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High-resolution distributed evaluation of climate and anthropogenic changes on the hydrology of an Alpine catchment

Paolo Burlando and Simone Fatichi
ETH Zurich, Institute of Environmental Engineering, Zurich, Switzerland (paolo.burlando@ethz.ch)

A distributed long-term hydrological balance of the upper Rhone basin was investigated including forcing due to climate change and anthropogenic disturbances (reservoirs, river diversions and irrigated areas) simulated at an unprecedented level of detail for catchment of this size and complexity. We downscaled climate model realizations using a methodology that allows us to account for stochastic variability of climate. The analysis aimed to propagate until the middle of the 21st century climate change effects on streamflow from high elevation headwater catchments to rivers in the major valleys. The study highlights the importance of accounting for uncertainties represented by the internal (stochastic) variability of future climate forcing. This seems to be, at least up to the middle of the 21st century, as large as the climate signal and its quantification can be useful to drive adaptation policies in engineering design.

In the specific case of the Rhone basin, despite a large uncertainty induced by stochastic climate variability, we identified an elevation dependence of climate change impacts on streamflow with a severe reduction at high-elevation, due to the missing contribution of water from ice melt, and a strongly dampened effect downstream. A decrease of summer discharge and an increase of hourly-daily maximum flows appear as the most robust projected changes for the different parts of the catchment. However, it is unlikely that major changes in total discharge from the entire upper Rhone basin will occur in the next decades. Finally, changes in the natural hydrological regime imposed by the existing hydraulic infrastructure are likely larger than climate change signals expected by the middle of the 21st century in most of the river network.