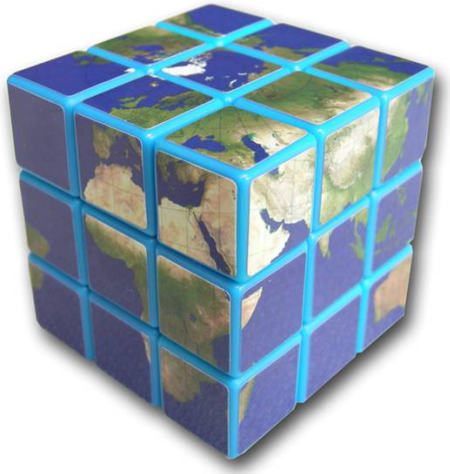
Lessons of the Northwest Earthcube

Cliff Mass
University of Washington

Shaping the Development of EarthCube to Enable Advances in Data Assimilation and Ensemble Prediction



EarthCube NW

- During the past two decades, a group of us in the Northwest have tried to build a Northwest "EarthCube"
- A testbed system for scientific exploration, technology development, education and outreach, and public value.
- First, a brief description of this effort and then some thoughts on its implications for the current meeting.

UW EarthCube

- High resolution deterministic forecasts (WRF: 36, 12, 4, 1.3 km)
- UW Ensemble System (36-12 km)
- UW EnKF data assimilation and forecast system (36-12 km)
- Collection of all regional weather data in real time.
- Regional quality control and verification.
- Regional air quality, ocean circulation, hydrology, smoke dispersion models drive by WRF in real time.
- Weather apps (e.g., RainWatch, SnowWatch)
- Transmission of grids to major users in area
- Graphics evaluable to all users.
- Social media interpretation and discussion of model and observational data.

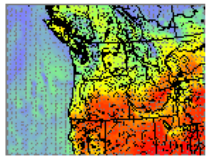
Pacific Northwest Environmental Forecasts and Observations

Supported by the Northwest Modeling Consortium

High Resolution Model Forecasts
More Information
Forecast Graphics Description

WRF-GFS
36km 12km 4km
Past Runs
Status
complete

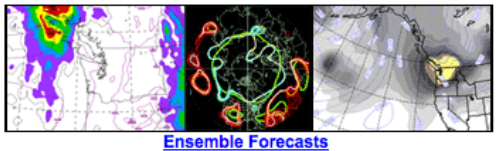
MM5-NAM
36km 12km
Past Runs
Status
complete



Experimental High-resolution WRF-GFS
1 1/3-km
Past Runs
Status
complete

Extended WRF-GFS
36km 12km
Past Runs
Status
complete

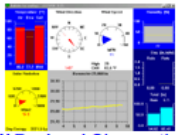
UW Ensemble Forecast System
More Information



