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Impact of large solar zenith angles on lower stratospheric dynamical and chemical processes in a coupled chemistry-climate model

D. Lamago[1,*], M. Dameris[1], C. Schnadt[1], V. Eyring[1], and C. Brühl[2]
[1]Institut für Physik der Atmosphäre, DLR-Oberpfaffenhofen, D-82234 Wessling, Germany
[2]Max-Planck-Institut für Chemie, D-55020 Mainz, Germany
[*]now at: ZWE FRM-II and Institut für Experimentalphysik E21, TU-München, D-85748 Garching, Germany

Abstract. Actinic fluxes at large solar zenith angles (SZAs) are important for atmospheric chemistry, especially under twilight conditions in polar winter and spring. The results of a sensitivity experiment employing the fully coupled 3D chemistry-climate model ECHAM4.L39(DLR)/CHEM have been analysed to quantify the impact of SZAs larger than 87.5° on dynamical and chemical processes in the lower stratosphere, in particular their influence on the ozone layer.

Although the actinic fluxes at SZAs larger than 87.5° are small, ozone concentrations are significantly affected because daytime photolytic ozone destruction is switched on earlier, especially at the end of polar night the conversion of Cl_2 and Cl_2O_2 into ClO in the lower stratosphere. Comparing climatological mean ozone column values of a simulation considering SZAs up to 93° with those of the sensitivity run with SZAs confined to 87.5° total ozone is reduced by about 20% in the polar Southern Hemisphere, i.e., the ozone hole is "deeper'' if twilight conditions are considered in the model because there is about 4 weeks more time for ozone destruction. This causes an additional cooling of the polar lower stratosphere (50 hPa) up to -4 K with obvious consequences for chemical processes. In the Northern Hemisphere the impact of large SZAs cannot be determined on the basis of climatological mean values due to the pronounced dynamic variability of the stratosphere in winter and spring. This study clearly shows the necessity of considering large SZAs for the calculation of photolysis rates in atmospheric models.

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