

Examination of CALIPSO cloud detection in broken cloud conditions using high resolution MODIS data

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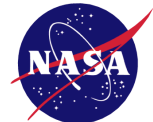
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CloudSat Science Team Meeting
Seattle, WA
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CloudSat Science Team
Meeting



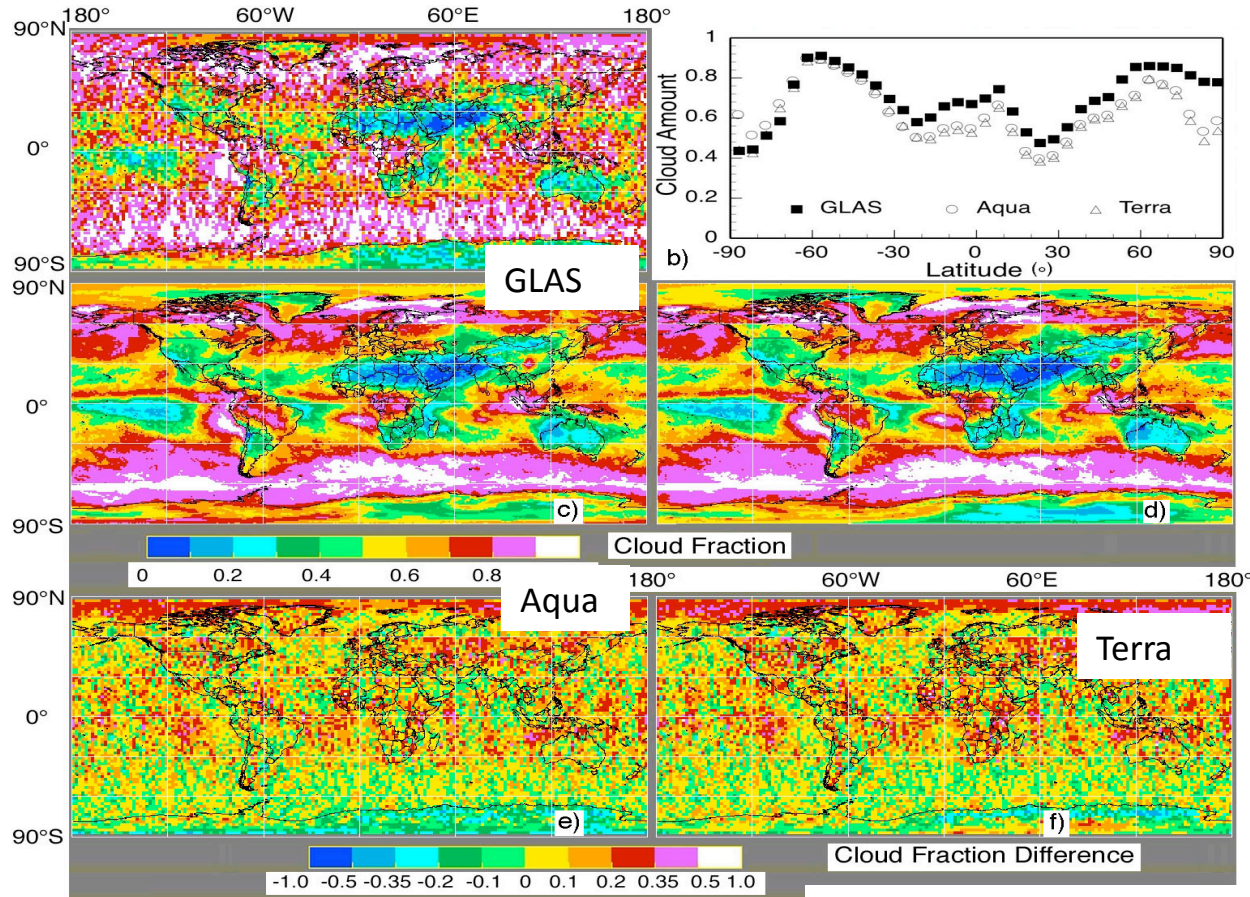
Outline

- The Cloud and the Earth's Radiant Energy System (CERES) cloud mask
 - Applied to Aqua- and Terra-MODIS data
 - Generally detects more warm clouds than CloudSat alone, but fewer than CALIPSO
- Broken cloud scenes can be problematic for CERES
 - e.g., trade cumulus
 - Cloud edges are also a problem; retrieved optical depth too small
 - Use 250-m MODIS visible reflectance and dynamic threshold technique to detect more small-scale clouds (area $\ll 1 \text{ km}^2$)
- Compare results of threshold method with CERES Cloud Mask and CALIPSO



CERES vs GLAS: 26 Sept – 18 Nov 2003

ICESat in near-terminator orbit, 532-nm med res clouds



- Zonal differences with GLAS similar to those between CERES and other passive retrievals, except in north polar areas
 - mean dif = 7.8%
- Regional differences mainly trade Cu, land, Arctic
 - polar mask has better agreement over land

Daytime agreement!

