1 Scatterplots of mixing ratios vs. clock tracer AoA from CLaMS results for four days in 2011 and 4 tracers

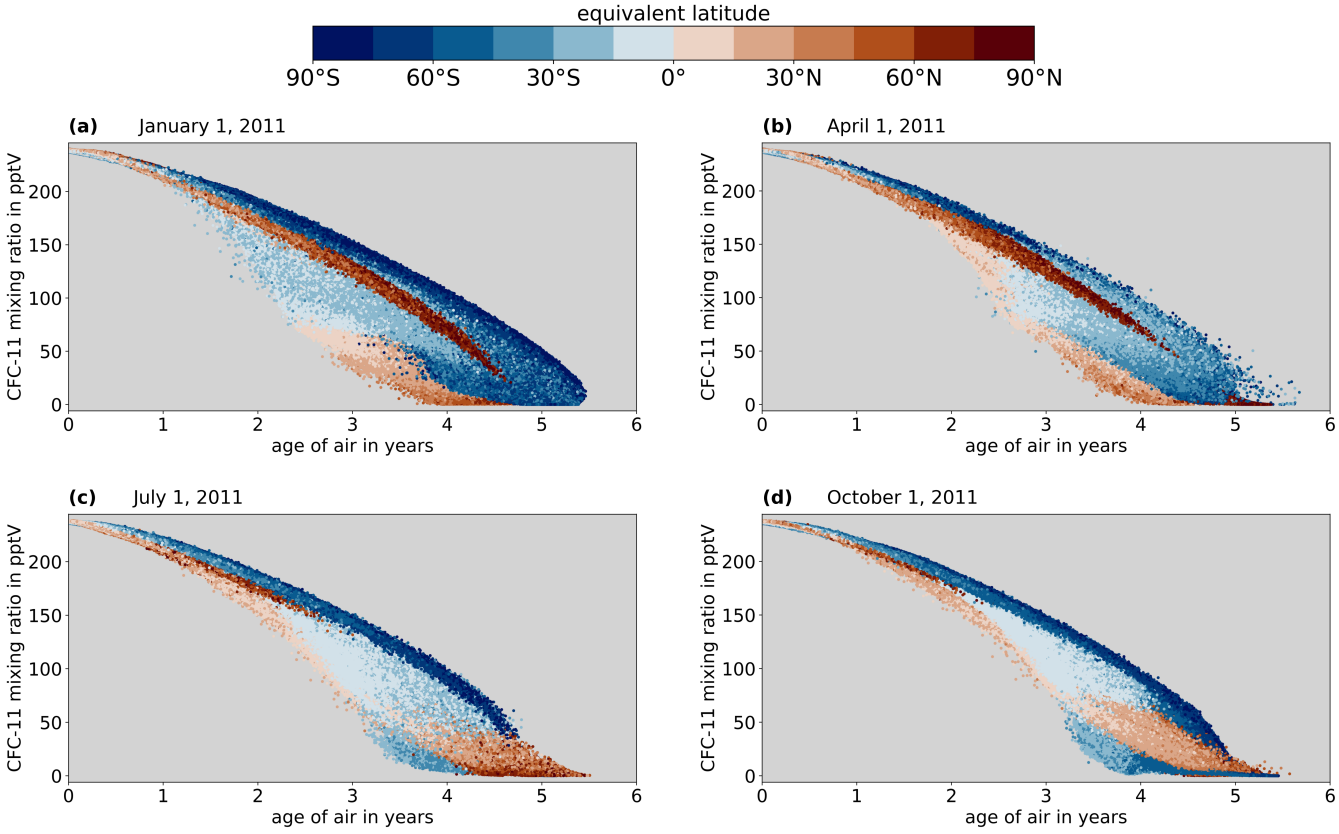

Figure S1. Results of CLaMS simulation up to 25 km at four different days in 2011, trichlorofluoromethane volume mixing ratios plotted against mean age of air from clock tracer with color-coded equivalent latitude.

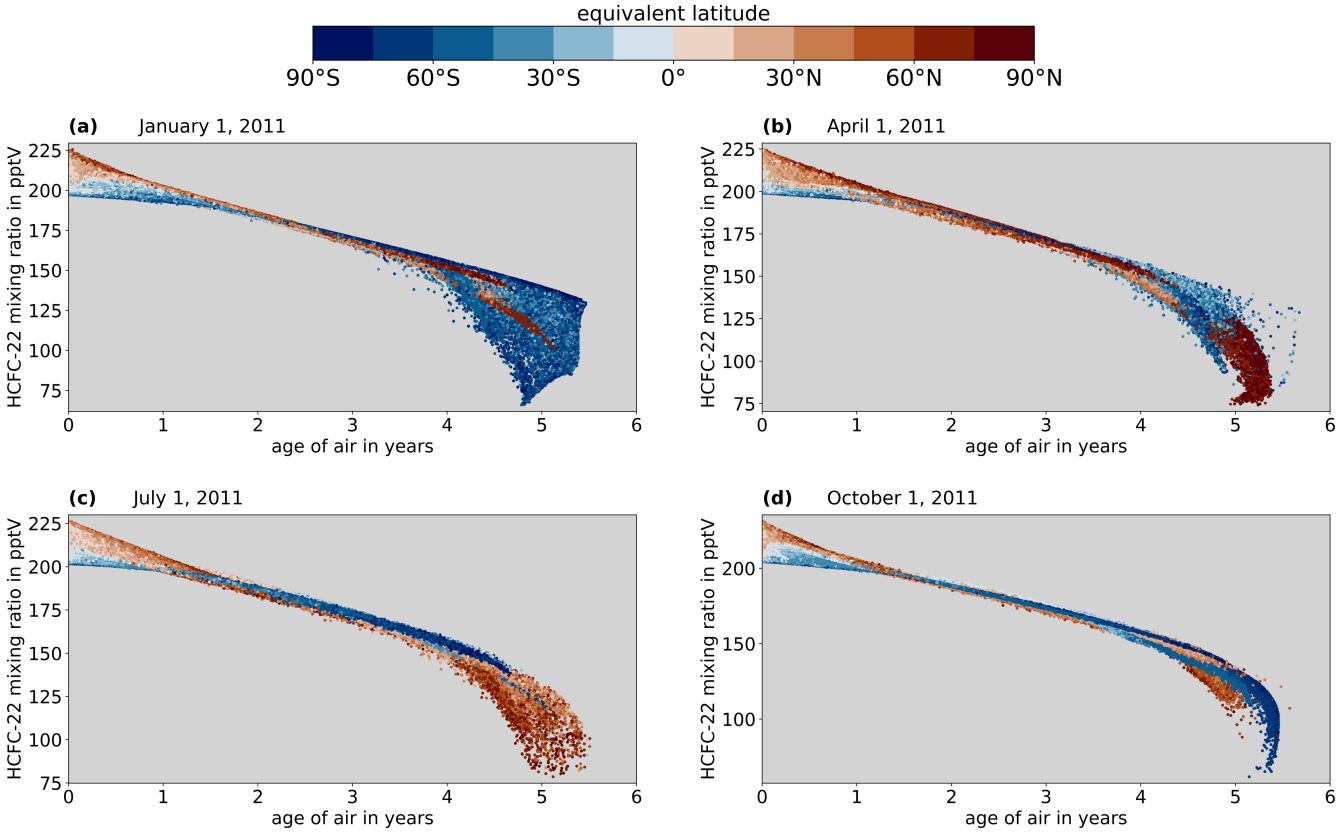

Figure S2. Same as Fig. S1 but for chlorodifluoromethane.

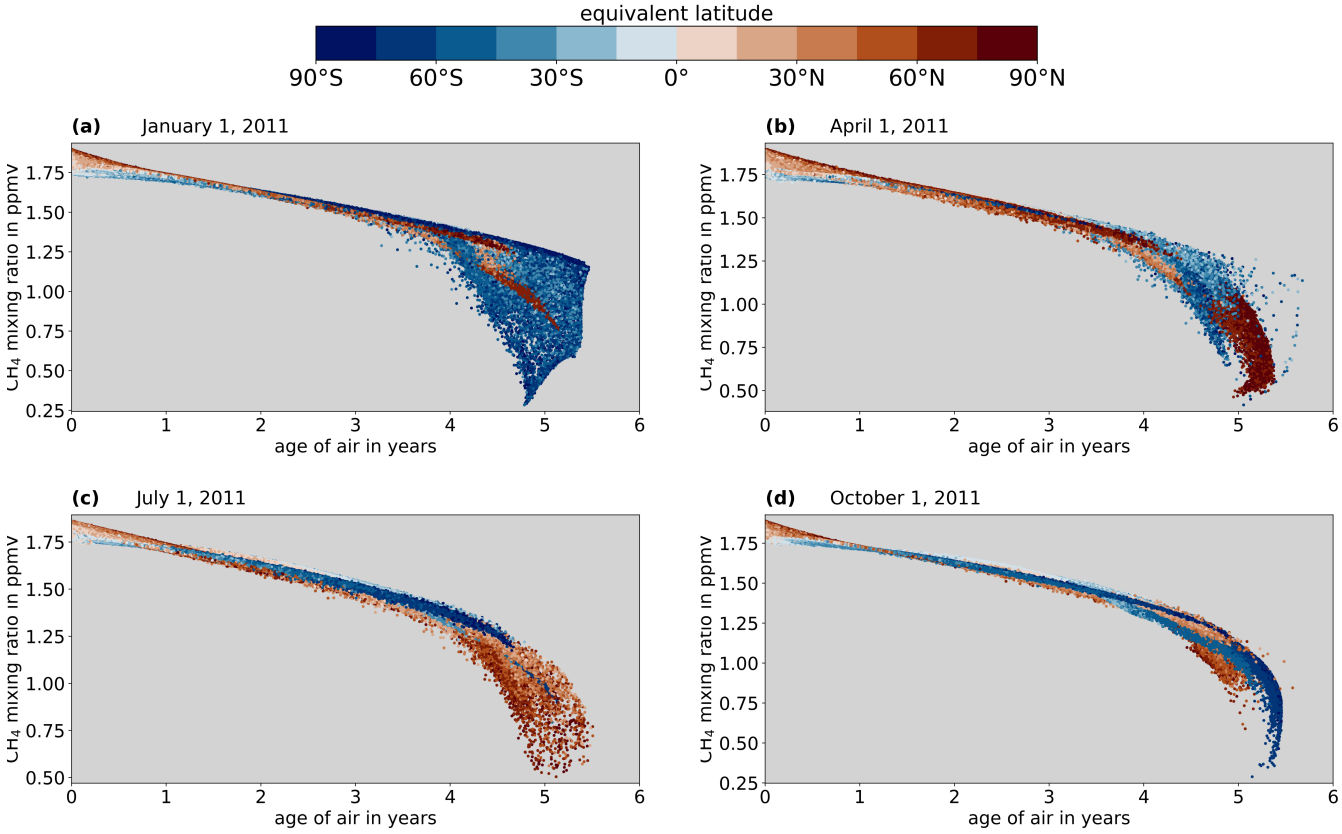

Figure S3. Same as Fig. S1 but for methane.

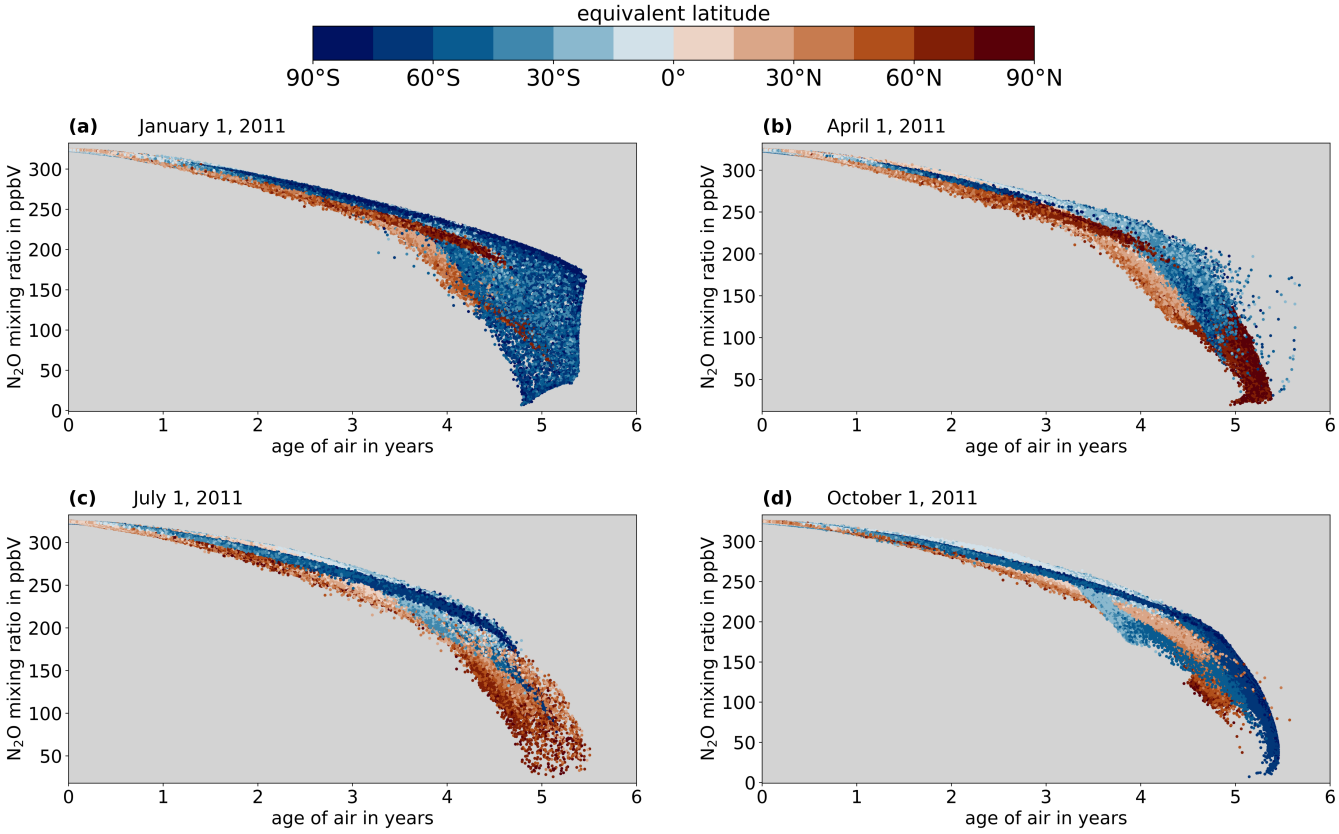

Figure S4. Same as Fig. S1 but for nitrous oxide.

2 Lookup tables

2.1 Full zonally-dependent (original, not zonally averaged) CLaMS results

2.1.1 Four days in 2011

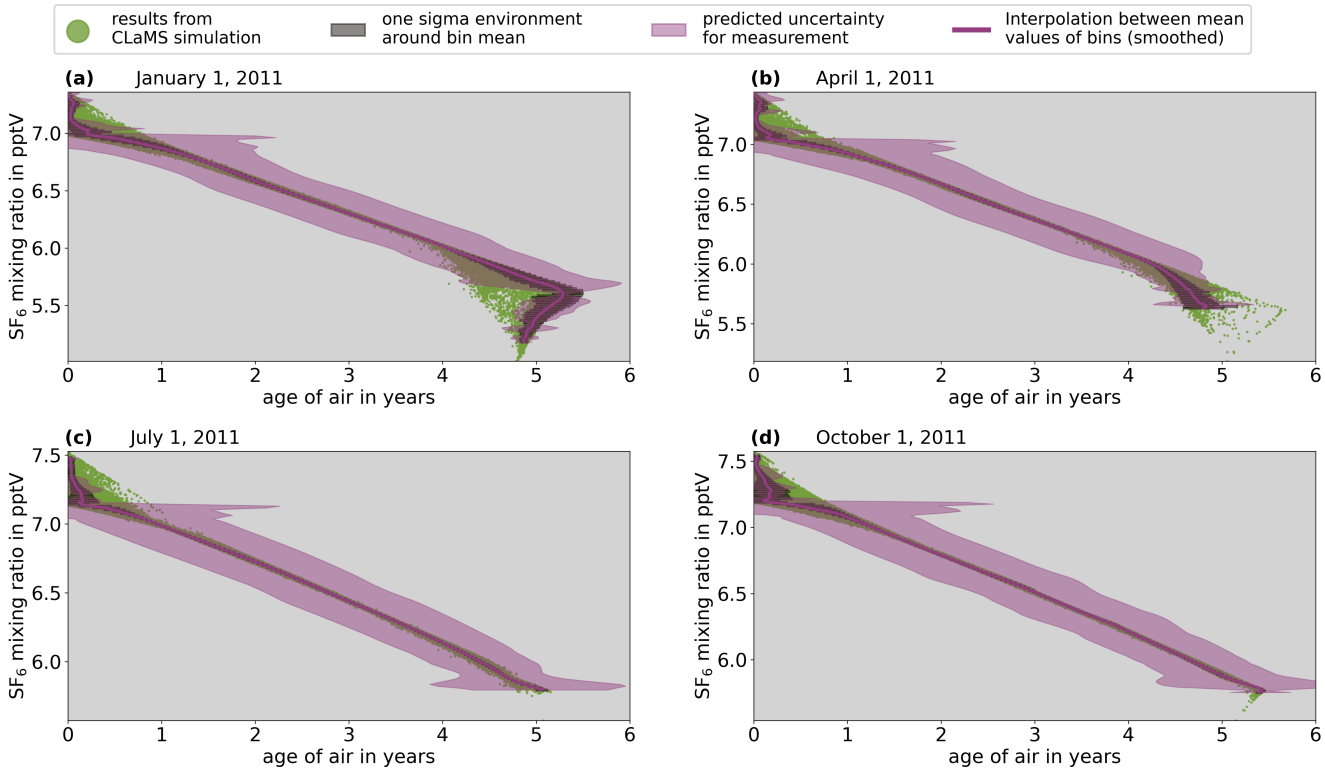

Figure S5. Green dots: Results of CLaMS simulation up to 25 km on southern hemisphere by equivalent latitude at four different days in 2011, SF_6 volume mixing ratios plotted against clock tracer AoA. Black boxes: One sigma environment around average AoA in volume mixing ratio bins included in lookup table (Part of uncertainty of AoA that arises from spread of data points). Magenta line: Series of bin midpoints (mean AoA/mean mixing ratio) smoothed with Savitzky-Golay-Filter (used as lookup table). Magenta shading: Part of uncertainty of AoA that arises from measurement of trace gas (estimated with expected uncertainty in Tab. 2 in article according to method illustrated in Fig. 2 in article).

