

WRFv3.1.1+ QNSE Test and Evaluation

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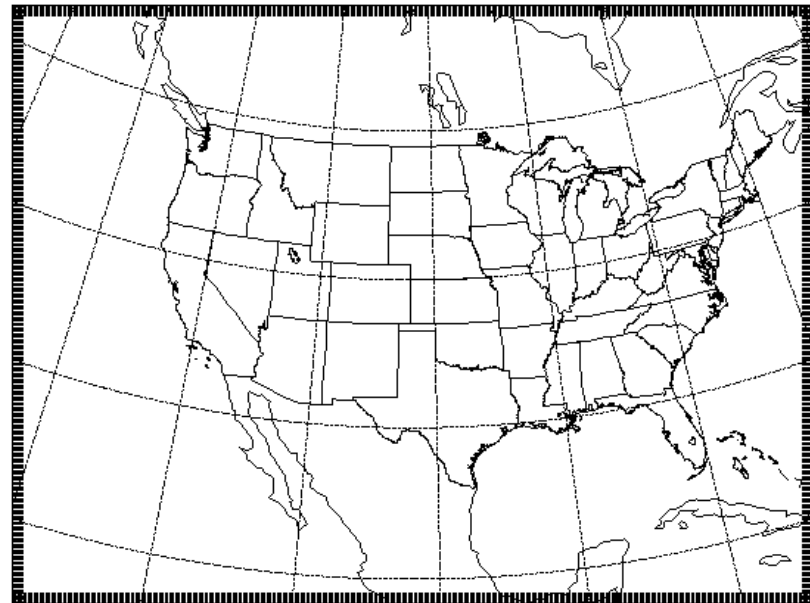
Overview

- 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
Microphysics	WRF Single-Moment 5	WRF Single-Moment 5
Radiation (SW/LW)	Dudhia/RRTM	Dudhia/RRTM
Surface Layer	Monin-Obukhov similarity theory	QNSE
Land Surface Model	Noah	Noah
PBL	Yonsei University	QNSE
Convection	Kain-Fritsch	Kain-Fritsch

