

### S1. A comparison of UEA and NOAA SF<sub>6</sub> time series

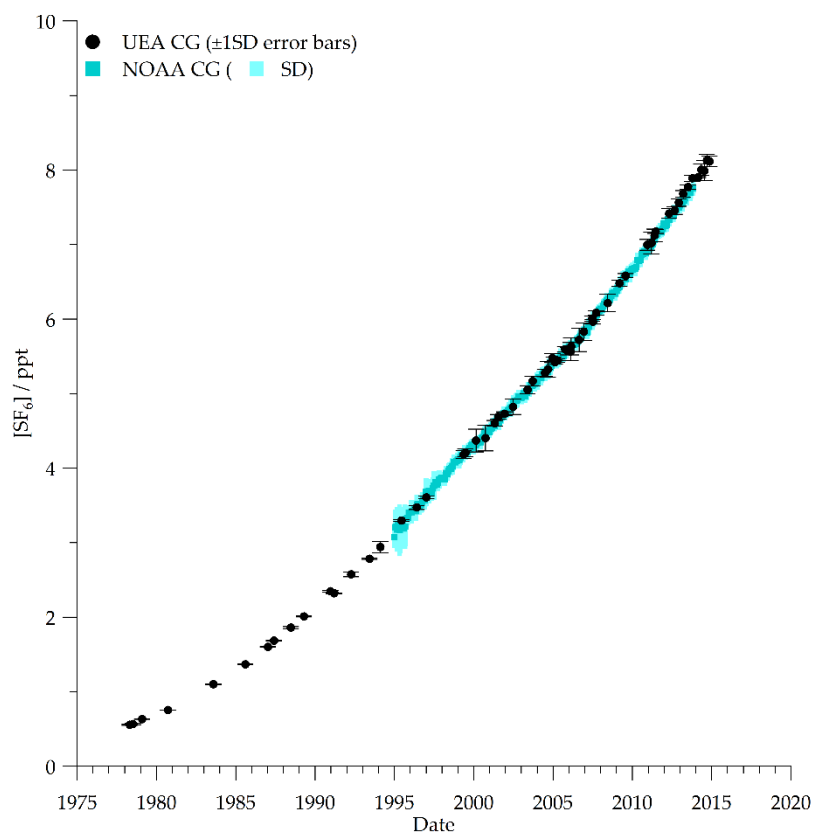


Figure S1. A comparison of Cape Grim (CG) time series data from UEA and NOAA (see inset legend) taken from flask measurements. The UEA CG time series analytical uncertainties are outlined in Section 2 of the main manuscript. The NOAA CG time series is a monthly average of approximately weekly flask samples with one standard deviation (SD) errors shown as the lighter shaded area. UEA SF<sub>6</sub> data is reported on the NOAA calibration scale. NOAA data was retrieved from the ‘Combined Sulfur hexafluoride data from the NOAA/ESRL Global Monitoring Division’ file on the NOAA server on 12<sup>th</sup> July 2017 and is accessible here: <https://www.esrl.noaa.gov/gmd/hats/combined/SF6.html>.

## **S2. A summary of all tests performed as part of the mean age uncertainty analysis described in Section 3**

An introduction to our terminology:

- ‘Raw’: UEA’s Cape Grim time series used as is (grey points in main manuscript Fig. 1)
  - ‘Raw\_min’ and ‘raw\_max’ tropospheric trends derived from the mean mixing ratio values  $\pm$  the analytical uncertainties outlined in Section 2.
- ‘Fit’ is the fit-interpolated dataset derived from UEA’s Cape Grim time series (blue line in main manuscript Fig. 1)
  - ‘Fit\_min’ and ‘fit\_max’ are derived from the fit  $\pm$  the uncertainties from the bootstrapping procedure outlined in Section 3a.
- ‘NOAA’: UEA stratospheric data used with a tropospheric trend derived from the NOAA SF<sub>6</sub> time series available from <https://www.esrl.noaa.gov/gmd/hats/combined/SF6.html>
- ‘SIO’: mean ages calculated using an independent analysis of the stratospheric samples performed by the Scripps Institution of Oceanography, SIO and tropospheric trends provided by SIO.
  - ‘SIO\_min’ and ‘SIO\_max’: as for ‘raw\_min’ and ‘raw\_max’ but derived from the SIO trends  $\pm$  their analytical uncertainties.
- MRs = mixing ratio
- The difference between ‘quadratic’ and ‘convolution’ AoA routines is described in the main manuscript Section 3c.
- The ‘base case’ column shows the scenario we compared the ages in question to when calculating the mean age difference, e.g. the differences shown in the residual plots (Fig. 2 and SI-3).

