# WRF Problems: Some Solutions, Some Mysteries

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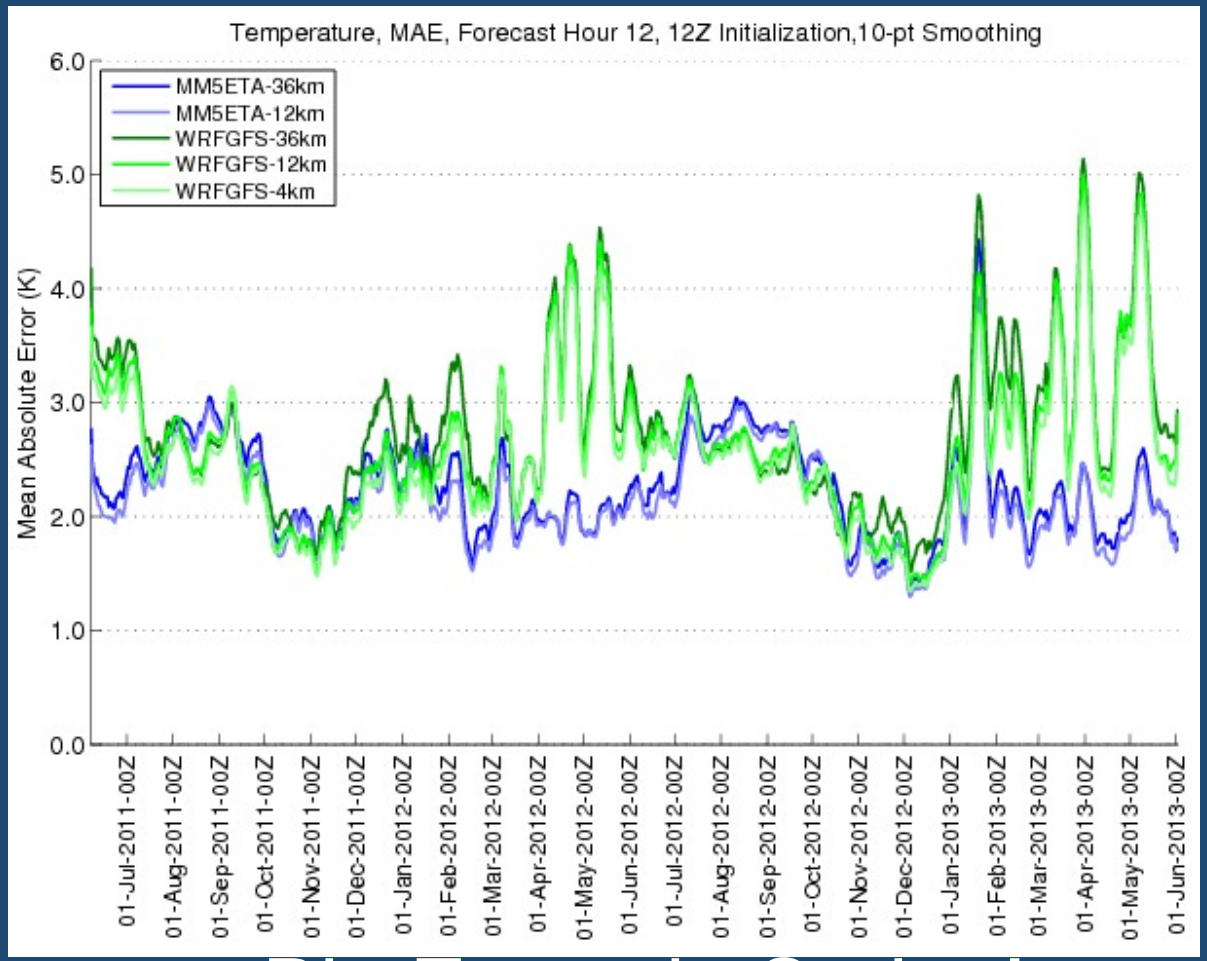
# WRF Still Has Some Significant "Issues"

- Unreasonably cold near-surface temperatures over snow.
- Strange linear features during low-stability periods over the oceans.
- Positive wind speed bias for low wind speeds.
- And more…
- For some issues, there are approaches for mitigation, for others, it is unclear what is wrong (at least to us!).

# Big Problem 1: WRF Air Temperatures Above Snow Fields Can Be WAY Too Cold As The Atmosphere Warms

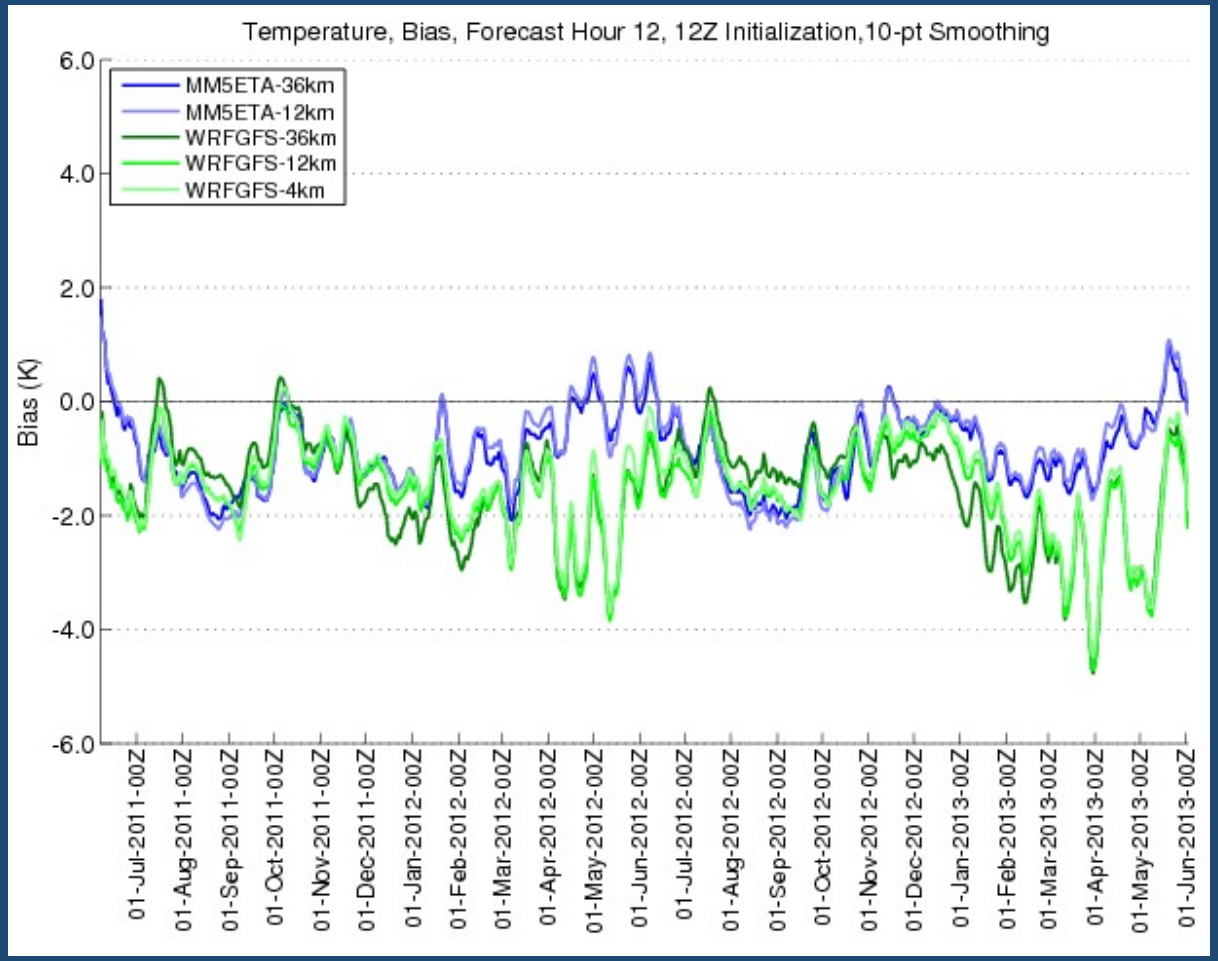
- Particularly evident during spring as the sun gets strong.
- Apparent in daytime temperatures, but not at night.

# Verification at 00 UTC (4-5 PM) for the UW WRF System (3.4.1) over the NW U.S.

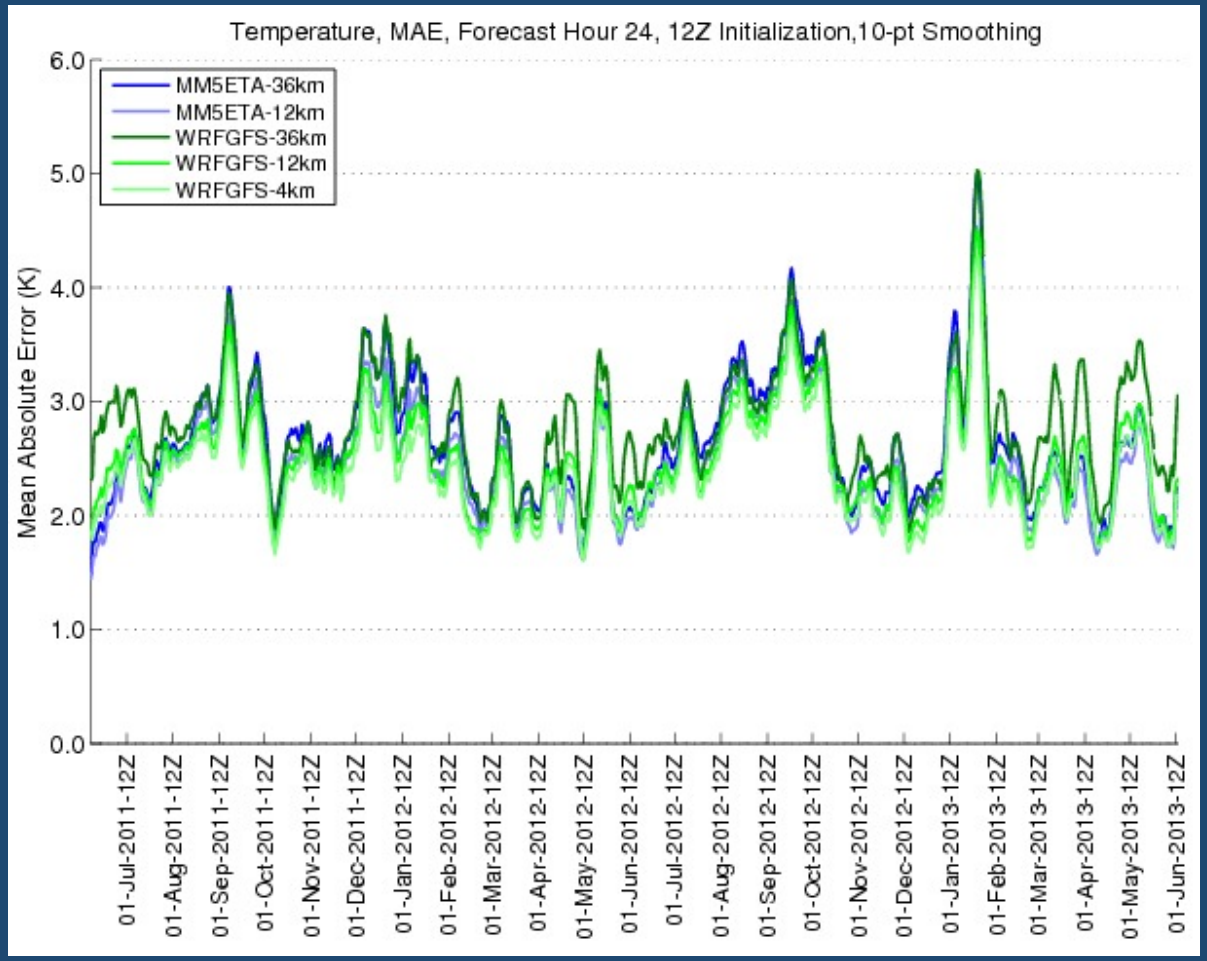



Big Errors in Spring!

