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The space-time structure of radar rainfall in complex terrain

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The space-time structure in rainfall fields is affected by topography to the extent that topography influences the multitude of processes that lead to precipitation on the ground, e.g., orographic forcing of moist air flow, condensation, convective activity, wind speeds and directions, etc. One way to analyse the structure in space-time precipitation fields is to study the time evolution of cumulated rainfall fields from radar data. Rainfall organization leads to a scaling relationship between the spatial variance and time with a characteristic scaling exponent H which is indicative of the nature of the memory (short or long) in the data. Rodriguez-Iturbe et al. (1998) developed this technique to show that space-time rainfall from radar at a daily time resolution exhibited consistent scaling and long-term memory (H>0.5) over a rather flat area of the Arkansas-Red River Basin in the U.S.

In this paper we investigate whether the time evolution of cumulated rainfall fields from radar data may be used in topographically complex terrain to study if topography has a measurable effect on the space-time structure of rainfall and to quantify this effect. We apply the method of Rodriguez-Iturbe et al. (1998) to determine the scaling relationship and characteristic scaling exponent H between the spatial variance and mean of rainfall measured by radar on a 120x120 km domain centered on the main Alpine divide around Kl. Matterhorn, covering parts of Switzerland and Italy. The radar product we use is the 30-min precipitation depth estimated at the ground at a 1 km grid resolution from MeteoSwiss C-band radar for a continuous period of about one year. The altitude within the study domain ranges from 140 to 4520 m.

As a first step the exponent H was evaluated by subdividing the study domain into 5x5 sub-domains, each with a resolution of 24x24 km, and averaging. We found that the scaling relationship is consistent and that long-term memory is present (H=0.84). We then evaluated H separately for each realization in each sub-domain and correlated it with topographic attributes of the sub-domain, such as mean altitude, relief, dominant aspect, etc. We found that H was statistically significantly correlated with mean altitude, with higher H present at higher altitudes where local topographic features lead to singularities in the rainfall field which increase the variance. However, at the same time the total rainfall amount was not well correlated with altitude, which suggests that it is the organization of the space-time structure in rainfall, not simply rainfall amount that is affected by topography. This study contributes observational evidence to the effect of orography on rainfall and the utility of radar data to study the space-time structure of rainfall.