

CLOUDS AS DETECTED BY GLAS, AND METHODS FOR COMPARISON WITH ECMWF MODEL-GENERATED CLOUDS

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INTRODUCTION:

The Geoscience Laser Altimeter System (GLAS) orbits the earth onboard the Ice, Cloud and Land Elevation Satellite (ICESat). ICESat travels at ~7 km/s ground speed in a near-polar orbit. GLAS emits laser pulses at a 40Hz rate, resulting in a backscatter cross section of the atmosphere with vertical resolution of 76.8 m, and a distance between laser footprints of 175 m. Peaks in the laser's backscatter profile mark the boundary layer top, clouds and elevated aerosol layers. Averaging several backscatter profiles together increases the signal-to-noise ratio and improves cloud and aerosol layer detection, but at the expense of horizontal resolution. The laser's signal may become fully attenuated in optically thick clouds (such as boundary layer clouds and deep convective clouds), yet it easily penetrates optically thin clouds, like cirrus.

STRATEGY:

Many interesting features can be found in the GLAS data. Two examples are shown in the blue boxes at the bottom of this poster. We concentrate here on the value of these new data for comparison with model-generated clouds (green boxes).

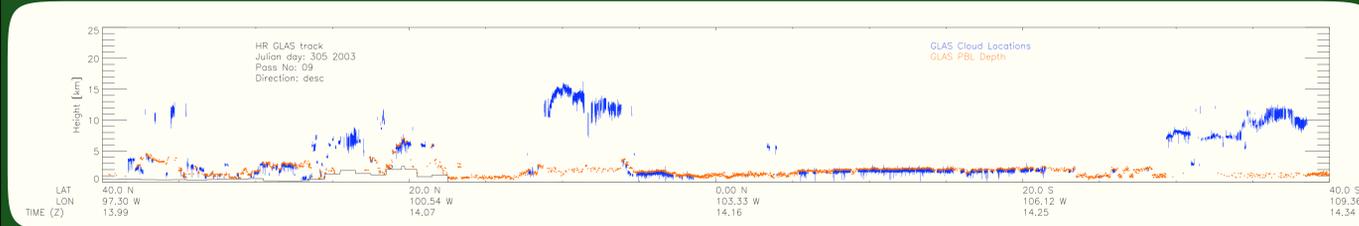
While GLAS can accurately detect the spatial dimensions and location of clouds in a 2D cross section of the atmosphere, it provides little information on the optical and microphysical properties of the observed clouds. The ECMWF model, on the other hand, generates clouds through use of cloud parameterizations, and the modeled cloud in a 3D grid box is characterized by e.g. cloud fraction, cloud liquid water and ice content.

In order to compare the GLAS-observed clouds with ECMWF model-generated clouds, the information provided by each of these systems must be brought to a common denominator. Classifying the observed/ modeled cloud allows not only a comparison of cloud location (as done in previous work by Miller et al., 1999), but also of cloud fraction and type.

OBJECTIVES:

Our goal is the evaluation of the ECMWF model clouds through comparison with the GLAS-observed clouds. Incorporating cloud type in the comparison allows assessment of each individual cloud parameterization scheme.

Determining cloud type from GLAS data

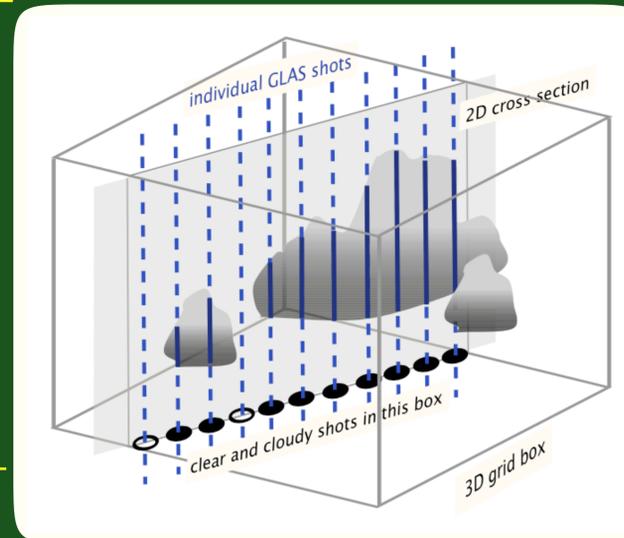
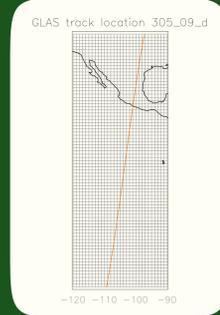


1. Co-locate the GLAS track in time and space with model data
2. Divide the 2D GLAS cross section into along-track - height boxes corresponding to the 3D model grid

3. Extract features associated with observed clouds in the 2D cross section. Features describing the clouds are e.g.:

- Average top height of clouds.
- Average cloud base height.
- The fraction of cloudy to clear shots.
- "Granularity": For a given cloud fraction, are the cloudy shots interspersed by clear shots (multiple small clouds) or all grouped together (one large cloud)?
- Optical depth of cloud, if cloud is thin (e.g. cirrus).

Combined, these features form a vector that uniquely describes the observed cloud.



4. Classify the GLAS clouds in the 2D box according to their features. The combination of features describing the cloud serves to identify the cloud type. We expect the feature vectors describing clouds of the same type to cluster in feature space.

