

Regional Modeling Update

March 31, 2010

Some Major Initiatives

- Update to latest version of WRF 3.1.1
- Better verification , including monthly average graphics.
- Added 4/3 km domain.
- Tested full range of planetary boundary layer parameterizations.
- Developed new approaches to improving surface and near surface winds.
- Developed high resolution EnKF mesoscale data assimilation and forecasting system.
- Improvements in hardware and software systems.

Pacific Northwest Environmental Forecasts and Observations

Supported by the [Northwest Modeling Consortium](#)

High Resolution Model Forecasts

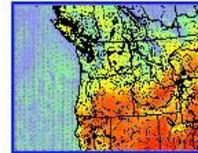
[More Information](#)
[Forecast](#)
[Graphics](#)
[Description](#)

WRF-GFS [36km 12km 4km](#) [Past Runs](#)

Status
finished with the 36 and 12 km domains,
4km to hr 32

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](#)

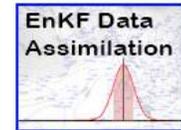
Status
complete

UW Ensemble Forecast System

[More Information](#)



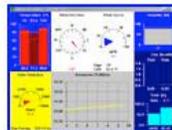
[Ensemble Forecasts](#)



[EnKF Analyses and Forecasts](#)

NW Regional Observations and Real Time Verification

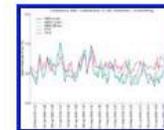
[More Information](#)



[NW Regional Observations](#)



[Observation Quality Control](#)



[Verification](#)

Regional Applications

[More Information](#)



[Transportation](#)



[Air Quality](#)



[Fire Weather](#)
[Airfire](#) [Bluesky](#)



[Hydrology](#)

Updated: Wed Feb 3 10:26:03 PST 2010

New Hardware

- We have acquired 8 nodes of the new Intel Newhalem processors (last week)..64 processors. They have the memory bandwidth that will allow much more effective use of resources
- These will be used to make high-resolution local data assimilation a reality for us (4-km), making use of as much of our local observations as possible.
- Exhausting enclosure for the last cluster. Hot air all heading outside.
- Replaced an old (failing) RAID disk storage array.
- System has been very, very stable





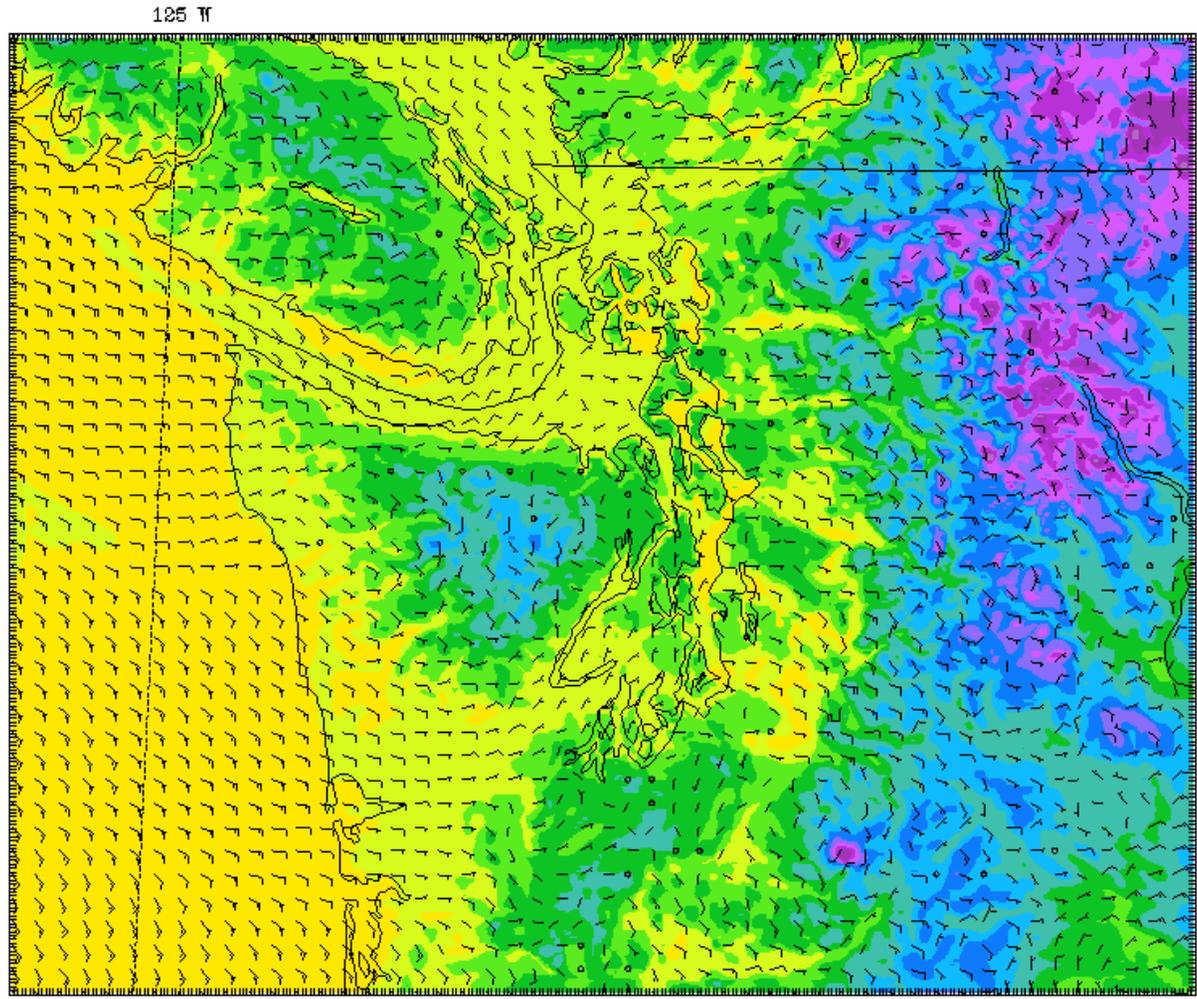
Major Changes and Improvements

- Beginning with the 2009123100 run, the WRF-GFS has switched to the latest version (3.1.1.)
 - Bug fixes in several of parameterizations we use.
 - Thompson microphysical scheme is now double moment in rain as well as ice (number concentration as well as mixing ratio calculated). This may help with a major issue...our light rain starts too late.
 - Lot more pbl options
 - Gravity wave drag parameterization.
 - More stable.

High Resolution 1.33 km Nest

- Western WA only used for evaluation, but later can be expanded or moved to where most needed.
- Once a day (0000 UTC cycle) to 36 h right now
- Uses the gap period after we finish all the real-time work on SAGE.
- Attempt to answer questions:
 - What is the payoff in getting the land-water boundaries and smaller scale terrain much better.
 - Does ultra high resolution improve objective verification or subjective structures?
 - Do optimal physics options change at ultra high resolution?

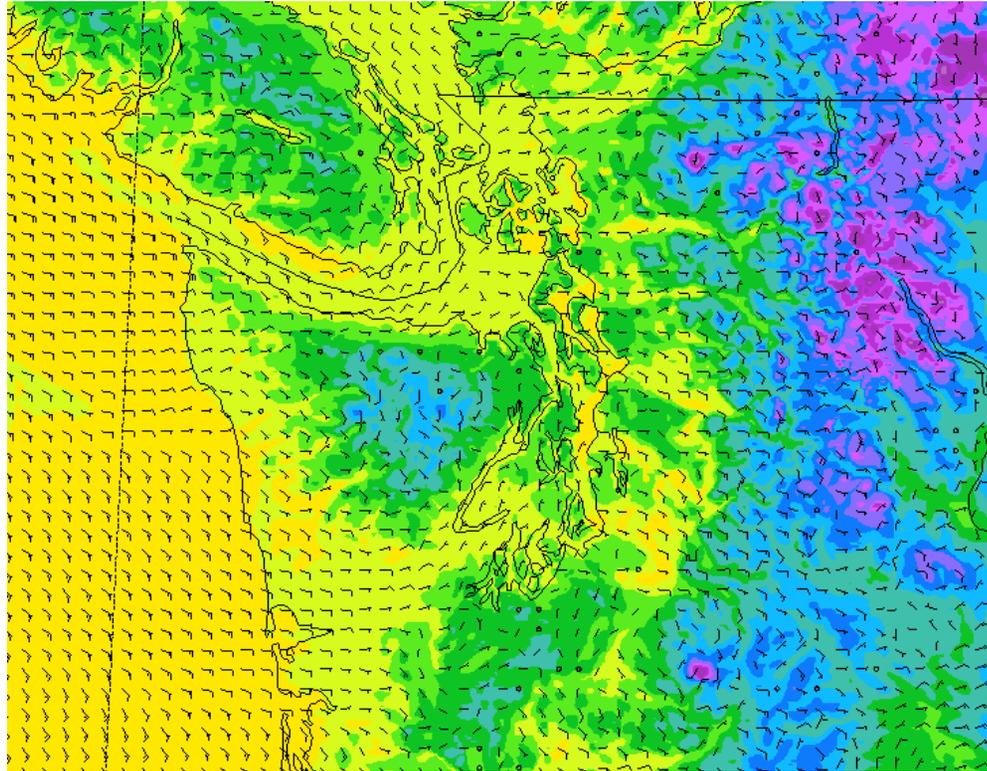
UW WRF-GFS 1.33km Domain Init: 00 UTC Wed 03 Feb 10
Fest: 12.00 h Valid: 12 UTC Wed 03 Feb 10 (04 PST Wed 03 Feb 10)
2m Temperature (°F) ----- 10m Wind (full barb = 10kts)



