Geophysical Research Abstracts
Vol. 17, EGU2015-1596-1, 2015
EGU General Assembly 2015

Stratospheric water vapour and temperature variability and their effect on polar stratospheric cloud formation and existence in the Arctic

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Based on more than 10-years of satellite measurements from UARS/HALOE, Envisat/MIPAS, Odin/SMR, Aura/MLS and SciSat/ACE-FTS we investigate water vapour (H_2O) variability in the northern hemisphere polar regions. We find from the observations a connection between cold winters and enhanced water vapour mixing ratios in the lower polar stratosphere (475 to 525 K). We perform a sensitivity study along air parcel trajectories to test how an increase of stratospheric water vapour of 1 ppmv or a temperature decrease of 1 K affects the time period during which polar stratospheric clouds (PSCs) can be formed and exist. Air parcel trajectories were calculated 6-days backward in time. The trajectories were started at the time and locations where PSCs were observed by CALIPSO (Cloud Aerosol Lidar and Infrared Pathfinder satellite observations) during the Arctic winter 2010/2011. We test the sensitivity of PSCs formation and existence to changes in H_2O and temperature based on PSC observations during this winter since it was one of the coldest Arctic winters in the last decade. The polar vortex persisted over a period of four months, thus leading to extensive PSC formation. During this winter PSCs were detected by CALIPSO on 42 days. In total, 738 trajectories were calculated and analysed. The resulting statistic derived from the air parcel trajectories shows a clear prolongation of the time period where PSCs can be formed and exist when the temperature in the stratosphere is decreased by 1 K and H_2O is increased by 1 ppmv. We derive an increase in time where the stratospheric air is exposed to temperatures below T_{ice} and T_{NAT}, respectively, by $\sim$6000 h. Thus, changes in stratospheric water vapour and temperature can prolong PSC formation and existence and thus have a significant influence on the chemistry of the polar stratosphere.