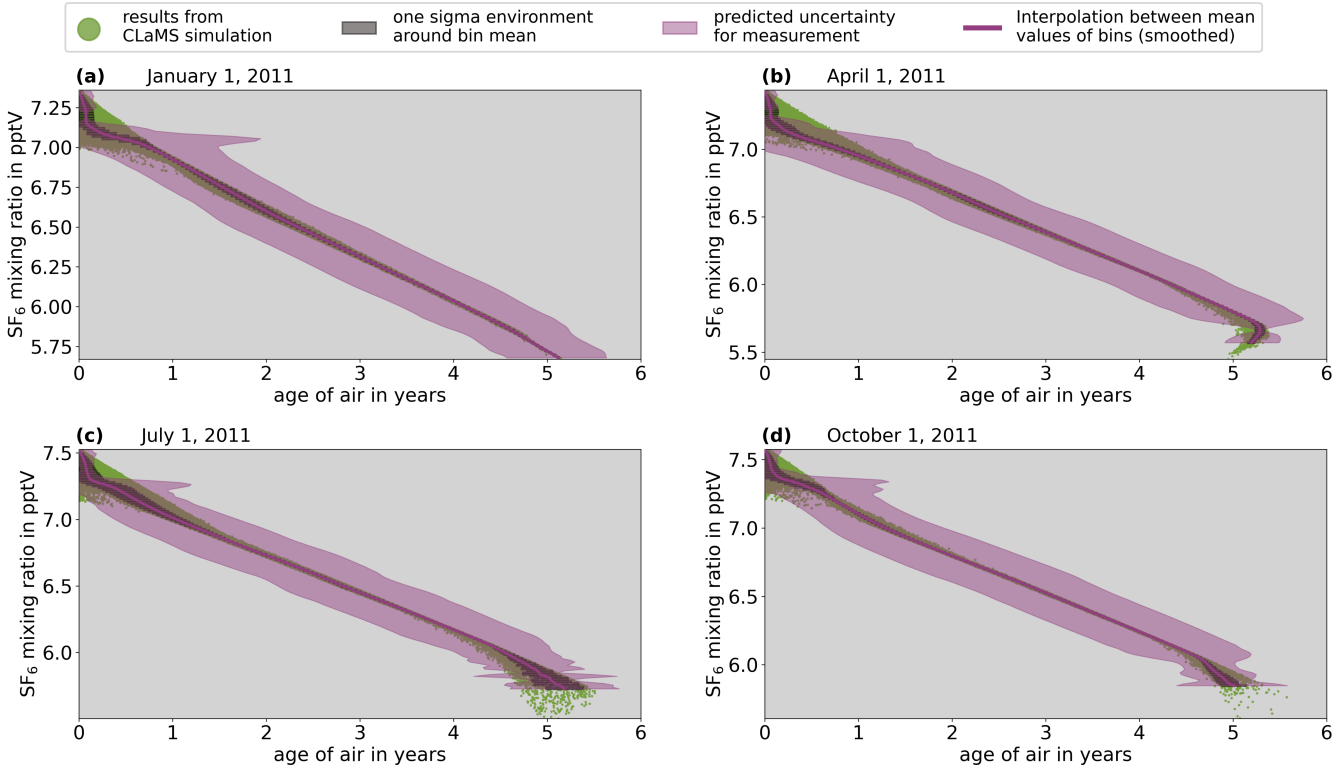

Figure S6. Same as Fig. S5 but for the northern hemisphere.

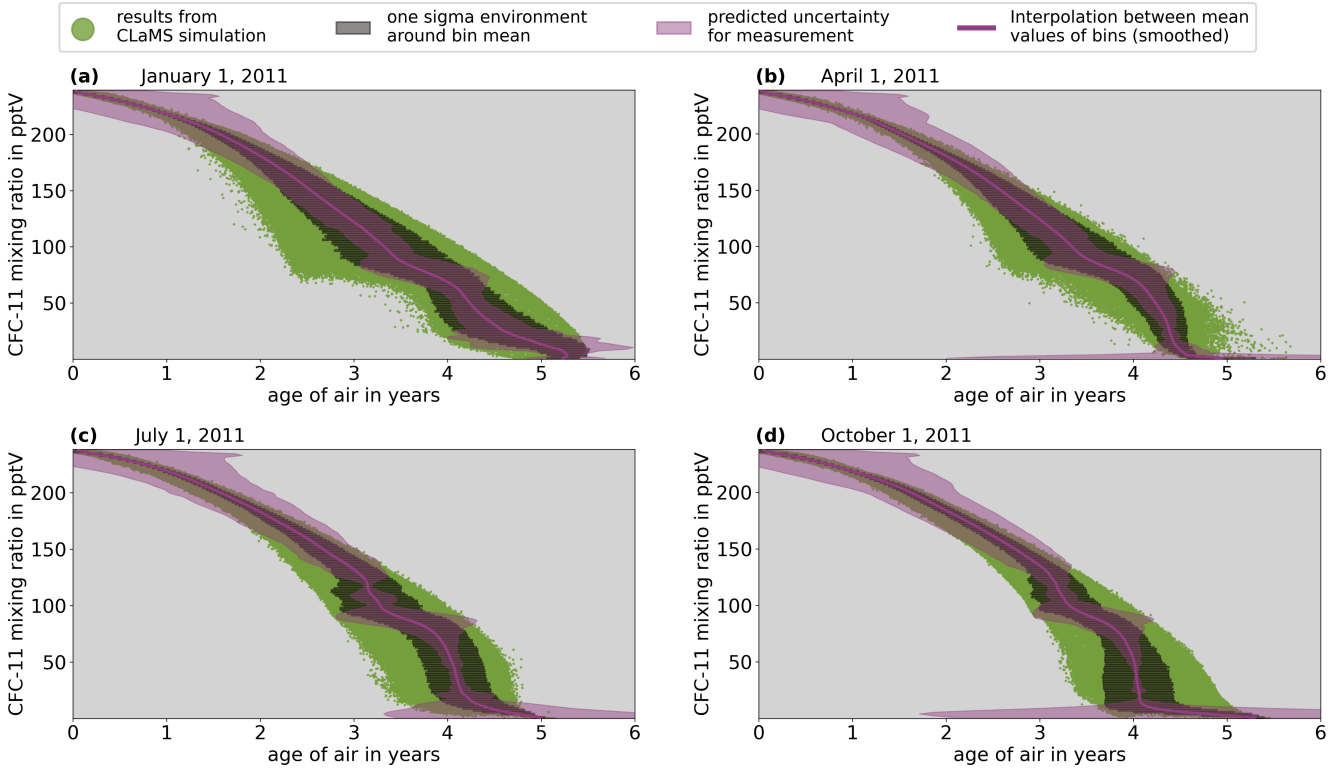

Figure S7. Green dots: Results of CLaMS simulation up to 25 km on southern hemisphere by equivalent latitude at four different days in 2011, CFC-11 volume mixing ratios plotted against clock tracer AoA. Black boxes: One sigma environment around average AoA in volume mixing ratio bins included in lookup table (Part of uncertainty of AoA that arises from spread of data points). Magenta line: Series of bin midpoints (mean AoA/mean mixing ratio) smoothed with Savitzky-Golay-Filter (used as lookup table). Magenta shading: Part of uncertainty of AoA that arises from measurement of trace gas (estimated with expected uncertainty in Tab. 2 in article according to method illustrated in Fig. 2 in article).

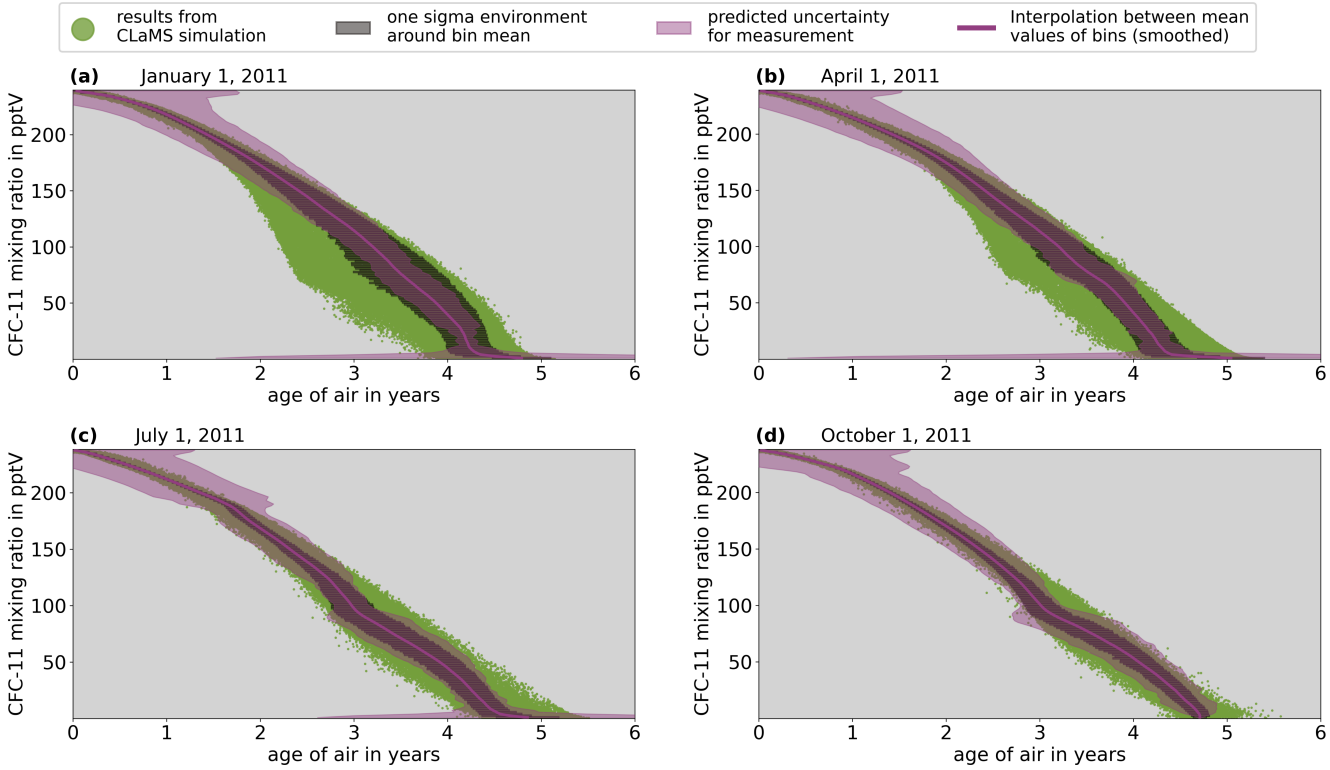

Figure S8. Same as Fig. S7 but for the northern hemisphere.

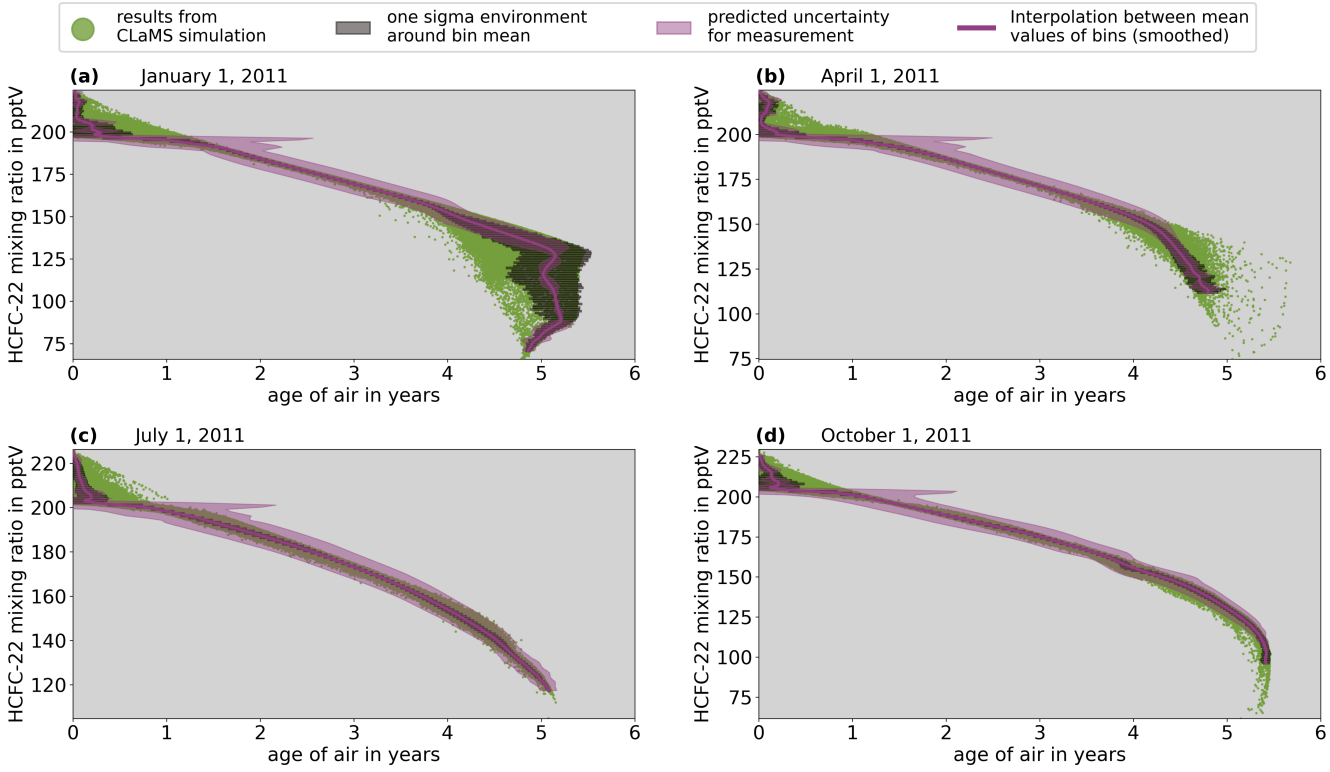

Figure S9. Green dots: Results of CLaMS simulation up to 25 km on southern hemisphere by equivalent latitude at four different days in 2011, HCFC-22 volume mixing ratios plotted against clock tracer AoA. Black boxes: One sigma environment around average AoA in volume mixing ratio bins included in lookup table (Part of uncertainty of AoA that arises from spread of data points). Magenta line: Series of bin midpoints (mean AoA/mean mixing ratio) smoothed with Savitzky-Golay-Filter (used as lookup table). Magenta shading: Part of uncertainty of AoA that arises from measurement of trace gas (estimated with expected uncertainty in table 2 in article according to method illustrated in Fig. 2 in article).

