

Empirical Correction of the Global Forecast System

Climate Dynamics and Experimental Prediction (CDEP)

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Empirical Correction Method

Leith 1976; DelSole and Hou 1999

$$\dot{\mathbf{x}} = g(\mathbf{x}) + \epsilon$$

tendency *GCM* *error*

Parameterize ϵ

$$\boldsymbol{\epsilon} = \mathbf{L} \mathbf{x} + \mathbf{b}$$

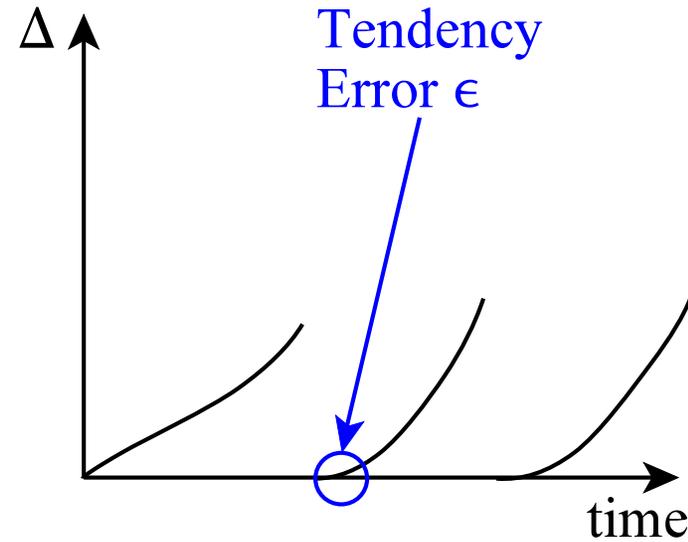
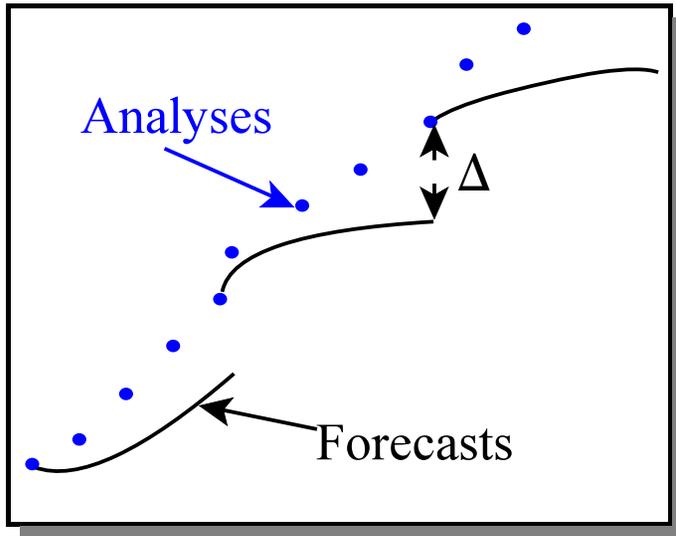
Least Squares Estimates

$$\mathbf{L} = \langle (\dot{\mathbf{x}} - \mathbf{g}(\mathbf{x}))' \mathbf{x}'^T \rangle \langle \mathbf{x}' \mathbf{x}'^T \rangle^{-1}$$

$$\mathbf{b} = \langle \dot{\mathbf{x}} - \mathbf{g}(\mathbf{x}) \rangle - \mathbf{L} \langle \mathbf{x} \rangle$$

Faller and Lee (1975); Faller and Schemm (1977);
Leith (1978); Achatz and Branstator (1999); DelSole
and Hou (1999); Danforth et al. (2007)

Estimation of Tendency Error



Estimate ϵ by Average Growth Rate

$$\epsilon = \left(\frac{\Delta_{\tau, t}}{\tau} \right)^t$$

Analysis Details

- Model: Current GFS, May 2007, σ -coordinate
- ϵ estimated from 6, 12, 18, 24 hour forecasts
- ϵ for U, V, T, Q, Ps, T62 coefficients, all levels
- Training period: June 2005-Jan 2007
- Verification Period: Jan 2006, 0.25 - 5d forecasts
- Verifying Analysis: GFS Analysis

