EGU21-8303
https://doi.org/10.5194/egusphere-egu21-8303
EGU General Assembly 2021

Using 1D-modelling to study Arctic chlorine activation, transport and VOC oxidation during Arctic springtime

Shaddy Ahmed[1], Jennie Thomas[1], Katie Tuite[2], Jochen Stutz[2], Frank Flocke[3], John Orlando[3], Rebecca Hornbrook[3], and Eric Apel[3]

[1]Institut des Géosciences de l'Environnement, Université Grenoble Alpes, Grenoble, France (shaddy.ahmed@univ-grenoble-alpes.fr)

[2]University of California Los Angeles, Los Angeles, CA, United States

[3]National Center for Atmospheric Research, Boulder, CO, United States

Polar halogen chemistry has long been known to be active, especially in spring, and is known to have an important influence on the lifetime of some volatile organics, ozone and mercury. Our understanding of polar halogen chemistry is changing, including the recognition that there is active chlorine, bromine and iodine chemistry occurring within the polar boundary. Recently, very high concentrations of molecular chlorine (Cl_2) were recorded at Utqiaġvik, Alaska during the Ocean-Atmosphere-Sea Ice-Snowpack (OASIS) campaign in spring 2009, with a correlation between daytime Cl_2 mixing ratios, ozone concentrations and sunlight. However, the chlorine radical concentrations inferred from these Cl_2 measurements, with the observed VOC abundances and lifetimes, cannot yet be fully explained via chemical box modelling alone. To explain these discrepancies, modelling that includes surface snow Cl_2 formation processes, subsequent atmospheric chemistry and vertical mixing is needed and is an essential tool in quantifying impacts on VOC lifetimes and the role of vertical mixing in controlling boundary layer chemistry.

In this work, we use a one-dimensional atmospheric chemistry and transport model (Platform for Atmospheric Chemistry and Transport in 1-Dimension, PACT-1D) to investigate surface Cl_2 production from snow, snowpack recycling, vertical transport and reactivity with VOCs at Utqiaġvik, Alaska during the OASIS campaign. We implement a new surface parameterization of chlorine emissions from the snowpack based on the solar irradiance and surface ozone levels and consider the role of vertical mixing processes. By considering both production and transport mechanisms, we are able to obtain good agreement between the model predicted Cl_2 mixing ratios and observations at 1.5 meters. The model predicts that nearly all reactive chlorine resides within the lowest 15 m of the boundary layer, resulting in increased chemical reactivities and oxidation rates in the lowest part of the atmosphere. VOC abundances near the surface that are co-located with elevated chlorine can be explained by downward mixing of VOCs from aloft, which replenishes VOCs from free tropospheric reservoirs. The proposed surface emission parameterization of chlorine in this work could be used to develop current 3D numerical models in order to explore chlorine emissions and reactivity over the entire Arctic as well as the effects of future Arctic climate scenarios on atmospheric halogen chemistry.