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Local Area Weather Radar in Alpine Setting

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Space-time variability of precipitation in orographically complex regions is a challenging research topic. The difficult accessibility of remote regions and the high elevations make difficult the operation of conventional raingauges and reduce the visibility of large scale radars. A solution to this limitation might be the use of a number of cost-effective short-range X-band radars as complement to raingauges and conventional, large and expensive weather radars.

This paper presents the results of a pilot experiment, which aimed at i) developing and assessing the performance of a cost-effective X-band Local Area Weather Radar (LAWR) located in the orographically complex Alpine region and ii) testing whether it could lead to better understanding of the nature of the precipitation process, e.g. identifying any possible dependence between precipitation and topography. The LAWR was deployed between August 2007 and October 2011 on the summit of the Kl. Matterhorn, located in the Swiss Alps at 3883 m a.s.l. (Valais, Switzerland). This was the first time that a cost-effective X-band radar was installed at such elevation and could be tested in operation-like conditions.

Beside the technological improvements that were necessary for a reliable functioning of the LAWR hardware, much effort went into the development of a set of radar corrections and into the design of a new Alpine Radar COnversion Model (ARCOM), which includes the algorithms necessary to convert radar received echoes into precipitation rates, specifically accounting for the presence of the pronounced topography. The ARCOM was developed and tested on the basis of a set of precipitation events for which precipitation was measured also by 43 automatic raingauges located within 60 km range from the radar antenna. Conversely to the state-of-the-art conversion models, ARCOM accounts not only for the seasonal climatological condition but also of geometric and orographic forcings such as partial beam filling and beam blocking.

The results showed that the LAWR systems and the newly developed ARCOM can be successfully deployed in high mountain settings. Indeed the experimental LAWR was able to measure precipitation in all its forms as well as its spatial variability. The ARCOM proved to be stable and robust across seasons, precipitation types and intensities, and to be able to account for the disturbances due to orography. The LAWR observations were additionally used to study the distribution of precipitation occurrences in relation to elevation and topography. The results show in most of the observed events precipitation occurs in this sector of the Alps significantly more often in a given range of elevations, regardless of the season and of the event type. This suggests the limitation of the assumption of positive gradient of precipitation with elevation, which is frequently used in hydrological modelling applications, and points to the importance of measuring more accurately the space-time distribution of precipitation in orographically complex areas for a correct representation of the hydrologic response of mountain watersheds.