Evaluating Developmental CAM Cloud Parameterizations With ARM Observations

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Overview

Cloud simulations in developmental versions of the Community Atmosphere Model (CAM) are assessed with ARM and other observations. The CAM is integrated in weather-forecast or CAPT mode to facilitate comparison with observations.

The focus is on the simulation of high clouds and their impact on outgoing longwave radiation. The sensitivity to two parameterizations of ice cloud fraction is explored.

Cloud Parameterizations

New CAM parameterizations relevant to the simulation of high clouds and their impact on longwave radiation include:

- ice nucleation and supersaturation (Liu et al. 2007)
- double moment cloud microphysics (Morrison and Gettelman 2008)
- RRTMG radiation code and ice cloud optics from David Mitchell (DRI)

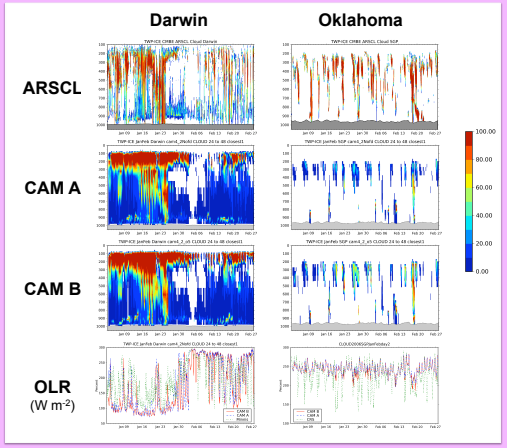
With ice supersaturation, it is not clear how to parameterize cloud fraction. Two forms are tested; these model cloud fraction as a function of:

A. Ice water specific humidity relative to saturation specific humidity from Wilson and Ballard (1998)

B. Total water (vapor+ice) specific humidity relative to ice saturation specific humidity

CAM simulations are initialized with ECMWF analyses for Jan-Feb 2006 and output from day 2 forecasts presented. CAM simulations are performed at 1.9° latitude by 2.5° longitude resolution with 30 vertical levels.

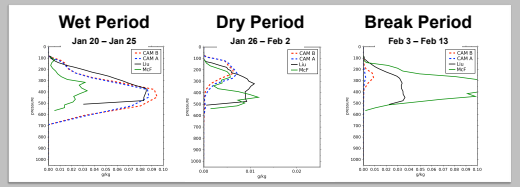
Cloud Fraction and Outgoing Longwave Radiation at ARM Sites



CAM overestimates high cloud fraction in the tropics but underestimates high cloud fraction in the midlatitudes. CAM with parameterization B has greater amounts of high cloud in both the tropics and midlatitudes.

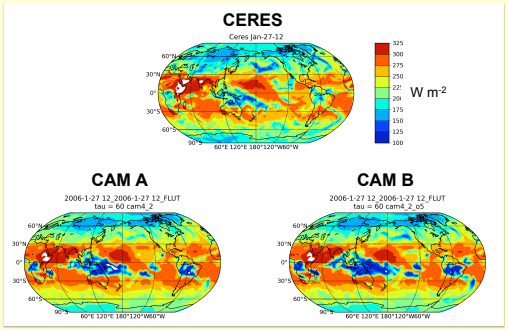
The biases at both sites are accompanied by outgoing longwave radiation (OLR) biases that could be explained by the corresponding biases in high cloud fraction.

Ice Water During TWP-ICE



Comparison of the vertical profile of in-cloud ice water specific humidity during three periods of TWP-ICE to satellite ("Liu") and ground-based ("McF") suggests that CAM produces reasonable values after considering the significant observational uncertainties. An overprediction of ice water content near 150 hPa during the Wet and Dry periods may contribute to the underestimates of outgoing longwave radiation.

Global Outgoing Longwave Radiation Distributions



The plots above show the global distribution of outgoing longwave radiation at 12Z Jan 12, 2006 from CERES observations and from CAM 60 hour forecasts.

These comparisons confirm that CAM A underestimates of the longwave cloud effect in midlatitudes and overestimates their effect in the tropics.

The increase of high cloud fraction in CAM B improves the midlatitude OLR but degrades tropical OLR.

Take Home Messages

Through the weather-forecast CAPT approach, ARM data is playing a role in assessing cloud simulations in CAM developmental versions.

CAM's underestimates the impact of high clouds on outgoing longwave radiation in the midlatitudes but overestimates the impact in the tropics. While other factors may be involved, these biases appear to be due to underestimates of high cloud fraction at midlatitudes and overestimates of high cloud fraction in the tropics.

A parameterization using total water ("CAM B") yields greater ice cloud fractions than a parameterization based on ice water content.

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