Detection of Riming in Stratiform Precipitation

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

Frederic Tridon[1,2], A. Battaglia[1,2], R. Chase[3], J. Turk[4], S. Kneifel[5], J. Leinonen[4], K. Mroz[1,2], S. Tanelli[4], S. Nesbitt[3] and A. Heymsfield[6]

UNIVERSITY OF LEICESTER

Objectives

Radar retrievals of full profiles of precipitation needed for evaluating CRMs → main locks in the ice phase

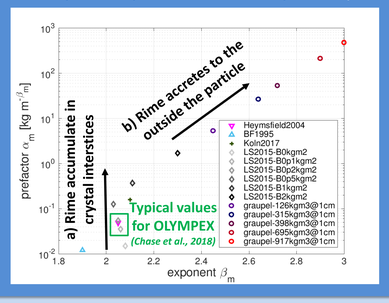
The microphysical characterization of ice particles (size, shape, structure, PSDs, mass-size relation) from observations is still a challenge. Complex microphysics processes (deposition, aggregation, riming) strongly alter these properties.

Rimed and fluffy aggregates have distinct signatures at mm-wavelength radar frequencies → optimal matching of multi-frequency radar observations for retrieving ice properties (D_m, IWC).

Study of a coordinated flight transect of triple frequency radar and in situ measurements obtained during OLYMPEX (*Houze et al., 2017*).

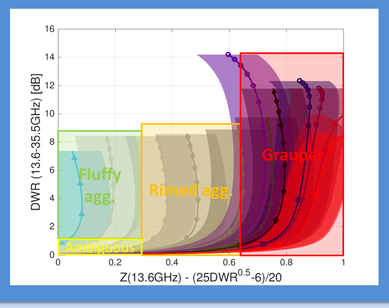
Radar Scattering Tables

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



Rimed Aggregates Classification

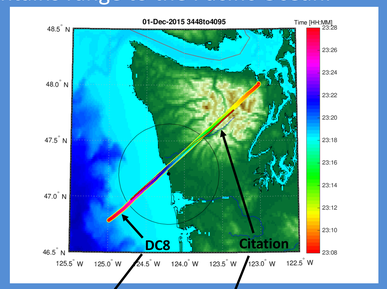
The K_u-K_a combination can be used to approximately detect zones of significant riming (*Tridon et al., in preparation*).

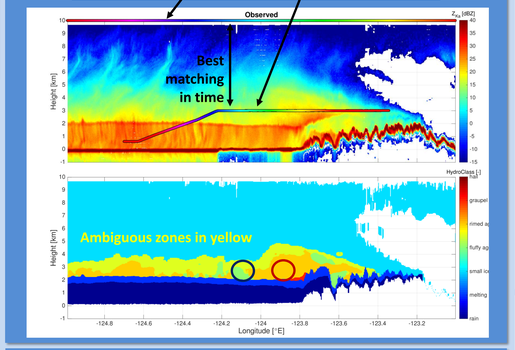


Case Study: 1st December 2015

Moist southwesterly flow from the Pacific ocean leading to widespread stratiform precipitation over the Olympic Peninsula.

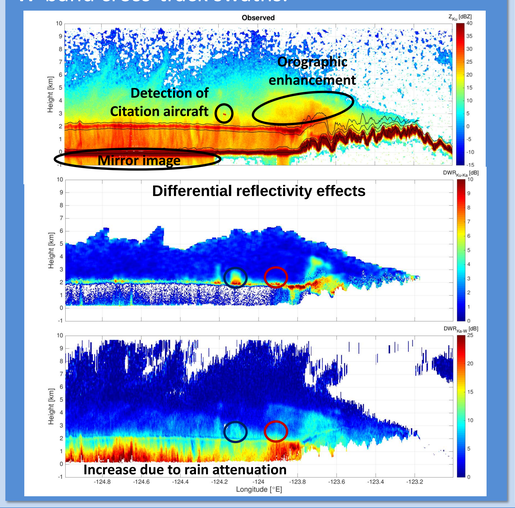
Coordinated northwest-northwest DC-8 (APR-3 K_u-K_a-W radar) and Citation (*in-situ* observations) transect from the Olympic Mountains range to the Pacific Ocean.





Radar Observations

Nadir curtains selected from APR-3 K_u, K_a and W-band cross-track swaths.

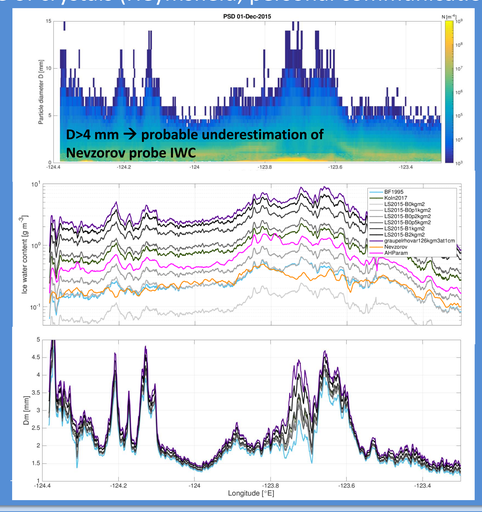


Airborne *in-situ* Observations

PSDs obtained via the combination of 2D-S (225 mm<D<1 mm) and HVPS3 (1 mm<D<3.25 cm) probes.

