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Profiles of stratiform precipitation during OLYMPEx: compatibility between 3-frequency radar and airborne in situ observations

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The link between stratiform precipitation microphysics and multi-frequency radar observables is thoroughly investigated by exploiting simultaneous airborne microwave remote sensing and in-situ observations collected from two aircraft during the OLYMPEx/RADEX (Olympic Mountain Experiment/Radar Definition Experiment 2015) field campaign. Above the melting level, in-situ images and triple-frequency radar signatures both indicate the presence of moderately rimed aggregates. Various mass-size relationships of ice particles and snow scattering databases are used to compute the radar reflectivity from the in-situ particle size distribution. At Ku and Ka band, best agreement with radar observations is found when using the self-similar Rayleigh-Gans approximation for moderately rimed aggregates. At W-band, a direct comparison is challenging because of the non-Rayleigh effects and of the probable attenuation due to ice aggregates and supercooled liquid water between the two aircraft. A variational method enables the retrieval of the full precipitation profile above and below the melting layer, by combining the observations from the three radars and from microwave radiometers. Even with three radar frequencies, the retrieval of rain properties is challenging over land, where the integrated attenuation is not available. Otherwise, retrieved mean volume diameters and water contents of both solid and liquid precipitation are in agreement with in-situ observations and indicate local changes of the degree of riming of ice aggregates, on the scale of 5 km. Finally, retrieval results are analysed to explore the validity of using continuity constraints on the water mass flux and diameter within the melting layer in order to improve retrievals of ice properties.