climate change initiative

LONG-LIVED GREENHOUSE GAS PRODUCTS PERFORMANCES

WP3400: ClaMS stratospheric circulation estimates

Felix Plöger, Florian Voet, Rasul Baikhadzhaev, Michaela Hegglin
(Institute for climate and energy research (ICE-4), Forschungszentrum Jülich)

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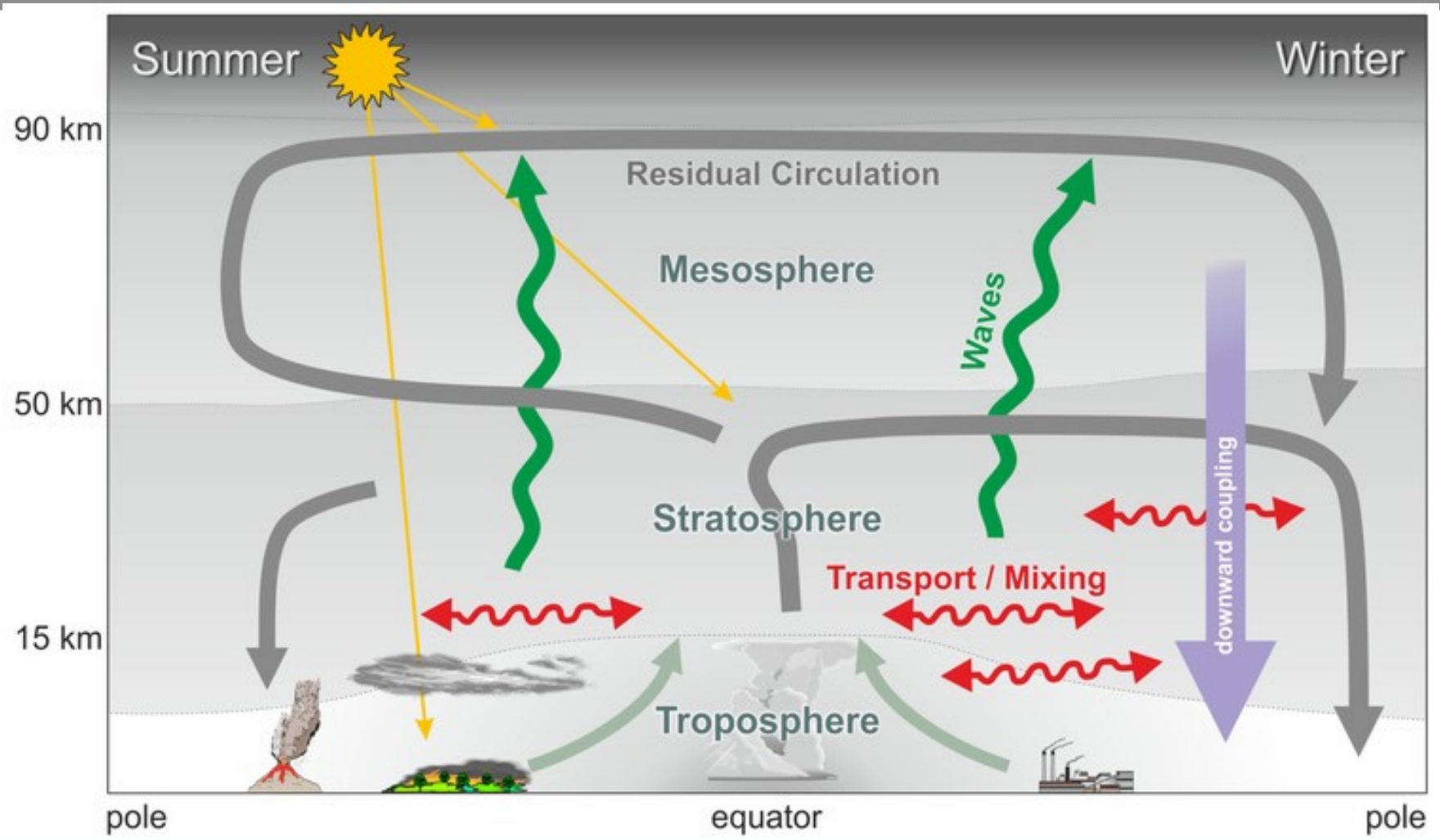
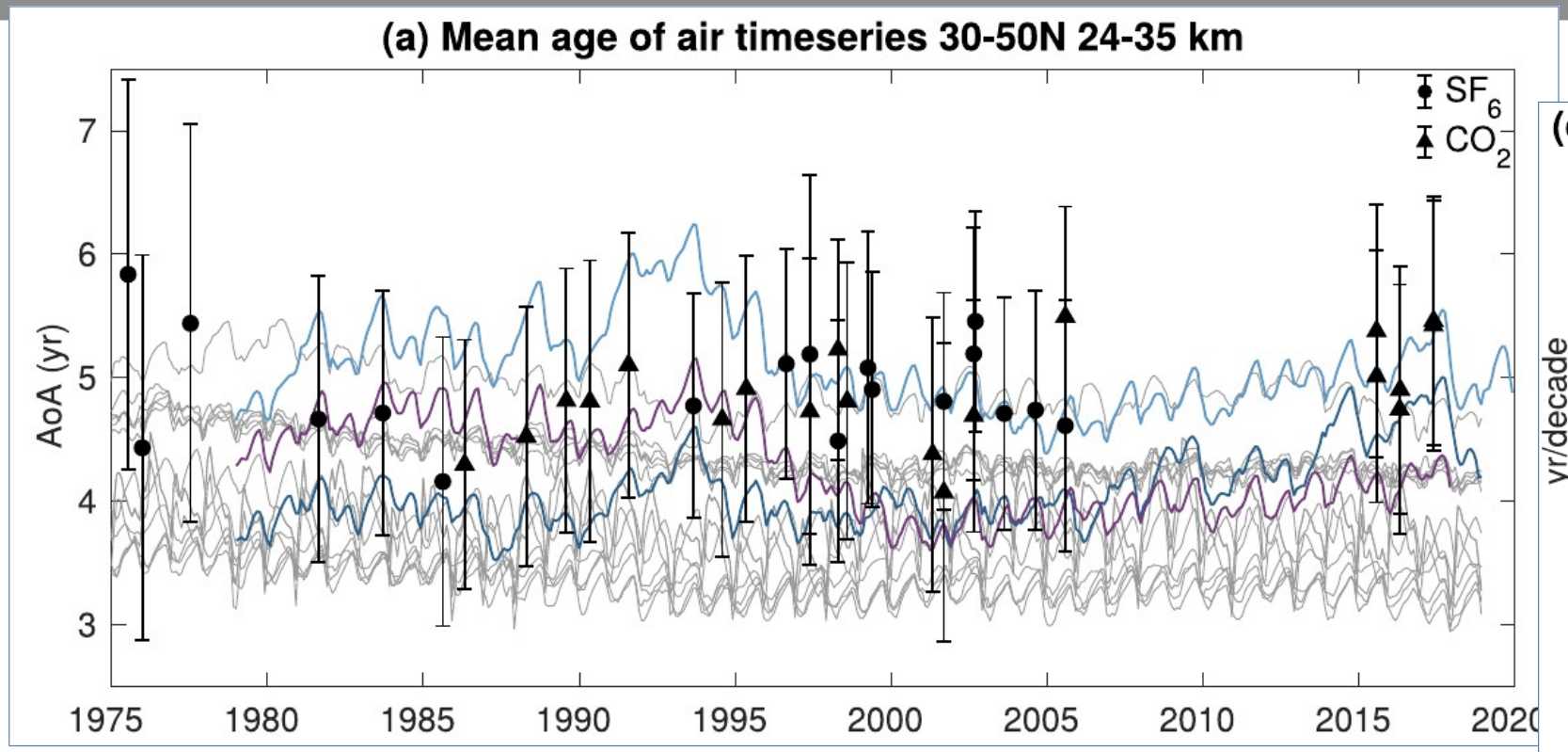
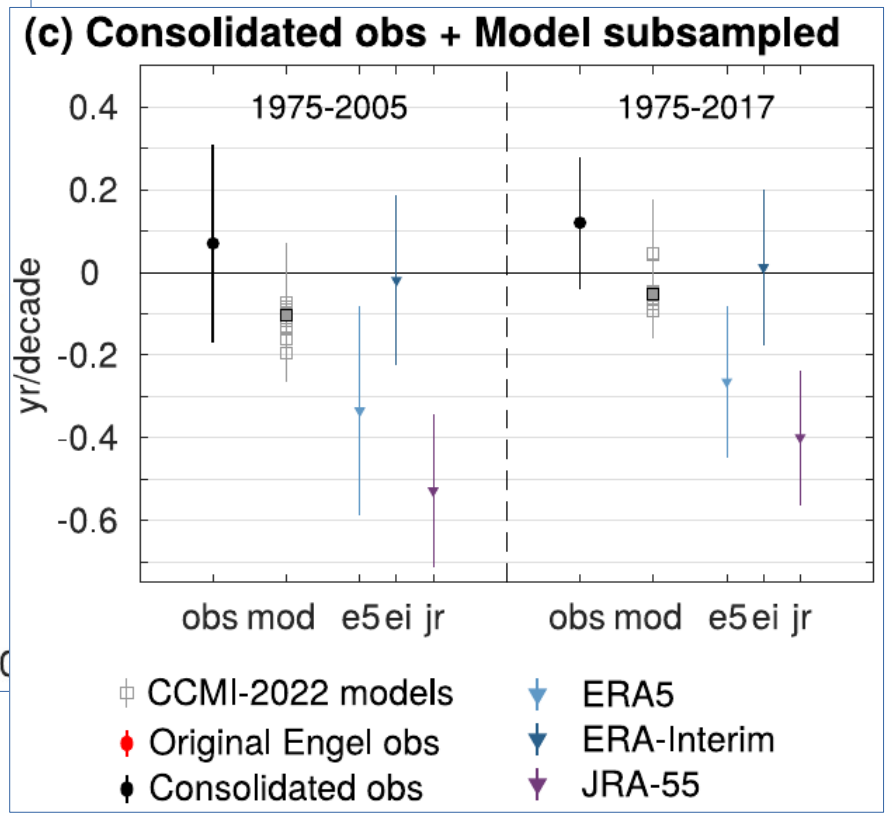
Stratospheric Brewer-Dobson Circulation (BDC)