# Error is Due to a Cold Bias!



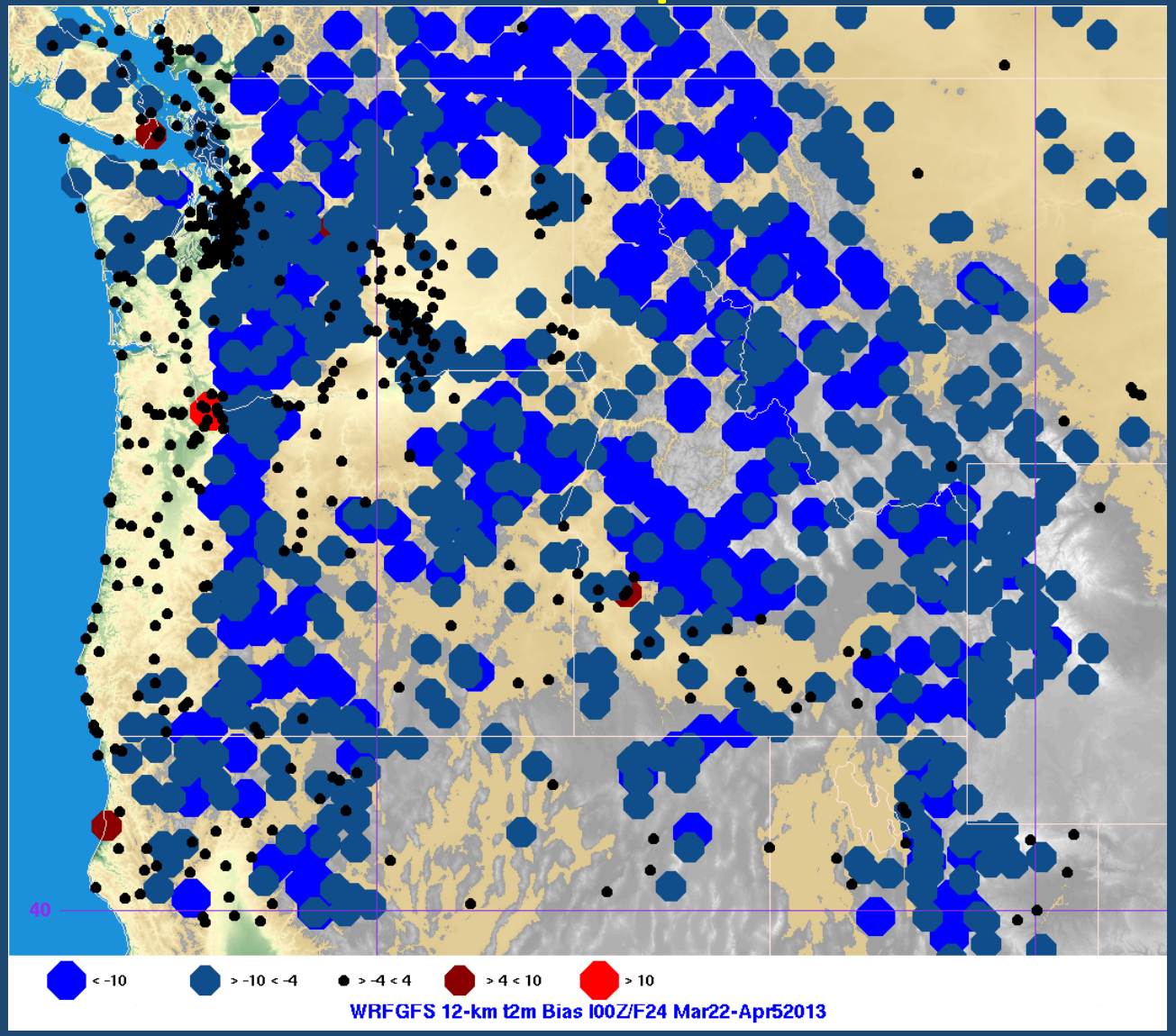
# But the Error Disappears at 12 UTC (4-5 AM)



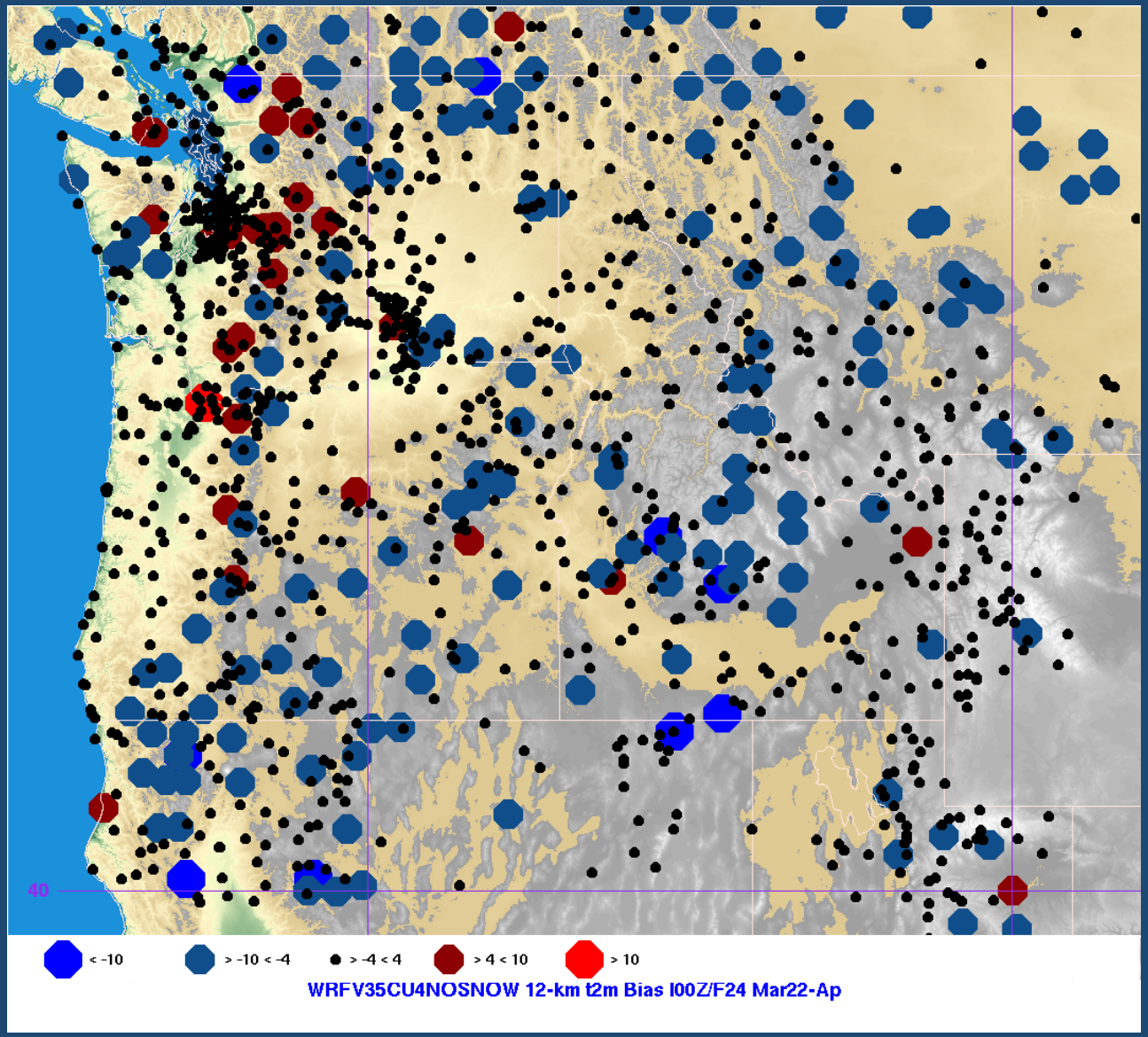
# We have had this problem for years… but worse this year because of additional sun and warmth

- Turns out the problem is related to snow coverage.
- When observed 2-m air temperature is in the 40s or 50s F during the day, the 2-m model air temperature is near freezing.
- Largest error in 2-m air temperature from PBL schemes, but evident in lower model levels.

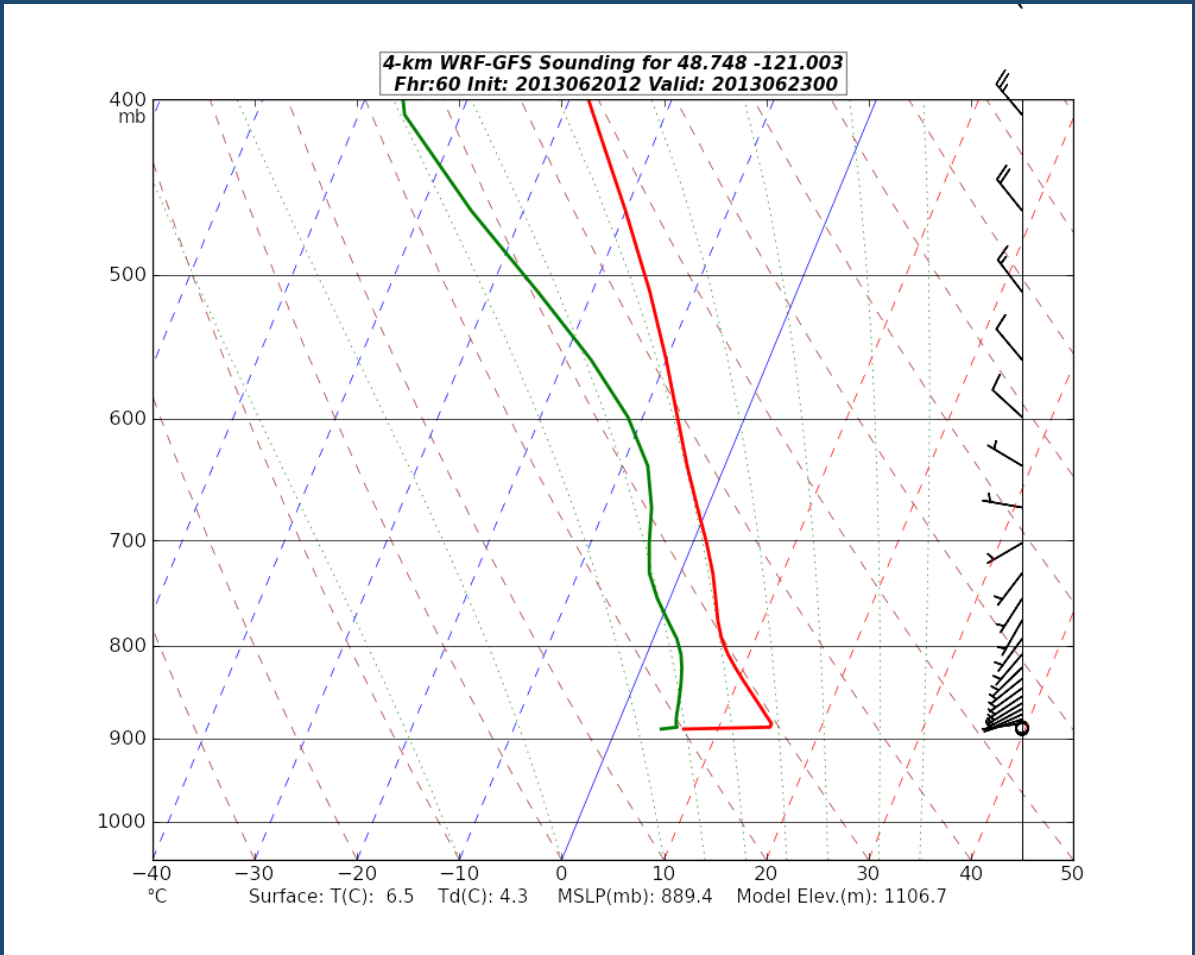
# 2-m WRF Temp. Bias at 00 UTC 24 March-5 April 2013



