Evaluating the Impact of Planetary Boundary Layer, Land Surface Model, and Microphysics Parameterization Schemes on Upper-level Cloud Objects in Simulated GOES-16 Brightness Temperatures

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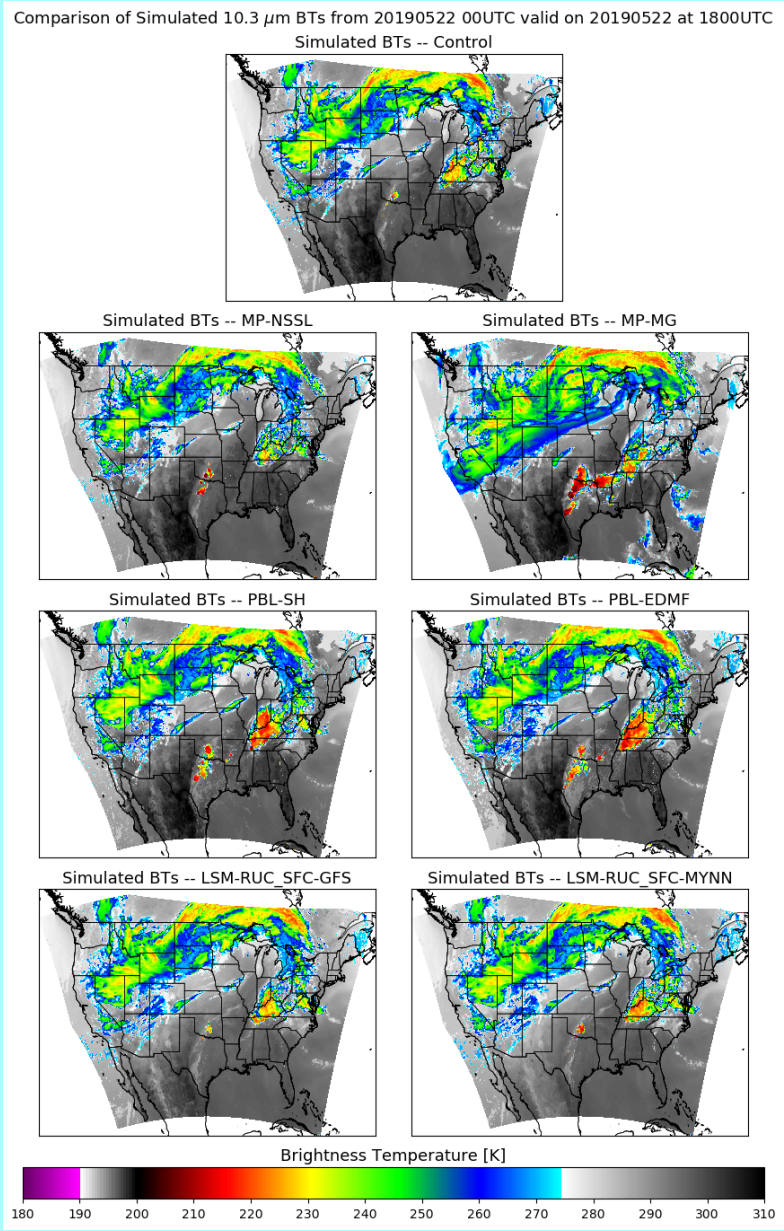
Model Configurations: FV3-LAM

Name	Microphysics Scheme	Planetary Boundary Layer Scheme	Surface Layer	Land Surface Model
Control	Thompson	MYNN	GFS	Noah
MP-NSSL	National Severe Storms Laboratory	MYNN	GFS	Noah
MP-MG	Morrison-Gettelman	MYNN	GFS	Noah
PBL-SH	Thompson	Shin-Hong	GFS	Noah
PBL-EDMF	Thompson	EDMF	GFS	Noah
LSM-RUC_SFC-GFS	Thompson	MYNN	GFS	RUC
LSM-RUC_SFC-MYNN	Thompson	MYNN	MYNN	RUC



