

Comparison of mean age of air in ERA5, ERA-Interim, MERRA2 and JRA-3Q using the BASCOE CTM and observations from MIPAS, ACE-FTS, GLORIA-B and CAIRT

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Introduction

We compare stratospheric mean age of air (AoA) derived from four recent reanalyses: ERA5, ERA-Interim, MERRA2, and JRA-3Q, using the BASCOE chemistry transport model (CTM). AoA is a transit time of air parcels that move from the troposphere to the stratosphere and is used as a proxy for circulation speed. Our analysis focuses on long-term trends and differences between the datasets. We compare our findings with previous studies and with satellite observations, including MIPAS and ACE-FTS, as well as GLORIA-B balloon measurements at Kiruna and Timmins, and simulated data from the proposed CAIRT mission for ESA's Earth Explorer 11.

Results

The daily variability of the simulated CAIRT age of air observations is small compared to the spread of the reanalyses (see Fig. 1).

The mean age of air trends deduced from the BASCOE simulations over the period 1980-2020 are comparable to those from Ploeger et al. 2019. Trends (in years/dec) were computed for the region in Fig. 2 after subtraction of the monthly climatology. The uncertainty is the 1σ std from

Reanalysis	Trend 1980-2020	Trend 2000-2020	CLaMS 1989-2015	CLaMS 1989-2018
ERA5	0.026 ± 0.003	0.067 ± 0.008	/	-0.13 ± 0.01
ERA-Interim	0.185 ± 0.005	0.027 ± 0.010	0.07 ± 0.01	0.15 ± 0.01
MERRA2	-0.366 ± 0.010	0.065 ± 0.009	-0.18 ± 0.01	/

the fit. However, due to the steplike change in MERRA2 in the 1990s the linear trend estimate is probably not a good representation of the evolution of the time series. Note also that in the BASCOE simulations ERA-Interim produces a higher age of air than ERA5, while Ploeger found the reverse. In general: convergence of the AoA in recent times. In Fig. 3, BASCOE age of air is compared with ACE-FTS and MIPAS in the space of the observations. There is a slight overestimation compared to ACE-FTS, especially with MERRA2. On the other hand, there is an underestimation with respect to MIPAS. Most notably with ERA5 and ERA-Interim.

There is good agreement between the GLORIA-B profiles and BASCOE profiles, though there are some differences in the vertical gradient (Fig. 4).

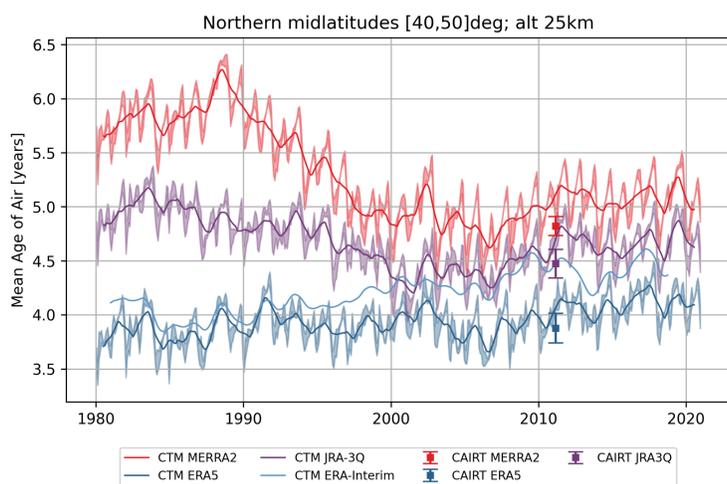


Fig. 1 BASCOE AoA simulations driven by ERA5, ERA-Interim, MERRA2 and JRA-3Q, smoothed with a 1-year running mean. The shaded area shows the standard deviation for the time series without applying the running average. The scatter points represent the simulated CAIRT data. This AoA was computed by applying the Voet et al. 2025 method to BASCOE CTM output that was interpolated to the CAIRT orbit tracks. The error bars are the 1σ daily variability (std).

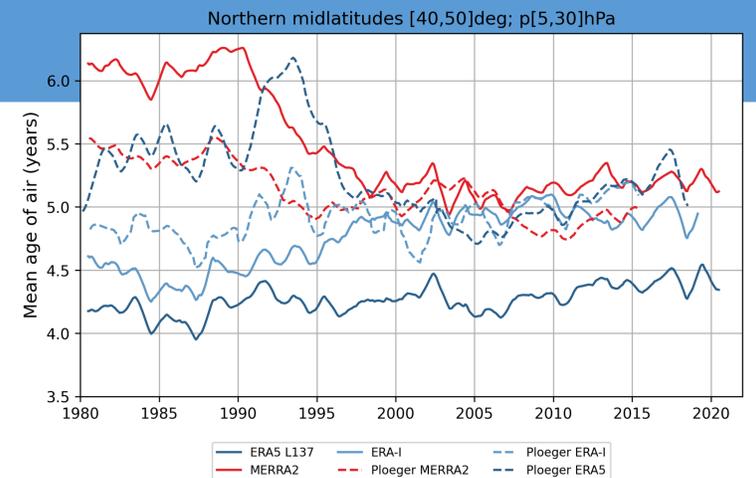


Fig. 2 BASCOE AoA simulations as in Fig. 1, averaged with a 1-year running mean, compared with ClAMS AoA from Ploeger et al. 2019, 2021. JRA-3Q and JRA55 not shown for readability.