BARB VECTORS: FULL BARB = 10 kts

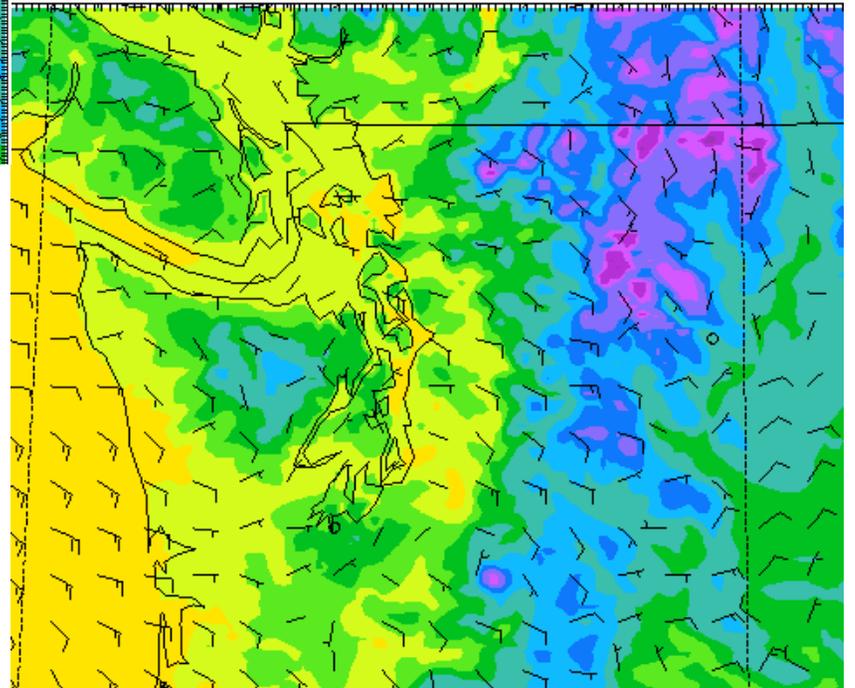


Model Info: V3.1.1 KF YSU PBL Thompson Noah LSM 1.3 km, 37 levels, 8 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor

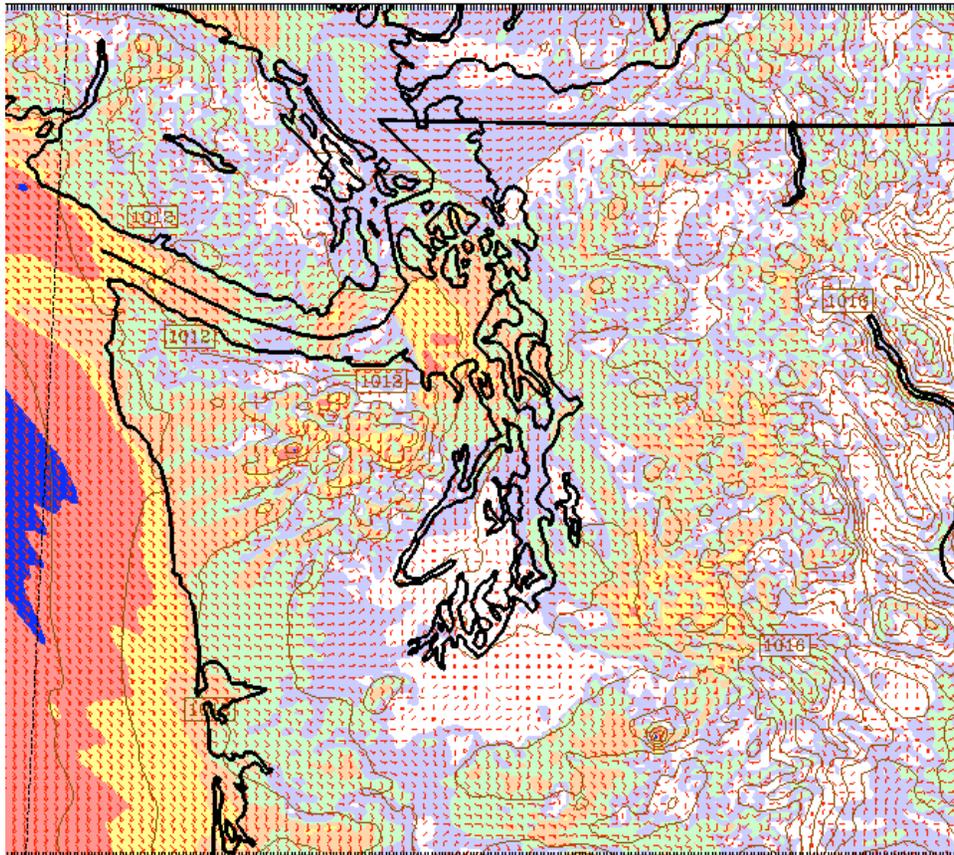


1.3

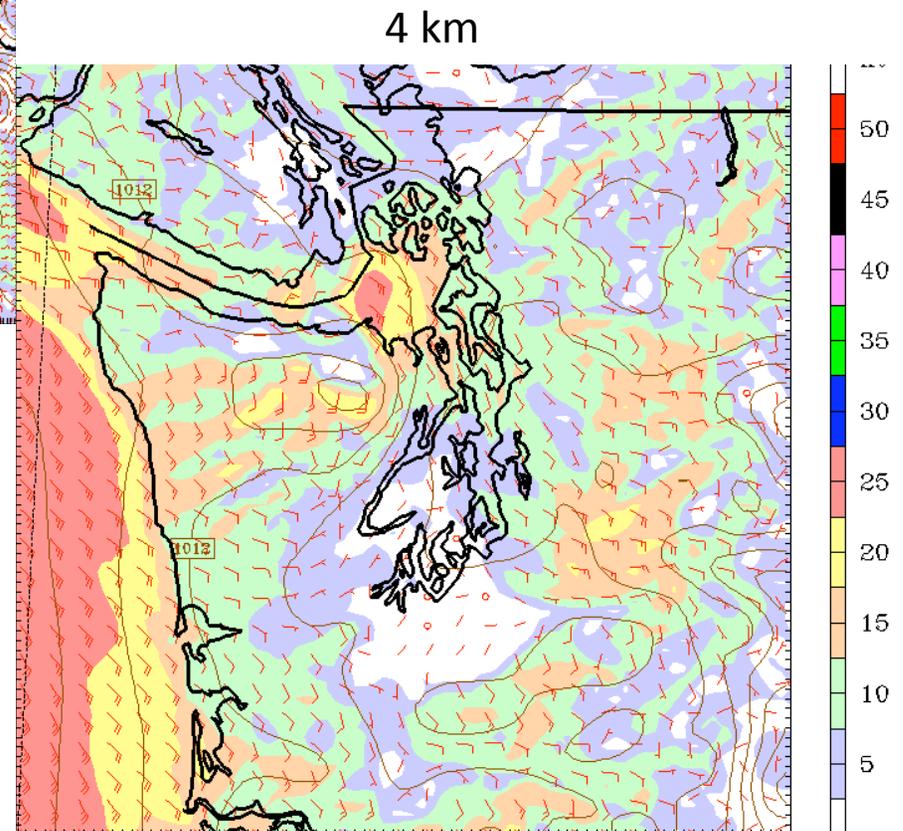
4 km



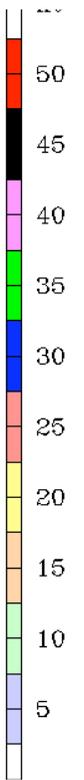
6-hr forecast, 10m wind speed and direction



