simultaneous estimations of cloud and rainfall parameters using ARM and auxiliary instruments

Traditionally, remote sensing radar - based methods for estimating cloud and precipitation parameters are developed separately

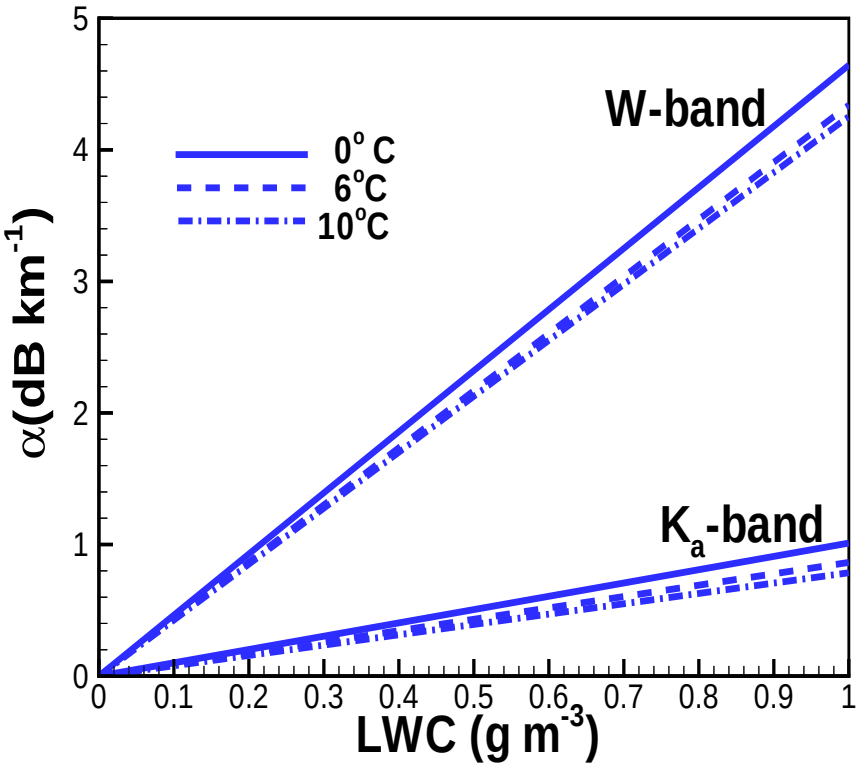
why estimating liquid cloud parameters in presence of rain have problems ?

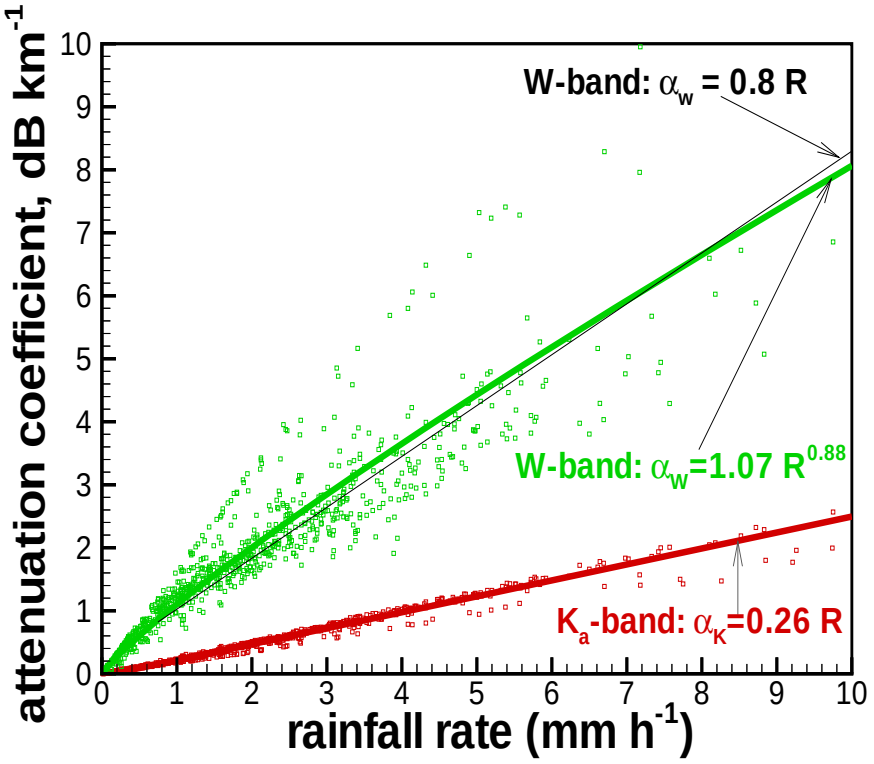
vastly different magnitudes of backscatter: clouds ~ -20 dBZ (LWC ~ 0.1 - 0.2 g m^{-3})
rainfall ~ 30 dBZ (R ~ 3 mm h^{-1})

why estimating ice cloud parameters above rainfall presents problems for vertically pointing radars ?

