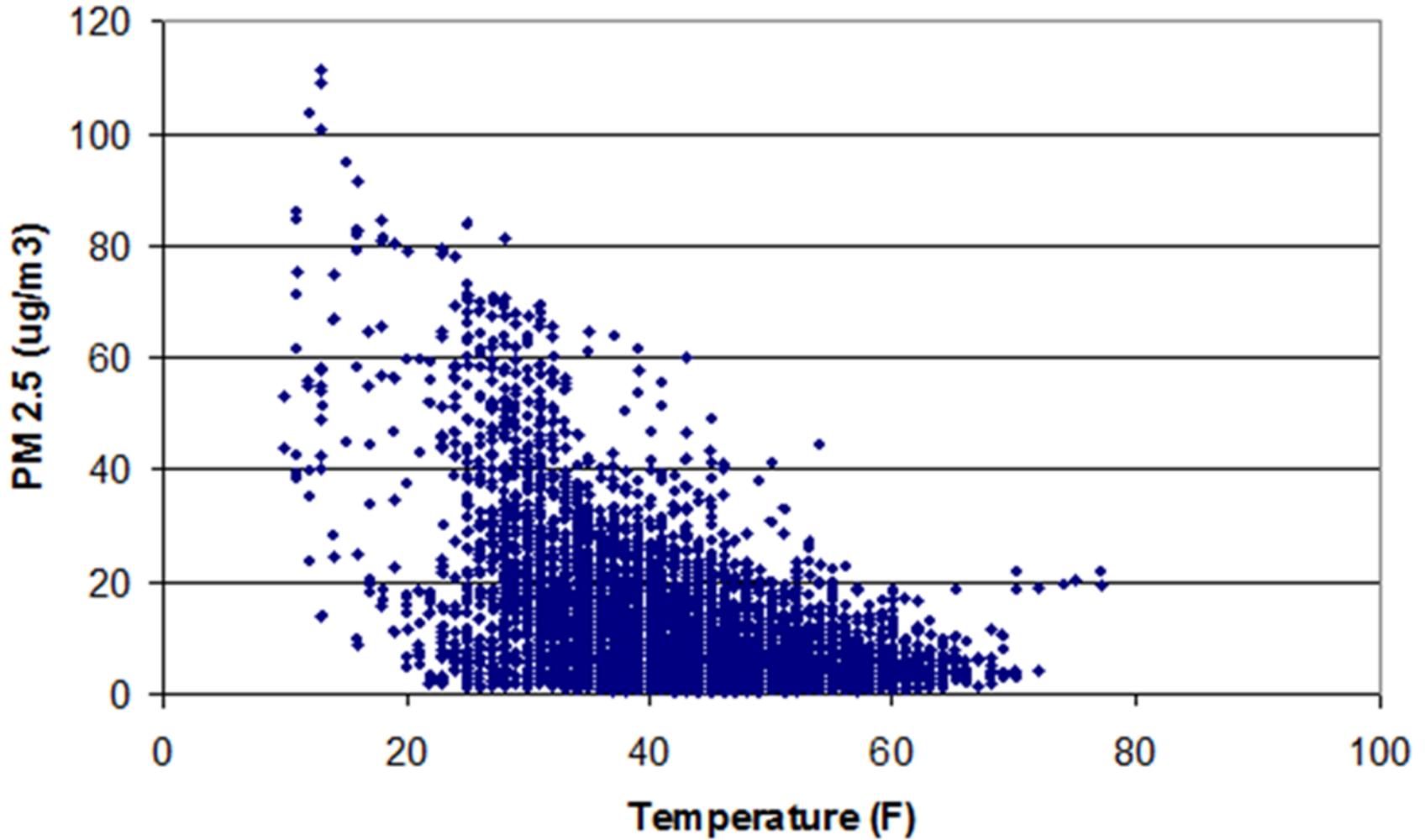
- Consider probable 24-hour averages
- Consider persistence/repeat (substitute yesterdays hours for future hours of todays midnight-midnight)
- Can vary between sites and within counties, closer to sound, along gaps in Cascades, etc
- Can have unique, stagnant conditions along the foothills and in pockets (Darrington) and in lee of Mt Rainier