# Remove Snow: Much Better!



# Recent Example: June 23, North Cascades



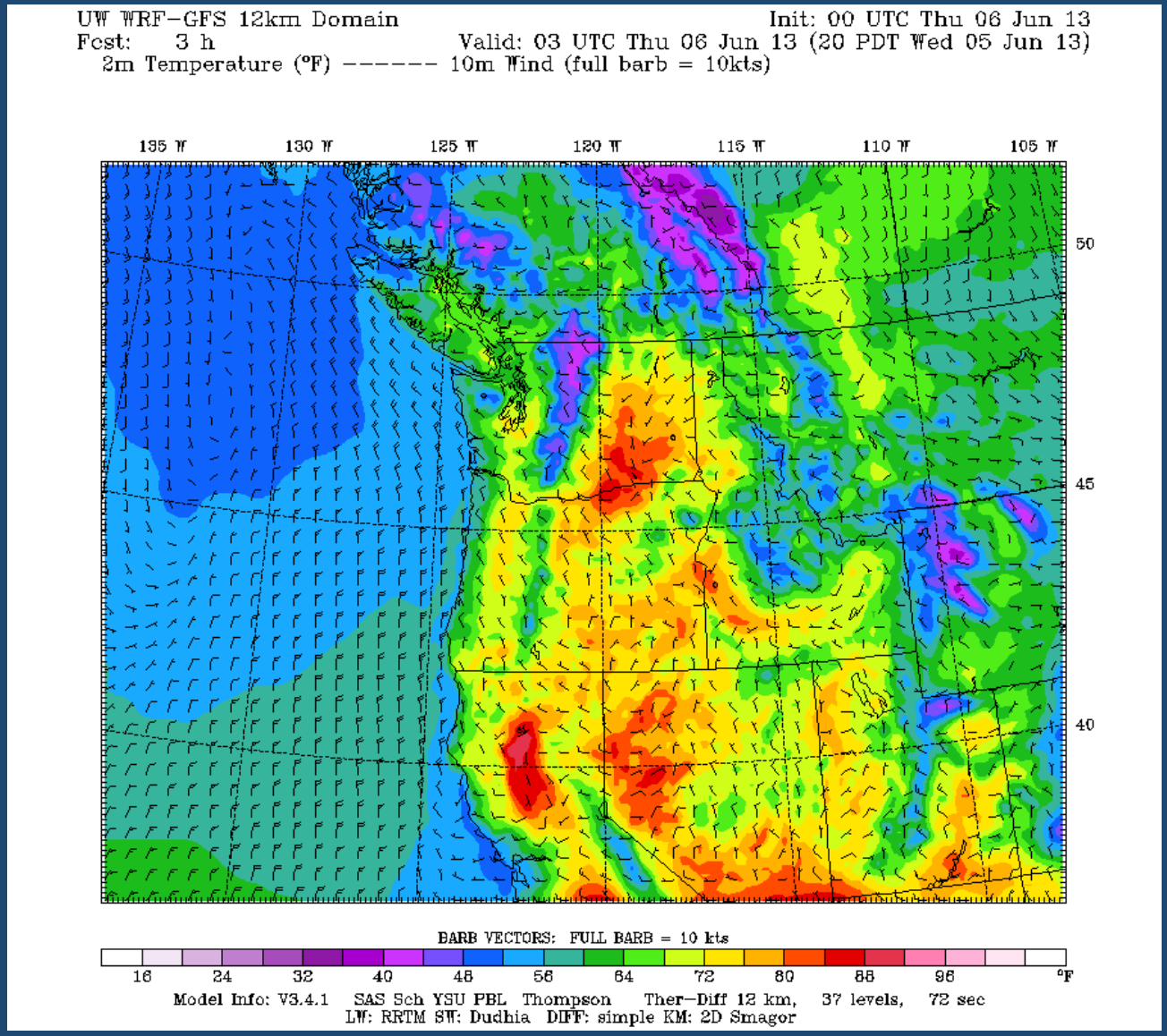
# Can We Fix This By Trying Different Physics Options?

- Current UW System is run at 36-12-4-1.3 km using WRF 3.4.1
- No improvement of snow-cold problem with resolution.
- Now using SAS Cu Parameterization, YSU PBL, Thompson Microphysics, RRTM LW, Dudhia SW, Five-layer soil scheme.
- Tried MANY other combinations: NOAH and NOAH MP LSM, RUC LSM, RRTM-G LW, Goddard Radiation, MYJ PBL.
- NOTHING FIXED THE PROBLEM

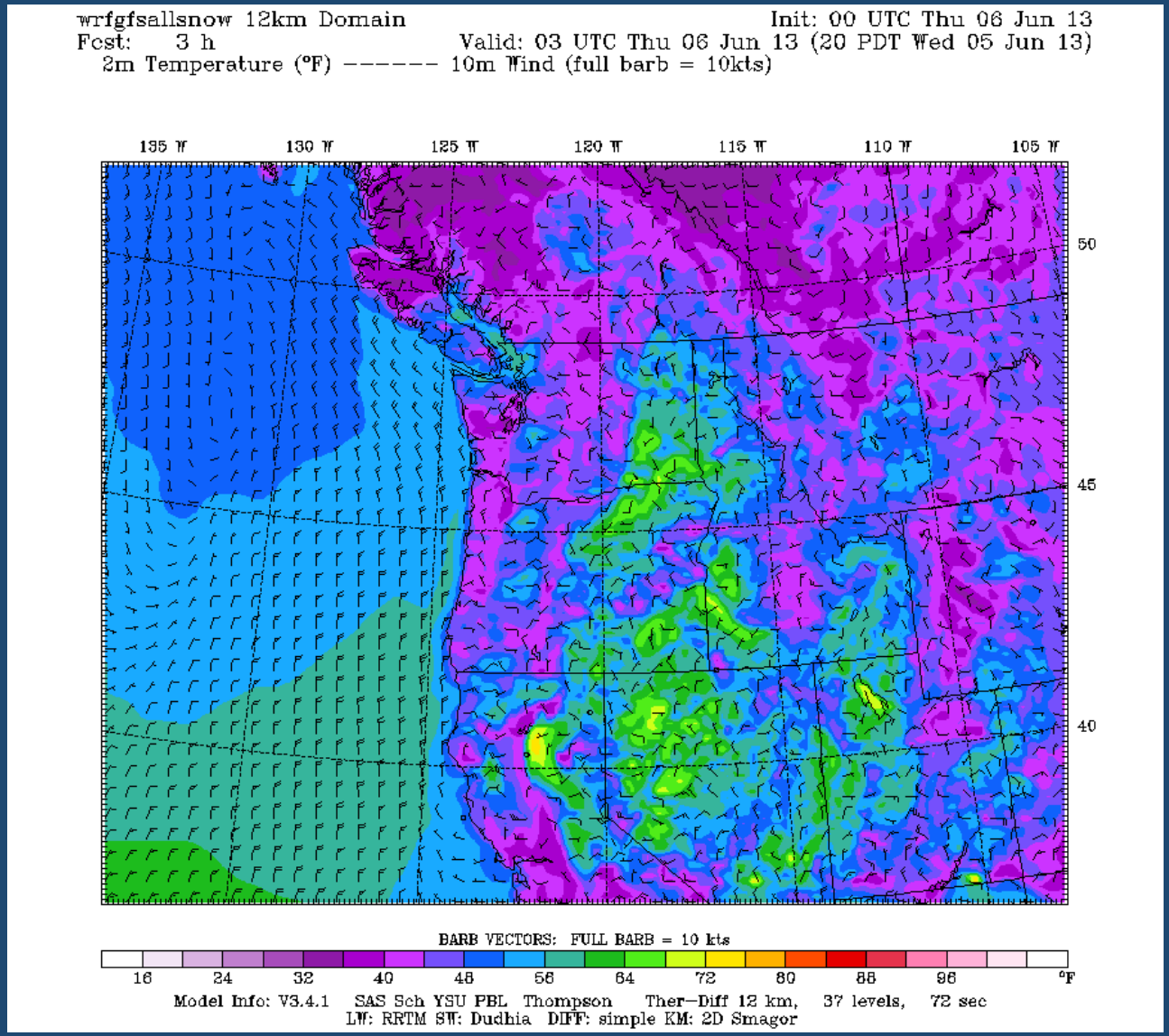
# To Show You How Messed Up Things Are We Tried a Run With Snow over the ENTIRE Western U.S.

