Simultaneous estimations of cloud and rainfall parameters using radars operating at different frequencies

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Purpose: Extending ARM column hydrometeor retrievals to include simultaneous estimations of cloud and rainfall parameters in stratiform precipitating systems

Approach: Differential attenuation (MMCR and WACR) radar measurements in the rain layer are used to retrieve cloud LWP and the mean rainfall rate. MMCR measurements in the general mode are then used to estimate IWP above the freezing level. KVNX NEXRAD measurements over the SGP ARM site are used to estimate effects of MMCR signal losses due to hydrometeor attenuation and the wet radome.

Relating attenuation and cloud/rain parameters

Ground-based Joss-Waldfogel disdrometer (JWD) measurements are used to model rainfall rate – attenuation coefficient relations that are specifically tuned for a particular observational event (Fig. 1 b). The Rayleigh scattering approximation is used for describing radar signal attenuation in liquid cloud phase.

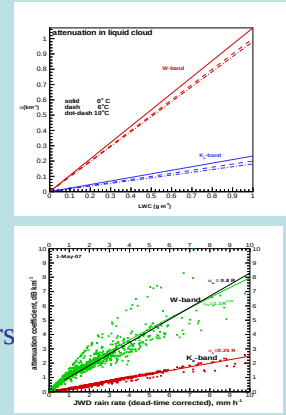

Fig.1. attenuation in liquid cloud (a) and rain (b) at K_a and W bands

Radar and JWD information

An example of ARM and KVNX NEXRAD radar reflectivity measurements is shown in Fig. 2 . This stratiform precipitation event was observed at the SGP site on May 1, 2007. The KVNX NEXRAD reflectivity time-height cross sections were obtained from the volume scans (the KVNX NEXRAD radar is located 60 km from the SGP central facility.

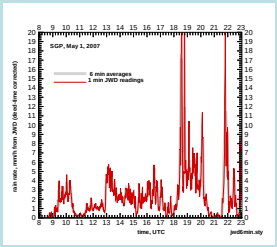

Fig.3. Time series of rain rate

Time series of retrieved mean layer rainfall rate with different temporal averaging are shown in Fig. 3. Typical changes in the vertical profiles of rain rate are less than 20%.

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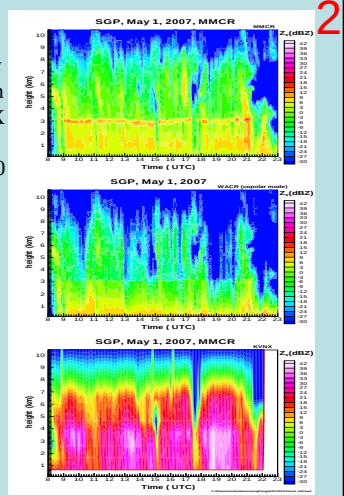

Fig.2. Radar data cross sections

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Cloud content retrievals

Figure 4 shows results of cloud LWP and IWP and also layer mean rainfall rate retrievals in the precipitating system observed on May 1, 2007.

While microwave radiometer LWP retrievals are not expected to provide reliable information during rain periods (thus they cannot be used for validation), lidar measured backscatter and cloud boundaries can be used for qualitative comparisons with radar-based retrievals.

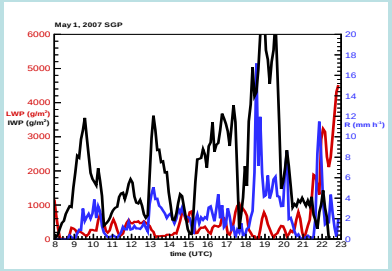

Fig. 4. Cloud LWP and IWP retrievals

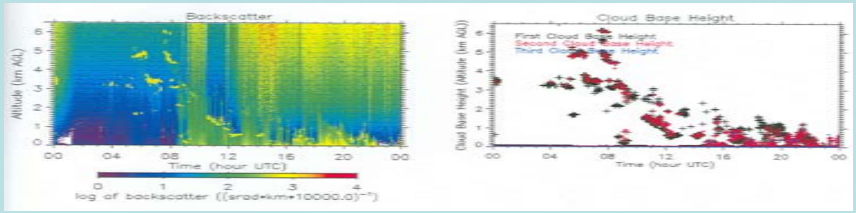

Fig.5. Lidar backscatter profiles and cloud boundary estimates

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Relations between cloud and rainfall parameters

Comparisons of vertically integrated amounts of cloud ice (IWP) and liquid water (LWP) with the layer-mean rain rate (*R*) indicate a noticeable correlation between *R* and IWP, The correlation between *R* and LWP is not very pronounced. This might indicate that snowflake melting is a dominant mechanism of forming liquid precipitation in the observed event.

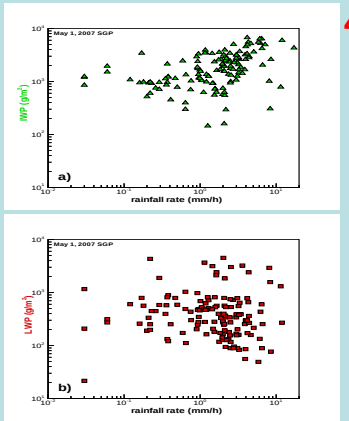

Fig.6. Scatter plots of retrieved cloud ice (a) and water (b) vertical amounts and the layer-mean mean rainfall rate

Conclusions:

- a combination of traditional and attenuation-based radar measurements can be used to derive cloud and rainfall parameters simultaneously in a vertical atmospheric column above the SGP ARM site
- the suggested remote sensing approach uses ARM MMCR and WACR radars complimented by the KVNX NEXRAD radar measurements and ground-based disdrometer data and is better suited for remote sensing of stratiform precipitating clouds
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