The Role of Initial Condition Errors in Danielle and Karl's Genesis Forecasts

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Overview

- PREDICT H5: *Despite potentially significant model errors, poor initial conditions are the key factor in poor predictions of genesis.*
- Want to evaluate this hypothesis by using objective techniques to determine the sensitivity of pre-genesis forecasts to the initial conditions

Ensemble Sensitivity

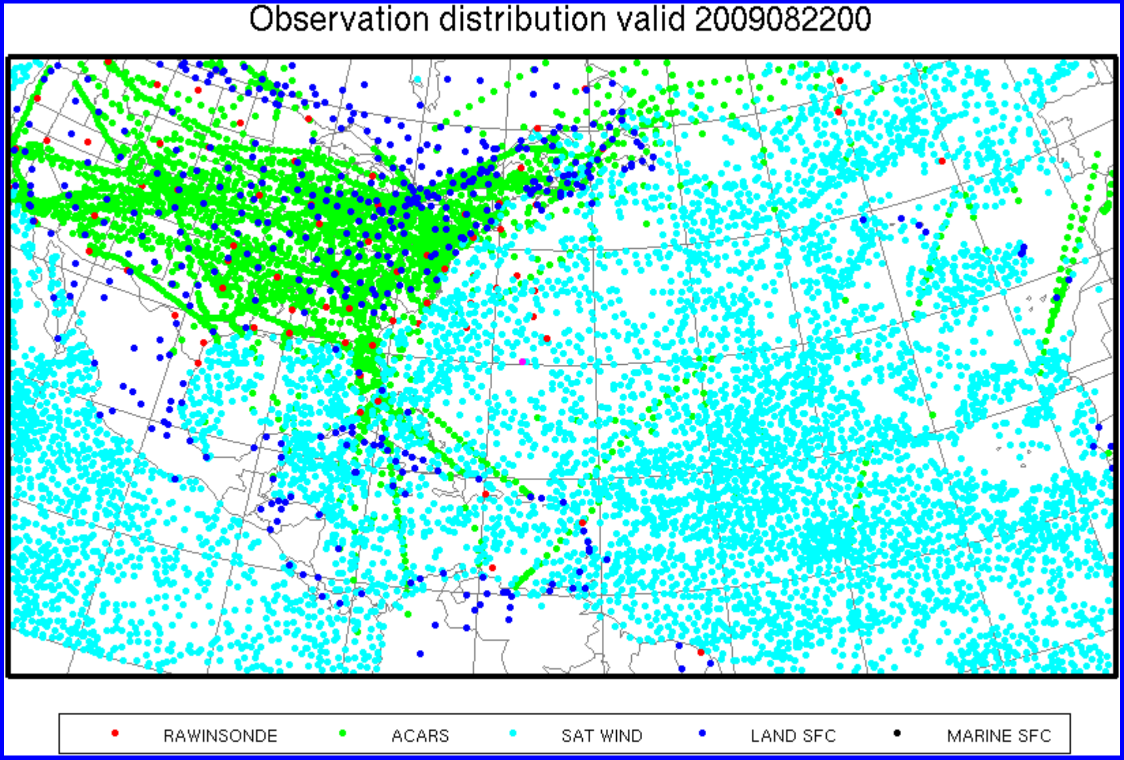
$$\frac{\partial J_e}{\partial x_j} \equiv cov(\delta J, \delta \mathbf{x}_{o,j})\mathbf{D}_j^{-1} = \frac{cov(\mathbf{J}, \mathbf{X}_j)}{var(\mathbf{X}_j)}$$

Ancell and Hakim 2007, Torn and Hakim 2008

- Ensemble-based method of computing the sensitivity to the initial conditions
- Above equation is linear regression based on ensemble:
  - Dependent variable is forecast metric
  - Independent variable is an element of state vector
- Can also obtain confidence bounds on sensitivity value

Ensemble Forecast Details

- WRF ARW (v3.1), 36 km horizontal resolution, 96 ensemble members, DART assimilation system.
- Observations assimilated each six hours from surface and marine stations (P_{sfc}), rawinsondes, Tri-agency dropsondes (at least 100 km from any TC), ACARS, sat. winds, TC position and minimum SLP, and GPS refractivity starting 1 August
- Cycle observations on 12 km nested domains that follow INVEST + TCs
- Initialize ensemble forecasts each 12 h from analysis ensemble. Nested domain for most interesting INVEST

