Evaluation of the NOAH-MP Land Surface Model Over the New York Region

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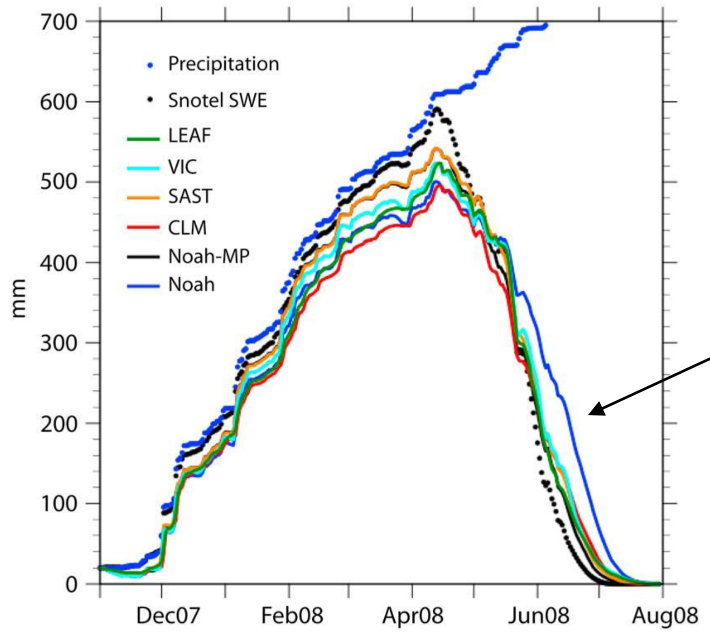
Agenda

- **Overview and Motivation.**
- **Experiment Design.**
- **Results.**
- **Summary.**
- **Future Work.**

Overview and Motivation

- **IBM Research's *Deep Thunder* (DT) is a high spatial and temporal resolution forecasting system that is deployable for custom applications. It is based, in part, on the ARW core of the WRF model.**
- **Current operations for the New York (NY) region make use of the NOAH Land Surface Model (LSM).**
- **NOAH-MP has a variety of options to represent key land-atmosphere interaction processes:**
  - Canopy radiative transfer with shading geometry
  - Separate vegetation canopy
  - Dynamic vegetation
  - Ball-Berry canopy resistance
  - Multi-layer snowpack
  - Snowpack liquid water retention
  - Interaction with aquifer
  - Snow albedo treatment

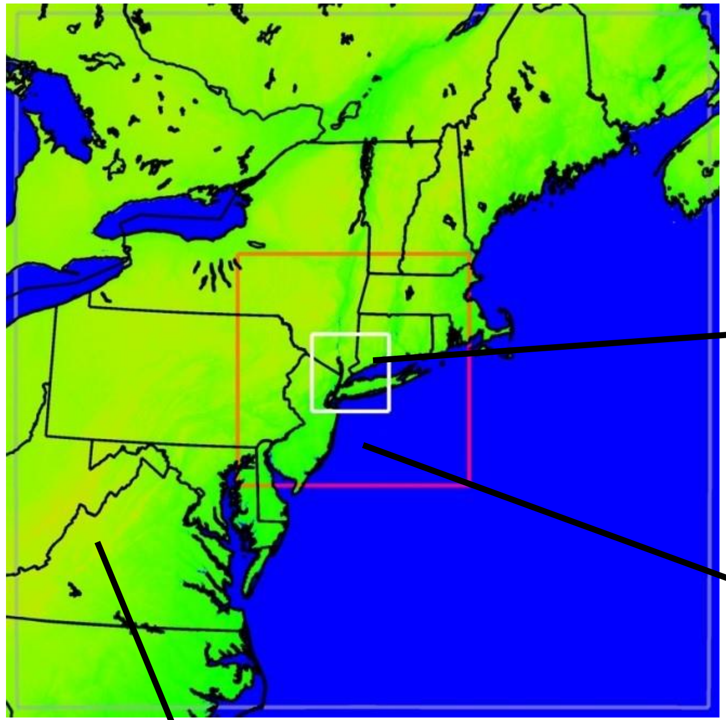


NOAH is keeping the snow for an extended period of time.

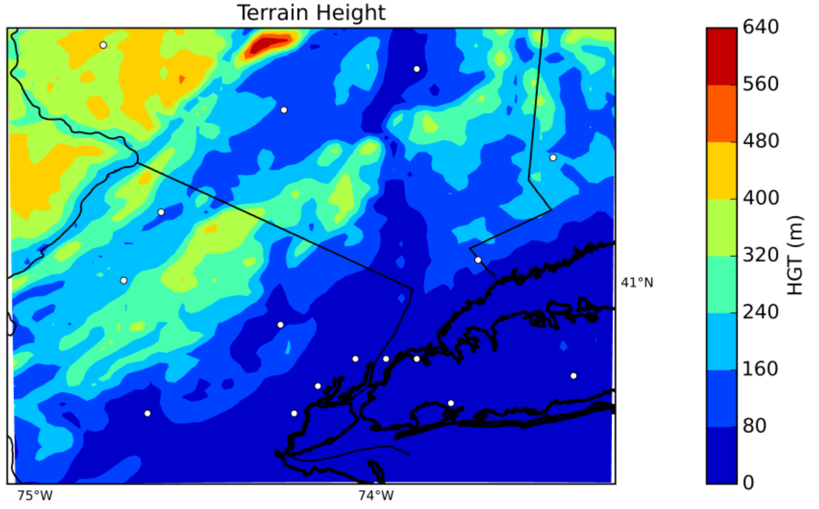
Chen et al, 2014 (fig. 3, *JGR*)

- **Chen et al (2014) evaluated multiple LSMs using 9-month offline point simulations for 112 SNOTEL sites.**
- **We seek to evaluate the performance of NOAH-MP (online) against classic NOAH (online) for this region, in terms of WRF forecast skill and integration time, with an eye towards operationalizing.**

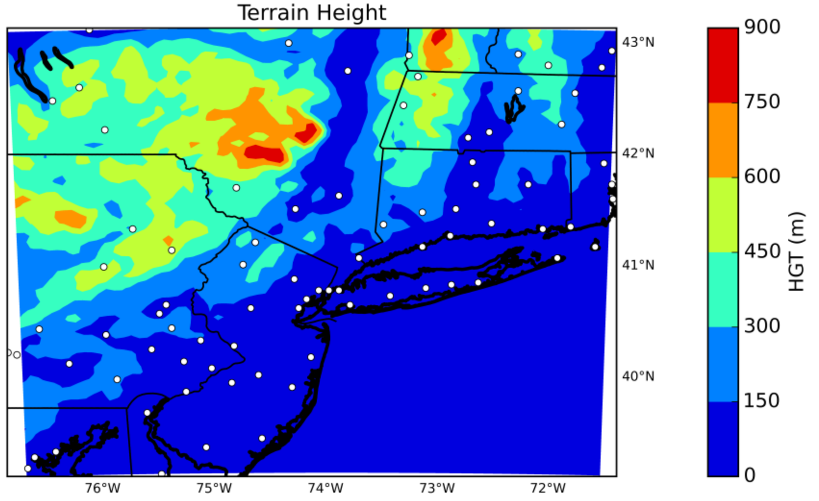
Domain Configuration



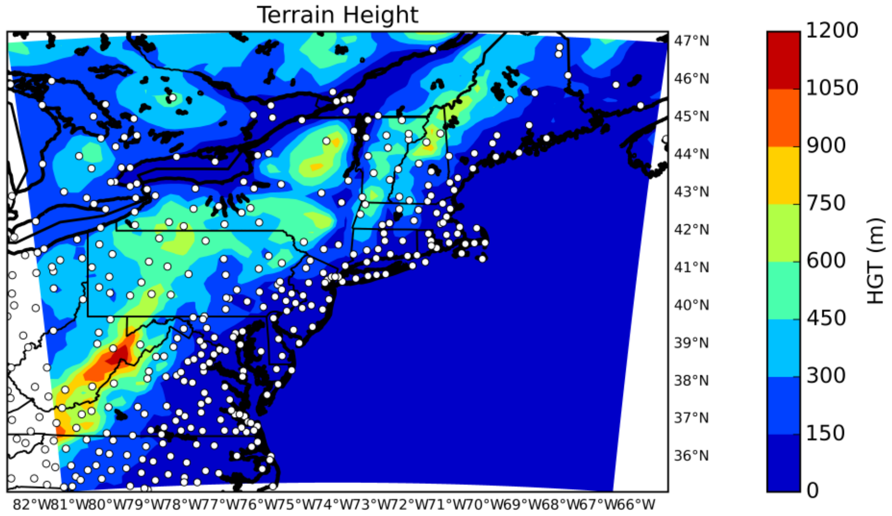
2 km
76x76



6 km
76x76

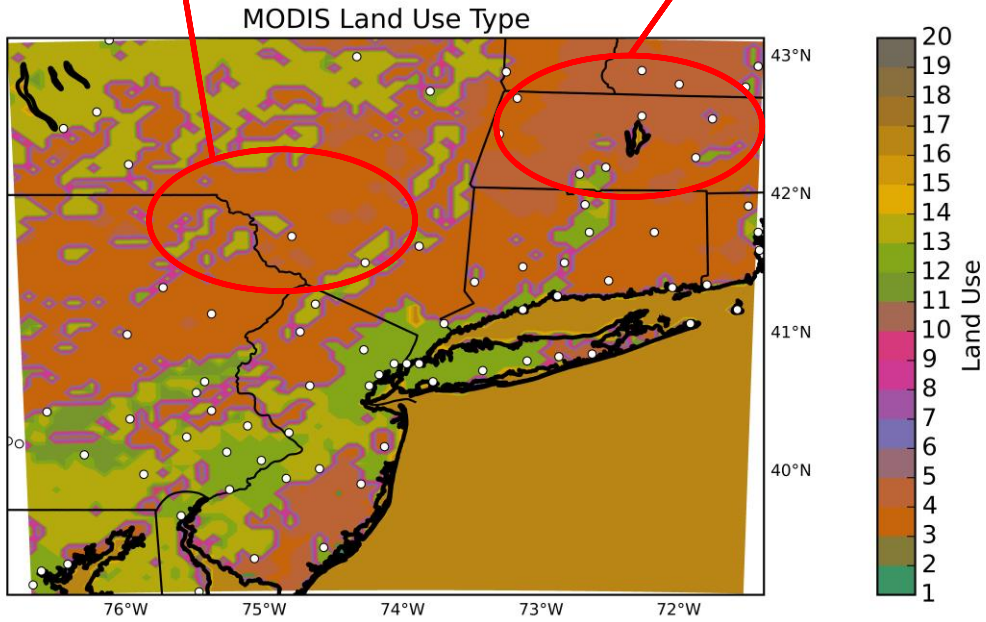


18 km
76x76



Deciduous Broadleaf Forest

Mixed forest



- The only configuration change is the LSM (either NOAH or NOAH-MP).
- No evaluation of other physics options.
- White dots represent surface METAR locations.

Experiment Design

- **Two months of hindcasts, using WRF-3.7.1: January 2015 and April 2015.**
- **One hindcast per day (00Z); 72 hour integration.**
- **12 km North American Mesoscale (NAM) model data for initial and boundary conditions.**
  – Note that the land surface fields coming from NAM are the result of the classic NOAH LSM.
- **2 km NASA SPoRT SST's, MODIS 1 km land use and vegetation fraction, 30/90 m SRTM topography.**
- **Evaluation:**
  1) Against high-quality METAR observations for each domain.
     - Approximate numbers of stations – 380 (d01), 80 (d02), 16 (d03).
  2) Time series.
  3) Against Canadian FLXNET (AMERIFLX) station to evaluate surface fluxes and soil temperature & moisture -- d01 only, 1 location.
  4) Spatial comparisons.
  5) Melting Parameter modification *(not shown)*