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

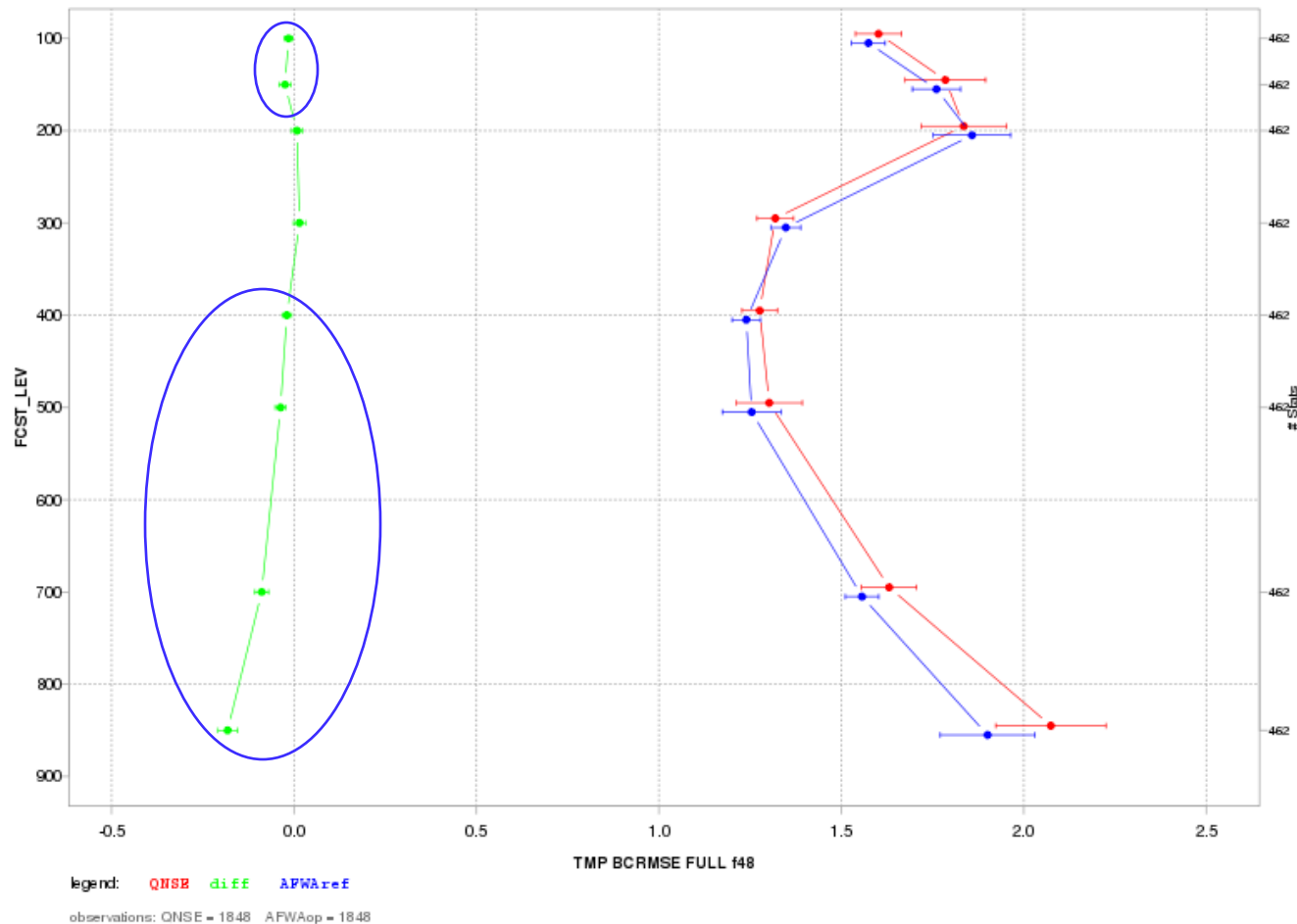
- Spatial aggregations:
 - Full CONUS domain and 14 sub-regions
- Temporal aggregations:
 - All cases (entire year) and seasonal (summer, fall, winter, spring)
- Initialization time:
 - For upper air statistics: 00 UTC and 12 UTC initializations aggregated
 - For surface statistics: 00 UTC and 12 UTC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