Ensemble Forecasts

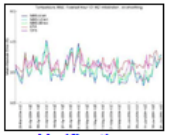
EnKF Analyses and Forecasts

NW Regional Observations and Real Time Verification
More Information



NW Regional Observations

Observation Quality Control



Verification

Regional Applications
More Information

Transportation

Air Quality

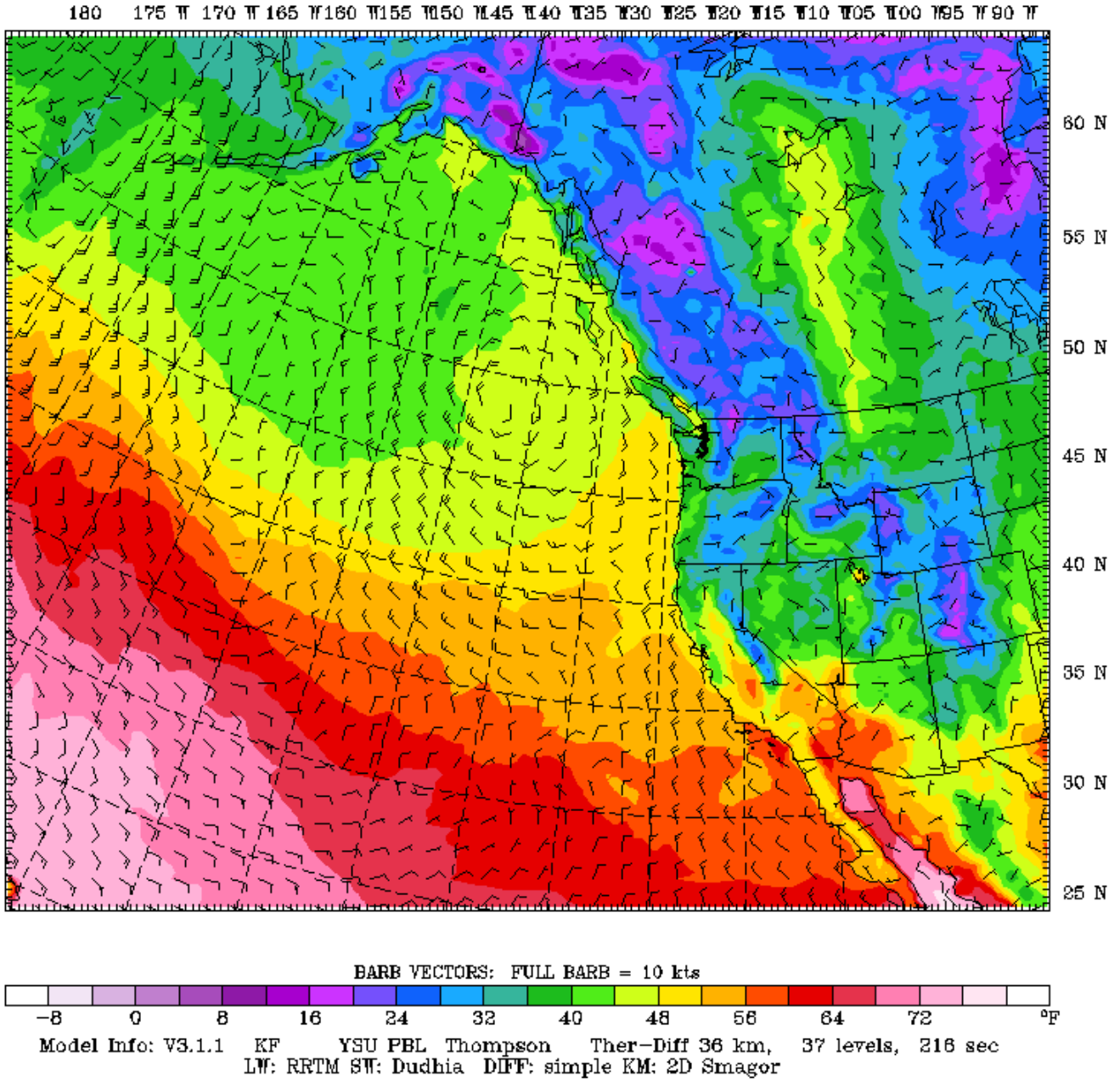
Fire Weather
Airfire Bluesky

Hydrology

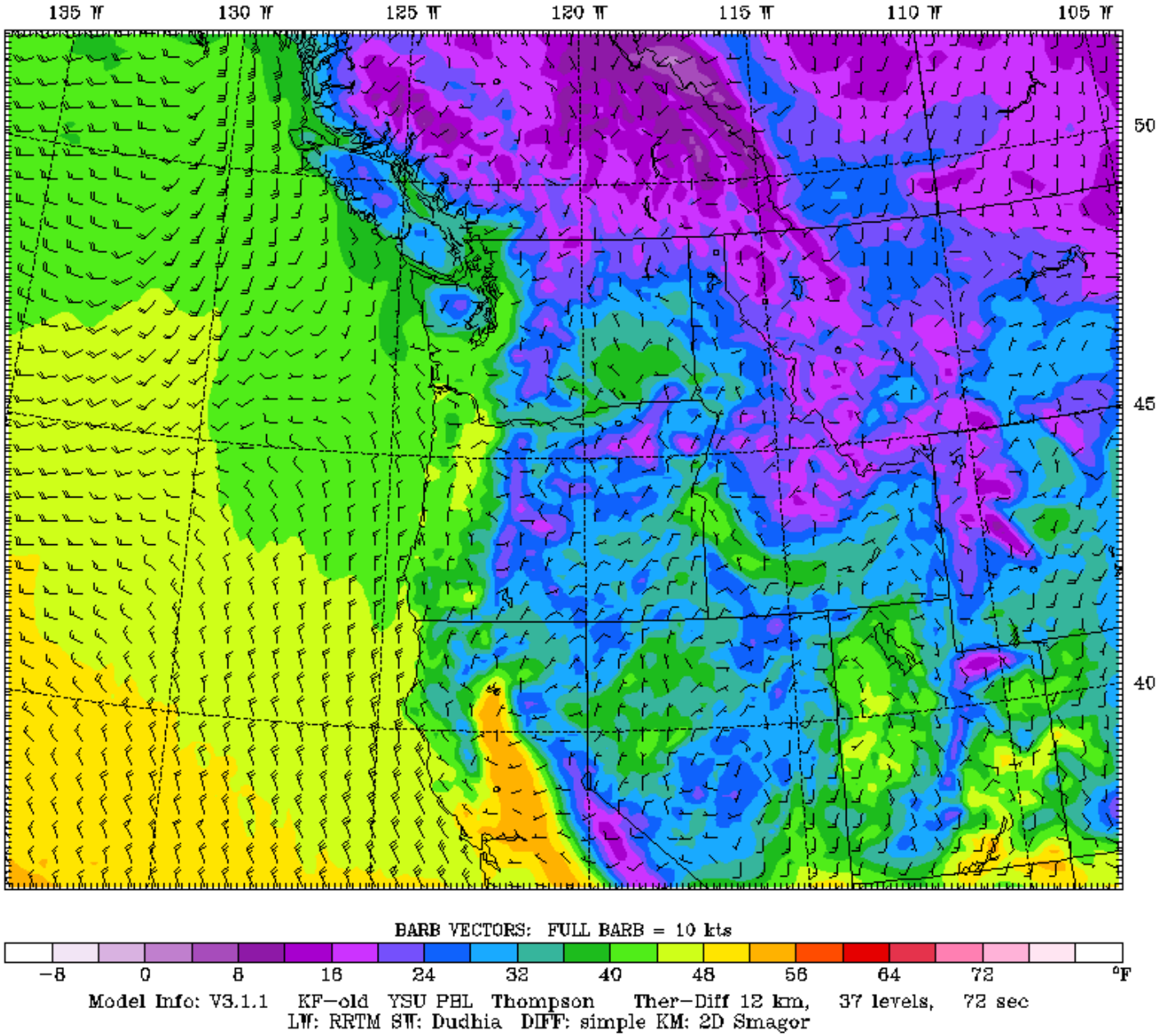
Updated: Thu May 12 17:20:02 PDT 2011

http://www.atmos.washington.edu/mm5rt/

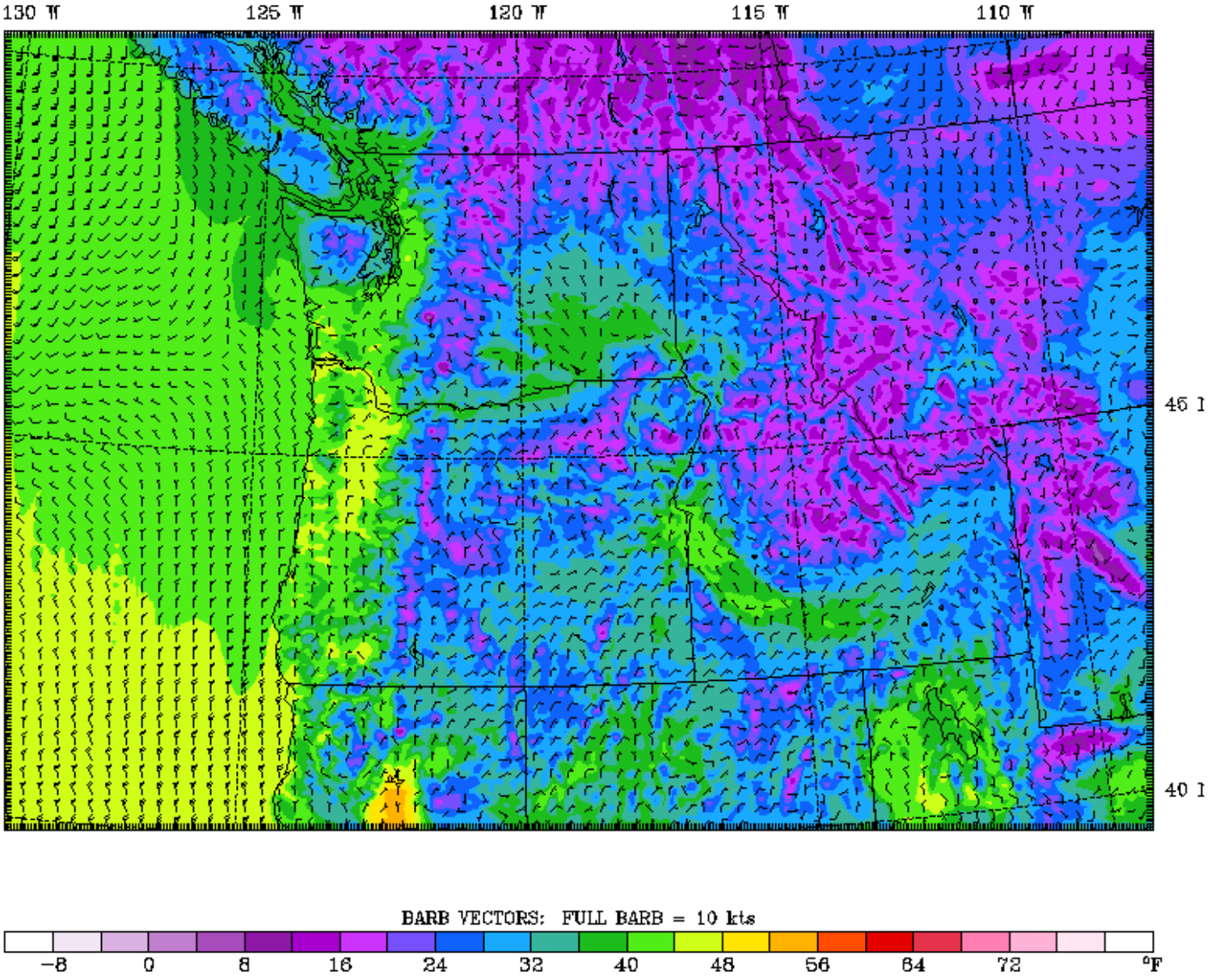
36 km

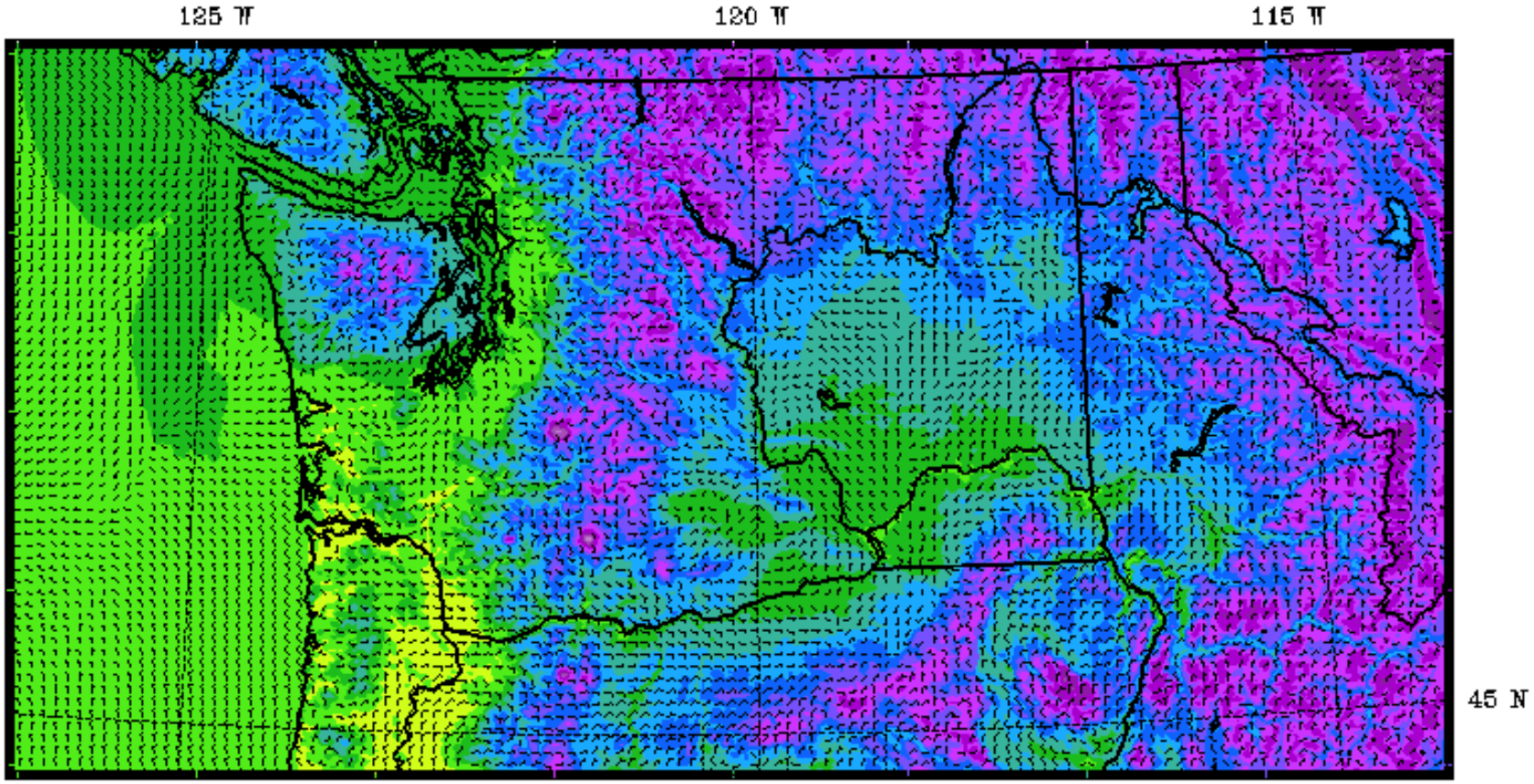

180 175 W 170 W 165 W 160 W 155 W 150 W 145 W 140 W 135 W 130 W 125 W 120 W 115 W 110 W 105 W 100 W 95 W 90 W
60 N
55 N
50 N
45 N
40 N
35 N
30 N
25 N
BARB VECTORS: FULL BARB = 10 kts
−8 0 8 16 24 32 40 48 56 64 72 °F
Model Info: V3.1.1 KF YSU PBL Thompson Ther−Diff 36 km, 37 levels, 216 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor

12 km


135 W
130 W
125 W
120 W
115 W
110 W
105 W
50
45
40
BARB VECTORS: FULL BARB = 10 kts
-8
0
8
16
24
32
40
48
56
64
72
°F
Model Info: V3.1.1 KF-old YSU PBL Thompson Ther-Diff 12 km, 37 levels, 72 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor

