THE RELATIONSHIP BETWEEN RAIN AND CLOUD WATER AS OBSERVED FROM THE A-TRAIN

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1. Introduction

Shallow maritime clouds are critical to regulating the climate of the Earth. Due to their warm cloud top temperatures and extensive horizontal coverage they have a larger net radiative effect at the top of the atmosphere than any other cloud type. In addition to playing a critical role in determining the radiative energy balance at the top of the atmosphere, they are also highly susceptible to environmental perturbations [1]. For example, it also proposed that their microphysics and thus albedo are highly susceptible to anthropogenic pollution [2] and observations show that their horizontal extent is largely controlled by the boundary layer inversion strength [3]. Furthermore, shallow clouds in subsidence regions also demonstrate the most uncertain response of any cloud type in their parameterization in climate models [4]. Because of the unique sensitivity and uncertainty associated with both microphysical and macrophysical processes associated with these clouds it is critical that a concerted effort be made ot enhance our current observational capabilities. In particular recent work [5] has suggested that the rainfall efficiency in these clouds is a key factor in modulating their extent and microphysics.

2. Results

We present a number of results from the A-train constellation that relate to light precipitation processes in shallow maritime clouds. Specifically, a largely unknown quantity is the ratio of cloud water path (CWP) to total water path (TWP) in shallow clouds. Two multi-sensor approaches are presented to quantify this ratio in shallow maritime clouds. The results of these two approaches are compared and the dependence of the ratio on environmental parameters as well as cloud macrophysical and microphysical state is explored.

The first approach utilizes collocated observations from the Moderate Resolution Imaging Spectroradiometer (MODIS) and the CloudSat Cloud Profilling Radar (CPR). We show that the MODIS CWP estimate is largely insensitive to the presence of precipitation mode water. We combine this estimate with an estimate of TWP from the CPR that is based on the path integrated attenuation (PIA) that can be estimated from the depression of the surface scattering cross section. This combination of observations provides an estimate of the ratio of the CWP to the TWP. This ratio is examined within the context of both cloud macrophysics and cloud microphysics. Results are compared to a class of one dimensional heuristic cloud models that are shown to overestimate the production of rain water.

The second approach extends upon the physically based optimal estimation algorithms of Elsaesser and Kummerow [6] and Rapp et al. [7]. From the heritage of these previous studies a physically based simultaneous retrieval of surface wind speed, column water vapor (CWV), the CWP and the TWP is applied to the AMSR-E observations. Simultaneous retrieval of the CWP and the TWP depends on the differential sensitivity of the 37 GHz and 89 GHz channels to the presence of precipitation mode water due to Mie effects on both the absorption and scattering properties of the cloud. The AMSR-E algorithm is used to explore the relationship between cloud water content and precipitation water content in shallow maritime clouds. This particular cloud type is unique in that collocated MODIS observations offer an independent estimate of the CWP. To facilitate this comparison AMSR-E antenna temperatures are adjusted to a common footprint size using the technique of Backus and Gilbert [8]. MODIS observations are also convolved with an appropriate antenna function to provide the independent CWP estimate at a common spatial resolution. The difference between MODIS CWP and AMSR-E TWP may be interpreted as the rain water path. Results from this retrieval are contrasted with those gleaned from the combined MODIS/CloudSat methodology.

3. References

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