1.3 km



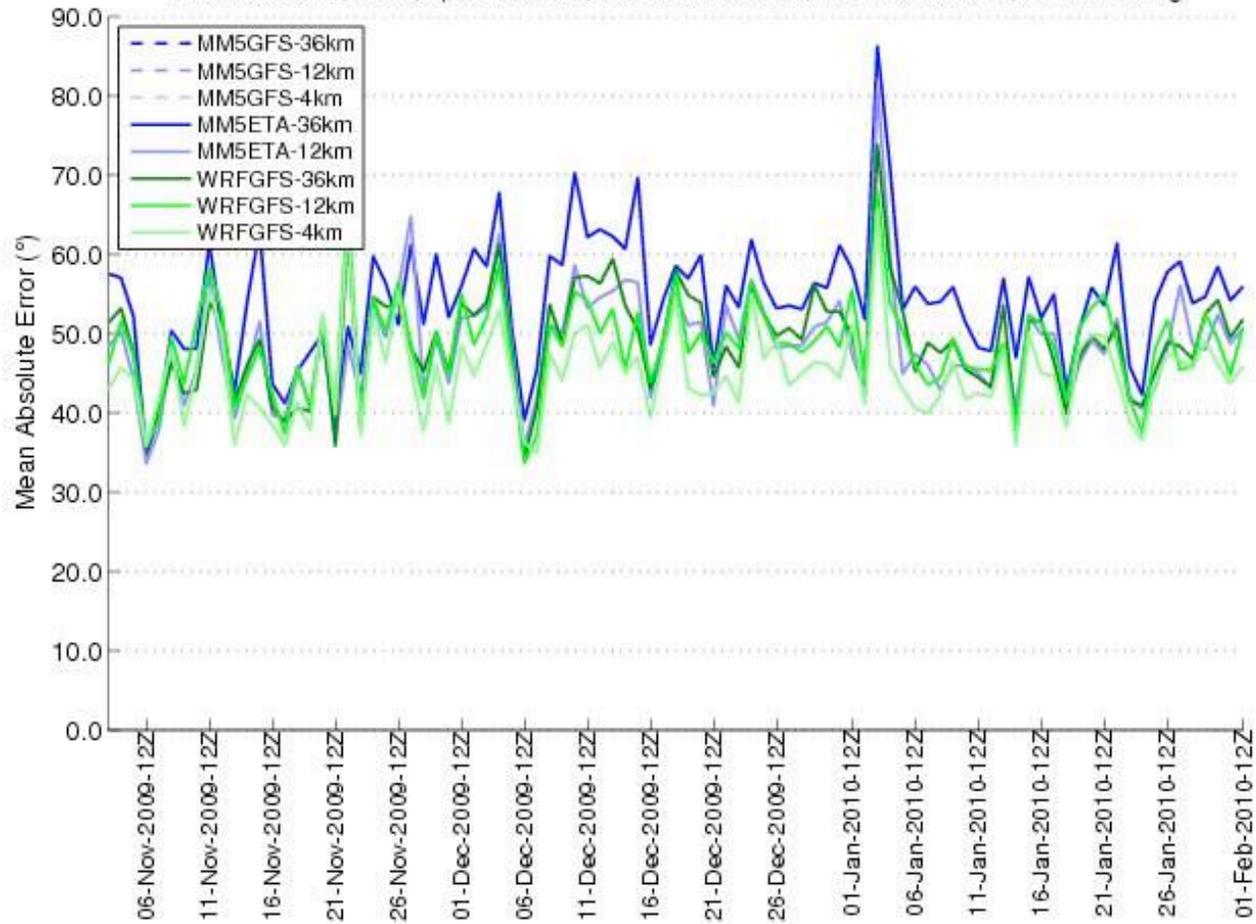
4 km



Verification Tools

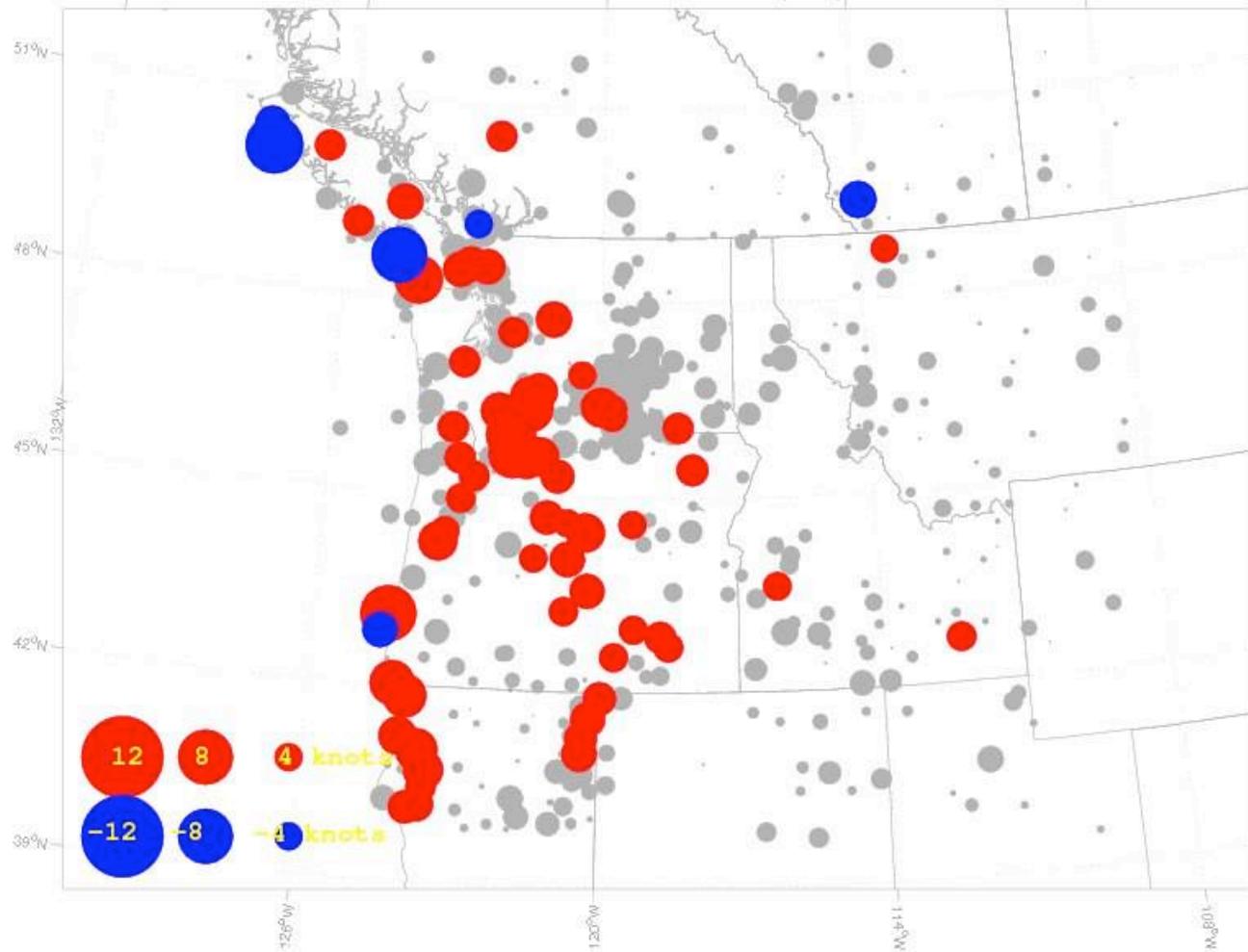
- A key aspect of our efforts has been comprehensive continuing verification based on roughly 70 surface networks, plus available upper air data.
- Reveals in real time strengths and weaknesses of our system which we try to address.
- Helps optimize the modeling system for our region.

Wind Direction, MAE, spd > 3 knots, Forecast Hour 24, 12Z Initialization, no smoothing

