An Evaluation of Vertical Thermodynamic Profiles and Derived Stability Parameters from Parallel FV3- and Spectral-Model GFS Forecasts

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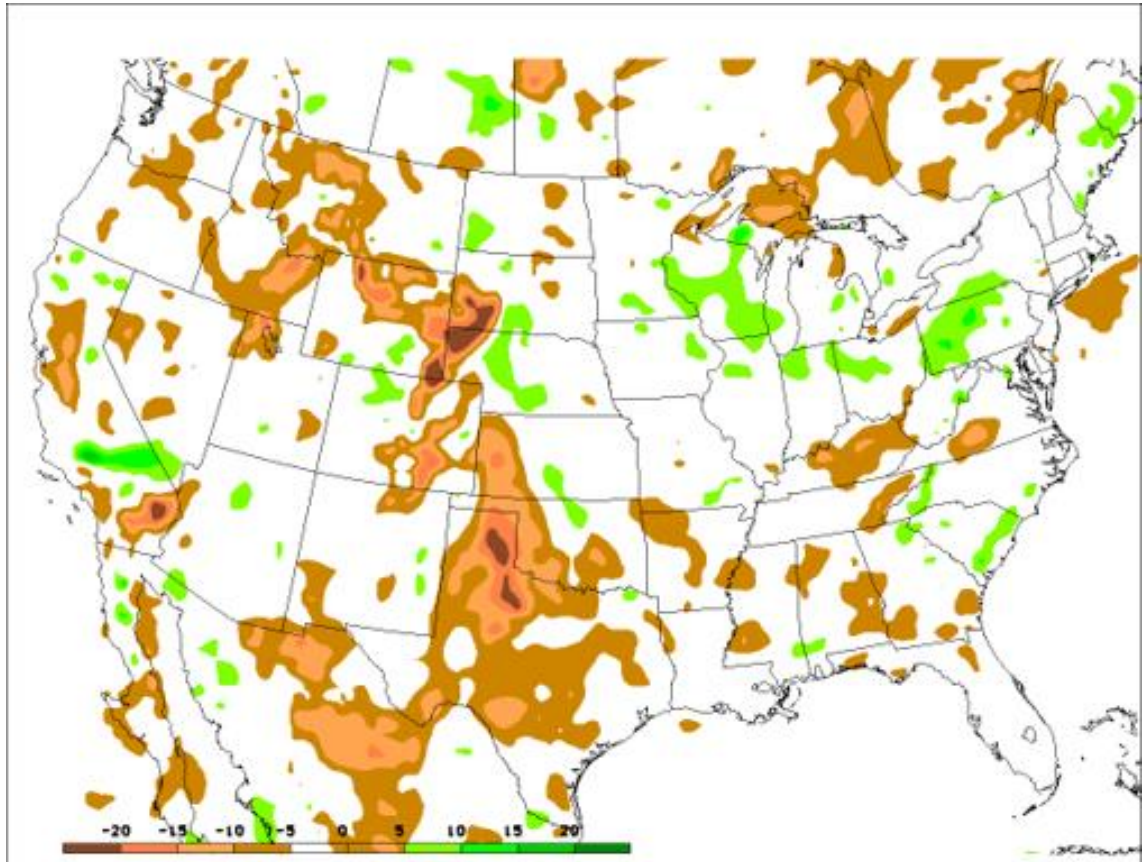
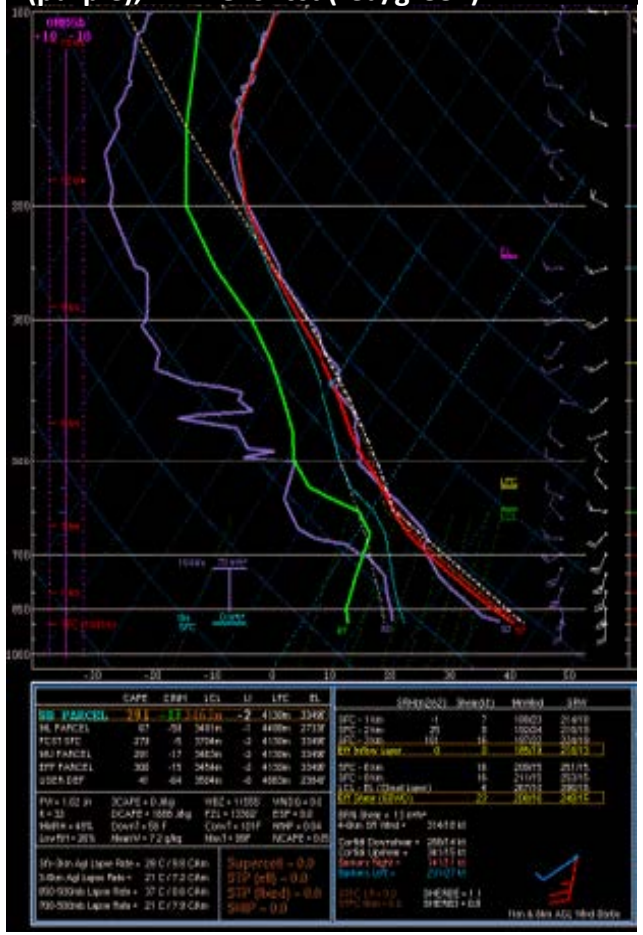
Motivation



2100 UTC 16 July 2016 2-m T_d bias (obs – 21-h GFS fcst; °F)

Amarillo, TX 0000 UTC 17 July 2016 – obs (purple), 24-h GFS fcst (red/green)



Previous GFS (v14) had issues in continental environments:

- Boundary layer too warm+dry in warm-season thunderstorm environments
- More broadly, however, it can be too cool and moist (Han et al. 2016)

