A Realization of Bias Correction Method in the GMAO Coupled System

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INTRODUCTION

Over the past several decades, a tremendous effort has been made to improve model performance in the simulation of the climate system. The cold or warm sea surface temperature (SST) bias in the tropics is still a problem common to most coupled ocean atmosphere general circulation models (CGCMs). The precipitation biases in CGCMs are also accompanied by SST and surface wind biases. The deficiencies and biases over the equatorial oceans through their influence on the Walker circulation likely contribute the precipitation biases over land surfaces. In this study, we introduce an approach in the CGCM modeling to correct model biases. This approach utilizes the history of the model's short-term forecasting errors and their seasonal dependence to modify model's tendency term and to minimize its climate drift. The study shows that such an approach removes most of model climate biases. A number of other aspects of the model simulation (e.g. extratropical transient activities) are also improved considerably due to the imposed pre-processed initial 3-hour model drift corrections. Because many regional biases in the GEOS-5 CGCM are common amongst other current models, our approaches and findings are applicable to these other models as well.

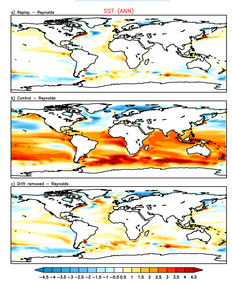
Part 1: The Bias Correction by Minimizing Model Drift in the GMAO CGCM

$$\left(\frac{\partial q^n}{\partial t}\right)_{total} = dynamics(adiabatic) + physics(diabatic) + \Delta q$$

By estimating 3-hour model errors every 6 hours

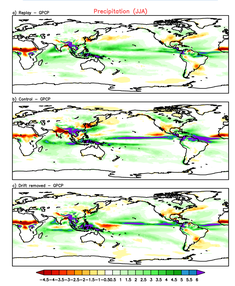
Δq is the Increments for fields u,v,T,ps in AGCM
Δq = Δq(x,y,z,hr,dy,mo,yr)
hr: 00z, 0z, 12z,18z
dy: 1, 2, …, 27, 28 or end of month
mo: Jan, Feb, …, Nov, Dec
yr: 1981, 1982, …, 2014, 2015

SST



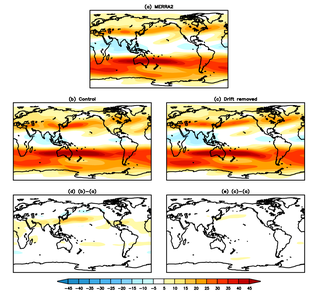
Annular mean sea surface temperature (SST) biases (℃) in the GMAO replay (upper), control (middle) and drift corrected (lower) CGCMs @1x1 resolution. The simulations over 1981-2016 are used to obtain the climatology. Reynolds SST is used for model validation.

Precipitation



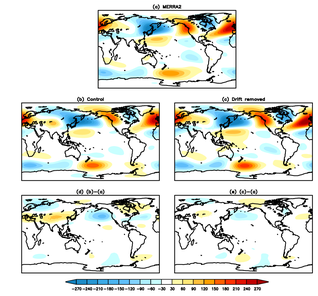
Same as SST plot except for JJA mean precipitation biases (mm/day). GPCP is used for model validation.

U250



JJA mean zonal wind and its model bias at 250mb (m/s) in the GMAO free-running (control) CGCM and the GMAO CGCM that has mean model drift corrected @1x1 resolution. The simulations over 1981-2016 are used to obtain the climatology. MERRA-2 is used for model validation.

H250



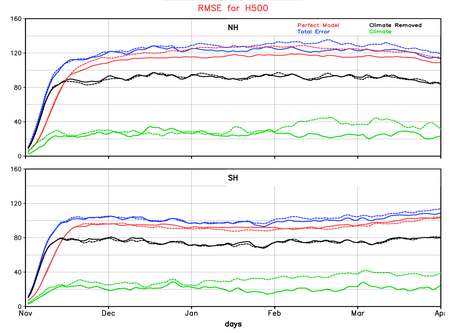
Same as mean zonal wind plot except for DJF mean eddy heights.

Part 2: The Bias Correction in the GMAO CGCM Improves the Winter Season Forecasting Skills

Winter Seasonal Hindcasting Experiments Design:

- ***Control hindcasts**: Started at 21z Nov. 1 to Mar. in 1995-2015*
- ***Bias corrected hindcasts**: Same as control except:*
  - *Forced by climate Δq (6-hourly data from 1980-2015)*
  - *Hindcast year's Δq was excluded from IAU climatology*
- *The GMAO coupled system @ 1.0°×1.0° resolution*
- *Ics: the GMAO coupled system replay run (Part 1)*
- *Δq: the GMAO coupled system replay run (Part 1)*
- *The verifications: MERRA-2 and GPCP precipitation*
- *All anomalies: deviations from MERRA-2 or model climatology*

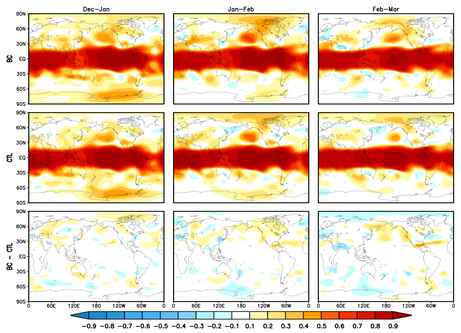
H250



Root-mean-square error (RMSE) for 500mb geopotential height:
- the error growth between each ensemble member
- the error growth between each ensemble member and MERRA-2
- the error growth between ensemble mean and MERRA-2
- the error growth between model and MERRA-2 climatology.

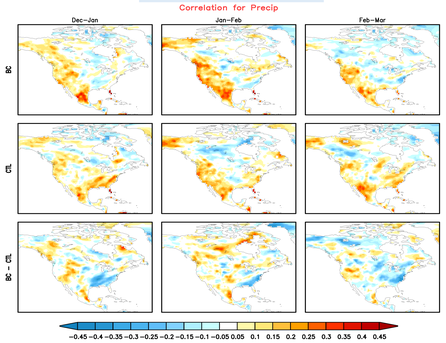
The solid lines are for the GMAO coupled system with an initial model drift removed and dashed lines are for the control. The results for the north/south hemisphere (NH/SH) are shown in upper/lower panel respectively.

H250



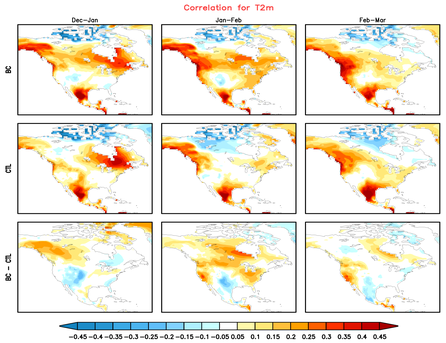
The temporal correlation coefficients between predicted and MERRA-2 250mb geopotential height. The upper panels show the plots for the GMAO coupled model with initial model drift removed and middle panels show the plots from the control model. The bottom panels show the differences. All predicted model anomalies are the departures from their own model climatology.

Precipitation



Same as H250 plot except for the temporal correlation coefficients between predicted and observed precipitation.

T2m



Same as H250 plot except the temporal correlation coefficients between predicted and MERRA-2 2-meter temperature.

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