Applications of Infrared Derived Microphysical Information Using MODIS

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1. Introduction

•In this NASA ROSES funded project, infrared observations were used calculate effective absorption optical depth ratios (β), as shown in the equations below.

•Effective absorption optical depth ratios are directly related to cloud microphysics (particle size, shape, and composition).

•Only infrared measurements are used, so β-derived cloud microphysical information is valid at all times of the day.

•The goals of this poster are to explore if and how infrared cloud microphysical information from MODIS can be used to study deep convection and to show that improved information on cloud phase can be gleaned from β.

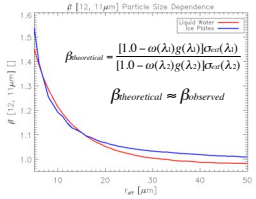
•This work will lead to improved understanding of the infrared microphysical results and their relationship to the daytime MODIS microphysical properties (MOD06 and MYD06).

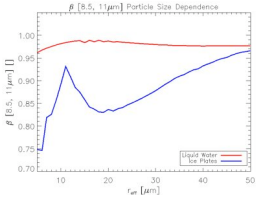
$$\varepsilon(\lambda) = \frac{Rad(\lambda)_{observed} - Rad(\lambda)_{clear}}{[Rad(\lambda)_{ac} + t(\lambda)_{ac} * B(\lambda, T_{eff})] - Rad(\lambda)_{clear}}$$

Spectral cloud effective emissivity

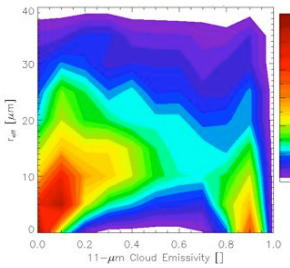
$$\beta_{observed} = \frac{\ln[1.0 - \varepsilon(\lambda_1)]}{\ln[1.0 - \varepsilon(\lambda_2)]}$$

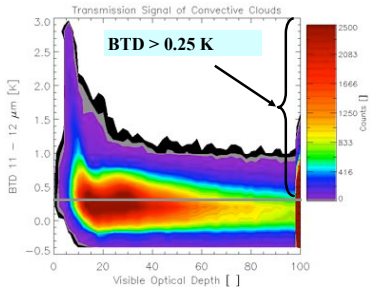
Spectral ratio of effective absorption optical depth





2. Microphysical Properties of Deep Convection

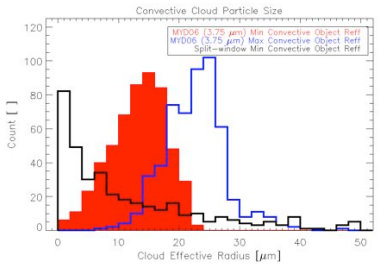




•Of the 17 cloud objects that the MYD06 NIR/VIS retrieval indicates are dominated by small ice crystals (max r_{eff} < 15 μm), the IR retrievals depict small particles for 16 of those objects.

•Of the 69 cloud objects that the MYD06 retrieval indicates are dominated by larger ice crystals (min r_{eff} > 20 μm), the IR retrievals depict larger particles for 42 of those objects.

•Differing radiative transfer processes may explain some of the discrepancies between the MYD06 and IR retrievals. Additional research is needed to explore this possibility further.

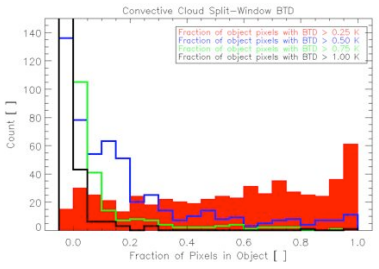


•While the 2D distribution of infrared ice cloud optical properties has several interesting features, this study is focused on high emissivity ice clouds (ε > 0.95).

•Ice clouds with an ε > 0.95 were analyzed using one day (May 5, 2008) of low and mid-latitude 1 km *Aqua*-MODIS data.

•The joint histogram of 11 - 12 μm BTD and MYD06 visible optical depth shows evidence that many large optical depth ice clouds exhibit a non-zero effective transmittance near cloud top, which can exploited to infer effective particle radius.

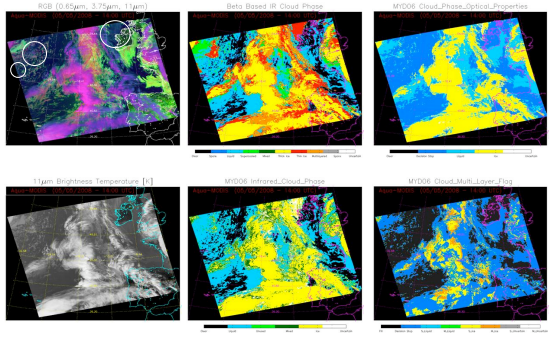
•The rest of this analysis utilizes cloud object statistics, where a cloud object is defined as a collection of spatially connected pixels with an ε > 0.95 (a total of 541 objects were analyzed).



3. Cloud Phase

•An infrared only cloud phase and multilayered cloud detection algorithm were developed using various β-ratios (as opposed to BTD's).

•A preliminary comparison of the β algorithm, the MYD06 NIR phase and multilayer cloud detection products, and the MYD06 IR phase product indicates that the β algorithm identifies more thin cirrus than the MYD06 products.



Cloud Phase Comparison

Phase	Beta	MYD06 NIR	MYD06 IR	PH05
Liquid	384,897 (18.99%)	578,969 (28.57%)	400,834 (19.78%)	512,162 (25.27%)
Mixed	15,304 (0.76%)	0 (0.00%)	154,485 (7.62%)	0 (0.00%)
Ice	1,626,616 (80.25%)	1,362,649 (67.23%)	1,212,086 (59.80%)	1,514,655 (74.73%)
Uncertain	0 (0.00%)	85,199 (4.20%)	259,412 (12.80%)	0 (0.00%)

Multilayer Detection Comparison

	Beta	MYD06 NIR	PH05
Multilayer Count	386,508 (19.07%)	258,768 (12.77%)	701,027 (34.59%)

4. Conclusions

•MODIS IR observations provide information on particle size and composition which complements the existing MYD06 products.

•Effective particle radius information derived from IR measurements in deep convective clouds is reasonably consistent with the MYD06 NIR/VIS product on a cloud object basis. Further research is needed to explain the differences that exist.

•A β-based cloud phase algorithm appears to be more sensitive to thin cirrus than the MYD06 NIR and IR phase products.

Pavolonis, M.J., 2010: Advances in extracting cloud composition information from spaceborne infrared radiances: A robust alternative to brightness temperatures. Part I: Theory, Submitted to *J. Appl. Meteor. and Climatol.* (November, 2009).

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