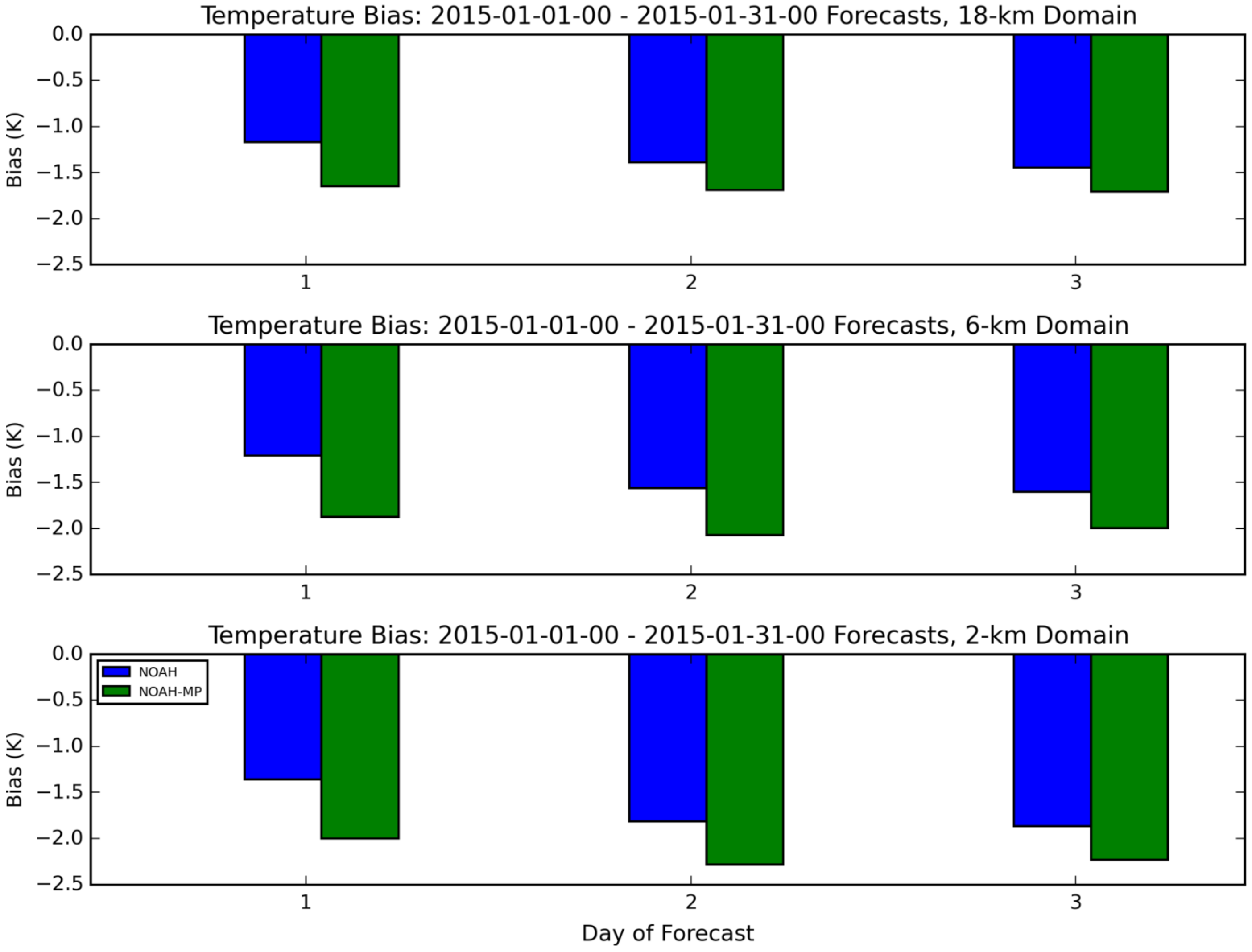
Results / Evaluation

I. Comparisons against METARs

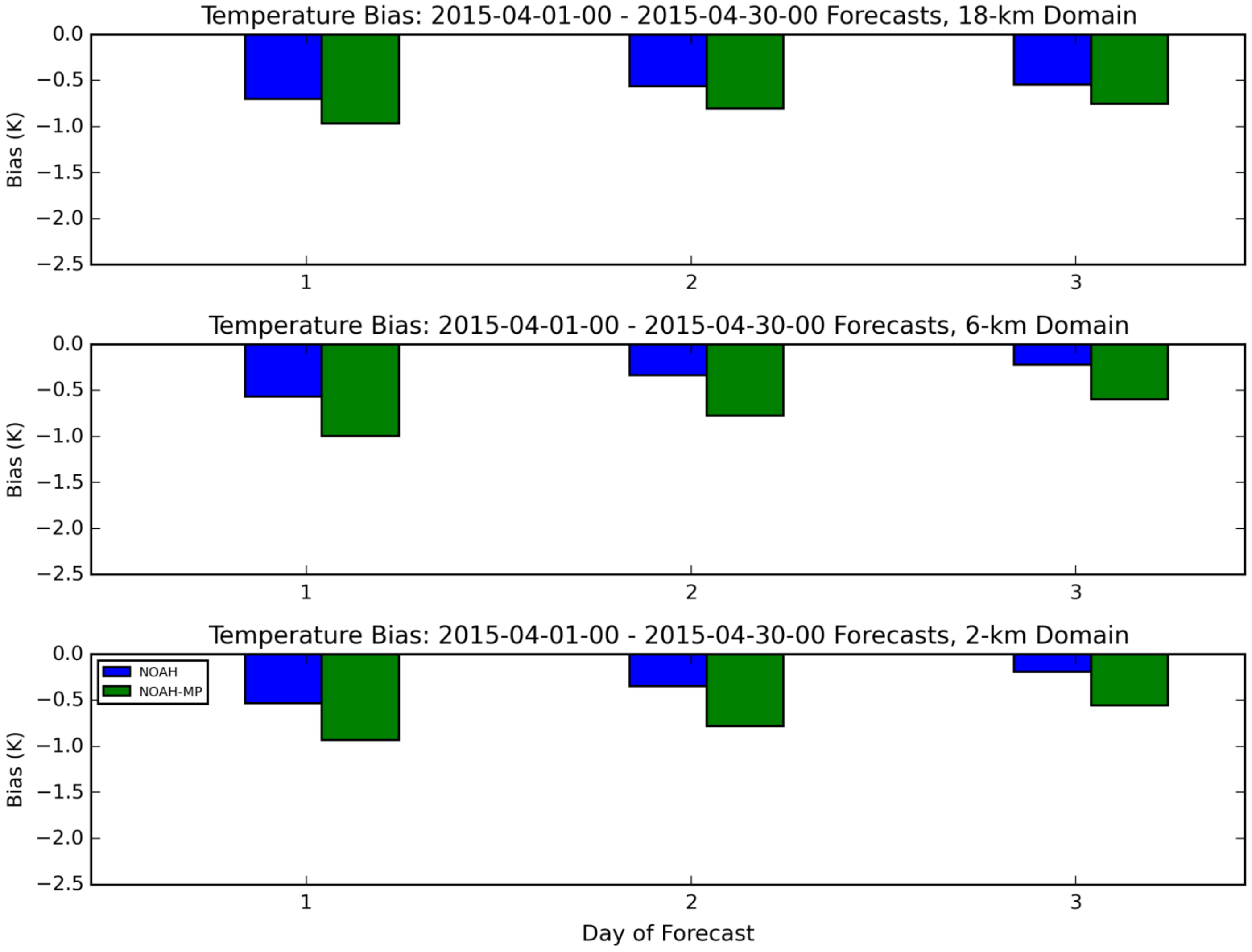
Temperature Bias

NOAH
NOAH-MP

January



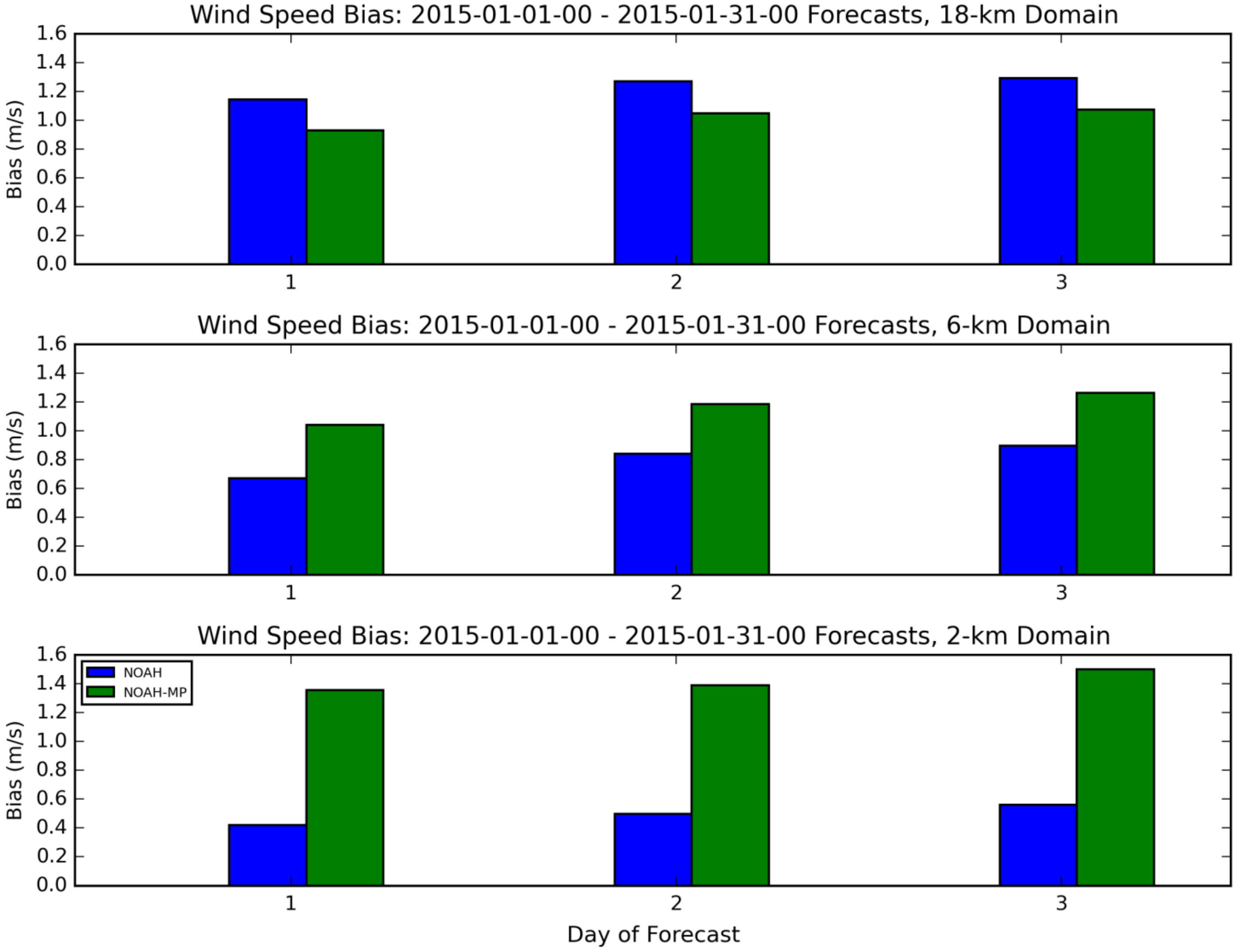
April



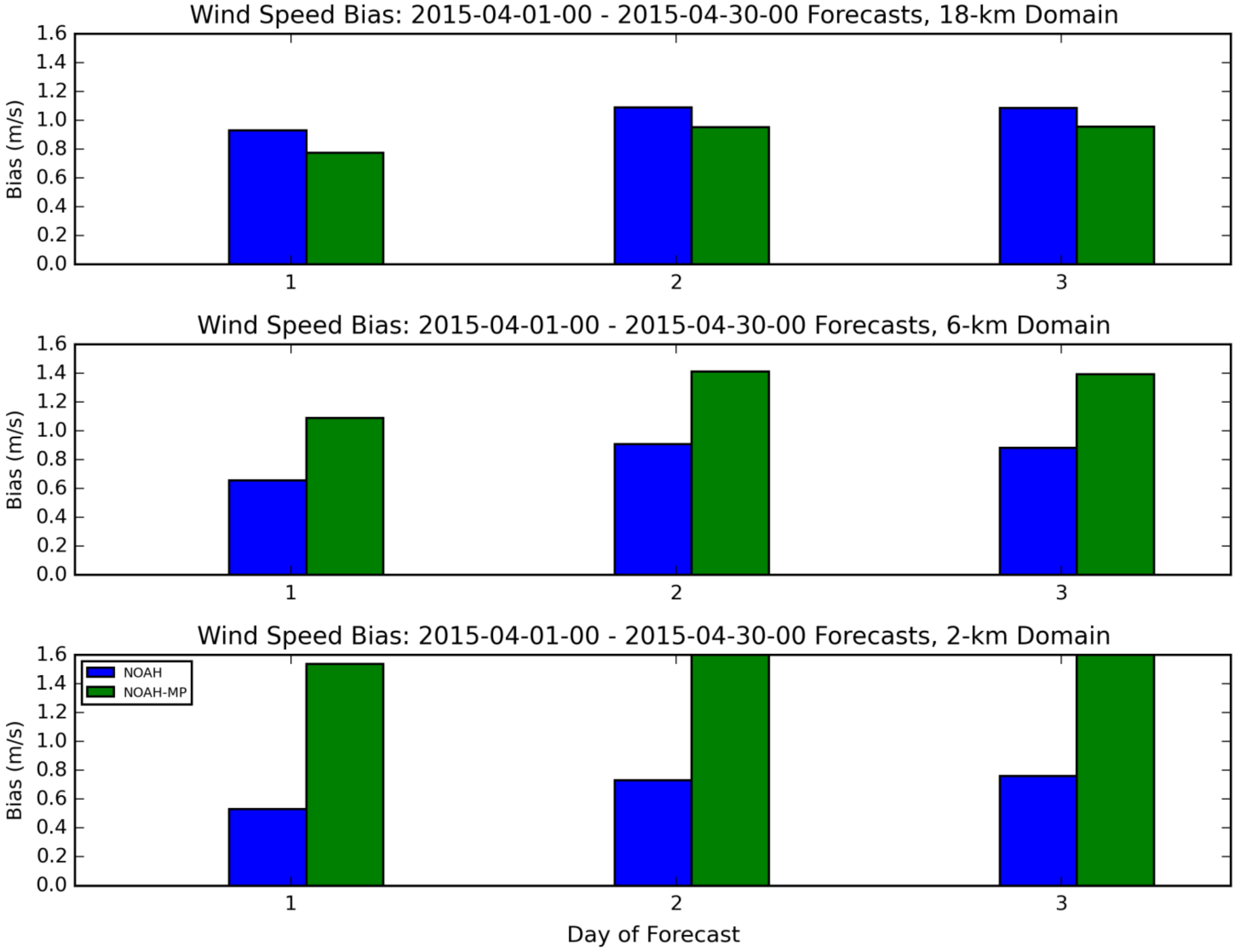
Wind Speed Bias

NOAH
NOAH-MP

January



April



January 2 km

Day 1

LSM	TMP	WSP	DPT
NOAH	-1.36	0.42	1.29
NOAH-MP	-2.0	1.36	-1.43

Day 2

LSM	TMP	WSP	DPT
NOAH	-1.81	0.50	0.97
NOAH-MP	-2.28	1.39	-2.55

Day 3

LSM	TMP	WSP	DPT
NOAH	-1.87	0.56	0.66
NOAH-MP	-2.23	1.5	-2.84

April 2 km

Day 1

LSM	TMP	WSP	DPT
NOAH	-0.53	0.53	0.76
NOAH-MP	-0.93	1.54	1.41

Day 2

LSM	TMP	WSP	DPT
NOAH	-0.35	0.73	1.18
NOAH-MP	-0.78	1.82	1.72

Day 3

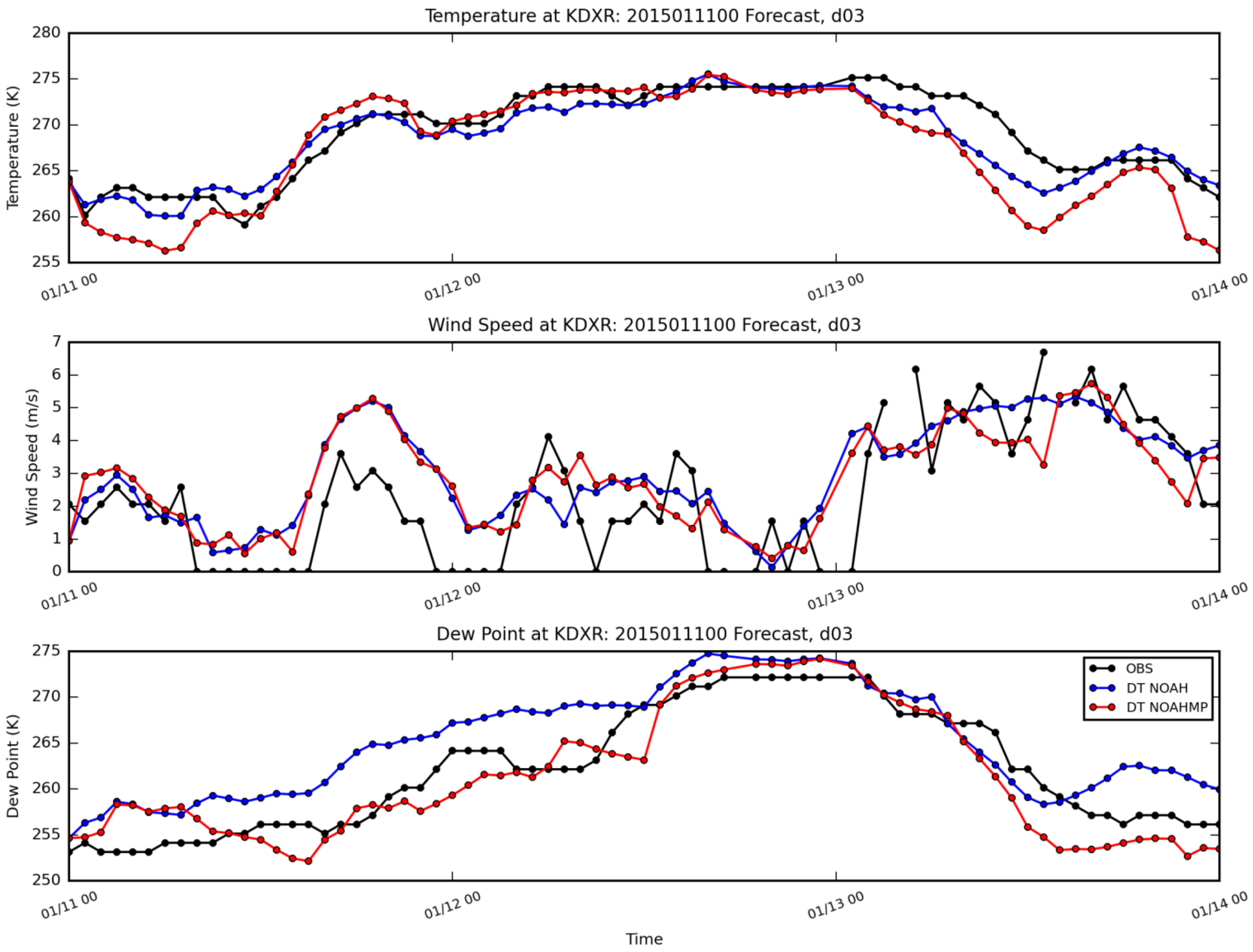
LSM	TMP	WSP	DPT
NOAH	-0.19	0.76	1.06
NOAH-MP	-0.55	1.88	1.68

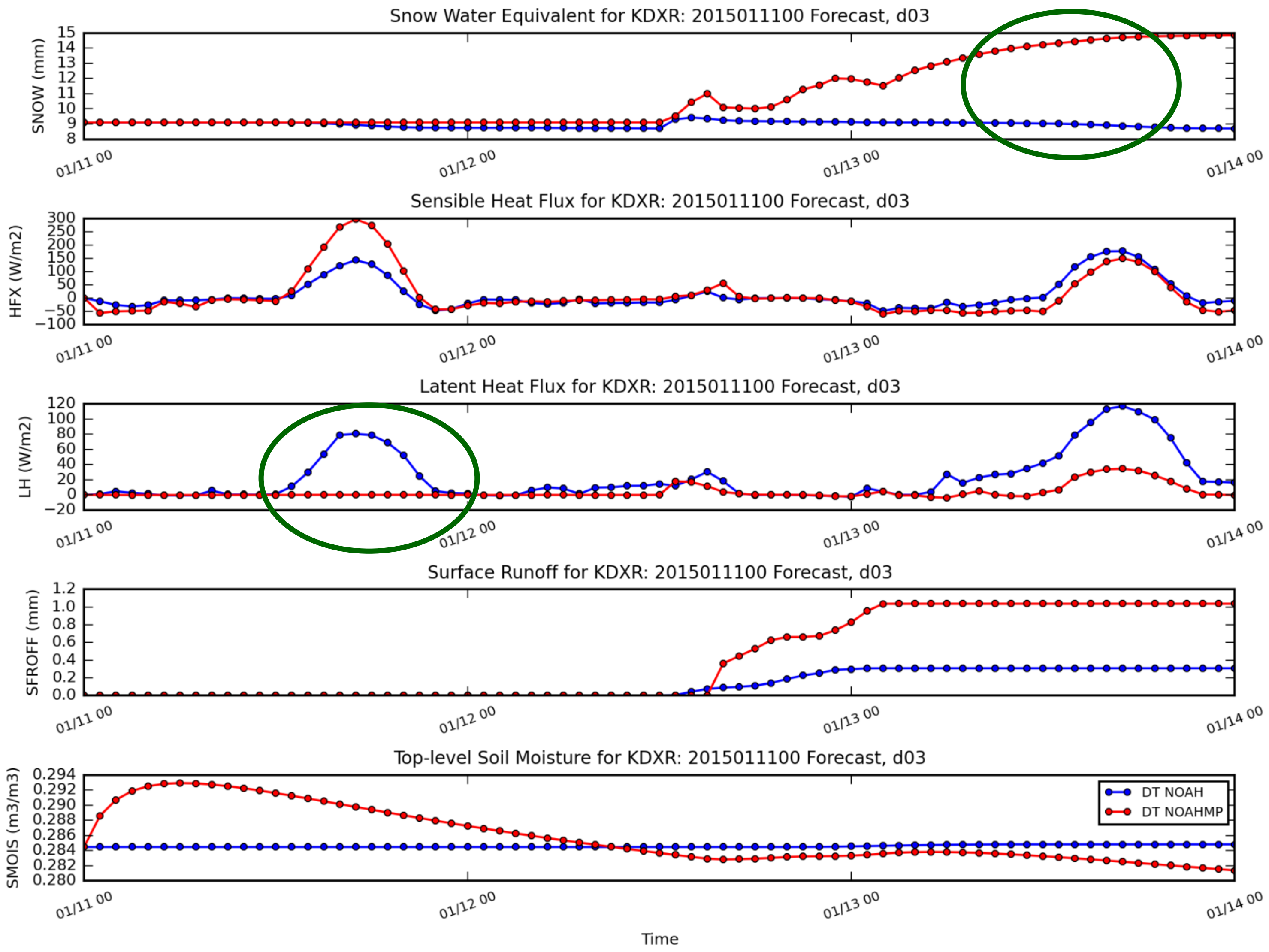
II. Site-specific Time Series (2 km)

KDXR: Danbury (CT) Municipal Airport, January hindcast

Land Use Type = *Deciduous Broadleaf Forest (4)*

NOAH
NOAH-MP
Obs.

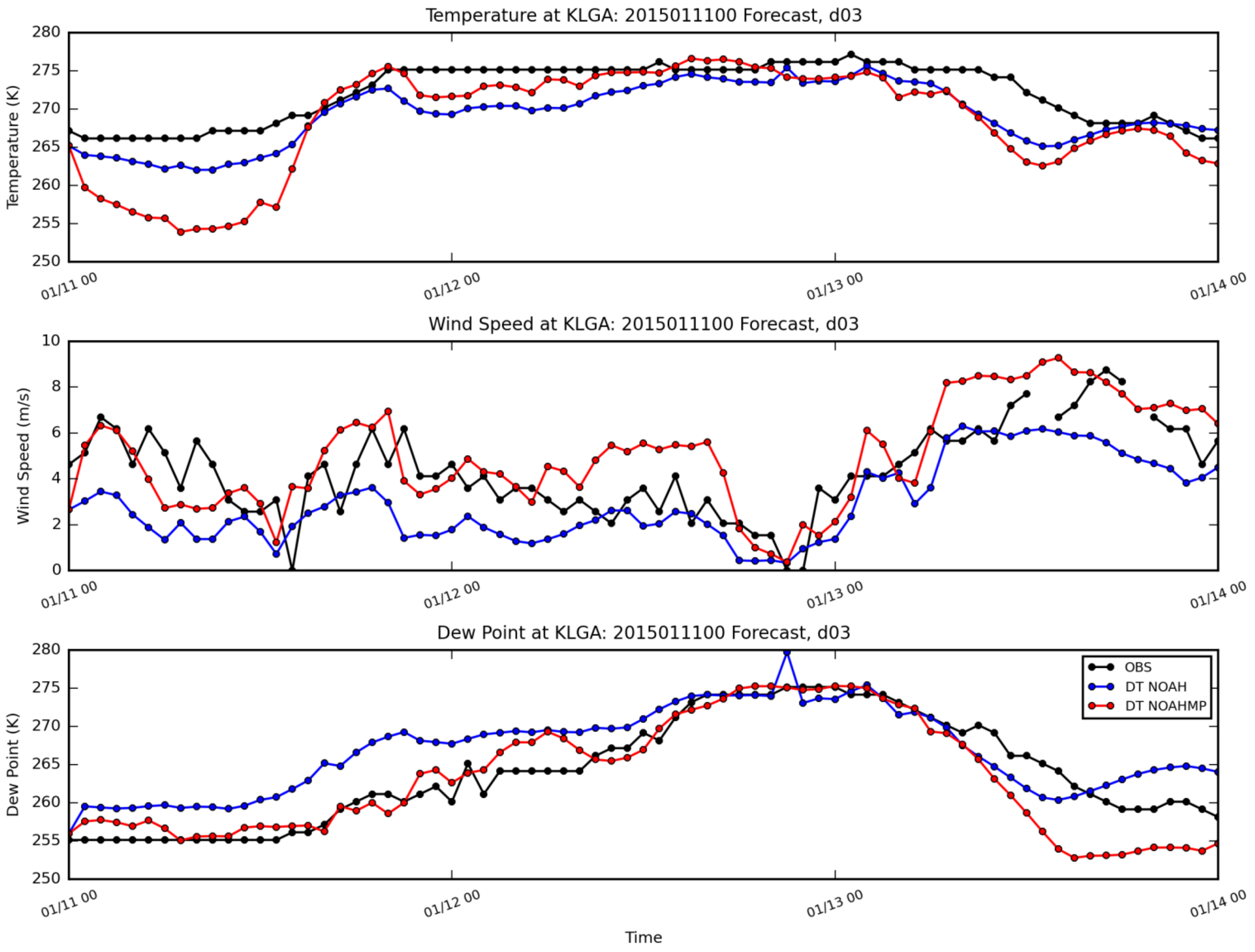


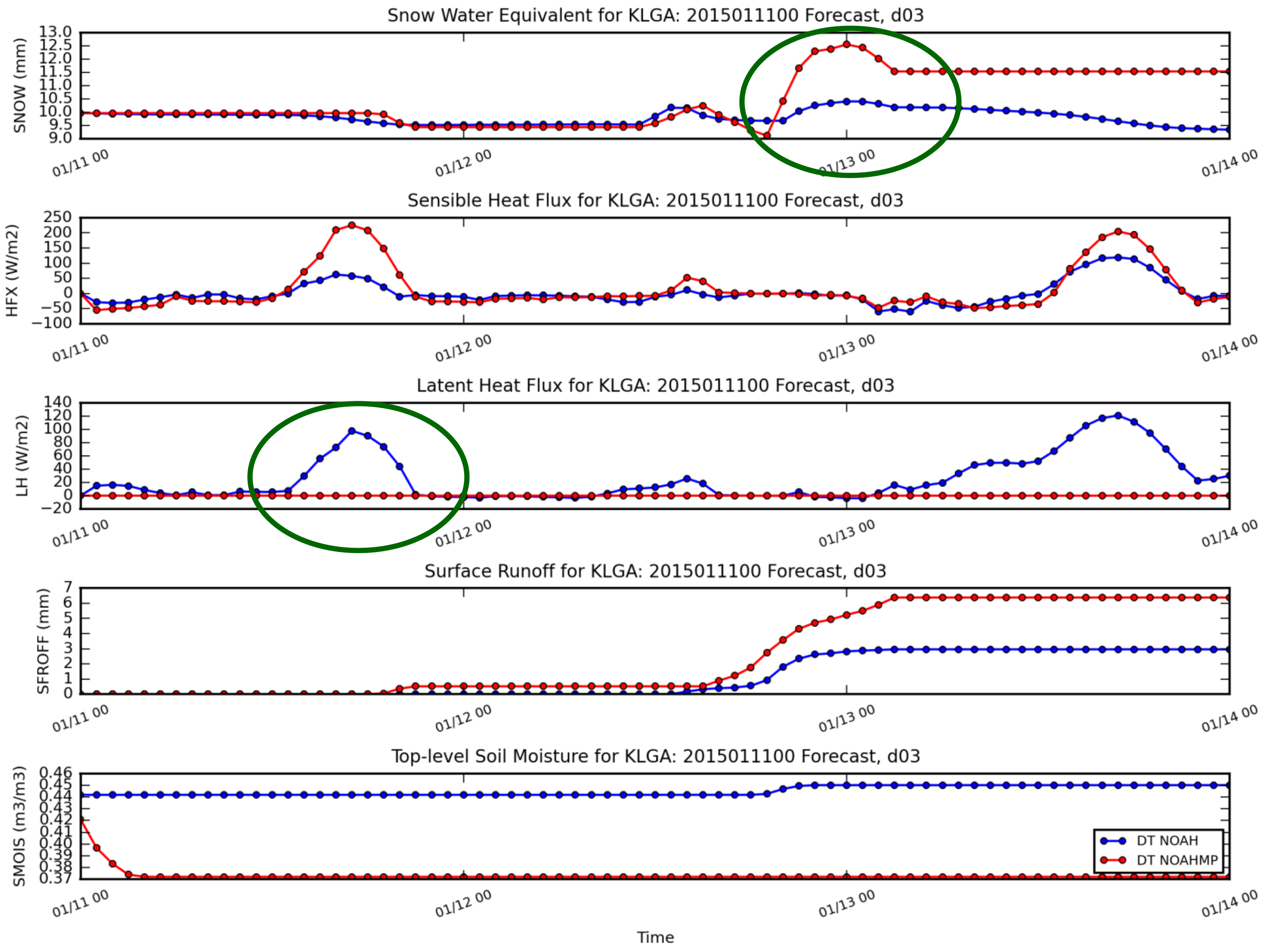


KLGA: LaGuardia (NY) Airport, January hindcast

NOAH
NOAH-MP
Obs.

