Detection of Rimming in Stratiform Precipitation

Compatibility between 3-frequency Radar and Airborne in-situ Observations during OLYMPEX

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Objectives
Radar retrievals of full profiles of precipitation needed for evaluating CRMs 
main locks in the ice phase
The microphysical characterization of ice particles (size, shape, structure, PSDs, mass-size relation) from observations is still a challenge. Complex microphysics processes (deposition, aggregation, riming) strongly alter these properties.
Rimed and fluffy aggregates have distinct signatures at mm-wavelength radar frequencies 
optimal matching of multi-frequency radar observations for retrieving ice properties (Dw, IWC).
Study of a coordinated flight transect of triple-frequency radar and in situ measurements obtained during OLYMPEX (Houze et al., 2017).

Radar Scattering Tables
SSRGA with different mass-size relations according to the degree of riming (Hogan and Westbrook, 2014; Leinonen et al., 2018).

Case Study: 1st December 2015
Moist southwesterly flow from the Pacific ocean leading to widespread stratiform precipitation over the Olympic Peninsula. Coordinated northwest-northwest DC-8 (APR-3 K\textsubscript{r}/K\textsubscript{s}; W radar) and Citation (in-situ observations) transect from the Olympic Mountains range to the Pacific Ocean.

Airborne in-situ Observations
PSDs obtained via the combination of 2D S (225 mm<3<1 mm) and HVPS3 (1 mm<3<3.25 cm) probes. Calculation of IWC and Dw using the mass-size relations corresponding to unrimed, rimed and heavily rimed aggregates and low-density graupel \(\rightarrow\) large uncertainty on IWC.
Independent estimates from the Nevzorov probe and from a parameterization taking into account the fractal shape of crystals (Heymsfield, personal communication).

Forward Modelling of Z from in-situ
K\textsubscript{r}/K\textsubscript{s} best agreement with slightly rimed aggregates mass-size relation (SSRGA-L52015-B0p25km2).
W-band: the 2-5 dB overestimate can be explained by attenuation from possible supercooled liquid water.

Example of Retrieval on two Contrasted Profiles
Variational method applied profile by profile: find the best unknowns (WC and D\textsubscript{s}) profiles optimally matching the measurements (Z\textsubscript{tt}, Z\textsubscript{rr} and Z\textsubscript{vv} profiles) using a scattering table relating Z and attenuation to an exponential PSD. For simplicity, melting layer Z is not fitted while its extinction is parameterized as a function of the rain rate underneath.

Fluffy aggregates

Rimmed aggregates

Full leg Retrieval/Comparison
Good homogeneity between successive retrieved profiles. Confirmation that slightly rimed aggregates are present for the majority of the leg.

Conclusions and Perspectives
Triple-frequency radar measurements have the potential for retrieving a degree of riming of aggregates. This requires a single scattering table which depends on the mass-size relation. Future studies will focus on the retrieval of such a parameter and further investigate the error due to the presence of supercooled liquid water.

References:

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