Improved Seasonal Prediction of Temperature and Precipitation Over Land in a High-resolution GFDL Climate Model

[2]Liwei Jia, [2]Xiaosong Yang, [1]Gabriel Vecchi, [1]Richard Gudgel, [1]Thomas Delworth, [2]Anthony Rosati

[1]Geophysical Fluid Dynamics Laboratory, Princeton, NJ and [2]University Corporation for Atmospheric Research, Boulder, CO

Objectives

- Test the hypothesis that atmosphere and land resolution is critical for seasonal prediction of 2m air temperature (t2m) and precipitation (pr) over land.
- Measure seasonal prediction skill of t2m and pr over land in a new high-resolution GFDL climate model.
- Explore possible sources of seasonal prediction skill of t2m and pr over land.

Model and Data

- Forecast-oriented Low Ocean Resolution version of CM2.5 (FLOR) and CM2.1.
- FLOR: 50km in the atmosphere and land; 1° in the ocean and sea ice.
- CM2.1: 2° latitude x 2.5° longitude in atmosphere and land; 1° in ocean and sea ice.
- 12–member (10-member) ensemble hindcasts from 1980-2012 (1982-2011) in FLOR (CM2.1).
- Hindcasts are initialized at the first day of each month, and run for 12 months.
- Seasonal mean 2m air temperature and precipitation.
- Observed 0.5 degree NOAA's precipitation reconstruction over land.
- Observed 0.5 degree GHCN Gridded V2 2m air temperature over land.

Methodology

Average Predictability Time is defined as the integral of average predictability over lead times (DelSole and Tippett, 2009)

$$APT = 2\sum_{\tau=1}^{\infty}\left(1-\frac{\sigma_\tau^2}{\sigma_{clim}^2}\right)$$

σ_τ^2 is the forecast variance at lead time τ; σ_{clim}^2 is the climatological variance.

We seek a linear combination of variables $\mathbf{q}^T\mathbf{x}$ that maximizes APT.
Vectors **q** that maximize APT are the eigenvectors of

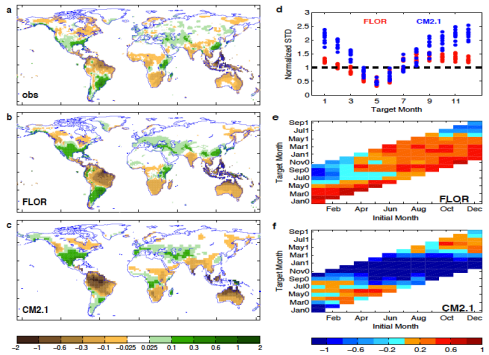
$$2\sum_{\tau=1}^{\infty}\left(\hat{\Sigma}_{clim}-\hat{\Sigma}_\tau\right)\mathbf{q}=\lambda\hat{\Sigma}_{clim}\mathbf{q}$$

Where $\hat{\Sigma}_\tau$ and $\hat{\Sigma}_{clim}$ are sample covariance matrices of forecast and climatology, and can be estimated from ensemble forecasts.

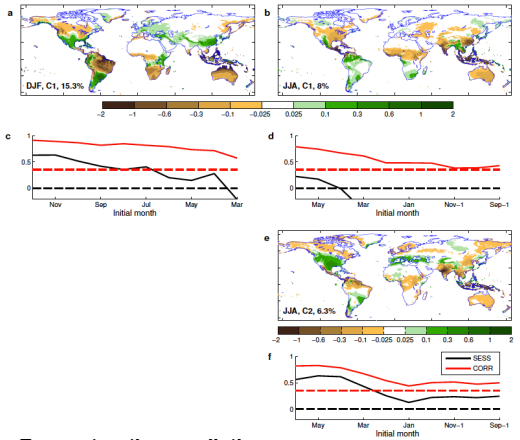
- Eigenvalues give the APT values.
- Time series and spatial pattern of a single component are $\mathbf{q}^T\mathbf{x}$ and **p** = $\hat{\Sigma}_{clim}\mathbf{q}$.
- Components are uncorrelated and ordered by their contribution to APT.

Reference: Jia et al. (2014), Journal of Climate.
DelSole and Tippett (2009), Journal of the Atmospheric Sciences.

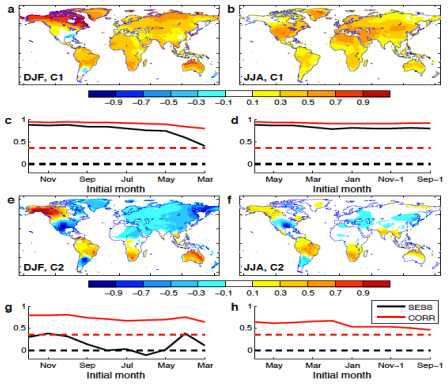
Skill of predictable pattern improved over CM2.1



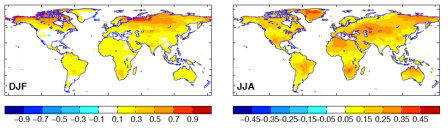
Predictable pattern and skill of seasonal pr



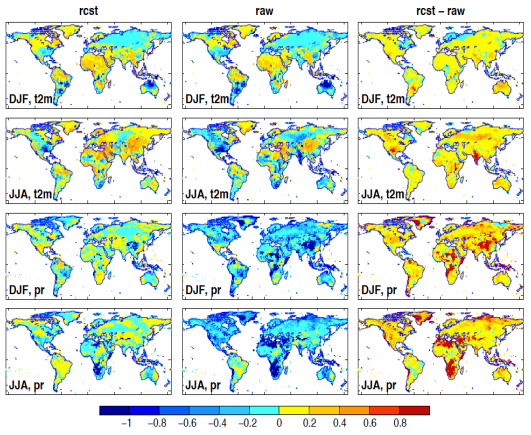
Predictable pattern and skill of seasonal t2m



Externally-forced pattern of t2m



Reconstructing predictions based on predictable components improves skill



Summary

- The high-resolution FLOR model outperforms the low-resolution CM2.1 model, and shows skillful prediction of t2m and pr over land.
- Changes in external forcing and ENSO contribute to the seasonal prediction of t2m. The skill of seasonal pr prediction arises from ENSO.
- Refined statistical optimization method together with high-resolution climate model improve seasonal prediction of t2m and pr over land.