

Enhancements to RUC Land-Surface Model implemented in the 3.7 release of WRF model and in Land Information System (LIS)

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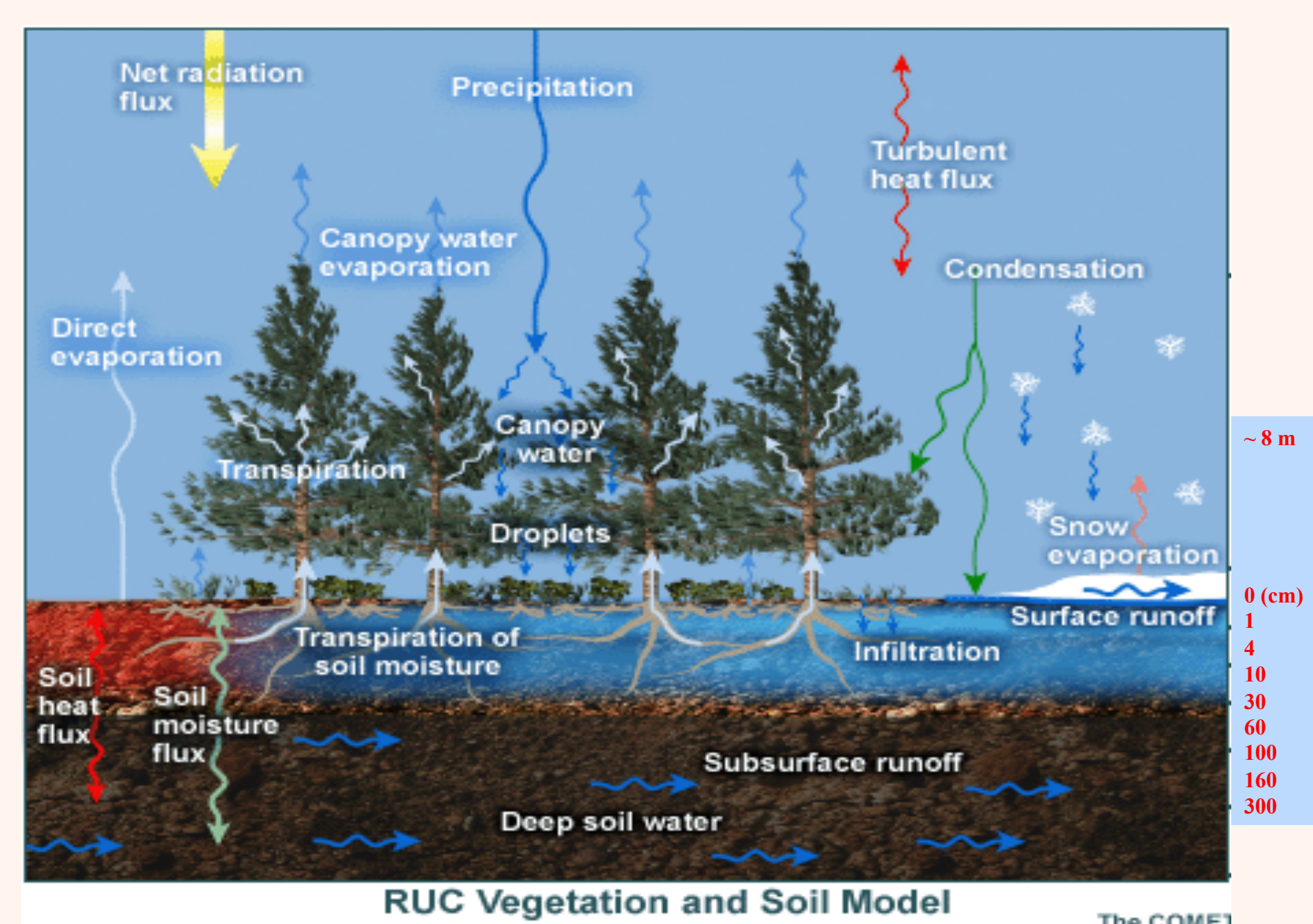
(2) Cooperative Institute for Research in Environmental Sciences (CIRES)

RUC Land Surface Model (RUC LSM) implemented in:

- Operational RUC: 1998 – May 2012
- Weather Research and Forecasting (WRF) modeling system in 2002, used in WRF by non-ESRL researchers
- Operational Rapid Refresh (RAP) system using Advanced Research WRF (ARW) dynamic solver over North America domain with vast areas of Arctic sea ice:
 - version 1 – May 2012; version 2 – February 2014;
 - version 3 – Fall 2015; (<http://rapidrefresh.noaa.gov>)
- Operational High-Resolution Rapid Refresh (HRRR)
 - version 1 – September 2014
 - version 2 – Fall 2015 (<http://rapidrefresh.noaa.gov/HRRR>)
- NASA Land Information System (LIS) – work in progress

Main characteristics of RUC LSM

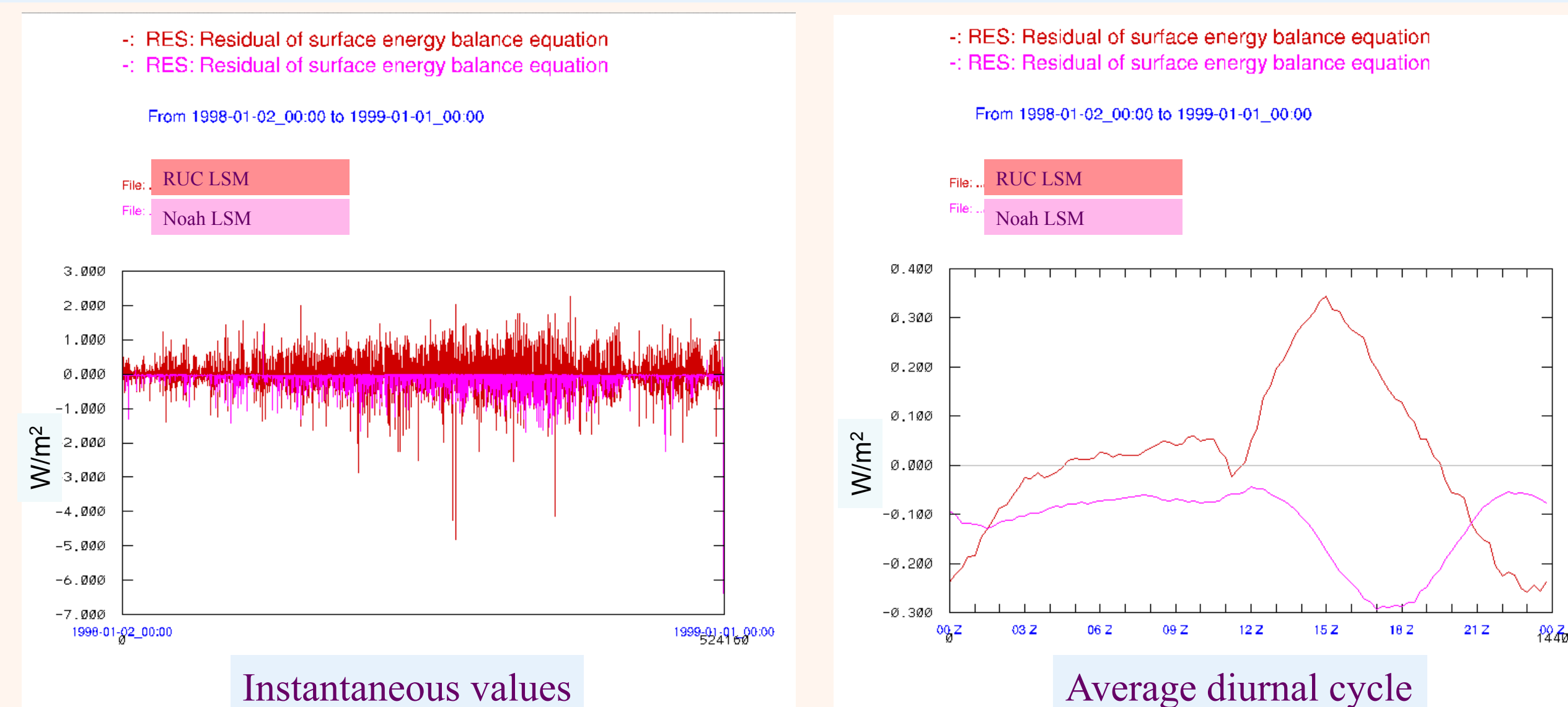
- Implicit solution of energy and moisture budgets
- Multiple soil levels with high vertical resolution near surface
- 2-layer snow model with iterative snow melting algorithm
- Treatment of mixed phase precipitation
- Simple but effective frozen soil physics algorithm



Changes to RUC LSM in 3.7 version of WRF

- Simple treatment of cropland irrigation during the growing season;
- Mosaic approach to snow-covered and snow-free portions of the grid cell;
- Ensured energy and moisture conservation, added necessary variables for energy and moisture budget research.

