University of Leicester

Rain profiles retrievals from K_a-UHF dual wavelength radar measurements at ARM SGP facility

Frederic Tridon
Department of physics and Astronomy
University of Leicester

Alessandro Battaglia, Pavlos Kollias and Edward Luke

ARM CLIMATE RESEARCH FACILITY

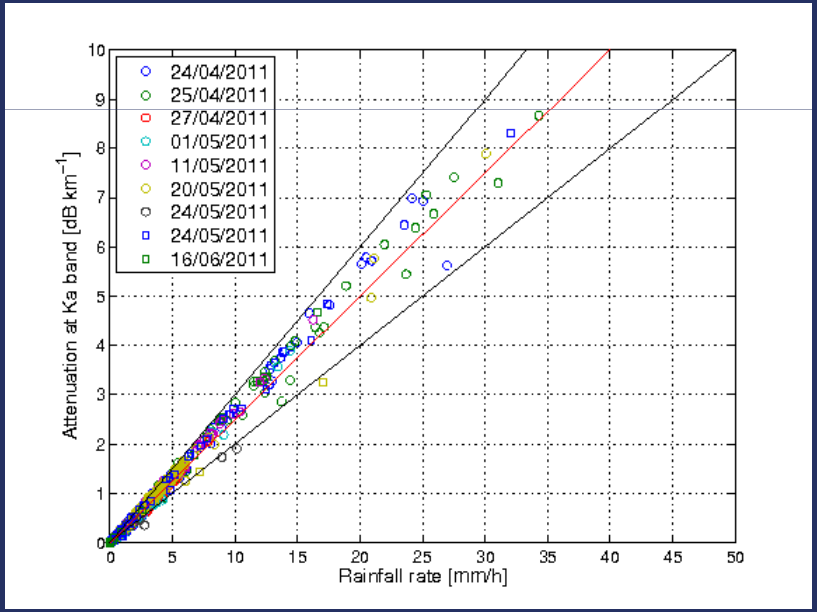
NATURAL ENVIRONMENT RESEARCH COUNCIL

Introduction

- DOE ARM: highly instrumented facilities with vertically pointing cloud radars at different sites → continuous observations of the formation processes of clouds and their influence on climate
- New research avenue: characterisation of the transition from clouds to precipitation since cloud radars adequately detect clouds and precipitation
- Attenuation of K_a band radar in rain can be used to retrieve precipitation characteristics
- Description of the dual wavelength method for rain rate retrievals, examples with the combination of the ARM SGP K_a band radar and wind profiler in a new precipitation mode

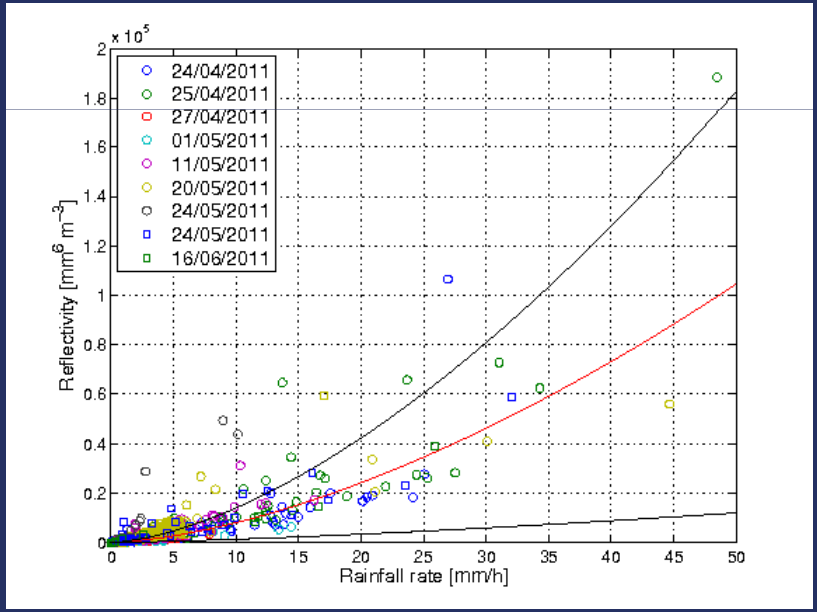
Close a-R relation at 35 GHz compared with Z-R relations