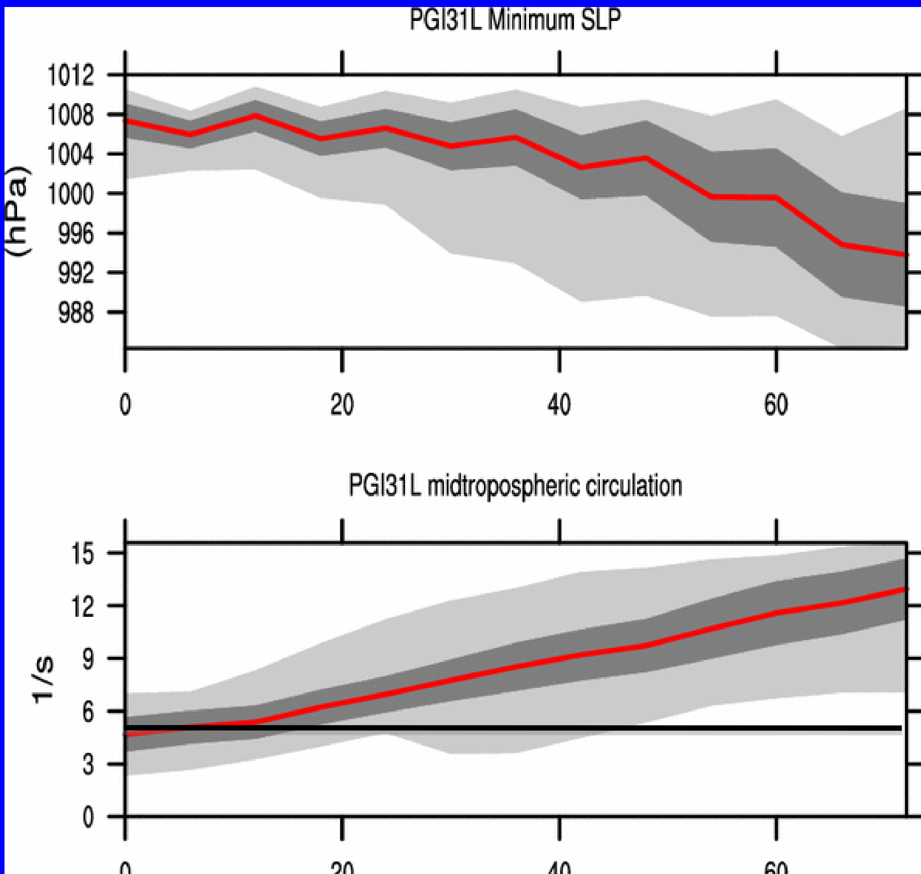


Forecast Metrics

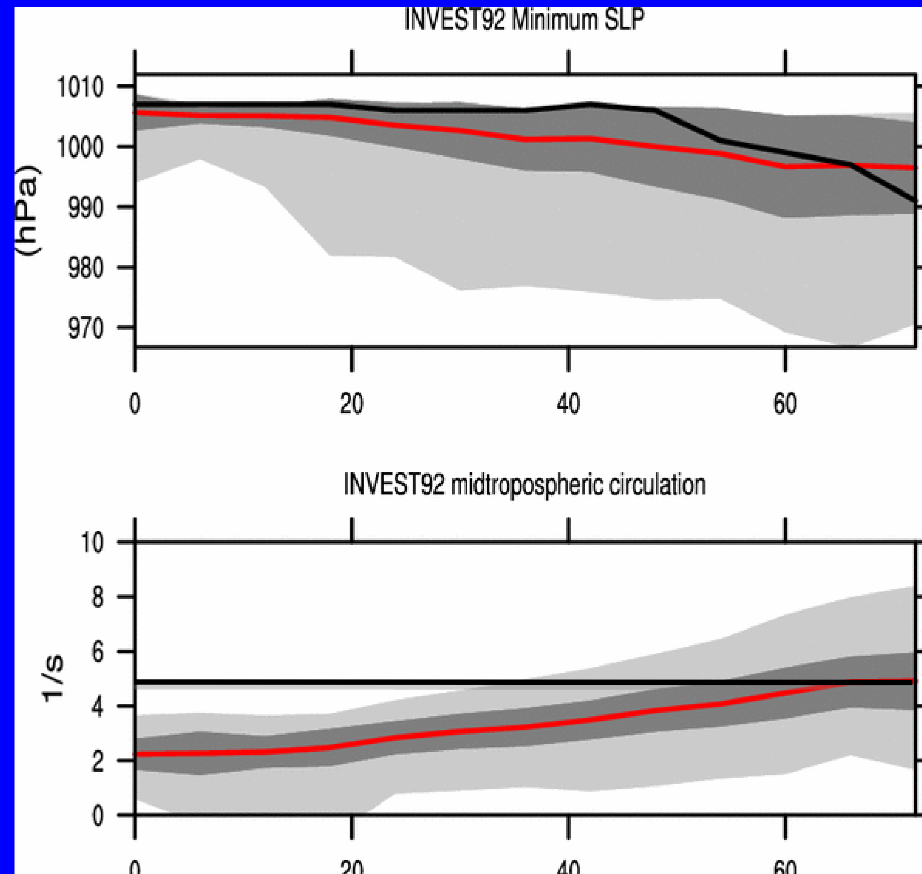
- Consider two forecast metrics
  - 850 hPa circulation (vorticity averaged within 200 km of center of circulation)
  - 200-850 hPa thickness anomaly (average within 250 km minus average within 1000 km of the center)