Hypothesis

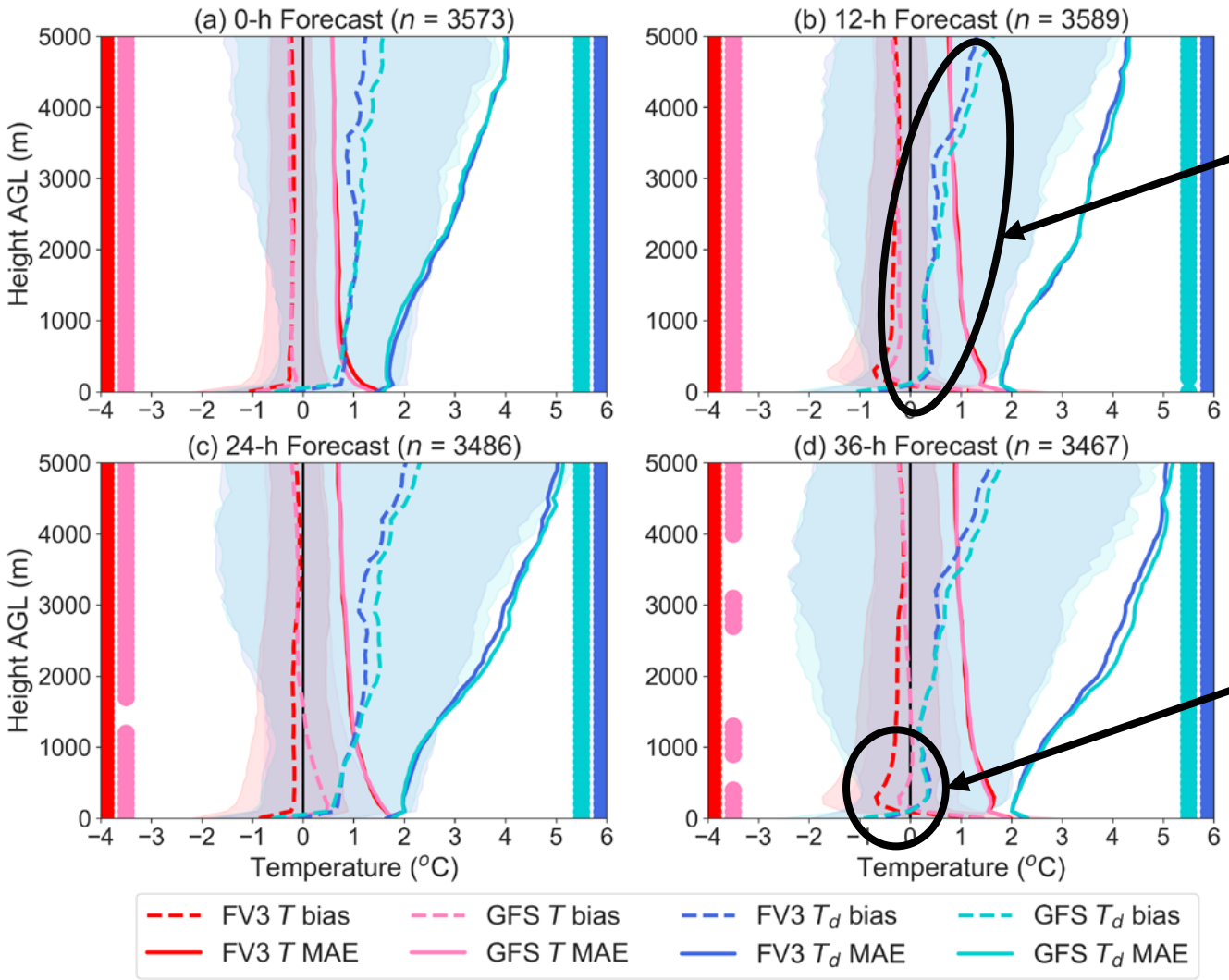
The FV3 will have similar issues to the previous GFS because the dynamical core update does not adequately address boundary layer processes that lead to issues in the continental warm-season, thunderstorm-supporting environments.

Methods

- We evaluate model-forecast vertical profiles from the spectral (v14) and FV3 (v15.1) GFS versions during the May-June 2019 parallel period.
  - Forecast cycles considered: 0000 and 1200 UTC
  - Forecast lead-times considered: 0-, 12-, 24-, and 36-h
  - Focus given to profiles in thunderstorm- and fire-supporting environments

- Caveat: data assimilation is tied to the spectral version of the GFS; this ensures a consistent initial analysis but introduces biases from the spectral model to the finite-volume forecasts.

