Underestimation of Anthropogenic $CHBr_3$ Emissions: Implications for Ozone Depletion

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Abstract

Using our recent $CHBr_3$ emission inventory containing both natural and anthropogenic sources, we reevaluated the role played by the latter in the total $CHBr_3$ flux into the Northern Hemisphere extratropical stratosphere. Derived mainly from ship ballast, power plant cooling and desalination plant brine water, these anthropogenic sources suggest a substantial underestimation in previous global $CHBr_3$ emission estimates. Anthropogenic sources have been underestimated by 31.5% globally, and more alarmingly, this underestimation escalates to 70.5% when focusing on the Northern Hemisphere (NH). Consequently, atmospheric $CHBr_3$ concentrations are also significantly higher than previous estimates, especially over the NH extratropics during boreal winter. The ODP-weighted emissions in the NH based on historical ECMWF meteorology (ERA-Interim) are ~28.2 Gg Br/year, increased by ~78% above previous estimates, suggesting a more significant contribution of anthropogenic $CHBr_3$ to stratospheric ozone depletion, especially in the NH lowermost stratosphere.

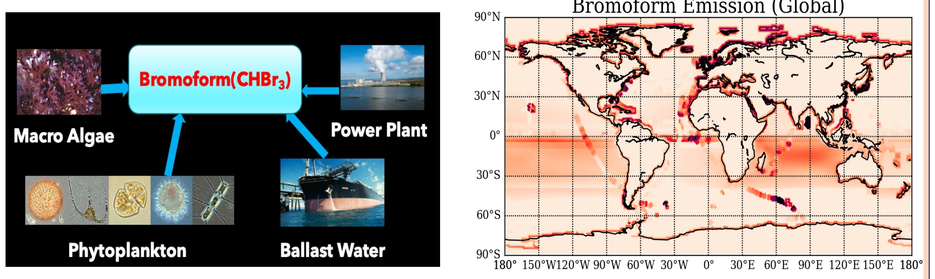

Fig. 1 Natural and anthropogenic sources of $CHBr_3$ and estimates of global $CHBr_3$ emission

- Global emissions of CHBr3 were underestimated by approximately 30%, with a more significant underestimation of over 70% in the Northern Hemisphere, particularly in developed and emerging economies.

Model vs Observation

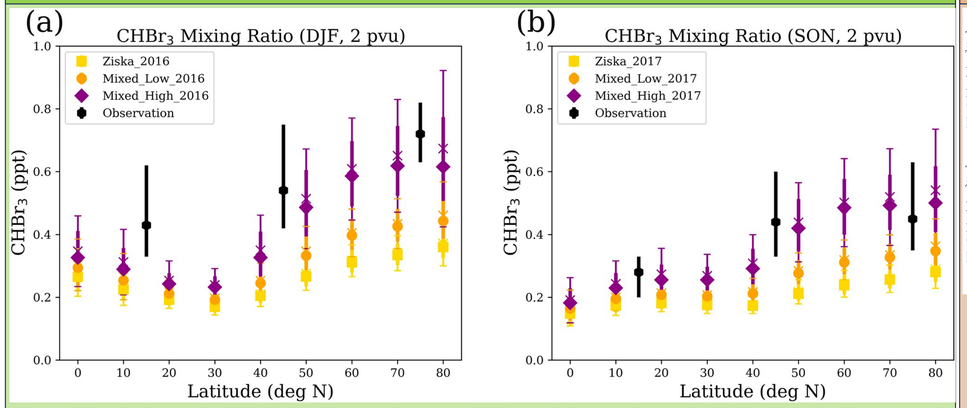

Fig. 2 Simulation vs observations, zonal-mean $CHBr_3$ mixing ratio at the tropopause. Each run is named in Scenario_Year format (e.g. Ziska_2016 is 2016 run with emission from [*Ziska et al., 2013*])

- The model simulations incorporating higher estimates of $CHBr_3$ emissions align better with observational data, suggesting the robustness the new higher end estimates of emission (Mixed_High).

