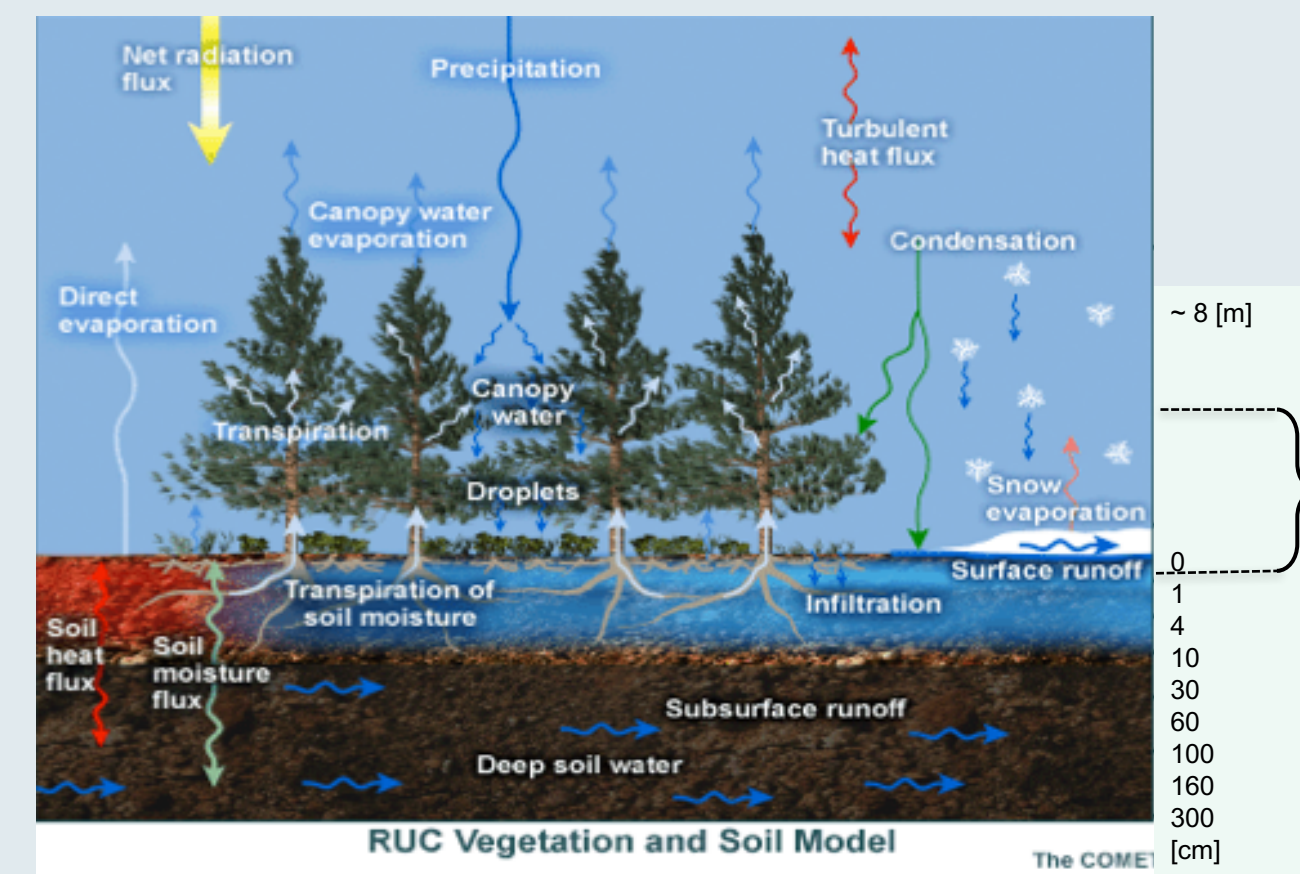


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 (1) NOAA Earth System Research Laboratory (NOAA/ESRL)

New features in RUC Land Surface Model (RUC LSM) available in 3.8 and 3.9 versions of the WRF model