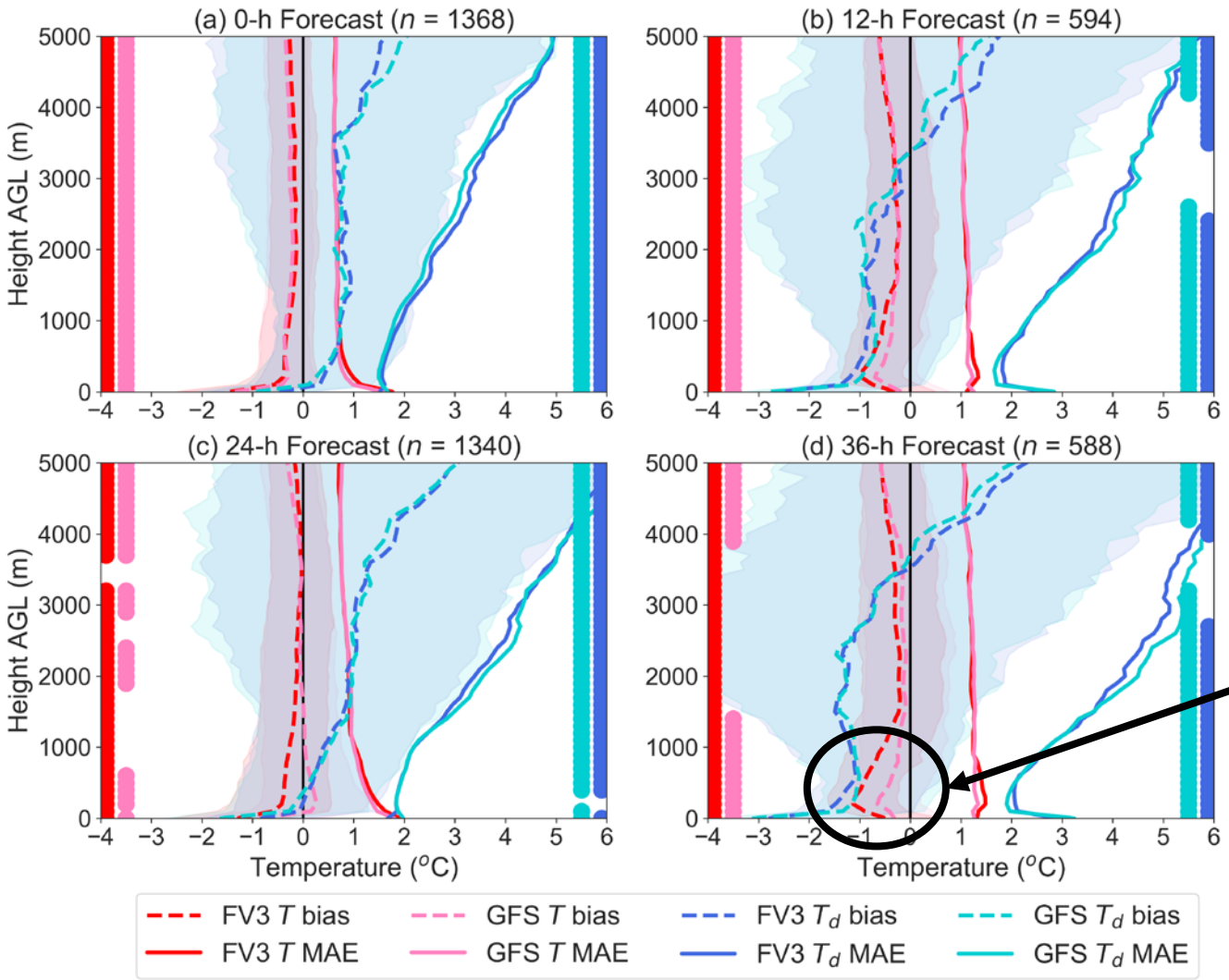
Results: 0000 UTC Initializations



Moist bias in the entire vertical profile in both versions

Cold bias near the surface in the finite-volume core

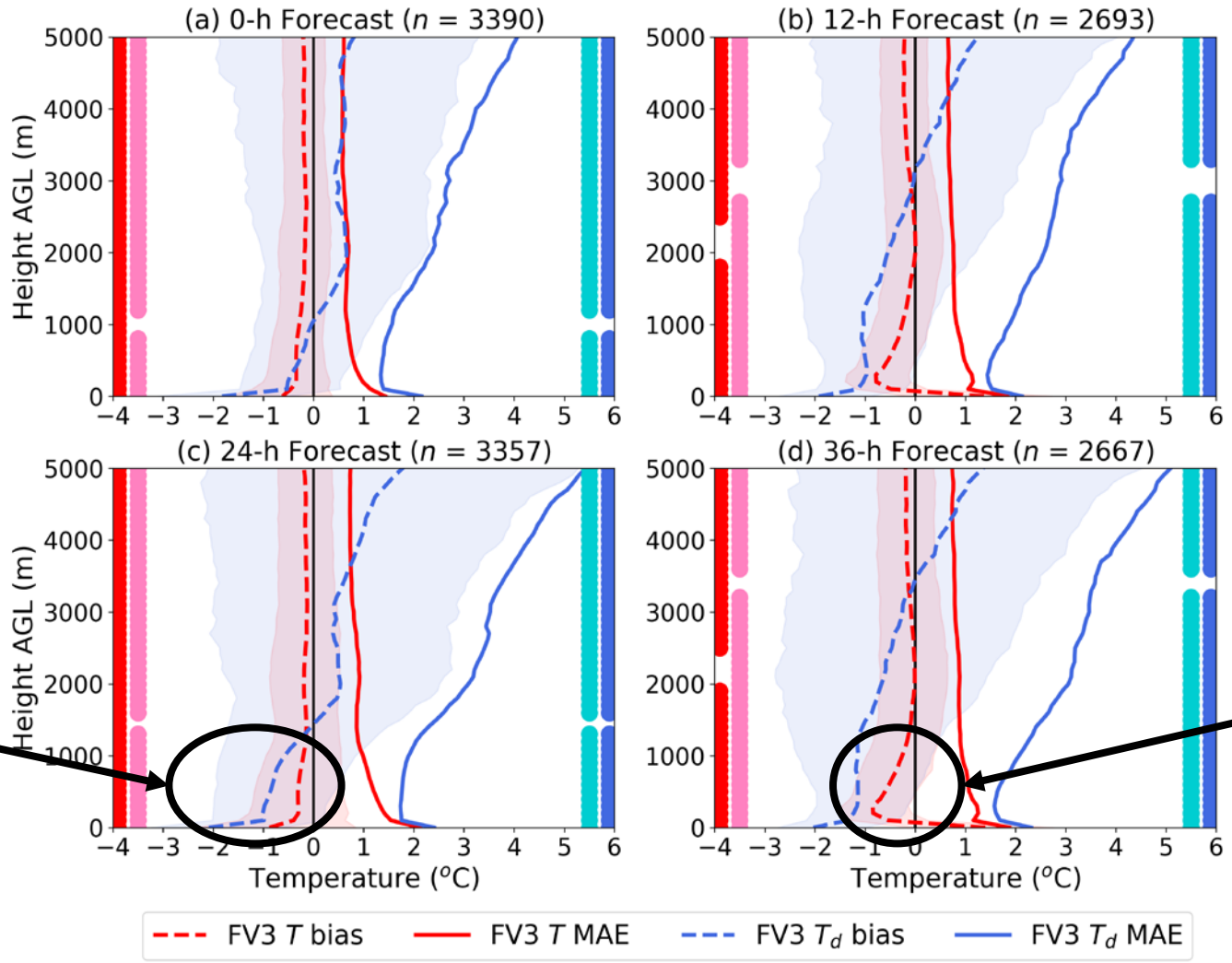
Results: Surface-Based CAPE > 100 J/kg



Cold bias near the surface

Results: Mixed-Layer CAPE > 500 J/kg

***FV3 only; from May – Nov 2019**



Dry bias in the lowest levels

Cold bias up to 1°C

Key Takeaways Thus Far

- There is evidence supporting both the Han et al. (2016) and the Storm Prediction Center findings – the latter primarily for thunderstorm-supporting environments.

- There are no significant differences in model-derived vertical profiles between the spectral and finite-volume cores of the GFS (hypothesis is not rejected).

