

# WRFv3.1.1+ QNSE Test and Evaluation

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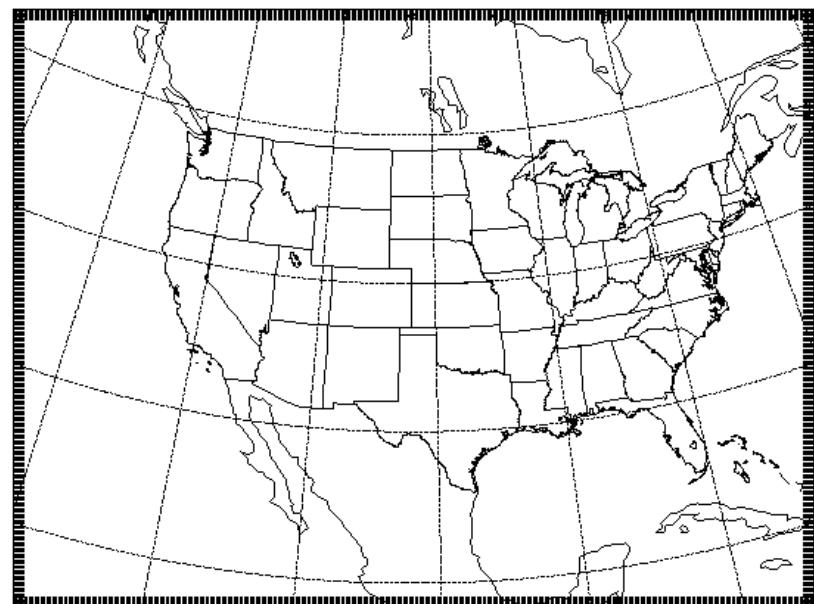
# Overview

- Goal: Assess the performance of new **Quasi-Normal Scale Elimination (QNSE)** PBL and surface layer schemes in WRF (available since WRFv3.1)

Physics Suites:	AFWA Op Config	QNSE Replacement
<b>Microphysics</b>	<b>WRF Single-Moment 5</b>	<b>WRF Single-Moment 5</b>
<b>Radiation (SW/LW)</b>	<b>Dudhia/RRTM</b>	<b>Dudhia/RRTM</b>
<b>Surface Layer</b>	<b>Monin-Obukhov similarity theory</b>	<b>QNSE</b>
<b>Land Surface Model</b>	<b>Noah</b>	<b>Noah</b>
<b>PBL</b>	<b>Yonsei University</b>	<b>QNSE</b>
<b>Convection</b>	<b>Kain-Fritsch</b>	<b>Kain-Fritsch</b>

# Experiment Design

- **End-to-end system:** WPS (v3.1.1), WRF (v3.1.1+ repo tag), WPP (v3.1), graphics, MET (v2.0)
- **Domain:** CONUS with 15-km grid spacing, 56 vertical levels, model top at 10 hPa
  - Capture diverse regional effects for worldwide comparability
- **Test Period:** 2 June 2008 – 31 May 2009
- **Retrospective forecasts:** 48h forecasts initialized every 36 hours (243 cases)
- **Initial and Boundary Conditions:** 0.5 x 0.5 degree GFS



# Model Verification

- Surface and Upper Air
  - Bias-Corrected Root Mean Square Error (BCRMSE) & Bias
    - Temperature, Dew Point Temperature, Winds
- Precipitation
  - Gilbert Skill Score (GSS) & Frequency Bias
    - 3-h and 24-h accumulations
- Applied pair-wise difference methodology (AFWA-QNSE)
- Computed confidence intervals at the 99% level

# Model Verification Stratifications

- Spatial aggregations:
  - Full CONUS domain and 14 sub-regions
- Temporal aggregations:
  - All cases (entire year) and seasonal (summer, fall, winter, spring)
- Initialization time:
  - For upper air statistics: 00 UTC and 12 UTC initializations aggregated
  - For surface statistics: 00 UTC and 12 UTC initializations kept separate

