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

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Oceanic very short-lived substances (VSLS), such as bromoform (CHBr3), contribute to stratospheric bromine loading and, thus, to ozone depletion. However, the 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 and the delivery of bromoform 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 created 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) and ocean biogeochemistry modeling of bromoform (Stemmler et al., 2015). The mass transport and atmospheric mixing ratios of bromoform were modeled for monthly varying and constant oceanic emissions for the year 2014 with the particle dispersion model FLEXPART driven by ERA-Interim reanalysis. We compare results between two emission scenarios: (1) monthly varying emissions and (2) constant emissions over the whole year. We compare these simulations with ship- and aircraft-based observations in the boundary layer and upper troposphere.

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 entrainment 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 entrainment of bromoform is in the same range whether using monthly or constant emissions in our Lagrangian calculations. 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 display 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 entrainment 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.

References:

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