WRF-Hydro Forcing Engine Overview

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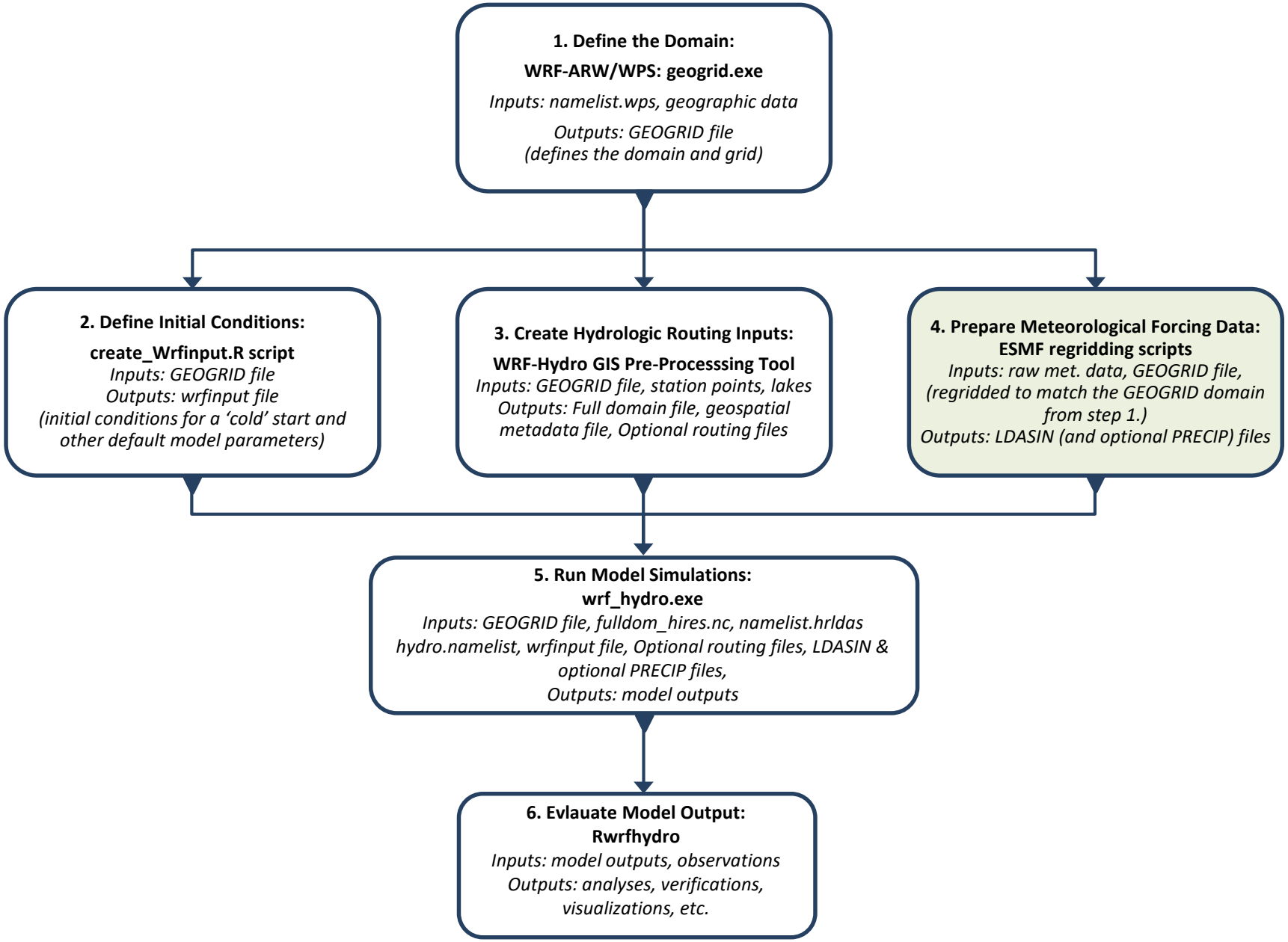
Office of Water Prediction

WRF-Hydro Workflow



Input Forcing Data Requirements

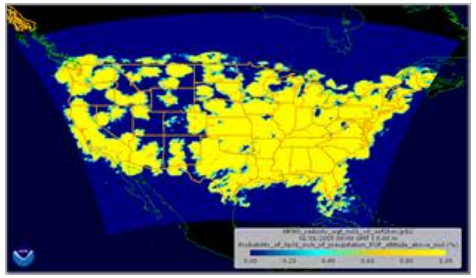
Variable name	Description	Units
SWDOWN	Incoming shortwave radiation	W/m^2
LWDOWN	Incoming longwave radiation	W/m^2
Q2D	Specific humidity	kg/kg
T2D	Air temperature	K
PSFC	Surface pressure	Pa
U2D	Near surface wind in the u-component	m/s
V2D	Near surface wind in the v-component	m/s
RAINRATE	Precipitation rate	mm/s or $kg/m^2/s$

ALL FORCING DATA IS MAPPED TO SAME GRID (based on the 'geogrid')

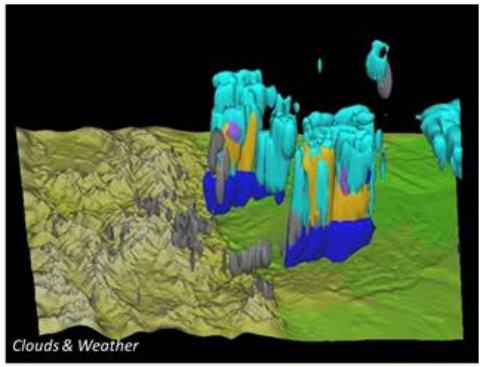
SPECIFIED PRECIPITATION MAY HAVE HIGHER TIME RESOLUTION (e.g. 5min)

NWM Meteorological Forcings:

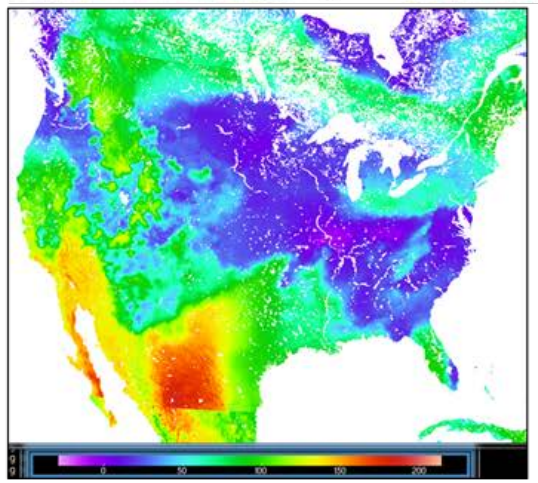
Seasonally-varying MRMS RQI



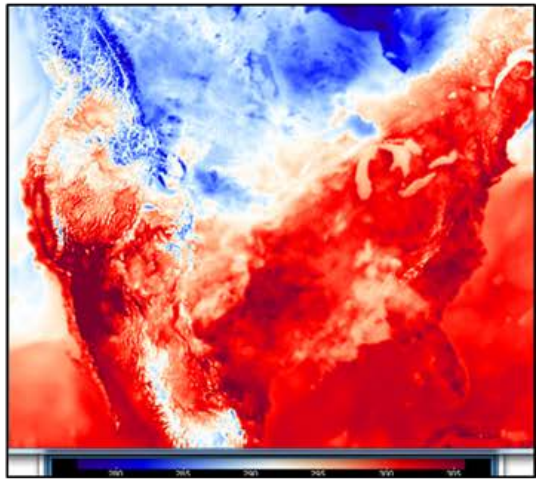
Blended MRMS-HRRR Precipitation



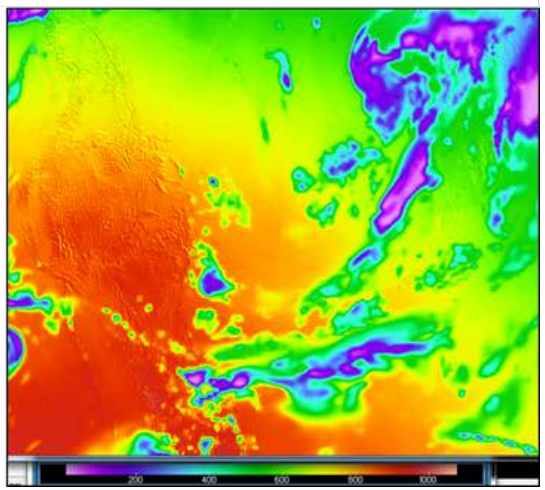
HRRR-RAP incoming longwave radiation



HRRR-RAP 2m Air Temperature

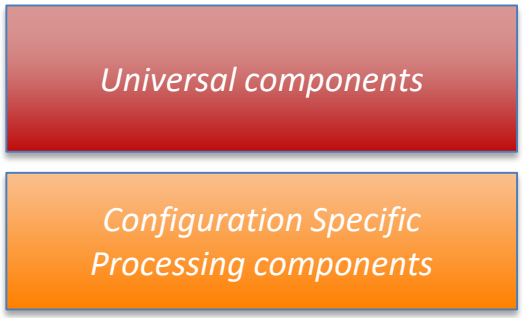


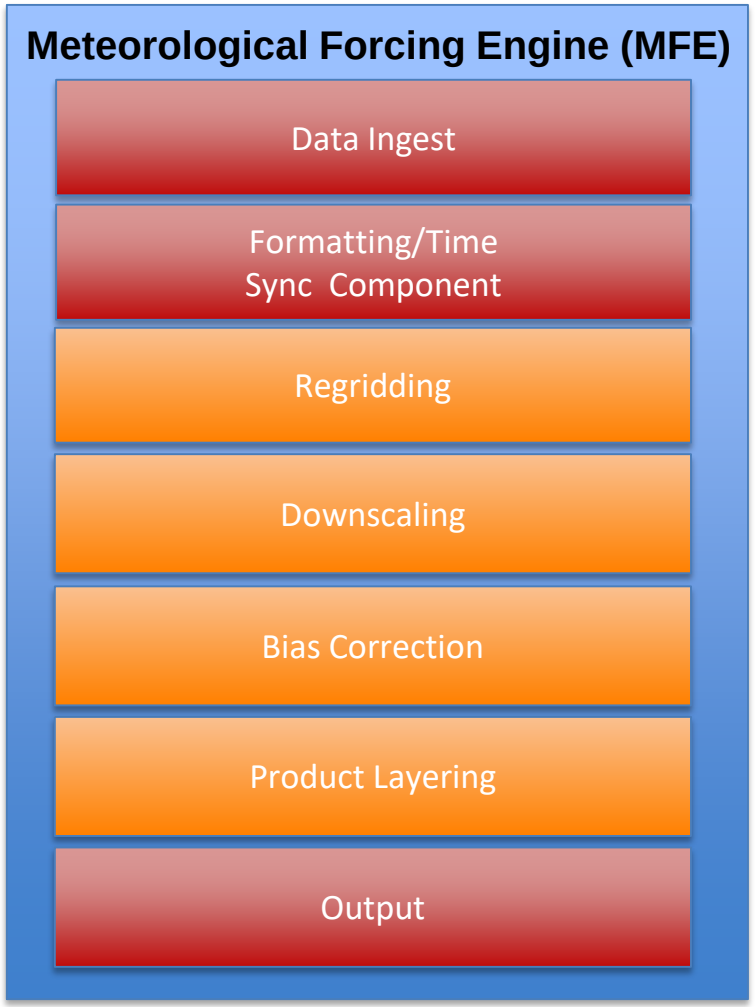
GFS – derived incoming shortwave radiation



