Assessment of the Asymmetric Convective Model V2 (ACM2) PBL scheme and the Pleim-Xiu surface schemes within the WRF system

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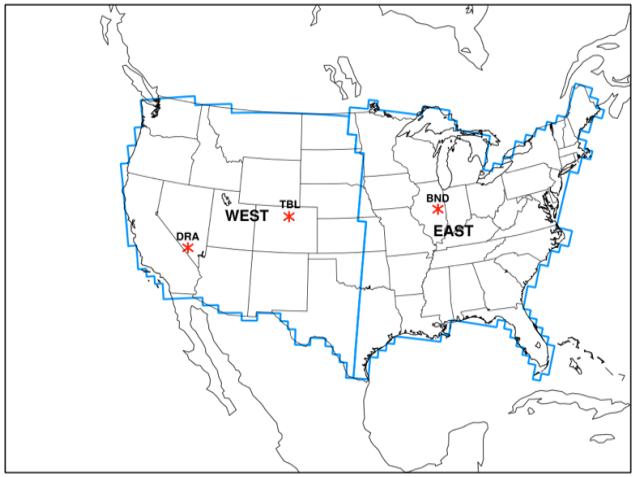
WRF Inter-comparison Testing and Evaluation (T&E)

- End-to-end system: WPS (v3.6.1), GSI (v3.3), WRF (v3.6.1), UPP (v2.2), and MET (v5.0)
- Test Period: August 2013 – August 2014, w/ 48-h warm start forecasts initialized every 36 h w/ DA
- Domain: 15-km CONUS grid
- Evaluation:
  - Surface and upper air [(BC)RMSE, bias] – temperature, dew point temperature, wind speed
  - Precipitation [Gilbert skill score (GSS), frequency bias] – 3- and 24-h accumulations
  - Statistical Assessment
    - Confidence intervals (CI) at the 99% level
    - Pair-wise difference methodology
    - Statistical significance (SS) and practical significance (PS)
  - Verification by observation station – temperature, dew point temperature, and wind speed bias
  - Accumulated stats over domain – base rate, GSS, frequency bias
  - Accumulated model output over domain – PBL height, sensible heat flux, and latent heat flux



WRF Inter-comparison T&E

- Functionally similar operational environment

	Air Force Operational Configuration	Replacement Configuration
Microphysics	WRF Single-Moment 5 scheme (opt 4)	WRF Single-Moment 5 scheme (opt 4)
Radiation SW and LW	Dudhia/RRTM schemes (opt 4)	Dudhia/RRTM schemes (opt 4)
Surface Layer	Monin-Obukhov similarity theory (opt 91)	Pleim-Xiu surface layer (opt 7)
Land-Surface Model	Noah (opt 2)	Pleim-Xiu (opt 7)
Planetary Boundary Layer	Yonsei University scheme (opt 1)	Asymmetric Convective Model (opt 7)
Convection	Kain-Fritsch scheme (opt 1)	Kain-Fritsch scheme (opt 1)

- Evaluation includes:
  - Performance assessment of the ACM2 PBL and corresponding surface schemes

Test and Evaluation (AFWAOC/ACM2PX):
http://www.dtcenter.org/eval/meso_mod/afwa_test/wrf_v3.6.1/index.php

Verification results

AF Operational Configuration (AFWAOC)

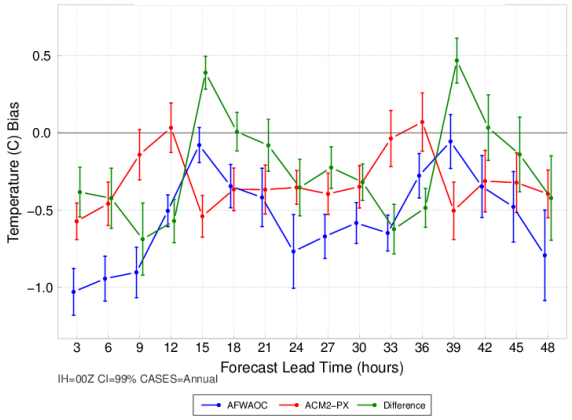
ACM2+PX Replacement Configuration (ACM2PX)

