Sulfuryl fluoride (SO_2F_2) atmospheric abundance and trend from the GGGRN North American Tower and Aircraft Networks and the HATS Global Flask Network

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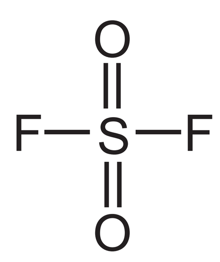
What is SO_2F_2 and why should we care?

Sulfuryl fluoride is a potent greenhouse gas that is increasing in useage and atmospheric abundance. Emission regulations are based on poorly understood 'bottom-up' emission estimates.



- Atmospheric lifetime = 36 ± 11 yrs.
- Global Warming Potential (GWP) = 4780 (100-yr horizon).
- Ozone Depletion Potential (ODP) ~ 0.
- Current global mean atmospheric abundance = ~ 2.3 ppt
- Annual atmospheric growth rate: ~9% per year.
- Predominant sink: hydrolysis in ocean waters (OH• reaction and tropospheric photolysis are very slow).
- No known natural sources.
- Industrial sources (in approximate order of predominance):
  - Fumigation:
    - Pest control in buildings, construction materials, timber, containers, warehouses, silos, soils and even transports.
    - Replacement for methyl bromide for many structural fumigation applications.
    - Postharvest fumigation of dried fruits, tree nuts, grains, and flours.
    - Registered for fumigation use in the United States, Canada, the Caribbean, Japan, Australia, Switzerland, and the European Union.
  - Used as a cover gas to replace potent IR-absorbing SF_6 in the magnesium industry.
  - Used in the semiconductor industry as a plasma cleaning gas.
  - Trace amounts of SO_2F_2 can be formed by electrical dissociation of SF_6.
- Industrial Trade Names: Vikane™, Zythor™, ProFume™

Figure 1: During structural fumigation, SO_2F_2 is typically injected into a tented enclosure producing a toxic atmosphere of several parts per thousand that effectively permeates deeply into building materials over ~24 hours to reach the target pests (e.g., termites). SO_2F_2 prevents insects from metabolizing the stored fats they need to maintain a sufficient source of energy for survival by disrupting the glycolysis cycle. Subsequent venting of the structure results in an estimated atmospheric emission of 88% of the injected amount.

Figure 2: Atmospheric SO_2F_2 measured in flasks from the HATS Global Flask Network. Locally-induced enhancements are evident in the Cape Kumukahi, HI (KUM), Niwot Ridge, CO (NWR) and Trinidad Head, CA (THD) data. A trend fit (red line) to the Northern Hemispheric data (solid dot symbols only) indicates a ~9% growth rate (c.f.,~5% from Muhle et al. 2008).