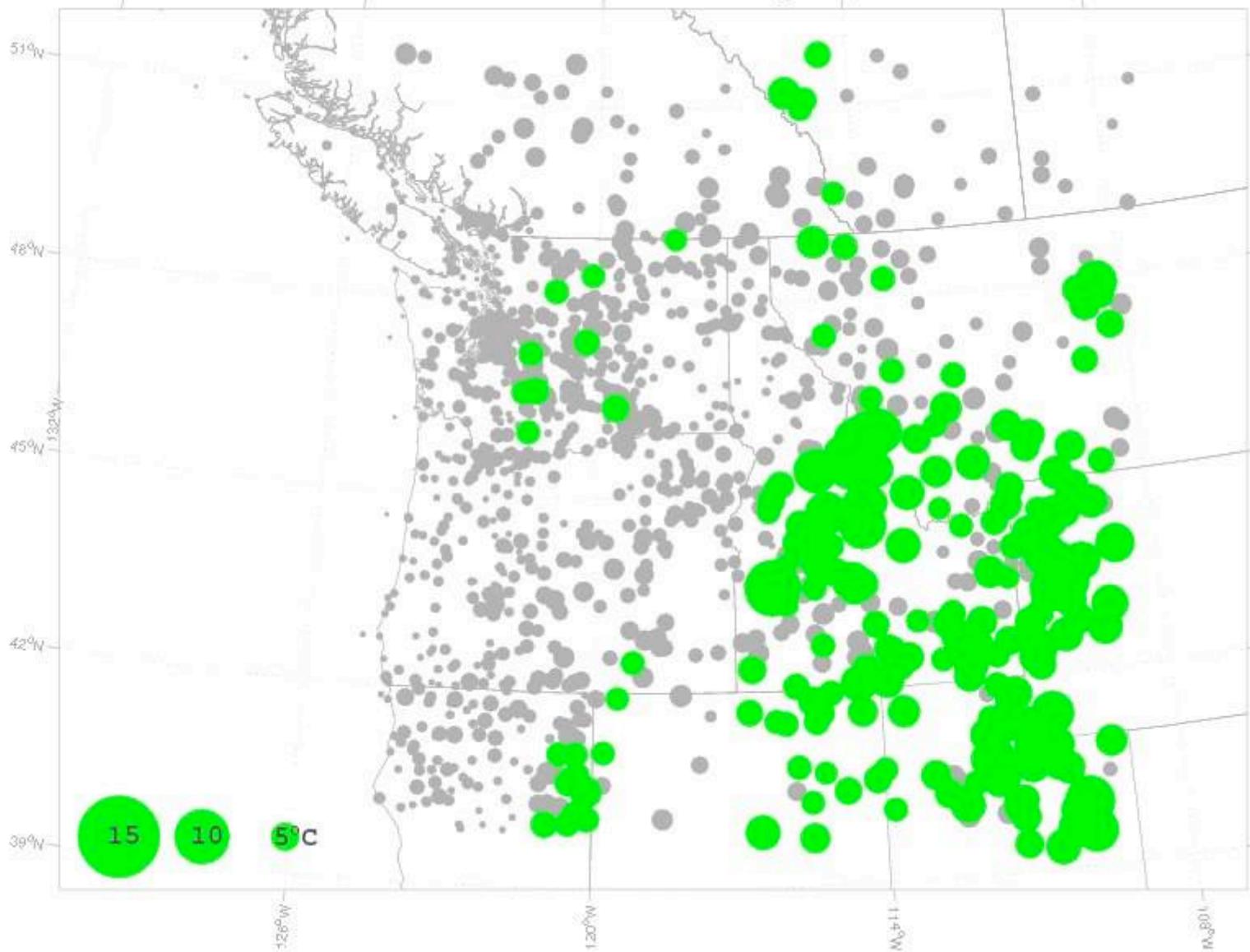


New Verification Tools: Monthly Average Graphics and Statistics

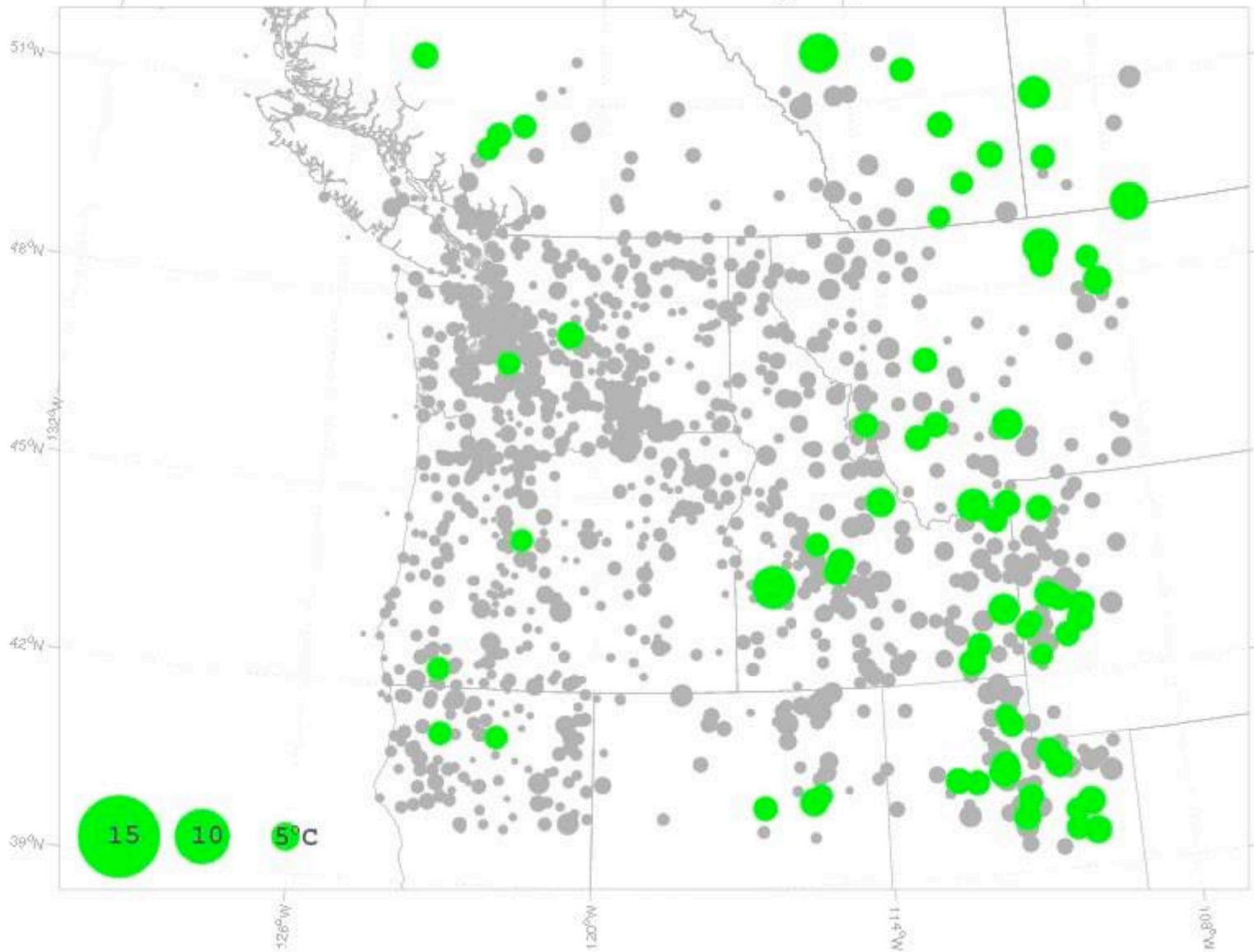
Average MEs, 10-m Wind Speed, WRFGFS-12km, 01-Feb-2010 - 28-Feb-2010, 00Z, fhr 24
Mean Error < -4 knots (blue)
Mean Error > 4 knots (red)



Average MAEs, Temperature, WRF-GFS-12km, 01-Feb-2010 - 28-Feb-2010, 00Z, fhr 24
Mean Abs Error $\geq 0^{\circ}\text{C}$ and $< 4^{\circ}\text{C}$ (gray)
Mean Abs Error $\geq 4^{\circ}\text{C}$ (green)



Average MAEs, Temperature, WRFGFS-12km, 01-Feb-2010 - 28-Feb-2010, 00Z, fhr 36
Mean Abs Error $\geq 0^{\circ}\text{C}$ and $< 4^{\circ}\text{C}$ (gray)
Mean Abs Error $\geq 4^{\circ}\text{C}$ (green)



Verification Driving Model Changes

- We have been diagnosing the problem of a cold bias for the max temps that started with the update WRF and found it associated with the “improved” WRF Land Surface Model (LSM).
- Problem is most profound inland over higher terrain.
- Have found that going back to the old 5-layer soil model will greatly improve surface temperature statistics.

Major Lower Tropospheric Issues of Importance to the AQ Community

- WRF mixes too much in the vertical and has particular problems for shallow stable boundary layers.
- Excessive wind speeds over land
- Winds over land and water too similar
- Excessive geostrophy at the surface
- Moisture (and I assume pollutants) mix out too quickly in stable situations.

Threw the kitchen sink at it

- Tried a range of PBL schemes (YSU, QNSE, ACM2, MYNN, MYJ, MYJ with Stauffer mods)
- Added 6th order diffusion and played with diffusion coefficient.
- Fully, interactive nesting
- Upper level diffusion and gravity wave drag
- Monotonic advection
- Varying vertical diffusion, both more and less

Our conclusion

- Hundreds of runs with all available PBL schemes revealed no magic bullet.
- Recently, we tried two things that really looks like they have the potential to help greatly...increasing the friction velocity...ustar..and reducing vertical diffusion in the model.

stdnocuqn2 1.33km Domain

Init: 12 UTC Sat 07 Nov 09

Fcst: 9.00 h

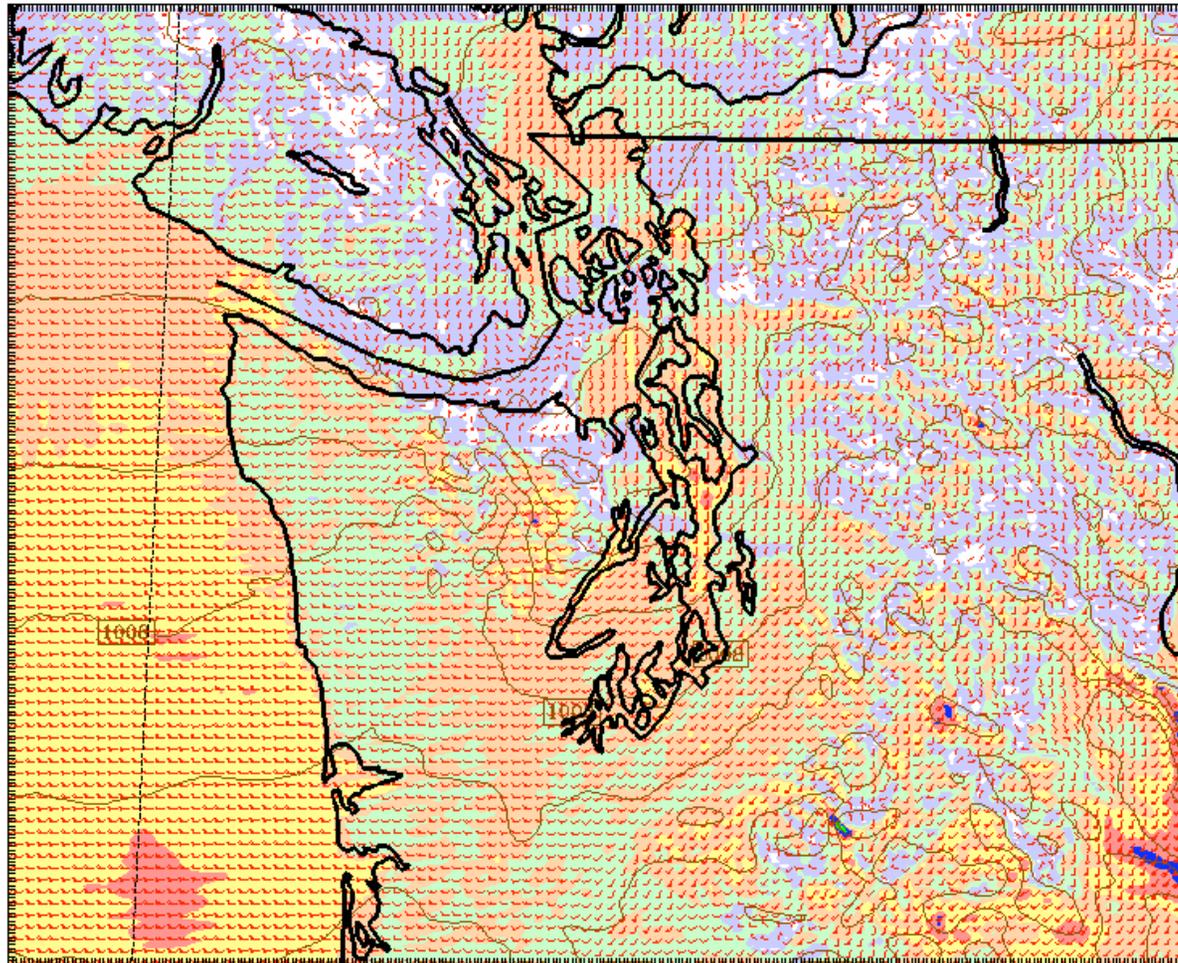
Valid: 21 UTC Sat 07 Nov 09 (13 PST Sat 07 Nov 09)

