

Assessment of the Noah LSM with Multi-parameterization Options (Noah-MP) within WRF

Michelle Harrold, Jamie Wolff, and Mei Xu

*National Center for Atmospheric Research
Research Applications Laboratory
and
Developmental Testbed Center*

AMS 22nd NWP and 26th WAF Conferences

6 February 2014



Motivation and Overview

- Assess forecast performance of Noah-MP within WRF-ARW for the Air Force Weather Agency (AFWA)
- Noah-MP: *Improvement upon Noah with more physical representation of biophysical and hydrological processes* with multiple options to parameterize:
 - Vegetation canopy layer
 - Modified two-stream radiation transfer scheme
 - Ball-Berry type stomatal resistance scheme
 - Short-term dynamic vegetation model
 - Simple groundwater model with runoff scheme
 - Physically-based three-layer snow model
 - Frozen soil scheme that produces greater soil permeability
- Test two configurations with the same namelist options with exception to the LSM (**Noah / Noah-MP**)

Physics Suite	Configuration
Microphysics	WSM5
Radiation (LW/SW)	RRTM/Dudhia
Surface Layer	Monin-Obukhov Similarity Theory
Land Surface	Noah/Noah-MP
PBL	YSU
Convection	Kain-Fritsch

```
&noah_mp
dveg = 4,
opt_crs = 1,
opt_sfc = 1,
*opt_btr = 2,
*opt_run = 3,
opt_frz = 1,
opt_inf = 1,
opt_rad = 3,
opt_alb = 2,
opt_snf = 1,
opt_tbot = 2,
opt_stc = 1,
/
```

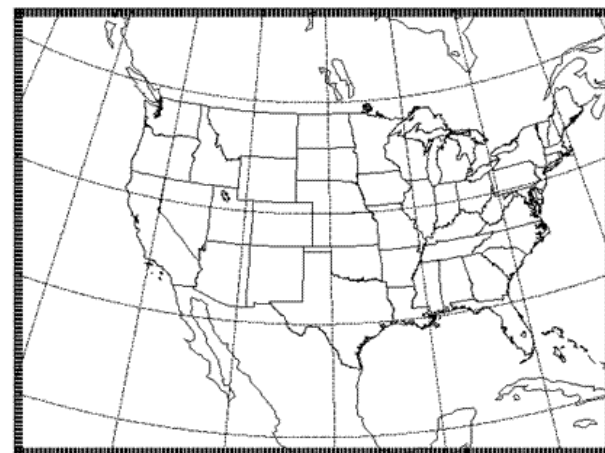
* Non-default option



Experiment and Evaluation

- **End-to-end system:** WPS, WRFDA, WRF-ARW, UPP, and MET
- **Test period:** July 2011 – June 2012, w/ 48-h warm start simulations initialized every 36 h (244 total cases)
- **Domain:** 15 km CONUS grid w/ 56 vertical levels and model top of 10 hPa
- **Evaluation:**
 - **Surface and upper air [(BC)RMSE, bias]** – temperature, dew point temperature, wind speed
 - **Precipitation [Gilbert skill score, frequency bias]** – 3- and 24-h accumulations
 - **GO Index** - weighted RMSE across variables, domain, and lead time
 - **Statistical Assessment**
 - Confidence Intervals (CI) at the 99% level
 - Statistical Significance (SS) and practical significance (PS)
 - **Accumulated stats over domain** - soil temperature, soil wetness, and snow variables
 - **Verification by observation station** - temperature, dew point temperature, and wind speed bias

Season	Date Range
Summer	July – Sept. 2011
Fall	Oct. – Dec. 2011
Winter	Jan. – March 2012
Spring	April – June 2012



Verification Results

CONUS Analysis

AFWA Operational Configuration (AFWAOC)

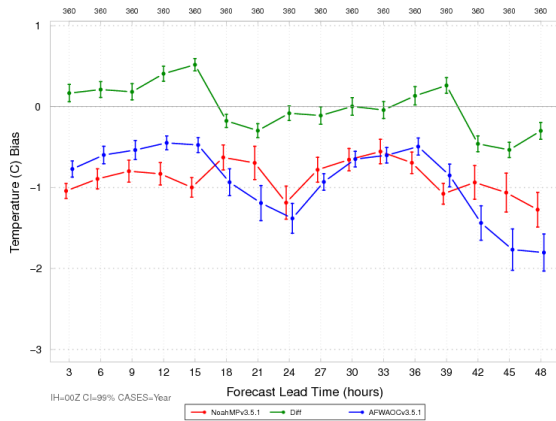
Noah-MP Replacement Configuration (Noah-MP)



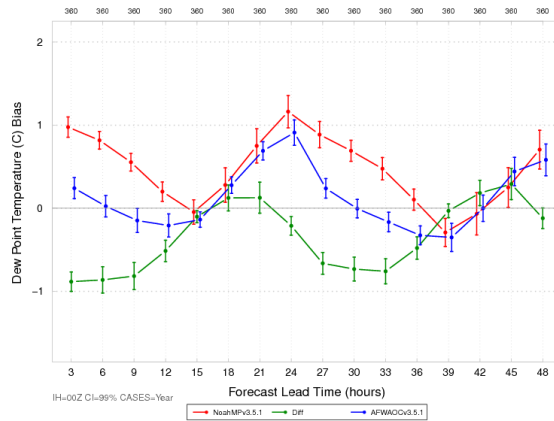
CONUS Surface Bias - Time Series

00 UTC Initializations by Temporal Aggregation

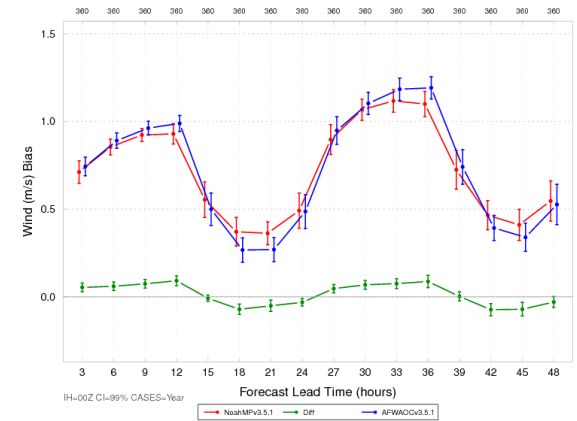
Surface Temperature



Surface Dew Point Temperature



Surface Wind Speed



SS (light shading) & PS (dark shading) differences for surface temp, dew point, & wind speed bias