CONUS Surface Bias - Time Series

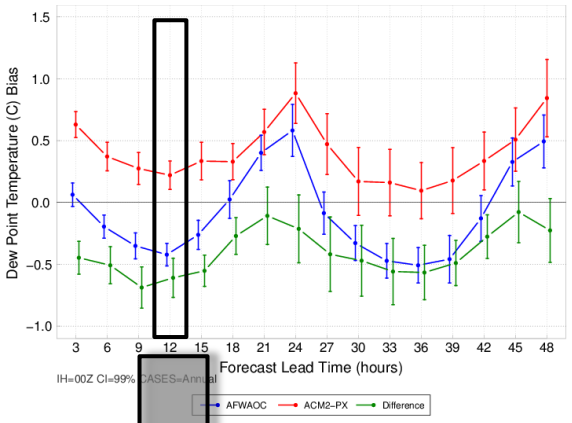
00 UTC Initializations

AFWAOC
ACM2PX
Difference

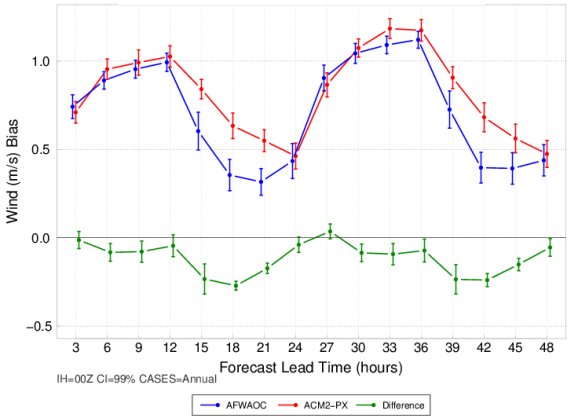
2 m Temperature



2 m Dew Point Temperature



10 m Wind Speed



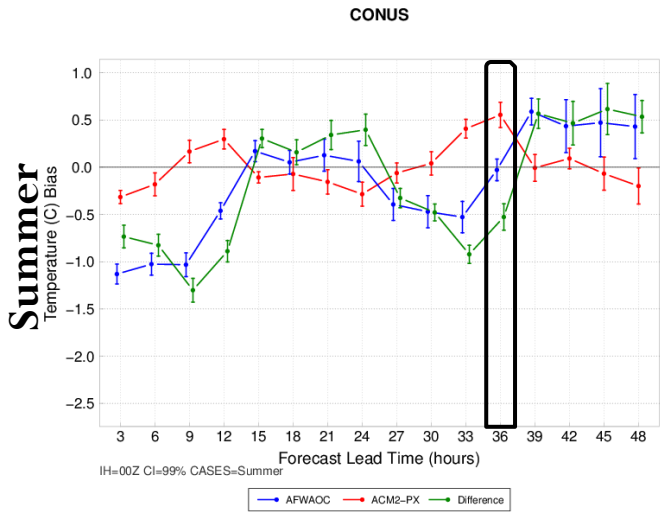
SS (light shading) & **PS (dark shading)** differences for *surface temp, dew point, & wind speed bias*

AFWAOC better performer **ACM2PX better performer**

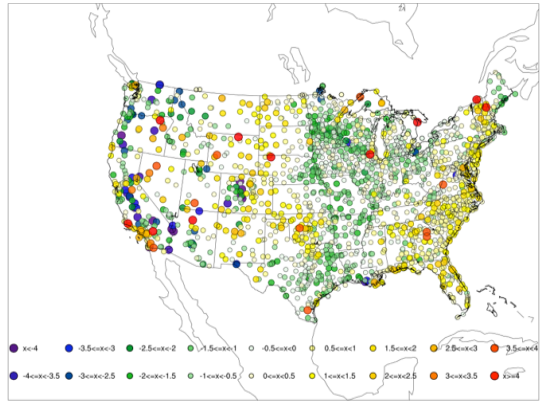
Forecast Hour		f03	f06	f09	f12	f15	f18	f21	f24	f27	f30	f33	f36	f39	f42	f45	f48
2-m Temp	Annual	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	AFWAOC *	--	--	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	AFWAOC *	--	--	ACM2PX *
	Summer	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	AFWAOC *	AFWAOC *	AFWAOC *	ACM2PX *	ACM2PX *	ACM2PX *	AFWAOC *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *
	Fall	--	--	--	ACM2PX *	AFWAOC *	AFWAOC *	AFWAOC *	ACM2PX *	--	--	ACM2PX *	ACM2PX *	AFWAOC *	AFWAOC *	AFWAOC *	ACM2PX *
	Winter	--	--	--	--	AFWAOC *	--	ACM2PX *	ACM2PX *	--	--	--	--	--	--	ACM2PX *	ACM2PX *
	Spring	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	--	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *
2-m Dew Point	Annual	AFWAOC *	AFWAOC *	ACM2PX *	ACM2PX *	AFWAOC *	AFWAOC *	--	--	AFWAOC *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	AFWAOC *	--	--
	Summer	AFWAOC *	AFWAOC *	ACM2PX *	ACM2PX *	AFWAOC *	AFWAOC *	AFWAOC *	AFWAOC *	AFWAOC *	AFWAOC *	AFWAOC *	AFWAOC *	AFWAOC *	AFWAOC *	AFWAOC *	AFWAOC *
	Fall	AFWAOC *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	AFWAOC *	--	AFWAOC *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	ACM2PX *	--	--
	Winter	--	--	--	--	--	--	ACM2PX *	ACM2PX *	AFWAOC *	AFWAOC *	AFWAOC *	AFWAOC *	--	--	ACM2PX *	--
	Spring	AFWAOC *	AFWAOC *	ACM2PX *	ACM2PX *	AFWAOC *	--	ACM2PX *	ACM2PX *	--	--	--	--	--	--	--	--
10-m Wind Speed	Annual	--	AFWAOC	AFWAOC	--	AFWAOC	AFWAOC	AFWAOC	--	--	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC
	Summer	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC
	Fall	AFWAOC	AFWAOC	AFWAOC	--	AFWAOC	AFWAOC	AFWAOC	--	--	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	AFWAOC	--
	Winter	ACM2PX	ACM2PX	ACM2PX	ACM2PX	ACM2PX	AFWAOC	--	ACM2PX	ACM2PX	ACM2PX	ACM2PX	ACM2PX	ACM2PX	AFWAOC	--	ACM2PX
	Spring	ACM2PX	--	--	--	AFWAOC	AFWAOC	AFWAOC	AFWAOC	ACM2PX	--	--	--	AFWAOC	AFWAOC	AFWAOC	AFWAOC

