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Enhanced precipitation analysis in Alpine catchments by combining a meteorological analysis and nowcasting system with a hydrological model

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The quality of real-time flood forecasting systems in small Alpine catchments is highly dependent on the quality of precipitation input. Both the precipitation analysis (for updating the system states of the hydrological model) and the precipitation forecasts are important in this respect. In Alpine catchments, a significant part of the uncertainty in the precipitation input is due to its large spatial variability caused by terrain effects. Moreover, the heterogeneous topography strongly contributes to the small-scale spatial variability of precipitation.

In the presented study coupled runoff simulations between the INCA analysis and nowcasting system, and a conceptual distributed runoff model are performed in high spatial and temporal resolution. The long-term objective of this investigation is to improve the understanding and quality of precipitation fields as well as the forecast ability by feeding hydrological information back to INCA.

The nowcasting system INCA (Integrated Nowcasting through Comprehensive Analysis) algorithmically combines station observations and remote sensing data (radar, satellite) in order to provide meteorological analysis and nowcasting fields at high temporal (15 min) and spatial (1 km) resolution. In addition to point measurements from raingauges and radar data, a newly developed, intensity-dependent parameterization of the elevation-gradient of precipitation is used in this system. The need for a parameterization of elevation effects arises from the fact that in spite of the generally high raingauge density in Central Europe, their area-height distribution is such that medium and upper elevations are generally under-represented by measurements.

In the continuous hydrological model, the runoff processes are modeled through a cascade of storages. The model requires precipitation and temperature as meteorological forcings. In the presented study, for the reason of simplicity and data quality, offline-data is used. The model accounts for the processes of snow accumulation and melt, interception storage, evapotranspiration from vegetation, snow and soil, evolution of soil moisture, surface runoff, inter flow, base flow and zone routing. The spatial discretization is grid based, where upstream grid cells drain into downstream cells.

Since the continuous runoff simulation represents a closed water cycle on the Earth′s surface, the simulated runoff can be seen as the integral over the precipitation in a catchment over a certain period. By comparing the simulated and observed runoff on a long-term, seasonal and single event-basis, different elevation-dependency parameterization experiments can be performed and validated. Realizations of precipitation fields are generated in the INCA analysis system, depending on assumptions made for different height dependencies of precipitation, also taking into account flow patterns, weather situations or season. The basis for these assumptions is to some extent made by the analysis of measurements, whereas there are the mentioned limitations due to the sparse observation network.

The methodology is applied to the upper Enns and Steyr river catchments in the north-central Austrian Alps. This region is characterized by a high spatial variability of rainfall climate. The two selected catchments exhibit very different behavior in terms of geology, characteristics of runoff generation and height. Furthermore the relatively large number (>50) of high-resolution precipitation stations and discharge measurements prove to be a benefit to the investigation.

Results of the ongoing study show that the hydrological model is sufficiently sensitive for the validation of different realizations of precipitation fields, and that the tested variations of the height dependency of precipitation have a clear effect on runoff simulation. Further work aims at taking into account uncertainties in rainfall measurements, the hydrological model parameters and the implementation of a height dependency parameterization scheme which is a function of meteorological conditions.