Determining Large-Scale 3D Cloud Ice Water Content by Combining Satellite and Surface Measurements in both Mid-Latitudes and the Tropics

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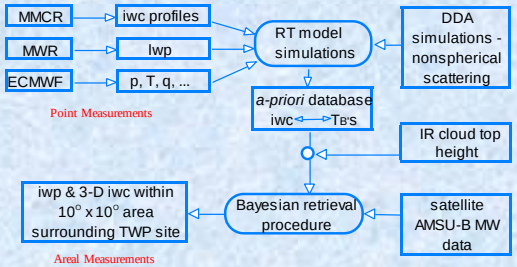
Objectives

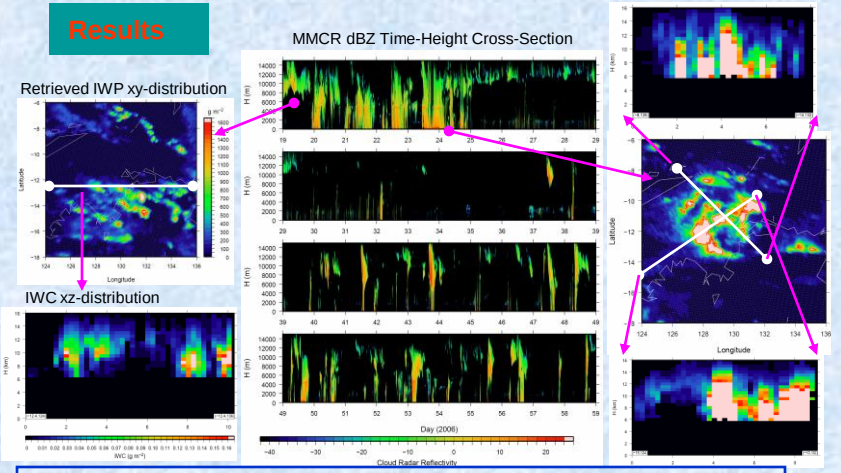
Large-scale distribution of cloud ice water amount (1) is required for deriving cloud water advective tendency as forcing term for single-column models, (2) can be used to validate cloud resolving and global climate models, and (3) is extremely useful for understanding cloud microphysical and precipitation processes. While excellent in quality, surface cloud radar observations provide only single-point measurements; thus unable to be used to derive areal cloud ice distributions. Satellite observations, however, can cover a large area in a very short time period while having limited ability in resolving vertical cloud distributions. In this study, we take the advantages of both satellite and surface cloud radar observations. By combining the two, we derive large-scale 3-D ice water contents in a 10°x10° area surrounding ARM sites. In this poster, we show one-year 3-D ice water retrieval and analysis results (7/1/05 -6/30/06) in a 10°x10° area centered at SGP and TWP-Darwin sites.

Retrieval Algorithm



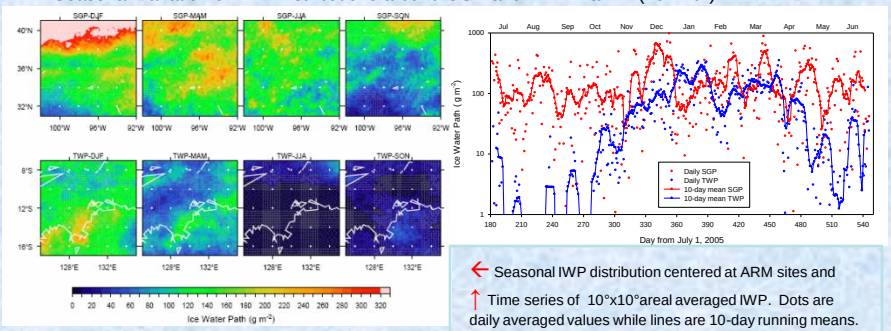
The ice water retrieval algorithm, schematically described in the above diagram, is based on Baye's Theorem. The main satellite data going into the retrieval algorithm are the high-frequency (89, 150, 183±1, 183±3, and 183±7 GHz) microwave data of AMSU-B/MHS, being available on NOAA-15, -16, -17 and -18 satellites. One of the most important components in a Bayesian retrieval algorithm is the *a-priori* database that, in this case, connects satellite brightness temperatures to ice water content (iwc) profiles. The iwc profiles should be realistic and representative of those occurred in the region and season of study. To accomplish this, MMCR radar reflectivity profiles at ARM sites during the same time period when retrievals are to be performed are analyzed. The iwc profiles converted from the radar reflectivity profiles are used as the input of radiative transfer model simulations, together with liquid water path from surface based microwave radiometer and sounding data observed at the ARM sites. Then, the radiative transfer model simulations produce the required *a-priori* database for the Bayesian retrieval. In the radiative transfer model, the single-scattering properties of the ice particles are calculated by using realistic non-spherical ice particle shapes and computed by Discrete Dipole Approximation, which are more accurate than those traditionally computed by assuming spherical ice particles. The relationship between iwc and TB's established based on the ARM ground-based measurements at the ARM sites is applied to satellite pixels over 10° x 10° area centered at the ARM sites. The end product of the algorithm is a 3-D ice water content, in addition to ice water path, at satellite pixel grid over 10° x 10° area centered at ARM sites.