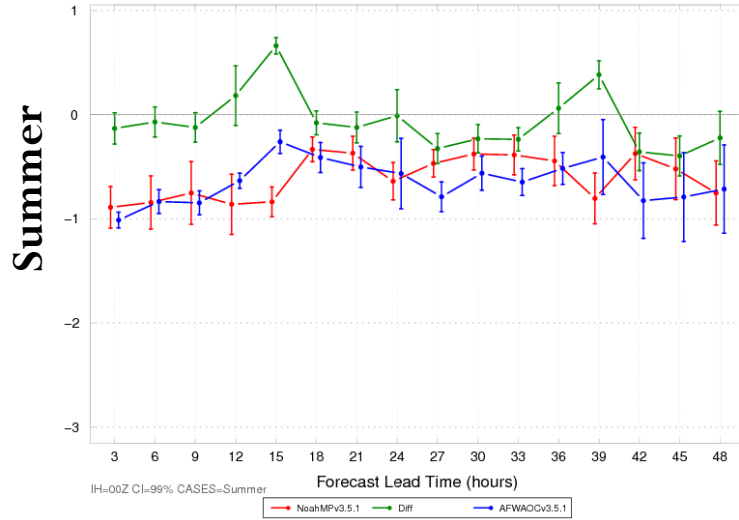
AFWAOC better performer

Noah-MP better performer

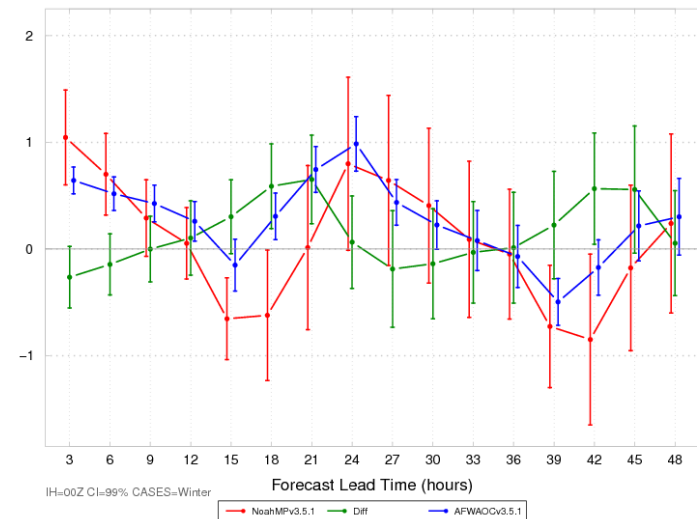
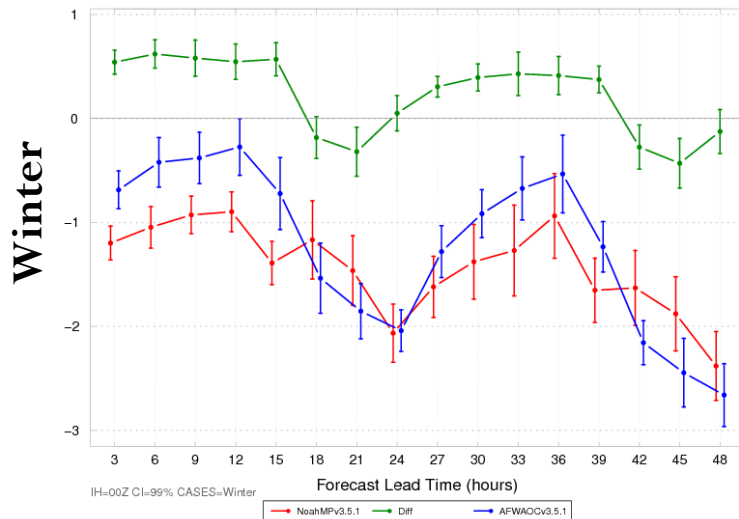
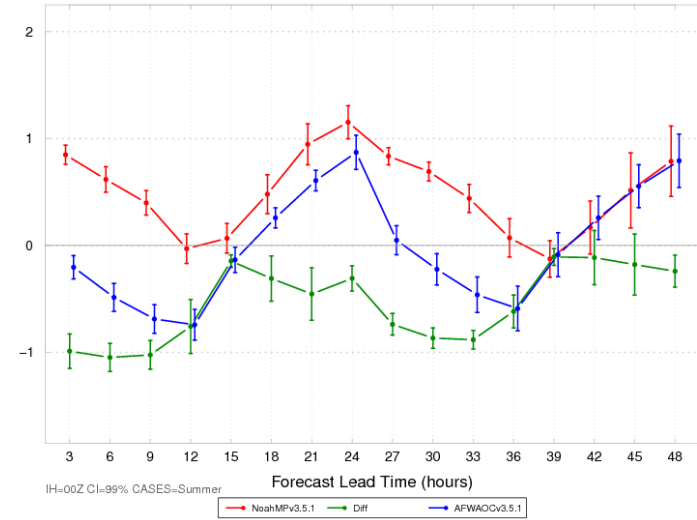
00 UTC Initializations		f03	f06	f09	f12	f15	f18	f21	f24	f27	f30	f33	f36	f39	f42	f45	f48
Surface Temperature	Annual	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	NoahMP*	NoahMP*	--	NoahMP*	--	--	AFWAOC*	AFWAOC*	NoahMP*	NoahMP*	NoahMP*
	Summer	--	--	--	--	AFWAOC*	--	--	--	NoahMP*	NoahMP*	NoahMP*	--	AFWAOC*	NoahMP*	NoahMP*	--
	Fall	AFWAOC*	--	--	--	AFWAOC*	--	NoahMP*	--	--	--	--	--	AFWAOC*	NoahMP*	NoahMP*	NoahMP*
	Winter	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	--	NoahMP*	--	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	NoahMP*	NoahMP*	--
	Spring	--	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	NoahMP*	NoahMP*	NoahMP*	NoahMP*	NoahMP*	NoahMP*	--	--	NoahMP*	NoahMP*	NoahMP*
Surface Dew Point Temp	Annual	AFWAOC*	AFWAOC*	AFWAOC*	NoahMP*	NoahMP*	--	--	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	NoahMP*	--	AFWAOC*	NoahMP*	--
	Summer	AFWAOC*	AFWAOC*	NoahMP*	NoahMP*	NoahMP*	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	NoahMP*	NoahMP*	NoahMP*	--	--	AFWAOC*
	Fall	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	--	AFWAOC*	NoahMP*	AFWAOC*	AFWAOC*	AFWAOC*	--	--	--	AFWAOC*	AFWAOC*	--
	Winter	--	--	--	--	--	AFWAOC*	NoahMP*	--	--	--	--	--	--	AFWAOC*	--	--
	Spring	AFWAOC*	AFWAOC*	AFWAOC*	NoahMP*	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	AFWAOC*	NoahMP*	AFWAOC*	--	--	AFWAOC*
Surface Wind Speed	Annual	NoahMP	NoahMP	NoahMP	NoahMP	--	AFWAOC	AFWAOC	AFWAOC	NoahMP	NoahMP	NoahMP	NoahMP	--	AFWAOC	AFWAOC	--
	Summer	NoahMP	NoahMP	NoahMP	NoahMP	--	AFWAOC	--	AFWAOC	NoahMP	NoahMP	NoahMP	NoahMP	--	AFWAOC	--	--
	Fall	--	--	--	--	--	AFWAOC	AFWAOC	--	--	--	--	AFWAOC	--	AFWAOC	AFWAOC	--
	Winter	--	--	--	--	--	AFWAOC	AFWAOC	--	--	--	NoahMP	--	--	AFWAOC	AFWAOC	--
	Spring	NoahMP	NoahMP	NoahMP	NoahMP	NoahMP	--	--	--	NoahMP	NoahMP	NoahMP	NoahMP	--	--	--	AFWAOC

CONUS: 2-m Temp and Dew Point Temp Bias 00 UTC initializations

Temperature Bias (°C)



Dew Point Temp Bias (°C)