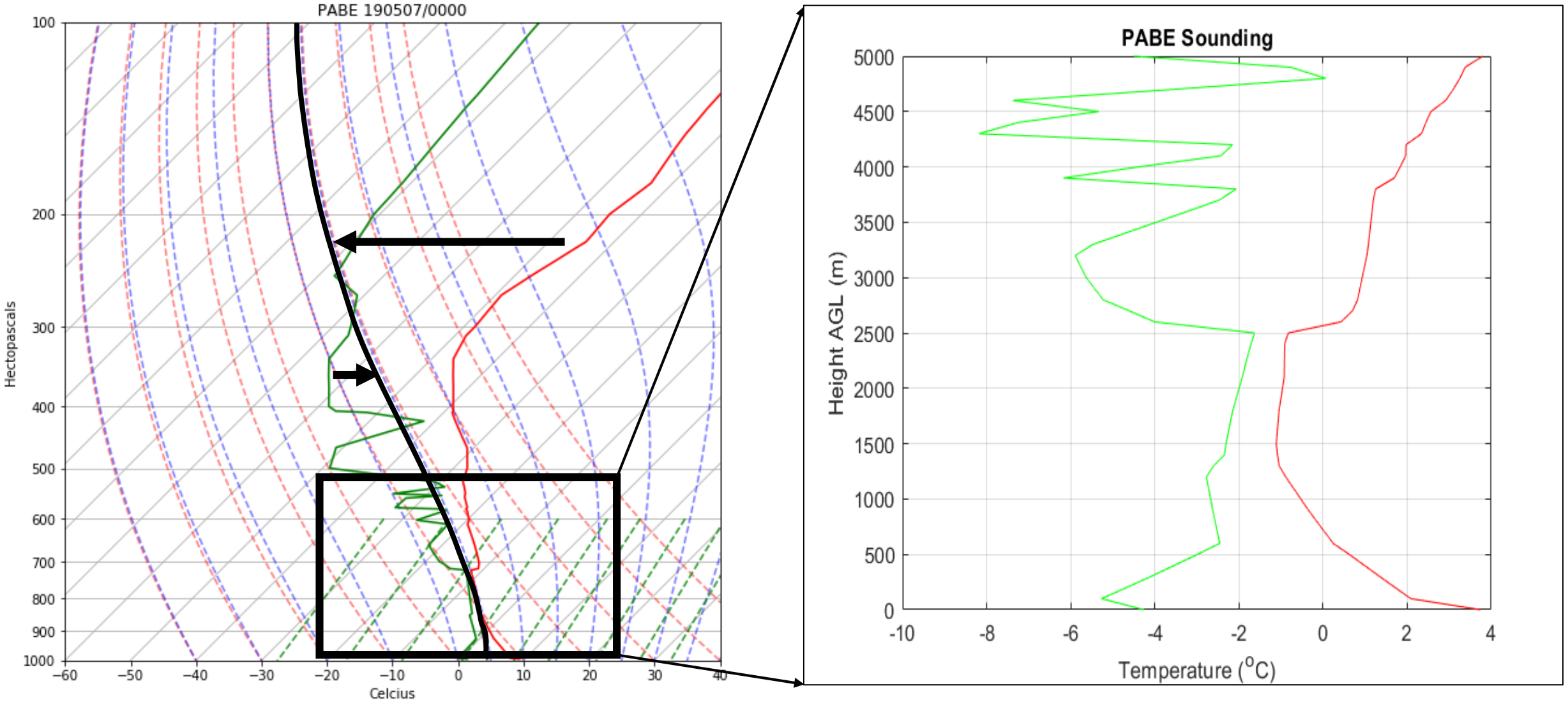
Motivation

- Boundary-layer structure is predicted using either an eddy-diffusivity (stable), countergradient (neutral/weakly unstable), or mass-flux (strongly unstable) formulation in GFS v14/15.x (Han et al. 2016).

- Environment-based stratifications can help isolate these stability conditions, but they are not bulletproof.

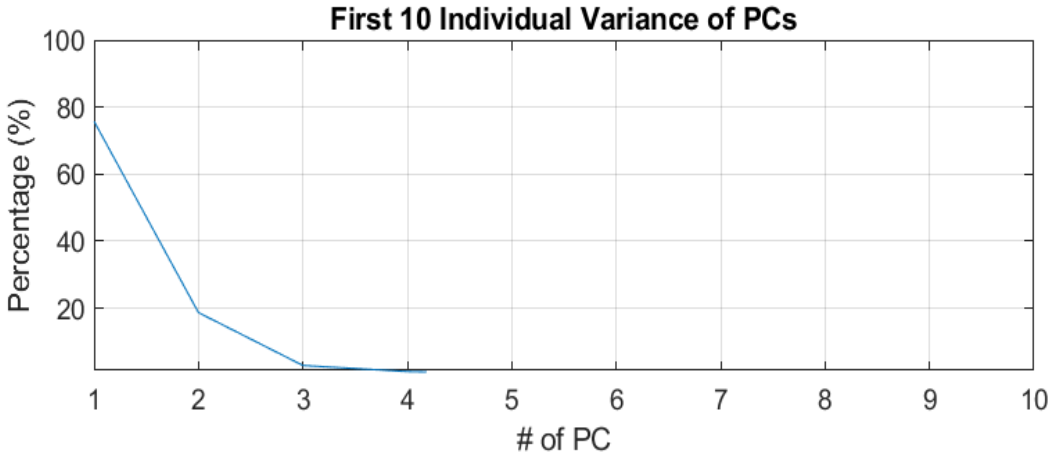
- Can we objectively classify soundings by the boundary-layer structures that typically emerge under these stability conditions?

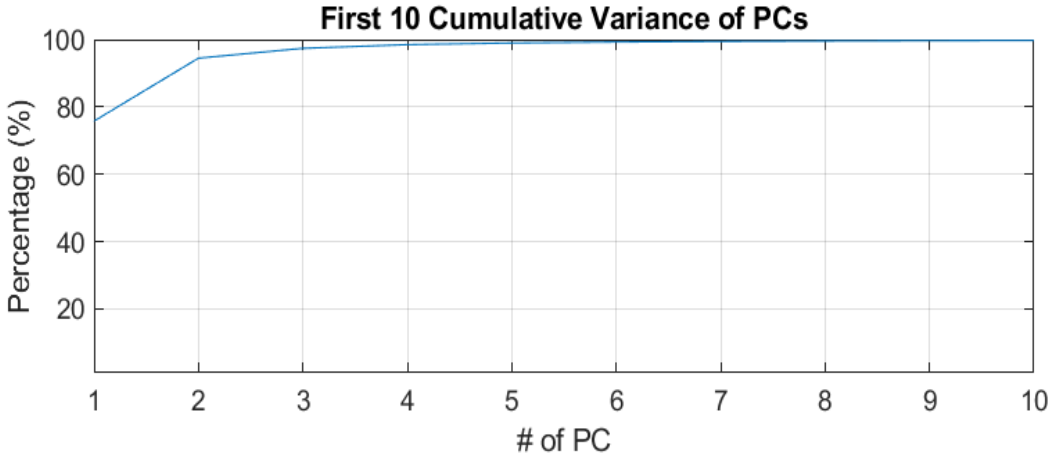
Methods


PABE 190507/0000
Hectopascals
100
200
300
400
500
600
700
800
900
1000
−60
−50
−40
−30
−20
−10
0
10
20
30
40
Celcius
PABE Sounding
Height AGL (m)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-10
-8
-6
-4
-2
0
2
4
Temperature (°C)