Calculation of IWC and D_m using the mass-size relations corresponding to unrimed, rimed and heavily rimed aggregates and low-density graupel → large uncertainty on IWC.

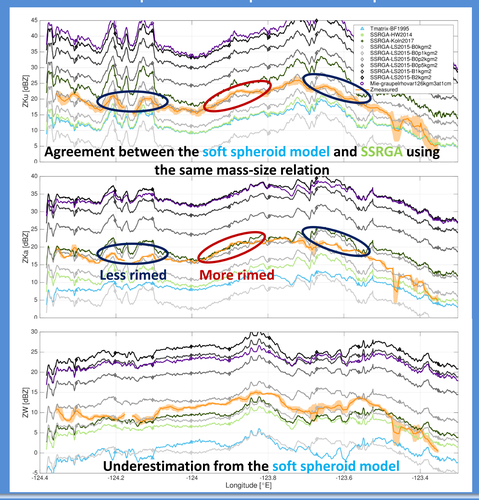
Independent estimates from the Nevzorov probe and from a parameterization taking into account the fractal shape of crystals (Heymsfield, personal communication).



Forward Modelling of Z from *in-situ*

K_u/K_a: best agreement with slightly rimed aggregates mass-size relation (SSRGA-LS2015-B0p2kgm2).

W-band: the 2-5 dB overestimate can be explained by attenuation from possible supercooled liquid water .

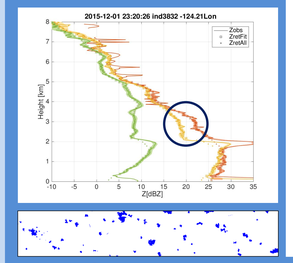


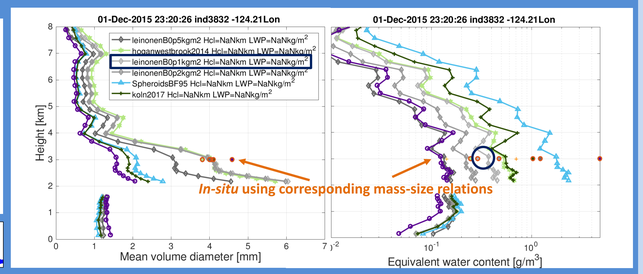
Example of Retrieval on two Contrasted Profiles

Variational method applied profile by profile: find the best unknowns (WC and D_m profiles) optimally matching the measurements (Z_{Ku}, Z_{Ka} and Z_W profiles) using a scattering table relating Z and attenuation to an exponential PSD.

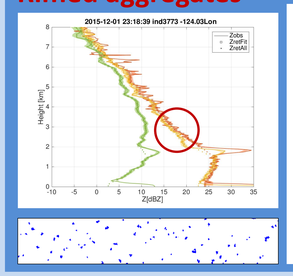
For simplicity, melting layer Z is not fitted while its extinction is parameterized as a function of the rain rate underneath.

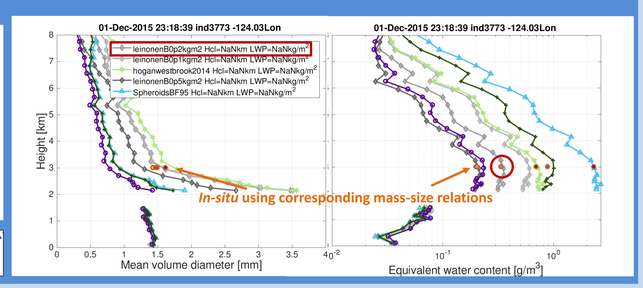
Fluffy aggregates





Rimed aggregates

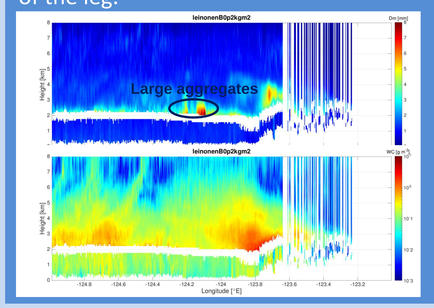


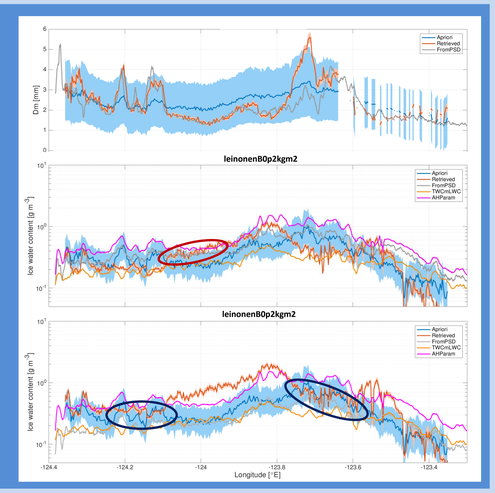


Full leg Retrieval/Comparison

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.

Affiliations:
[1]*Earth Observation Sciences, Department of Physics and Astronomy, University of Leicester, Leicester, United-Kingdom (Corresponding author e-mail: f.tridon@leicester.ac.uk)*
[2]*National Center Earth Observation, University of Leicester, Leicester, UK*
[3]*Department of Atmospheric Sciences, University of Illinois at Urbana–Champaign, Urbana, Illinois*
[4]*Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA*
[5]*Institute for Geophysics and Meteorology, University of Cologne, Cologne, Germany*
[6]*NCAR, Boulder, CO, USA*

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