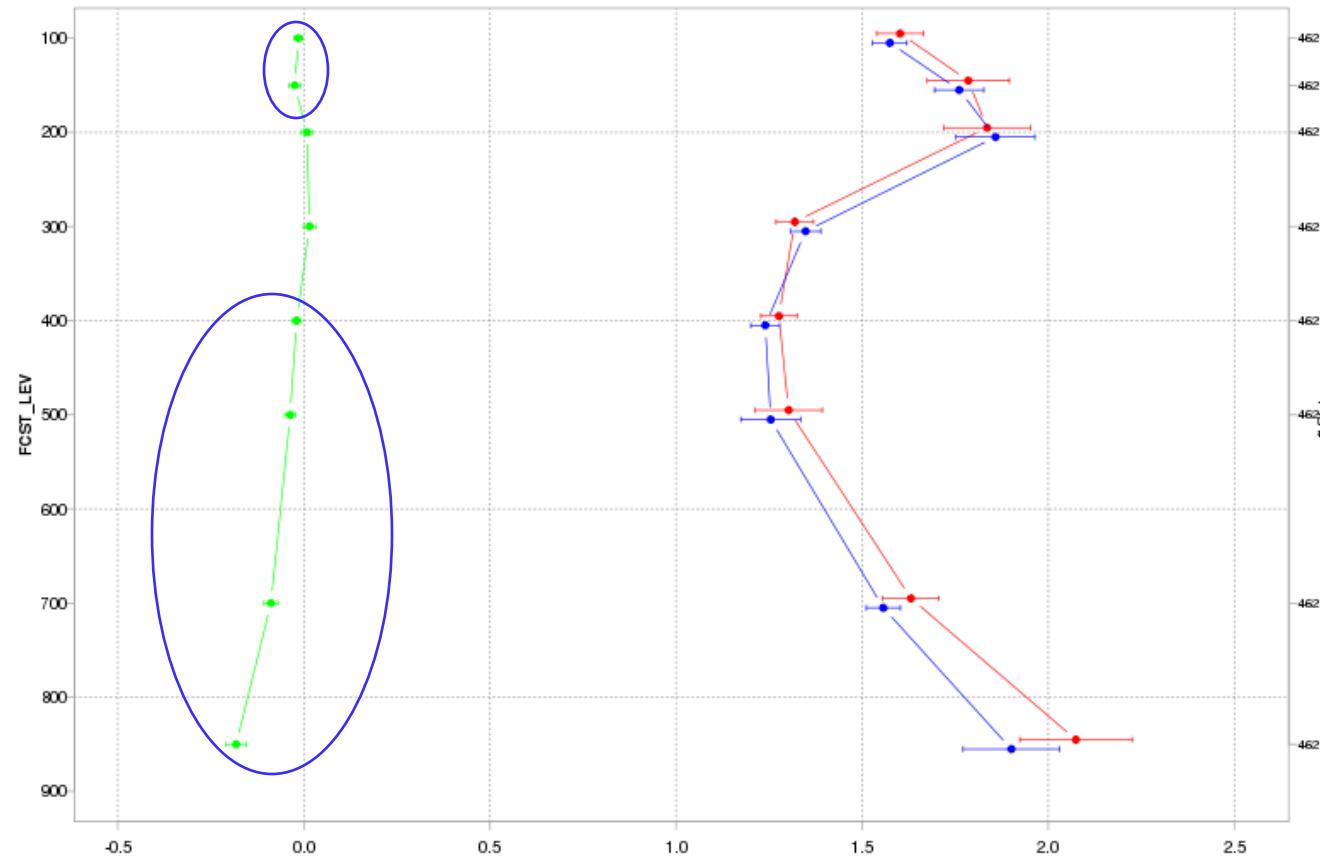
\*subset presented here

# Verification Results

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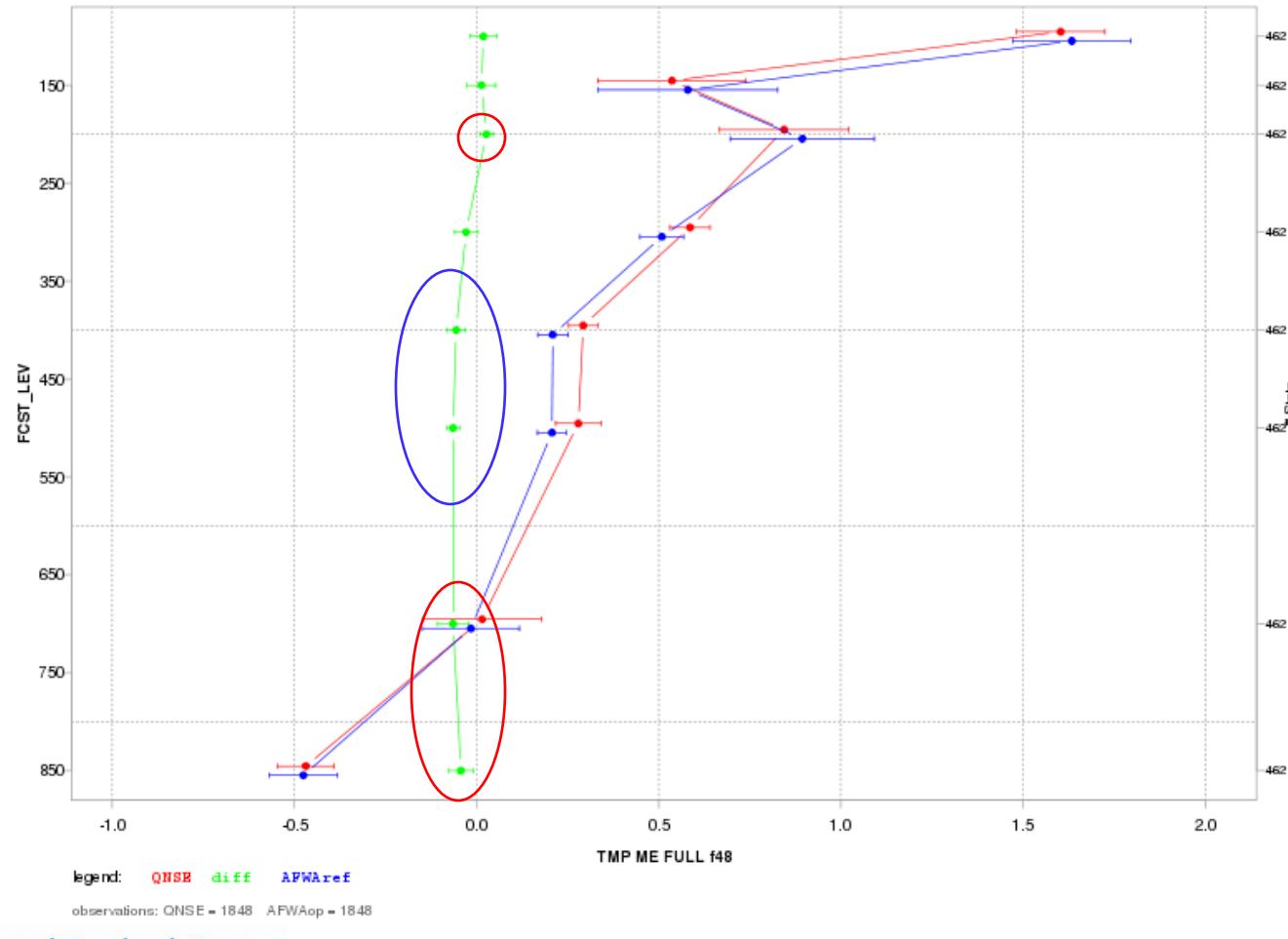
