# Super Cold Waves and NOAH-MP … and much more

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**University of Washington**
**WRF Workshop June 2019**

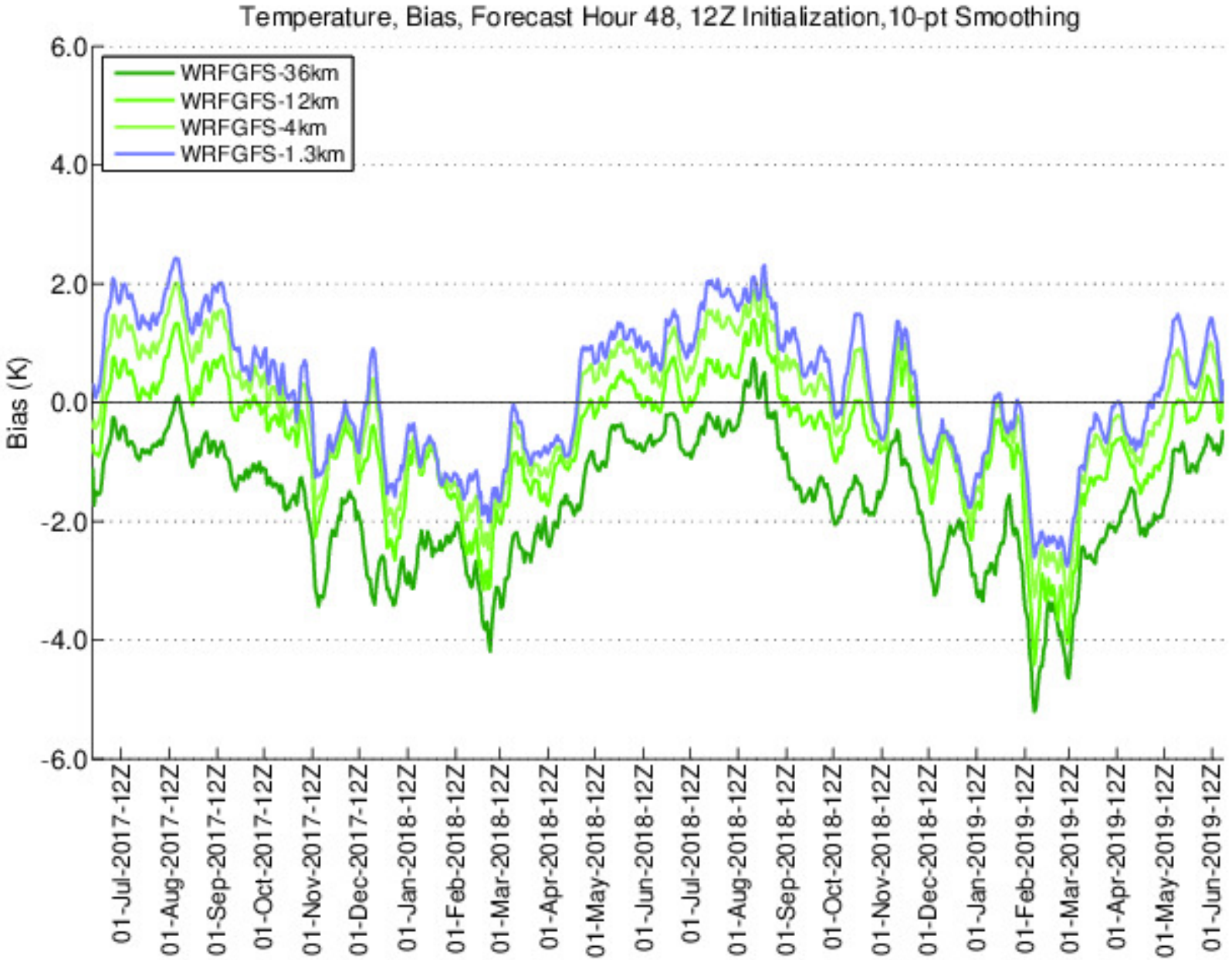
# Talk theme: Adding Complexity Does Not Necessarily Make a Better Forecast

"Life is really simple, but we insist on making it complicated." …. It takes ….a lot of courage to move in the opposite direction."

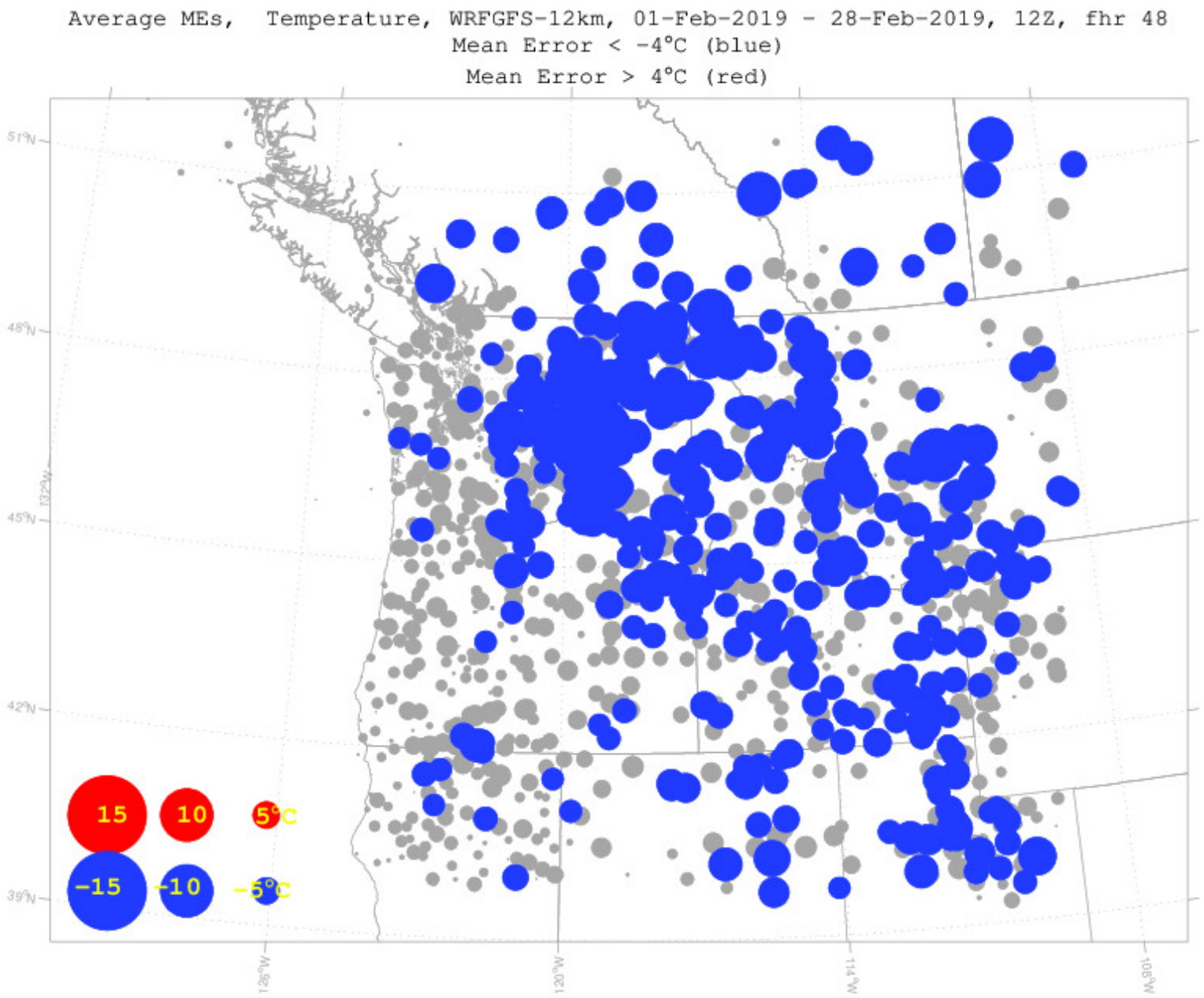
# UW Real-Time WRF Configuration

- V 3.7.1:  36-12-4-1.3 km
- YSU PBL
- NOAH MP LSM
- Thompson Microphysics
- RRTMG Radiation
- Grell-Frietas Convection
- Driven by NOAA/NWS GFS global model

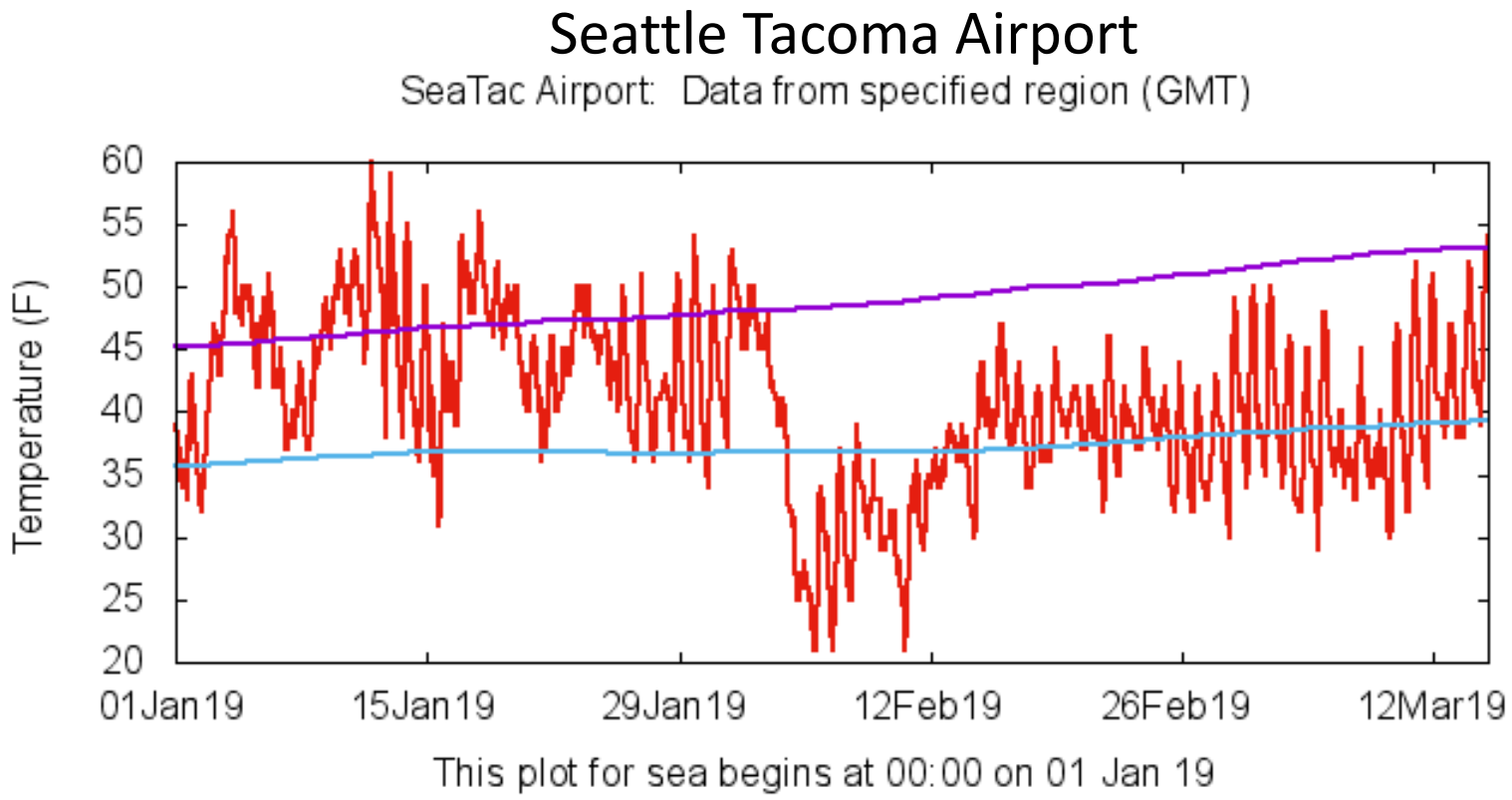
# UW WRF Temperature Bias for Minimum Temps July 2017 to Now