Methodology

Utilize Method for Object-Based Diagnostic Evaluation (MODE)

1. Object-based analysis

Object-based Threat Score (OTS) : $OTS = \frac{1}{A_f + A_o}\left[\sum_{p=1}^{P} I^p (a_f^p + a_o^p)\right]$

A_f and A_o : Area of all forecasted and observed objects.
P : number of matched simulated and observation object pairs
I^p : interest score between the matched simulated and observation object
a_f^p and a_o^p : areas of the forecast and observation objects in the matched pair

2. Pixel-based analysis

Mean Absolute Error (MAE): $MAE = \frac{1}{N}\sum_{i=1}^{N}|F_i - O_i|$

Mean Bias Error (MBE): $MBE = \frac{1}{N}\sum_{i=1}^{N}(F_i - O_i)$

F and O : forecast and observation BTs

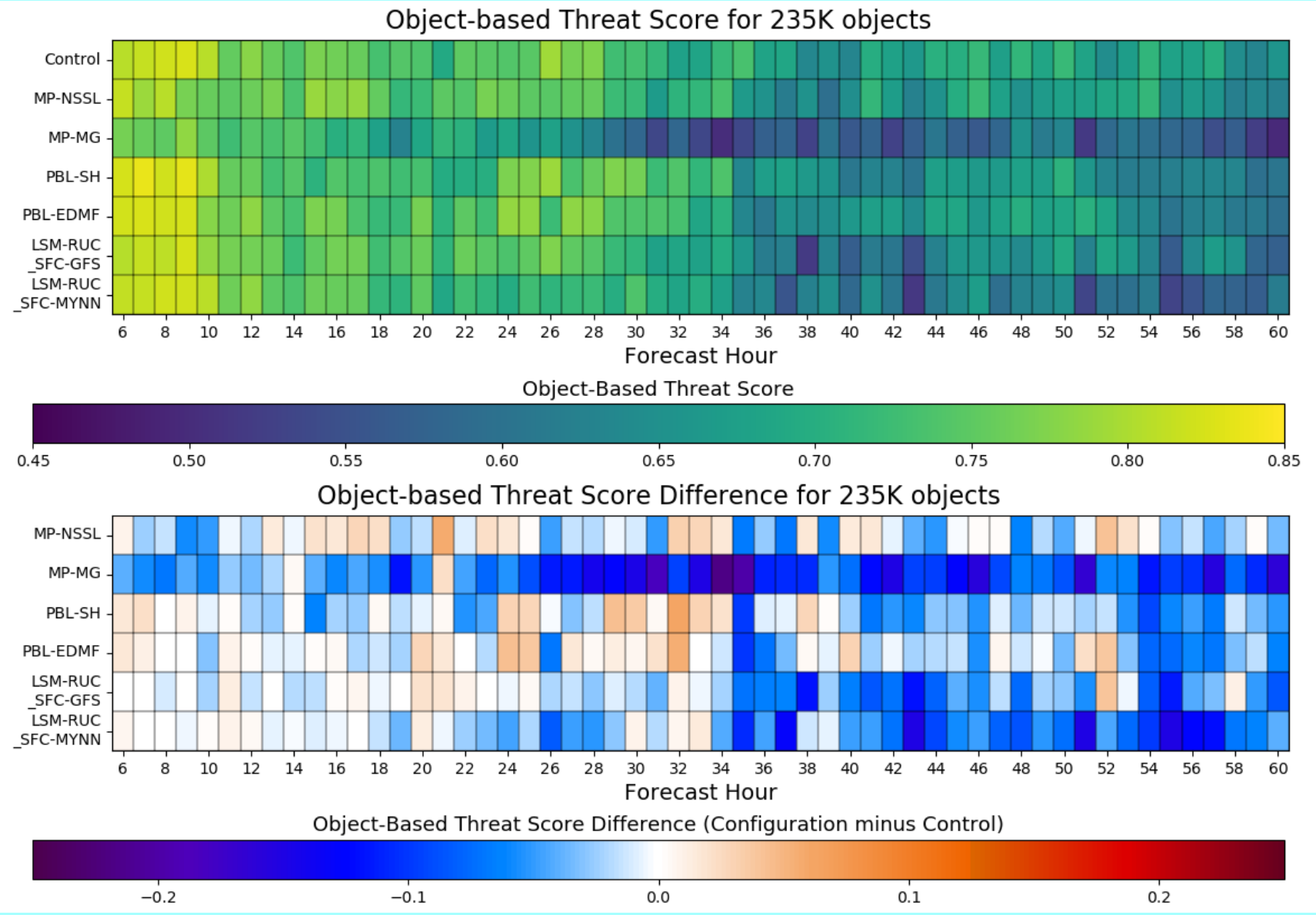
Methodology