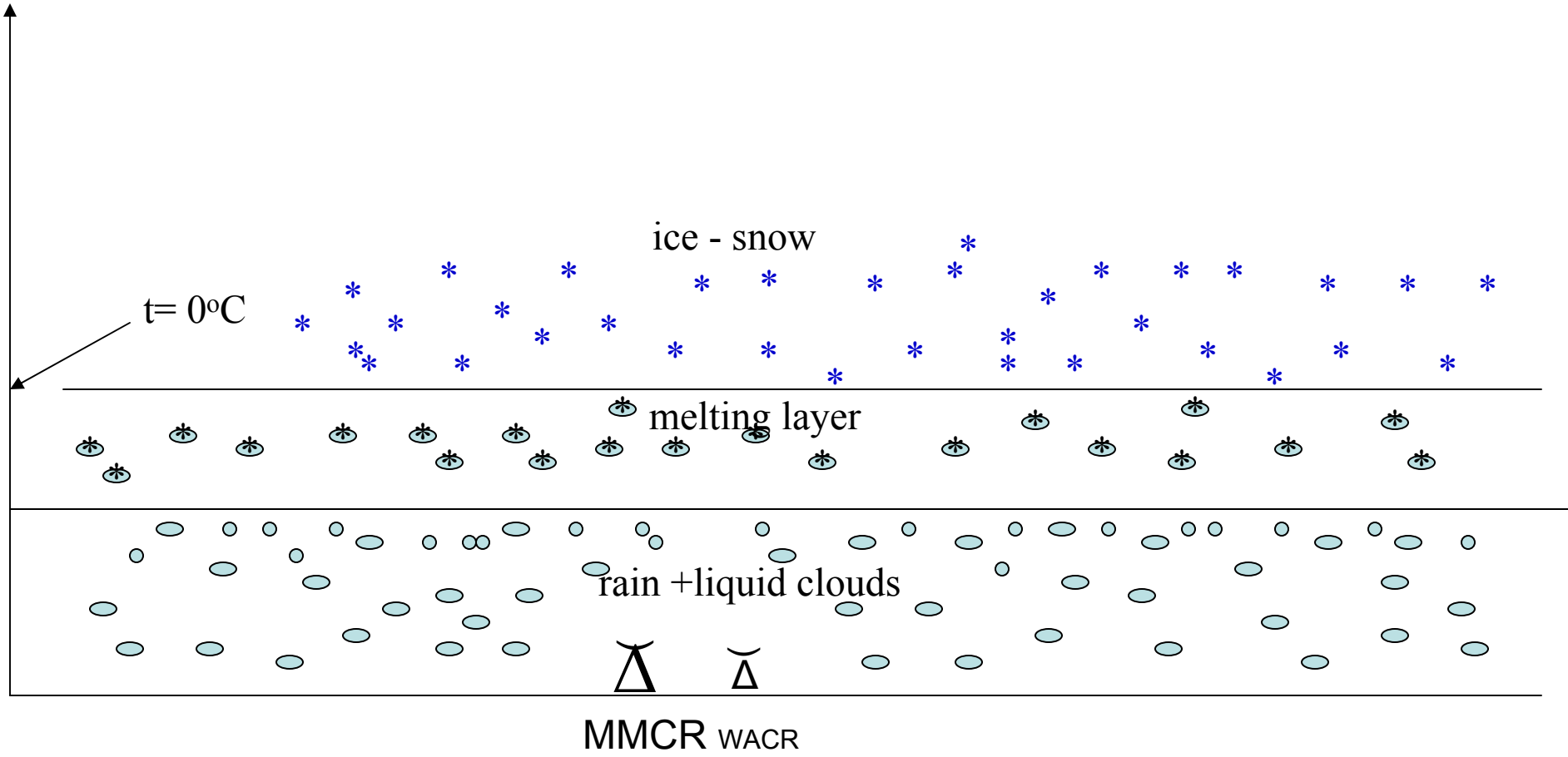
strong attenuation of mm-wavelength radar signals in the rain and melting layers

while backscatter in liquid clouds and rain differs vastly, attenuation does not

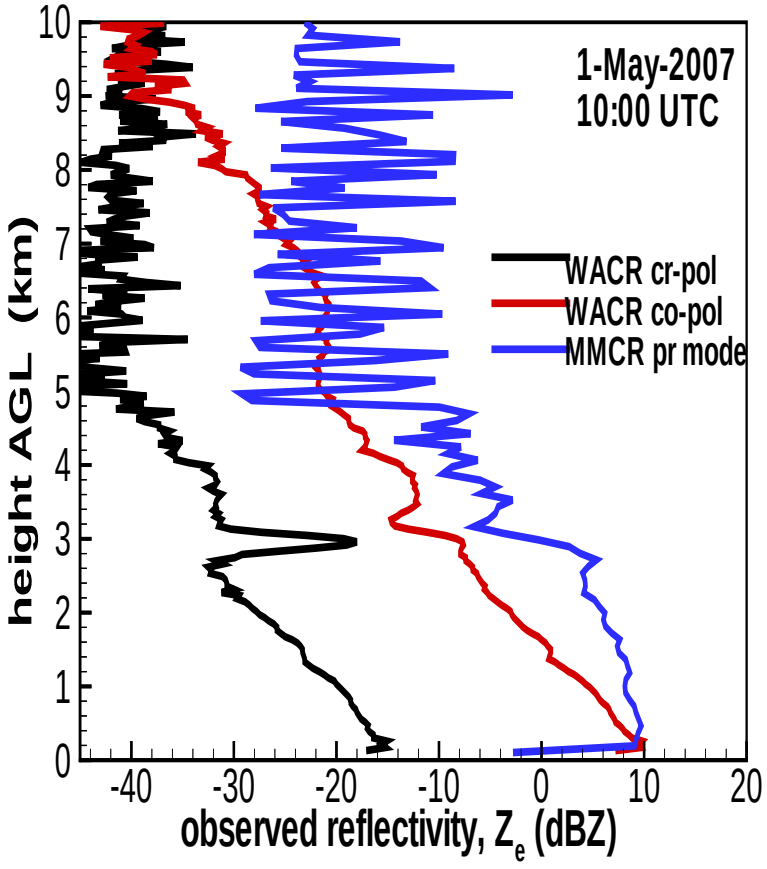


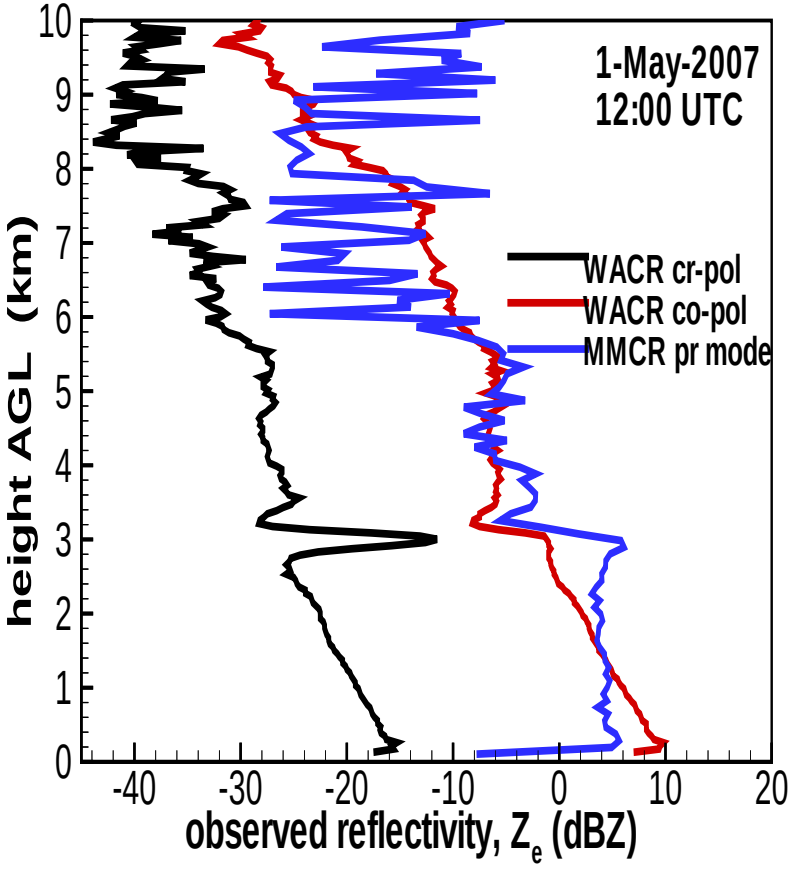


A simplified scheme of stratiform precipitation event



Vertical profiles of MMCR and WACR reflectivity measurements during a stratiform precipitation event