CONUS: 2 m Temperature Bias

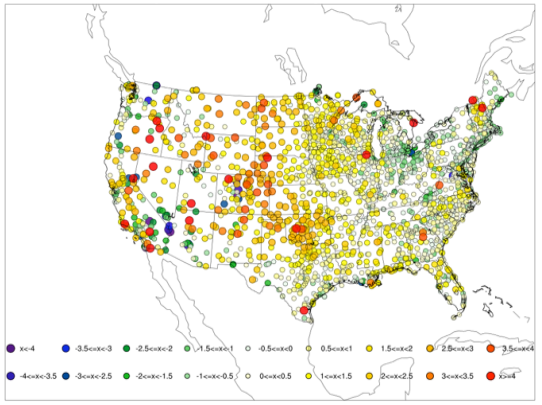
00 UTC initializations – Fcst Hr 36

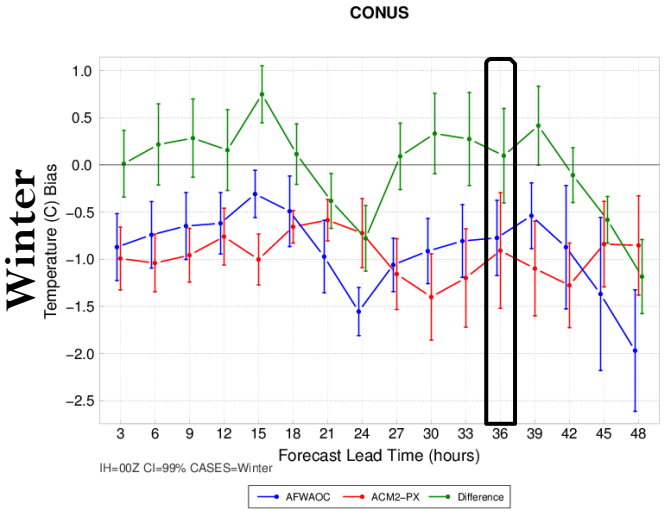


AFWAOC

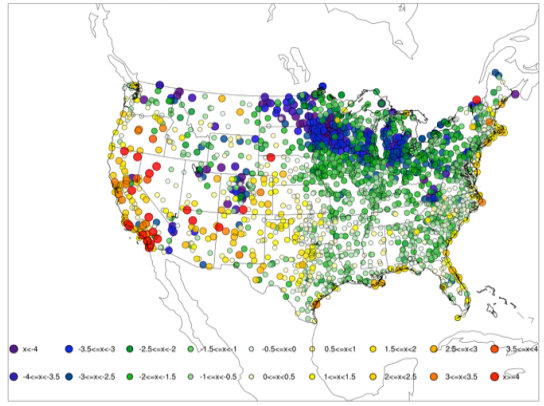


ACM2PX





AFWAOC



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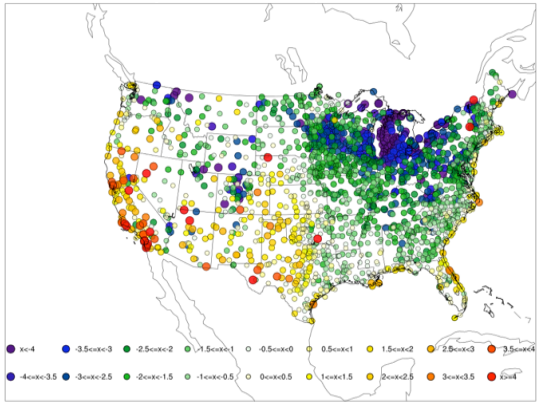
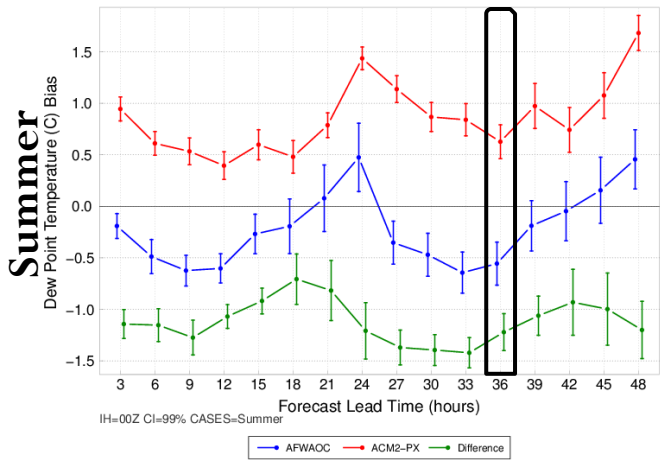


CONUS: 2 m Dew Point Temperature Bias

00 UTC initializations – Fcst Hr 36



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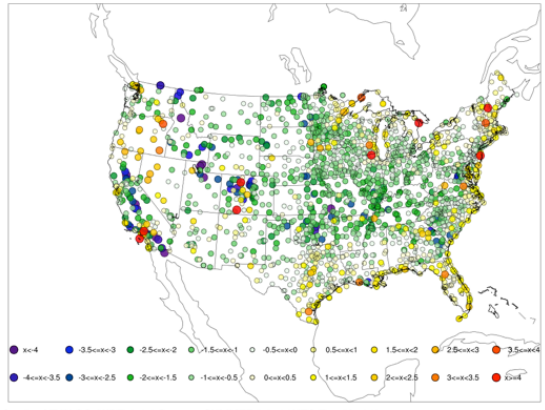

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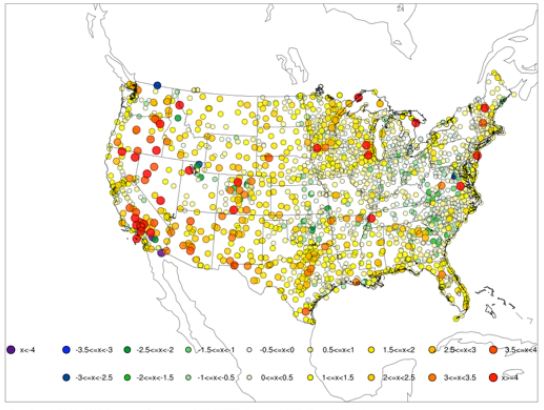

