

## **Forecasting and modelling ice layer formation on the snowpack due to freezing precipitations in the Pyrenees**

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In the Pyrenees, freezing precipitations in altitude occur at least once per winter, leading to the formation of a pure ice layer on the surface of the snowpack. It may lead to accidents and fatalities among mountaineers and skiers, with sometimes a higher human toll than avalanches. Such events are not predicted by the current operational systems for snow and avalanche hazard forecasting.

A crowd-sourced database of surface ice layer occurrences is first built up, using reports from Internet mountaineering and ski-touring communities, to mitigate the lack of observations from conventional observation networks. A simple diagnostic of freezing precipitation is then developed, based on the cloud water content and screen temperature forecast by the Numerical Weather Prediction model AROME, operating at 2.5-km resolution. The performance of this diagnostic is assessed for the event of 5-6 January 2012, with a good representation of altitudinal and spatial distributions of the ice layer. An evaluation of the diagnostic for major events over five winters gives good skills of detection compared to the occurrences reported in the observation database.

A new modelling of ice formation on the surface of the snowpack due to impinging supercooled water is added to the detailed snowpack model Crocus. It is combined to the atmospheric diagnostic of freezing precipitations and resulting snowpack simulations over a winter season capture well the formation of the main ice layers. Their influence on the snowpack stratigraphy is also realistically simulated.

These simple methods enable to forecast the occurrence of surface ice layer formations with good confidence and to simulate their evolution within the snowpack, even if an accurate estimation of freezing precipitation amounts remains the main challenge.