WRF-Hydro Meteorological Forcing Engine:

General Forcing Data Engine Schematic

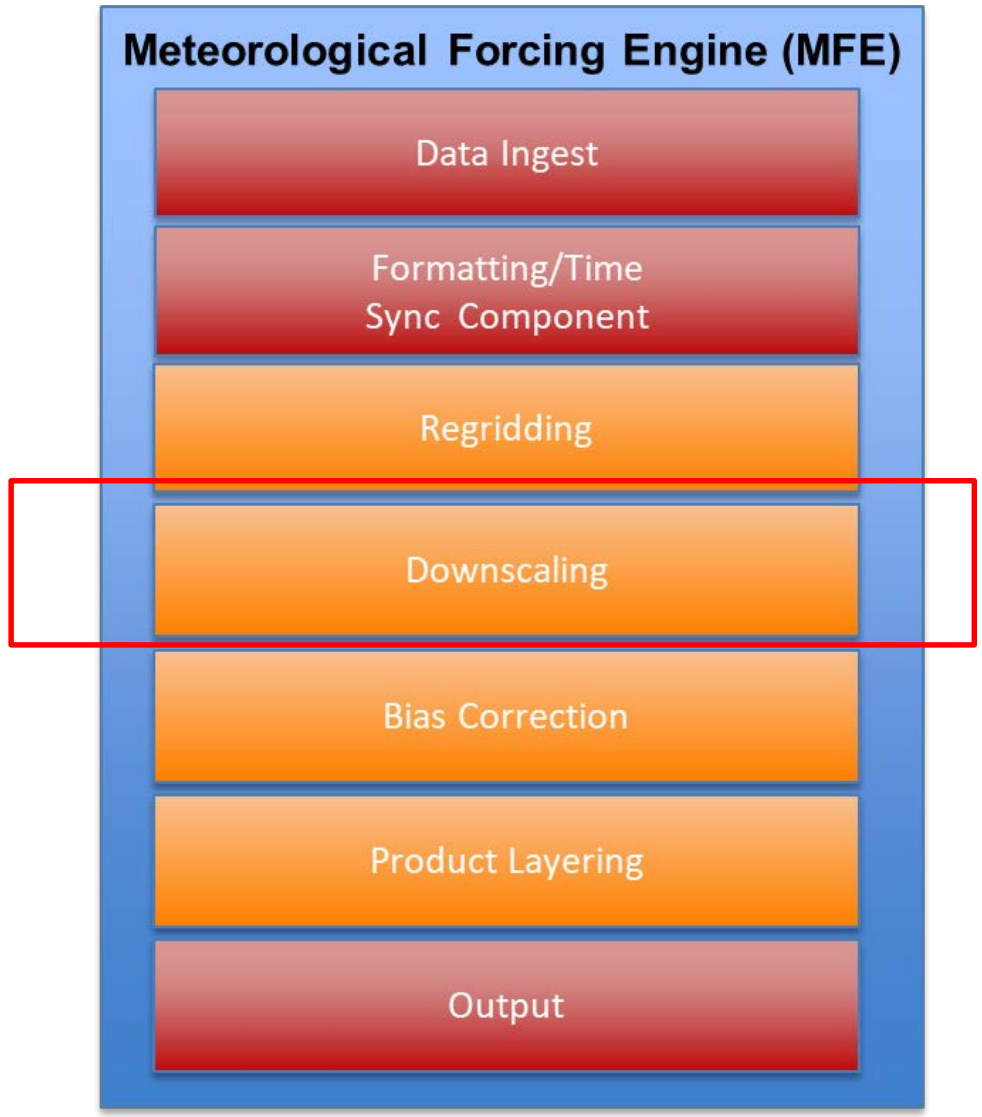




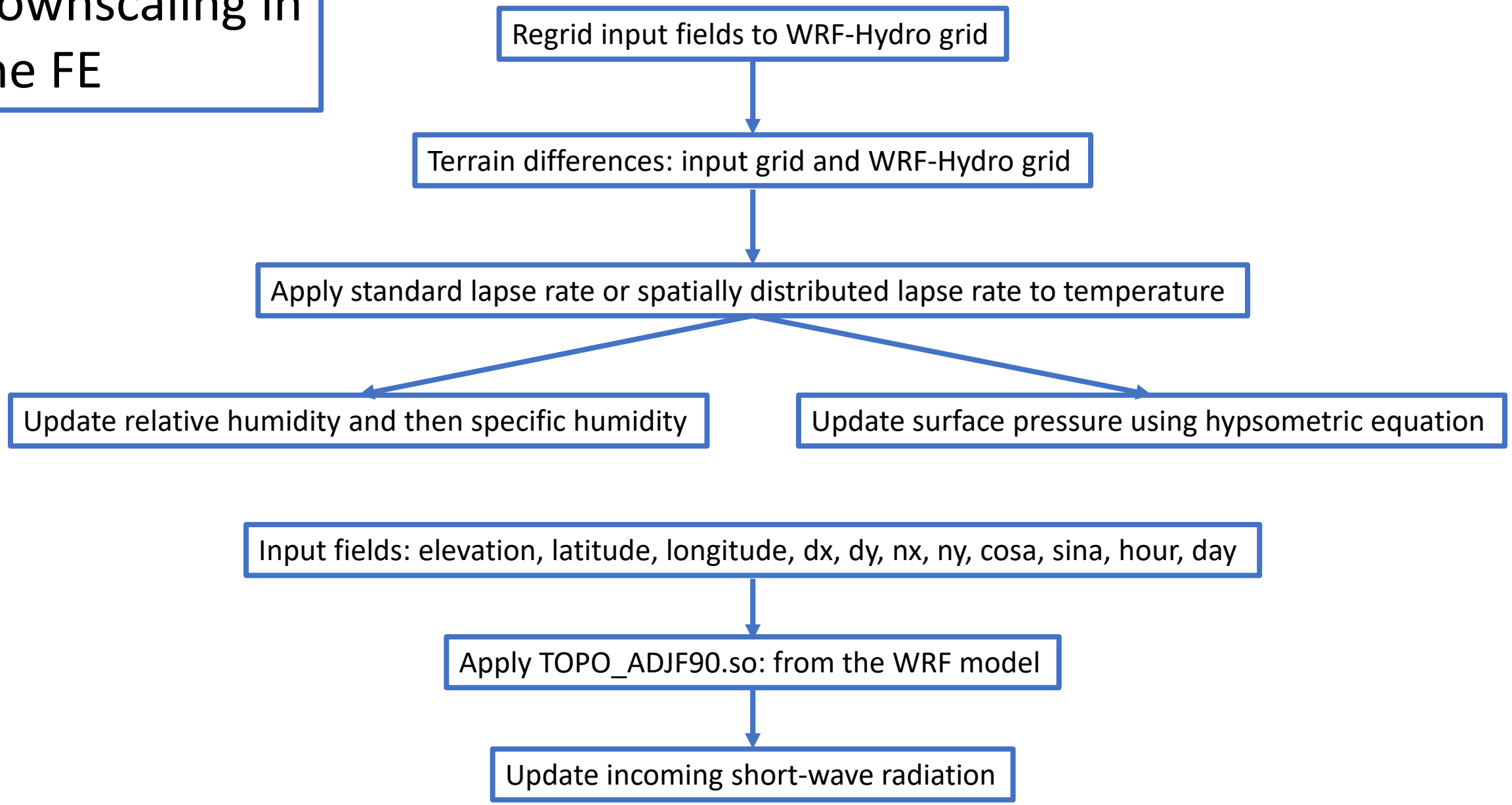
- Recently recoded form ncl into Python
- Wraps FORTRAN library functions

NWM Forcing Data Engine Construction

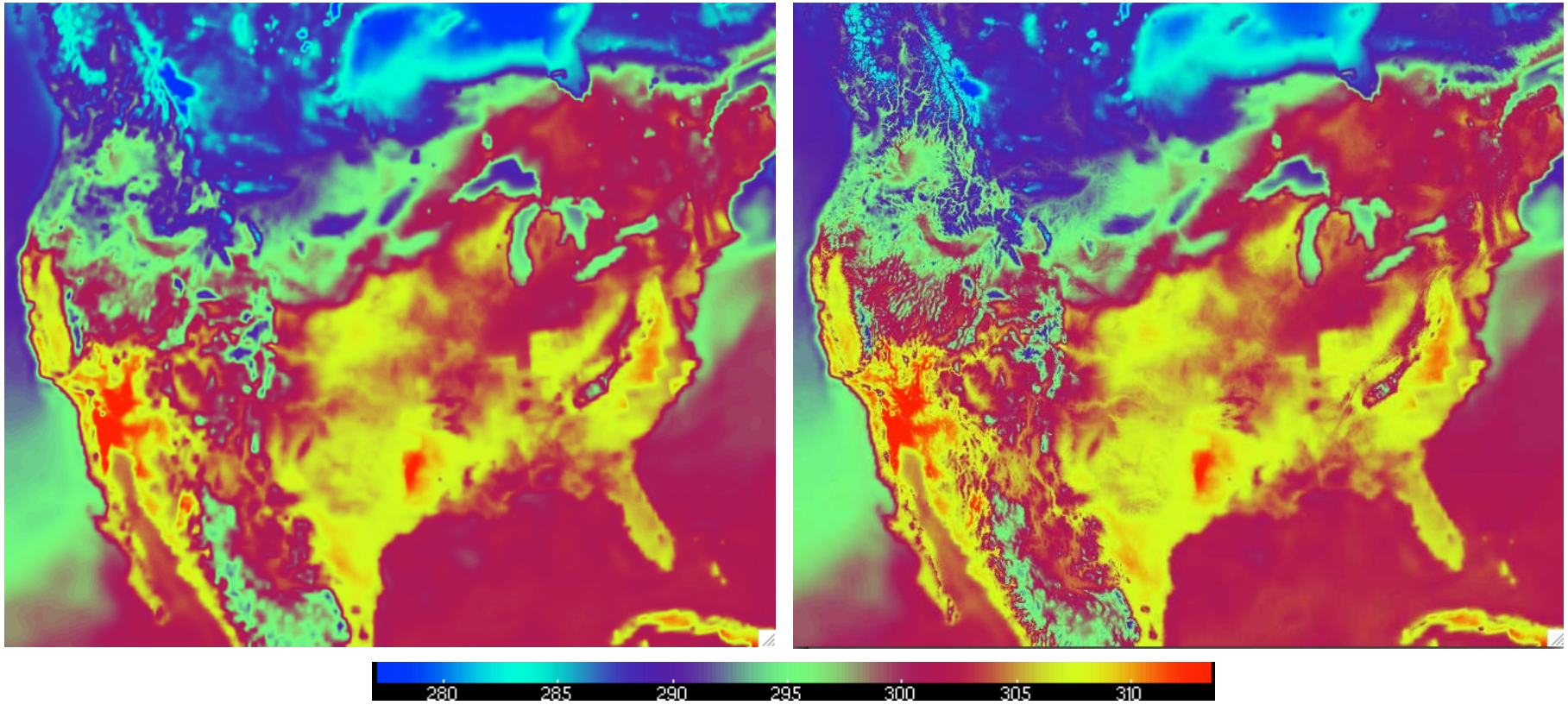
1. Create national 1km gridded fields of:
   - Temperature, mixing ratio, surface pressure, u-, v-windspeed, longwave and shortwave radiation, precipitation rate
2. Downscaling of:
   - Temperature (NARR distributed climatological lapse rate)
   - Mixing ratio (conserve RH)
   - Surface pressure
   - Incoming shortwave radiation (terrain slope and aspect)