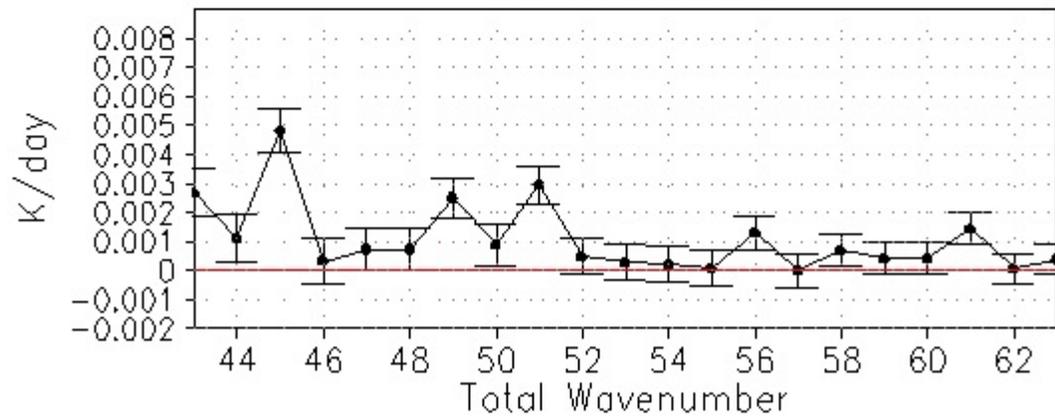
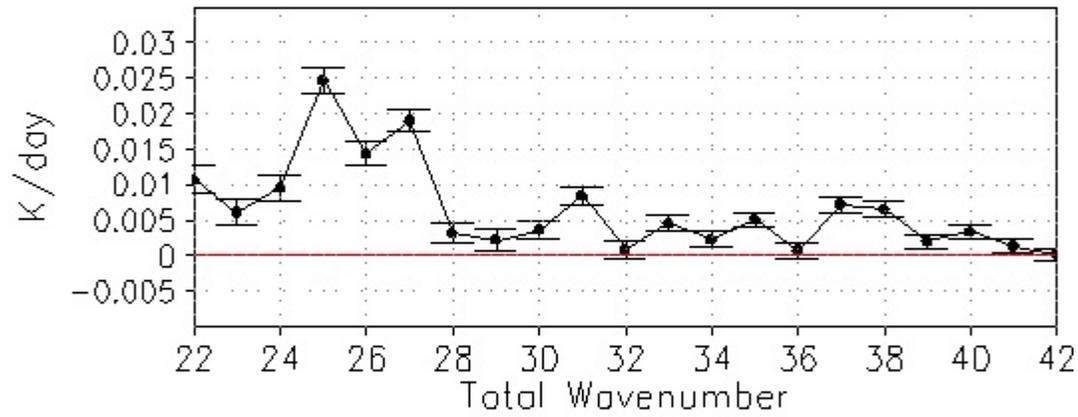
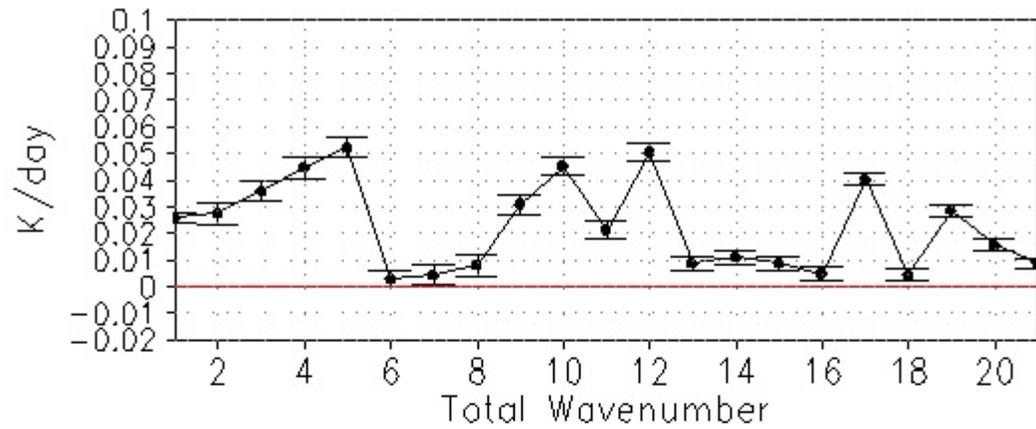
GFS: Seasonal Cycle

$$\frac{\Delta_{\tau, t}}{\tau} = \beta_1 + \beta_2 \cos(\omega t) + \beta_3 \sin(\omega t)$$