Interest Scores: similarity between matching forecast and observation MODE objects

Object Pair Attribute	User-Defined Weight (%)	Description
centroid_dist	4 (25.0)	Distance between objects' "center of mass"
boundary_dist	3 (18.75)	Minimum distance between the objects
convex_hull_dist	1 (6.25)	Minimum distance between the polygons surrounding the objects
angle_diff	1 (6.25)	Orientation angle difference
area_ratio	4 (25.0)	Ratio of the forecast and observation objects' areas (or its reciprocal, whichever yields a lower value)
int_area_ratio	3 (18.75)	Ratio of the objects' intersection area to the lesser of the observation or forecast area (whichever yields a lower value)

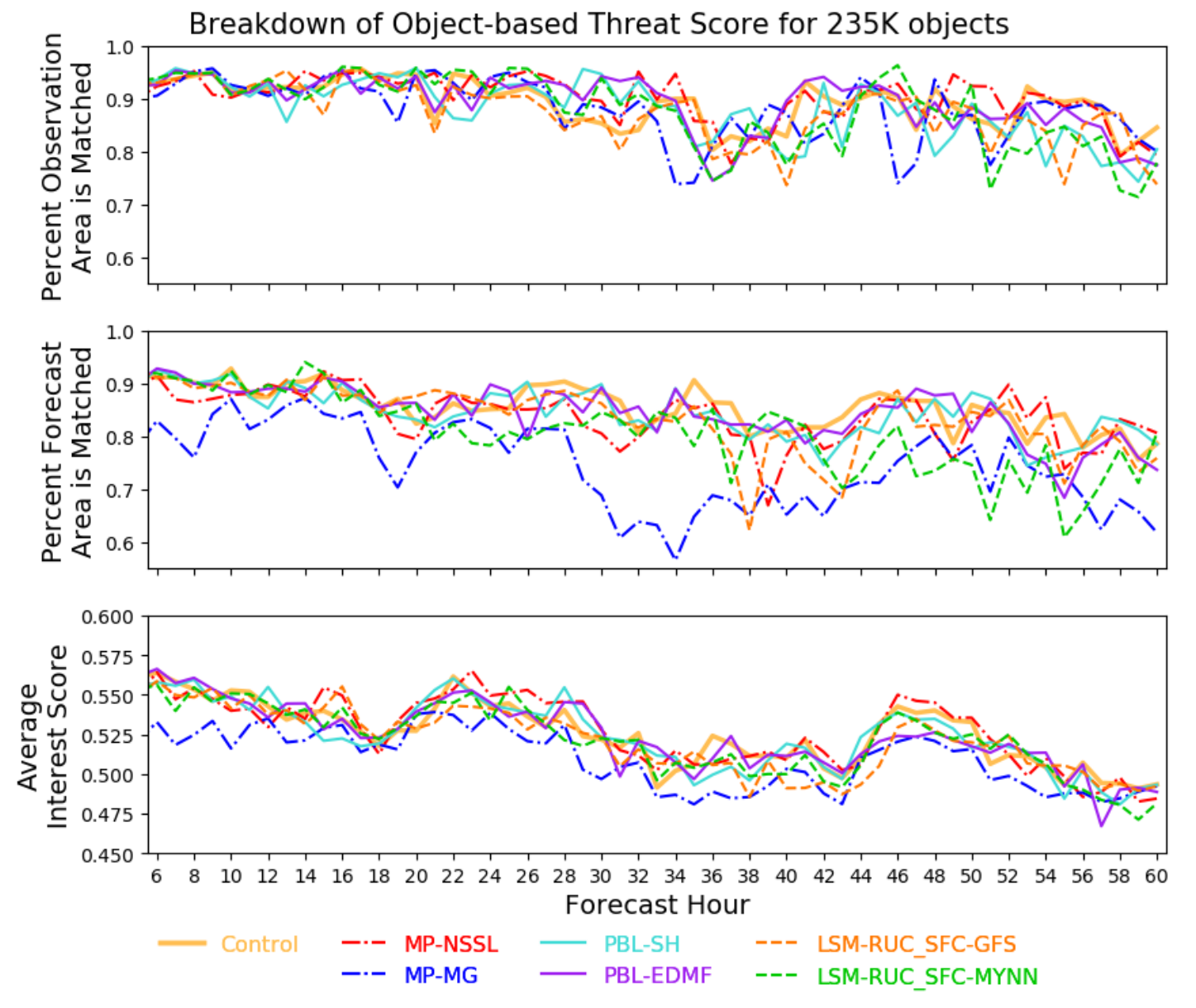
Objects defined using GOES-16 ABI brightness temperatures $\leqq 235$ K