Downscaling in the FE



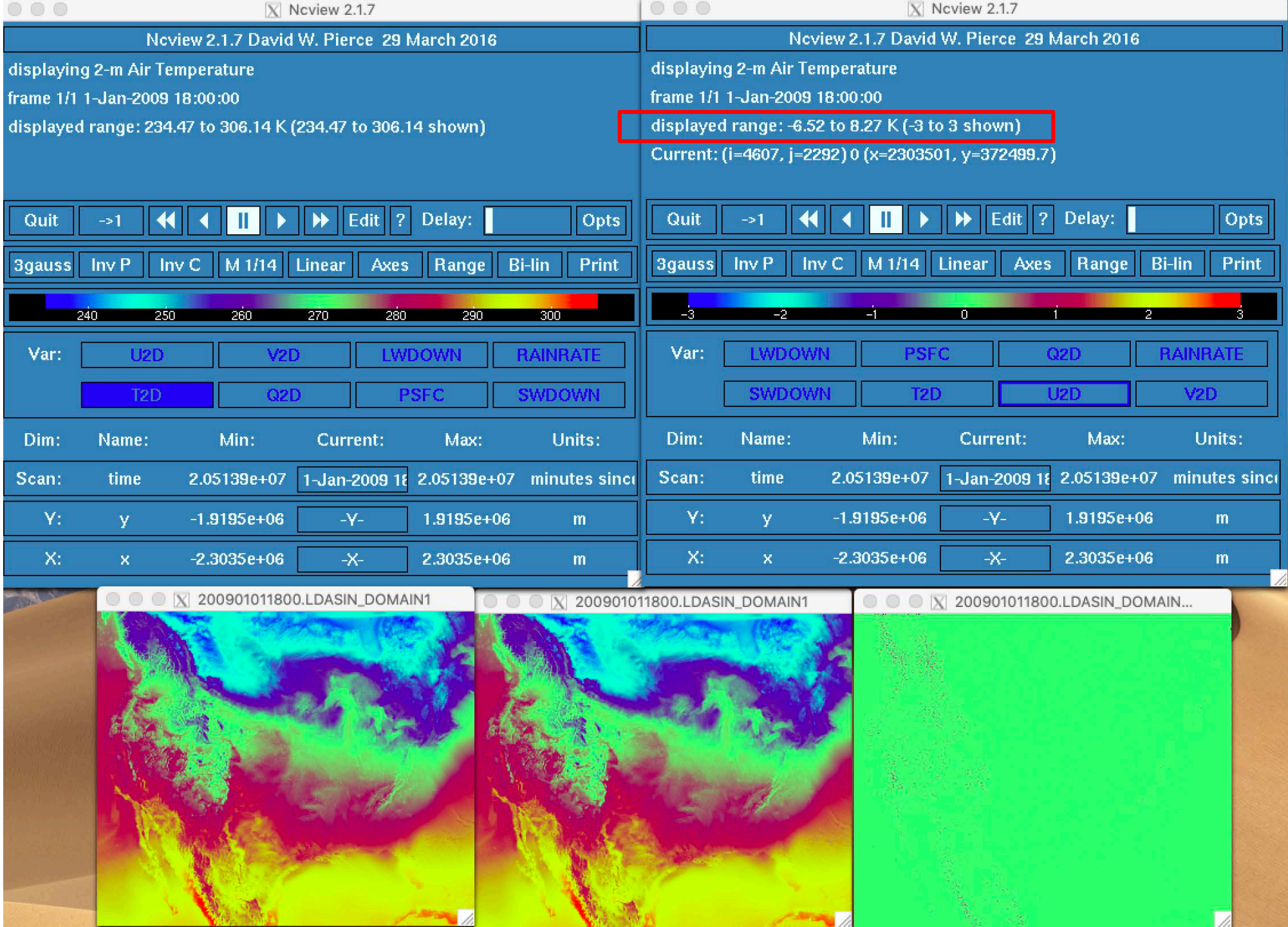
2 m Air Temperature



T2m
Valid at 18Z Jan 1, 2009

With downscaling: left
No downscaling: right
Middle: differences

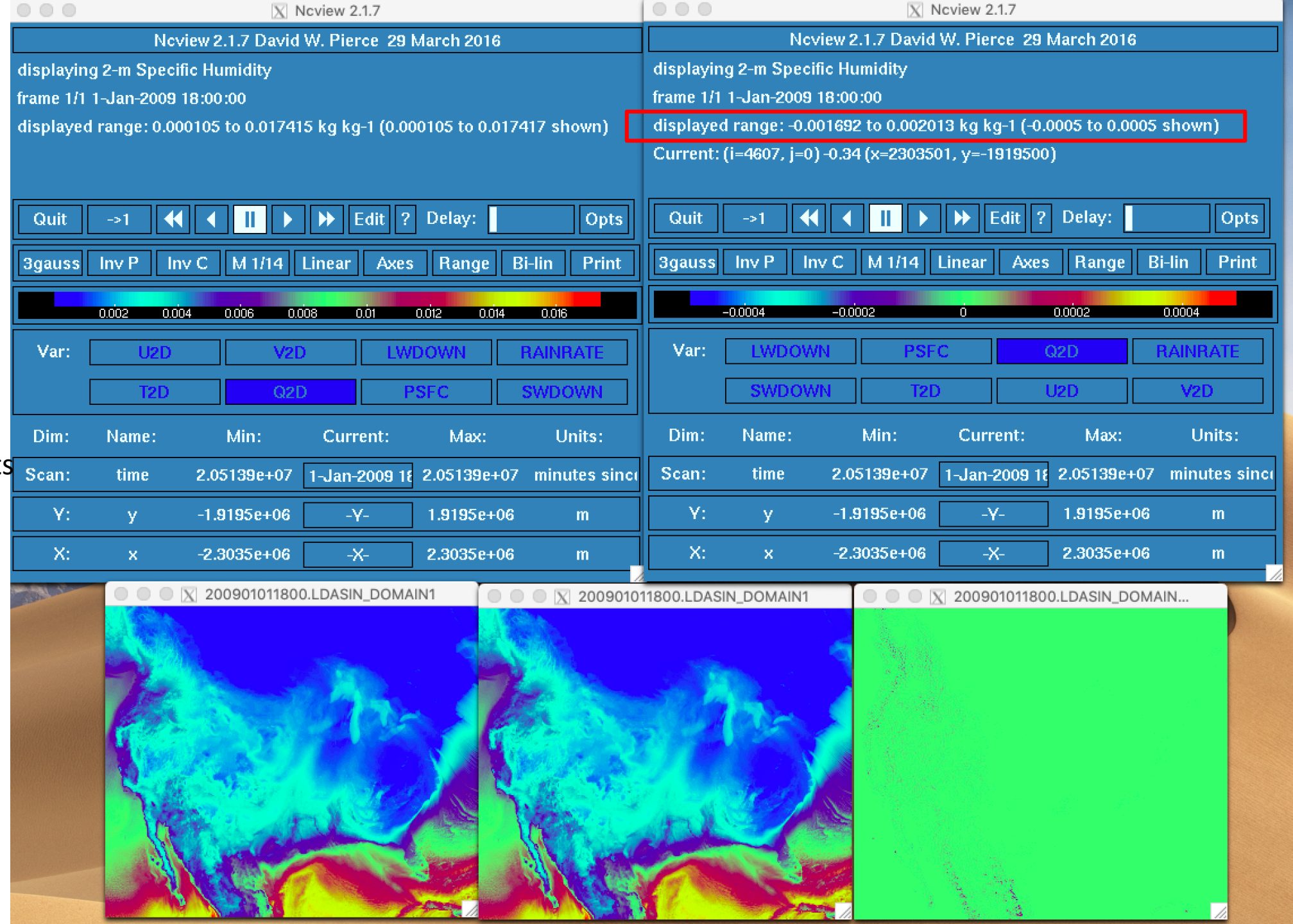
Result: Local adjustments to temps in a range of -6 to +8 deg C



Q2m
Valid at 18Z Jan 1, 2009

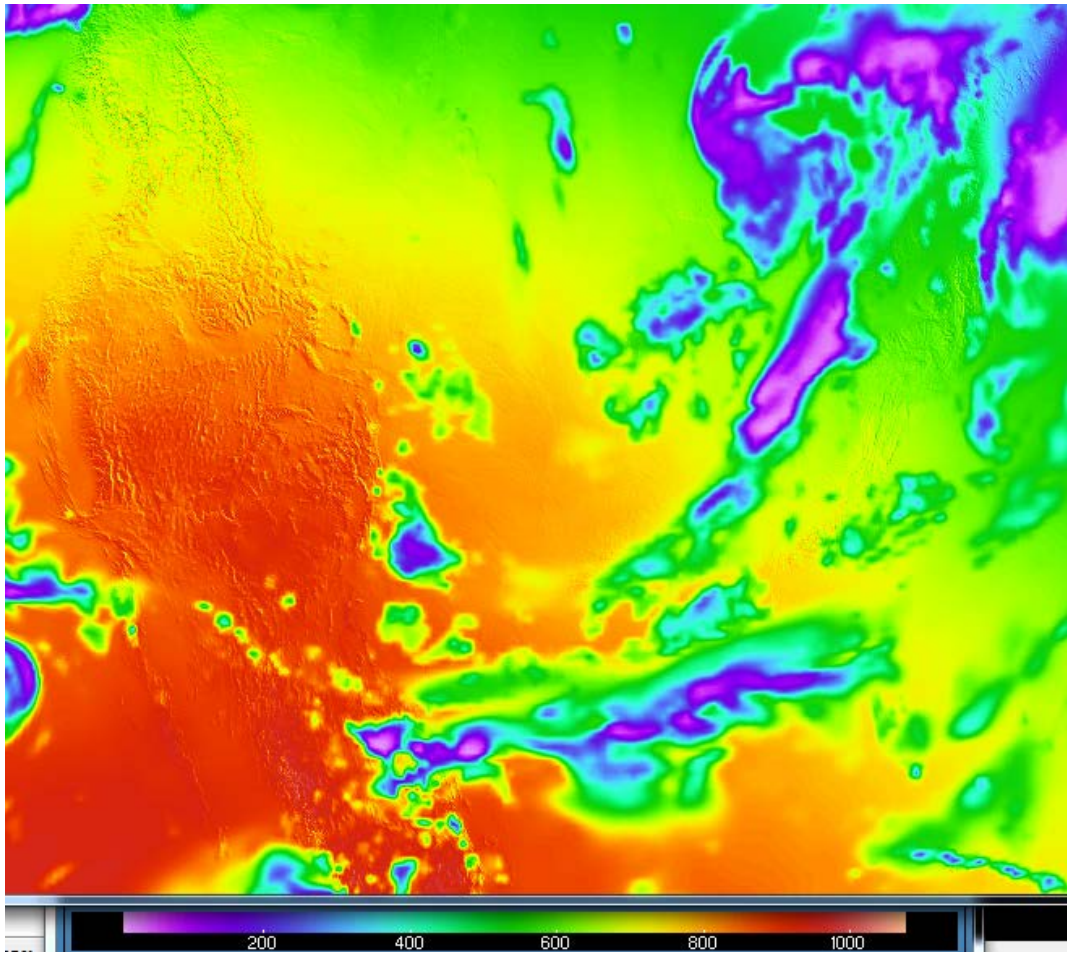
With downscaling: left
No downscaling: right
Middle: differences

