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Distributed modelling of catchment hydrology using radar derived precipitation

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Current catchment scale hydrologic modelling efforts in Norway usually involve hourly or daily precipitation data obtained from a network of raingauges. There is often a mismatch between the spatial density of rainfall gauges and the spatial scale of precipitation events. Therefore the spatial distribution of precipitation inferred by interpolation of point observations in raingauges introduces errors due to the imprecise knowledge of precipitation distribution in space. A dense network of gauges, is available only for a few catchments. In the case of precipitation events with localized cells, even a dense network would not be adequate to capture the spatial pattern. With the inaccuracy of precipitation input often identified as one of the main sources of error in hydrologic simulations, the inability to obtain reliable precipitation over a catchment is a major bottle-neck. In recent years, however, the implementation of weather radars in Norway by the Norwegian Meteorological Institute has made radar a potential tool to improve estimation of precipitation between the raingauges and to detect localized events. In this study we investigated if spatially distributed estimates of precipitation derived from the radar measurements could provide more accurate and realistic streamflow predictions than those derived from a raingauge network.

The test catchment (3092 km2) used is located in central Norway. 3D reflectivity measurements from a C-band Doppler radar and hourly records from raingauges located within and around the catchment were used to derive two sets of distributed precipitation inputs with a spatial resolution of 1x1km. The catchment lies within 80-120km range from the radar. Given the sparseness of the radar network in Norway, each with an operational range of 240 km and hardly any of them overlapping, the choice of a test catchment at a range where range-dependent reflectivity measurement errors are present was intentional. The reflectivity measurements were corrected for errors due to beam-blockage and non-uniform vertical profile of reflectivity. The reflectivity measurements (Z) were converted to precipitation rates (R) using a Z-R relationship optimized through radar-raingauge comparison. The hydrologic model used for the simulation was event-based and implemented based on the principles of TOPMODEL. A GIS was used to delineate the stream network and sub-divide the study catchment into sub-catchment units. Overland flow and saturated subsurface flow generated within a sub-catchment was added as a lateral inflow to the corresponding stream reach. Kinematic channel routing carried the flow through the network of sub-catchments to the catchment outlet, providing capability for spatially distributed flow simulations.

The model was calibrated using hourly streamflow observations at the catchment outlet. Two sets of hourly streamflow simulations were carried out - one with gauge-derived precipitation and another with radar-derived precipitation. The precipitation events selected for simulation included both stratiform events with uniform spatial distribution and convective events with localized cells. The results were evaluated by comparing observed and simulated streamflows at four interior discharge gauges.