- $R \propto D^{3.67}$, $Z \propto D^{6}$ → Z-R estimators relate the 3.67th and 6th moments of DSD and are very sensitive to its variability (major source of error in QPE)
- $\alpha \propto D^{3}$ in Rayleigh approximation. At K_a band, Mie deviation → $\propto D^{3.63}$.
  → α and R are almost proportional to the same moment of the DSD



$$\alpha(dB\ km^{-1}) = cR\ (mm\ h^{-1})$$

$$c = 0.25 \pm 0.05$$



$$Z(mm^6\ m^{-3}) = aR^b\ (mm\ h^{-1})$$

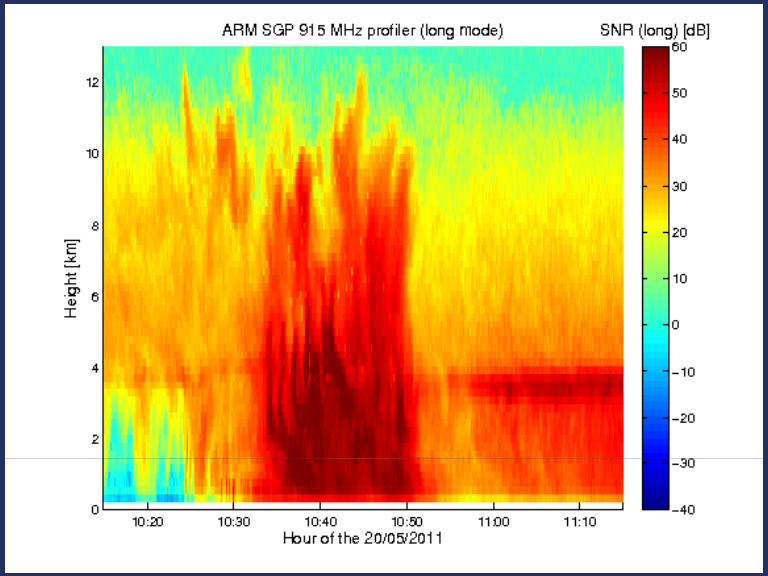
$$a = 200 \pm 150$$
$$b = 1.6 \pm 0.2$$

Method for rain profile retrievals with ARM K_a band radar (Matrosov et al. 2005, 2006)

- Successful retrieval of rain rate with an error of the order of 15 to 30%
- Most of the error: no Rayleigh scattering radar available for providing non-attenuated reference reflectivity profiles
- → Strong assumption needed: reflectivity is assumed to be constant within layers of 1 or 2 km
- Such reference reflectivity now available at SGP facility thanks to the reconfiguration of the 915 MHz wind profiler in precipitation mode: vertically pointing mode and with high temporal resolution
- Prior to any scientific study: careful check of the quality of the wind profiler measurements

Signal post-processing of the ARM 915 MHz Wind Profilers

- Strong underestimation of SNR in heavy precipitation: computation of an improved noise floor from clear air estimates
- Very good agreement with a collocated 2DVD → computation of absolutely calibrated wind profiler reflectivities