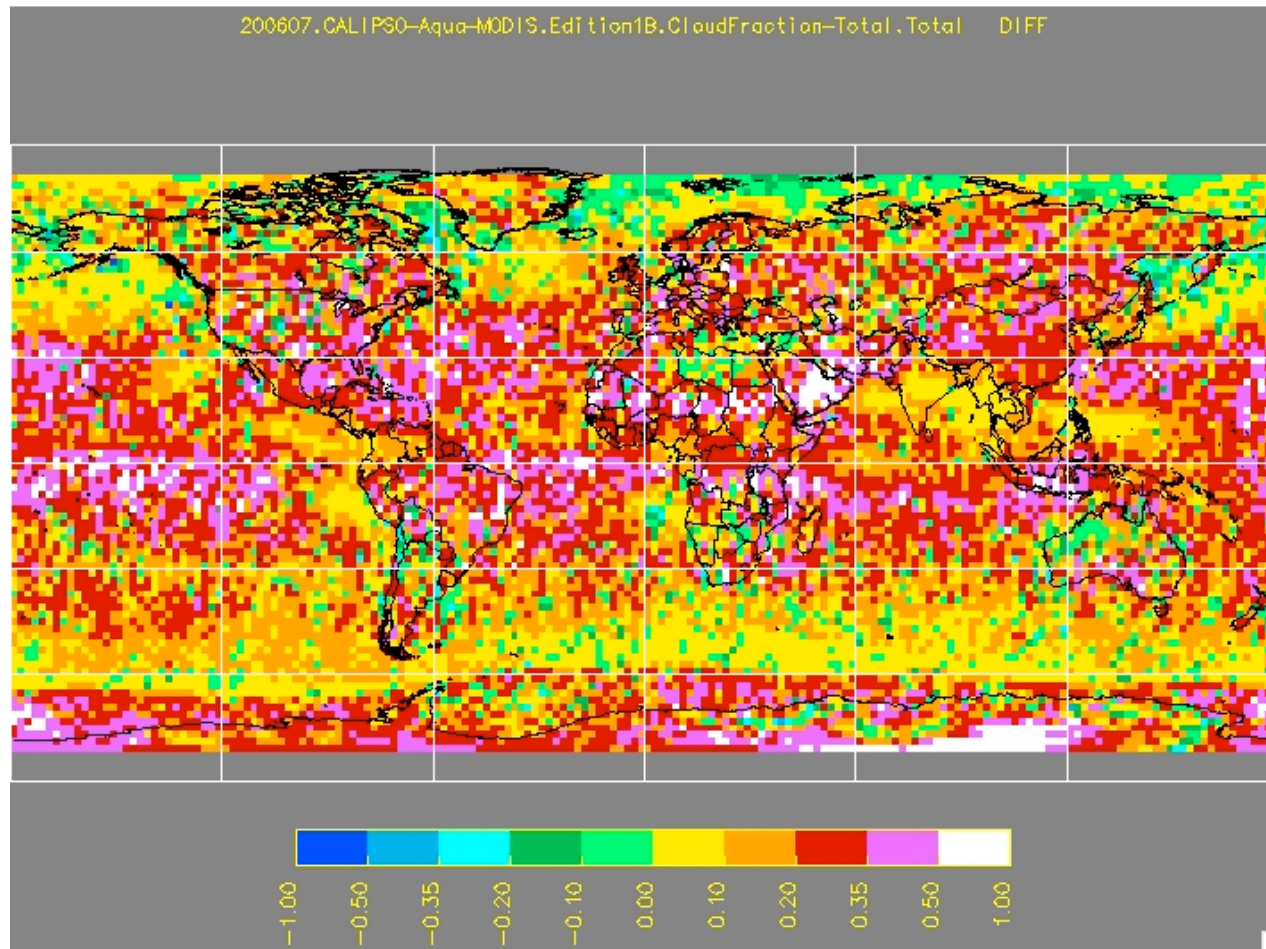
	Day	Night	Total
GLAS 532	62.8 (63.2)	74.1 (74.4)	68.9 (70.3)
CERES Aqua	62.0	60.6	61.3
CERES Terra	60.5	61.3	60.9



