An Examination Of Interesting Properties Regarding A Physics Ensemble

2012 WRF Users' Workshop

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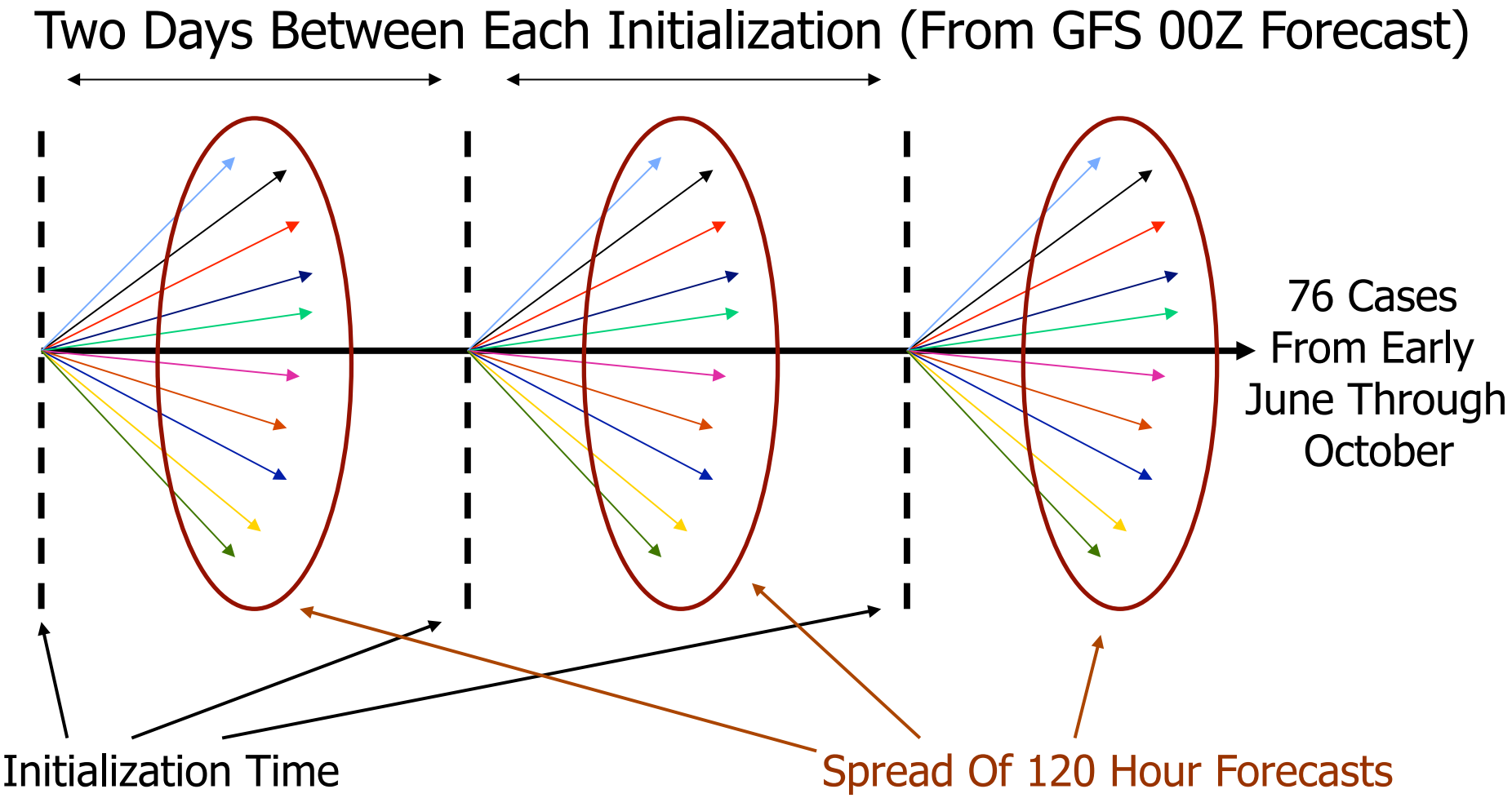
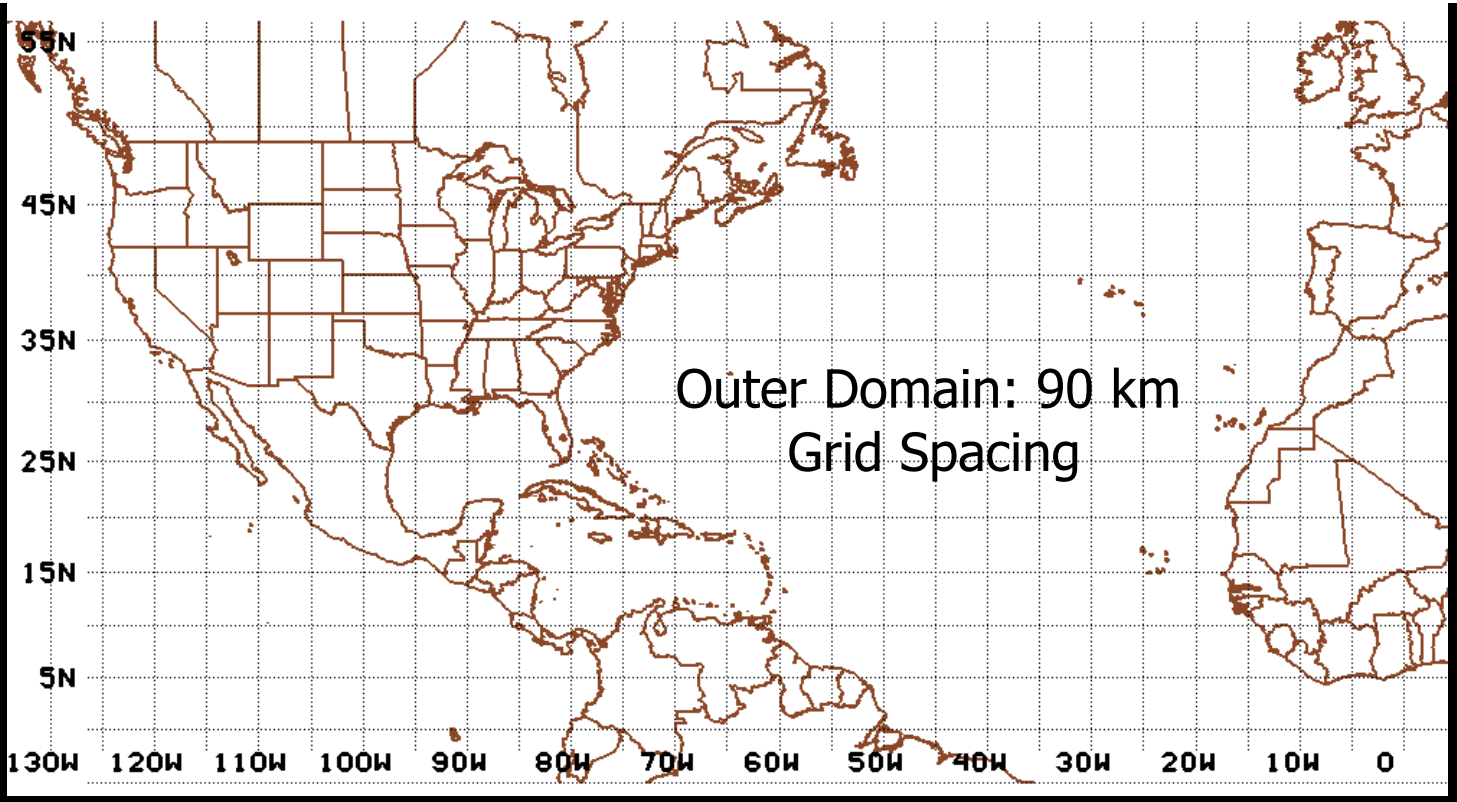
Introduction

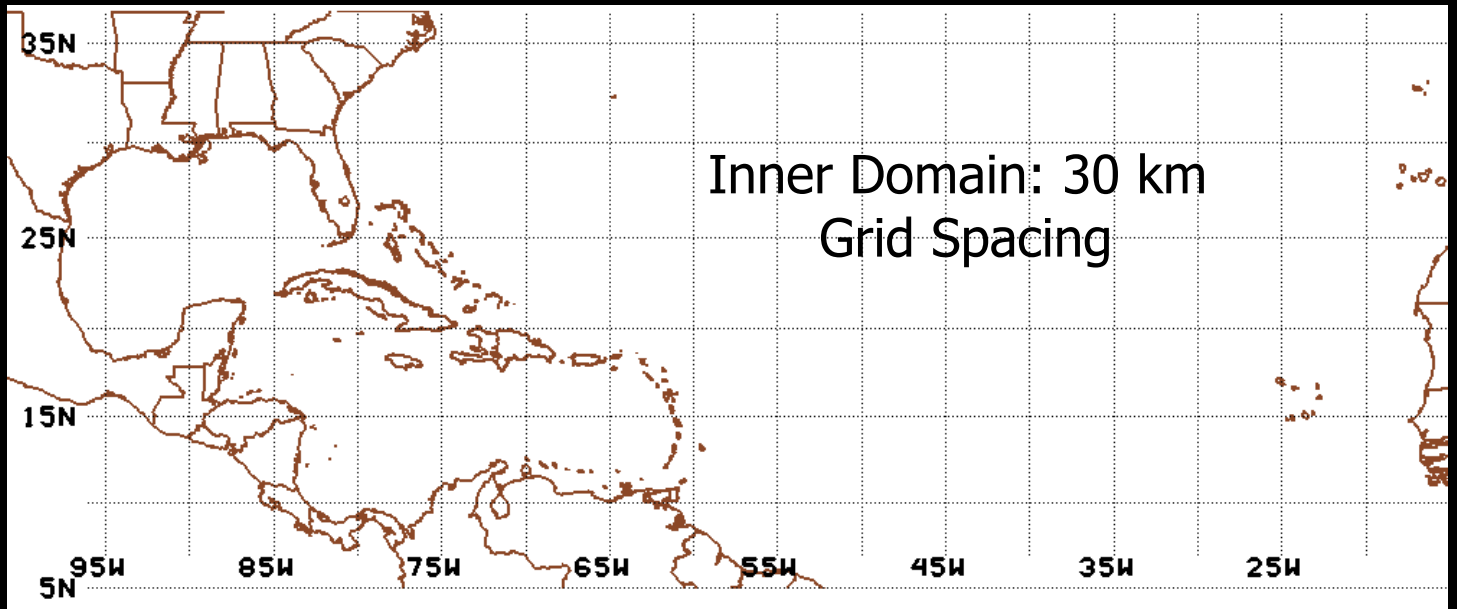
- During the 2009 North Atlantic hurricane season, a real-time ensemble was created locally once per day
- Using simple linear regression techniques, I will present a few (potentially) interesting results comparing a low resolution WRF-ARW physics ensemble with the operation GFS ensemble