*subset presented here

Verification Results

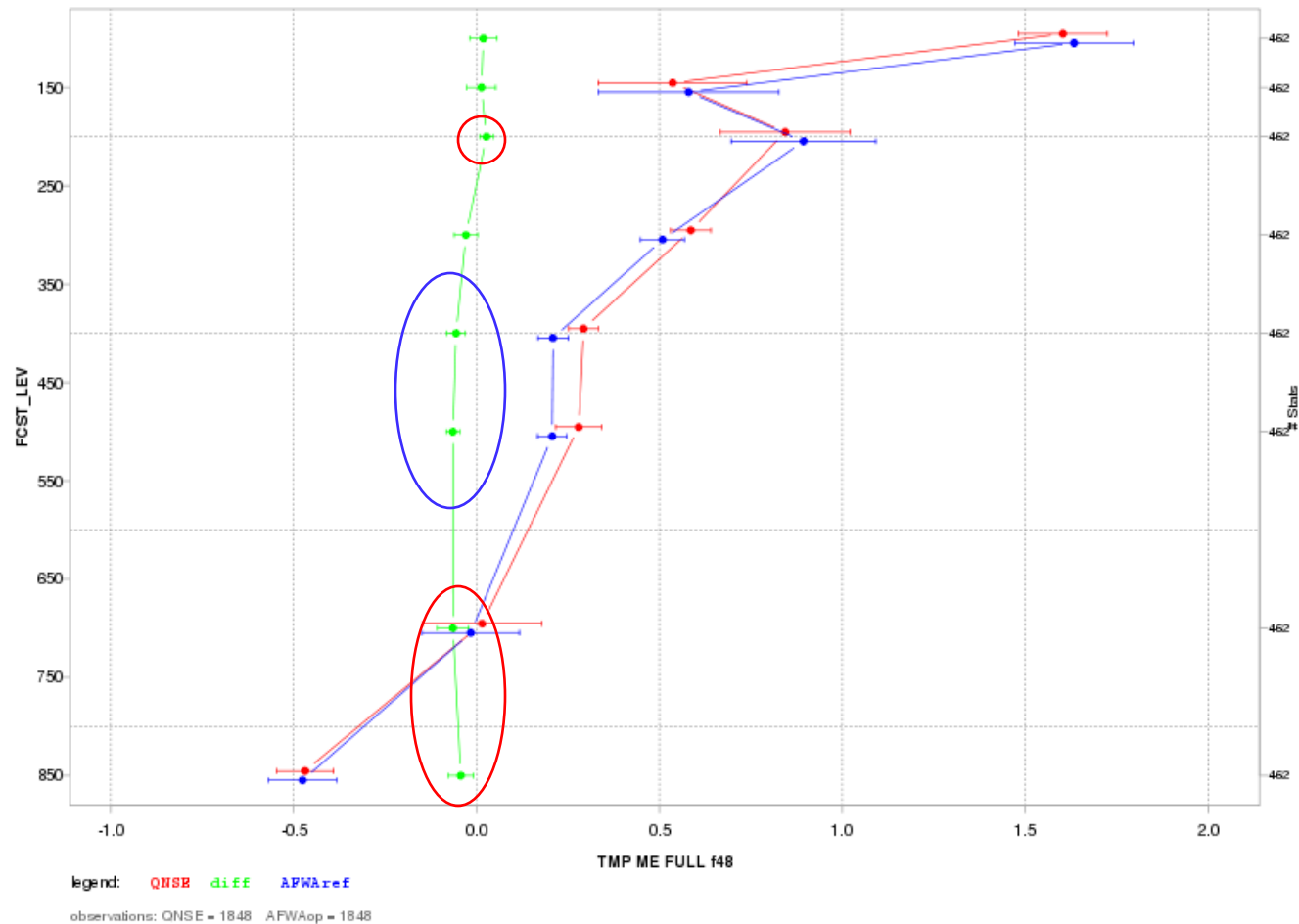
Upper Air Temperature - BCRMSE

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



Upper Air Temperature - Bias

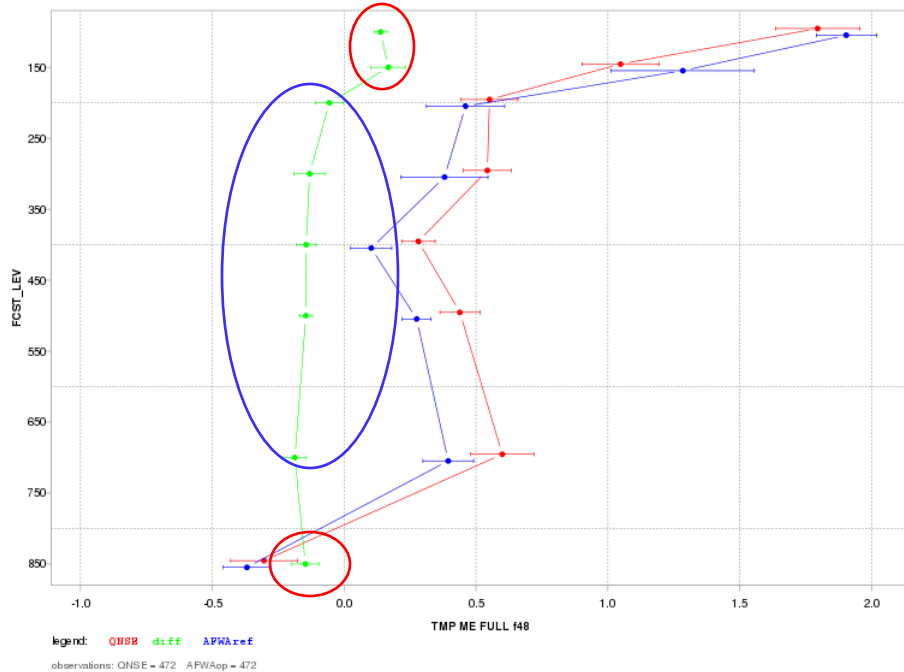
Vertical profile plot at the 48-hour lead time.