Land Use Type = *Urban (13)*





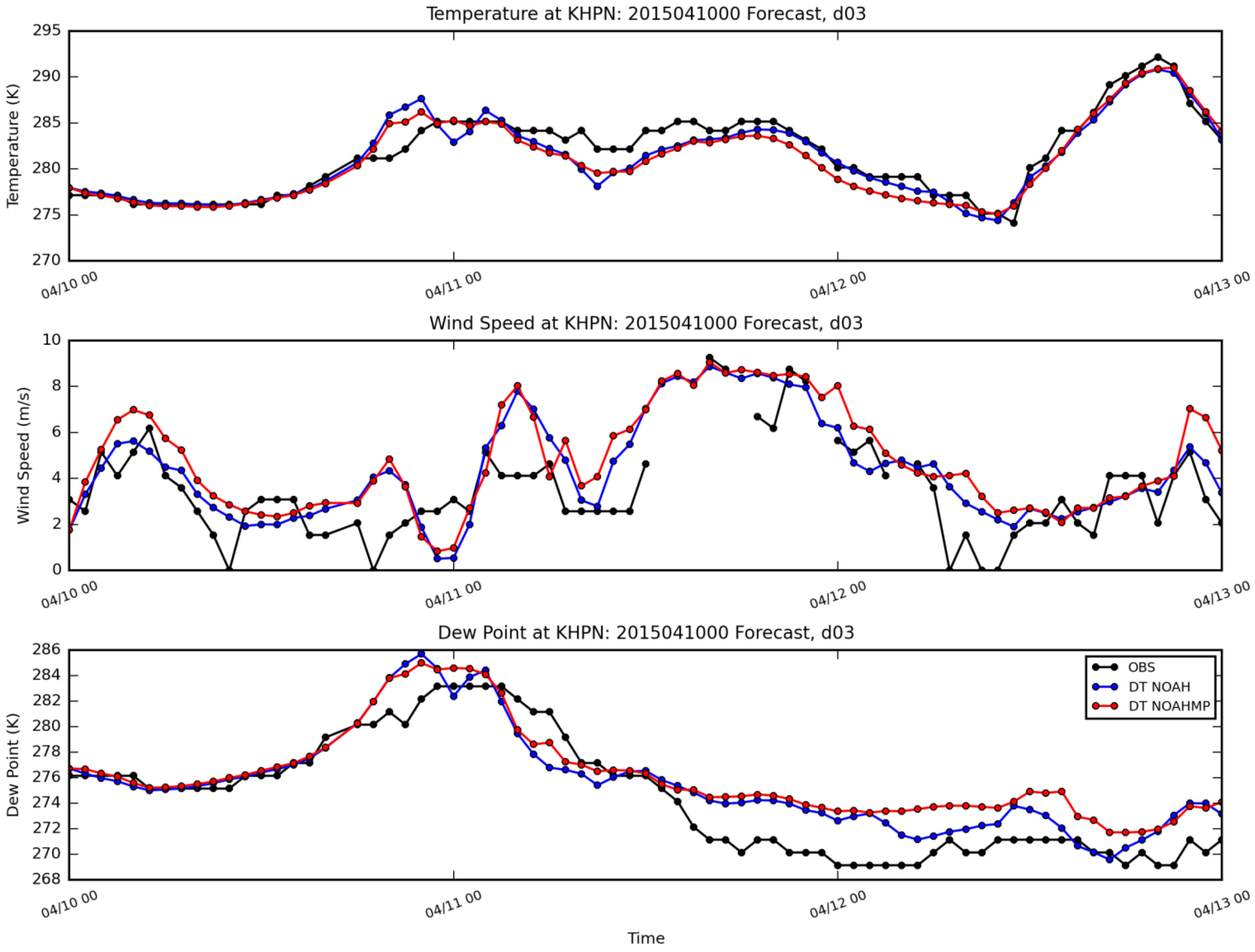
KHPN: White Plains (NY) Airport, April hindcast

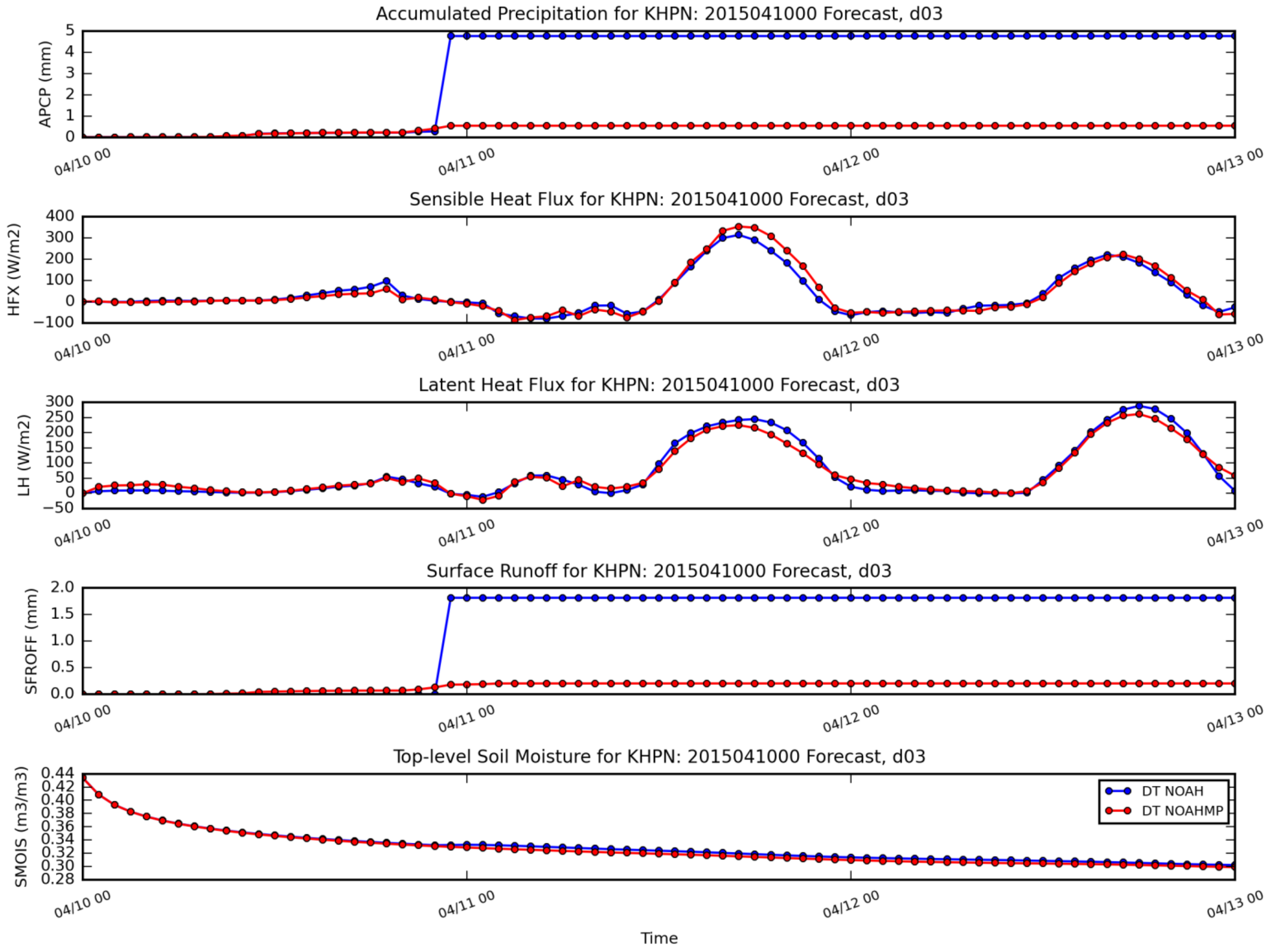
Land Use Type = *Croplands (12)*

NOAH

NOAH-MP

Obs.





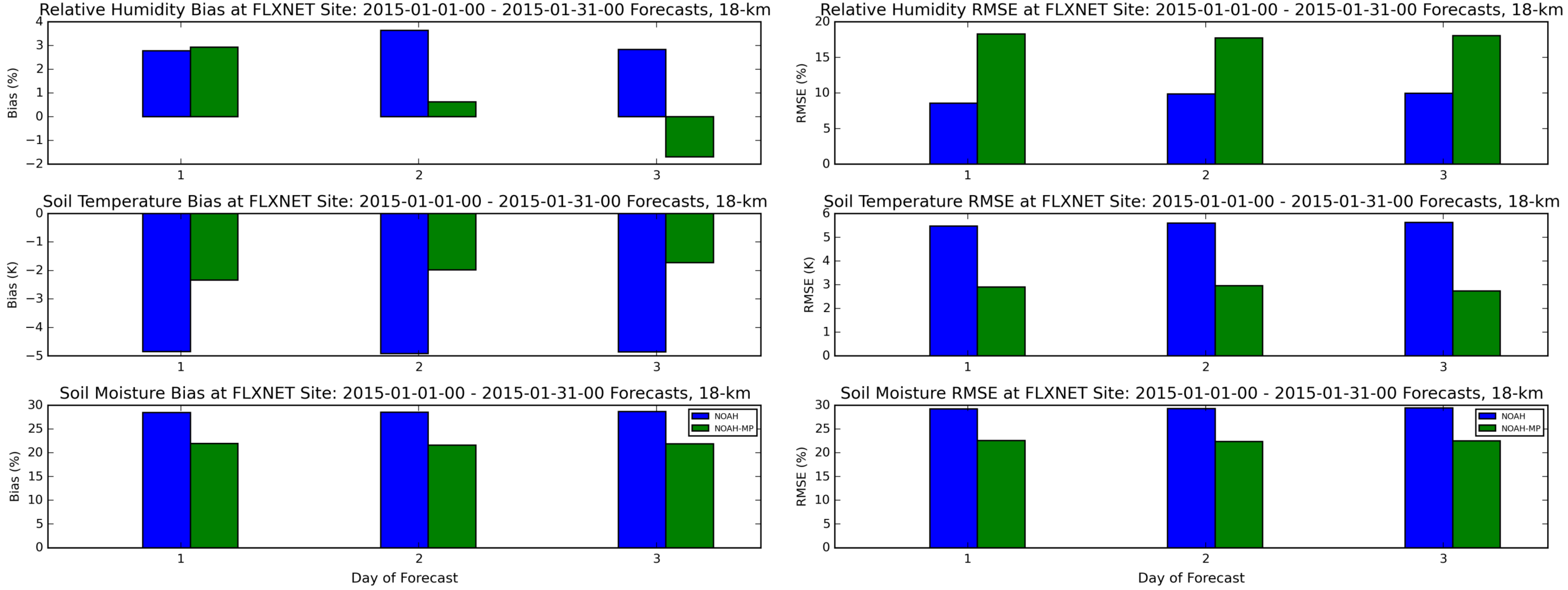
III. Comparisons against FLXNET Station

Relative Humidity, Soil Temperature/Moisture

NOAH
NOAH-MP

January Bias

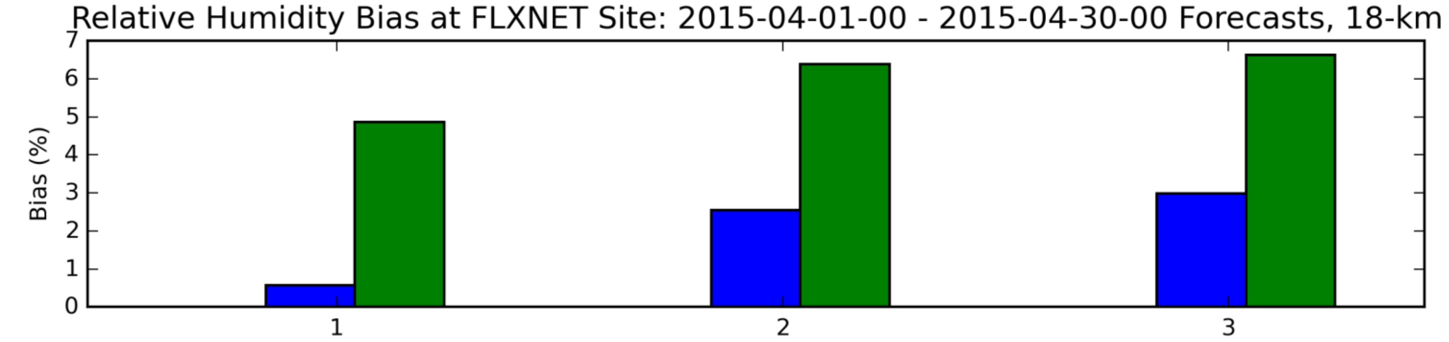
January RMSE

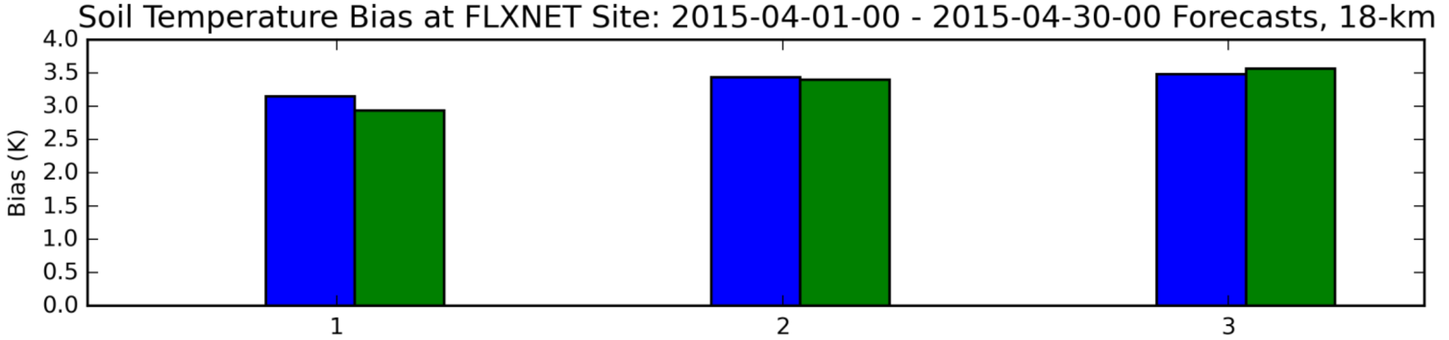


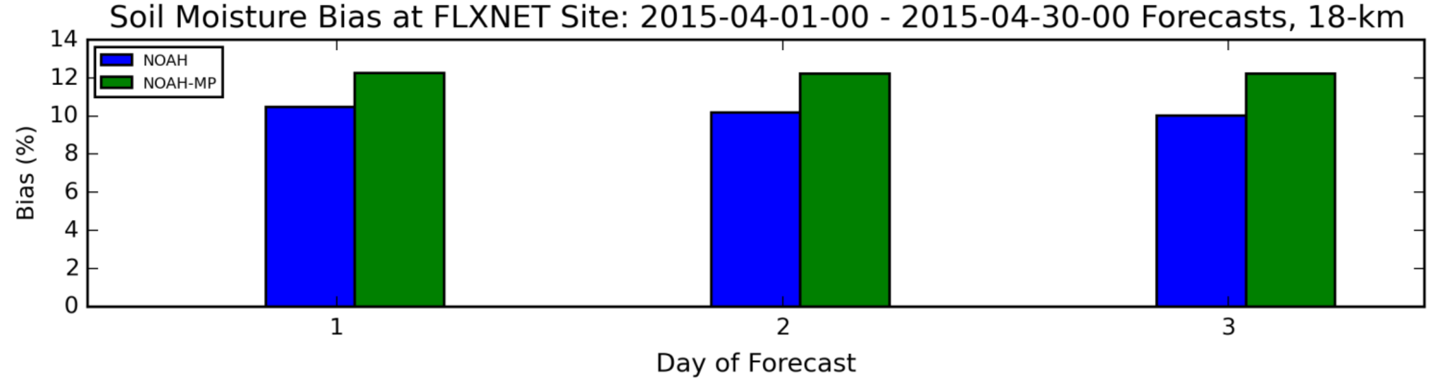
Relative Humidity, Soil Temperature/Moisture

NOAH
NOAH-MP

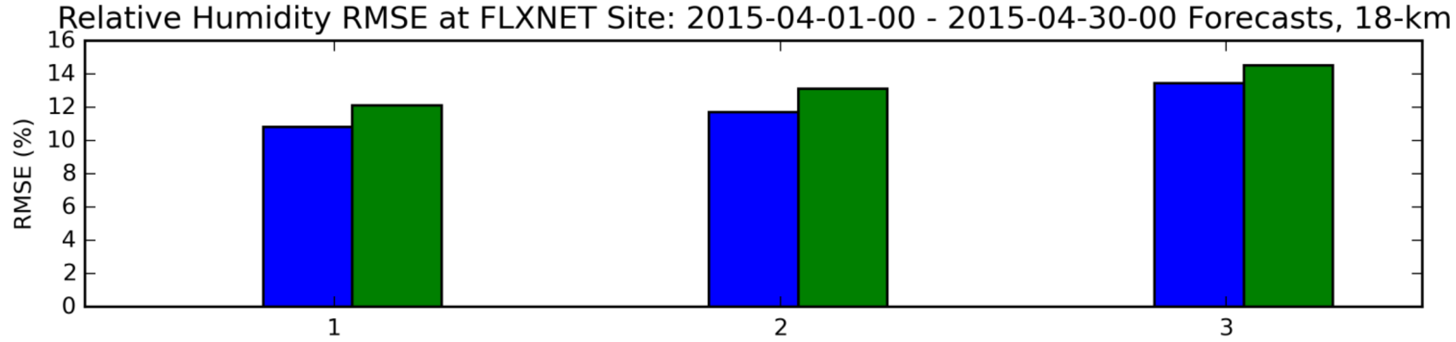
April Bias

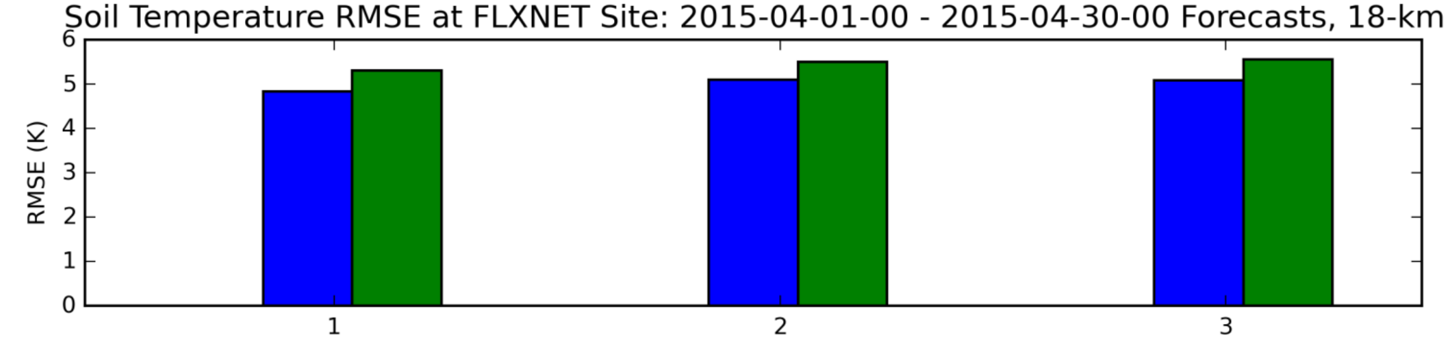


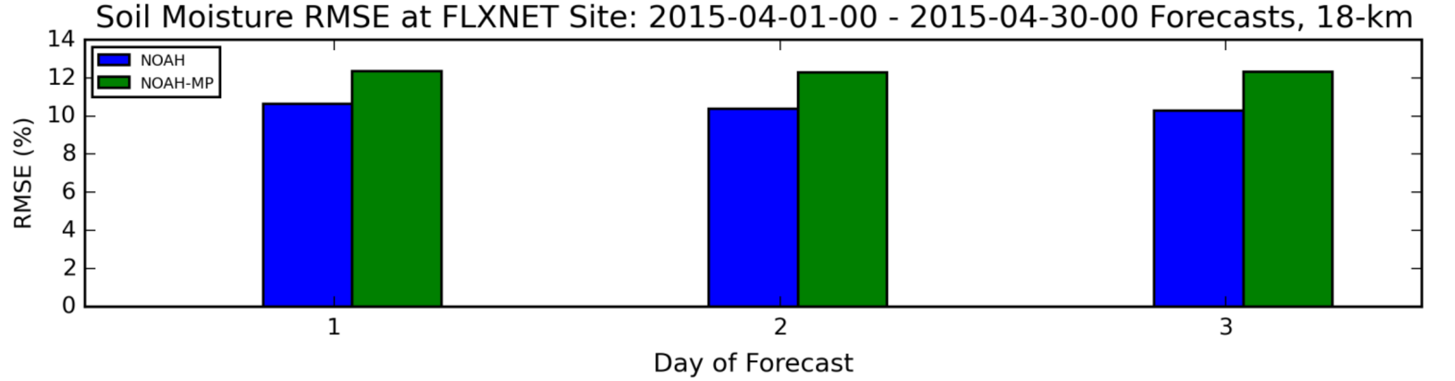




April RMSE







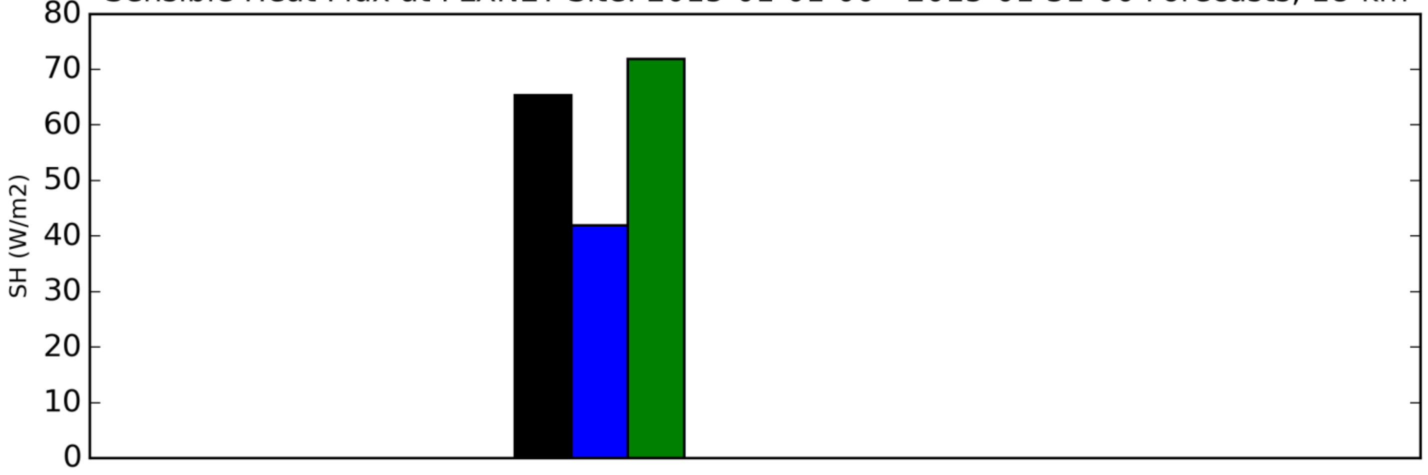
Average Daytime (12:00-21:00 UTC) Sensible and Latent Heat Fluxes

NOAH
NOAH-MP
Obs.