Data Generation Overview

Dynamical Core is WRF-ARW 3.0



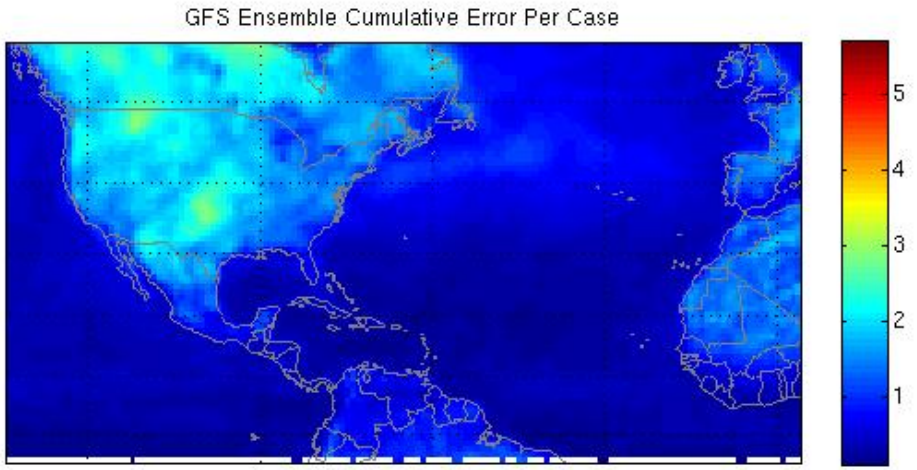

55N
45N
35N
25N
15N
5N
130W
120W
110W
100W
90W
80W
70W
60W
50W
40W
30W
20W
10W
0
Outer Domain: 90 km
Grid Spacing

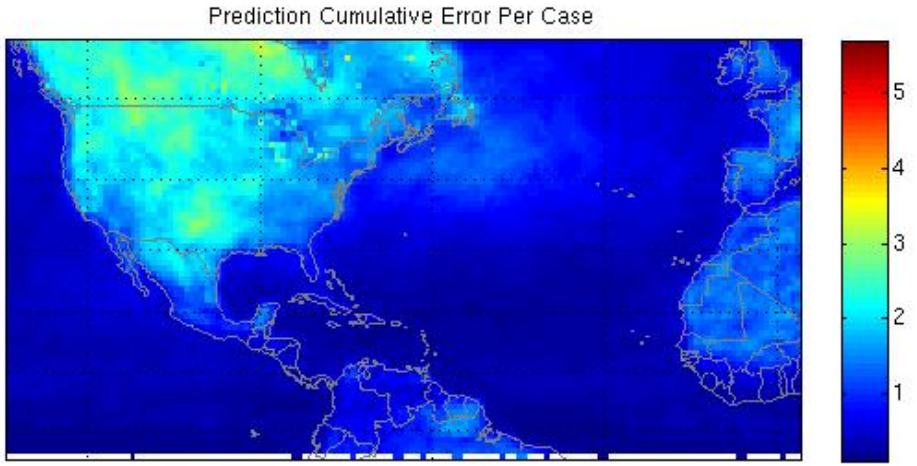

35N
25N
15N
5N
95W
85W
75W
65W
55W
45W
35W
25W
Inner Domain: 30 km
Grid Spacing

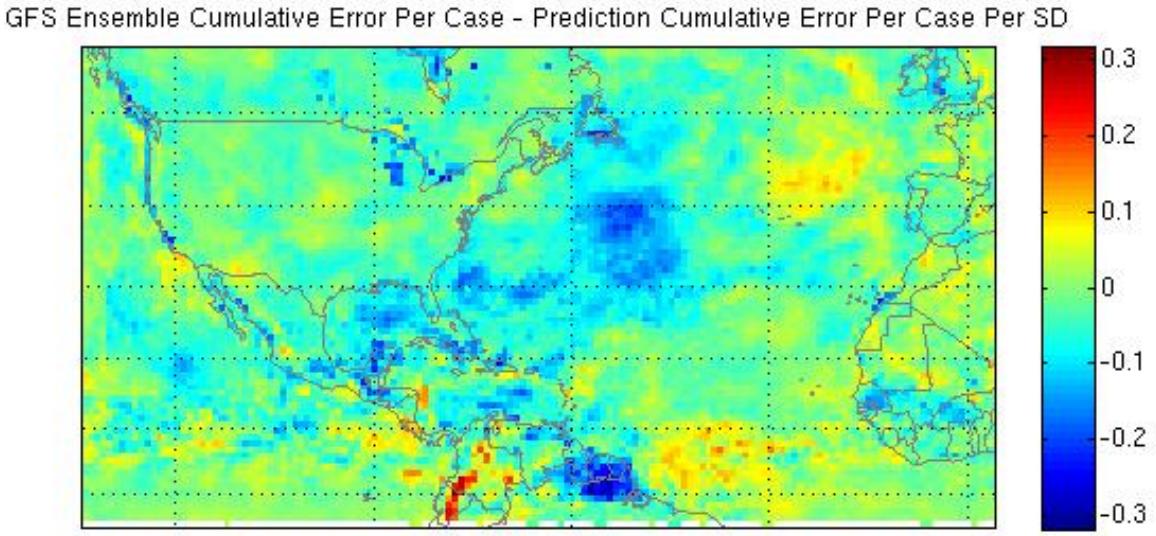
Physics Ensemble vs. GFS Ensemble

- The results shown were calculated as follows:
  - Tune 120 hour forecasts to 0 hour GFS analyses for both the physics ensemble* and GFS ensemble comprised of an equal number of members
  - After this is done, it's easy to calculate the average error per case for both ensembles
  - The average error will be shown, along with the difference between the two normalized to the standard deviation of the variable in question

* Using outer 90 km grid

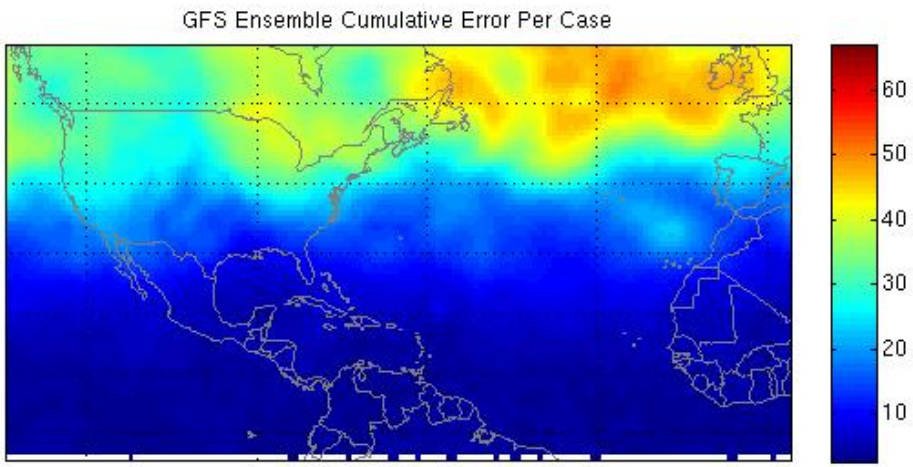


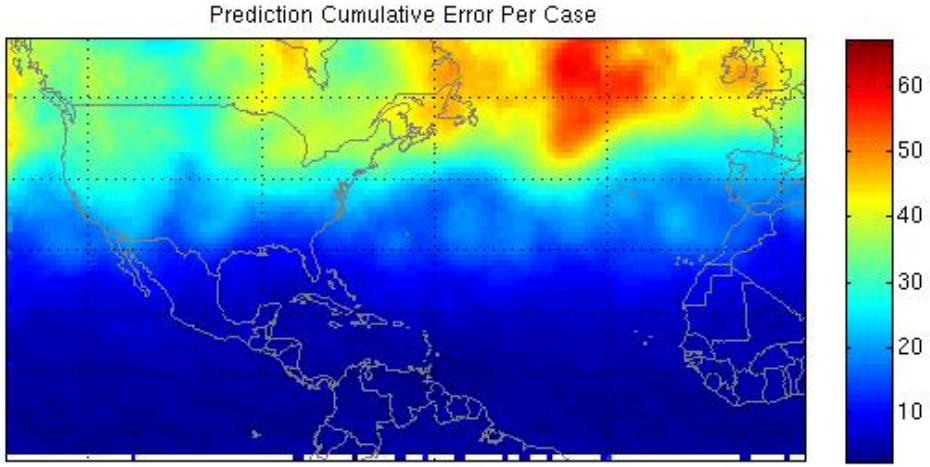




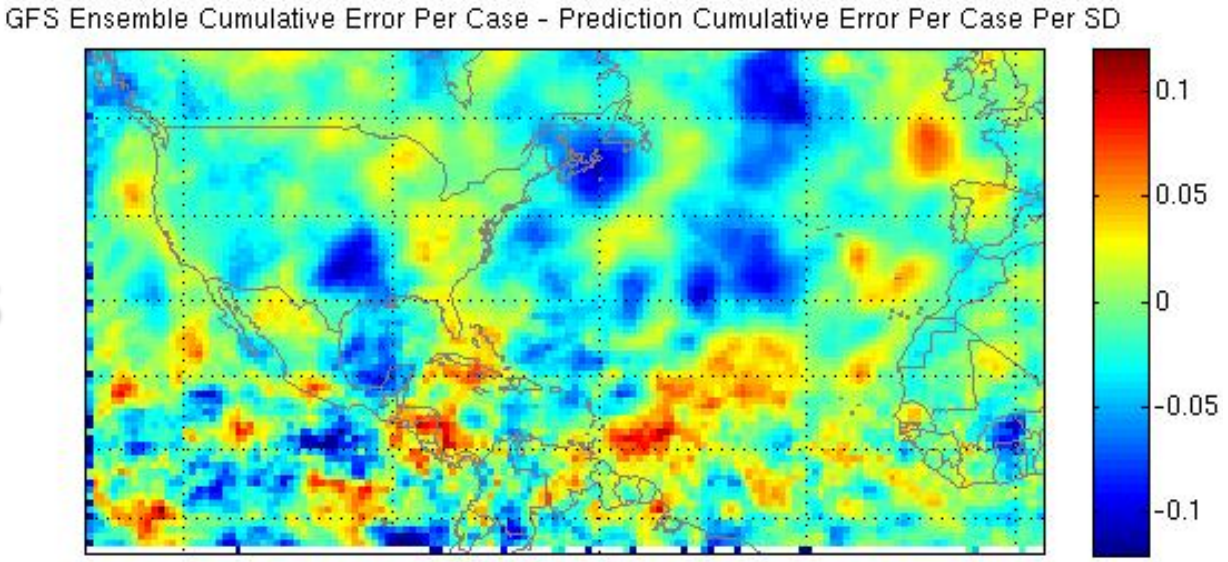
(Left): Yellow and red colors mean the parameterization ensemble outperformed the GFS ensemble, blue colors mean the opposite

