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## Identification of snowfall microphysical processes from vertical gradients of polarimetric radar variables

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The accurate representation of snowfall is still a challenge for weather forecast and climate models. It mostly relies on the parameterization of microphysical processes that govern snowfall growth and decay. Recently, strong discrepancies have been pinpointed between different microphysical schemes in cold precipitations over Antarctica, questioning the reliability of surface mass balance assessments. A better understanding and an improved parameterization of these processes require the acquisition of observational data, which nonetheless remains difficult in polar or mountainous regions due to the remote location and harsh meteorological conditions.

Polarimetric radars offer continuous measurements of precipitation with a large spatial coverage, retrieving information about the microphysical processes that govern its evolution. This study presents a new method, called Process Identification based on Vertical gradient Signs (PIVS), to spatially identify the occurrence of the dominant microphysical processes (aggregation and riming, crystal growth, sublimation) governing snowfall evolution from polarimetric radar scans.

We first propose a theoretical framework to assess in which meteorological conditions a vertical analysis of the radar signal reflects the underlying microphysical processes. Then PIVS identifies aggregation and riming, crystal growth and sublimation based on the sign of the local vertical gradients of reflectivity ZH and differential reflectivity ZDR

We then applied our method on two frontal snowfall cases, one in Adélie land, Antarctica and one in the Taebaek mountains, South Korea. We successfully compare PIVS results with an hydrometeor classification and with snowflake observations using a Multi-Angle Snowflake Camera. In Antarctica, PIVS indicates that crystal growth dominates above 2500m a.g.l., aggregation and riming prevail between 1500m and 2500m a.g.l., and sublimation occurs mainly below, concurring with previous studies stating that snowflakes preferentially sublimate in the relatively dry katabatic boundary layer. In south Korea, the structure is similar although the altitudes are shifted, with aggregation and riming between 4000m and 4800m a.g.l., sublimation below and crystal growth above. Moreover, the statistical analysis of different radar variables provides quantitative information to further characterize the microphysical processes of interest.

Finally, we highlight further possible improvements of the method - notably the addition of complementary polarimetric variables - and illustrate the potential of PIVS to evaluate the microphysical schemes in numerical models.