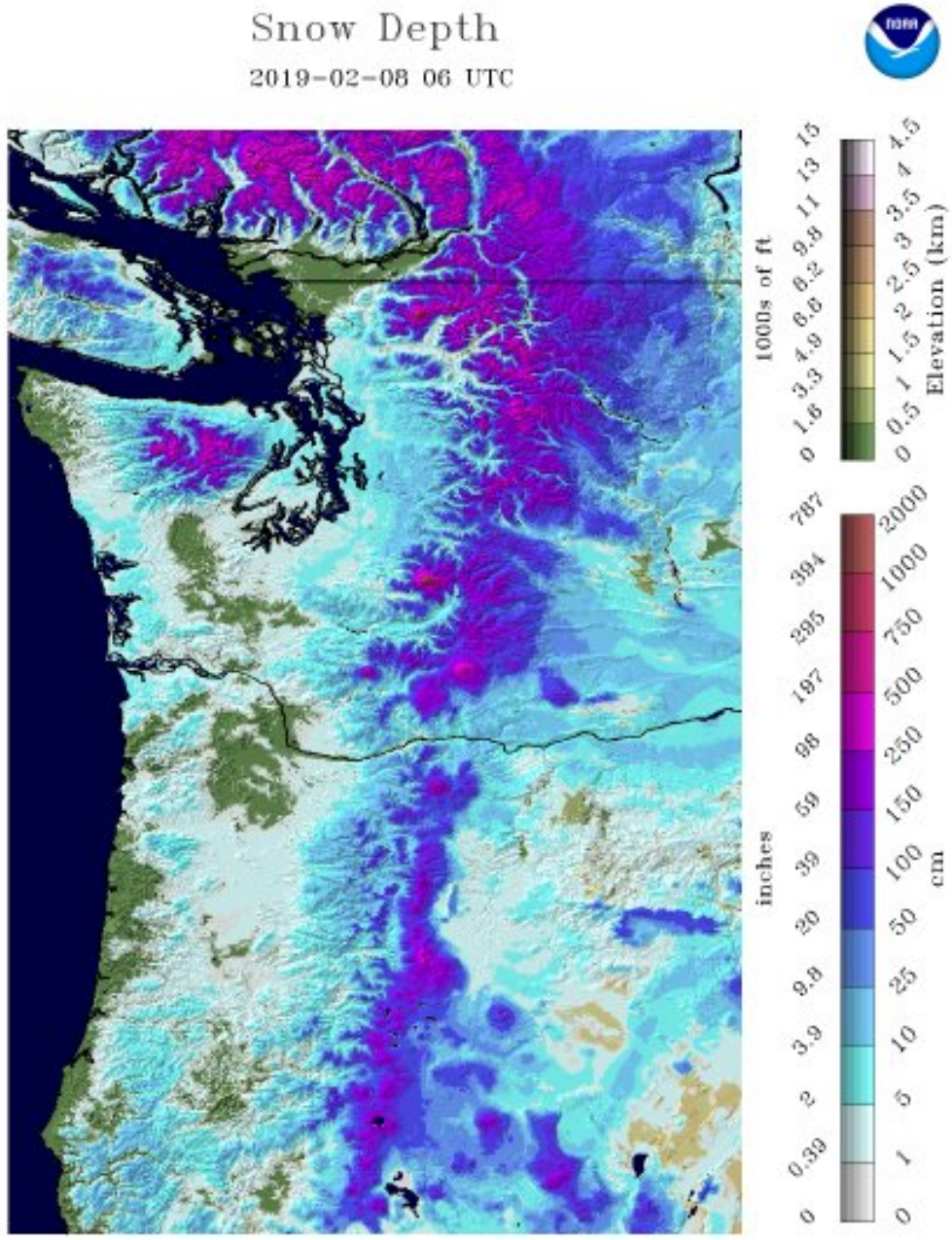
# Cold Bias for Month of February



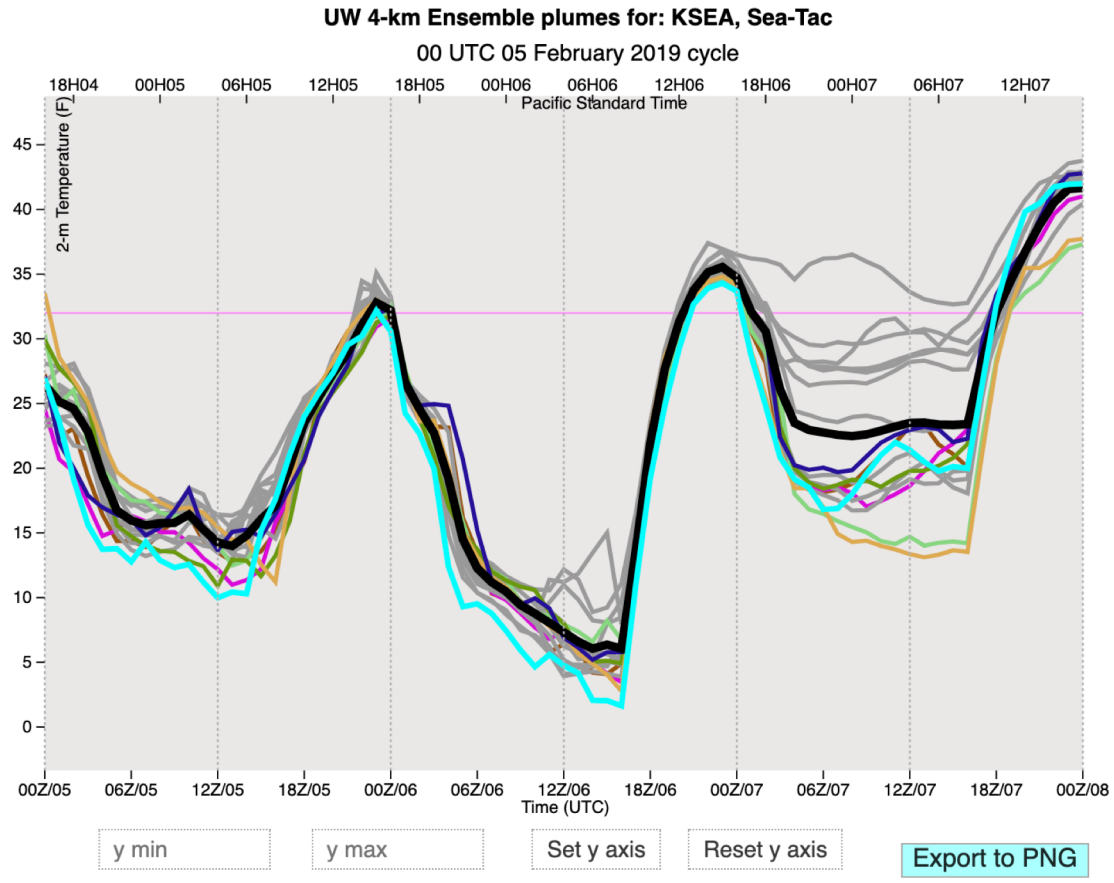
# During February 2010, the Pacific Northwest Was Hit by an Unusual Cold Spell



# And Brought Unusual Amounts of Snow to the Coastal Portions of the Pacific Northwest.

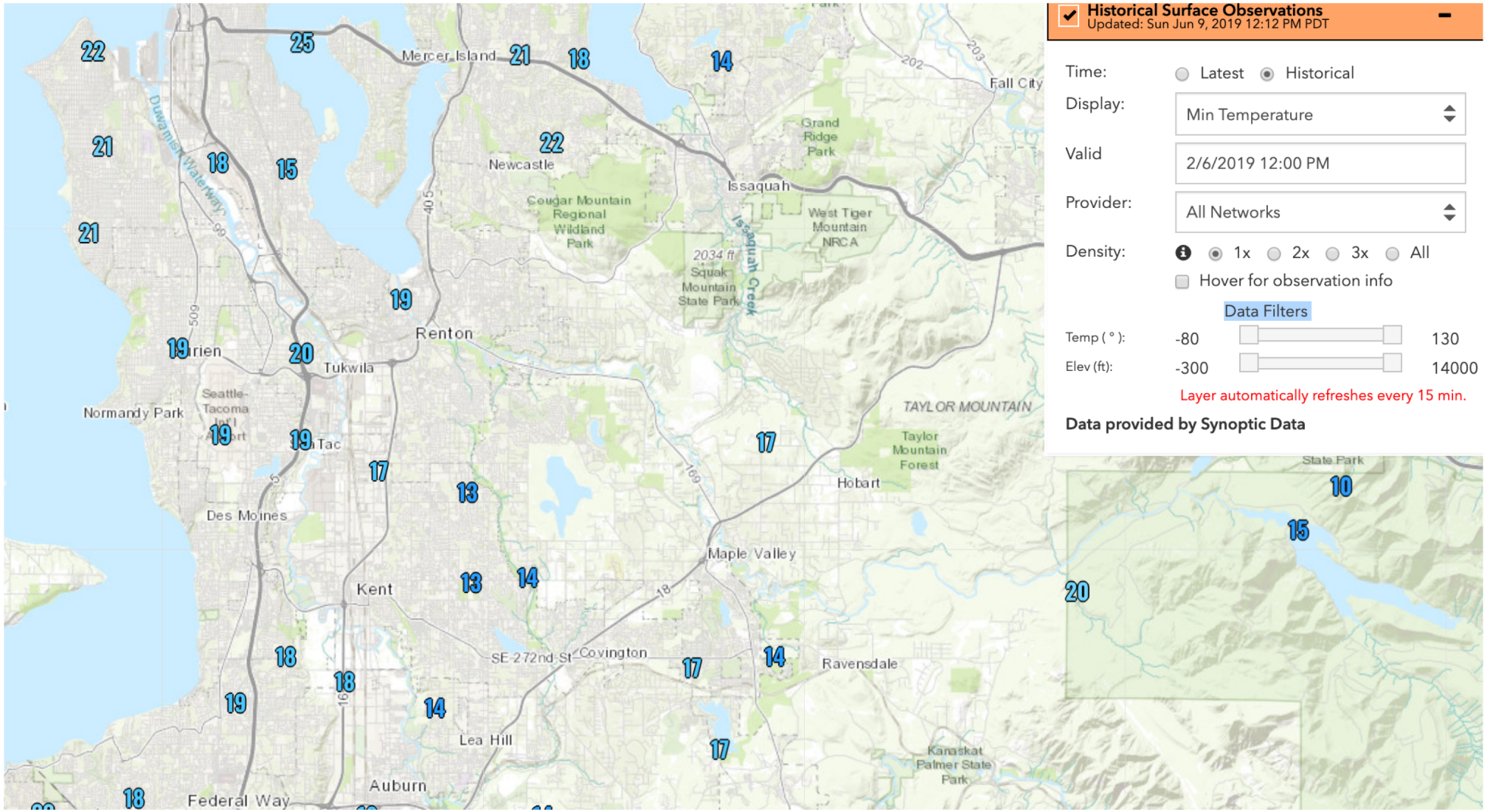


# Unfortunately, the UW WRF Running WRF 3.7.1 and Using NOAH-MP Was Doing Something Extreme




Minimum Temperatures Forecast by WRF on February 6th were around 5 F.