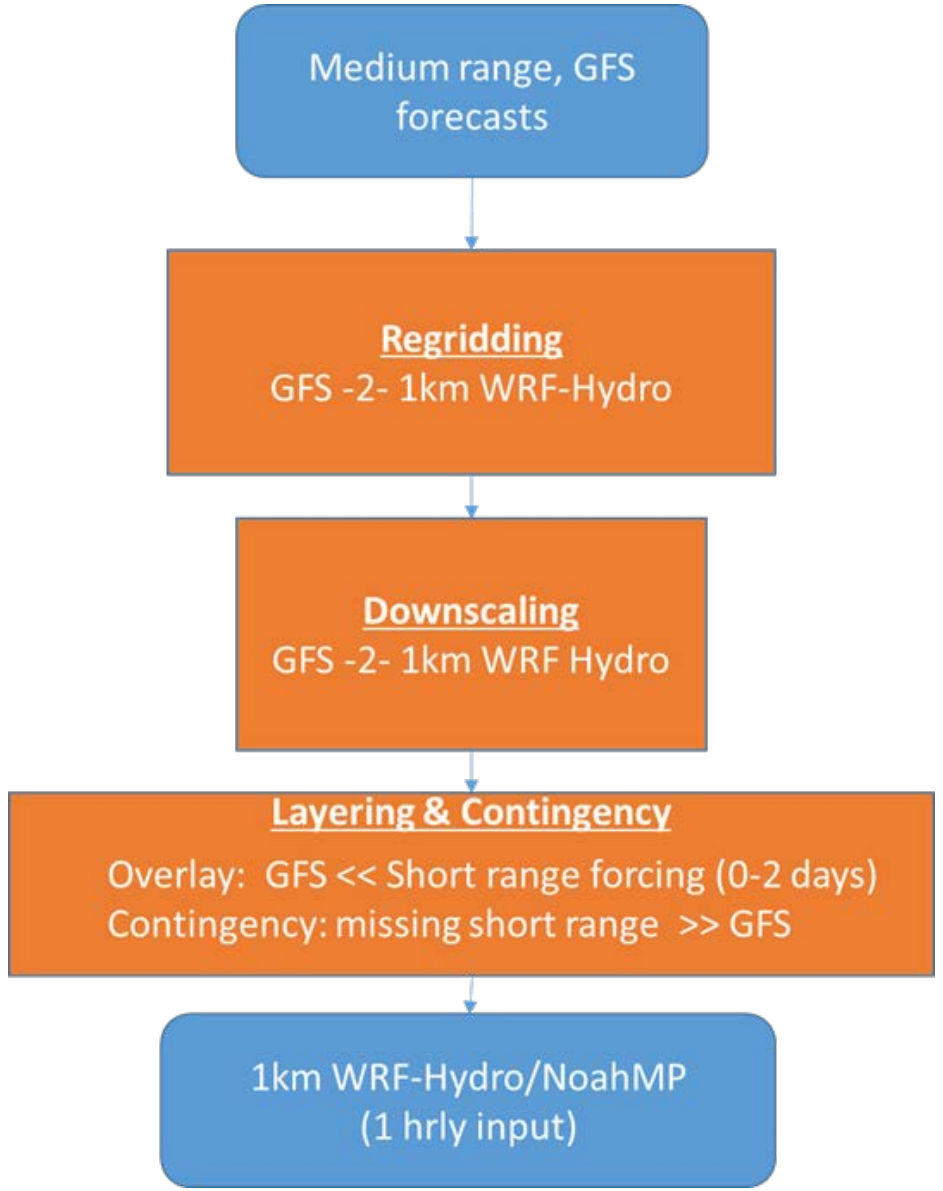
Result: Local adjustments to mixing ration in a range of -0.0017 to +0.002 kg/kg



NWM Forcing Data Engine Construction

- Medium Range Configuration
  - Downscaled GFS (incoming shortwave radiation Sept. 11, 2015 21Z)

