

The Dual-Wavelength Radar Doppler Spectral Ratio technique

Disentangling Mie and attenuation effects in rain

Frederic Tridon

University of Leicester, Leicester, United-Kingdom

Alessandro Battaglia and Pavlos Kollias

Multi-wavelength radar techniques

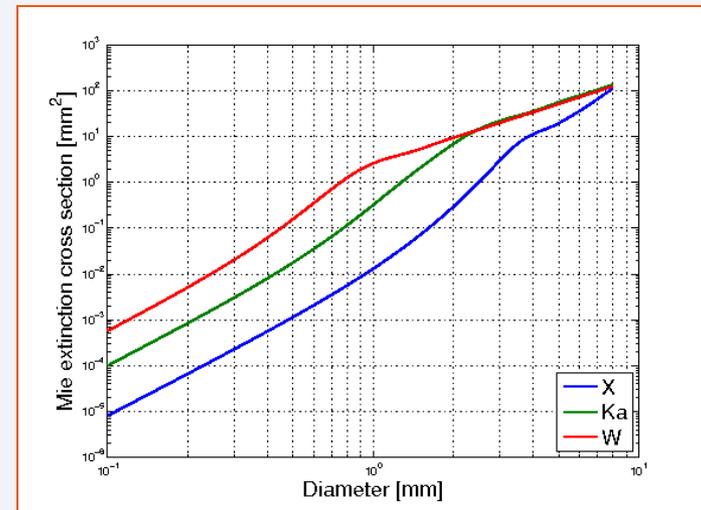
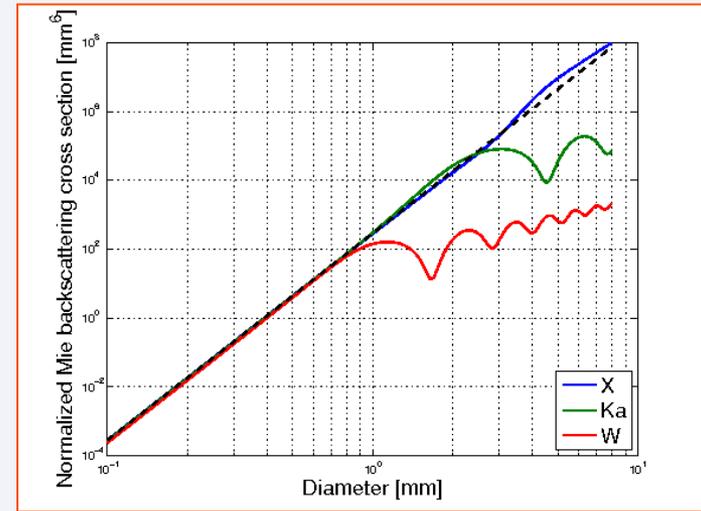
- Wavelength dependence of scattering and attenuation properties
 - Example of liquid phase at the X-, Ka- and W-bands

- Dual-Wavelength Ratio (dB):

$$\begin{aligned}
 DWR(r) &= Z_{m,\lambda_1}(r) - Z_{m,\lambda_2}(r) \\
 &= \underbrace{Z_{e,\lambda_1}(r) - Z_{e,\lambda_2}(r)}_{\text{Mie effect}} + \underbrace{2 \int_0^r \alpha_{\lambda_2}(s) - \alpha_{\lambda_1}(s) ds}_{\text{Attenuation effect}}
 \end{aligned}$$

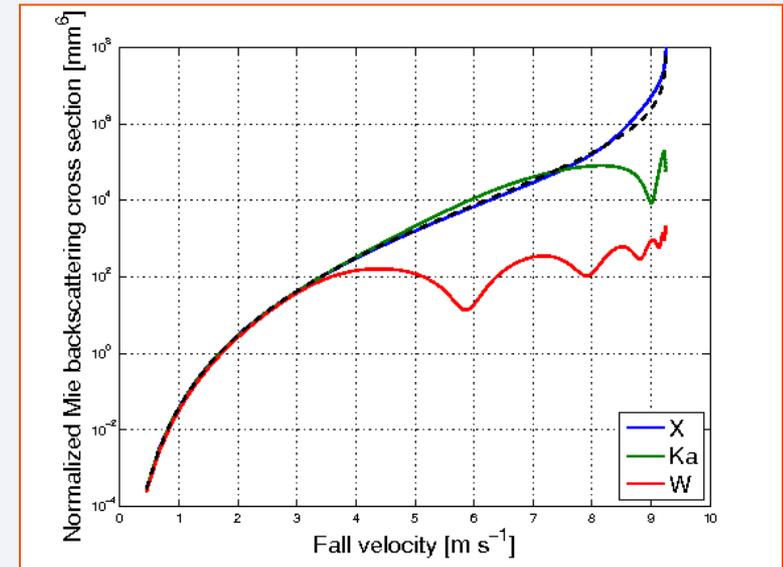
- Examples of dual-wavelength techniques:

- LWC retrieval from differential attenuation (in case of no Mie effects → stratocumulus clouds or light rain)
- Sizing from Mie effects (in case of negligible attenuation → ice clouds, light snow)



