

Simultaneous Estimates of Cloud and Rainfall Parameters
In the Atmospheric Vertical Column above the ARM SGP Site

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THE CURRENT REMOTE SENSING METHOD FOR SGP

Retrievables: mean rainfall rate (R_m) and/or rain water path (**RWP**),
cloud liquid water path (**LWP**) ($D < 50 \mu\text{m}$ or so)
(cloud and rain water can co-exist in the same volume)

ice water path (**IWP**) and/or ice water content (**IWC**) profiles
in a precipitating cloud above the freezing level

(All retrieved parameters correspond to the same vertical column)

Approach: attenuation based retrievals using WACR (and MMCR)
in the liquid hydrometeor layer

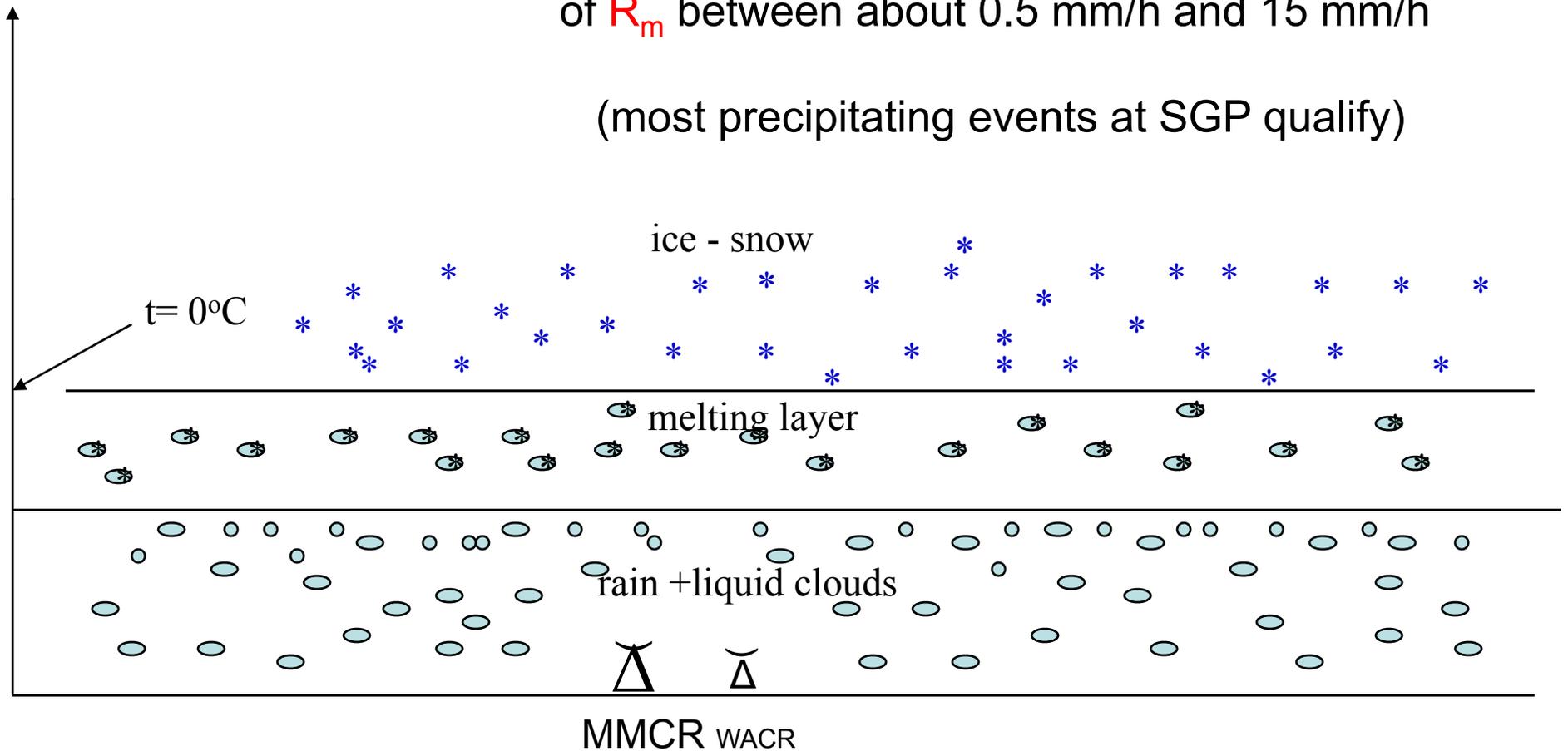
MMCR absolute reflectivity based retrievals of **IWP** and **IWC**
(the reflectivities are corrected for attenuation)