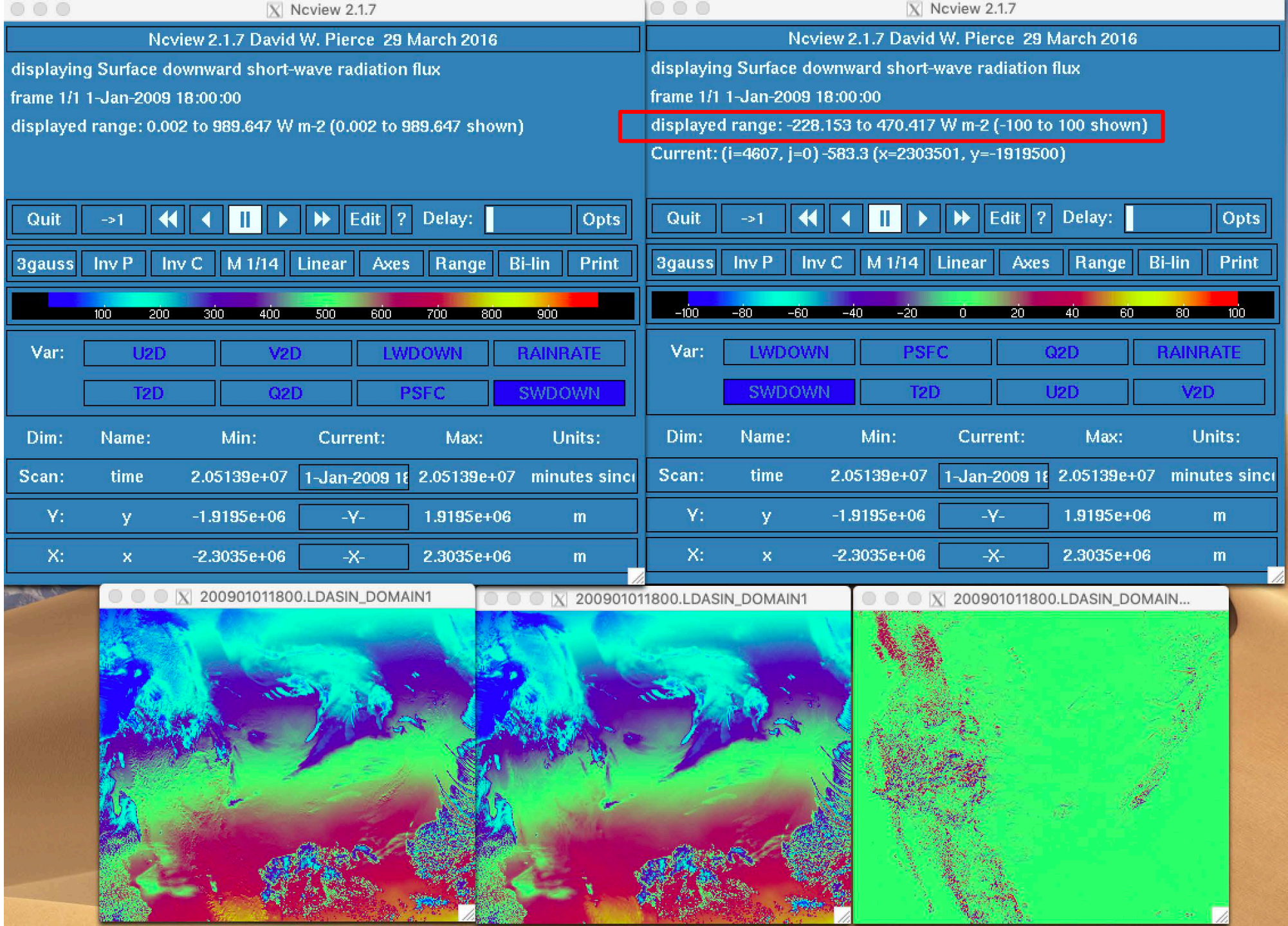




SWDOWN
Valid at 18Z Jan 1, 2009

With downscaling: left
No downscaling: right
Middle: differences

Result: Local adjustments to incoming SW in a range of -228 to +470 W/m^2



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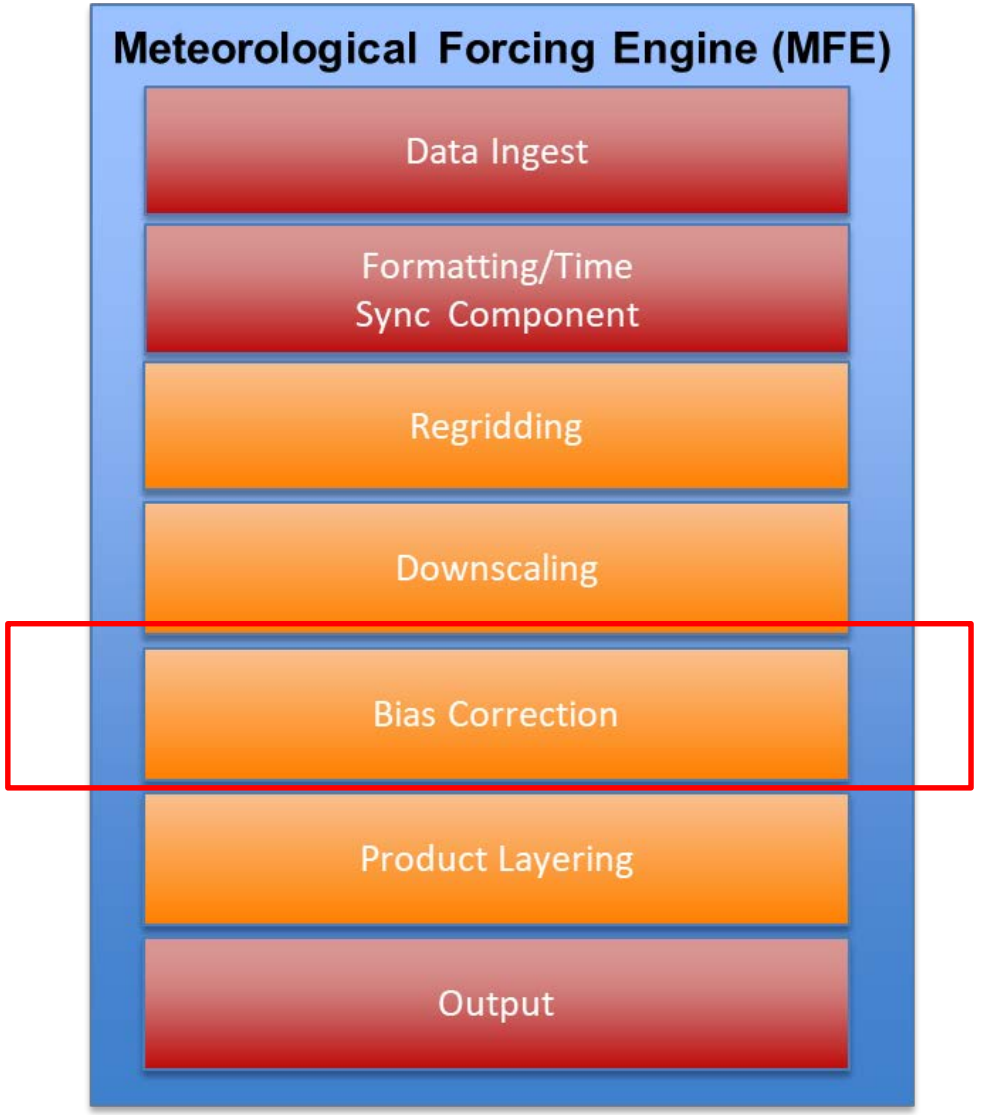
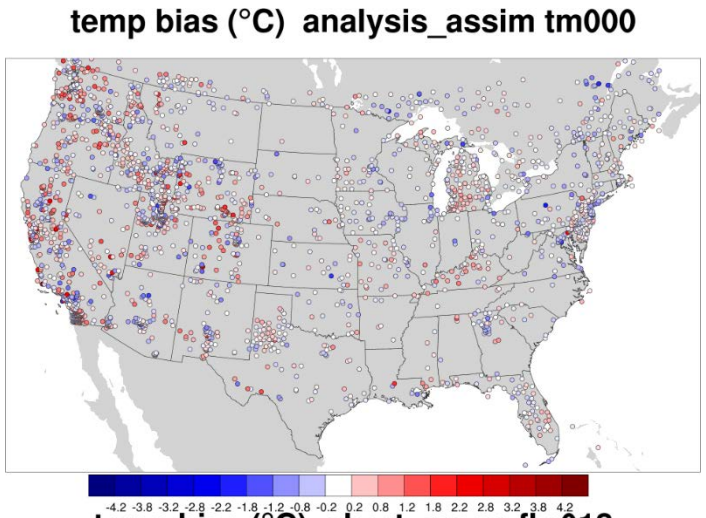


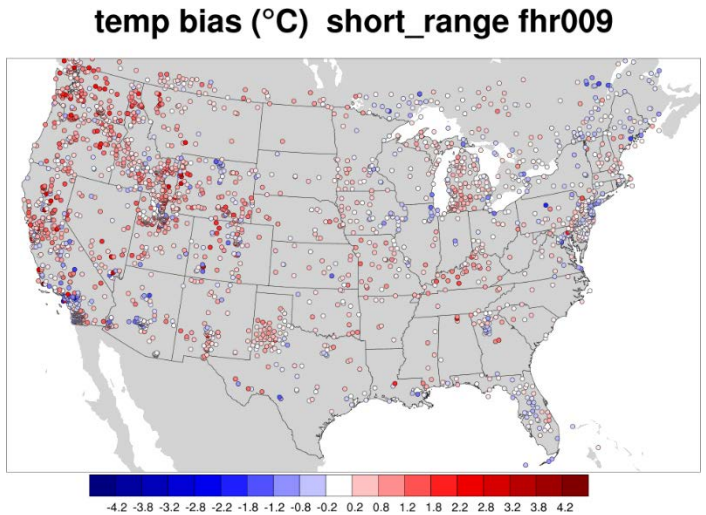
WRF-Hydro Meteorological Forcings: Bias Corrections

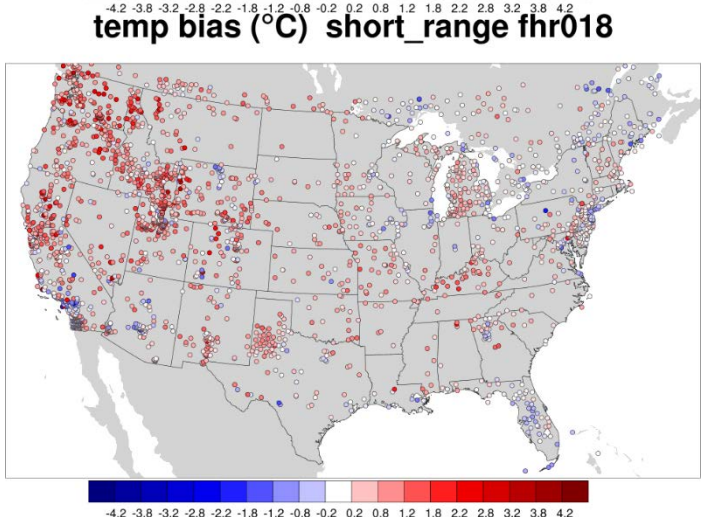
- Air temperature
- Humidity
- Incoming solar radiation
- Incoming longwave radiation
- Wind speed

- Precipitation

NWM Meteorological Forcings: Bias Corrections….HRRR model



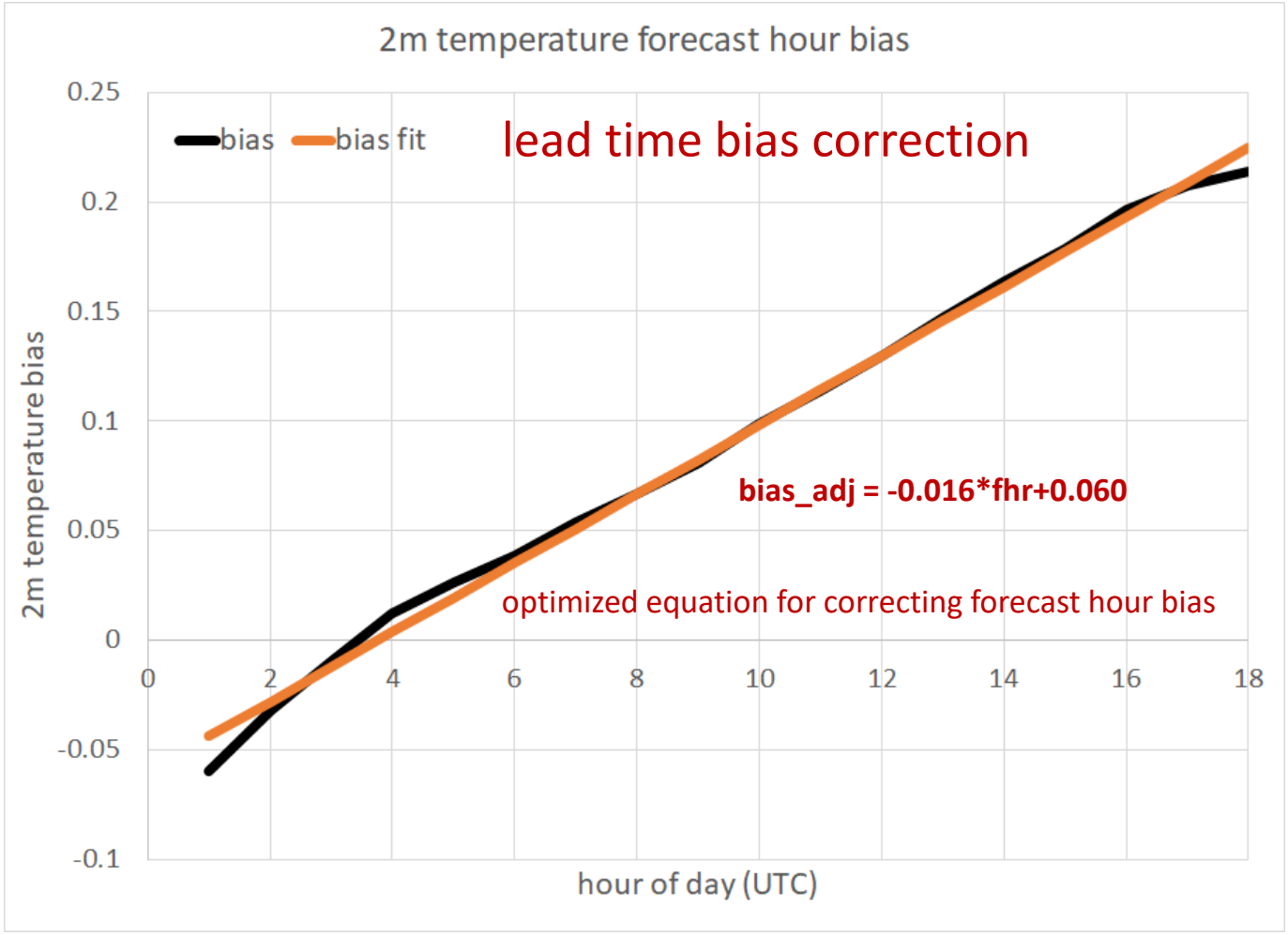




- some regional variation too
- increases with lead time

- regional pattern less distinct than other patterns
- focus on correcting for:
  - lead time
  - diurnal
  - seasonal

