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An Objective Method to derive the variable height-dependence of precipitation

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Most mountain ranges of the world show a significant vertical gradient of precipitation. Besides the general problem of precipitation measurement in mountainous terrain, the basic problem in deriving the height dependence is the fact, that observing stations never are strictly vertically collocated. Hence we can only derive gradients along slopes, which consist of the (wanted) vertical but also of a horizontal gradient component. With the aid of the VERA (Vienna Enhanced Resolution Analysis) system, both components may be separated objectively. The key of this procedure is the splitting of the known precipitation at observing stations into a field distribution of a predescribed vertical and a horizontal function and a residual. A variational procedure allows to derive the strength (weight) of the vertical as well as of the horizontal component of the gradient and the residual part. The mathematical constraint is the smoothness condition of the residual, which is that part of the precipitation field, unexplained by the predescribed vertical and horizontal function. One can think of the latter as being the hypothetic precipitation field, which would exist, if no mountains were in that region. The analysis system can be run with different assumptions of the vertical as well as horizontal gradient function to test, which response is strongest.

The determination of the height dependence of precipitation in the larger Alpine area has been carried out in six-hourly intervals for one calendar year, to learn about its short term and spatial variability . The results clearly show, that in general there is a significant increase of precipitation with height. The increase, however is different between the Southern and Northern edges of the Alps and the inner Alpine region. The results furthermore show a seasonal dependence of the gradient and a variability with regard to the flow regime. Knowing such relations, one can also use the vertical functions to downscale precipitation fields from numerical weather prediction models.

The basic setup of the system, the results of the statistical evaluation of the one-year test phase and possible applications in a climatological, diagnostic real time as well as prediction mode is being discussed.