



Comparison of Cloud Heights from MODIS, GOES and the ER-2 CPL During TC4



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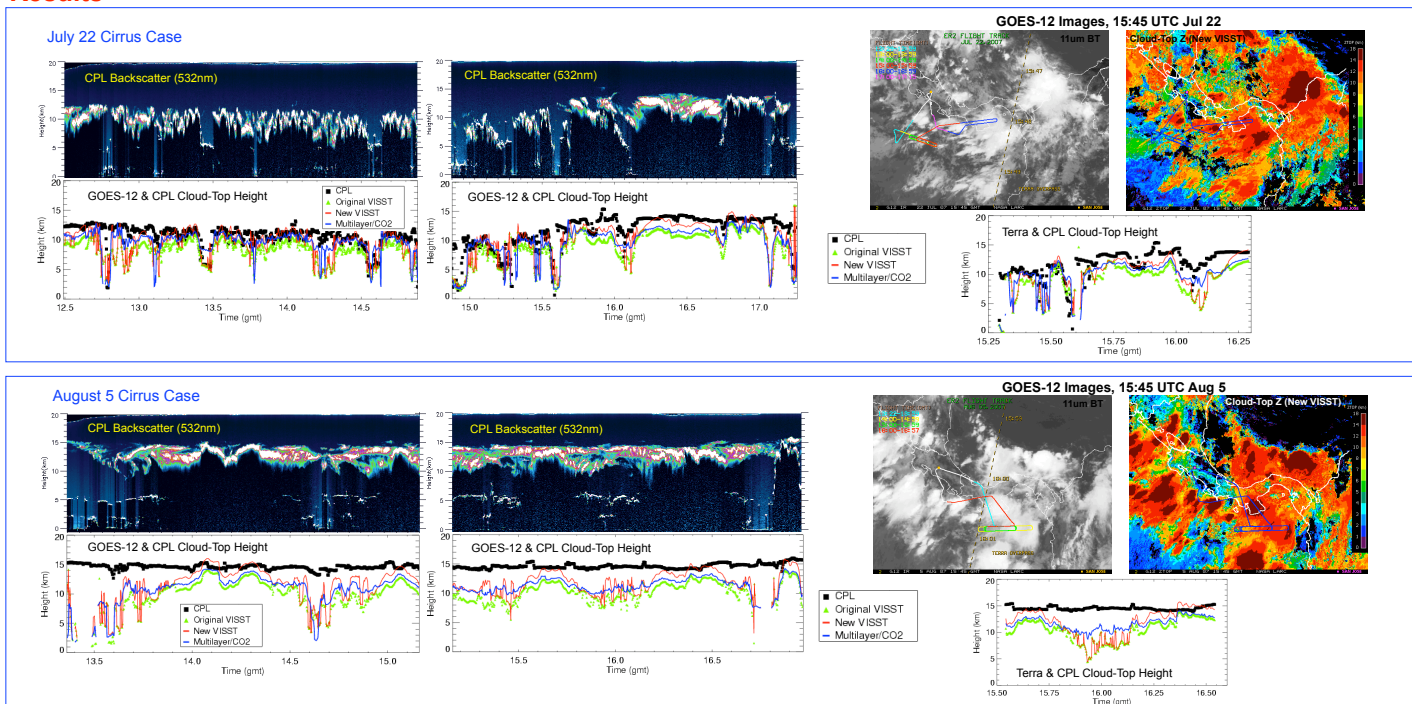
Introduction

Retrieval of accurate cloud-top height (Z_{top}) from passive satellite imagers remains elusive because of uncertainties in cloud optical properties, cloud layering, and model temperature profiles. In this study, Z_{top} determined using satellite multispectral and multilayer techniques is compared to cloud lidar returns from the Cloud Physics Lidar (CPL), which flew on the ER-2 aircraft during TC4. The results will be used to quantify errors in the satellite retrievals and provide a basis for improving them.