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CALIPSO – CERES Cloud Amount Differences, July 2006



In general, CERES detects fewer clouds compared to CALIPSO -

Mostly polar night & tropics (high & low clouds)

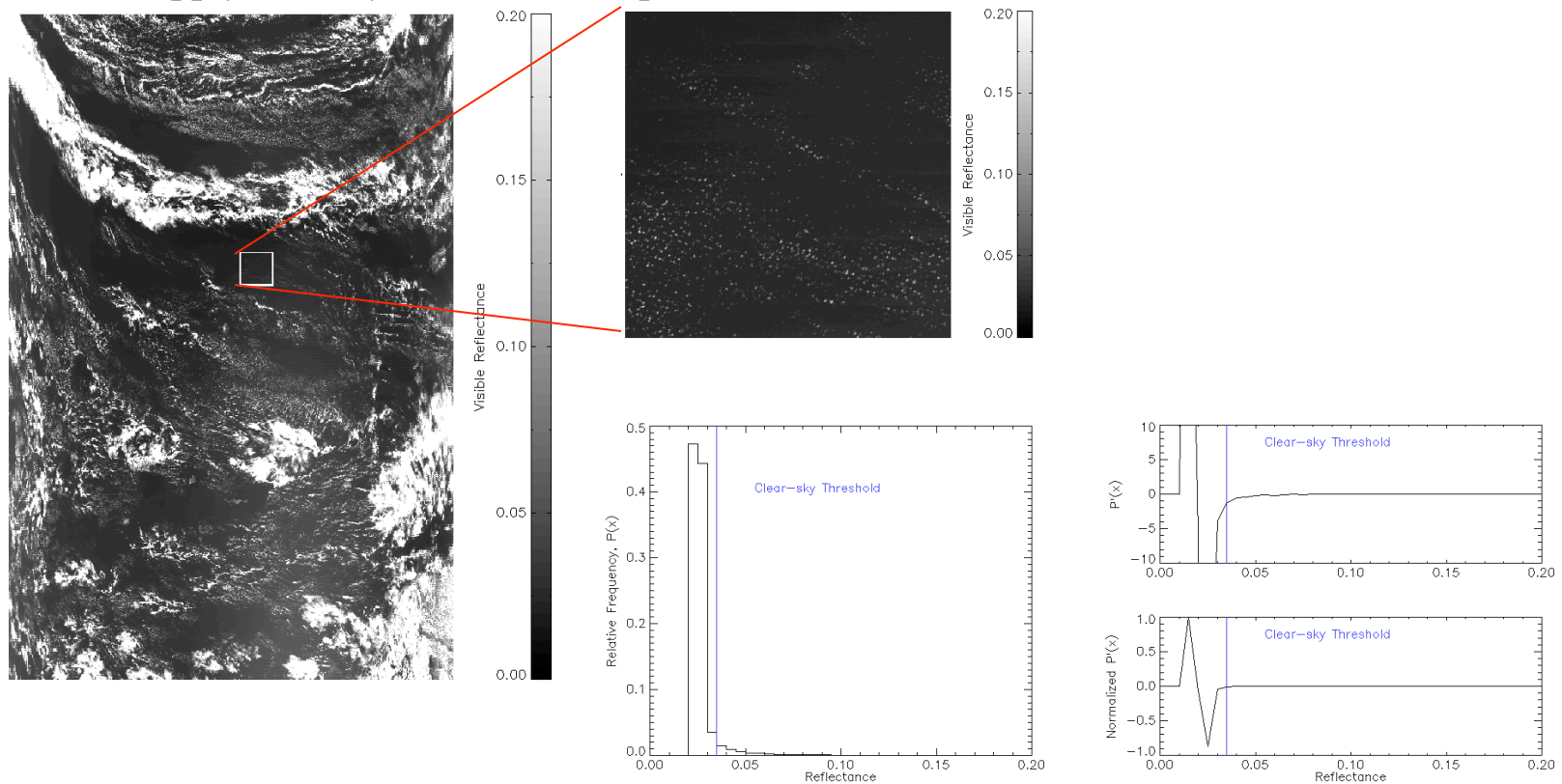


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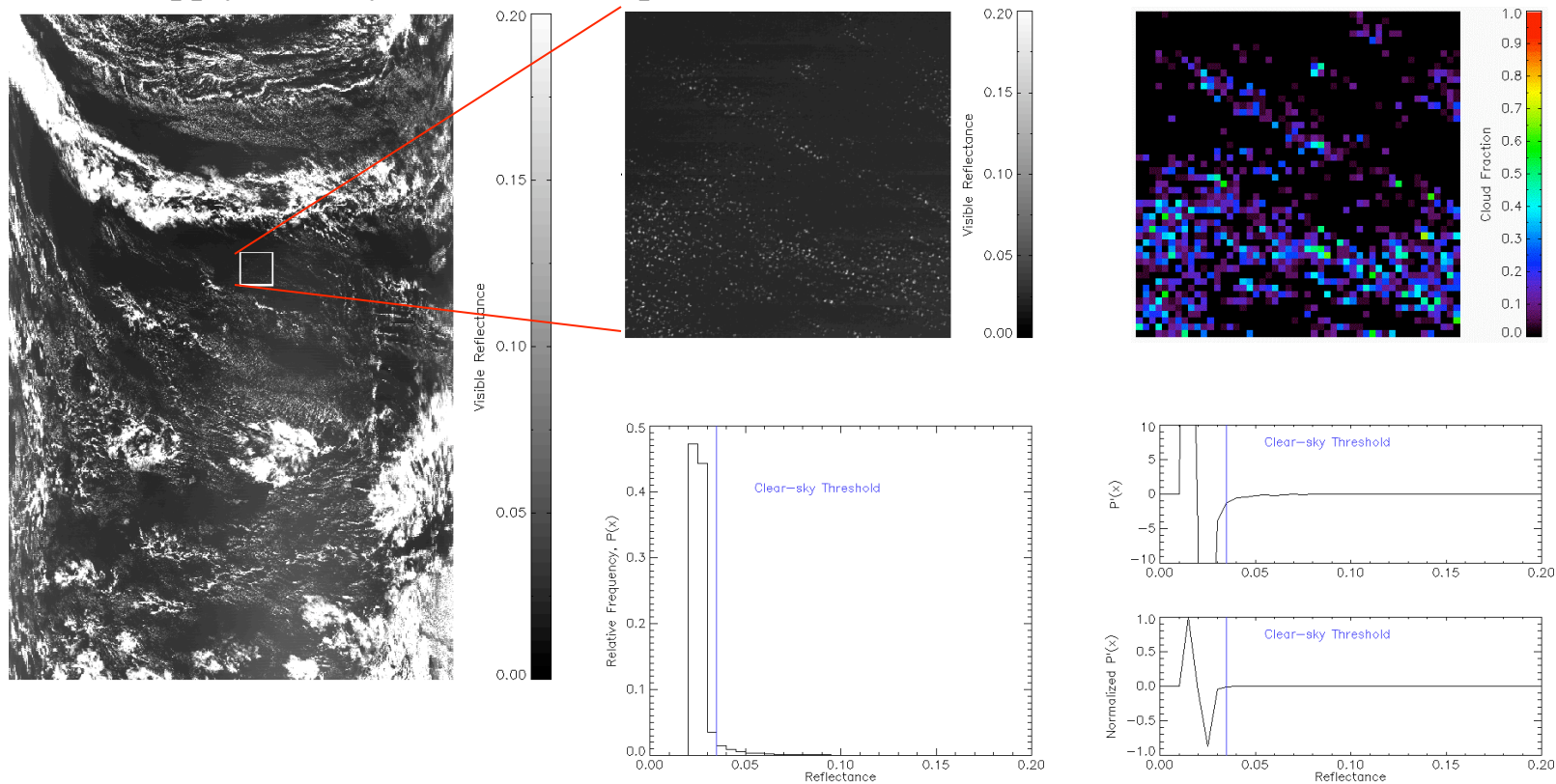
250-m cloud mask

- Use 250-m MODIS visible reflectance to assess Aqua-CERES cloud amounts
 - Based on the derivative of the reflectance frequency distribution
 - Tuned by comparing initial results with MODIS 250-m reflectance images
 - Apply to every 1-km MODIS pixel