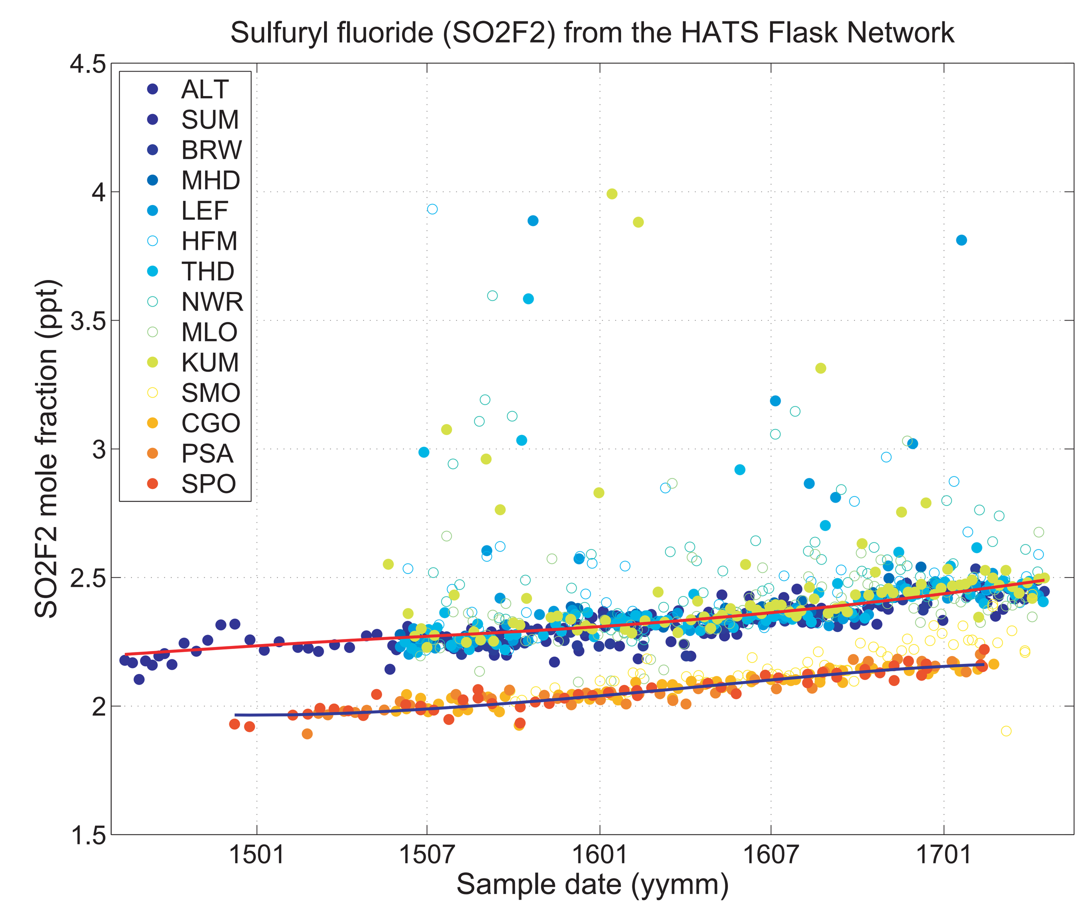


Figure 3: Atmospheric SO_2F_2 measured in flasks collected at 5 tower and 2 aircraft sites (12 and 15 sites total, respectively) of the GGGRN Programmable Flask Network (PFP). Mole fractions as high as 500 ppt were observed within the Los Angeles Basin (LAC). Cape Kumukahi (KUM, Cooperative Network) data are shown as background comparison.