# Reality Was Much Warmer—About 20F

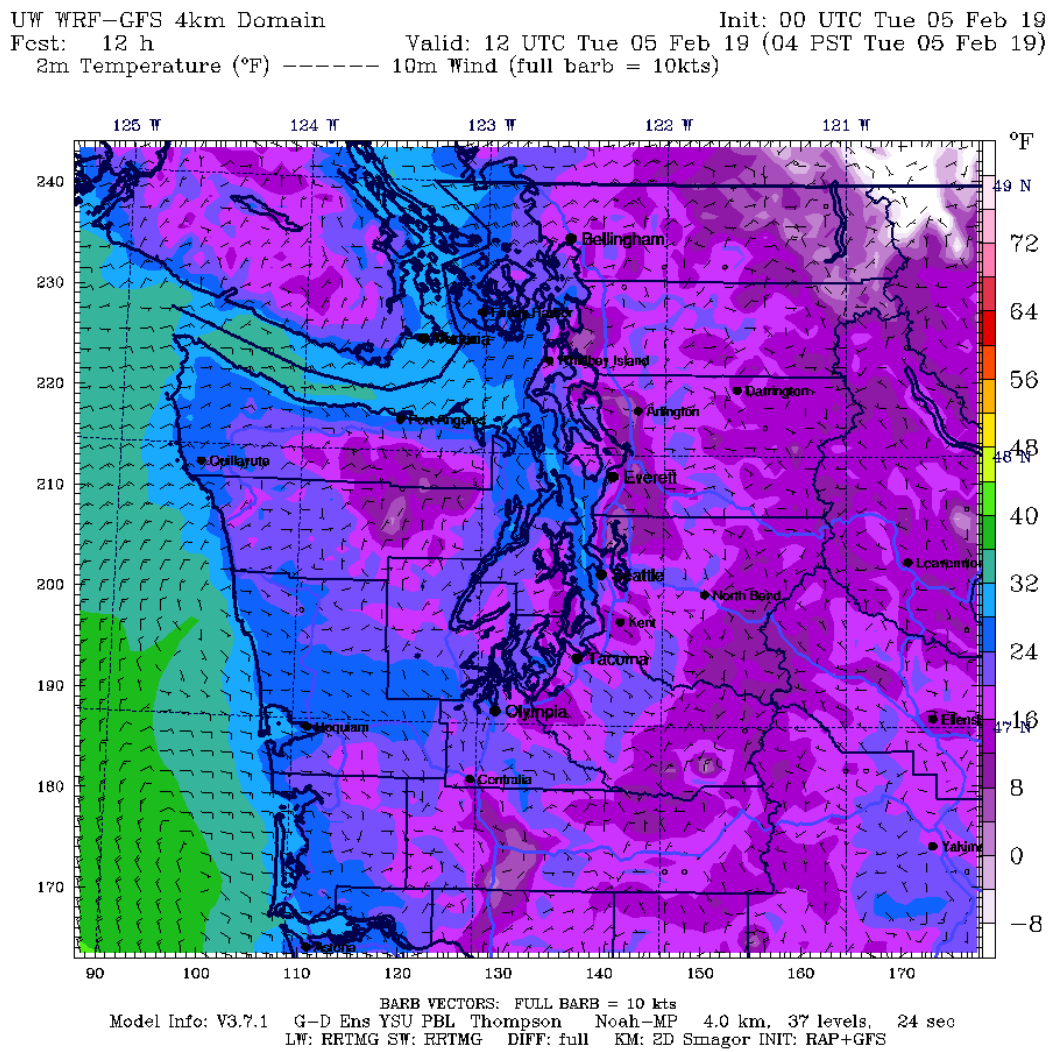


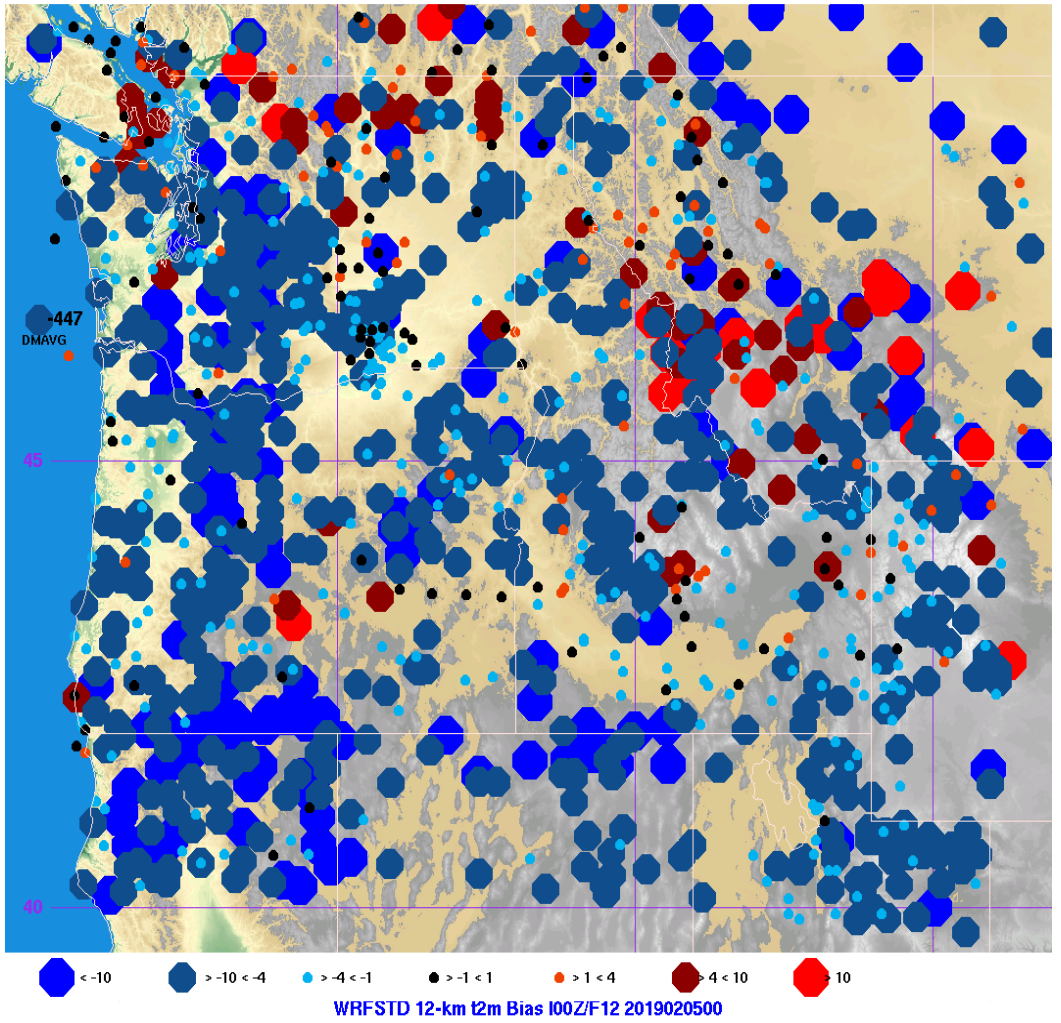
# Strong Diurnal Modulation of the Problem

**Large cold bias for minimum**
**Little bias for maximum**
**NOAH MP makes it worse**

# WRF NOAH-MP 2-m Temperature Forecasts over Snow are Unrealistically Cold

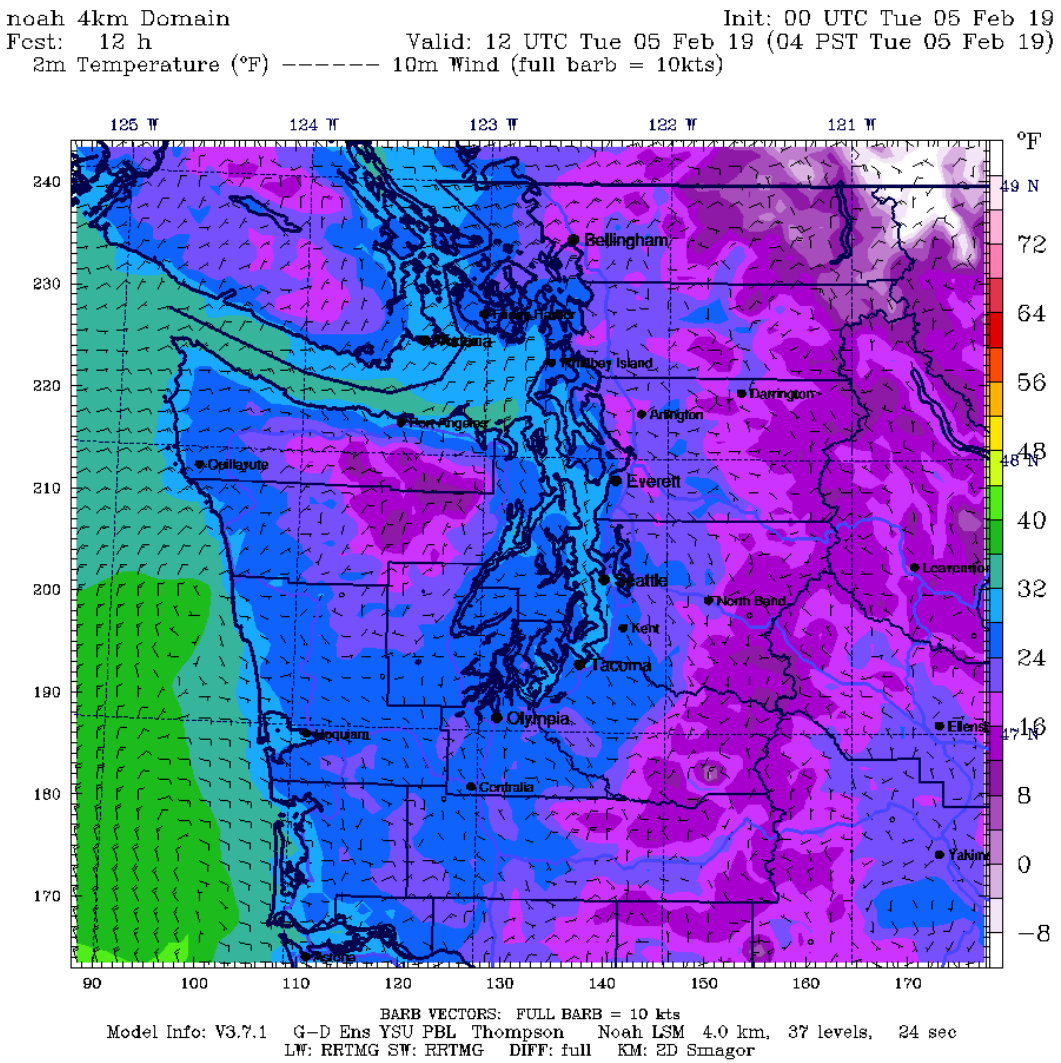
- Forecast for 12Z Feb 5, 2019 forecast. cold biases around Seattle of more than 4ºF.
- The mean error was -4.97ºF.