4 km


130 W
125 W
120 W
115 W
110 W
46 I
40 I
BARB VECTORS: FULL BARB = 10 kts
−8
0
8
16
24
32
40
48
56
64
72
°F



1.33 km

WRF-GFS 4 km Domain
Initialized 2012121800 UTC
4 pm PST Mon 17 Dec 2012

	Product	Loop By Type	Forecast Hour																		
ypes	Loop by Hour Now excludes soundings		L 0	L 3	L 6	L 9	L12	L15	L18	L21	L24	L27	L30	L33	L36	L39	L42	L45	L48	L51	L5
	SLP, 10 m winds, and temp	LOOP	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54
	WA **SLP**, 10m winds, and temp	LOOP	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54
	OR **SLP**, 10m winds, and temp	LOOP	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54
	ID **SLP**, 10m winds, and temp	LOOP	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54
	Western WA **SLP**, 10m winds, and temp	LOOP	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54
	Columbia Gorge **SLP**, 10m winds, and temp	LOOP	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54
	925 mb temperature, winds	LOOP	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54
	Temperature	LOOP	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54
	WA Surface (2m) temperature	LOOP	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54
	Columbia Gorge Surface (2m) temperature	LOOP	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54
	Bias-corrected Surface (2m) temperature	LOOP	6	12	18	24	30	36	42	48	54	60	66	72							
	Surface (2m) temperature bias	LOOP	6	12	18	24	30	36	42	48	54	60	66	72							

On-The-Fly Graphics

WRF-GFS on the Fly Sounding Generator

Links:

On the Fly Timeheights Generator

On the Fly Meteogram Generator

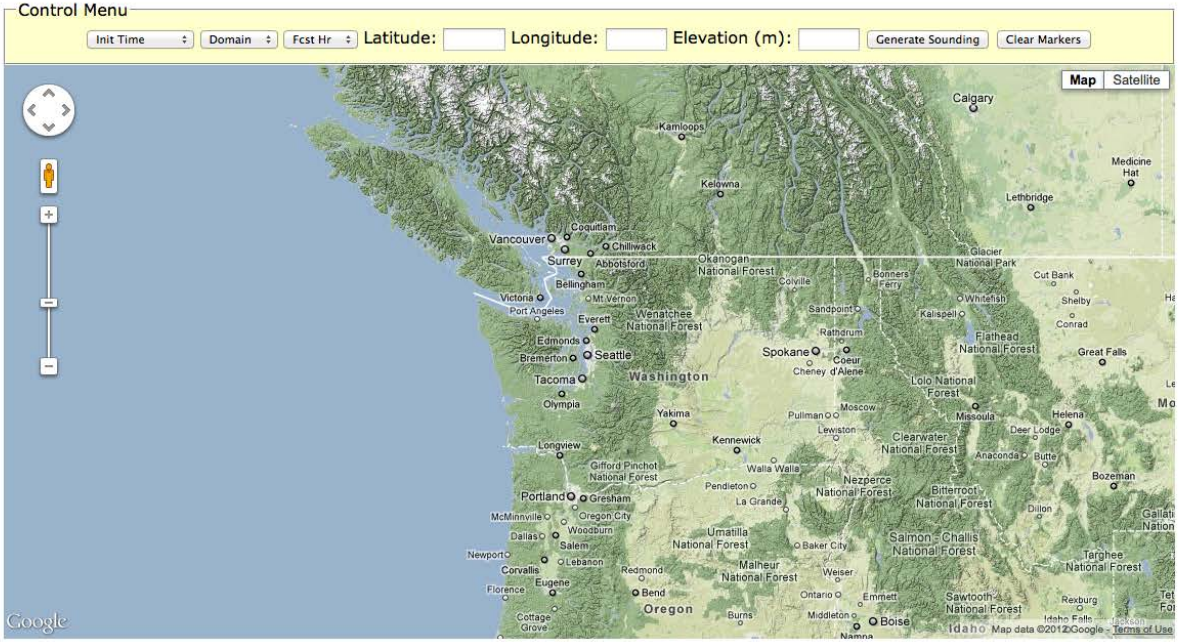
Instructions:

1. Select an initialization time
2. Select domain
3. Click location of desired sounding
4. To plot press "Generate Sounding"

Your exact location is bilinearly interpolated from the nearest four grid points using the UW-Dept. of Atmospheric Sciences WRF-GFS model output. The displayed model elevation above is from the GoogleMaps API while the elevation given on the plot will be the interpolated WRF model elevation.

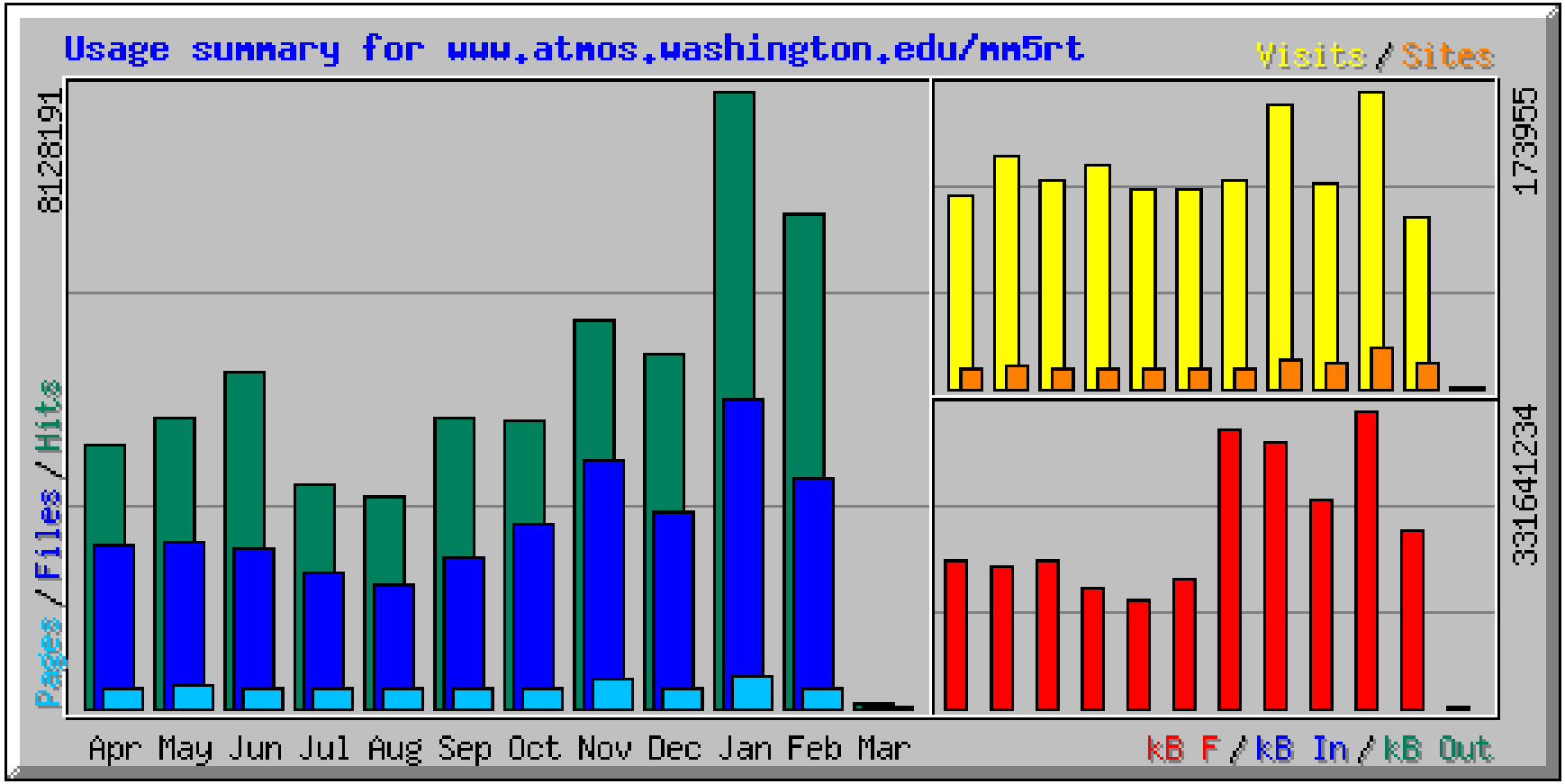
Please disable Pop-up blockers on this website in order for Sounding to be displayed properly.

For best results please upgrade your browser to IE9, Firefox 4, Chrome 10.0+, Safari 5.0+, or Opera 11.0+.