Forecast Overview

Pre-Danielle 0000 UTC 20 August

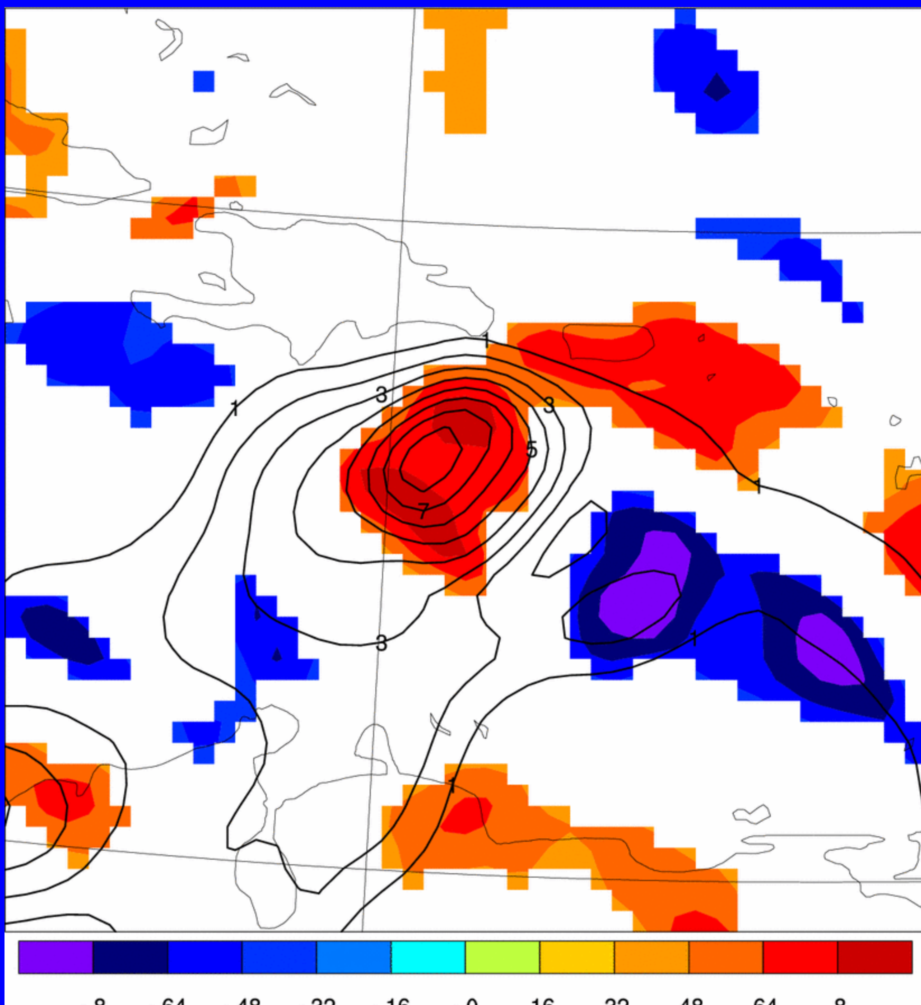


Pre-Karl 1200 UTC 12 September

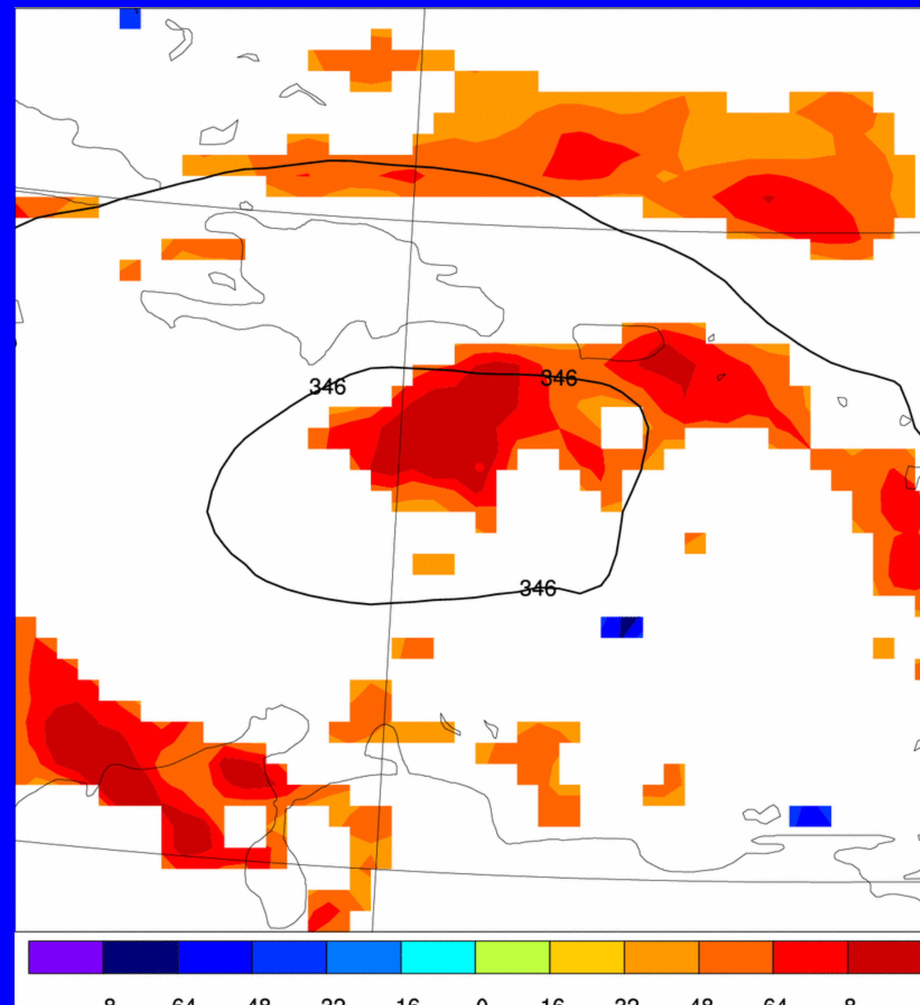


Karl Forecast Sensitivity Maps

850 hPa Circulation



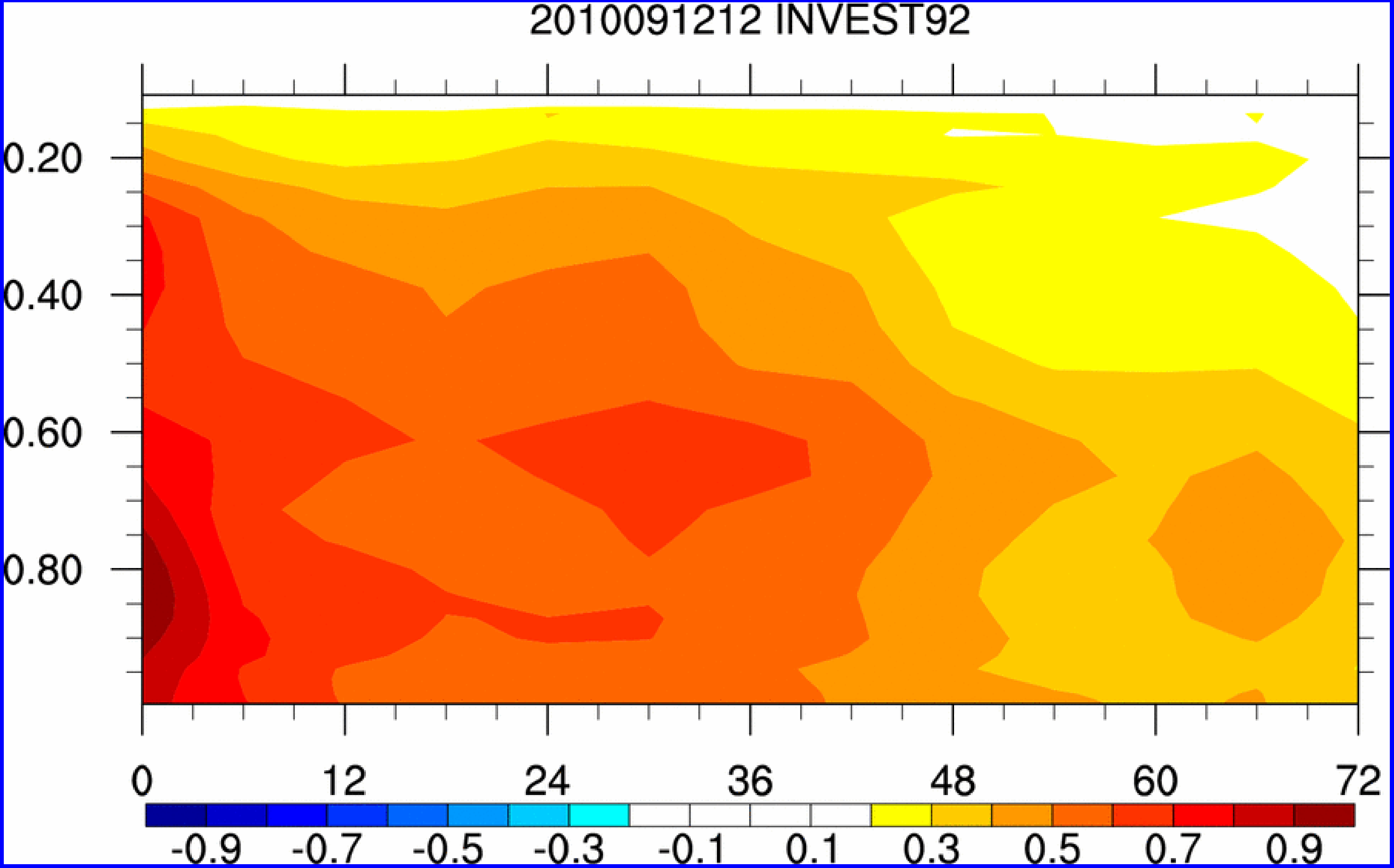
200-500 hPa θ_e



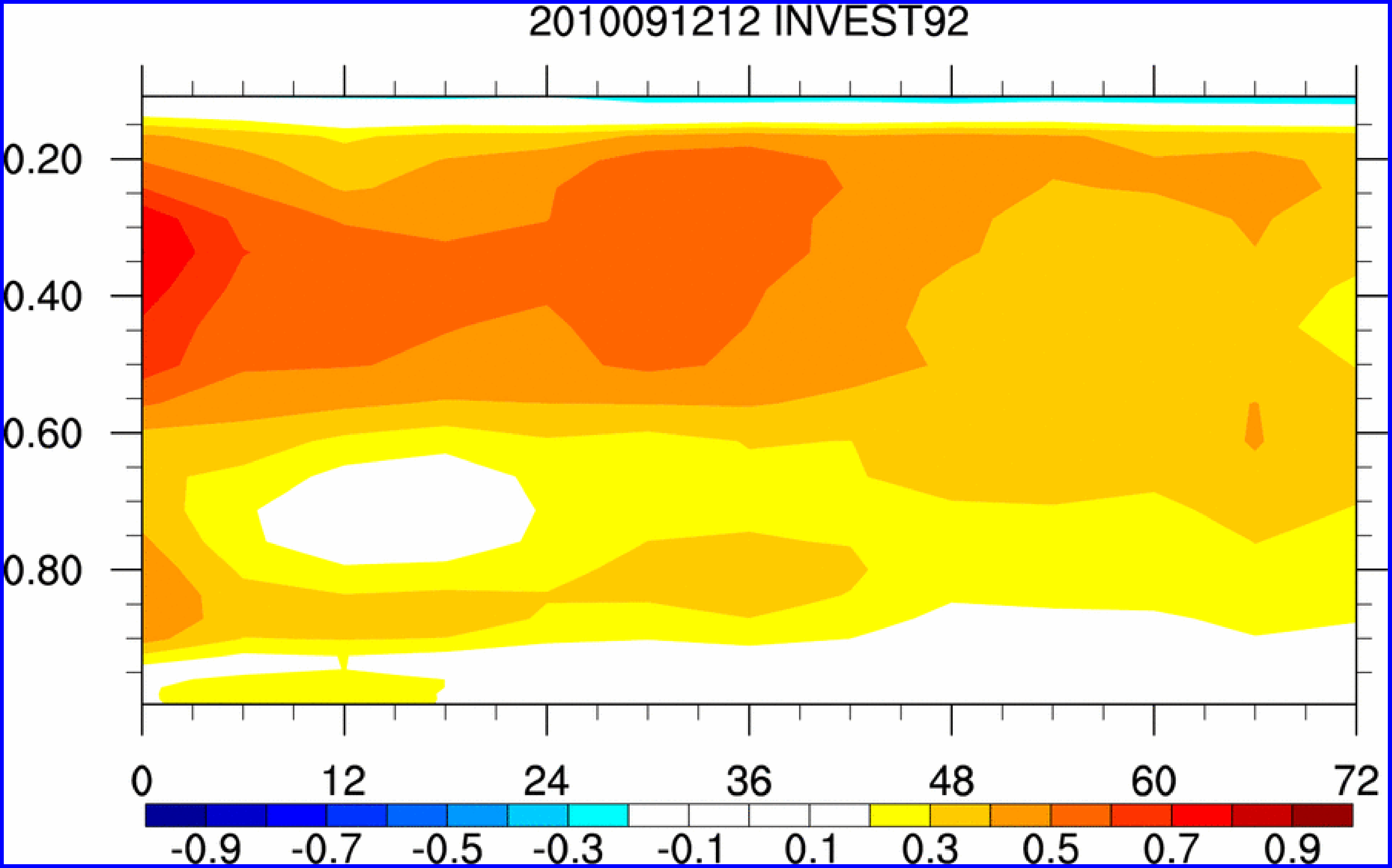
Pouch Sensitivity

- Much of the sensitivity appears to be associated with the pouch structure
- Compute mean quantities within 200 km of the center of pouch at each vertical at the initial time
- Correlate with the 850 hPa circulation each 6 h of the forecast
- Demonstrates how sensitive forecast is to initial pouch structure at various levels and lead times