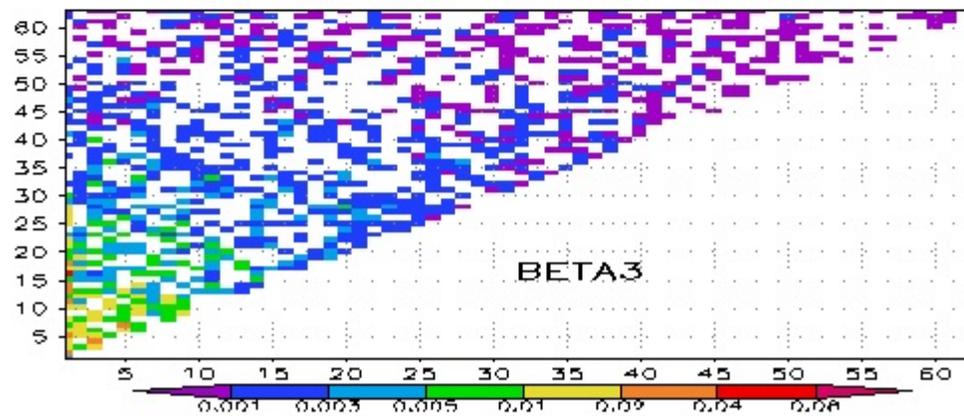
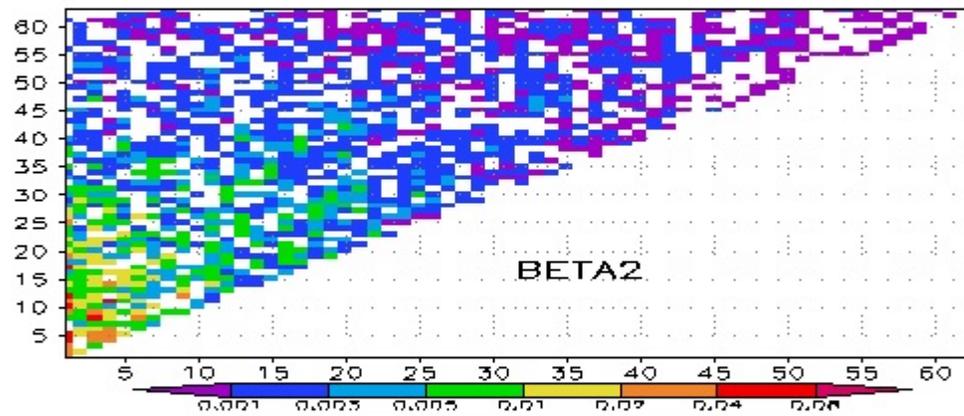
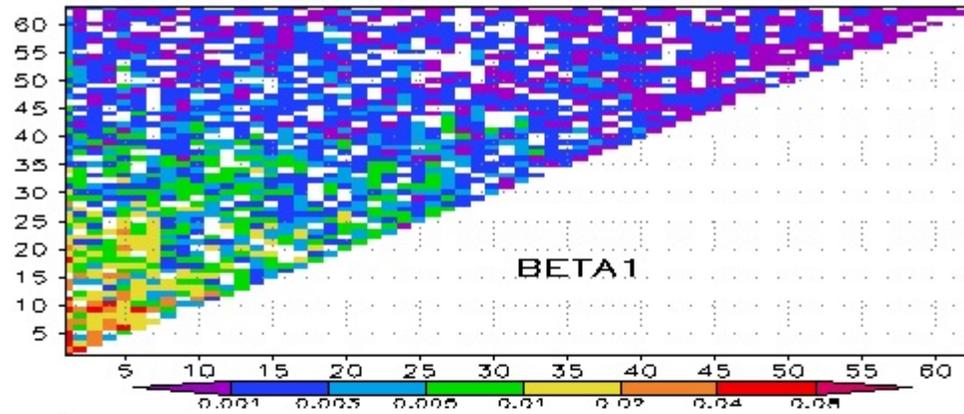
β -parameters estimated by regression methods

Regression performed in **Spectral Space**

Beta2 (m=0) (2004-2005)

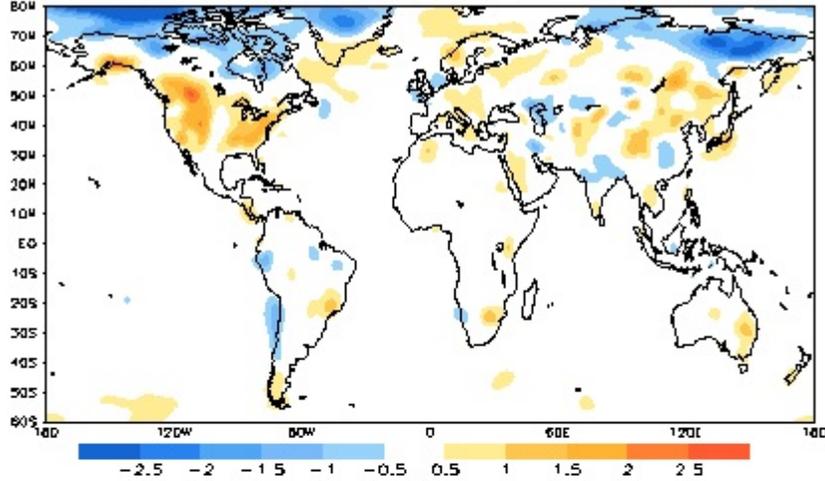


TEMP (z=1.0)