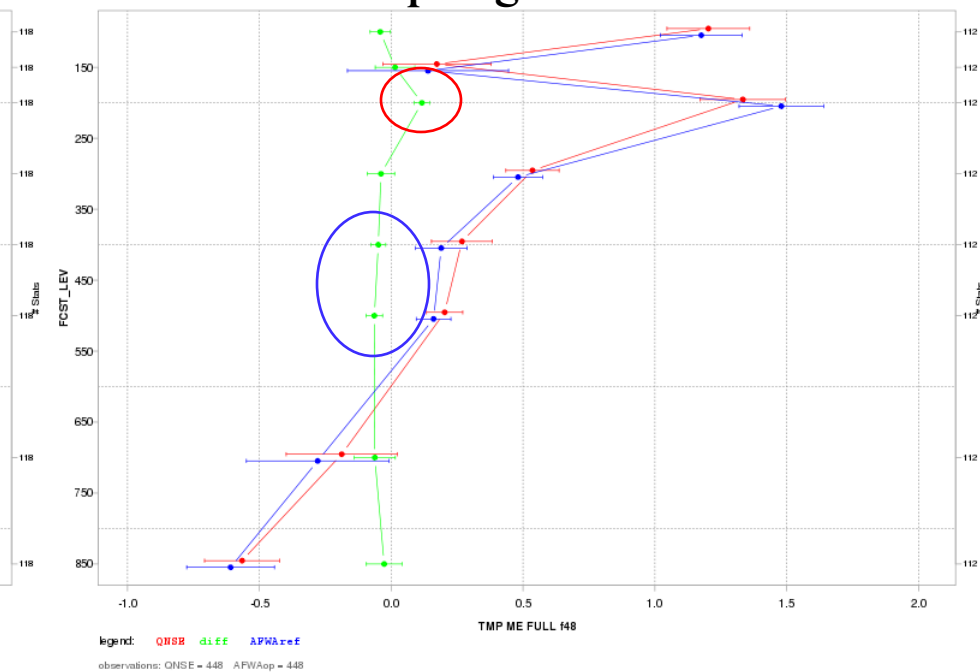
Upper Air Temperature - Bias

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

Summer Season



Spring Season



Upper Air Temperature - SS Table

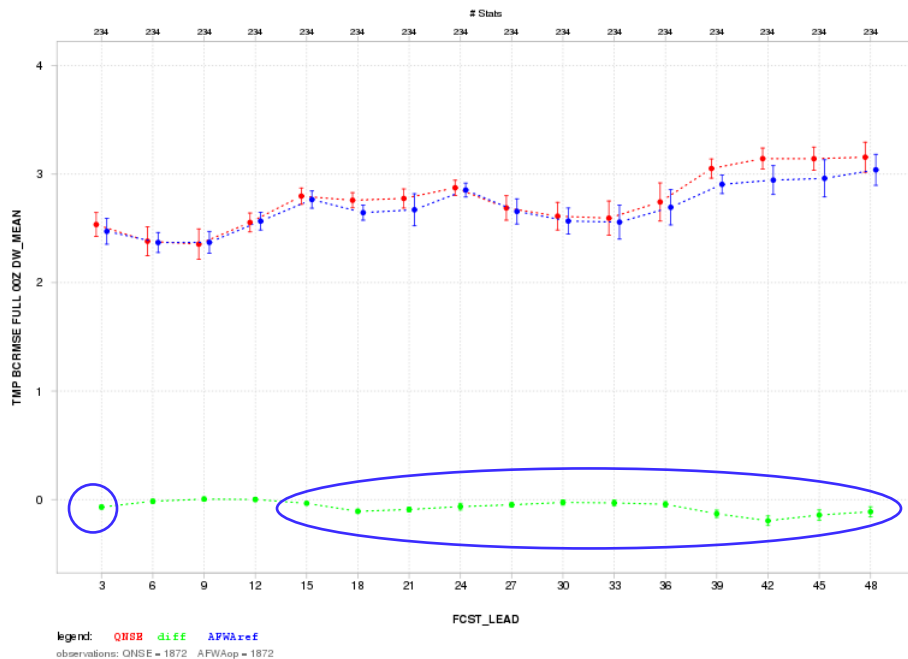
Statistically Significant (SS) differences for BCRMSE and bias by pressure level, season, and lead time.

