Automatic identification of the dominant microphysical processes in snowfall over the Antarctic coast using polarimetric radar observations

Noémie Planat¹, Josué Gehring², Etienne Vignon³, and Alexis Berne⁴

¹Environmental Remote Sensing Laboratory (LTE), Ecole Polytechnique Fédérale de Lausanne, Switzerland (noemie.planat@epfl.ch)
²Environmental Remote Sensing Laboratory (LTE), Ecole Polytechnique Fédérale de Lausanne, Switzerland (josue.gehring@epfl.ch)
³Environmental Remote Sensing Laboratory (LTE), Ecole Polytechnique Fédérale de Lausanne, Switzerland (etienne.vignon@epfl.ch)
⁴Environmental Remote Sensing Laboratory (LTE), Ecole Polytechnique Fédérale de Lausanne, Switzerland (alexis.berne@epfl.ch)

Microphysical processes in cold precipitating clouds are not fully understood and their parametrization in atmospheric models remains challenging. In particular, the lack of evaluation and validation of the microphysical parameterizations in polar regions questions the reliability of the ice sheet surface mass balance assessments. Recently, strong discrepancies have been found in the precipitation structure between simulations with different microphysical parameterizations over the Antarctic coast.

The dissimilarities between simulations seem to be due to different treatments of the riming, aggregation and sublimation processes.

Evaluating the representation of a particular microphysical process in a model is delicate, especially because it is difficult to obtain in situ estimations, even qualitative, of a given microphysical process. In this study, we developed a method to identify the regions in radar scans where either aggregation and riming, vapor deposition or sublimation are the dominant microphysical processes.

This method is based on the vertical (downward) gradients of reflectivity and differential reflectivity computed over columns extracted from range height indicator scans. Because of the expected increase in size and decrease in oblateness of the particles, aggregation and riming are identified as regions with positive gradients of reflectivity and negative gradients of differential reflectivity. Because of the expected increase in size and oblateness, vapor deposition is identified as regions with positive gradients of reflectivity and positive gradients of differential reflectivity. Because of the expected decrease in size and in concentration, snowflake sublimation, and possibly snowflake breakup, are defined as regions with negative gradients of reflectivity.
The method was employed on two frontal precipitation events, which took place during the austral summer APRES3 campaign (2015-2016) in Dumont d'Urville (DDU) station, Antarctic coast. Significant differences appear in the mean altitudinal distribution where each process takes place. Given that the radar signal extends up to 4500 m a.g.l., we could show that crystal growth dominates around 2800 m while aggregation and riming prevail around 1500 m. Sublimation mostly occurs below 900 m, concurring with previous studies stating that snowflakes preferentially sublimate in the relatively dry katabatic boundary layer.

Moreover the statistical distributions of different radar variables provides quantitative information to further characterize the microphysical processes of interest.

This method could be further used to assess the ability of atmospheric models to reproduce the correct microphysical processes at the correct locations.