Improvements in Characterizing ARM Cloud and Radiation Fields Using Satellite Data

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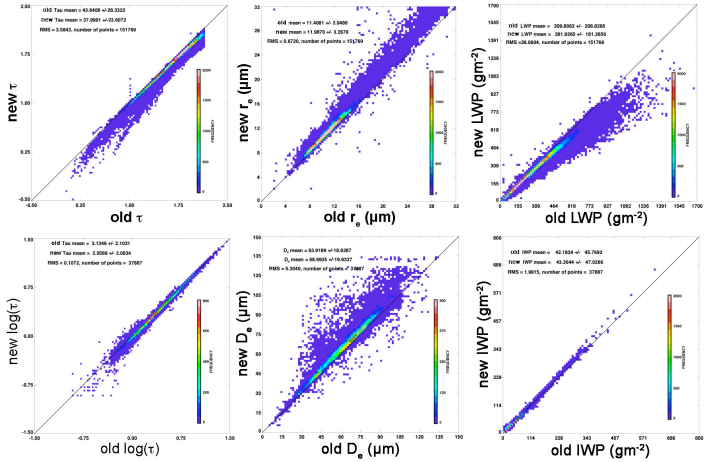
http://www-angler.larc.nasa.gov/satimage/products.html

Introduction

Cloud and radiation properties derived from satellite data at NASA Langley Research Center provide an essential component of the ARM ensemble of measurements used for characterizing the radiation budget at a variety of scales. With the availability of ARM instruments in new locations, new value-added products (VAP), and new models of cirrus ice crystals, as well as new satellite data, it is possible to develop improved techniques for retrieving cloud properties. These properties include cloud vertical structure, liquid or ice water path, and optical depth. This paper discusses improvements in the cloud retrievals over the ARM sites and elsewhere.

Improved Daytime Cloud Optical Depths & Water Paths

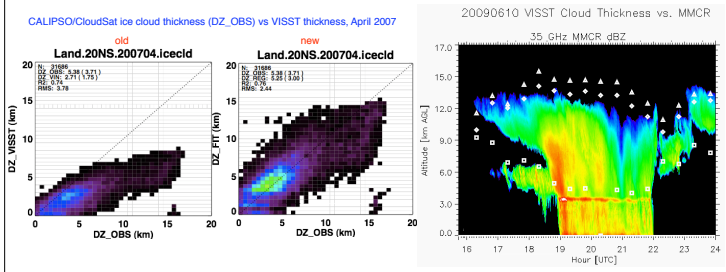
Previous studies indicate that GOES-retrieved cloud optical depths for thin ice clouds are too large and LWP for thick clouds is too large. More accurate parameterizations of 0.65-μm Rayleigh scattering and ozone absorption have reduced the optical depths for all clouds and LWP for thick clouds and resulted in more accurate retrievals of cloud height for thin ice clouds.



Parameterization changes yield smaller optical depths (τ), larger droplet effective radii (r_e), and mostly smaller LWPs for liquid clouds (top row). Ice cloud (bottom row) τ slightly decreased, ice crystal effective diameter D_e increased, and IWP virtually unchanged. Cloud top heights slightly decreased by 0.1 km, on average. Example from GOES-12 over USA, 14 December 2009.

Improved Cloud Thickness

Cloud geometrical thickness is essential for representing cloud 3-D structure. More accurate parameterizations of cloud thickness have been developed as functions of latitude, water path, optical depth, and particle size using matched MODIS, CALIPSO, and CloudSat data. These new parameterizations are being testing for the near-real time retrievals.