2 Meter Temperature (°C)

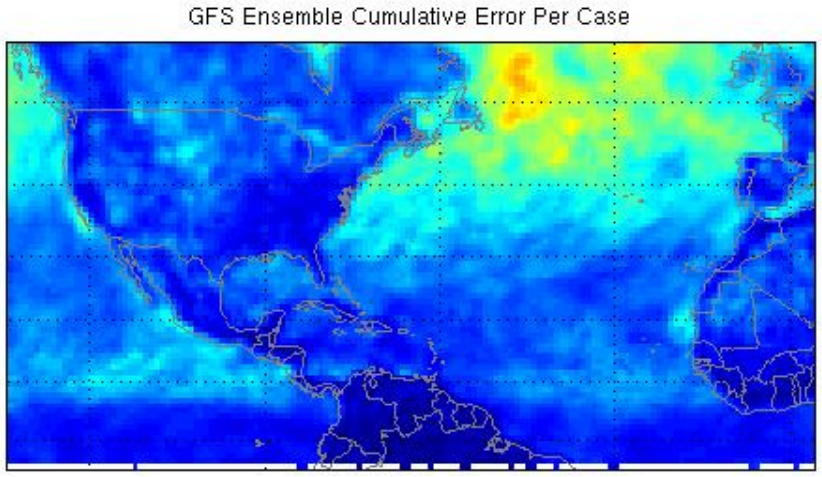


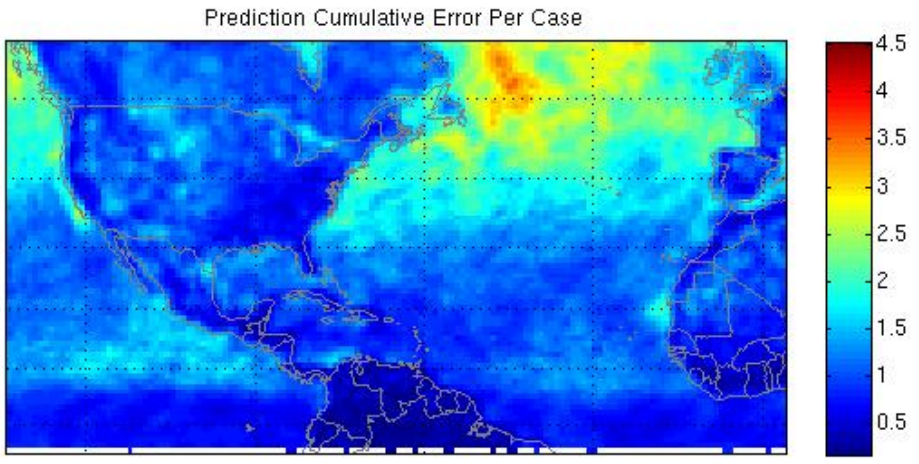


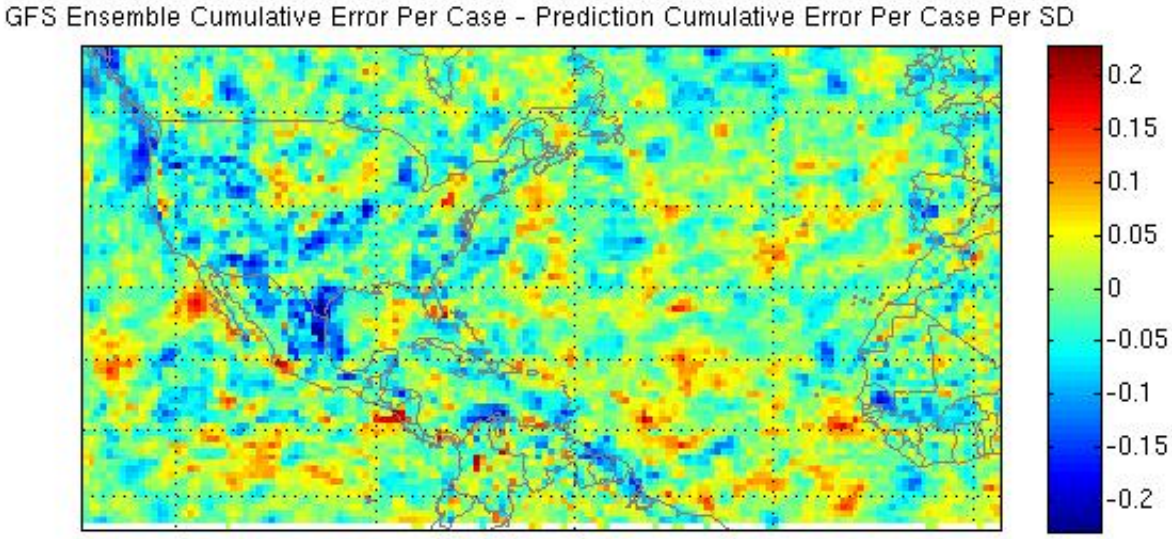
- (Right): Yellow and red colors mean the parameterization ensemble outperformed the GFS ensemble, blue colors mean the opposite



500 hPa Geopotential Height (m)







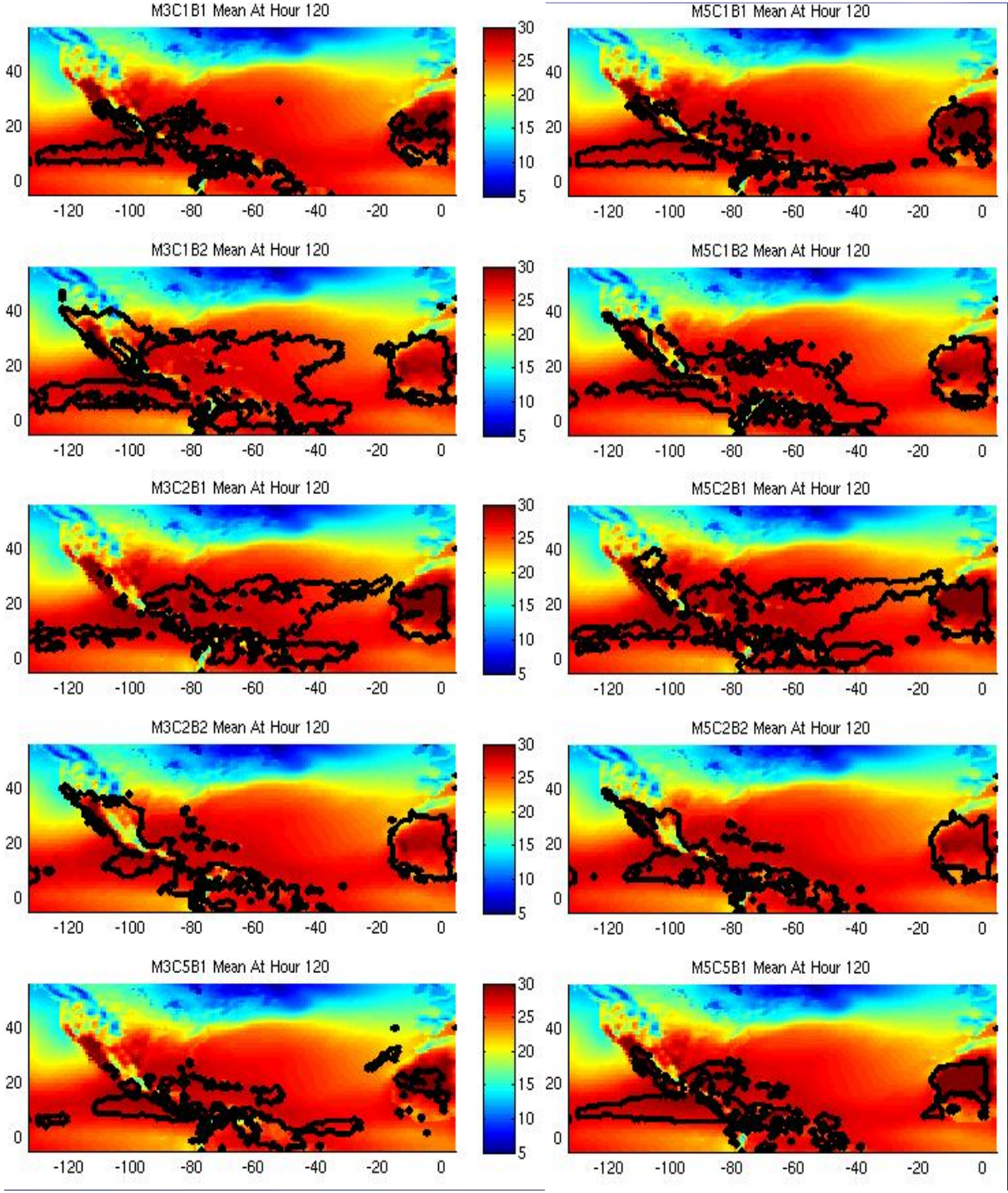
(Left): Yellow and red colors mean the parameterization ensemble outperformed the GFS ensemble, blue colors mean the opposite

