Studies in Cirrus Microphysics using MODIS-IR Observations

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Background

•MODIS IR observations (8.5, 11 and 12 μm) provide direct information on cirrus cloud microphysics (optical depth, particle size).
•These observations coupled with the standard MYD06 CO_2 slicing cloud height retrievals allow for estimation of cirrus microphysics for all times of day.
• This day/night consistency will **allow for diurnal studies of cirrus cloud microphysics** – a fundamental property missing from the standard daytime only MYD06 retrievals of cloud properties.
• The work shown below also demonstrates these observations can be used to infer **information on the dominant ice crystal habit at cloud-top**.
• This knowledge may prove critical in resolving the spectral inconsistency in the cirrus optical depths derived from solar reflectance and IR channels.

Our Project Status

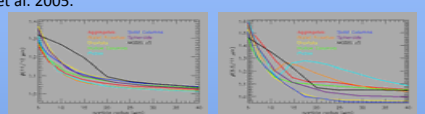
• Develop an algorithm to derive cirrus optical and microphysical properties from the MODIS IR observations coupled with existing MYD06 cloud heights [**DONE**]

• Conduct studies to characterize and understand the IR results in relation to the existing daytime products. [**In Progress**]

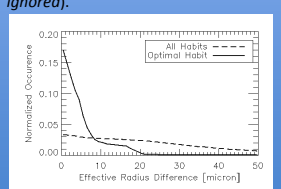
• Implement into future MODIS/NPP Atmospheres data products. [**To be Done – not funded yet**]

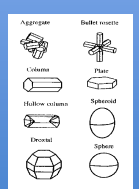
Methodology

•Using MYD06 cloud height, cloud emissivities are computed for 8.5, 11 and 12 μm observations from which β values (akin to Angstrom exponents) are derived from the 8.5/11 and 11/12 channel pairs. Only single layer cirrus pixels used.
•For a given habit and a given channel combination, a value of effective radius can be derived from each β value (see figures of β values as a function effective radius for each habit.) Ice scattering properties provided by Ping Yang et al. 2005.



•An optimal habit is selected based on the habit with produces the minimum difference in the effective radius from each β value. As shown below resulting effective radius difference is << 10 μm which indicates that is method has skill. (*optimal differences are small than those when habit is ignored*).





•Analysis of results for all habits shows that certain habits behave similarly. We therefore defined the following bulk habits
- **Bulk Spheroids** = aggregates + spheroids
- **Bulk Plates** = plates + droxtals
- **Bulk Columns** = solid columns + hollow columns + bullet rosette + MODIS Collection 5 (*Bryan Baum et al.*)

Comparison to Current MYD06

•For greatest impact, we have to understand and reconcile the IR and MYD06 estimates.

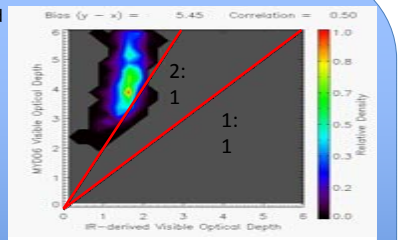
•MYD06 optical depths **are roughly a factor of two larger** than IR optical depths (adjusted to 0.65 μm)

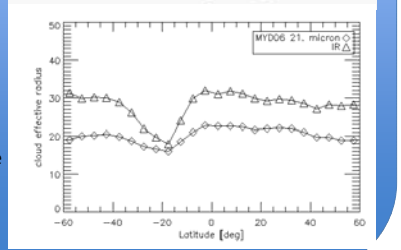
• Note this is **similar to comparisons of CALIPSO/CALIOP** optical depths to MYD06.

• MYD06 particle radii are much smaller than the IR estimates using the optimal habit.

• This implies that MYD06 models are *too absorbing at 2.1 μm* and scatter *too much in the forward direction at 0.65 μm*. [relative to the IR models]

•Zhibo Zhang's recent work indicates that vertical variations can not account for this.