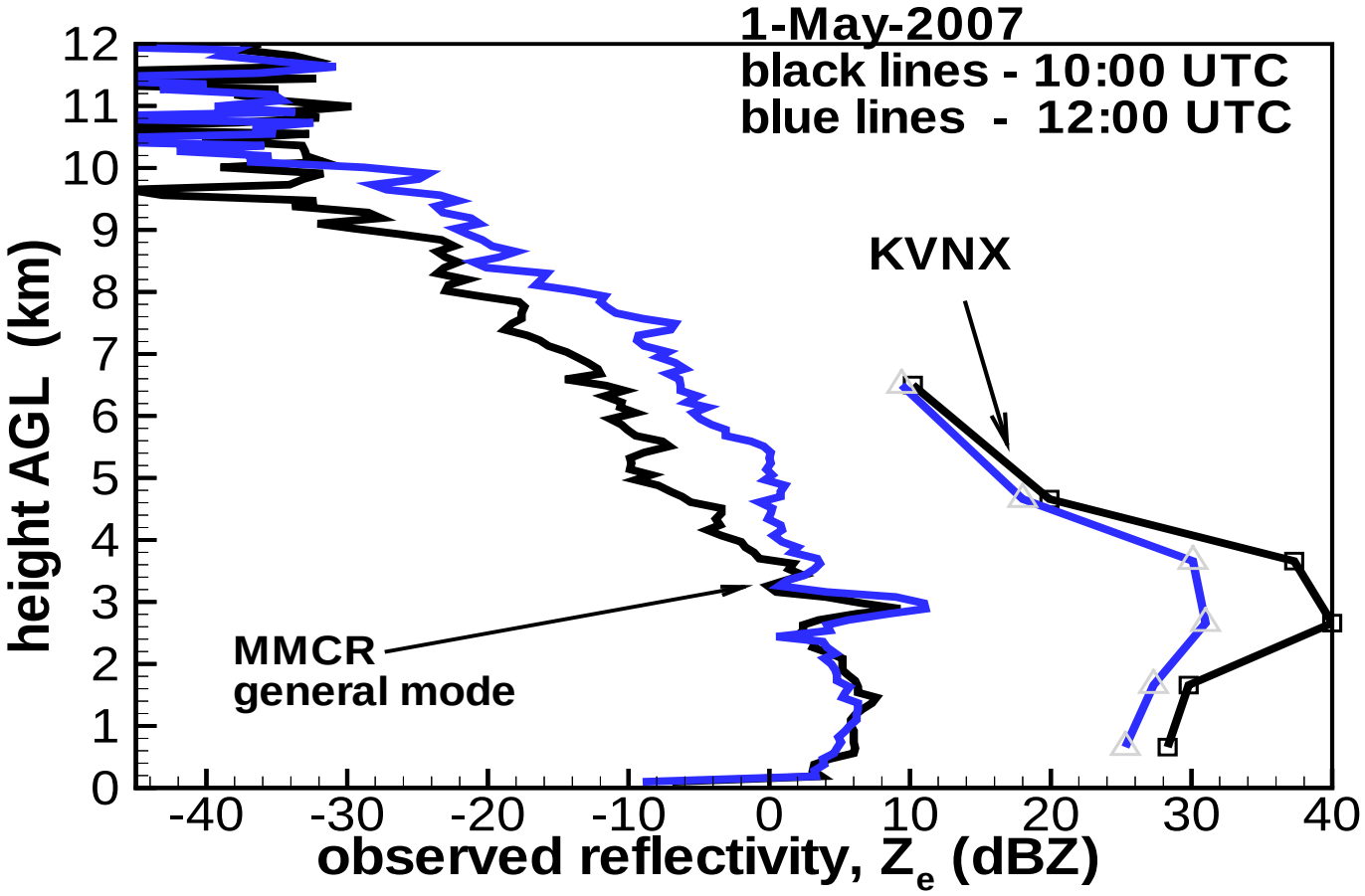
Estimations of mean layer rainfall rate (R_m) and cloud liquid water path (LWP) in the hydrometer (rain + liquid water clouds) layer below the melting layer

Measurables: observed reflectivity differences at W- (WACR co-polar mode) and K_a-bands (MMCR precipitation mode) at the beginning and the end of the liquid hydrometeor layer

Retrievables: cloud LWP and R_m

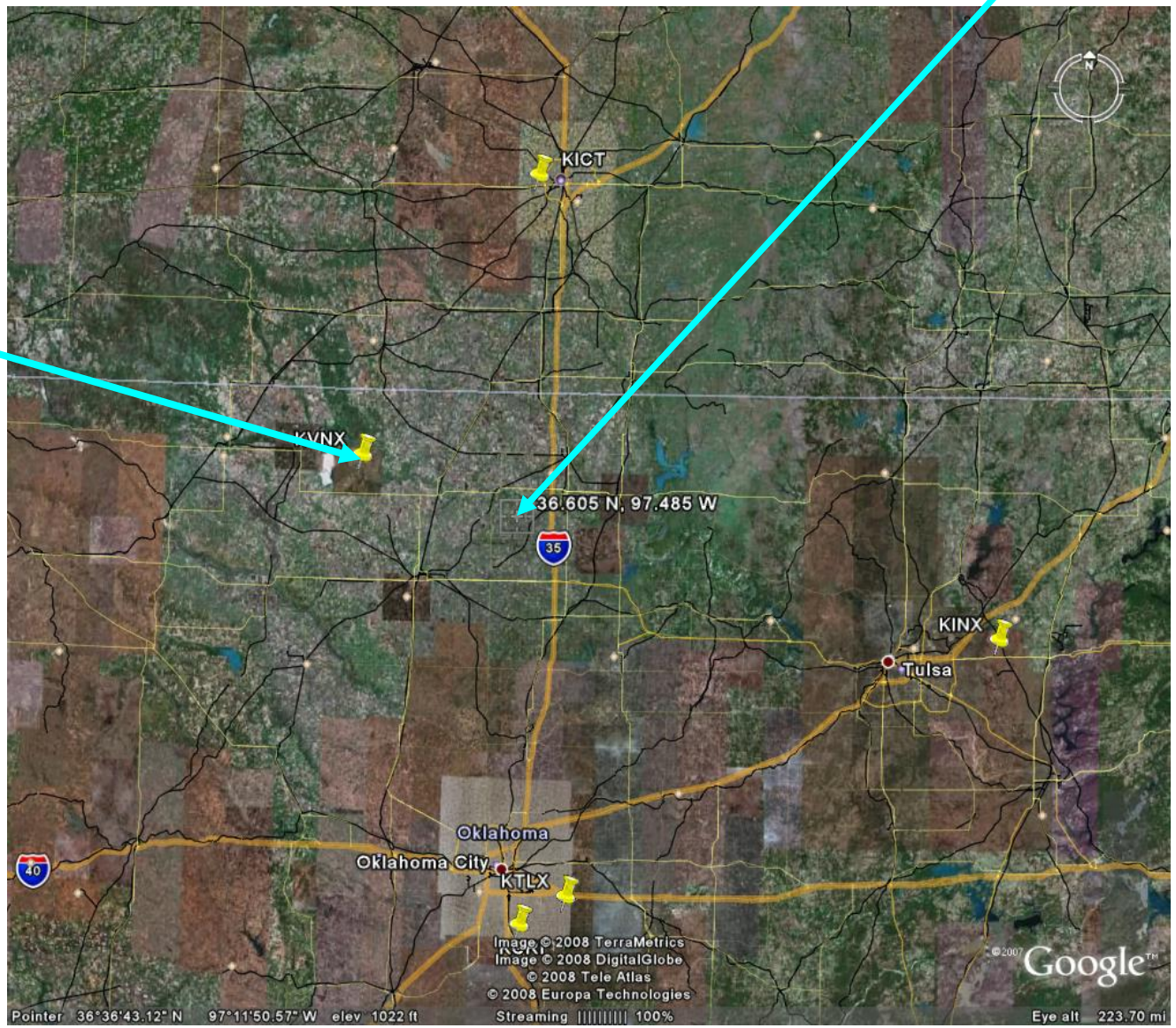
The attenuation-based method is immune to the absolute calibration uncertainties of WACR and MMCR, and is unaffected by the “wet radome” attenuation