Object-Based Threat Score



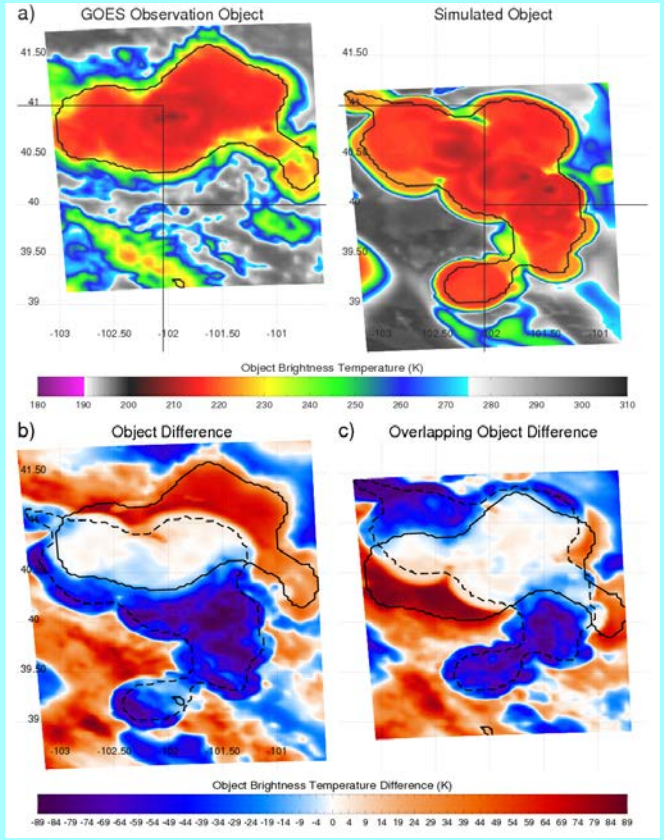
- Control has the highest average OTS.
- MP-MG has the lowest average OTS.
- LSM-RUC_SFC-MYNN has the steepest decline in OTS by forecast hour.
  - Correlated with an increased number of objects
- Parameter changes have a neutral to positive impact on OTS in early FHs compared to Control.

