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An application of seasonal prediction for estimating cryospheric resources in the Alps

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In order to allow management decisions related for example to water resources and tourism, developing seasonal projections of the state of cryospheric resources (snow cover and glaciers) in the Alps is a desirable goal. We describe the development of a modelling chain in which seasonal forecast variables produced by the C3S seasonal prediction system are downscaled to three selected instrumented sites, close to five Alpine glaciers, in the North-Western Italian Alps and used as input for a physically-based multi-layer snowpack model (Snowpack; Lehning et al. 2012) and an empirical glacier model (Peano et al. 2016), calibrated with historical data. A stochastic downscaling procedure is used for precipitation data in order to allow an estimate of uncertainties linked to small-scale variability in the forcing. The downscaled input data, which in addition to precipitation and near-surface air temperatures include radiative fluxes, wind and humidity, are bias corrected and their seasonal variations are validated against observations from the measurement stations. After using the same data as input for the cryospheric models, we evaluate uncertainties affecting the skill of the modelling chain in predicting the winter evolution of the snowpack and glacier frontal variations in hindcast simulations, comparing against historical measurement data of glacier mass balance and length changes, and with snow depth and snow water equivalent measurements by automatic stations in the study areas. The chain is tested considering seasonal forecast starting dates in November and May which are relevant for the snowpack and glacier processes respectively. The sensitivity of the models to the spatial and temporal resolution and the accuracy of the input variable will be discussed.

• Lehning et al., 2002. A physical SNOWPACK model for the Swiss avalanche warning, Part II. Snow microstructure, Cold Regions Science and Technology 35, 2002, 147–167.
• Peano, D., Chiarle, M., & von Hardenberg, J. (2016). A Minimal Model Approach for Glacier Length Modeling in the Western Italian Alps. Geografia Fisica e Dinamica Quaternaria, 39(1), 69–82.