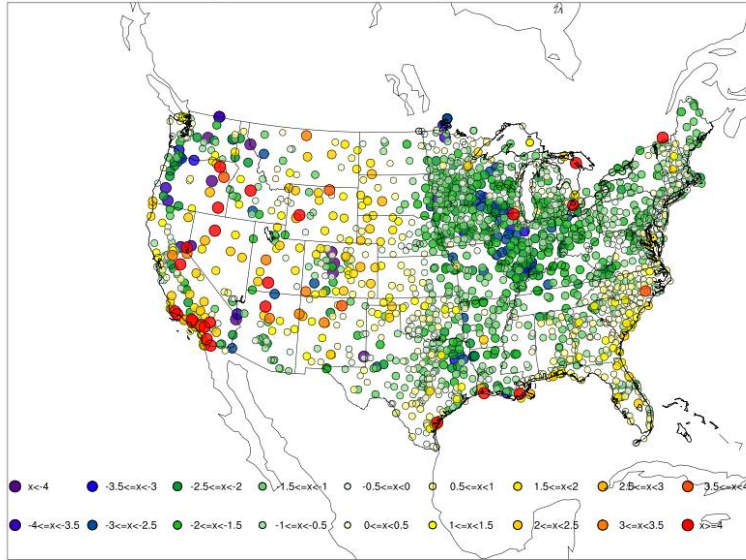
Point Verification

Summer 00 UTC Initializations – 36 h forecast

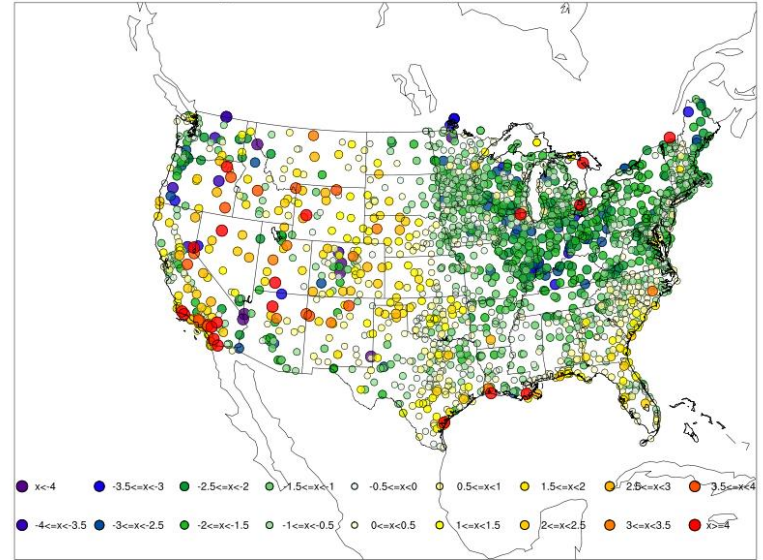
AFWAOC

Noah-MP

Temperature Bias

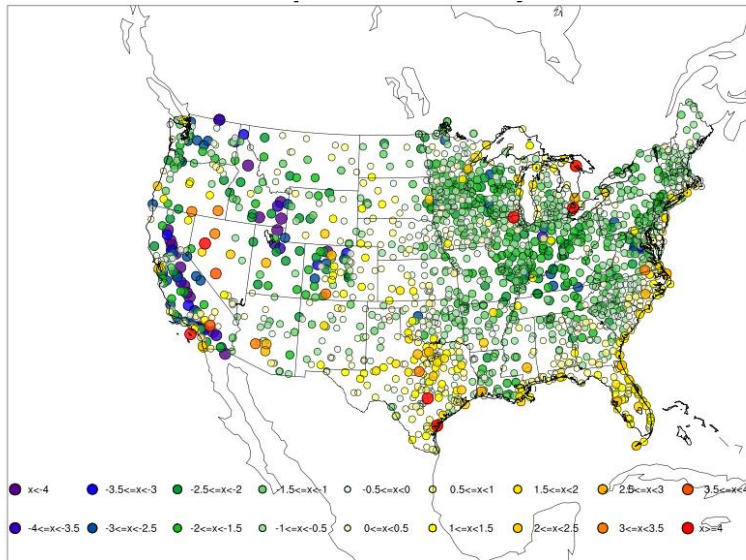


Config=AFWAOC_WRFv3.5.1 Season=SUMMER Init=00UTC Fcst Hr=36h

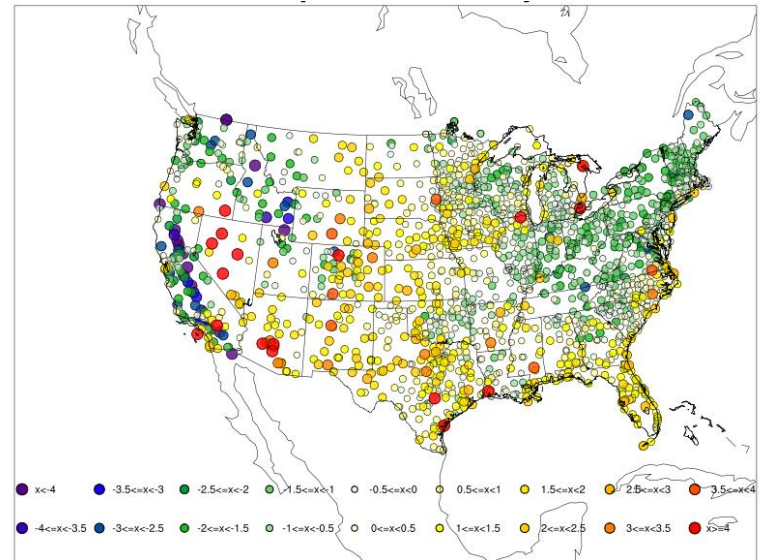


Config=NoahMP_WRFv3.5.1 Season=SUMMER Init=00UTC Fcst Hr=36h

Dew Point Temp Bias



Config=AFWAOC_WRFv3.5.1 Season=SUMMER Init=00UTC Fcst Hr=36h



Config=NoahMP_WRFv3.5.1 Season=SUMMER Init=00UTC Fcst Hr=36h

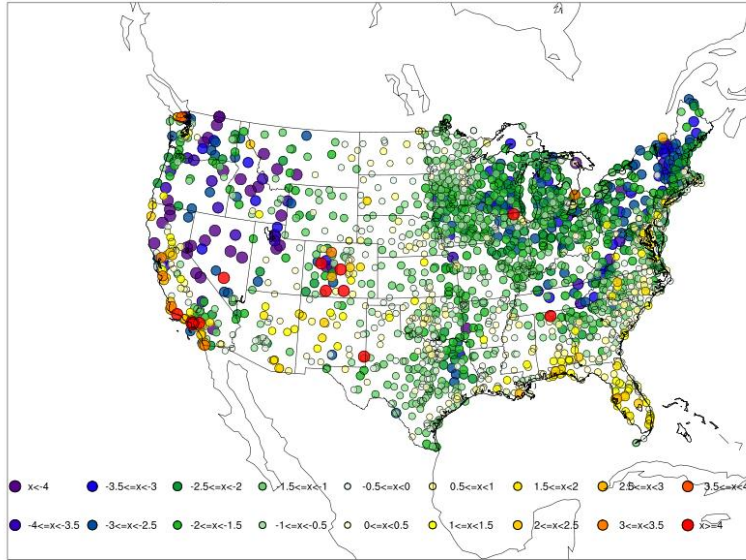
Point Verification

Summer 00 UTC Initializations – 48 h forecast

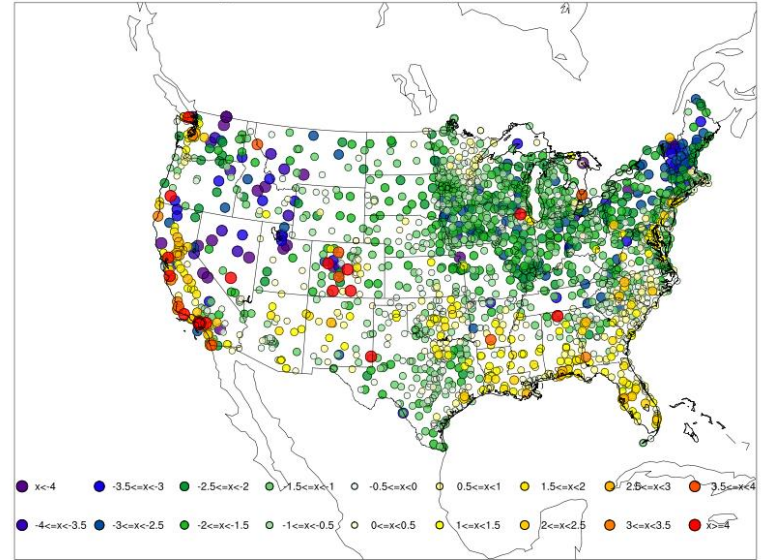
AFWAOC

Noah-MP

Temperature Bias

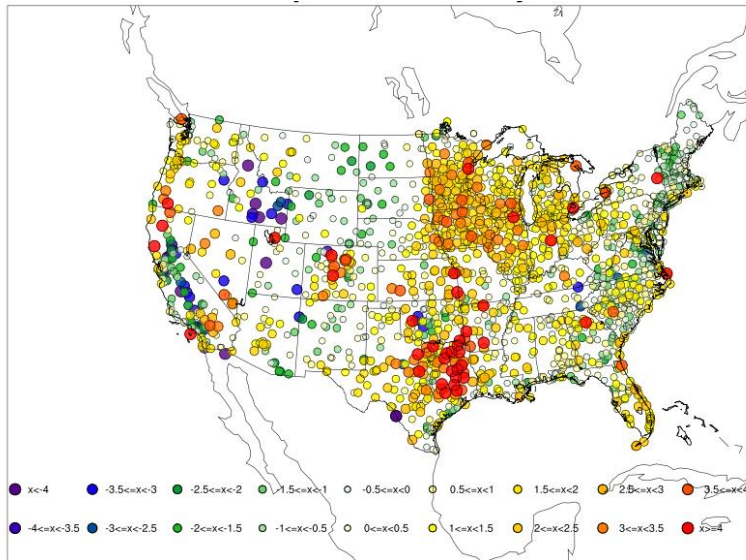


