Evaluation of In-situ and Satellite-derived Cirrus Microphysical Properties During SPARTICUS

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Introduction

Proper characterization of cirrus microphysical properties is important for accurately quantifying the cloud albedo and greenhouse effects in global climate models.

High-altitude cirrus clouds are composed of ice crystals of various sizes and shapes. These properties vary with altitude and different remote sensing techniques yield different cloud properties.

The Small Particles in Cirrus (SPARTICUS) field experiment was conducted to improve our understanding of cirrus microphysical structure and to resolve discrepancies in measured cirrus properties.

Approach

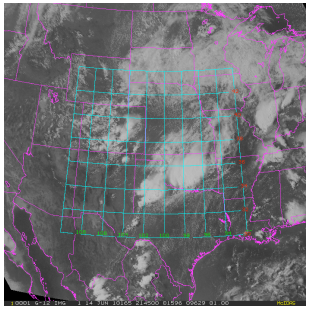
During SPARTICUS, the 2D-Stereo [2D-S, see *Lawson et al.*, (2006)] cloud probe aboard the SPEC Learjet-25 obtained in-situ measurements of cloud particle size, number concentration, and water content.

Cloud physical and microphysical properties were retrieved from the GOES and MODIS imagers over the SPARTICUS domain by the NASA Langley Cloud and Radiation Group using the methods of *Minnis et al.* (2011).

Cloud particle number concentrations from the 2D-S were integrated to obtain effective ice particle diameter D_{eff}. D_{eff} was also retrieved from satellite observations using 2.13-, 3.7-, 11.0-, and 12.0-μm spectral bands. Shorter wavelengths are more sensitive to deeper cloud layers.

Dual-satellite observations were used to estimate cloud-top ice water content (IWC) along the flight track of the Learjet-25 using the method described in *Yost et al.* (2010).

Cloud properties from both satellite and aircraft measurements were binned by the depth of the Learjet-25 below cloud top in order to infer cloud vertical structure.



SPARTICUS domain

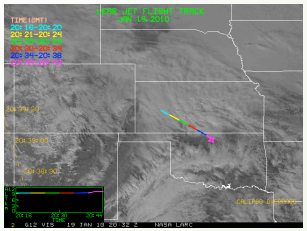
Summary

Cloud ice water content and effective particle size were retrieved from GOES and MODIS radiance measurements and matched in space and time with integrated number concentrations and ice water content, respectively, from the 2D-S cloud probe.

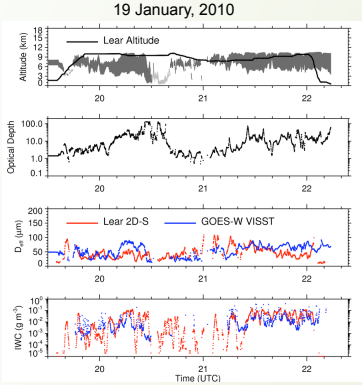
Satellite and cloud properties agree well with in-situ measurements within ~1 km of cloud top in most cases.

Differences between the satellite and in-situ cloud properties are a function of the aircraft's vertical position relative to cloud top. Active remote sensors can reduce errors caused by mischaracterization of cloud top.

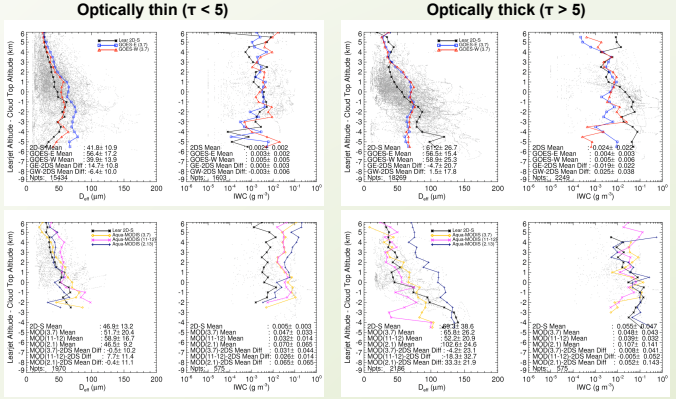
Results



Visible image (above) and time series (below) of GOES-12 and 2D-S cloud properties from 19 January, 2010



Optically thin (τ < 5) **Optically thick (τ > 5)**



The satellite retrievals of D_{eff} and IWC generally follow the same trends as the in-situ measurements (below left). The differences in magnitude are a function of how far below cloud-top the Learjet was (above).

For thin cirrus, the in-situ properties show little variability in the vertical. D_{eff} rarely exceeds 80 μm on average. GOES IWC retrievals agree well with the 2D-S measurements within ~1 km of cloud top.

For optically thick clouds, in-situ IWC and D_{eff} generally increase with decreasing altitude below cloud top. The differences between the in-situ and satellite properties also increase with depth below cloud top, because the passive satellite retrievals are not very sensitive to deep cloud layers.

Errors in retrieved cloud-top height complicate the analysis. Cloud heights from an airborne lidar could help eliminate uncertainties.

References

Lawson, R. P., D. O'Connor, P. Zmarzly, K. Weaver, B. Baker, and Q. Mo (2006), The 2D-S (Stereo) probe: Design and preliminary test of a new airborne, high-speed, high-resolution particle imaging probe, *J. Atmos. Oceanic Tech.*, *23*, 1462-1477.

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2D-S data products are available from ftp://iopshare.archive.arm.gov/

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