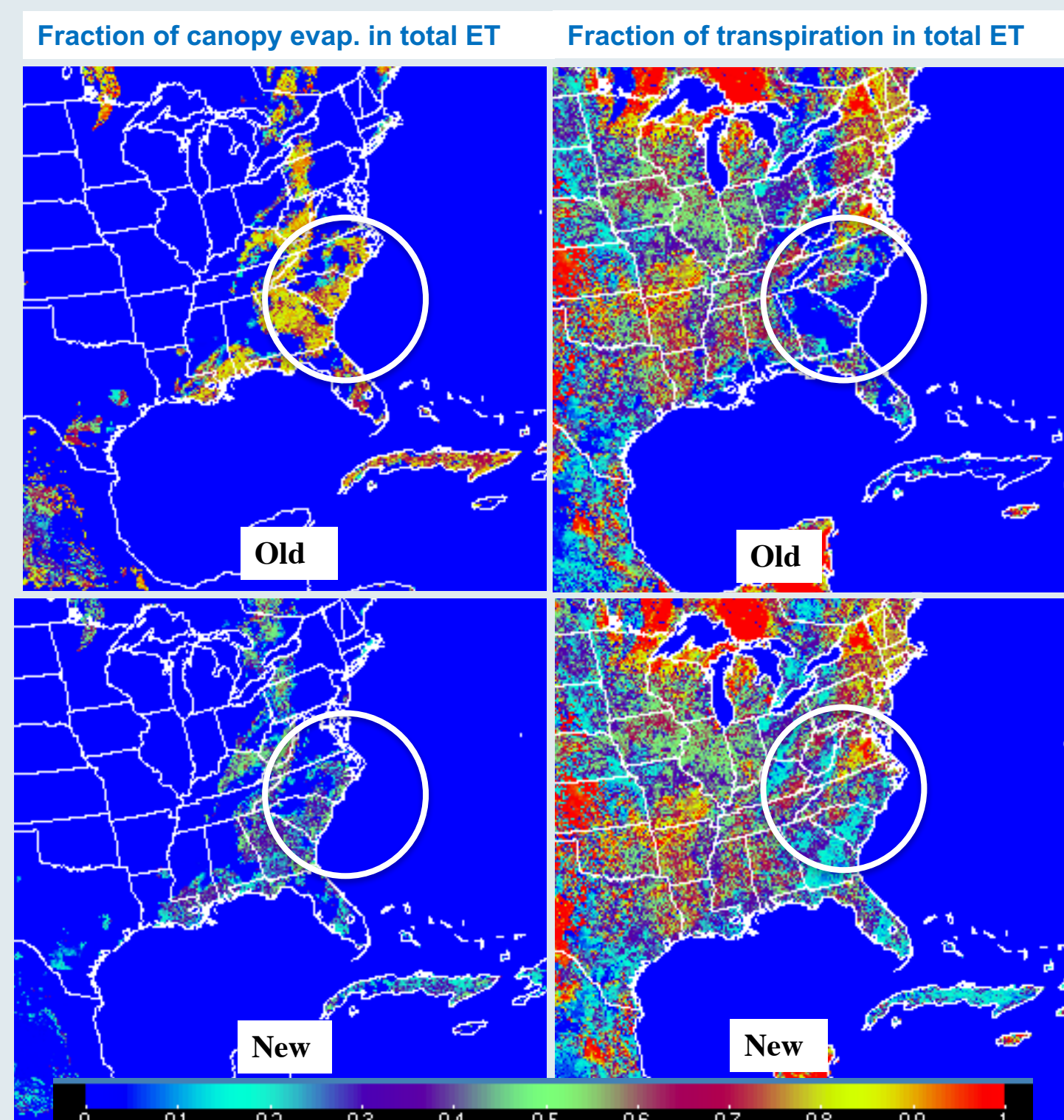


RUC LSM options in WRF:

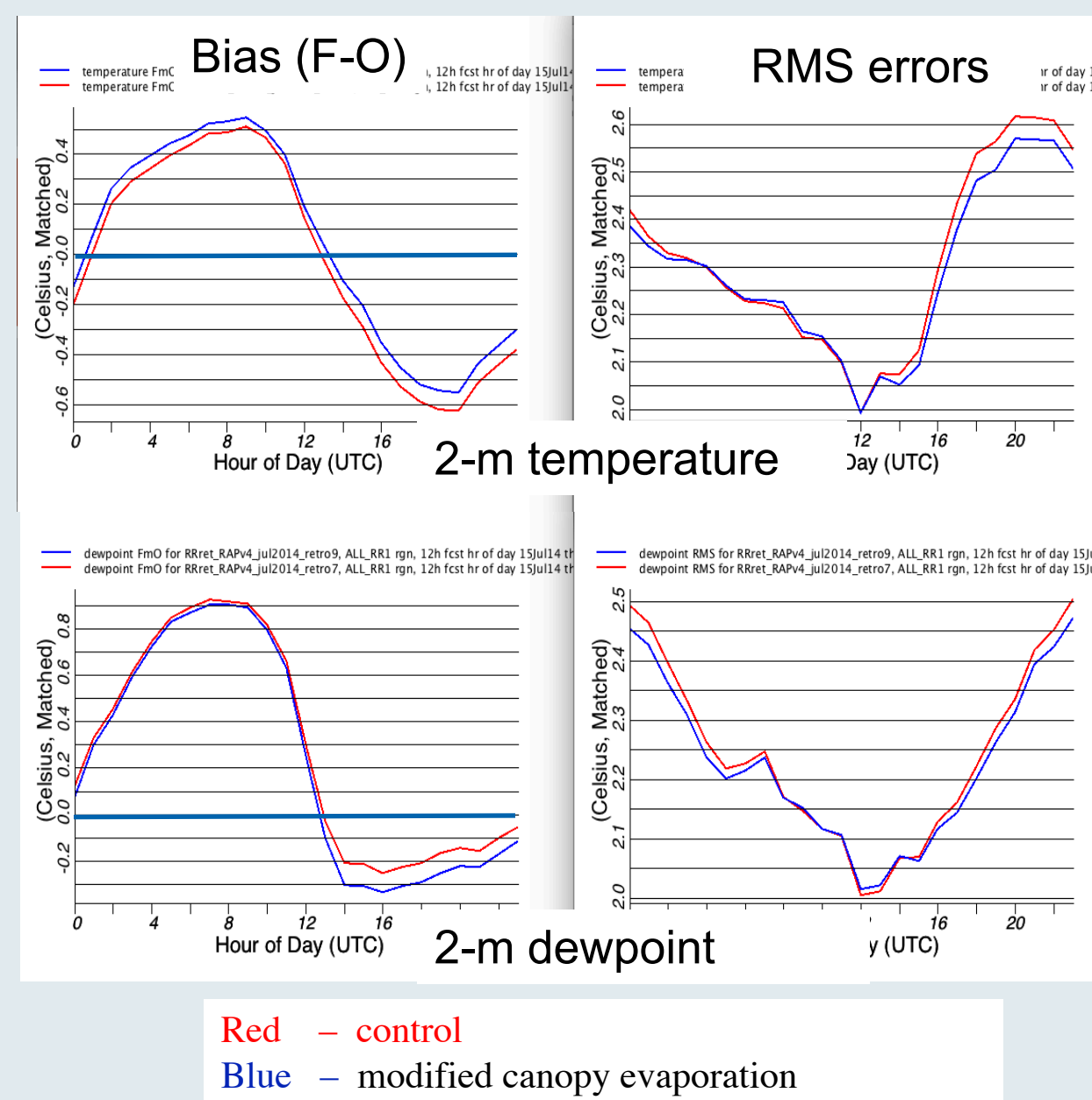
```
sf_surface_physics = 3
num_soil_layers    = 9
mosaic_lu          = 1
mosaic_soil        = 1
```