NWM Meteorological Forcings: Bias Corrections….HRRR model



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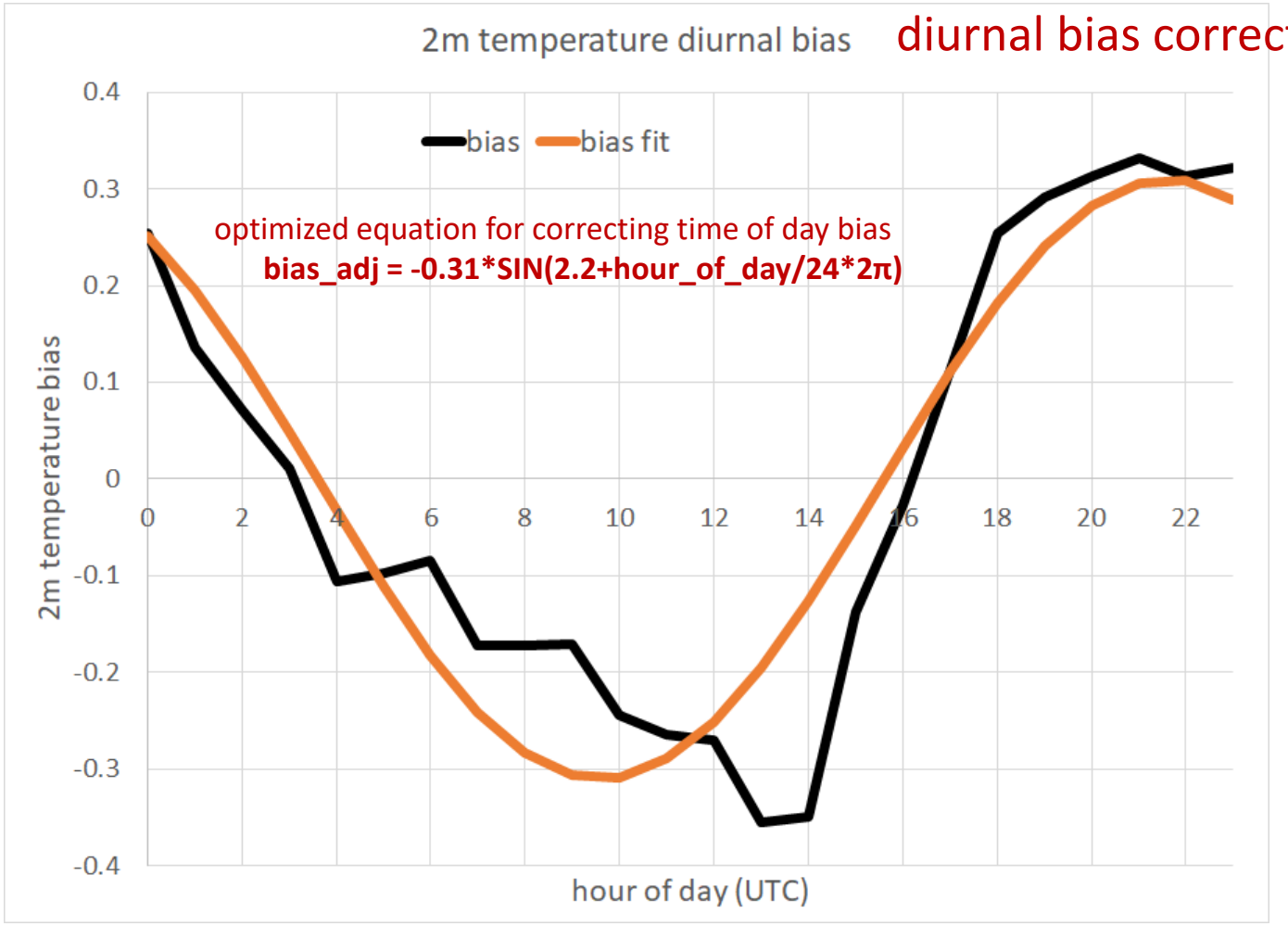
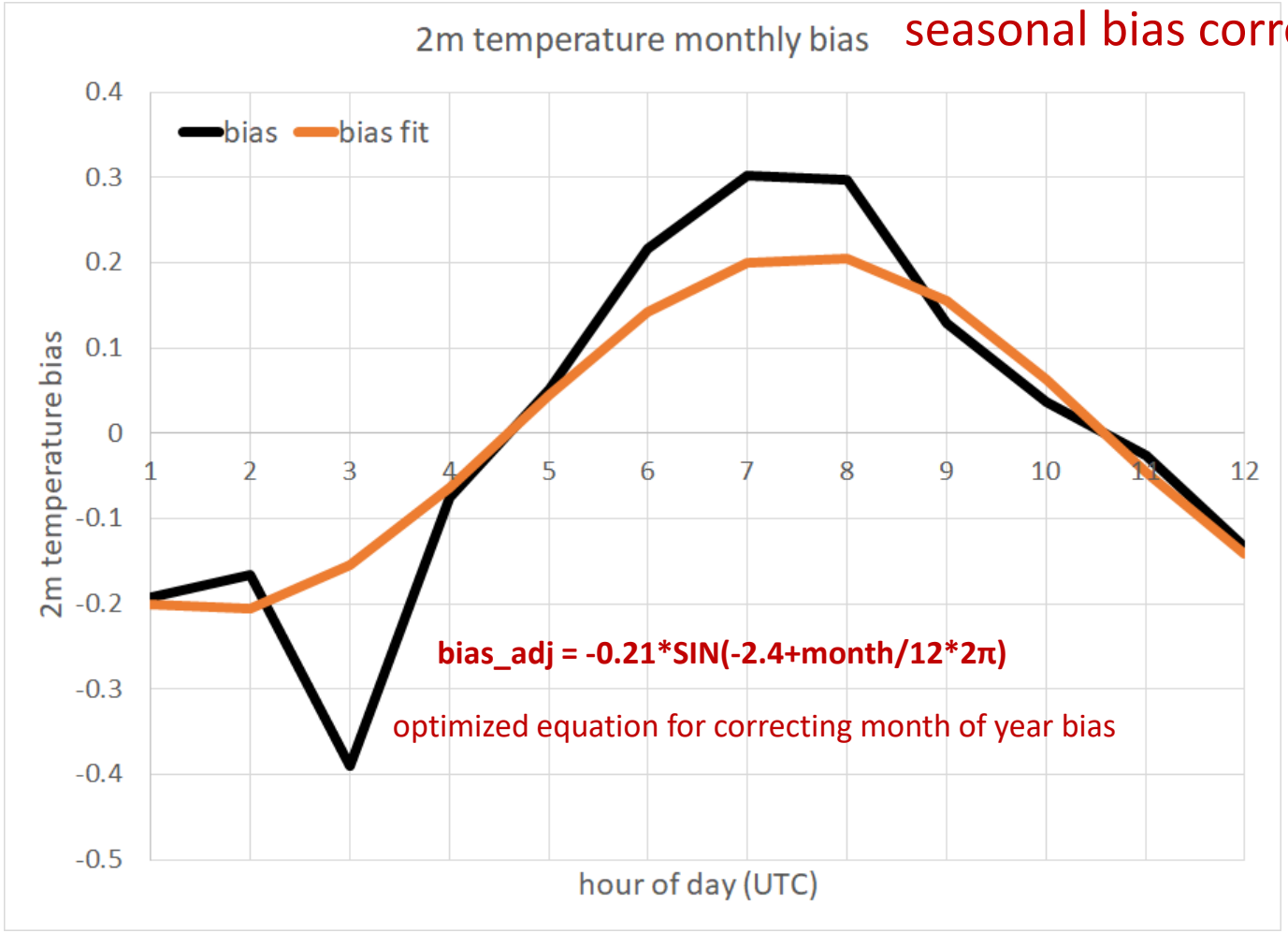


NWM Meteorological Forcings: Bias Corrections….HRRR model



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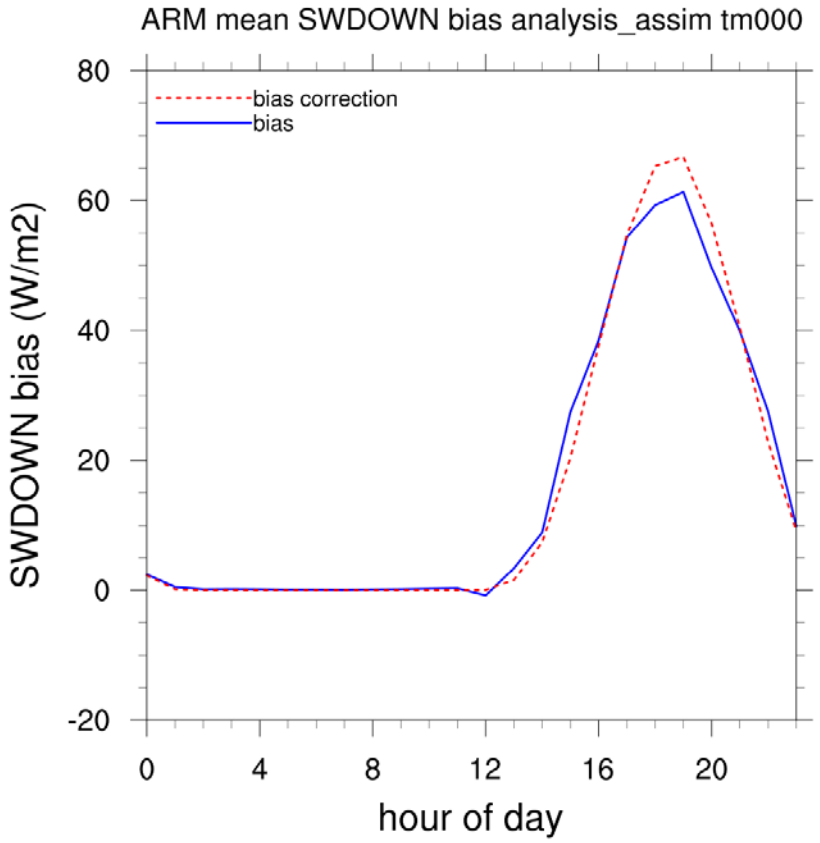