LA Under Our Experiment

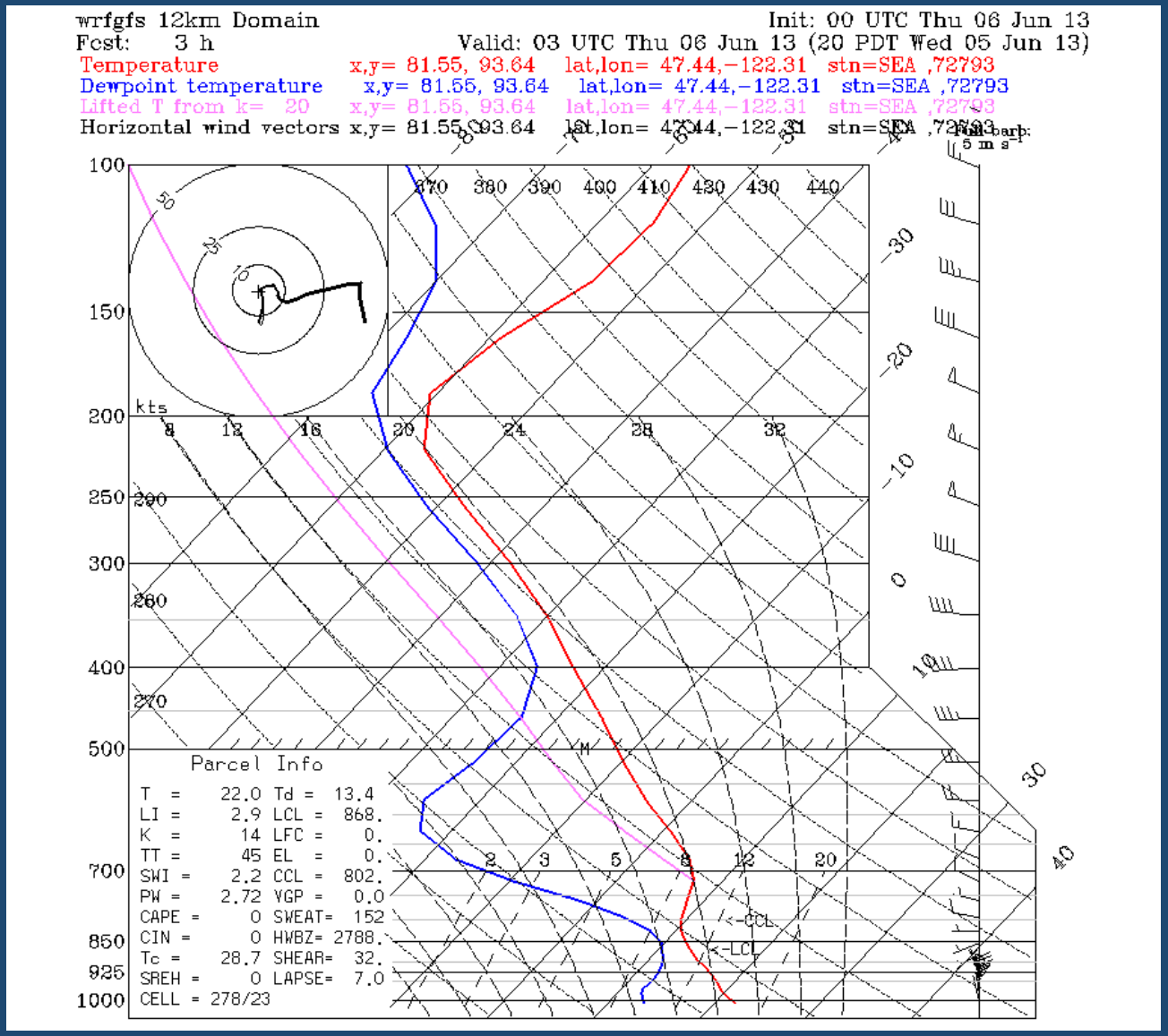
# Observed Snow: 3 hrs In



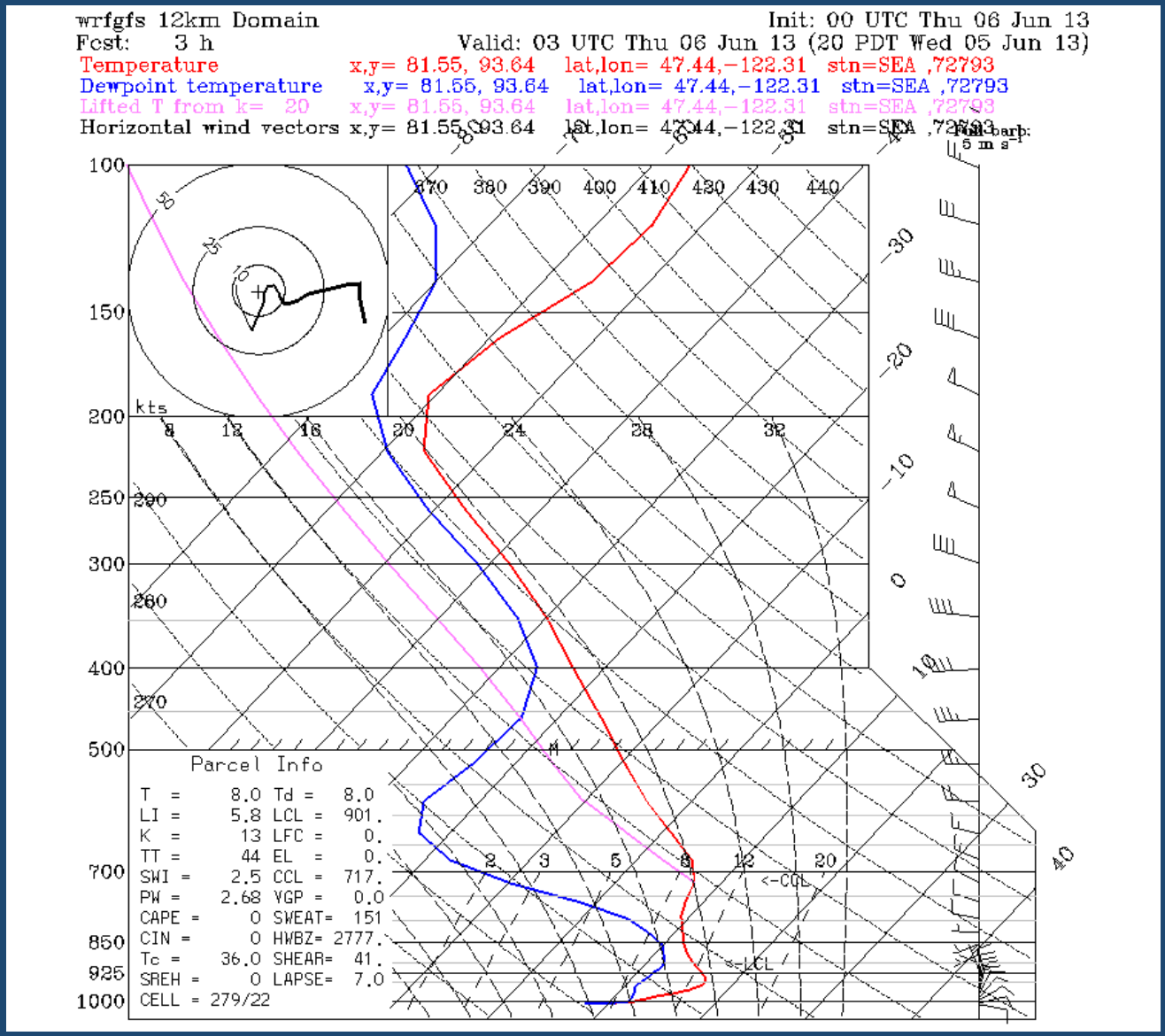
# All Land Covered in Snow: 3 hr

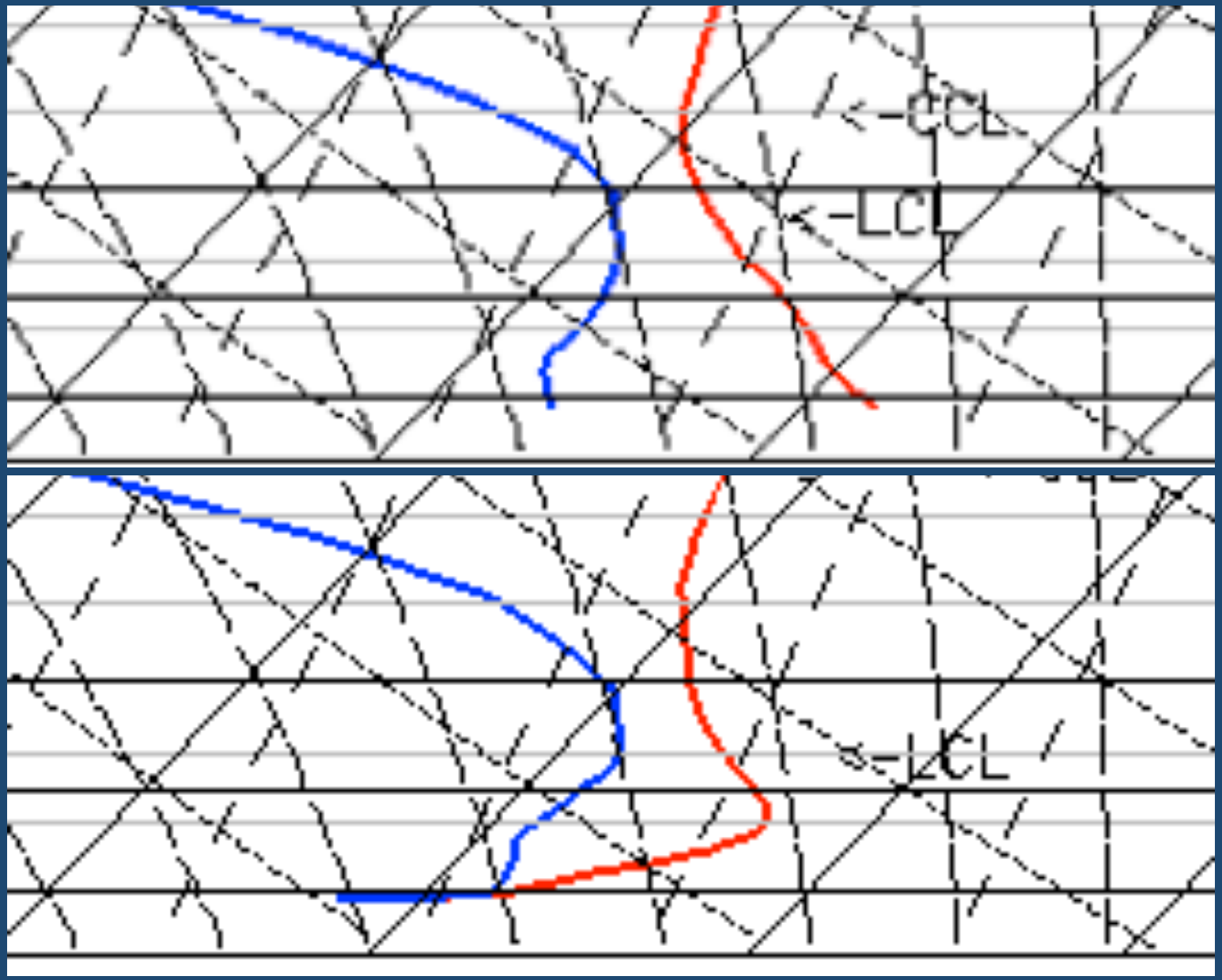


# Sounding at Seattle: Observed Snow

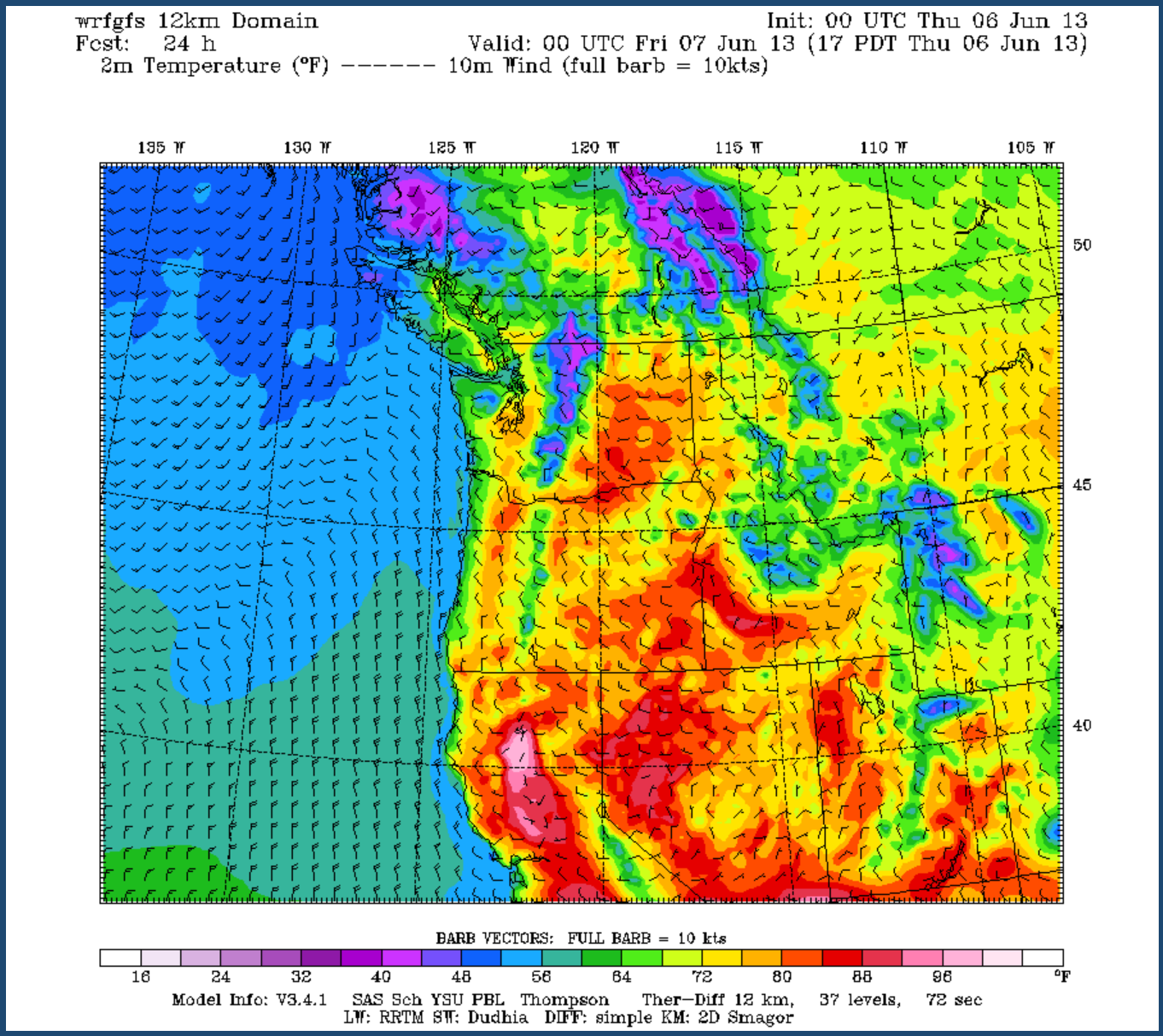


# Snow World

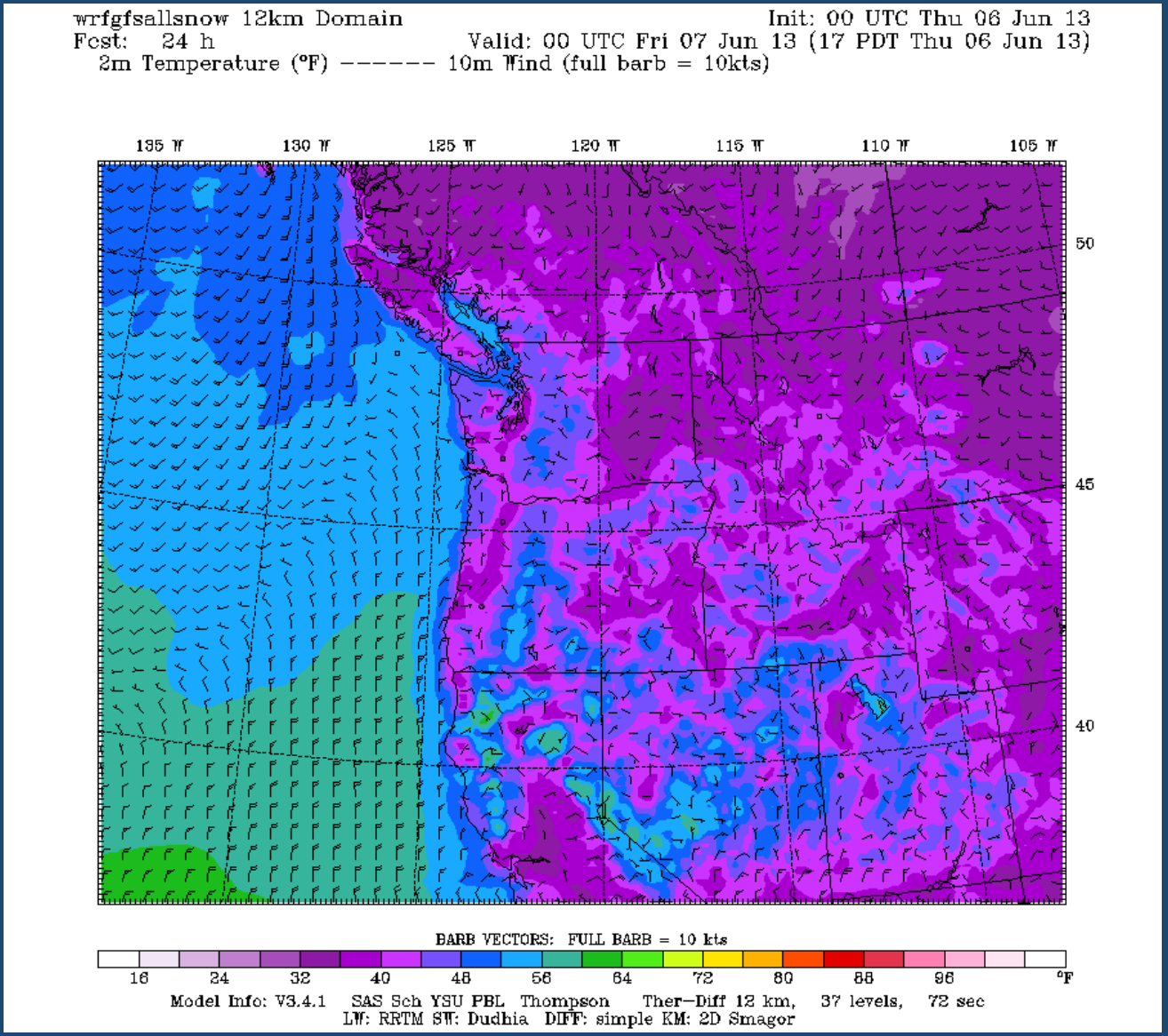

wrfgfs 12km Domain
Init: 00 UTC Thu 06 Jun 13
Fcst: 3 h
Valid: 03 UTC Thu 06 Jun 13 (20 PDT Wed 05 Jun 13)
Temperature x,y= 81.55, 93.64 lat,lon= 47.44,-122.31 stn=SEA ,72793
Dewpoint temperature x,y= 81.55, 93.64 lat,lon= 47.44,-122.31 stn=SEA ,72793
Lifted T from k= 20 x,y= 81.55, 93.64 lat,lon= 47.44,-122.31 stn=SEA ,72793
Horizontal wind vectors x,y= 81.55, 93.64 lat,lon= 47.44,-122.31 stn=SEA ,72793
Full barb: 5 m s-1
kts
Parcel Info
T = 8.0 Td = 8.0
LI = 5.8 LCL = 901.
K = 13 LFC = 0.
TT = 44 EL = 0.
SWI = 2.5 CCL = 717.