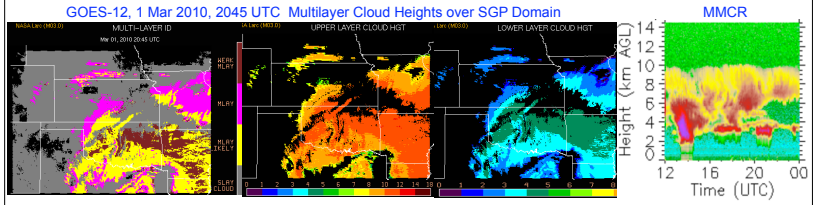


Plot at right shows GOES VISST cloud boundaries plotted over MMCR cloud profile, 10 June 2009, using new parameterization. Triangles indicate cloud physical top, diamonds: cloud radiating height, squares: cloud base.

For deepest cloud, top is near tropopause (15.1 km), radiating heights are above radar tops, bases slightly above melting layer.

Multilayered clouds over the SGP, Europe, & eastern North America

Recent advances in multilayered cloud detection and retrieval using 10.8 and 13.3 μm channels (Chang et al., 2010) are being incorporated into the real time retrievals for GOES-12 and Meteosat-8/9. These new techniques provide better 3-D characterization of large-area cloud fields by providing upper (UL) and lower layer (LL) properties instead of just single-layer (SL) properties from the VISST.

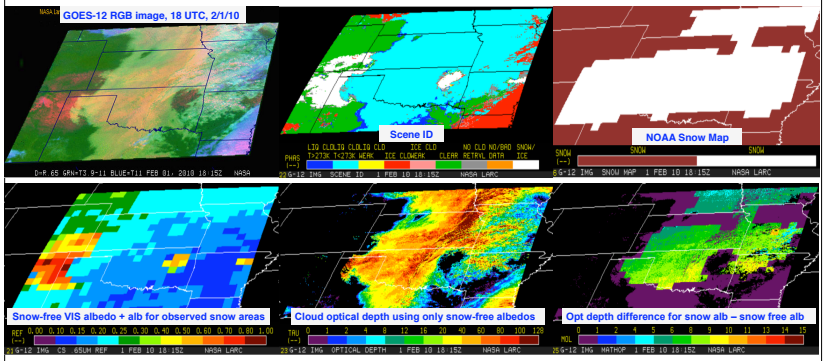


Example above shows 3 levels of multilayer cloud classifications (brown is most likely contiguous thick clouds). Upper and lower-layer cloud heights are in very good agreement with SGP MMCR cloud layer tops.

Chang, F.-L.,et al., 2010: A modified method for inferring cloud top height using GOES-12 imager 10.7- and 13.3-μm data. *J. Geophys. Res.*, **115**, doi:10.1029/2009JD012304

Retrieving Cloud Properties over Snow & Ice

Cloud retrievals using multispectral imager (e.g., MODIS) data can utilize near-infrared channels to estimate cloud optical depths because the snow is strongly absorbing at 1.6 and 2.1 μm. For GEO imagers such as GOES, no such channels are available, necessitating the use of the 0.65 μm (VIS) channel, which is used over darker surfaces. It can be used over snow, if the background reflectance is known fairly well. Time series of observations will be used to establish reasonable VIS albedos over snow surfaces for GOES to improve retrieval accuracy.

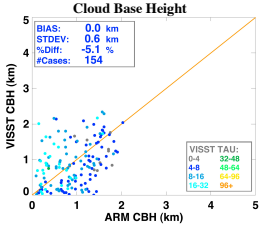


Inclusion of more accurate sfc albedo (here, we used avg of clear snow areas) for snow-covered surfaces realistically decreases the retrieved optical depth and LWP (by 100 gm^{-2} or more). Future VISST will include regional (0.5° or less) based on time series of GOES data. Should greatly improve accuracies of radiation budget & cloud properties over snow.

Summary

- These & other new algorithms have been developed and tested using ARM and other datasets to improve the characterization of the large scale 3-D cloud and radiation fields that only satellite data can provide
- These new techniques are being introduced into operational ARM satellite analyses during 2010
- Improved method development will continue & changes implemented as they are proven

AZORES ARM VS MSG (new thickness)
Cloud Base Height



Cloud base heights improved using new thickness parameterization

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