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Sensitivity of snow cover spatio-temporal dynamics to the spatial distribution of meteorological forcings in a mid altitude alpine catchment: model analysis

Aniket Gupta, Didier Voisin, and Jean-Martial Cohard
Institut des Géosciences de l'Environnement (IGE), Université Grenoble Alpes

Mountainous catchments play an important role in water regulation as they store water along winter time and release it when snow melts several months after precipitations. Mid-altitude catchments are more prone to respond to climate changes as snow cover dynamics is directly impacted by temperature changes. Along with large scale precipitation events snow cover dynamics is also driven by small scale terrain characteristics which impact deposition, wind transport, melting through distributed solar insolation along slopes. These highly characteristic patterns impact snow cover dynamics significantly and the hydrological response even in small catchments.

This study focus on a small mid altitude alpine catchment at Col du Lautaret (France) which is a 15.28 ha subalpine catchment with the elevation range between 2000-2200 meter, typically 5-6 months period of full snow coverage over a grass dominated vegetation. Over this catchment, we simulated the impact of small scale snow spatial variability on the water cycle with the surface-subsurface coupled hyper-resolution distributed hydrological model ParFLOW/CLM. It consisted in several meteorological forcing scenarios prescribed to the model including distributed (2D) or non-distributed (1D) precipitation, solar radiation and wind. The model is able to simulate the snow cover distribution through the CLM energy balance module according to a combination of these forcings. The water transfers are then calculated through the Richards and kinematic wave equations following the ParFLOW formulation.

2D forcings induce a more spatially heterogeneous snowpack, which becomes patchy at the melt season. This asynchronous melt results in a longer melt period and a smoother hydrological response. However, 1D forcings do not generate such patchiness. Amongst the mechanisms responsible for the 2D distribution of the forcings, precipitation redistribution is the most important. Solar insolation distribution ads to the differential melting and wind distribution is not very important as a primary agent on the surface energy budget, but is important as it impacts precipitation redistribution in the watershed, which we treated separately.