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High resolution wind field simulations explain local snow accumulation (snow dunes)

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The inhomogeneous snow distribution found in alpine terrain is the result of wind and precipitation interacting with the snow cover. In such complex terrain characteristic local wind flow patterns are induced by the topography. This results in the formation of distinctive maxima in the local seasonal snow depth. This general understanding is, however, difficult to quantify and predict because local wind fields are difficult to obtain with the necessary resolution and accuracy.

Our goal is therefore to achieve a better understanding for specific small scale deposition features of snow over complex terrain. In particular, we choose to examine two huge cross-slope snow dunes or cornices. We expect the mean flow pattern to give us insight into the formation of these locally predominant deposition features. While mean flow patterns have been used previously to explain mean snow depths at the ridge scale and larger scale deposition for glacier accumulation areas, this investigation looks at a scale of a few meters.

In contrast to most studies trying to explain snow depth variability due to drifting and blowing snow, we present an unique data set consisting of a high density network of automatic weather stations and LIDAR (TLS) measurements of snow depth at the Wannengrat area (Davos, Switzerland). In this study we compare measured wind data of several wind stations, distributed within the study area, against modeled wind fields. Wind fields were computed with the atmospheric model Advanced Regional Prediction System (ARPS). The applied numerical grid has a high horizontal resolution of 5 m and less. The vertical resolution at the first level above ground is up to 1.3 m. To measure snow distribution with a resolution of a few meters we use a Riegl LPM321 terrestrial laser scanner. Terrestrial laser scanning provides the possibility to gain area-wide, small scale data of snow cover and snow depth in the investigation area. Resolutions of less than 30 cm in horizontal and about 10 cm in vertical direction are available. We validated the accuracy of the laser data by comparing measurements with data gained in a Tachymeter survey. Measured snow distribution is available for the end of the accumulation season 2007/2008.

The results of the atmospheric flow modeling clearly show the flow features which cause the cross-slope cornices, which are measured with the laser scanner. It is shown that these cornices are not built by cross-ridge flow but by gradients of cross slope flow velocity due to smaller scale cross-slope ridges and negative vertical wind velocities. The modeled cross-slope flow was found to be very characteristic for westerly flow situations in the respective area and could be verified against measured wind features at the meteorological stations.