10 Meter Wind Speed (m/s)

Observations

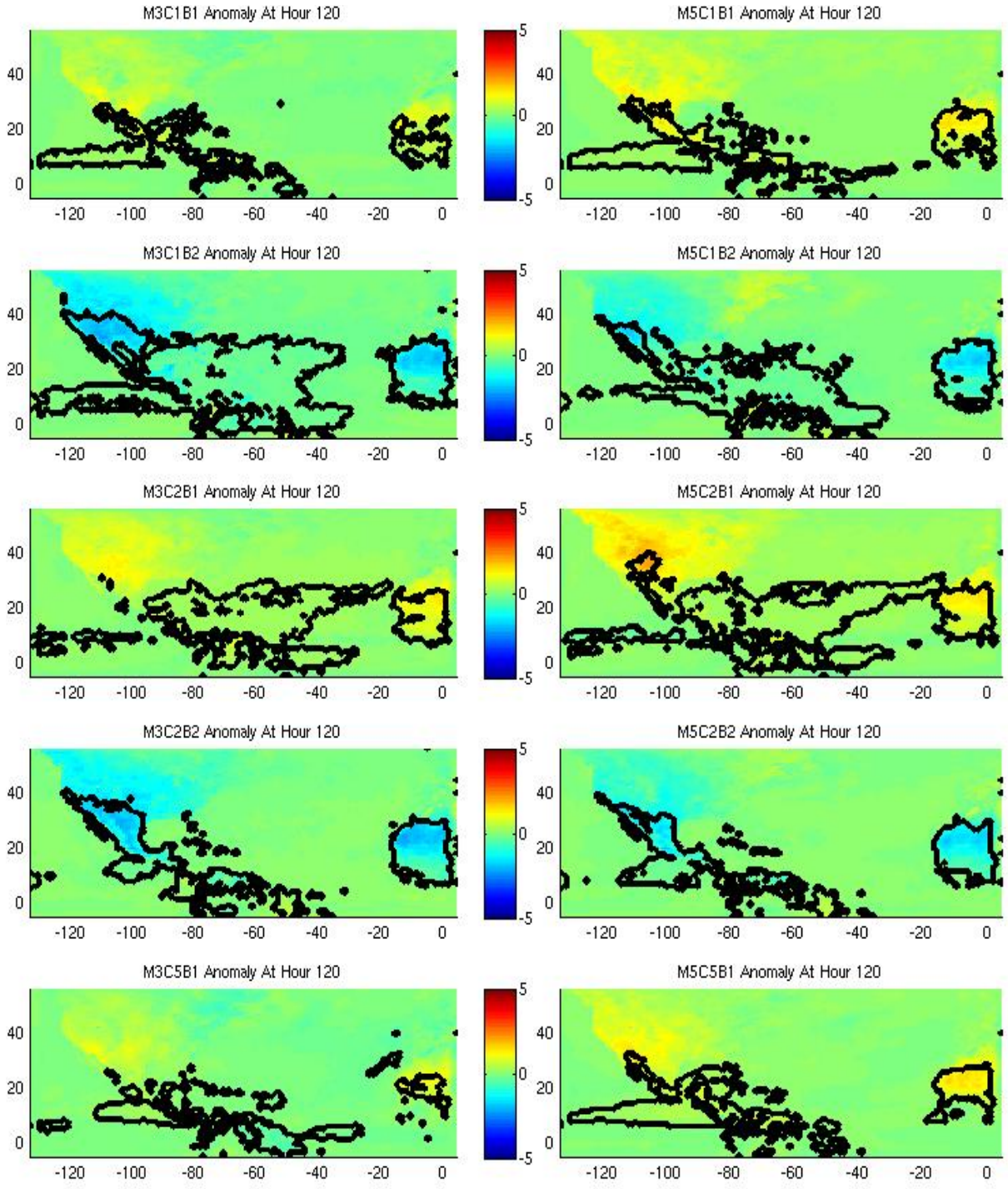
- On average, the GFS ensemble "wins" by ~0.01 standard deviations for any given variable
- Generally speaking, the parameterization ensemble performs better in the tropics, while the GFS ensemble performs better in the sub/ extratropics

Let's examine the 2 m temperature more closely …



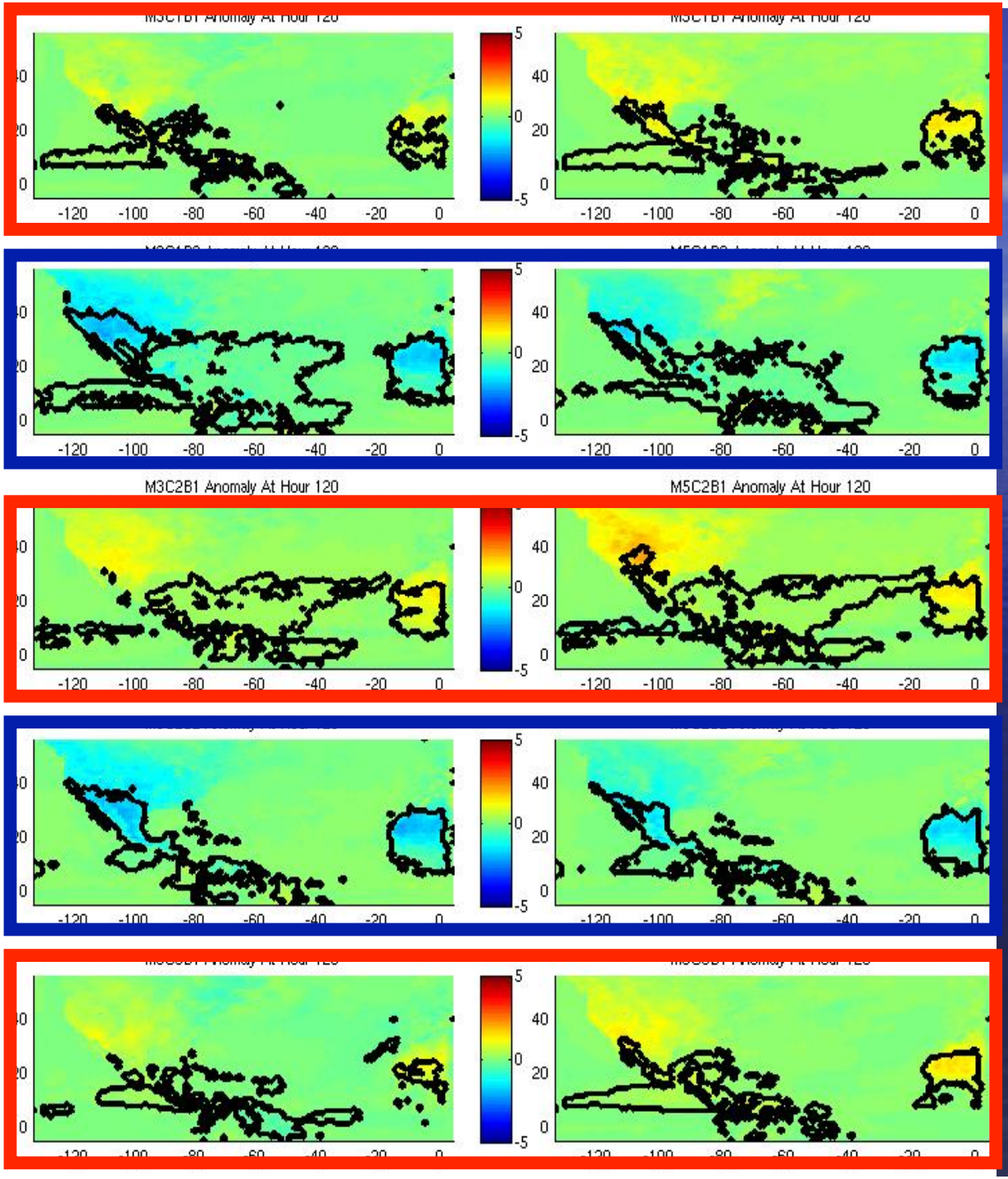
2 Meter Temperature Composites

- The fill is the mean 2 m temperature at hour 120 for the parameterization ensemble members
- The contour is the 95% significance threshold



2 Meter Temperature Composites

- The fill is the mean 2 m temperature anomaly at hour 120 for the parameterization ensemble members
- The contour is the 95% significance threshold as seen previously



