An assessment of the CAM5/CARMA model: TTL cirrus cloud representation through comparisons with ATTREX 3 and CALIPSO observations

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The CAM5/CARMA model resolves ice particle size distribution

Figure from Bardeen et al., 2014
The size distribution compares well between model and observations for the mission.
CAM5/CARMA grid box averaged RH_{ice} is generally drier than all sky RH_{ice} seen during ATTREX 3.
CPL reveals two persistent cloud layers throughout ATTREX 3 between 12-14 km 16-17 km
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The two observed cloud layers fall into the warm and cold cloud regimes described in Krämer et al., 2009.
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For cold clouds, 0.005 – 0.2 cm$^{-3}$ ice number range and 1 – 10 µm sizes have been previously observed.
Higher ice concentrations and larger particles expected in warm clouds

2DS

CAM5/CARMA
Tropics cloud fraction is too low in CAM5/CARMA in the ATTREX 3 timeframe
COSP simulator shows CAM5/CARMA under predicts high cloud fraction.
CAM5/CARMA under predicts total cloud fraction

GOCCP-CALIPSO

CAM5/CARMA w/ COSP
Conclusions

**ATTREX 3 Comparison:**
- CAM5/CARMA represents clouds along ATTREX 3 flight track, but has too many large particles
- Resolution limitation causes the model to struggle with finer features

**CALIPSO Comparison:**
- At 1x1 degree resolution, CAM5/CARMA underestimates cloud fraction vertical profile above 8 km for the ATTREX 3 timeframe
- COSP simulator shows the model misses high cloud fraction around the equator
Future Work

- Perform a CAM5/Morrison & Gettleman COSP simulation to determine if CAM5/CARMA is improving on CAM5’s cloud representation
- Continue to evaluate the model with COSP simulator against CALIPSO observations
- A combined CARMA aerosol and CARMA cloud model??
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Extra Slides
Low Cloud Fraction

GOCCP-CALIPSO Annual Avg Low Cloud Fraction

CARMA/COSP Annual Avg Low Cloud Fraction
Mid Cloud Fraction
COSP Flow Chart

CFMIP Observation Simulator Package

What would a satellite see if the atmosphere had the clouds of a climate model?

Climate Model Clouds

Pseudo-Satellite Observations

COSP Flow Chart

gridbox mean profiles

gridbox mean profiles

“down-scaler”

forward models retrieval algorithms

CloudSat
CALIPSO
ISCCP
MISR
MODIS
RTTOV

Statistical aggregation

COSP outputs

Actual Satellite Observations

Figure credit: Jim Boyle, Alejandro Bodes-Salcedo and Stephen Klein

Image taken from NCAR’s Climate Data Userguide
Maximum/random overlap scheme from Hogan and Illingworth (2000)
CAM5/CARMA Overestimates Number and Mass For Cold Cirrus Clouds
CAM5/CARMA Does a Good Job Capturing Warm Cloud Ice Concentration and Mass

ATTREX3 mission average 205K

Ice Concentration

Ice Mass Density

Maximum Diameter (μm)

Maximum Diameter (μm)
CALIPSO Provides a Useful Tool to Evaluate GCM cloud representation

- Global coverage since 2006
- CALIOP lidar onboard capable of resolving high thin cirrus
- Few CARMA comparisons with CALIPSO
- COSP has not been used with CARMA

Image from NASA LaRC EPO site