		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
	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
Bias	850	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	QNSE	--
	500	AFWA	AFWA	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	QNSE
	150	--	--	--	--	QNSE	QNSE	QNSE	QNSE	QNSE	--	--	--	AFWA	AFWA	AFWA	AFWA	--	--	--	--
	100	QNSE	--	--	--	QNSE	QNSE	QNSE	QNSE	QNSE	QNSE	--	--	--	--	AFWA	AFWA	--	AFWA	AFWA	AFWA

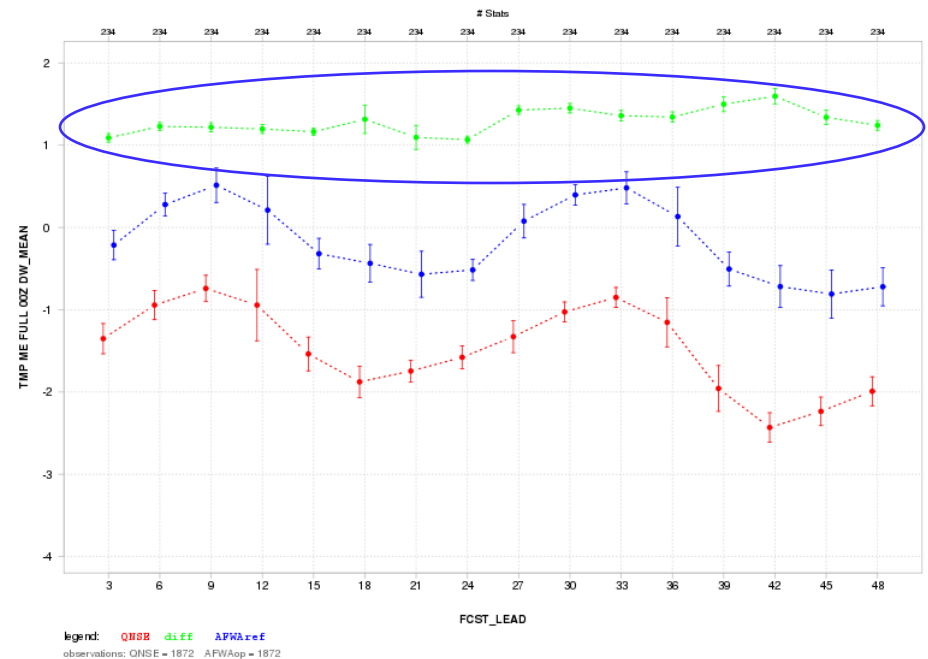
2m Temperature – BCRMSE/Bias

Time series plot for **00 UTC** initializations only

BCRMSE

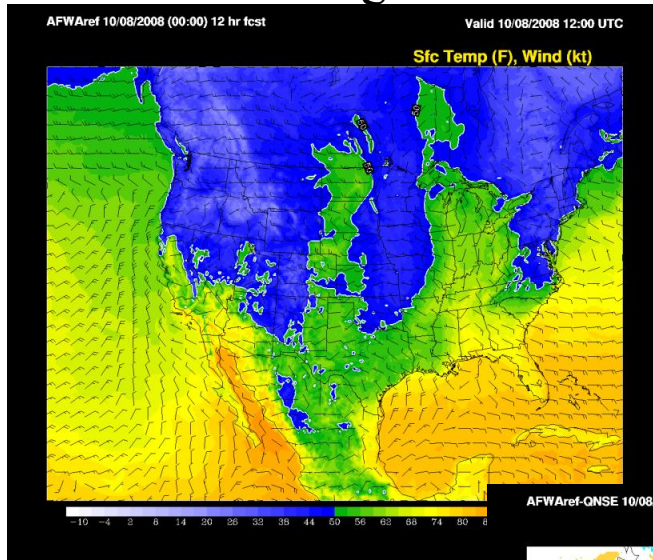


Bias

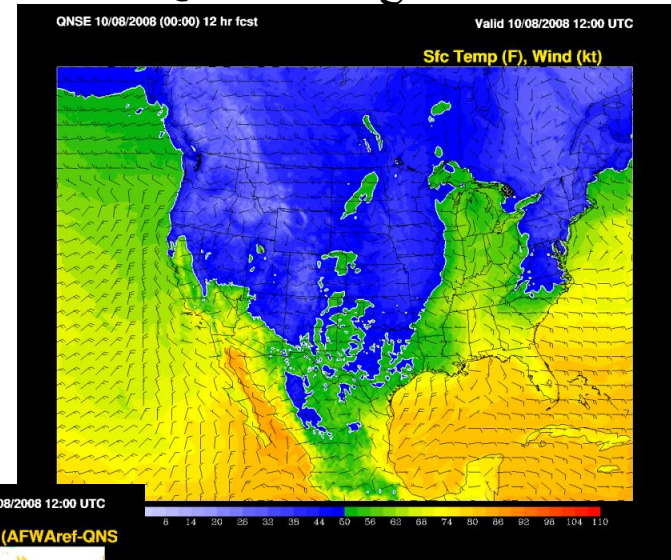


Spatial plot – 2m Temp

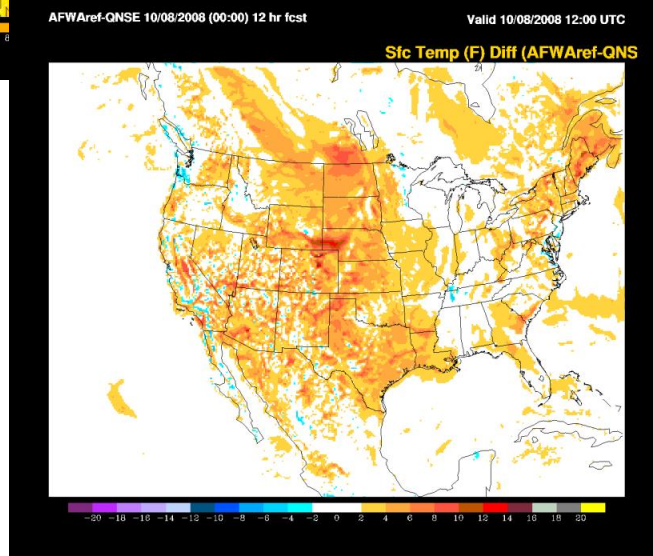
AFWA configuration



QNSE configuration



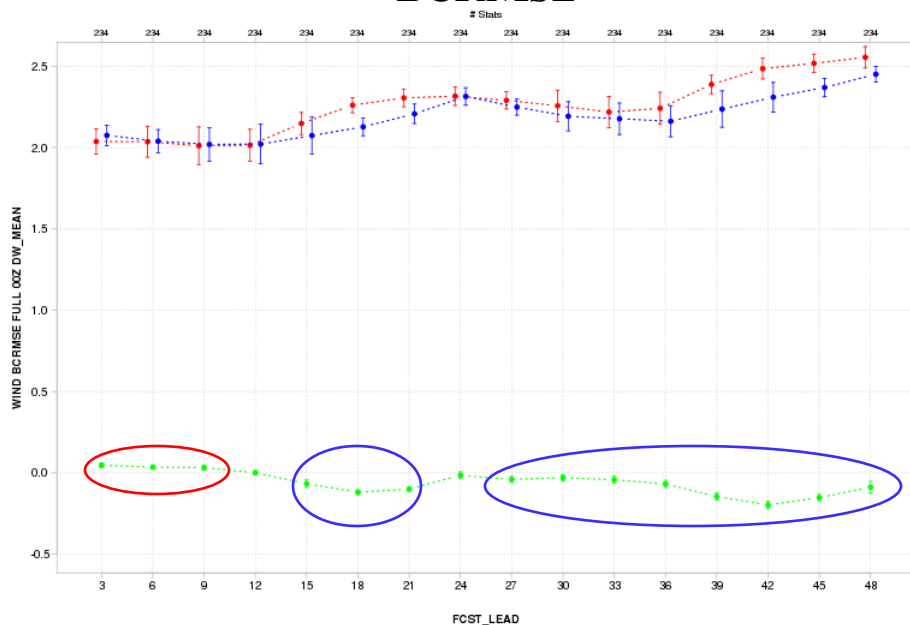
AFWA - QNSE



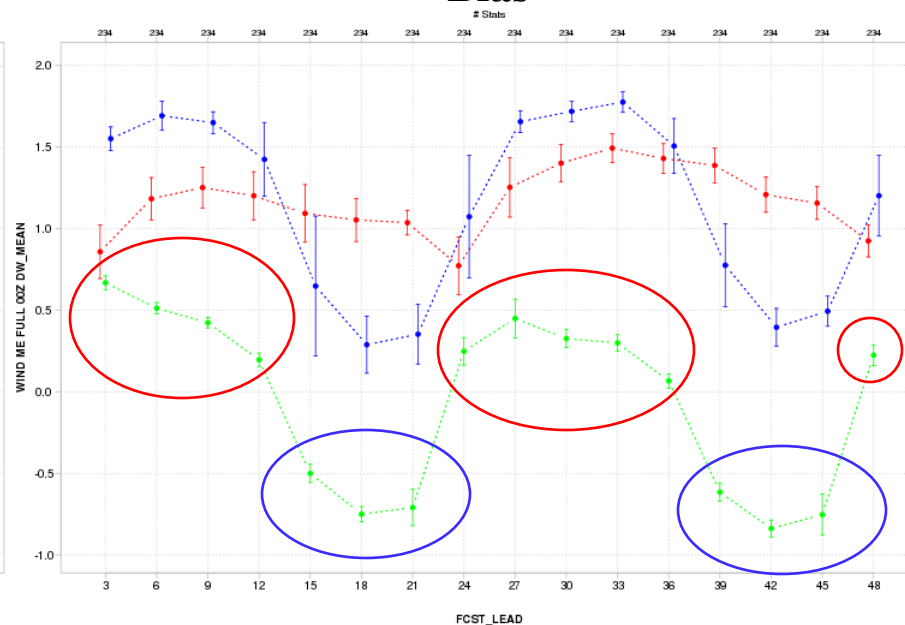
