Error in GEOS-Chem RCP OC emissions rates

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The original IPCC RCP emissions files contain inconsistent molecular weights for OC. Three of the RCPs (2.6, 4.5, and 8.5) have a molecular weight of 106.8 g/mol in the 0.5°x0.5° NetCDF emissions files provided directly by the IPCC RCP groups (http://www.iiasa.ac.at/web-apps/tnt/RcpDb), but RCP 6.0 uses a molecular weight of 12 g/mol. This discrepancy has propagated through to the model-ready GEOS-Chem bpch emissions files under the assumption that the molecular weight of OC is identical across the original IPCC RCP files and given on a carbon basis, i.e., 12 g/mol. Here, I describe the implications of the error and provide new RCP bpch emissions files.

Anthropogenic OC emissions are thought to be ~10 Tg(C)/yr in 2000 (Ito and Penner, 2005). All RCP scenarios give global OC emissions rates of ~12 Tg/yr in 2000, but only RCP 6.0 reports this on a carbon basis, as shown in Figure 1. If the emissions rates for the other RCPs is converted to a carbon basis (using a molecular weight of 12 rather than 106.8), the OC emissions rates are too low by a factor of 106.8/12, which results in ~1.3 Tg(C)/yr in 2000 (Figure 2). Thus, the molecular weight reported in the original IPCC RCP files (106.8 g/mol) is almost certainly incorrect.

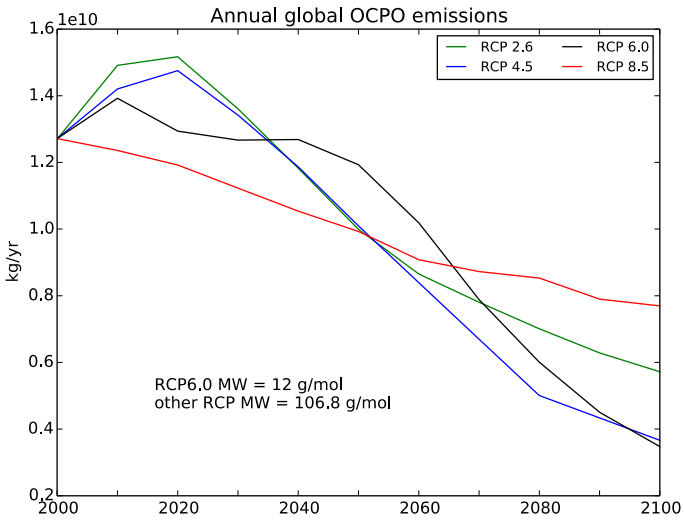


Figure 1. Annual global OCPO emissions in the model-ready 2°x2.5° GEOS-Chem emissions files. Molecules/cm$^2$/yr have been converted to kg/yr using a molecular weight of 12 g/mol for all RCP 6.0 and 106.8 g/mol for the other three. These emissions rates agree with the original IPCC 0.5°x0.5° NetCDF emissions files (see http://acmg.seas.harvard.edu/geos/wiki_docs/emissions/GEOS-Chem_RCP_emissions.pdf).