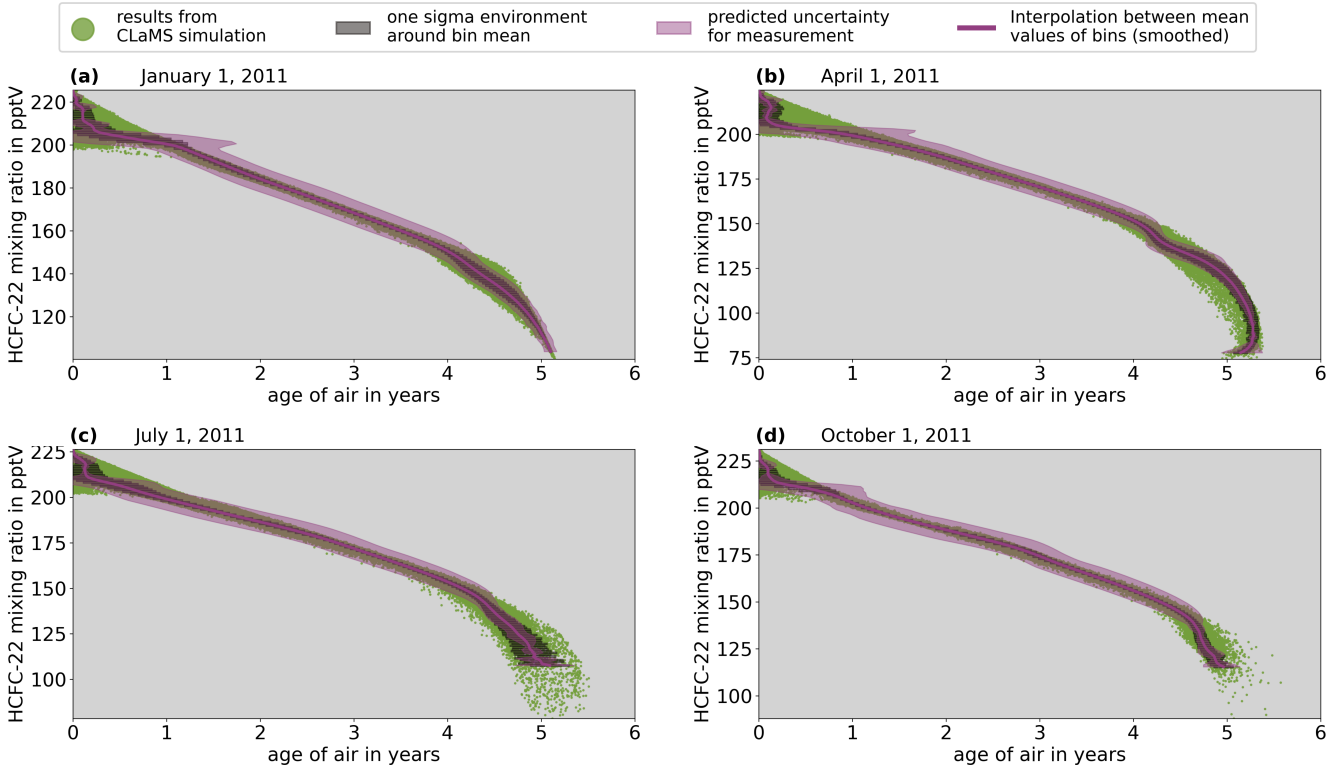

Figure S10. Same as Fig. S9 but for the northern hemisphere.

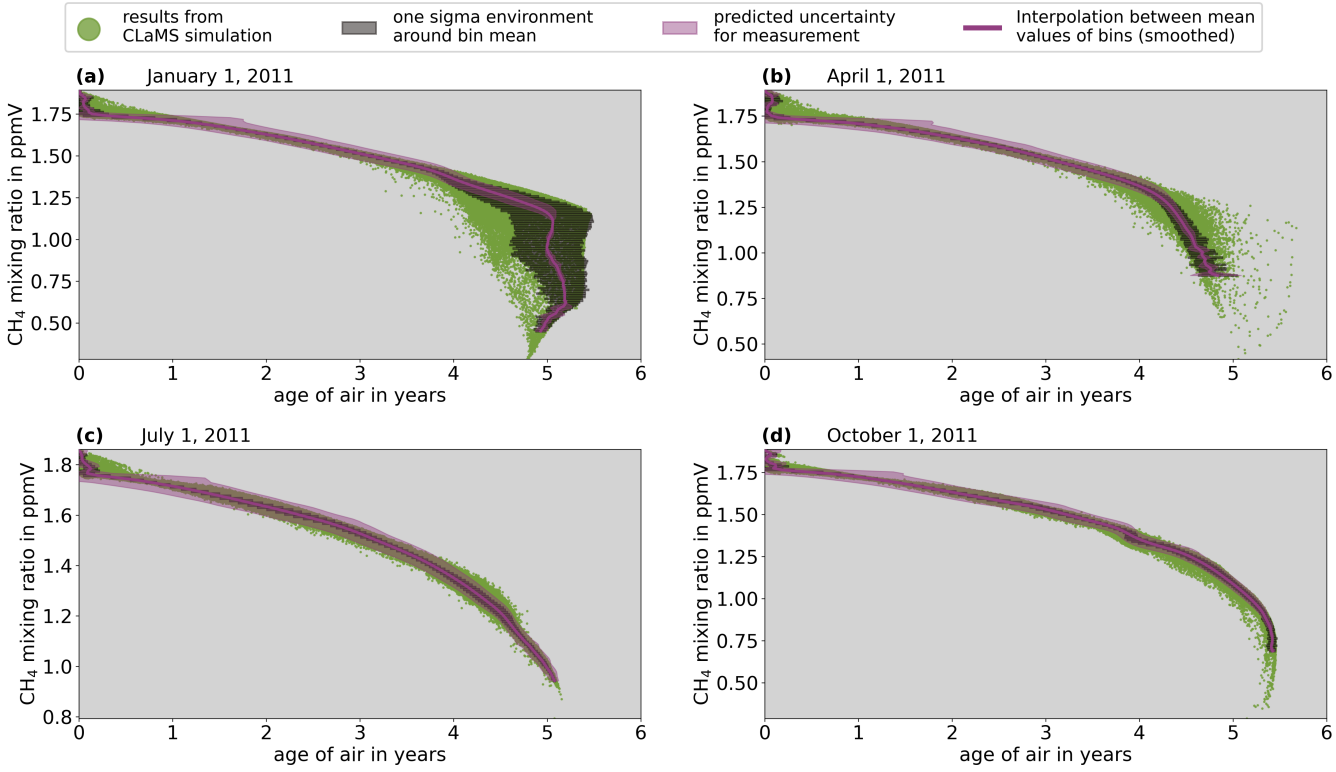

Figure S11. Green dots: Results of CLaMS simulation up to 25 km on southern hemisphere by equivalent latitude at four different days in 2011, CH_4 volume mixing ratios plotted against clock tracer AoA. Black boxes: One sigma environment around average AoA in volume mixing ratio bins included in lookup table (Part of uncertainty of AoA that arises from spread of data points). Magenta line: Series of bin midpoints (mean AoA/mean mixing ratio) smoothed with Savitzky-Golay-Filter (used as lookup table). Magenta shading: Part of uncertainty of AoA that arises from measurement of trace gas (estimated with expected uncertainty in Tab. 2 in article according to method illustrated in Fig. 2 in article).

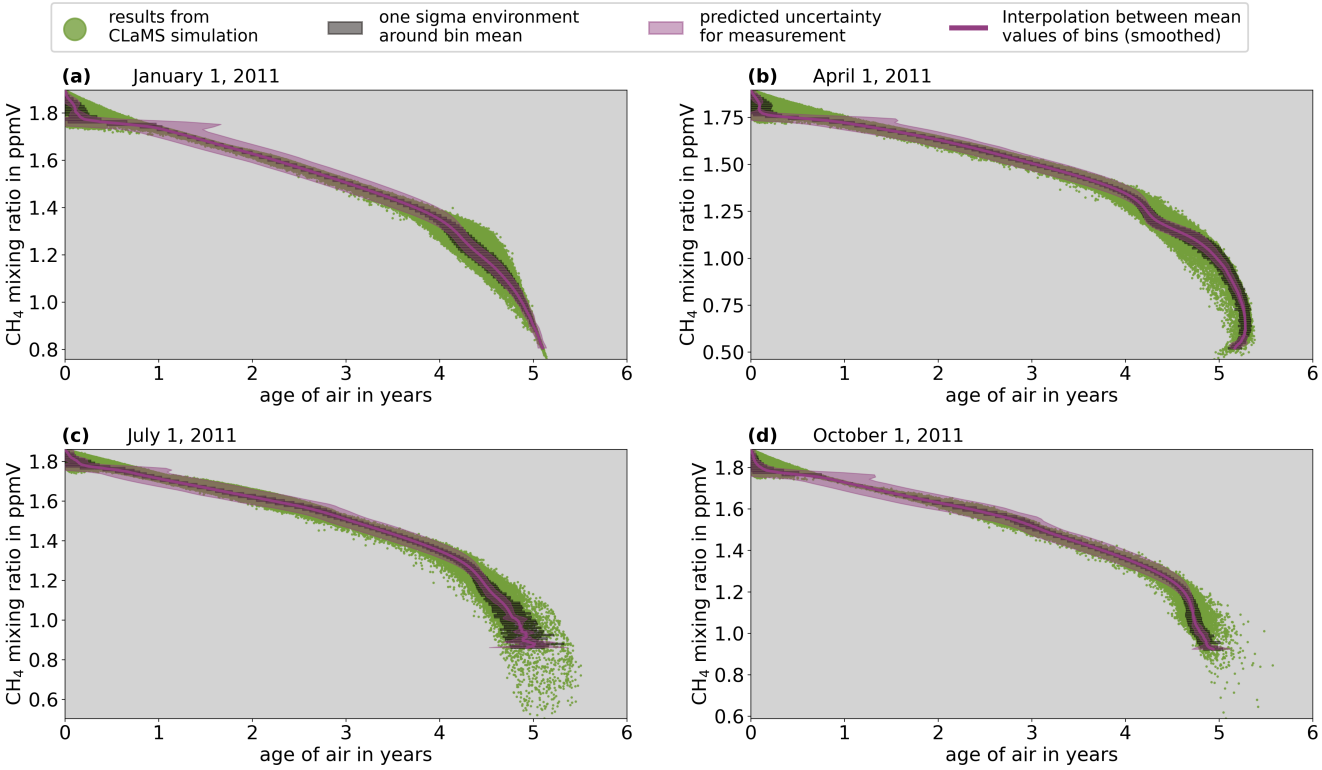

Figure S12. Same as Fig. S11 but for the northern hemisphere.

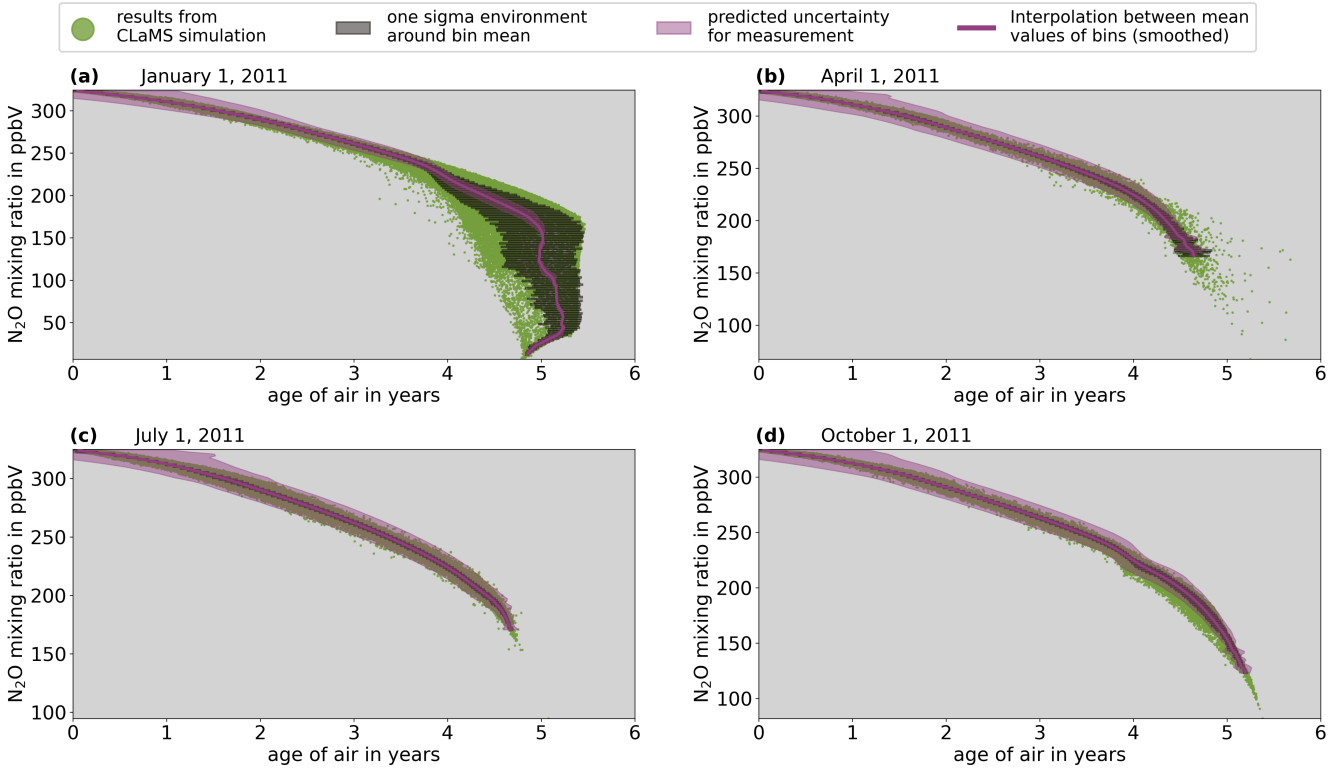

Figure S13. Green dots: Results of CLaMS simulation up to 25 km on southern hemisphere by equivalent latitude at four different days in 2011, N_2O volume mixing ratios plotted against clock tracer AoA. Black boxes: One sigma environment around average AoA in volume mixing ratio bins included in lookup table (Part of uncertainty of AoA that arises from spread of data points). Magenta line: Series of bin midpoints (mean AoA/mean mixing ratio) smoothed with Savitzky-Golay-Filter (used as lookup table). Magenta shading: Part of uncertainty of AoA that arises from measurement of trace gas (estimated with expected uncertainty in table 2 in article according to method illustrated in Fig. 2 in article).

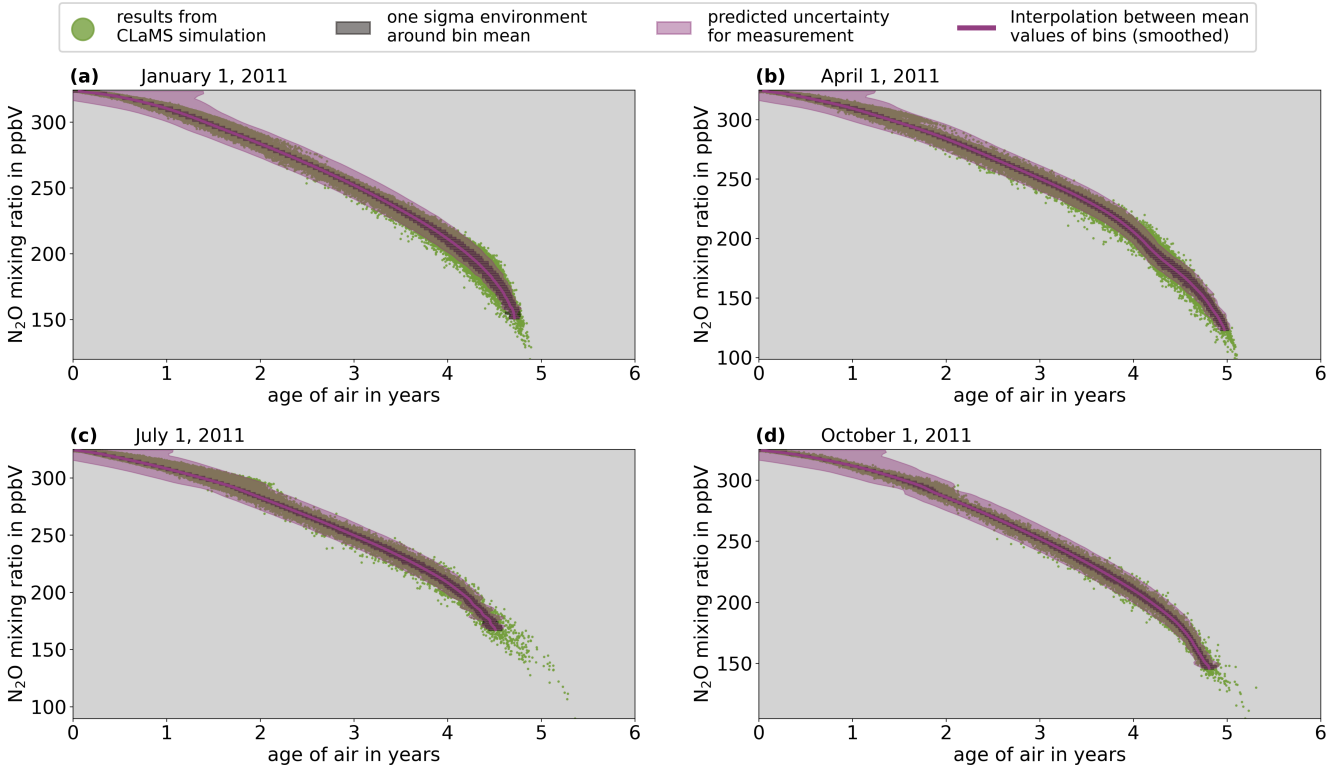

Figure S14. Same as Fig. S13 but for the northern hemisphere.