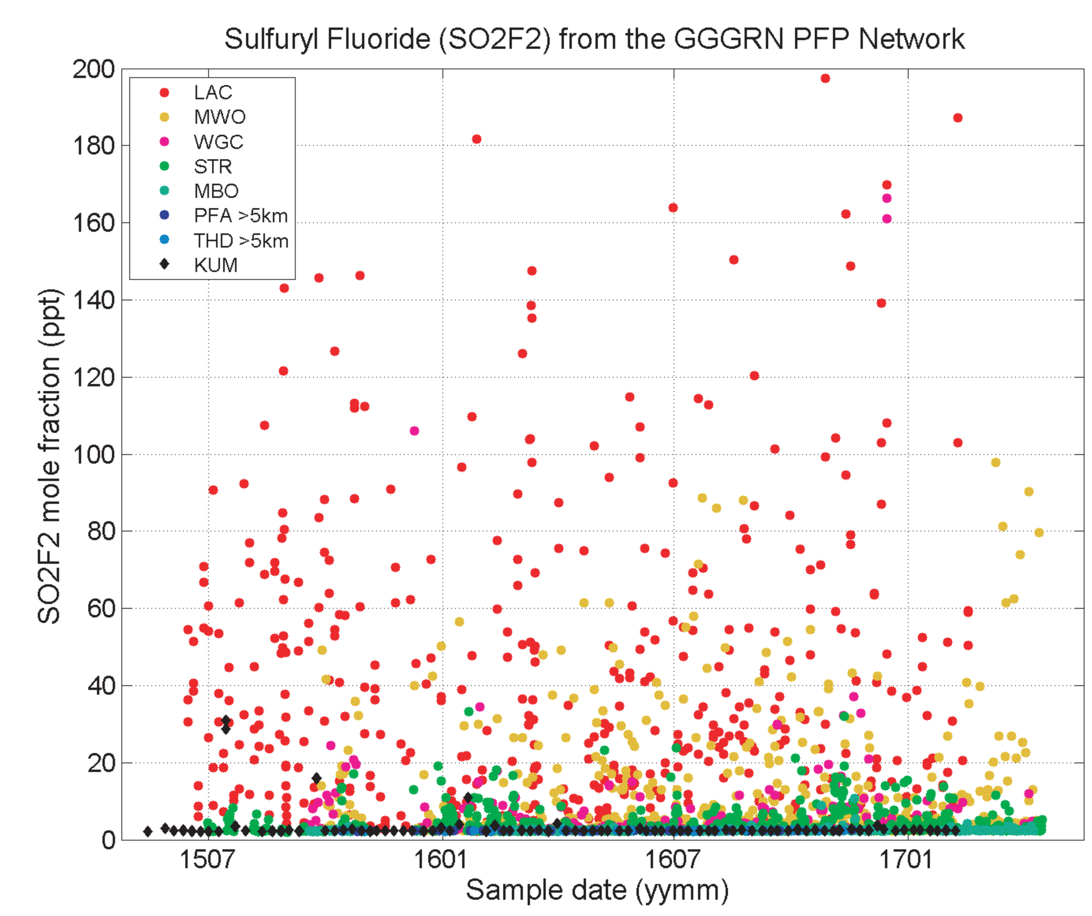


Figure 4: 3-box atmospheric modelling of SO_2F_2 global emissions ('top-down') based on adjusting estimated emissions to produce a reasonable match to atmospheric observations. The emissions (1960-2008) estimated by Muhle et al. (2008) were used to optimize model parameters by fitting the Cape Grim Air Archive (CGAA) archive data of the Southern Hemisphere. The emissions required to match the NOAA data of later years were then estimated. These later emissions are shown graphically in Figure 5.

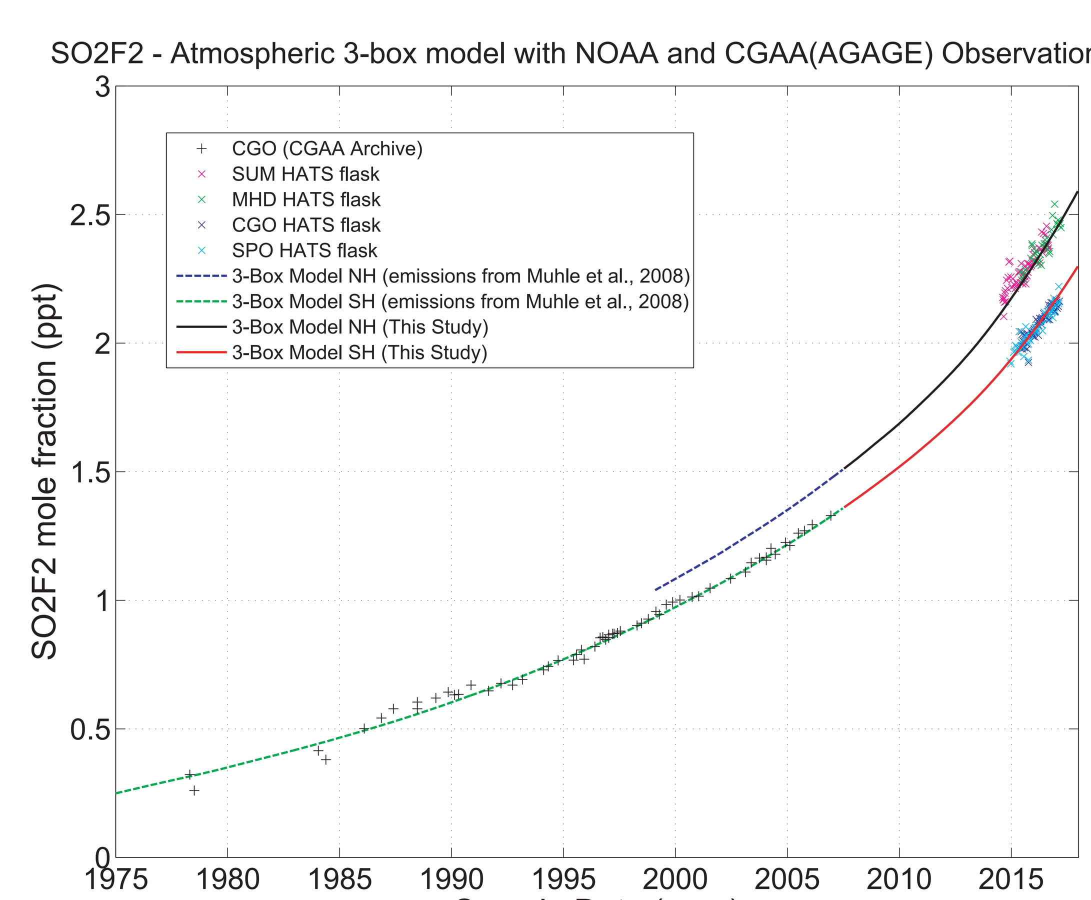


Figure 5: The published figure of 'top-down' emissions of Muhle et al. (2008) are shown here as an inset. They also included global, USA industrial and California State 'bottom-up' emission estimates (black symbols). They noted the large discrepancy between these two estimation techniques. The larger plot from the 3-box model results (red circles) of this study extends those previous estimates. Recent, apparently revised, California estimates (blue triangles) show agreement with the later part of the older estimates, then rise markedly to greatly exceed the global estimates (red circles) of this study. Clearly, emission regulation on regional and global scales requires more accurate knowledge of actual emissions.