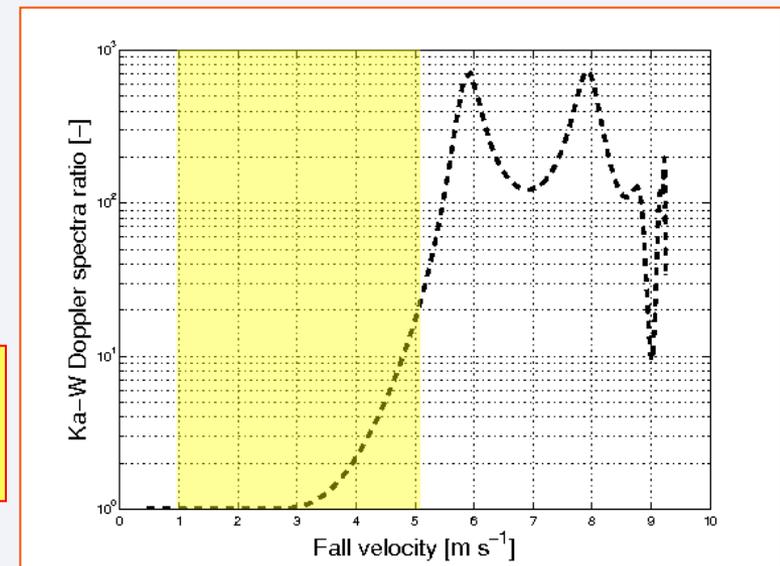
Case of rain with K_a -W band combination

- Scattering with the K_a -W band combination
 - Important differential attenuation
 - Important Mie effect: Rayleigh conditions not satisfied as a whole
 - But, smallest drops scatter in the Rayleigh regime \rightarrow their contribution on the DWR depends on differential attenuation only



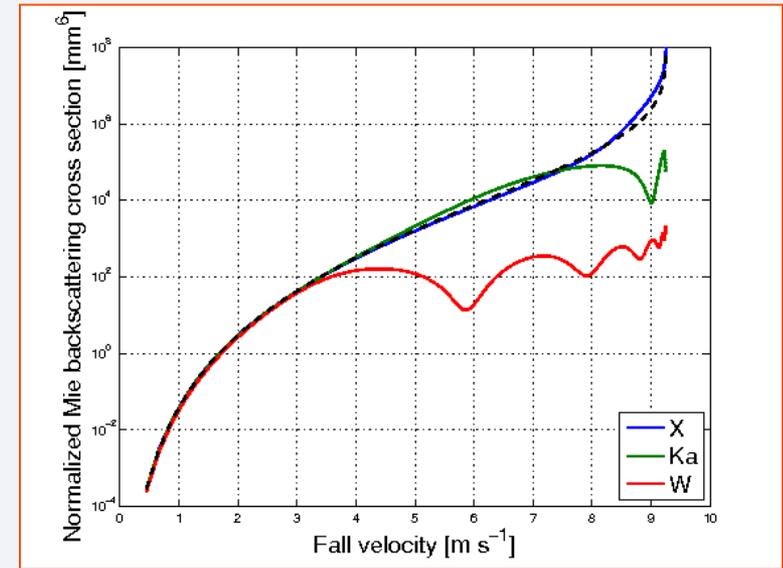
- Doppler spectra ratio (DSR)
 - Drops sorted according to their fall velocity and size with $V_t=f(D)$ (Atlas et al., 1973)
 - The DSR emphasizes the two scattering regimes
 - Rayleigh regime plateau
 - Mie region (with two peaks)