Note: Where ‘symmetrical’ tests were performed, namely ‘min’ and ‘max’ analyses where the same uncertainty was either added or subtracted, the average of both of these results combined is presented to simplify the table.

Experimenting with...	Case #	Tropospheric trend input	Stratospheric data	AoA routine	Parameterisation of width of age spectrum	Average absolute difference / months								Manuscript section
						Base case	SF <sub>6</sub>	C <sub>2</sub> F <sub>6</sub>	C <sub>3</sub> F <sub>8</sub>	CHF <sub>3</sub>	HFC-125	HFC-227ea	CF <sub>4</sub>	
Tropospheric trend inputs	1	Fit	Mean MRs	Quadratic	0.7									Base case
	2	Raw	Mean MRs	Quadratic	0.7	1	0.5	2.2	0.8	0.9	1.1	1.8		-
	3	NOAA	Mean MRs	Quadratic	0.7	1	1.9							-
	4	Fit_min	Mean MRs	Quadratic	0.7	1	1.1	1.8	2.5	1.5	0.6	2.4		3a
	5	Fit_max	Mean MRs	Quadratic	0.7	1								
	6	Raw_min	Mean MRs	Quadratic	0.7	2	3.2	3.8	2.2	4.8	0.9	3.2		-
	7	Raw_max	Mean MRs	Quadratic	0.7	2								
Stratospheric sample inputs	8	Fit	Min MRs	Quadratic	0.7	1	2.5	5.8	3.2	4.5	0.6	2.9		3b
	9	Fit	Max MRs	Quadratic	0.7	1								
	10	Raw	Min MRs	Quadratic	0.7	2	2.5	5.9	3.3	4.5	0.7	2.7		-
	11	Raw	Max MRs	Quadratic	0.7	2								
Parameterisation of width of age spectrum	12	Fit	Mean MRs	Quadratic	0.5	1	0.2	0.7	0.7	0.2	0.6	0.5		3d
	13	Fit	Mean MRs	Quadratic	1	1	0.3	0.8	0.7	0.4	0.4	0.4		3d
	14	Raw	Mean MRs	Quadratic	0.5	2		0.7	0.8	0.4	0.9	0.9		-
	15	Raw	Mean MRs	Quadratic	1	2		0.8	0.8	0.3	0.8	0.8		-
	16	NOAA	Mean MRs	Quadratic	0.5	3	0.3							-
	17	NOAA	Mean MRs	Quadratic	1	3	0.5							-
AoA routine (samples >1 yr mean age only)	18	Fit	Mean MRs	Convolution	0.7	1	0.2	0.7	1.2	0.1	0.6	0.2		3c
	19	Raw	Mean MRs	Convolution	0.7	2	1.1	3.4	1.4	2.3	2.9	10.4		-
	20	NOAA	Mean MRs	Convolution	0.7	3	0.4							-
Tropospheric trend inputs using the ‘convolution’ AoA routine	21	Fit_min	Mean MRs	Convolution	0.7	18	2.8	1.8	2.2	3.2	0.6	2.2		-
	22	Fit_max	Mean MRs	Convolution	0.7	18								
	23	Raw_min	Mean MRs	Convolution	0.7	19	3.4	3.6	3.1	4.2	0.9	13.3		-
	27	Raw_max	Mean MRs	Convolution	0.7	19								
Stratospheric sample inputs using the ‘convolution’ AoA routine	28	Fit	Min MRs	Convolution	0.7	18	2.4	5.9	2.5	4.3	0.6	2.8		-
	29	Fit	Max MRs	Convolution	0.7	18								
	30	Raw	Min MRs	Convolution	0.7	19	2.4	6.5	2.8	4.2	0.6	4.8		-
	31	Raw	Max MRs	Convolution	0.7	19								
Independent verification using SIO data	32	SIO	Mean SIO	Quadratic	0.7									Base case for SIO data
	33	SIO	Min SIO	Quadratic	0.7	32	2.8	11.1					4.2	3b
	34	SIO	Max SIO	Quadratic	0.7	32								
	35	SIO_min	Mean SIO	Quadratic	0.7	32	2.6	4.2					2.1	3a
	36	SIO_max	Mean SIO	Quadratic	0.7	32								

### S3. Residual plots showing the uncertainties associated with Sections 3c and 3d of the main manuscript

‘Residual plots’ are plots showing the difference between the mean age derived from the base case and those derived from variations on this used to test the impact of measurement (and other) uncertainties on derived mean ages.

