A comparison of cirrus clouds retrieved from POLDER-3/PARASOL and MODIS/AQUA

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Introduction

MODIS and POLDER are two key instruments in the “A-Train” for cloud observations. The two instruments offer different yet complementary advantages for remote sensing of the microphysical and optical properties of cirrus clouds. The wide spectral coverage and high spatial resolution of MODIS make it ideal for cloud detection and cloud optical property retrieval. The multidirectional and polarization-sensitive observations from POLDER contain rich and unique information on cloud microphysical properties. A combination of the two provides an unprecedented opportunity for ice cloud study. In this paper, we compare the collocated MODIS and POLDER Level-2 cloud products for a given MODIS granule. We also explore the synergistic use of the two instruments for retrieving ice cloud microphysical properties.

Data & case selection

MODIS and POLDER Level-1 geolocated radiance products and Level-2 operational cloud products have been collocated at POLDER full resolution (6 km) using a state-of-the-art data fusion system developed by LOA (France). A MODIS granule near Costa Rica on July 22th, 2007 is selected for the Level-2 cloud product comparison in this paper. A deep convective system that had developed earlier to the south of Panama had dissipated, leaving behind the anvil clouds that cover the center of the granule. To the northeast of the anvil is another convective system at an earlier stage of development.

Cloud thermodynamic phase

MODIS makes use of the differences between ice and water in absorption at SWIR and thermal IR bands for cloud phase retrieval. POLDER data can discriminate water clouds from ice clouds by the strong angular and polarization features of the water and ice particles. The combination of MODIS and POLDER is greatly helpful for assessing the confidence level of cloud phase retrieval and interpreting the ambiguous cases, such as when optically thin cirrus clouds overlay water clouds (Riedi et al. 2007).

Optical thickness of cirrus clouds

The comparison of ice cloud optical thickness between MODIS and POLDER is shown in Figs. 3 and 4. The results reveal that the ice cloud optical thickness from POLDER retrieval is substantially smaller than that from MODIS. As shown in Fig. 4b, the POLDER retrievals are smaller than MODIS retrievals for over 80% of the collocated pixels. As revealed in Fig. 4a, for over 50% of the collocated pixels, POLDER retrievals are smaller than those from MODIS by more than 30%. The main reason causing such substantial differences between POLDER and MODIS is that the two retrievals are based on different ice cloud bulk scattering models as shown in Fig. 5.

Climate Implications

The above comparison reveals that there currently exists a widely divergent view of the scattering phase function of ice clouds, which in turn results in substantial uncertainty in ice cloud optical thickness retrieval. Of concern to climate studies is whether and how this uncertainty affects the computation of the radiative forcing of ice clouds. As shown in Fig. 7, the ratio of the difference between the IHS and Baum05 model-based optical thickness retrievals, respectively, is substantially smaller than unity for the cirrus clouds shown in Fig. 1a. This difference is consistent with the finding from the above comparison in addition, the ratio is also sensitive to the scattering angle. Note that this angular dependent difference is the result of the difference in the higher-order moments of scattering phase function, instead of the asymmetry factor. Because of the MODIS angular sampling scheme shown in Fig. 8, such angular dependence has an important implication. That is, as shown in Fig. 9, it may cause some uncertainty in deriving the seasonal variation of optical thickness and radiative forcing of cirrus clouds from satellite measurements.