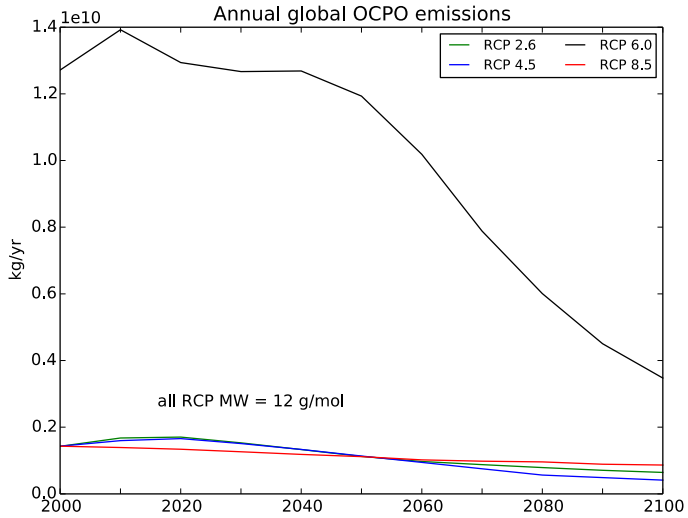


Figure 2. Annual global OCPO emissions in the model-ready 2°x2.5° GEOS-Chem emissions files. Molecules/cm$^2$/yr have been converted to kg/yr using a molecular weight of 12 g/mol for all RCPs. RCPs 2.6, 4.5, and 8.5 underestimate the total emitted mass of OCPO because the molecular weight used in the original IPCC 0.5°x0.5° NetCDF emissions files is 106.8 g/mol.

The implication of this molecular weight error for GEOS-Chem users is that the emissions rates of OC in the bpch files (molec/yr) is too low by a factor of 106.8/12 (Figure 3) in RCPs 2.6, 4.5, and 8.5. This is because the model-ready bpch files were translated from kg/yr – the units of the original IPCC RCP files – to molec/yr using each files' internal molecular weight. Since three of the original RCP scenarios use a larger molecular weight, this leads to a lesser number of molecules.

There are three manageable solutions to this problem. First, OCPO (and OCPI) mass can simply be calculated *post factum* using 106.8 g/mol for simulations run using emissions from RCPs 2.6, 4.5, and 8.5. This is not a desirable solution, however, because model processes (e.g. deposition, transport) will have error introduced since the number of OC molecules is incorrect (too low). A second solution involves updating the GEOS-Chem source code to multiply OC emissions rates in RCPs 2.6, 4.5, and 8.5 by 106.8/12. A third solution, which is likely the easiest to implement, is to simply amend the model-ready 2°x2.5° GEOS-Chem emissions files.

I have prepared new model-ready emissions files with the OC emissions rate adjusted upwards by 106.8/12 in RCPs 2.6, 4.5, and 8.5.

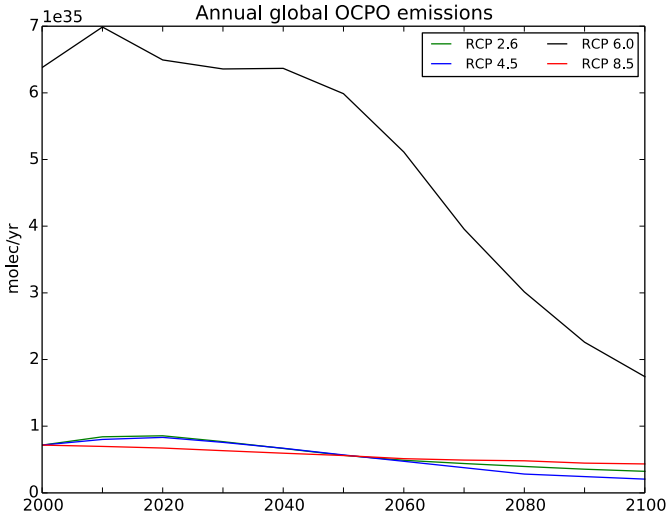


Figure 3. Annual global OCPO emissions in the model-ready 2°x2.5° GEOS-Chem emissions files. RCP 6.0 is correct, i.e., the molecular weight (12 g/mol) is consistent across the original IPCC 0.5°x0.5° NetCDF emissions files and the GEOS-Chem bpch files. The other three RCPs are too low by a factor of 106.8/12 because the original IPCC emissions files use a molecular weight of 106.8 g/mol.

Ito, A., and J. E. Penner (2005), Historical emissions of carbonaceous aerosols from biomass and fossil fuel burning for the period 1870–2000, *Global Biogeochem. Cycles, 19*, GB2028, doi:10.1029/2004GB002374.