# 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 poster,we compare the collocated *MODIS* and *POLDER* Level-2 cloud products for a given *MODIS* granule. We also explore the synergetic use of the two instruments for retrieving ice cloud microphysical properties.

| **POLDER-3** | **MODIS** |
|---|---|
| Advantages / Uniqueness : | Advantages / Uniqueness : |
| • **Multi-direction** (up to 16 angles) | • **Wide spectral coverage** (36 bands 0.4 ~ 15 µm) |
| • **Polarization sensitive** (Linear polarization at 3 bands) | • **Horizontal resolution** (Nadir) (250m ~ 1km) |
| Limitations | Limitations |
| •Horizontal resolution (6km) | • Single direction |
| •Narrow spectral coverage ( 9 bands 0.443~1.020 µm) | • No polarization |
| | • Column retrieval |

## Data & case selection

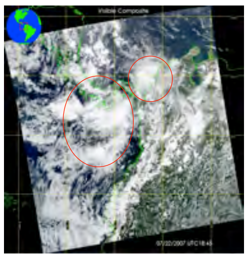


**Fig.1a:** *MODIS* granule visible composite UTC18:45, July 22th, 2007.

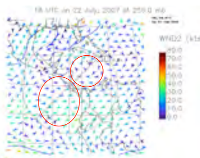

**Fig.1b:** NCEP 12-hr 250hp wind forecast

*MODIS* and *POLDER* Level-1 geolocated radiance products and Level-2 operational cloud products have been collocated at *POLDER* full resolution (6km) 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***).

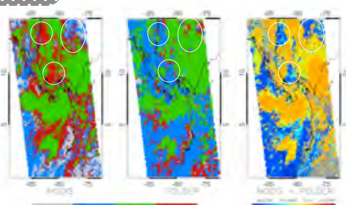

**Fig. 2:** *MODIS*, *POLDER* and combined cloud phase retrieval.

## Optical thickness of cirrus clouds

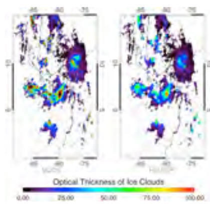


**Fig. 3:** *MODIS* and *POLDER* cirrus cloud optical thickness retrieval.

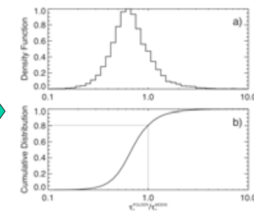


**Fig. 4:** a) Probability density function and b) cumulative distribution function of $\tau^{POLDER}/\tau^{MODIS}$

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 ($\tau^{POLDE}$) is substantially smaller than that from MODIS ($\tau^{MODIS}$). As shown in Fig. 4b, the POLDER retrievals are smaller than MODIS retrieval 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.

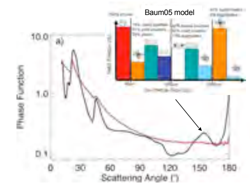


**Fig.5:** Visible scattering phase functions of *MODIS* (black)and *POLDER* (red) cirrus cloud optical models.

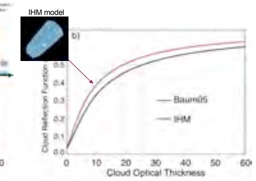


**Fig.6:** Look-Up-Tables based on the cirrus cloud optical models for cloud optical thickness retrieval

## 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 between the IHM and Baum05 model-based optical thickness retrievals, $\tau^{IHM}$ and $\tau^{Baum05}$, 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.

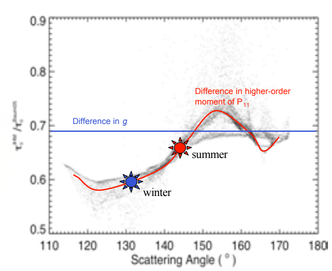


**Fig. 7** The ratio of $\tau^{POLDER}/\tau^{MODIS}$ as a function of MODIS scattering angle.

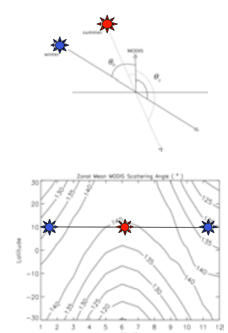


**Fig. 8** Zonal mean MODIS scattering angle as a function of month.

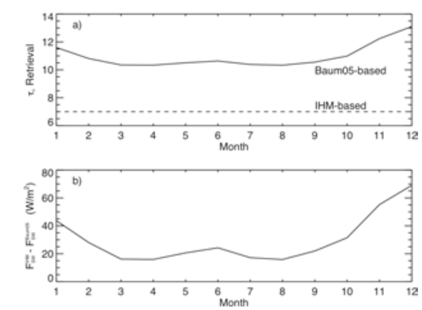


**Fig. 9:** Assuming that ice clouds at 10° N have a constant optical thickness, say 7.0, and their bulk scattering properties follow the IHM model, the dashed line in a) denotes the optical thickness retrieval based on the IHM model and soiled line denotes the retrieval based on the Baum05 model. The difference in derived shortwave radiative forcing between Baum05-based and IHM-based retrieval is shown in b).