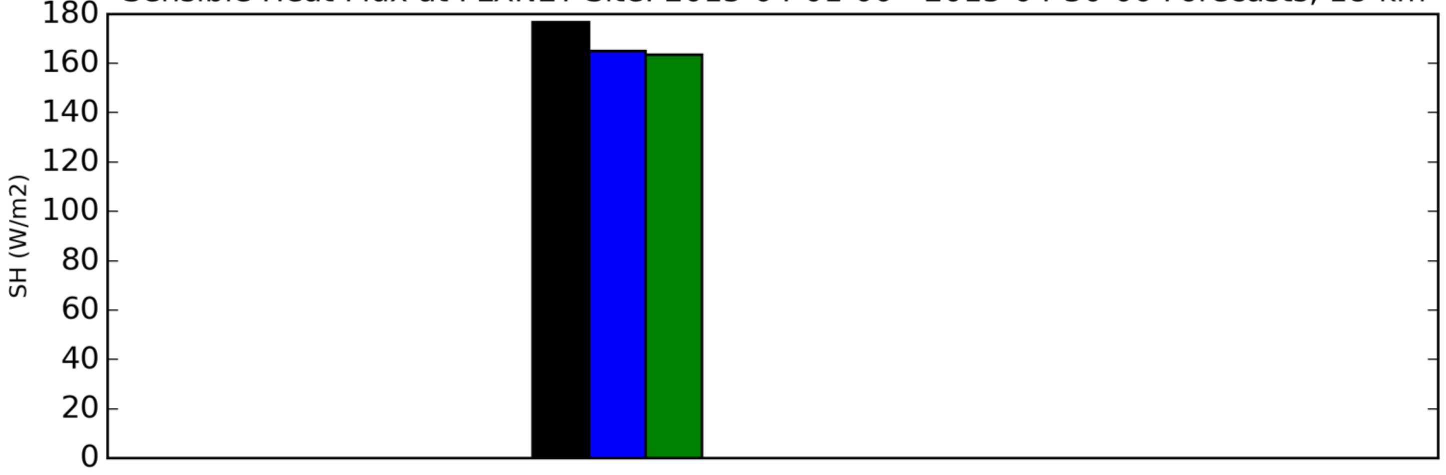
January

April

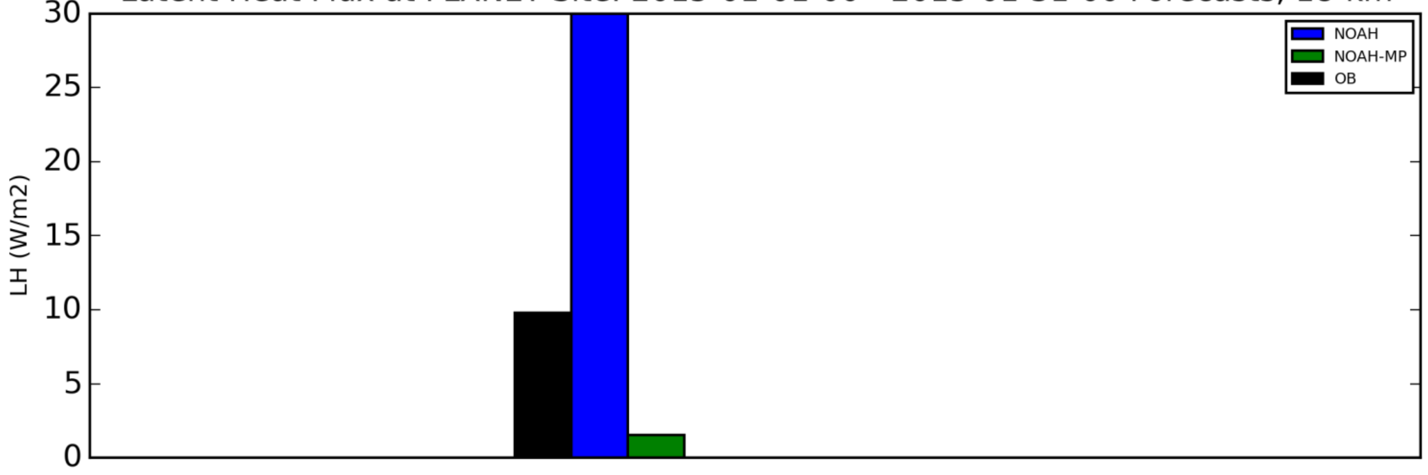
Sensible Heat Flux at FLXNET Site: 2015-01-01-00 - 2015-01-31-00 Forecasts, 18-km



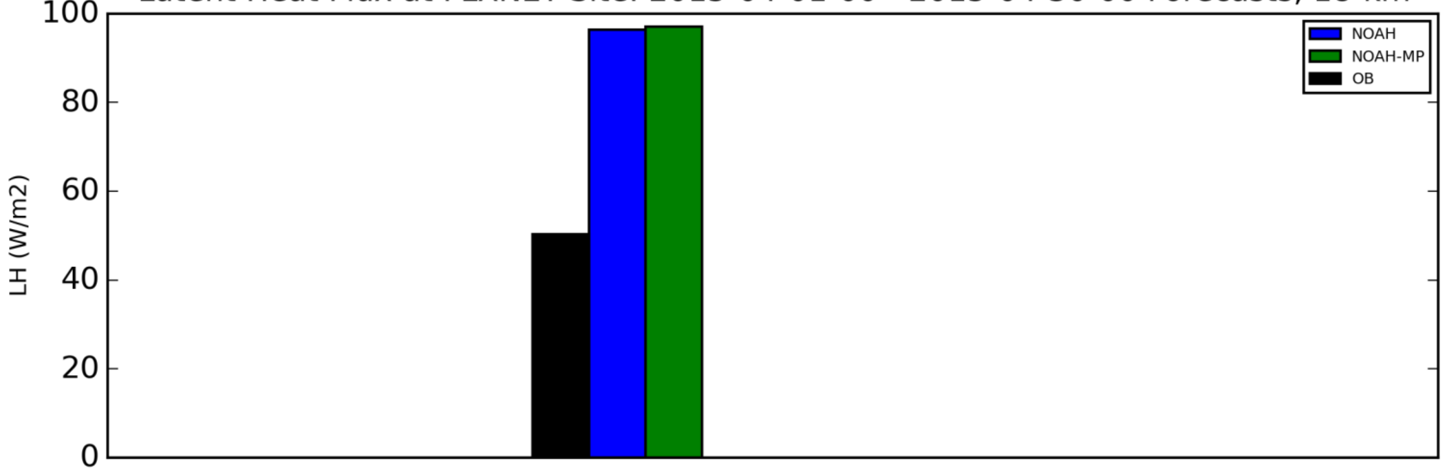
Sensible Heat Flux at FLXNET Site: 2015-04-01-00 - 2015-04-30-00 Forecasts, 18-km



Latent Heat Flux at FLXNET Site: 2015-01-01-00 - 2015-01-31-00 Forecasts, 18-km



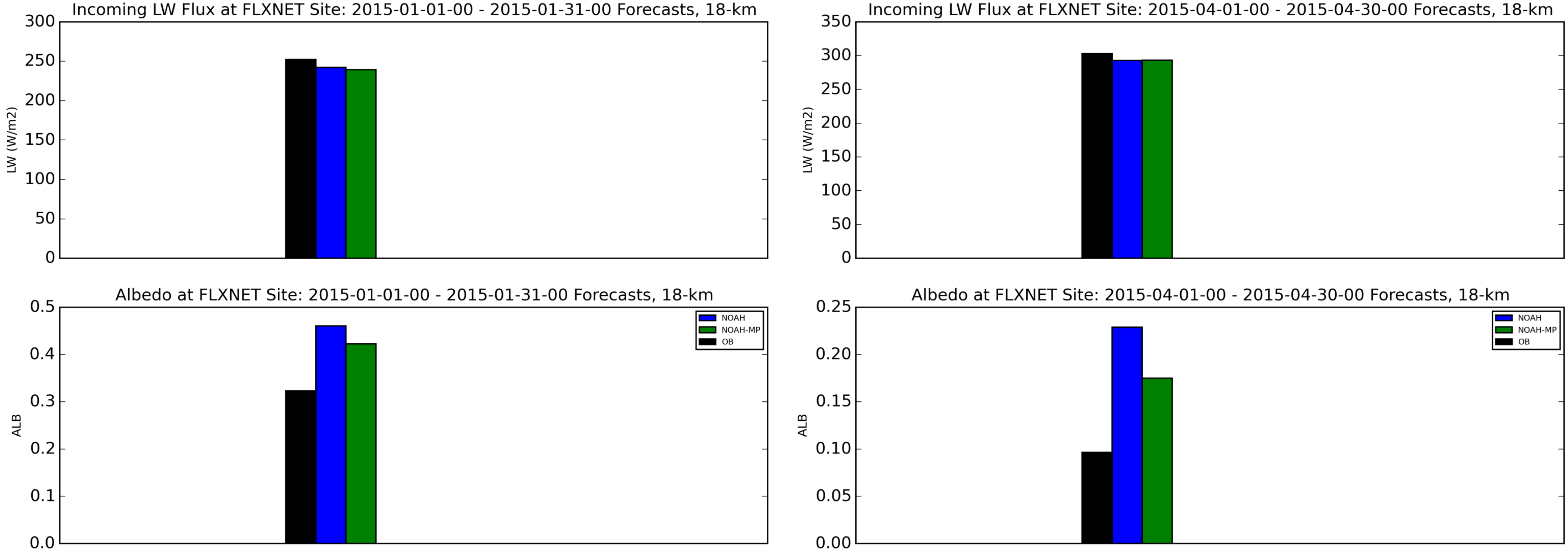
Latent Heat Flux at FLXNET Site: 2015-04-01-00 - 2015-04-30-00 Forecasts, 18-km



Average Daytime (12:00-21:00 UTC) Incoming Long Wave Flux and Albedo

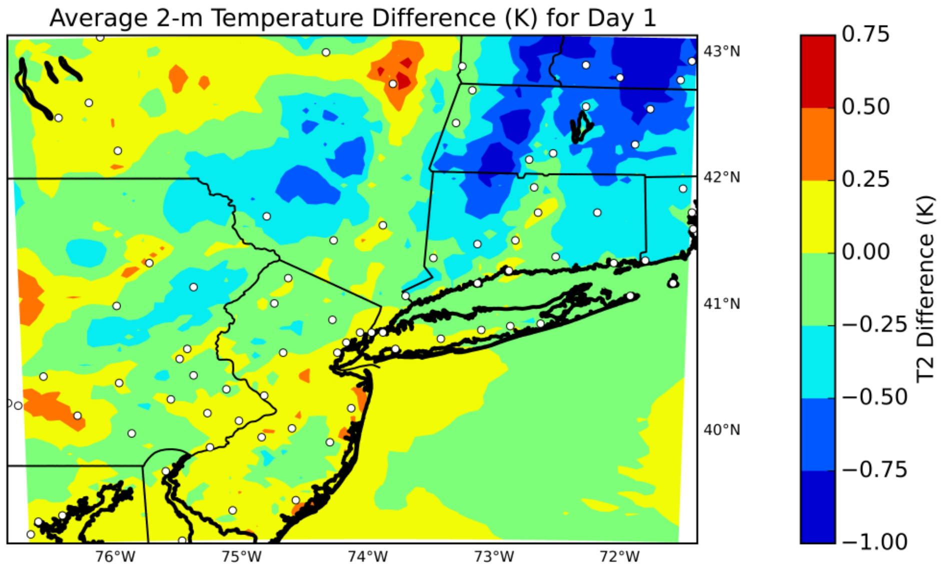
NOAH
NOAH-MP
Obs.

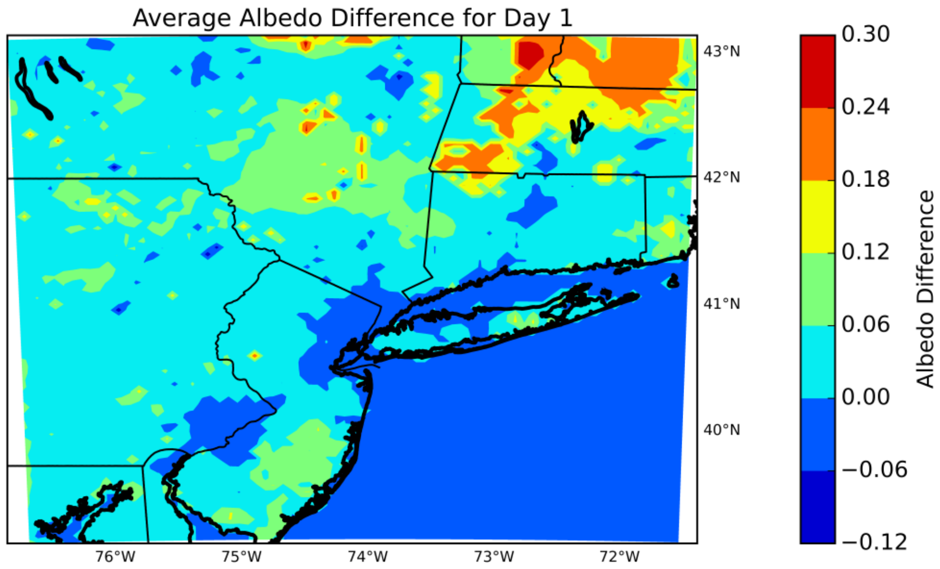
January | April

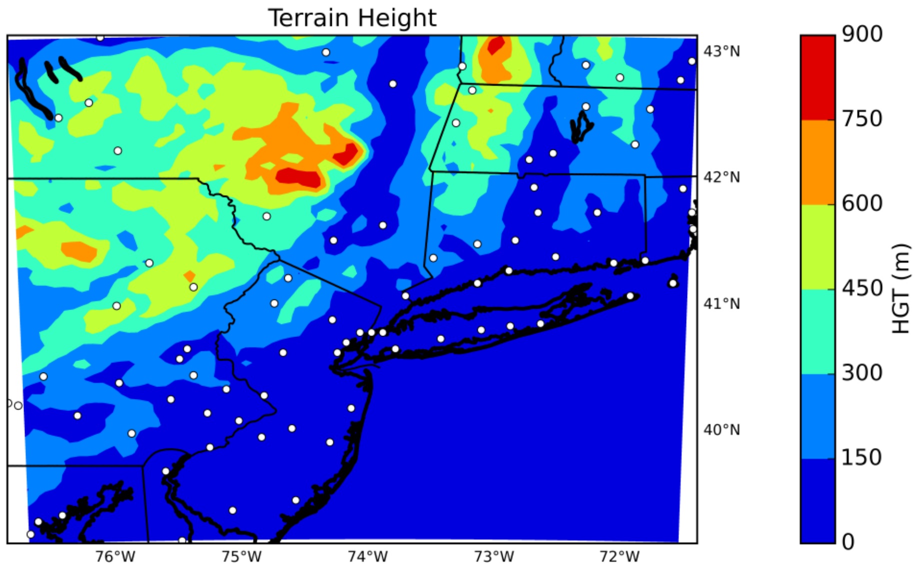


IV. Spatial Differences in the LSM Output

January

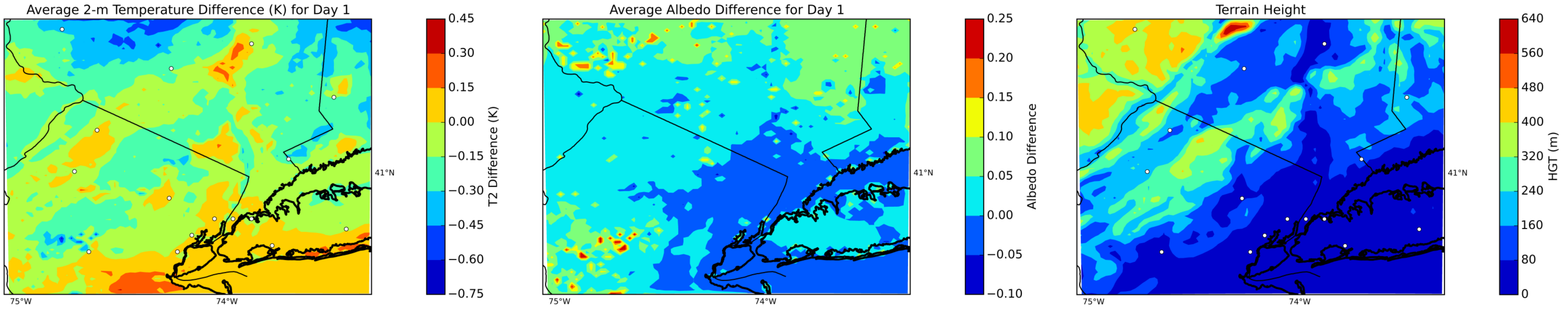






- Difference in average T2 and Albedo between NOAH and NOAH-MP simulations.
  - [NOAH – NOAH-MP]
- Middle (6 km) domain.
- Possible correlation between colder temperatures from classic NOAH (higher albedo) and higher terrain elevation.

January



- Difference in average T2 and Albedo between NOAH and NOAH-MP simulations.
  - [NOAH – NOAH-MP]
- Innermost (2 km) domain.

Summary

- **When comparing against METAR observations:**
  – NOAH temperature bias & RMSE are of smaller magnitude when compared to NOAH-MP.
  – NOAH-MP wind speed bias is of smaller magnitude for coarser resolution (18 km) only.

- **When looking at individual time series:**
  – Differences between LH and soil moisture (particularly in winter), which is an area of investigation.

- **When comparing against AMERIFLX FLXNET observations:**
  – Results for temperature and wind speed are analogous to the METAR comparisons.
  – NOAH generally outperforms NOAH-MP for RH.
  – NOAH-MP outperforms NOAH for soil moisture & soil temperature in January.
  – NOAH-MP correlates better with observations of LH, SH, and Albedo:
    - Similar to Chen et al (2014 *JGR*), figure 9.

- **What is causing the average colder bias and higher RMSE for NOAH-MP temperature?**
  – NOAH-MP has a higher albedo over parts of NY and NJ, which may contribute to the colder bias.
  – Correlation between higher terrain and higher albedo (colder temperatures) from NOAH.

- **NOAH-MP takes 12-15% longer to run.**
    - Difference may be minimal enough to justify operational implementation.