2.1.2 Northern hemisphere on 21/08/2021 (GLORIA-B launch date at Kiruna, Sweden)

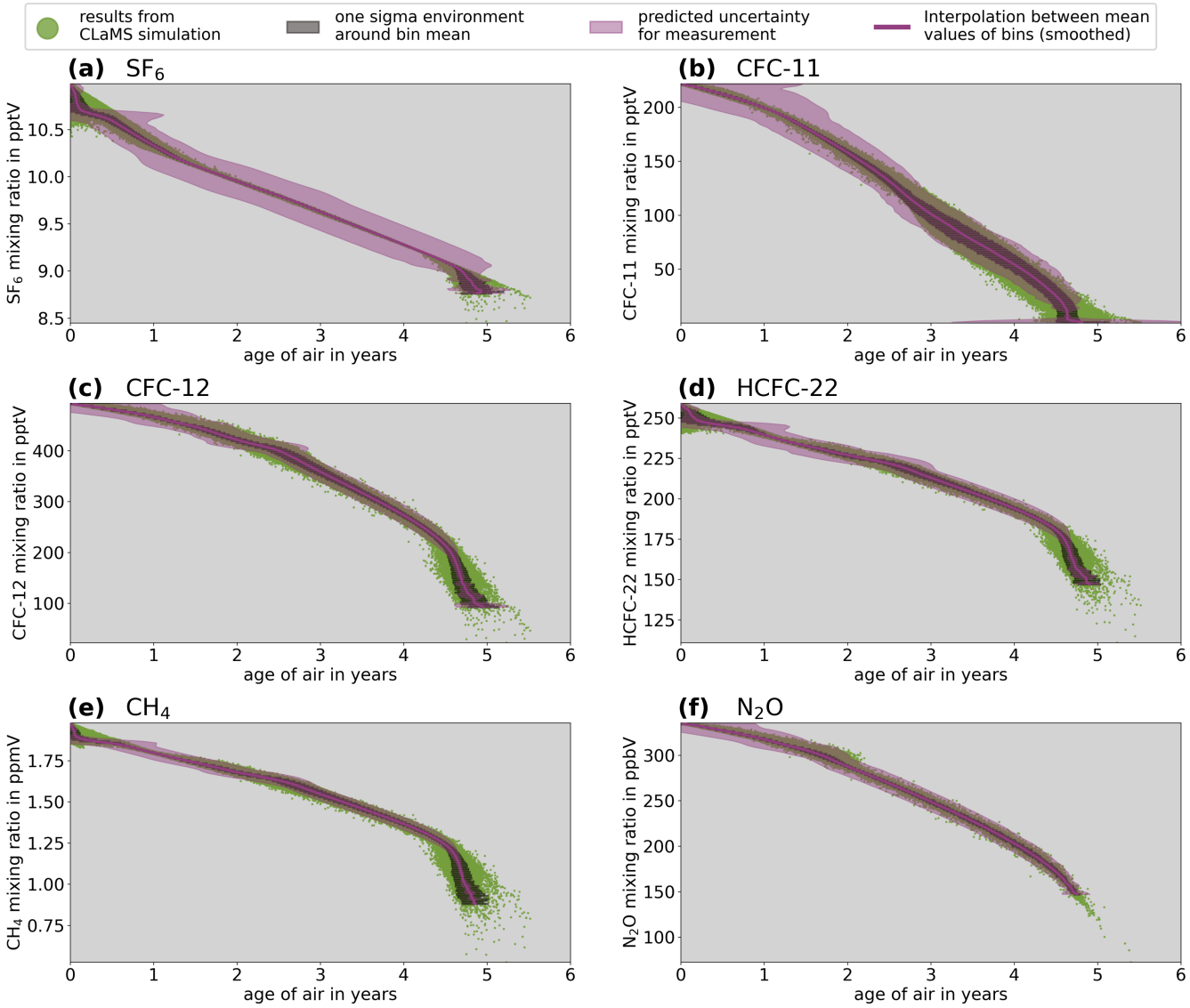

Figure S15. Green dots: Results of CLaMS simulation up to 25 km on northern hemisphere by equivalent latitude for all six tracers at 21/08/2011 (launch date of GLORIA-B from Kiruna, Sweden), volume mixing ratios plotted against clock tracer AoA. Black boxes: One sigma environment around average AoA in volume mixing ratio bins included in lookup table (Part of uncertainty of AoA that arises from spread of data points). Magenta line: Series of bin midpoints (mean AoA/mean mixing ratio) smoothed with Savitzky-Golay-Filter (used as lookup table). Magenta shading: Part of uncertainty of AoA that arises from measurement of trace gas (estimated with expected uncertainty in table 2 in article according to method illustrated in Fig. 2 in article .)

2.1.3 Northern hemisphere on 23/08/2022 (GLORIA-B launch date at Timmins, Canada)

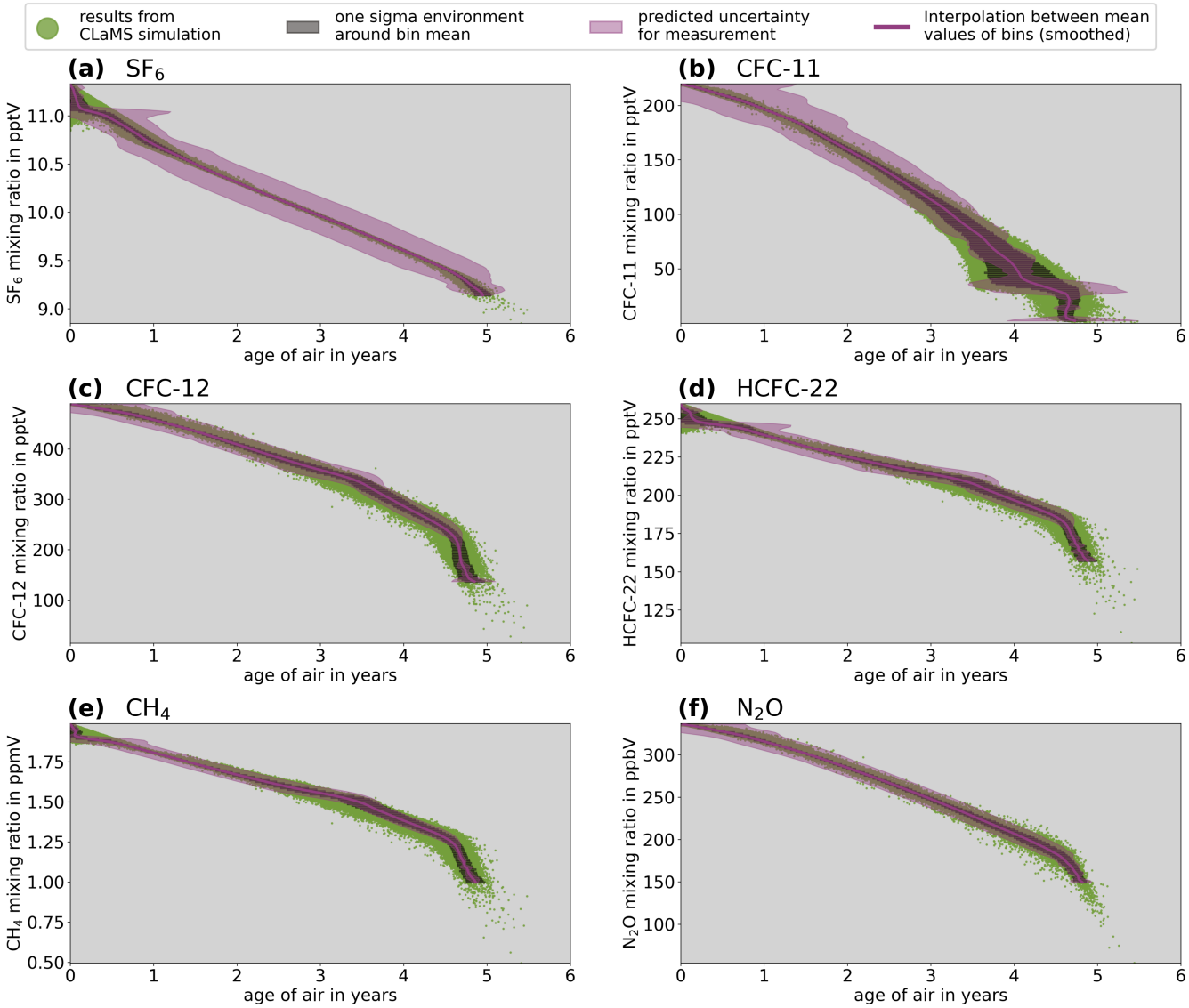

Figure S16. Same as Fig. S15 but for 23/08/2022 (launch date of GLORIA-B from Timmins, Canada).

2.2 Zonally averaged CLaMS results for 1st of January, April, July and October 2011

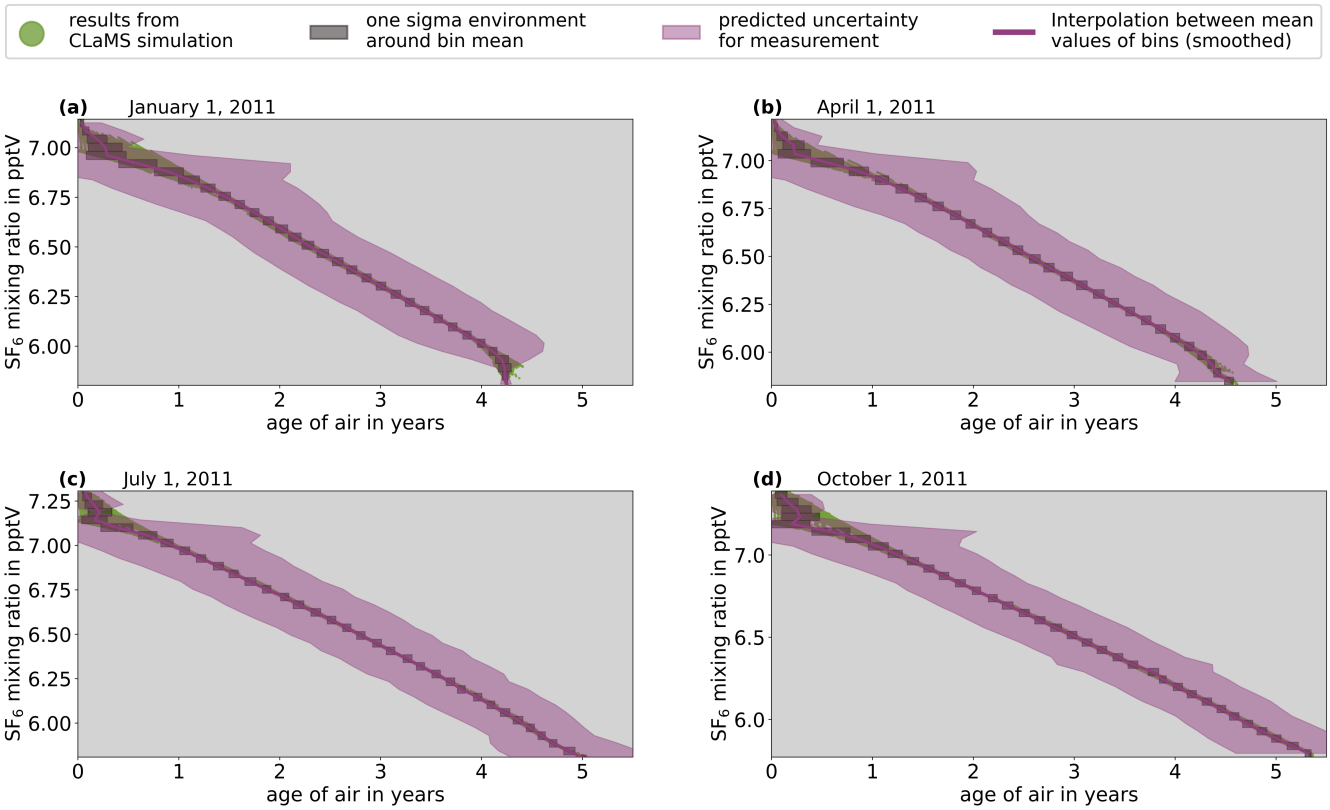

Figure S17. Green dots: Zonally averaged results of CLaMS simulation up to 25 km on southern hemisphere by equivalent latitude at four different days in 2011, SF_6 volume mixing ratios plotted against clock tracer AoA. Black boxes: One sigma environment around average AoA in volume mixing ratio bins included in lookup table (part of uncertainty of AoA that arises from spread of data points). Magenta line: Series of bin midpoints (mean AoA/mean mixing ratio) smoothed with Savitzky-Golay-Filter (used as lookup table). Magenta shading: Part of uncertainty of AoA that arises from measurement of trace gas (estimated with expected uncertainty in Tab. 2 in article according to method illustrated in Fig. 2 in article).

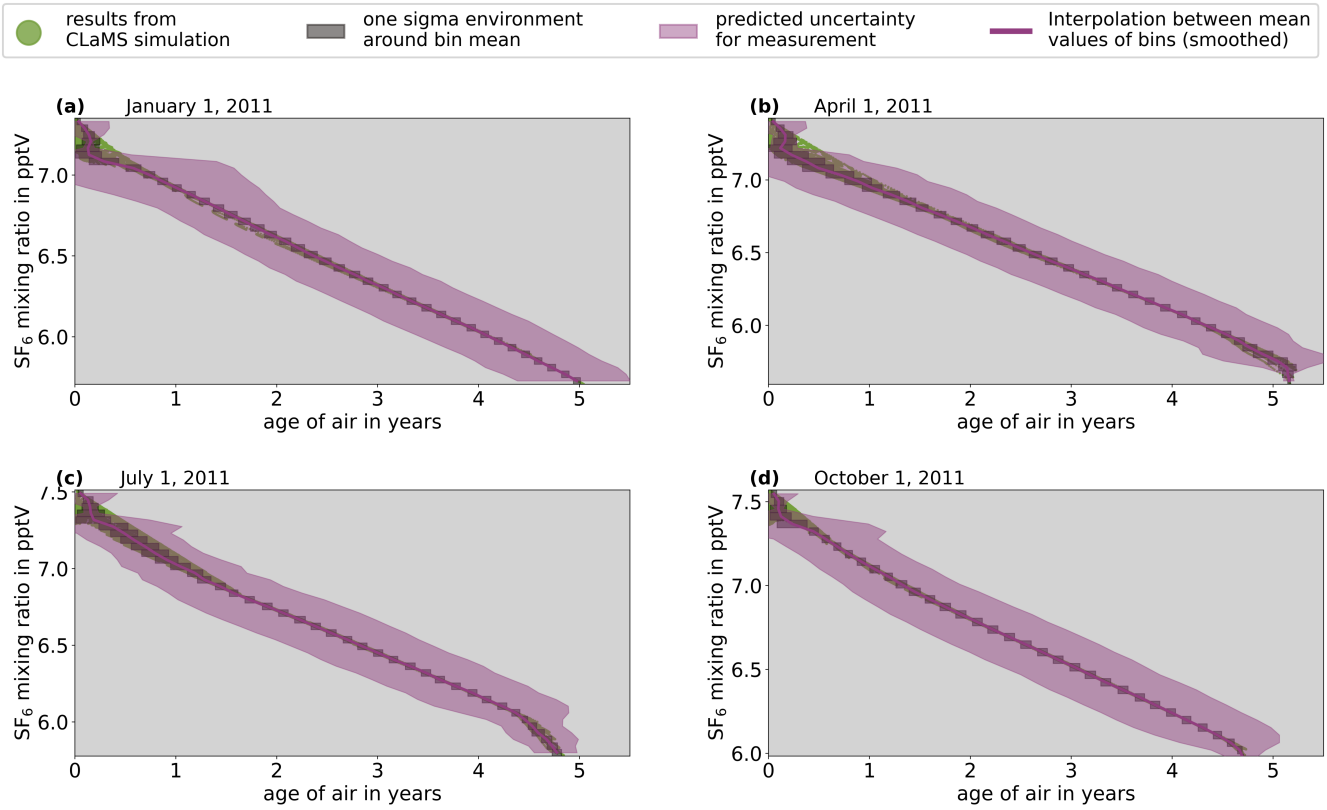

Figure S18. Same as Fig. S17 but for northern hemisphere.