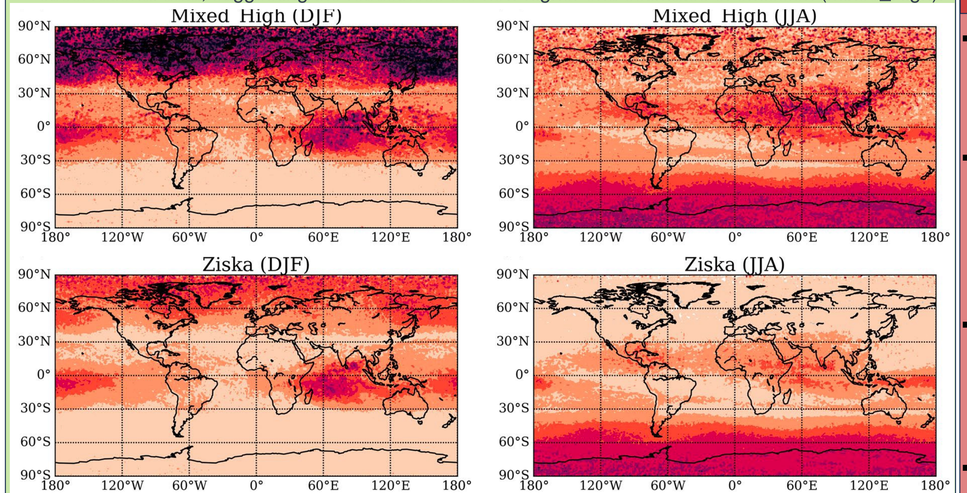

Fig. 3 Simulated bromoform distribution at the tropopause and comparison with observations

- Including anthropogenic sources, $CHBr_3$ mixing ratios show a significant increase at the tropopause, particularly during the NH winter. This indicates a greater entrainment of bromine to the stratosphere, potentially affecting the ozone layer.

ODP-Weighted Emission

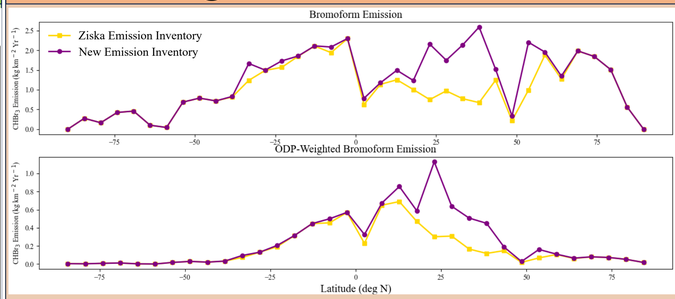

Fig. 4 Bromoform emission vs ODP-weighted emission

- The ODP-weighted emissions increased significantly in the NH, especially in the midlatitudes suggesting a more significant contribution of anthropogenic $CHBr_3$ to stratospheric ozone depletion, especially in the NH lowermost stratosphere
- The impact on ozone recovery needs further study utilizing chemistry-climate model

Summary& Research Vision

- In the previous estimates, the $CHBr_3$ emission was significantly underestimated, especially in the Northern Hemisphere.
- The observed $CHBr_3$ mixing ratios at tropopause are reasonably well reproduced by simulations based on the $CHBr_3$ emission inventory with higher estimates of anthropogenic sources.
- The ODP-weighted emission in the NH have risen more than the non-weighted emissions, indicating a larger role of anthropogenic $CHBr_3$ in stratospheric ozone depletion.
- Further research on the social and environmental impacts of anthropogenic $CHBr_3$ emission is necessary, with the ultimate goal to inform effective policy making.

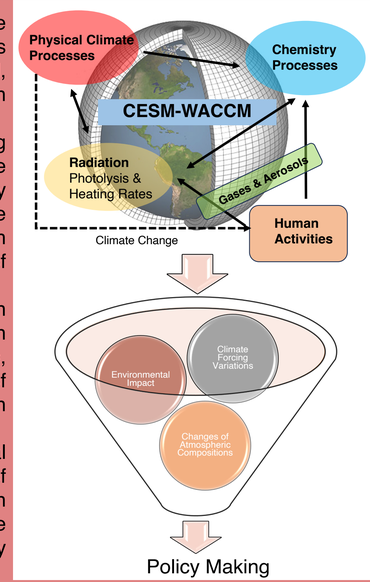

Fig. 5 Vision for subsequent studies

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