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Diurnal variations of $BrONO_2$ observed by MIPAS-B in the Arctic, at mid-latitudes, and in the Tropics

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Despite being much less abundant, the contribution of bromine to stratospheric ozone depletion is similar to that of chlorine. Moreover, against the background of abating levels of chlorine in the stratosphere, bromine is important due to its natural sources. The two major inorganic bromine (Br_y) species in the lower stratosphere are bromine oxide (BrO) and bromine nitrate ($BrONO_2$). The relative abundances of these molecules are mainly controlled by photochemical processes.

The first stratospheric measurements of the diurnal variation of $BrONO_2$ around sunrise and sunset are reported. Arctic flights of the balloon-borne Michelson Interferometer for Passive Atmospheric Sounding (MIPAS-B) were carried out from Kiruna (68°N, Sweden) inside the stratospheric polar vortices in January 2010 and March 2011 where diurnal variations of $BrONO_2$ around sunrise have been observed. High nighttime $BrONO_2$ volume mixing ratios of up to 22 parts per trillion by volume (pptv) were detected in the late winter 2011 in the absence of polar stratospheric clouds (PSC). In contrast, the amount of measured $BrONO_2$ was significantly lower in January 2010 partly due to heterogeneous destruction of $BrONO_2$ on PSC particles. A further balloon flight took place at mid-latitudes from Timmins (49°N, Canada) in September 2014. Mean $BrONO_2$ mixing ratios of 23 pptv were observed after sunset in the altitude region between 22 and 29 km. Day- and nighttime profiles of $BrONO_2$ were also inferred from limb emission spectra recorded during a tropical balloon flight from Teresina (5°S, Brazil). Significant differences of the stratospheric $BrONO_2$ amount with up to 23 pptv during night and up to 12 pptv during day were found.

Measurements are discussed in comparison to a multi-year simulation performed with the Chemistry Climate Model EMAC (ECHAM5/MESSy Atmospheric Chemistry). The combination of model simulations with MIPAS-B measurements gives an estimate of stratospheric total inorganic bromine.