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Estimation of dichloromethane emissions in East Asia using recent high-altitude aircraft observations and synthesis inversion

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Although the Montreal Protocol has been successful in reducing the emissions of long-lived ozone-depleting substances, certain unregulated, chlorinated very short-lived substances (VSLS, lifetimes < 6 months) are believed to be having an increasing impact on stratospheric ozone depletion. The major sources of the chlorinated VSLS are anthropogenic. Emissions of chlorinated VSLS have been reported to be increasing from both bottom-up estimates and observations in recent years, among which dichloromethane (DCM) is the most abundant. Emissions from East Asia have been identified as contributing significantly to this increase (Oram et al., 2017; Claxton et al., 2020; Adcock et al., 2021; An et al., 2021).

Here we use synthesis inversion to derive an estimation of DCM emissions with a focus on East Asia, with input from the TOMCAT/SLIMCAT 3-D offline chemical transport model (CTM), a gridded annual global emission estimate, and aircraft observations from three recent campaigns - POSIDON (2016, https://csl.noaa.gov/projects/posidon/), StratoClim (2017, http://www.stratoclim.org/), and ACCLIP (2021, https://www2.acom.ucar.edu/acclip). The CTM contains the production and loss of DCM and is driven by reanalysed meteorology (Chipperfield,

2006), with gridded emission field of DCM (Claxton et al., 2020). In the model we set up more source regions than previous studies based on prior information, transport pathways into stratosphere, and the distribution of major city clusters. The inversion is performed by finding the minimum of the cost function (Tarantola and Valette, 1982): $x_a = x_b + [G^T R^{-1} G + B^{-1}]^{-1} G^T R^{-1} [y - G x_b]$, where y has the observations, x_b is the prior estimate, B and R are the error covariance matrix of the prior estimates and the observations respectively, and G is the sensitivity matrix, as an operator mapping the emissions onto the observations by the CTM. Then x_a can be calculated as known as the posterior estimate. Coupling the model and observations, x_a is considered the best estimate and reduces the errors in the prior estimate.

We will present our analysis of DCM emissions up to the present day and compare them with previously published values and longer-term trends.

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