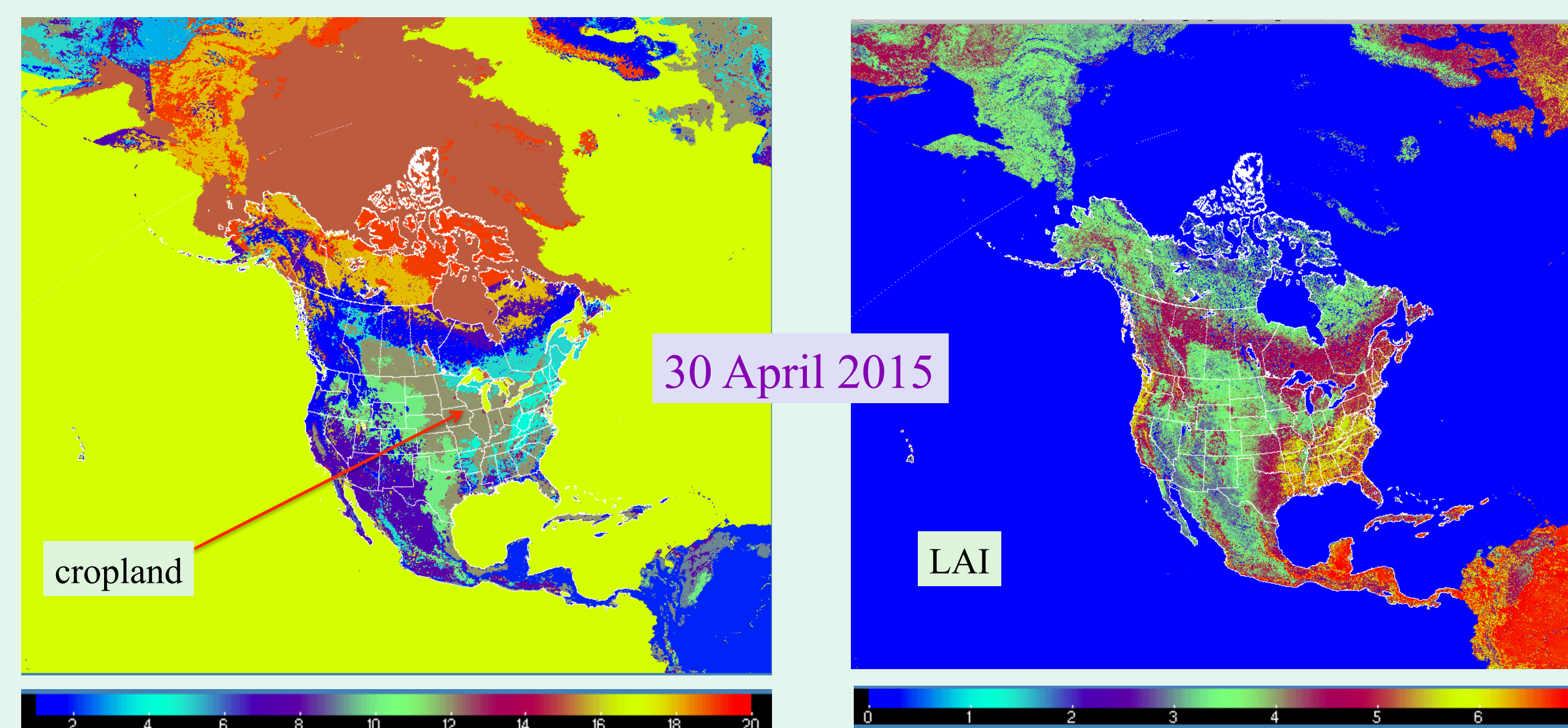
3. Residual of surface energy budget for Bondville, IL (1998 dataset) (LIS implementation testing is underway)



1. “Irrigation” treatment during the growing season

30” MODIS Land-use

Leaf Area Index (LAI)



RUC LSM assumptions:

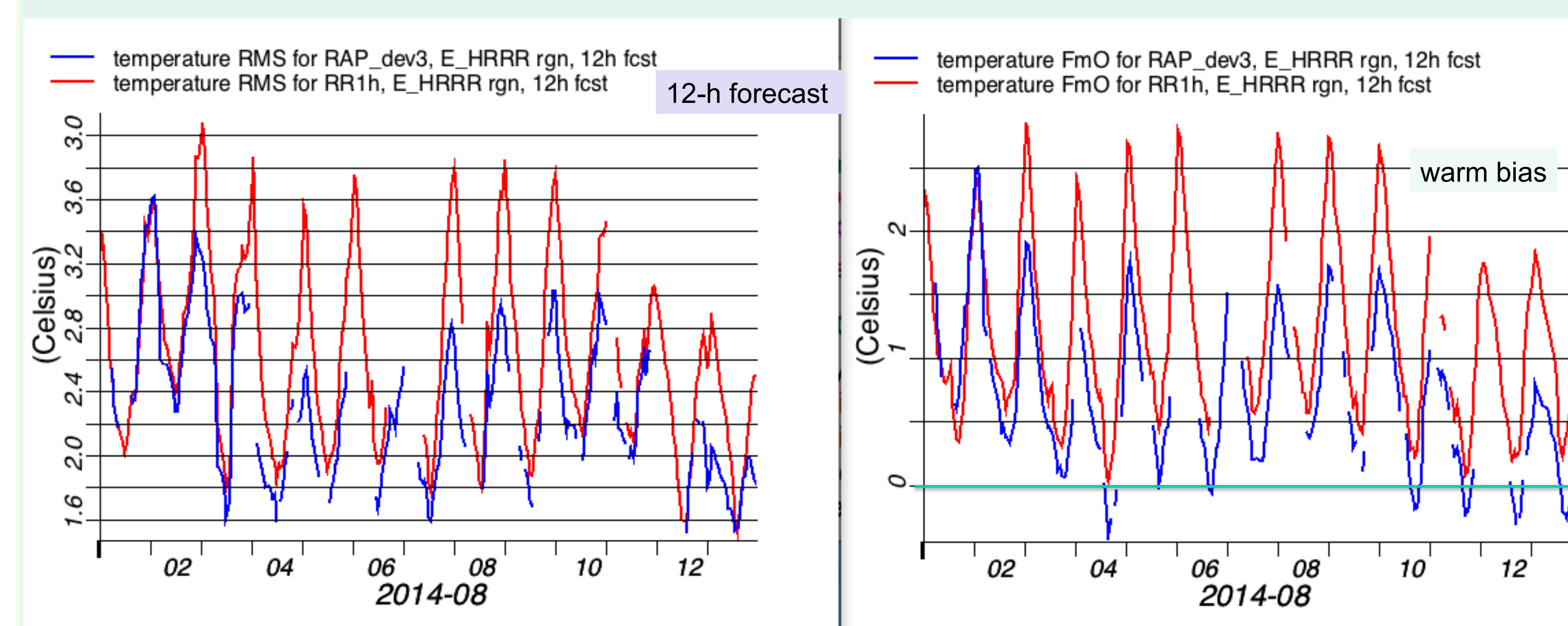
- During the crops growing season simple irrigation treatment keeps model soil water content above the wilting point value for a given soil type;
- Use $LAI > 1.1$ criterium to define the growing season;

Applied to:

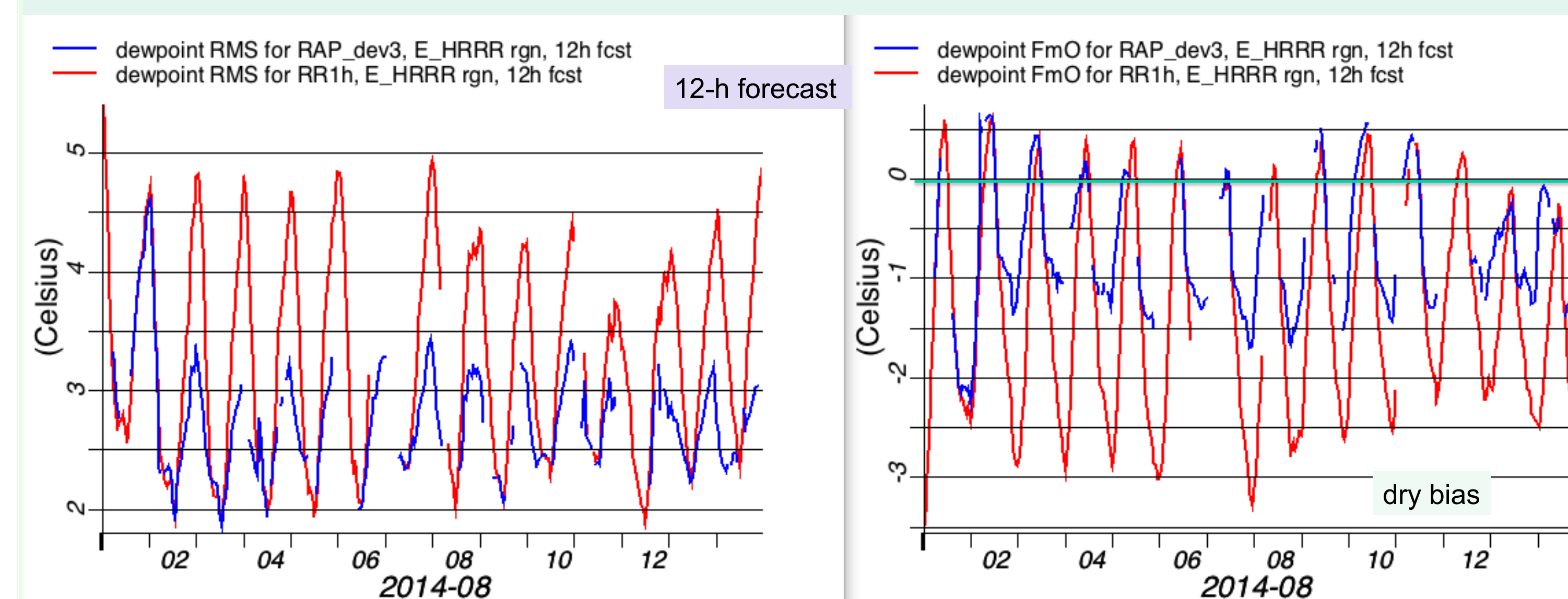
- Portions of grid cells with cropland category;
- 40% of grid cells portion with grassland category;

- Implemented in experimental version of RAP (RAP_dev3) on 3 August 2014 to reduce dry/warm biases in the Eastern US

2-m temperature RMS errors (left) and biases (right)



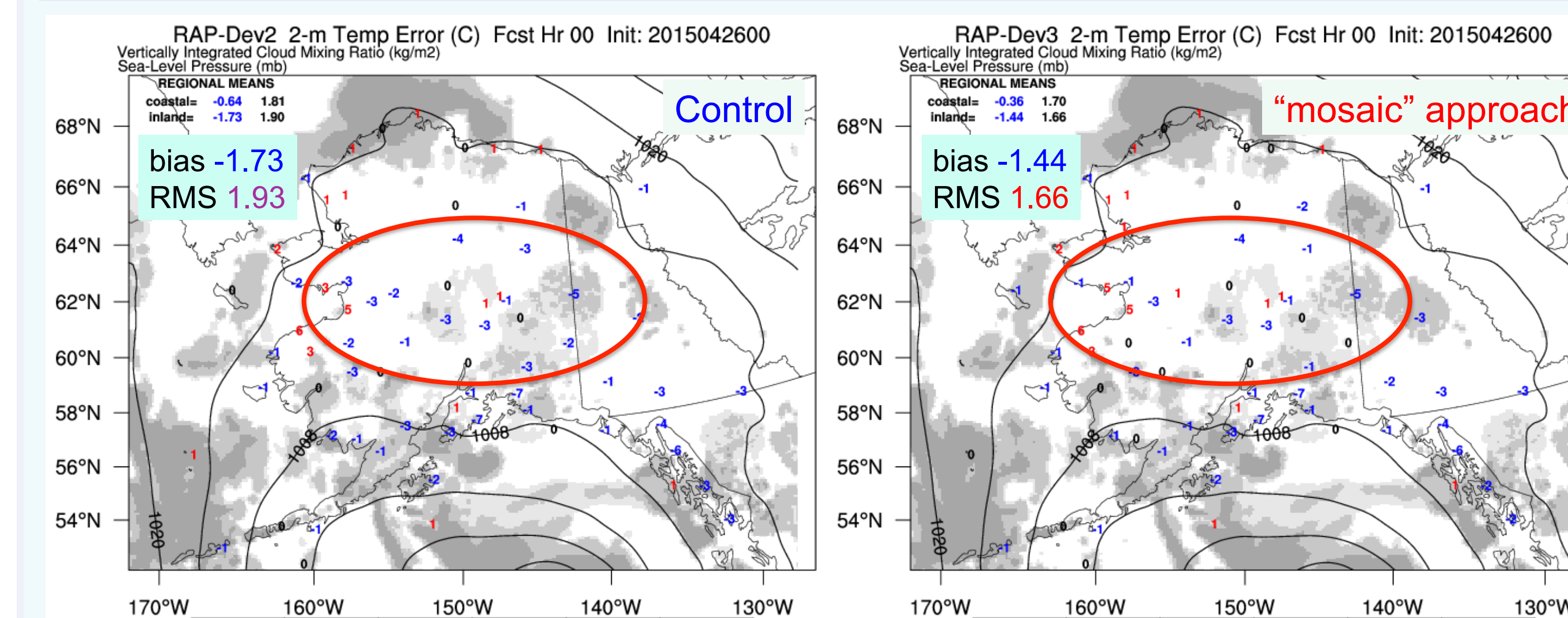
2-m dewpoint RMS errors (left) and biases (right)