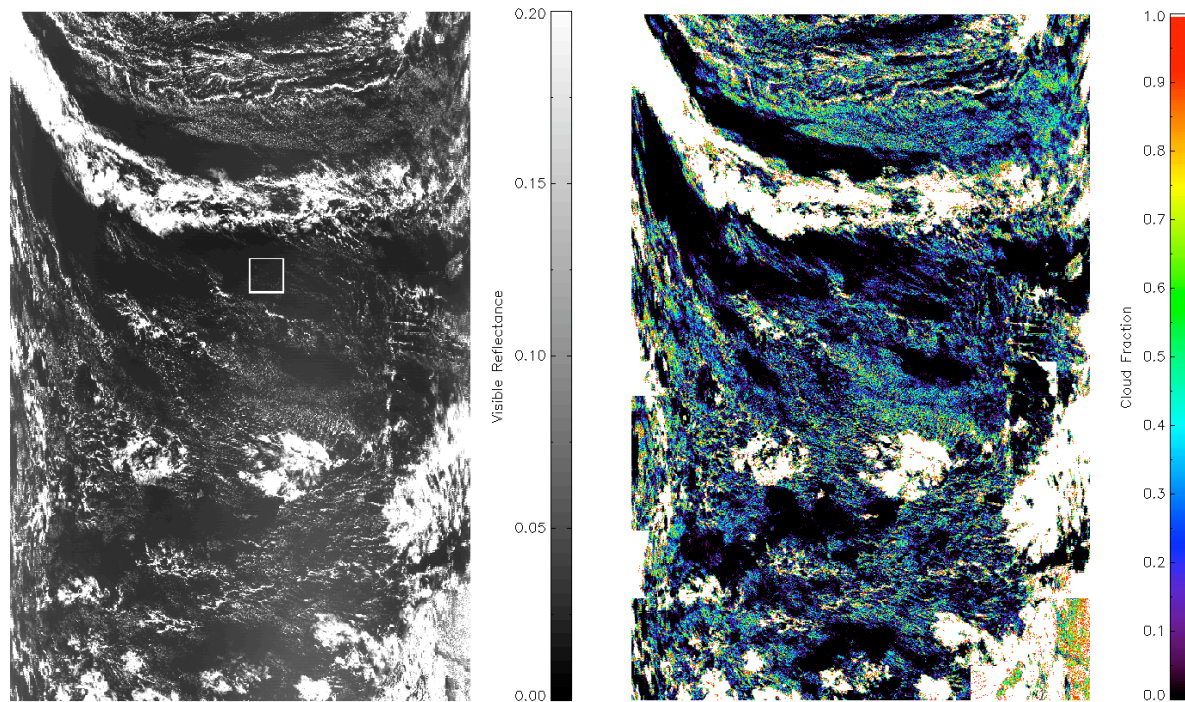
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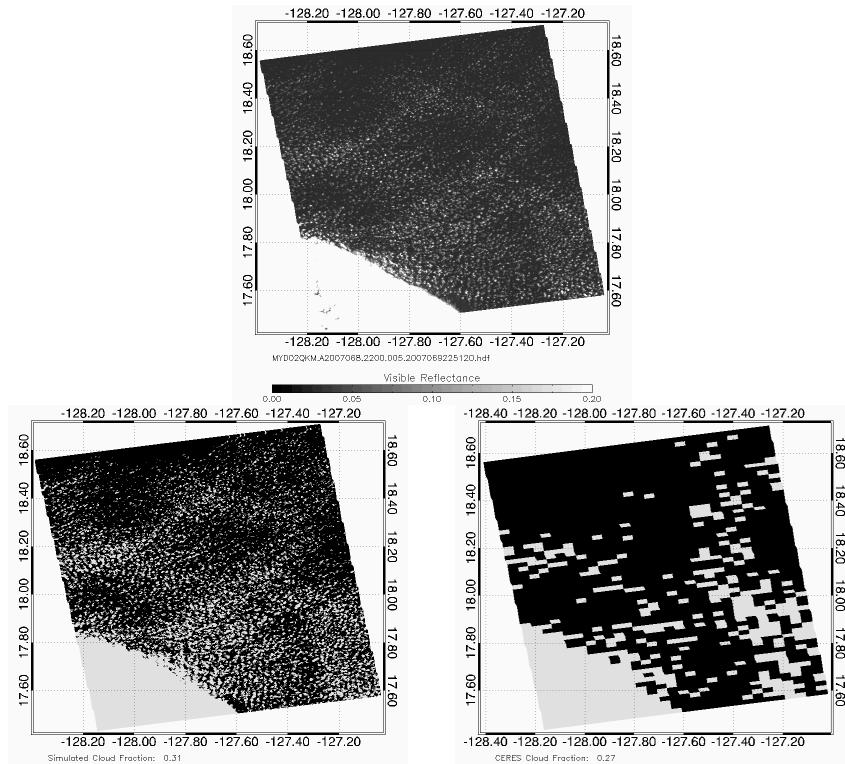
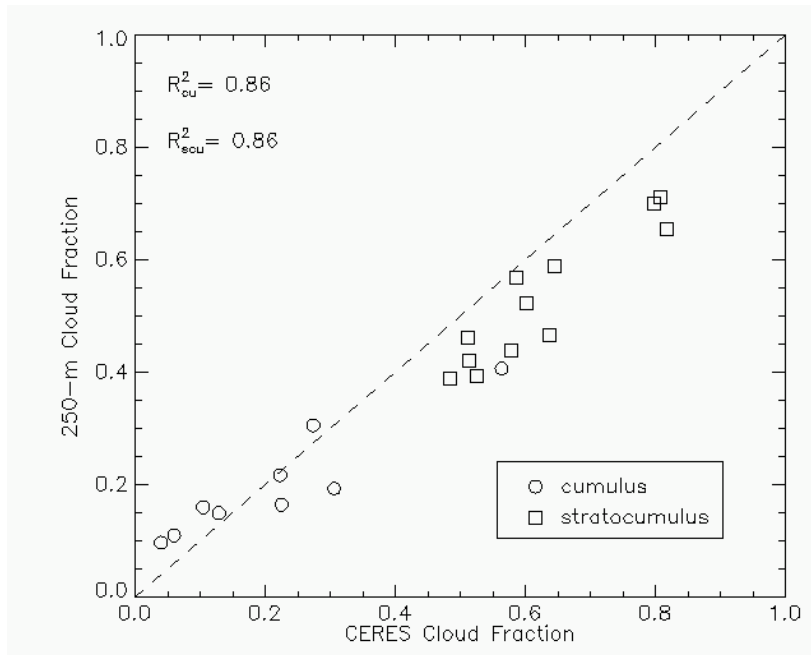
250-m cloud mask