Object-Based Threat Score



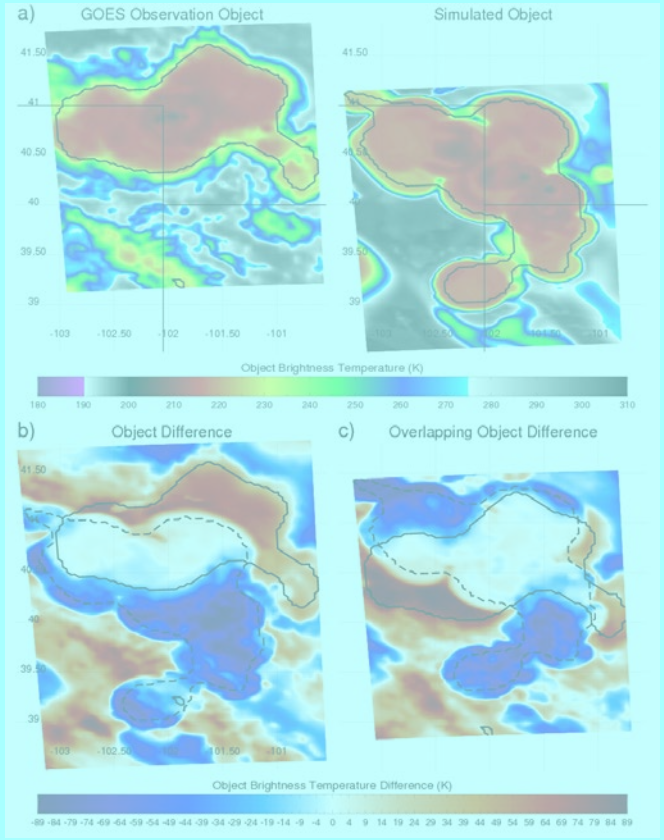
- Similar Percent of Observation Objects matched $(\frac{a_o}{A_o})$
- MP-MG much lower Percent Forecast Objects matched $(\frac{a_f}{A_f})$
  - MP-MG has highest number of objects.
- Local maximum in interest scores due to lower distance between matched objects $(\frac{1}{P}\sum_{p=1}^{P} I^p)$

