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Supplement of

Mean age from observations in the lowermost stratosphere: an improved method and interhemispheric differences

Thomas Wagenhäuser et al.

Correspondence to: Thomas Wagenhäuser (wagenhaeuser@iau.uni-frankfurt.de)

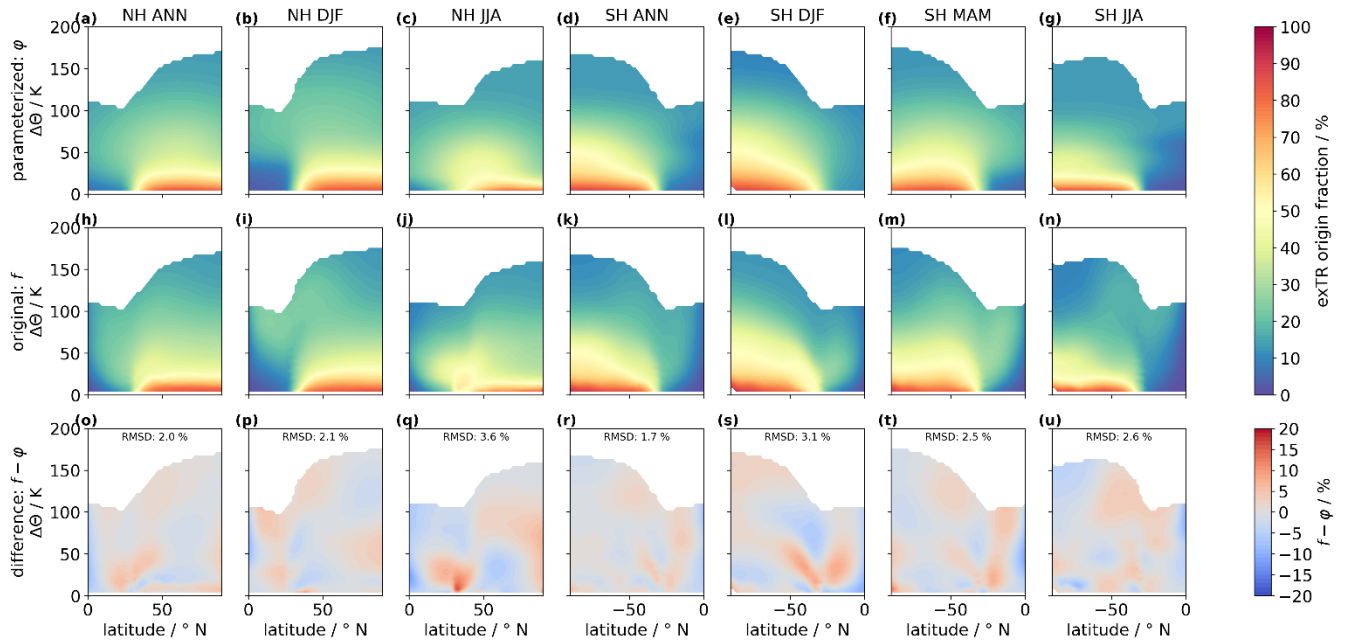# S1 CLaMS origin fraction parameterizations

Figure S1: Same as Fig. 1 in the manuscript, but for all the remaining seasons that are not shown there.

S2 Time shifts to three entry regions: Monte Carlo simulation to test slopes in annual mean time shifts

Table S1: Mean slopes and slope standard deviation from Monte-Carlo simulation using the data shown in Fig. 2. Ratios of mean slopes and standard deviations have been calculated prior to rounding.

	mean time shift slope / years years-1	time shift slope standard deviation / years years-1	ratio of mean slope and standard deviation
NH exTR entry region	$-2*10^{-3}$	$3*10^{-3}$	-0.9
TR entry region	$-5*10^{-4}$	$3*10^{-3}$	-0.2
SH exTR entry region	$-1*10^{-3}$	$2*10^{-3}$	-1.1

S3 Software implementation of calculating mean age in the LMS

Our conceptual framework on how to calculate mean age of air in the LMS is outlined in Sect. 2.1 in the manuscript. Here, we focus on detailed aspects on how the concept is implemented in our python software. The python code can be accessed at https://doi.org/10.5281/zenodo.7267203.

We tested calculating mean age from SF_6 measurements assuming an inert ideal quadratic tracer (Eq. (6) in the manuscript) versus using the G-match approach and found only negligible differences for mean ages greater than one year. For lower mean ages the G-match approach leads to numerical issues that cause larger deviations. Therefore, we decided to use Eq. (6) for all mean age calculations in context of this study.

The software requires input of eight arguments:

1. The absolute time axis of the TR ground reference time series
2. concentrations of the TR ground references time series
3. time of tracer observation
4. observed tracer concentration
5. ratio of moments
6. exTR origin fraction
7. exTR tropopause time shift to the reference time series
8. TR tropopause time shift to the reference time series

The input is handled in a four steps process to derive the mean age:

(i) The TR ground reference time series (arguments 1. and 2.) is shifted relative to the time of stratospheric observation.

(ii) A second order polynomial fit is applied to the shifted reference time series, taking into account transit times covering 98 % of a first guess age spectrum plus one year after the observation. At least five years of data before the observation are taken into account.

(iii) The TR origin fraction is calculated by subtracting the exTR origin fraction from one.

(iv) The fit parameters, the observed tracer concentration, the ratio of moments, the exTR and the TR origin fraction, as well as the exTR and the TR time shifts to the reference time series are put into Eq. (6), to derive two solutions for mean age. The solution that is closer to zero is selected.

In context of this study, we use the tropical ground SF_6 mixing ratio time series and the time shifts described in Sect. 2.2.2 of the manuscript. exTR origin fractions are calculated from the parameterizations introduced in Sect. 2.2.1 of the manuscript. We apply a ratio of moments $\lambda=1.2$ years to parameterize the width of the age spectrum. The conventional TR-only method was implemented by using the same software and inputs, but setting the exTR fraction to zero.