Config=AFWAOC_WRFv3.5.1 Season=SUMMER Init=00UTC Fcst Hr=48h

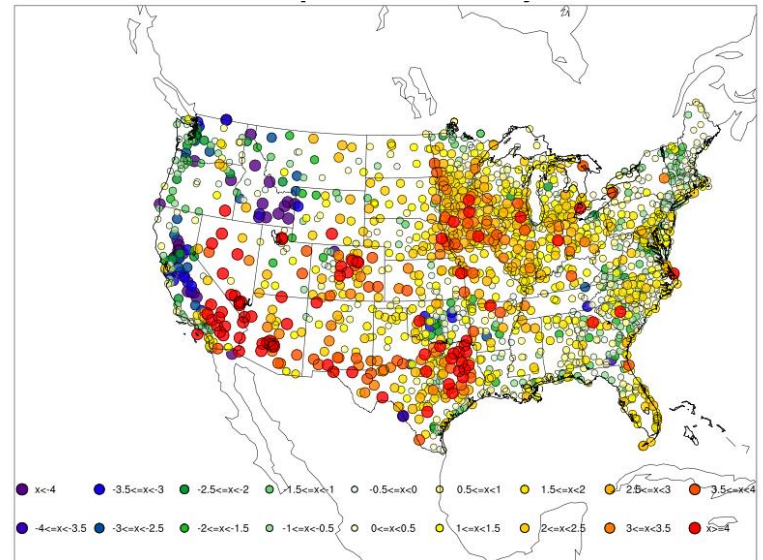


Config=NoahMP_WRFv3.5.1 Season=SUMMER Init=00UTC Fcst Hr=48h

Dew Point Temp Bias



Config=AFWAOC_WRFv3.5.1 Season=SUMMER Init=00UTC Fcst Hr=48h



Config=NoahMP_WRFv3.5.1 Season=SUMMER Init=00UTC Fcst Hr=48h

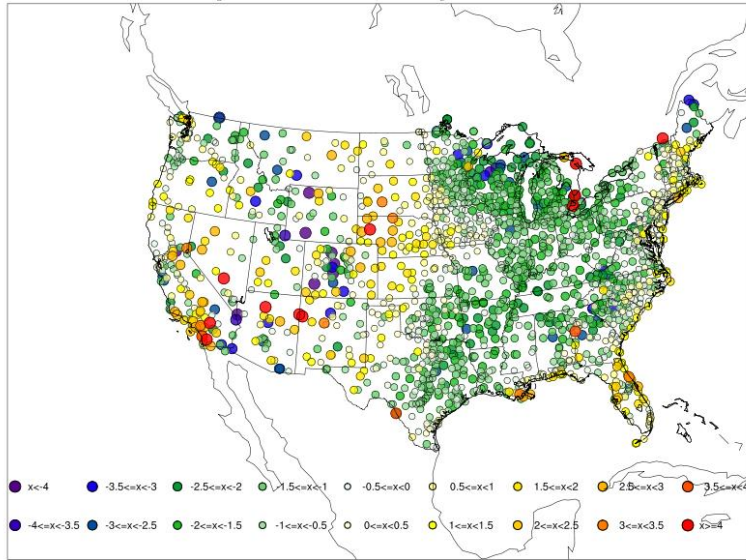
Point Verification

Winter 00 UTC Initializations – 36 h forecast

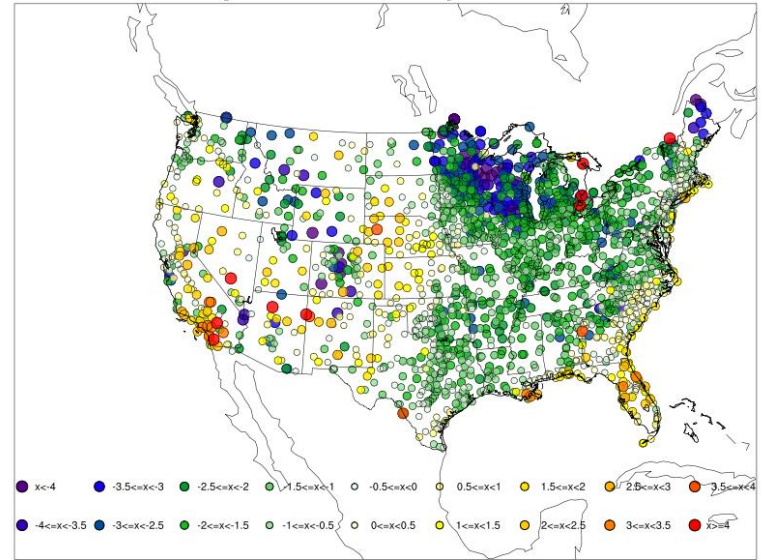
AFWAOC

Noah-MP

Temperature Bias

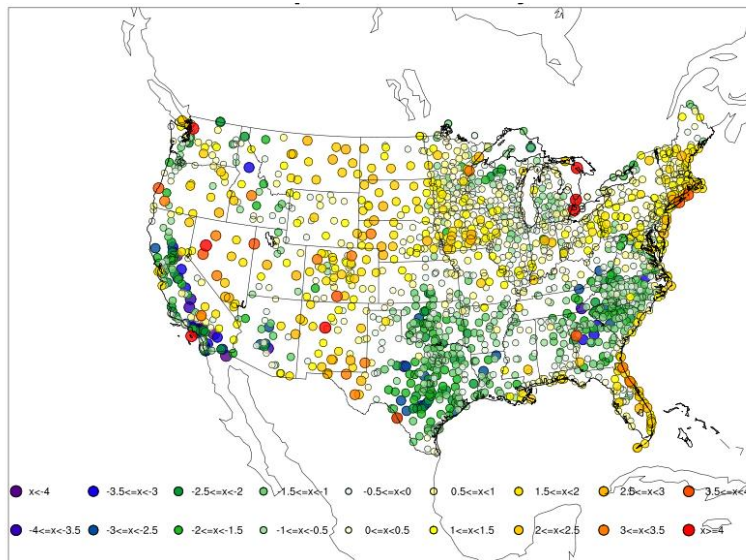


Config=AFWAOC_WRFv3.5.1 Season=WINTER Init=00UTC Fcst Hr=36h

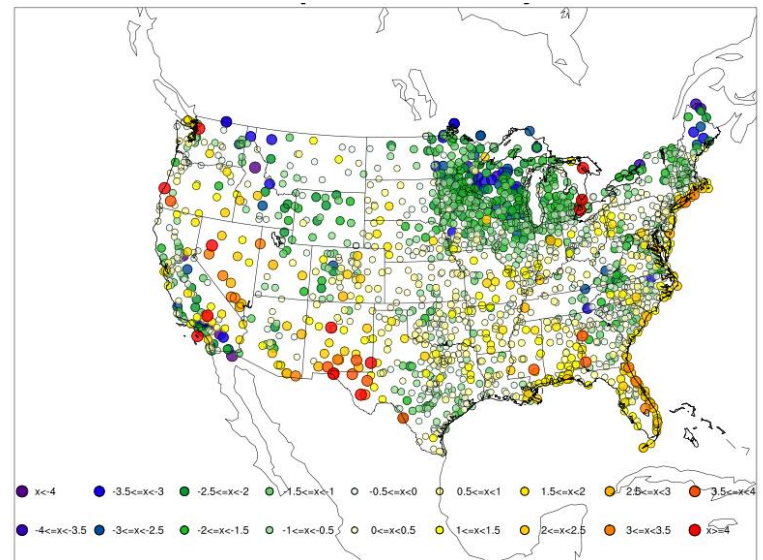


Config=NoahMP_WRFv3.5.1 Season=WINTER Init=00UTC Fcst Hr=36h

Dew Point Temp Bias



Config=AFWAOC_WRFv3.5.1 Season=WINTER Init=00UTC Fcst Hr=36h



