

Projections of meteorological and snow conditions in the Pyrenees using adjusted EURO-CORDEX climate projections

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Current and future availability of seasonal snow is a recurring topic in mountain regions such as the Pyrenees, where winter tourism and hydropower production are large contributors to the regional revenues in France, Spain and Andorra. Associated changes in river discharges, their consequences on water storage management, the future vulnerability of Pyrenean ecosystems as well as the occurrence of climate-related hazards such as debris flows and avalanches are also under consideration.

However, to generate projections of snow conditions, a traditional dynamical downscaling approach featuring spatial resolutions typically between 10 and 50 km is not sufficient to capture the fine-scale processes and thresholds at play. Indeed, the altitudinal resolution matters, since the phase of precipitation is mainly controlled by the temperature which is altitude-dependent. Moreover, simulations from general circulation models (GCMs) and regional climate models (RCMs) suffer from biases compared to local observations, and often provide outputs at too coarse time resolution to drive impact models. RCM simulations must therefore be adjusted before they can be used to drive specific models such as land surface models.

In this study, time series of hourly temperature, precipitation, wind speed, humidity, and short- and long-wave radiation were generated over the Pyrenees for the period 1950-2100, by using a new approach (named ADAMONT for ADjustment of RCM outputs to MOuNTain regions) based on quantile mapping applied to daily data, followed by time disaggregation accounting for weather patterns selection. Meteorological observations used for the quantile mapping consist of the regional scale reanalysis SAFRAN, which operates at the scale of homogeneous areas on the order of 1000 km² within which meteorological conditions vary only with elevation. SAFRAN combines large-scale NWP reanalysis (ERA40, ARPEGE) with in-situ meteorological observations. The SAFRAN reanalysis is available over the entire Pyrenean chain since 1980. Outputs from EURO-CORDEX simulations spanning 6 different RCMs forced by 6 different GCMs under 3 representative concentration pathways scenarios (RCP 2.6, 4.5 and 8.5) over Europe were downscaled at the massif scale and for 300 m elevation bands and statistically adjusted against the SAFRAN reanalysis. These corrected fields were then used to force the SURFEX/ISBA-Crocus land surface model over the Pyrenees. Here we present as an example a reanalysis and future projections (using adjusted EURO-CORDEX data) of meteorological and snow conditions obtained using this method at the site of La Mongie in the French Pyrenees, which we compare to in-situ observations carried out since the 1970s. These results further enable us to identify and apportion the main drivers for changes in snow conditions at the site, and the various uncertainty components at play. This work is a direct contribution of the French GICC ADAMONT project, and of the Interreg project “Clim’Py”, aiming to develop the Pyrenean Observatory of Climate Change.