Modifications to evapotranspiration:

- Water intercepted by the canopy as function of LAI (Lawrence et al. 2006);
- Canopy area covered with water is < 50 % (only top side of the leaf can hold water);
- Solar factor is added to the transpiration function (Avisar et al. 1985).

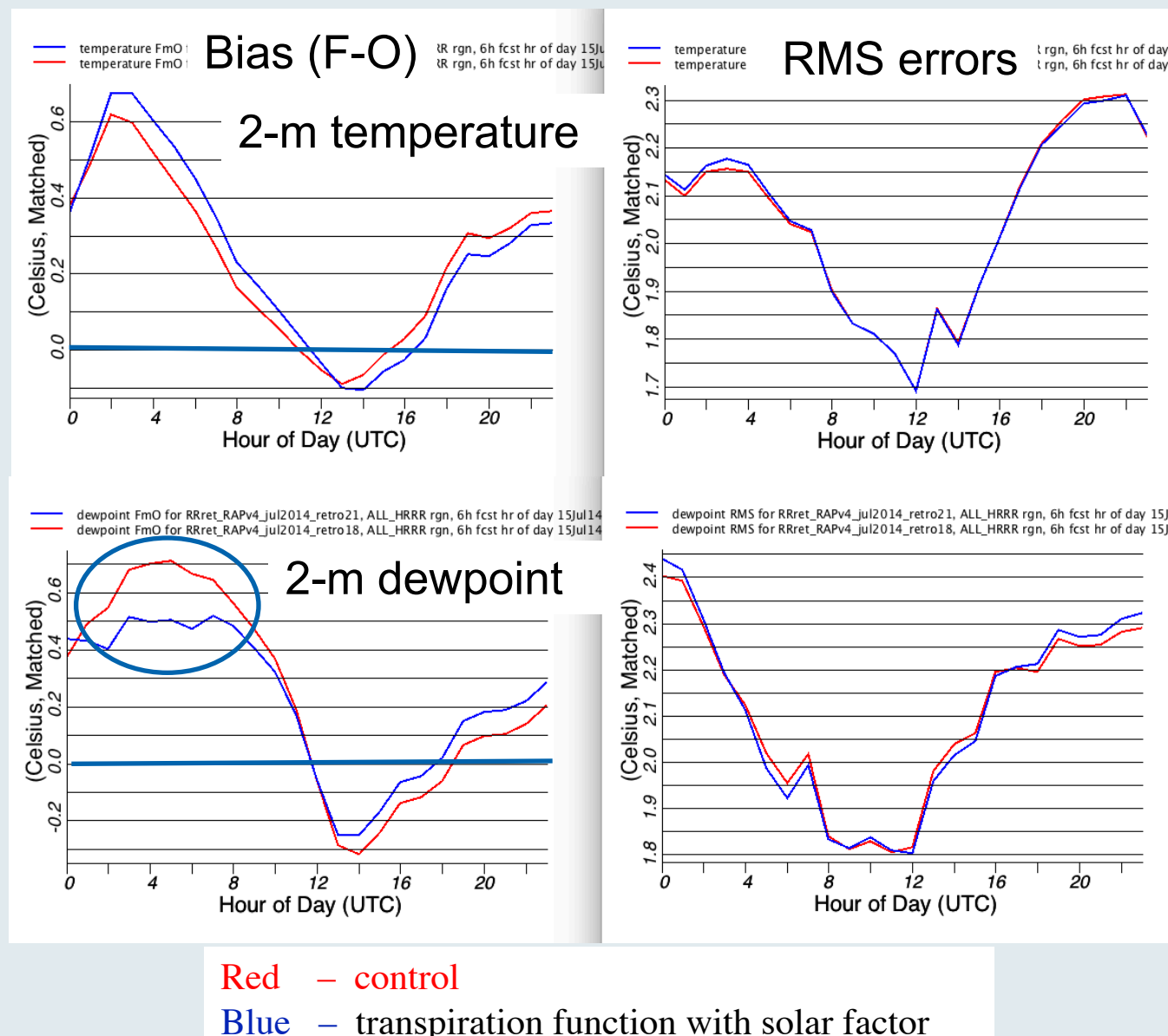


