CAM horizontal and vertical resolution experiments

Stephen A. Klein[1], Sungsu Park[2] and J. Boyle[1]

(1) Lawrence Livermore National Laboratory (2) National Center for Armospheric Research.

Horizontal Resolution Experiment

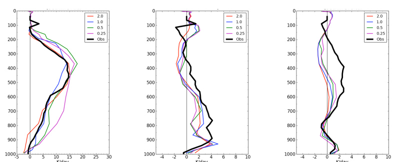
The Community Atmospheric model (CAM) version 3.5 was run in forecast mode over the TWP-ICE period using ECMWF analysis as initial conditions at nominal horizontal resolutions of 2.0, 1.0, 0.5 and 0.25 degrees. In the vertical the default 26 levels were used. All other parameters were unchanged from the 0.25° default settings. Results of day 2 (24 to 48h) forecasts will be shown.

Diabatic Heating at TWP-ICE

The figures below display the diabatic heating at TWP-ICE computed from observations and for day 2 forecasts at the four horizontal resolutions. Depicted are the averages for the Wet, Dry and Break periods of the experiment.
The model does respond to the different large forcings for the periods. For the wet period the model captures the top heavy heating profile characterizing an MJO passage. For these averages over the 2.5 degree TWP-ICE polygon there is not an obvious advantage to the increased resolution.

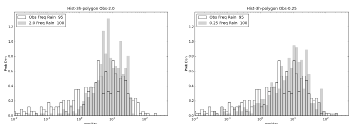
Q1 in the TWP-ICE region averaged over the weather regimes of the experiment.

Wet Dry Break



RainFall at TWP ICE

Below are histograms for 1 hr precipitation for the 2.0 and 0.25 degree models and the C-Pol radar for the TWP-ICE region over Jan and Feb 2006. The 2.0 degree model under estimates the occurrence of rainfall in the highest and lowest categories. The 0.25 model is a significant improvement over the 2.0.

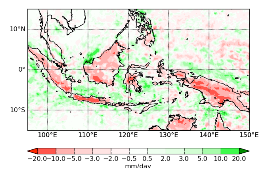


2° model and Obs 0.25° model and Obs

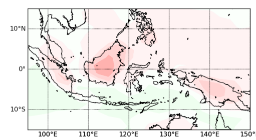
Ratio of stratiform to total rainfall

The ratio of stratiform to total rainfall increases with increasing resolution. The values at TWP-ICE over the wet period are 11,15,18 and 39 for the 2°,1°, 0.5° and 0.25° models, respectively. The 0.25° model values compares well to the estimate of 32 by Courtney Schumacher from the C-POL radar for the same period.

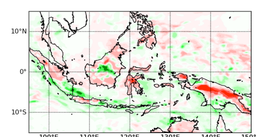
Diurnal Rainfall



TRMM
00 GMT
Precip Anomaly



2.0°



0.25°

Above are plots of rainfall for 00 GMT averaged over Jan and Feb 2006 with the daily mean removed. At this time the observed (TRMM) rainfall displays a minimum over the land and maximum over the ocean. The 2.0 model captures the sense of this pattern. The 0.25 model while not perfect does much better in depicting the detail and amplitude of the local features.
The mean areal rainfall bias with respect to the TRMM observations over this region was actually worse for the 0.25° modell, (30%bias) , then the 2.0° model, 20%..

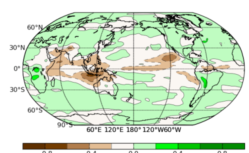
Vertical Resolution Experiment

CAM version 3.6 was run in AMIP mode for five years at vertical resolutions of 30 (default) and 80 layers. The 80 layers match the lowest 80 layers of the current ECMWF operational forecast model. CAM3.6 uses Morrison-Gettleman microphysics, UW shallow cumulus, UW boundary layer and ZM deep convection as modified by Neale.

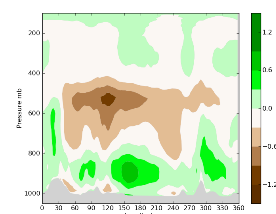
Moisture in L80 vs L30

Both the L80 and L30 models overestimate the global mean precipitable water although the L80 is drier and closer to the observed.
In the Tropics the L80 has a reduced deep convective mass flux and thus a deeper PBL, and reduced convective rainfall. The reduction in convective rain is compensated by an increase in the stratiform rain. This results in a stratiform/total ratio closer to observations. The reduced convective activity in the L80 model may be attributable to the way the convective source air is defined within the PBL in the ZM scheme.
The spatial pattern of PBL height, and convective mass flux differences is similar to the precipitable water differences shown below.
The 80L dryer Tropics seen in the precipitable water plot is a result of the drier upper levels overwhelming the moister lower levels. This is consistent with the deeper PBL and reduced deep convective flux.
The L80 model reduces the stratus deck off the west coast of continents. Experiments have shown that this undesirable feature can be ameliorated by decreasing the penetrative entrainment efficiency at the top of the shallow cumulus in the UW scheme with only small effects outside of the regions of the stratus decks.

Precipitable Water Annual Mean
80L – 30L

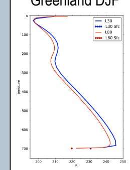


Specific Humidity Annual Mean 30S to 30N
80L -30L



Excessive winter low temperatures

Greenland DJF



The figure shows a temperature profiles over Greenland for DJF means for a 5 year AMIP simulation. The L80 model indicates substantially cooler lower level temperatures With respect to the L30. Similar features are seen in the JJA profiles over the Antarctic Plateau. The lower temperatures might be due to the sensitivity to vertical resolution of the treatment of the stable boundary layers in the UW turbulent flux scheme.

Partioning of rain sources

The relative contributions of the parameterizaitons producing rainfall are substantially altered in going from 30 to 80 levels. As shown in the table below both models overestimate the annual rain rate. The 30 level model has a much higher contribution by the Deep (Zhang McFarlane) convection. In the 80 level model the decrease in the deep convection is mostly compensated by an increase in the large scale rainfall.

Global Mean Annual Mean Precipitation
Obs (GPCP) = 2.61 mm/day

Model	Global mean Total	Convective Percent of Total	Large Scale Percent of Total	Shallow Convection Percent of Total	Deep Convection Percent of Total
30 level	3.08	75	25	10	65
80 level	3.15	58	42	16	42

Conclusions

The higher horizontal resolutions models show positvie gains in depicting the spatial and temporal details seen in the observations.

The CAM is able to produce useful simulations across a very wide range of resolutions but resolution alone is not a cure for model biases.

The character of the model simulation is somewhat sensitive to changes in the vertical resolution.

The 80 level models evinces a shift away from the deep convection scheme to the large scale and shallow convection.

This work is supported by the Office of Science of the United States Department of Energy as part of the ASR and the Regional and Global Climate Modeling programs. Auspices This work was performed under the of the U. S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. UCRL : LLNL-POST-425223