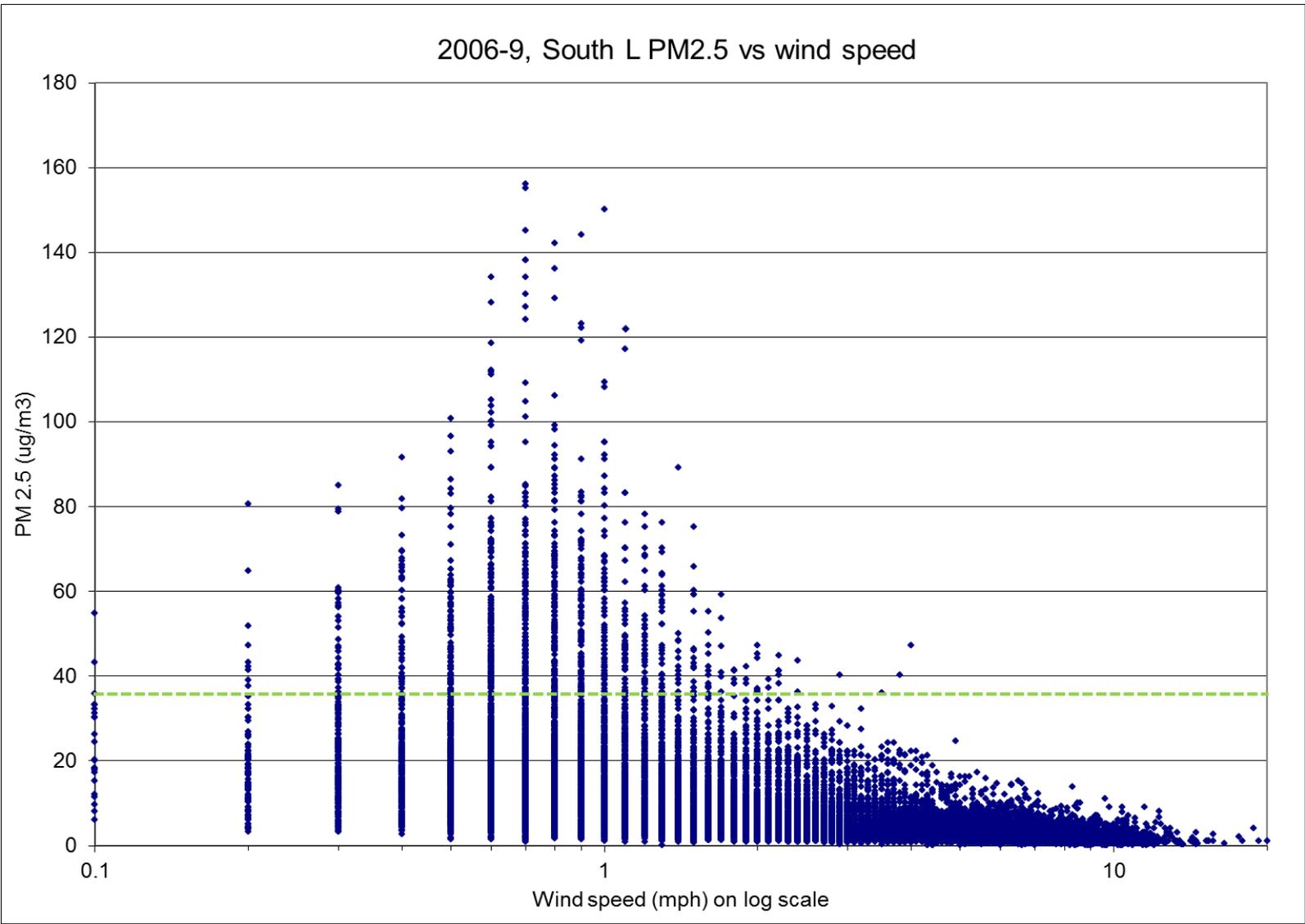
10m Wind Speed (knots)  
Wind at 10m (full barb = 10kts)  
Sea Level Pressure (hPa)



### South L Winter-Fall PM 2.5 hourly



# Distribution with wind speed



# Exceedances only occur with inversion

Joint distribution of PM<sub>2.5</sub> and 50m inversion strength