10m Wind Speed (knots)

Wind at 10m (full barb = 10kts)

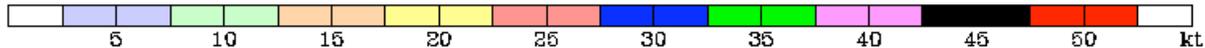
Sea Level Pressure (hPa)

125 W



CONTOURS: UNITS=hPa LOW= 1005.0 HIGH= 1011.0 INTERVAL= 1.0000

BARB VECTORS: FULL BARB = 10 kts



Model Info: V3.1 No Cu YSU PBL Thompson Noah LSM 1.3 km, 37 levels, 8 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor

Increasing USTAR

wrfv311ustar4 1.33km Domain

Init: 12 UTC Sat 07 Nov 09

Fcst: 9.00 h

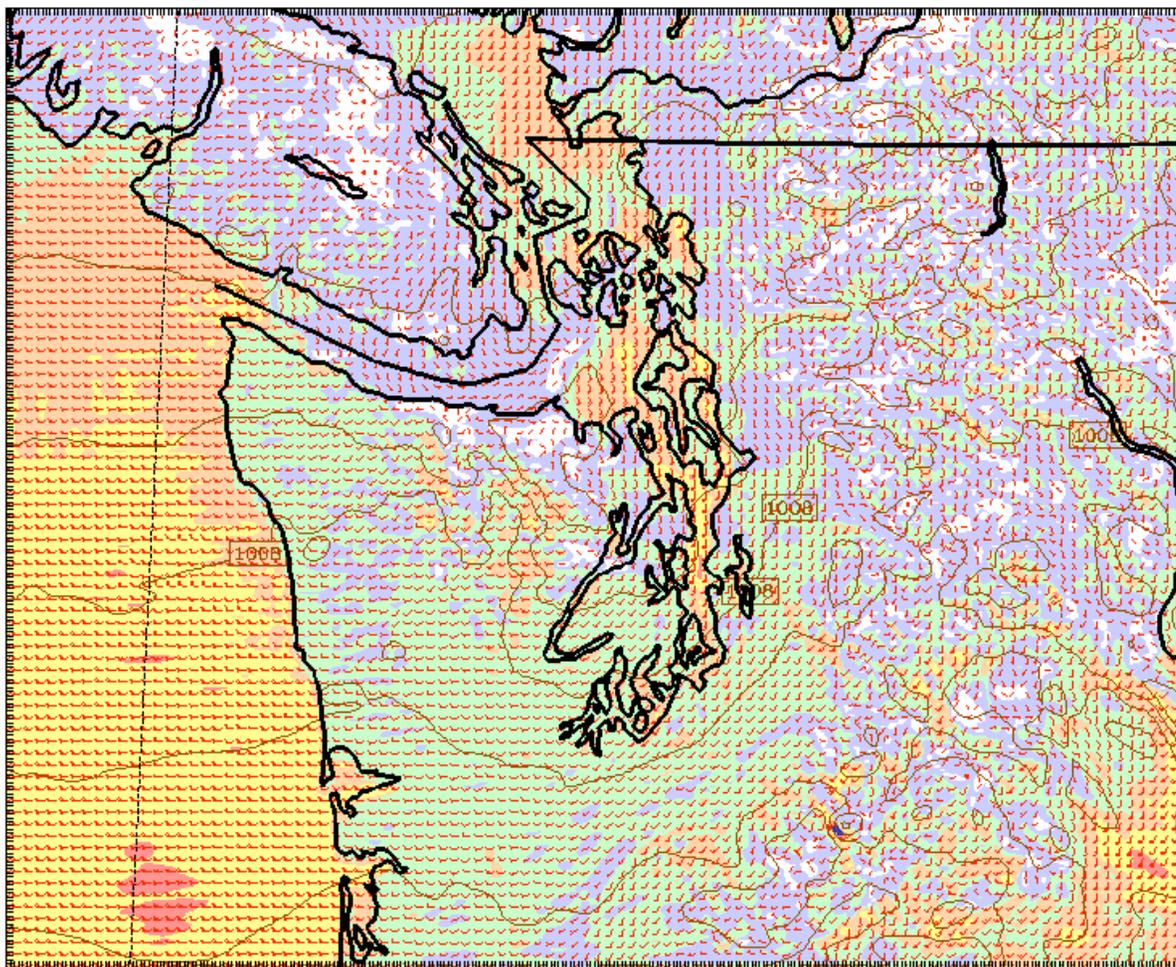
Valid: 21 UTC Sat 07 Nov 09 (13 PST Sat 07 Nov 09)

10m Wind Speed (knots)

Wind at 10m (full barb = 10kts)

Sea Level Pressure (hPa)