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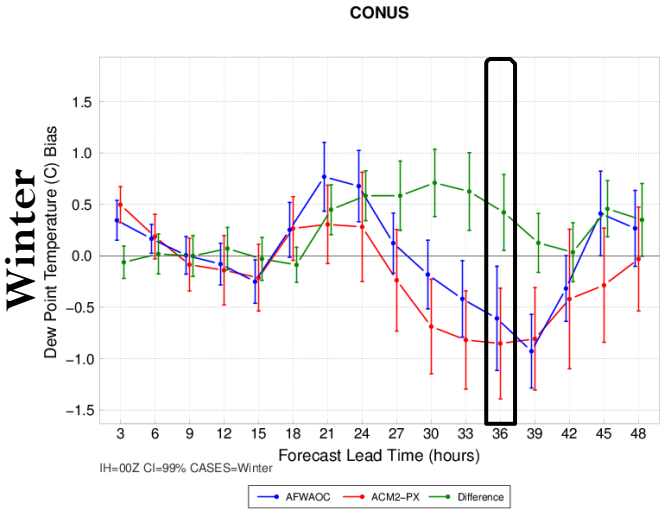
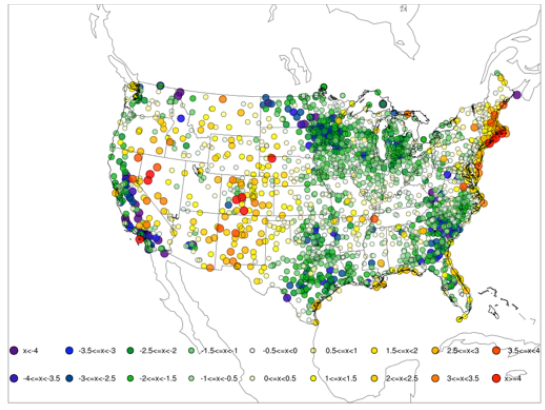


AFWAOC



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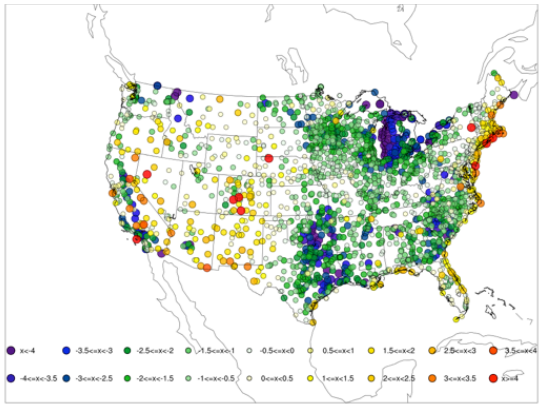

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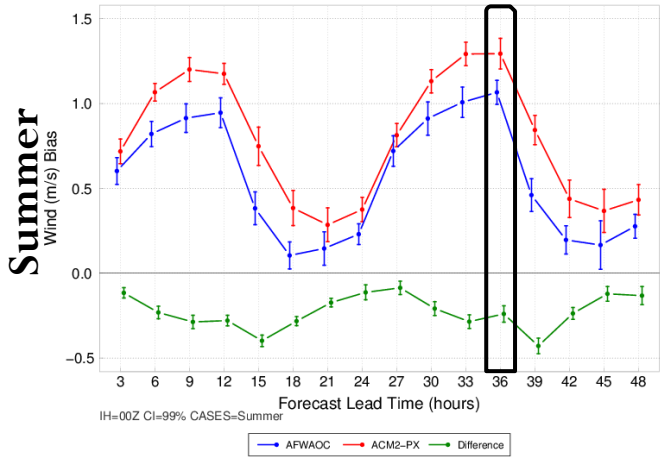
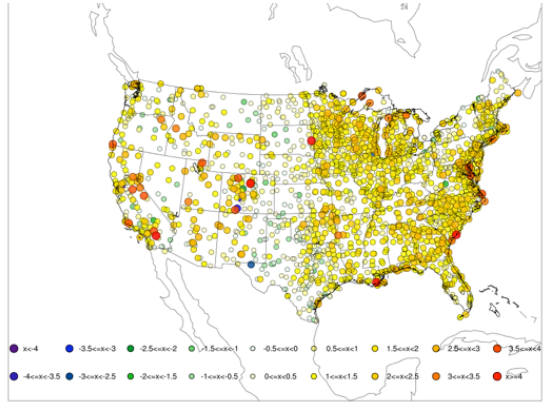
CONUS: 10 m Wind Speed Bias