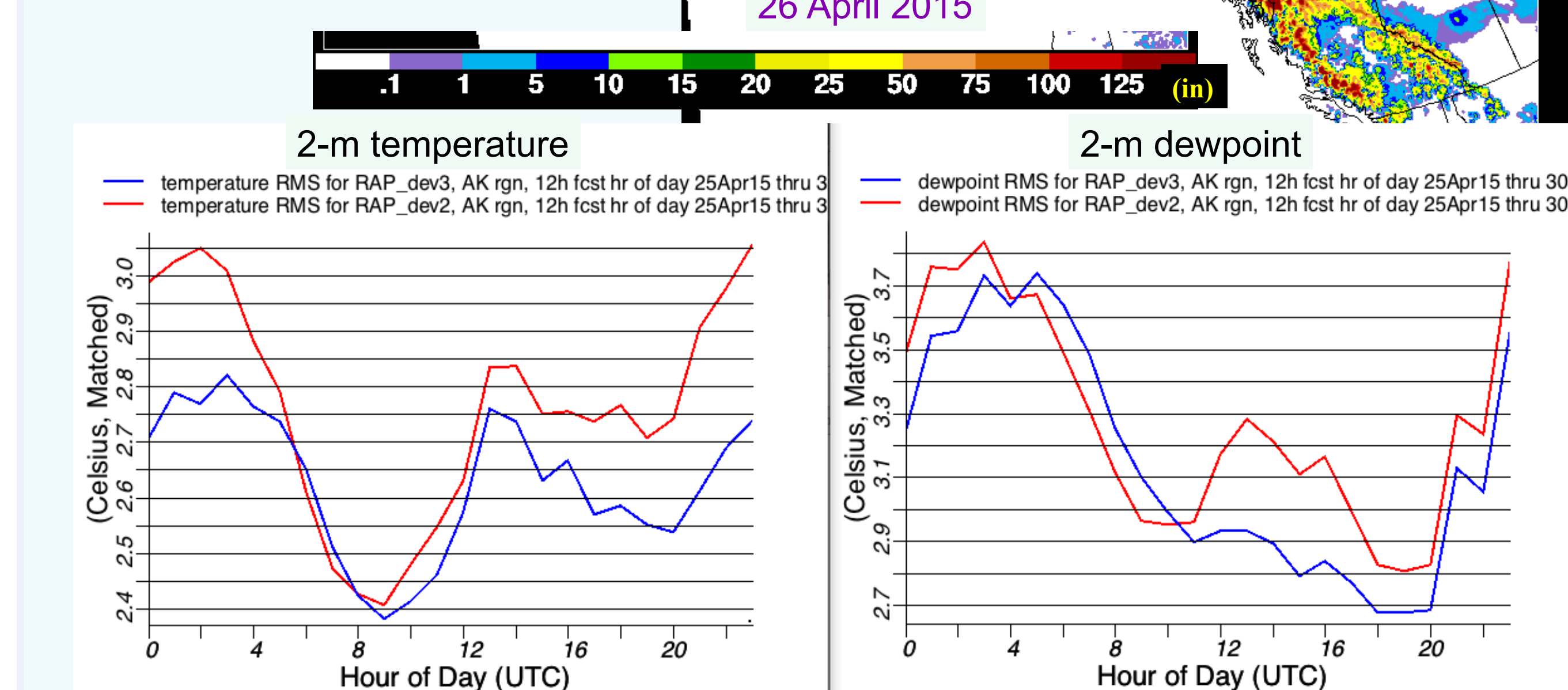
- RR1h – control; RAP_dev3 – uses simple irrigation treatment