Data and Methodology

- GOES-12: 4 km res pixels used. Terra MODIS: 2 km res pixels used.
- NASA-Langley VISST used to retrieve Z_{top}. See Minnis et al. (1995, 2003) for details.
- Original VISST run operationally during TC4.
- New VISST has the following major updates:
 - (1) CO₂/13.3um channel results used for thin ice clouds, (2) optically thick ice cloud Z_{top} increase based on Calipso & CPL comparisons, (3) adjusted model T profile in low levels based on lapse rates.
- Distance-weighted mean of nearest 4 satellite pixels centered on ER-2 position used for matching with CPL data. Nearest 9 pixels used to get satellite spatial standard deviation (σ).
- For comparing with GOES-12 & Terra, CPL data averaged to 2 km along ER-2 track.

Results



Statistics for 4 flight days:

CPL & GOES-12 Mean Cloud-Top Height and RMS Error (km)

Flight Day	Primary Cloud Type	CPL	GOES-12 Orig VISST	GOES-12 New VISST	GOES-12 Multilayer/CO2	N
Jul 22	Cirrus	11.6 Z _{top} >6	8.8 ± 3.3	10.1 ± 2.7	10.0 ± 2.5	1603
Jul 29	Stratus	1.6 Z _{top} >6	1.4 ± 0.9	2.0 ± 1.1	1.9 ± 0.9	985
Aug 5	Cirrus	14.6 Z _{top} >6	10.0 ± 5.1	11.6 ± 4.0	11.1 ± 4.1	1246
Aug 8	Cirrus	13.9 Z _{top} >6	9.7 ± 5.0	10.9 ± 4.2	10.8 ± 3.8	1776

* Z_{top} indicates CPL restriction used for the comparisons
 * Comparisons done for satellite Z_{top} spatial $\sigma < 3$ km

CPL & Terra Mean Cloud-Top Height and RMS Error (km)

Flight Day	Primary Cloud Type	CPL	Terra Orig VISST	Terra New VISST	Terra Multilayer/CO2	N
Jul 22	Cirrus	12.1 Z _{top} >6	9.2 ± 3.6	10.1 ± 3.1	10.2 ± 2.8	335
Jul 29	Stratus	0.8 Z _{top} >6	0.9 ± 0.3	1.9 ± 1.1	1.8 ± 1.1	257
Aug 5	Cirrus	14.5 Z _{top} >6	10.5 ± 4.6	11.8 ± 3.9	11.7 ± 3.1	360
Aug 8	Cirrus	14.8 Z _{top} >6	11.3 ± 4.5	12.2 ± 4.0	12.3 ± 3.3	350

Summary & References

- Compared to CPL, VISST and CO₂ Z_{top} showed an improvement (increase) of 1-1.5 km compared to the original algorithm run during TC4. RMS Errors reduced by 0.5-1.5 km using new algorithms.
- New VISST and multilayer algorithms somewhat overestimated stratus cloud Z_{top} on July 29 off the west coast of South America; likely due to sounding/lapse rate used.
- Cases when satellite Z_{top} appreciably underestimated CPL Z_{top} were those having weak lidar backscatter returns.
- The new VISST algorithm, which incorporates the CO₂ method, performed best for cirrus clouds.
- Current VISST algorithm Z_{top} agrees with CPL to within 1.5-3.0 km for cirrus clouds occurring with tropical convection. Discrepancy reduces if discounting thinnest CPL clouds occurring above main cirrus cloud deck.

Minnis, P., et al., 1995: Cloud Optical Property Retrieval (Subsystem 4.3). In *Clouds and the Earth's Radiant Energy System (CERES) Algorithm Theoretical Basis Document, Vol. III: Cloud Analyses and Radiance Inversions (Subsystem 4)*, NASA RP 1376 Vol. 3, edited by CERES Science Team, pp. 135-176.

Minnis, P., D. F. Young, S. Sun-Mack, P. W. Heck, D. R. Doelling, and Q. Z. Trepte, 2003: CERES cloud property retrievals from imagers on TRMM, Terra, and Aqua. *SPIE 10th Intl. Symp. Remote Sens., Conf. on Remote Sens. Clouds and Atmos.*, Barcelona, Spain, September 8-12, 37-48.

- * To obtain satellite cloud property data and information for TC4, please see our web page: <http://angler.larc.nasa.gov/tc4>
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