Please direct questions/comments/errors to Mark Albright

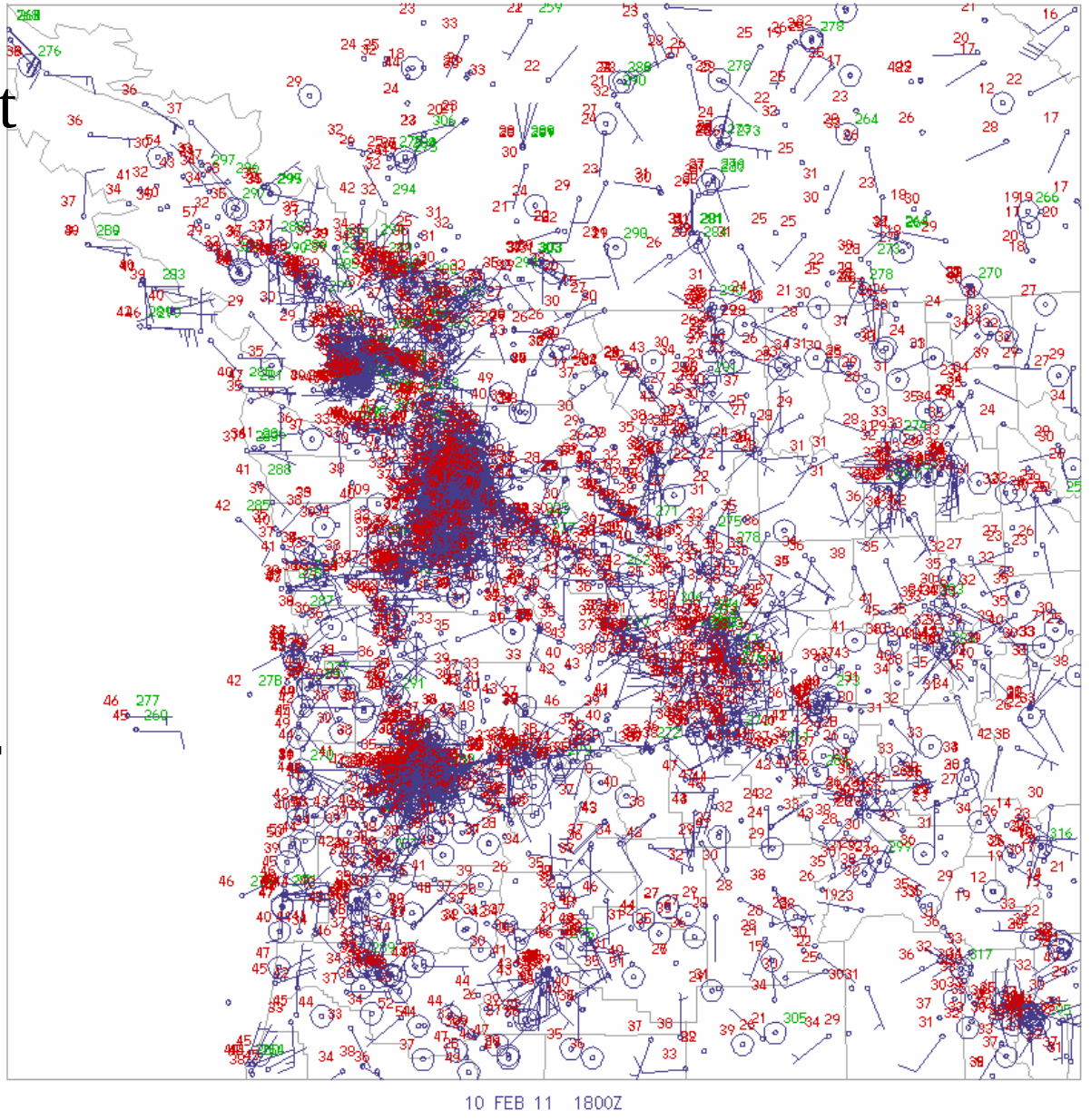
Tens to Hundreds of Thousands of Hits Per Day on Web Site



NorthwestNet

Over 72 different networks

3000-4000 observations per hour over WA and OR



Observations QC Summary Page

University of Washington Dept. of Atmospheric Sciences

Current | Status | Stats | Maps | Experimental | Documentation | Logs | Contact

Flagged Data For All Networks

12-13-2012 16:00 PST through 12-17-2012 15:00 PST

Network	Total Observations	Total Observations Flagged	Percent Observations Flagged
Citizens Weather Observer Network	442743	16840	3.80
Weather Underground	352498	14964	4.24
Unknown	318678	6875	2.15
RAWS Networks (BLM + USFS)	286998	5201	1.81
Automated Surface Observation System (ASOS)	263522	2355	0.89
Oregon RWIS	21475	1735	8.07
BC MoT Weather Network	29959	1261	4.20
UVic School-Based Weather Station Network	49028	1159	2.36
WSDOT Road Weather Information System (RWIS) Network	33509	665	1.98
Automated Weather Source (AWS) Schoolnet	200169	553	0.27
GPS Meteorology	1078	339	31.4
Desert Research Institute	6560	217	3.30
California Air Resources Board	928	179	19.2
WSU Public Agricultural Weather (PAWS) Network	52516	136	0.25
Union Pacific Railroad	5233	133	2.54

Verification Page

University of Washington Dept. of Atmospheric Sciences

Plots | Documentation | Observations Quality Control | History / Change Log | Contact

Verification Plots

		 Temperature	 Dewpoint Temperature	 Wind Speed	 Wind Direction	 Sea Level Pressure	 6-hour Precipitation	 Relative Humidity
MM5 vs WRF Verification Plots	Time Series Plots	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	n/a
	Maps	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	n/a
	Upper Air	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	n/a	n/a	00Z | 12Z
	d1 Monthly Average Error Maps	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	n/a
	d2 Monthly Average Error Maps	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	n/a
MM5 & WRF vs. Synoptic Models Verification Plots	Synoptic Time Series Plots	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z	00Z | 12Z

Cyberstructure

Two Ensemble Systems

- 9 member 36-12 km ensemble forced by major global modeling systems
  - BMA post processing
  - Innovative displays (PROBCAST)

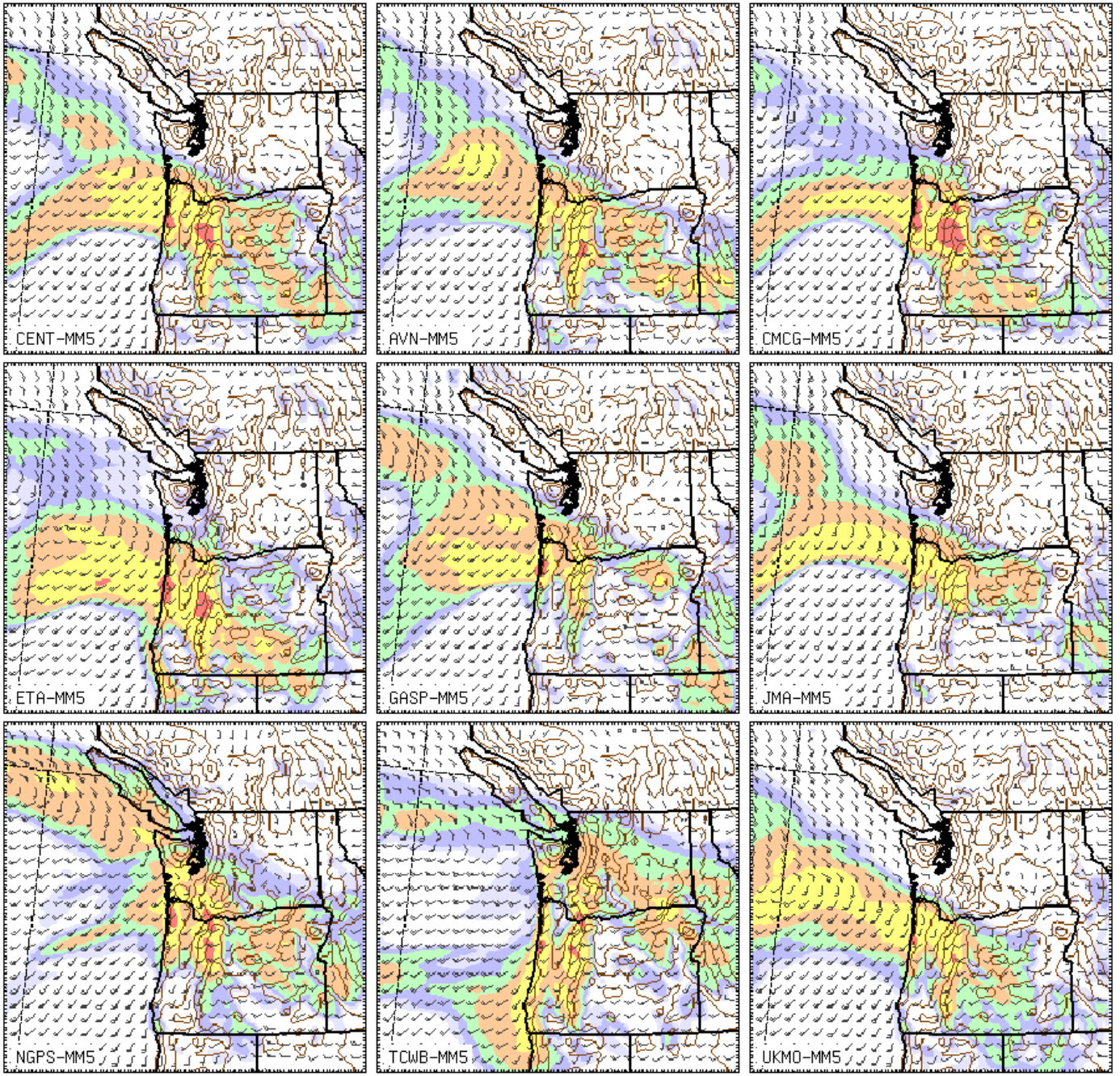
- 60 member EnkF system (Dart, WRF). 36-4 km Three-hour cycling, 24 h forecasts

The UW Mesoscale Ensemble Prediction System (UWME)

Abbreviation/Model/Source	Type	Resolution (~ @ 45 °N) Computational	Resolution (~ @ 45 °N) Distributed	Objective Analysis
avn, Global Forecast System (GFS), National Centers for Environmental Prediction	Spectral	T254 / L64 ~55km	1.0° / L14 ~80km	SSI
cmcg, Global Environmental Multi-scale (GEM), Canadian Meteorological Centre	Spectral	T199 / L28 ~100km	1.25° / L11 ~100km	3D Var
eta, Eta limited-area mesoscale model, National Centers for Environmental Prediction	Finite Diff.	12km / L45	90km / L37	SSI
gasp, Global AnalysiS and Prediction model, Australian Bureau of Meteorology	Spectral	T239 / L29 ~60km	1.0° / L11 ~80km	3D Var
jma, Global Spectral Model (GSM), Japan Meteorological Agency	Spectral	T106 / L21 ~135km	1.25° / L13 ~100km	OI
ngps, Navy Operational Global Atmos. Pred. System, Fleet Numerical Meteorological & Oceanographic Cntr.	Spectral	T239 / L30 ~60km	1.0° / L14 ~80km	OI
tcwb, Global Forecast System, Taiwan Central Weather Bureau	Spectral	T79 / L18 ~180km	1.0° / L11 ~80km	OI
ukmo, Unified Model, United Kingdom Meteorological Office	Finite Diff.	5/6°×5/9°/L30 ~60km	*same* / L12	3D Var