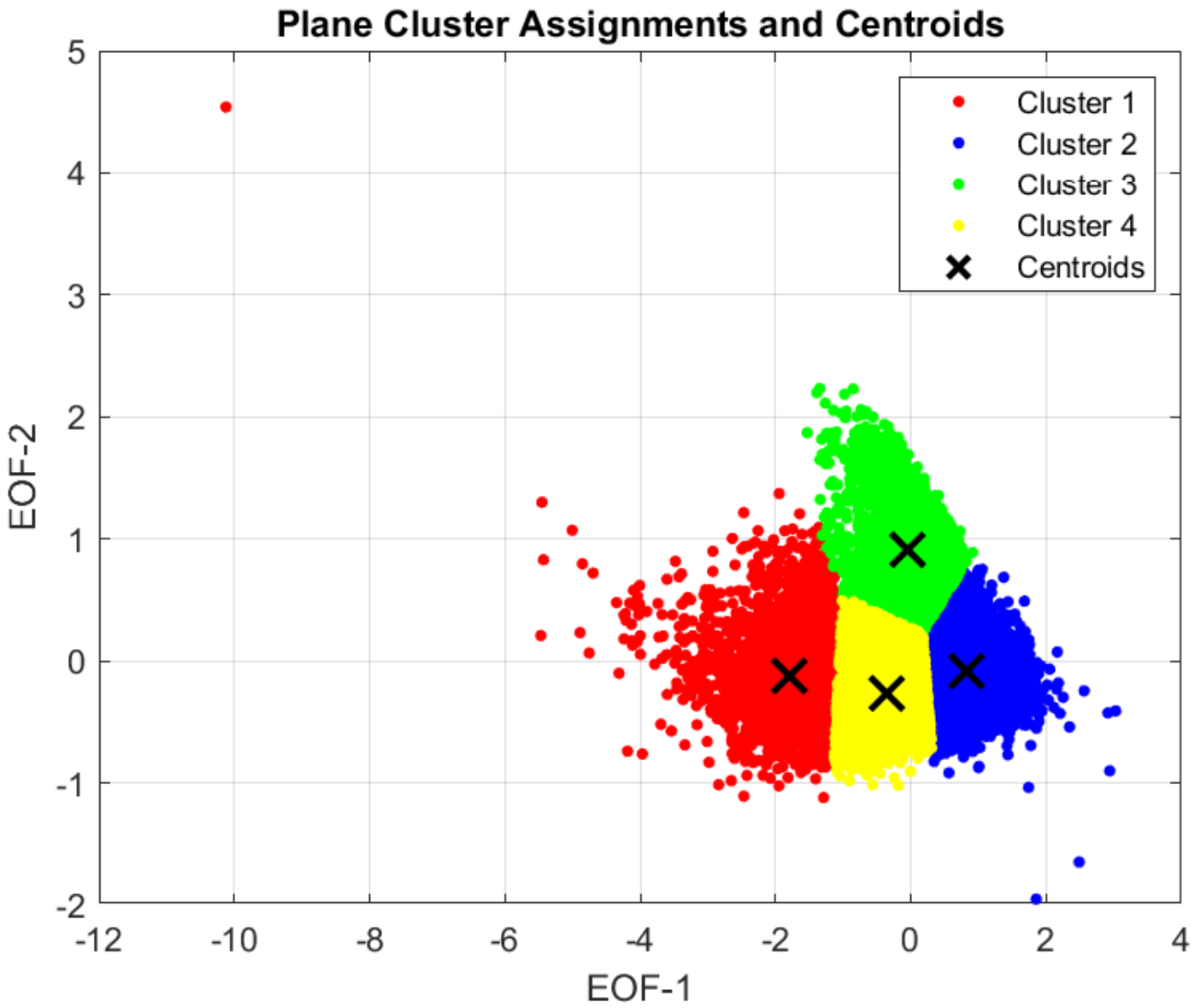
Methods

- 16,344 observed soundings from May – Nov 2019 across the United States are normalized and examined.
- Singular-value decomposition is used to obtain the leading EOFs and PCs (temperature only), with k-means clustering used to identify patterns in these data.
- Composite-mean profiles for each cluster are calculated to visualize the leading environments.

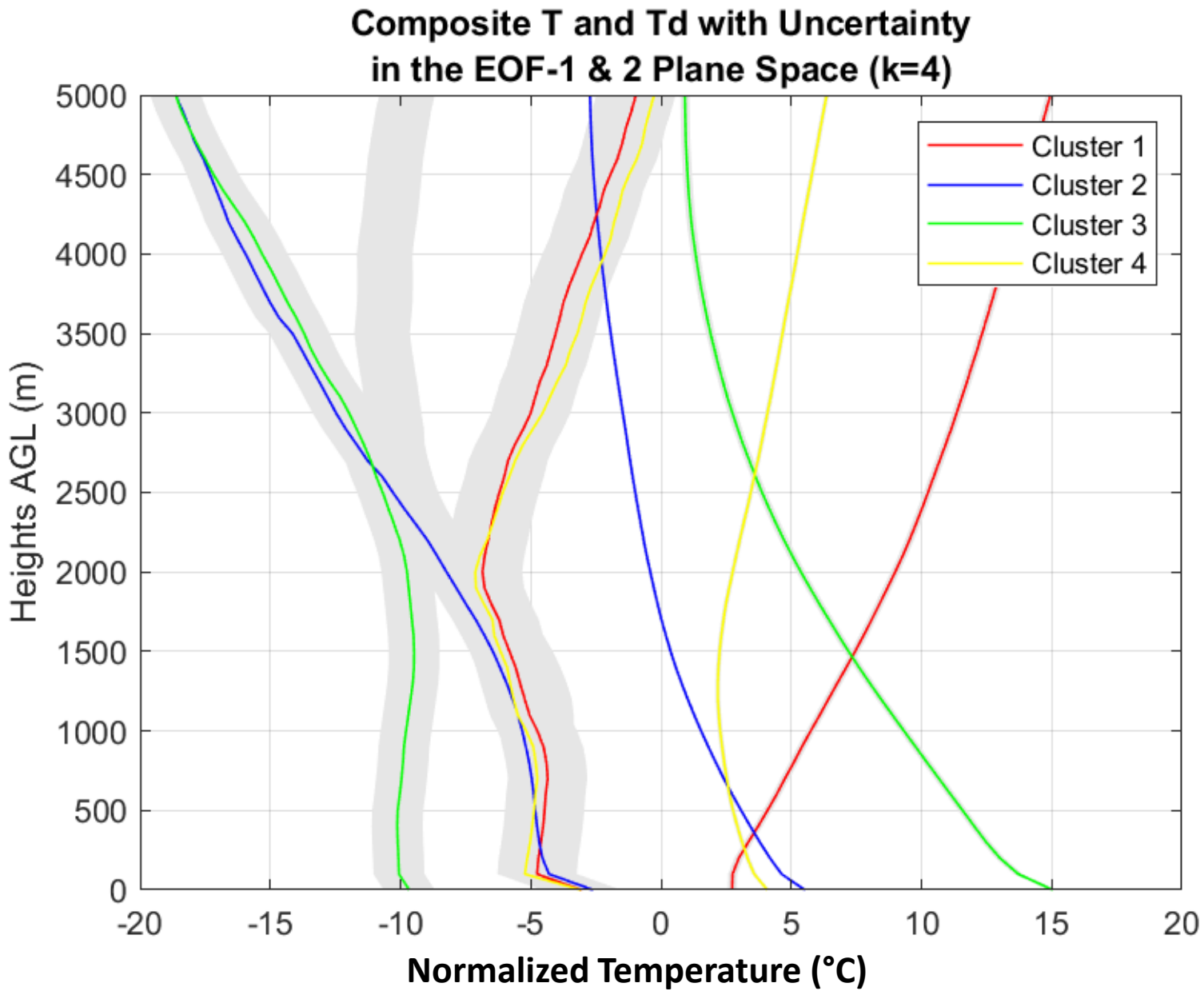




Results


Plane Cluster Assignments and Centroids
Cluster 1
Cluster 2
Cluster 3
Cluster 4
Centroids
EOF-2
EOF-1
5
4
3
2
1
0
-1
-2
-12
-10
-8
-6
-4
-2
0
2
4

Results


Composite T and Td with Uncertainty
in the EOF-1 & 2 Plane Space (k=4)
Heights AGL (m)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-20
-15
-10
-5
0
5
10
15
20
Normalized Temperature (°C)
Cluster 1
Cluster 2
Cluster 3
Cluster 4

Future Work

- Multivariate EOF and/or self-organizing map (SOM) analyses based on temperature and dew-point temperature.

