Implementation of vapour diffusion and isotopes in the Crocus snowpack model

ALEXANDRA TOUZEAU[1*], SAMUEL MORIN[2], AMAELLE LANDAIS[1], LAURENT ARNAUD[3], GHISLAIN PICARD[4]

[1]LSCE, CNRS UMR8212, UVSQ, Université Paris-Saclay, Gif-sur-Yvette, France (*correspondence: alexandra.touzeau@lsce.ipsl.fr; amaelle.landais@lsce.ipsl.fr)
[2]Météo-France - CNRS, CNRM UMR3589, CEN, Grenoble, France (samuel.morin@meteo.fr)
[3]LGGE, CNRS UMR5183, Univ. Grenoble Alpes, Grenoble, France (ghislain.picard@univ-grenoble-alpes.fr; laurent.arnaud@univ-grenoble-alpes.fr)

Isotopic compositions measured in ice-cores are used to reconstruct past temperatures as well as other climatic parameters. They are supposed to have preserved the compositions in the original snow layers. However, within the snowpack, several processes can modify the original isotopic composition of the snow after deposition. During metamorphism, recrystallization processes induce variations of the isotopic composition of ice because of fractionation linked to phase change, and intrinsic differences in the isotopic composition of the sublimed/condensed matter. The effects are stronger when water vapour is transported in the snow, along temperature gradients or through wind-pumping, which are both maximized in near-surface snow.

We introduced vapor transport due to temperature gradients in the detailed snowpack model Crocus. At each step, 1) the initial isotopic composition of vapor is taken at equilibrium with solid phase, 2) kinetic fractionation is applied during transport, and 3) condensation is realized without fractionation. Snow ventilation is not implemented yet in Crocus.

Vapor leaves warm layers and becomes condensed in relatively colder layers. Because vapor is ^{18}O-depleted, the warm layers tend to become enriched in ^{18}O in the simulations (+0.2 ‰ over 6 months, under gradient of 16 °C/m). In summer, the isotopic composition of fresh snow coming from snowfall is propagated downward where internal temperatures are lower than near the surface. In winter, vapor transport is limited by the low temperatures. Compaction of the snow also limits diffusion. Over 10 years, the $\delta^{18}O$ of the layers changed by ~0.9 ‰ (hence 12 % attenuation of the original seasonal signal of 11 ‰).