Quasi universal pattern



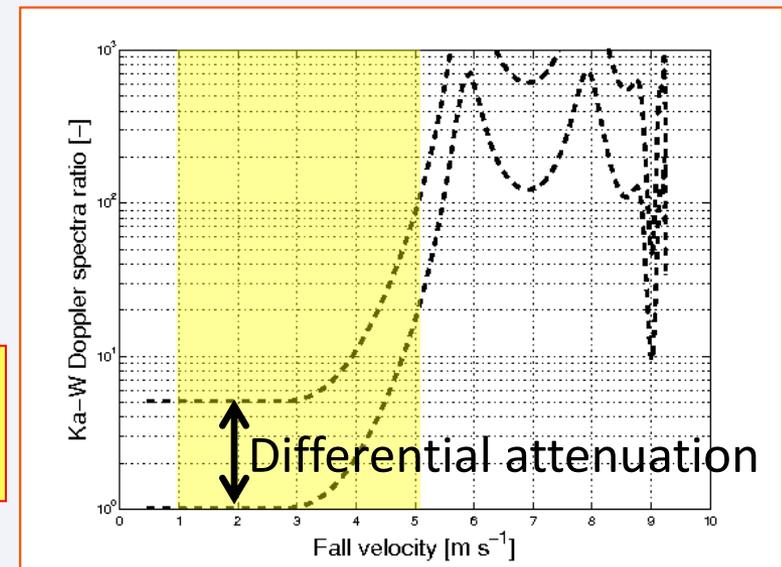
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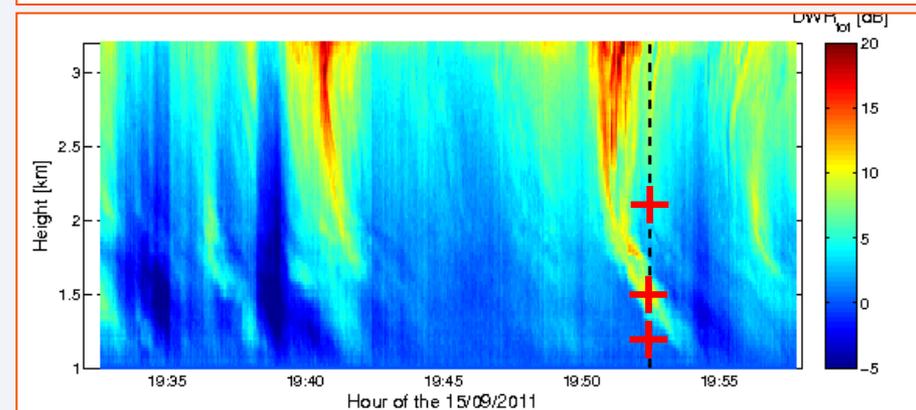
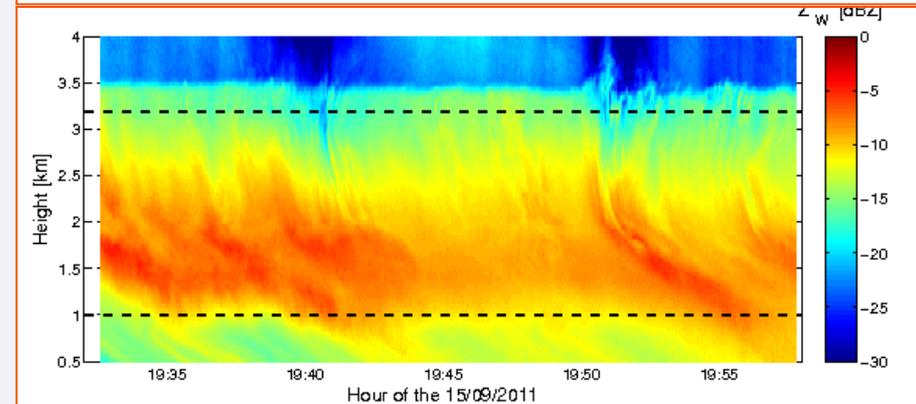
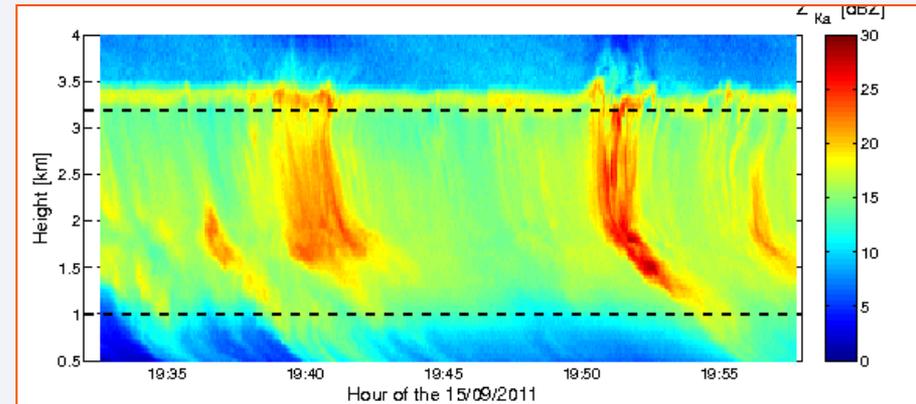
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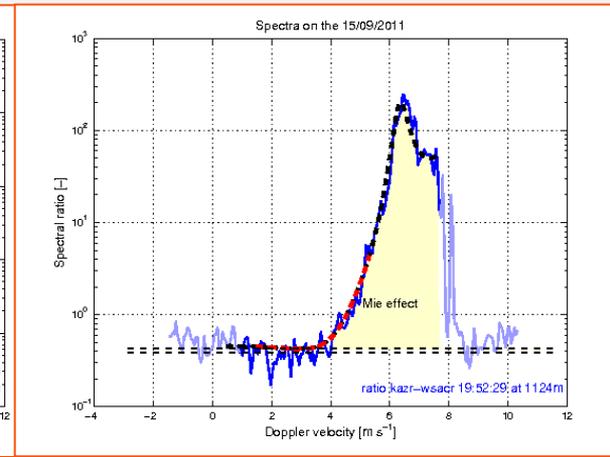
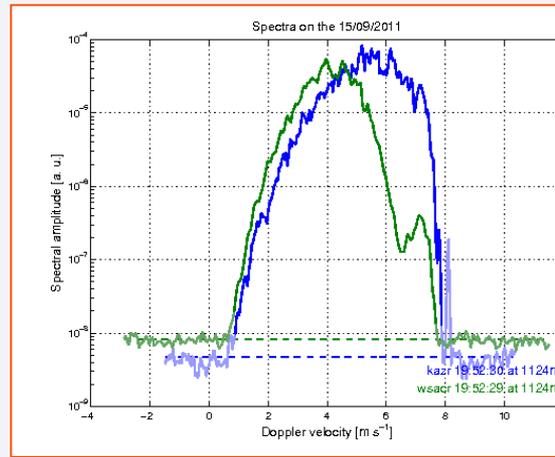
Light rain observed by ARM radars at SGP