- Verify soundings within each EOF- and/or SOM-based cluster to assess the extent to which forecast error stratifies by sounding structure(s).

- Repeat for the GFS v15.x to v16 upgrade, which includes changes to the PBL parameterization (scale-aware TKE-based EDMF) and vertical resolution (doubling the number levels, higher model top).

NWS/OSTI 2018 Federal Funding Opportunity (FFO) Project

Evaluation of GFS-FV3 Vertical Profile and Thermodynamic Environment Fidelity

What are your capstone delivery, outcome, accomplishments?

- SPC has completed and continues to conduct operational and, joint with NSSL, testbed evaluations of operational GFS (v14, 15.x; using EMC physics) and limited-area regional FV3 (EMC and GSD physics) forecasts.

- We completed an evaluation of 12-, 24-, and 36-h forecast vertical profiles from the EMC Advanced Physics evaluation (winter-spring 2019). Our findings support the decision to upgrade the PBL parameterization to the scale-aware TKE-based EDMF parameterization (suite 2); full details are available upon request.

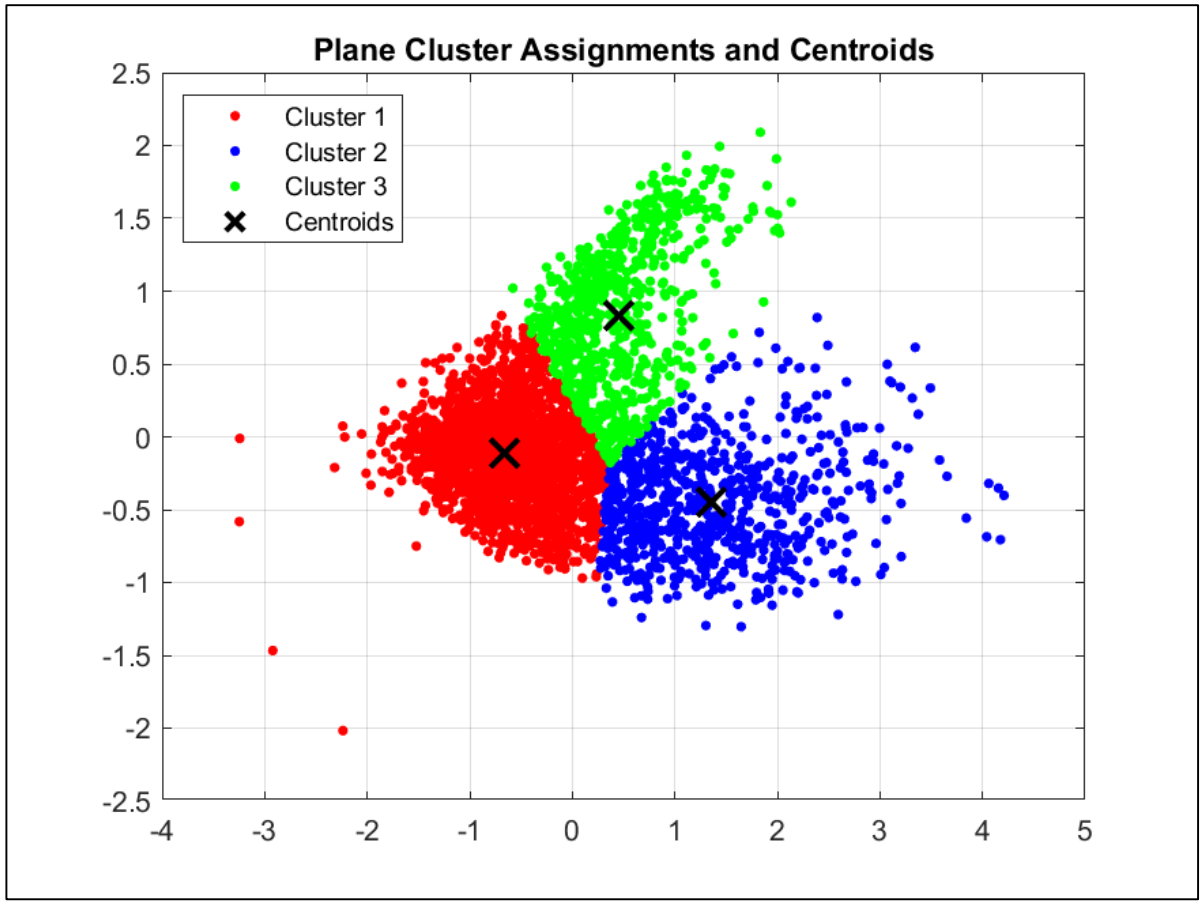
- We completed an evaluation of 0-, 12-, 24-, and 36-h forecast vertical profiles from the spring 2019 parallel period (GFS v14 vs. GFS v15.1). Our findings, reported on in this presentation, indicate that the dynamical core upgrade does not result in a significant change to the model's forecast representation of PBL structure (and associated thermodynamic parameters) in warm-season, thunderstorm-supporting environments.

