Reconciling Estimates of SF₆ Emissions Using NOAA Observations

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The NOAA ESRL Carbon Cycle Group measures sulfur hexafluoride (SF₆) from discrete samples collected at ~60 sites globally. SF₆ is a strong absorber of terrestrial IR radiation, and it has a lifetime estimated at 3200 years. Taken together, these properties make SF₆ the strongest known greenhouse gas with a global warming potential of 22,800 over a 100 year time horizon. SF₆ sources include electricity distribution systems, magnesium production, manufacture of electronic circuit boards, automobile tires, and sneakers. SF₆ is inert in the lower atmosphere; its sinks are photolysis and reaction with electrons in the mesosphere.

SF₆ is the best known tracer for testing transport schemes used in atmospheric transport models. For example, Peters et al. [JGR, doi: 10.1029/2004JD005020, 2004] used an established emissions distribution in “Tracer Model 5” and found that the modeled latitudinal gradient was ~20% greater than the observations. To identify errors in transport, we need accurate estimates of the magnitude and distribution of SF₆ emissions globally.

Fortunately, we can assess the magnitude of emissions from observations, because the SF₆ lifetime is long enough, that all emissions remain in the atmosphere. SF₆ has increased from zero in pre-industrial times to more than 6 pmol mol⁻¹ (ppt) in 2007. Since 1998, the average rate of increase in the global burden of SF₆ has been 0.21 ppt yr⁻¹ (top panel), corresponding to 5.4 Gg SF₆ yr⁻¹. Our observations suggest that since the start of our measurements in 1997, SF₆ emissions have increased by ~15%. This increase in emissions has happened despite attempts to reduce SF₆ emissions under the Kyoto Protocol. Long-term measurements of SF₆ can be used to verify global emission inventories based on national statistics. SF₆ emissions calculated from the observed annual atmospheric increases (blue circles) are compared with emissions reported by Annex I countries (red triangles) to the United Nations Framework Convention on Climate Change (UNFCCC: http://unfccc.int). The large difference between the two estimates can be attributed to either a rapid increase in non-Annex I emissions or Annex I countries underestimating emissions reported to UNFCCC.

Figure 1. Globally averaged SF₆ trend from the NOAA ESRL global cooperative air sampling network (top). Global emissions of SF₆ calculated from annual increase (circles) and from emissions reported by Annex I countries to the UNFCCC (triangles). Annex I Parties include the industrialized countries that were members of the Organization for Economic Co-operation and Development (OECD) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States.