PW = 2.68 YGP = 0.0
CAPE = 0 SWEAT= 151
CIN = 0 HWBZ= 2777.
Tc = 36.0 SHEAR= 41.
SREH = 0 LAPSE= 7.0
CELL = 279/22
<-CCL
<-LCL


CCL
LCL
LCL

# 24h In: Observed Snow



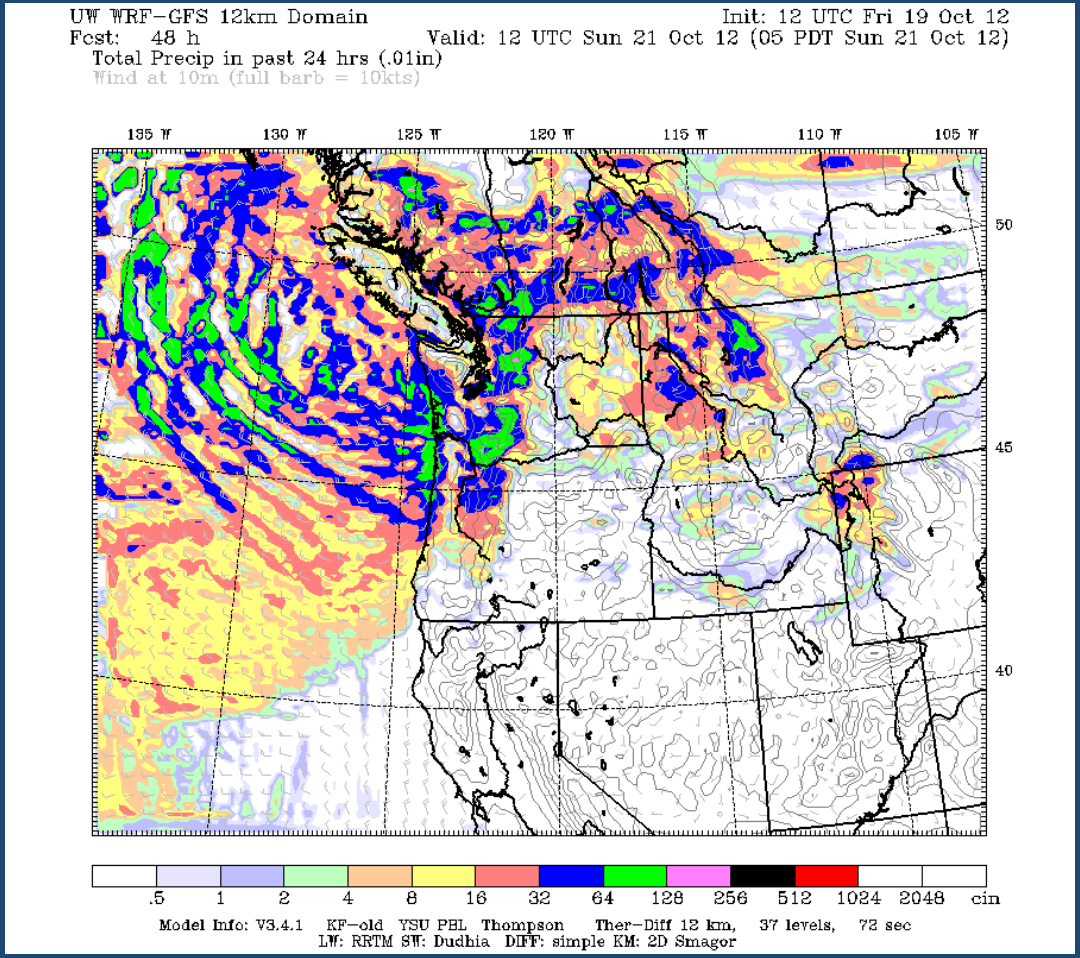
# All Snow!


wrfgfsallsnow 12km Domain
Init: 00 UTC Thu 06 Jun 13
Fcst: 24 h
Valid: 00 UTC Fri 07 Jun 13 (17 PDT Thu 06 Jun 13)
2m Temperature (°F) ------- 10m Wind (full barb = 10kts)
135 W
130 W
125 W
120 W
115 W
110 W
105 W
50
45
40
BARB VECTORS: FULL BARB = 10 kts
16
24
32
40
48
56
64
72
80
88
96
°F
Model Info: V3.4.1 SAS Sch YSU PBL Thompson Ther-Diff 12 km, 37 levels, 72 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor

# Fixing the Problem

- Talked to NCAR developers…they know there is a problem.
- NCEP folks have seen the same issue with NAM-NMM
- NOAA ESRL have noted the same problem in RR and HRRR.
- Could the issue be with the surface schemes?

