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Estimating the oceanic uptake of CCl4 : Constraints from an ocean biogeochemistry model and global datasets

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Carbon tetrachloride (CCl4) is an ozone depleting agent, the production of which is currently governed under the Montreal Protocol. Recent assessments (Carpenter et al. 2014, SPARC 2016) highlight ongoing uncertainties with the present-day atmospheric CCl4 budget and call for improved quantification of atmospheric CCl4 sources and sinks. A recent global model analysis (Chipperfield et al. 2016) suggests that uncertainty in current estimates of oceanic uptake of CCl4 is potentially the most significant influence on estimates of atmospheric CCl4 decay.

Oceanic CCl4 uptake is influenced by a combination of processes including surface air-sea gas exchange, ocean circulation and water mass mixing, chemical hydrolysis and presumably biologically-mediated degradation. This flux has previously been quantified through the representation of 1st-order degradation processes in surface waters (e.g., Yvon-Lewis and Butler, 2002), and more recently by an analysis of surface and water-column measurements (Butler et al. 2016).

Here we provide new estimates of the air-sea flux of CCl4 for the period 1990-2010 using simulations from a global ocean biogeochemistry model (NEMO-PlankTOM) in combination with depth-resolved CCl4 observations from the GLODAPv2, CARINA and PACIFICA ocean databases (Olsen et al. 2016). CCl4 is simulated as a non-conserved tracer in the NEMO-PlankTOM model and subject to a time-varying atmospheric boundary condition in combination with gas-exchange at the air-sea interface, ocean circulation processes, and hydrolysis and degradation in the ocean interior. We present estimates of ocean CCl4 uptake derived from a range of model sensitivity analyses including: (a) parameterizations using reported literature values on hydrolysis and degradation rates; (b) model analyses optimised using data from the global CCl4 databases; and (c) evaluation of the sensitivity of results to parameterization of air-sea gas exchange. We report on the implications of our results for estimation of the partial atmospheric lifetime of CCl4 with respect to ocean uptake, and for the global CCl4 budget.

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