#### S3.1 Supplementary plot for main manuscript Section 3c: Comparing different methods for implementing the tropospheric time series component of the mean age calculation

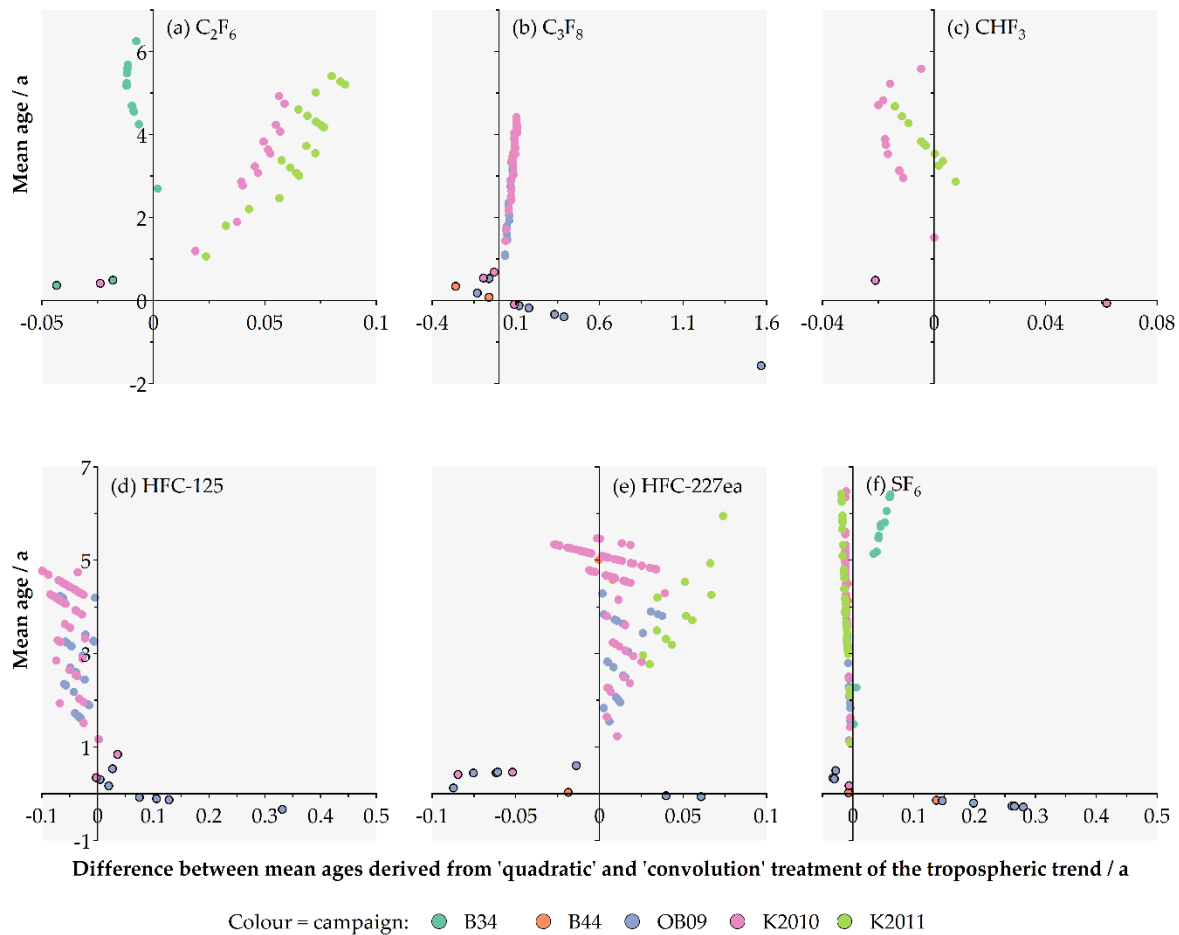


Figure S2. Residual plots showing the uncertainties associated with varying the treatment of the tropospheric trend within the age of air routine. The base case uses the standard quadratic fit and this is compared to a convolution approach. See main manuscript Section 3c for full details. The x-axis shows the difference between these two approaches, plotted against the mean age from the quadratic approach. Marker colour denotes the stratospheric campaign, see inset legend. Values for mean ages less than 1 year were removed from further analysis, see details in Section 3d, these are highlighted by a black outline in this figure. Vertical axis labels for each row are in the left panel.