In the Future …

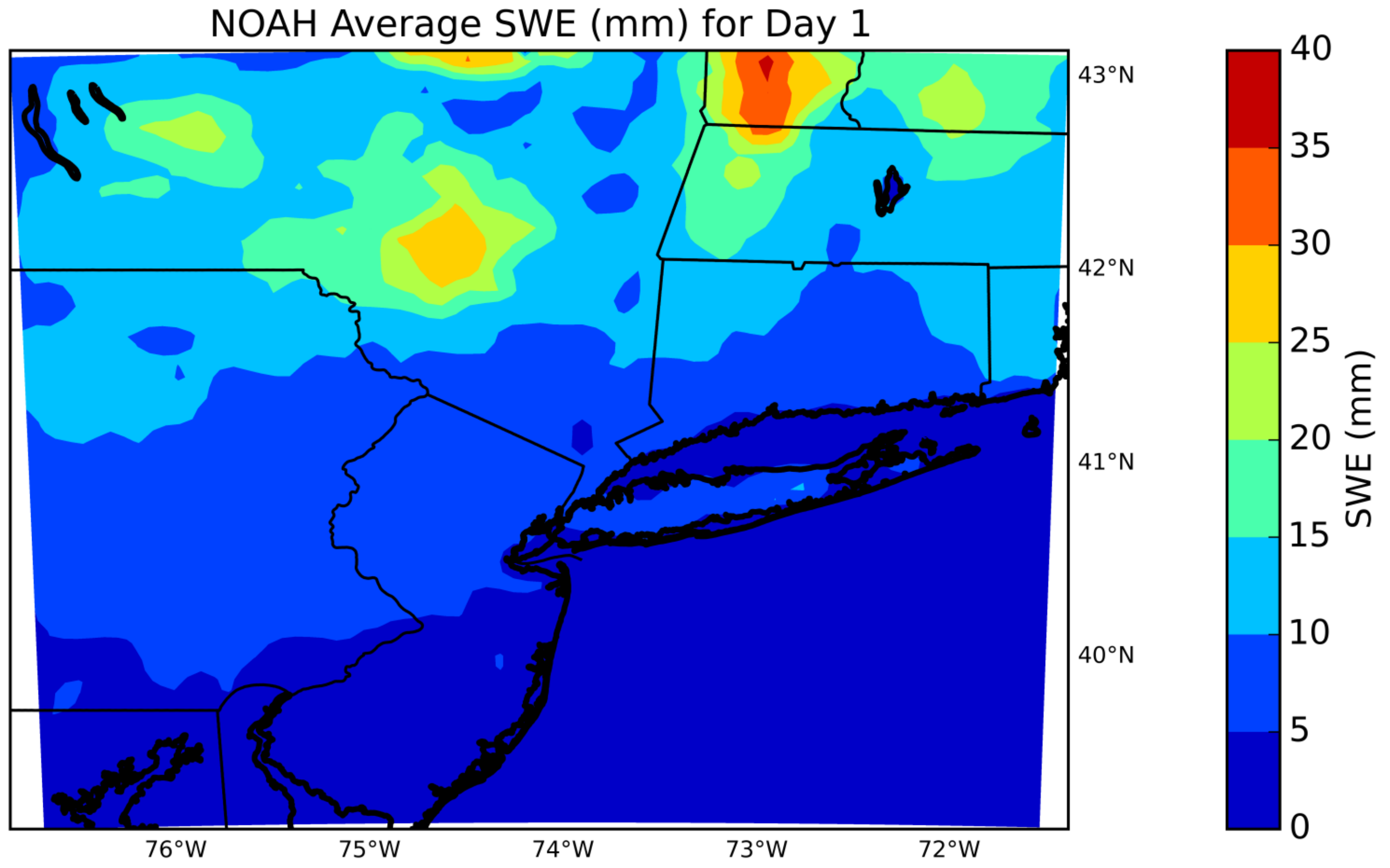
- **One of the primary goals is to enable an online operational implementation of NOAH-MP.**
- **There are more tests and evaluation to be completed before that implementation can occur, specifically related to the roles of terrain height, albedo, and land use type.**

Thank You

Questions?

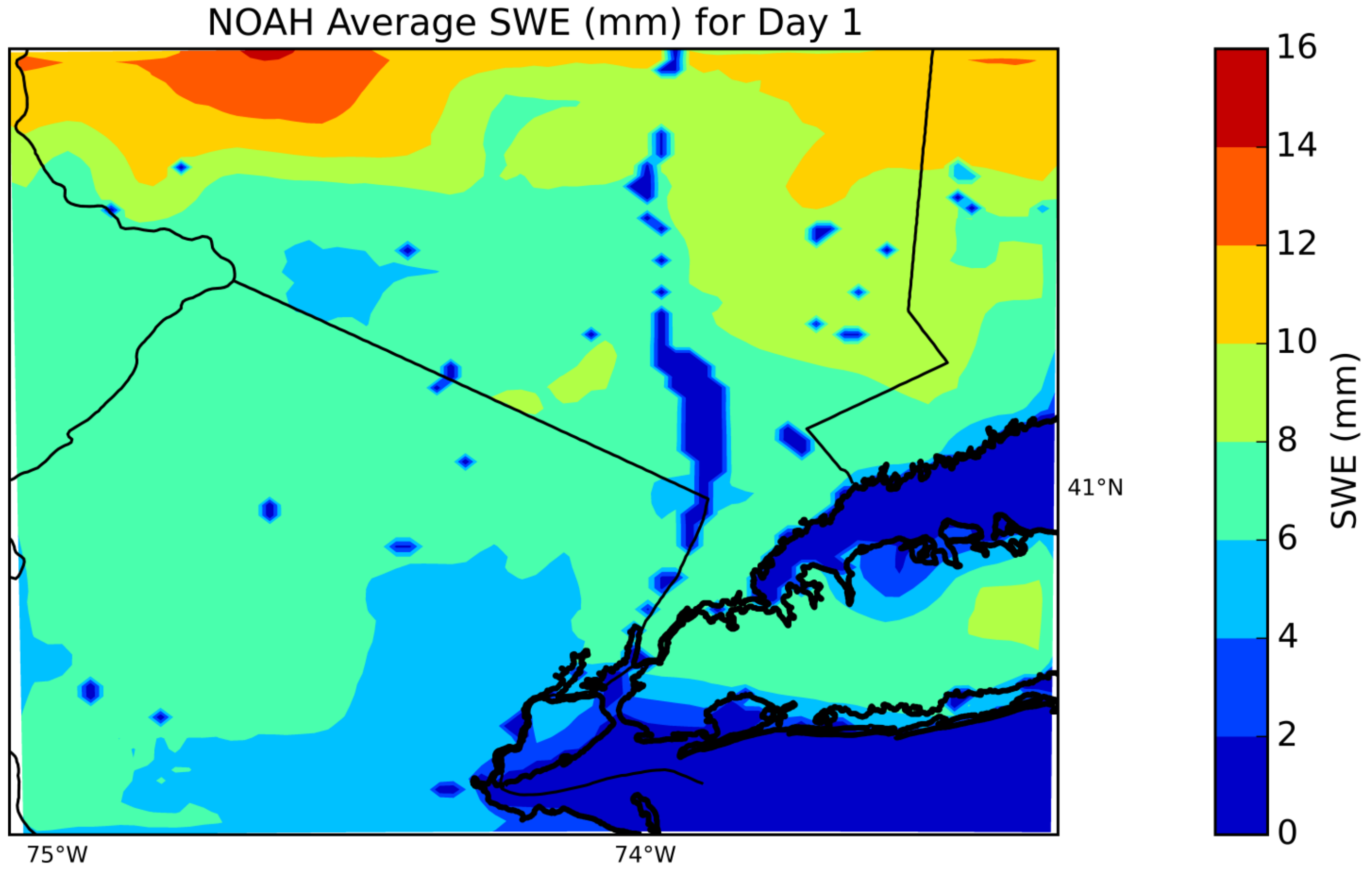
Back-up

Average SWE (January)



