Global View of Aerosol Vertical Distributions from CALIPSO Lidar Measurements and GOCART Simulations: Regional and Seasonal Variations

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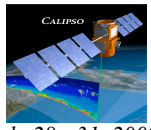

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1. MOTIVATION & OBJECTIVES

♦ CALIOP/CALIPSO has been acquiring the first-ever, nearly continuous measurements of global aerosol vertical distributions since June 13, 2006.

♦ Our OBJECTIVES are to

- analyze regional and seasonal variations of vertical distribution of aerosol extinction using CALIOP measurements
- examine differences between CALIOP observations and GOCART simulations

2. DATASETS & DATA ANALYSIS

◆ **CALIOP Data**: Level 2 Version 2.01 5-km Aerosol & Cloud **LAYER** Products

◆ **GOCART Model:** 2.5°x2°, 30 layers; 3-hr outputs of extinction & backscatter

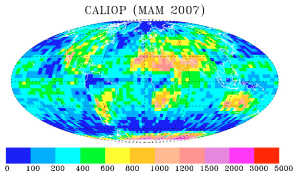
◆ **CALIOP Screening:** Nighttime; Cloud-free; CAD score=[-50, -100]; initial lidar ratio (Sa) = final Sa

◆ **CALIOP Dust aerosol:** volume depolarization ratio $\delta_v > 0.06$

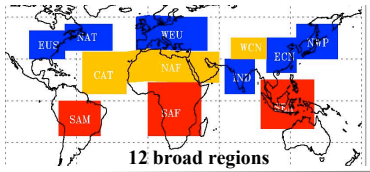
◆ **GOCART Sampling:** following CALIPSO track

◆ **Comparisons:** Scale height (H), profiles of extinction (σ) & Sa at 532 nm over 5°x4° grids & 12 broad regions (from June 2006 to November 2007)

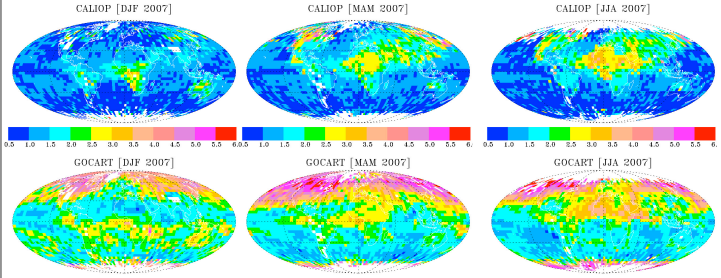
# of cloud-free profiles

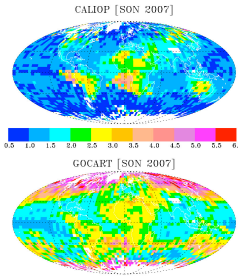


$$\int_0^H \sigma dz = (1 - e^{-1}) AOD = 0.63 AOD$$



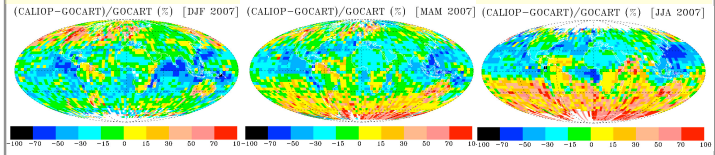
3. AEROSOL EXTINCTION SCALE HEIGHT (km)



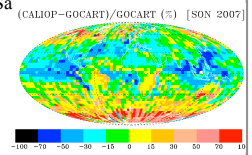


- CALIOP observations show higher scale height in summer/spring than in winter/fall over land.
- CALIOP scale height is consistently lower than GOCART simulation, with the difference depending on region:
  - relatively small over major source regions (dust, smoke, and some pollution regions)
  - substantial in NH middle & high latitudes where aerosol is transported from outside (usually associated with cloud systems).
- Possible Reasons:
  - CALIOP has a detection limit of 0.01 km^{-1} for extinction.
  - GOCART may have too strong upward transport.
  - CALIOP cloud-free condition vs GOCART-represented all-sky condition.

4. LIDAR RATIO (Sa)



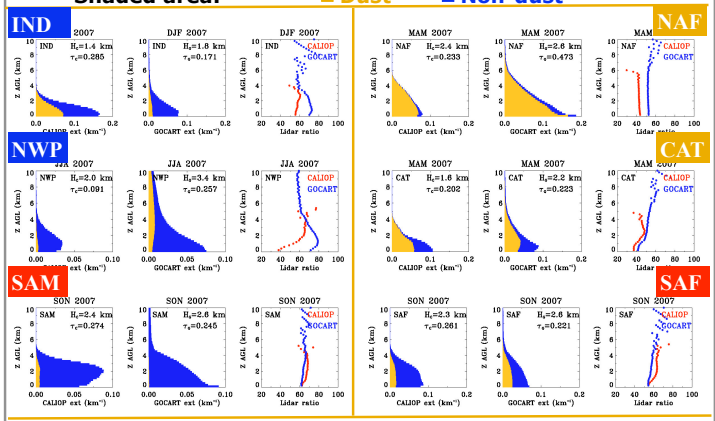
- In the "dust belt", CALIOP Sa is lower than GOCART Sa by ~20%.
- In the ABL, CALIOP and GOCART agree within ±30% in most regions, but can differ by more than 50% in coastal areas influenced by pollution/smoke outflow (CALIOP lower) and over some high-latitudes (CALIOP higher).
- Above ABL (>2 km), CALIOP & GOCART generally agree within ±20%.



(Surface – 1 km)

5. EXAMPLES OF REGIONAL PROFILES

Shaded area: ■ Dust ■ Non-dust



WHAT WE HAVE LEARNED (Focusing on Differences):

1. In the ABL of smoke/dust source regions (SAM, NAF), lower CALIOP extinction could result partially from the attenuation of laser light by overlying heavy aerosol.
2. At high altitudes, CALIOP generally detects aerosol less frequently than GOCART does, which could bias the CALIOP scale height lower.
3. In Indian sub-continent (IND), GOCART underestimates extinction (corroborated by AERONET); While CALIOP indicates a larger dust fraction than the model does, a more robust dust/non-dust partition is needed for guiding model improvement.
4. In dust source regions, GOCART extinction is much larger than CALIOP, possibly because of CALIOP misclassification of heavy dust as cloud, CALIOP miss of ABL dust, and/or GOCART overestimate of dust emission.
5. In South America (SAM), significant amount of smoke is raised above the daytime convective ABL (typically < 2 km based on observations).
6. In the marine BL of continental outflow regions (e.g., NWP, NAT, SEA), CALIOP Sa is much lower than GOCART Sa; CALIOP frequently attributes aerosol feature to "clean marine" (Sa=20, a factor of 3 smaller than "polluted continental") (generally more than 40-60%). Efforts are needed to improve CALIOP aerosol sub-typing scheme.