Pixel-Based Analysis

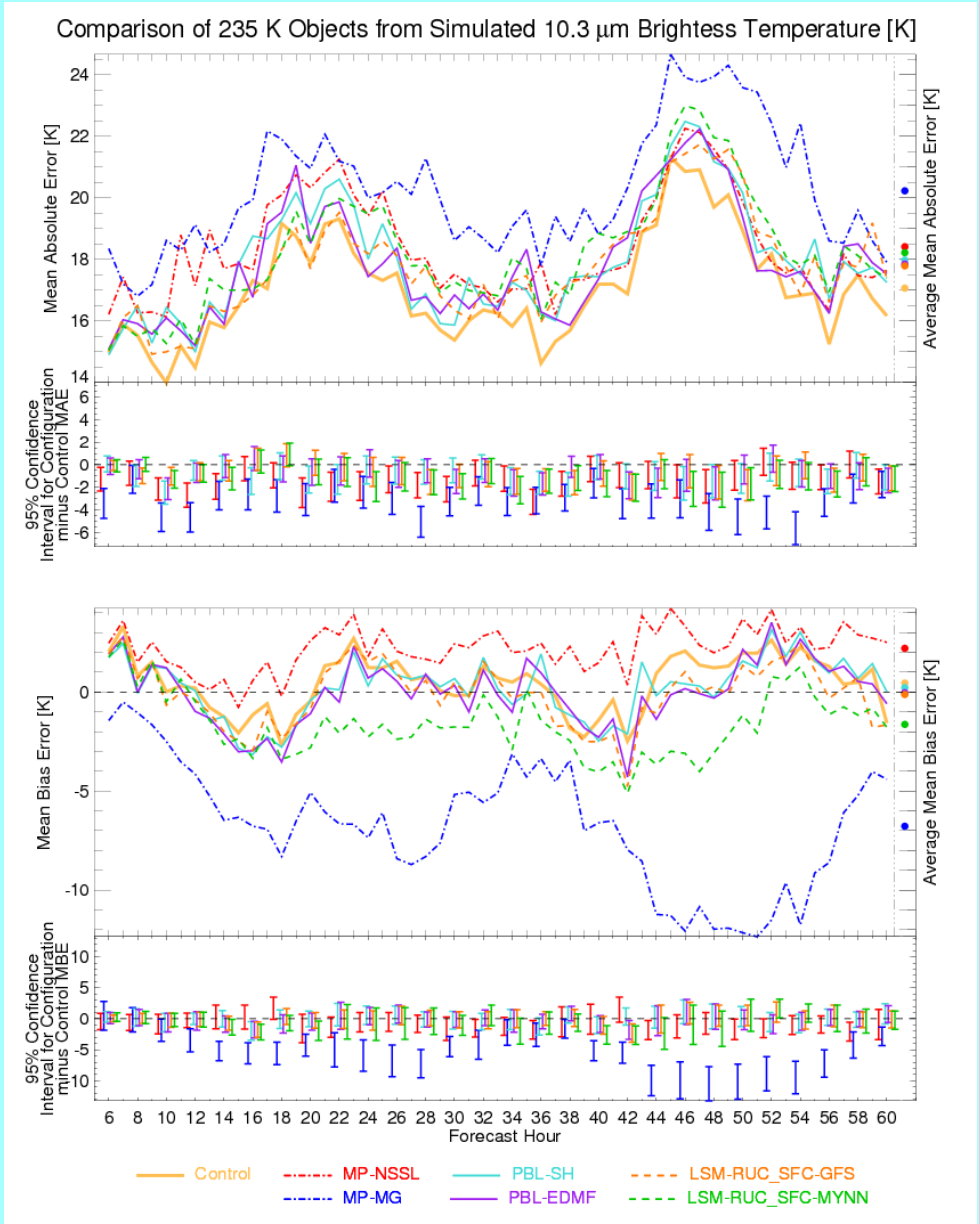


Matched objects are centered like this example.