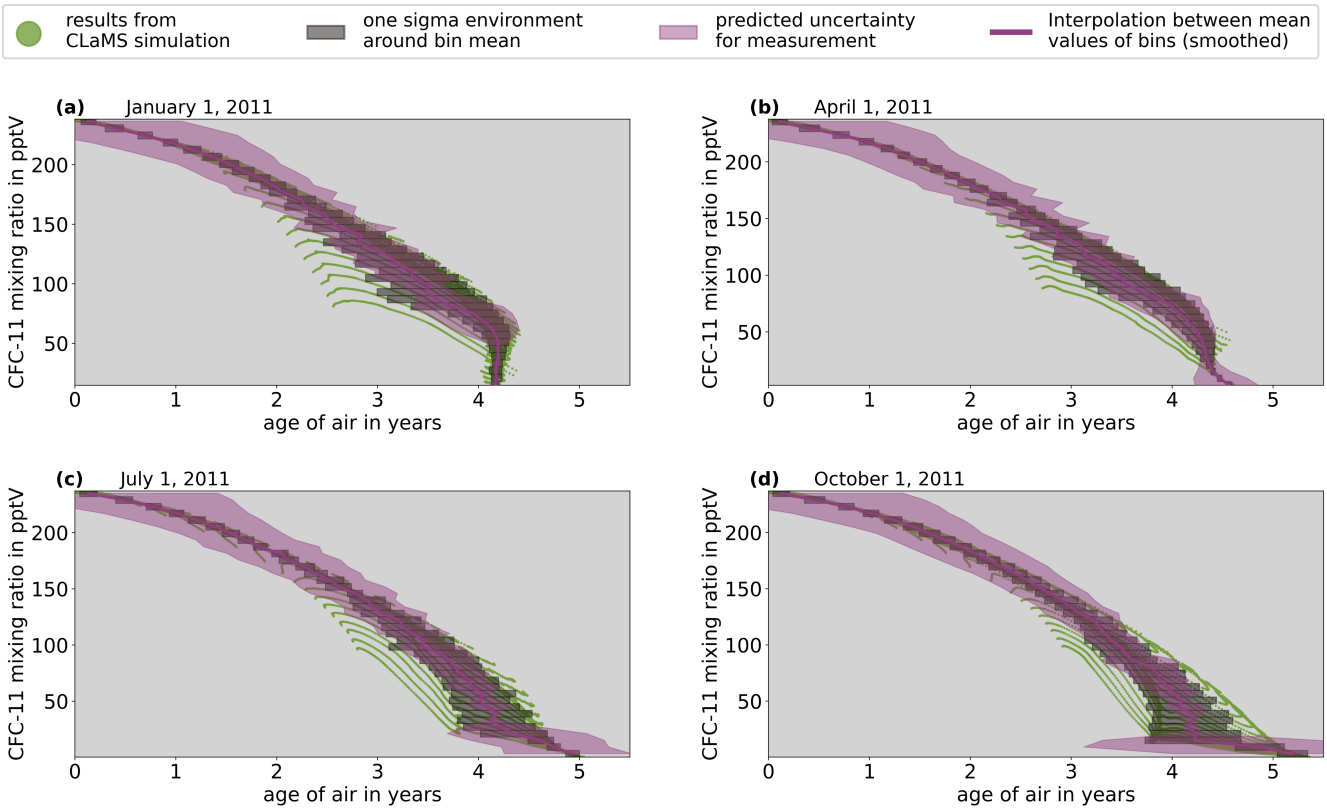

Figure S19. Green dots: Zonally averaged results of CLaMS simulation up to 25 km on southern hemisphere by equivalent latitude at four different days in 2011, CFC-11 volume mixing ratios plotted against clock tracer AoA. Black boxes: One sigma environment around average AoA in volume mixing ratio bins included in lookup table (part of uncertainty of AoA that arises from spread of data points). Magenta line: Series of bin midpoints (mean AoA/mean mixing ratio) smoothed with Savitzky-Golay-Filter (used as lookup table). Magenta shading: Part of uncertainty of AoA that arises from measurement of trace gas (estimated with expected uncertainty in Tab. 2 in article according to method illustrated in Fig. 2 in article).

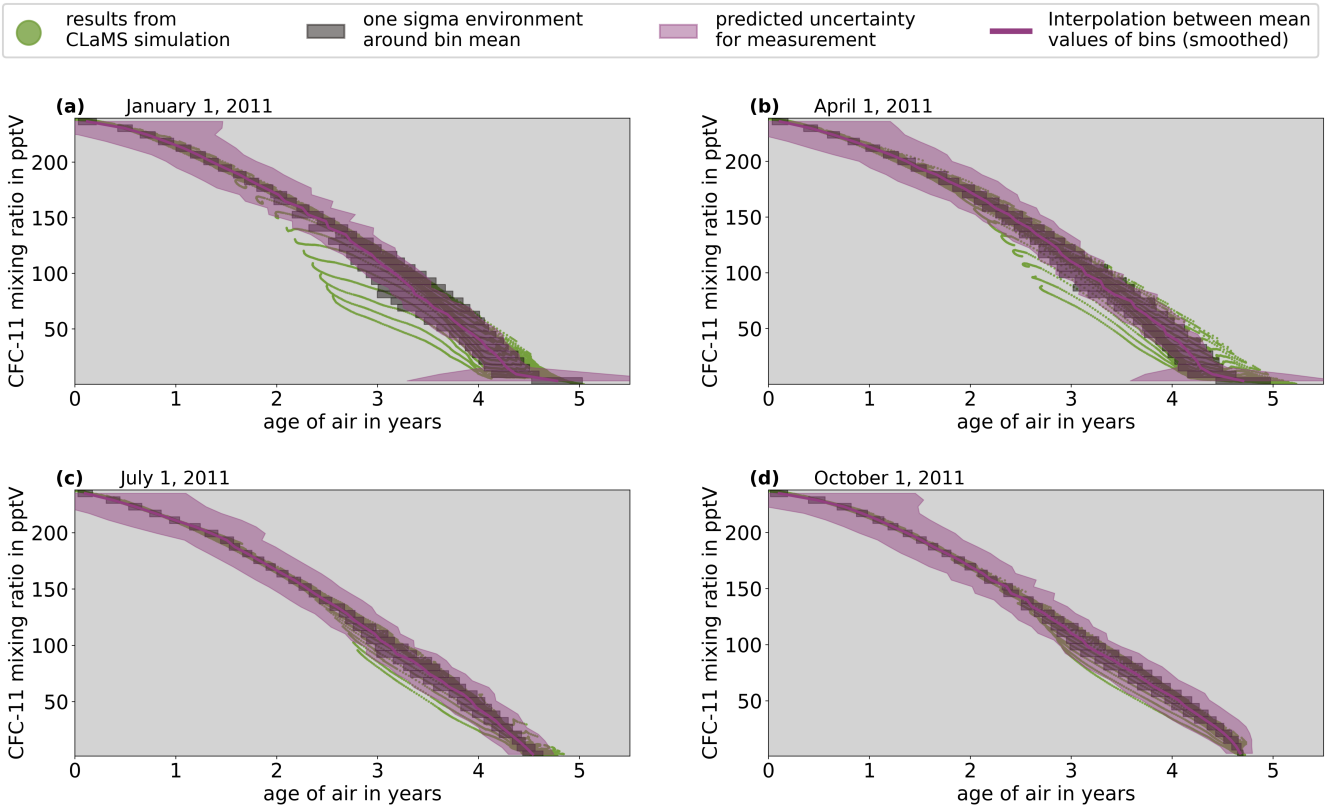

Figure S20. Same as Fig. S19 but for northern hemisphere.

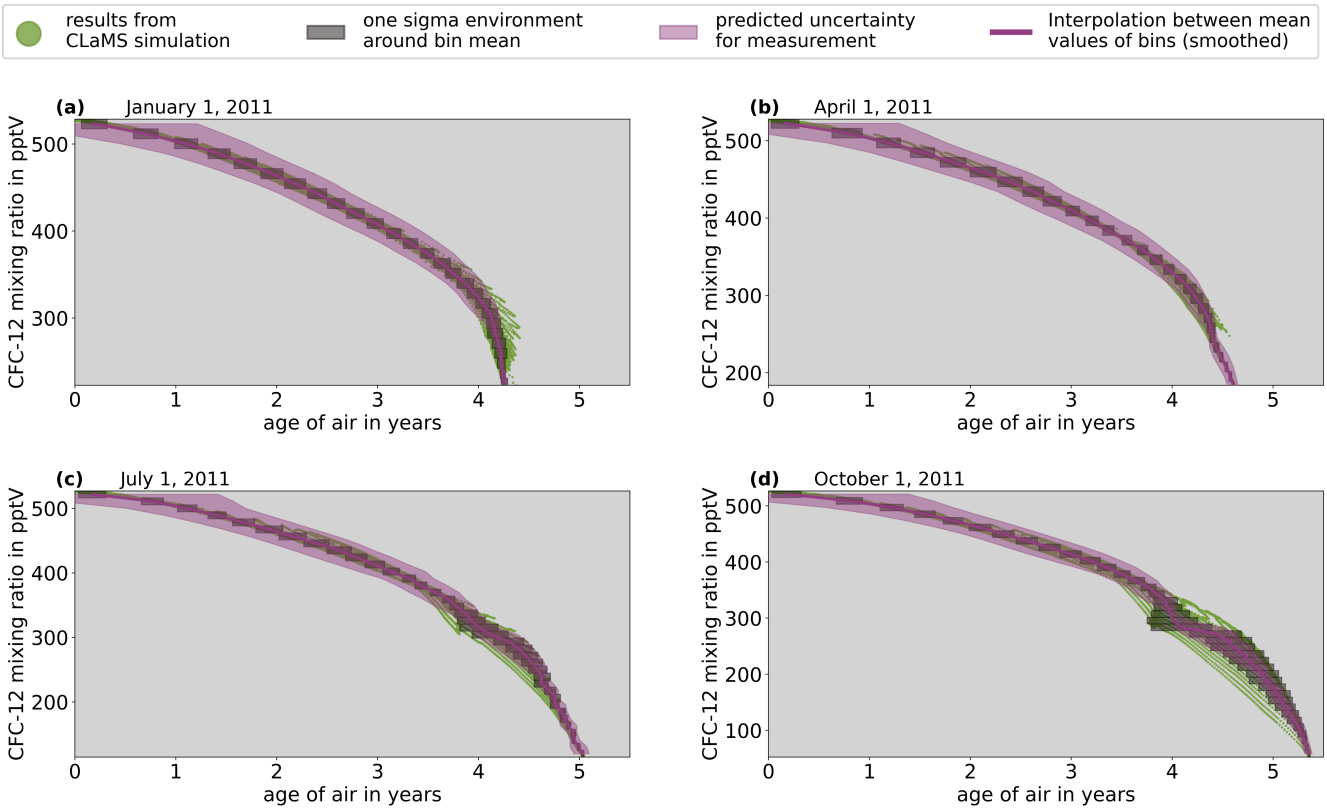

Figure S21. Green dots: Zonally averaged results of CLaMS simulation up to 25 km on southern hemisphere by equivalent latitude at four different days in 2011, CFC-12 volume mixing ratios plotted against clock tracer AoA. Black boxes: One sigma environment around average AoA in volume mixing ratio bins included in lookup table (part of uncertainty of AoA that arises from spread of data points). Magenta line: Series of bin midpoints (mean AoA/mean mixing ratio) smoothed with Savitzky-Golay-Filter (used as lookup table). Magenta shading: Part of uncertainty of AoA that arises from measurement of trace gas (estimated with expected uncertainty in Tab. 2 in article according to method illustrated in Fig. 2 in article).

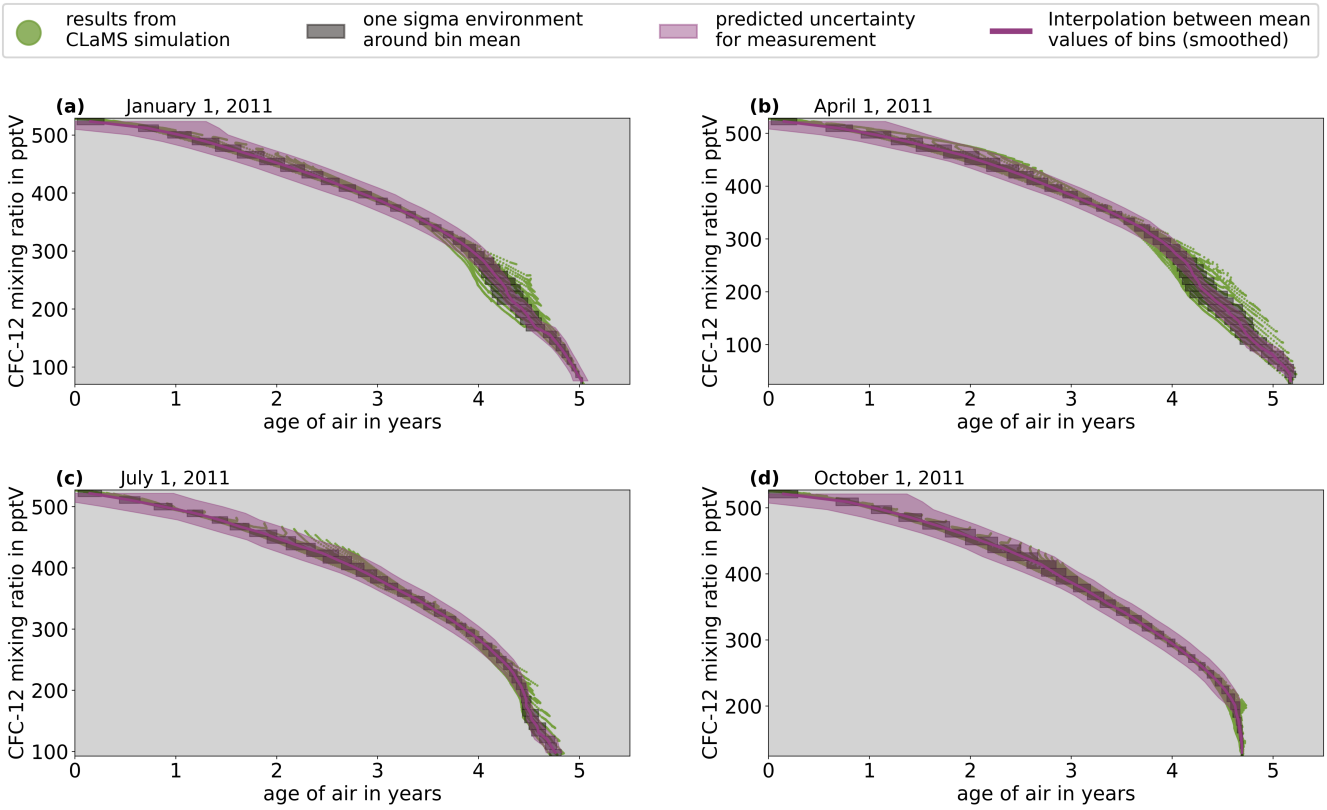

Figure S22. Same as Fig. S21 but for northern hemisphere.

