Large-Scale 3-D Cloud Ice Water Features Determined by Combining Satellite and Surface Measurements during TWP-ICE

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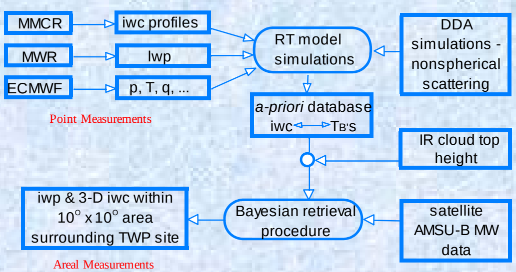
Objectives

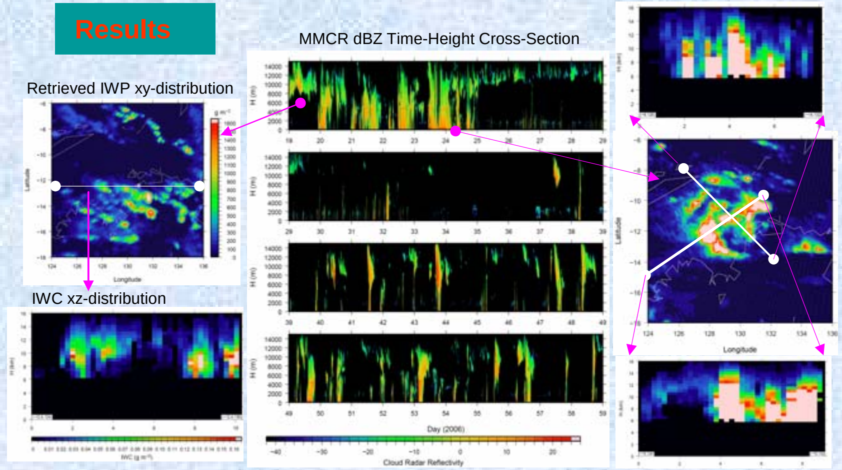
Large-scale distribution of cloud ice water amount (1) is required for deriving cloud water advective tendency as forcing term for single-column models, (2) can be used to validate cloud resolving and global climate models, and (3) is extremely useful for understanding cloud microphysical and precipitation 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 the results during TWP-ICE at Darwin site, as well as those during March 2000 at SGP site for comparison.

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 other satellite pixel grids over 10° x 10° area centered at the ARM sites. Further refinement to the retrieval procedure has been carried by sub-setting the a-priori database to include only those data-points having similar cloud top heights to satellite (infrared) observed. This refinement helps the algorithm better determine the ice water location. 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.

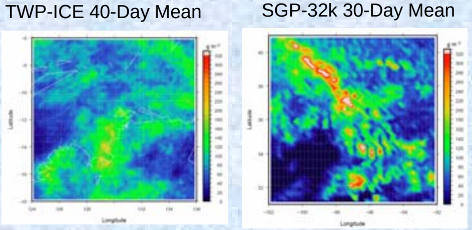
Results



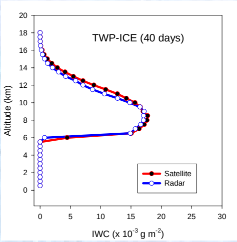
↑ The diagram in the middle shows the MMCR radar reflectivity time-height cross section observed at ARM Darwin site during the 40 days of TWP-ICE. Cloud ice water content retrievals are performed using data observed by 4 satellites (NOAA-15/16/17/18), resulting in ice water retrievals available up to 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.

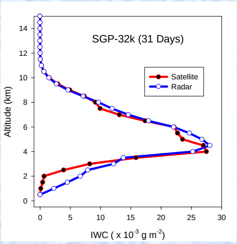
Compare Ice water characteristics of TWP-ICE with SGP March 2000 ↓

IWP Distribution (10°x10°)

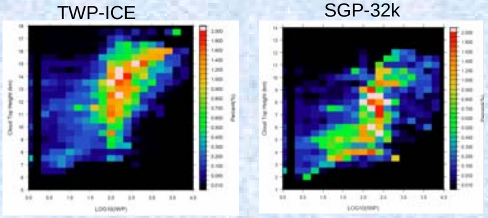


Mean IWC Profiles





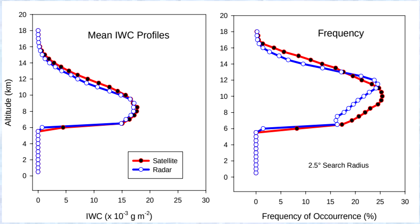
IWP – Cloud Top Height Relations



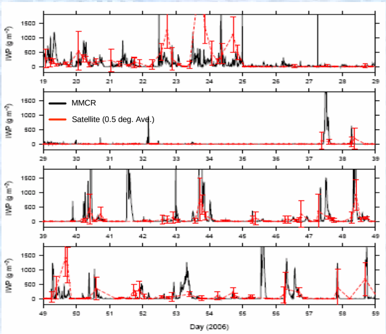
Validation

Comparison with MMCR (TWP-ICE)

- Mean IWC Profiles & Frequency of Occurrence (40 Days)



- Time Series of IWP



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°)

- Retrievals are validated by MMCR data for TWP-ICE

- Characteristics of cloud ice water differ between TWP-ICE and SGP March 2000

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

-Support: ARM DE-FG02-03ER63526