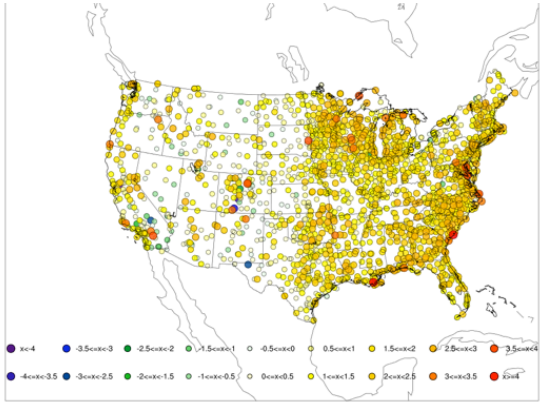
00 UTC initializations – Fcst Hr 36

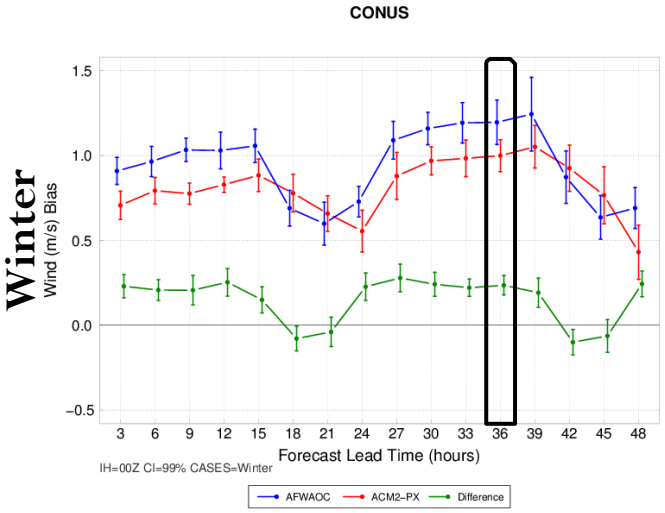


AFWAOC

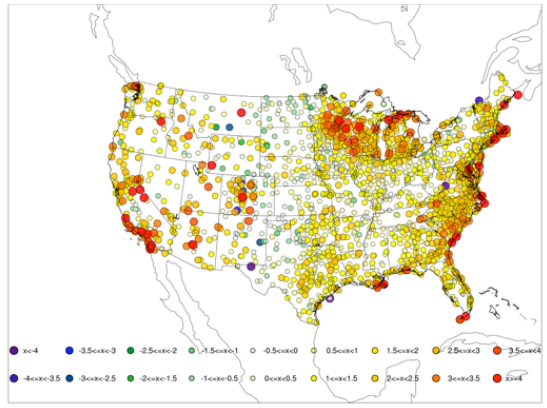


ACM2PX

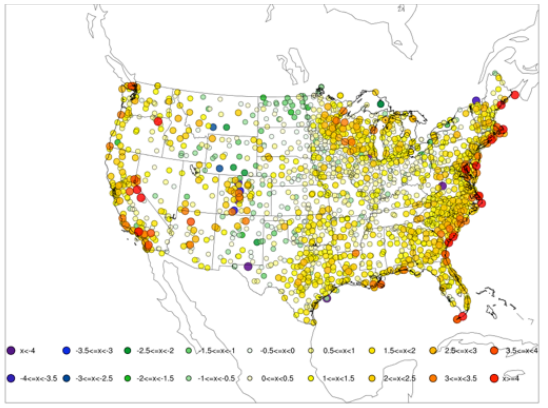




AFWAOC



ACM2PX



Inter-comparison of model output

AFWAOC – ACM2PX

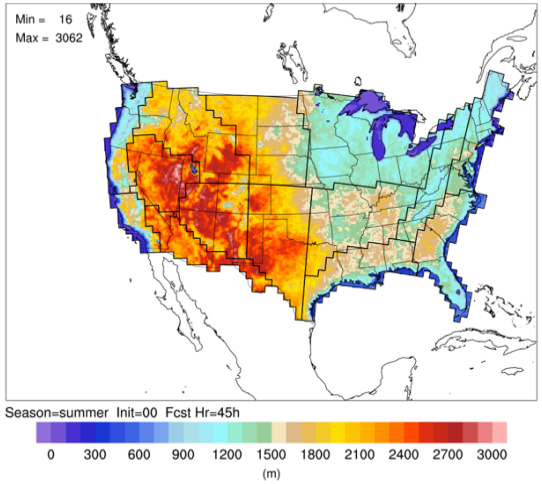
Diff > 0 → **AFWAOC** has **larger** values

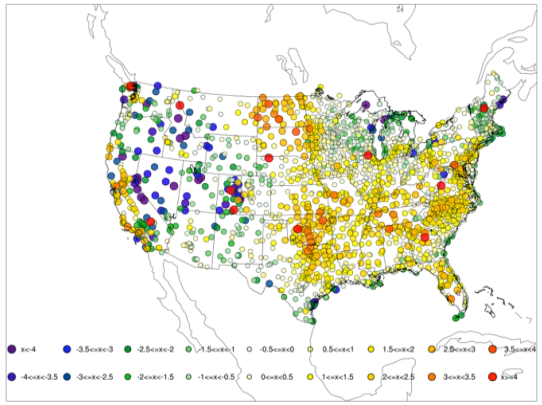
Diff < 0 → **ACM2PX** has **larger** values