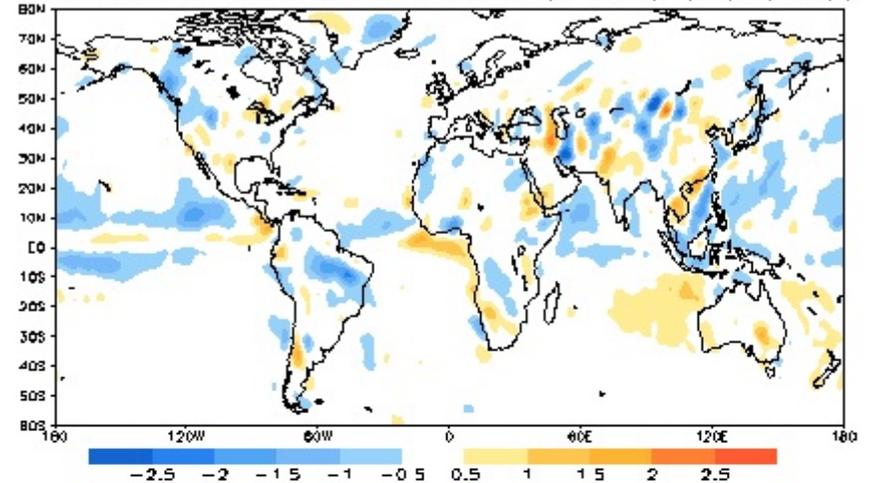


Statistically Significant Corrections for January

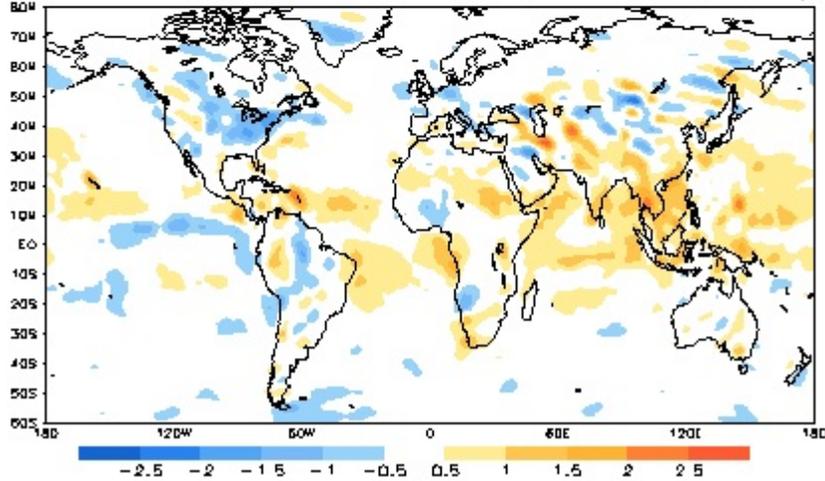
Correction Coefficient TEMP ($z=0.2$) (K/day)



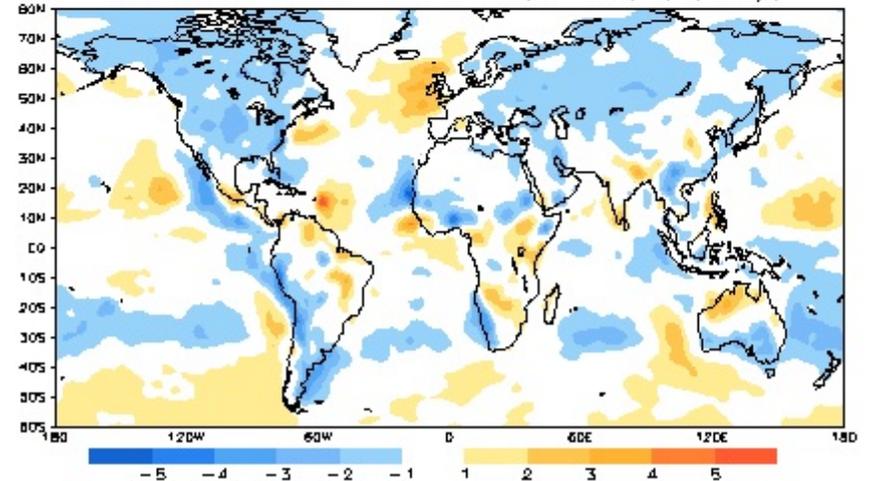
Correction Coefficient V-Wind ($z=0.2$) (m/s/day)



Correction Coefficient U-Wind ($z=0.2$) (m/s/day)



Correction Coefficient Q ($z=1.0$) (1/day)