Pouch Circulation Sensitivity

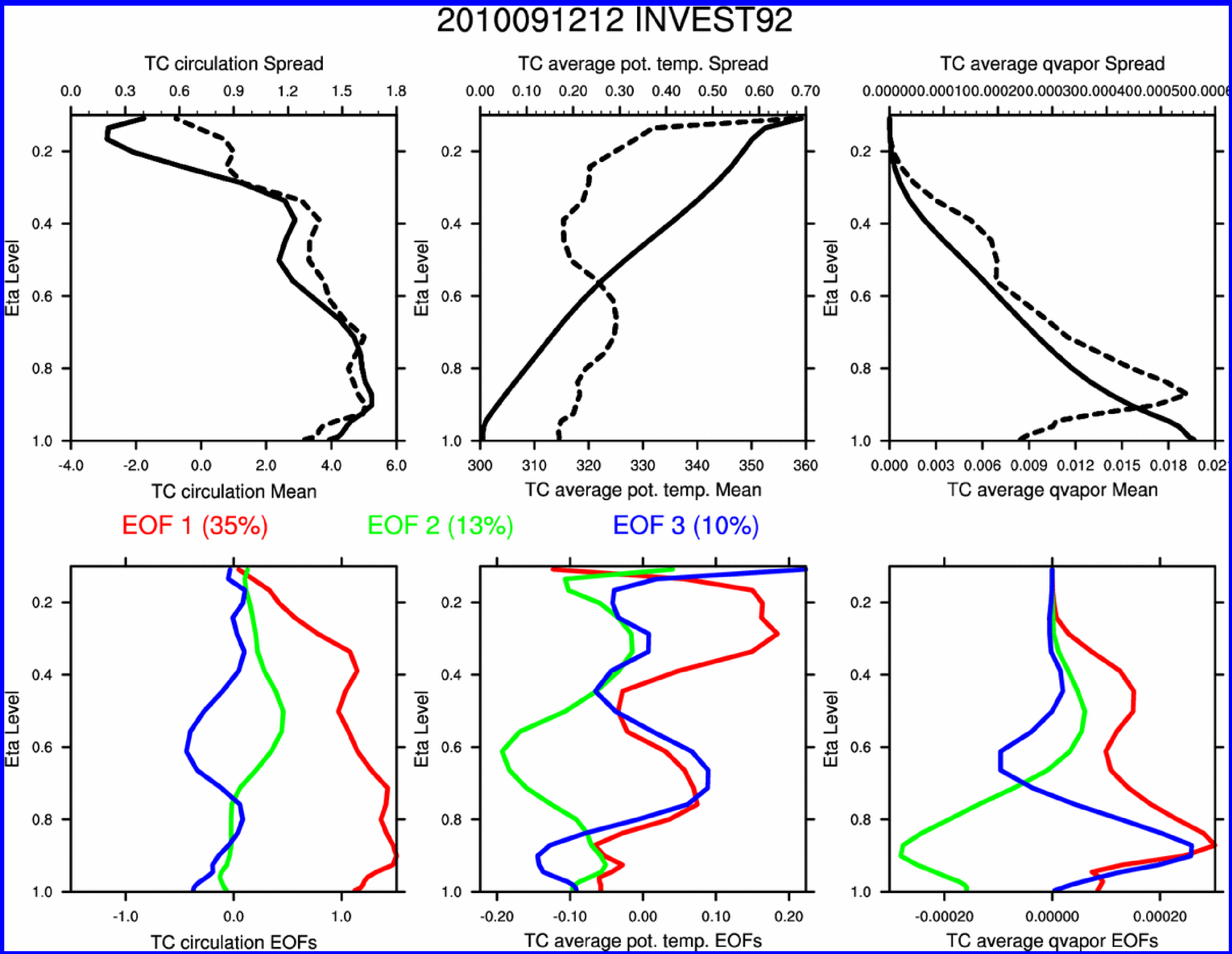


Pouch θ_e Sensitivity

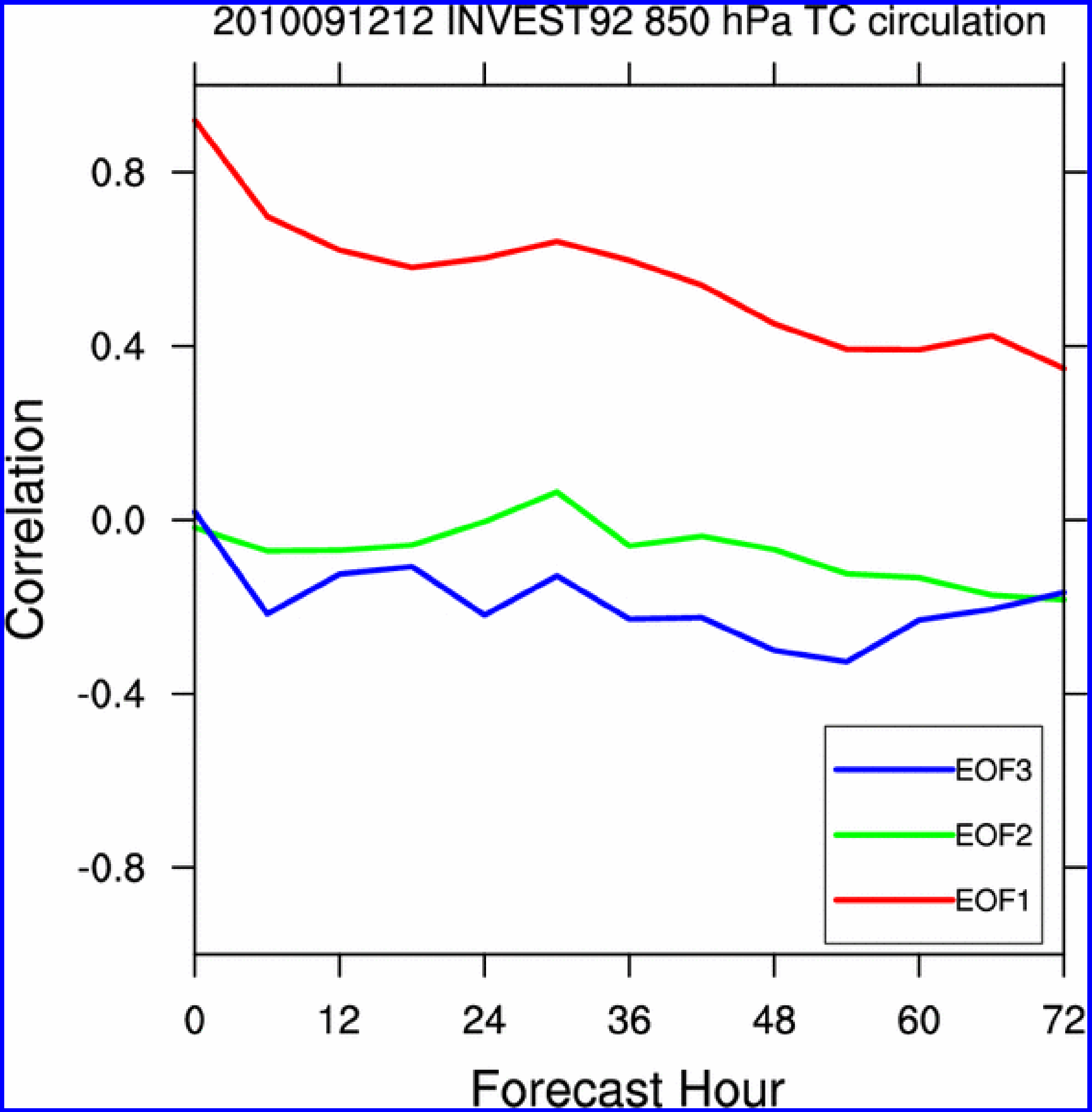


EOF Analysis

- It is likely that the pouch circulation and moisture fields are correlated with each other both in the vertical and between fields
- Want to identify initial condition structures that are unique
- Compute EOF of initial pouch circulation, theta and qvapor fields as a function of height (normalized by standard deviation)
- Correlate PCs of the EOFs with the forecast metrics at various lead times