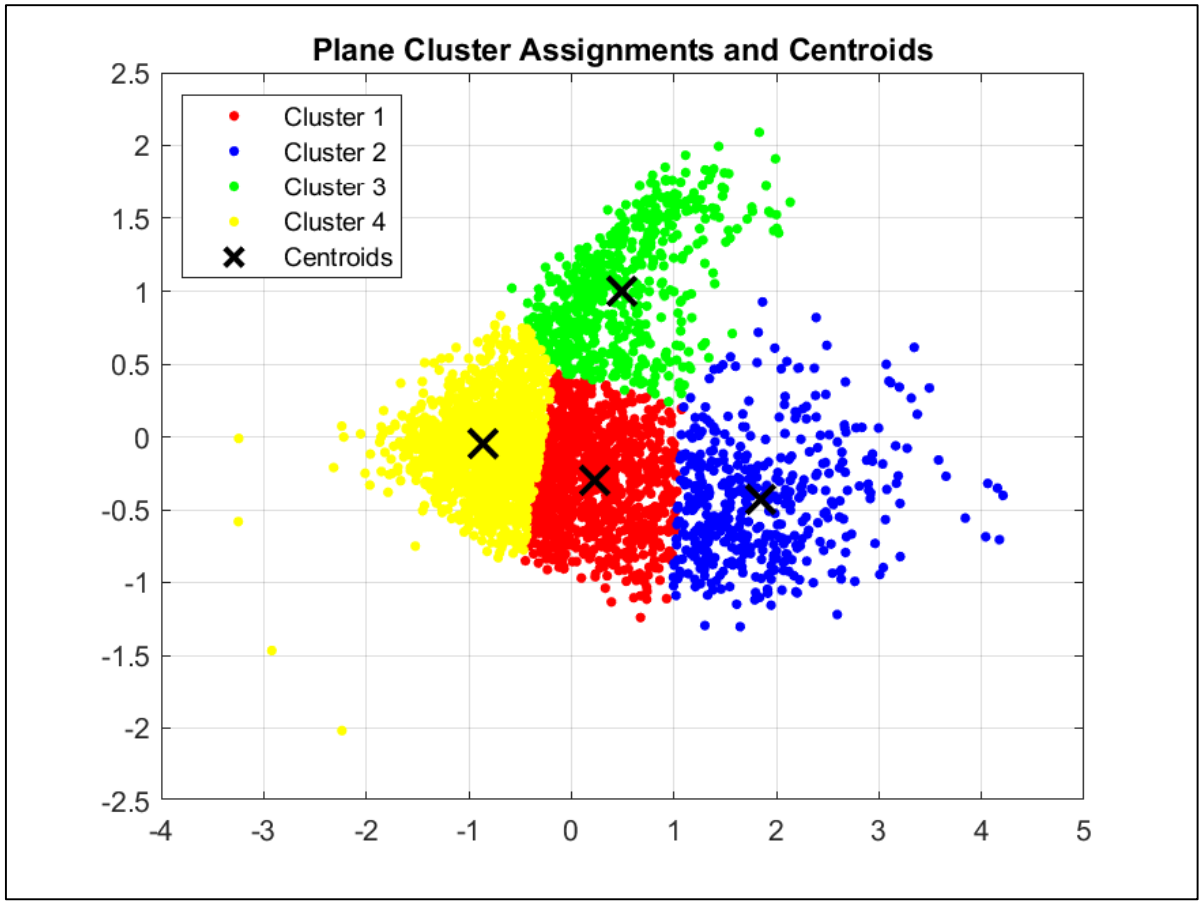
Results/Figures/Highlights

- Please refer to the full UFS Users Workshop presentation for full details; brief details are provided above.

