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

\[
\frac{\Delta q}{\Delta t} = \text{dynamics (adiabatic) + physics (diabatic) + } \Delta q
\]

\(\Delta q\) is the increments for fields u,v,T,p in AGCM

\(\Delta q = \delta q(x,y,z,h,rd,ym,gr)\)

hr: 00z, 0z, 12z, 18z
dy: 1, 2, ... 27, 28 or end of month
mo: Jan, Feb, ..., Nov, Dec

By estimating 3-hour model errors every 6 hours

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

Winter Season Hindcasting Experiments Design:

- Control hindcast: Started at 22z, Nov 1 to Mar in 1995-2015
- Bias-corrected hindcast: Same as control except:
  - Forced by climate EQ (6-hourly data from 1980-2015)
  - Hindcast year’s \(\Delta q\) was excluded from IAV climatology
  - The GMAO coupled system @ 2.0°x1.0° resolution
  - IC: the GMAO coupled system replay run (Part 1)
  - \(\delta q\): the GMAO coupled system replay run (Part 1)
  - The verifications: MERRA-2 and GPCC precipitation
  - All anomalies: deviations from MERRA-2 or model climatology

Root mean square error (RMSE) for 500mb geopotential height

- The error growth between each ensemble member
- The error growth between ensemble member and MERRA-2
- The error growth between ensemble member and GMAO-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 northsouth hemispheres (NH) are shown in upper lower panel respectively.

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.

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