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MOD06 (Cloud top height) validation

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Abstract: Cloud top pressures derived in MOD06 collection 4 were transformed into cloud top heights (CTH) using the ECMWF operational analysis profiles and compared against MISR stereo heights, radar cloud top heights from ARM SGP and Chilbolton CFARR and SIRTA lidar cloud top heights. MODIS CTHs are derived with two alternative methods: CO_2-slicing technique for clouds above ≈3km and 11µm brightness temperature if clouds are below 3km. The SGP site is in Oklahoma (36.6°N-97.5°W), CFARR (UK) is at 51.2°N-1.4°W and SIRTA is situated near Paris at 48.7°N-2.2°E. SGP radar is a 35GHz Millimeter cloud radar, CFARR possesses a 94GHz MMCR and SIRTA uses a 532nm lidar to derive cloud boundaries and when possible cloud optical depth less than 0.3. Finally, some preliminary results are shown for comparison between MODIS and ICESAT-GLAS laser cloud top heights.

Comparison between MODIS, radar and MISR cloud top heights at SGP and CFARR

- March 2000 to September 2003

When cloudy+no broken clouds+MISR overpass available+instruments fully functioning:

- 75 cases selected at SGP

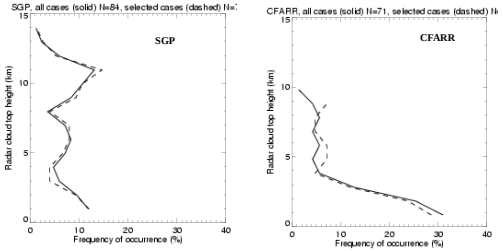
- 42 cases at CFARR due to interruption in radar from March 2002 to April 2003 + loss in sensitivity in 2001-2002

Method

CTH MODIS & MISR: median calculated in a latitude-longitude box of size ±0.2° centred on SGP and CFARR

CTH radar: median CTH calculated over 600s at SGP and 4800s at CFARR centred on MODIS start time

Cases selected to remove heterogeneous scenes according to:
- Max radar CTH-median CTH < 3km
- Standard deviation radar CTH < 2km
- radar cloud fraction > 0.1

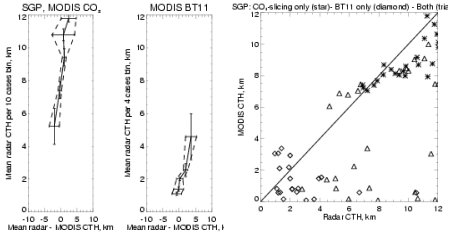


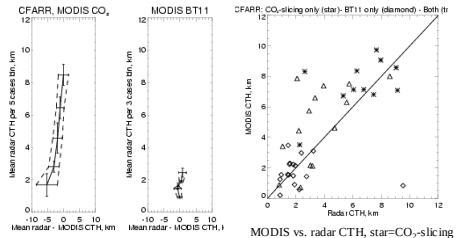
Radar CTH frequency of occurrence over entire 2000-2003 period, all cases (solid), cases within thresholds (dashed)

Clouds at SGP vs CFARR

SGP: high clouds more frequent than mid-level or low clouds, optically thin clouds frequent. 89% of cases remain after thresholds

CFARR: low clouds more frequent than mid or high level clouds, overlap more frequent and broken high clouds also. 59% of cases remain after thresholds





Mean difference Radar-MODIS CTH as a function of radar CTH and method

MODIS vs. radar CTH, star=CO_2-slicing only, diamond=BT11 only, triangle= both in box

Results for MODIS

SGP: CO_2-slicing gives 83.4% of cases with Radar-MODIS CTH=0.47±1.25km; BT11 gives 81% of cases with 0.4 ±1.5km

Problem: clutter in radar data for low clouds

CFARR: CO_2-slicing gives 68% of cases with Radar-MODIS CTH=-0.87±1.26km; BT11 gives 94% of cases with -0.04 ±0.9km

Problem: radar attenuated in 2001-2002, affects high clouds and multi-layer situations

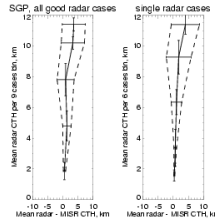
Discussion

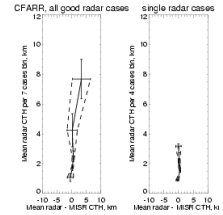
SGP: best for high clouds
MODIS in good agreement with CO_2-slicing, low bias
MISR in good agreement when low and/or single/thick level clouds

CFARR: best for low clouds, too many cloud layers when high clouds present
MODIS shows high bias for CO_2-slicing
MISR shows very small bias

CFARR best for low clouds and SGP for high and thin clouds

Clouds with optical depth < 5 at SGP:
- MODIS CTH within cloud extent, low bias of 1.34km and standard deviation of 0.98km with CO_2-slicing
- MISR CTH agrees depending on scene homogeneity more than optical depth