RAP 12-h forecast 15 - 22 July 2014



- More realistic partitioning of evapotranspiration components;
- Drier and warmer with the new ET, improvements in RMS errors for both 2-m temperature and dew point during the day;

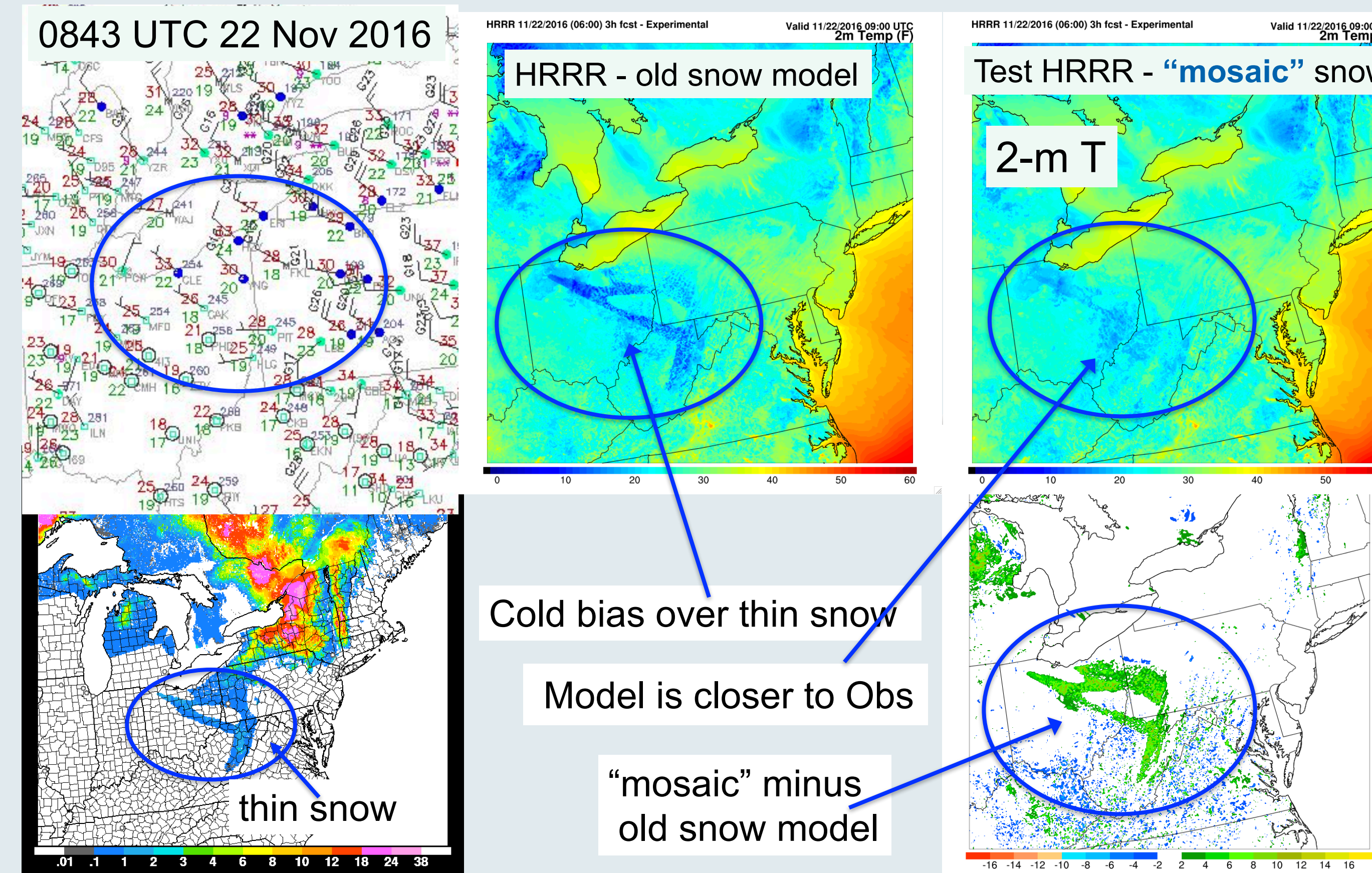
RAP 6-h forecast 15 - 22 July 2014



Transpiration dependence on incoming shortwave radiation:

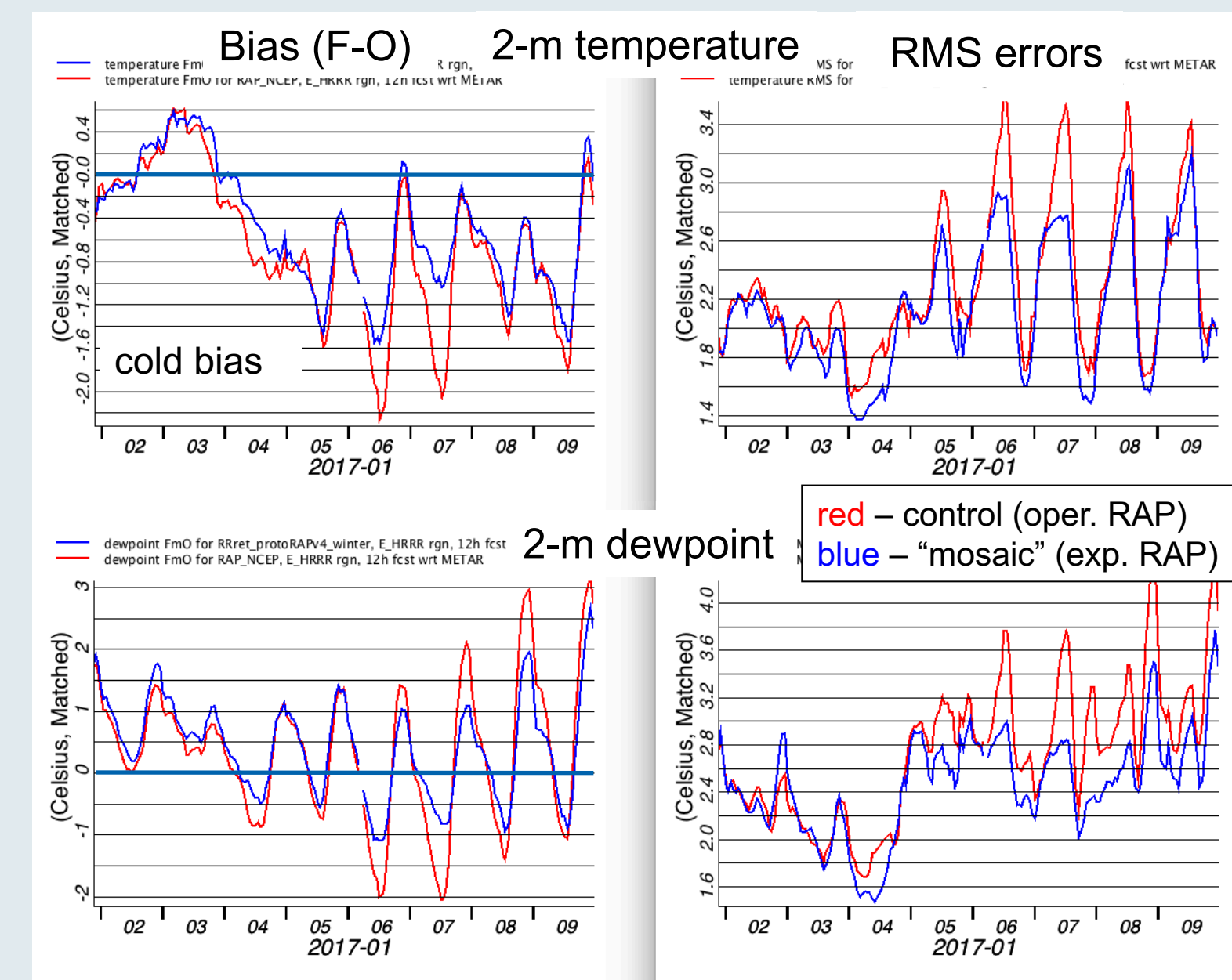
- Addition of solar factor reduces the transpiration function at close to sunset hours;
- Night-time moist bias caused by overestimated transpiration is significantly reduced;
- RMS errors for control and experimental runs are close for both 2-m temperature and dewpoint.