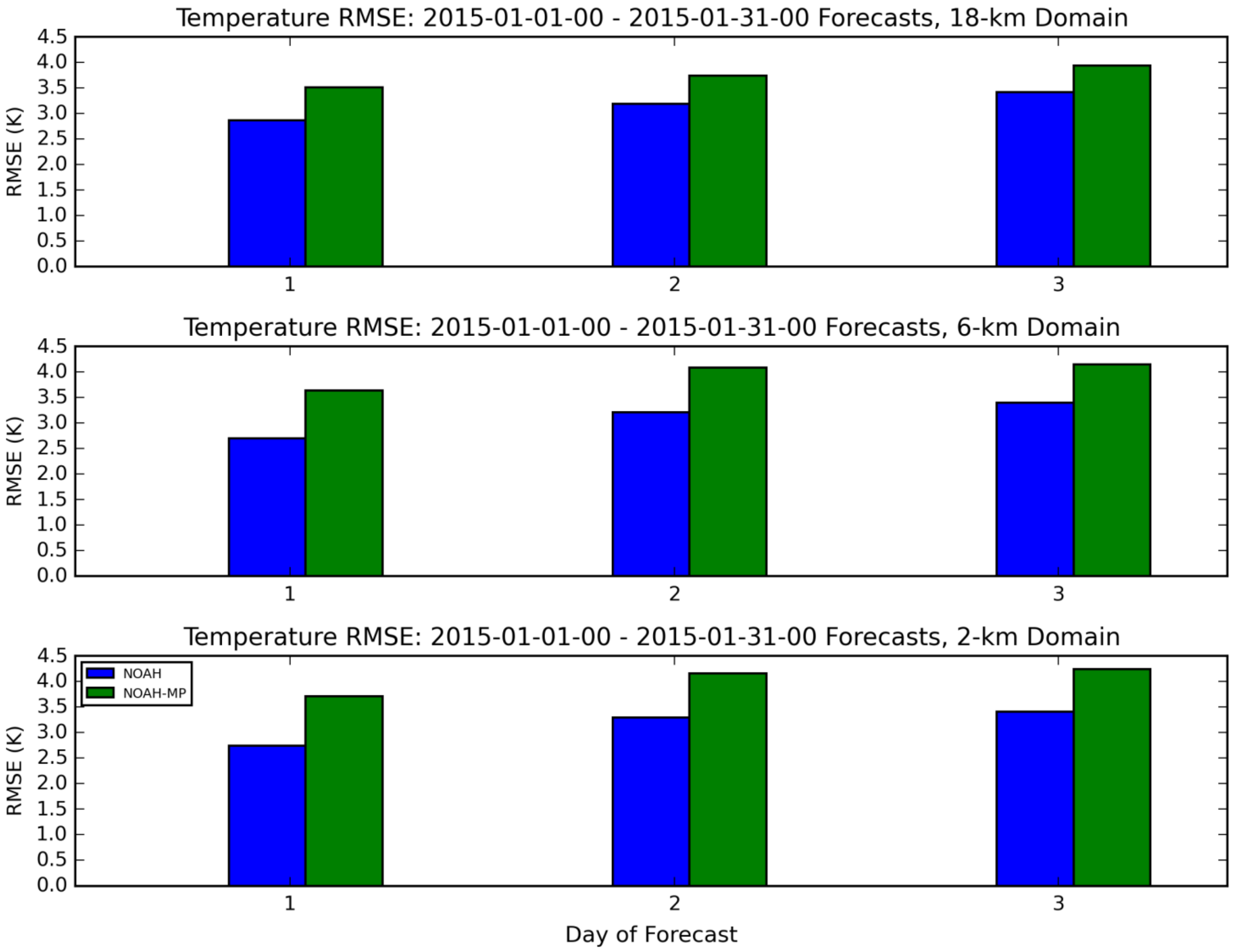
6 km

2 km

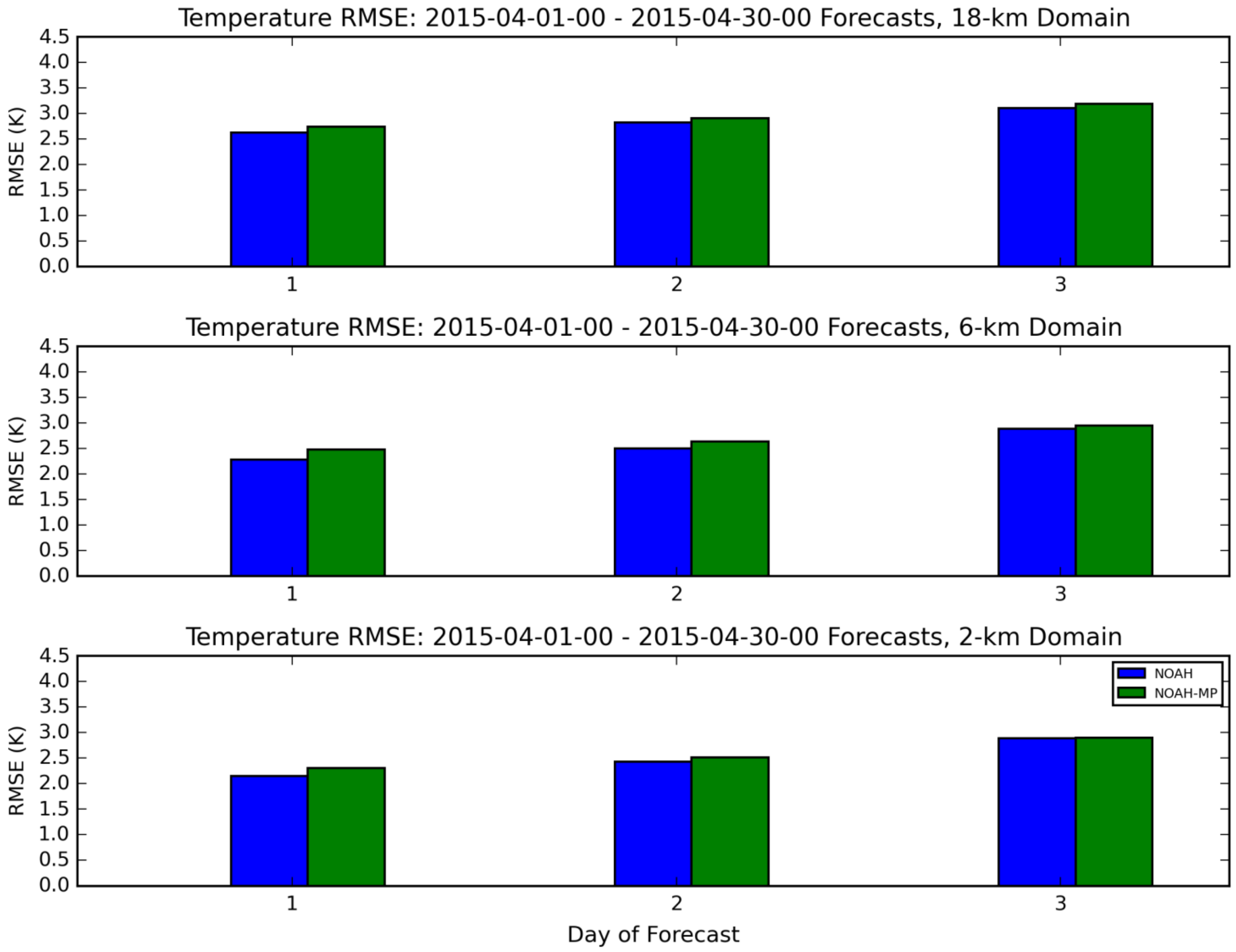


METAR Comparisons: Temperature RMSE

January

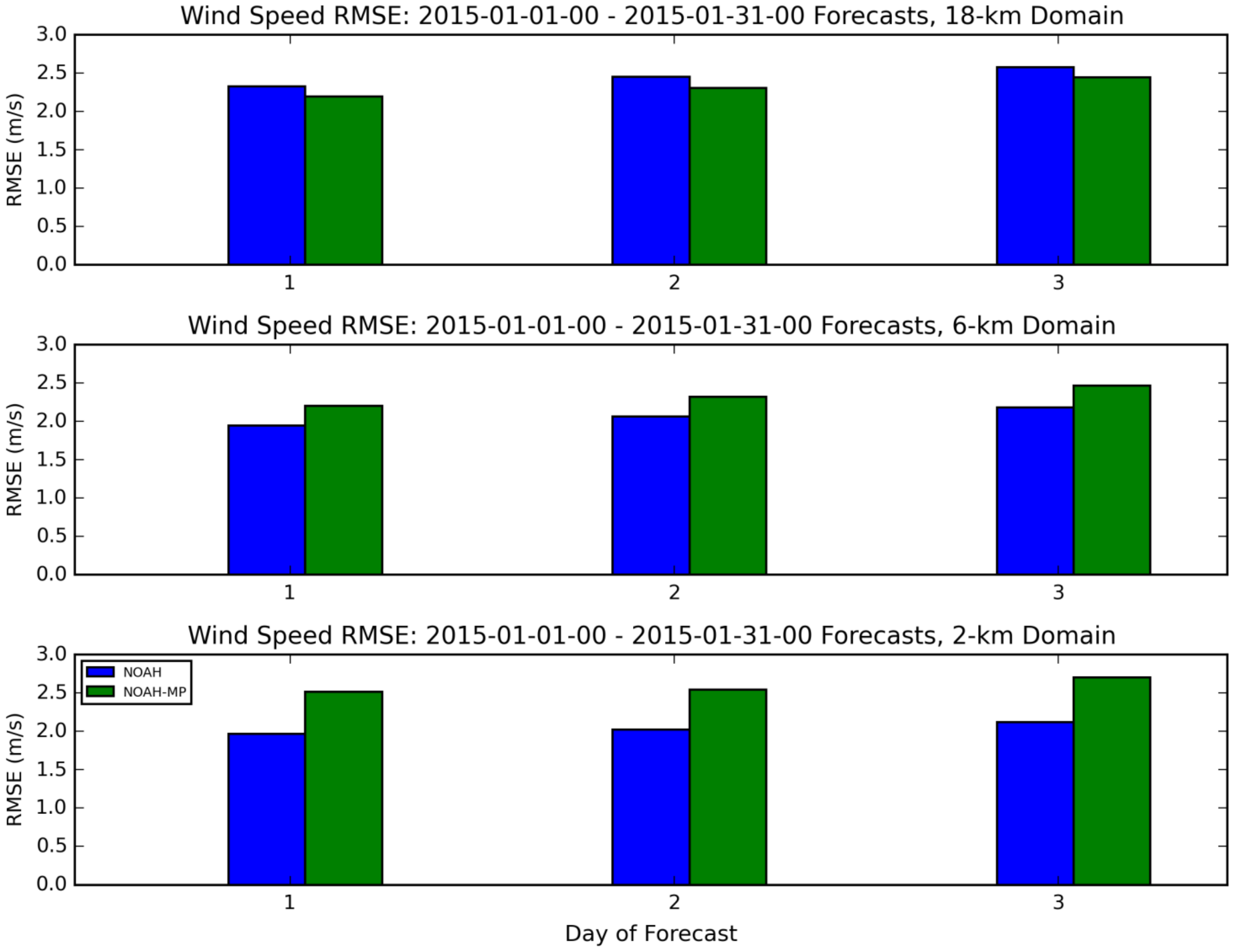


April

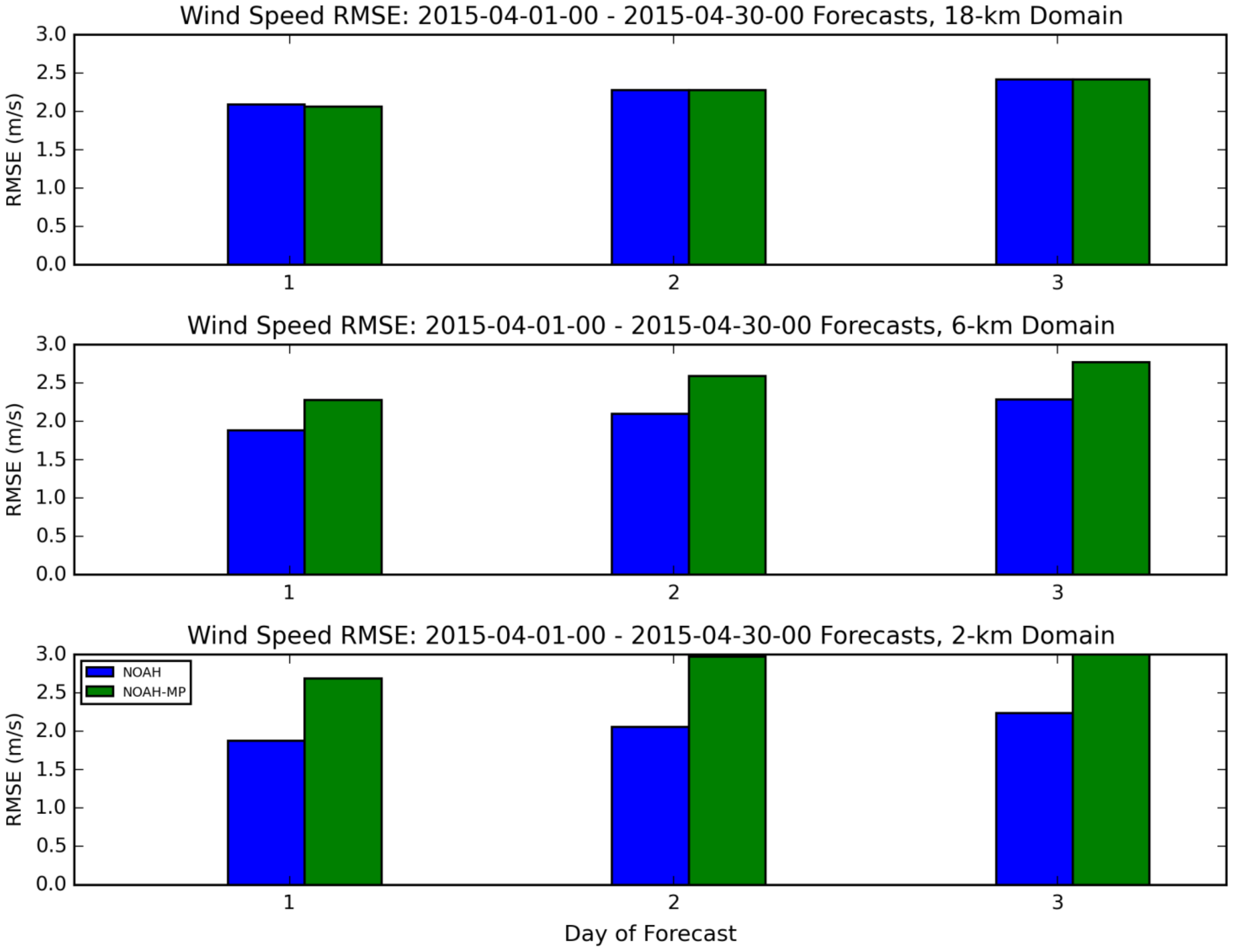


METAR Comparisons: Wind Speed RMSE

January



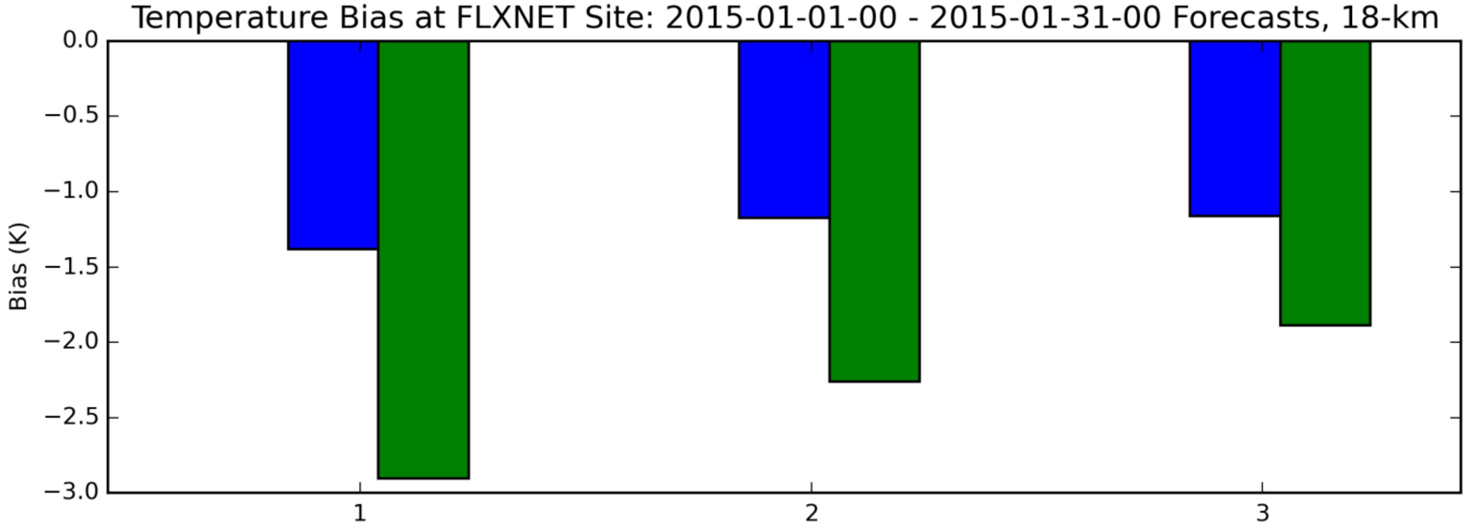
April

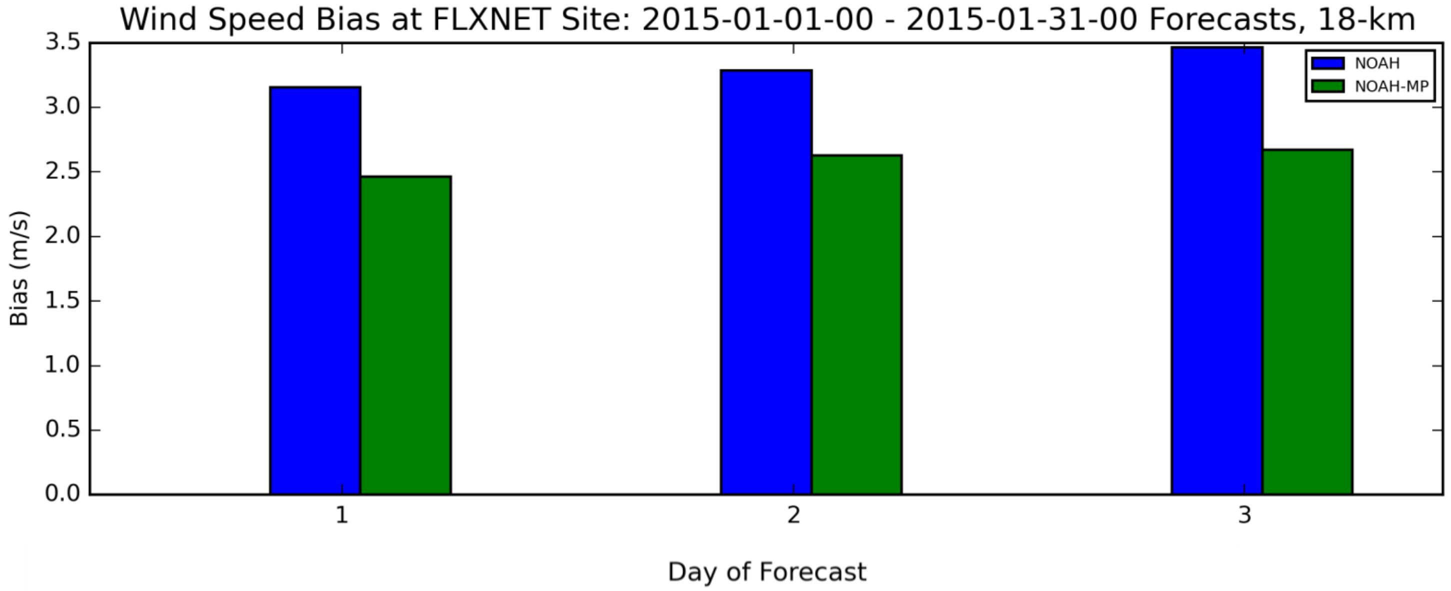


FLXNET: Temperature and Wind Speed

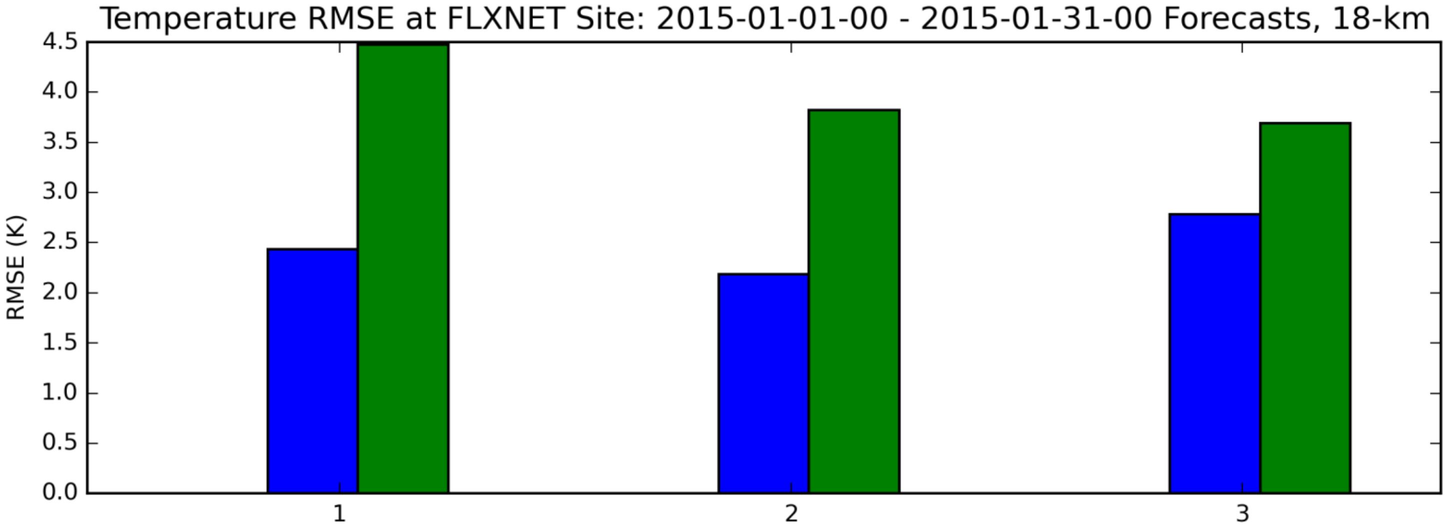
NOAH
NOAH-MP

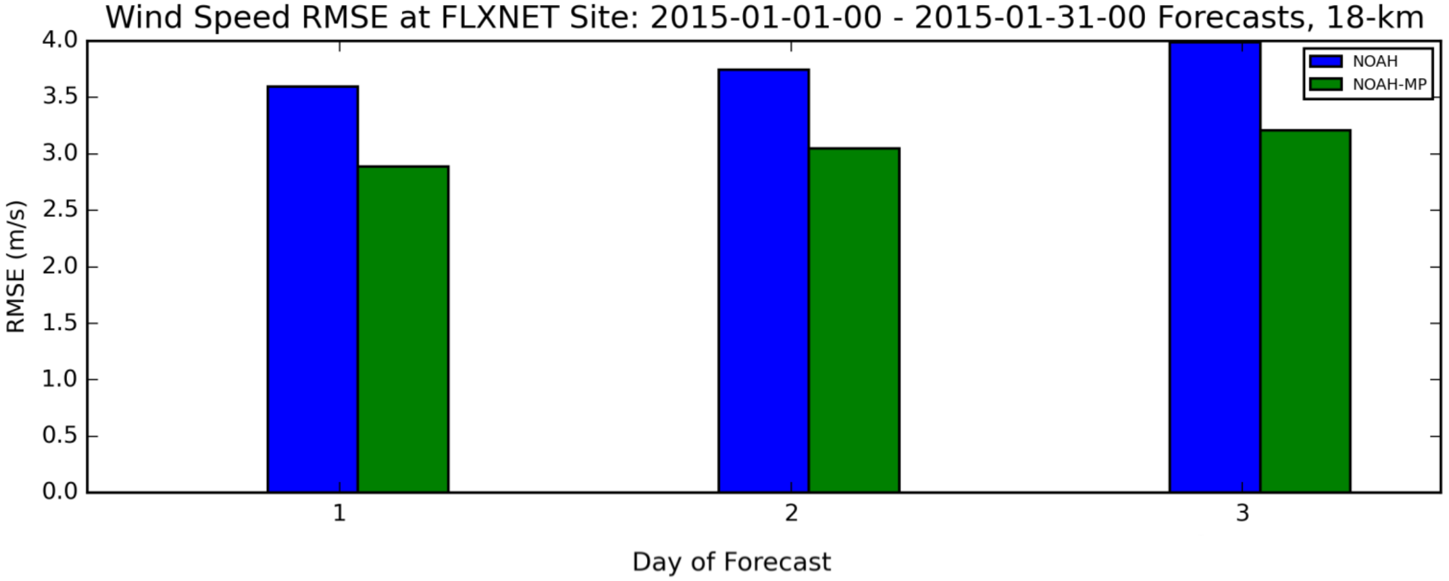
January Bias





January RMSE



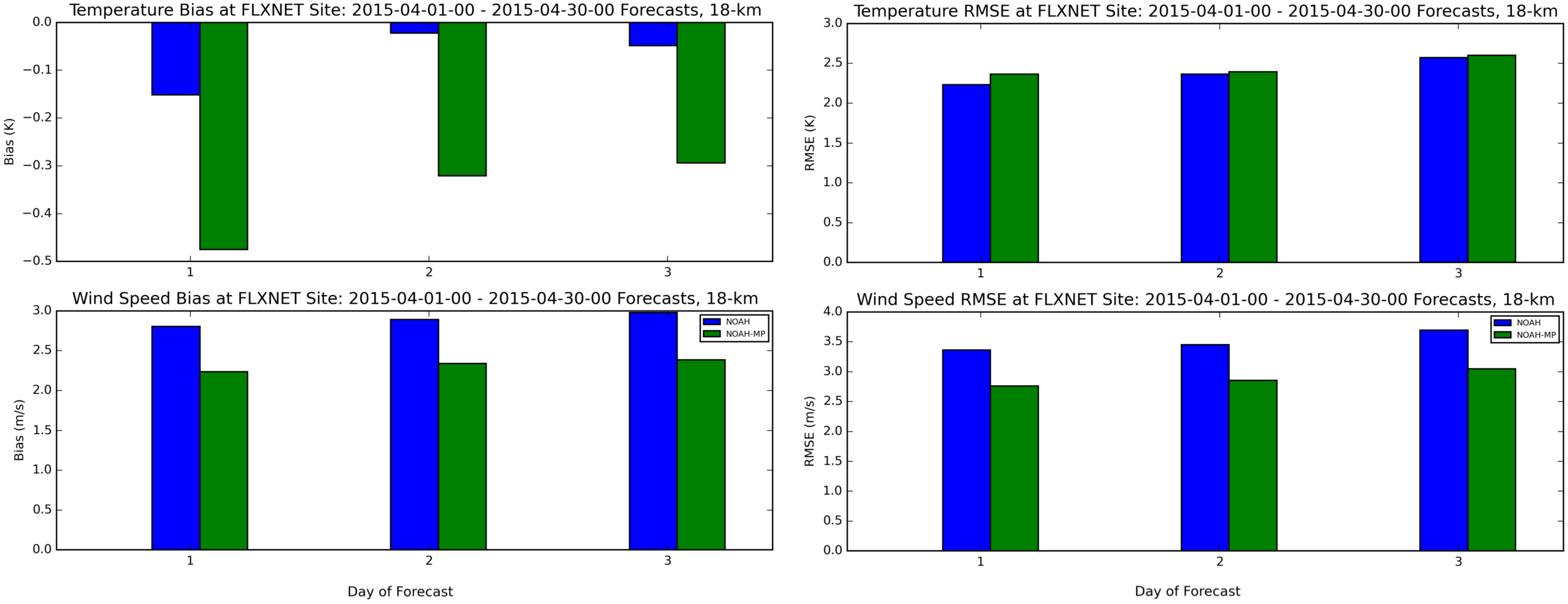


FLXNET: Temperature and Wind Speed

NOAH
NOAH-MP

April Bias

April RMSE



Ongoing and Future Work

- Further investigation of albedo/temperature differences.
- Continue evaluation based on the tuning of NOAH-MP melting parameter.
- Run NOAH-MP offline (HRLDAS) to generate domain-specific initial conditions for MP simulations.
- Configure a domain for a geography which contains additional FLXNET stations, to better understand flux and soil temperature/moisture behavior.
- Verification based on land-use classification.
- Quantitative verification against MODIS LST and SNODAS data.
- Operationalize NOAH-MP ?

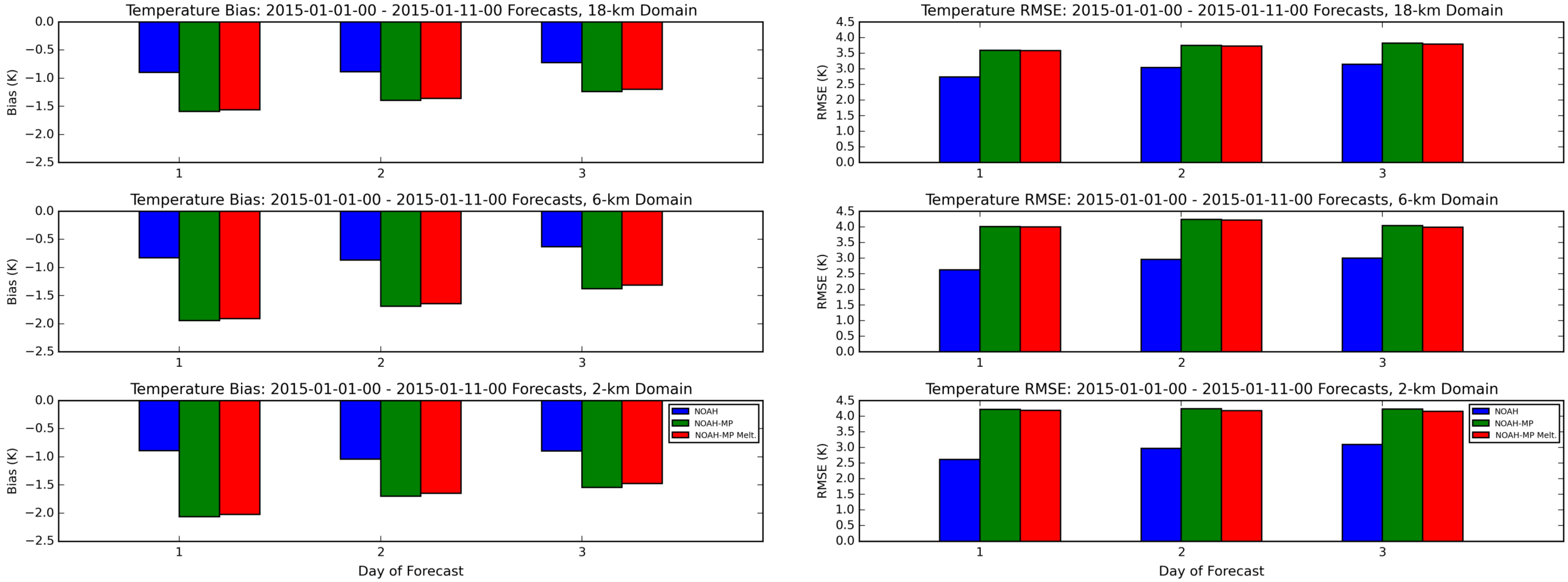
V. Melting Parameter Modification:

If we increase the melting parameter for NOAH-MP, existing snow cover should be reduced at a faster rate.

This may decrease the magnitude of the temperature bias.