# Another Issue: Strange Linear Features over the Ocean



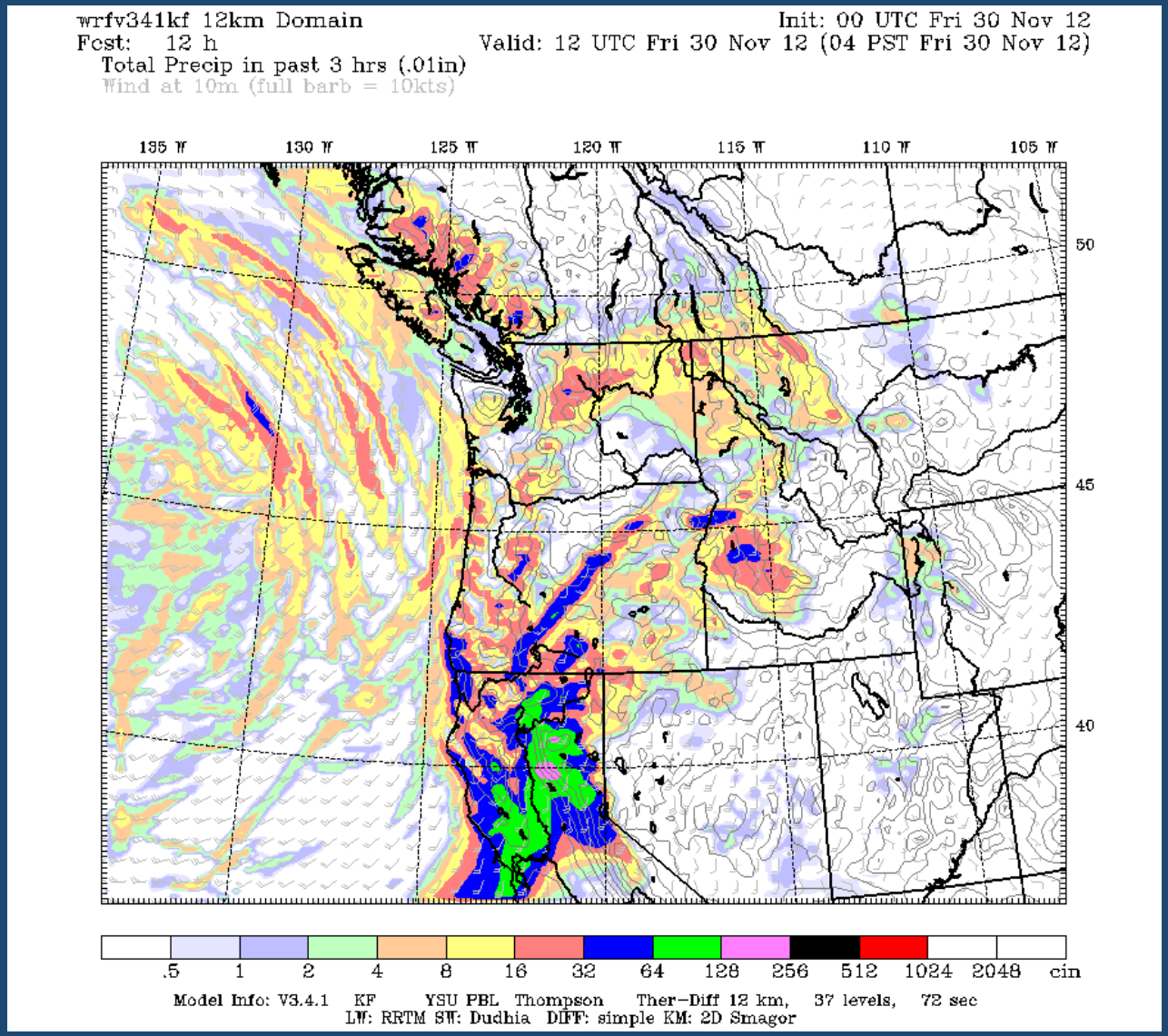
# Wacky Linear Features in Precipitation

- Generally most evident over the ocean
- Usually occurs in post-frontal flow that is relatively unstable (cold air aloft over relative warm—45-50F– sea surfaces).

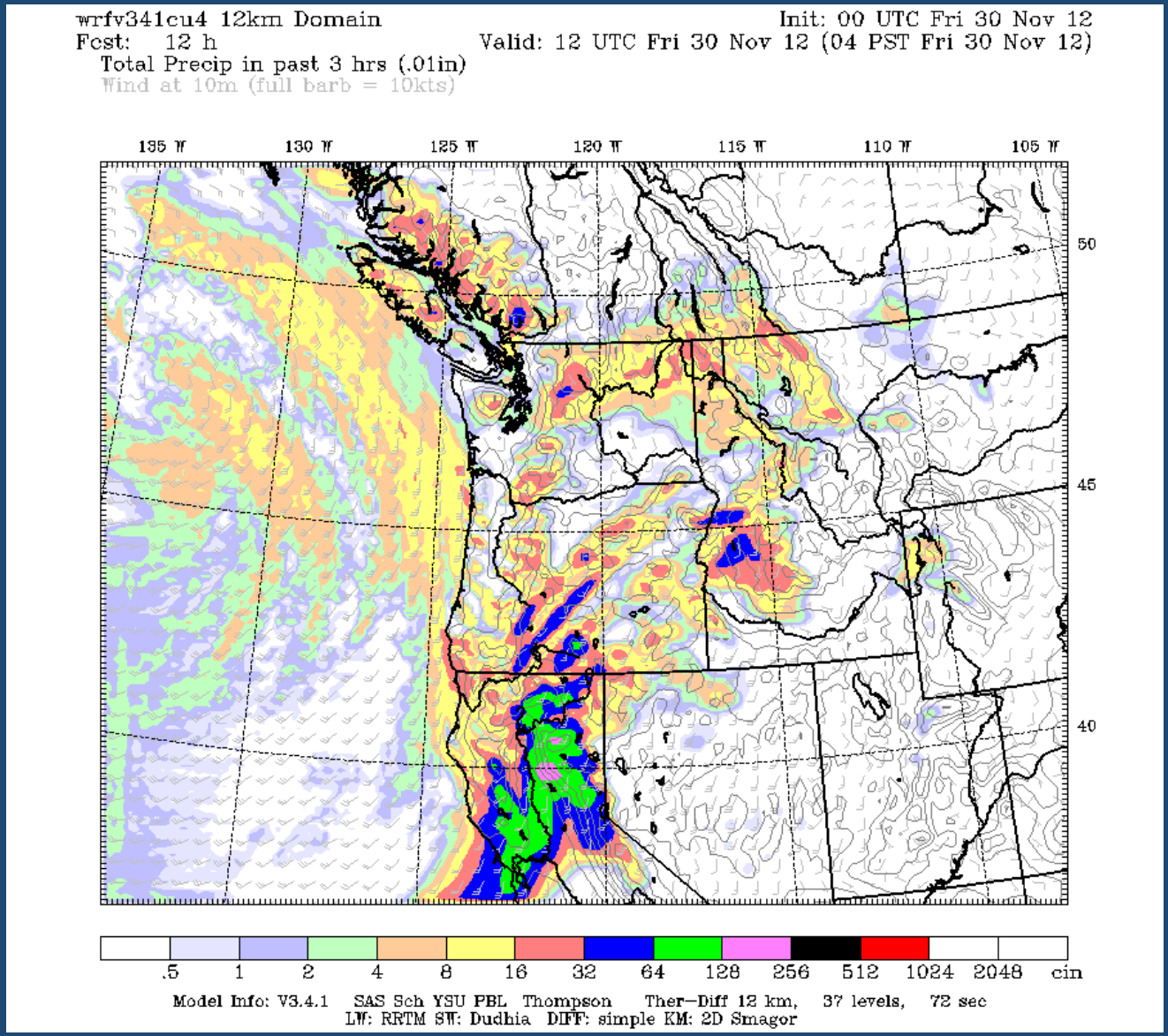
# The origin? The convective parameterization (in our case, Kain-Fritsch)

- Comprehensive experimentation by Dave Ovens of all available convective schemes.
- Also seen in Grell.
- Best choice: SAS (Simplified Arakawa Schubert) scheme.
- Also improves our substantial underforecasting of summer convection over the mountains—another significant problem.