Cold bias over thin snow in operational HRRR 3-h forecast, valid at 09 UTC 22 Nov 2016



Solution:

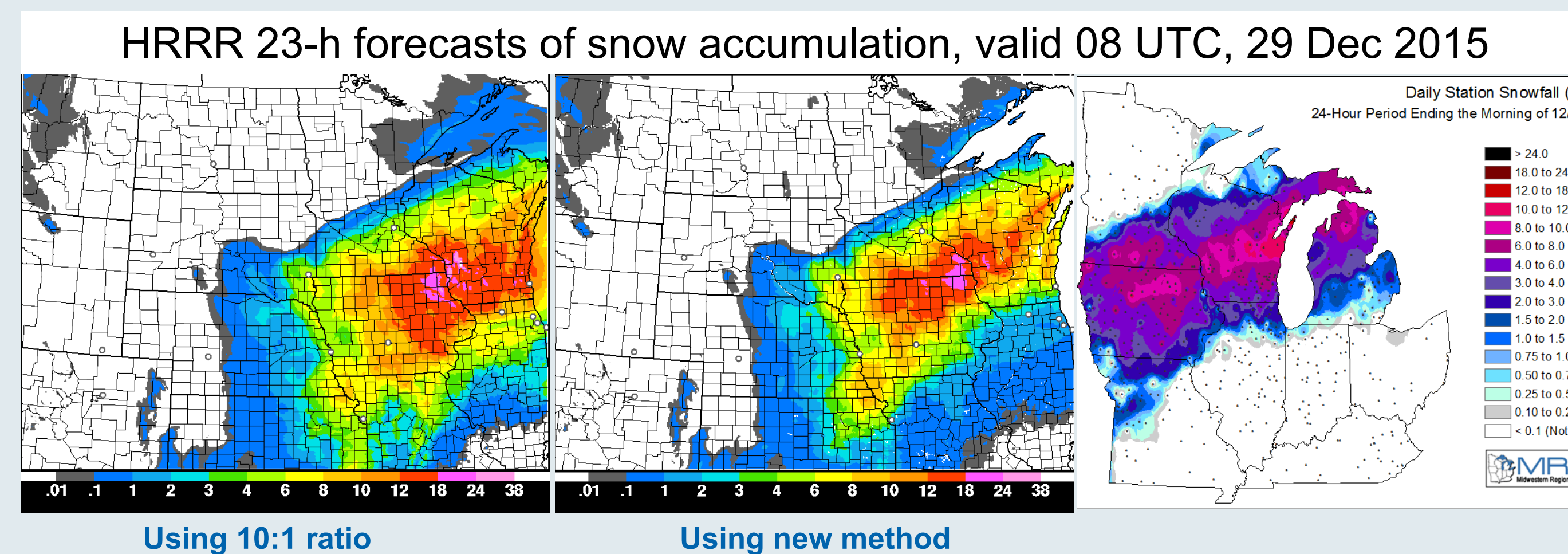
- Separate treatment of energy and moisture budgets for snow-covered and snow-free portions of the grid cell
- Aggregate solutions at the end of time step
- Reduced cold bias
- Improved daytime 2-m dewpoint



Density of frozen precipitation in RUC LSM

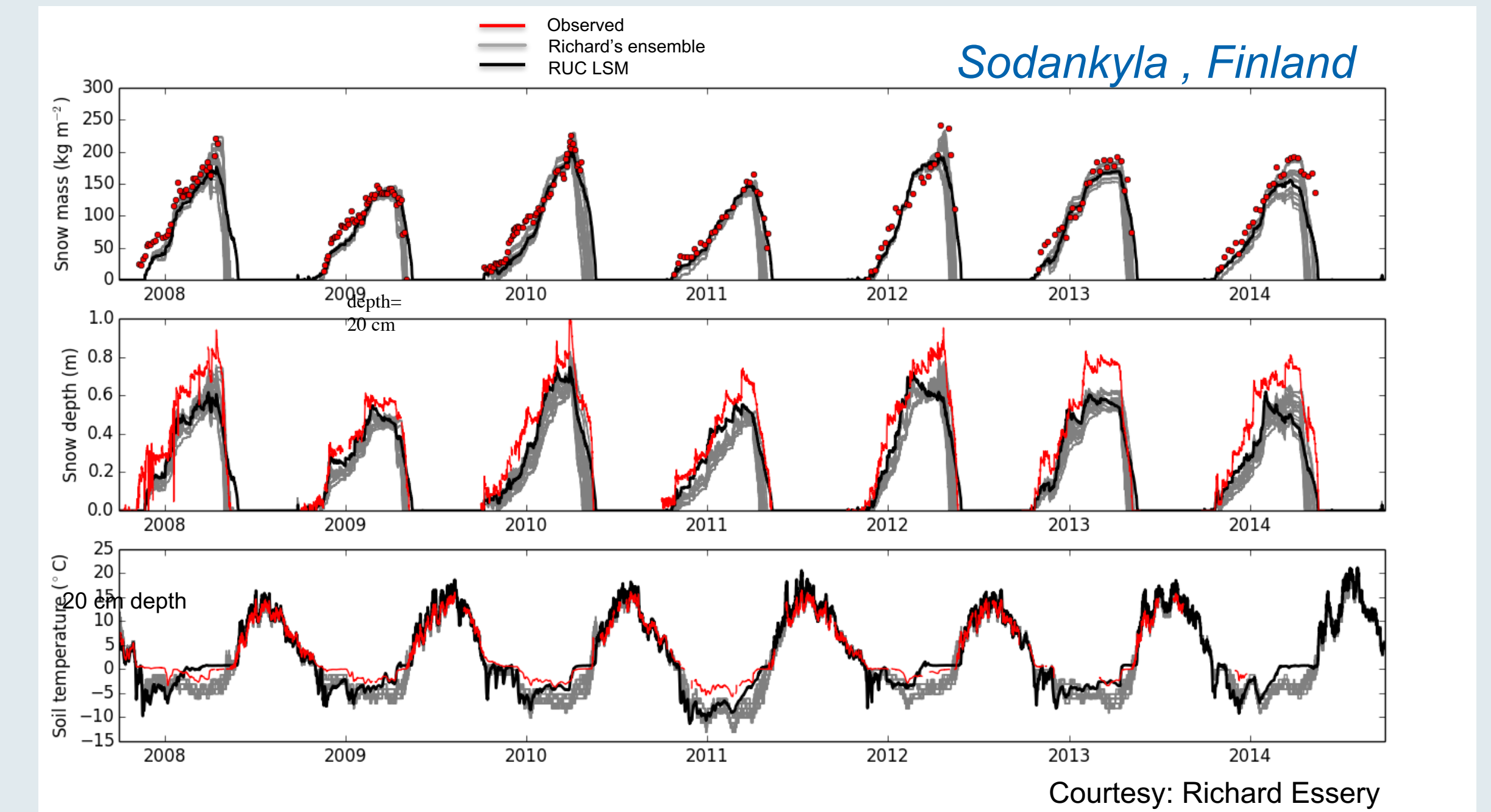
- Use of empirical temperature-dependent equations for each hydrometeor;
- Averaged density of frozen precipitation:

$$\rho_{fr} = \rho_{sn} * \alpha_{sn} + \rho_{gr} * \alpha_{gr} + \rho_{ice} * \alpha_{ice}$$



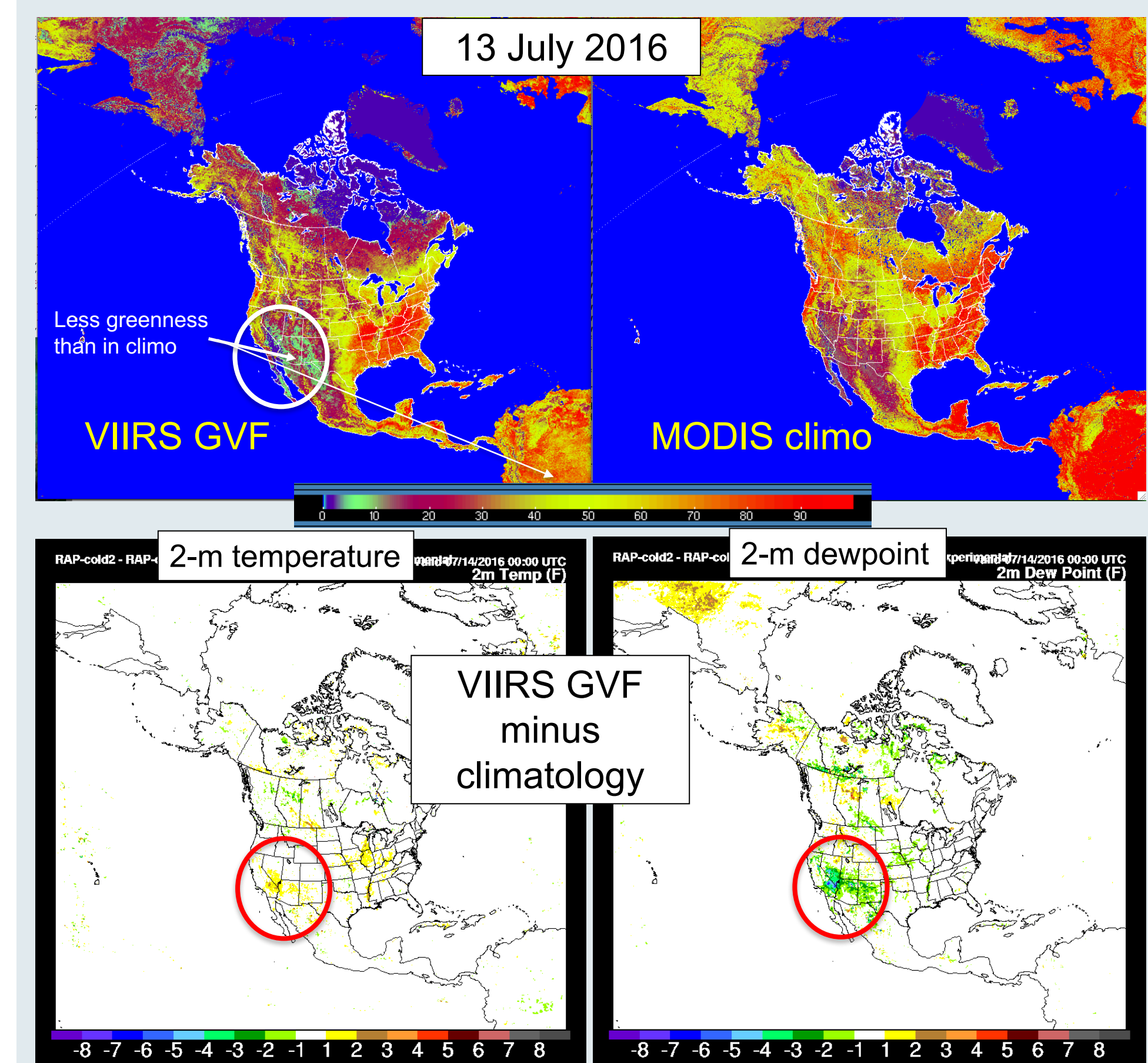
- The new method gives a better, further north location of maximum snow accumulation;
- High amounts of snow with 10:1 ratio are trimmed in central and southern Iowa and in the Chicago area where both observed and model precipitation had a high content of sleet.