UWME
36 and 12 km
Grid spacing

Precipitation



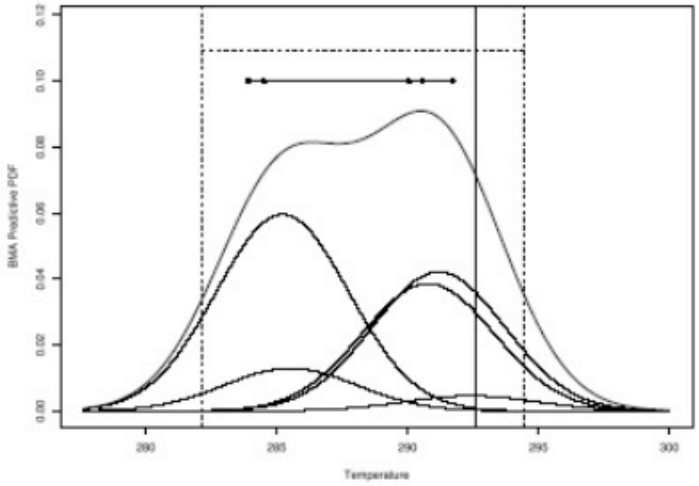
Bayesian Model Averaging (BMA) Summary

- The predictive PDF is a mixture of PDFs, each one centered on one of the forecasts after bias correction.
- Let y be the observed value.
- Let $\tilde{y}_k$ be the kth forecast from the ensemble
- The BMA model is:

$$p(y|\tilde{y}_1, \ldots, \tilde{y}_K) = \sum_{k=1}^{K} w_k N(a_k + b_k \tilde{y}_k, \sigma^2)$$

where $w_k \geq 0$ and $\sum_{k=1}^{K} w_k = 1$.

- The model is estimated from a training set of recent data by maximum likelihood using the EM algorithm.



PROBCAST: www.probcast.com

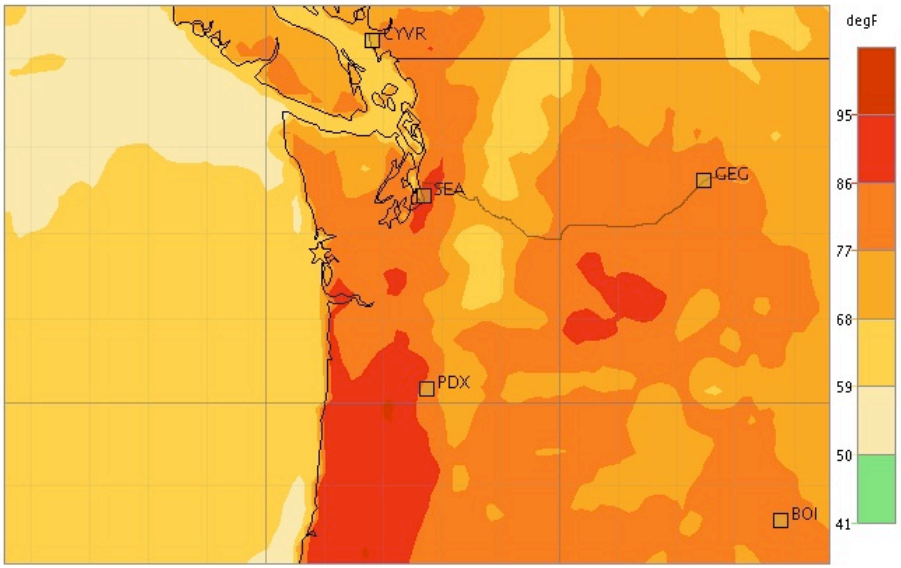
University of Washington Probability Forecast

Click a number on the table to select a new weather map; **click the weather map** or **fill in a zip code** to select a new location for the table. The yellow box shows the current map; the star shows the current location.

Grayland, WA 98547 (46.78 N, 124.08 W) City or Zip Code: 98547 go

	Fri Sep 1	Fri Sep 1 Night	Sat Sep 2	Sat Sep 2 Night	Sun Sep 3
TEMP	Daytime High 66°	Nighttime Low 55°	Daytime High 62°	Nighttime Low 55°	Daytime High 63°
	As high as: 71° As low as: 62°	Chance freeze: 0% As high as: 59° As low as: 51°	As high as: 67° As low as: 57°	Chance freeze: 0% As high as: 61° As low as: 49°	As high as: 70° As low as: 56°
xPRECIP	Chance of Precip 10%	Chance of Precip 10%	Chance of Precip 10%	Chance of Precip 10%	Chance of Precip 15%
	Likely Amount: .0" As Much As: .0"	Likely Amount: .0" As Much As: .0"	Likely Amount: .0" As Much As: .0"	Likely Amount: .0" As Much As: .0"	Likely Amount: .0" As Much As: .03"

High temperature for Fri Daytime, Sep 1 2006 -- Select a new weather map --



Snap to nearest zip code on map click (Improves speed)
Select exact click location (slower)

Learn more about this page.

This website provides uncertainty information along with a probabilistic weather forecast; move the mouse over a feature to learn more about its function.

This website was developed at the UW Applied Physics Laboratory, on the basis of research conducted at the UW departments of Atmospheric Science, Statistics and Psychology. It is funded by the Office of Naval Research.

TAKE THE SURVEY

Contact ptewson@apl.washington.edu with questions, comments, and reports of errors.

An Aside

- Probcast is very popular in lay communityNo obvious place to get support to continue this work (was supported by DOD MURI).
- No real grant program to bring probabilistic prediction to the public and other users.
- But decision making agencies still wary of probabilistic predictions.

UW Psychologist Susan Joslyn has been working on the problem of communication

Probability of Precipitation

Instructions:
The picture to the left displays the rain forecast for the Seattle-Tacoma Airport. Please use it to answer the following questions.

1. How likely is rain today?

(Please record your answer by drawing a vertical line (——|——) in the scale below)

Very Unlikely |---------- Very Likely

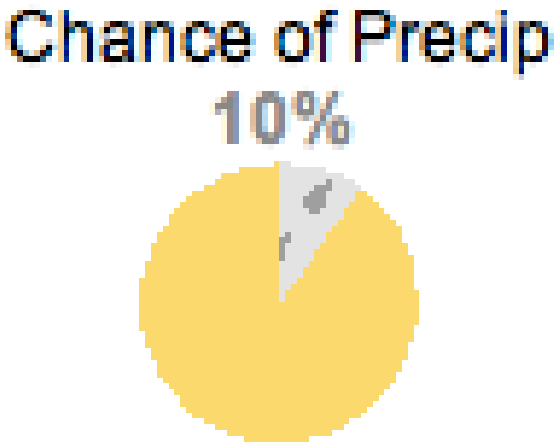
2. Would you take an umbrella with you (or wear a hooded jacket) today? (please check one answer)
___Yes ___No

3. How much will it likely rain today? (please check one answer)
___No Measurable Rain ___Less than half an inch
___More than half an inch ___Can't tell from this forecast

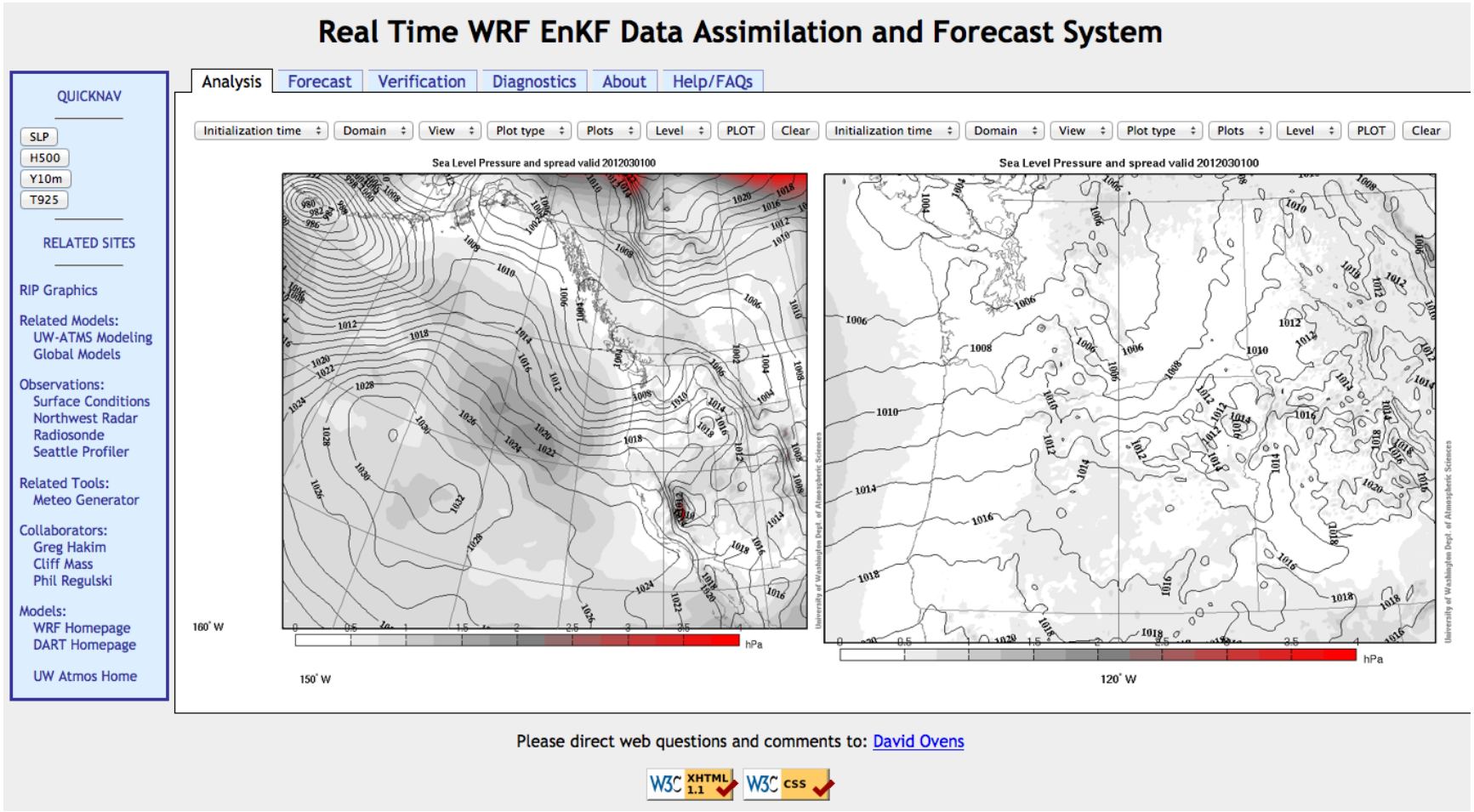
4. Over approximately what area of Puget Sound will it likely rain today? (please check one answer)
___None of the Area ___Less than half of the area
___More than half of the area ___Can't tell from this forecast