Estimations in the ice phase above the freezing level are based on measurements of MMCR general mode reflectivity (IWC -Z_e relations)



SGP Central Facility

KVNX
NEXRAD
(WSR-88D)



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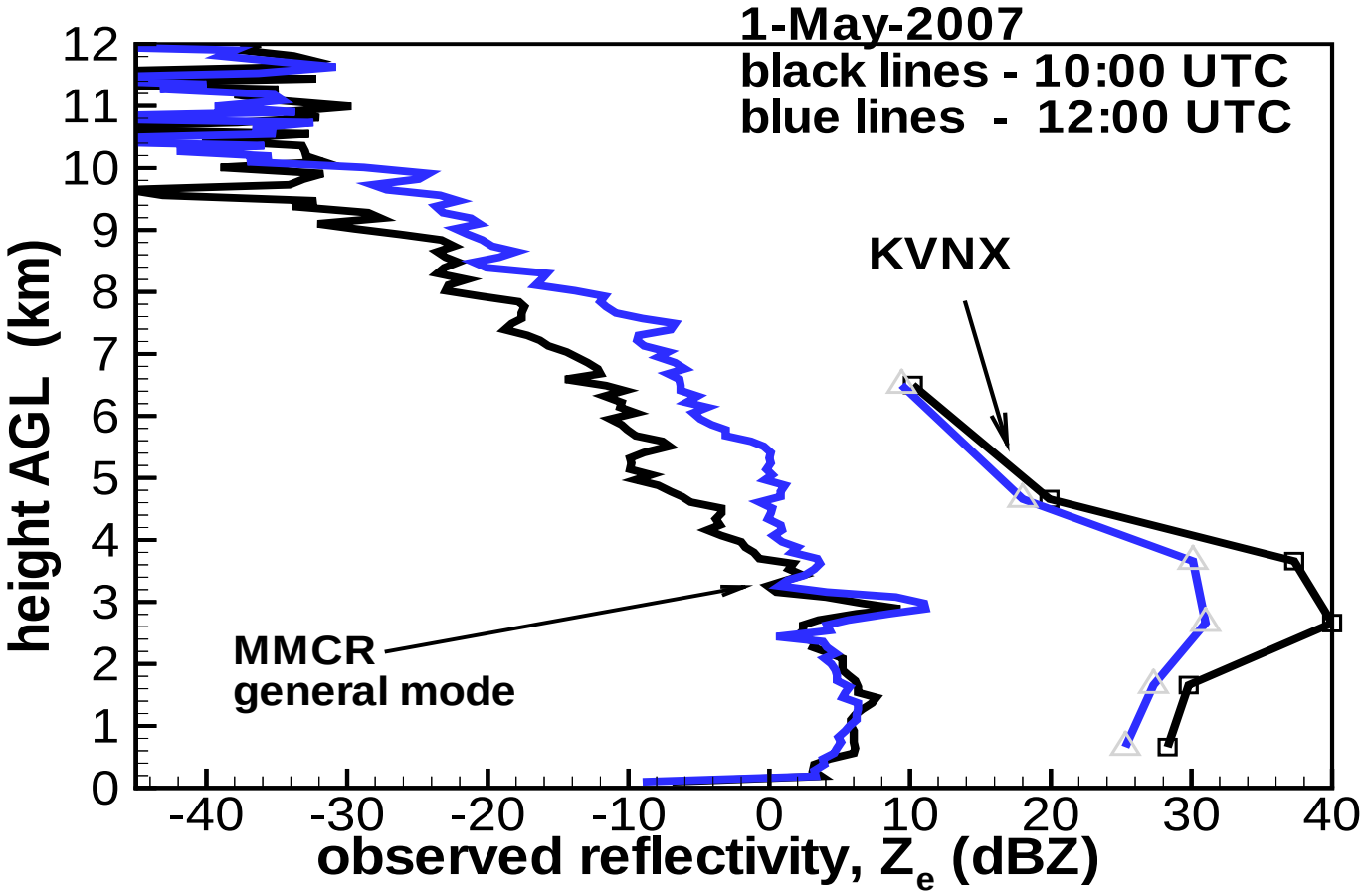
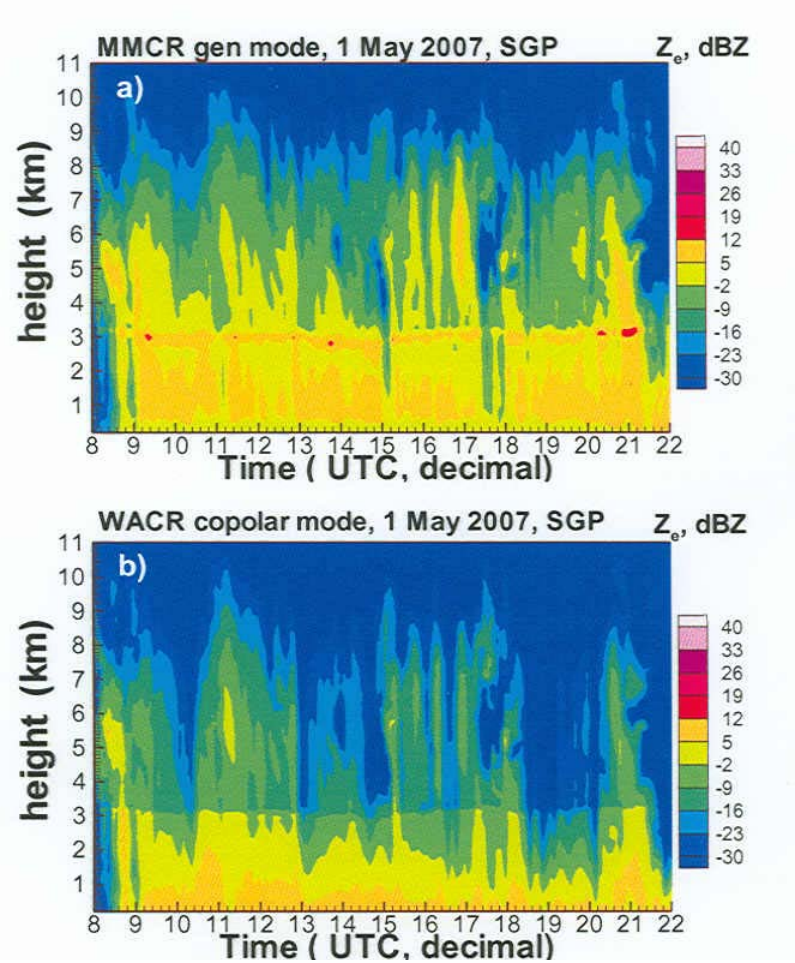
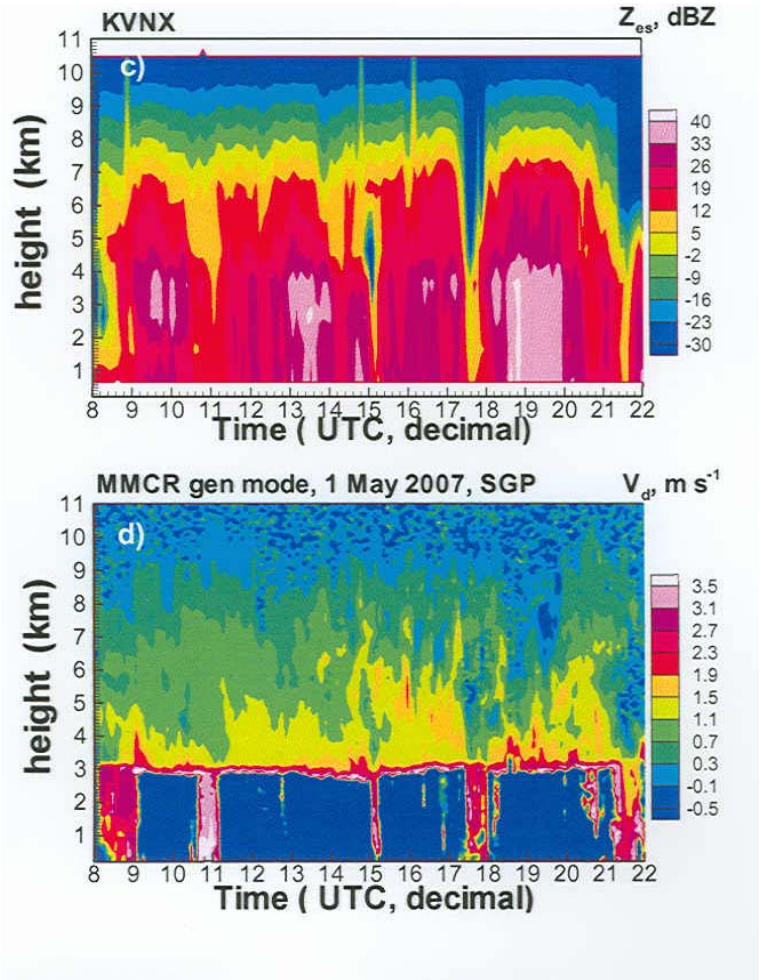
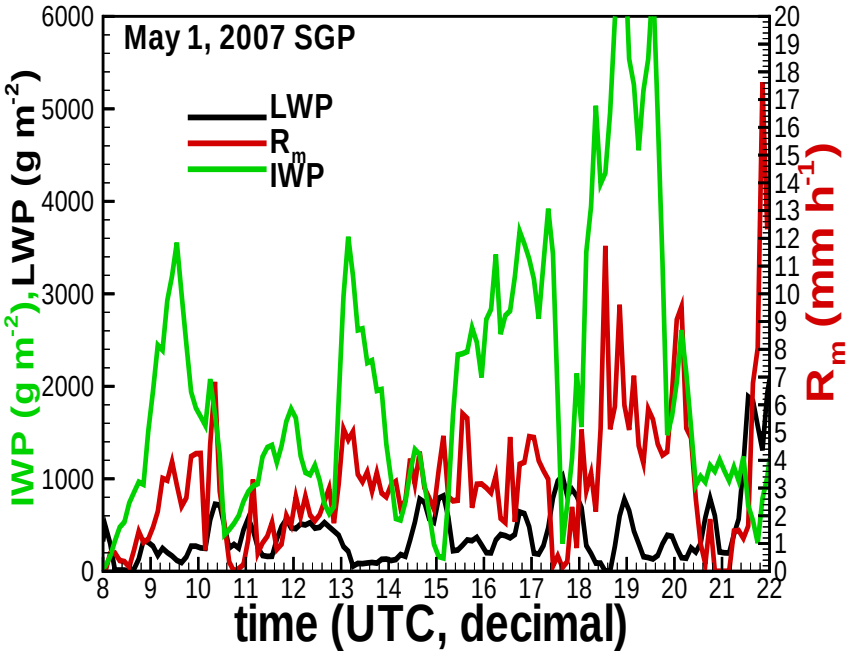


A stratiform precipitation case study at SGP (1 May 2007)