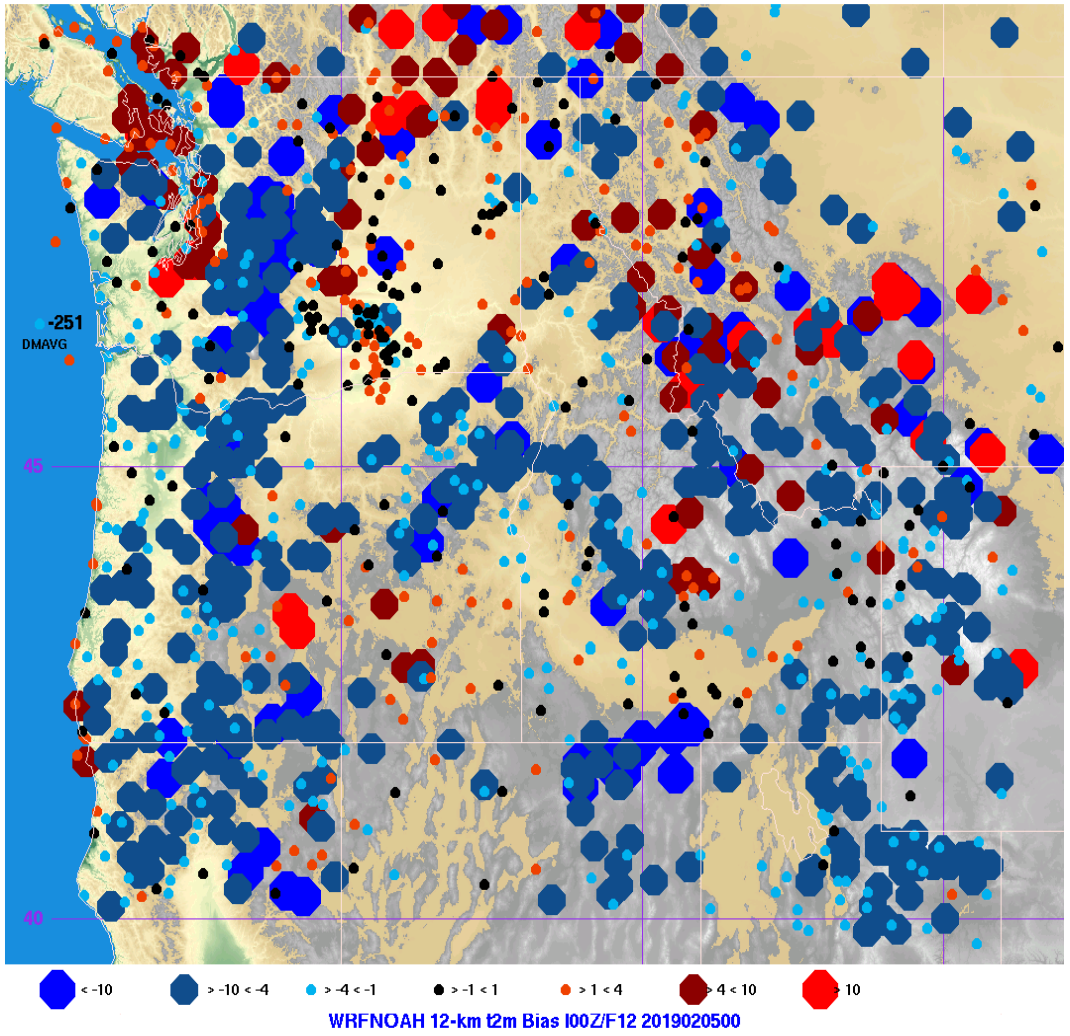


# NOAH LSM; Reduced temperature biases near Seattle.

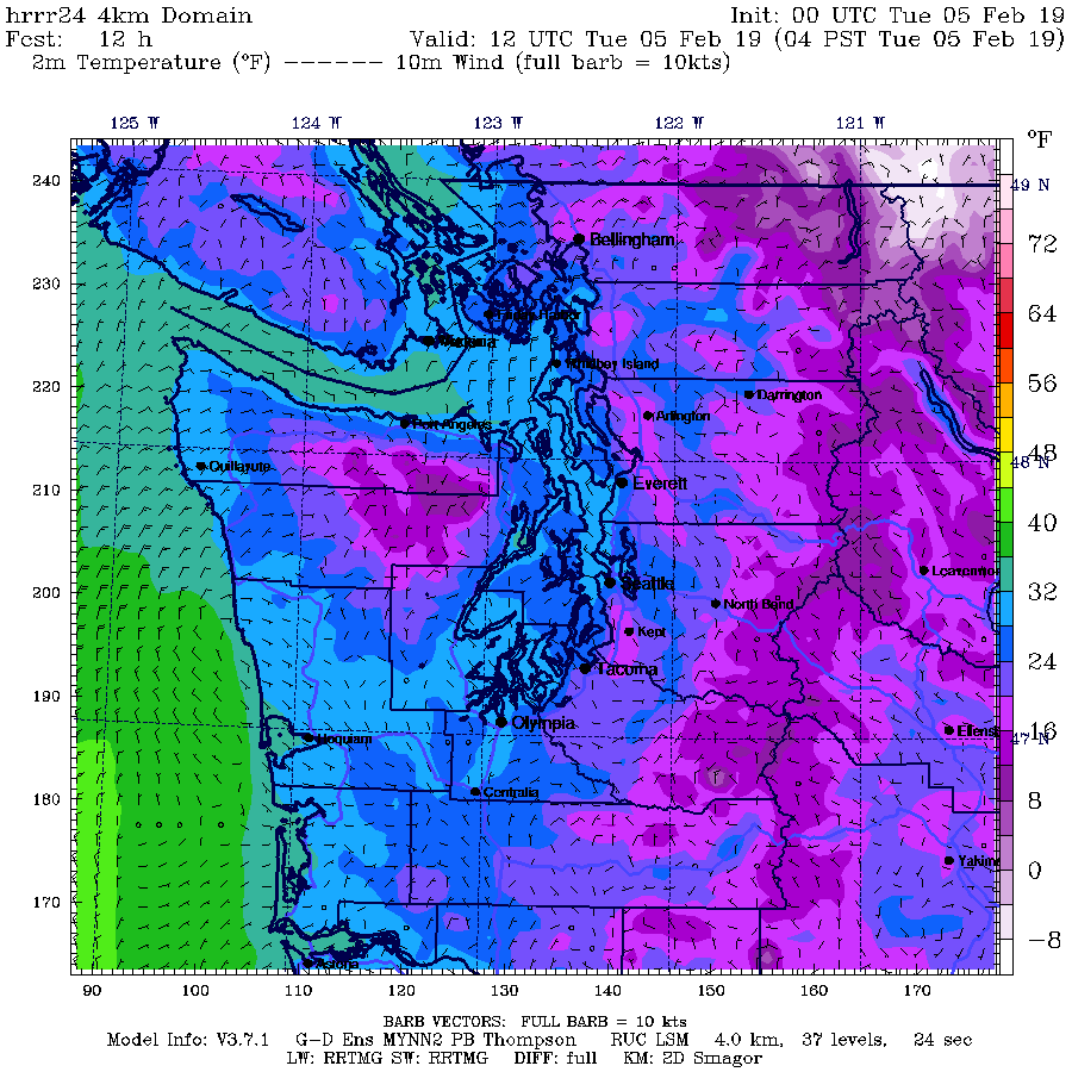
- Overall 4-km domain 2-m temperature bias is -2.51ºF.