# Upper Air Temperature - BCRMSE

Vertical profile plot at the **48-hour lead time**.



# Upper Air Temperature - Bias

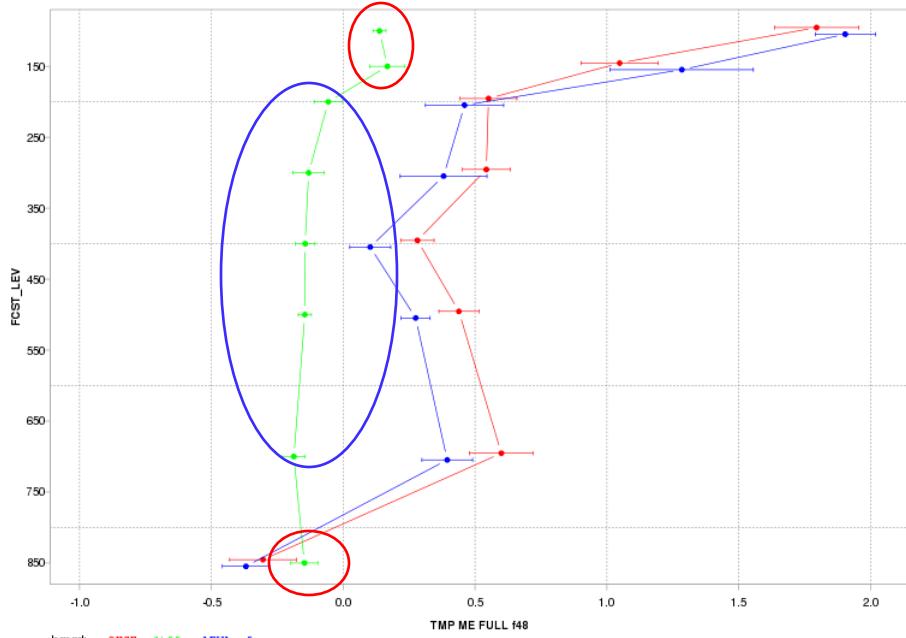
Vertical profile plot at the 48-hour lead time.