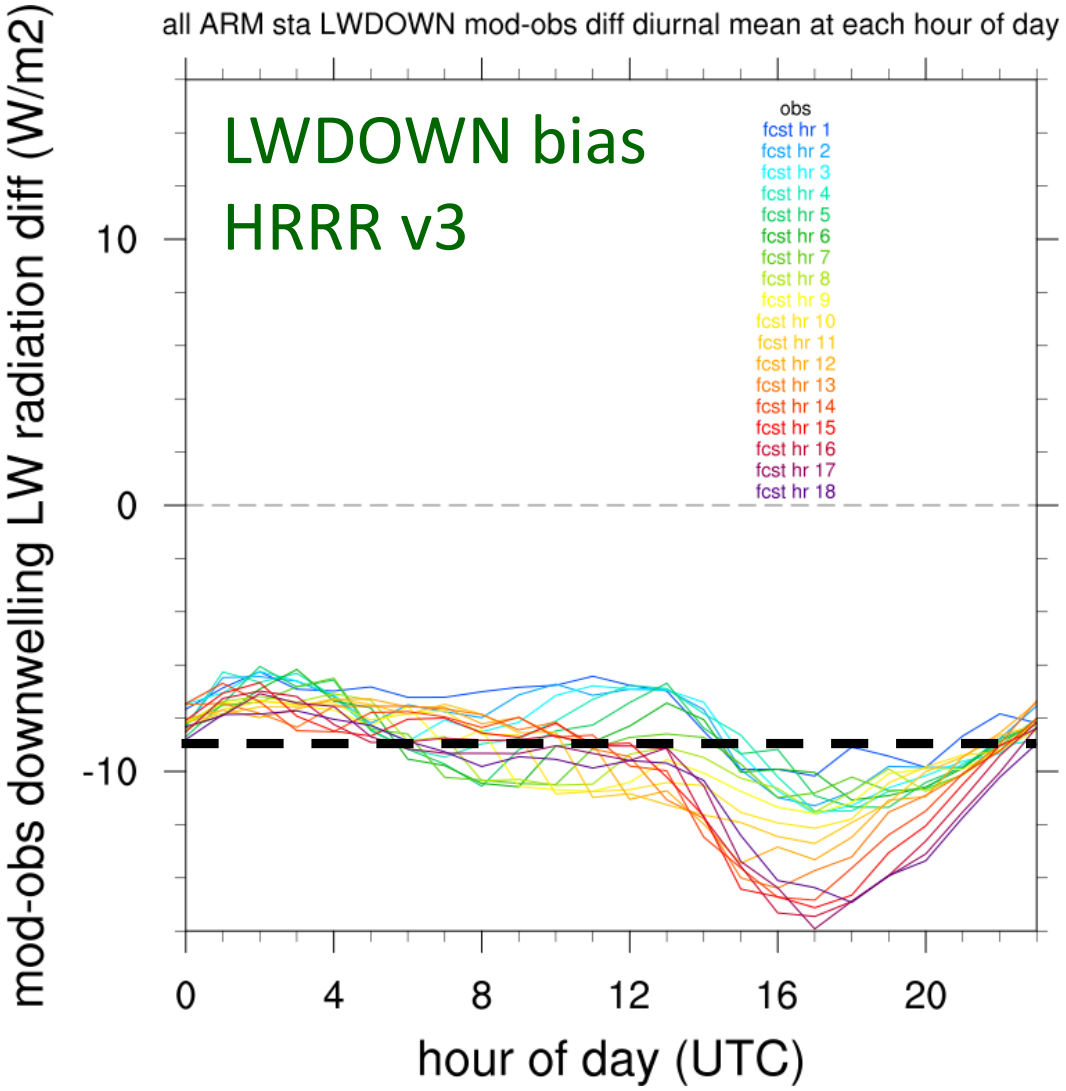
SWDOWN bias & correction

primary patterns

- forecast lead time
- time of day (solar angle)

$$SWDOWN_{bias} = \left(c_1 + c_2 * \frac{fhr - 1}{n\_fhr - 1}\right) * \cos(\varphi_{solar}) * SWDOWN_{model}$$

NWM Meteorological Forcings: Bias Corrections….HRRR model



LWDOWN bias & correction

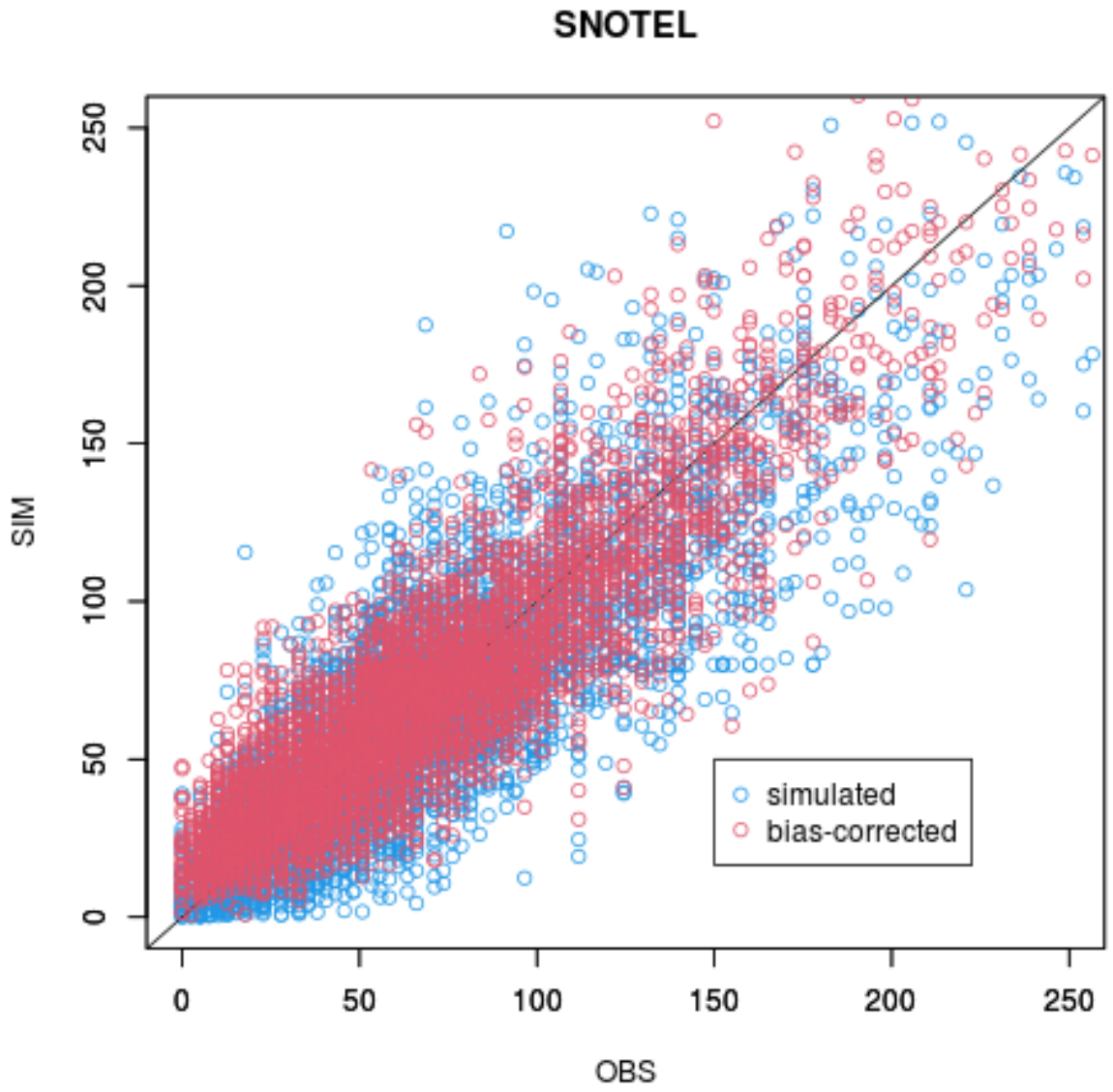
primary pattern
- net bias

secondary pattern
- time of day

adjust by +9 W/m2 at all times

have not yet done bias correction for
- mixing ratio
- air pressure

Meteorological Forcings: Bias Corrections….Quantile Regression correction of precipitation