- Good overall performance over ocean surfaces
 - Trouble areas
 - Over land (use IGBP index)
 - High viewing zenith angles - pixel smearing
 - Thin cirrus - blends in with the underlying surface, but some is detectable



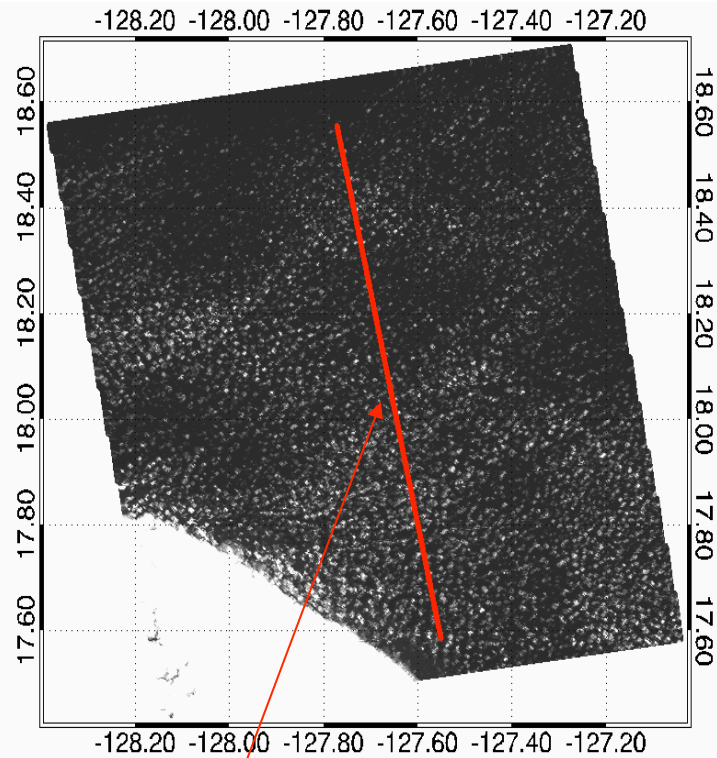
250-m Mask Performance

- Examined 21 cases of Scu and Cu from Jun 2006 - Mar 2007
- Good linear correlation with CERES for both Cu and Scu fields
- CERES generally has higher cloud fraction values, especially for Scu
- Higher CERES cloud fractions expected - CERES has larger FOV
- CERES may underestimate cloud fraction when true fraction is < 0.30



