

## Crossing physical simulations of snow conditions and a geographic model of ski area to assess ski resorts vulnerability

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In order to face climate change, meteorological variability and the recurrent lack of natural snow on the ground, ski resorts adaptation often rely on technical responses. Indeed, since the occurrence of episodes with insufficient snowfalls in the early 1990's, snowmaking has become an ordinary practice of snow management, comparable to grooming, and contributes to optimise the operation of ski resorts. It also participates to the growth of investments and is associated with significant operating costs, and thus represents a new source of vulnerability. The assessment of the actual effects of snowmaking and of snow management practices in general is a real concern for the future of the ski industry.

The principal model used to simulate snow conditions in resorts, Ski Sim, has also been moving this way. Its developers introduced an artificial input of snow on ski area to complete natural snowfalls and considered different organisations of ski lifts (lower and upper zones). However the use of a degree-day model prevents them to consider the specific properties of artificial snow and the impact of grooming on the snowpack. A first proof of concept in the French Alps has shown the feasibility and the interest to cross the geographic model of ski areas and the output of the physically-based reanalysis of snow conditions SAFRAN – Crocus (François et al., CRST 2014).

Since these initial developments, several ways have been explored to refine our model. A new model of ski areas has been developed. Our representation is now based on gravity derived from a DEM and ski lift localisation. A survey about snow management practices also allowed us to define criteria in order to model snowmaking areas given ski areas properties and tourism infrastructures localisation. We also suggest to revisit the assessment of ski resort viability based on the "one hundred days rule" based on natural snow depth only. Indeed, the impact of snow management must be considered so as to propose reliability indices that are both physically and socio-economically meaningful.

Our contribution proposes to present these works in the context of a test resort in the French Alps and its snow conditions during the period 2000-2012. In order to show the impact of different management practices three configurations are considered: natural snowfalls, groomed natural snowfalls and managed snow (natural and artificial snowpack combined with grooming) and discuss the implications of the results in terms of the assessment of the climate vulnerability of ski resorts.