- Need **well-matched beams** to avoid artefacts
- Light stratiform rain with higher Z fall-streak \rightarrow zoom to avoid BB and low SNR due to wind shear
- Dual wavelength ratio
 - increase with height because of rain and gas attenuation
 - except right above the fall-streak \rightarrow possible with important Mie effect in the fall-streak due to larger drops
- Check by looking at spectra



Observed DSRs

- Below the fallstreak
 - Spectra: Rayleigh vs. Mie
 - DSR
 - expected shape
 - focus on the SNR>5 dB part
 - fit → plateau level
 - comparison with 1 km level: differential attenuation
- In the fallstreak
 - Slightly larger attenuation
 - Important Mie effect
- Above the fallstreak



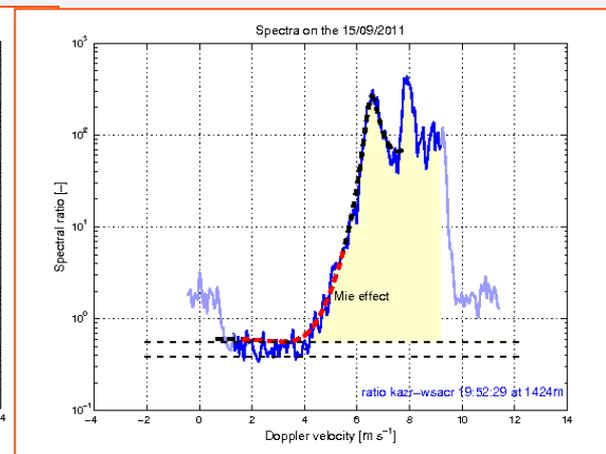
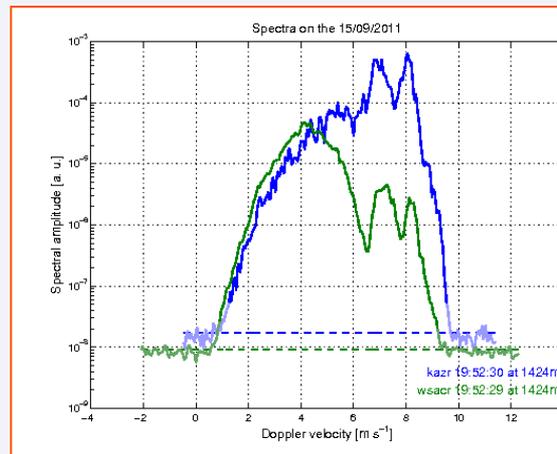
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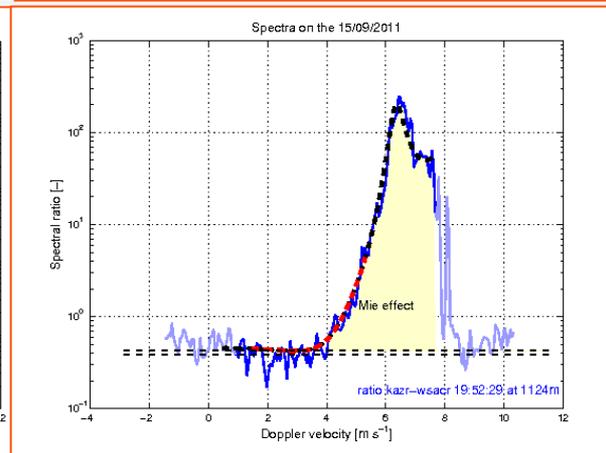
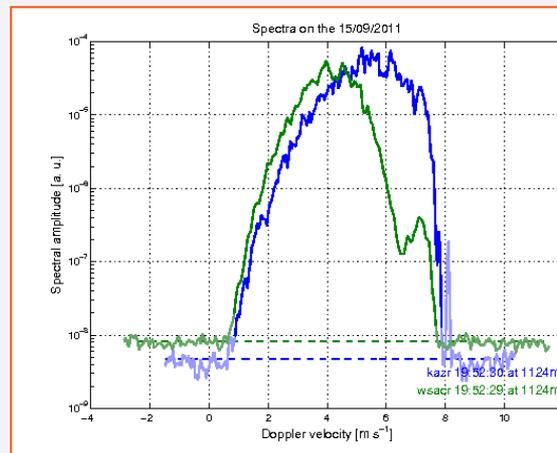


