NATURAL ENVIRONMENT RESEARCH COUNCIL

DEPARTMENT OF GEOMATIC ENGINEERING

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New York, N.Y.

MODIS and SEVIRI Cloud top height assessment with GLAS

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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. Coincidences with the ICESAT platform of TERRA and AQUA were found when the laser GLAS instrument was functioning. Version 19 of GLAS optical depth data was available for the period between September 25th and November 18th 2003. Comparisons between MODIS and GLAS cloud-top heights were performed for 16 AQUA granules and 15 TERRA 5-minute granules for this period, mainly over the polar regions. Also, a similar comparison was performed between SEVIRI SAFNWC and GLAS cloud top heights. For low thick clouds MODIS and SEVIRI overestimate whilst for high thin clouds, MODIS and SEVIRI underestimate the CTH.

ICESAT-GLAS data and method

- Laser pulses at 1064 and 532nm, 70m footprint every 170 m, globally. Problems with laser 1 meant that data was only available for limited periods:
- First period: 12-20 March 2003 with laser 1
- Second period: 09/25-11/18 2003 with laser 2a
- latest version of processing algorithm (v19) released in March 2005 included cloud top and base height for up to 10 cloud layers and optical depth in product GLA11. Not attenuated by clouds with optical depth less than 2-3. So optical depth only available when optical depth less than 3. Only includes second period.
- All products distributed by NSIDC-DAAC.

Method

Coincidences between ICESAT and TERRA/AQUA found thanks to GHRC search engine available at: http://ghrc.msfc.nasa.gov/orbit-cgi-bin/execute?orbit+concur

Period Fall 2003: 16 (5 cloudy) AQUA granules and 15 (11 cloudy) TERRA granules **mainly over Polar regions**

GLAS CTH and optical depth selected over MODIS 5 minute granules then distance in latitude and longitude between GLAS footprint at each time step and MODIS nearest pixel calculated. Comparison performed if distance less than 1°with a maximum of a 5 minute delay.

MODIS CTP transformed into CTH using profiles from ECMWF OP dataset, then compared with GLAS nearest CTH on a granule by granule basis as well as for all pixels over entire period

Comparison between MODIS and GLAS CTH: results

- Large discrepancies in cloud detection over polar regions, especially at night, in agreement with Mahesh et al (2004)

- Differences in CTH similar whether MODIS on TERRA or AQUA, mainly depends on type of cloud

- Low clouds detected higher with MODIS than GLAS
- High clouds detected lower with MODIS than GLAS

-Thick or opaque clouds (τ>3) usually below 5km, and detected at higher altitude with MODIS

-Thin or semi-transparent clouds (τ<3) usually above 5km and detected at lower altitude with MODIS

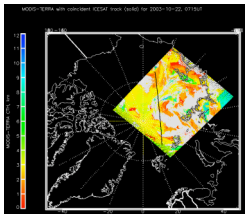
Relationship with optical depth

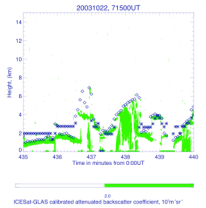
-no clear relationship between differences in CTH and optical depth when all pixels considered, large scatter; pyramidal shape indicates larger differences as optical depth decreases.

- ordering all pixels according to GLAS CTH, and evaluating the mean CTH in bins with an equal number of pixels, we find that the difference increases with increasing GLAS CTH, with low clouds at higher altitude for MODIS and higher clouds at lower altitude with MODIS.
- ordering all pixels according to GLAS optical depth, and evaluating the corresponding mean optical depth and mean difference in bins of equal number of pixels, we find that the difference increases with decreasing optical depth.
- same conclusion whether only one thin cloud layer is present or multiple cloud layers are present, with a tendency for MODIS to miss cloud layers with an optical depth less than 0.1.

Mean & std GLAS-MODIS CTH (km)	Distance 1°	Distance 0.1°
Thick clouds	**-0.3±1.46km**	**-0.22±1.48km**
Thin clouds (all)	**2.22±2.25km**	**2.19±2.26km**
Thin clouds (single layers)	**1.09±2.15km** **τ=0.6 ±0.54**	**0.89 ±2.21km** **τ=0.7 ±0.55**

Example of comparison between MODIS-TERRA and GLAS for 2003-10-22





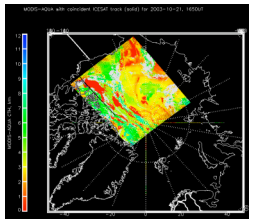
ICESat-GLAS 1064nm lidar calibrated attenuated backscatter coefficient ($10^6 m^{-1} sr^{-1}$) with MODIS (stars) and GLA (diamonds) CTH

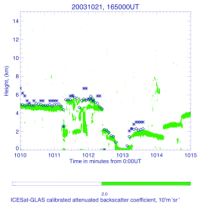
Results

225 pixels: diff=0.25 ±1.34 km
45 thin clouds: diff=1.91 ±1.52km
GLAS=4.35 ±1.56km
MODIS=2.44 ±0.87km
τ=0.1 ±0.1