5. How much of the time will it likely rain today? (please check one answer)
___None of the time ___Less than half of the time
___More than half of the time ___Cant tell from this forecast

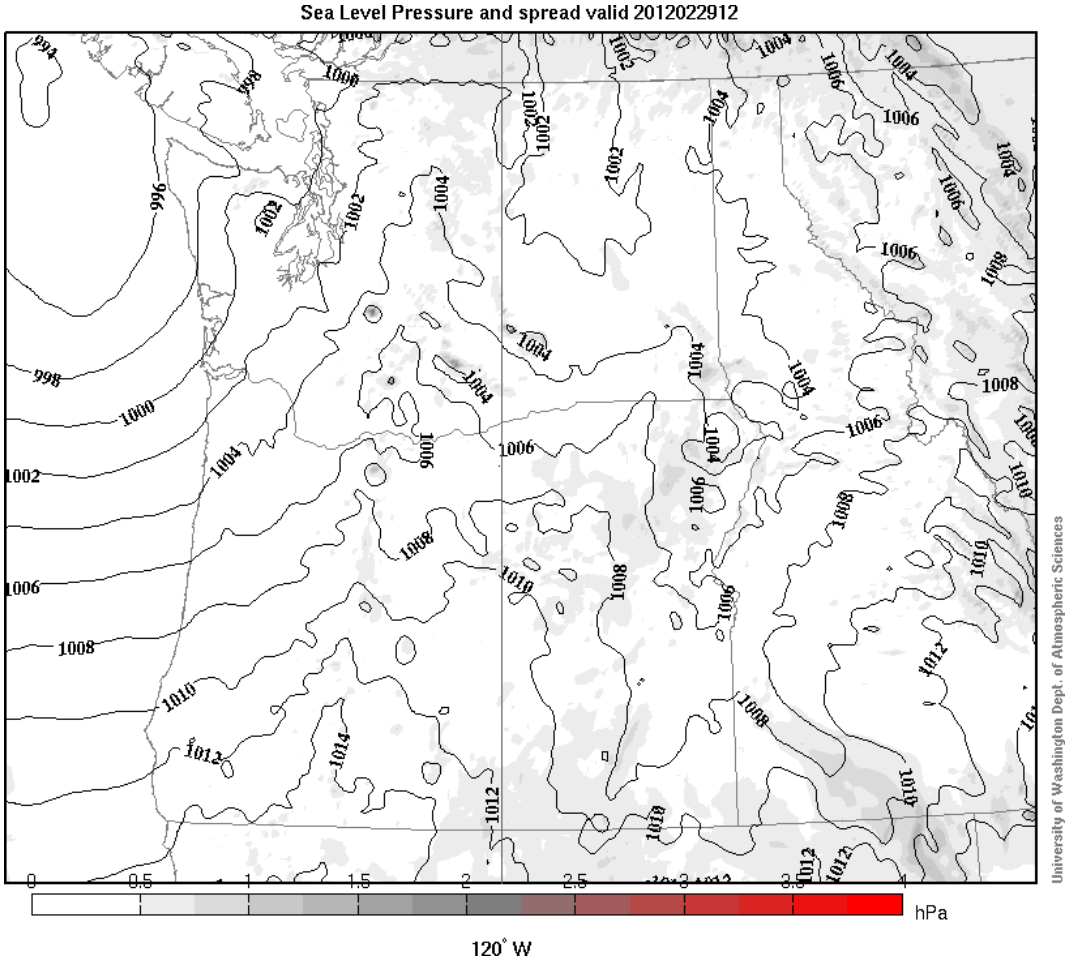
The Winner



Regional Data Assimilation and Forecasting



4 km analyses



Gridded Output Is Provided to Regional Users

- Regional NWS Offices
- Private Sector firms
- To drive real time, air quality, ocean models, hydrological, wildfire, and other models.

King-5 TV Futurecasts Driven by UW WRF

WSU Air Quality Modeling

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Air-quality forecasting for the Pacific Northwest
AIRPACT

AIRPACT Home
Graphics Products
LAR Home

Intro to AIRPACT
Domain
Collaborators
Background
Change Log
News
Disclaimer
Contact

Activities/Related Programs:

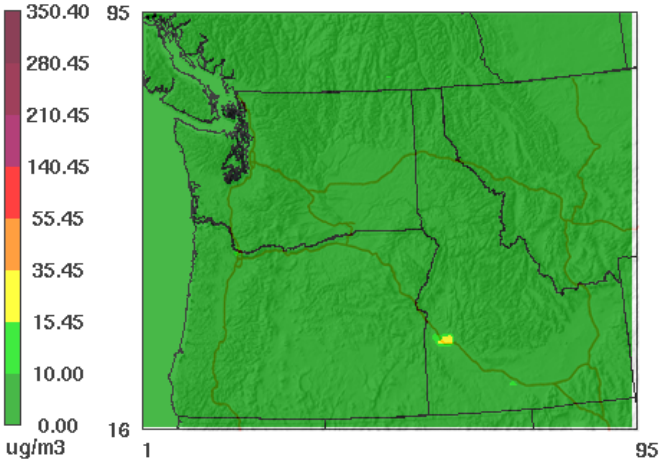
NW-AIRQUEST
AIRNow
BioEarth
BlueSky
CEREO
ClearSky
WRF Forecasting
NSPIRE
WSU Laboratory for Atmospheric Research

Today's PM2.5 Modeling Prediction

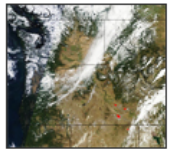
(click here for today's OZONE modeling prediction)

AQI-colored Rolling 24-hr Avg PM2.5

from two AIRPACT-3 CMAQ runs:
2012041600 and 2012041700



April 19,2012 2:00:00 (PST)
Min= 0.19 at (14,70), Max= 21.85 at (60,33)



Daily MODIS imagery

Flash Animation Products

Managing Field Burning

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

A dispersion forecasting system supported by NW-AIRQUEST
ClearSKY

ClearSKY Home
Visitor's Area
LAR Home

Function
Technical Description
Timing
Disclaimer
Project Contacts
User-Prescribed Burn Scenarios (pwd protected)

Activities/Related Programs:

NW-AIRQUEST
AIRPACT
BlueSky
EI Web Center
WRF Forecasting
WSU Laboratory for Atmospheric Research

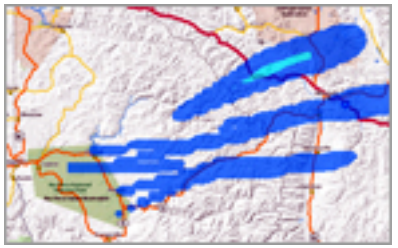
ClearSky dispersion forecasting system for management of agricultural field burning smoke in the Pacific Northwest.

