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# The role of ozone atmosphere-snow gas exchange on polar, boundary-layer tropospheric ozone – a review and sensitivity analysis

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Abstract. Recent 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 ozone deposition to the snowpack possibly depends on parameters including the quantity and composition of deposited trace gases, solar irradiance, snow temperature and the substrate below the snowpack. Current literature spans a remarkably wide range of ozone deposition velocities ($v_{dO3}$); several studies even reported positive ozone fluxes out of the snow. Overall, published values range from $\sim -3 < v_{dO3} < 2$ cm $s^{-1}$, although most data are within $0 < v_{dO3} < 0.2$ cm $s^{-1}$. This literature reveals a high uncertainty in the parameterization and the magnitude of ozone fluxes into (and possibly out of) snow-covered landscapes. In this study a chemistry and tracer transport model was applied to evaluate the applicability of the published $v_{dO3}$ and to investigate the sensitivity of tropospheric ozone towards ozone deposition over Northern Hemisphere snow-covered land and sea-ice. Model calculations using increasing $v_{dO3}$ of 0.0, 0.01, 0.05 and 0.10 cm $s^{-1}$ resulted in general ozone sensitivities up to 20–30% in the Arctic surface layer, and of up to 130% local increases in selected Northern Latitude regions. The simulated ozone concentrations were compared with mean January ozone observations from 18 Arctic stations. Best agreement between the model and observations, not only in terms of absolute concentrations but also in the hourly ozone variability, was found by applying an ozone deposition velocity in the range of 0.00–0.01 cm $s^{-1}$, which is smaller than most literature data and also significantly lower compared to the value of 0.05 cm $s^{-1}$ that is commonly applied in large-scale atmospheric chemistry models. This sensitivity analysis demonstrates that large errors in the description of the wintertime tropospheric ozone budget stem from the uncertain magnitude of ozone deposition rates and the inability to properly parameterize ozone fluxes to snow-covered landscapes.

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