Evaluation of tropical cloud simulations in forecasts with CAM3 using the A-Train data

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Observations

Tropics (23.5°S - 23.5°N)  Averaged June - September 2006

A “curtain” of CloudSat data

Radar reflectivity included in 2B-GEOPROF (Mace et al. 2007)

The combined hydrometeor mask is generated using 2B-GEOPROF and 2B-GEOPROF-LIDAR data products (Mace et al. 2008)
Model evaluated: NCAR’s CAM3

CAPT: **CCPP-ARM Parameterization Testbed**

- Perform weather forecasts with climate models
- Identify model deficiencies before longer-time scale feedbacks develop
- Be able to link deficiencies with atmospheric processes through case study

NCAR’s CAM3 was initialized with NCEP GDAS analysis data for Jun-Sep 2006 (J. Boyle, LLNL)

Examine 24-48 hour forecasts
COSP: CFMIP Observation Simulator Package

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- Yuying Zhang and Steve Klein (LLNL)
- Roger Marchand (U. Washington)
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Convert model data into variables similar to observations

Consider instrument limitations including minimum detected signal and attenuation of signals

Avoid effects of inconsistent assumptions
Flowchart of CloudSat/CALIPSO Simulator for GCMs

GCM output

Subcolumns

cloud cover  mixing ratio  precip flux

subcolumn calculation

SCOPS + PREC_SCOPS

Model
Observation

Radar/Lidar simulator processing

Model “CloudSat”

Model “CALIPSO”

Statistical processing to produce joint histogram
Sample result from the Simulator with CAM3.1 forecast

Meridional mean in tropics for June-Sept. 2006

- Cloud Fraction from model
- Combined radar/lidar simulation
- Observed CloudSat/CALIPSO data

Pressure

Longitude

Relative Frequency of Occurrence (%)
Methodology for model evaluation

- Traditional method: Climatological maps
- More objective: Clustering analysis

ISCCP D1 dataset (Rossow et al. 2005)

CloudSat (Zhang et al. 2007)

CloudSat+CALIPSO (Zhang et al. 2008)

Domain size: ~200 km

Revised method: profile
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Rain or drizzle
Tropical cloud regimes derived from the CloudSat/CALIPSO data

1. Low clouds without detectible precipitation
2. Low clouds with precipitation
3. Thin cirrus
4. Congestus
5. Cirrus anvils
6. Deep convection and heavy precipitation
Clustering method: describe the principal cloud regimes in tropics

The vertical structures of cloud fields are defined using the joint histogram of altitude and reflectivity

Sample of congestus

Sample of deep convection and heavy precipitation
Model simulations are then assigned to the cloud clusters determined from observations.
Model simulations from CAM 3.5 compared to observations

1= low clouds w/no det. precip.  
2= Low clouds with precip.  
3= Thin cirrus  
4= Congestus  
5= Cirrus anvils  
6= Deep convection and heavy precip
Geographical distributions of the principal cloud regimes

CloudSat+CALIPSO

CAM3.1

1 = low clouds w/no det. precip.
2 = Low clouds with precip.
3 = Thin cirrus
4 = Congestus
5 = Cirrus anvils
6 = Deep convection and heavy precip
Different versions of the model

Major difference: parameterization of deep convection

**CAM 3.1 : Undilute Plume**
- air parcel ascends pseudoadiabatically, not mixing with the environment
- insensitive to tropospheric moisture

**CAM 3.5 : Dilute plume**
- air parcel mixes with environmental air as it ascends through the atmosphere
- more sensitive to moisture
Geographical distributions for different versions of the model

CAM3.1

1. Low clouds with less precip
2. Low clouds w/ precip
3. Thin cirrus
4. Congestus
5. Anvil clouds
6. Deep conv & heavy precip

CAM3.5

Produce more mid-level clouds
Reduce high clouds
Summary and future work:

Summary:

- The comparison between modeled and observed clouds shows the model deficiencies:
  
  overestimate high clouds
  underestimate mid-level and some low-level clouds

- The new parameterization improves the cloud simulations:
  
  reduce high clouds
  produce more mid-level clouds and low-level precipitation

Future work:

- Use compositing technique and other data sources
- Extend to mid-latitude and longer time period
- Pilot study of model intercomparison with Met Office in U.K. and LMD in France
- Include GEOS-5
What the LLNL team needs from CERES

- We would like to describe the radiative characteristics of the individual regimes and examine the impact of the cloud regimes on the cloud radiative forcing (including shortwave and longwave) at the TOA. The collocated data along the CloudSat flight track would be perfect.

  - Steve Klein
The End