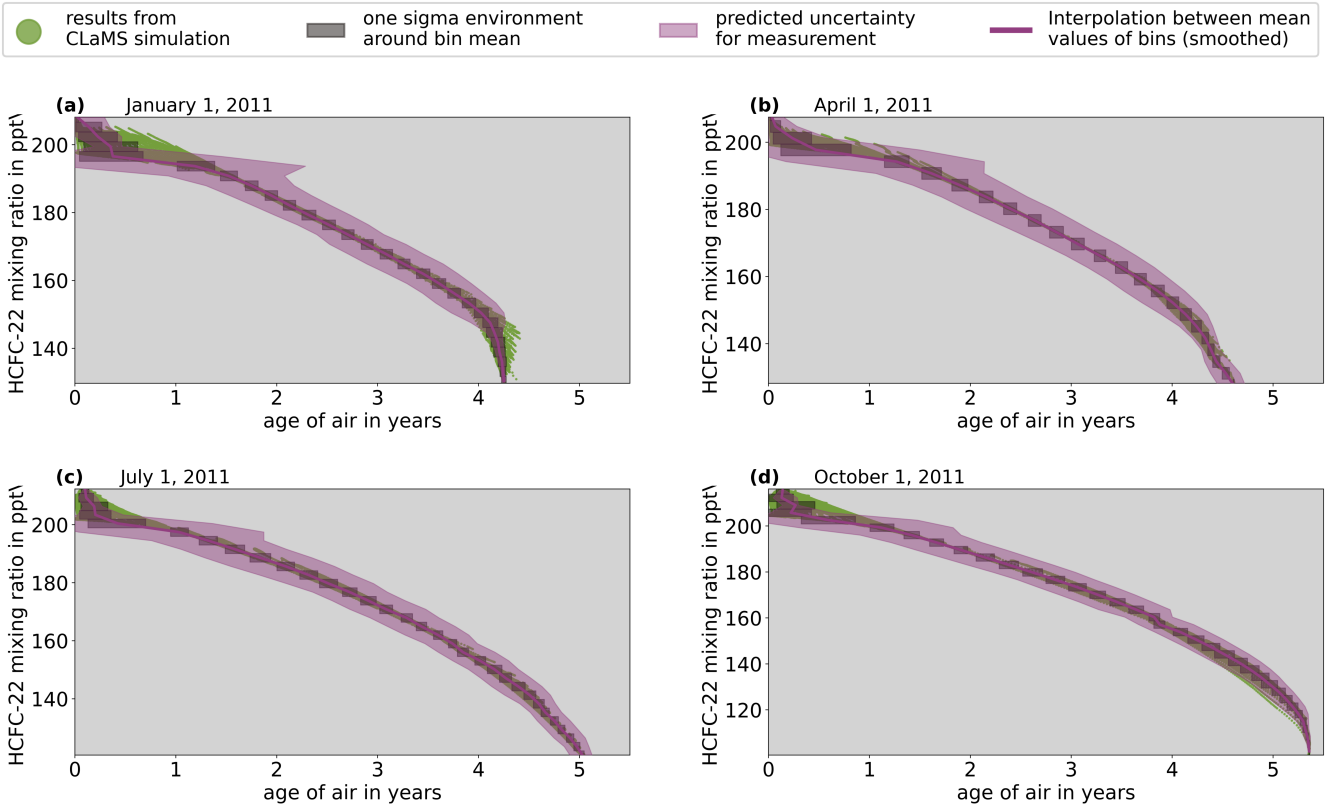

Figure S23. Green dots: Zonally averaged results of CLaMS simulation up to 25 km on southern hemisphere by equivalent latitude at four different days in 2011, HCFC-22 volume mixing ratios plotted against clock tracer AoA. Black boxes: One sigma environment around average AoA in volume mixing ratio bins included in lookup table (Part of uncertainty of AoA that arises from spread of data points). Magenta line: Series of bin midpoints (mean AoA/mean mixing ratio) smoothed with Savitzky-Golay-Filter (used as lookup table). Magenta shading: Part of uncertainty of AoA that arises from measurement of trace gas (estimated with expected uncertainty in Tab. 2 in article according to method illustrated in Fig. 2 in article).

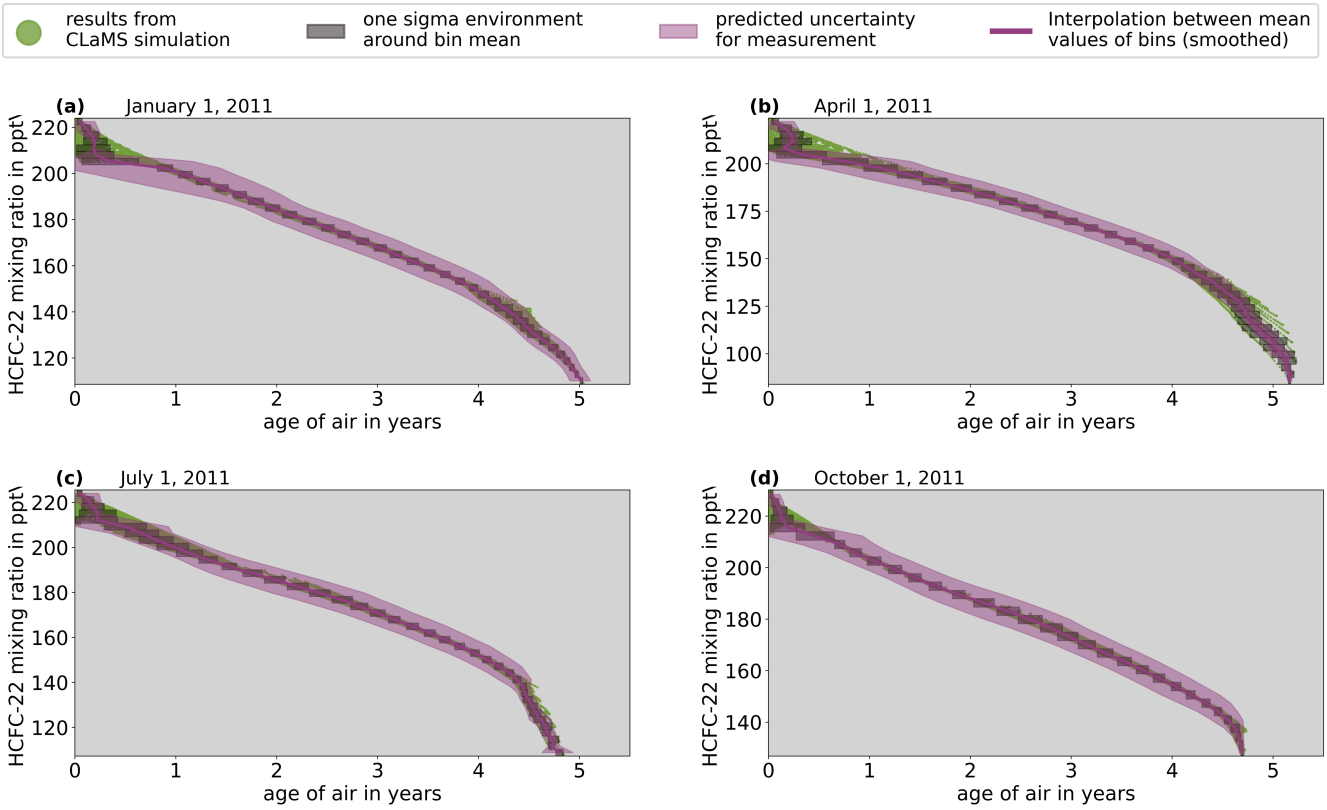

Figure S24. Same as Fig. S23 but for northern hemisphere.

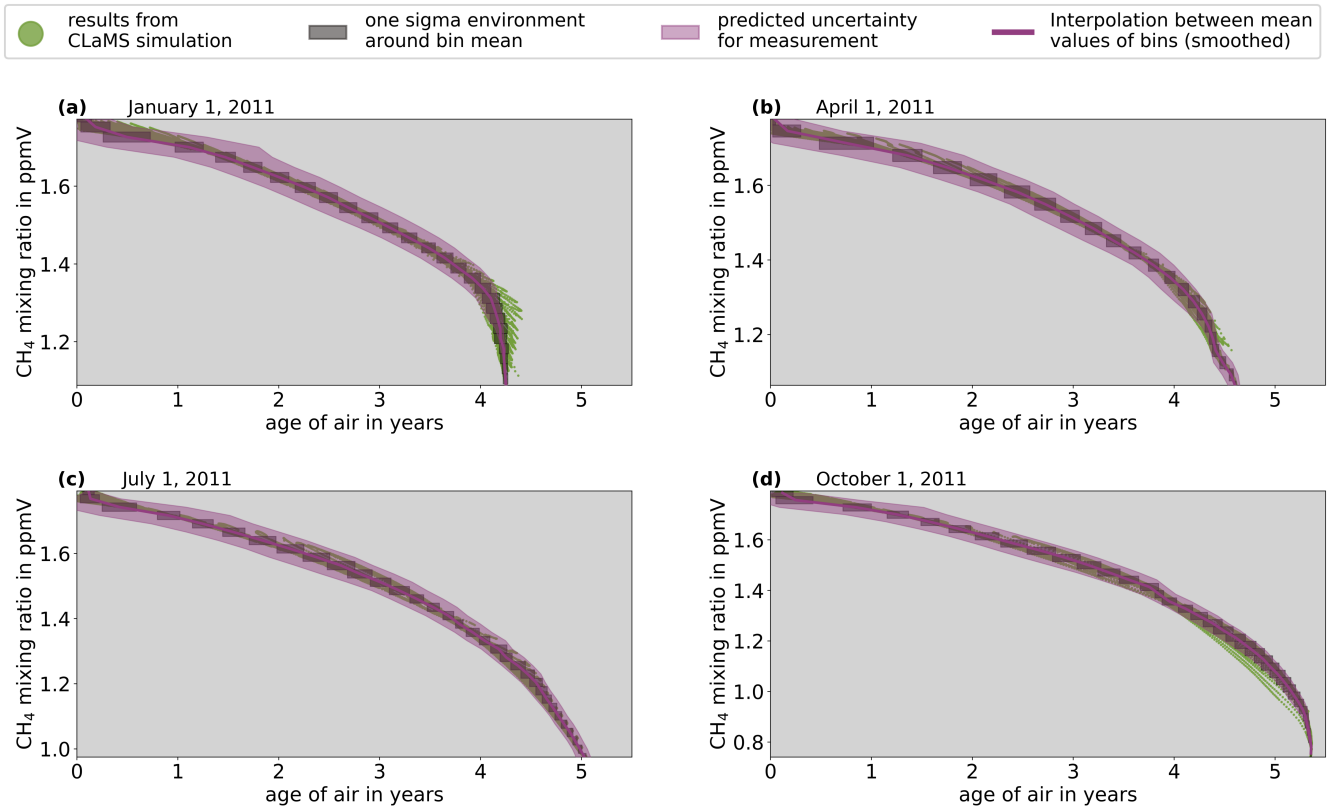

Figure S25. Green dots: Zonally averaged results of CLaMS simulation up to 25 km on southern hemisphere by equivalent latitude at four different days in 2011, CH_4 volume mixing ratios plotted against clock tracer AoA. Black boxes: One sigma environment around average AoA in volume mixing ratio bins included in lookup table (part of uncertainty of AoA that arises from spread of data points). Magenta line: Series of bin midpoints (mean AoA/mean mixing ratio) smoothed with Savitzky-Golay-Filter (used as lookup table). Magenta shading: Part of uncertainty of AoA that arises from measurement of trace gas (estimated with expected uncertainty in Tab. 2 in article according to method illustrated in Fig. 2 in article).

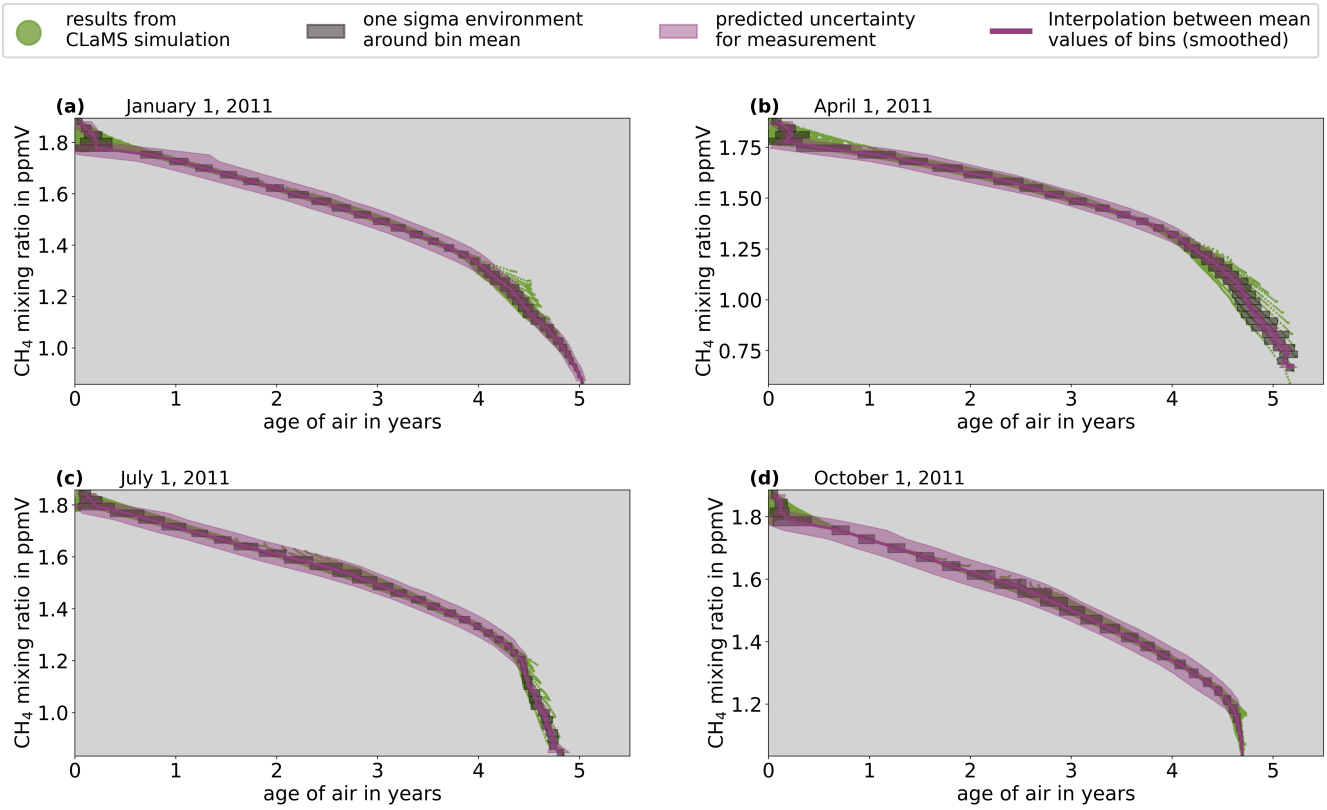

Figure S26. Same as Fig. S25 but for northern hemisphere.

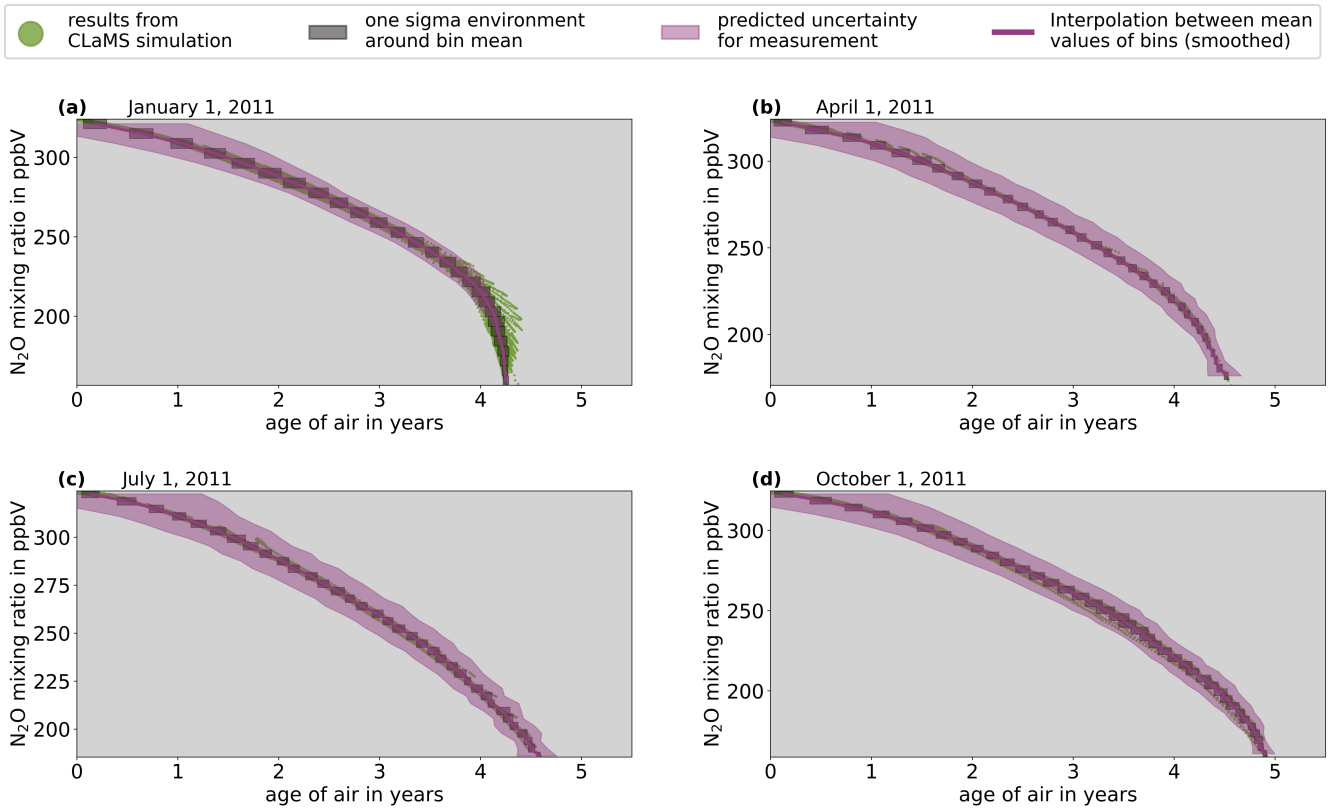

Figure S27. Green dots: Zonally averaged results of CLaMS simulation up to 25 km on southern hemisphere by equivalent latitude at four different days in 2011, N_2O volume mixing ratios plotted against clock tracer AoA. Black boxes: One sigma environment around average AoA in volume mixing ratio bins included in lookup table (part of uncertainty of AoA that arises from spread of data points). Magenta line: Series of bin midpoints (mean AoA/mean mixing ratio) smoothed with Savitzky-Golay-Filter (used as lookup table). Magenta shading: Part of uncertainty of AoA that arises from measurement of trace gas (estimated with expected uncertainty in Tab. 2 in article according to method illustrated in Fig. 2 in article).