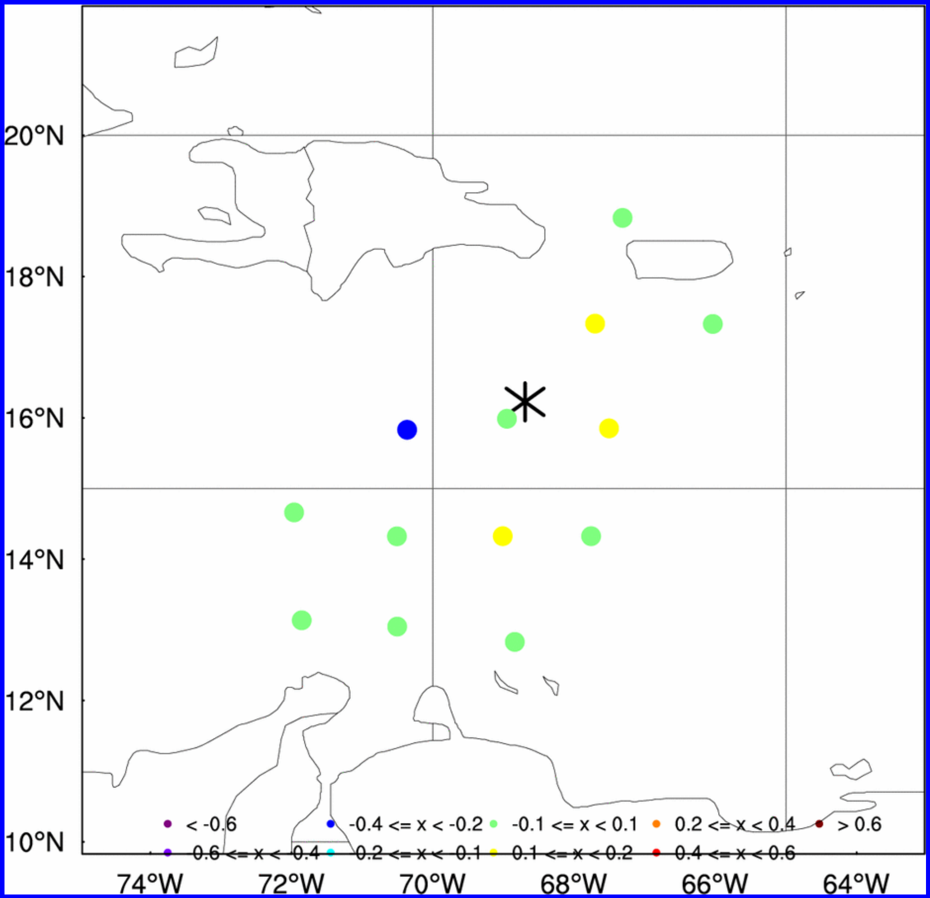

2010091212 INVEST92
TC circulation Spread
TC average pot. temp. Spread
TC average qvapor Spread
Eta Level
TC circulation Mean
TC average pot. temp. Mean
TC average qvapor Mean
EOF 1 (35%)
EOF 2 (13%)
EOF 3 (10%)
TC circulation EOFs
TC average pot. temp. EOFs
TC average qvapor EOFs

Metric Correlations

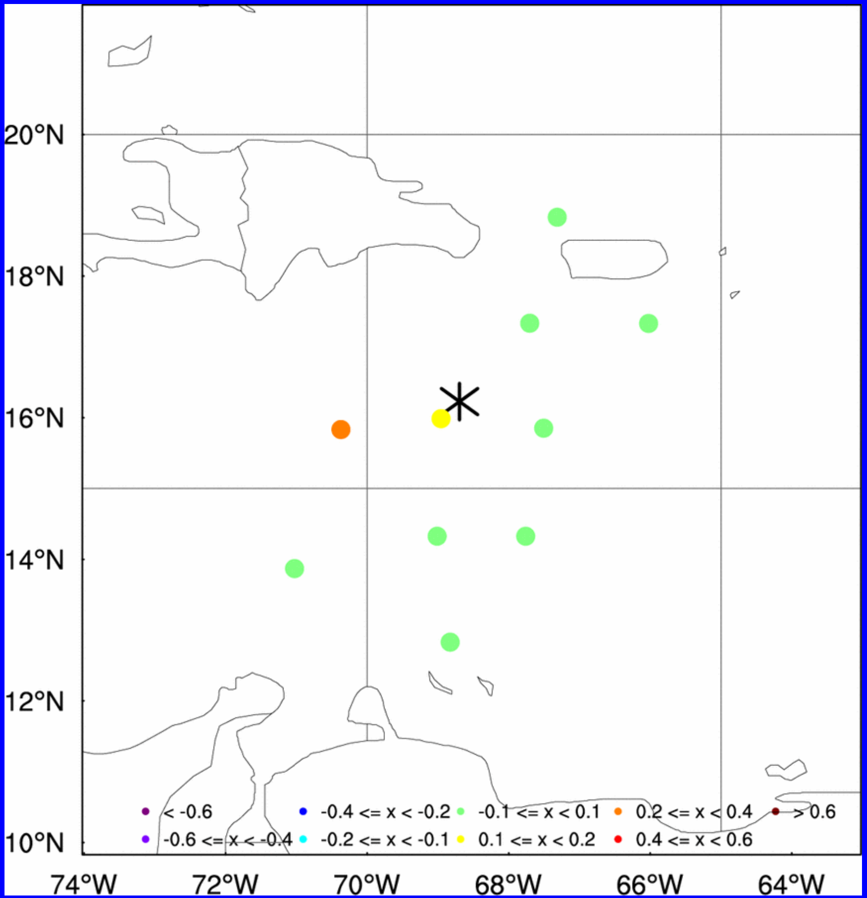


PREDICT Obs.