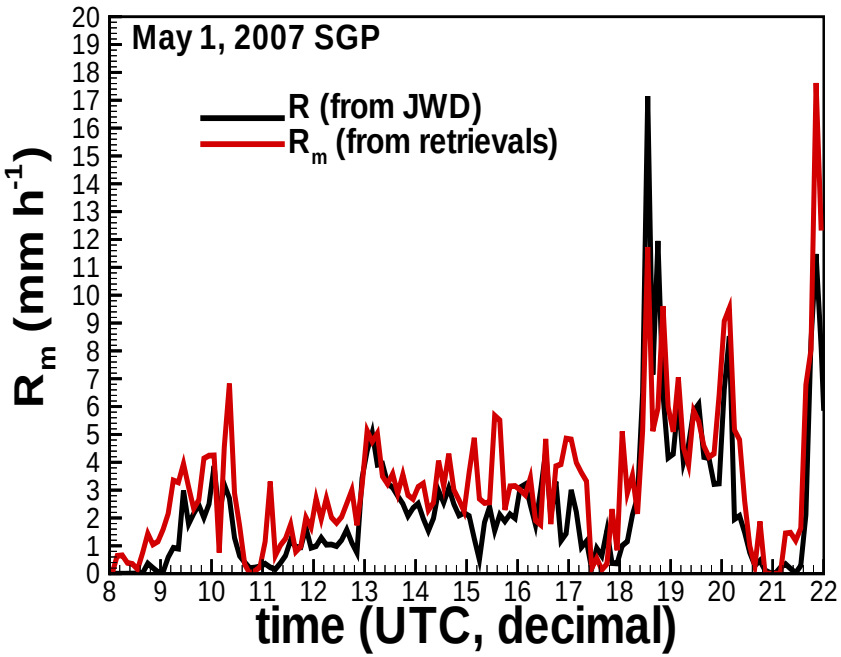




Time series of cloud and rain parameter retrievals

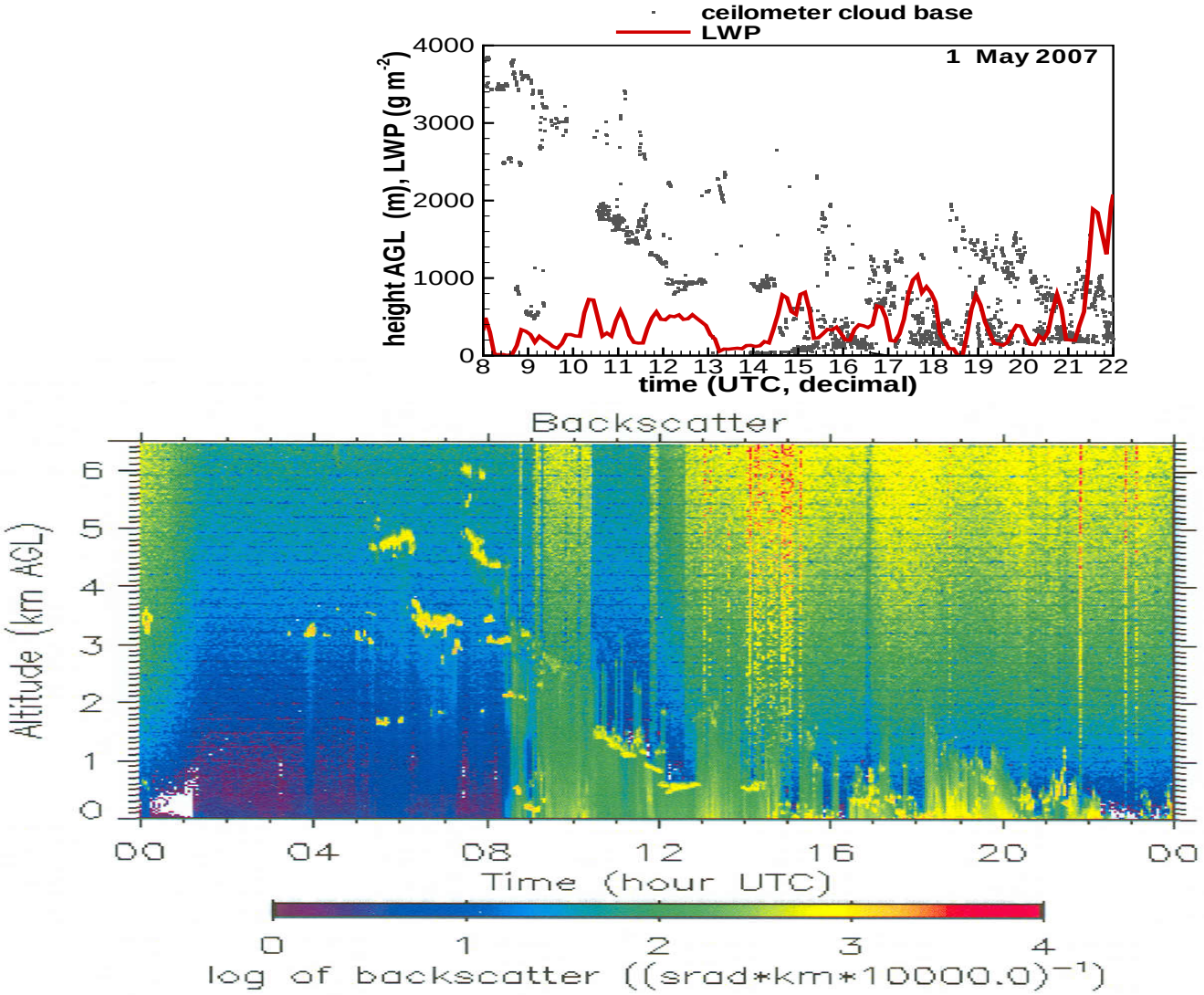


Comparisons of radar-retrieved and JWD rainfall rates

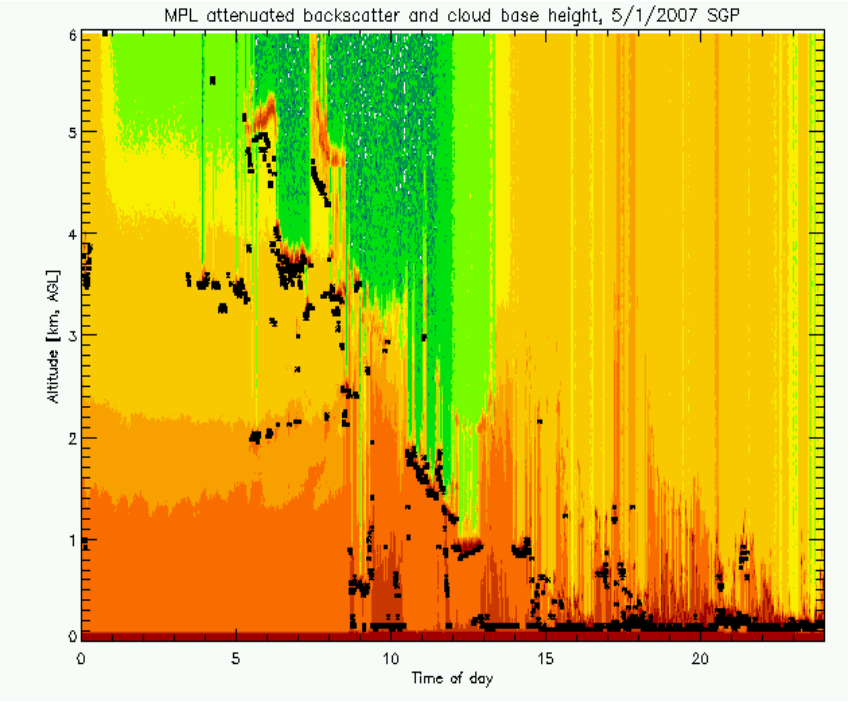


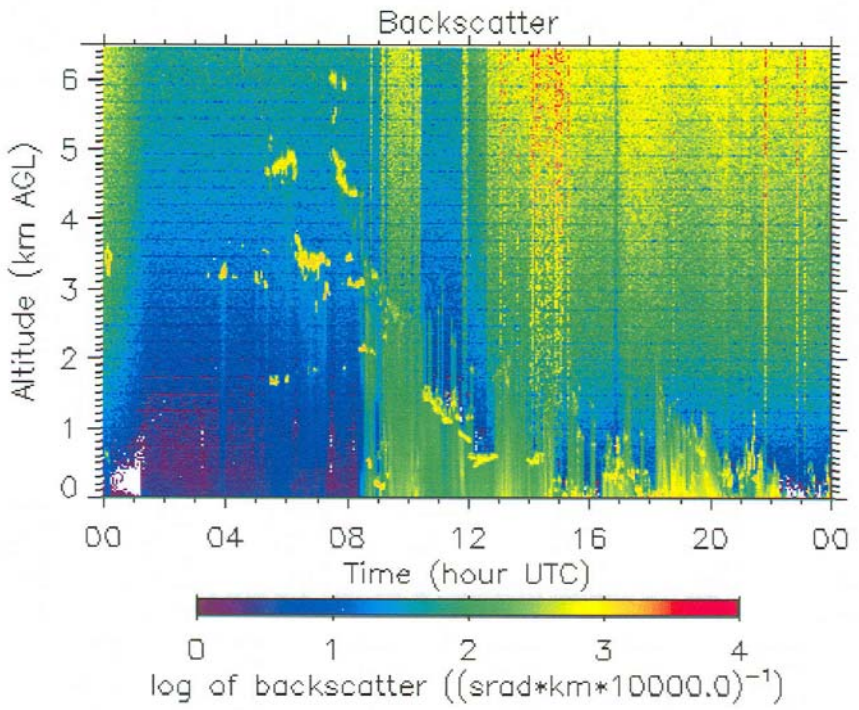
