Implementation of sulfur hexafluoride (SF_6) in the Belgian Assimilation System for Chemical ObsErvations (BASCOE)

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Abstract

Sulfur hexafluoride (SF_6) is a greenhouse gas that is emitted at the surface because of its use in electrical transmission equipment and electronic devices. Due to its quasi-linear emission growth and its very long lifetime, SF_6 has been used in the literature as a tracer for the Age of Air (AoA) to diagnose changes in the Brewer Dobson Circulation (BDC). The chemistry of SF_6 has been implemented in the Chemistry Transport Model (CTM) of the Belgian Assimilation System for Chemical ObsErvations (BASCOE). The chemical reaction scheme follows that of Löffel et al. (2022) while the reaction rates and electron climatology were obtained from Reddmann et al. (2001)

In this contribution, BASCOE-CTM simulations driven by ERA5 and MERRA2 are discussed considering SF_6 with mesospheric sinks. During the course of the simulations, the computed mixing ratios have also been saved in the space of MIPAS observations (version V5R_224/225) to analyze the impact of sampling on the final picture.

Method

Model set-up

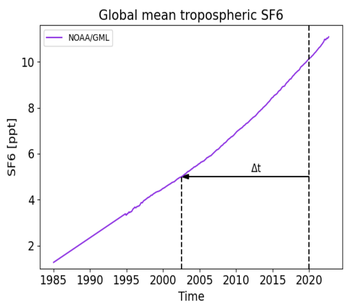
- Initial conditions from EMAC model output (2002-01)
- Lower boundary conditions adjusted from Meinhausen et al. 2016 and Gidden et al. 2019 to compare with EMAC
- Model top at 1Pa, 42 vertical levels, horizontal resolution of 2°x2.5°
- No assimilation was done in these simulations
- For MERRA2 and ERA-interim we use a subset of the vertical levels

AoA calculation

- Using a tropospheric reference curve
- Correction for nonlinearity of emissions

SF_6 chemistry

$$SF_6 + e^- \rightarrow (SF_6^-)^* \quad \text{auto-attachment}$$
$$(SF_6^-)^* + M \rightarrow SF_6^- \quad \text{stabilization}$$
$$(SF_6^-)^* \rightarrow SF_6 + e^- \quad \text{autodetachment}$$
$$SF_6^- + O_3 \rightarrow SF_6 + O_3^-$$
$$SF_6^- + H \rightarrow SF_5^+ + HF$$
$$SF_6^- + HCl \rightarrow \text{products}$$
$$SF_6^- + h\nu \rightarrow SF_6 + e^- \quad \text{photodetachment}$$



The age spectrum

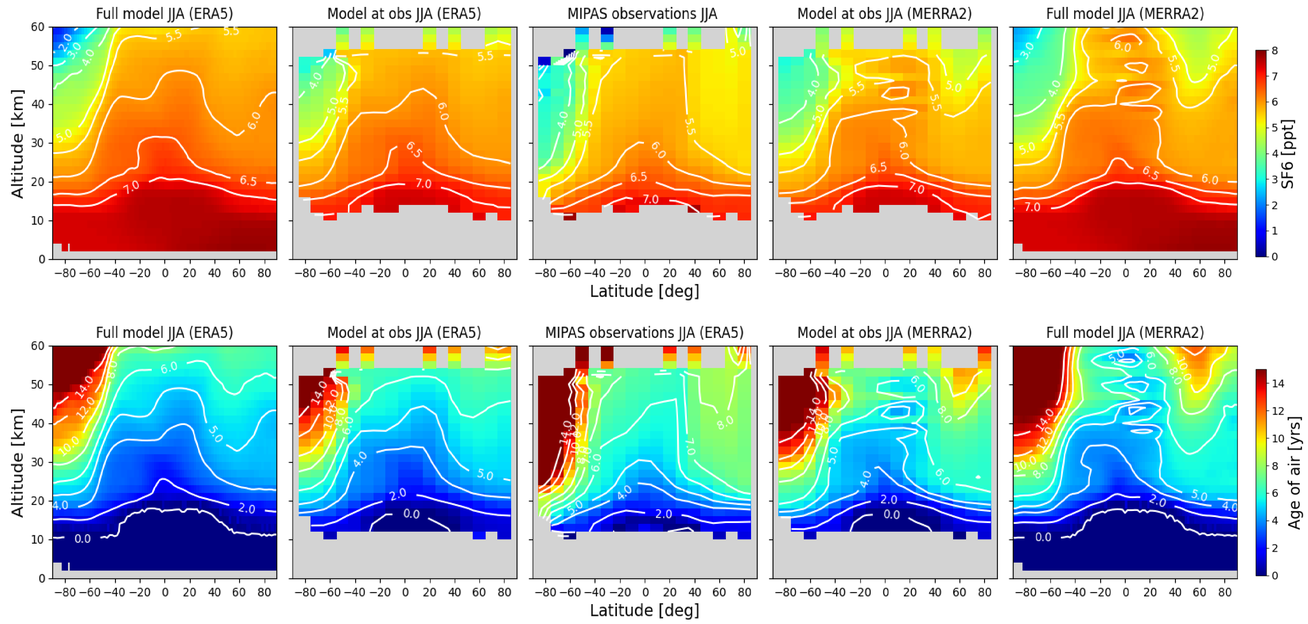
SF_6 is "propagated" from the troposphere to the stratosphere by the age spectrum *G*.

