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Planetary wave patterns in stratospheric ozone and water vapor and their effects on vertical coupling processes from tropo- to mesosphere

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The aim of our project related to the CAWSES programme is to investigate the long-term changes of planetary wave patterns in stratospheric ozone and water vapour and their influence on the vertical coupling of atmospheric layers due to the induced radiation perturbations. For this purpose, we derived zonally asymmetric components of ozone and water vapour from assimilated data (ERA-40, ERA-Interim) and satellite data (SAGE, GOME, ODIN). For northern winter, we found a pronounced quasi-stationary wave one structure in both stratospheric ozone and strato- and mesospheric water vapour with maximum amplitudes of about 20% of zonal mean values during the last decades. We found also a nearly linear increase of the amplitude during the last decades and some pronounced variations which may partly be due to the 11-year cycle in solar radiation activity. In the southern hemisphere, pronounced amplitudes occur particularly during polar vortex breakup period. Based on model simulations with the GCM MAECHAM5 and the CCM HAMMONIA, we discuss the dynamical and chemical processes which lead to the observed planetary wave patterns in ozone and water vapour, as well as their vertical structure, their interannual and decadal variability and their feedback on temperature, dynamics and chemistry. For example, MAECHAM5 model calculations with and without prescribed zonally asymmetric ozone (O3*) show significant changes in temperature and geopotential from lower stratosphere to mesosphere due to an O3*-induced increase in amplitude and a shift in phase of stratospheric wave one structure, accompanied by a shift of up- and eastward directed quasi-stationary wave trains from the eastern to the western hemisphere, indicating a feedback to the forcing of planetary waves from troposphere. We analysed also long-term equilibrium simulations with the CCM HAMMONIA to understand the involved dynamical-chemical interactions configuring the observed planetary wave patterns and to verify the effect of the 11-year cycle in solar radiation activity on planetary wave patterns. Overall, the results suggest that zonally asymmetric anomalies in ozone, water vapour and other important absorbers contribute largely to observed long-term changes in temperature, planetary waves and atmospheric circulation, and provide a new perspective for validating and improving GCMs and CCMs.