Config=NoahMP_WRFv3.5.1 Season=WINTER Init=00UTC Fcst Hr=36h

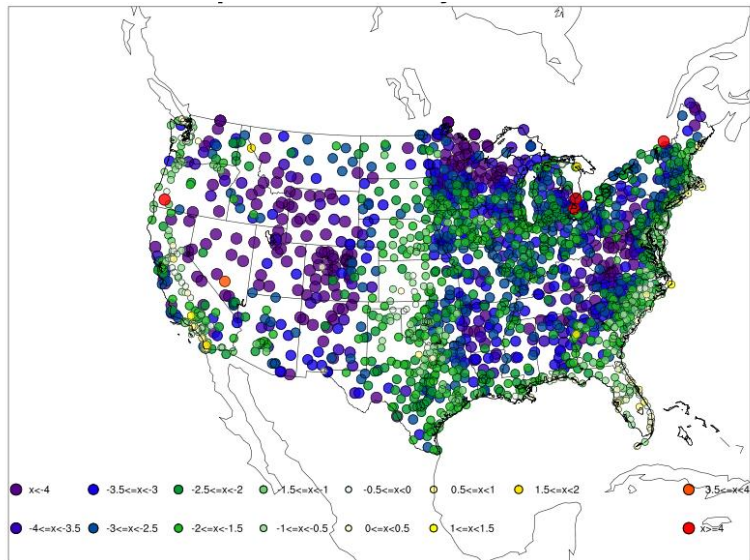
Point Verification

Winter 00 UTC Initializations – 48 h forecast

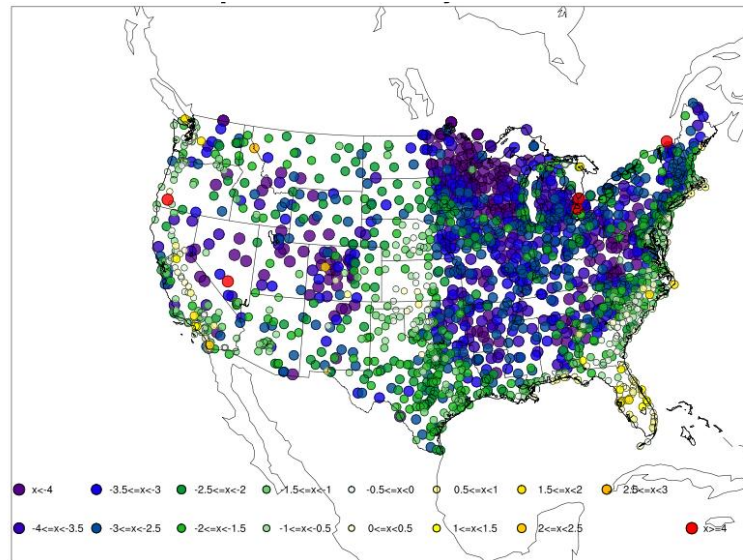
AFWAOC

Noah-MP

Temperature Bias

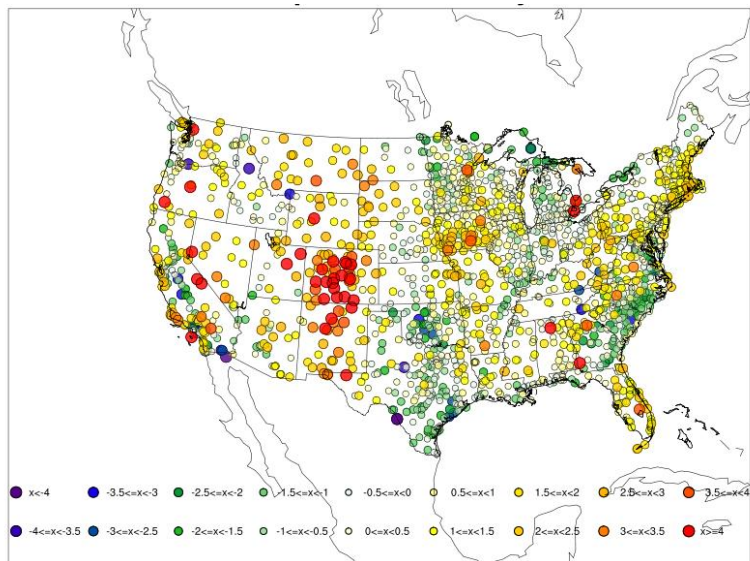


Config=AFWAOC_WRFv3.5.1 Season=WINTER Init=00UTC Fcst Hr=48h

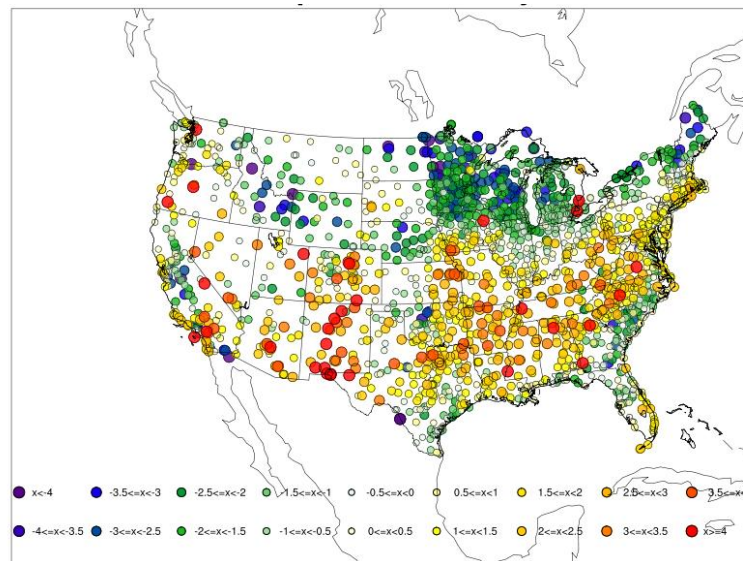


Config=NoahMP_WRFv3.5.1 Season=WINTER Init=00UTC Fcst Hr=48h

Dew Point Temp Bias



Config=AFWAOC_WRFv3.5.1 Season=WINTER Init=00UTC Fcst Hr=48h



Config=NoahMP_WRFv3.5.1 Season=WINTER Init=00UTC Fcst Hr=48h

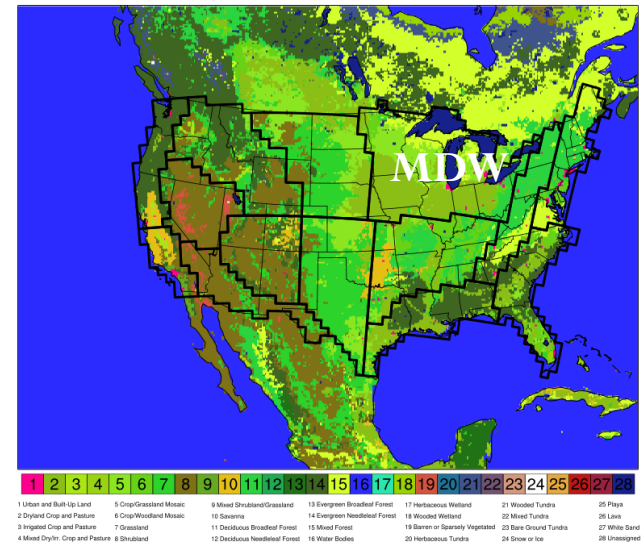
Verification Results

Midwest (MDW) Regional Analysis

AFWA Operational Configuration (AFWAOC)

Noah-MP Replacement Configuration (Noah-MP)