Burn Locations:

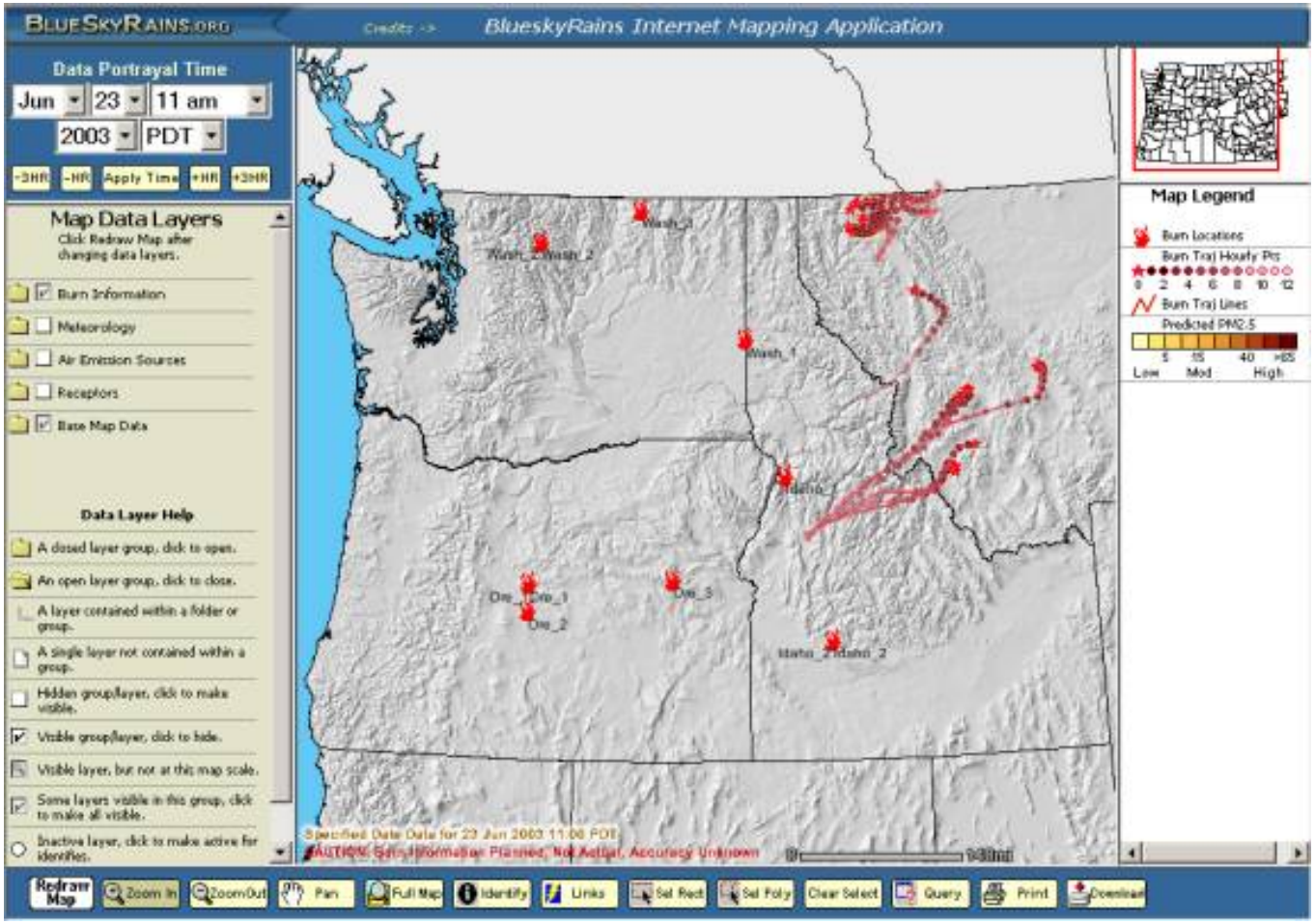
- Eastern Washington
- Northern Idaho
- Clearwater & Nez Perce Reservation
- Boundary County

Burn Scenarios:

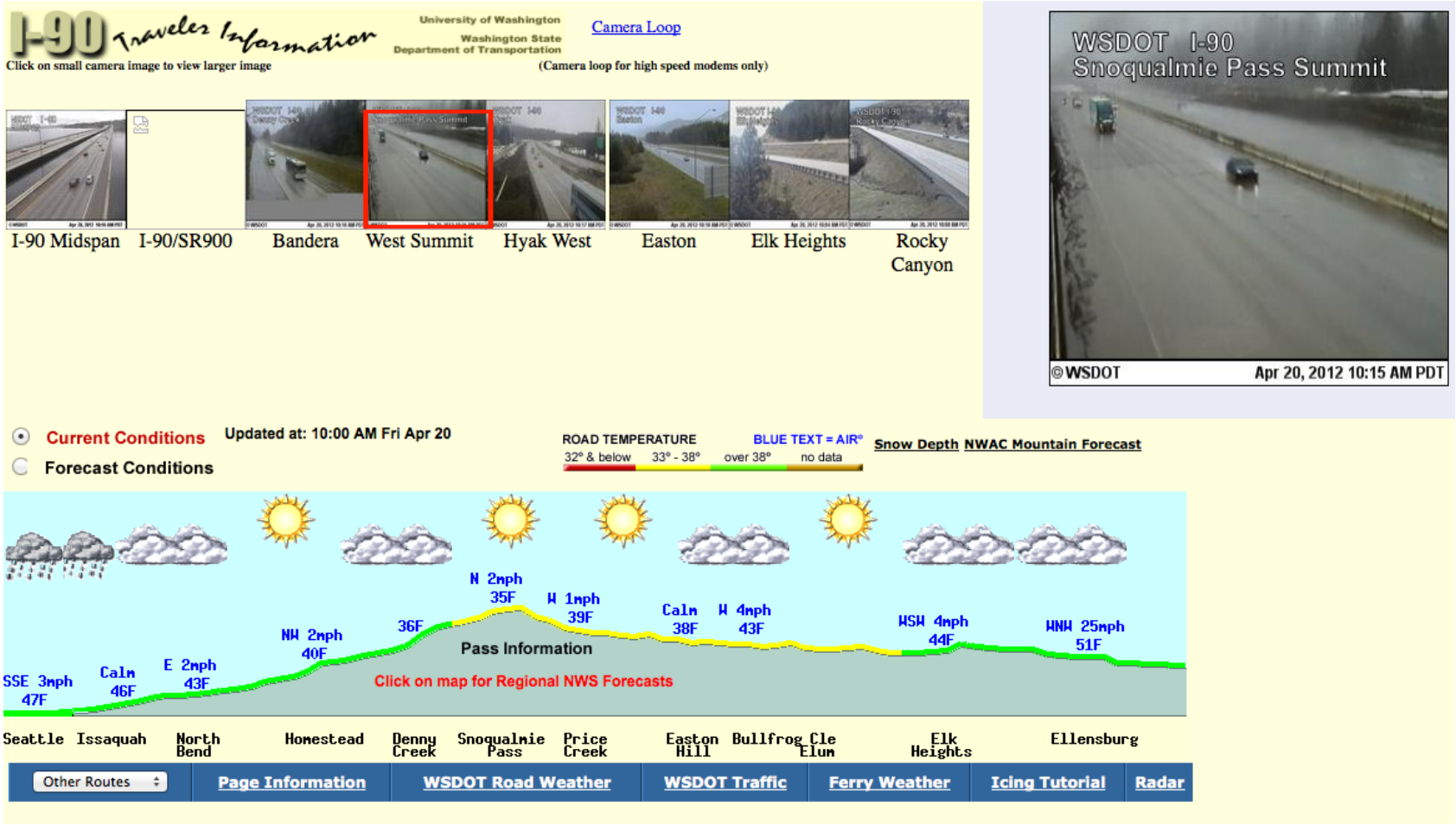
- Default user-prescribed burn scenarios (password protected)