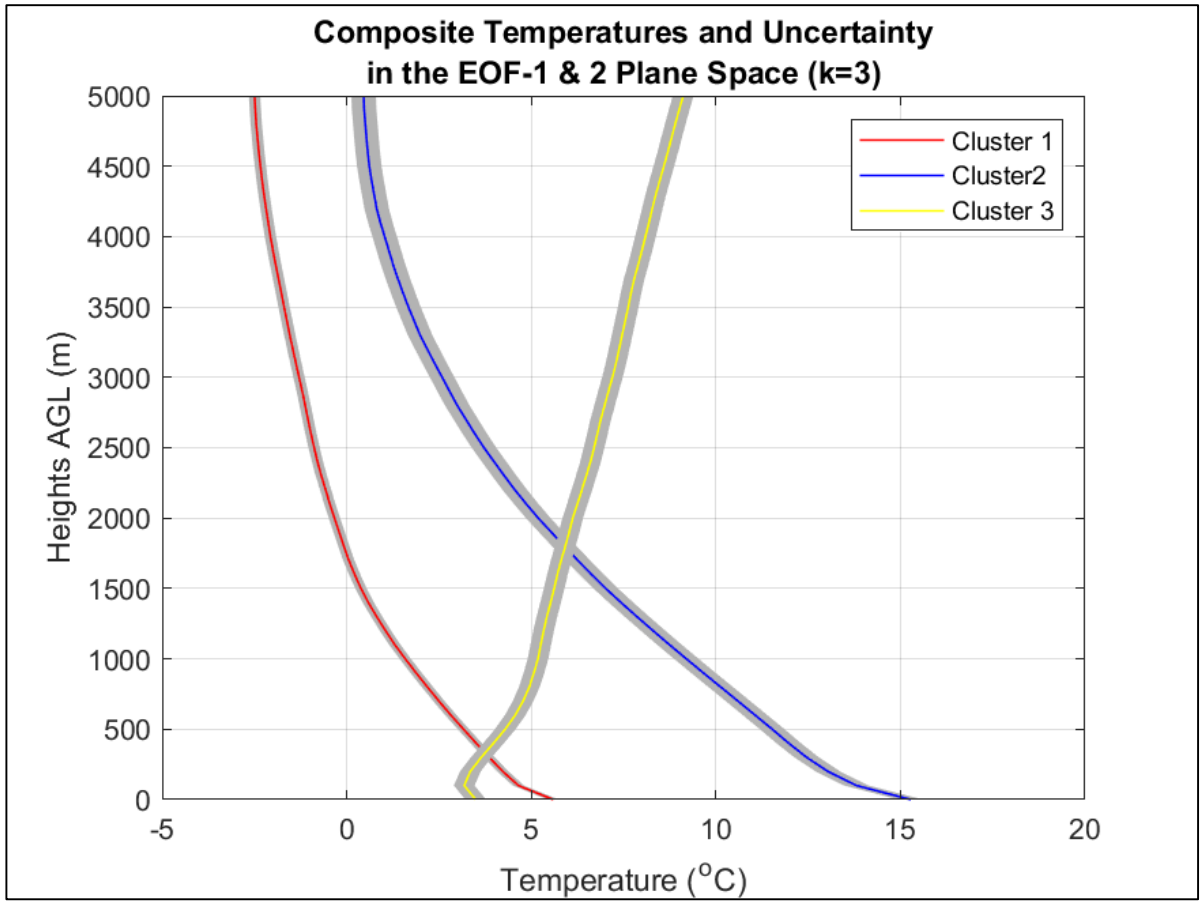
Extra Slides

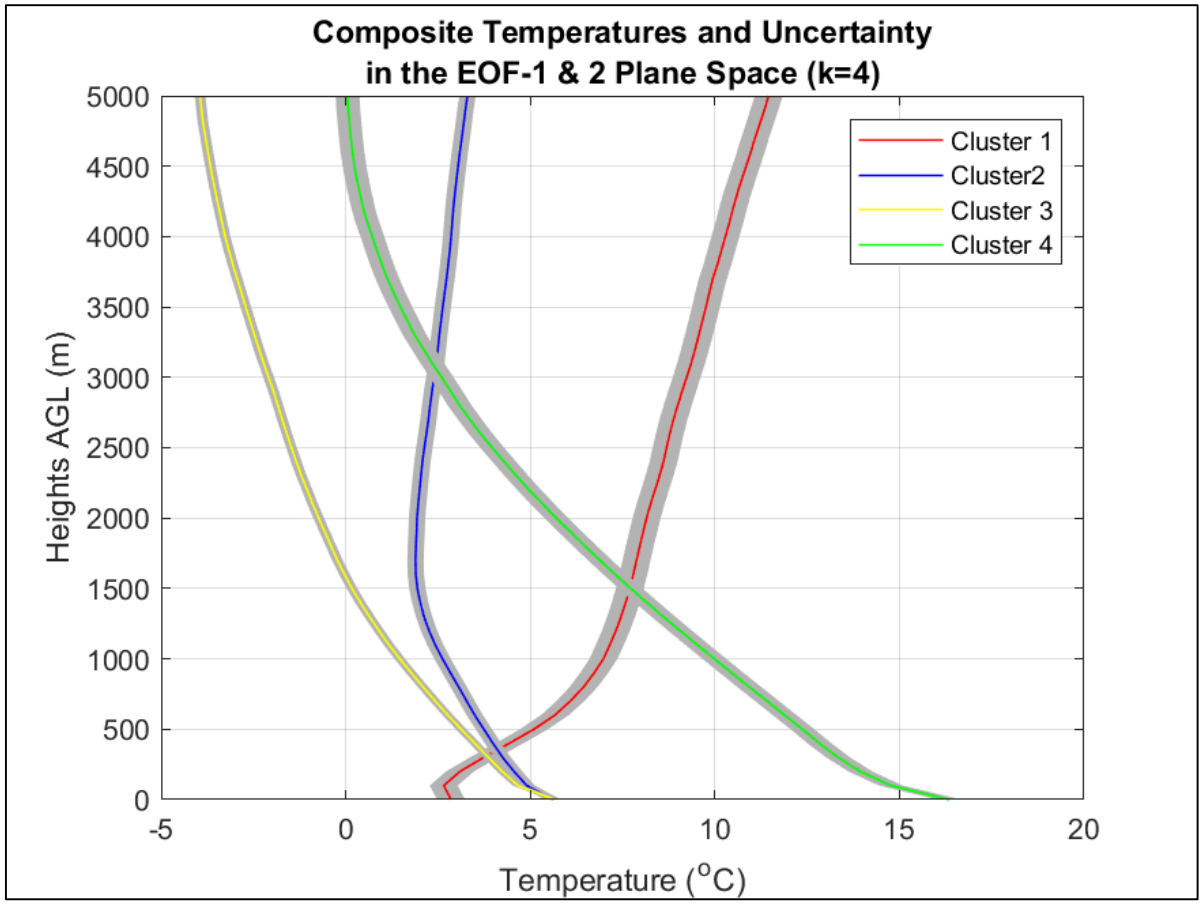
Results (Norm July)



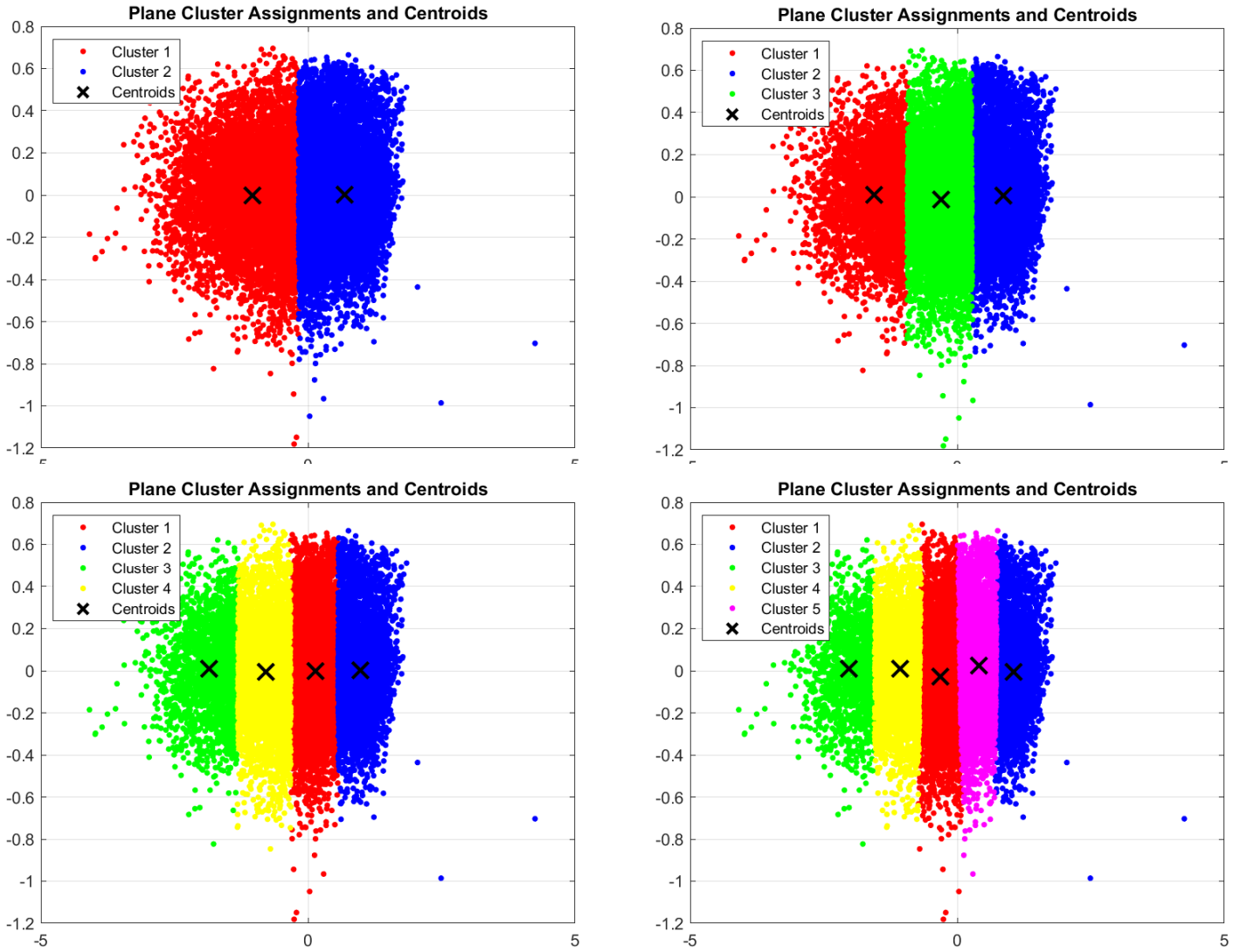


Results (Norm July)





Results (All Raw)



Results (All Raw)