Identifying Climate Model Deficiencies in Simulation of Tropical Intraseasonal Variability Under the CCPP-ARM Parameterization Testbed (CAPT) Framework

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Introduction

Identifying specific model deficiencies that contribute to the problem in simulating tropical intraseasonal variability is difficult in climate simulations since results usually depend on all aspects of the model and the compensation of multiple errors can mask real model problems. To help address this issue, in this study we attempt to examine model deficiencies in simulating tropical intraseasonal variability by running climate model in numerical weather forecast (NWP) model under the U. S. Department of Energy (DOE)'s Climate Change Prediction Program (CCPP) – Atmospheric Radiation Measurement Program (ARM) Parameterization Testbed (CAPT) framework.

We believe that diagnosis of drifts from and differences with observations in short-range (<10 days) integrations of a climate model initialized with NWP analyses can reveal a lot about the character of model errors and potentially be an insightful way to interpret the errors in a model's climate. This is because the errors are so large that they can only be ascribed to errors in the climate model (and generally the parameterized physics) rather than to errors in the analyses we use or our omission of data assimilation techniques in the production of our initial conditions.

Models and Experiments

- **Two major U. S. climate models are examined:**
  - NCAR CAM3 and GFDL AM2
- **A new closure for the CAM3 deep convection scheme is tested:**
  - Original closure: CAPE
  - New closure: CAPE change rate due to the large-scale forcing in the troposphere (Zhang 2002)
- **For the TOGA-COARE period from November 1992 to February 1993:**
  - We have performed a series of 10 day integrations with CAM3 and AM2 starting every day at 00Z from the ECMWF ERA-40 reanalysis data

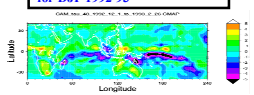
Issues to Address

- Are short-range weather forecasts relevant for climate?
- Are there any systematically developing trends of weather forecast errors over longer timescales?
- What is impact of cumulus parameterizations on the model simulated tropical intraseasonal variability?

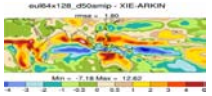
Weather Forecasts vs. Climate Simulations

CAM3

Day 3 Precipitation Error for DJF 1992-93

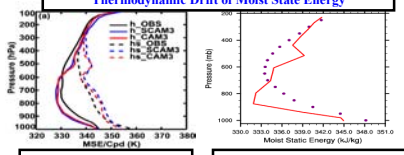


DJF Climatological Error



Similar error pattern is seen in CAM3 weather forecasts and climate simulations

Thermodynamic Drift of Moist State Energy



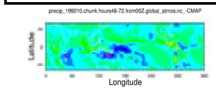
Short-range SCM and GCM forecasts show the same unrealistic profile of moist static energy that persists in model's climate!

12-36 Hour Forecasts

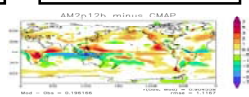
AMIP July Climate for Truk

AM2

Day 3 Forecast for DJF 92-93

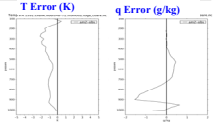


DJF Climatological Error



AM2 precipitation errors in weather forecasts are less relevant for its climate biases

Day 3 Forecast Error at IFA

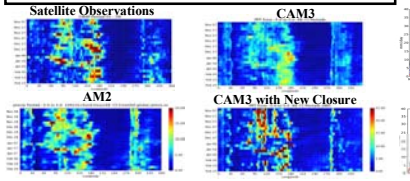


Climatological Error

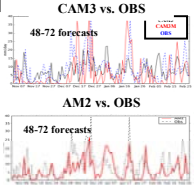
AM2 short-range drifts from ERA-40 have some correspondence to the climate drifts of the model in T & q

Tropical Precipitation Variability

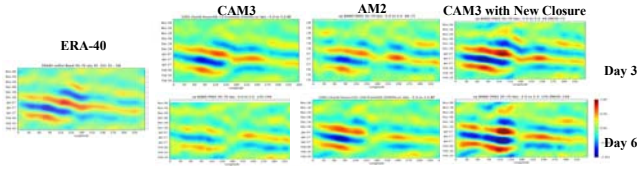
Precipitation averaged over 5-day intervals and averaged from 5N to 5S between Nov. 92 and Feb. 93



Precipitation at at IFA

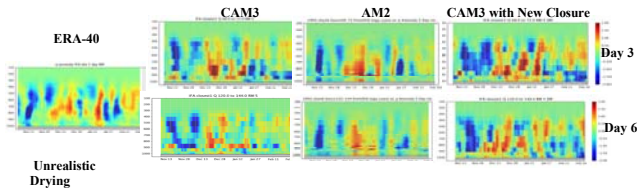


Intraseasonal Variability in 200 hPa Velocity Potential

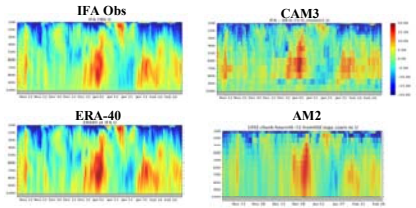


CAM3 shows a much weaker intraseasonal variability than the observations and ERA40. This problem is reduced in the CAM3 with the modified convection scheme. AM2 sustains intraseasonal variability present in the observations and ERA40

Moisture Variability at IFA



Zonal Wind Variability at IFA



Westerly wind bursts are largely underestimated below 850 hPa in CAM3

Tentative Results

- Some model climate errors develop at a very early stage: e.g., precipitation errors in CAM3 and vertical errors in T & q in AM2
- Intraseasonal variability in CAM3 weather forecasts is much weaker than that present in the observations and in ERA40
- Intraseasonal variability is significantly enhanced when a modified deep convection scheme is used in CAM3
- AM2 is able to sustain intraseasonal variability present in the observations and ERA40
- Both CAM3 and AM2 show a lack of moisture build-up prior to deep convection over a longer timescale (day 6 forecasts) but this problem is not shown in the CAM3 with the modified convection scheme
- Significant errors are present in CAM3 surface wind anomalies

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