Advancements in the Representation of Cloud-Aerosol Microphysics in the GEOS-5 AGCM

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The main features of cloud microphysical properties are simulated by the McRAS-AC (Microphysics of Clouds with Relaxed Arakawa-Schubert and Aerosol-Cloud interaction) scheme implemented in the GEOS-5 AGCM. The version shown uses Fountoukis and Nenes (2005) CCN activation and Barahona and Nenes (2008, 2009) IN activation. Monthly aerosol loading is from GOCART with log-normal size distribution of each species assumed. Other key features of McRAS-AC are level-by-level cloud-scale thermodynamics, and precipitation microphysics from Sud and Lee (2007) based on Seifert and Beheng (2005). One-year model runs with prescribed SST fields are evaluated against satellite data. Fig. 1 shows the microphysical processes of McRAS - AC. Liquid and ice cloud water are double moment (independent number density and mass) prognostic variables, but rain and snow mass fractions are diagnosed.

Sea Salt Sensitivity test

Sea salt (SS) aerosol is a major CCN source over ocean. But global mean of GOCART SS concentration over ocean at 900hPa is only 4 cm⁻³. With increasing SS, TWP increases, TOA net SW and liquid r_eff decrease (Table 1), making disagreement with MODIS SST worse.

Cloud water w/o Carbon

Fig. 3 indicates that McRAS generates too thick cloud over central Africa and the Amazon basin, locations of high carbon aerosol loading due to biomass burning. When carbon aerosol is neglected in McRAS, large reductions in TWP occur.

Initiation temperature of Bergeron process

Simulation of the B-F process makes for better zonal – height profiles of IW, but causes too little (too much) liquid (ice) in the mixed phase; so it needs to be tempered. This can be achieved by modifying temperature for the onset B-F process (figures show results for T=273, 268, and 263 K).

TOA Radiative Fluxes

The global annual mean of TOA net SW matches quite well CERES, but includes cancellations of warming at high latitude and tropical cooling. TOA fluxes are consistent with cloud water path (Fig. 3). Along the equator, especially over highly polluted areas, very thick clouds are formed that increase the planetary albedo. In high latitudes, cloud water path does not reach the MODIS values. The AGCM OLR is greater than CERES by 2.4 W/m². Fig. 8 indicates that model IWC seems to be located lower than CloudSat IWC, though the overall patterns are similar.

Summary

- Aerosol-cloud interaction is well simulated by McRAS-AC in the GEOS-5 GCM, it shows quite reasonable latitude-contrasts, sensitivity of cloud optical properties to aerosol number concentration.
- Aerosol loading was based on GOCART data; the current simulations clearly show the importance of the aerosol data.
- Bergeron-Findelise process plays a central role in producing mixed phase clouds; there is large sensitivity to the B-F initiation temperature, suggesting need for further research.

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