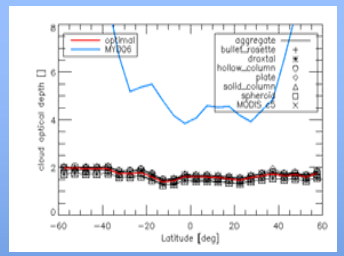
Impact of Habit on IR Retrievals

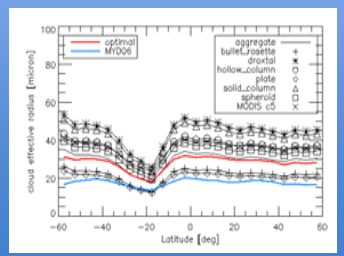
• No habit can bring the MYD06 and IR optical into agreement.

• Plates generated mean zonal particle sizes close to MYD06.

•The optimal habit results more closely follow aggregates, not plates.

•C5 results do not follow MYD06 *(though C5 habit mixture used in MYD06)*





Distribution of Dominant Cloud-Top Ice Crystal Habit

• Bulk habit distributions show distinct and coherent patterns over these 10 days.

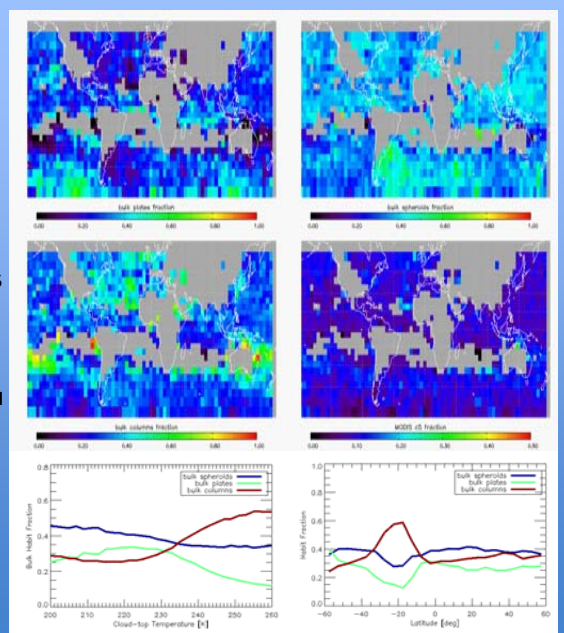
•**Global distributions of cloud-top dominant ice habit are largely unexplored.**

•Zonal distributions and distributions with MYD06 cloud-top temperature are show below.

• Relative occurrence of MODIS C5 (wrt to all individual habits) is rare.

• Distribution with temperature shows definite patterns **that could be exploited in future bulk scattering models.**

•**For this 10 day period, plates were the most common habit around -20N which is also the region where the IR and MYD06 are in closest agreement.**



Conclusions

• The MODIS IR observations provide useful information on cirrus microphysics that complements that available currently in MYD06.

•This includes some information on ice crystal habit – this work represents one of the first satellite inferences of habit

• **This methodology fits in well with the current MYD06 framework and could be added to future versions of MYD06. We are proposing this.**

• The IR results are not consistent with the MYD06 results generated from solar reflectances.

•Our analysis indicates that the C5 mixture may be too heavily influenced by columns

•These inferences are likely to change when new more realistic scattering models are available from Ping Yang.

References

Heidinger, A.K., M.J. Pavolonis, R. E. Holz, B. A. Baum, and S. Berthier (2010), Using CALIPSO to Explore the Sensitivity to Cirrus Height in the Infrared Observations from NPOESS/VIIRS and GOES-R/ABI, J. Geophys. Res., doi:10.1029/2009JD012152, in press.

Heidinger, A.K., and M.J. Pavolonis, 2009: Gazing at Cirrus Clouds for 25 Years through a Split Window. Part I: Methodology. *J. Appl. Meteor. Climatol.*, **48**, 1100–1116.

We gratefully acknowledge the support of NASA/ROSES for this effort.