### S3.2 Supplementary plot for main manuscript Section 3d. Uncertainty in parameterisation of width of age spectrum

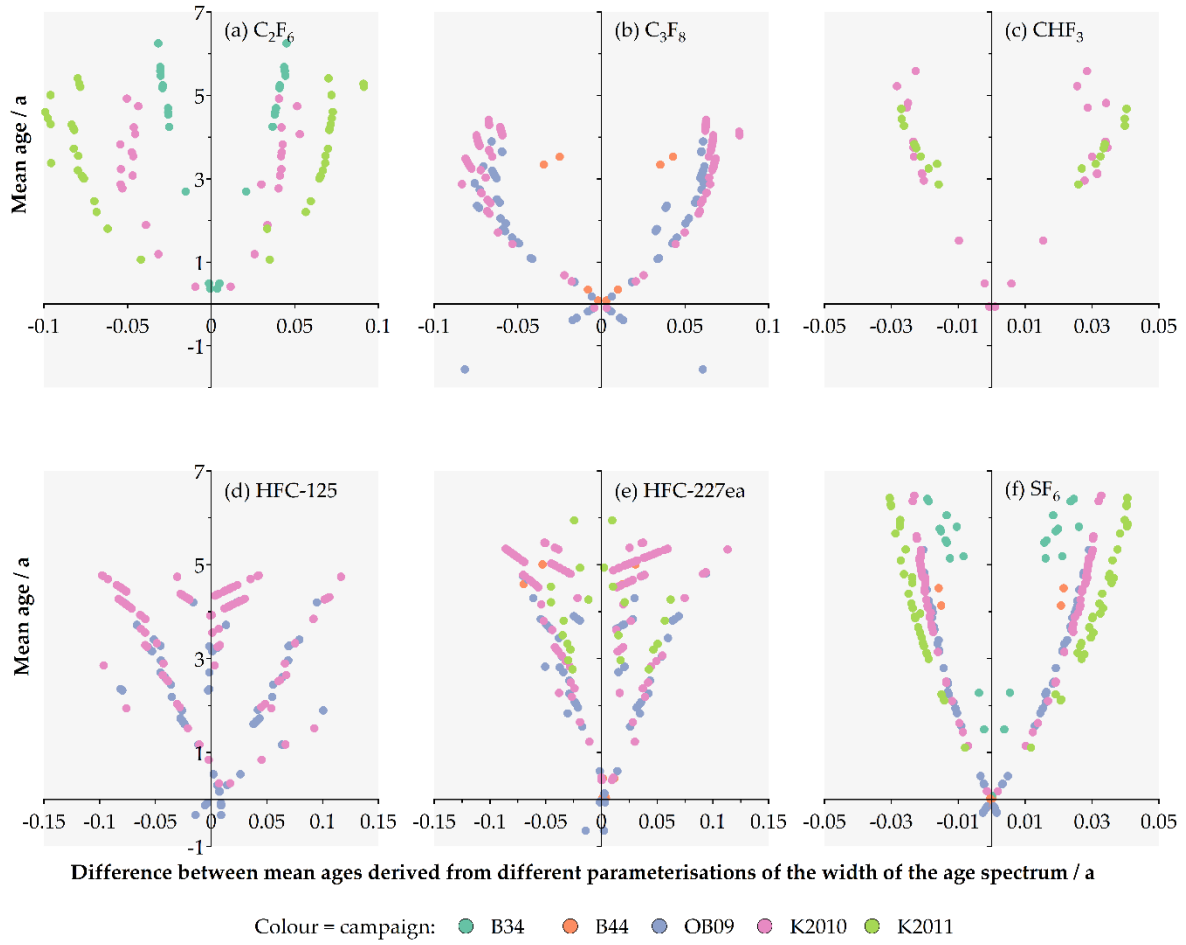


Figure S3. Residual plots showing the uncertainties associated with varying the parameterisation of the width of the age spectrum, see main manuscript Section 3d for further details. The x-axis shows the difference between the base case (width = 0.7) and the variants (widths = 0.5 and 1), plotted against the mean age derived from the base case. Marker colour denotes the stratospheric campaign, see inset legend. Vertical axis labels for each row are in the left panel.