Pixel-Based Analysis

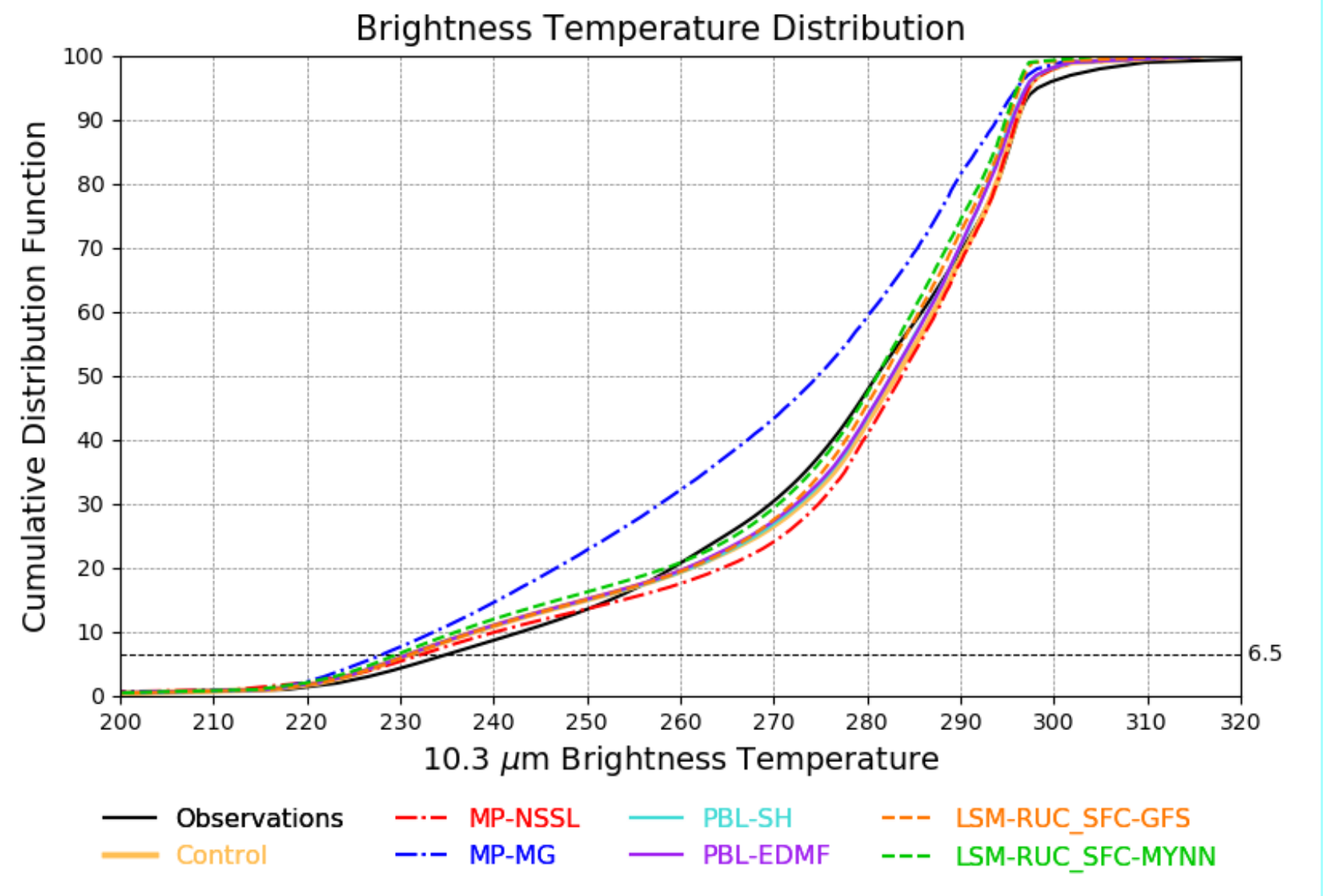


Matched objects are centered like this example.



- Control has the lowest MAE.
  - Most accurate.
- MP-MG has the highest MAE.
  - Lowest MBE.
- MP-NSSL has highest MBE.
- Updating the PBL schemes from MYNN to Shin-Hong/EDMF or LSM to RUC results in less accurate BTs that have a more neutral bias.