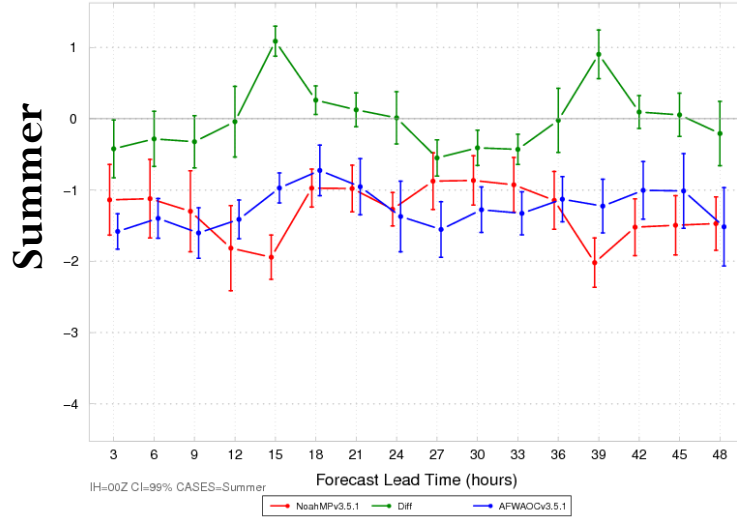
Land Use Categories



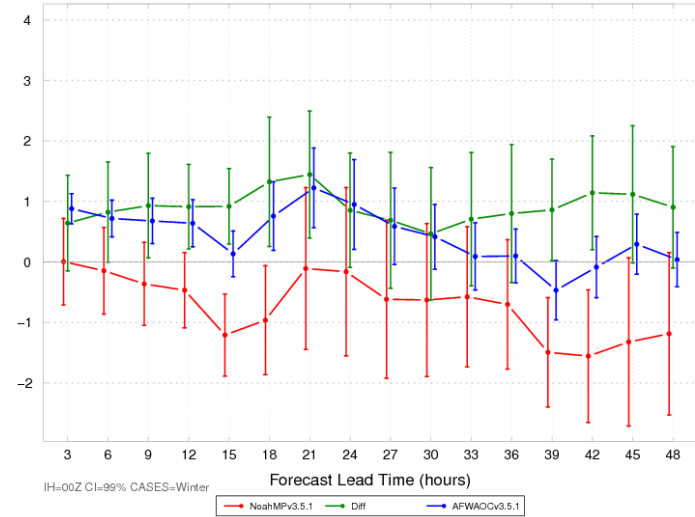
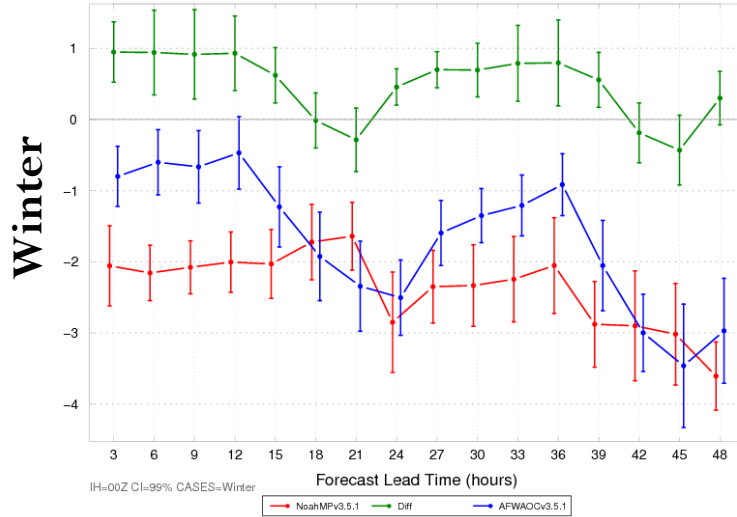
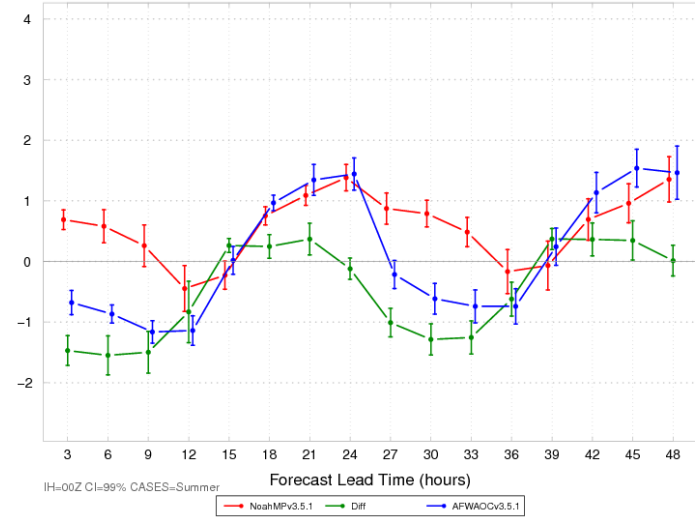
MDW: 2-m Temp and Dew Point Temp Bias

00 UTC initializations

Temperature Bias (°C)



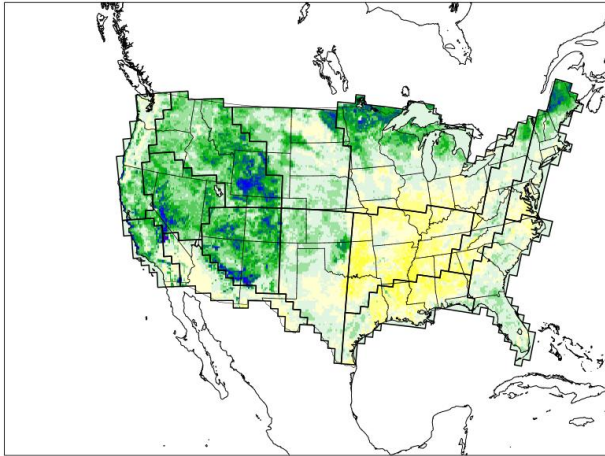
Dew Point Temp Bias (°C)



Configuration Comparisons

Winter 00 UTC initializations – 48 h forecast

Soil Temperature (0-10 cm)



Season=Winter Init=00 Fcst Hr=48h

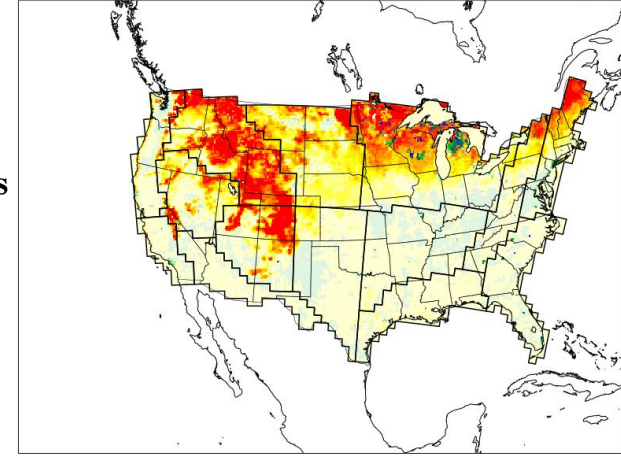


AFWAOC – Noah-MP

Diff > 0 → AFWAOC has larger values

Diff < 0 → NoahMP has larger values

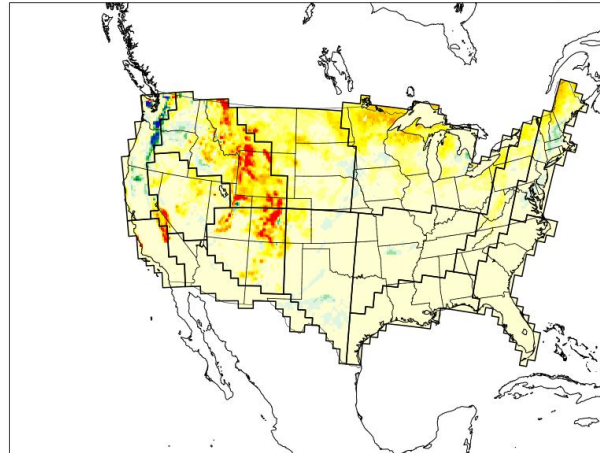
Soil Moisture (0-10 cm)



Season=Winter Init=12 Fcst Hr=48h



Snow Depth



Season=Winter Init=00 Fcst Hr=48h



- AFWAOC in MDW:
 - Lower soil temps
 - Higher soil moisture
 - Larger snow depths