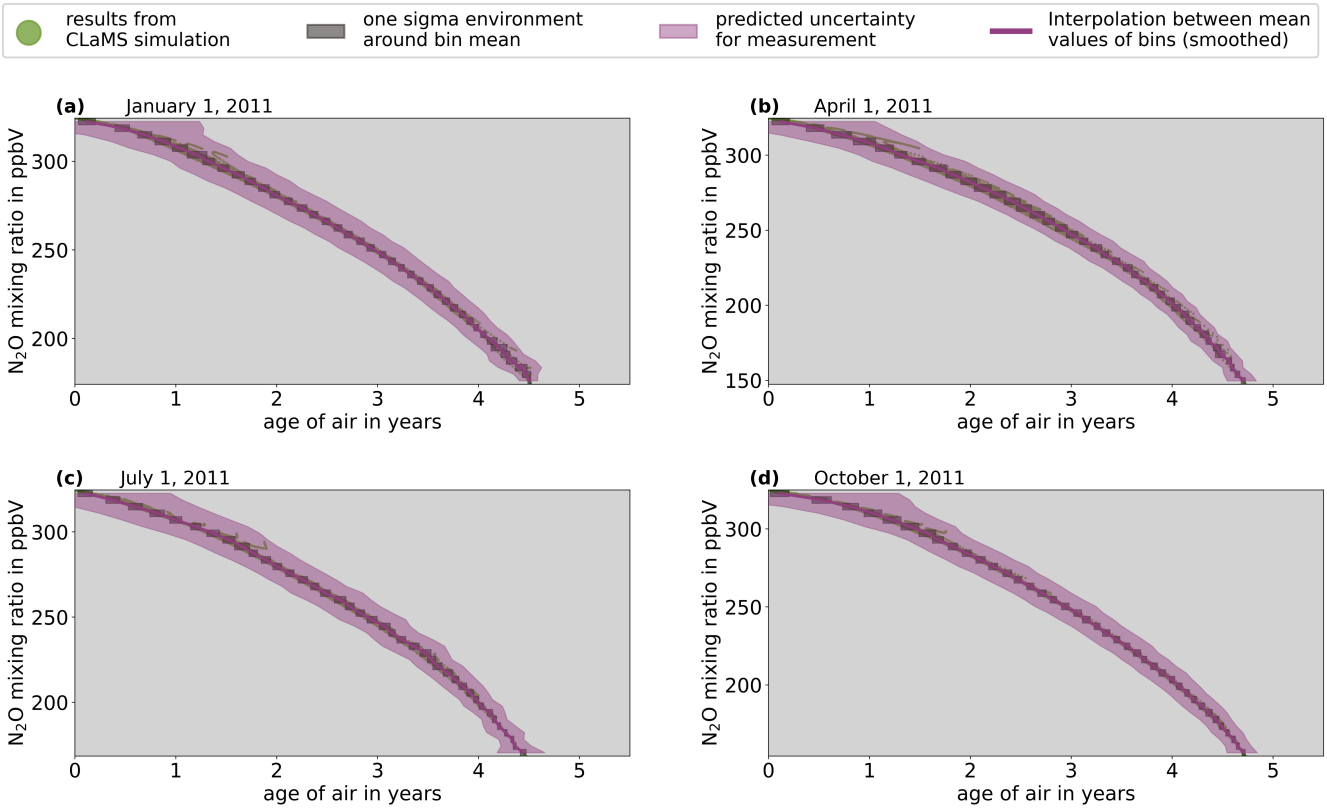

Figure S28. Same as Fig. S27 but for northern hemisphere.

3 Comparisons between weighted mean AoA from lookup tables and "true" model AoA from clock tracer

3.1 Full zonally-dependent (not zonally averaged) CLaMS results for 1st of January, April, July and October 2011

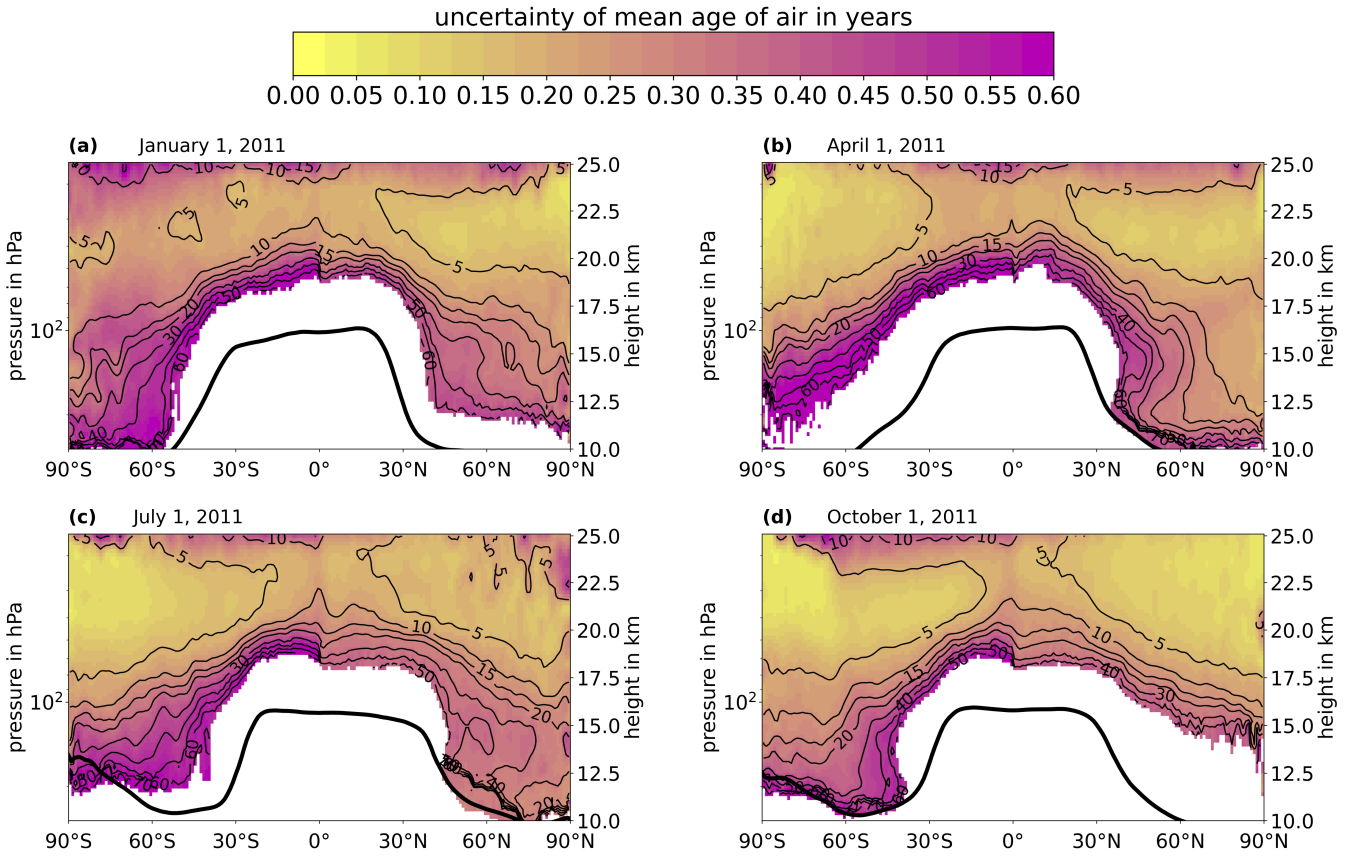

Figure S29. Estimation of zonally averaged uncertainty of weighted mean AoA (from synthetic measurements with lookup tables for non zonally averaged CLaMS data) created by adding together the differences in Fig. 8 and the standard deviations in Fig. 9 by means of gaussian error propagation. Color-coding: absolute error. Contours: relative error with respect to true model AoA in percent. White areas correspond to regions with "true" model AoA from clock tracer below one year (tropospheric air, not shown because of irrelevance and to avoid distraction)

3.2 Zonally averaged CLaMS results for 1st of January, April, July and October 2011

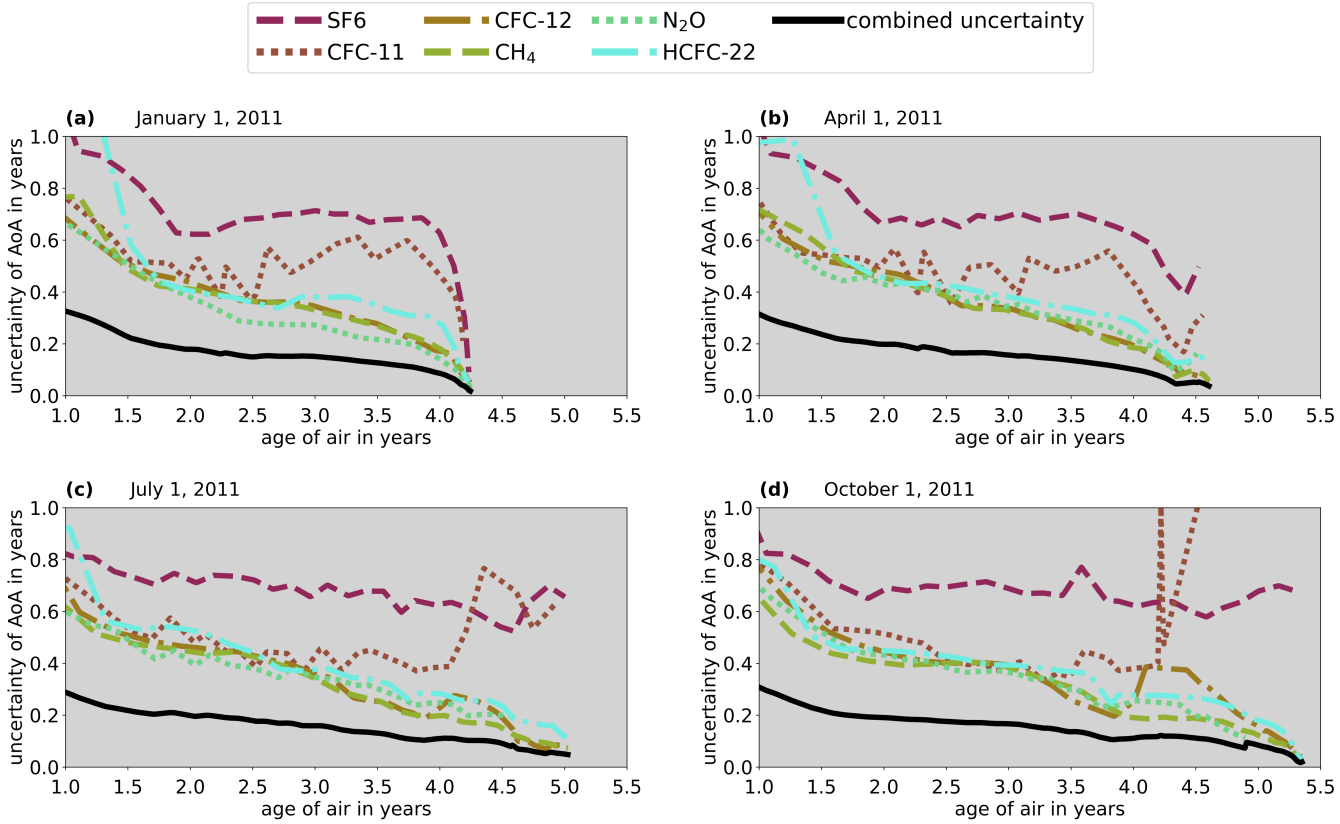

Figure S30. Dashed/dotted/dash-dotted colored lines: Individual total uncertainties of the six trace gases (from lookup tables for zonal mean CLaMS data) on the southern hemisphere at the four considered days in 2011 over the AoA ranges of the respective lookup tables. Black lines: combined total uncertainty calculated with formula 2 from the individual total uncertainties.

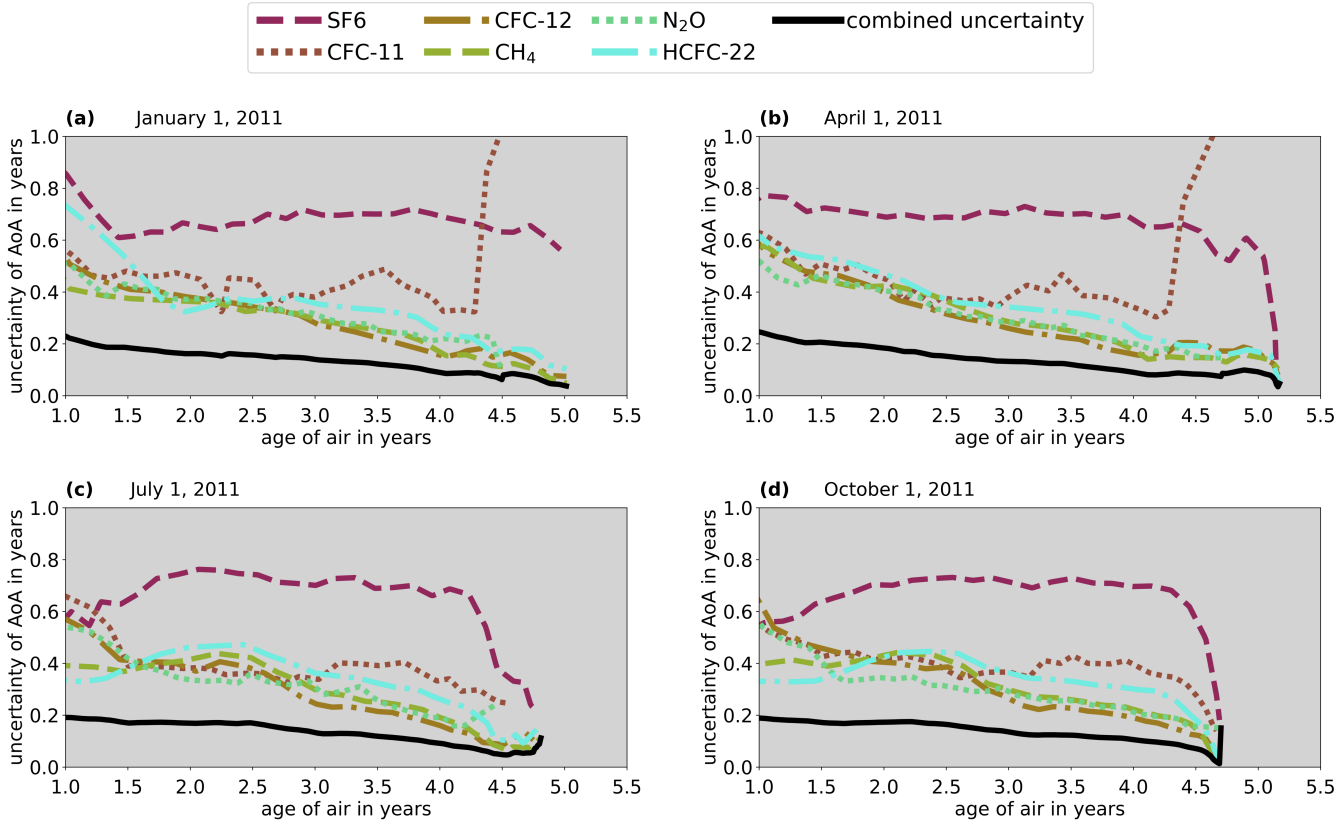

Figure S31. Dashed/dotted/dash-dotted colored lines: Individual total uncertainties of the six trace gases (from lookup tables for zonal mean CLaMS data) on the northern hemisphere at the four considered days in 2011 over the AoA ranges of the respective lookup tables. Black lines: combined total uncertainty calculated with formula 2 from the individual total uncertainties.