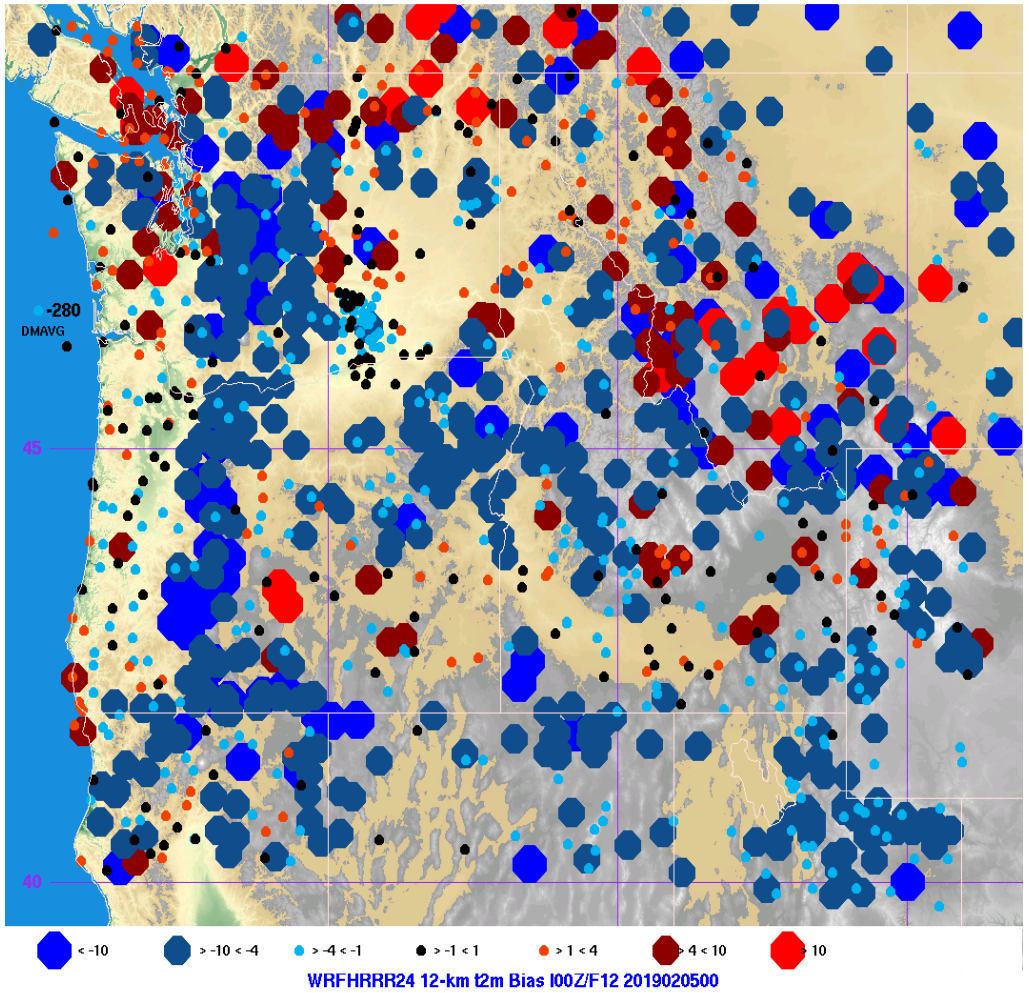


# Using HRRR physics with RUC physics improved cold biases near Seattle compared to NOAA-MP

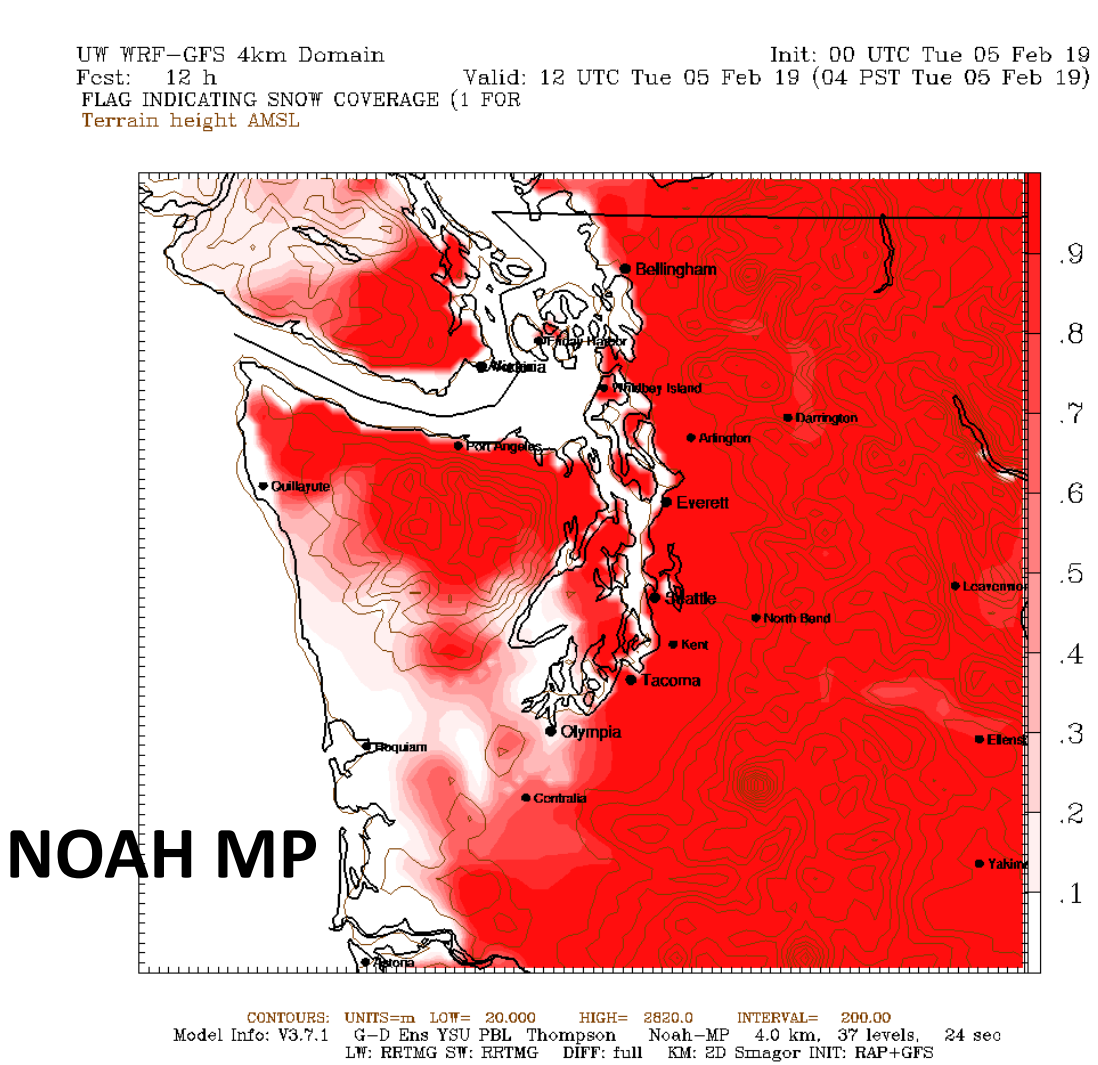
- **Overall 4-km domain 2-m temperature bias is -2.8ºF.**



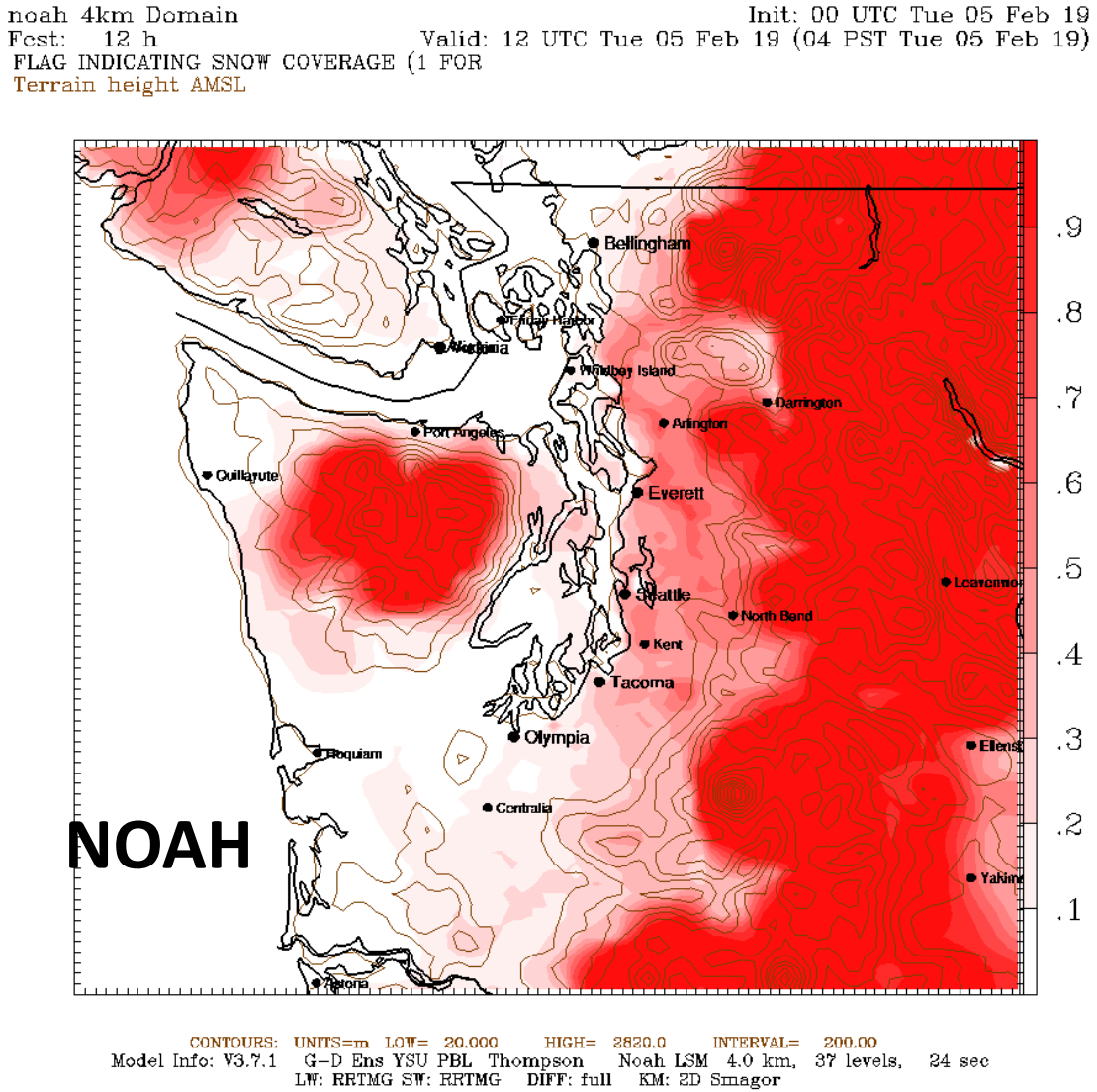



# Big differences between NOAH-MP and NOAH in snow field.

- **These differences appear by the first hour of the simulation, though forecast hour 12 is shown**