2. “Mosaic” approach to snow model:

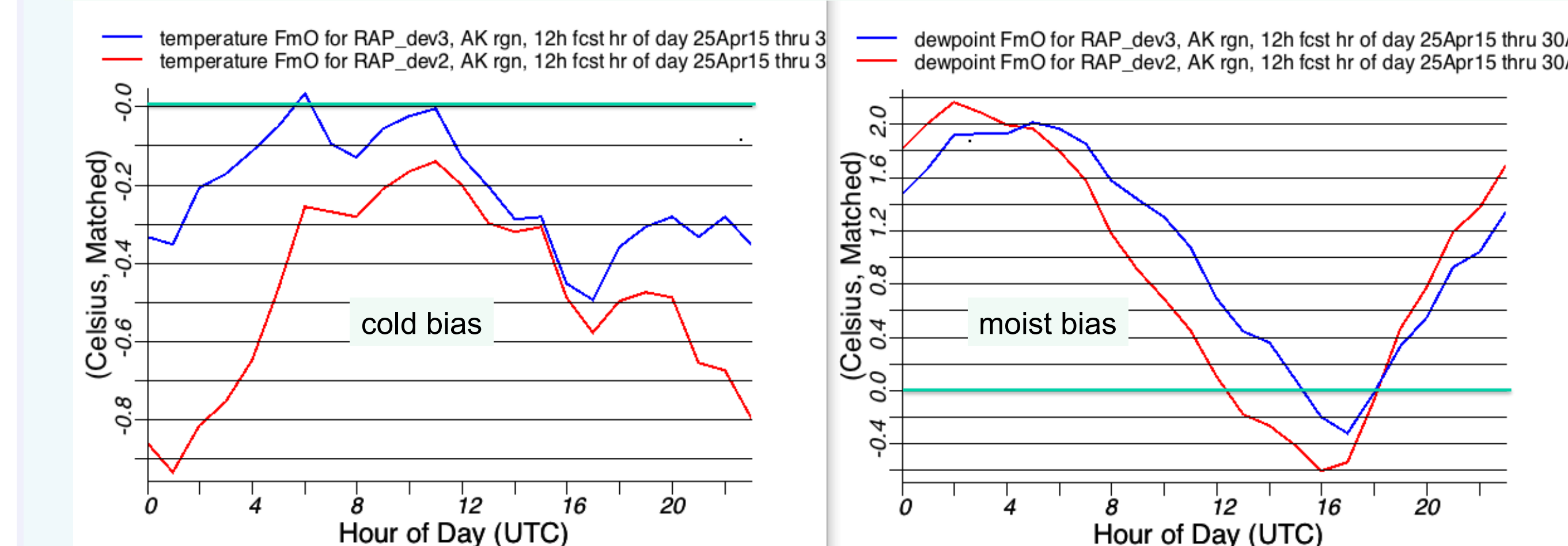
- Separate solutions of energy and moisture budgets of snow-covered and snow-free portions of the grid cell;
- Aggregate solutions at the end of time step;
- Snow fraction defined from the ratio: $snhei/snhei_crit$, where $snhei_crit = snow_density * 0.016$ [m]



- “Mosaic” approach applied to snow areas inside the red oval;
- reduced cold biases;
- Improved 2-m dewpoint during the daytime.



Diurnal cycle of 12-h forecast RMS errors (above) and biases (below) over Alaska averaged for 25-30 April 2015



- RAP-dev2 – control; RAP_dev3 – uses “mosaic” approach

CONCLUSIONS:

2015 RUC LSM modifications implemented in WRF-based RAP and HRRR resulted in improvements in surface predictions over snow:

- reduced cold biases of 2-m temperature;
- reduced RMS errors for 2-m temperature and dewpoint