Radar – MISR CTH against Radar CTH for all cases (left) and single cloud cases (right): MISR performs best for low clouds and in particular single level clouds

Comparison between MODIS and SIRTA lidar (LNA) cloud top heights

Method

- CTH MISR: median calculated in a latitude-longitude box of size ±0.2° centred on SIRTA, compared with CTH LNA calculated for 40minutes centred on TERRA overpass time.
- CTH MODIS: median calculated in a latitude-longitude box of size ±0.1° centred on SIRTA, compared with CTH LNA calculated for 20minutes centred on TERRA overpass time
- Optical depth LNA: average calculated over 40 minutes
- Optical depth MODIS: median calculated in ±0.1° box

Discussion

- October, 10 2002: high thin cloud, good agreement between MISR, MODIS and LNA, optical depth of 0.5.

-May, 13 2003: 2 cloud layers, MISR CTH in between, MODIS CTH below lowest layer, optical depth 0.6 for lNA and 0.5 for MODIS.

- September, 9 2003: high thin cloud with some scattered low, MISR only detects low clouds, MODIS in good agreement with LNA when only CO_2-slicing used.

Conclusion

MODIS CTH:
- Problems when cloud too thin (optical depth less than 0.2) or if clouds are low.

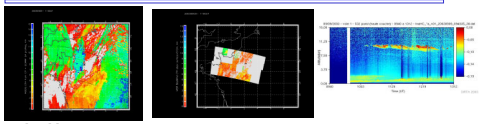
- OK if optical depth at least 0.5

MISR CTH:
- problems when more than one cloud layer

-OK for single level clouds, no clear sensitivity to optical depth

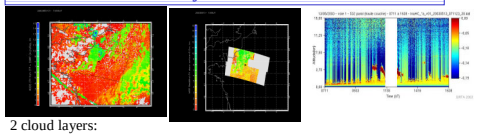
References:
www.cloudmap.org
Naud C., M. Haeffelin, J.P. Muller, Y. Morille and A. Delaval, Assessment of MISR and MODIS cloud top heights through inter-comparison with a back-scattering lidar at SIRTA,*Geophys. Res. Lett.*, 31(4), L04114, 2004.

September, 9 2003



2 cloud layers:
- LNA low cloud: CBH=1.3km, CTH=1.4km, high cloud: CBH=9.7km, CTH=10.3km, τ=0.2±0.2
MISR CTH=1.1km, MODIS CTH=10.3km, τ=0.1±0.0

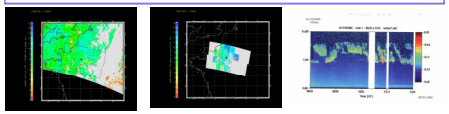
May, 13 2003



2 cloud layers:

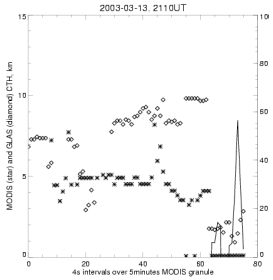
LNA low cloud: CBH=1.4km, CTH=2.2km,
mid-level cloud: CBH=3.7km, CTH=4.6km, τ=0.6±0.7
MISR CTH=3.2km, MODIS CTH=0.9km, τ=0.5±0.6

October, 10 2002

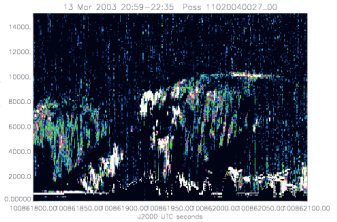


High single cloud: LNA CBH=9.1km, CTH=12.2km, τ=0.5±0.4
MISR CTH=11.1km, MODIS CTH=10.4km, τ =0.2 ±0.1

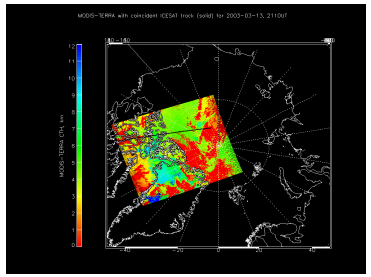
Comparison between MODIS and ICESAT-GLAS cloud top heights (first results)



CTH retrieved with MODIS (star) and ICESAT-GLAS (diamond) for 2003-03-13, 21:10UT with MODIS optical depth (solid) on the right axis. The first part of the coincidence is dark, so no retrieval of optical depth available.



Normalised 1064nm lidar signal measured by GLAS laser on 2003-03-13, between 2110UT and 2115UT



MODIS cloud top height at the time of the coincidence with ICESAT (black line).

Only one coincidence found so far between TERRA and ICESAT due to problems with coincidence search engine (http://ghrc.msfc.nasa.gov/orbit-cgi-bin/execute?orbit+concur) on 2003-03-13, 21:10UT. MODIS CTH lower than GLAS CTH, but seems to be within cloud extent, as seen before, often the case for thin clouds.

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