Skill Assessment: Mean Square Error

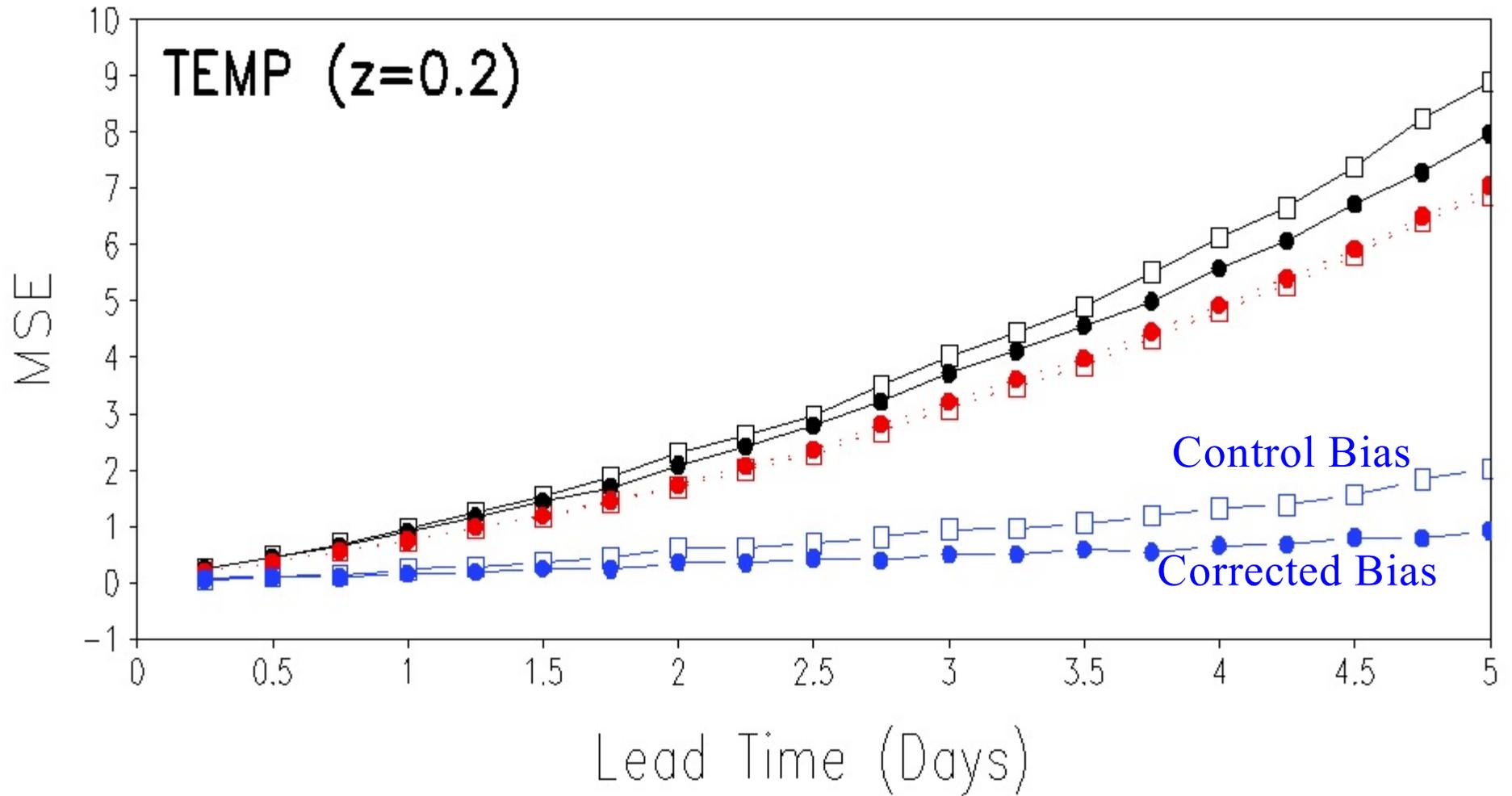
$$\mathit{Bias} = \langle \mathbf{f} - \mathbf{a} \rangle$$

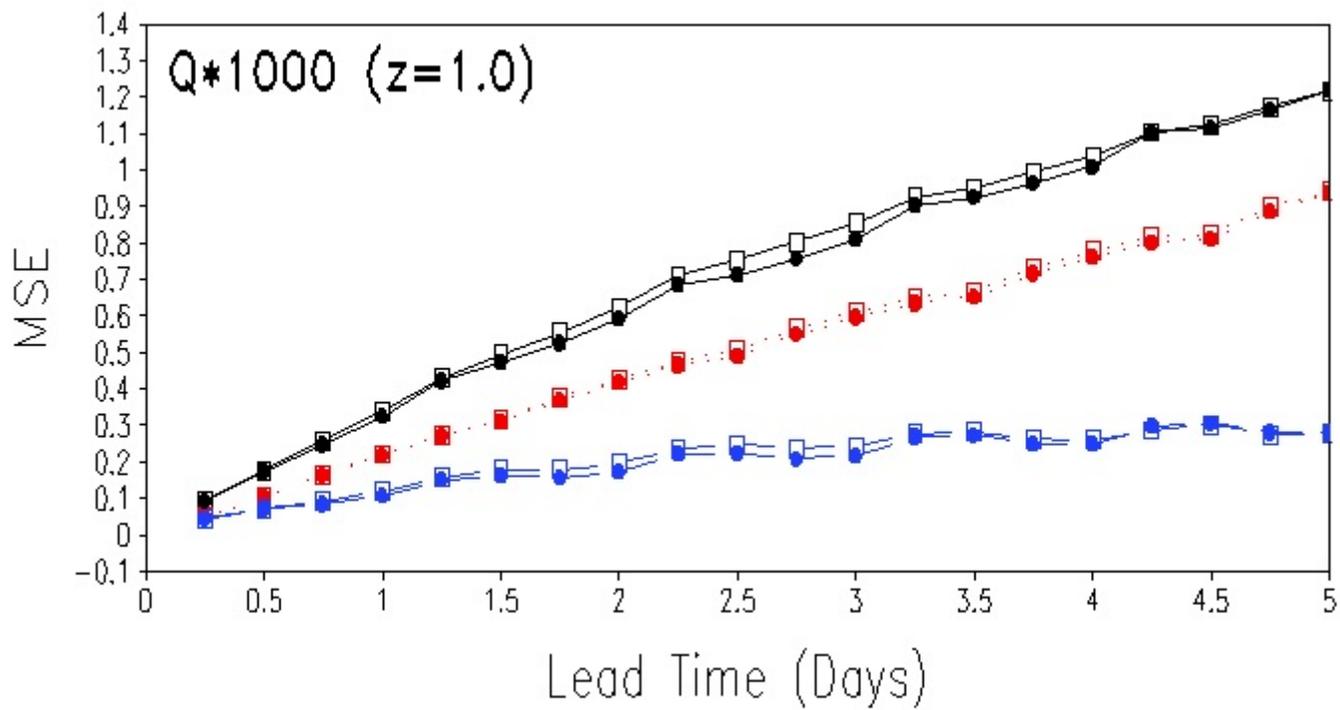
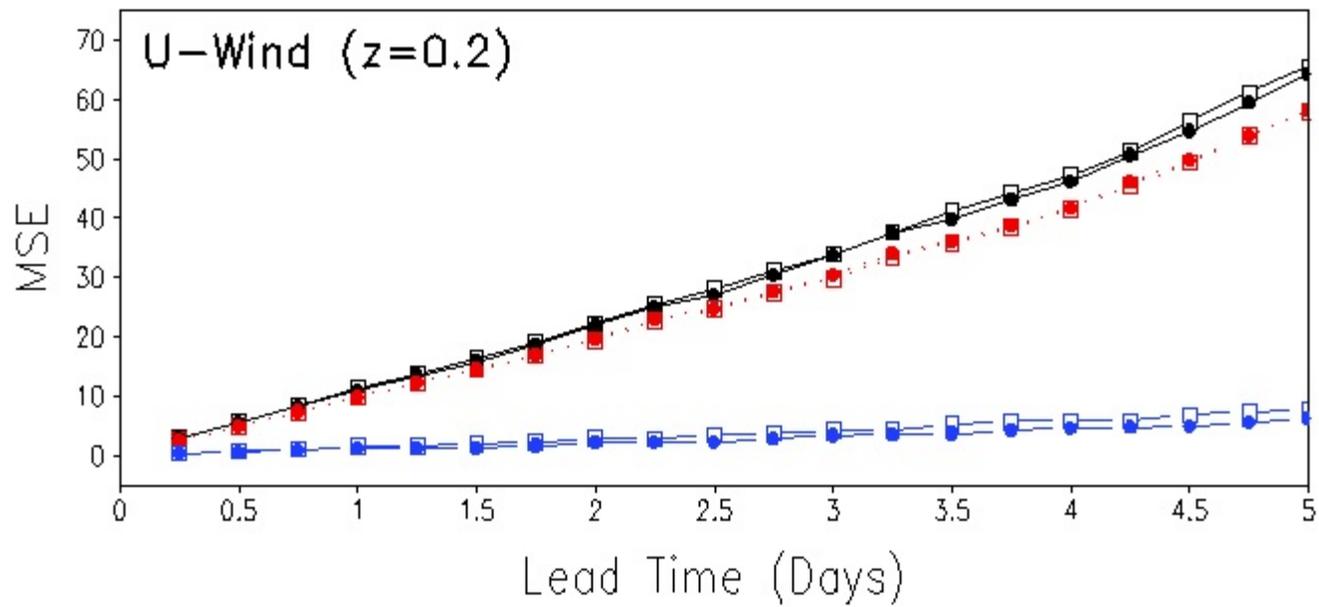
$$\mathit{Random} = \langle (\mathbf{f} - \mathbf{a} - \mathit{bias})^2 \rangle$$