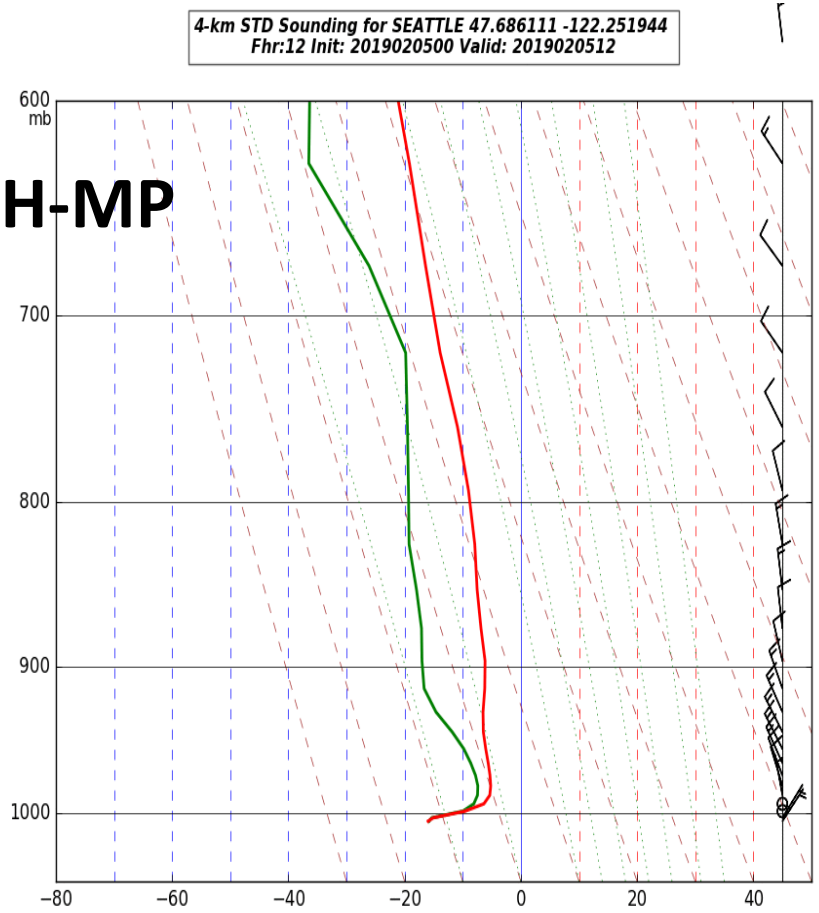

**NOAH MP**



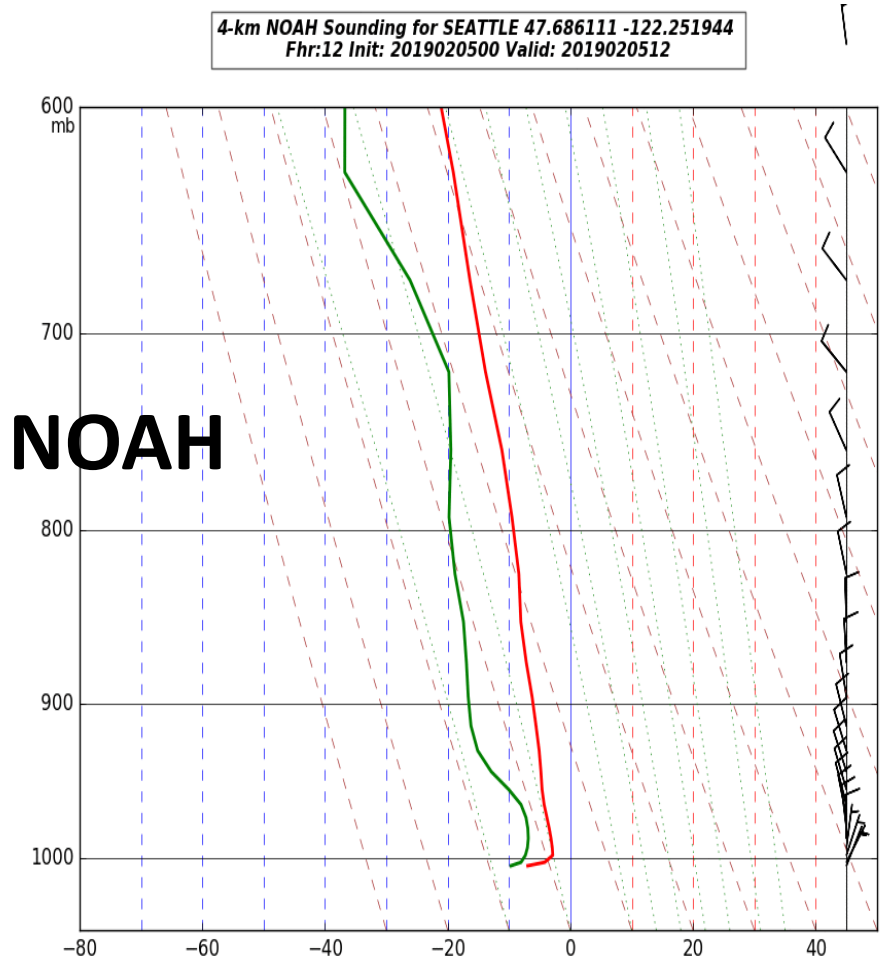

**NOAH**

# Vertical profiles illustrate that an unrealistic inversion formed in the Noah MP case and the more realistic Noah LSM profile.

**NOAH-MP**

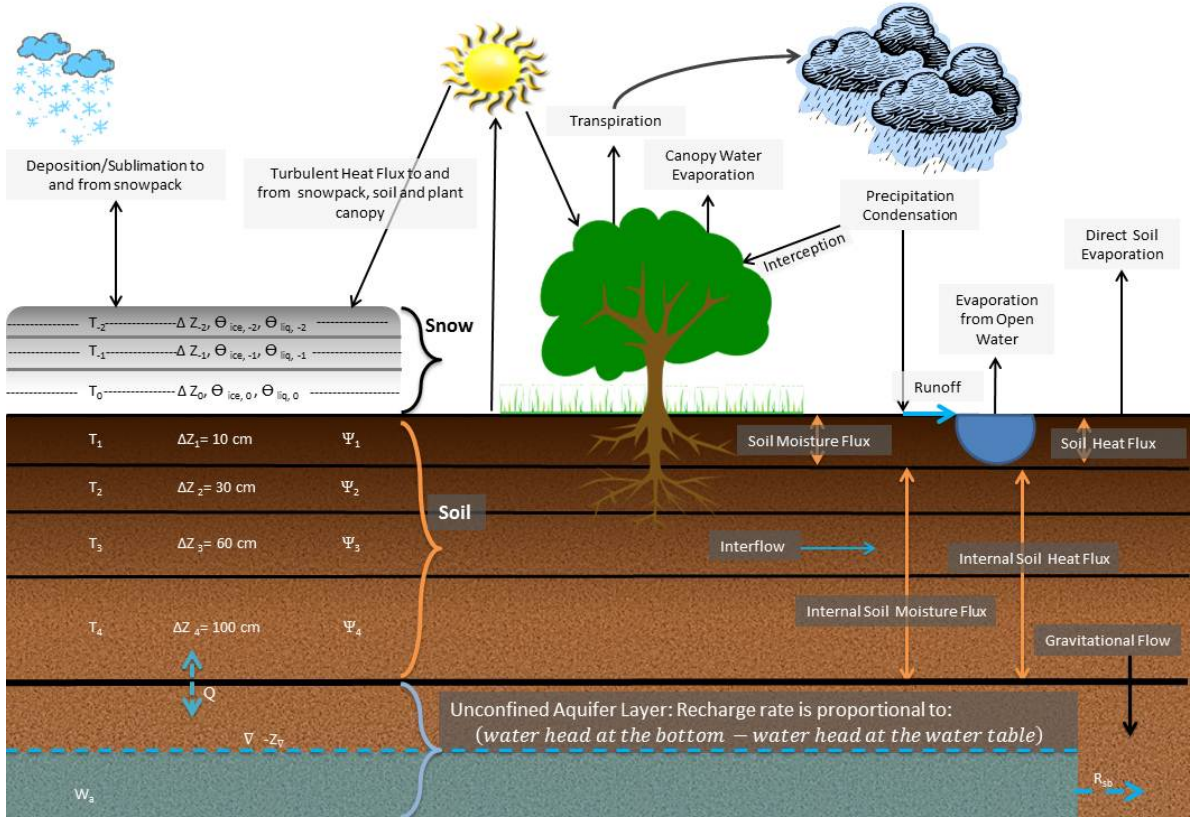



**NOAH**

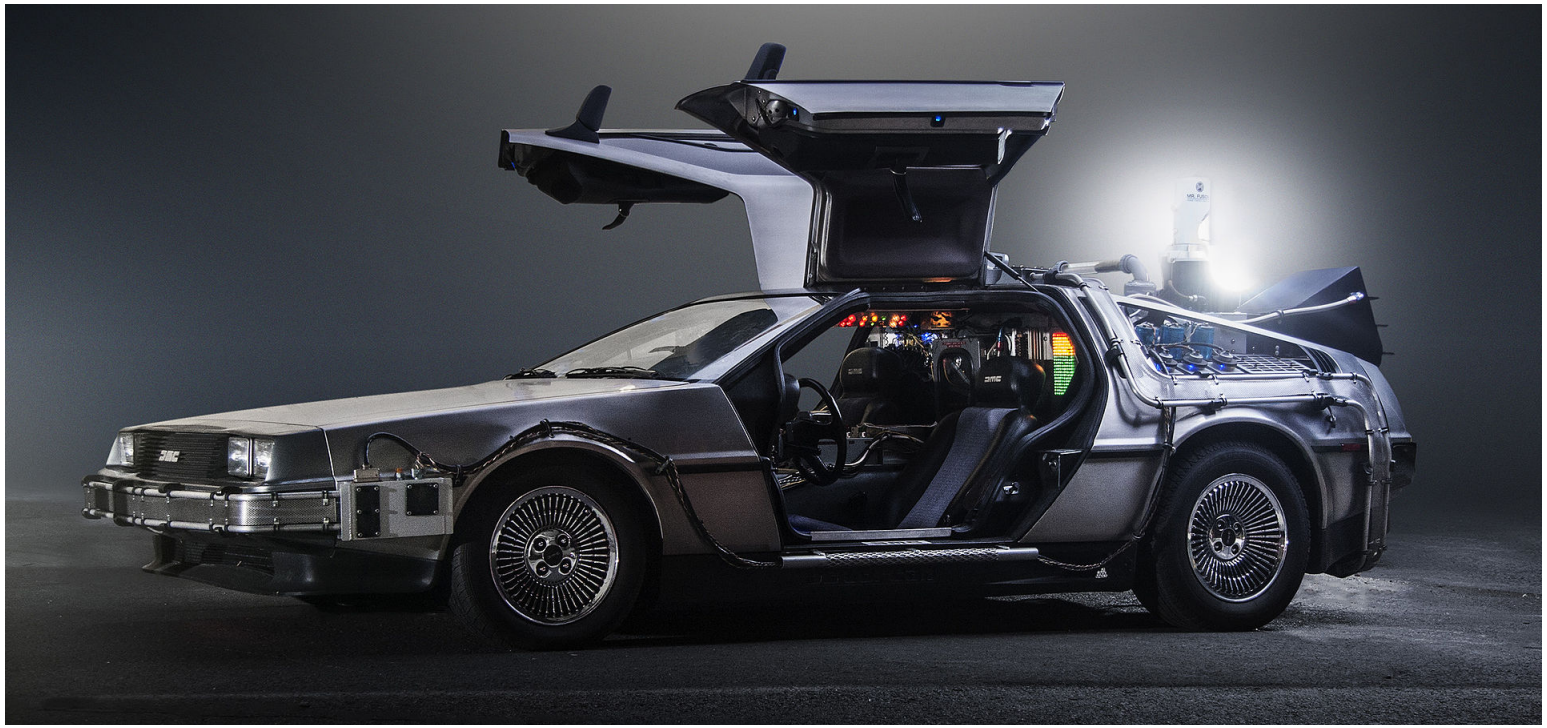


# We are not alone in having this problem—also seen in Conus simulations with NOAH-MP (Jimy Dudhia)

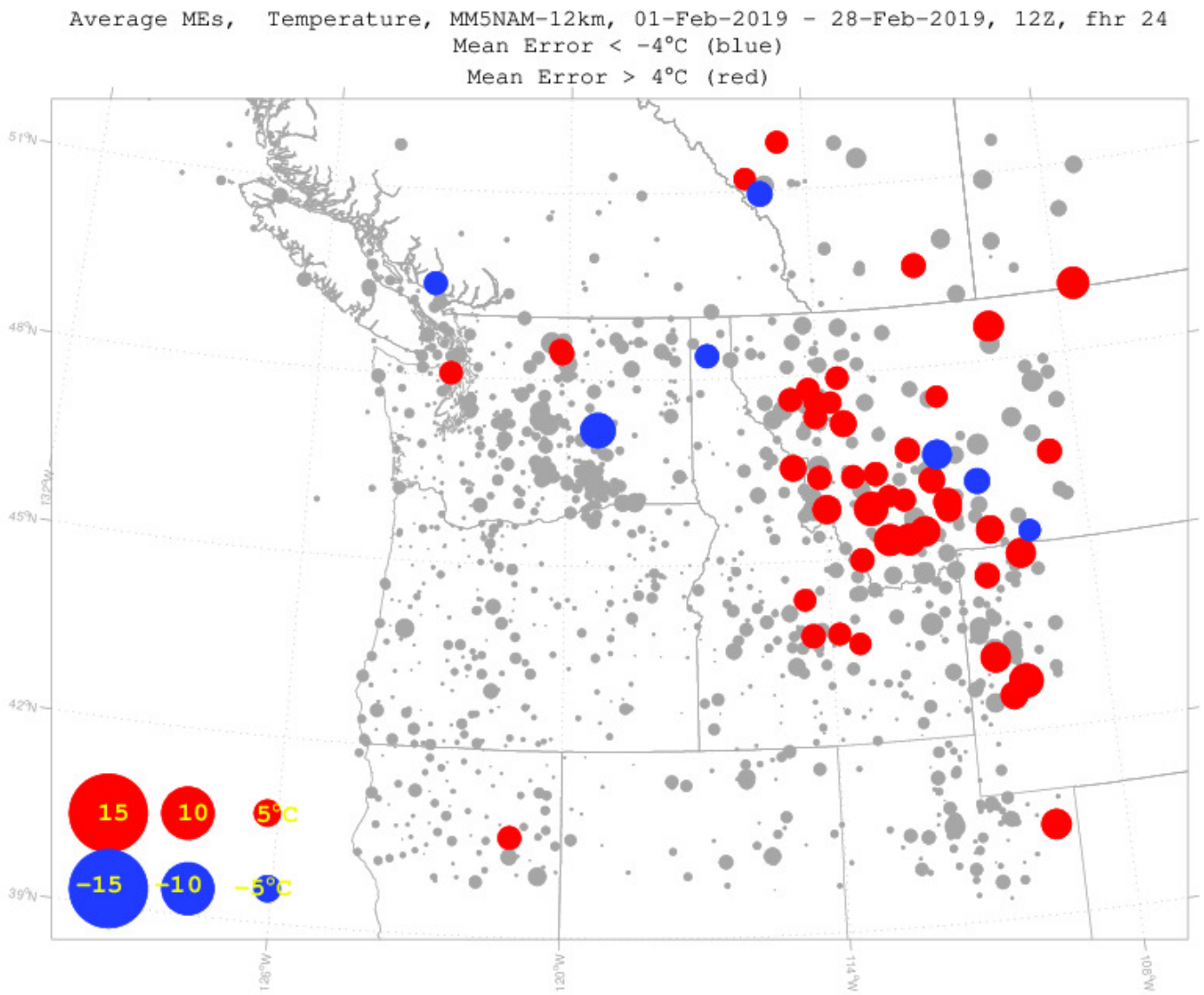
- Why worse in NOAH-MP?
- Why to lesser extent with most other LSM's?