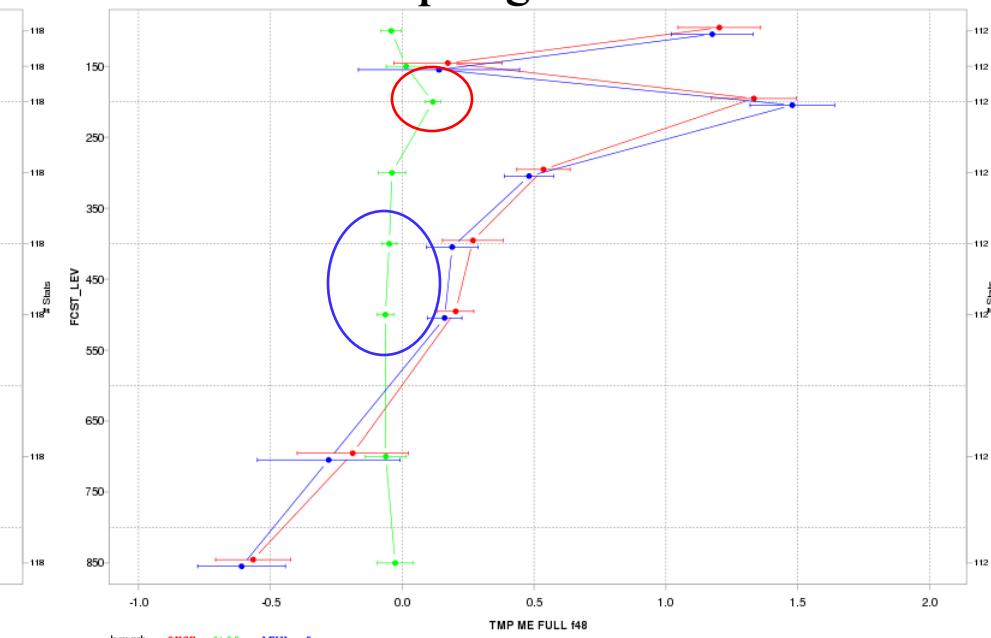
# Upper Air Temperature - Bias

Vertical profile plot at the **48-hour lead time** for:

**Summer Season**



**Spring Season**



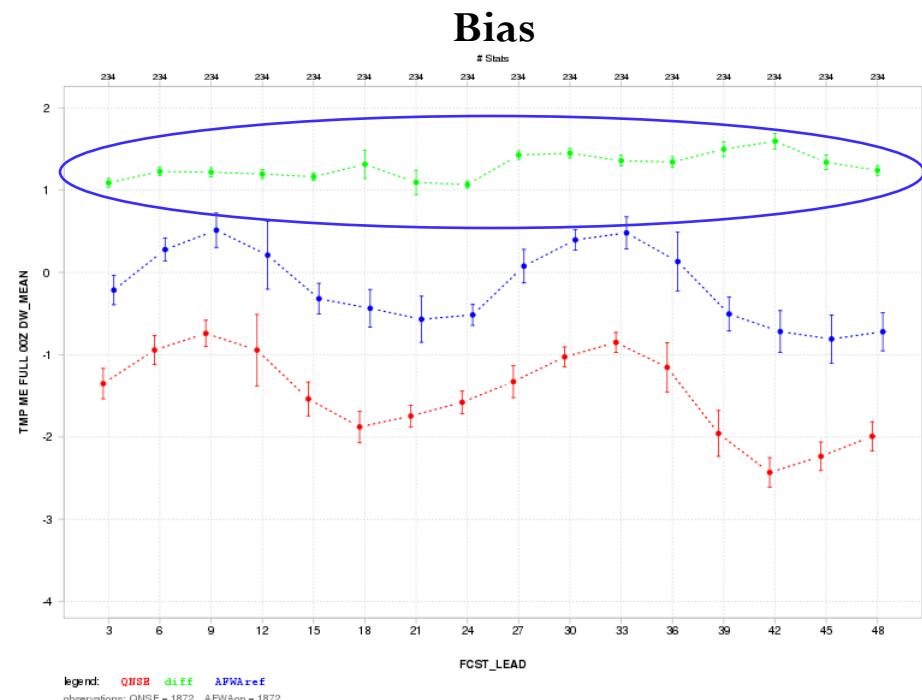
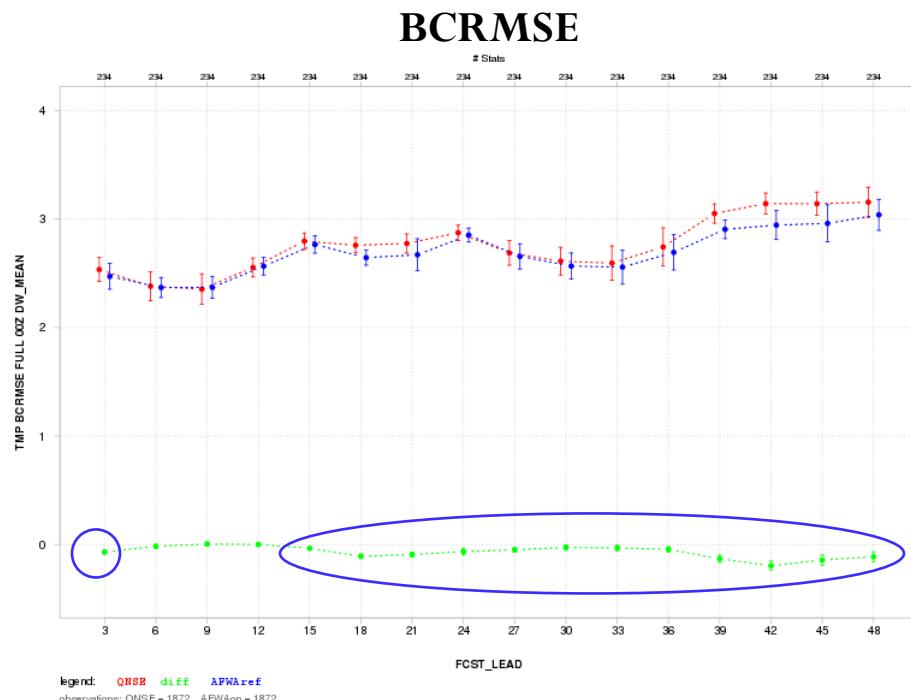
# Upper Air Temperature - SS Table

Statistically Significant (SS) differences for BCRMSE and bias by pressure level, season, and lead time.

		Annual				Summer				Fall				Winter				Spring				
		f12	f24	f36	f48	f12	f24	f36	f48	f12	f24	f36	f48	f12	f24	f36	f48	f12	f24	f36	f48	
BCRMSE	850	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	
	700	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	
	500	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	--	--	--	--	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	--	--	AFWA	AFWA
	400	AFWA	AFWA	AFWA	AFWA	--	QNSE	--	--	--	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	--	--	AFWA	AFWA	
	300	--	QNSE	--	--	--	QNSE	QNSE	QNSE	--	--	--	--	--	--	AFWA	--	--	--	--	--	
	200	QNSE	QNSE	QNSE	--	QNSE	QNSE	QNSE	--	QNSE	QNSE	--	--	QNSE	--	--	--	QNSE	QNSE	QNSE	--	
	150	AFWA	--	AFWA	AFWA	--	--	QNSE	--	--	AFWA	AFWA	AFWA	--	AFWA	AFWA	AFWA	--	--	AFWA	--	
	100	--	AFWA	--	AFWA	--	--	--	--	--	--	--	--	AFWA	--	AFWA	--	AFWA	AFWA	AFWA	AFWA	
Bias	850	QNSE	QNSE	QNSE	QNSE	QNSE	QNSE	QNSE	QNSE	QNSE	QNSE	QNSE	--	QNSE	--	--	--	AFWA	QNSE	QNSE	--	--
	700	AFWA	AFWA	AFWA	QNSE	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	--	--	--	--	--	--	AFWA	QNSE	--	
	500	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	--	--	--	--	--	AFWA	AFWA	AFWA	AFWA	
	400	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	--	--	AFWA	AFWA	--	AFWA	AFWA	AFWA	AFWA	
	300	AFWA	--	--	--	AFWA	AFWA	AFWA	AFWA	--	--	--	--	--	--	--	--	AFWA	--	--	--	
	200	QNSE	QNSE	QNSE	QNSE	--	--	--	AFWA	QNSE	QNSE	QNSE	--	QNSE	QNSE	--	--	QNSE	QNSE	QNSE	QNSE	
	150	--	--	--	--	QNSE	QNSE	QNSE	QNSE	QNSE	--	--	--	AFWA	AFWA	AFWA	AFWA	--	--	--	--	
	100	QNSE	--	--	--	QNSE	QNSE	QNSE	QNSE	QNSE	QNSE	QNSE	--	--	--	--	AFWA	AFWA	AFWA	AFWA		