$$\mathit{Total} = \langle (\mathbf{f} - \mathbf{a})^2 \rangle$$

$$\mathit{Bias}^2 + \mathit{Random} = \mathit{Total}$$

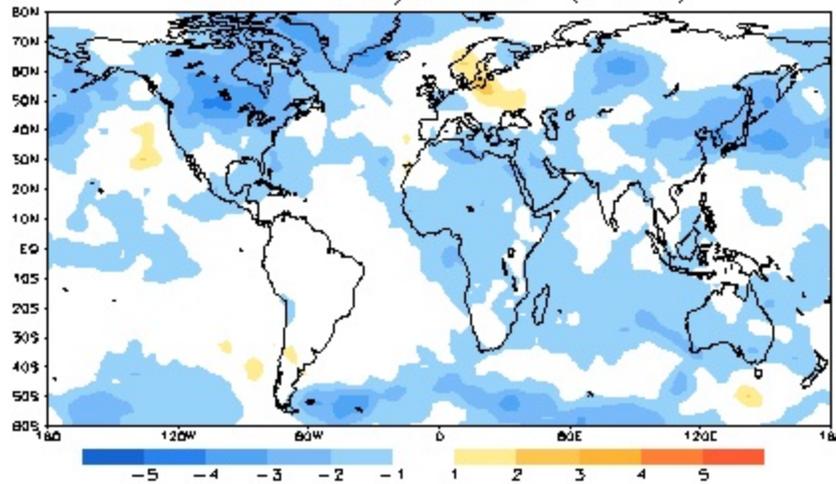
Mean Square Error vs. Lead Time (N. Hem., January 2006)