# We know of one potential solution—but no one will like it….



# MM5 (driven by NWS NAM)



# This is another sobering example about how slowly the overall skill of forecasts improve

## Is WRF Getting Better?

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**University of Washington**

2015

# WRF Versions Tested

- 2.2.1 - October 31, 2007
- 3.1.1 - July 31, 2009
- 3.5 - April 18, 2013
- 3.7 - April 20, 2015

# No consistent improvement

## Sea Level Pressure (24h Forecast)

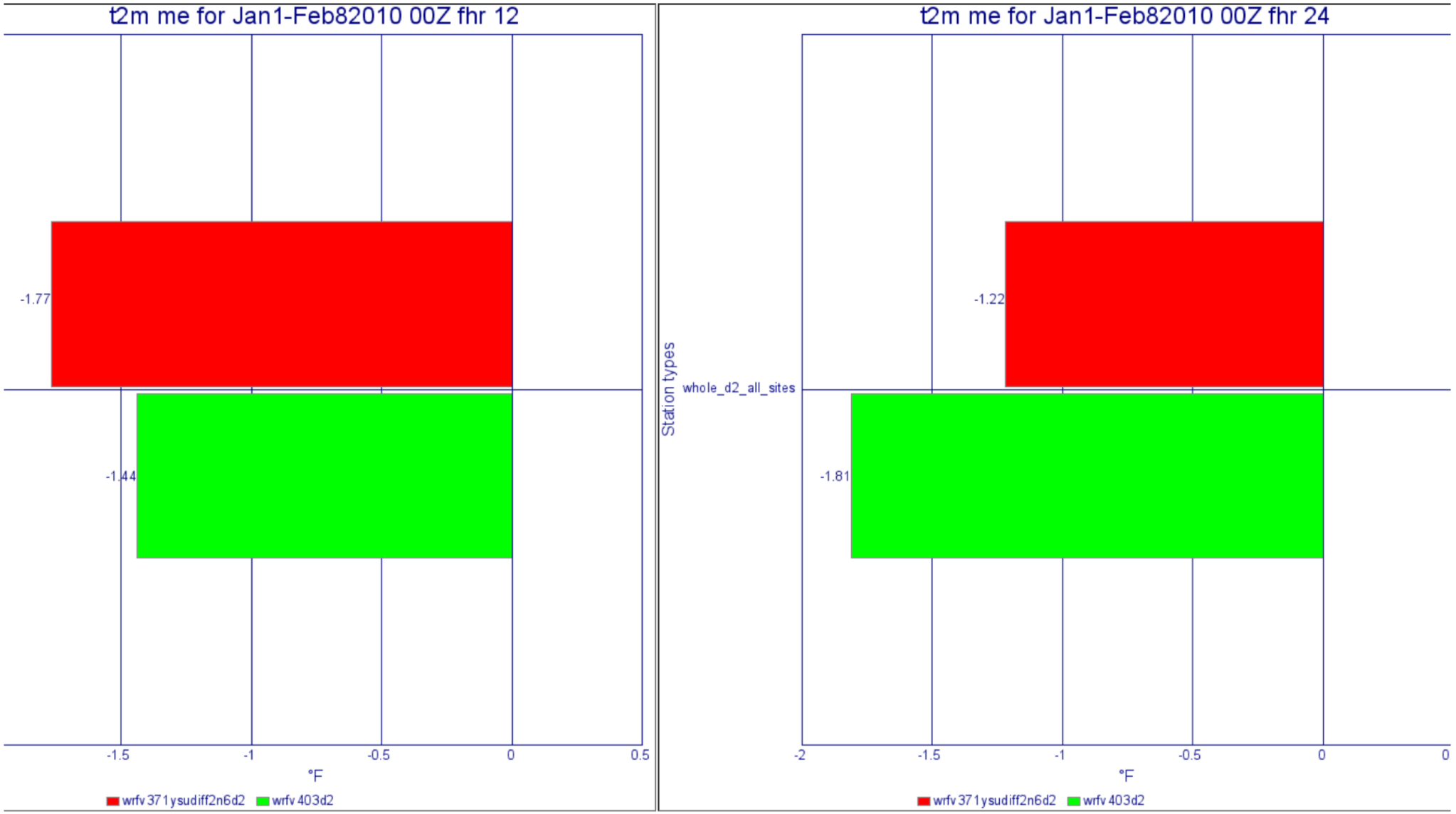
| Field | ME | MAE | RMS | STDEV | COUNT | Case |
|---|---|---|---|---|---|---|
| slp | -1.42 | 2.33 | 3.50 | 3.20 | 6793 | wrfv221 |
| slp | -1.72 | 2.39 | 3.56 | 3.12 | 6793 | wrfv311 |
| slp | -1.97 | 2.52 | 3.67 | 3.10 | 6793 | wrfv35r |
| slp | -2.22 | 2.66 | 3.78 | 3.06 | 6793 | wrfv37d |

**221 WINS, Forecasts GET WORSE Over Time**

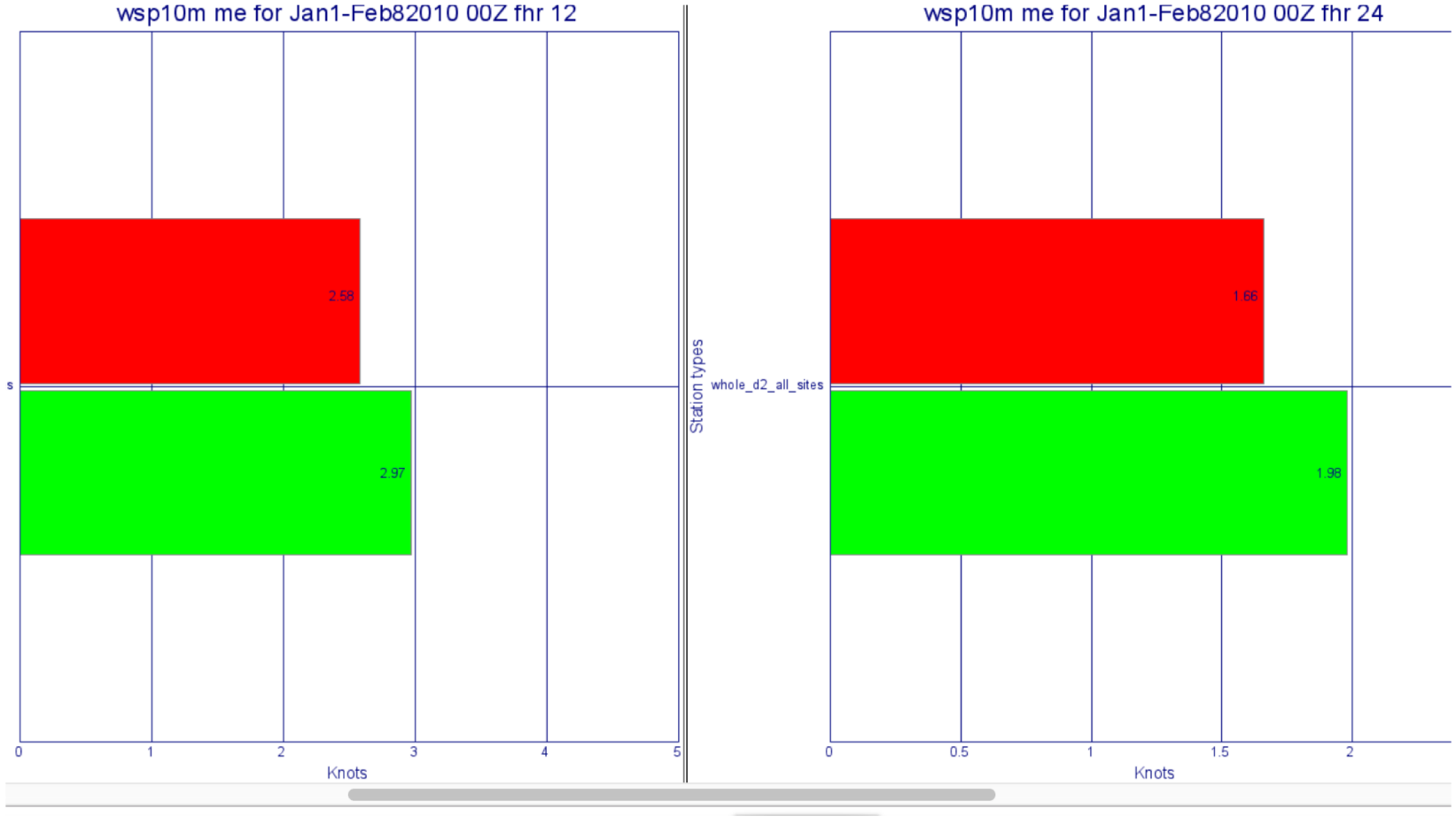
**Recently, we compared WRF V3.7.1 with WRF 4.0.3 with all the bells and whistles (e.g., hybrid vertical coordinate)**