10m Wind – BCRMSE/Bias

Time series plot for **00 UTC** initializations only

BCRMSE



Bias



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	Annual	QNSE	QNSE	QNSE	--	AFWA	AFWA	AFWA	--	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	
		Summer	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	AFWA	QNSE	--	--	--	AFWA	AFWA	AFWA	AFWA	--	
		Fall	QNSE	QNSE	QNSE	--	AFWA	AFWA	AFWA	--	--	--	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	
		Winter	--	QNSE	QNSE	--	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	--	AFWA	AFWA	AFWA	AFWA	AFWA	
		Spring	--	QNSE	--	--	AFWA	AFWA	AFWA	--	AFWA	--	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	
	12 UTC	Annual	AFWA	AFWA	AFWA	QNSE	--	--	--	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA
		Summer	AFWA	AFWA	AFWA	QNSE	--	--	--	AFWA	AFWA	AFWA	AFWA	QNSE	--	AFWA	AFWA	AFWA	
		Fall	--	AFWA	AFWA	--	--	--	--	--	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	
		Winter	--	--	--	--	--	--	--	--	--	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	
		Spring	AFWA	AFWA	AFWA	--	--	--	--	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA	AFWA

Bias	00 UTC	Annual	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE
		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	QNSE
		Winter	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	--	AFWA	AFWA	AFWA	QNSE
		Spring	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	--	AFWA	AFWA	AFWA	QNSE
	12 UTC	Annual	AFWA	AFWA	AFWA	QNSE	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	QNSE	--
		Fall	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	QNSE
		Winter	--	AFWA	AFWA	QNSE	QNSE	QNSE	QNSE	QNSE	AFWA	AFWA	AFWA	QNSE	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