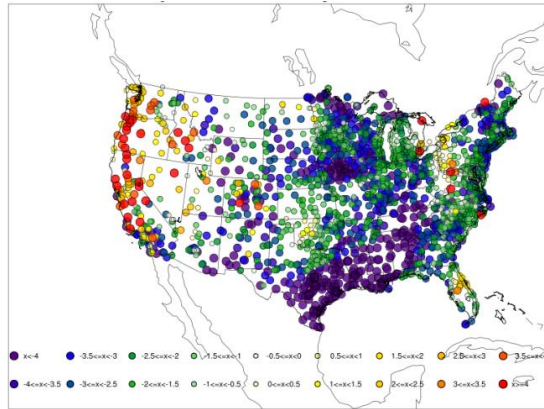
Case Study: 27 January 2012 i00f42

AFWAOC

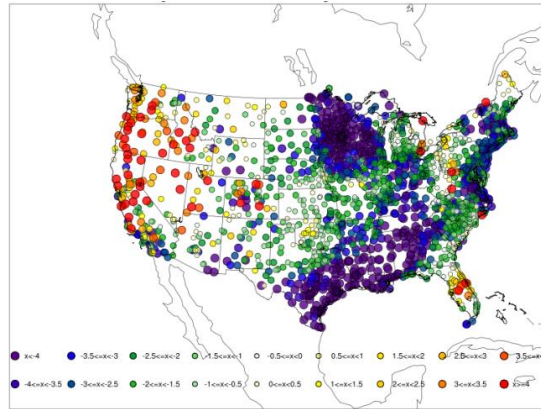
Noah-MP

Difference

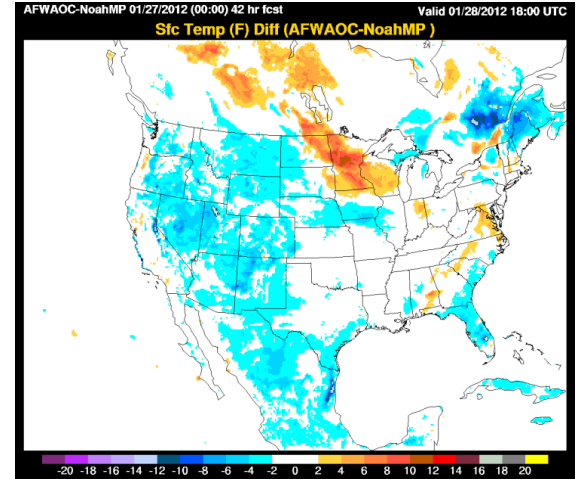
Temperature Bias



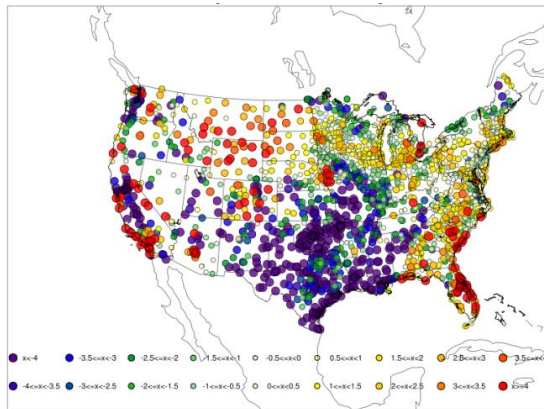
Config=AFWAOC_WRFV3.5.1 Season=2012012700 Init=00UTC Fcst Hr=42h



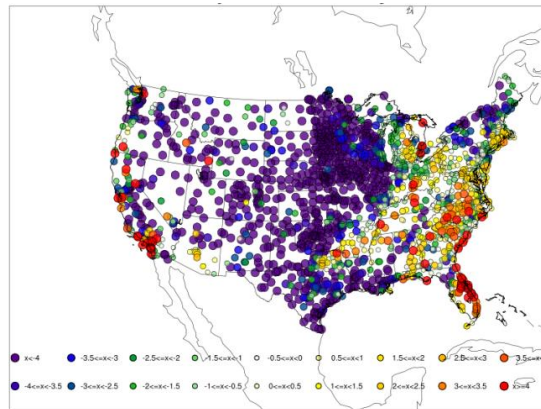
Config=NoahMP_WRFV3.5.1 Season=2012012700 Init=00UTC Fcst Hr=42h



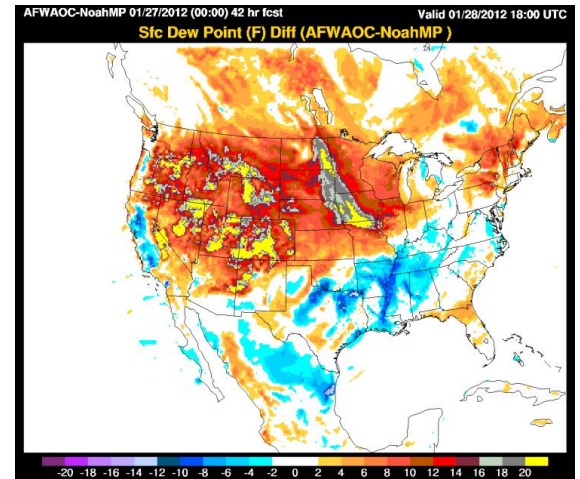
Dew Point Temp Bias



Config=AFWAOC_WRFV3.5.1 Season=2012012700 Init=00UTC Fcst Hr=42h



Config=NoahMP_WRFV3.5.1 Season=2012012700 Init=00UTC Fcst Hr=42h



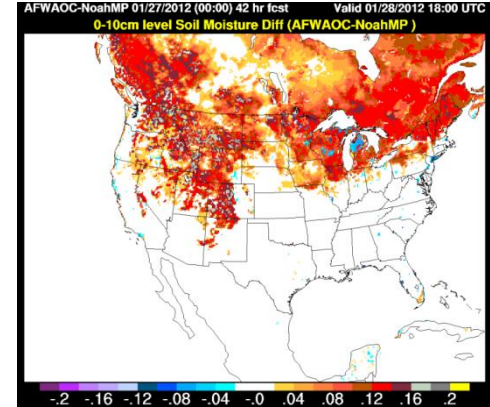
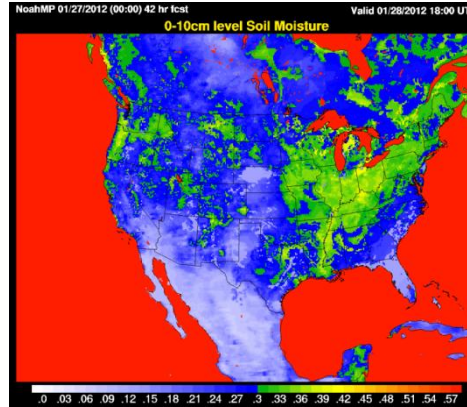
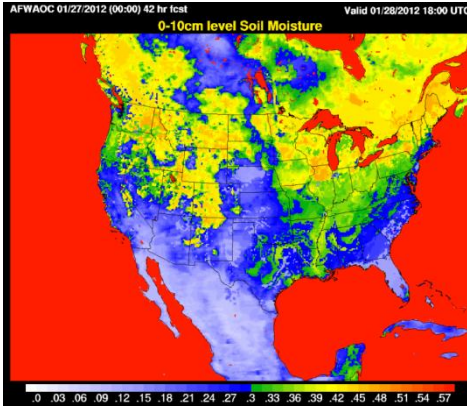
Case Study: 27 January 2012 i00f42