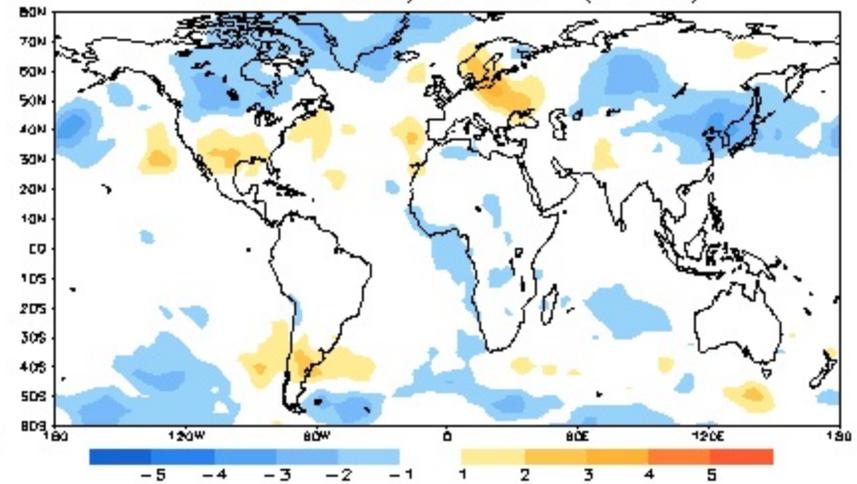


5-Day Forecast Error Z05JAN2006-Z31JAN2006

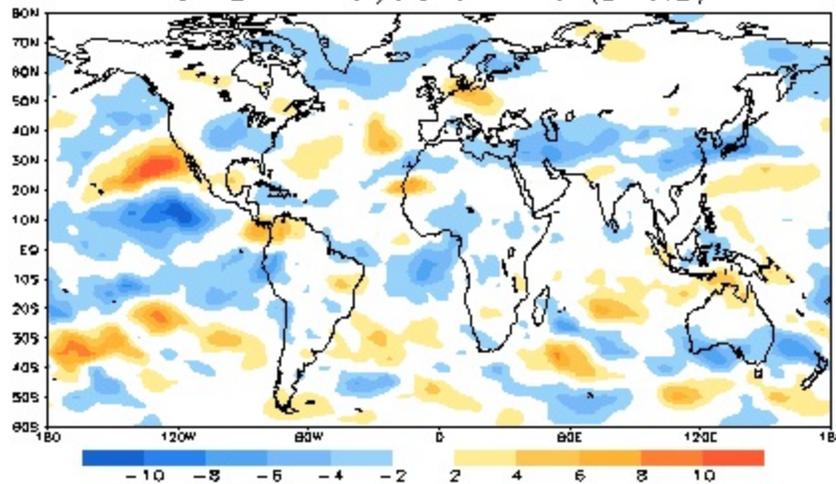
CNTL - Analysis TEMP (z=0.2)



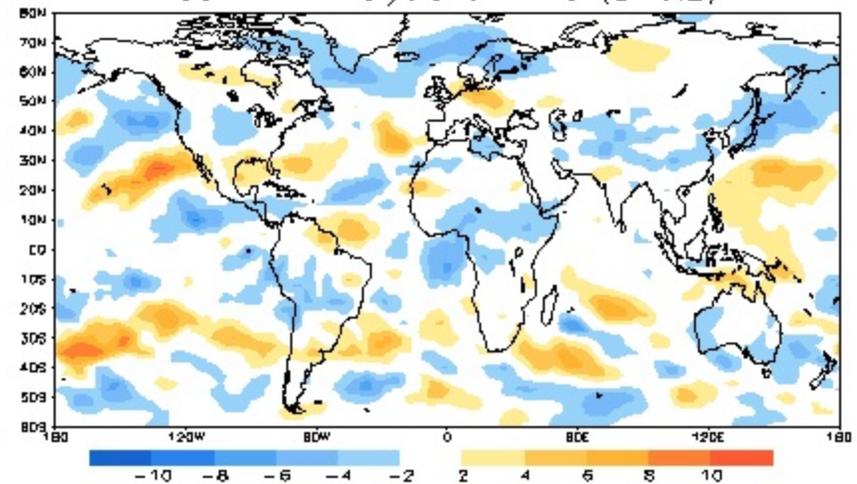
CORR - Analysis TEMP (z=0.2)



CNTL - Analysis U-Wind (z=0.2)

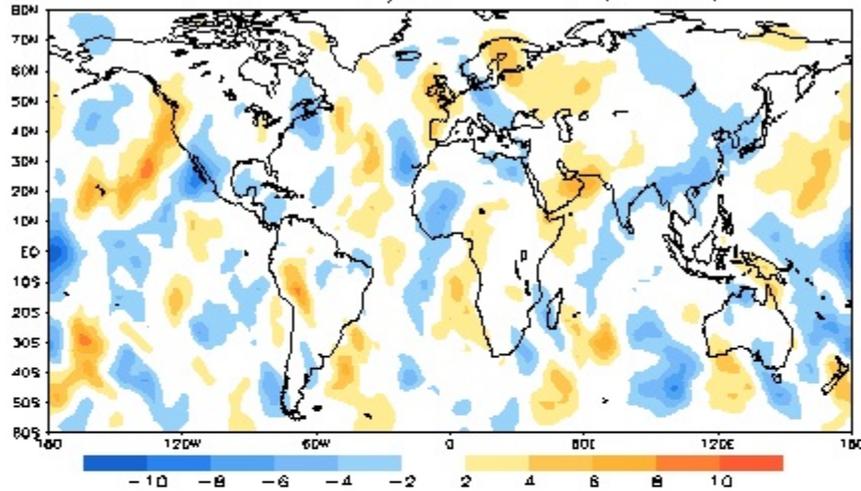


CORR - Analysis U-Wind (z=0.2)