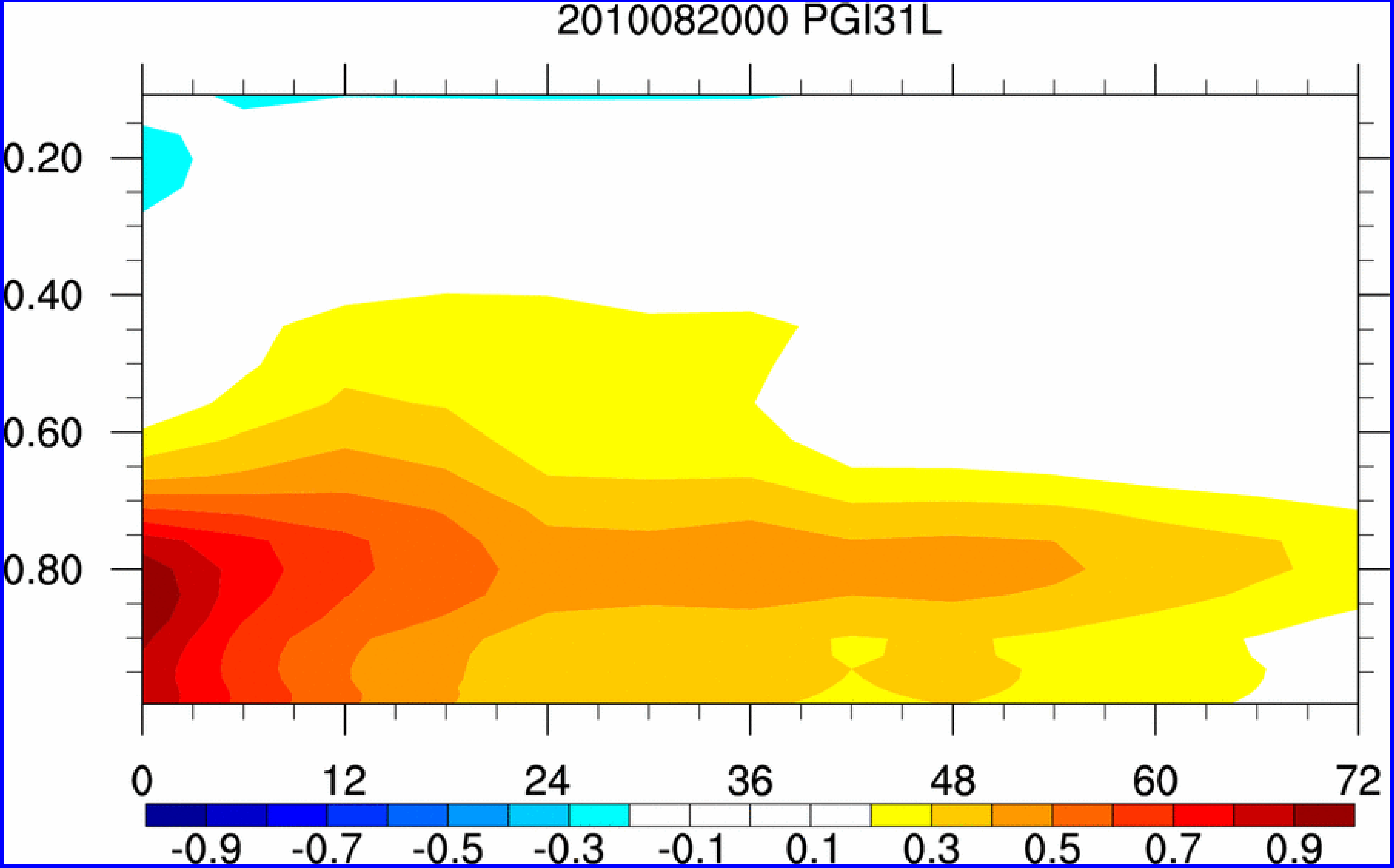
Meridional Wind



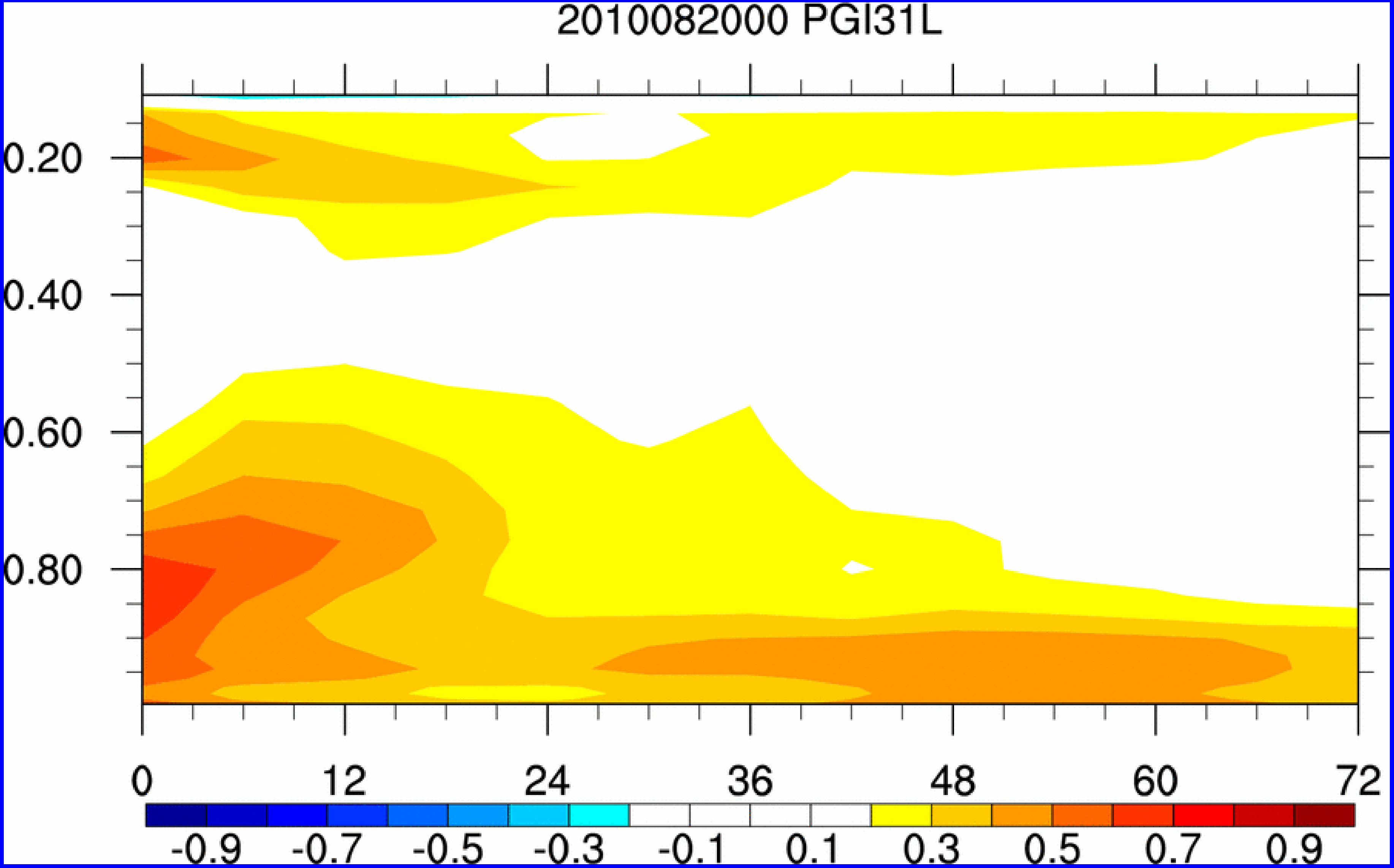
Specific Humidity

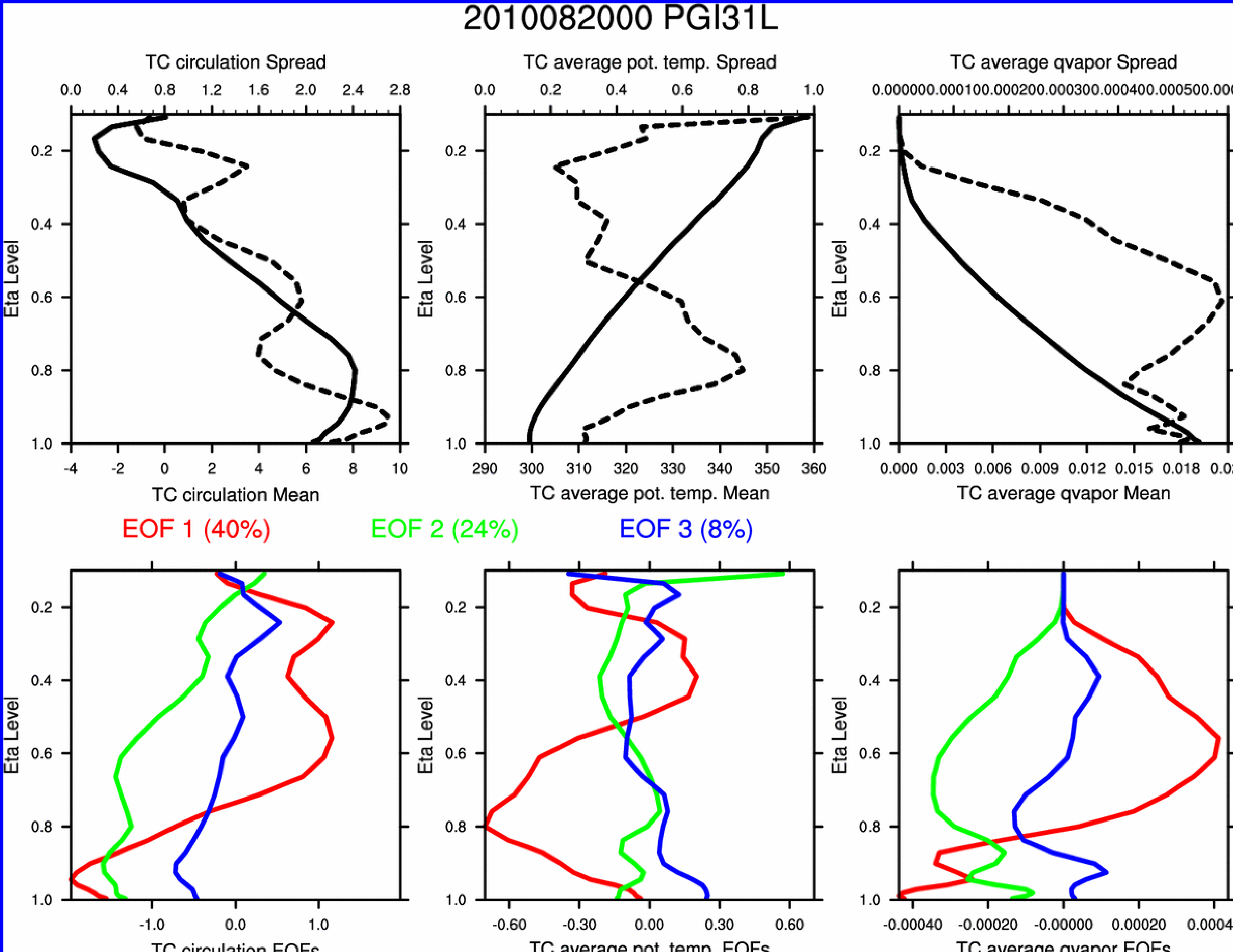


Danielle Circulation Sensitivity

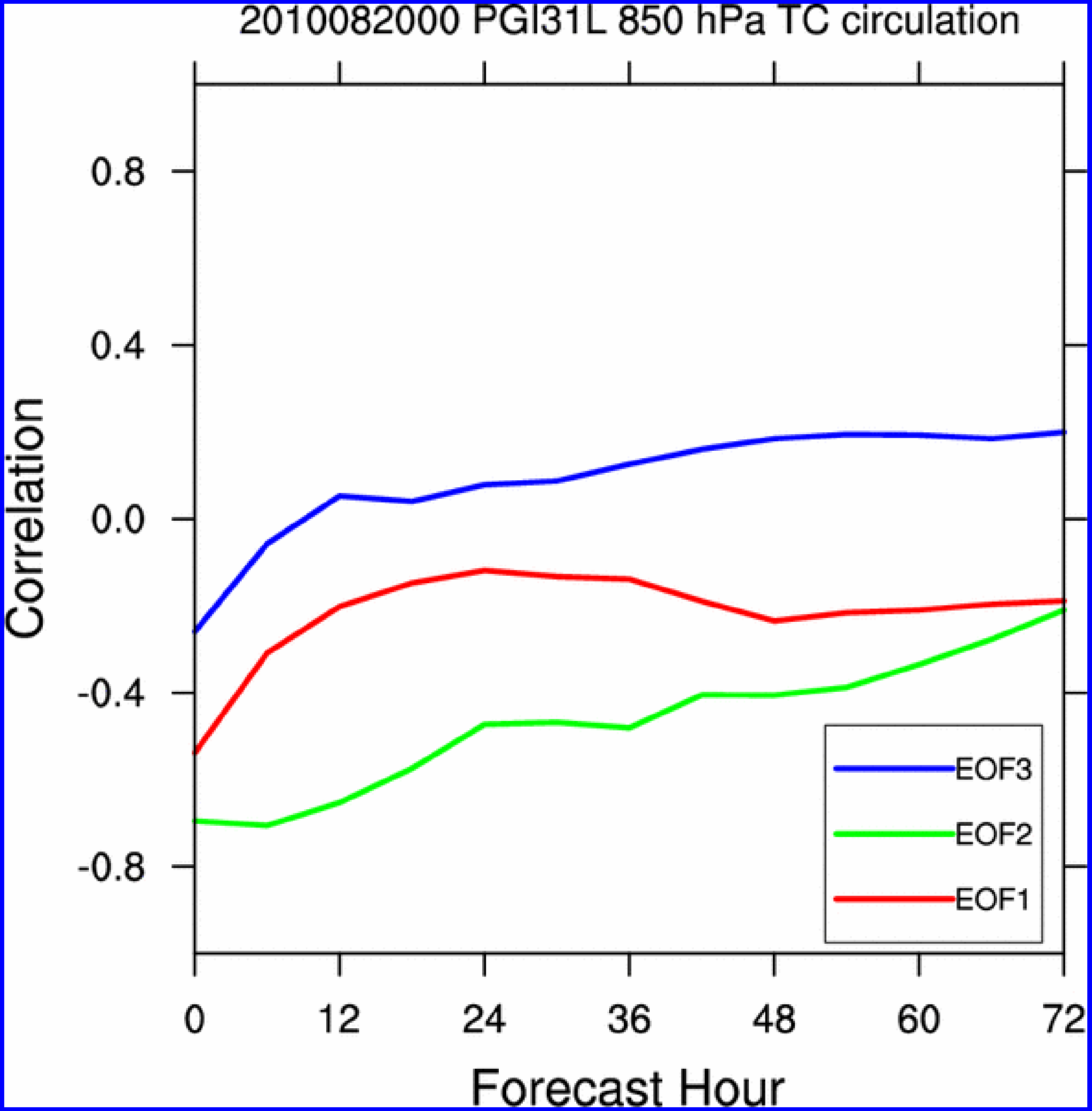


Danielle θ_e Sensitivity




2010082000 PGI31L
TC circulation Spread
TC average pot. temp. Spread
TC average qvapor Spread
Eta Level
TC circulation Mean
TC average pot. temp. Mean
TC average qvapor Mean
EOF 1 (40%)
EOF 2 (24%)
EOF 3 (8%)
TC circulation EOFs
TC average pot. temp. EOFs
TC average qvapor EOFs

Danielle Forecast



Preliminary Conclusions

- Karl Forecasts sensitive to:
  - Initial low-level circulation
  - upper tropospheric temperature, moisture
- GV Dropsondes near center of pouch correlate with this most sensitive structure, thus they are more likely to impact the forecast
- Danielle forecasts show greater sensitivity to lower tropospheric quantities, but initial EOF structure is similar

Future Work

- Expand analysis to include environmental factors. Evaluate how pouch structure vs. environmental factors influence development
- Repeat analysis on other PREDICT cases, particularly Gaston, Matthew, Nicole
- Series of data denial experiments where PREDICT data assimilated or withheld