125 W

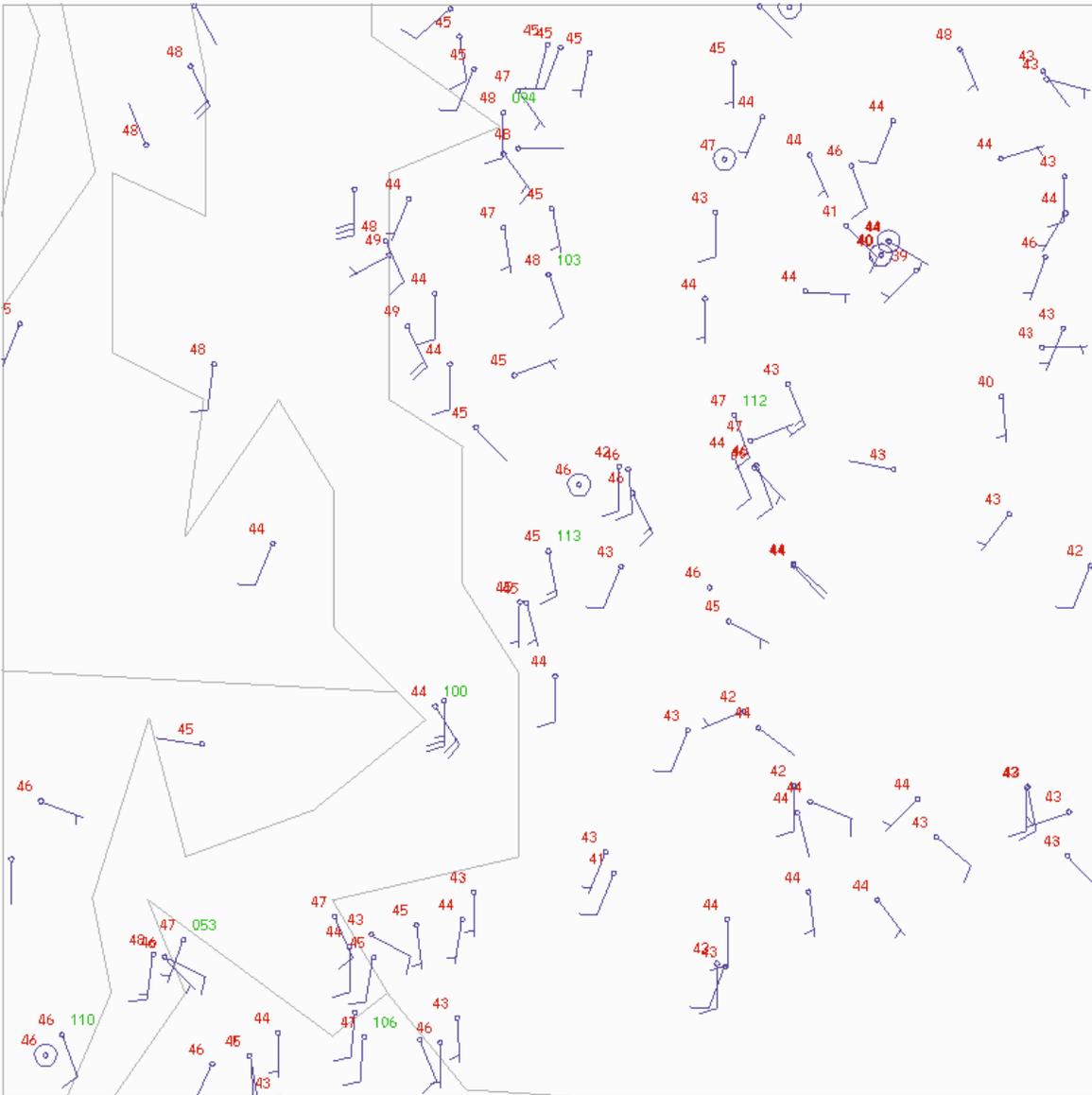


CONTOURS: UNITS=hPa LOW= 1006.0 HIGH= 1012.0 INTERVAL= 1.0000

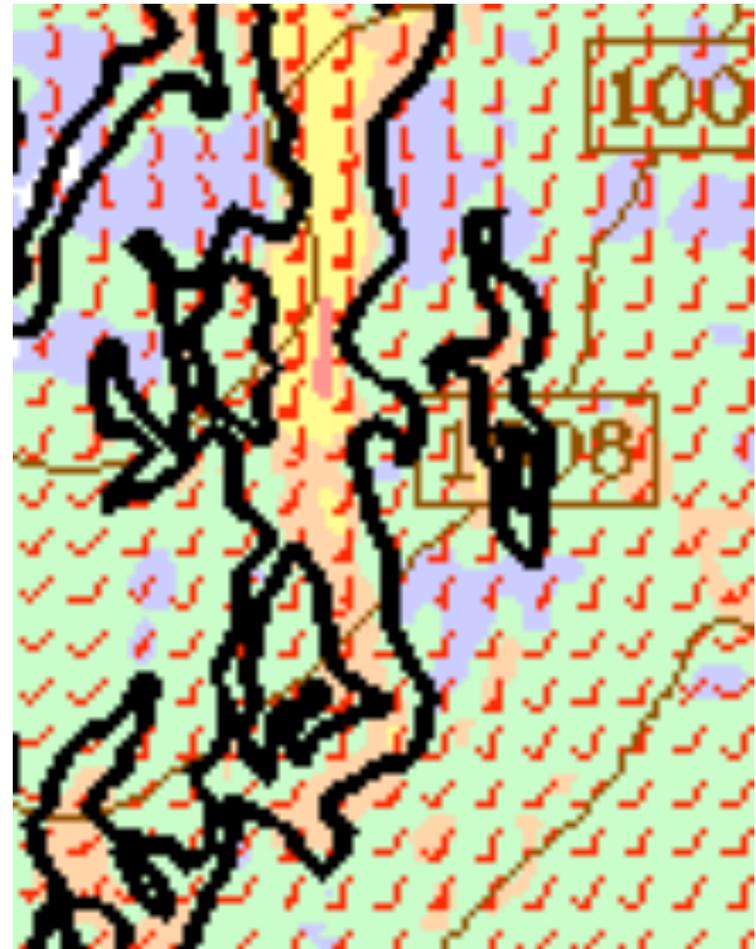
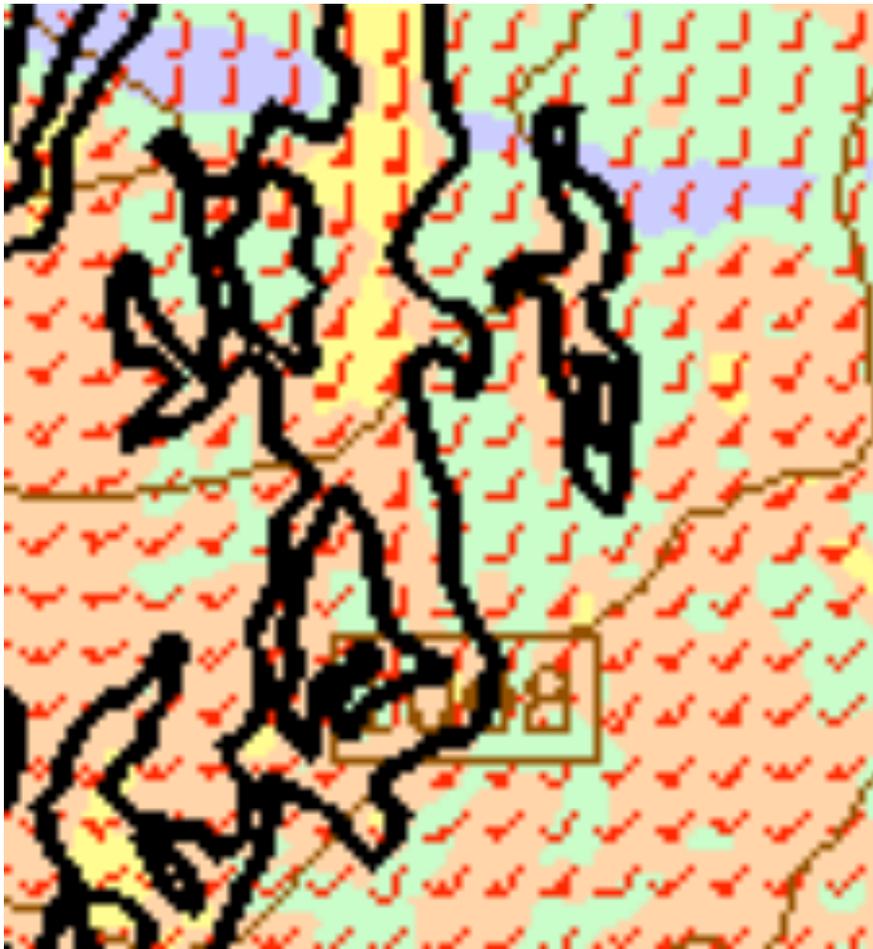
BARB VECTORS: FULL BARB = 10 kts



Model Info: V3.1.1 No Cu YSU PBL Thompson Noah LSM 1.3 km, 37 levels, 8 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor



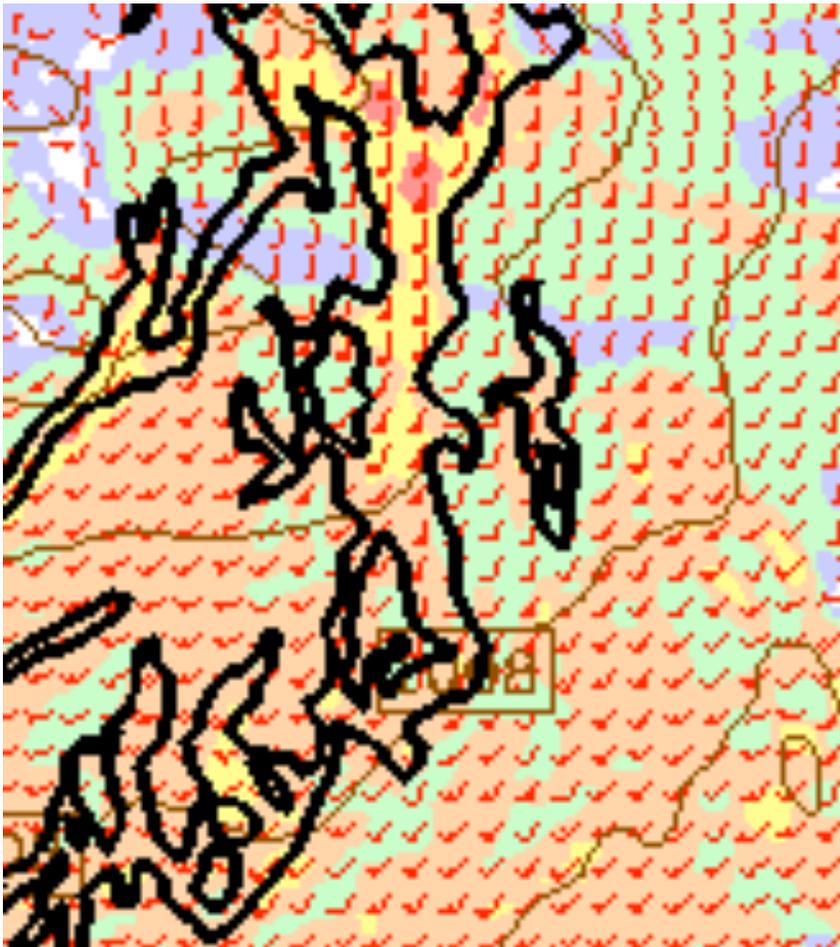
07 NOV 09 2100Z



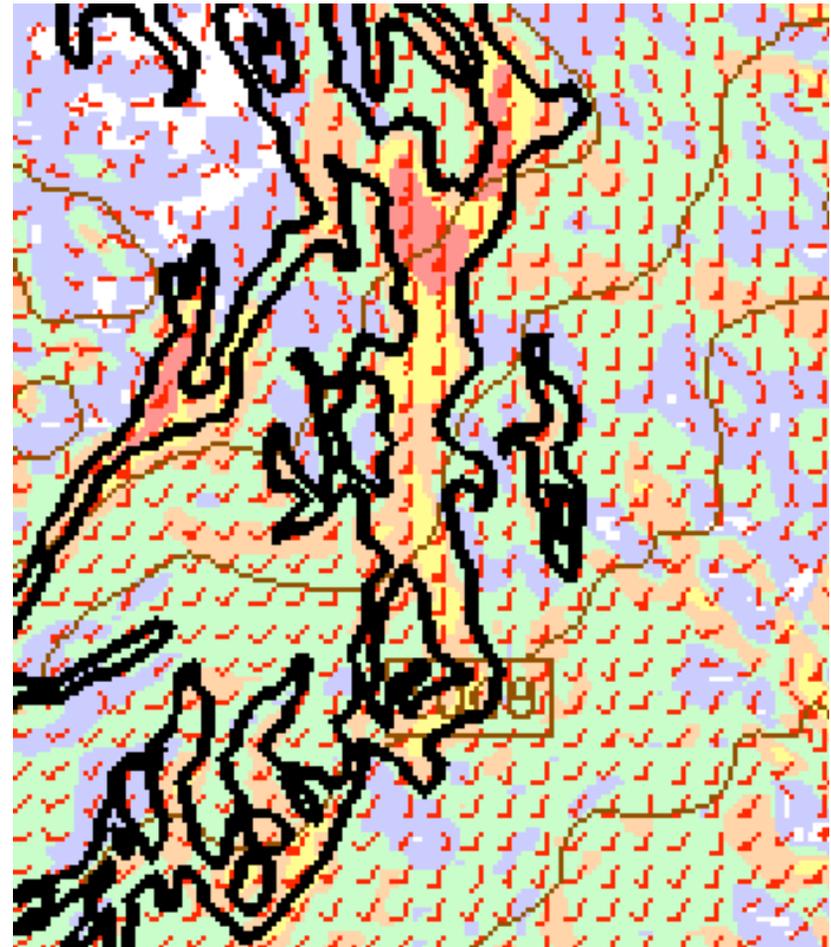
BARB VECTORS: FULL BARB = 10 kts



BARB VECTORS: FULL BARB = 10 kts



Standard



Low Vertical Diffusion

We have done one-month evaluations of various combinations of increasing ustar and reducing vertical diffusion

- Appears that we can greatly improve our lower tropospheric winds and lessen the over-mixing
- Target date for change: April 30.