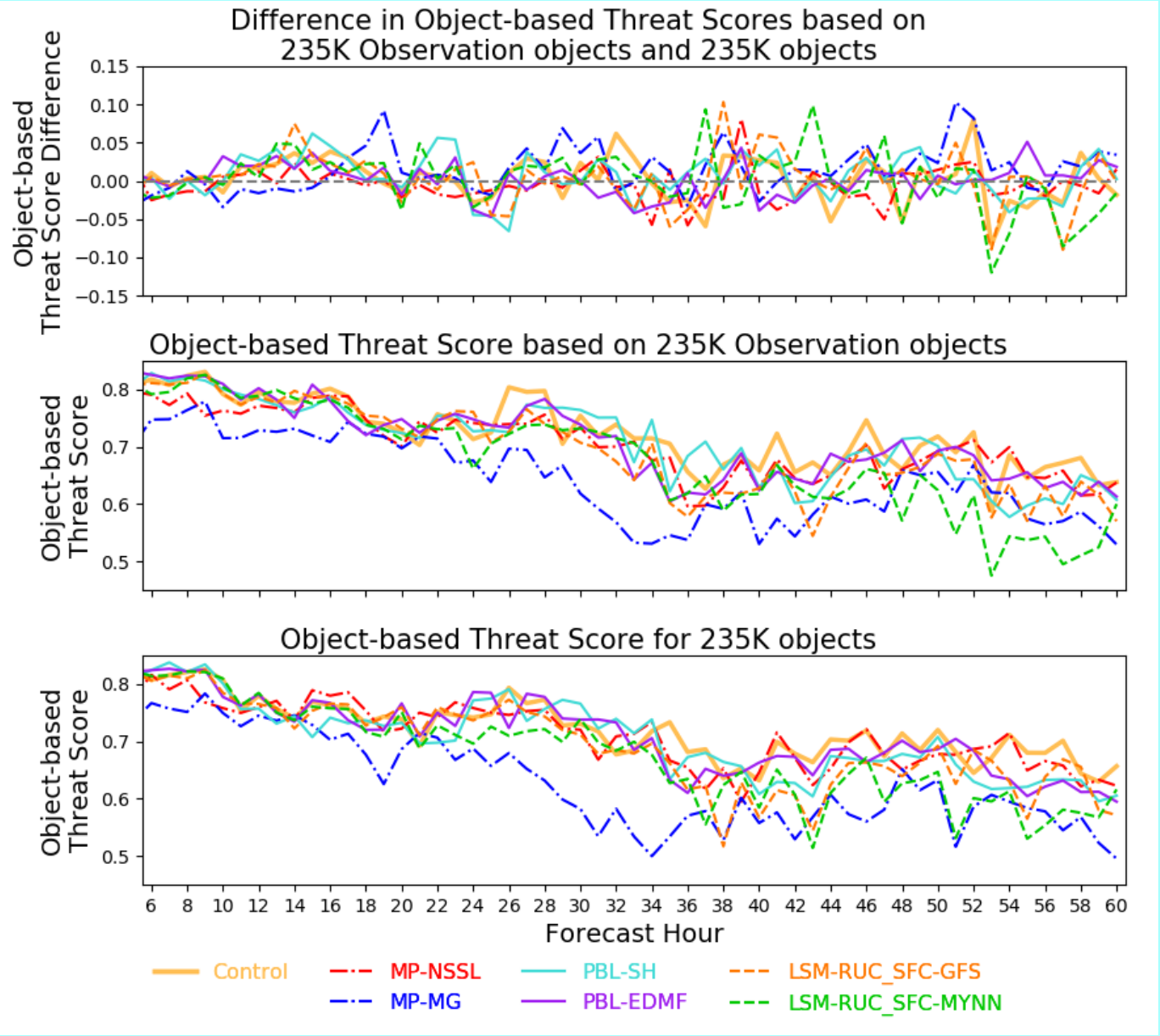
Brightness Temperature Bias



BT corresponding to the 6.5th percentile:

- Observations: 235.0 K
- Control : 231.0 K
- MP-NSSL: 232.3 K
- MG-MG: 228.1 K
- PBL-SH: 230.9 K
- PBL-EDMF: 230.9 K
- LSM-RUC_SFC-GFS: 231.1 K
- LSM-RUC_SFC-MYNN: 229.7 K

OTS comparison



- Overall, the OTS is better when accounting for the BT bias.
- MP-MG still has the lowest OTS.
  - Average Interest Scores between matched object pairs still lowest
- Control has highest OTS
  - Order of accuracy unchanged except MP-NSSL drops from 2nd to 4th.

Conclusions

1. Changing the microphysics scheme from Thompson:
- Morrison-Gettelman results in lower BTs, which are overall less accurate.
- NSSL results in higher BTs, which are also less accurate.

2. Changing the PBL scheme from MYNN:
- reduces the high BT bias, though the BTs are less accurate based on the OTS and MAE.

3. Updates to the surface also reduce the accuracy of simulated BTs.

4. Accounting for model bias when calculating the OTS does not impact the relative performance of each model configuration.