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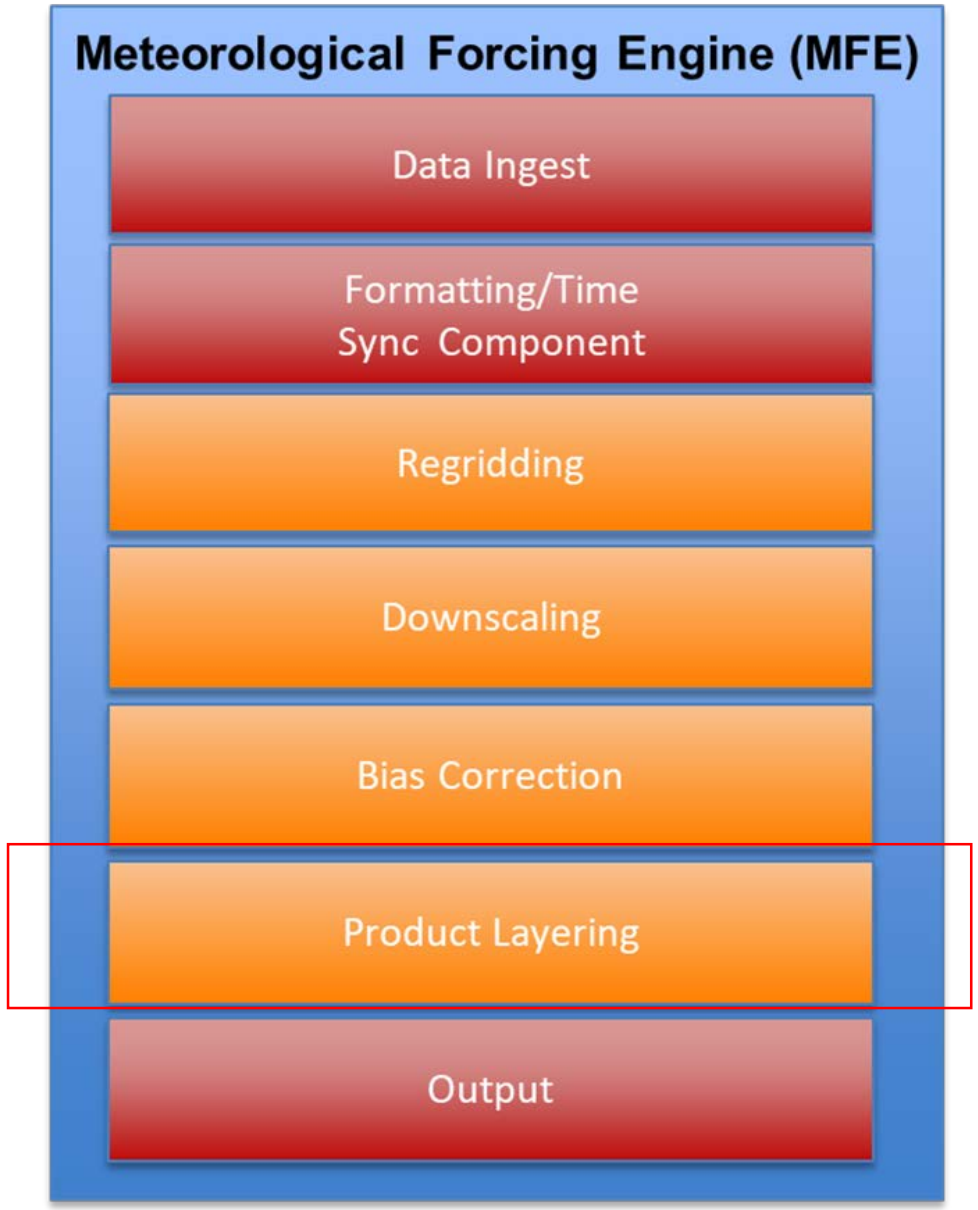
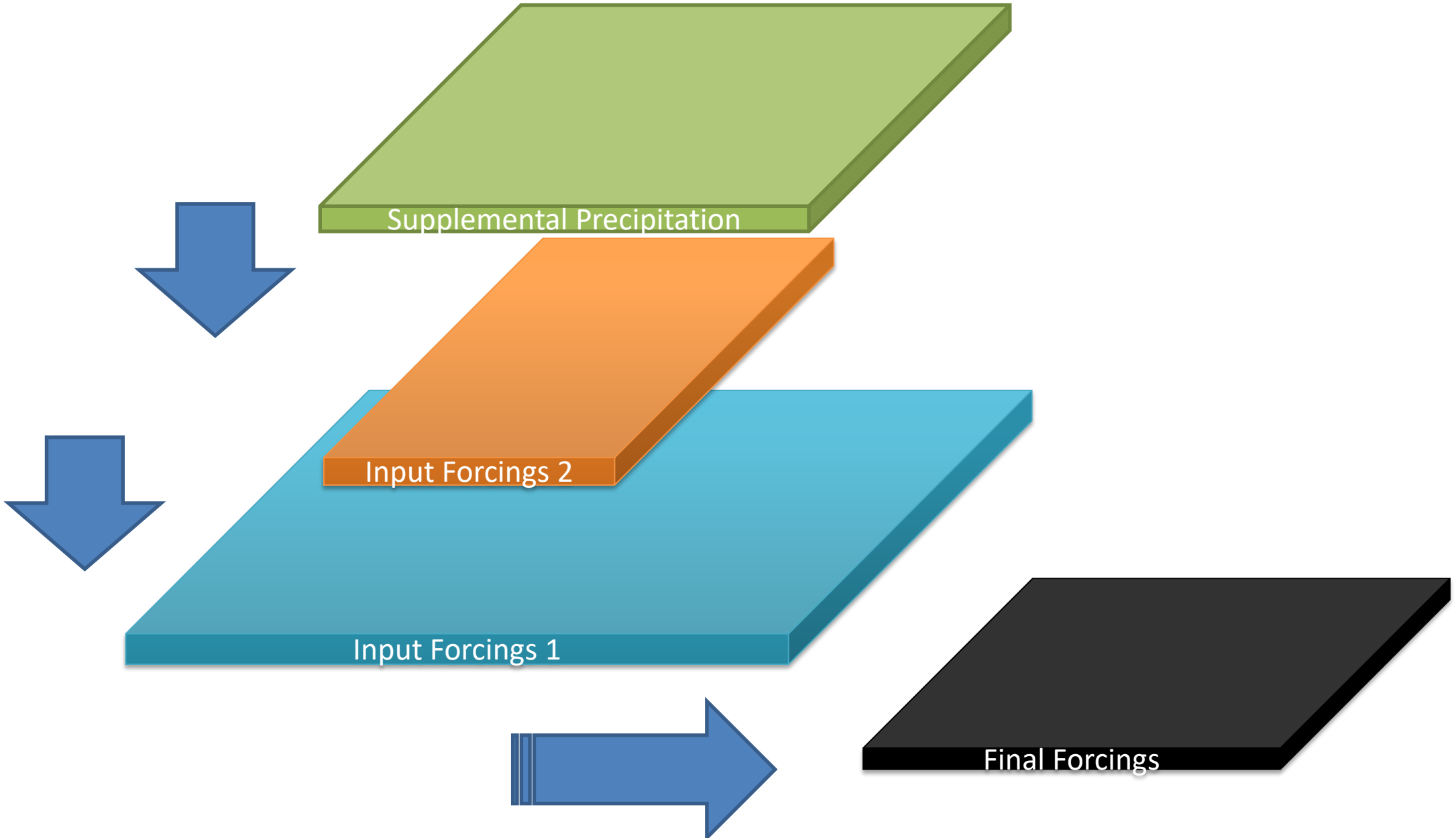
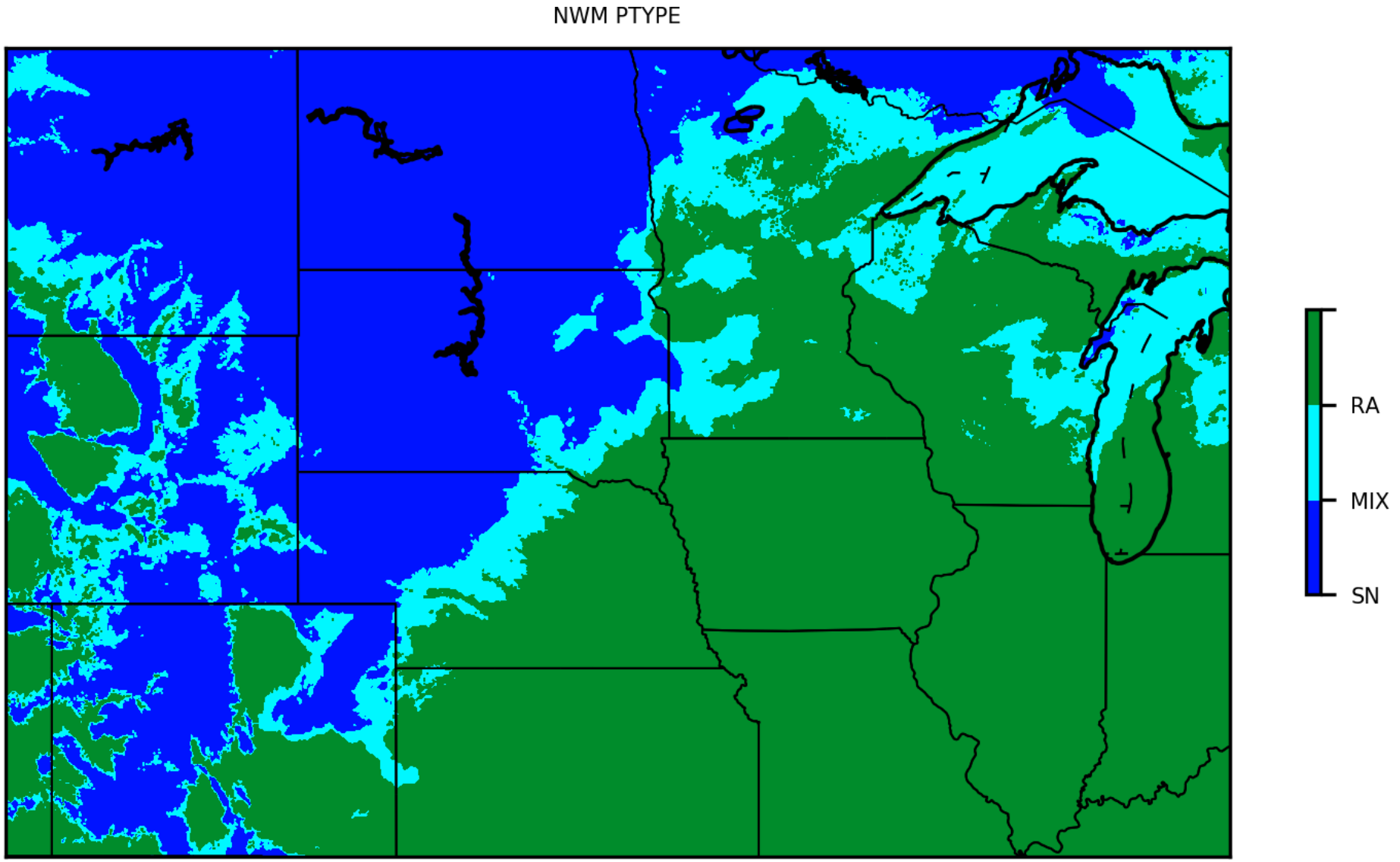


Product Layering:

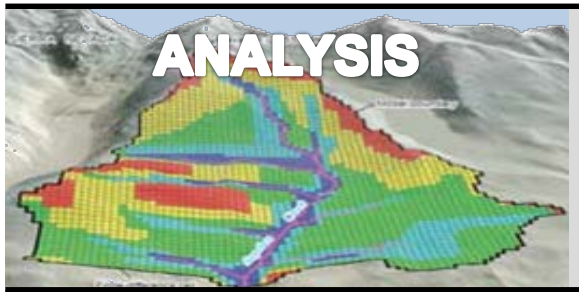


Precipitation liquid/frozen fraction:



MRMS also producing experimental precipitation type (frozen/liquid) product

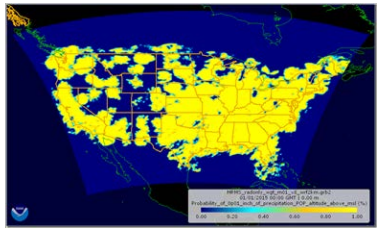
NWM Operational Cycles

	Cycling	Forecast	Met Forcing	Outputs
	Hourly	-3 - 0 hrs	MRMS QPE	1-km spatial fluxes (water & energy); 250-m routed fluxes (water); NHDPlus channel routing
	Hourly	1 – 18 hrs	Downscaled HRRR/RAP Blend	1-km spatial fluxes (water & energy); 250-m routed fluxes (water); NHDPlus channel routing
	4x Daily	to 10 days	Downscaled GFS	1-km spatial fluxes (water & energy); 250-m routed fluxes (water); NHDPlus channel routing
	Daily x 16 ensembles	to 30 days	Downscaled & NLDAS2 Bias-Corrected CFS	1-km spatial fluxes (water & energy); NHDPlus channel routing

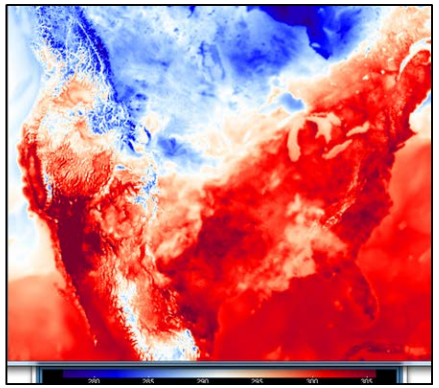
NWM Meteorological Forcing Engine (MFE)

1. Create national 1km gridded fields of:
   - Temperature, mixing ratio, surface pressure, u-, v-windspeed, longwave and shortwave radiation, precipitation rate
2. Terrain Downscaling of:
   - Temperature (NARR distributed climatological lapse rate)
   - Mixing ratio (conserve RH)
   - Surface pressure
   - Incoming shortwave radiation (terrain slope and aspect)
   - Rain-snow portioning (in development)
   - Wind (in development)
3. Statistical Bias Correction
4. Open source ncl/bash scripted workflow utilizing ESMF regridding tools
5. Multi-thread job, scales almost linearly because there is no memory sharing across processors (1-d calculations)

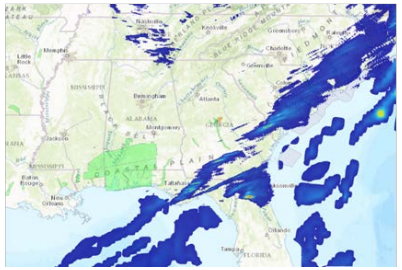
Seasonally-varying MRMS RQI



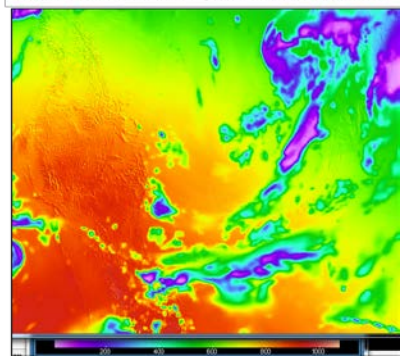
HRRR-RAP 2m Air Temperature



Blended MRMS-HRRR Precipitation



GFS – derived incoming shortwave radiation



Developed by Linlin Pan and Wei Yu with contributions from D. Kitzmiller, G. Fall, A. RafieeiNasab

Questions?