Using CALIOP to Validate the GOES-R Cloud Phase and Volcanic Ash Algorithms

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1. Introduction

CALIOP is used to validate and characterize cloud phase and volcanic ash algorithms developed for the next generation of GOES satellites, GOES-R. These algorithms, which utilize infrared measurements, are tested using SEVIRI as a proxy for the Advanced Baseline Imager (ABI). SEVIRI infrared measurements can be combined with CALIOP-derived cloud boundaries and clear sky radiative transfer modeling to cast the validation in terms of cloud emissivity and microphysics (e.g. effective particle size). In the infrared, the measurements can be tied to theoretical particle distributions via β-ratios, as shown below.

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

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

$$\beta_{theoretical} = \frac{[1.0 - \omega(\lambda_1)g(\lambda_1)]\sigma_{ext}(\lambda_1)}{[1.0 - \omega(\lambda_2)g(\lambda_2)]\sigma_{ext}(\lambda_2)}$$

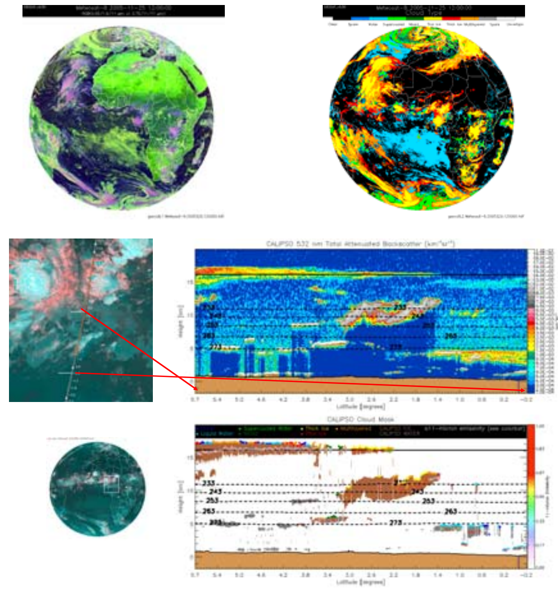
Spectral ratio of scaled extinction coefficients

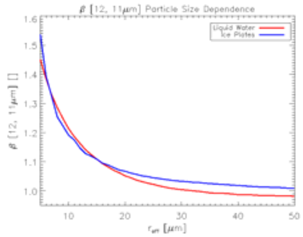
$$\beta_{theoretical} \approx \beta_{observed}$$

This relationship provides a direct link from the measurements to theoretical particle distributions

2. Cloud Phase

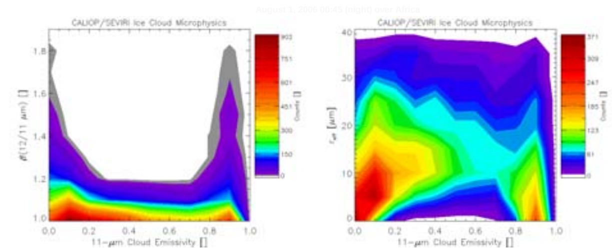
•The GOES-R cloud phase algorithm compares favorably with CALIOP when "definite" liquid water and ice cloud are considered. High quality cloud phase information is needed to validate mid-level clouds.





•The cloud phase algorithm has to account for a large range of ice cloud effective radii and emissivity.

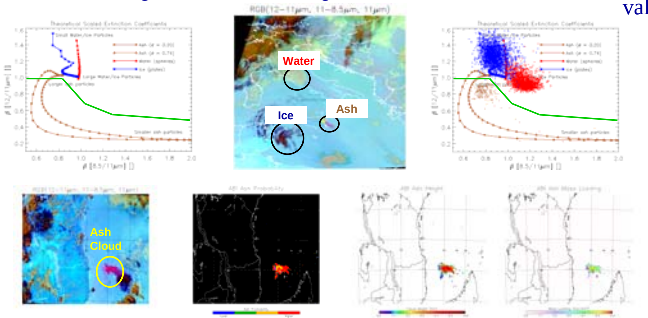
•Combined CALIOP and infrared measurements are valuable for studying ice cloud microphysics.



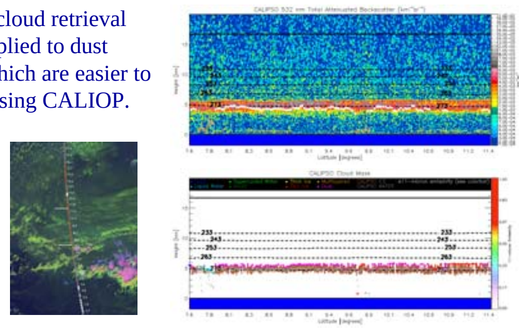
Category	CALIPSO Count	ABI Phase Count	Percent Agree	Percent Disagree
Liquid Water/ Supercooled water	6556	6365	97.09%	2.91%
Unknown Phase	2753	?	?%	?%
Ice Phase	5661	4881	86.22%	13.78%
Total	12,217	11,246	92.05%	7.95%

3. Volcanic Ash

•The GOES-R algorithm is designed to detect volcanic ash then retrieve the height and mass loading of ash clouds.



•The ash cloud retrieval can be applied to dust clouds, which are easier to validate using CALIOP.



Product	Accuracy	Precision
Ash Top Height	-1.245 km	0.464 km
Ash Mass Loading	0.270 tons/km^2	0.269 tons/km^2

4. Conclusions

•CALIOP is extremely valuable for validating and characterizing the GOES-R cloud algorithms.

•Comparisons with CALIOP indicate that the GOES-R cloud phase and volcanic ash algorithms produce high quality results.

•High quality cloud phase profiles are desperately needed to better understand the microphysics of mid-level clouds.

•Combined CALIOP/SEVIRI emissivity and effective particle radius retrievals reveal an interesting distribution, which warrants further study.

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