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- The fill is the mean 2 m temperature anomaly at hour 120 for the parameterization ensemble members
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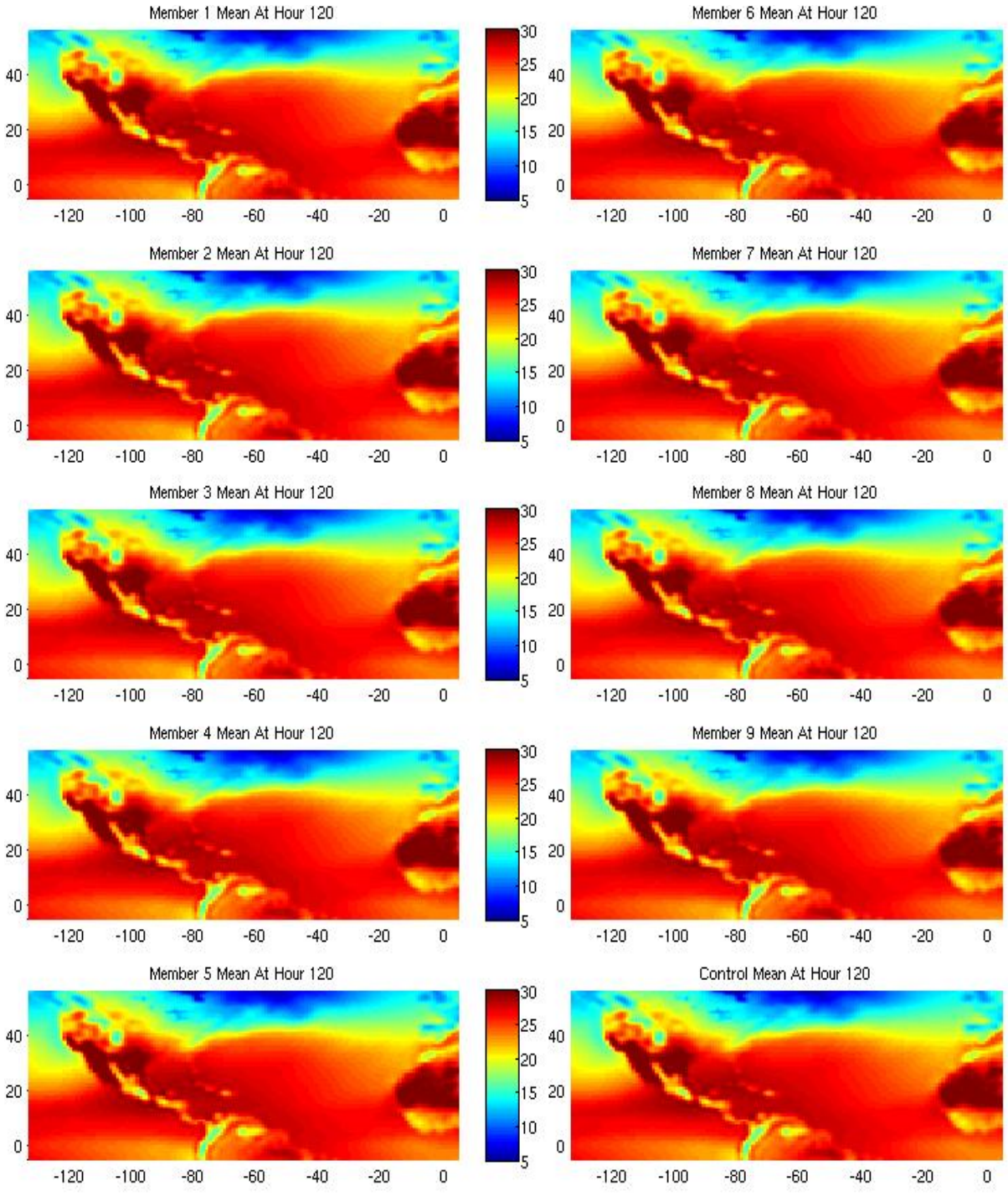
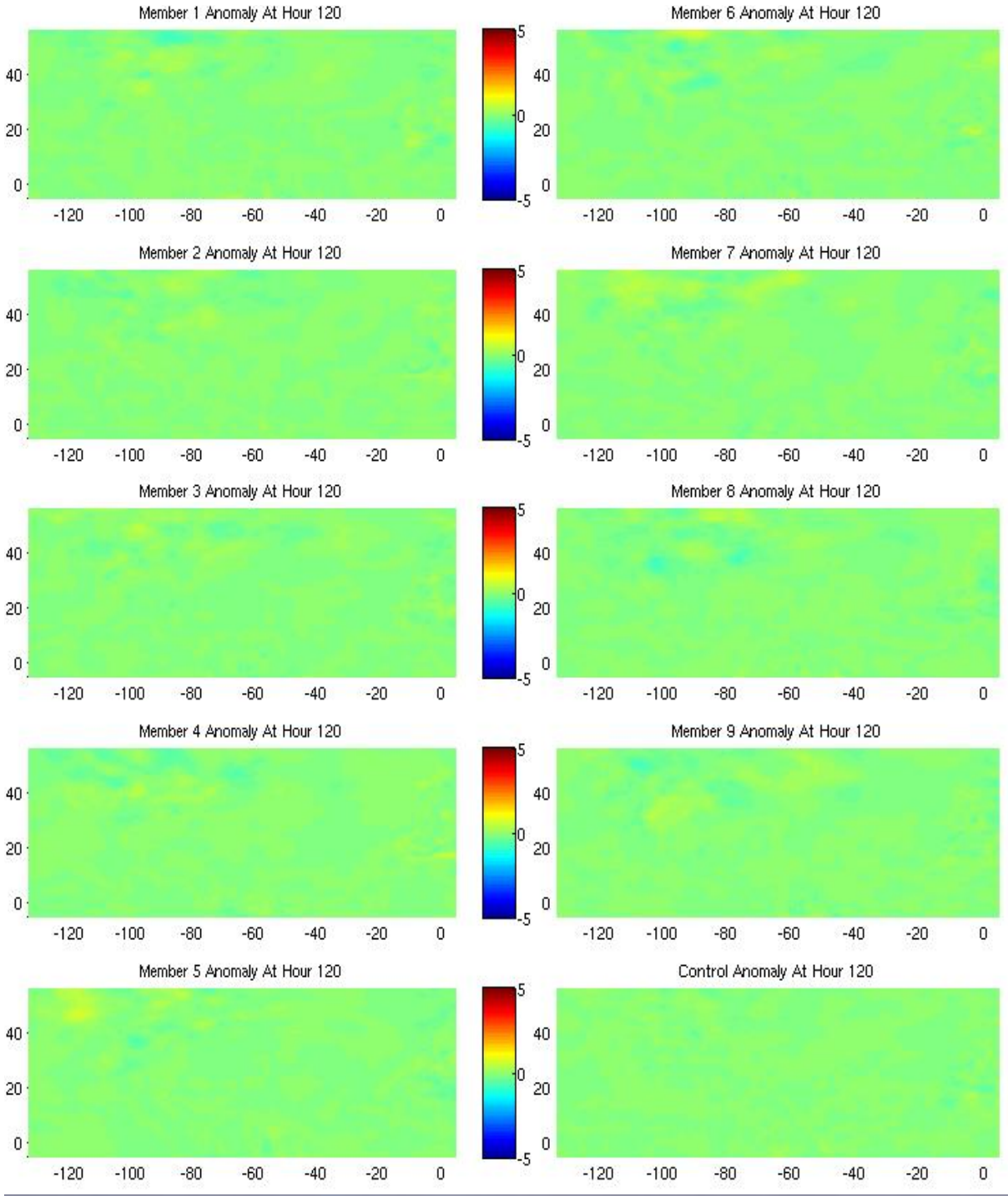


2 Meter Temperature Composites

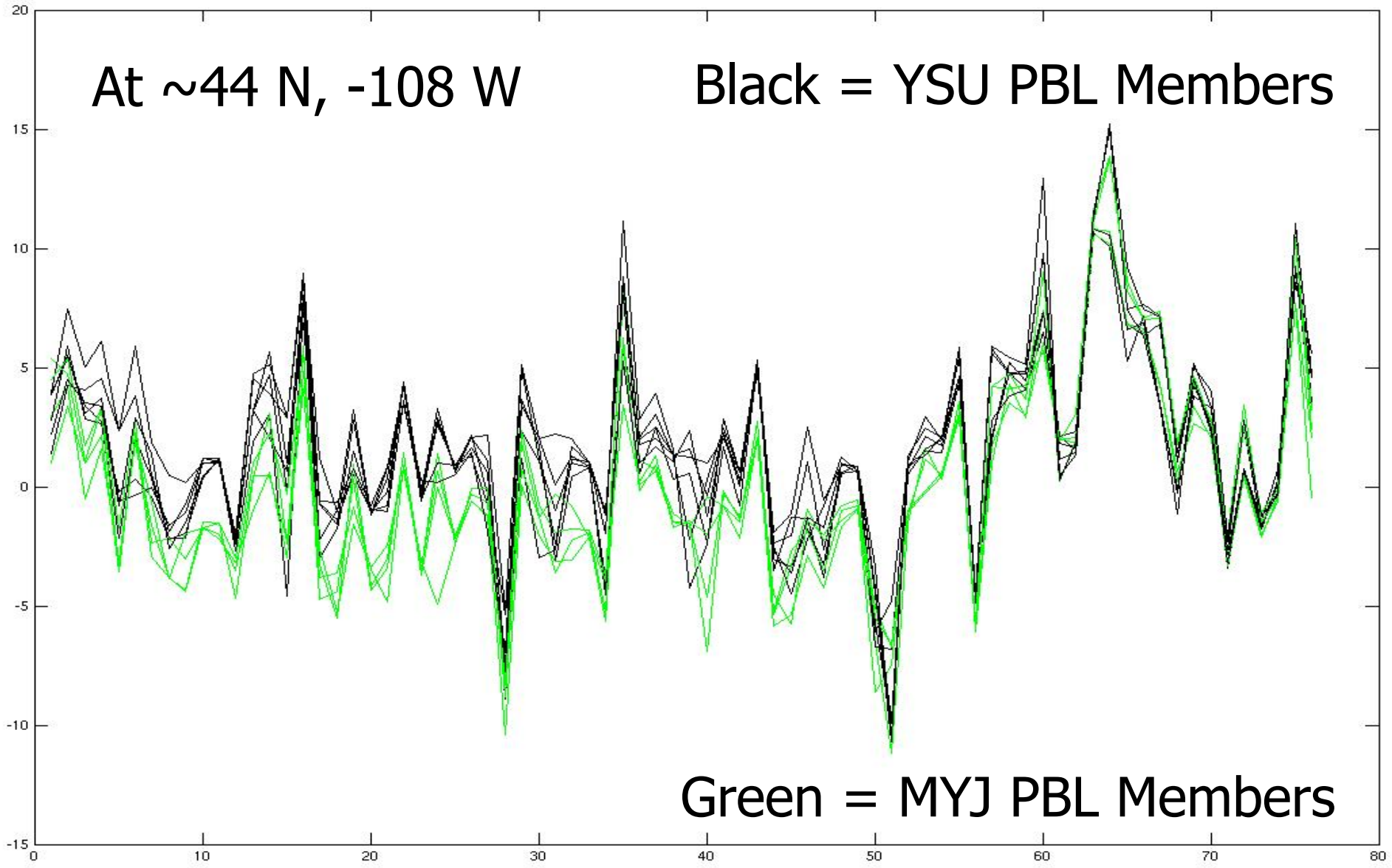
- The fill is the mean 2 m temperature at hour 120 for the GFS ensemble members
- Note – no significance contour is shown



