1. Introduction

MISR multi-angle measurements, with their greater combined sensitivity to both cloud optical depth and cloud morphology, hold the promise of improving our understanding of cloud microphysical processes, such as entrainment and cloud-aerosol interactions, through their impacts on the cloud reflectance field. MISR can also near-simultaneously determine both aerosol and cloud properties, with the furthest off-nadir views being most sensitive to aerosol and the near-nadir views most useful for retrieving cloud properties. Prior work concluded that optical and spatial variability at scales smaller than the 275 m horizontal resolution, and ~500 m vertical resolution of MISR are important to domain-averaged reflectances (Zuidema et al., 2003). This will be particularly true for very thick, spatially-complex clouds such as cumulus congestus.

Forward modeling is the most confident approach for linking the cloud radiation field to the underlying cloud properties, and for understanding the dependence on scale. This poster describes the first look at the radiative behavior of a three-dimensional cumulus congestus cloud simulation.

2. Models

Cloud Simulation: We use a cloud model with an emphasis on microphysical realism and additionally possessing a realistic small-scale cloud geometry; a modified nested grid version of the Straka Atmospheric Model. This model has been used to simulate the evolution of drop size spectra in convective clouds observed off the coast of Florida during the Small Cumulus Microphysics Experiment (Lasher-Trapp et al., 2001). Simulated cloud radar matched those observed, attesting to the realism of the simulation. The horizontal and vertical model resolution is 50 m by 50 m, and the domain size is 4 km by 4 km. The modeled cloud water surface of 0.001 g/kg of the cloud field we have utilized is shown in Fig. 1a, and the liquid water content field in Fig. 1b, showing that most of the cloud liquid is within the upper half of the cloud. As shown in Fig. 1c) the liquid water path is quite significant.

3. Three-dimensional RT calculation of fluxes

We utilized the Community Monte Carlo Model developed under the auspices of the International 3-Dimensional Radiative Transfer Code Intercomparison Project. This model currently can calculate fluxes, but not yet radiances. We utilized a Henyey-Greenstein phase function, a single-scattering albedo of 1.0, and a solar zenith angle of 0 degrees. We find a difference in the total domain-averaged albedo of 2% between the two cloud fields shown in Fig. 2, increasing from 3% for the homogeneous mixing assumption to 36% for the inhomogeneous mixing assumption. Comparisons against plane-parallel calculations still need to be done, to ascertain if 3D effects had an influence.

4. Remarks

So far, our major accomplishment has been a successful implementation of this cloud model output into the DRC Monte Carlo code, making us the first users of a code that is not yet documented or utilized by an other than the developer. Much work remains to be done by us, a salient task being the writing of a radiance module.

Ultimately, the physical questions we hope to address include:

* What is the radiative signature of different mixing processes, and cloud-aerosol interactions? (Aerosols are easily incorporated by the RT model)

* What is the relative contribution of cloud microphysics and cloud morphology to the radiative signature? Do observed cumulus congestus appear bright to us because of their microphysics, or their morphology? We will investigate this by degrading the resolution of the cloud model simulations.

* How well do the forward radiative transfer calculations compare to MISR observations for this cloud type, i.e., are these simulated cloud fields representative?

* Can the multiple angles of MISR lead to improved cloud optical depth retrievals for this "difficult" cloud type, over single-angle retrievals?

* Can the aerosol indirect effect, whereby increases in aerosol lead to smaller drop sizes, be detected by MISR for this cloud type?

References:


Why are (some) clouds so bright ?? Forward 3DRT calculations of modeled Cu congestus

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Fig. 1 a) modelled cloud water surface of 0.001 g/kg and b) liquid water content (dimensionless units), and c) liquid water path.

Fig. 2: Optical depths of cloud field shown in Fig. 1, using two different assumptions for entrainment.

Fig. 3: Histogram of optical depths for cloud fields shown in Fig. 2.