Default = “2.5”
Test = “3.0”

Temperature Statistics: 01/01/2015 – 01/11/2015

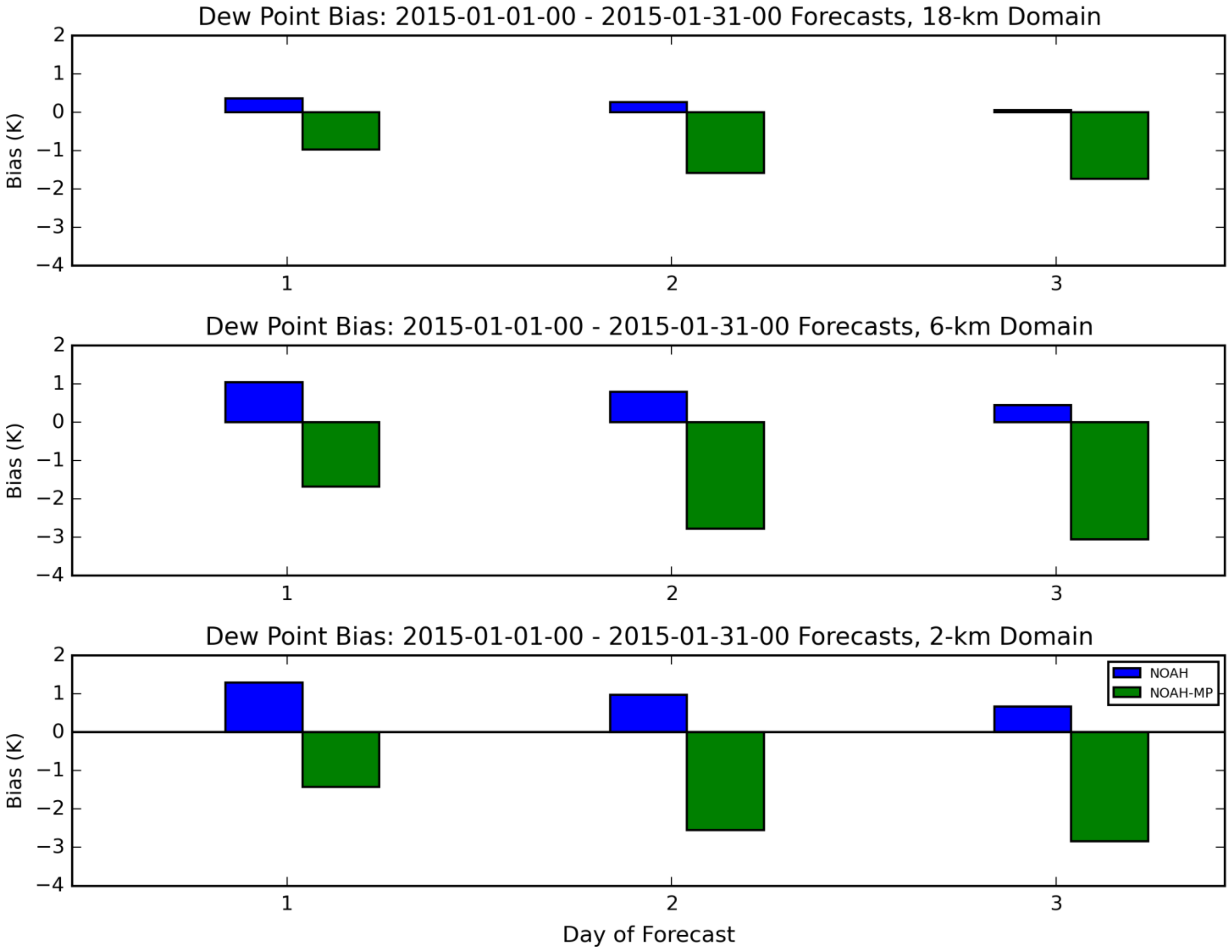


V. Preliminary Thoughts

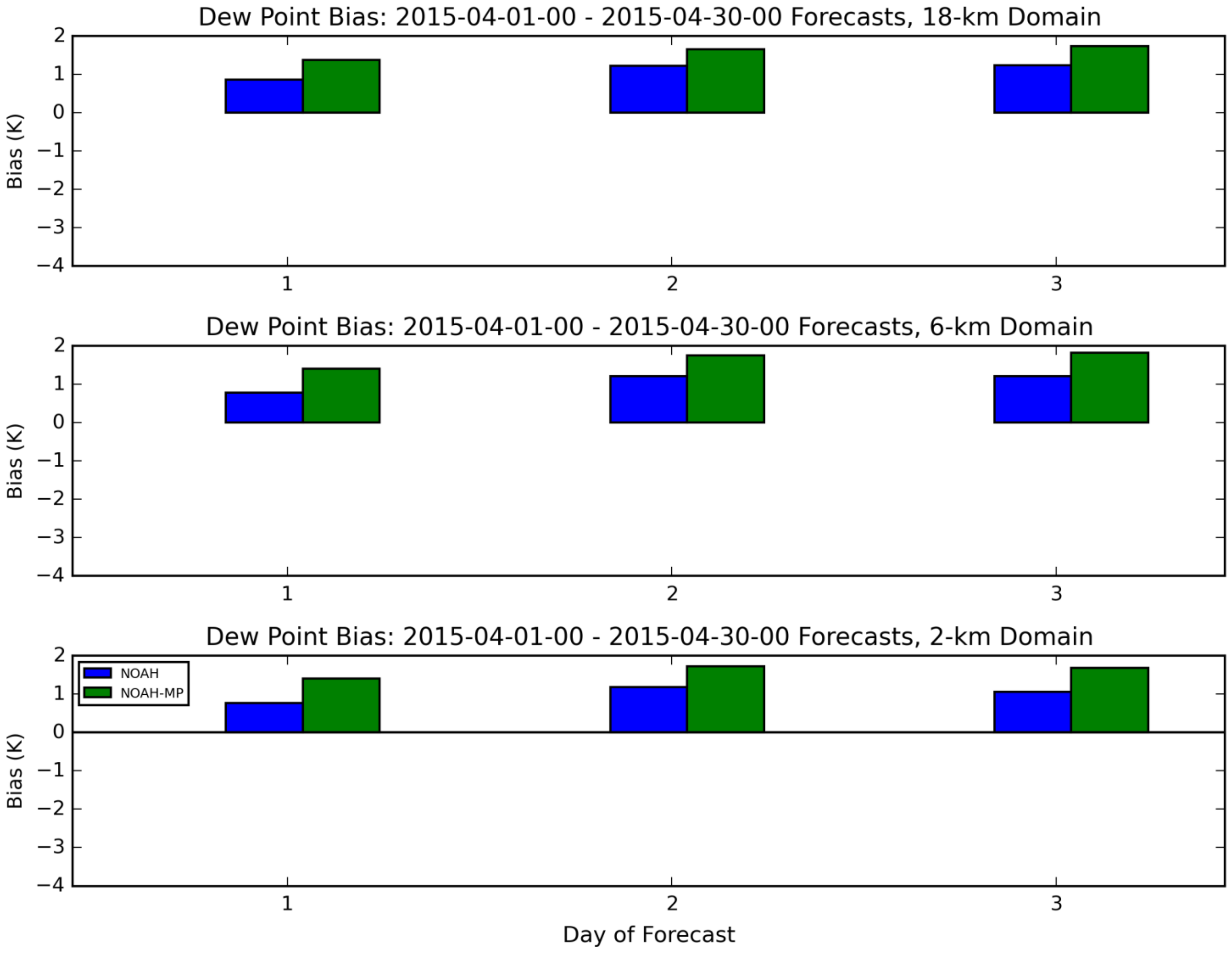
- **Increasing the melting parameter yielded a small decrease in the magnitude of the temperature bias (& RMSE).**
- **There were not enough snow events in the 11-day period for the melting parameter to have a significant impact on model results.**
  - Additional evaluation of snow cases is necessary.

Comparisons Against METARs – Dew Point Bias

January

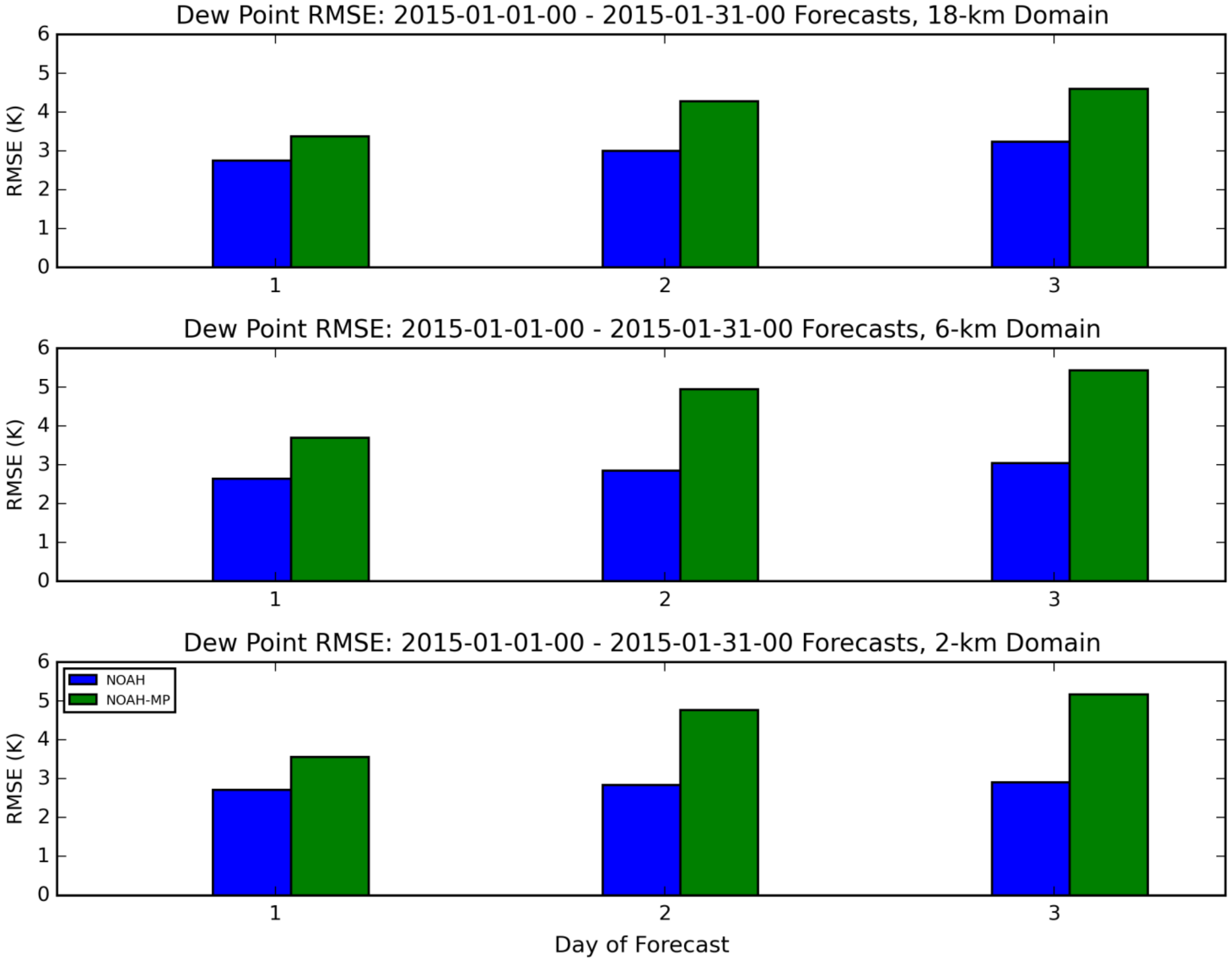


April

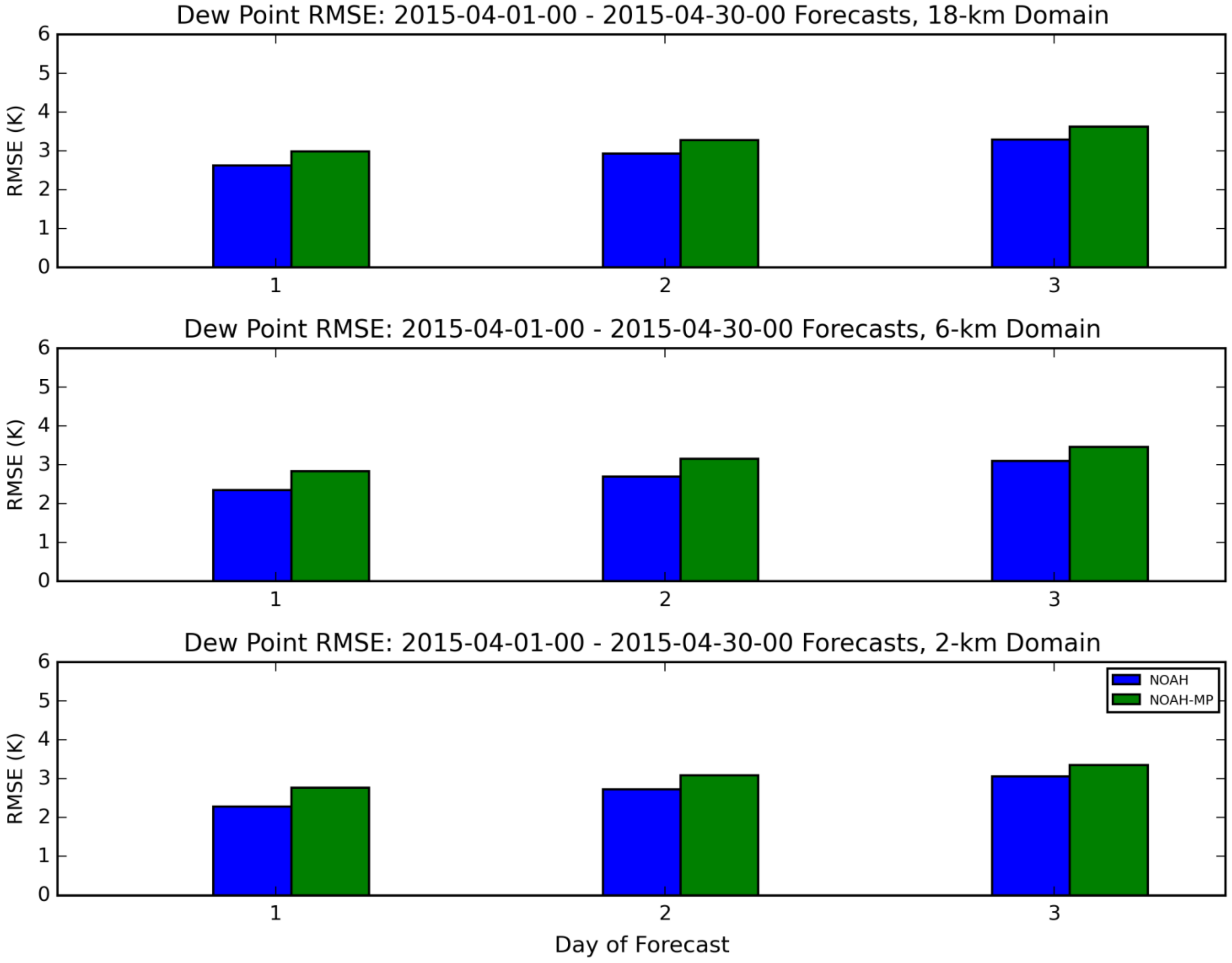


Comparisons Against METARs – Dew Point RMSE

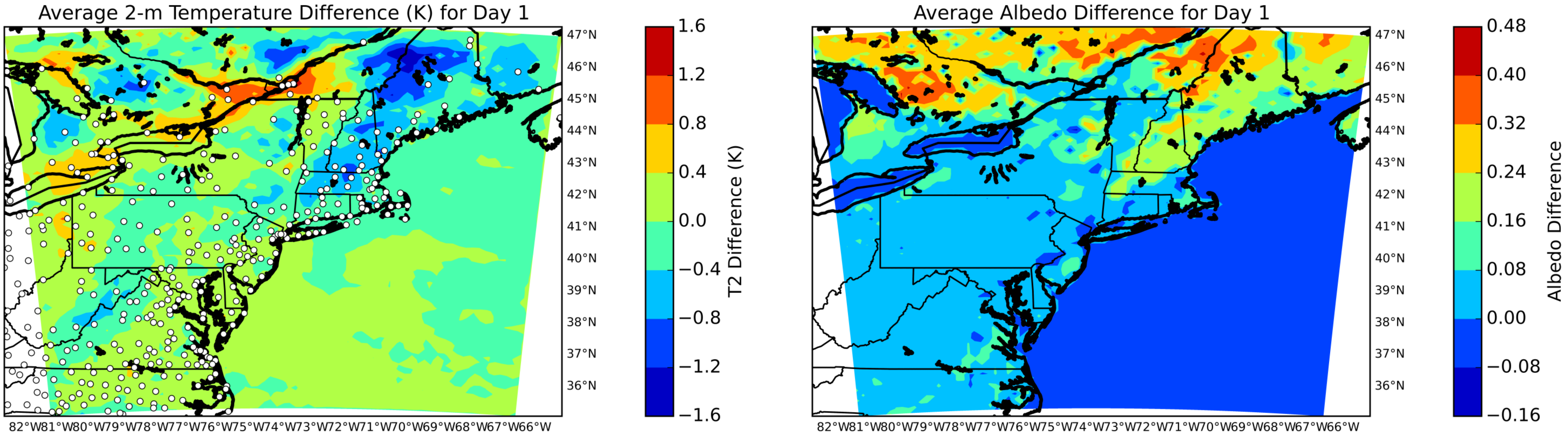
January



April

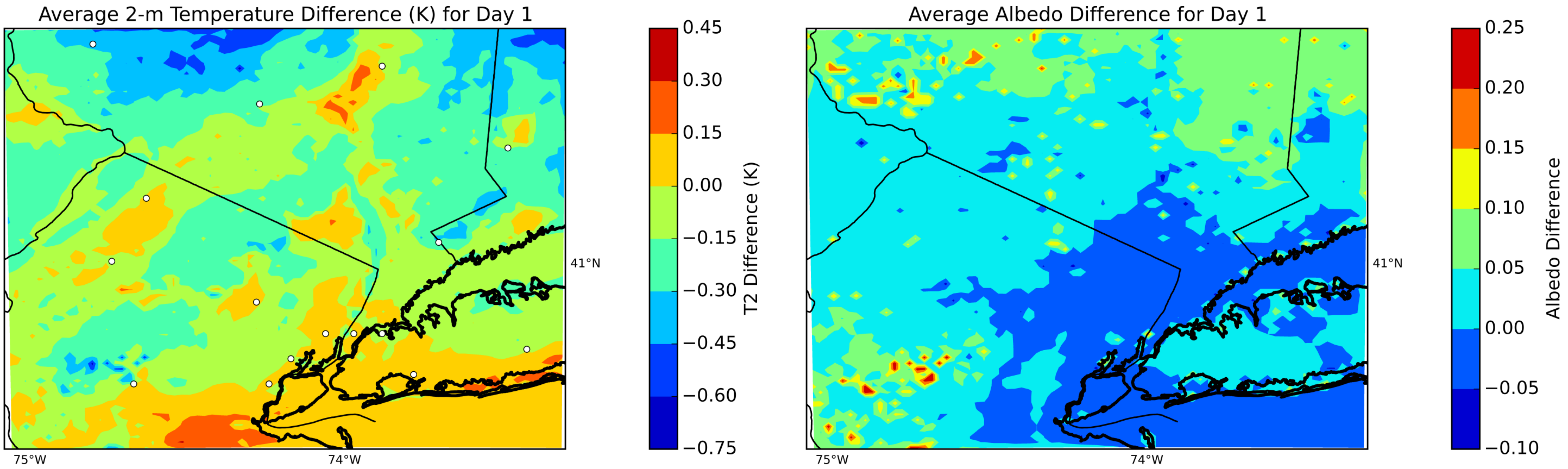


January



- Difference in average T2 and Albedo between NOAH and NOAH-MP simulations.
  - [NOAH – NOAH-MP]
- Outermost (18 km) domain.

January



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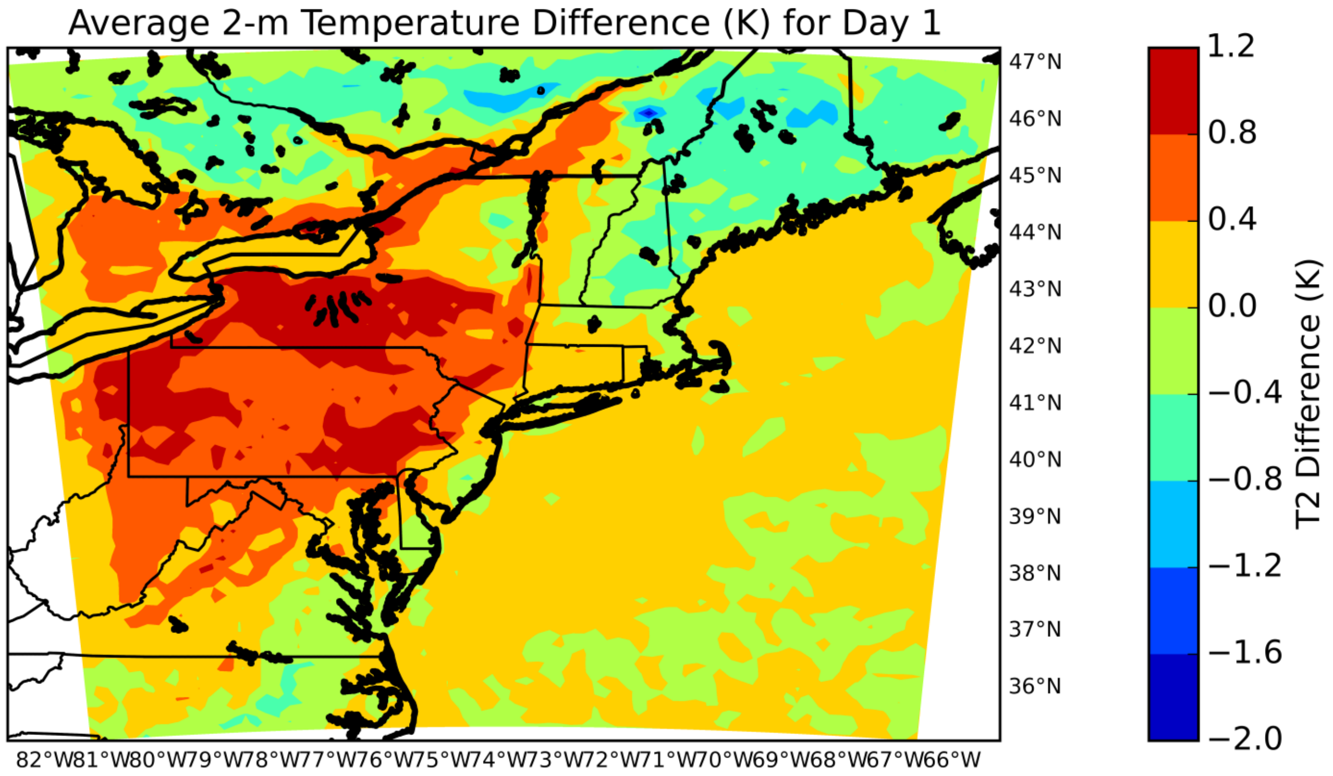
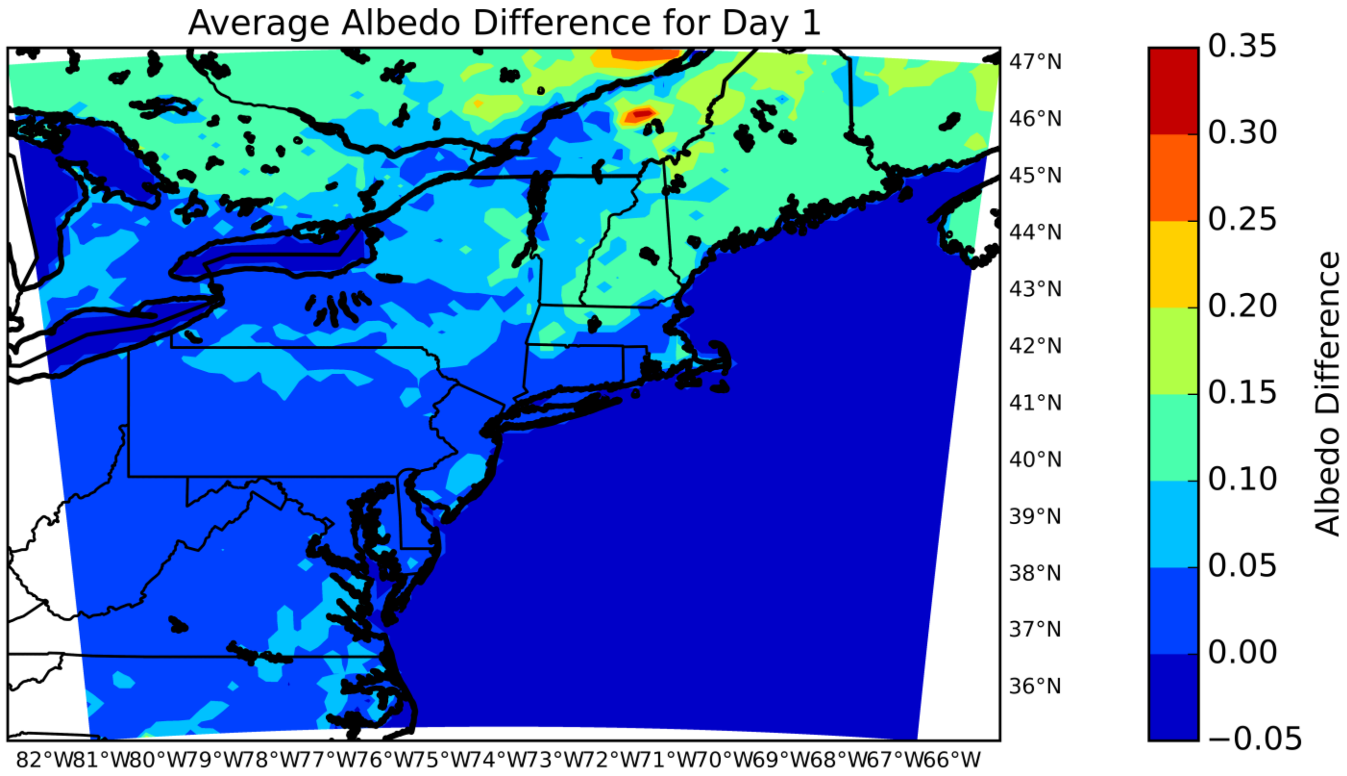
April