In the fallstreak

- Slightly larger attenuation

- Important Mie effect

Above the fallstreak



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- DSR

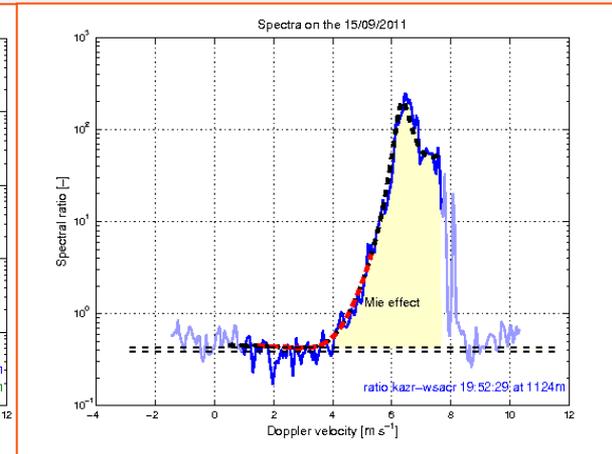
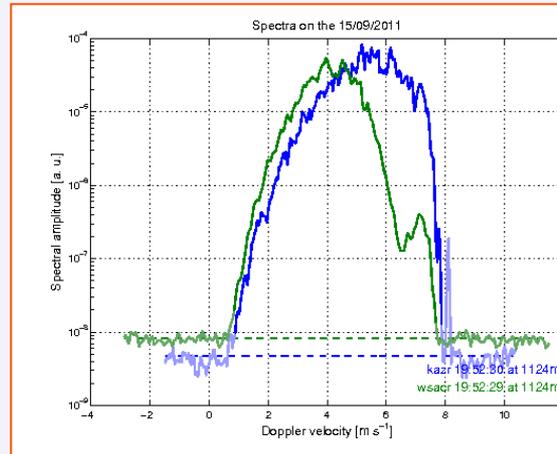
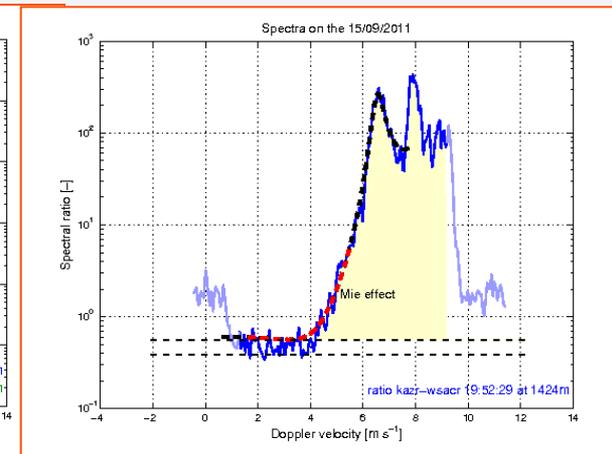
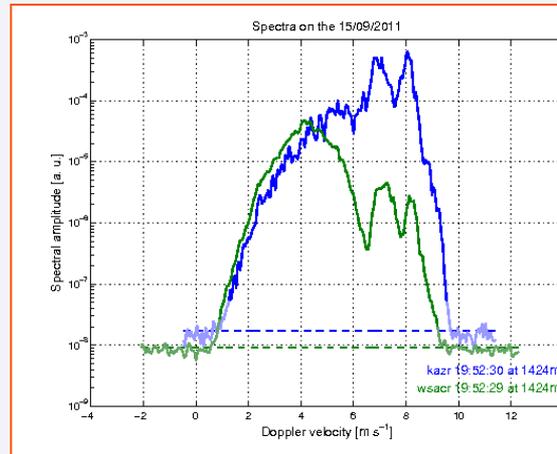