Some Statistics from the Tests

```
12-hr Forecast 12 UTC (4 am PST) 12-km verification statistics for SA stations
Field          ME    MAE    RMS    STDEV  COUNT  Case
dir10m         14.55 63.44 82.60 81.31   9221  wrfv311u3s2d2_201000.12.diffs.stats2
dir10m         14.61 63.48 82.63 81.33   9221  wrfv311u3s2oldlsmld2_201000.12.diffs.stats2
dir10m         15.88 63.83 82.98 81.46   9221  wrfv311ustar3d2_201000.12.diffs.stats2
dir10m         15.46 64.34 83.39 81.95   9221  wrfv311ovensld2_201000.12.diffs.stats2
dir10m         15.44 64.98 84.01 82.58   9221  wrfv311stauffer3d2_201000.12.diffs.stats2
dir10m         16.98 65.07 84.10 82.37   9221  wrfv311ustar4d2_201000.12.diffs.stats2
dir10m         16.76 66.07 84.98 83.32   9221  wrfv311stauffer2d2_201000.12.diffs.stats2
dir10m         19.25 67.35 86.13 83.96   9221  wrfgfsd2_201000.12.diffs.stats2
dir10m         19.03 67.52 86.26 84.14   9221  wrfapr08d2_201000.12.diffs.stats2

wsp10m         0.14  3.47  4.70  4.69   9331  wrfv311ustar3d2_201000.12.diffs.stats2
wsp10m        -0.44  3.50  4.80  4.78   9331  wrfv311u3s2d2_201000.12.diffs.stats2
wsp10m        -0.44  3.50  4.80  4.78   9331  wrfv311u3s2oldlsmld2_201000.12.diffs.stats2
wsp10m         0.41  3.58  4.81  4.79   9331  wrfv311ovensld2_201000.12.diffs.stats2
wsp10m         1.11  3.70  4.91  4.79   9331  wrfv311ustar4d2_201000.12.diffs.stats2
wsp10m         1.13  3.85  5.11  4.99   9331  wrfv311stauffer3d2_201000.12.diffs.stats2
wsp10m         1.89  4.09  5.39  5.04   9331  wrfv311stauffer2d2_201000.12.diffs.stats2
wsp10m         2.75  4.52  5.94  5.26   9331  wrfgfsd2_201000.12.diffs.stats2
wsp10m         2.84  4.57  6.01  5.30   9331  wrfapr08d2_201000.12.diffs.stats2
```

Legend of the tests

Case Name(s) namelist.input file namelist.input diff from std	Description
1. UW WRF-GFS std namelist.input	current standard run, with Kain-Frisch
2. wrfv311stauffer2 namelist.input diff from std	v3.1.1, halved vertical mixing coefficients K, no KF, no 6th order diffusion, new Q nudging
3. wrfv311stauffer3 namelist.input diff from std	v3.1.1, 1/4 vertical mixing coefficients K, no KF, no 6th order diffusion, new Q nudging
4. wrfv311ustar3 namelist.input diff from std	v3.1.1, Increased ustar (friction velocity) by factor of 2 only over land, no cumulus param, no 6th order diffusion, new Q nudging
5. wrfv311ustar4 namelist.input diff from std	v3.1.1, Increased ustar (friction velocity) by factor of 1.5 only over land, no cumulus param, no 6th order diffusion, new Q nudging
6. wrfv311ovens1 namelist.input diff from std	v3.1.1, Combination of wrfv311stauffer2 wrfv311ustar4: 1/2 vertical mixing coefficients and 1.5 times increase in ustar (friction velocity) only over land, no cumulus param, no 6th order diffusion, new Q nudging
7. wrfv311u3s2 namelist.input diff from std	v3.1.1, Combination of wrfv311stauffer2 wrfv311ustar3: 1/2 vertical mixing coefficients and 2 times increase in ustar (friction velocity) only over land, no cumulus param, no 6th order diffusion, new Q nudging
8. wrfv311u3s2oldlsm1 namelist.input diff from std	v3.1.1, Combination of wrfv311stauffer2 wrfv311ustar3: 1/2 vertical mixing coefficients and 2 times increase in ustar (friction velocity) only over land and some modifications attempting to use older Noah LSM, no cumulus param, no 6th order diffusion, new Q nudging

Ensemble Kalman Filter Data Assimilation

- The goal of this project is to create very good mesoscale analyses using all available data assets.
- Based on running a large ensemble of analyses/forecasts
- These analyses are probabilistic.
- Also produces probabilistic forecasts.

Ensemble Kalman Filter

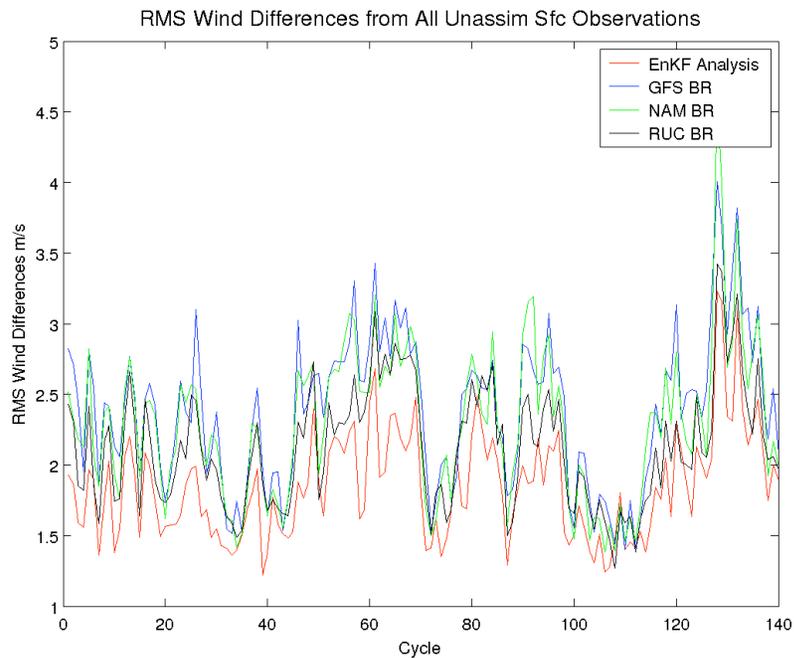
- During the fall, we tested the EnKF data assimilation system at 4 km resolution with a three hour update cycle.
- Results were promising, but it became clear we lacked the computational power to do this consistently and dependably (loss of a single node and we ran behind).
- We also lacked the resources to go to a one-hour cycle, which people want.

Some Initial Results

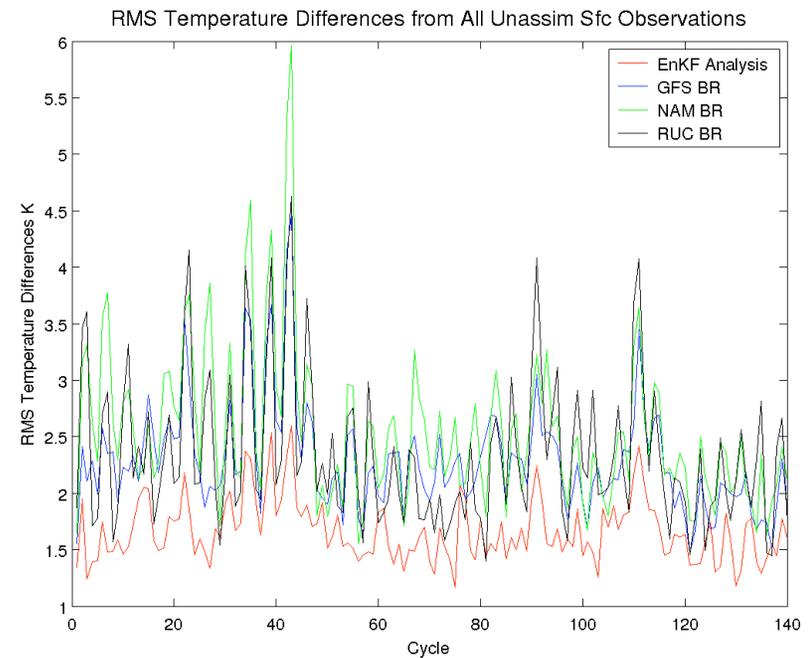
- With the help of Mike Gilroy we acquired new processors that greatly increase our potential.
- Just finished creating a system based on a 3-hr update with observations, using the NCAR DART system as the core.
- During the next few months we will optimize this system and will move towards a one-hour cycle.
- This information will be available for consortium application by the middle of the year.

