CAM3 Simulations for TWP-ICE Using the CAPT Framework

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Abstract

In this work the NCAR Community Atmospheric Model (CAM) version 3.3 is used to generate short term forecasts during the TWP-ICE period for the purpose of validating the parameterizations used in the model against the comprehensive data gathered during the experiment. Three different parameterizations of deep convection are tested.

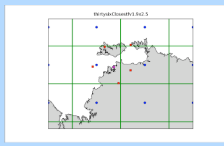
CAM Convection Parameterization and Modifications

The modification to the Zhang-McFarlane (ZM) deep convection parameterization described by Zhang and Mu (2005) was implemented in the CAM. Three changes are made to the original CAM deep convection scheme. First, a new closure is used in place of the Convective Available Potential Energy (CAPE) based closure of the original scheme. The new closure assumes that there is a quasi-equilibrium between the free tropospheric component of CAPE change due to the large-scale processes and that due to convection during convectively active periods. Second, a relative humidity threshold of 80 percent is set for the convection trigger. Third, the restriction that the convection only originates from below the PBL top is removed. This allows mid-level convection to be included the the ZM scheme.

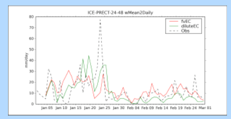
A second modification to the convective parameterization tested here was that of Richard Neale and J. Richter at NCAR. This modification the ZM scheme changes the method by which the scheme calculates the CAPE and the maximum convective depth. The calculation is performed using a reference parcel that entrains environmental air, such that the parcel doubles its mass every 1000m, as opposed to the ZM undilute parcel ascent method. In addition the convective momentum tendencies for the deep convection scheme are also computed.

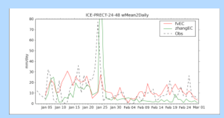
Summary

Using a climate model as a forecast model allows the forcing of specific events. This makes validation quite specific, and more exacting regarding specific parameterizations than statistics from a climatology.
The model results are for forecast over the second day (24 to 48 h).
• The TWP-ICE experiment provides a wide range of variation in tropical weather to evaluate the model parmeterizations.
• The control rains too often and produces rain events of insufficient intensity. The dilute simulation appears to capture the intense rain events more than the control. The Zhang fluctuates between rain events which are too large and too small.
• Both the dilute and Zhang simulations appear to correct the persistent high cloud bias in the control model. The dilute does so a bit better.
• Although the dilute and Zhang modifications to the convective parmeterizations correct some deficiencies in the cloud and rain simulation, they both introduce new biases and errors in the temperature, wind and moisture fields.



Locator map for TWP-ICE. Squares are locations of rawindsonde stations, magenta square is Darwin. Blue circles are the centers of the CAM 1.9x2.5 grid. Green lines delineate the edges of the CAM grid boxes.

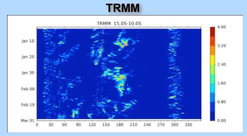




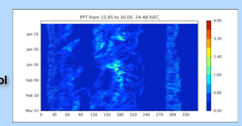
Daily Average rainfall at the TWP-ICE. Observational estimate over budget region, dilute and control forecast Day 2 (top) , observations, control and Zhang forecast Day 2 (bottom)

The figure above shows the locations of the observing stations for TWP-ICE and the model grid for the CAM 1.9x2.5 finite volume dynamical core. It can be seen that TWP-ICE region straddles two model gridboxes. After some experimentation is was decided to use a weighted average of the two model boxes encompassing the region. The greater weight given to the western box, the weight being proportional to the area of the TWP-ICE region in each grid box. Ii is obvious that such comparisons of model and observations must be done carefully. As an extreme example is that of the ARSCL cloud which is provided for a point over Darwin

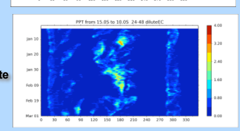
TRMM



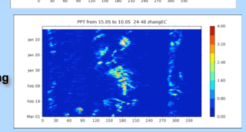
Control



Dilute

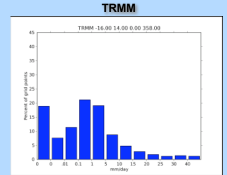


Zhang

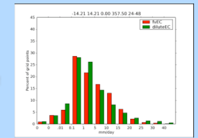


Figures 3 and 4 display rainfall spanning the entire globe for the months of January and February and centered near the latitude of Darwin (12.425S). The figures show the observed estimates from TRMM and the Day 2 (24 - 48h) forecasts for the models. These figures agree with the previous precipitation figures. The control consistently underestimates the rainfall while the dilute has maxima in line with the observations and the Zhang has events well in excess of the observed. The Zhang also misses some period of rain in the Indian Ocean (60 E)

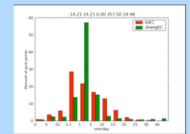
TRMM



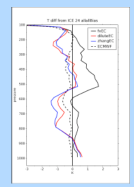
Dilute and control day 2



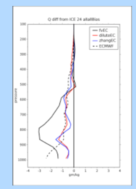
Zhang and control day 2



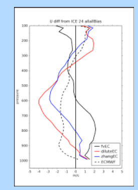
Rainfall rate for the entire Tropics (15 N to 15 S) for the observed estimates and the models. All the CAM variants show a reluctance to not rain compared to the observations, although the TRMM estimates might miss some rain. The main point is that the distributions shown in the figure to the right, which are for the entire Tropics, are in accord with the precipitation (real and modeled) at TWP-ICE. The dilute shifts the default distribution to events with more amplitude, while the Zhang produces a drizzle or downpour dichotomy.



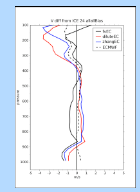
T



Q



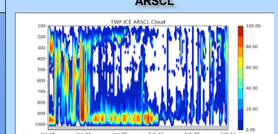
U



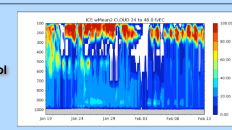
V

Average bias for the whole period for the models and the ECMWF data used to initialize the models. The bias is computed by subtracting data from the variational analysis. Across all the variables, the control appears to be the outlier with the dilute and Zhang sharing many common aspects. Except for the moisture, Q, the modifications do not show a consistent superiority.

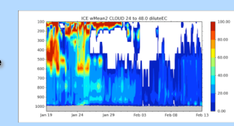
ARSCL



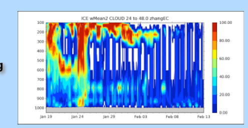
Control



Dilute



Zhang



The observed estimated and model cloud fraction. The ARSCL clouds are a single point over Darwin and the fraction represents a time fraction. The model clouds are spatial fractional coverage over a whole gridbox.

This work was performed under the auspices of the U.S. Department of Energy by University of California Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

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