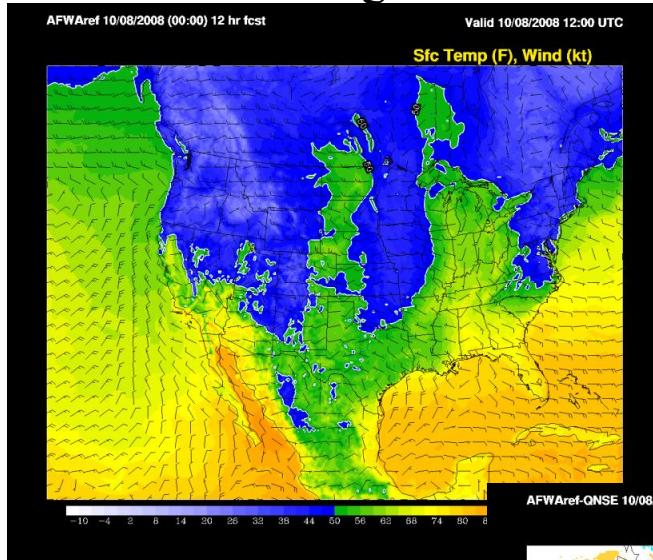
# 2m Temperature – BCRMSE/Bias

Time series plot for 00 UTC initializations only

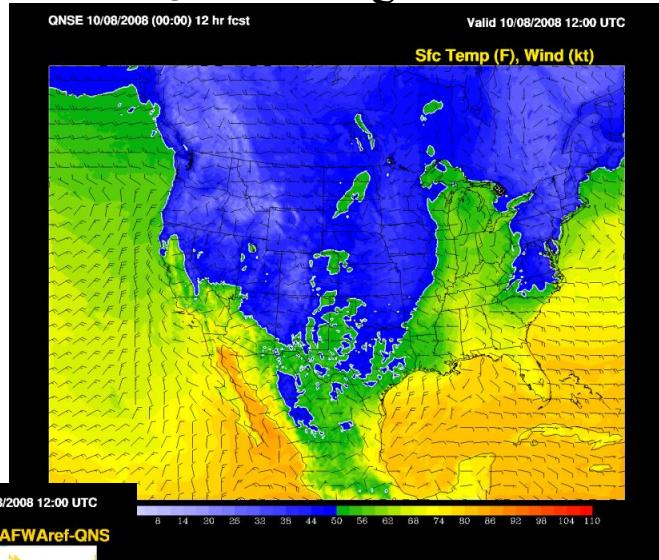


# Spatial plot – 2m Temp

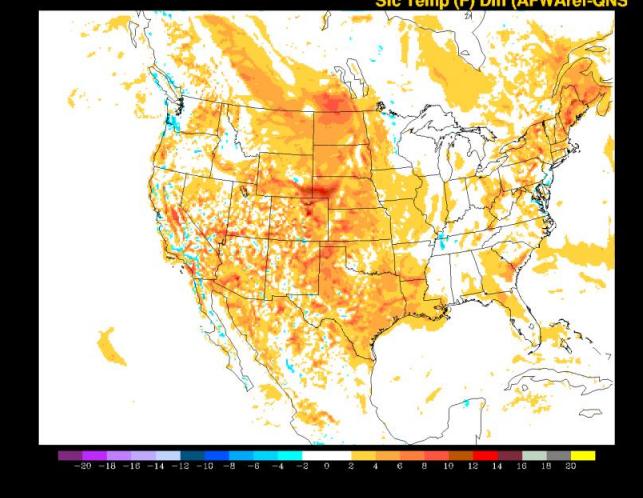
AFWA configuration



QNSE configuration

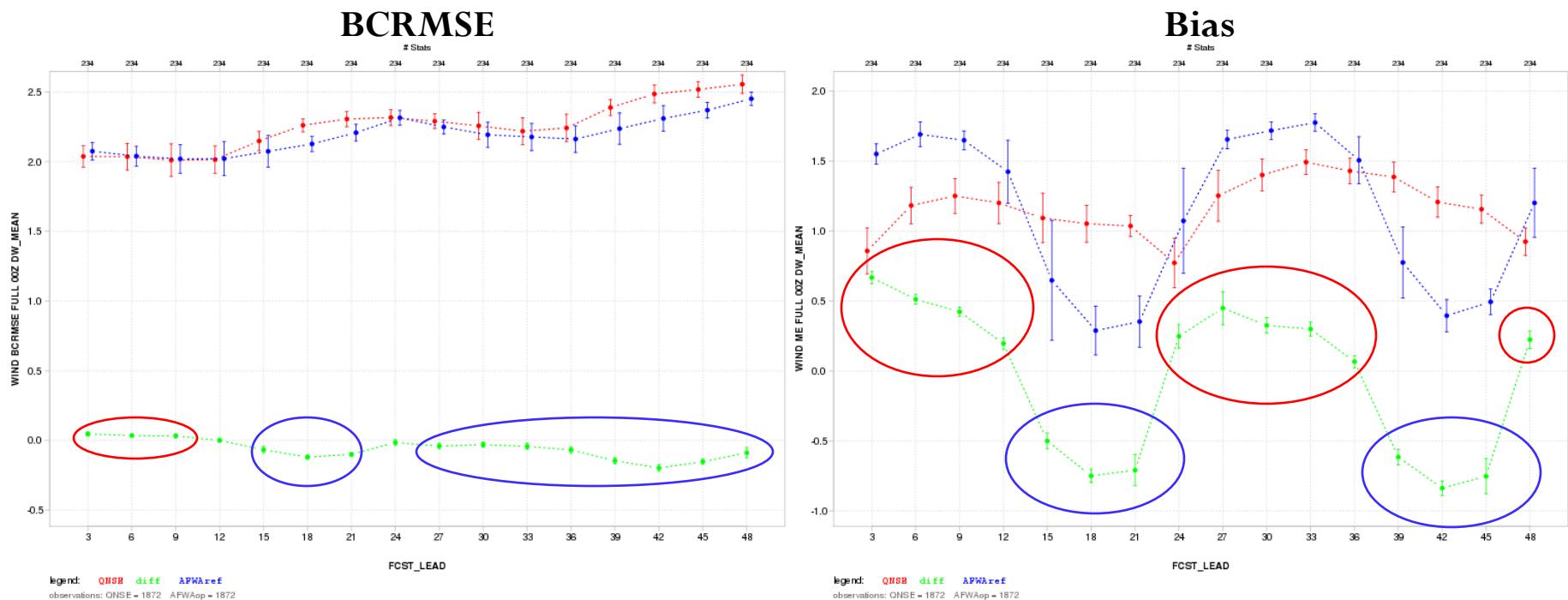


AFWA - QNSE



# 10m Wind – BCRMSE/Bias

Time series plot for 00 UTC initializations only



# 10m Wind – SS Table

Statistically Significant (SS) differences for BCRMSE and bias by season, initializations and lead time.

	f03	f06	f09	f12	f15	f18	f21	f24	f27	f30	f33	f36	f39	f42	f45	f48	
BCRMSE	00 UTC Initializations	Annual	QNSE	QNSE	QNSE	--	AFWA	AFWA	AFWA	--	AFWA						
		Summer	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	AFWA	QNSE	--	--	--	AFWA	AFWA	AFWA	--
		Fall	QNSE	QNSE	QNSE	--	AFWA	AFWA	AFWA	--	--	--	AFWA	AFWA	AFWA	AFWA	AFWA
		Winter	--	QNSE	QNSE	--	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	--	AFWA	AFWA	AFWA	AFWA
		Spring	--	QNSE	--	--	AFWA	AFWA	AFWA	--	AFWA	AFWA	AFWA	AFWA	AFWA	--	
	12 UTC Initializations	Annual	AFWA	AFWA	AFWA	QNSE	--	--	--	AFWA							
		Summer	AFWA	AFWA	AFWA	QNSE	--	--	--	AFWA	AFWA	AFWA	AFWA	QNSE	--	AFWA	AFWA
		Fall	--	AFWA	AFWA	--	--	--	--	AFWA							
		Winter	--	--	--	--	--	--	--	AFWA							
		Spring	AFWA	AFWA	AFWA	--	--	--	AFWA								
Bias	00 UTC Initializations	Annual	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA
		Summer	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	--	AFWA	AFWA	AFWA
		Fall	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA
		Winter	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	--	AFWA	AFWA	AFWA	QNSE
		Spring	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	--	AFWA	AFWA	AFWA	QNSE
	12 UTC Initializations	Annual	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	--
		Summer	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	--
		Fall	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE
		Winter	--	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE	QNSE	--	--
		Spring	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	--	AFWA	AFWA	AFWA	--	QNSE	QNSE	QNSE