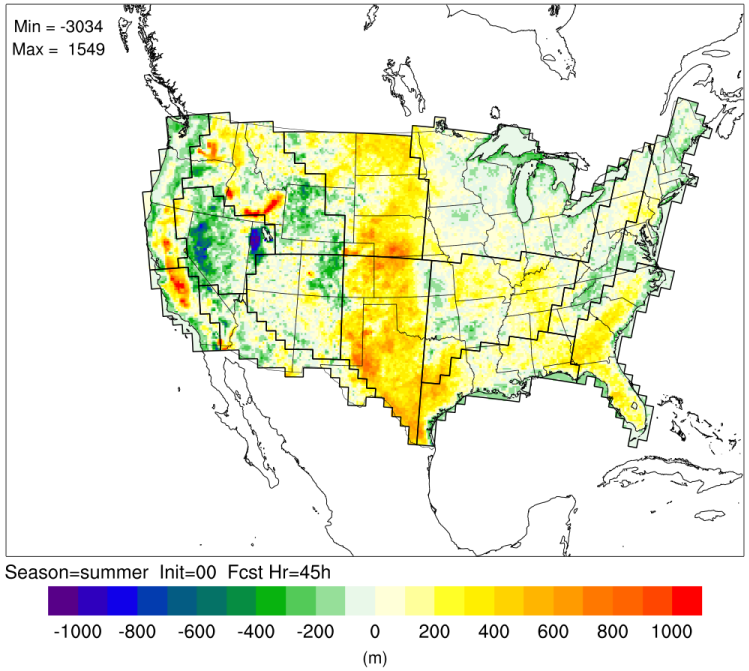
Planetary Boundary Layer Height

00 UTC Initializations – Fcst Hr 45; Summer

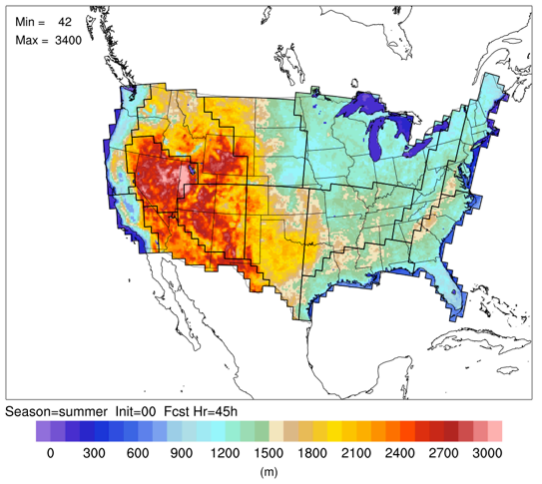
AFWAOC

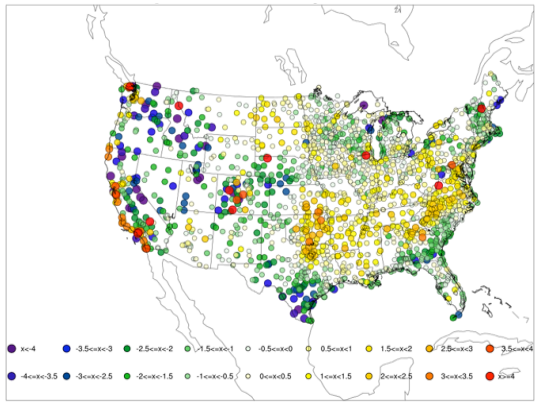






ACM2PX





AFWAOC – ACM2PX

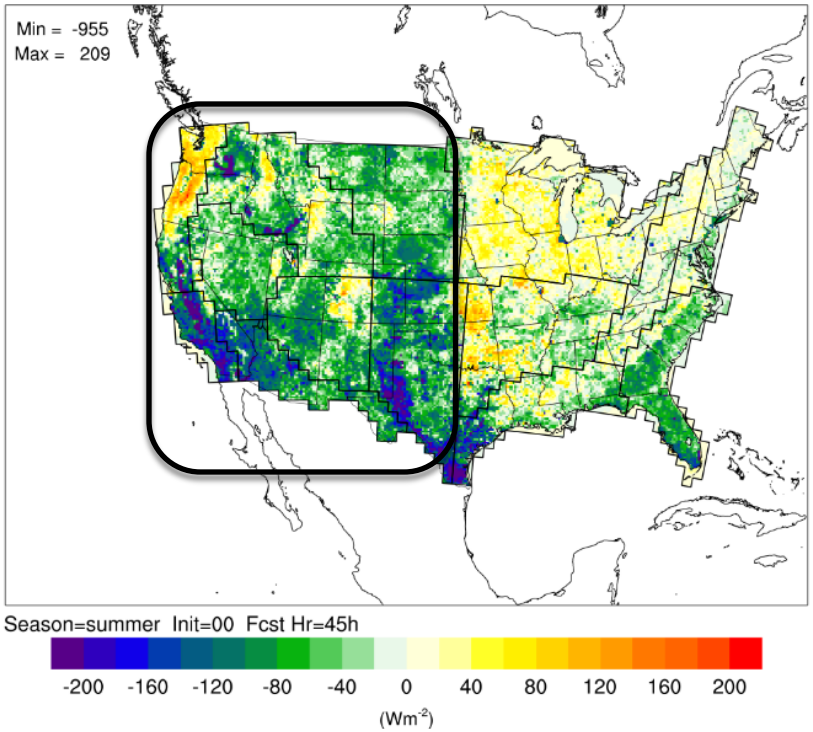
Diff > 0 → AFWAOC has larger values

Diff < 0 → ACM2PX has larger values

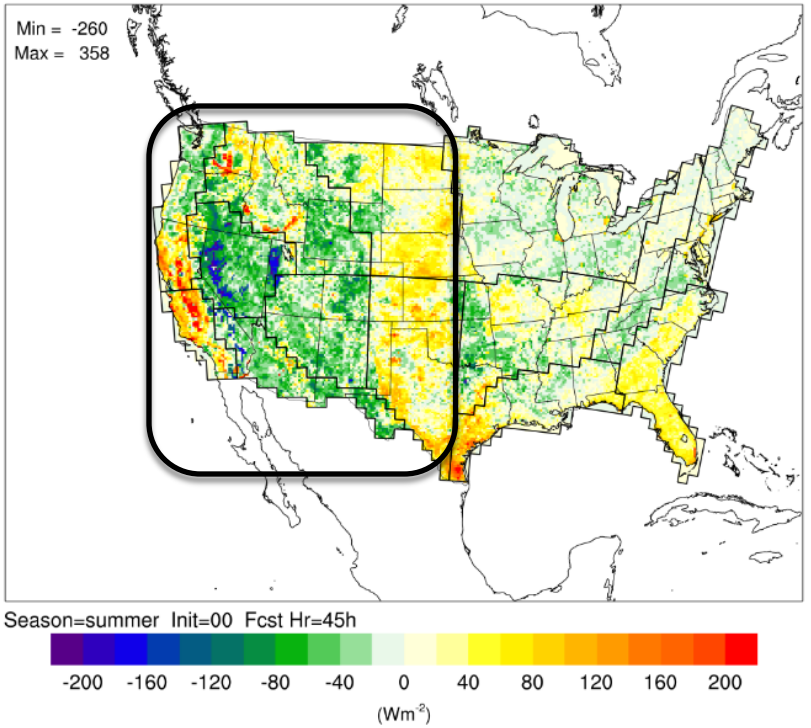
Latent and Sensible Heat Flux

00 UTC Initializations – Fcst Hr 45; Summer

Latent Heat Flux



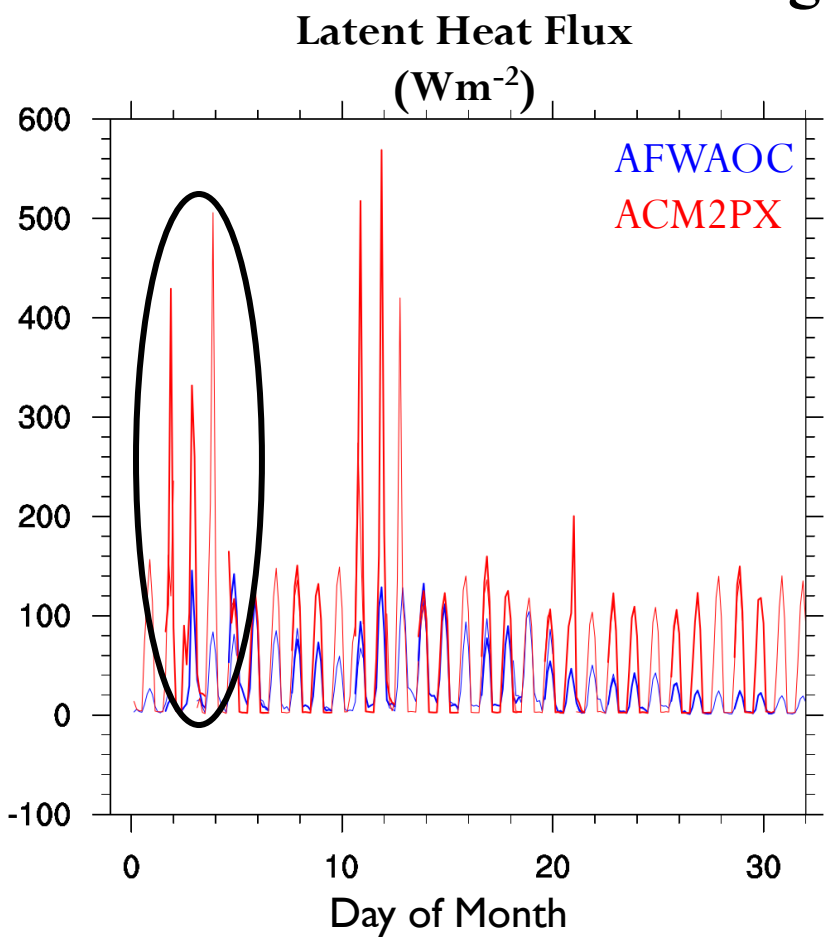
Sensible Heat Flux