180 thick clouds: diff=-0.17 ±0.91km
GLAS=2.33 ±1.15km
MODIS=2.50 ±0.70km

Example of comparison between MODIS-AQUA and GLAS for 2003-10-21





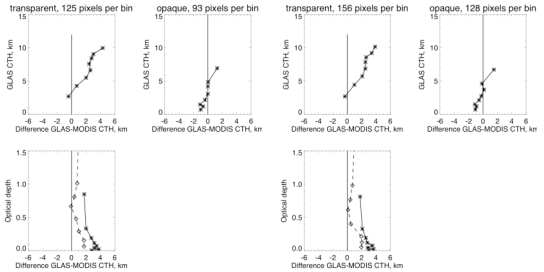
ICESat-GLAS 1064nm lidar calibrated attenuated backscatter coefficient ($10^6 m^{-1} sr^{-1}$) with MODIS (stars) and GLA (diamonds) CTH

Results

118 pixels: diff= -0.39 ±1.15 km
13 thin clouds: diff=1.39 ±1.51 km
GLAS=6.61 ±1.44 km
MODIS=5.22 ±1.61km
τ=0.1 ±0.3

105 thick clouds: diff=-0.61 ±0.88km
GLAS=4.12 ±1.47km
MODIS=4.73 ±1.63km

All pixels found over 09/25-11/18 2003 period



Distance in latitude-longitude less than 0.1°

Top left: Thin clouds distributed in 8 GLAS CTH bins of 125 pixels each
top right: thick clouds distributed in 8 GLAS CTH bins of 93 pixels each
bottom left: single (dashed) and multilayer (solid) cloud pixels in 8 GLAS optical depth bins

Distance in latitude-longitude less than 1°

Top left: Thin clouds distributed in 8 GLAS CTH bins of 156 pixels each
top right: thick clouds distributed in 8 GLAS CTH bins of 128 pixels each
bottom left: single (dashed) and multilayer (solid) cloud pixels in 8 GLAS optical depth bins

Comparison between SEVIRI and GLAS CTH

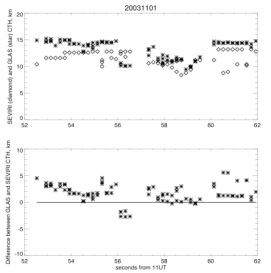
SEVIRI= imager onboard Meteosat Second Generation, Geostationary, CTH retrieved at Lannion SAF-NWC and provided by KNMI. Files only available for 11:00UT, scan takes 12minutes. 6 coincidences with GLAS for Fall 2003. Thermal channels used, and in particular 11µm BT for low and thick clouds like for MODIS.

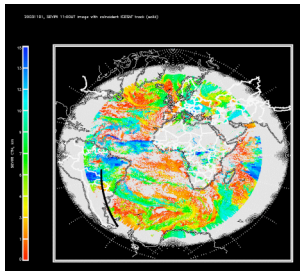
Comparison:
- Thin clouds: 304 pixels over all cases, diff=1.50 ±1.84km
- Thick clouds: 125 pixels, diff=-0.37 ±2.12km

High and thin clouds CTH underestimated with SEVIRI

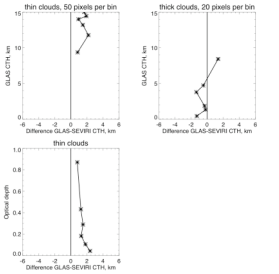
Low and thick clouds CTH overestimated with SEVIRI

Example of comparison between SEVIRI and GLAS for 2003-11-01





All pixels found over 09/25-11/18 2003 period



Top left: GLAS CTH versus difference GLAS-SEVIRI CTH for 8 bins containing 50 thin cloud pixels

Top right: GLAS CTH versus difference GLAS-SEVIRI CTH for 8 bins containing 20 thick cloud pixels

Bottom left: GLAS optical depth versus difference GLAS-SEVIRI CTH for 8 bins with 50 thin cloud pixels.

Discussion

Thick clouds CTH overestimated for very low clouds and clouds at 4km. Lowest cloud often occur in areas with sudden changes in CTH, differences probably due to low resolution for SEVIRI.

Thin clouds CTH underestimated, greater differences for optical depth less than 0.4, and probably limit in accuracy for optical depth less than 0.1.

Conclusion

Very similar results for both MODIS and SEVIRI CTH despite different retrieval techniques (for high-level clouds) and instruments:
- Thick clouds CTH slightly overestimated with MODIS or SEVIRI (inherent to 11µm brightness temperature) by 0.3-0.4km

-If optical depth greater than 0.5, layer detected and difference within 2km, if optical depth less than 0.2, more chances that cloud layer will be missed. Differences larger than theoretical CO_2 slicing accuracies for CTP (50hPa)

- Problems over Polar regions for MODIS cloud mask. However if cloud mask OK then MODIS CTH OK.

- SEVIRI CTH may be slightly more accurate for thin high clouds.

Acknowledgements: the authors are particularly grateful to NSIDC for their very efficient helpdesk.

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