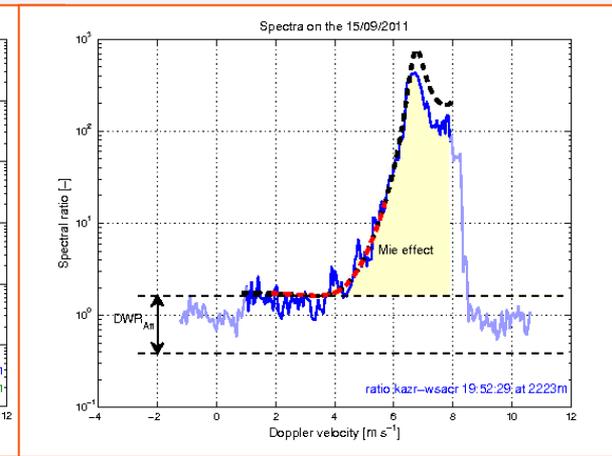
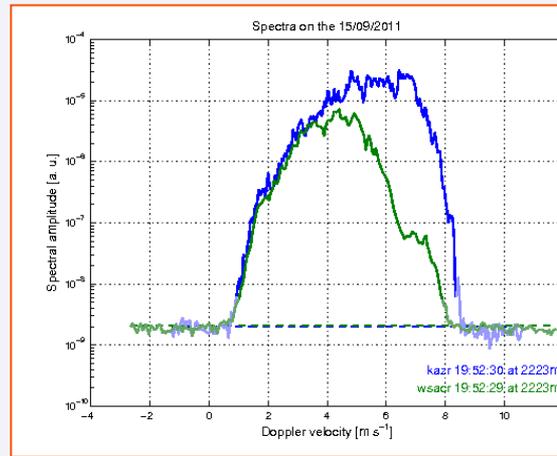
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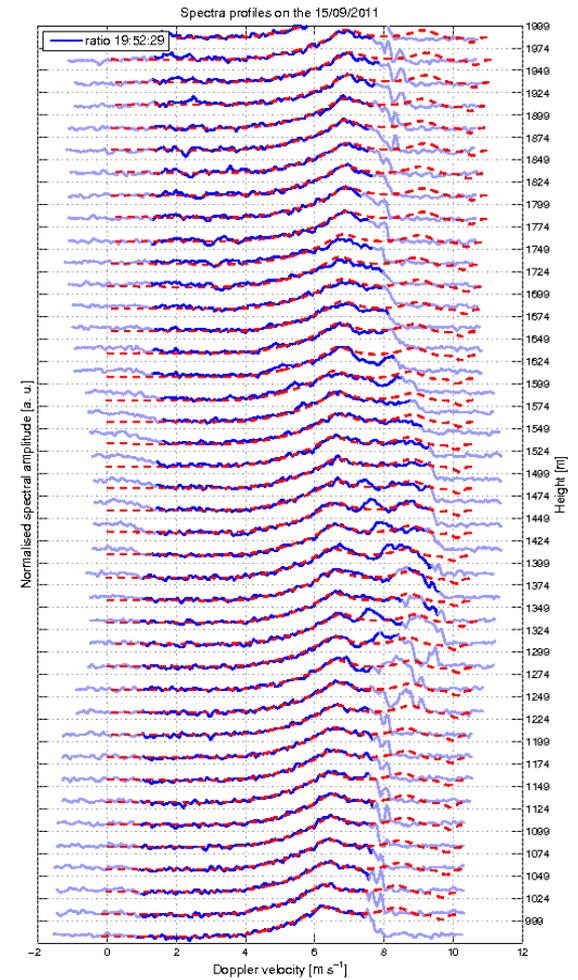
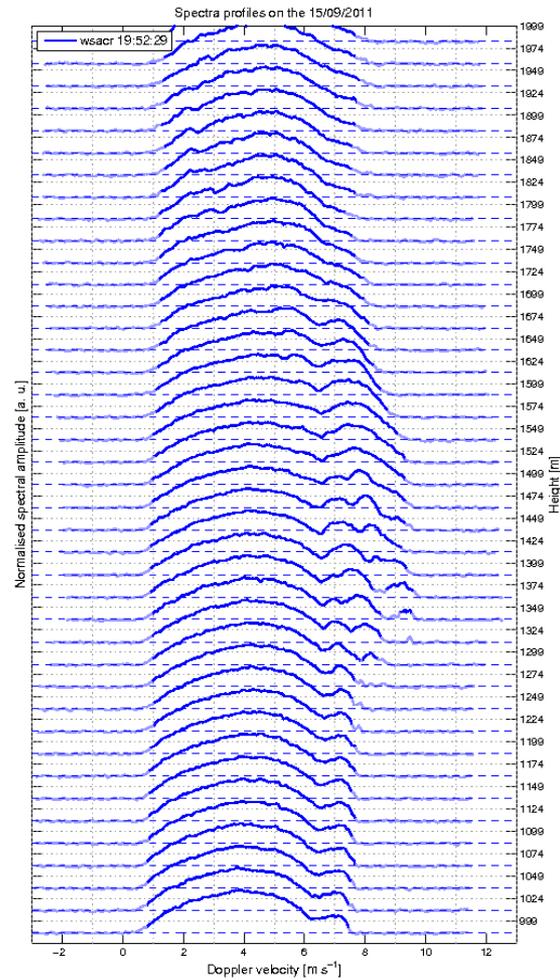
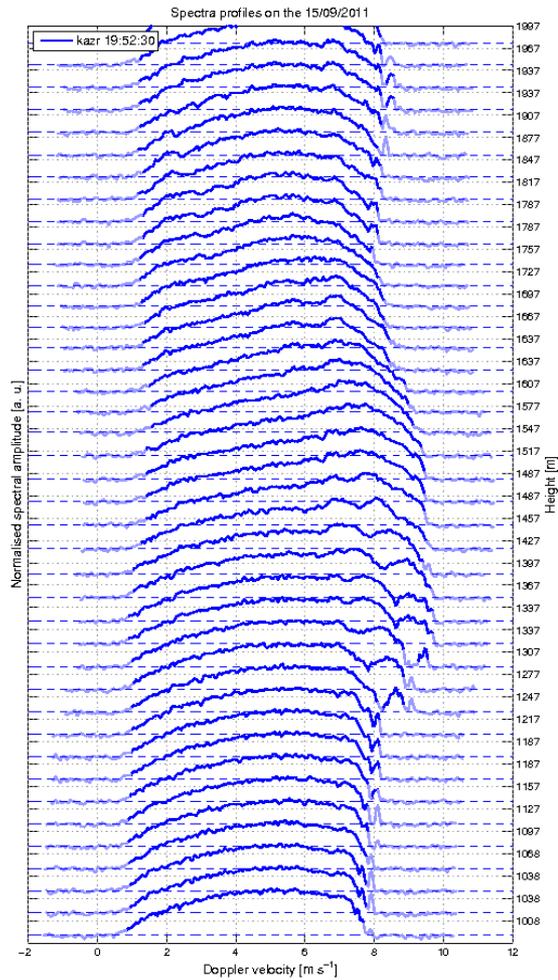
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Profile of K_a and W-band spectra and DSRs