FUTURE WORK:

Currently, lidar-in-space data are available for ~2 months only, precluding seasonal studies. In the future, CALIPSO, as part of the Earth Observing System's A-train will hopefully provide data for a longer time span. Orbiting in the A-train, the lidar data from CALIPSO will be complemented by near-synchronous measurements from the other satellites, adding information about the optical and microphysical properties of the observed clouds.

REFERENCES:

Miller, S.D., G.L. Stephens and A.C.M. Beljaars, 1999: A Validation Survey of the ECMWF Prognostic Cloud Scheme using LITE. *Geophys. Res. Lett.*, 26, 1417-1420.

Zwally, H.J., R. Schutz, S. Palm, W. Hart, S. Hlavka, J. Spinirne, and E. Welton. 2005. GLAS/ICESat L2 Global Planetary Boundary Layer & Elevated Aerosol Layer Heights V019 and GLAS/ICESat L2 Global Cloud Heights for Multilayer Clouds V019, 26 September to 18 November 2003. Boulder, CO: National Snow and Ice Data Center. Digital media.

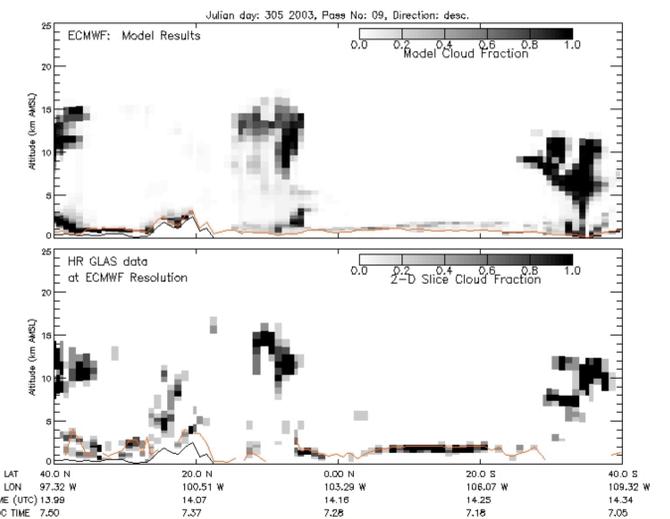
Determining cloud type from ECMWF model data

1. Co-locate the GLAS track in time and space with model data, and consider only those 3D grid boxes transected by the GLAS cross section.
2. The model provides information about
 - The PBL type and cloud parameterization used in a given model column, such as
 - cloudy ("stratocumulus") or clear PBL
 - shallow, mid-level or deep convection.
 - The base and top level of the modeled cloud.
 - The cloud fraction.
 - Cloud liquid water and ice content.

The combination of these features determines the model cloud type.

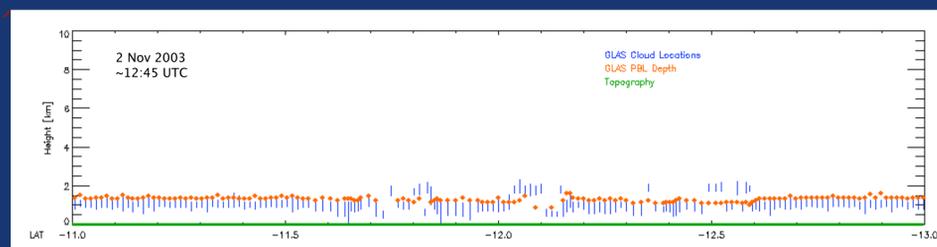
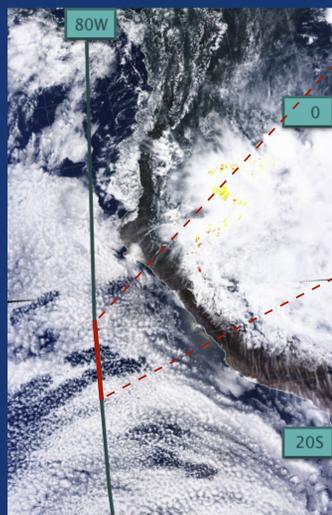
COMPARISON:

Here, the ECMWF cloud fraction (3D) and PBL depth (red line) are compared to the cloud fraction (2D) and PBL depth observed by GLAS.



ACKNOWLEDGMENTS:

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GLAS captures the stratocumulus cloud deck off the South American coast very well. It even detects the pocket of open cells (POC, see e.g. Stevens et al. 2005) around 12S (above). The extent of the disturbance is smaller in the GLAS data compared to the view from MODIS (left). However, the MODIS picture was taken approximately 2 hours after the GLAS overpass, and the disturbance might have grown during that time.

Stevens, B., G. Vali, K. Comstock, R. Wood, M. C. van Zanten, P. H. Austin, C. S. Bretherton, and D. H. Lenschow, 2005: Pockets of open cells (POCs) and drizzle in marine stratocumulus. *Bull. Amer. Meteor. Soc.*, 86, 51-57. The MODIS images were provided by the MODIS Atmosphere Image Browser (<http://modis-atmos.gsfc.nasa.gov/index.html>)

The boundary layer (PBL) top is frequently marked by a large gradient in aerosol concentration. Unless the lidar signal is attenuated on its way to the surface, GLAS can detect the PBL top. If optically thick PBL clouds exist (e.g., Sc), the PBL top is assigned at the cloud top. The figure shows an average of all successful PBL retrievals from October 2003. In the stratocumulus regime, almost all retrievals are successful, in the deep convective regions only about 20%. Our confidence is higher where more successful retrievals are averaged together, i.e. in the East Pacific.