# QNSE bug fix

- Significant misrepresentation of surface (2m and 10m diagnostics) variables
  - Discovery made based on preliminary results (from one month of testing) DTC provided to QNSE developers
- Bug fix checked into the WRF repository in mid-Dec 2009
- Impact will be assessed in follow-up testing with WRF version 3.2 later this year

# QNSE T&E Executive Summary

- Vertical profile:
  - Temperature
    - **BCRMSE**: SS differences at and below 400 hPa and above 150 hPa favor AFWA, while those at 200 and 300 hPa favor QNSE.
    - **Bias**: SS differences between 700 and 300 hPa favor AFWA, while those at 850 and 200 hPa favor QNSE.
  - Dew Point Temperature
    - **BCRMSE**: All SS differences favor AFWA.
    - **Bias**: In general, SS differences favor QNSE.
  - Winds
    - **BCRMSE**: All SS differences favor AFWA.
    - **Bias**: All SS differences at 850 hPa favor AFWA, those above 700 hPa favor QNSE.

# QNSE T&E Executive Summary, Cont.

- Surface:
  - In general, for all variables, SS differences favor the AFWA configuration more often
    - Main exception: Overnight hours for Dew Point Temperature and Wind Speed **bias** - both of which favor the QNSE configuration
  - For precipitation , there are very few SS differences, however, with no exceptions the AFWA configuration is favored
- In general, the relative magnitude of SS differences favoring the AFWA configuration are larger than for the QNSE configuration

# QNSE T&E Webpage

[http://verif.rap.ucar.edu/eval/afwa\\_rc](http://verif.rap.ucar.edu/eval/afwa_rc)

The screenshot displays the QNSE Sensitivity Test interface, which includes several panels:

- Left Panel:** A sidebar with "DTC Home", "Reference Configurations", "Testing and Evaluation", and "Verification".
- Top Center:** A "Test Description" panel titled "QNSE Sensitivity Test Description". It lists "Codes Employed": WRF Preprocessing System (WPS), WRF-AFW model, WRF Post Processor (WPP), Model Evaluation Tools (MET), NCAR Command Language (NCL), and R for confidence intervals.
- Middle Left:** A "Verification" panel titled "Aggregate Verification". It contains three steps:
  - Choose Aggregation and Plot: Set to "year" for "Plot Type" and "Time Series" for "Plot Region".
  - Choose Variable and Metric Specifics: Set to "Sfc Temp" for "Variable", "20 ns" for "Init Hour", "na" for "Forecast Hour", "BCRMSE" for "Metric", "na" for "Convolution Radius", and "na" for "Precipitation Accumulation".
  - Submit Choices: Includes a "View Plot" button.
- Middle Center:** A plot titled "YEARTIME\_SERIES\_TMP\_BCRMSE\_FULL\_002\_UW\_MEAN" showing "TMP BCRMSE FULL 002 UW\_MEAN vs. FCST LEAD". The Y-axis ranges from 0 to 3, and the X-axis ranges from 3 to 48. The plot shows a blue dotted line with red error bars, generally increasing over time.
- Bottom Right:** Two maps titled "Wind (kt)" and "Sfc Temp (F), Wind (kt)". Both maps show a color-coded field over a geographic area, with "Wind (kt)" having a color scale from 0 to 40 and "Sfc Temp (F), Wind (kt)" having a color scale from 40 to 75.
- Bottom Center:** Buttons for "view full-sized image" and "animate all hours".
- Right Side:** A "QNSE Sensitivity Test" panel with sections for "Surface Air", "Clouds", and "Gounding". It includes a "Submit Choices" button and a note about viewing and animation options.

# Future Work

- Reference Configuration designation
  - Assess performance of each configuration individually  
*(For more information on Reference Configurations, see P.72 Reference Configuration Implementation)*
- <http://www.dtcenter.org/config/>**
- Retest both configurations with latest code (WRF v3.2)
  - Evaluate performance of most recent release
    - Comparison of each configuration for v3.1.1 versus v3.2
    - Intercomparison of AFWA/QNSE configurations using v3.2

# Thank you!

# Questions?

**Acknowledgements:** The DTC is funded by the National Oceanic and Atmospheric Administration, the Air Force Weather Agency, and National Center for Atmospheric Research (NCAR). NCAR is sponsored by the National Science Foundation.



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