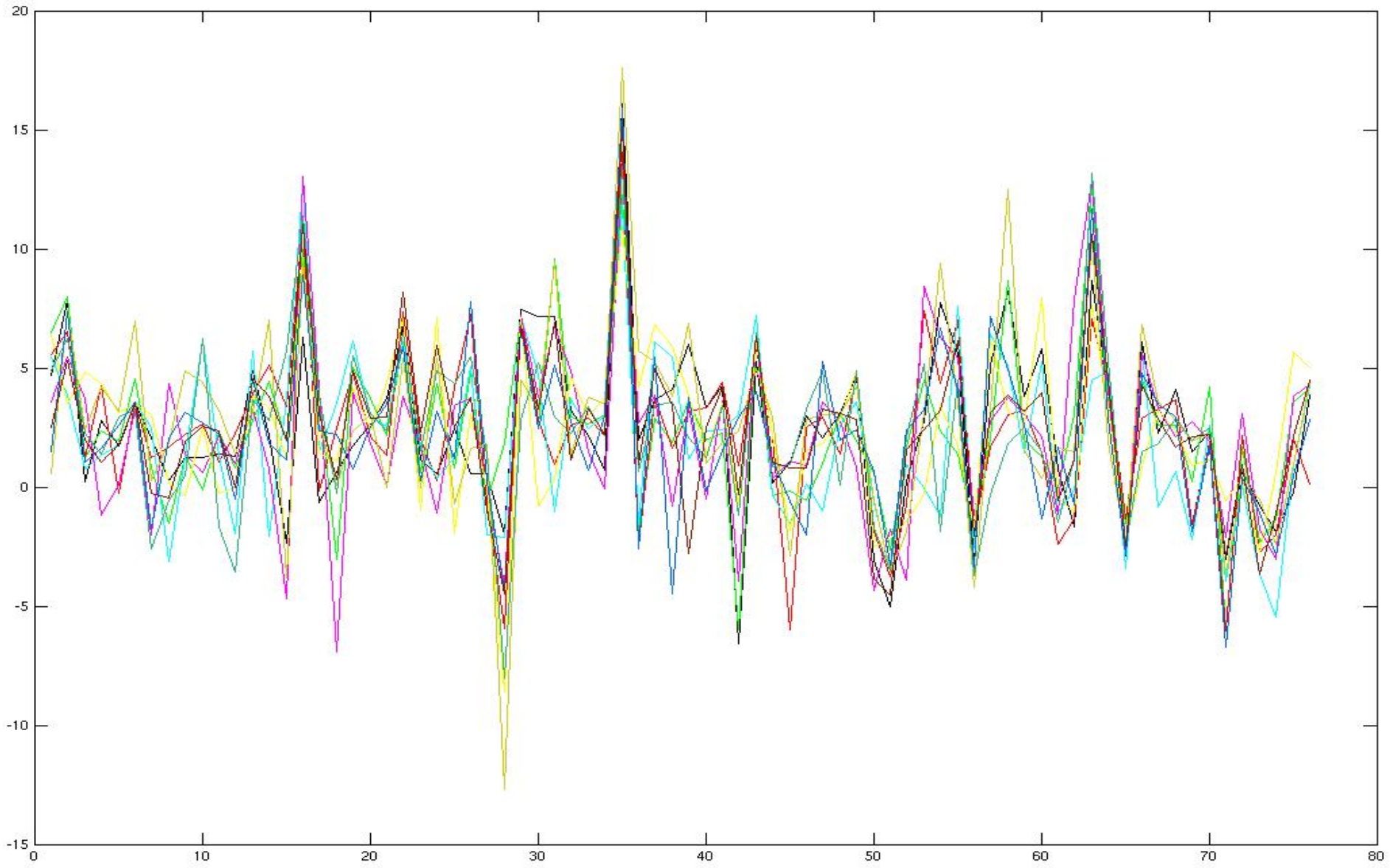
2 Meter Temperature Composites

- The fill is the mean 2 m temperature anomaly at hour 120 for the GFS ensemble members
- Note how indistinguishable one member is from another
- Unlike the physics ensemble, member differences aren't correlated from run to run

Parameterization Ensemble Member Errors



GFS Ensemble Member Errors

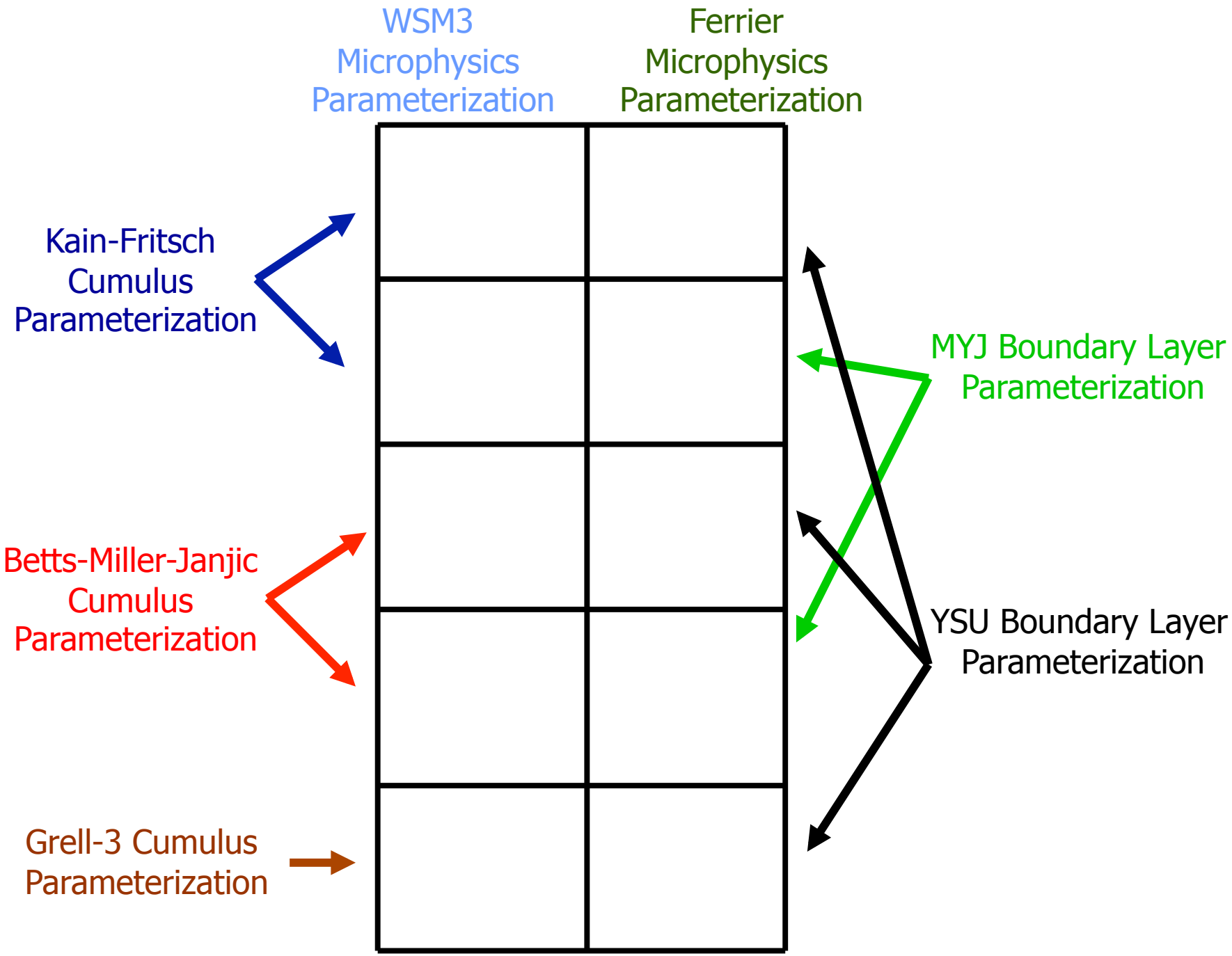


Conclusions

- Different parameterization combinations do have certain (statistically significant) biases
- Pure parameterization ensembles theoretically are better than pure initial condition ensembles, since member differences are correlated from run to run
- Using this information, a simple (read: dumb) parameterization ensemble can perform equivalently to a "superior" ensemble
- This is done by viewing parameterization biases as a **benefit**, not a problem

Future Work

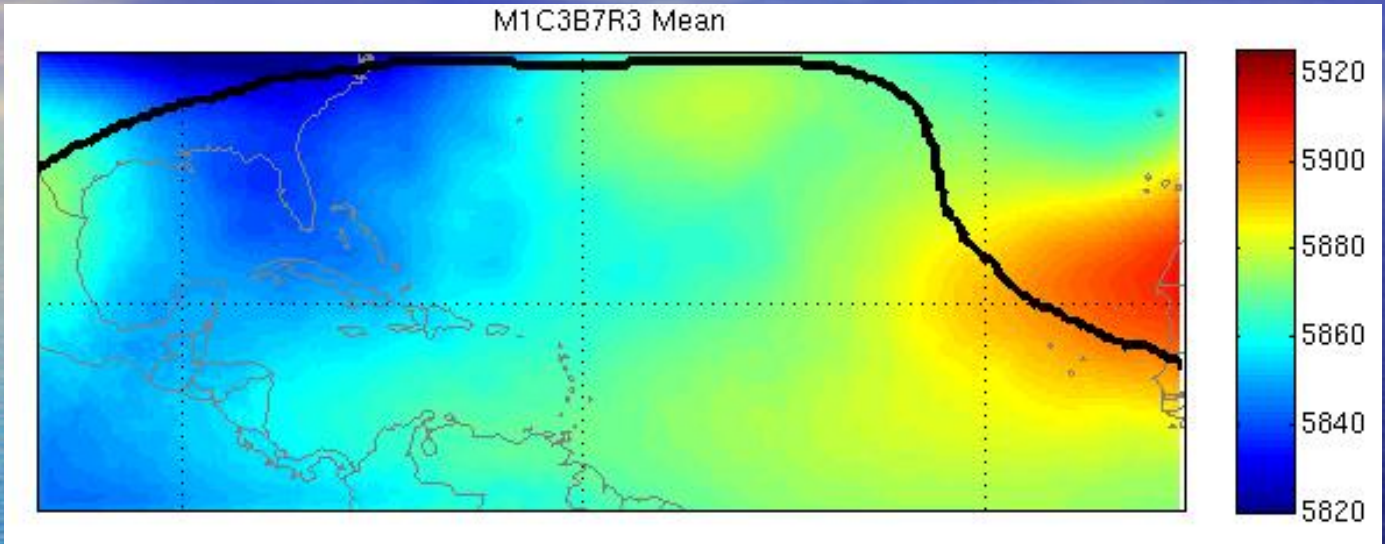
- Currently, the parameterization ensemble vs. GFS ensemble results are being redone with the use of Global WRF
- More advanced statistical techniques could be used to improve on these results
  - Unequal weighting
  - Using more predictors
  - Identifying regimes

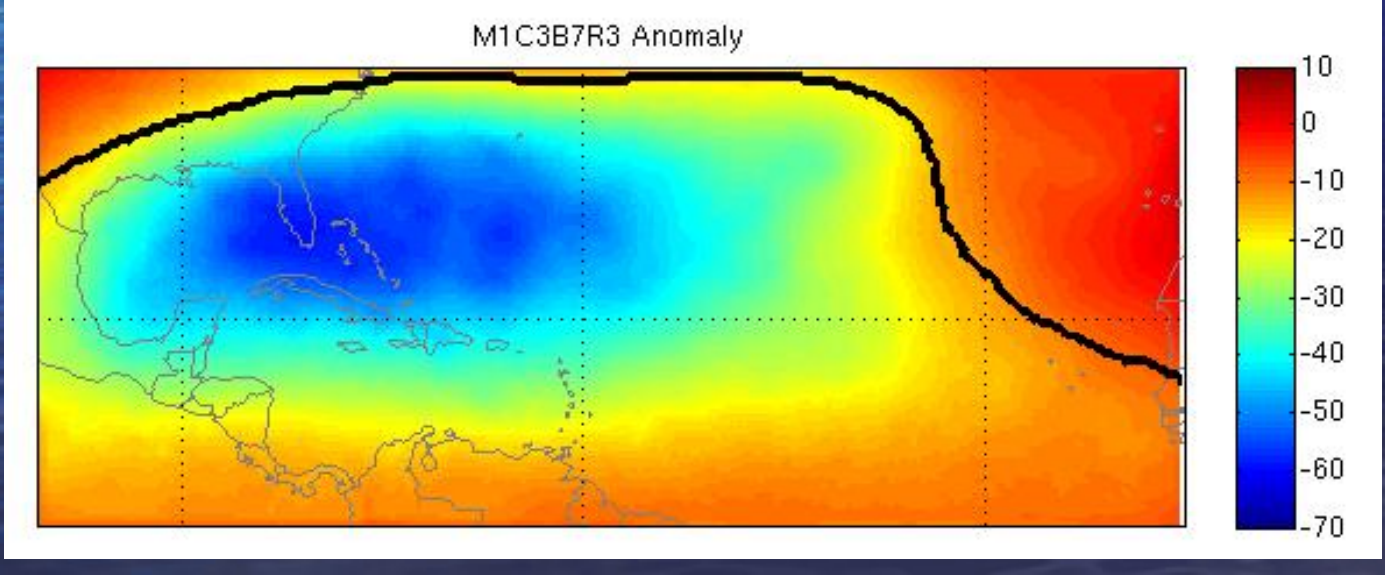

WSM3
Microphysics
Parameterization
Ferrier
Microphysics
Parameterization
Kain-Fritsch
Cumulus
Parameterization
MYJ Boundary Layer
Parameterization
Betts-Miller-Janjic
Cumulus
Parameterization
YSU Boundary Layer
Parameterization
Grell-3 Cumulus
Parameterization