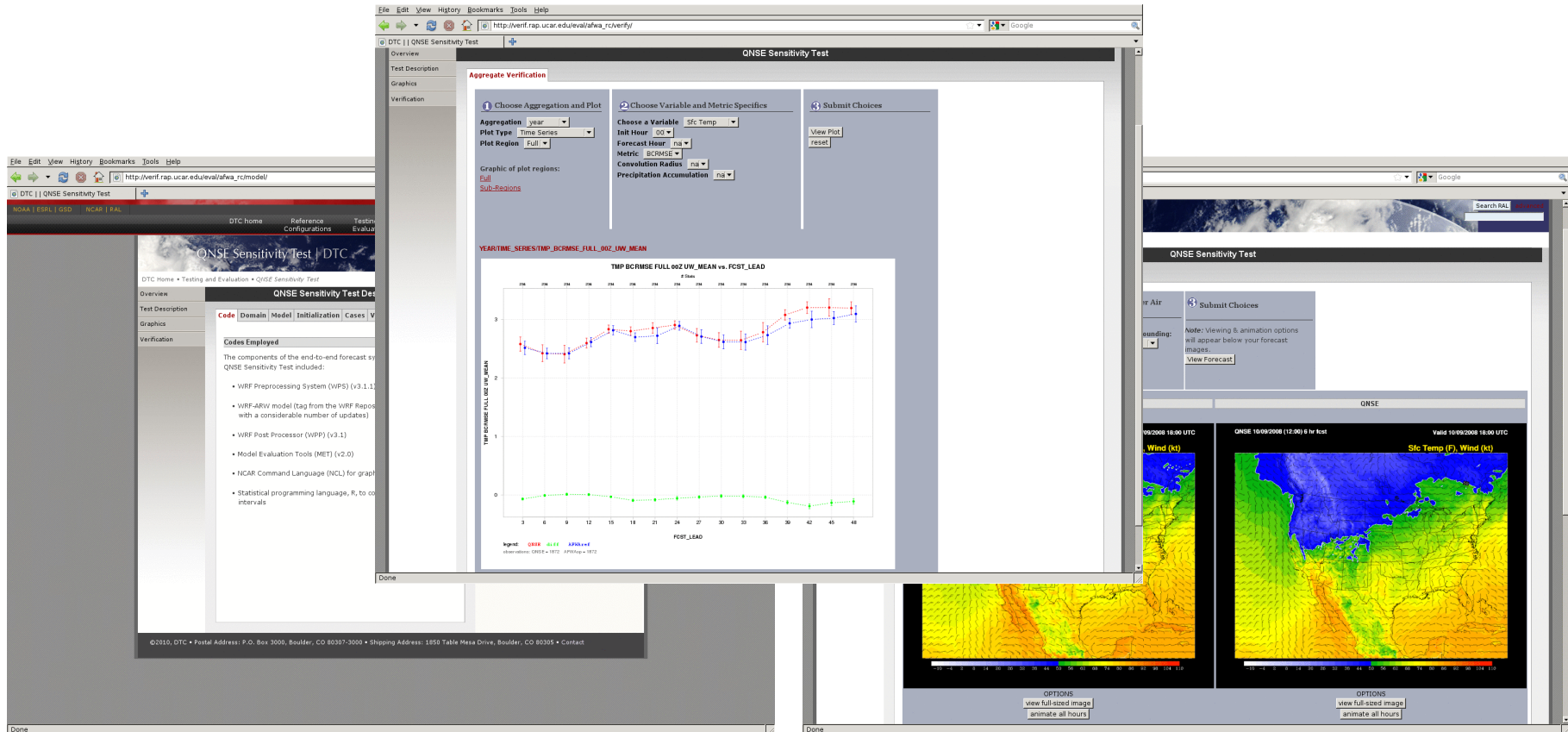
- Vertical profile:
 - Temperature
 - **BCRMSE**: SS differences at and below 400 hPa and above 150 hPa favor AFWA, while those at 200 and 300 hPa favor QNSE.
 - **Bias**: SS differences between 700 and 300 hPa favor AFWA, while those at 850 and 200 hPa favor QNSE.
 - Dew Point Temperature
 - **BCRMSE**: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



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.*