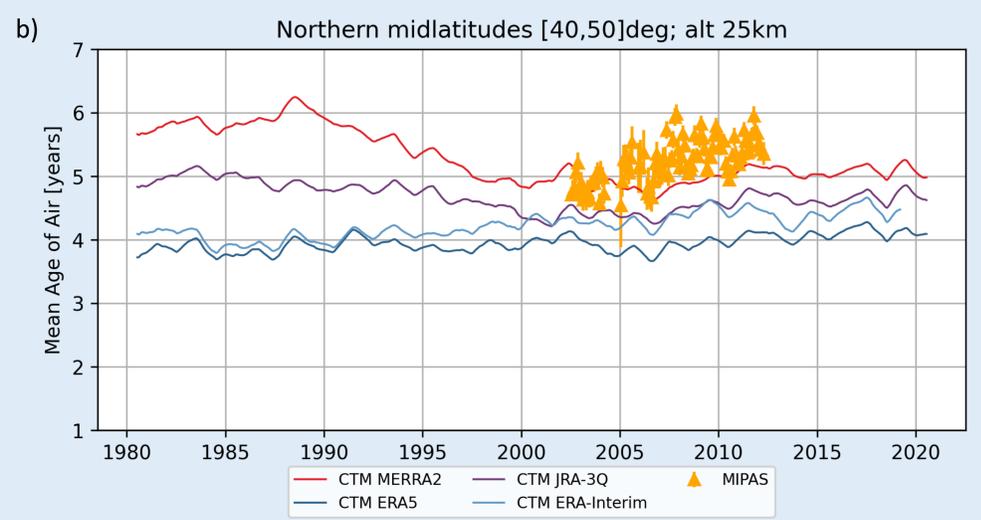
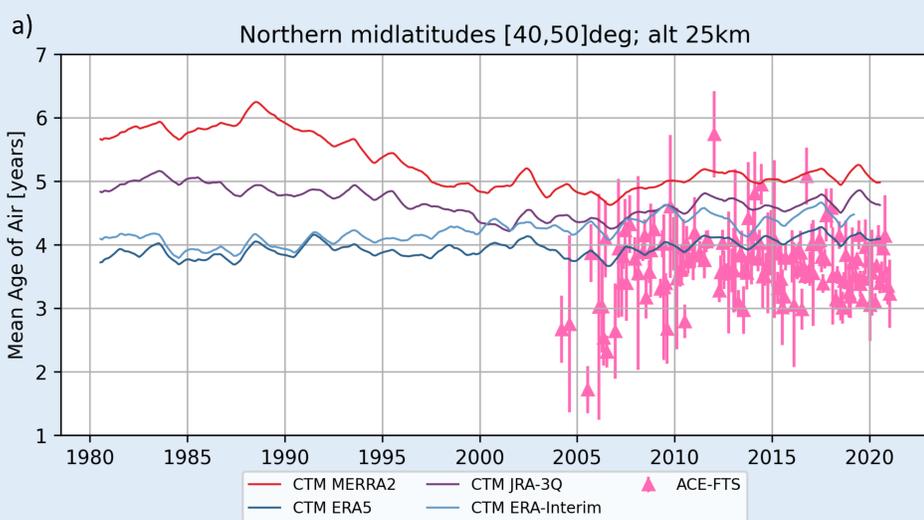


Fig. 3 a) BASCOE AoA at the latitudes of ACE-FTS zonal mean AoA in the Northern midlatitudes at 25 km. The error bars on the satellite data represent the standard error of the mean; b) BASCOE AoA at the latitudes of MIPAS zonal mean AoA in the Northern midlatitudes at 25 km. Error bars as in (a).

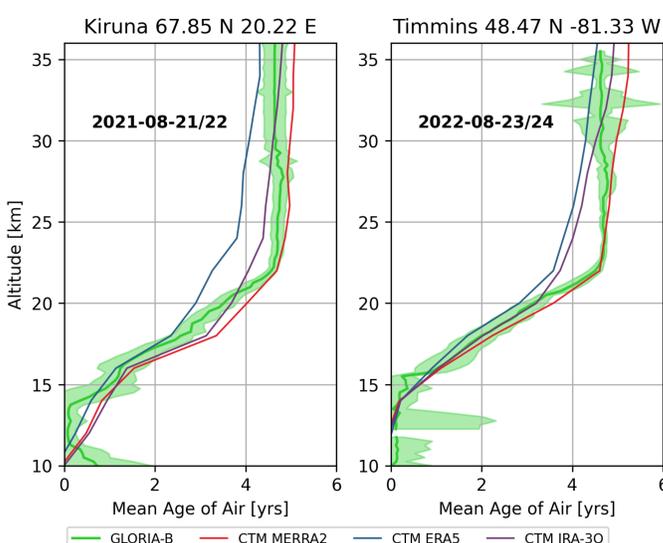


Fig. 4 BASCOE AoA at the the locations of Kiruna and Timmins, where GLORIA-B balloon measurements are available. The error band is based on the retrieval error of the observation. AoA is computed with the tropical tropopause (100 hPa, 10S-10N) as reference.

Conclusions

We find positive mean age of air trends with ERA5 and ERA-Interim and a negative trend with MERRA2 and JRA-3Q. Trends computed after 2000 are positive for all four reanalyses. Simulated CAIRT observations look promising. The error bars on the MIPAS and ACE-FTS satellite data are quite small, but there is a lot of scatter. There is good agreement between the balloon profiles of GLORIA-B and corresponding BASCOE profiles, although the vertical gradient is slightly weaker in BASCOE, especially for ERA5 and JRA-3Q. There are large differences between the ClAMS AoA and the BASCOE AoA, most notably for simulations with ERA5.

References

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Data

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