Retrieval accuracies: for R_m - about 30% for a typical value of R_m ~ 3-4 mmh^{-1}
for LWP – about 200 g m^{-2}
for IWP - can reach a factor of 2

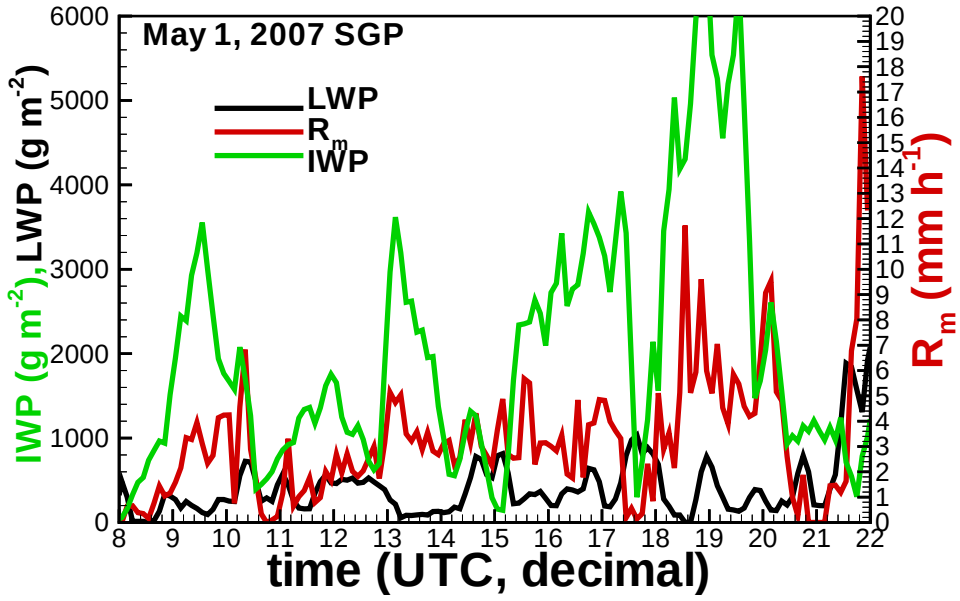
Qualitative comparisons of retrieved LWP and ceilometer measurements