K_a

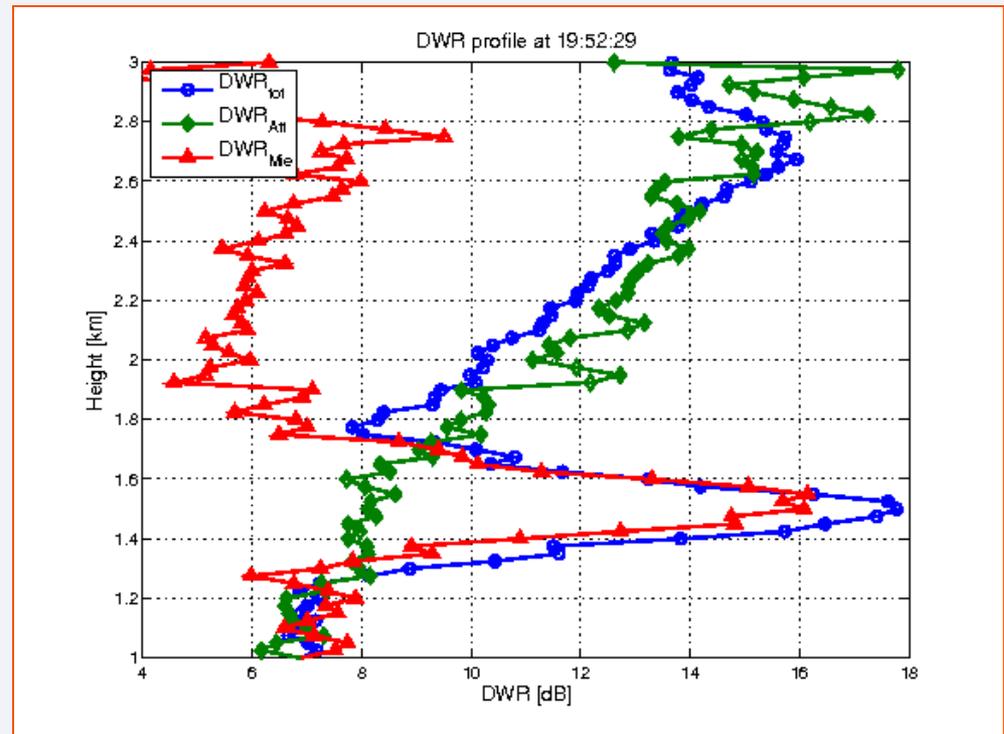
W

DSR

Full profile of DWR components

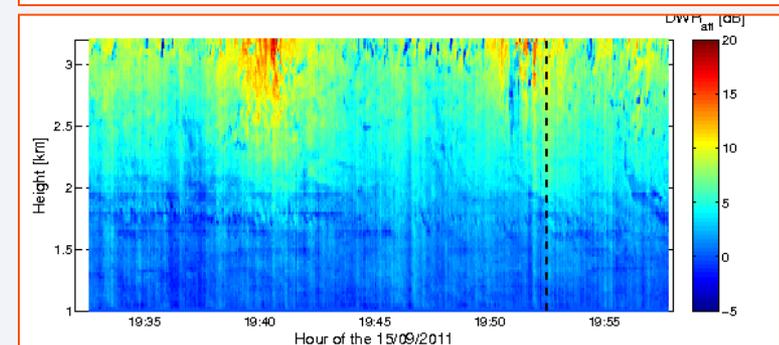
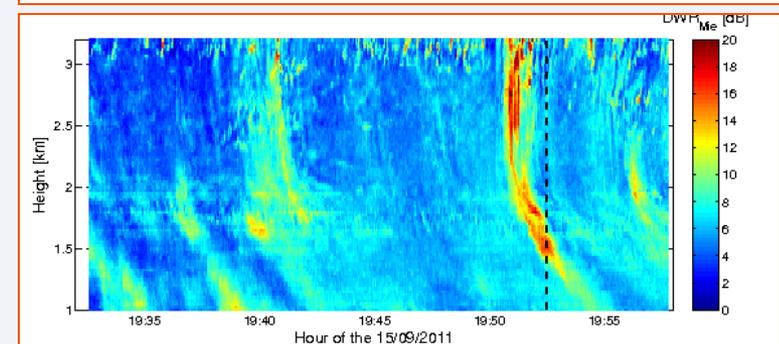
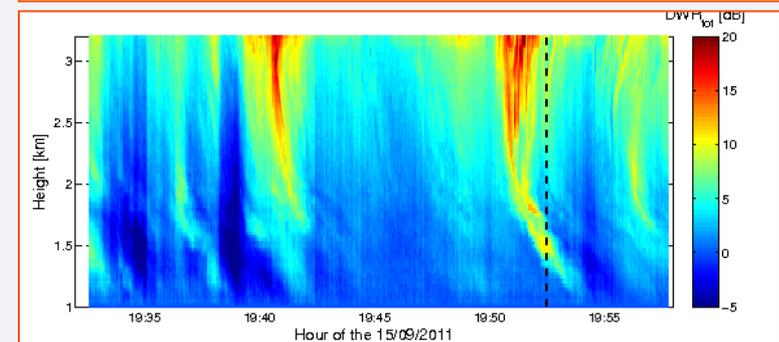
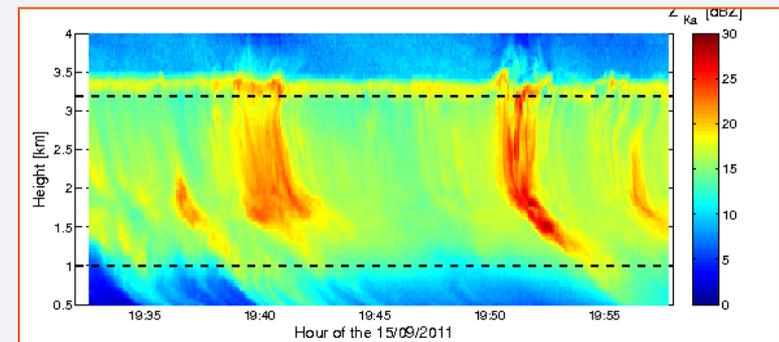
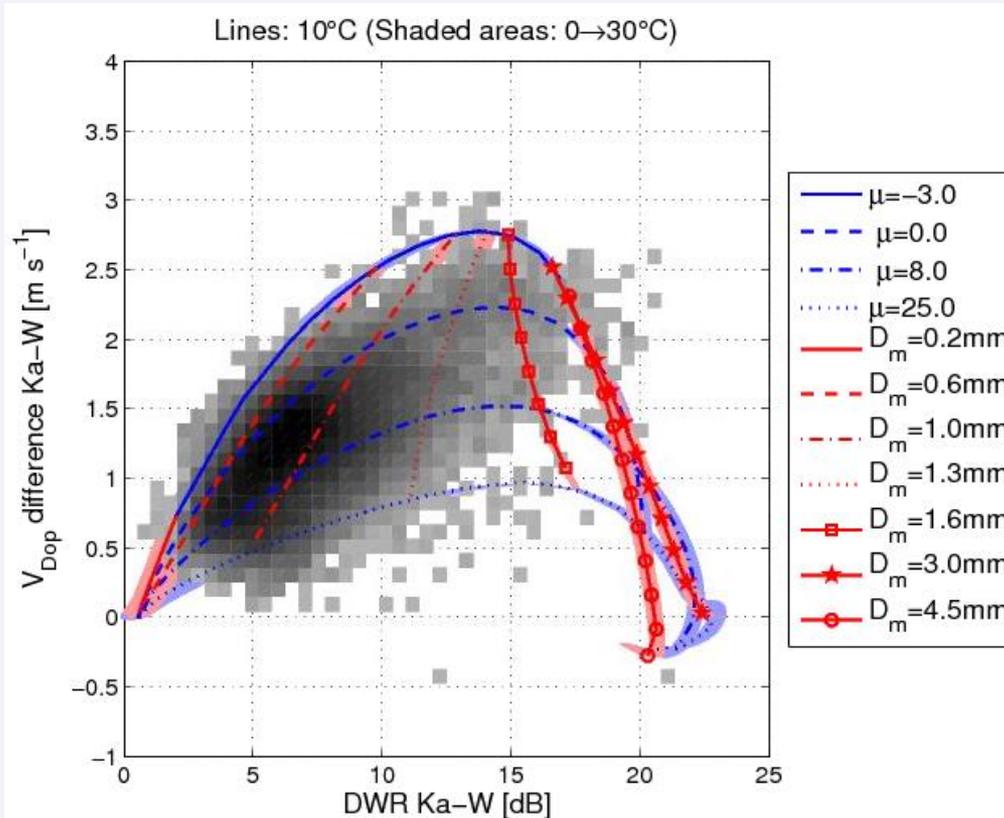
- DWR_{Tot} and DWR_{Att} are relative to the 1km level while DWR_{Mie} is absolute

- DWR_{Tot} increases with height with a peak at the fallstreak



- The peak is clearly due to Mie effects and DWR_{Att} increases regularly with height
- Product noisy (about 1dB accuracy) because of the stochastic nature of spectral measurements but with high resolution (2s, 25m) → temporal and vertical averaging possible

Results



- Self-consistency check with the differential Doppler velocity
- Published in Tridon et al. (2013), *Geophys. Res. Lett.*, 40

Conclusion and outlooks

- DSR technique was successful to disentangle Mie and attenuation effects in this low turbulence light stratiform rain
- D_m and RWC retrieval or full DSD retrieval
 - Statistical studies of DSD parameters (vertical evolution, μ - λ relations)
- Investigation of its potential in
 - Heavier rains (larger turbulence, more mismatch effect)
 - Drizzling stratocumulus (separation of Mie effect due to drizzle)
 - Snow or ice clouds: detection of attenuation due to supercooled layers

Thanks for your attention

Questions?