# Kain-Fritsch, 3-h Precipitation

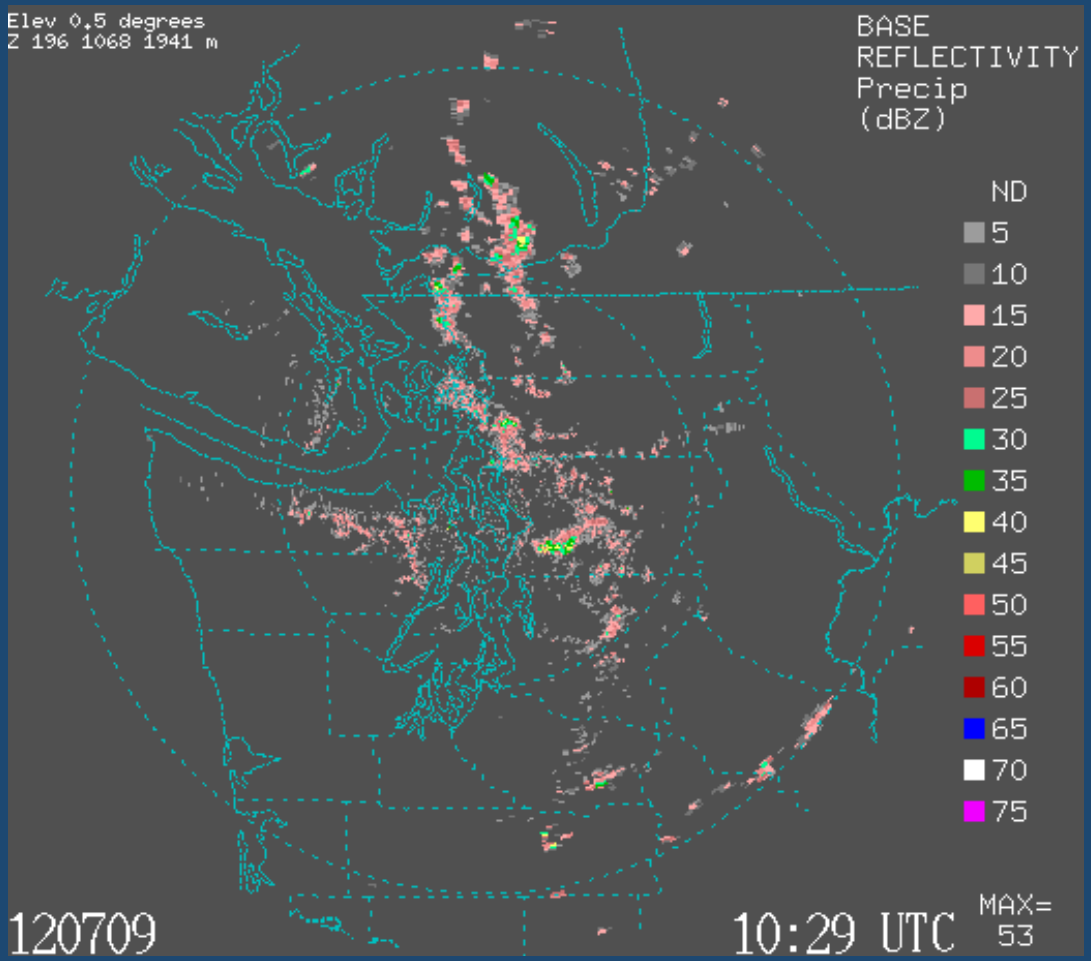


# SAS

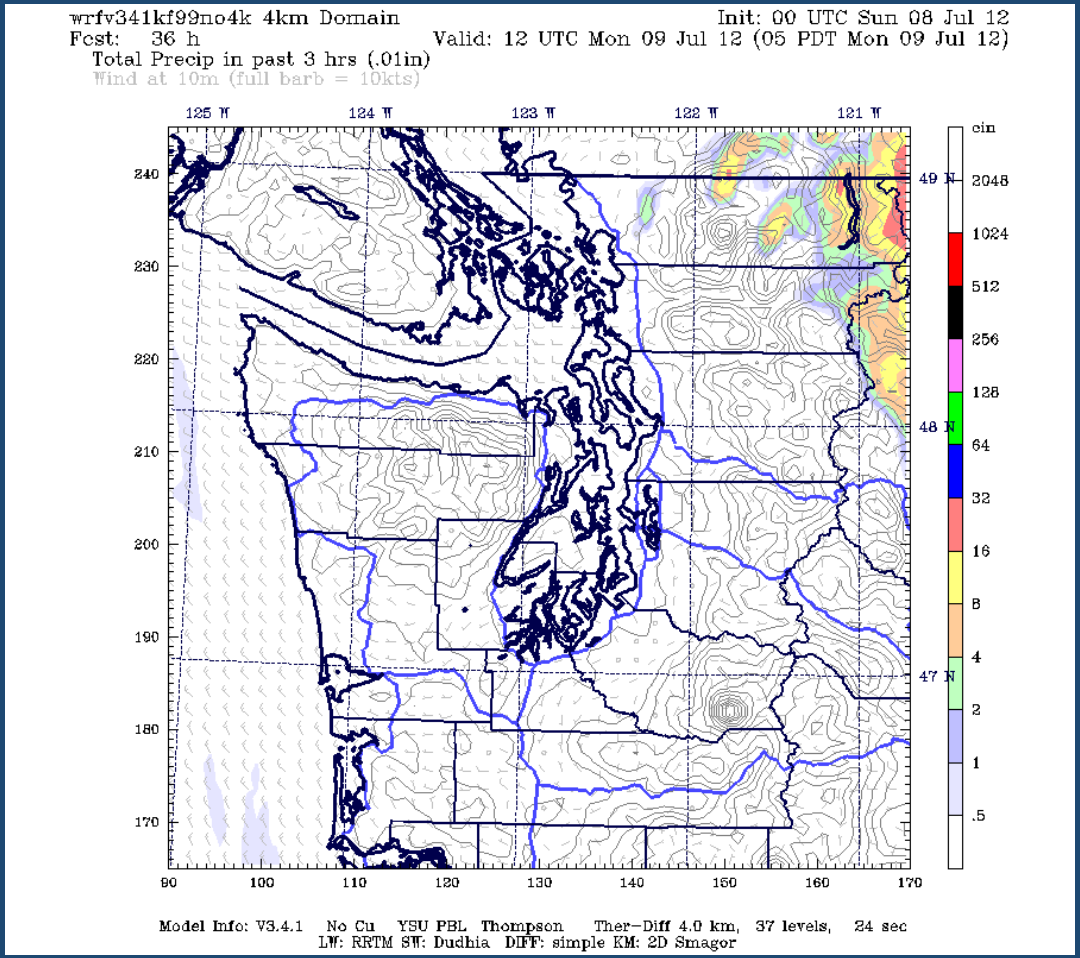

wrfv341cu4 12km Domain
Init: 00 UTC Fri 30 Nov 12
Fcst: 12 h
Valid: 12 UTC Fri 30 Nov 12 (04 PST Fri 30 Nov 12)
Total Precip in past 3 hrs (.01in)
Wind at 10m (full barb = 10kts)
135 W
130 W
125 W
120 W
115 W
110 W
105 W
50
45
40
.5
1
2
4
8
16
32
64
128
256
512
1024
2048
cin
Model Info: V3.4.1 SAS Sch YSU PBL Thompson Ther-Diff 12 km, 37 levels, 72 sec
LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor

# Improvement of Shallow Convection Coming off Cascade Mts with SAS

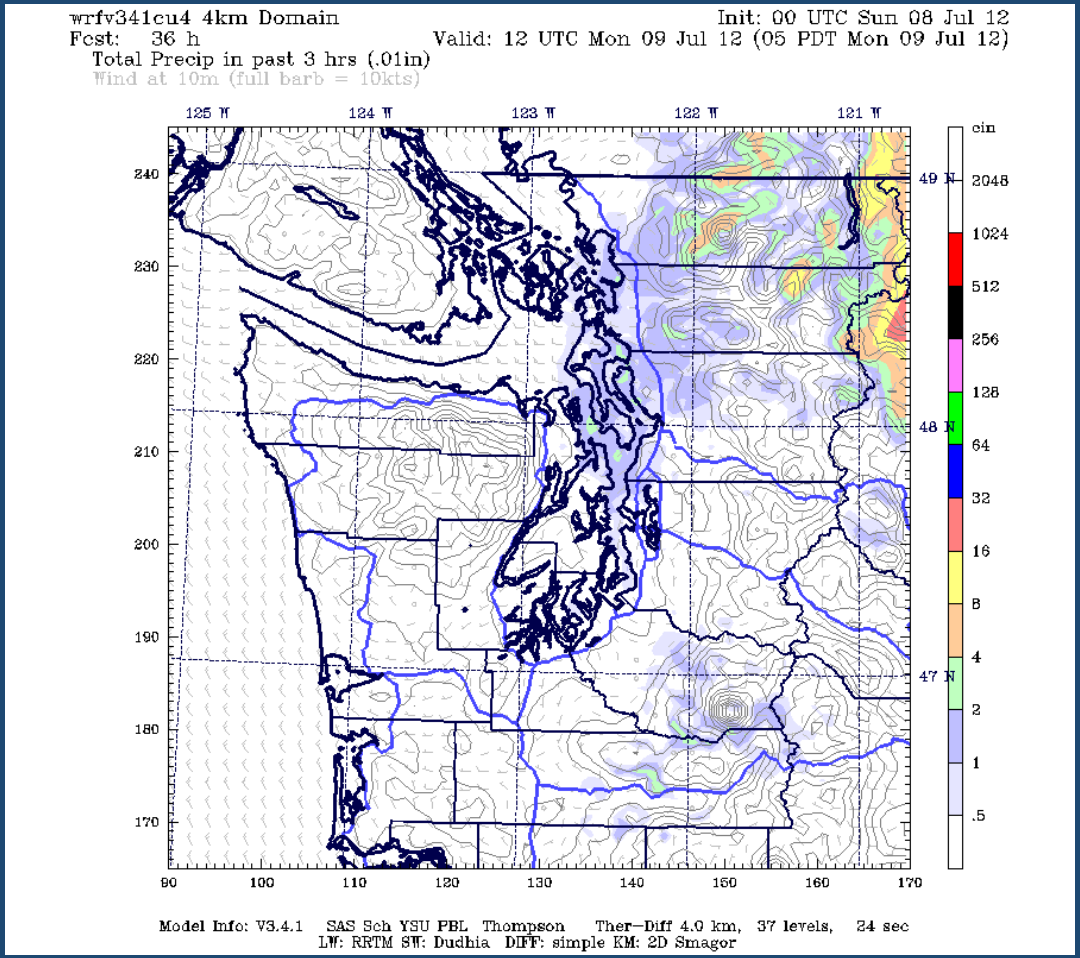
# July 9, 2012 1029 UTC, Camano Is. Radar



# Kain Fritsch: Nothing



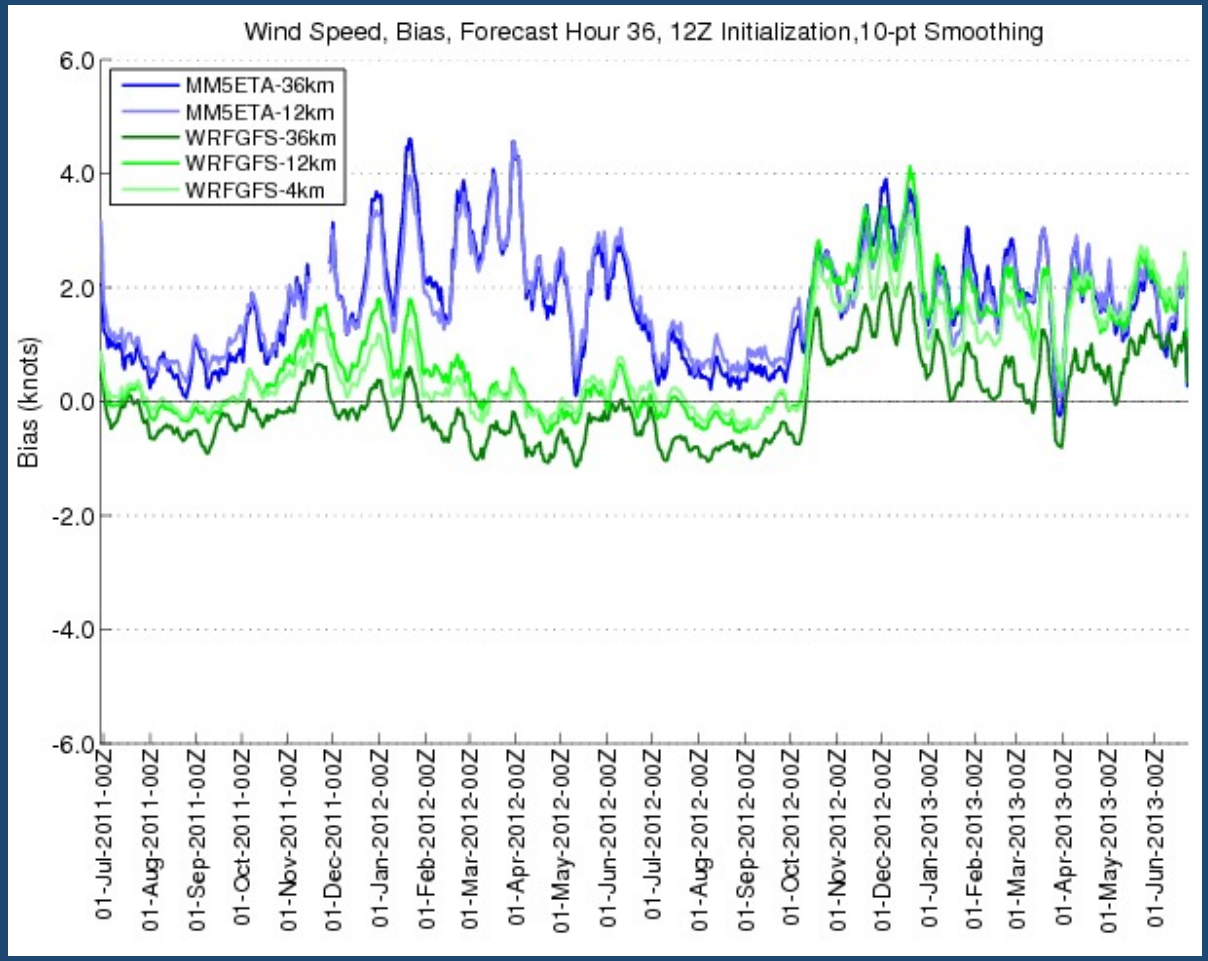
# SAS: More Realistic



# Sub-Grid Drag Scheme Update

- Last year reported on our subgrid drag scheme…which is now available in WRF.
- Changes in 3.4.1, and particularly in YSU, resulted in our drag scheme causing winds to be too too slow.
- As a result, dropped its use in the NW Regional Prediction System and began work on a new version.
- New version drops extra drag in well mixed situations