Participation in Earth System Model-Snow Model Intercomparison Project (ESM-SnowMIP) :



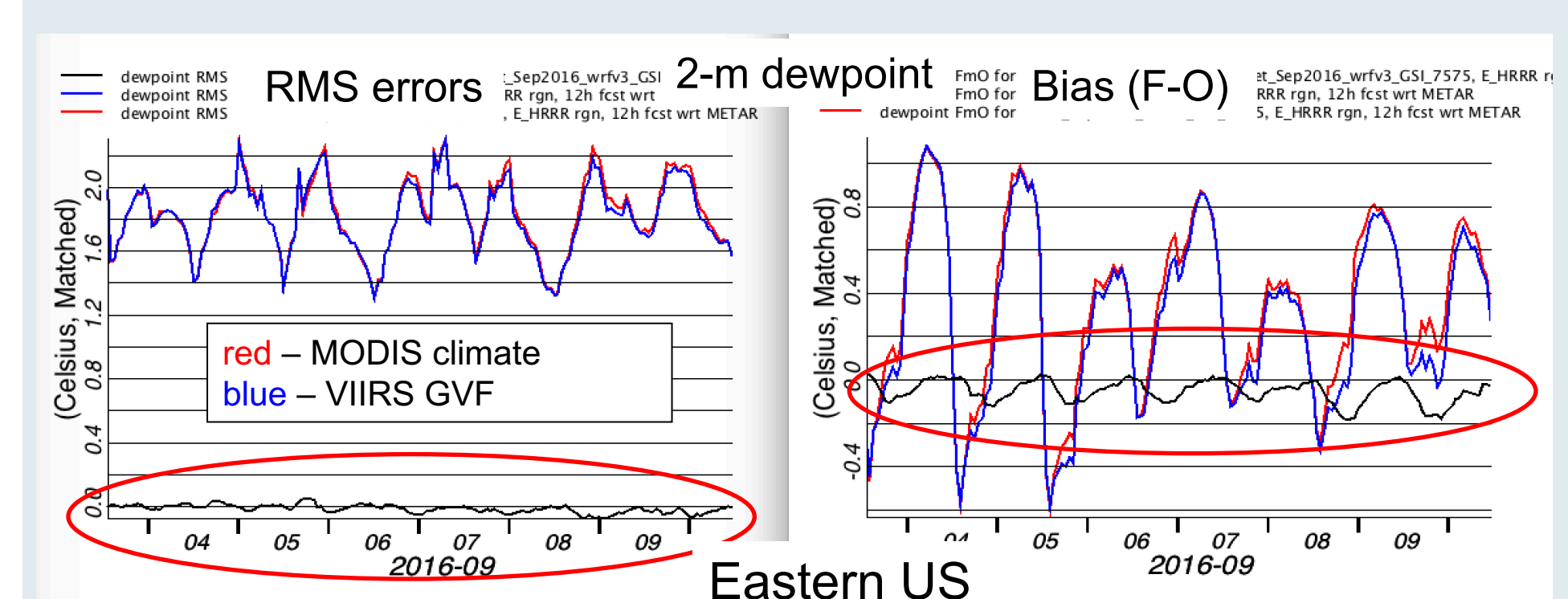
- RUC LSM demonstrates compatible performance;
- Other sites represent polar, alpine, continental and maritime conditions (United States, Japan, France and Switzerland);
- Global off-line simulations.

Use of real-time VIIRS Green Vegetation Fraction (GVF) to replace MODIS climatology:



- Real-time greenness affects regions that significantly deviate from climate, like SW of US for July 2016;
- Warmer and drier in SW of US with the use of real-time VIIRS GVF;
- More pronounced effect for 2-m dewpoint.

RAP 12-h forecast, 3 - 9 September 2016



- 2-m Td RMS errors are slightly better with real-time GVF (0.05 K in late daytime)
- 2-m Td moist bias is smaller with GVF (0.2 K in late daytime)

- Smirnova et al., Modifications to the Rapid Update Cycle Land Surface Model (RUC LSM) available in the Weather Research and Forecast (WRF) model, *Mon. Wea. Rev.*, 2016
- Benjamin et al., A North American Hourly Assimilation and Model Forecast Cycle: The Rapid Refresh, *Mon. Wea. Rev.*, 2016