$$[SF_6]_{\text{modeled}} = \int_t G(\Gamma, \Delta, t) \cdot [SF_6]_{\text{trop}}(t) dt$$

$$G(\Gamma, \Delta, t') = \frac{1}{2\Delta\sqrt{\pi t'^3}} \exp\left[\frac{-\Gamma^2(t'-1)^2}{4\Delta^2 t'}\right]$$

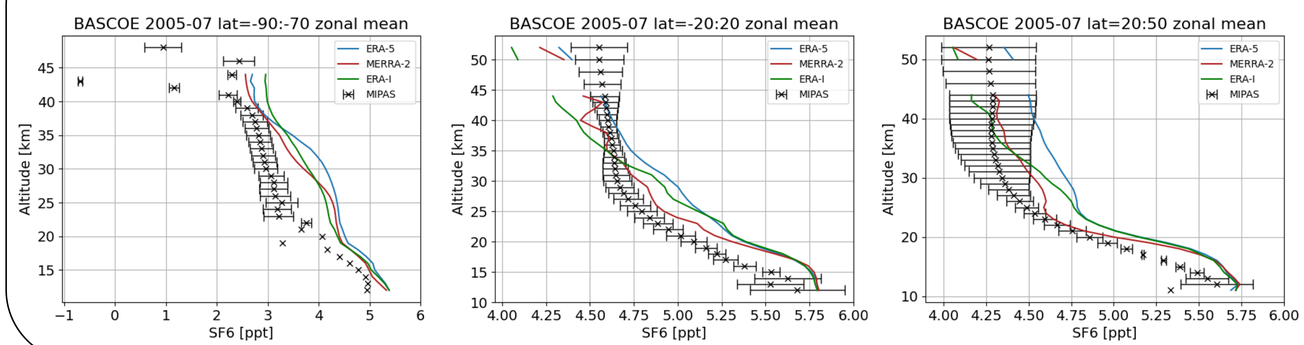
Almost linear increase of SF_6 in the troposphere. Reference curve linearly extrapolated below 1995.

Evaluation of the importance of sampling: BASCOE driven by ERA5 and MERRA2 (JJA 2011)



Top: SF6 concentrations. **Bottom**: corresponding mean apparent age of air**. Left to right**: full model output with ERA5, model interpolated at the observations, MIPAS observations, model interpolated at the observations with MERRA2 and full model output with MERRA2. All plots are zonal means.

Evaluation of SF_6 : comparison with MIPAS



SF_6 volume mixing ratios for a monthly mean of January in 2005 in 3 different latitude bands: the South Pole (90°S-70°S), the tropics (20°S-20°N) and the northern mid-latitudes (20°N-50°N).

The error bars on the MIPAS data are standard deviations of the variability calculated over the latitude bands.

Conclusions

- The mean apparent AoA is younger in the model than in the observations
- Sampling the full model output with the same sampling as the observations, brings the output closer to observational picture
- It seems that simulations with MERRA2 lie a little closer to the observations than simulations with ERA5 at this stage of the study

Future research

- Weaker mixing barriers/faster transport in BASCOE?
- Why is the impact of sampling so important?

Acknowledgements

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