Evaluation of General Circulation Model (GCM) cloud vertical structure using data from OMI and the A-train

Joanna Joiner, Alexander Vassilkov, P. K. Bhartia, OMI team (KNMI, FMI, NASA)
Lazaros Oreopoulos, MODIS team (NASA)
Arlindo da Silva and GEOS team (NASA GMAO)
CloudSat team Colorado State (G. Stephens et al.)
Wisconsin cloud group (Paul Menzel et al.)
Robert Spurr (RTsolutions)
Motivation: Evaluate model clouds, focus on cloud vertical structure

• CloudSat radar: the most detailed information on cloud vertical structure
  – With MODIS gives cloud extinction profiles
  – Spatial sampling is limited

• Passive sounders (e.g., OMI and MODIS): daily snapshots, ~2 pieces of information on cloud vertical structure
  – Can examine assimilated data on daily basis
  – Good sampling for examining monthly, seasonal, or annual time-scales
What do real clouds look like to passive sensors?

CloudSat/MODIS optical depth profiles

- □: MODIS- CO₂ slicing cloud-top
- ◊: OMI simulated from Cloudsat
- Δ: OMI optical centroid cloud pressure from Raman scattering

CloudSat radar reflectivity

- Thin upper deck over lower deck
- Optical depth peaks in liquid water portion of cloud
- Optical depth peaks in ice portion of cloud

New OMI/MODIS cloud simulator

- Fast (simple) simulation of OMI Raman cloud optical centroid pressure (similar in concept to ISCCP cloud simulator)

- Reflectance-weighted pressure scheme – currently does not properly account for in- or between-cloud scattering/absorption, but could apply correction

- Tested with various cloud overlap schemes

- Can be easily modified for other centroid measurements (e.g., $P^2$ weighting for $O_2$-$O_2$ absorption)
Single day (13 Nov 2006)
Cloud-top pressure, $\tau > 1$

GEOS-5 has higher cloud-tops, closer to MODIS, very similar spatial features
13 Nov 2006, optical centroid cloud pressure (OCCP)

GEOS-5 has higher optical cloud altitudes, closer to OMI, very similar spatial features.
Single day (13 Nov 2006) optical centroid cloud – cloud-top pressure difference

GEOS-5 closer to OMI/MODIS, very similar spatial features

overpass
Use “scaled-\(\tau\)” approach of Chou and Suarez to visualize GEOS

OMI Cloud OCP Simulator

CloudSat track, 13 November 2006

OMI Raman OCP
Use “scaled-τ” approach of Chou and Suarez to visualize GEOS

CloudSat/MODIS extinction

OMI Cloud OCP Simulator

CloudSat track, 13 November 2006
Use “scaled-τ” approach of Chou and Suarez to visualize GEOS CloudSat track, 13 November 2006.

OMI Cloud OCP Simulator

CloudSat track, 13 November 2006
Summary and Current Work

• We developed a fast (reflectance-weighted) simulation of OMI-Raman cloud optical centroid pressure

• GEOS-5 clouds significantly improved over GEOS-4

• More detailed validation of OMI cloud optical centroid pressures with CloudSat

• Compare OMI and GEOS-5 for different seasons, etc.
  – Are we getting a good comparison for the right reasons?
  – How well does model simulate clouds in data assimilation vs. climate (coupled and uncoupled) modes

• We plan to add this to the COSP package that includes cloud simulators for many other instruments