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Parameterization of elevation effects in short-duration precipitation analyses

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Hydrological forecast models require high-resolution, short-duration (typically 15 minutes to 1 hour) precipitation analyses and forecasts as part of their input. With regard to analysis, this information is usually provided by spatial interpolation of raingauge observations or by radar data, or through a combination of both. In complex terrain, there arises the additional difficulty of parameterizing elevation effects not resolved by the raingauges or the radar data. While regional variations of elevation dependence of monthly or annual precipitation have been thoroughly documented, especially in the Alps, it is unclear how to best 'translate' a given annual average elevation dependence into one applicable to individual 15-min analyses. By cross-validation for a typical northern Alpine upslope area (the Salzach catchment) it is shown that applying annual average height gradients leads to an increase in analysis error compared to station interpolation without height effects. However, if the elevation effect is parameterized as a function of precipitation rate, this error can be reduced substantially. It is shown that the form of the parameterization suggested by the observations conforms to what one would expect based on the physics of the orographic precipitation process (the seeder-feeder mechanism). At low precipitation rates, orographic precipitation is 'conversion-limited', thus increasing roughly linearly with precipitation rate. At higher rates, orographic precipitation becomes 'condensation-limited' thus leading to an additive rather than multiplicative orographic precipitation enhancement.