Ground-based Observations of Falling Snow Microphysical Properties; Applications to multi-frequency radar snowfall rate estimation

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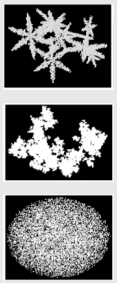
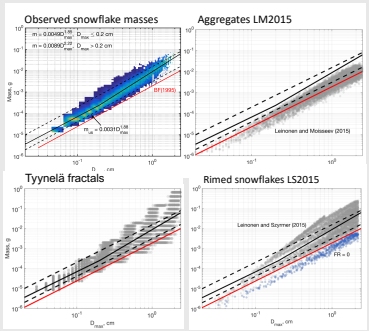
Ice particle models

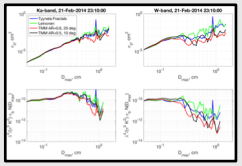


Tyynelä et al. (2011)

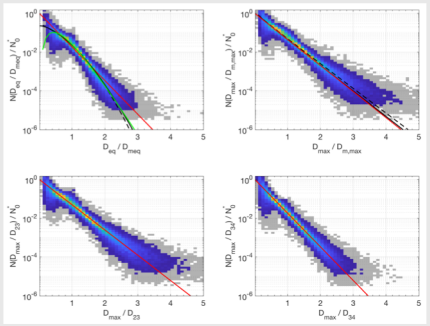


Retrieved masses of snowflakes observed at UH research station in Hyytiälä during two winters 2013/2014 and 2014/2015.

Masses and maximum dimensions of complex "realistic" ice particle models, aggregates, rimed aggregates and fractals.

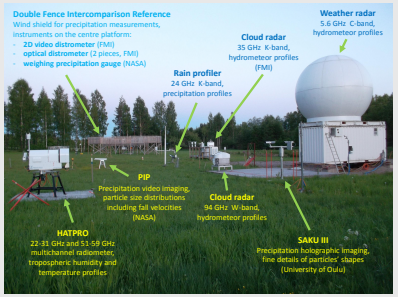


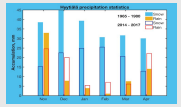
Different particle models and scattering computation methods result in different results at mm-wavelengths. The differences affect large snowflakes.



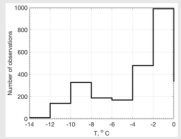
Normalized PSD in snowfall. If particle dimensions are described using equivalent melted drop diameter, generalized Gamma better describes the observations. If we are using mass weighted D_{max} or D_{23}, D_{34} the PSD is close to the inverse exponential form.

Measurement setup





Precipitation accumulation during winter months

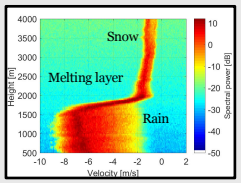


Air temperature during recorded snowfall

UH Hyytiälä Station (61.84 N , 24.29 E)
- ACTRIS Cloud profiling station
- Extensive precipitation measurements
- GPM GV site

Continuous snow microphysical and multi-frequency radar observations allows to test different particle scattering models.

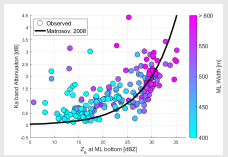
Melting layer attenuation

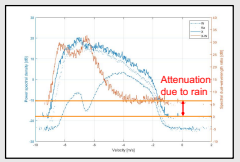


Spectral DWR below ML

Using spectral dual-wavelength ratio measurements at X and Ka bands in Rayleigh regime in rain and snow to estimate: calibration + attenuation (radome+rain) + ML attenuation

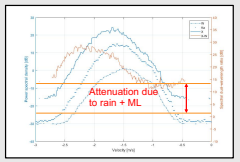
ML attenuation using X/Ka band radar Doppler spectra



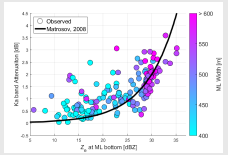


Spectral DWR above ML

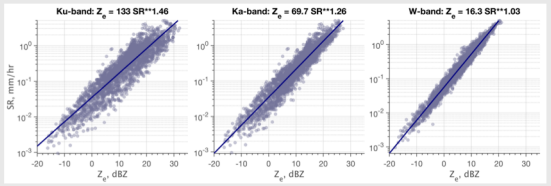
Using spectral dual-wavelength ratio in rain and comparing it to sDWR in snow ML attenuation is retrieved. It is compared to ML attenuation estimated by matching X, Ka band observations at ice cloud top



ML attenuation using Doppler spectra and cloud top observations

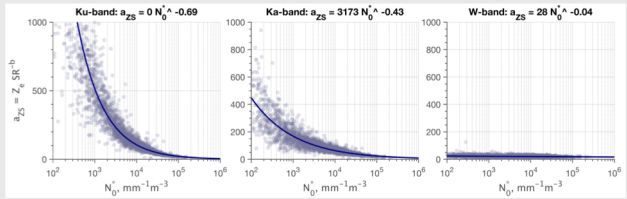


Multi-frequency radar snowfall estimate



Ku, Ka and W band Ze-S relations computed using 2 years of m(D) and PSD data and single-scattering tables of Leinonen et al and Tyynela et al.

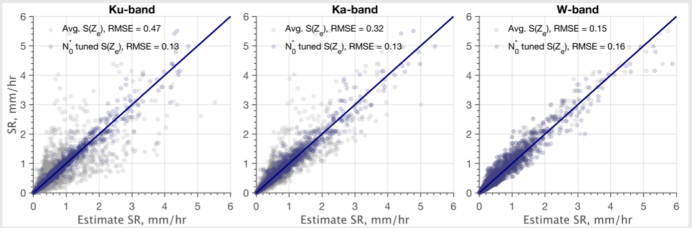
Dependence of the Ze-S relation prefactor on N_0^* for the three radar frequencies

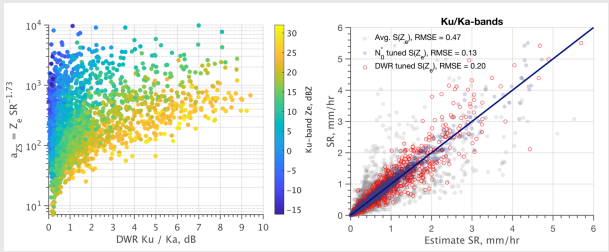


Instantaneous Ze-S relations. The exponents of the relations are computed by minimizing RMSE in the estimated snowfall rate. For Ku: b = 1.76, Ka: b=1.26, W: b=1.07

Best snowfall rate estimates at Ku, Ka and W band radar frequencies

Best possible snowfall rate estimates are computed by retrieving Ze-S prefactors using N_0^*





Multi-frequency radar observations can be used to adjust Z_e-SR relations leading to more accurate SR estimate.

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