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Development of a mechanistic representation of snow-atmosphere exchange of reactive compounds for implementation in large-scale models

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Research on snowpack processes and atmosphere-snow gas exchange has demonstrated that chemical and physical interactions between the snowpack and the overlaying atmosphere have a substantial impact on the composition of the lower troposphere. These observations also imply that deposition, e.g. of ozone to the snowpack and the potential release of reactive oxidized nitrogen, NOx, possibly depends on parameters including the quantity and composition of deposited trace gases, radiation, snow pack physical properties and the substrate below the snowpack. Such dependencies are not yet considered in large-scale models where the representation of snow-atmosphere exchanges is generally ignored or limited to the use of constant uptake rate approaches. The snowpack is deemed by many of the atmospheric chemistry community to be an inert medium only relevant in terms of its albedo and low temperatures. This is also supported by the fact that observed dry deposition velocities, e.g., that of ozone (VdO3) are small, typically a factor 40 smaller than removal rate over tropical forests. However, sensitivity analysis using a range of VdO3 has demonstrated that simulated surface layer ozone concentrations over snow are highly sensitive to small changes in VdO3 due to the long timescales of turbulent transport and chemical transformations.
Results from field campaigns have revealed interesting chemical cycling inside and above the snowpack that should be considered in order to ensure a fair evaluation of the simulated chemistry over the Earth's snow- and ice covered regions. It would require the development of a more mechanistic representation of the exchange of reactive compounds between the snowpack and the atmosphere as a function of micrometeorological drivers and snowpack physical and chemical properties. However, an essential prerequisite of such a mechanistic snow-atmosphere exchange representation is its simplicity to accommodate its application in large-scale atmospheric chemistry models. Development of such a mechanistic snow-atmosphere exchange model is one of the goals of our current research. This work also includes field observations of in-snowpack and surface layer chemistry and fluxes for O3 and NOx at a midlatitude seasonal snow site (Niwot Ridge, CO), a polar site with permanent snow cover (Summit, Greenland) and snow cover over permafrost (Toolik Lake, AK). We will present results from the measurement campaign and model developement and application.

Primary author: GANZEVELD, Laurens (1Earth System Sciences - Climate Change group, department of Environmental Sciences, Wageningen University and Research Centre, Wageningen, Netherlands)

Presenter: GANZEVELD, Laurens (1Earth System Sciences - Climate Change group, department of Environmental Sciences, Wageningen University and Research Centre, Wageningen, Netherlands)

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