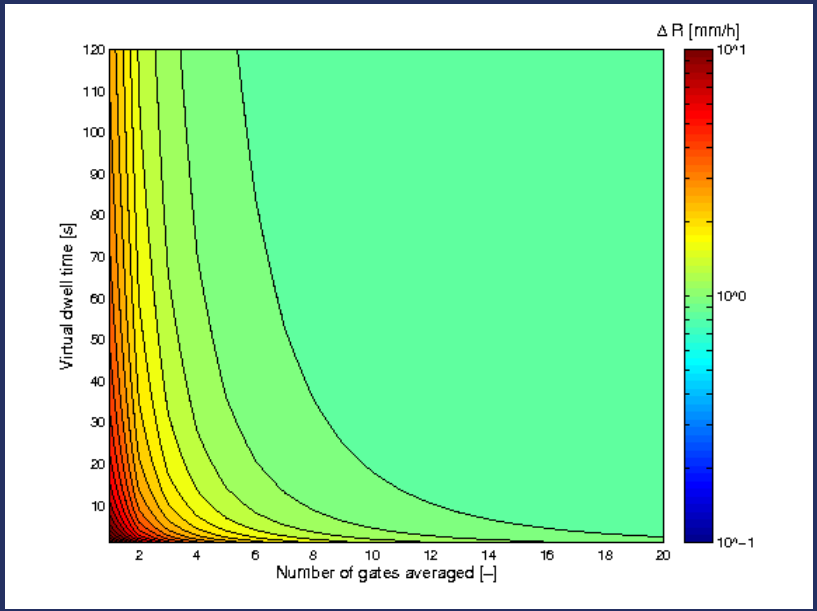


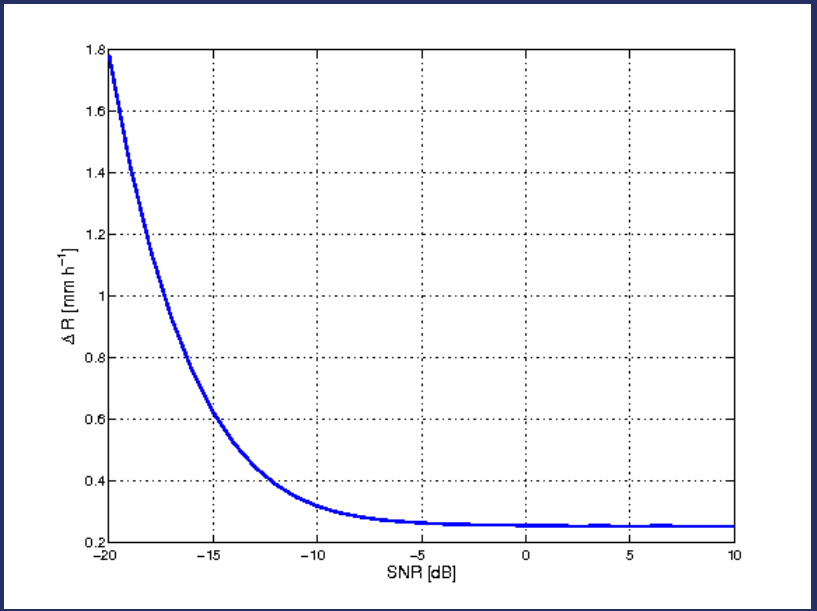
- Operation with 2 interlaced modes with differing pulse widths and inter-pulse periods:
  - Z with different range resolution and sensitivities
  - V_{Dop} over different Nyquist intervals → dealiasing
- Merging of the two modes in order to provide full profiles with high dynamic range and resolution