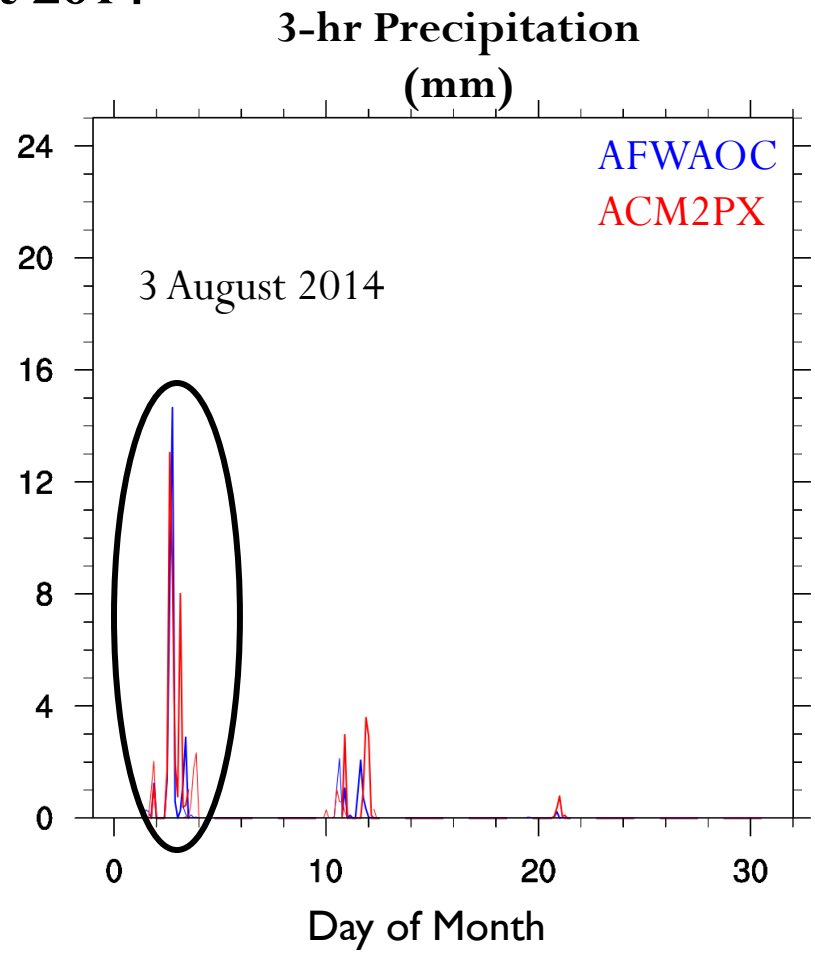


Further Investigation

Precipitation and latent heat response

Desert Rock
August 2014

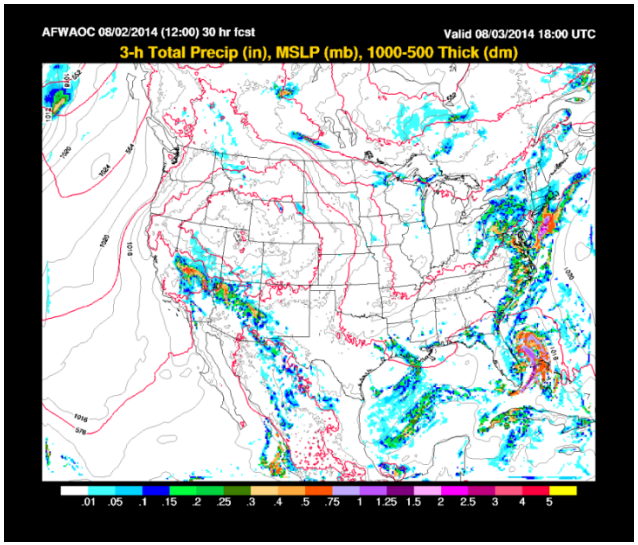


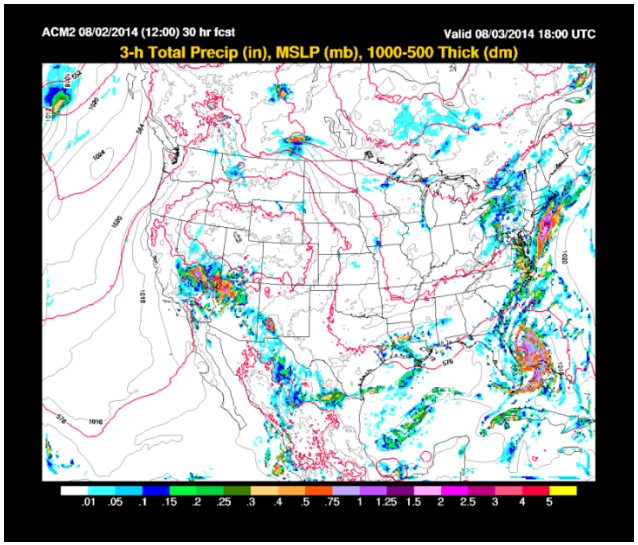


Further Investigation

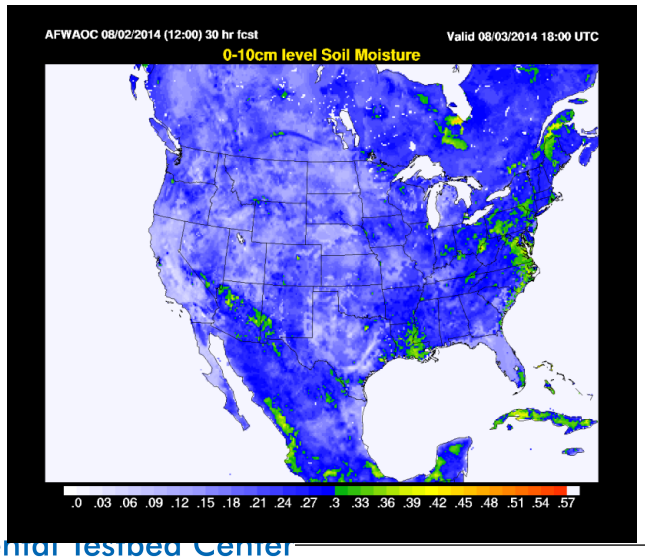
Precipitation and soil moisture response

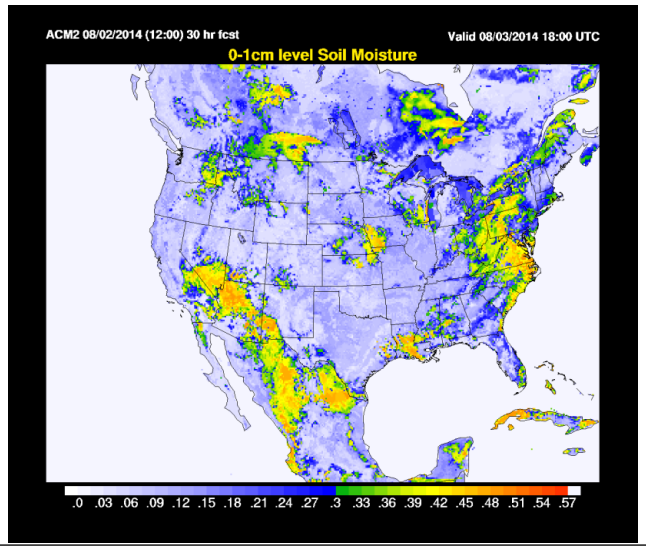
AFWAOC | **ACM2PX**





Soil Moisture (level 1) 0–10 cm





Soil Moisture (level 1) 0–1 cm

Summary

- Performed extensive T&E on two WRF configurations
  - Largest differences concentrated in the surface and lowest levels
  - Performance differs spatially and temporally
  - Strong relationship among:
    - Precipitation, soil moisture, latent heat flux, dew point temperature
    - PBL height, sensible heat flux, temperature
  - For more information and results:

Test and Evaluation (AFWAOC/ACM2PX):
http://www.dtcenter.org/eval/meso_mod/afwa_test/wrf_v3.6.1/index.php

Reference Configuration (AFWAOC w/ WRFv3.6.1):
http://www.dtcenter.org/config/v3.6.1/ARW_PS4.4.4.91.2.1.1/index.php

Reference Configuration (ACM2PX w/ WRFv3.6.1):
http://www.dtcenter.org/config/v3.6.1/ARW_PS4.4.4.7.7.7.1/index.php