Instruments: WACR, MMCR, KVN radar (NEXRAD), JWD (disdrometer)

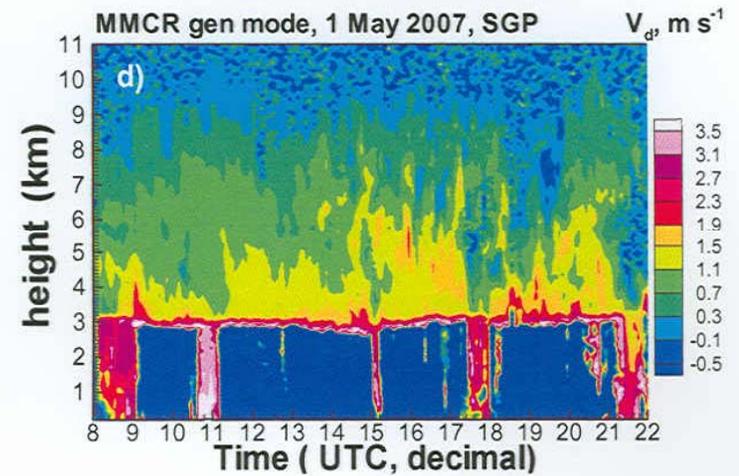
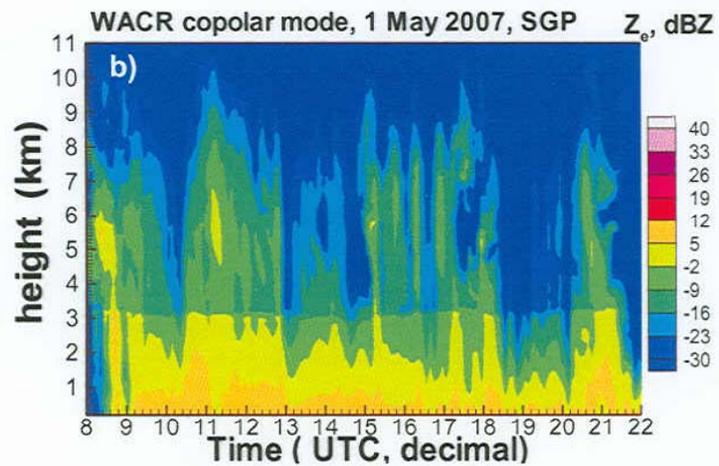
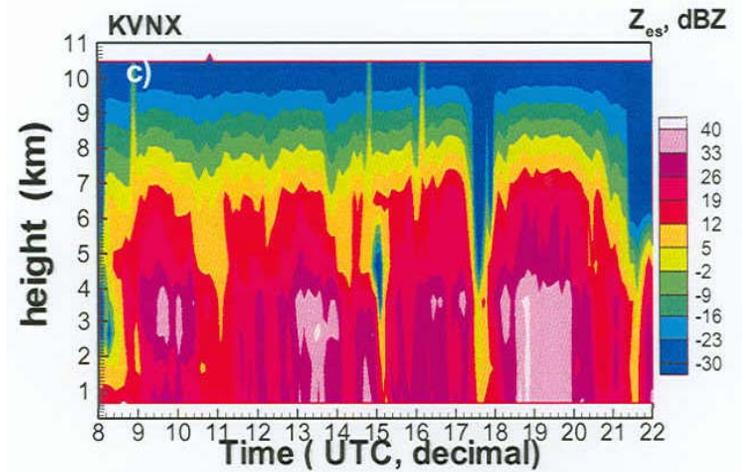
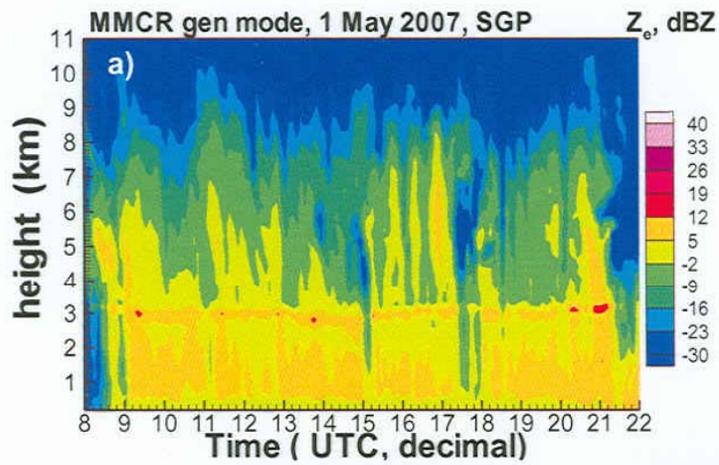
THE CURRENT REMOTE SENSING METHOD FOR SGP

