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Sensitivity of streamflow components to spatial variability of meteoreological forcing in high alpine watershed: application of a wireless sensor network

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A field campaign was conducted in a 20 km^2 high alpine catchment in the Swiss Alps, with a distributed sensor network, to investigate the impact of the catchment spatial variability and forcing parameters on stream flow generation and soil moisture. Twelve sensorscope weather and soil moisture stations were installed over a wide range of elevations and aspects to capture some aspects of the spatial variability of different hydrological parameters including: soil moisture, precipitation, air temperature, relative humidity, wind speed and direction, solar radiation and land-surface skin temperature. Streamflow discharge at the outlet of the catchment was monitored with high temporal resolution. Rainfall and air temperature were both influenced by spatial location where temperature was found to be related to morphological features of the catchment. Snow and ice melt streamflow components, which are particularly important in the Alps, display a diurnal trend of different amplitudes and duration declining throughout the summer. The long-term seasonal decreasing trend of the baseflow contribution to streamflow appeared to not be affected by catchment spatial variability. Summer and fall rainfall-runoff events were dominated by the highly spatial occurrence of convective rainfall events. To support the data analysis, streamflow was modeled using two models of different complexity: a 3D-spatially distributed model (GEOtop) and a lumped degree-day model. The GEOtop model proved to be more suitable for reproducing rainfall-runoff response, and the lumped model was at least as accurate to describe the snow melt. Initial conditions on snow depth over the catchment are necessary for spatially explicit models to simulate snow melt; however the lumped approach worked well simply knowing the average daily air temperature. The spatialy explicit model was successful in reproducing spatial and temporal soil moisture patterns, which are important in slope stability analysis. Spatially distributed models, though conceptually more appealing than the lumped, require a substantial amount of meteorological input which is typically not available in Alpine environments.