Results



↑ The diagram in the middle shows the MMCR radar reflectivity time-height cross section observed at ARM Darwin site during the 40 days of TWP-ICE. Cloud ice water content retrievals are performed using data observed by 4 satellites (NOAA-15/16/17/18), resulting in ice water retrievals available up to 8 times a day. Two examples (Jan. 19 & Jan. 24) of the ice water retrievals are shown, both in horizontal distribution of ice water path and in distance-height cross-section of ice water contents.

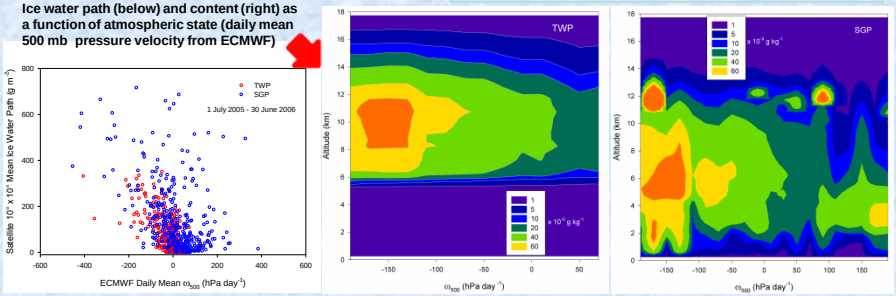
Seasonal Variation of IWP Distributions around SGP and TWP-Darwin (10°x10°)



← Seasonal IWP distribution centered at ARM sites and

↑ Time series of 10°x10°areal averaged IWP. Dots are daily averaged values while lines are 10-day running means.

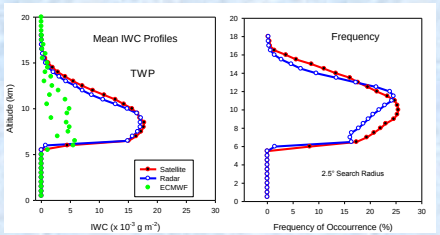
Ice water path (below) and content (right) as a function of atmospheric state (daily mean 500 mb pressure velocity from ECMWF)

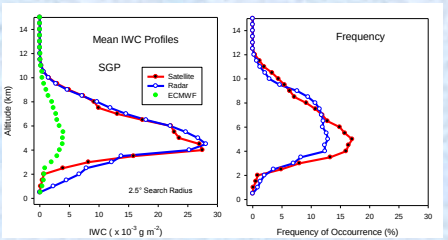


Validation

Comparison with MMCR (TWP-ICE &SGP –March2000)

- Mean IWC Profiles & Frequency of Occurrence





The retrievals are compared favorably with MMCR cloud ice water retrievals, while largely different in magnitude with ECMWF cloud ice amount.

Conclusions

- Combining satellite and surface radar observations enables us to retrieve 3-D cloud ice water contents over large-scale surrounding ARM sites (10°x10°). Retrieved data are available for 7/1/2005 – 6/30/2006 for 10°x10° areas covering SGP and TWP-Darwin.

- Retrievals are validated by MMCR data for TWP-ICE and SGP March 2000 IOP. Characteristics of cloud ice water as ω-regimes are studied.

- Data available: PI products at ARM Website, as well as at http://cirrus.met.fsu.edu

-Support: ARM DE-FG02-03ER63526