EnKF 12-km vs. GFS, NAM, RUC

Wind



Temperature



RMS analysis

errors

GFS **2.38 m/s**
NAM **2.30 m/s**
RUC **2.13 m/s**
EnKF 12- **1.85 m/s**
km

2.28 K
2.54 K
2.35 K
1.67 K

WRF 4-KM ENKF

Init: 06 UTC Tue 30 Mar 10

Fest: 0 h

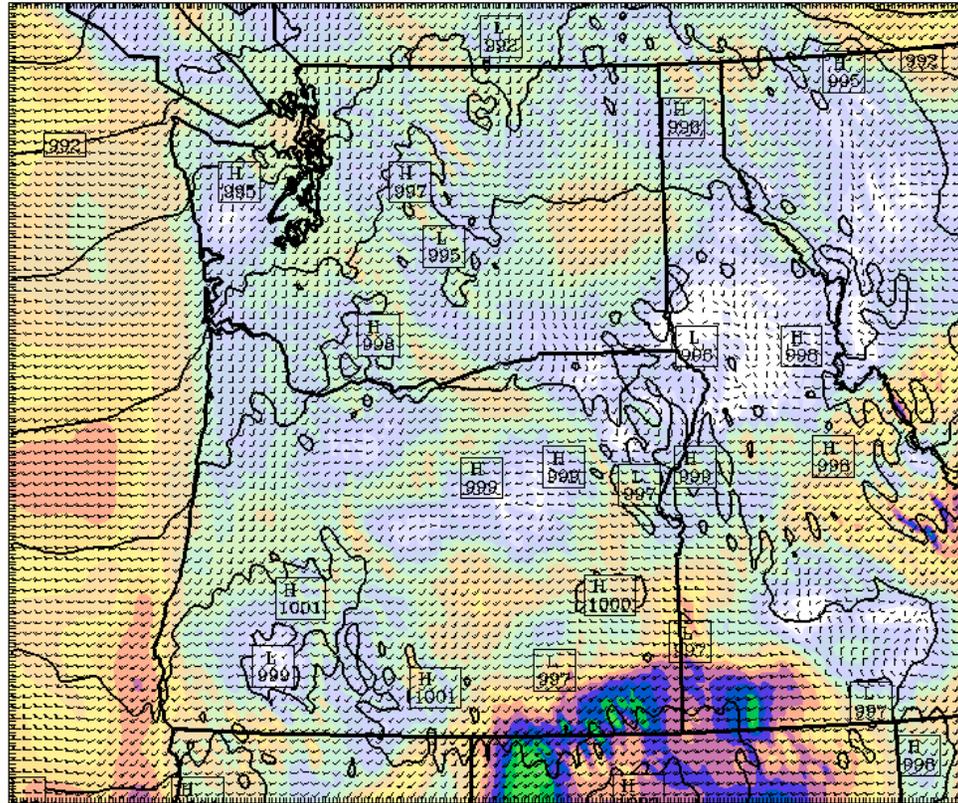
Valid: 06 UTC Tue 30 Mar 10 (22 PST Mon 29 Mar 10)

20-m Windspeed

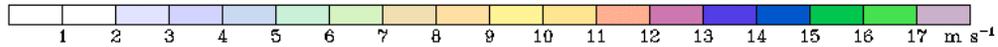
Sea Level Pressure (hPa)

Wind at 20m (full barb = 10kts)

120 W



CONTOURS: UNITS=hPa LOW= 990.00 HIGH= 1002.0 INTERVAL= 2.0000



Model Info: V3.0.1.1 KF YSU PBL WSM 3class Noah LSM 4.0 km, 37 levels, 25 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor

WRF 4-KM ENKF

Fcst: 3 h

20-m Windspeed

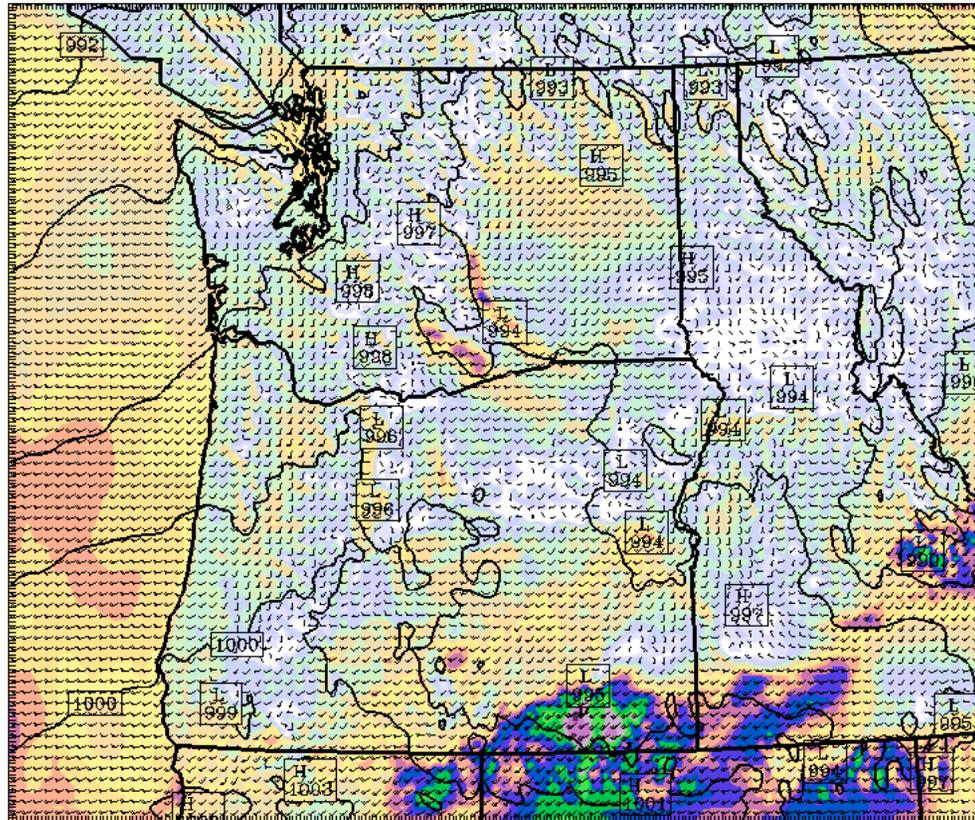
Sea Level Pressure (hPa)

Wind at 20m (full barb = 10kts)

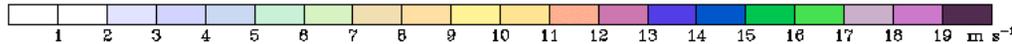
Init: 06 UTC Tue 30 Mar 10

Valid: 09 UTC Tue 30 Mar 10 (01 PST Tue 30 Mar 10)

120 W



CONTOURS: UNITS=hPa LOW= 990.00 HIGH= 1002.0 INTERVAL= 2.0000



Model Info: V3.0.1.1 KF YSU PBL WSM 3class Noah LSM 4.0 km, 37 levels, 25 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor

WRF 4-KM ENKF

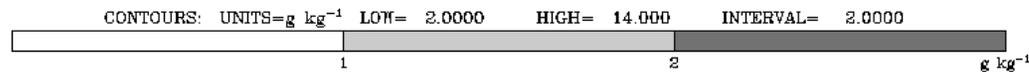
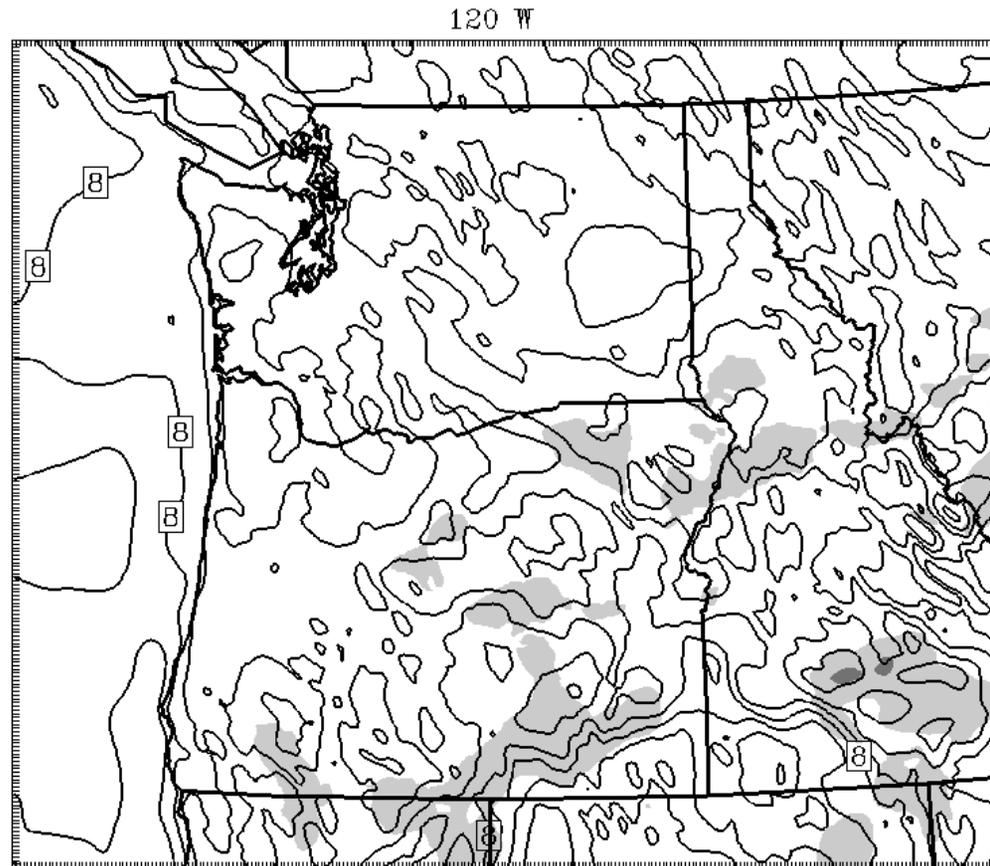
Init: 06 UTC Tue 30 Mar 10

Fcst: 0 h

Valid: 06 UTC Tue 30 Mar 10 (22 PST Mon 29 Mar 10)

Surface windspeed standard deviation (m/s)

Mean Surface Windspeed (m/s)



Model Info: V3.0.1.1 KF YSU PBL WSM 3class Noah LSM 4.0 km, 37 levels, 25 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor

The End