The Evolution of SF_6 as an Age of Air Tracer

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The long lifetime and steady growth rate of sulfur hexafluoride (SF_6) have made it a useful trace gas to estimate the age of air in the atmosphere. This estimation is complicated somewhat by the loss of SF_6 in the lower mesosphere due to free electron association. Mesospheric air with SF_6 loss is transported down into the stratosphere, especially in the winter polar vortices where mean age derived from SF_6 has been shown to be biased old due to the presence of air with substantial SF_6 loss. Recent theoretical and modeling work has shown that since the amount of SF_6 loss is proportional to the mixing ratio, which has grown larger by several times over the past few decades, the deviation of SF_6 mean ages from the ideal mean age is also expected to have grown larger over this time period. In this work we compare mean age estimates from aircraft campaign and balloon measurements of SF_6, as well as other mean age tracers such as CO_2 and nitrous oxide (N_2O), over the past several decades, including measurements from the recent DCOTTS and SABRE aircraft missions and AirCore flights. We use a newly developed correction technique to adjust observed SF_6 mean ages based on the year and latitude of the measurements to help evaluate the theoretical and model-based estimates of the evolution of SF_6 mean age biases over time.

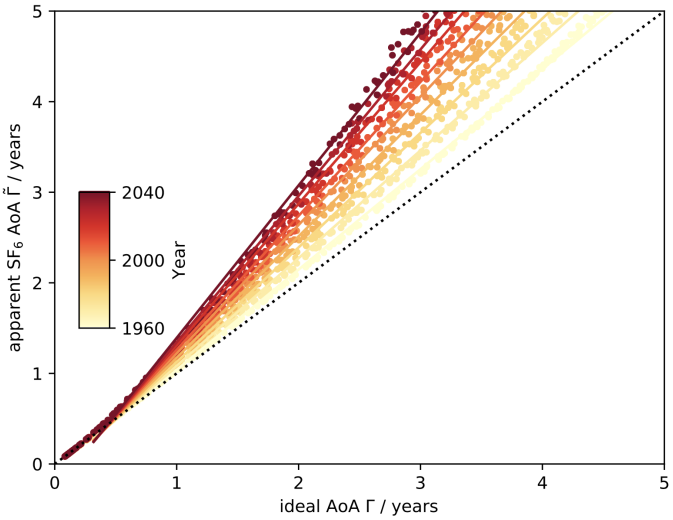

Figure 1. Theoretical SF_6 mean age bias compared to idealized modeled mean ages colored by year from 1960-2040.

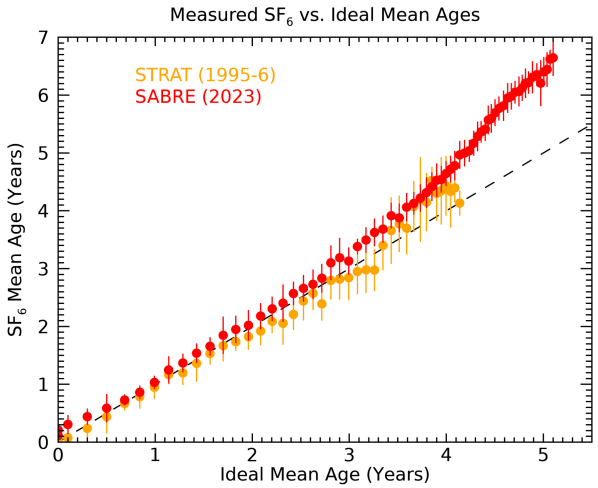

Figure 2. SF_6 mean ages from the STRAT (1995-6) and SABRE (2023) aircraft campaigns vs. an idealized mean age based on CO_2 and N_2O measurements from many aircraft campaign measurements.