See poster 140 CR

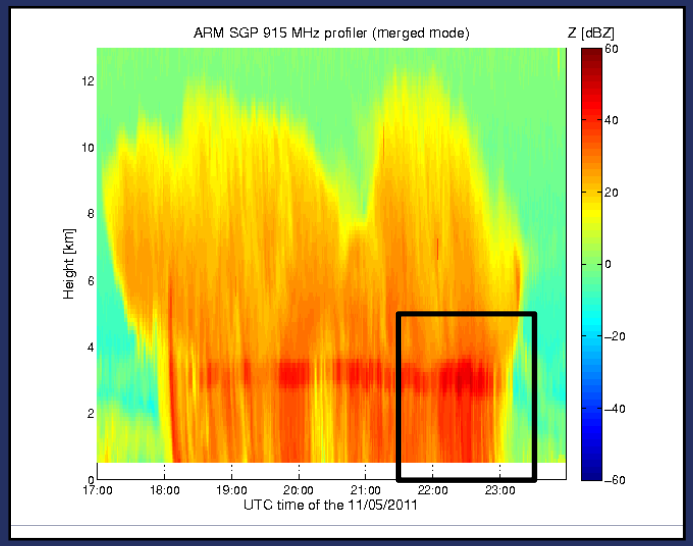
Assessment of retrieval error

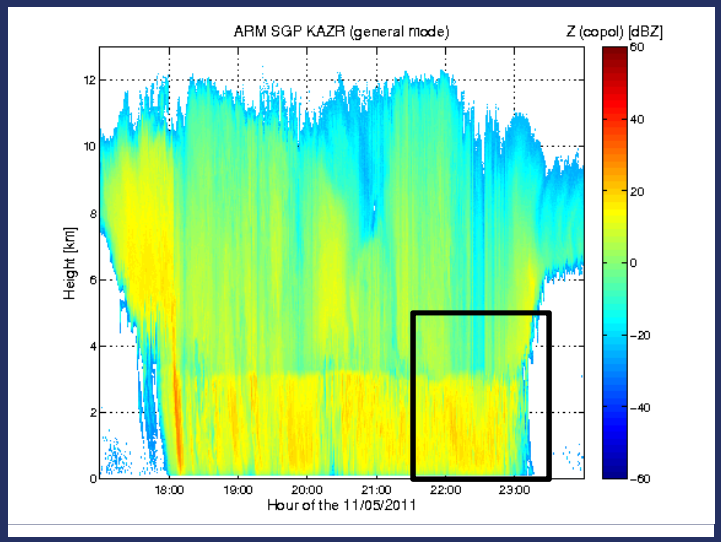
- Three sources of uncertainty:
  - Error in the relation between α and R: dominated by the DSD variability (about 20%)
  - Non-matched beams: random error alleviated by the temporal averaging
  - Error on the reflectivity measurements (Hogan et al., 2005): the precision can be increased by averaging the reflectivities → Definition