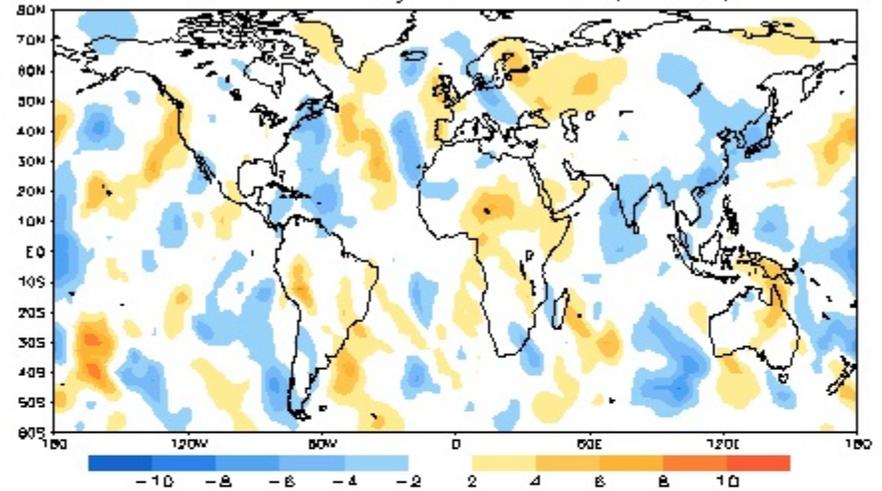


5-Day Forecast Error Z05JAN2006–Z31JAN2006

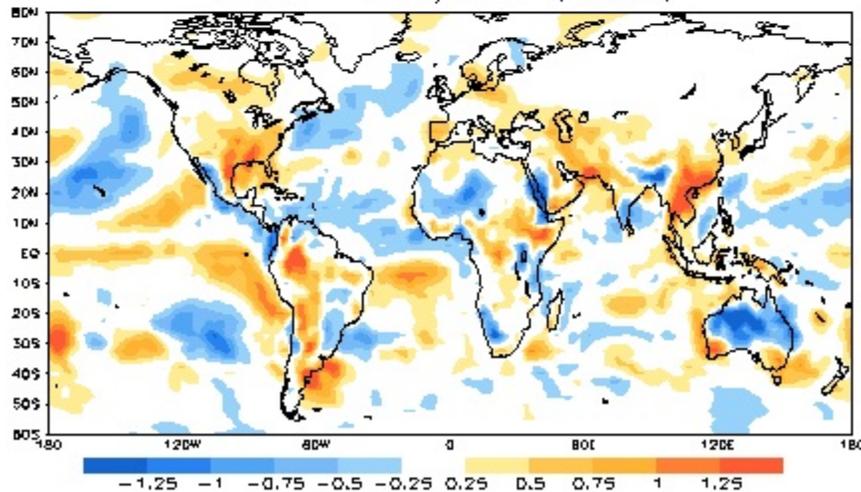
CNTL – Analysis V-Wind ($z=0.2$)



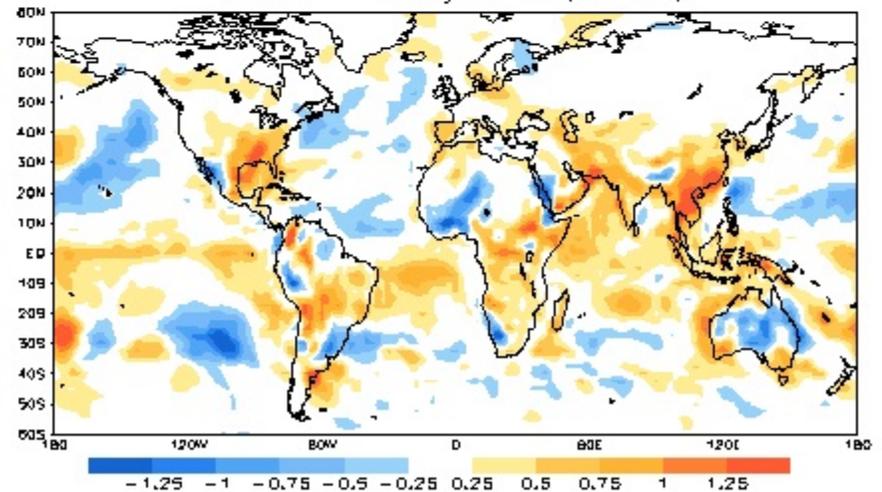
CORR – Analysis V-Wind ($z=0.2$)



CNTL – Analysis Q ($z=1.0$)



CORR – Analysis Q ($z=1.0$)



Conclusions and Future Work

1. Statistically Significant Biases in the GFS Temp. forecasts were reduced by over 50% by the empirical correction method.
2. Wind biases were marginally corrected, but are small anyway.
3. Moisture biases could not be corrected significantly, but also were not amplified.
4. Impact on GFS data assimilation will be assessed.
5. Impact on CFS long-term forecasts will be assessed (where we expect to see significant improvement).
6. Results provide rigorous constraints on the construction of stochastic parameterizations.