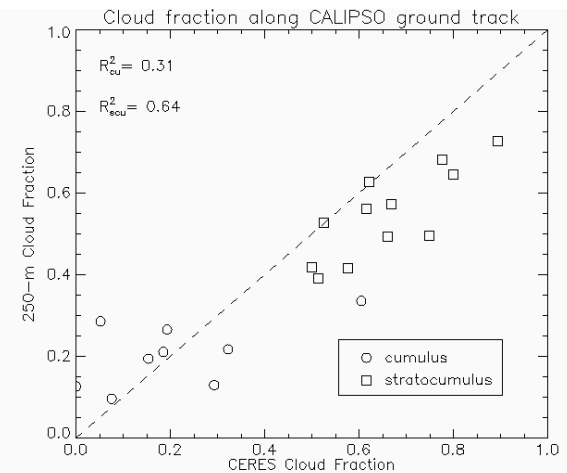
Cloud Fractions

- Examine cloud fractions along CALIPSO track for same 21 cases
- Matched data from CERES, Aqua-MODIS, and CloudSat to CALIPSO track



CALIPSO track

CERES

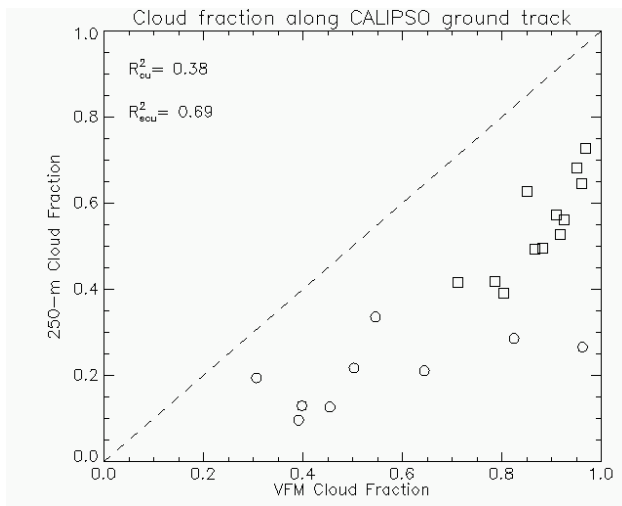


- CERES
 - Scu - fairly good linear correlation; overestimates
 - Cu - more scatter; tends to underestimate for cloud fractions < 0.30
- CloudSat - very few cloud detections at the highest 2 levels of confidence (clouds too low?)

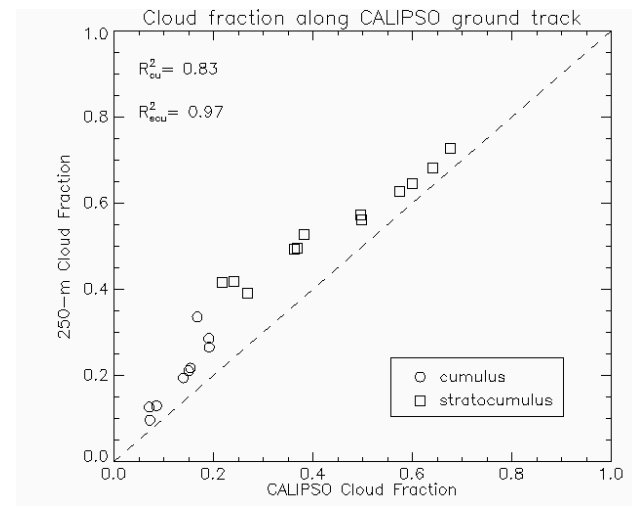


Cloud Fractions

- Examined 2 CALIPSO products
 - Vertical Feature Mask (VFM)
 - Contains cloud/aerosol classifications
 - 30-m vertical resolution from -0.5 - 8.2 km AMSL
 - 333-m Cloud Layer Product
 - Cloud products for up to 5 cloud layers
 - Valid from the surface to 8.2 km



VFM has many more cloud detections, but very good agreement with the CALIPSO cloud products