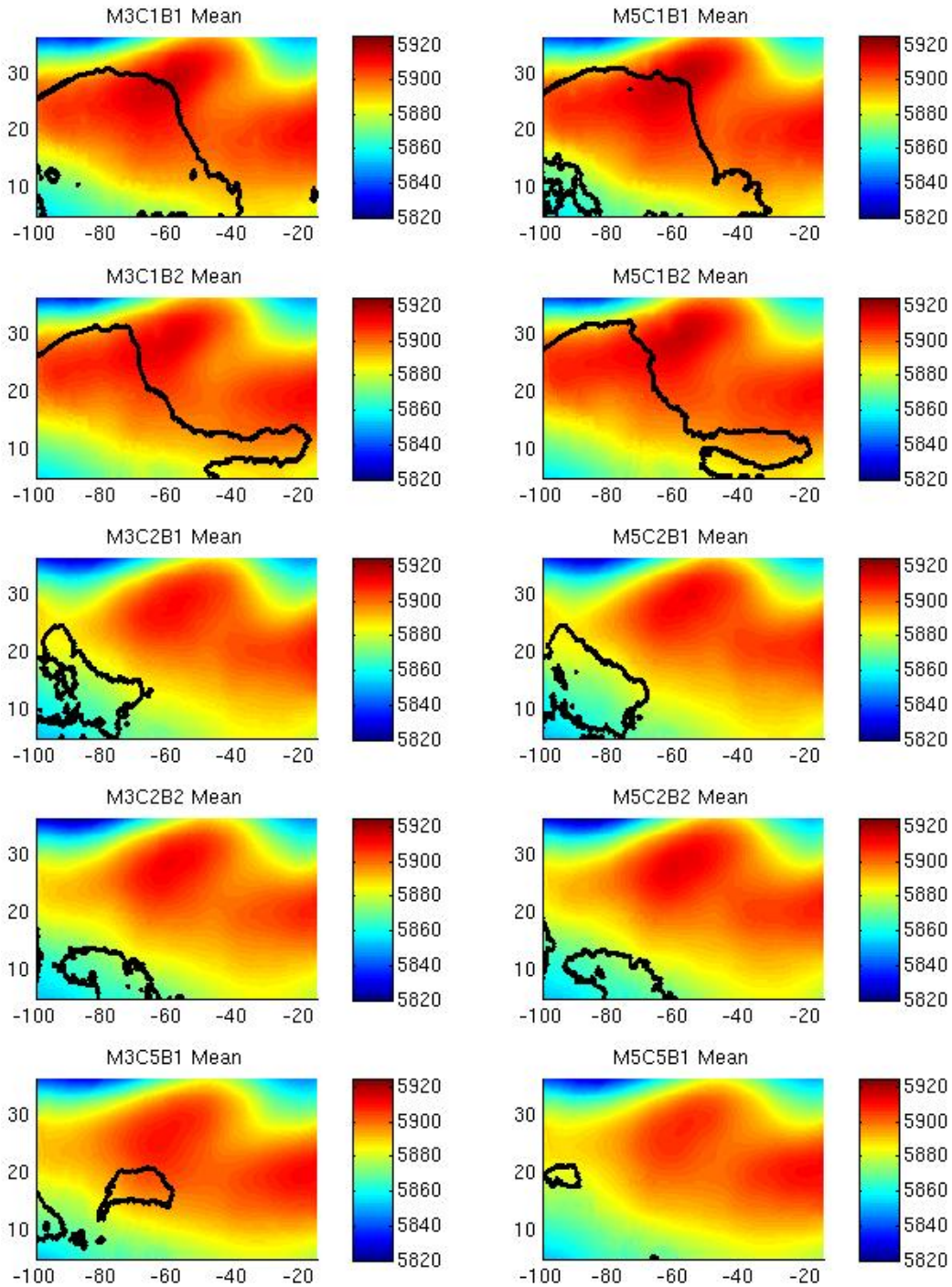
Idea: Predicting Predictions

- Generically speaking, all of these models are pretty similar
- For each forecast day, I ran an additional model with completely different parameterizations, which were purposely chosen to be "bad" (at least in combination)
- Afterward, I used the original ten models to predict the new one (i.e. a prediction of a prediction) using multivariate linear regression