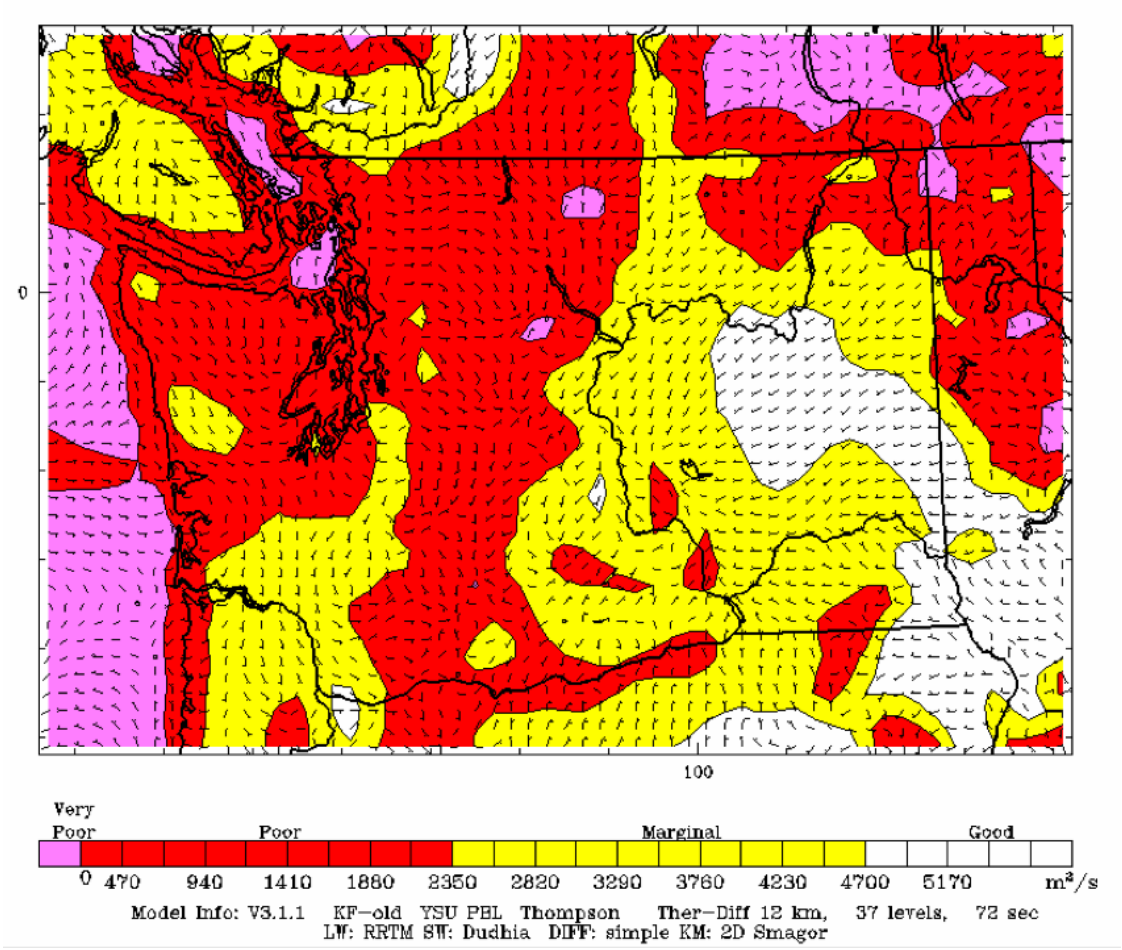
U.S. Forest Service



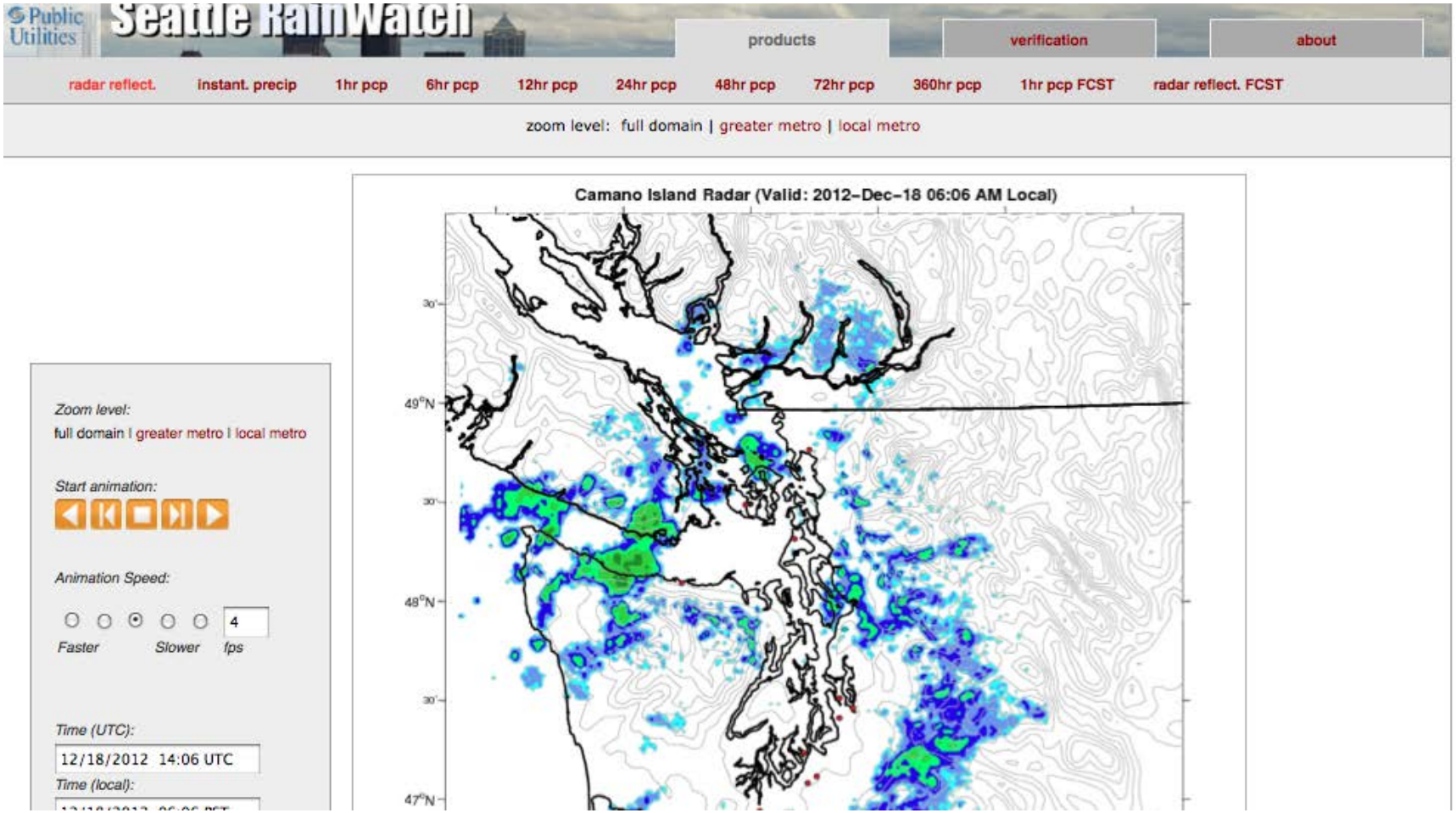
WSDOT


I-90 Traveler Information
University of Washington
Washington State Department of Transportation
Camera Loop
Click on small camera image to view larger image
(Camera loop for high speed modems only)
I-90 Midspan
I-90/SR900
Bandera
West Summit
Hyak West
Easton
Elk Heights
Rocky Canyon
WSDOT I-90
Snoqualmie Pass Summit
©WSDOT
Apr 20, 2012 10:15 AM PDT
Current Conditions
Updated at: 10:00 AM Fri Apr 20
Forecast Conditions
ROAD TEMPERATURE
BLUE TEXT = AIR°
32° & below
33° - 38°
over 38°
no data
Snow Depth
NWAC Mountain Forecast
SSE 3mph 47F
Calm 46F
E 2mph 43F
NW 2mph 40F
36F
N 2mph 35F
W 1mph 39F
Calm 38F
W 4mph 43F
WSW 4mph 44F
WNW 25mph 51F
Pass Information
Click on map for Regional NWS Forecasts
Seattle
Issaquah
North Bend
Homestead
Denny Creek
Snoqualmie Pass
Price Creek
Easton Hill
Bullfrog
Cle Elum
Elk Heights
Ellensburg
Other Routes
Page Information
WSDOT Road Weather
WSDOT Traffic
Ferry Weather
Icing Tutorial
Radar

Ventilation Index for AQ Agencies



WeatherApps

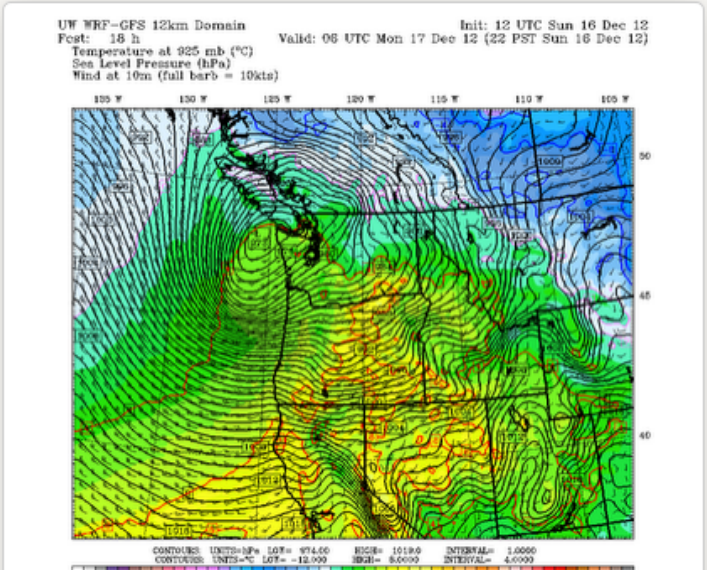


Social Media Outreach: the Blog

Big Storm: But the Worst South of Seattle

The most powerful storm of the season will hit the Northwest tonight and tomorrow AM, but the strongest winds will be over southwestern Washington and northeast Oregon.

Each run of our computer models have been moving the low southward, and particularly the areas of big pressure gradients, which are associated with high winds. Let me show you a sequence of pressure forecasts from the UW WRF model for 10 PM tonight, 1 AM tonight, and 4 AM tomorrow morning. At 10 PM a 973 hPa low is offshore our coast, but the area of very large pressure gradient (change) is offshore and swings towards the Oregon coast. Expect big winds (gusts above 50 mph) along the Oregon coast at this time.



Daily Hit Rate: cliffmass.blogspot.com

Ensemble General Comments

- Filling the 4D datacube (or EarthCube?) is only half the problem.
  - Getting users to take advantage of probabilistic information effectively is the harder problem.
- Ensembles are not the only way to get probabilistic information (e.g., analog/reforecasting, MOS)
- Post-processing is a huge part of the problem.

DataCube Directions

- We have a choice between two options:
  - **DataCube Interactive**
  - **DataCube Grande**

DataCube Interactive

- Better software for viewing, manipulating, and exploring model output and data.
- More convenient archival of ensemble output
- Improved data formats, metadata, and data structures.
- Weather and climatological data access still has problems. Example: ask a question: when is the windiest time of the year in Denver. How would you get the answer?
- If DataCube Interactive is the priority, we need a meeting focused on it. Including demonstrations of real world analysis/problem solving. Cultural change is needed.

DataCube Interactive

- If you create it, they might not use it. Or use it effectively.

DataCube Grande

- Dealing with serious and long-standing issues that are slowing or undermining the community's ability to:
  - Produce high quality probabilistic analyses and forecasts.
  - Effectively and efficiently make scientific progress.

DataCube Grande

- Probabilistic Prediction Initiative
  - Bring the community together to work effectively as a team to foster rapid development of ensemble-based probabilistic prediction and to more progress on attendant scientific issues.
  - Includes a testbed facility and staff to serve as testing and scoreboard center
  - Organizing committee to oversee and prioritize efforts
  - Funding will support some Pis working directly on initiative goals.

DataCube Grande

- Creating a rationally designed observing system.
  - OSEs and OSSEs, plus adjoint/ensemble sensitivity approaches
  - How do we create an effective observing system for the least possible cost?
  - Organizing committee and grant funding to keep folks on track and directed.

DataCube Grande

- Once started, there would be a good chance to secure funding from other (non-NSF sources).

The END