**Did forecast verifications improve?**

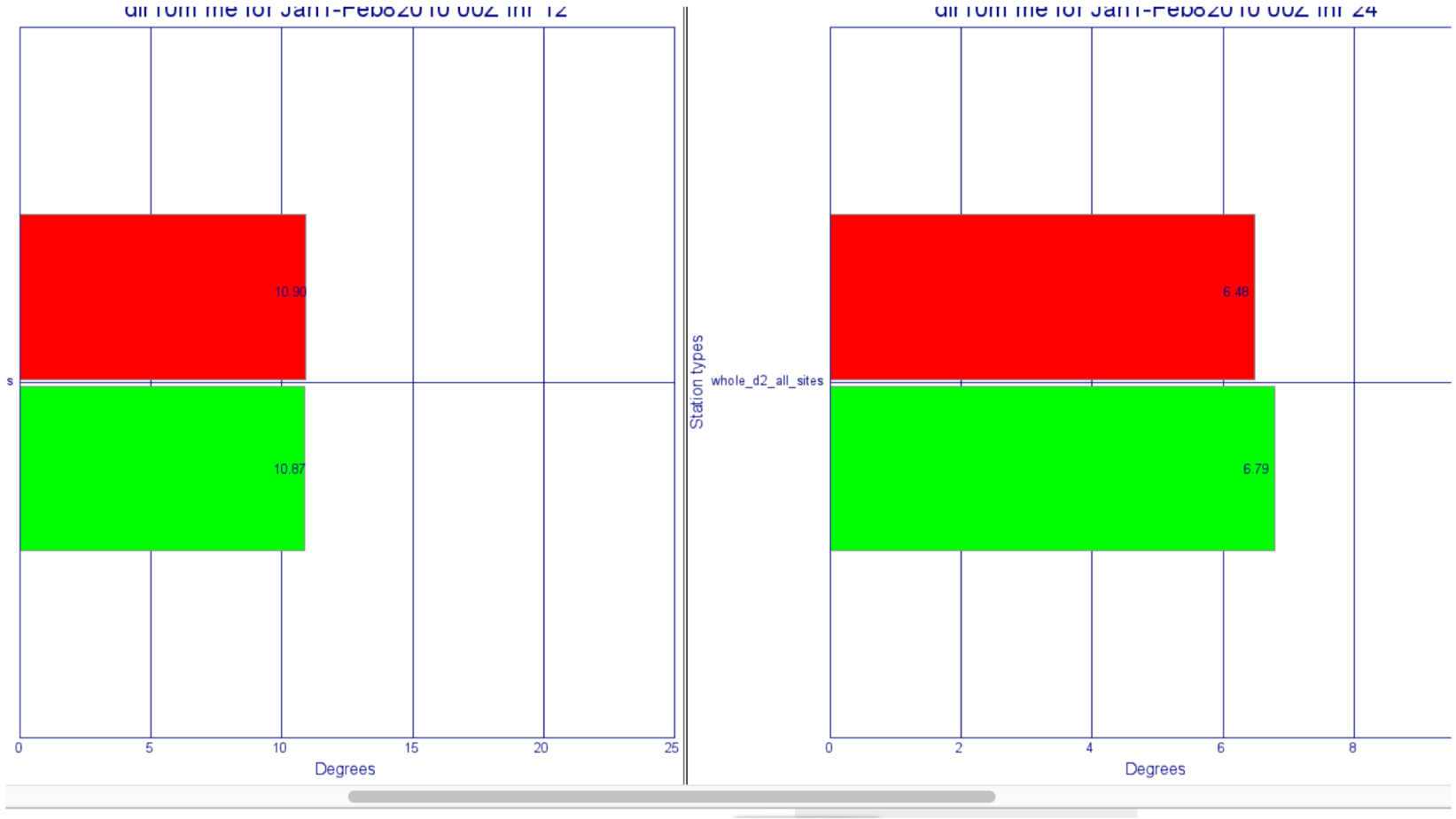
# Surface air temperature



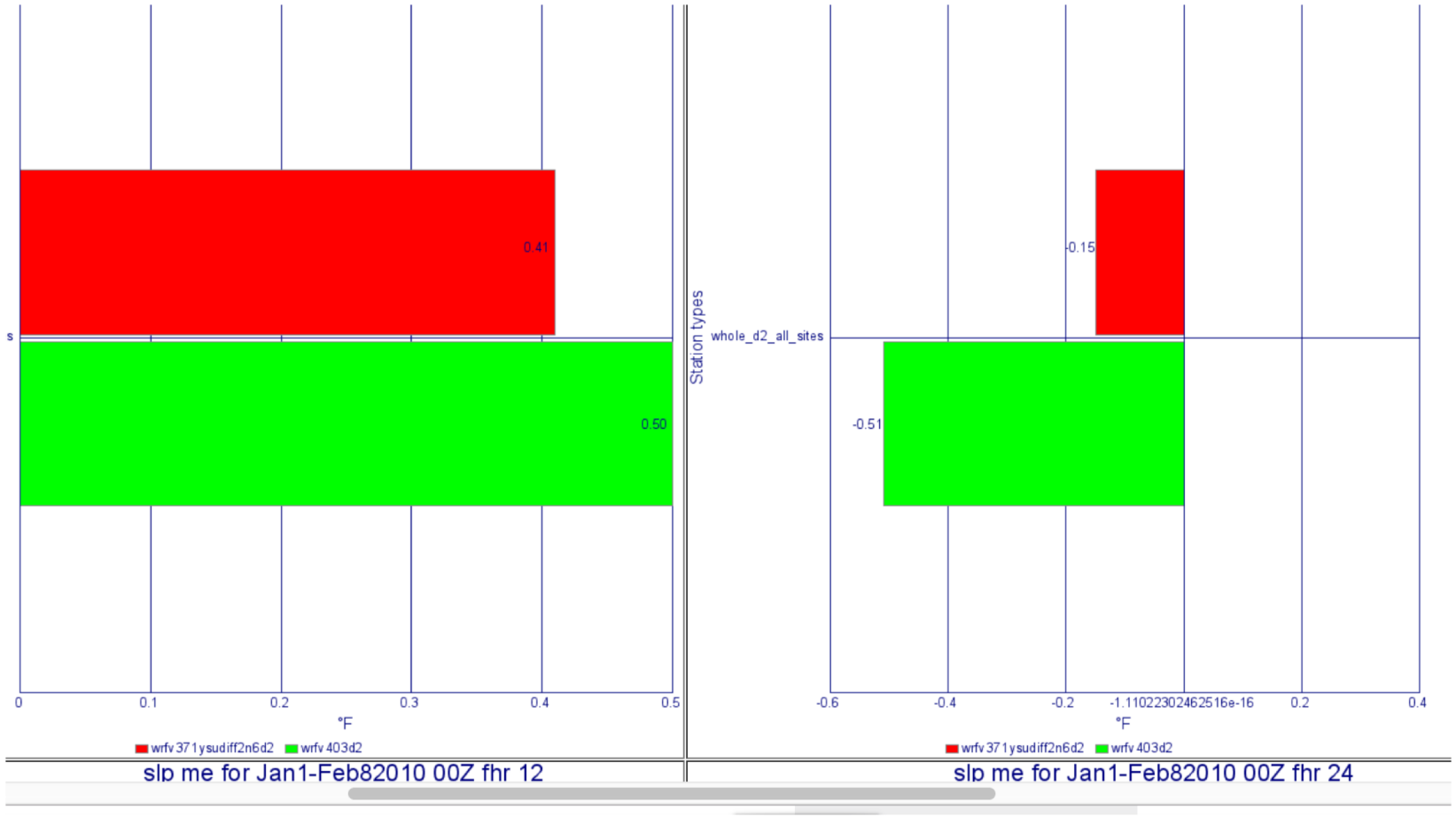
# Surface Wind Speed



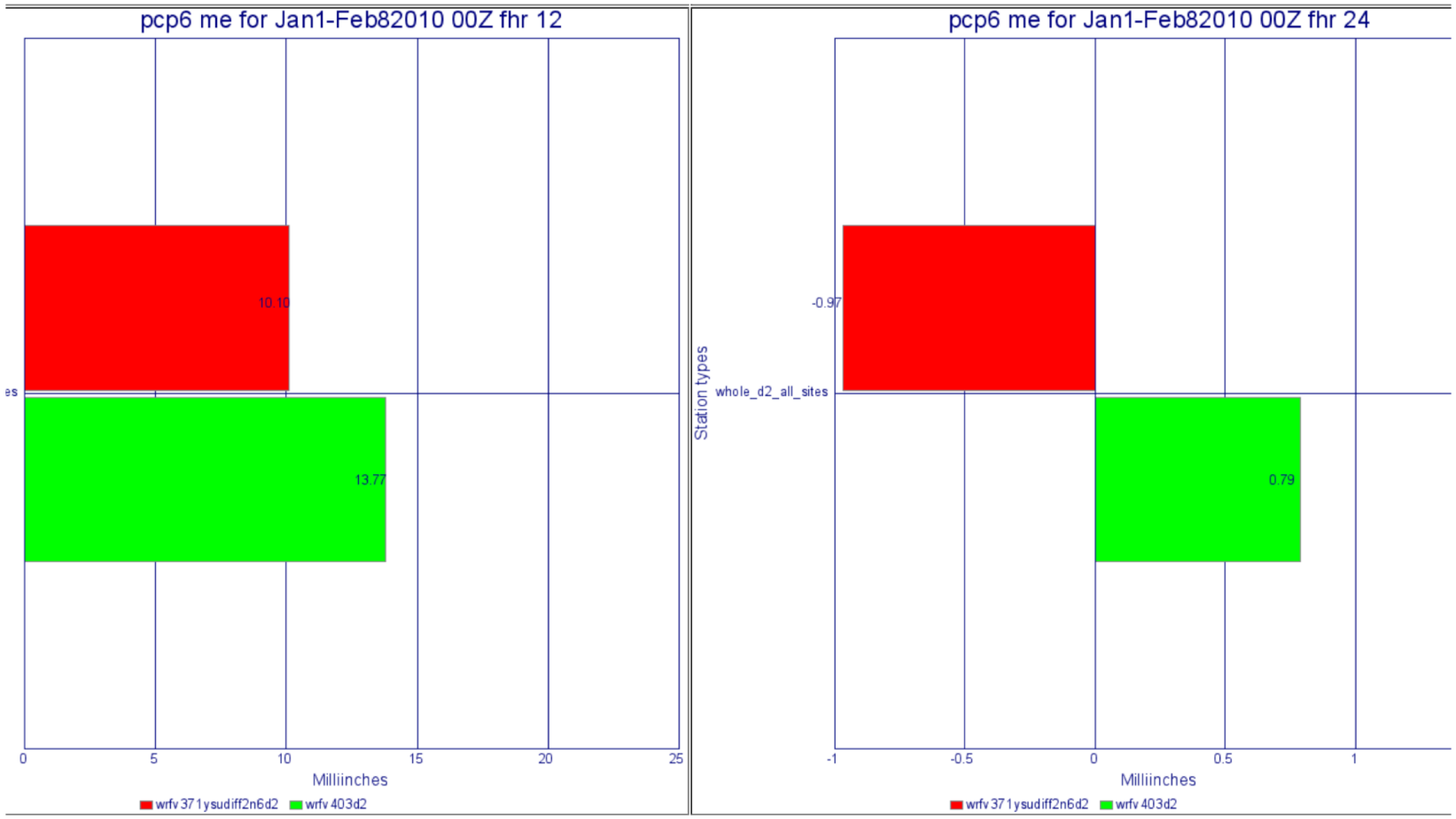
# Wind Direction



# Sea Level Pressure



# Precipitation



WINNERS

# Take Home Message

- There is no doubt that there have been improvements in the WRF model over the years.
- A number of changes have been to add complexity and more processes.
- Some “improvements” have resulted in degradations in some aspects of forecast performance.
- The overall integrated performance of the modeling system has not changed much over the past ten years.
- How do we move forward in improving total integrated performance: another talk.

# The End