For Reference: New Composites of 500 mb Height






M3C1B1 Mean
M5C1B1 Mean
M3C1B2 Mean
M5C1B2 Mean
M3C2B1 Mean
M5C2B1 Mean
M3C2B2 Mean
M5C2B2 Mean
M3C5B1 Mean
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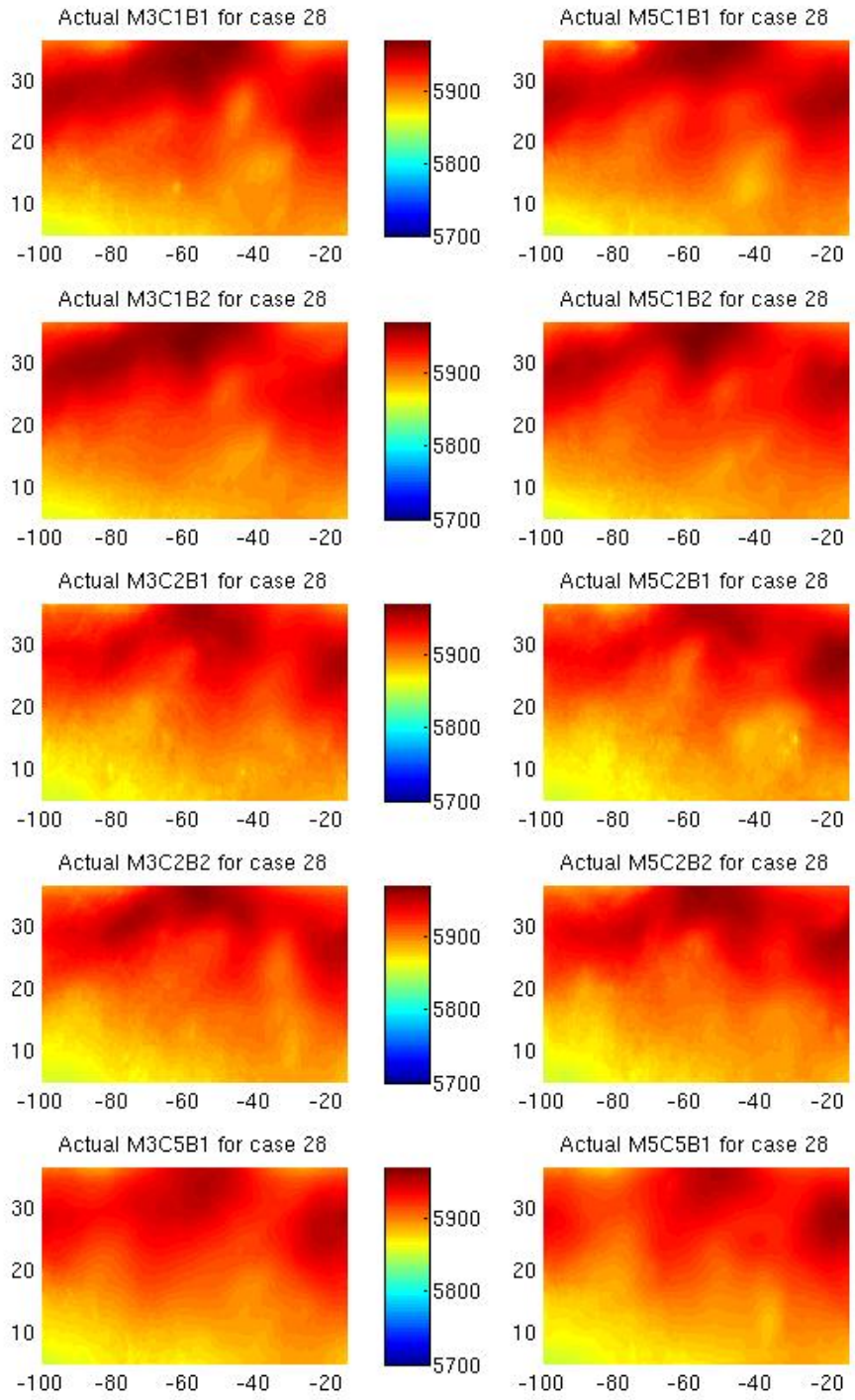
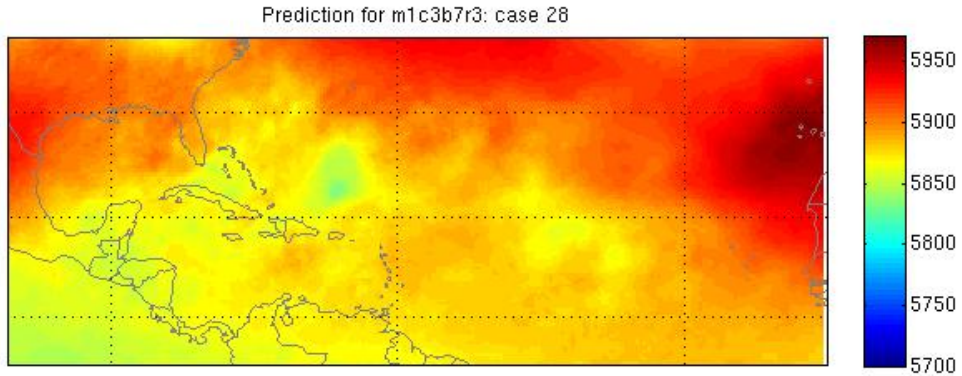
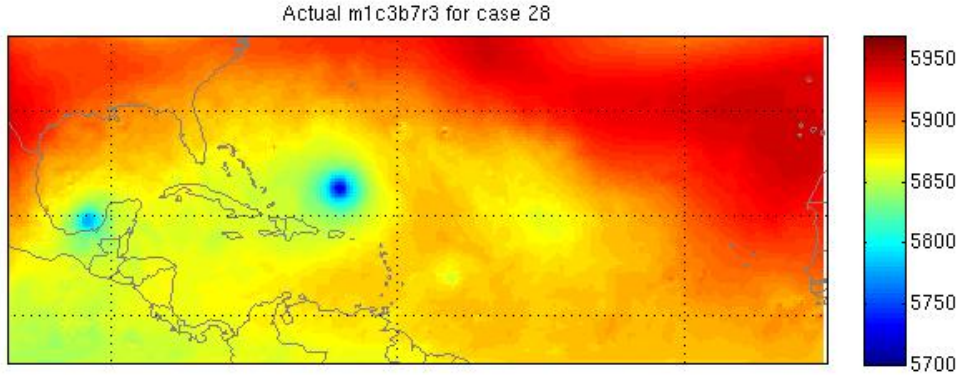
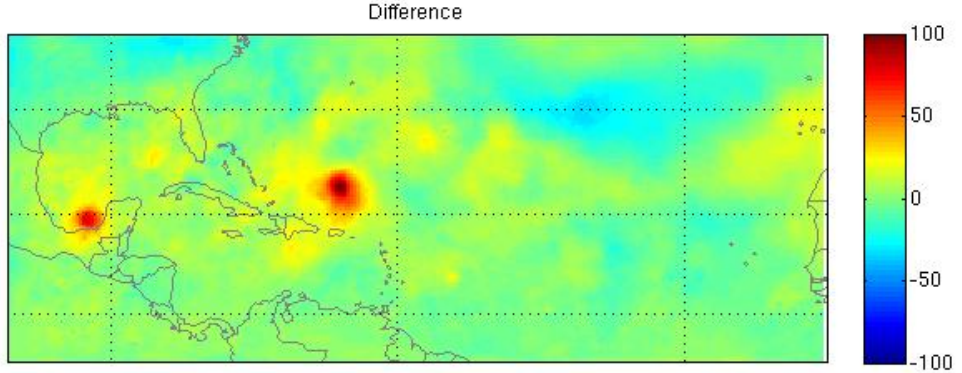
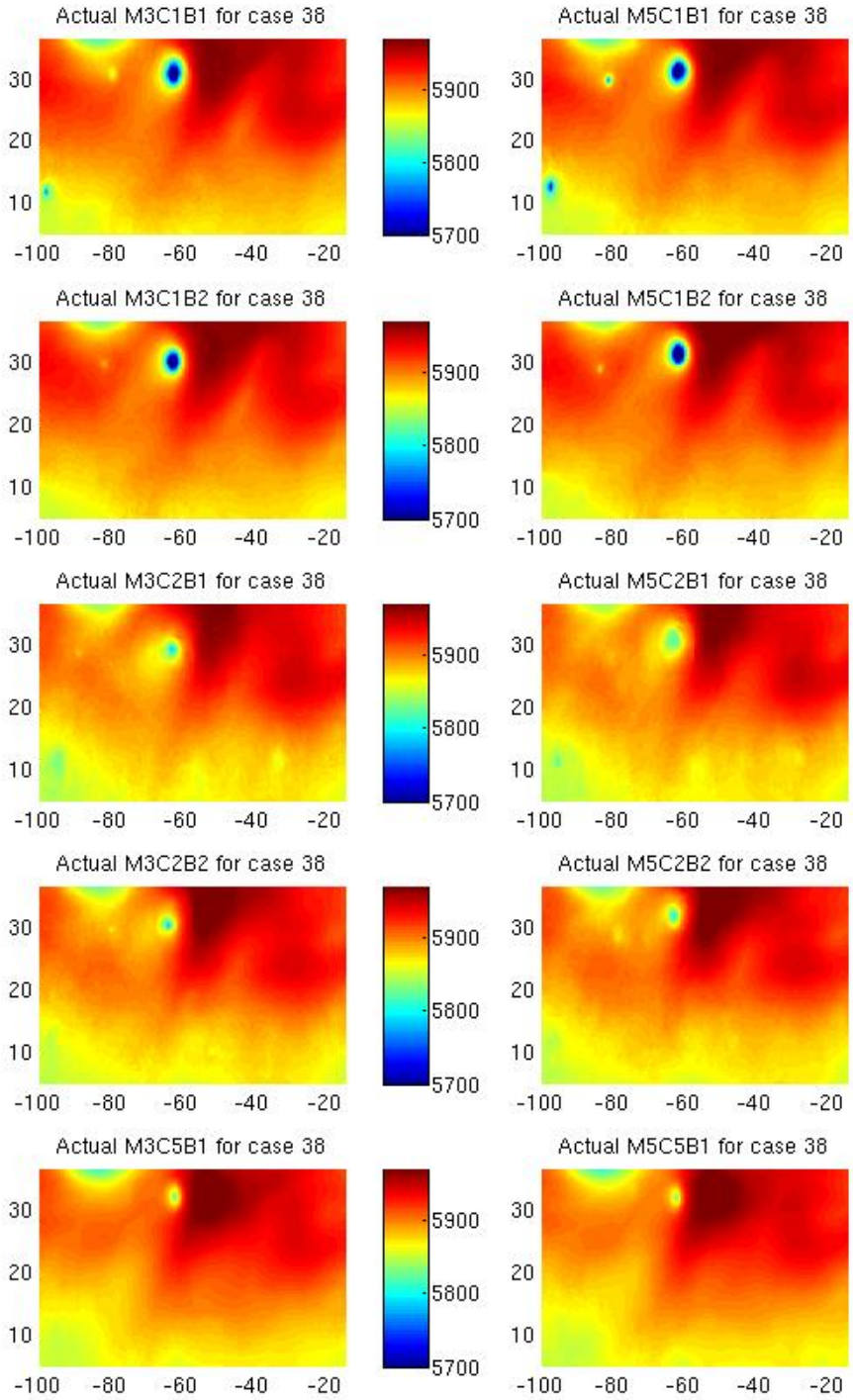


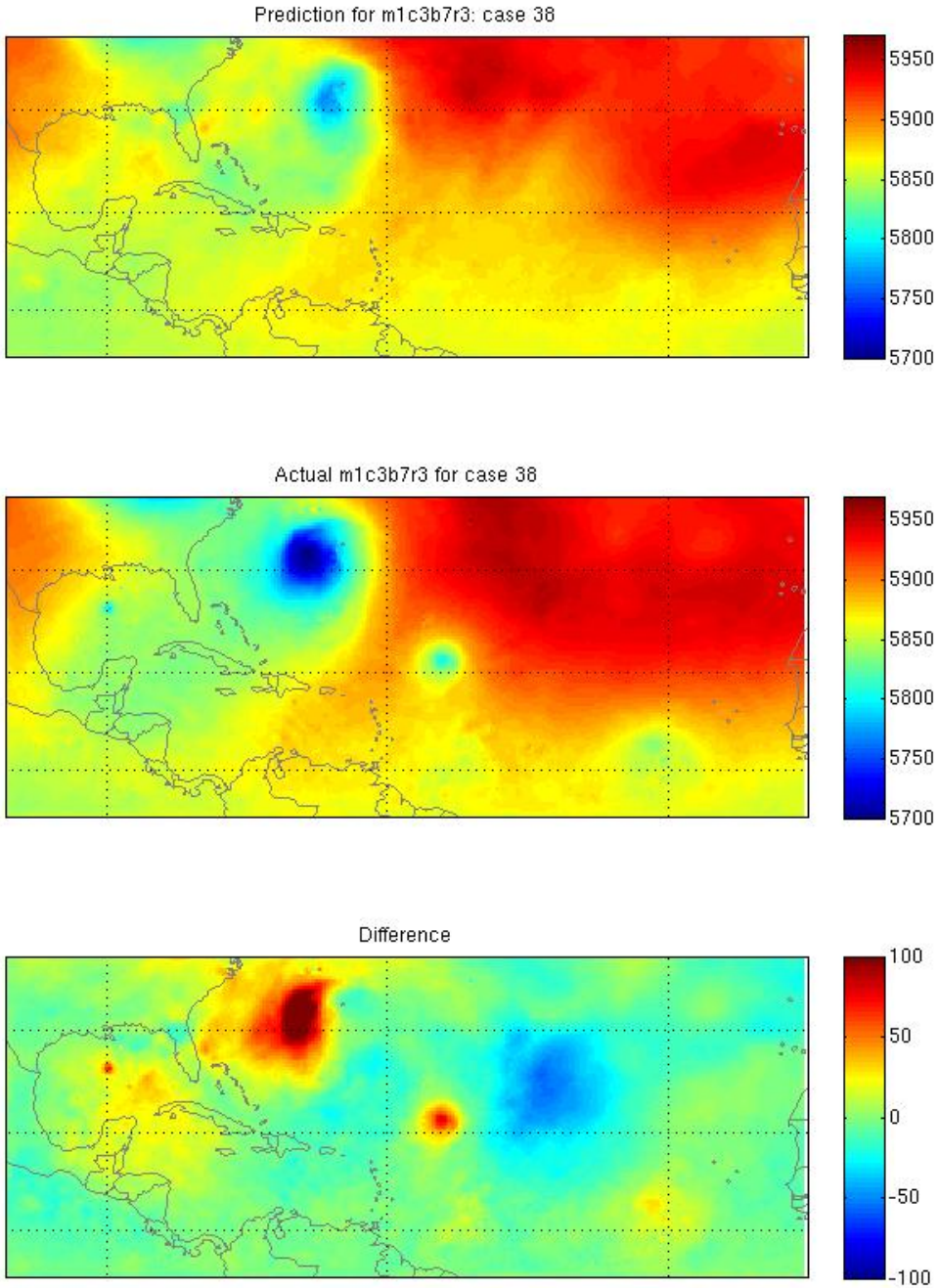






Case 28: July 28th 2009





Case 38: August 17th 2009