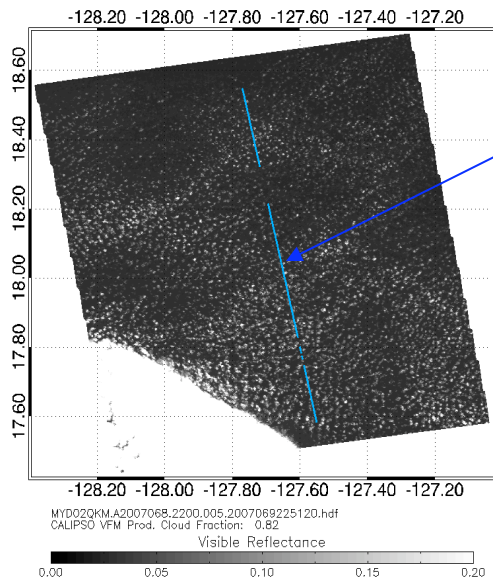
VFM Product

333-m Cloud Product

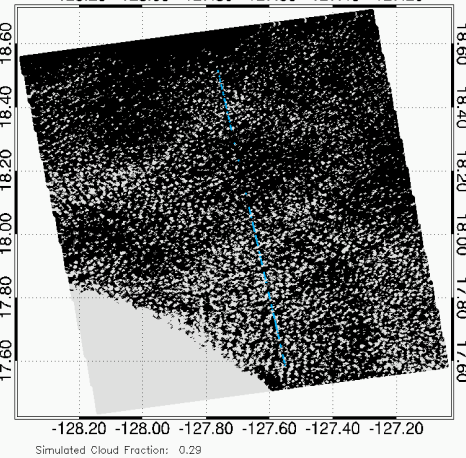
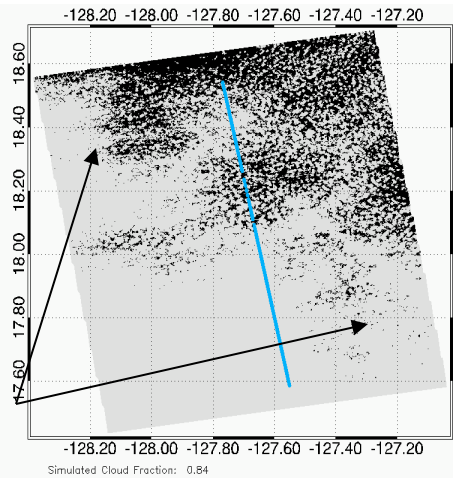
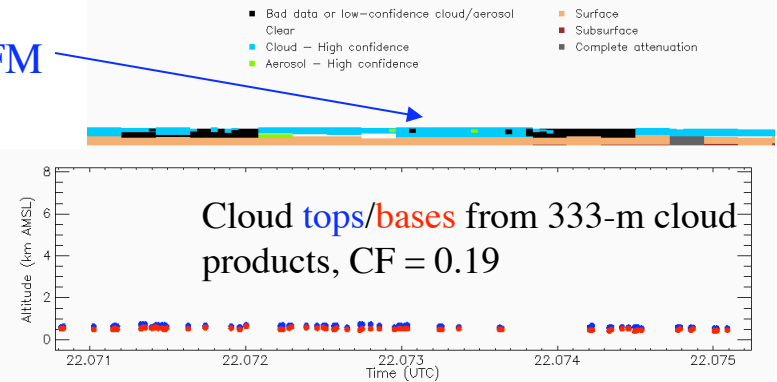


Cloud Fractions

- Relaxed thresholds to match VFM product
- VFM shows solid deck of clouds while satellite images show scattered Cu
- Some cloud detections get averaged out in the Cloud Layers product?



Solid cloud deck in VFM
CF = 0.82



Normal threshold seems to match satellite image, CF = 0.29

Too much cloudiness in areas of scattered cumulus, CF = 0.84, relaxed threshold too low



Summary

- Used 250-m Aqua-MODIS data to determine cloud fraction within each 1-km footprint
 - Based on the derivative of the reflectance frequency distribution
- Generally good agreement with CERES
 - Highly correlated
 - CERES tends to overestimate cloud amount for StCu because its FOV is larger
 - CERES may underestimate cloud fraction for scattered cumulus scenes
 - 250-m MODIS visible reflectance data should help in both cases
- Good agreement with CALIPSO 333-m Cloud Layers product
- CALIPSO VFM finds much more cloudiness than all methods
 - Given large number of water clouds with $\tau < 0.3$, VFM may misclassify haze as clouds
- Future work - examine effects on retrieved cloud properties, especially optical depth and effective size, for cumulus clouds and cloud edges