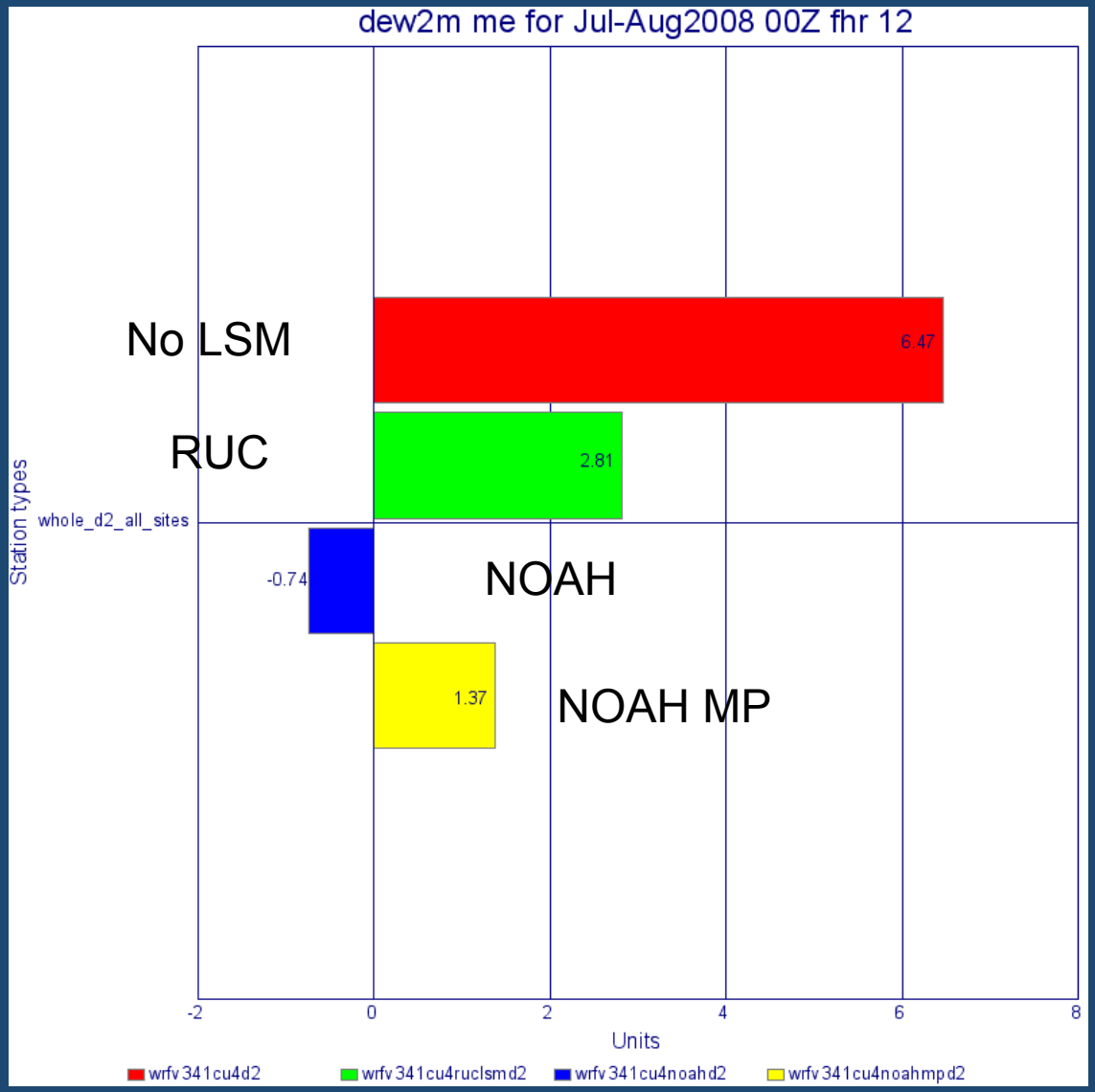
# NW WRF Wind Speed Verification



# Some Other Problems

- NOAH MP LSM showed improved verifications in tests over the Northwest, but does not appear to be stable—too many lost runs and sensitive to number of processors.
- Stability issues of RUC LSM with RTTMG LW radiation scheme.
- One big advantage of LSMs:  dramatic improvement of low-level humidity.

# Dew Point Bias at 12 UTC




THE END

- **8.2 Strange linear features in WRF clouds and precipitation: Diagnosis and correction**
- 
- **Mass, Clifford,** and David Owens, *University of Washington*
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- During the past year it became obvious that the model output over the Pacific Ocean often showed strange, and often persistent, linear features, particularly in a post-frontal environment in which stability was reduced. In a comprehensive series of experiments, in which various boundary-layer schemes, vertical resolutions, and cumulus parameterizations were, it was found that these lines were highly sensitive to the convective parameterization, with only the SAS scheme providing satisfactory results. Other sets of strange linear features, mainly over land were also noted, and it was found they originated in reflections off the upper boundary (100 hPa) in the model. Lifting the model top to 50 hPa and using the WRF Rayleigh damping scheme with a sufficient number of levels near the model lid, radically reduced the phantom lines and improved the structure and tilt of mountain waves.
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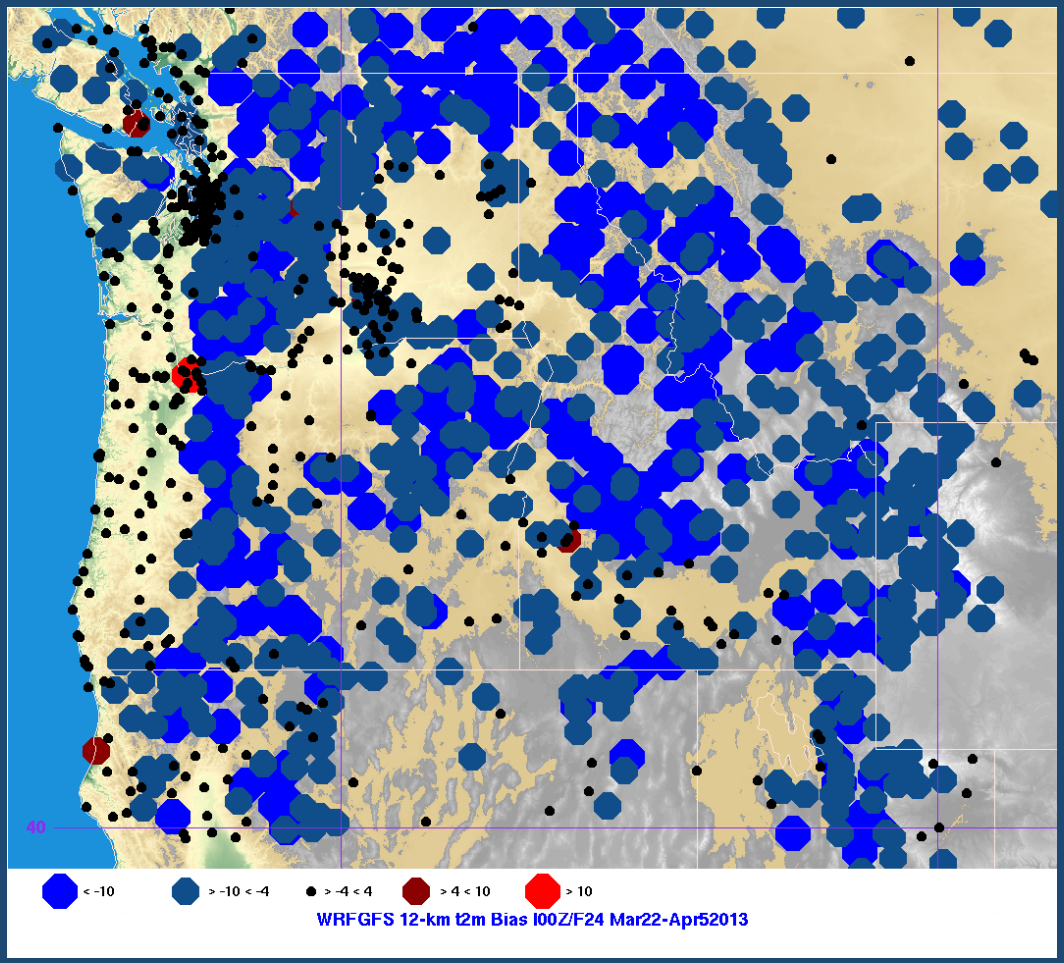
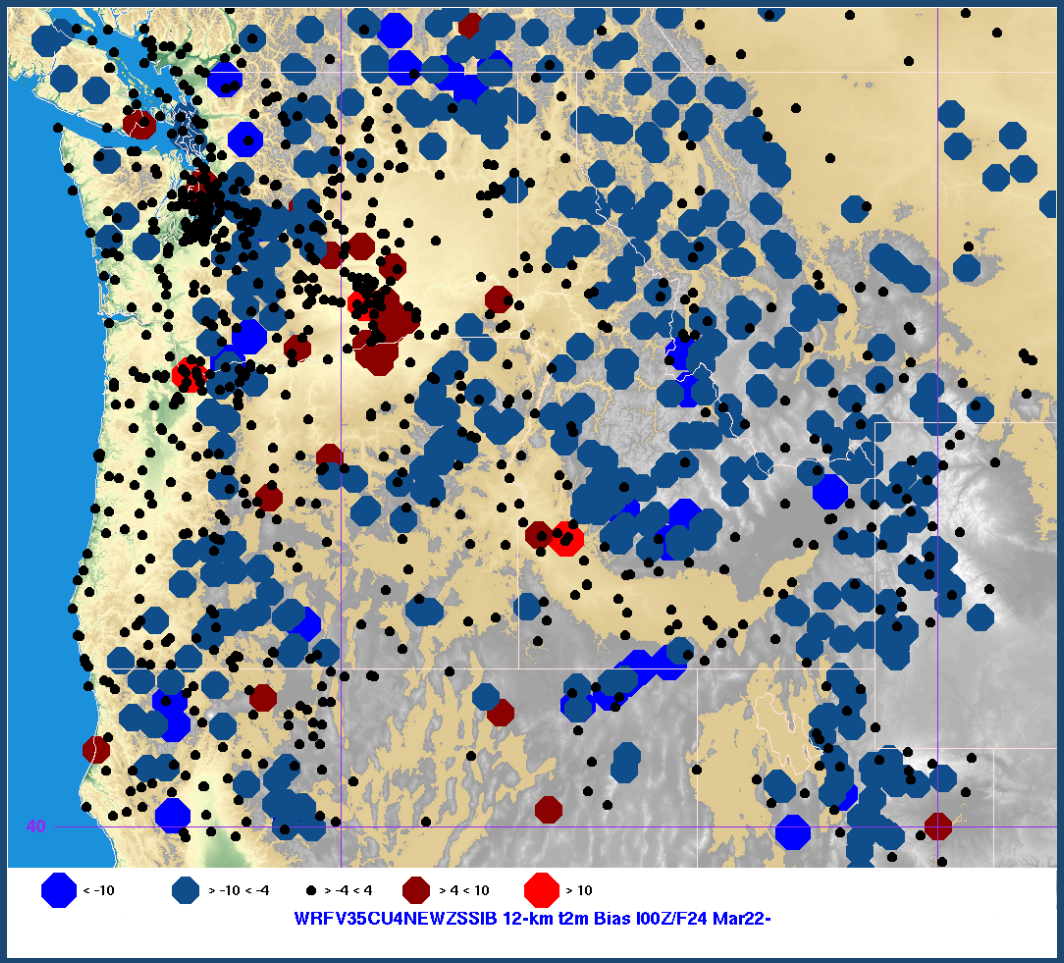

40
< -10
> -10 < -4
> -4 < 4
> 4 < 10
> 10
WRFGFS 12-km t2m Bias I00Z/F24 Mar22-Apr52013


40
< -10
> -10 < -4
> -4 < 4
> 4 < 10
> 10
WRFV35CU4NEWZSSIB 12-km t2m Bias I00Z/F24 Mar22-