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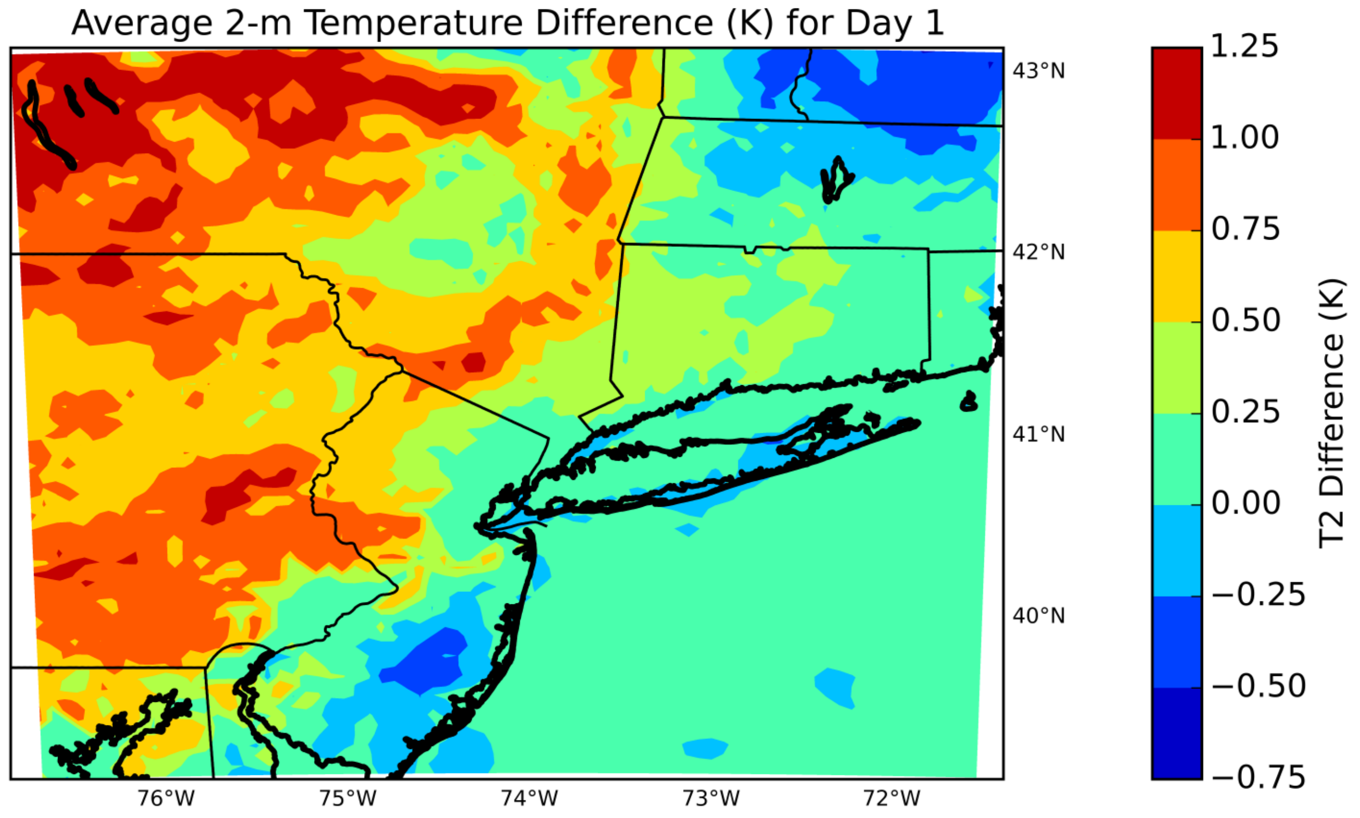
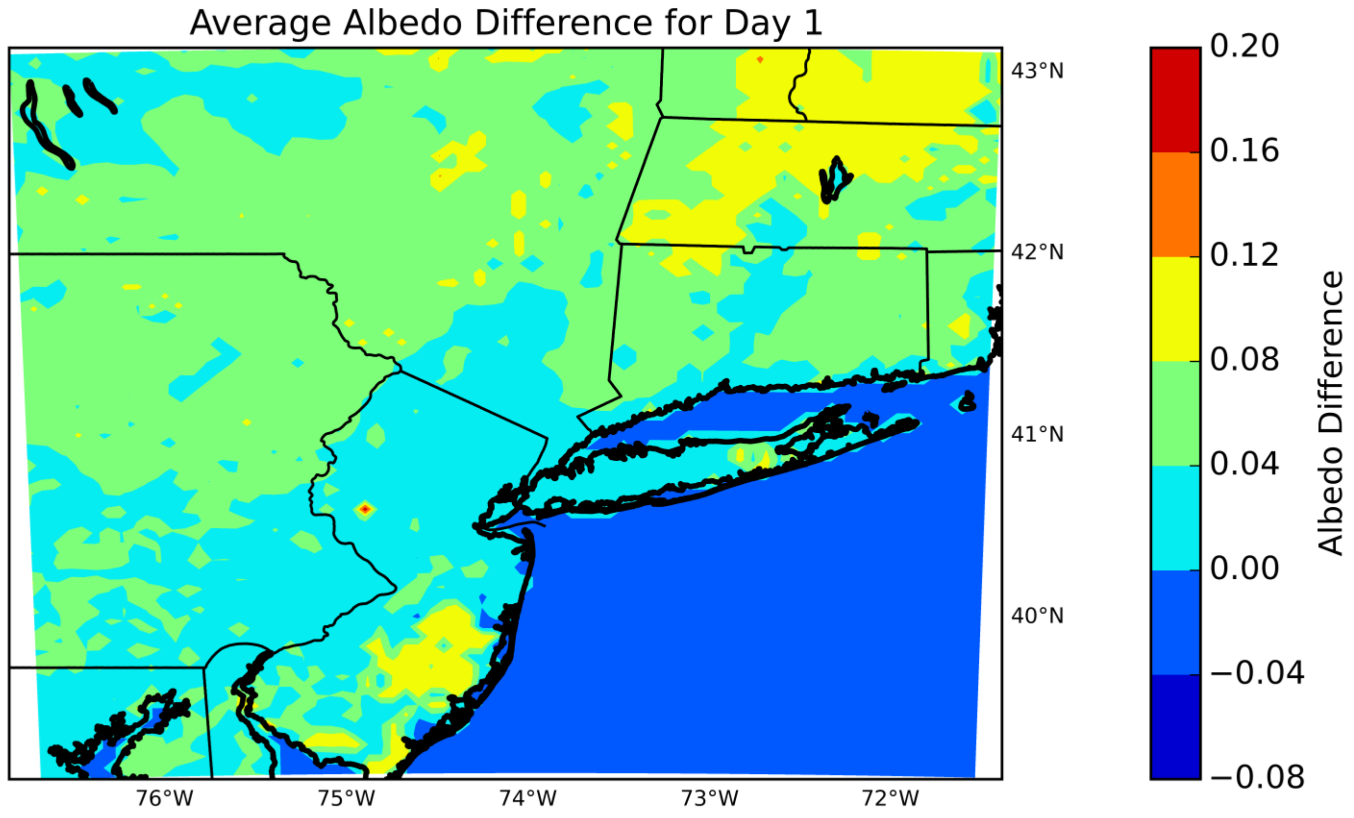
- Outermost (18 km) domain.

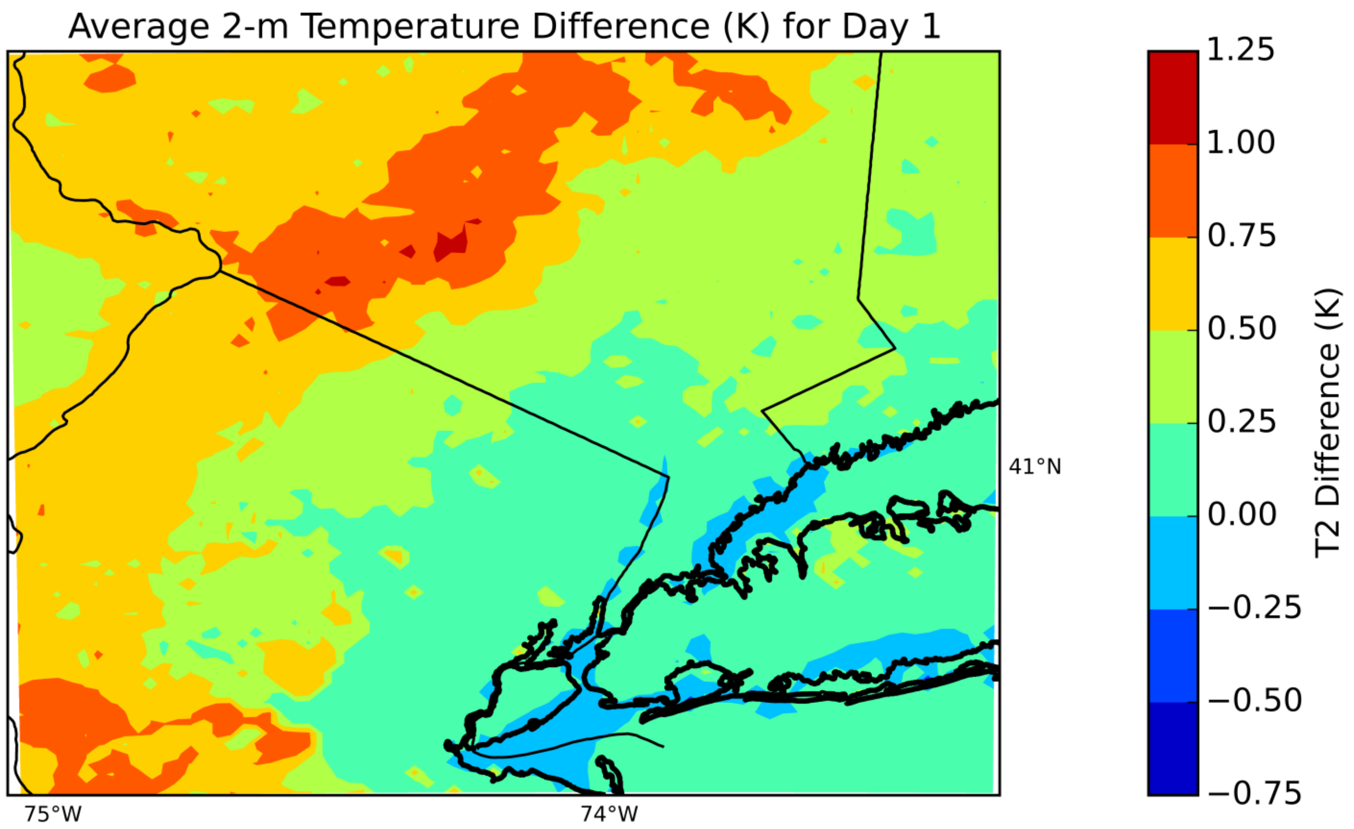
April

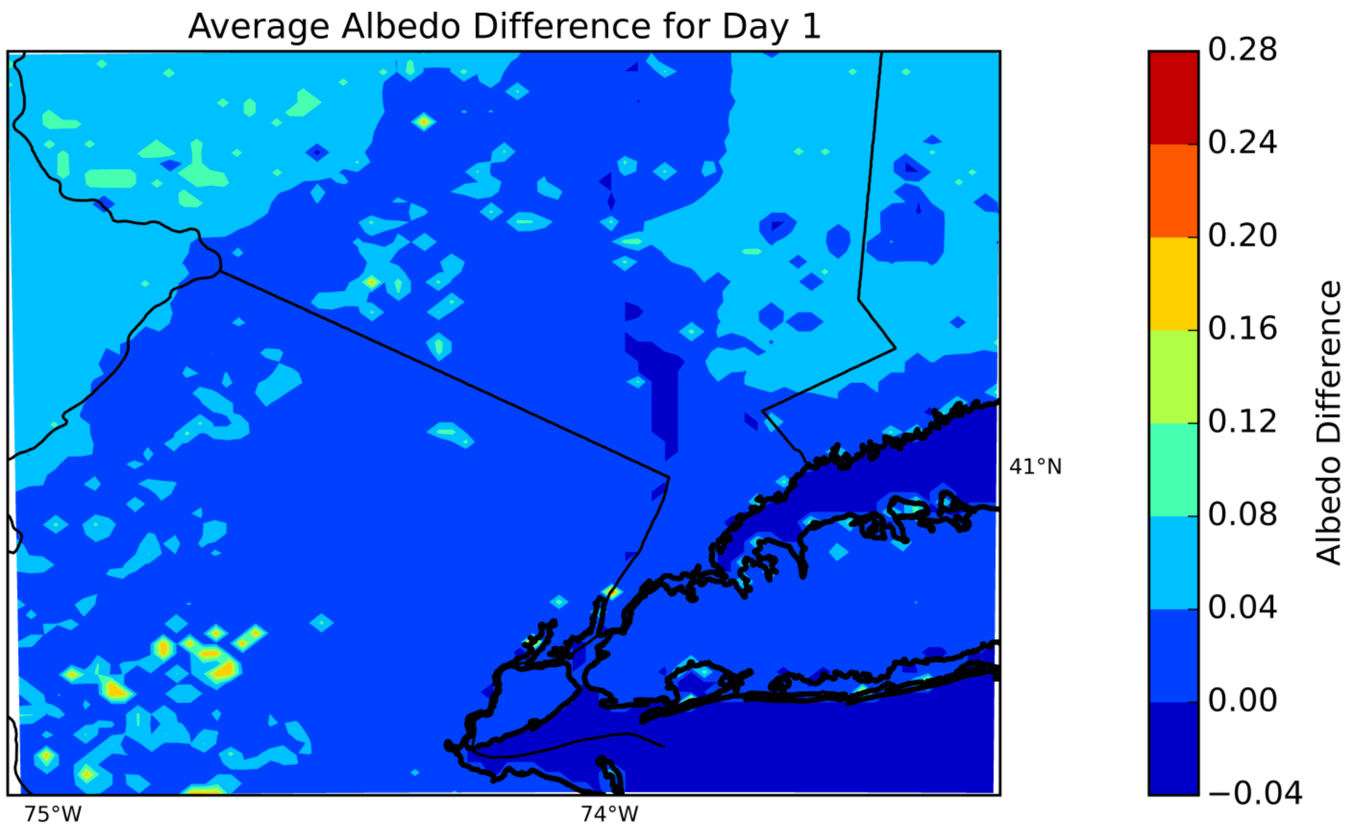




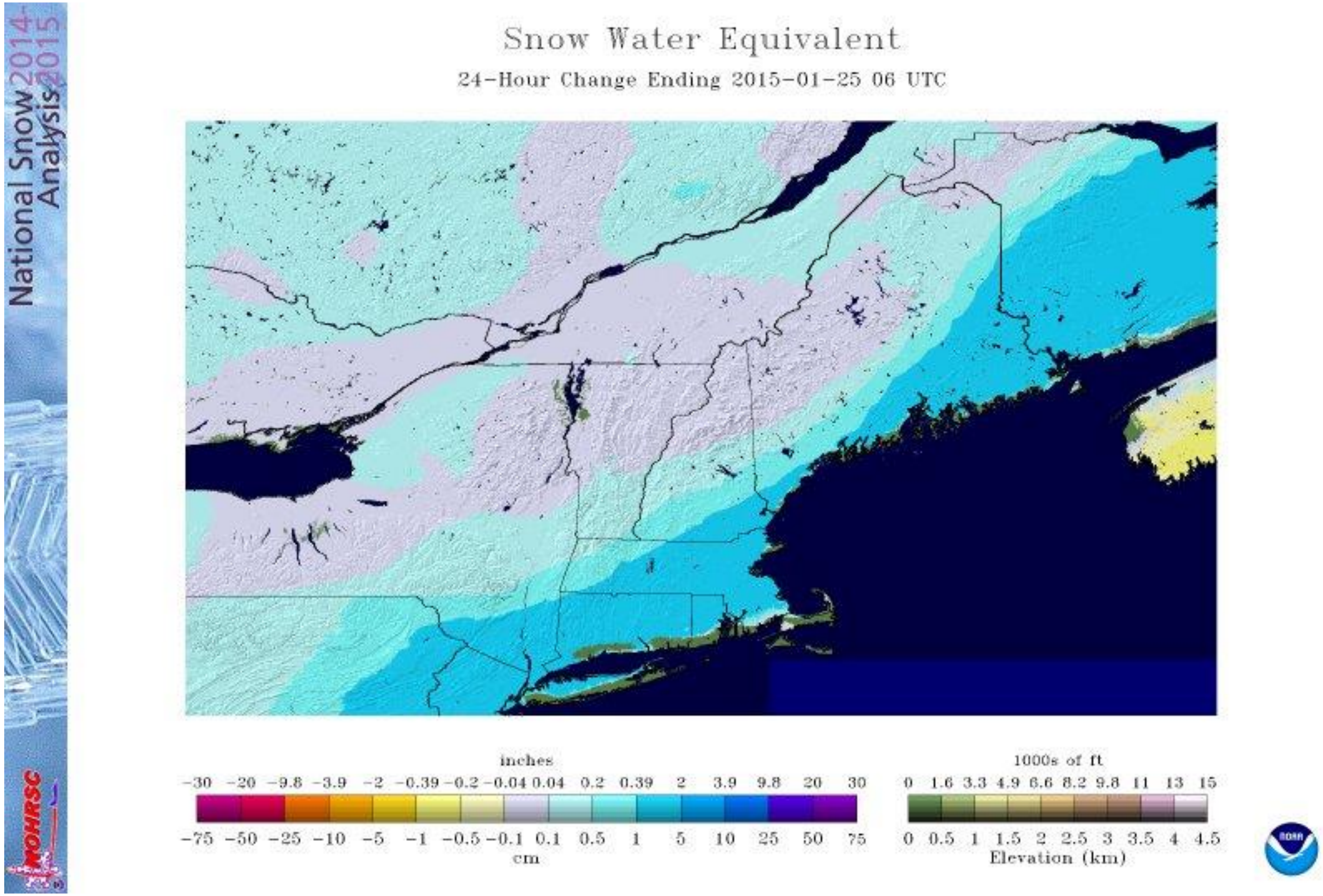
- Difference in average T2 and Albedo between NOAH and NOAH-MP simulations.
  - [NOAH – NOAH-MP]
- Middle (6 km) domain.

April





- Difference in average T2 and Albedo between NOAH and NOAH-MP simulations.
  - [NOAH – NOAH-MP]
- Innermost (2 km) domain.



Courtesy of NOAA NOHRSC (http://www.nohrsc.noaa.gov/nsa/).