Applicability of the method: stratiform precipitation events with radar detected separation of phases (liquid, ice, mixed) and values of R_m between about 0.5 mm/h and 15 mm/h

(most precipitating events at SGP qualify)

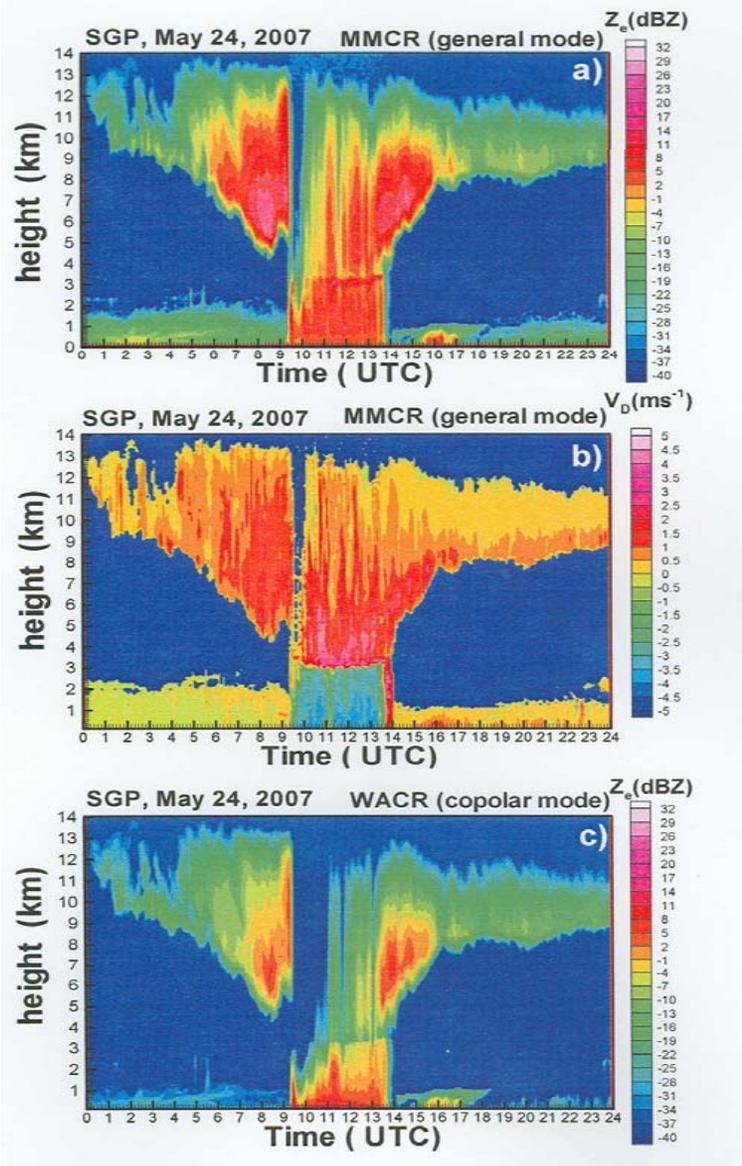


An example of the radar measurements for a stratiform precipitating event

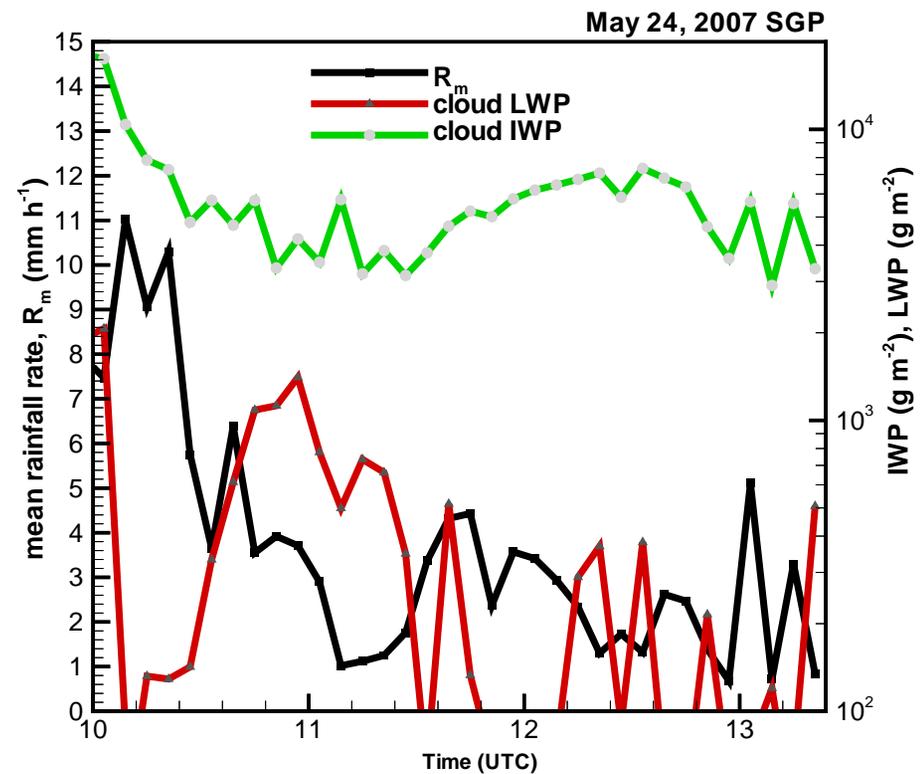


An example of the event with convection in the beginning and stratiform rain after that

