Ozone trends and interannual variability in the Arctic lower stratosphere

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Long-term changes in Arctic ozone profiles are of considerable interest, because the Arctic lower stratosphere is directly affected by chemical ozone depletion. Ozone is also a greenhouse gas whose radiative forcing is depending on its vertical distribution. Therefore, the long-term changes in ozone profiles are not only important to the earth UV shield, they are of considerable climatic interest too. However, the information on long-term changes in ozone over the Arctic is limited as there are only a few regular measurement programs of ozone profiles that have sufficient length and measurement frequency for long-term data studies. In this study we have first constructed an ensemble data set based on available long-term ozonesonde measurements from the Arctic from the period 1989-2003. The data set was made homogeneous by applying corrections for the changes in operational procedures. The results from test flights made in Sodankylä were used to apply the altitude dependent corrections to the ozone sonde profiles. Secondly, in order to explain the trends and interannual variability, a multilinear regression model was applied to the ensemble ozone sonde data. We found that a model using the following explanatory variables in the stratosphere: average tropopause height, the calculated volume of polar stratospheric clouds, 100 hPa eddy heat flux averaged over 45-70 N, and the mean aerosol backscatter in 200-100 hPa range, was able to explain 65 -95 % of the observed variance throughout the stratosphere depending on the altitude in January-April. The proxies account for the changes in the synoptic scale dynamical processes, the vortex ozone depletion, the ozone transport through meridional circulation, and the Pinatubo aerosol effect, respectively. At altitudes between 50 and 70 hPa it can be estimated that chemical polar ozone depletion accounted for up to 50 % of the March ozone variability. The model suggests that negative trends in lower stratosphere prior to 1997 can be attributed to the combined effect of dynamical changes, impact of Pinatubo aerosols and to winters of relatively large chemical ozone depletion. Since 1996-1997 the observed increase in lower stratospheric ozone can be attributed primarily to dynamical changes.