AFWAOC

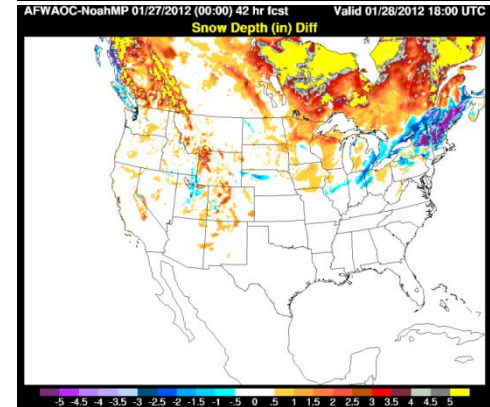
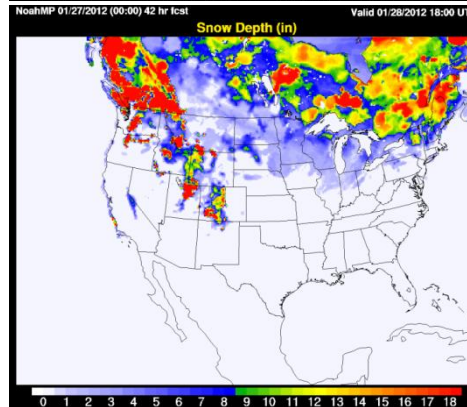
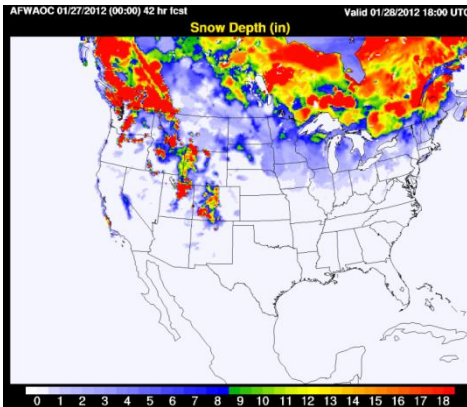
Noah-MP

Difference

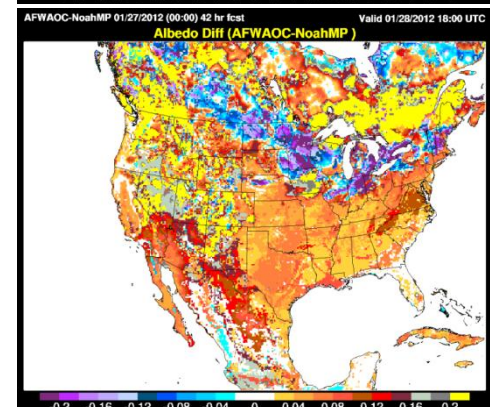
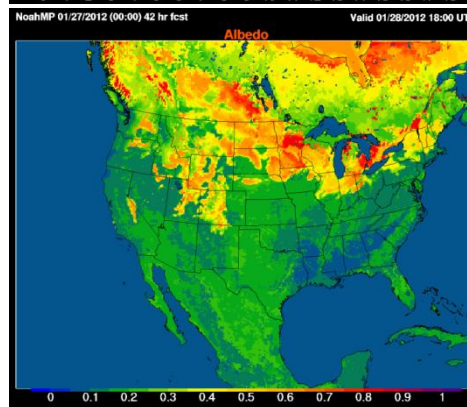
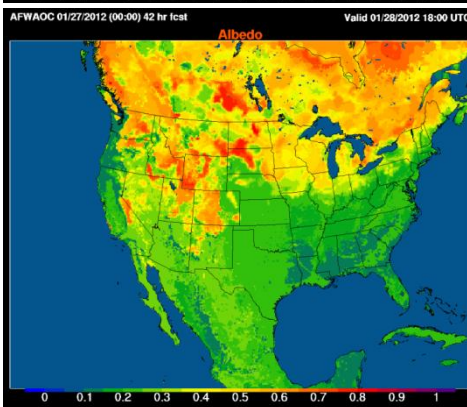
Soil Moisture
(0-10 cm)



Snow Depth

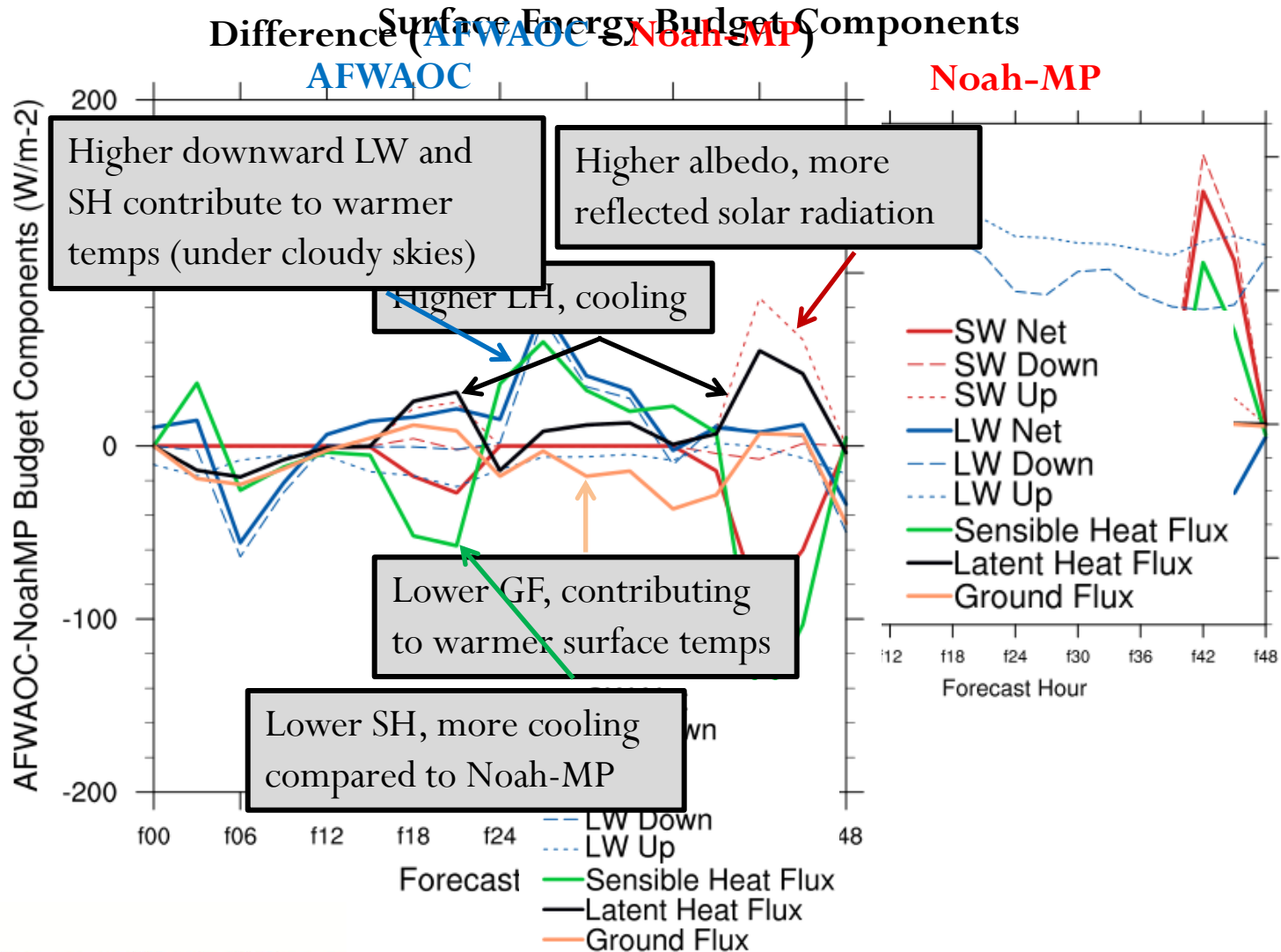


Albedo



Case Study: 27 January 2012 00 UTC

Surface Energy Budget – Bemidji, MN



Summary and Next Steps

- Performed extensive T&E on two WRF configurations in order to assess the performance of Noah-MP
 - Generally, a cold temperature bias for both configurations
 - Performance differs spatially and temporally:
 - During the summer, in the central CONUS and desert SW, Noah-MP has significantly higher dew point biases (better performer is dependent on forecast hour)
 - In the Midwest during winter, Noah-MP has significantly cooler temperature biases at times valid from 03 – 15 UTC (AFWAOC typically closer to observations)
- Areas of further investigation:
 - Differences in soil moisture (w/ emphasis on winter season)
 - Differences in snow water equivalent/snow depth/melting
 - Water/moisture budgets → where is it going?
 - Areas of high dew point temperature biases for Noah-MP in the summer

