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Reproducing snow making strategies with deterministic modeling and image-based validation

P. Allamano, P. Claps, and D. Poggi
Politecnico di Torino, DIATI, Torino, Italy (paola.allamano@polito.it)

Almost all winter resorts rely on artificial snow production as a surrogate for natural snow when the natural snow cover is missing or inadequate. The sustainability of snowmaking practices represents a debated issue, with two contrasting views: on the one hand the need for enhancing the value of mountain regions in terms of touristic appeal; on the other hand, the question whether the production of artificial snow is sustainable from an environmental point of view.

We present here the outcomes of a pilot study aimed at assessing the impact of snowmaking practices on water resources management in the Gressoney valley. The study area is located in the Aosta Valley (North-Western Italy). The total area covered by ski runs is of about 95 ha, with an elevation range of 2000 m and an average snow production over the last 5 seasons of 200.000 m^3 of water per year. Daily records of water volume used for artificial snow making were made available by the ski runs administrators for the last 5 seasons along with webcam images taken for the last 2 years. Daily meteorological records (of temperature and precipitation) were retrieved in 5 meteo stations within the district area since 1928 (83 years).

The snowpack evolution in the skiable domain is modeled by means of a distributed water balance model which adopts a radiation-temperature index representation to describe snowmelt, and accounts for the topographic complexity of the area by modeling radiation over a very fine terrain grid (10 by 10 m cells). The model requires distributed daily temperature and precipitation as inputs. The snowmelt module is calibrated locally at the five stations. The snow-making module, aimed at synthesizing the production strategies at the district scale, is calibrated by keeping the required average snow cover depths on the ski runs as a free parameter.

After calibrating the model parameters, also with the aid of visual comparison of modeled and real snow patterns registered by the webcams, we were able to reconstruct the seasonal evolution of natural and artificial snow cover over the whole district since 1928. A 83 years-long synthetic record of seasonal volumes potentially allocated for artificial snow production was obtained and a preliminary evaluation of the probability to have insufficient resource to face both domestic and snow production needs was performed. The system was found to have a 10% probability of deficiency, with deficit volumes ranging from 10.000 to 100.000 m^3.