radar observations

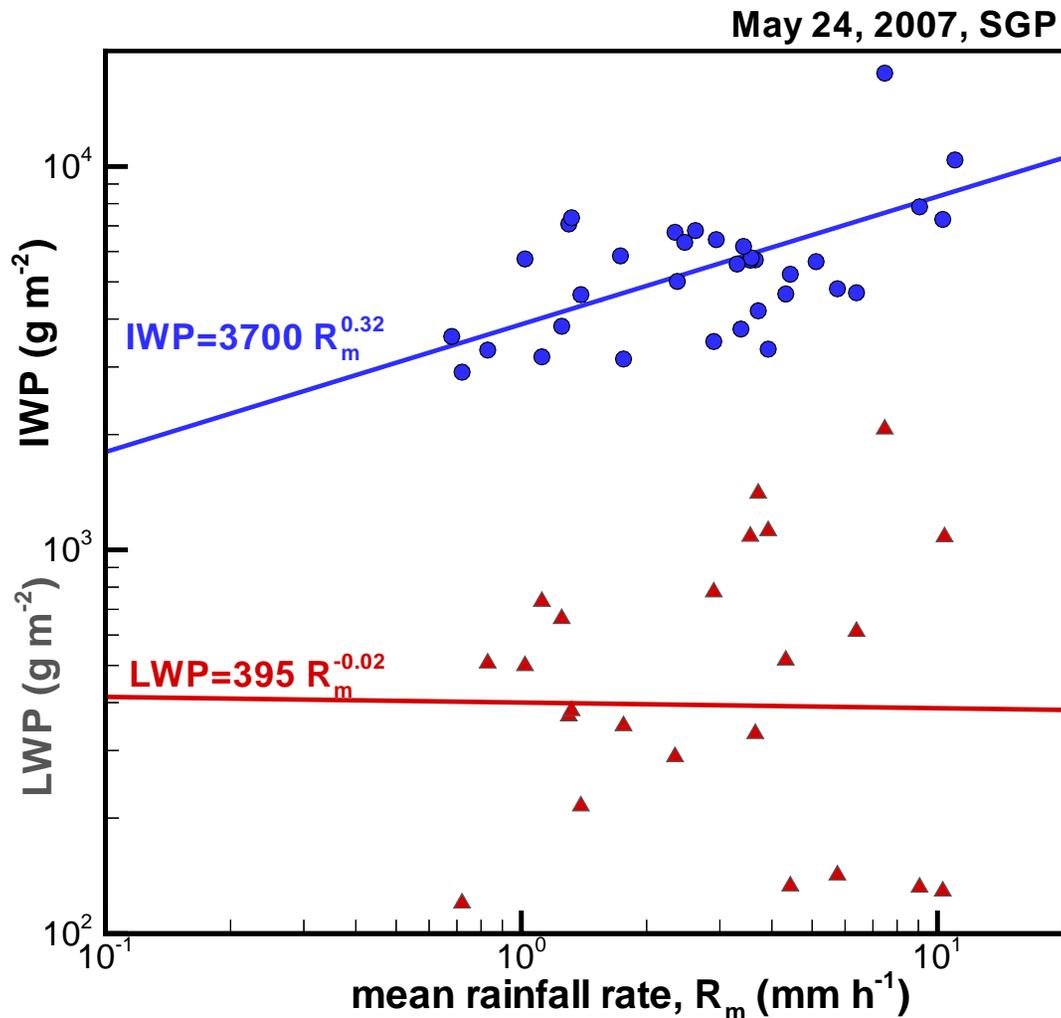


retrievals for a stratiform part of the event



For stratiform precipitation events

IWP are usually much higher than LWP (in the same vertical column)
There is some weak-to-moderate correlation between IWP and R_m
but not a significant correlation between LWP and R_m



Availability of cloud and precipitation parameter retrievals at SGP

* 2007 warm season data are processed (11 events during May – June period). No retrievals during July, August, September due to data issues (e.g., WACR not operational).

* Retrievables are available as time series of R_m , RWP, LWP, IWP over the SGP CF.

Time resolution of retrievals: 6 min

Retrieval uncertainties: ~ 20-30% for R_m , ~ 200-250 g/m² for LWP, ~50-70% for IWP

See poster for the results of these retrievals:

Estimates of Cloud and Precipitation Parameters above the SGP site during spring-summer 2007

For what ARM locations retrievals can be performed (with existing radars)?

- At SGP during 2007 (already done) and 2008 (no WACR measurements after Sep 08) with the current (or modified) retrieval method
- Potentially at TWP (Darwin) if the combination MMCR and C-POL proves to be effective (further technique development is required, higher retrieval uncertainties are likely)
- Potentially at the ARM Mobile Facilities if/when they are equipped with JWDs and measurements from nearby (at distances less than 50-60 km) S- or C- band radars are available.

Other potential approaches for Cloud / Rain liquid retrievals

- Traditional ARM MWR (20, 30, and 90 GHz) approaches for retrievals of LWP in precipitating clouds are not applicable (they do not produce LWP + RWP either)

Problems: melting layer contamination, the Rayleigh assumption is not valid, etc...

- Polarimetric MWR measurements can potentially separate RWP and LWP for slant beam measurements ($\sim 30^\circ$)