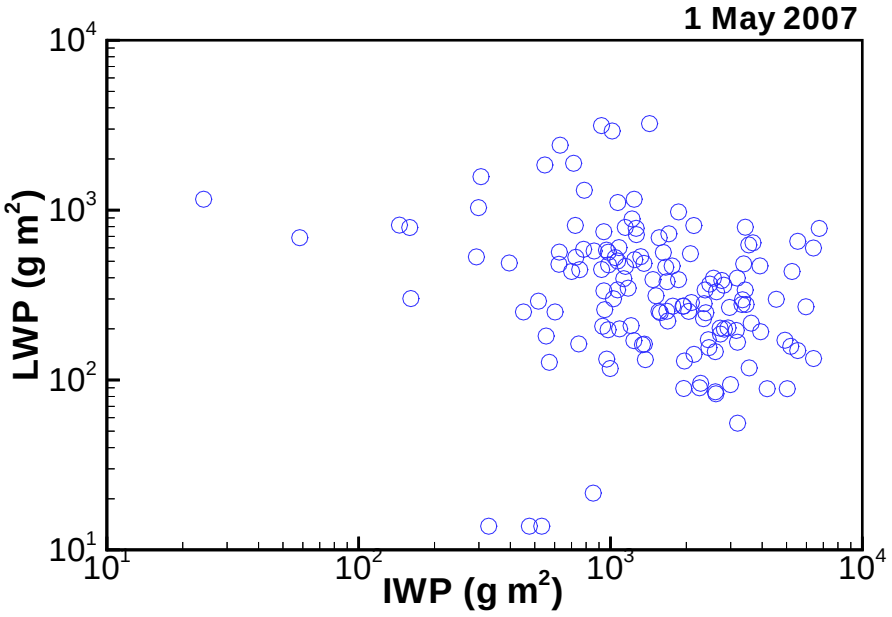


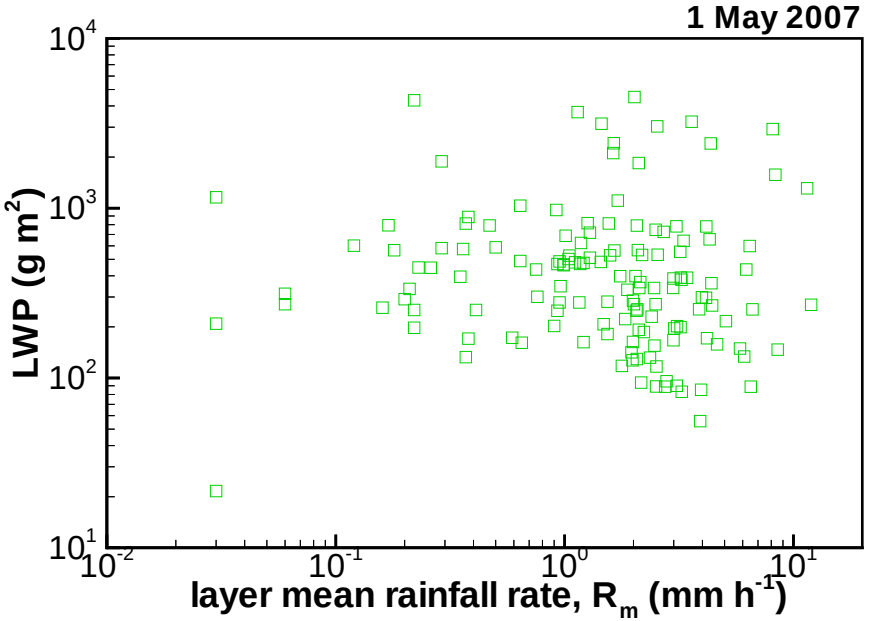
MPL vs ceilometer

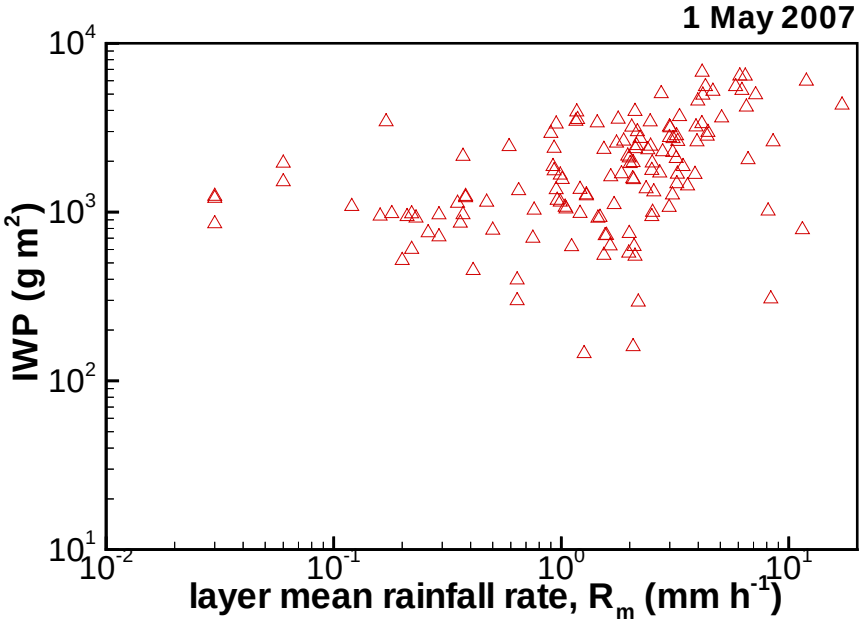




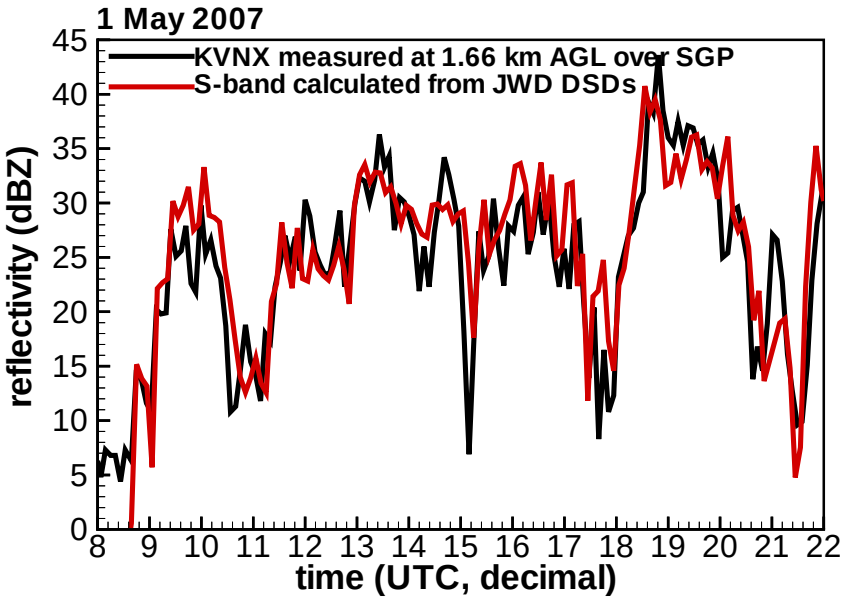

May 1, 2007 SGP
LWP
R_m
IWP
IWP (g m^{-2}),LWP (g m^{-2})
R_m (mm h^{-1})
time (UTC, decimal)


1 May 2007
LWP (g m^2)
IWP (g m^2)

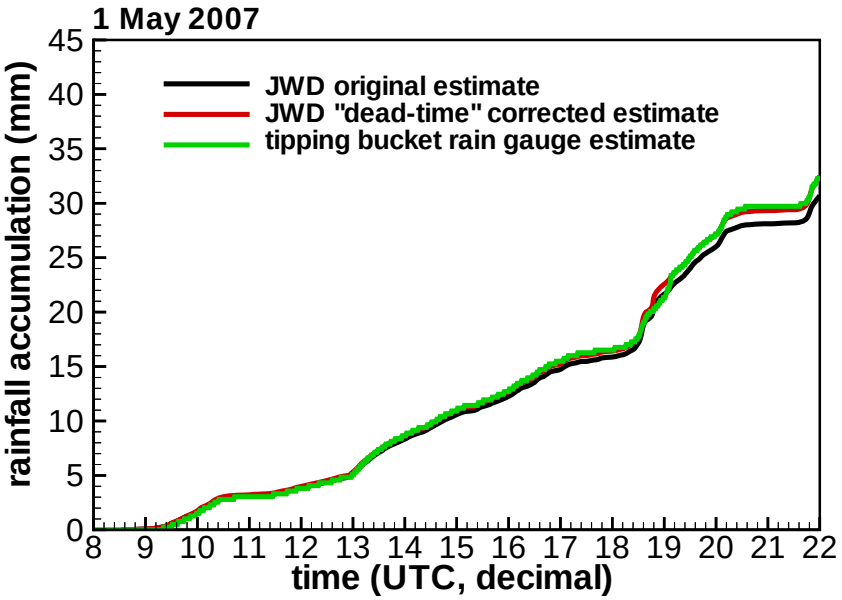

1 May 2007
LWP (g m^2)
layer mean rainfall rate, R_m (mm h^{-1})


1 May 2007
IWP (g m^2)
layer mean rainfall rate, R_m (mm h^{-1})

Comparisons of KVNX and S-band JWD reflectivities



Comparisons of JWD and rain gauge total rainfall accumulations



Conclusions

ARM cloud radars can be used to simultaneously retrieve total cloud liquid content and mean rainfall rate in a vertical column over the ACRF site. The retrievals are performed based on attenuation effects and do not require the absolute calibration of the radars

Measurements from non-attenuated radars (e.g., WSR-88D) are needed for constraining cloud radar measurements in the ice parts of precipitating systems for retrievals of the total ice content above the freezing level

The current version of the suggested approach for combined cloud-rainfall retrievals is primarily applicable to stratiform precipitating systems where different phases (ice, melting, liquid) can be separated using polarimetric and Doppler radar measurements