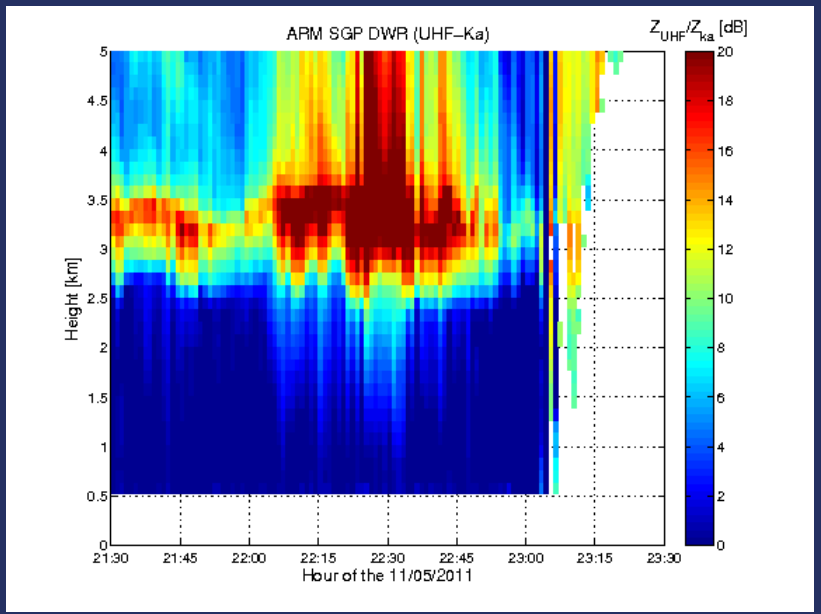


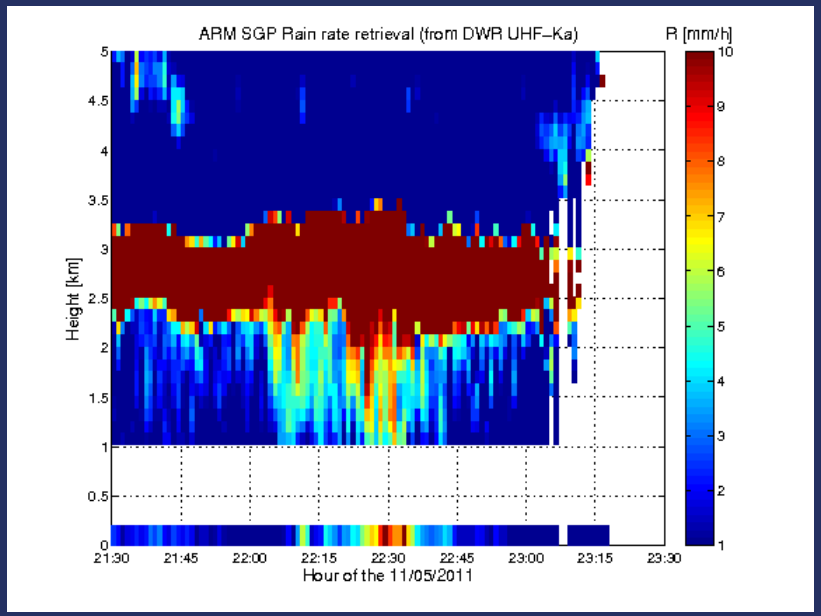


Example of retrievals 11/05/2011

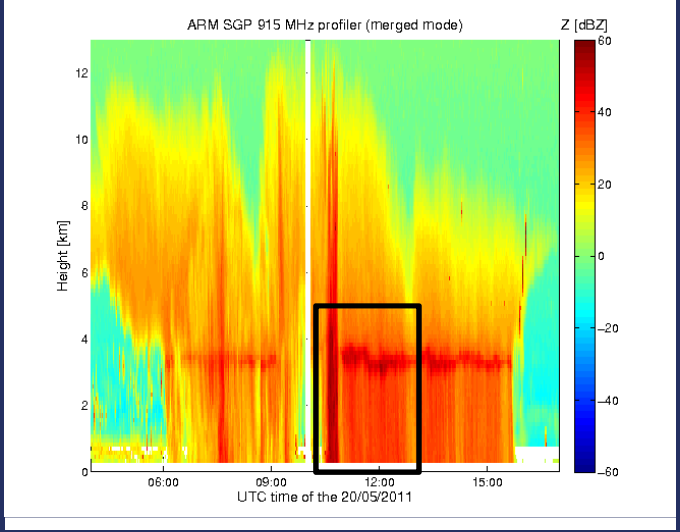


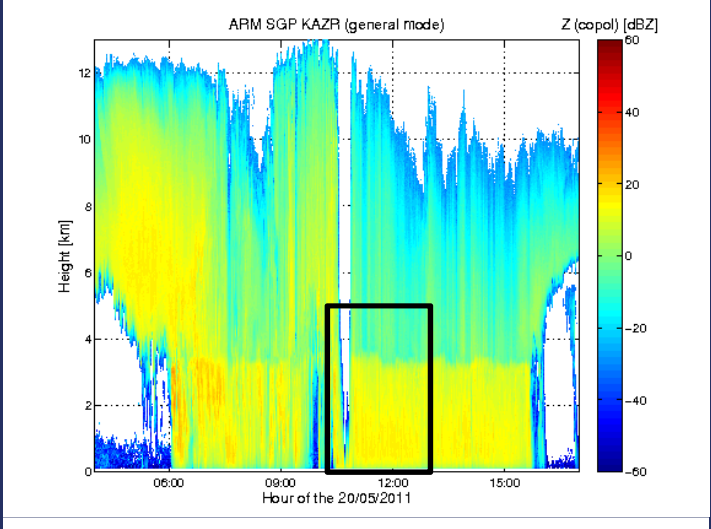


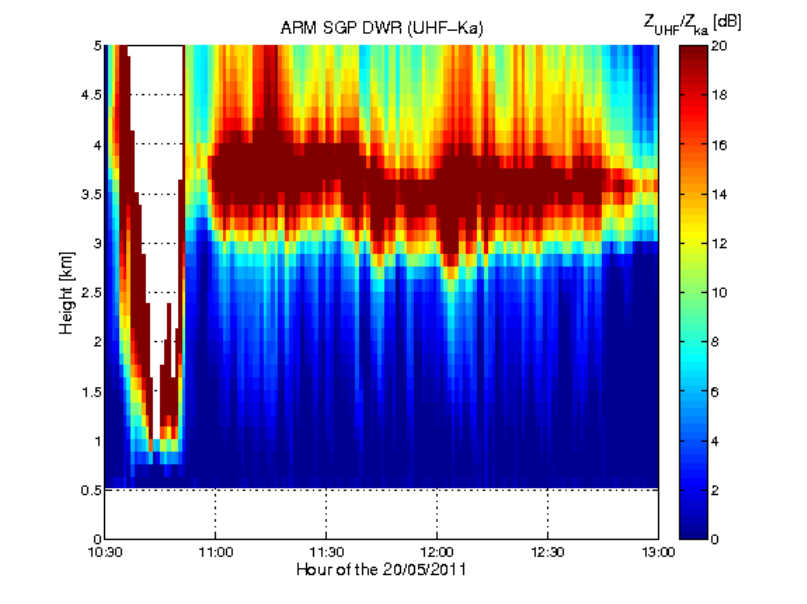


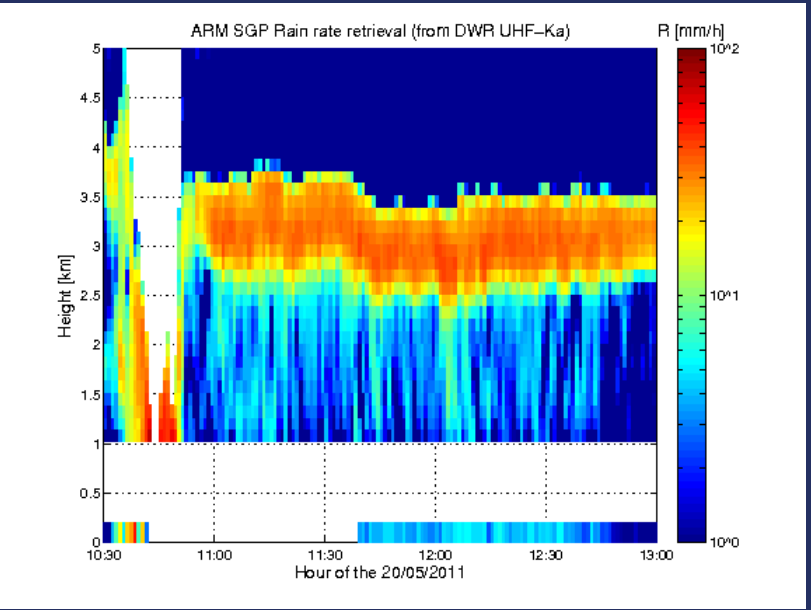


Possible range of retrievals – Squall line of the 20/05/2011



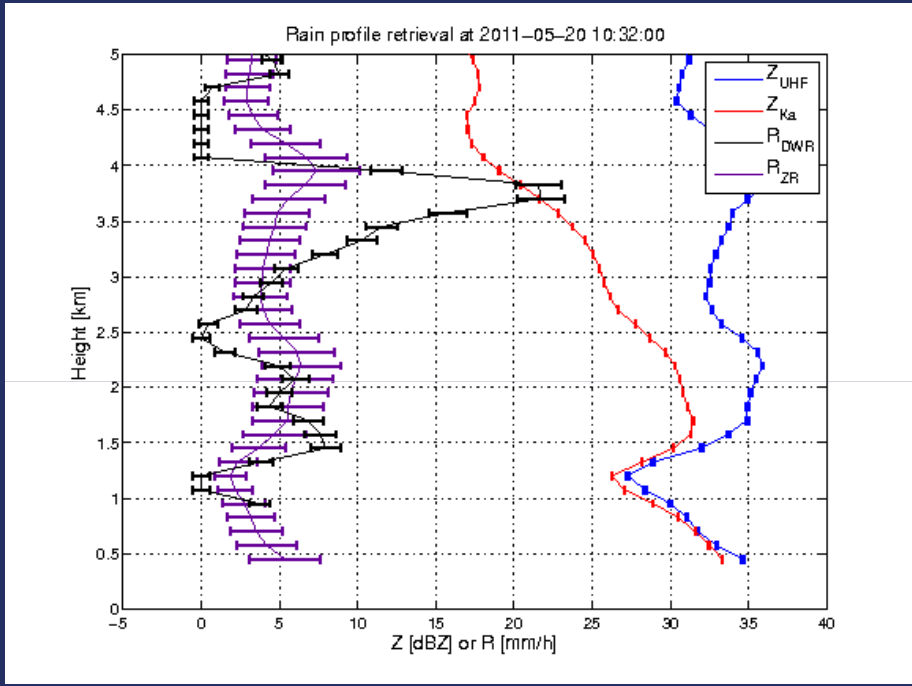




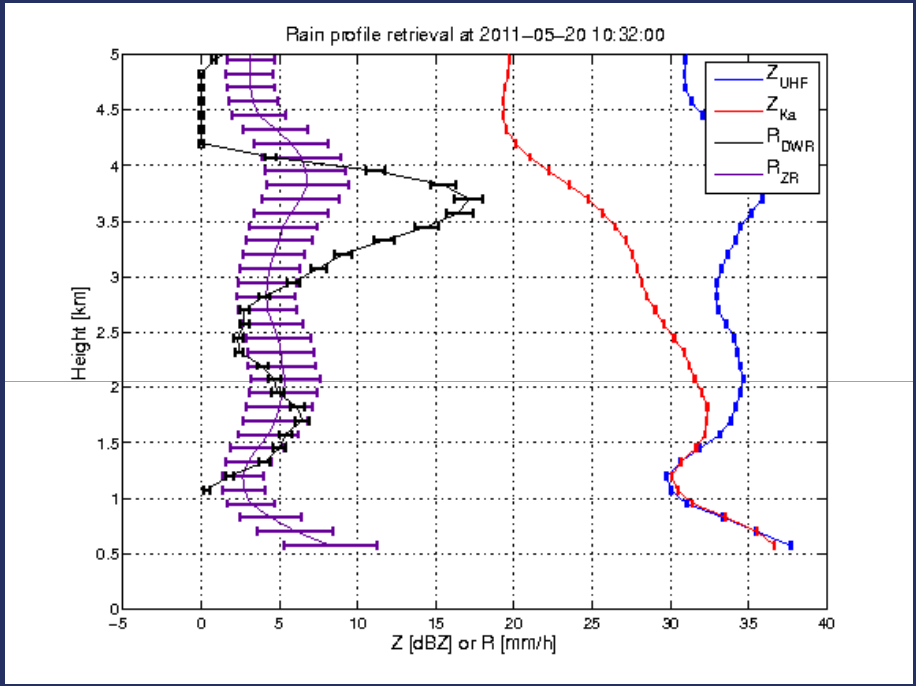


Example of individual profile – Effect of averaging

Average over 3 gates and 30 sec.



Average over 5 gates and 60 sec.



- Z-R retrievals have larger errors and the profile has a strongly different shape
- Effect of averaging:
  - Smoothing and reduction of error
  - No rainfall at 30 GHz → non-uniform rain? Saturation of K_a above 500 m?

Conclusions

- Dual wavelength technique to retrieve profiles of rain rate:
  - ARM UHF profiler in high resolution precipitation mode provides the reference non-attenuated reflectivity profiles
  - The deduced attenuation of the collocated ARM K_a band radar give a direct estimate of rain rate thanks to the close relation between attenuation and rain rate at this wavelength
- The retrievals are limited at high and low rain rates:
  - By complete extinction of K_a band signal (about 50 mm/h)
  - By the accuracy of retrievals at low reflectivities (about 2 mm/h)
- This range could be increased by using a similar technique at other attenuated wavelength:
  - W-band for low rain rates (available at ARM SGP facility)
  - K_u-band for high rain rates

Thanks for your attention
Questions?