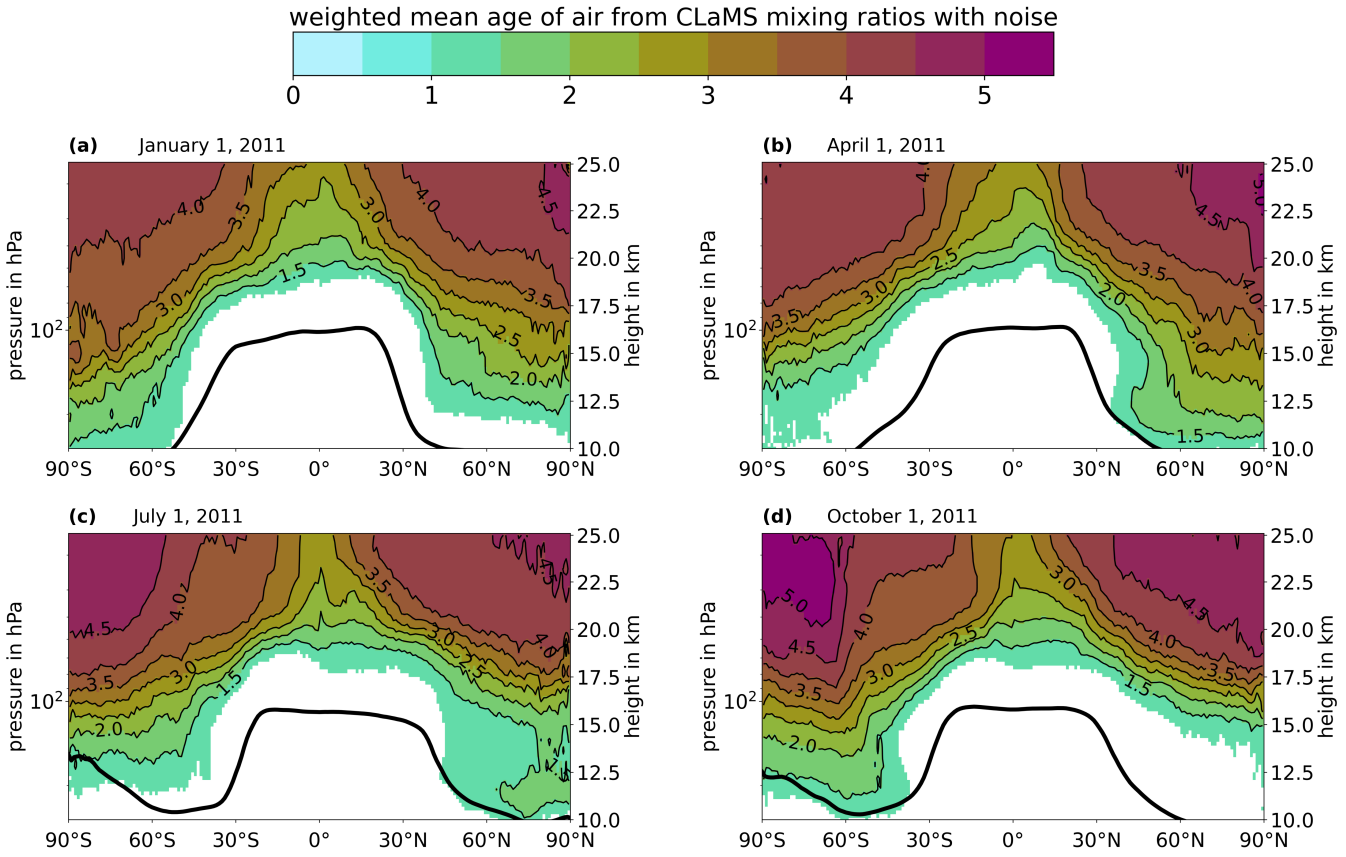

Figure S32. Zonally averaged weighted mean AoA calculated from lookup tables for zonal mean CLaMS data for the six trace gases and synthetic measurements created with CLaMS. Thick black lines: Position of the zonally averaged tropopause at respective day according to European Centre for Medium-Range Weather Forecasts Reanalysis v5 reanalysis. White areas correspond to regions with "true" model AoA from clock tracer below one year (tropospheric air, not shown because of irrelevance and to avoid distraction)

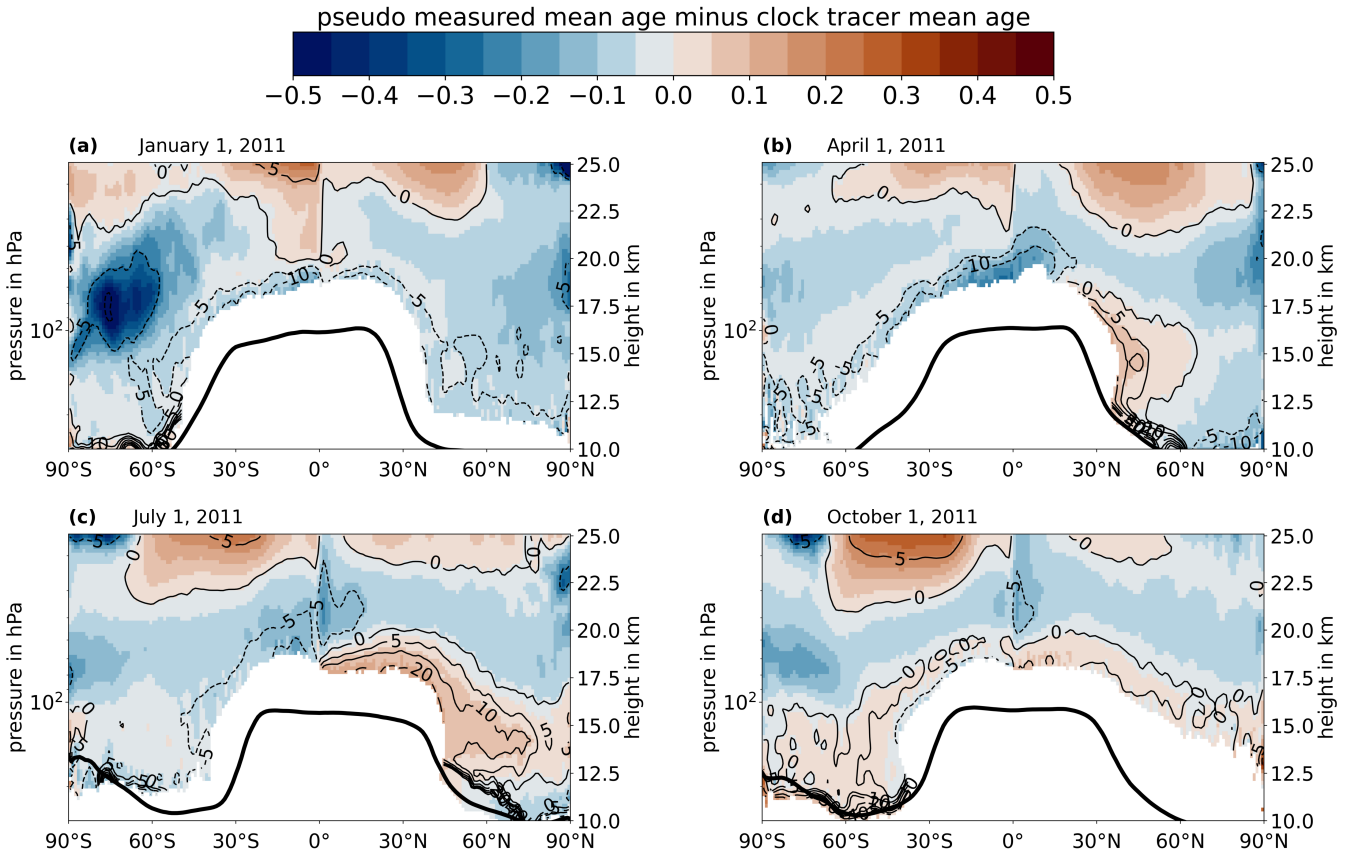

Figure S33. Zonally averaged difference between weighted mean AoA (from synthetic measurements with lookup tables for zonal mean CLaMS data) and "true" CLaMS AoA (from clock tracer) in latitude-altitude-plane for the four days in 2011 (Color-coding: Absolute difference in years. Contours: Relative difference in percent.). Thick black lines: Position of the zonally averaged tropopause at respective day according to European Centre for Medium-Range Weather Forecasts Reanalysis v5 reanalysis. White areas correspond to regions with "true" model AoA from clock tracer below one year (tropospheric air, not shown because of irrelevance and to avoid distraction)

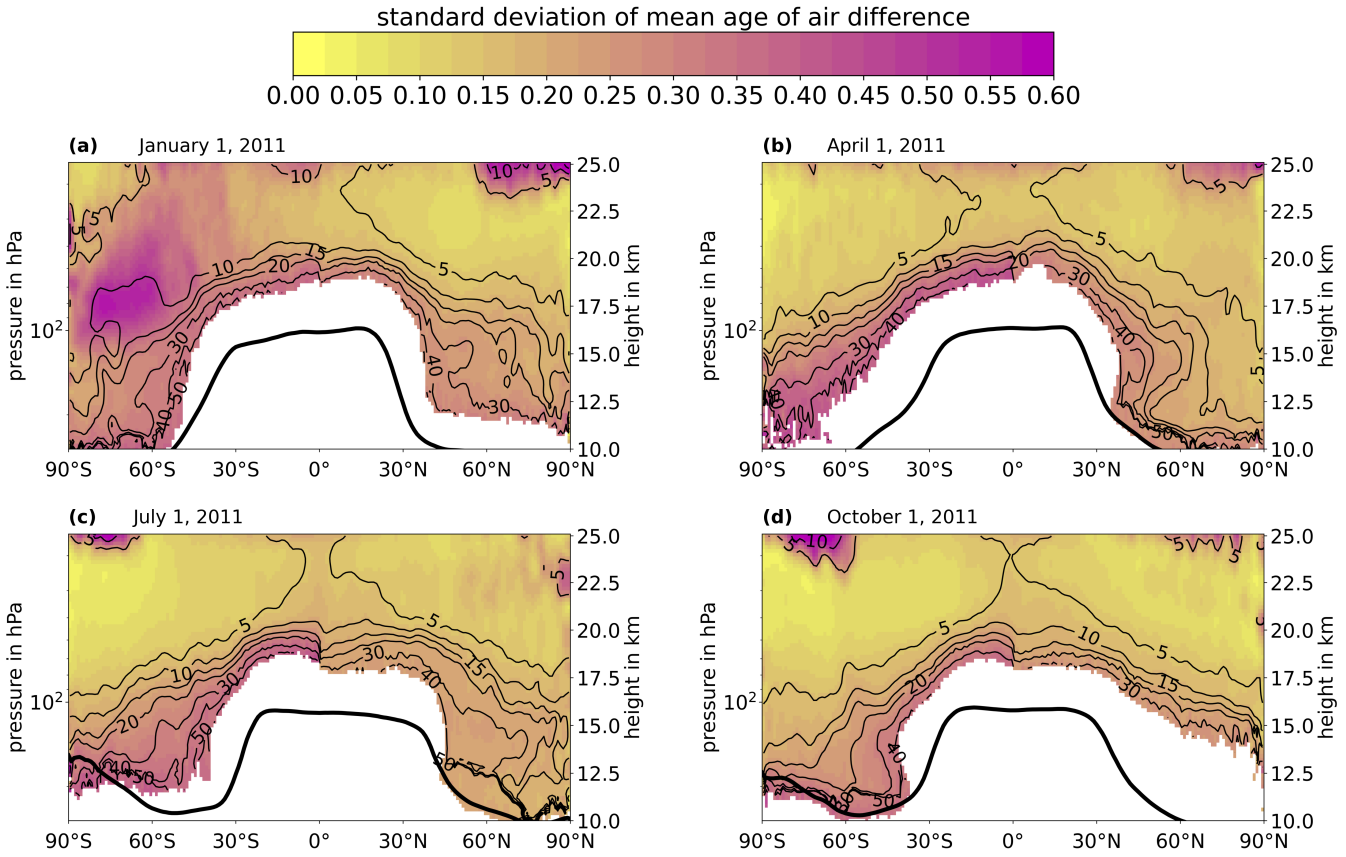

Figure S34. Zonally averaged standard deviations of differences between weighted mean AoA (from synthetic measurements with lookup tables for zonal mean CLaMS data) and "true" CLaMS AoA (from clock tracer) in latitude-altitude-plane for the four days in 2011. Color-coding: Standard deviations of absolute difference. Contours: Standard deviations of relative difference in percent. Thick black lines: Position of the zonally averaged tropopause at respective day according to European Centre for Medium-Range Weather Forecasts Reanalysis v5 reanalysis. White areas correspond to regions with "true" model AoA from clock tracer below one year (tropospheric air, not shown because of irrelevance and to avoid distraction)

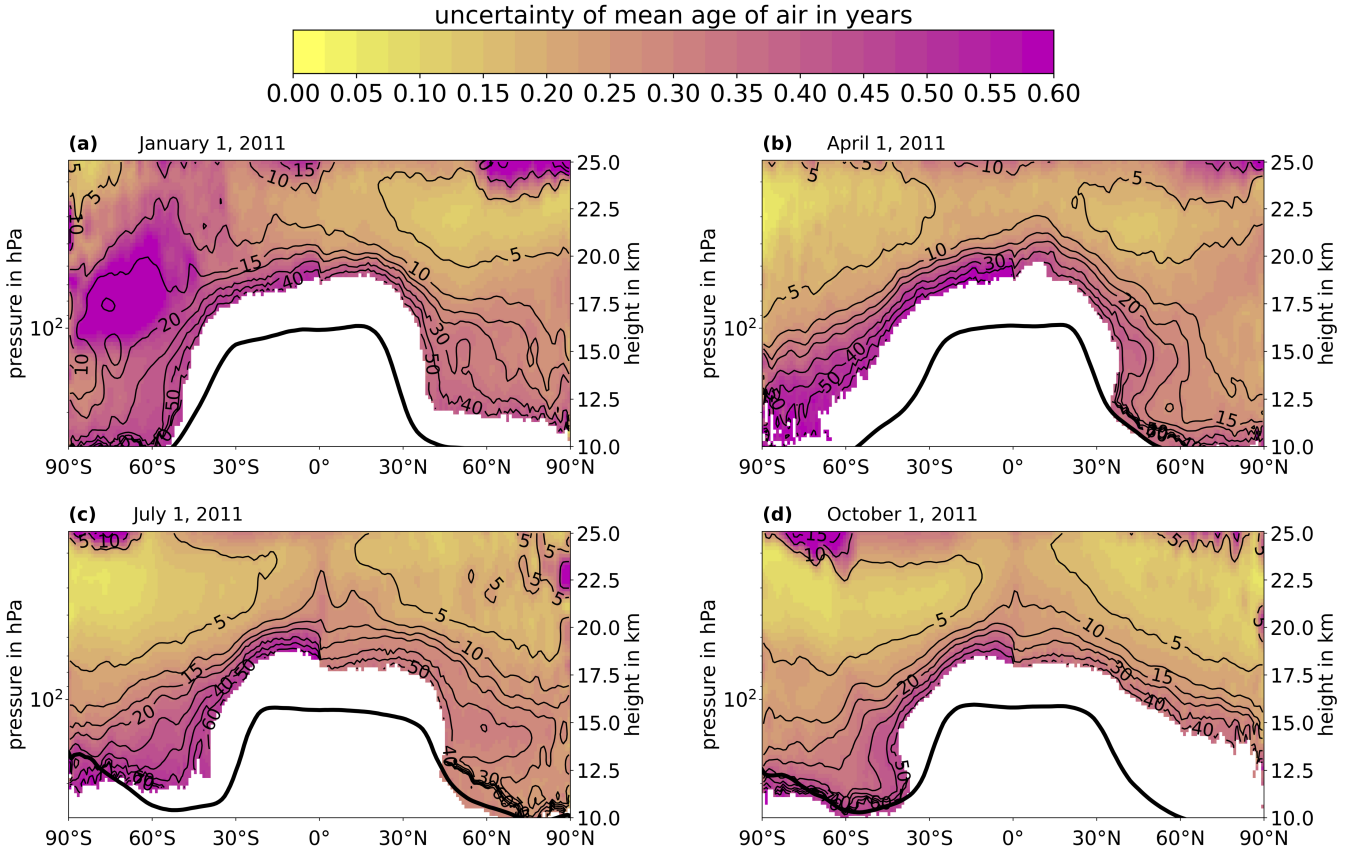

Figure S35. Estimation of zonally averaged uncertainty of weighted mean AoA (from synthetic measurements with lookup tables for zonal mean CLaMS data) created by adding together the differences in Fig. S33 and the standard deviations in Fig. S34 by means of gaussian error propagation. Color-coding: absolute error. Contours: relative error with respect to true model AoA in percent. White areas correspond to regions with "true" model AoA from clock tracer below one year (tropospheric air, not shown because of irrelevance and to avoid distraction)