Importance of seasonally resolved oceanic emissions for bromoform delivery to the stratosphere through the Asian monsoon

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Very short-lived substances (VSLS) of marine origin, such as bromoform (CHBr3), contribute to stratospheric bromine loading and, thus, to ozone depletion. However, amount, timing, and region of bromine delivery to the stratosphere through one of the main entrance gates, the Asian monsoon circulation, are still uncertain. The atmospheric distribution of bromoform and its delivery to the stratosphere have been the topic of several chemistry transport and chemistry climate modeling studies, but only few studies considered seasonally varying surface water concentrations or emissions in their model simulations.

In this study, we create two bromoform emission inventories with monthly resolution for the tropical Indian Ocean and West Pacific based on new in situ bromoform measurements in the tropical West Indian Ocean (Fiehn et al., 2017) incorporated into the observation based climatology (Ziska et al., 2013), and the ocean biogeochemistry modeling (Stemmler et al., 2015) of bromoform. Mass transport and atmospheric mixing ratios of bromoform are simulated for the year 2014 with the particle dispersion model FLEXPART driven by ERA-Interim reanalysis. Model experiments are performed with two emission scenarios: (1) monthly varying emissions and (2) constant emissions over the whole year. We compare these model results with ship- and aircraft-based observations in the boundary layer and upper troposphere lower stratosphere.

Using monthly emissions, main oceanic source regions for the stratosphere include the Arabian Sea and Bay of Bengal in boreal summer and the tropical west Pacific Ocean in boreal winter. The corresponding main stratospheric injection occurs over the southern tip of India in boreal summer associated with the high local oceanic sources and strong convection of the summer monsoon. The annually averaged stratospheric injection of bromoform is in the same range independent of temporal resolution of the emissions. However, monthly emissions result in highest mixing ratios within the Asian monsoon anticyclone in boreal summer and above the central Indian Ocean in boreal winter, while constant emissions show a maximum above the West Indian Ocean in boreal spring. Our results for the Asian monsoon circulation underline that the seasonal and regional stratospheric bromine injection from the tropical Indian Ocean and west Pacific critically depends on the seasonality and spatial distribution of the VSLS emissions next to the variability in the atmospheric transport. Finally, we discuss our results with respect to circulation changes of the Asian monsoon which shows an increase in bromoform delivery between 2000 and 2015.

Key words: VSLS, ocean to stratosphere transport, Asian monsoon, ozone

References:

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