[only modeling studies so far, e.g., Czekala et al. GRL (2001), no real data/retrievals]

Problems: melting layer contamination, saturation at larger rainfall rates, the absence of polarimetric signal at lower rainfall rates (< 2 mm/h or so), dependence of the results on the drop shape assumption and a need to measure T_b difference with an accuracy of ~ 1 K

Satellite – based techniques exist to estimate IWP, R_m (and LWP) using passive measurements at different frequencies

Use of vertically pointing Doppler measurements in rain

W-band spectra (methodology exists – Giangrande et al.) :

Possible retrievals of raindrop exponential DSD slope parameters

Possible retrievals of up/down vertical air motion

W-band spectra + non-attenuated radar measurements (methodology does not exist yet)

(Estimations of 2 parameters of exponential raindrop DSD is feasible)

S-band spectra + (wind profiler) methodology exists

Estimations of 2 (3) parameters of exponential raindrop DSD is possible

Retrievals of liquid cloud DSDs from Doppler radar measurements is not possible

Retrievals of ice clouds PSDs from Doppler radar measurements is feasible but large [uncertainties are likely due to the absence of the unique **fall velocity – size** and **mass – size** relations for ice particles]

Questions to CMWG members

- Are the results of available ARM simultaneous retrievals of **LWP**, **RWP** and/or **R_m**, and **IWP** in the same vertical column useful for their modeling studies ?
- Is providing **IWC** profiles (rather than integrated **IWP** values) desirable ?
- What other products are desirable and under what precipitation conditions ?
At what ARM sites? Any particular dates?
- Are snowfall retrievals of interest (what parameters)?
- Are ice hydrometeor habit/shape retrievals of interest?
(may become possible with SWACR and other scanning ARM radars)
- What are the requirements for the uncertainty of the retrieval products to be useful ?