- Motion is upward in tropics, downward in extratropics (e.g. Butchart, 2014)
- Deep and shallow circulation branches (Birner & Bönisch, 2011)

Long-term trends of BDC remain uncertain

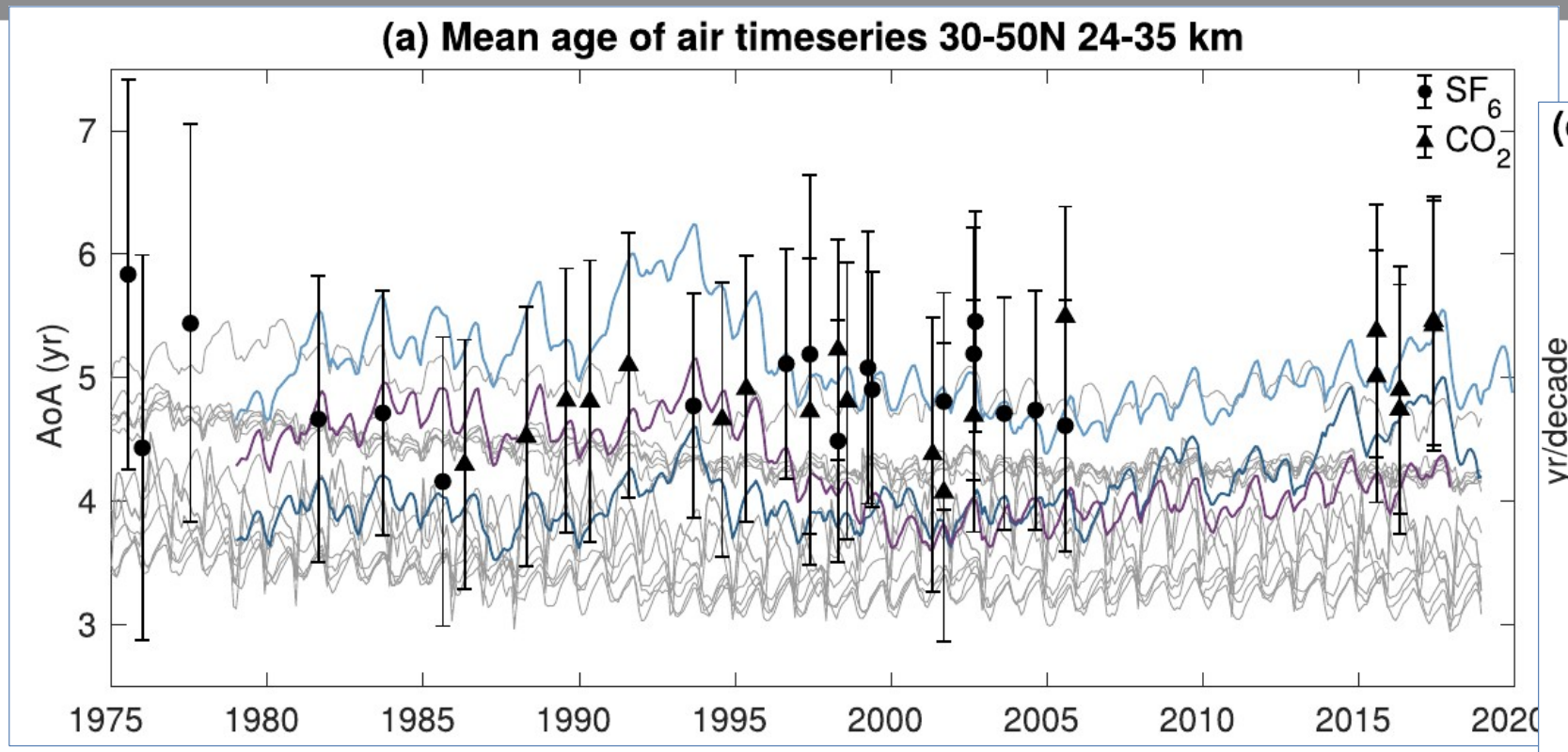


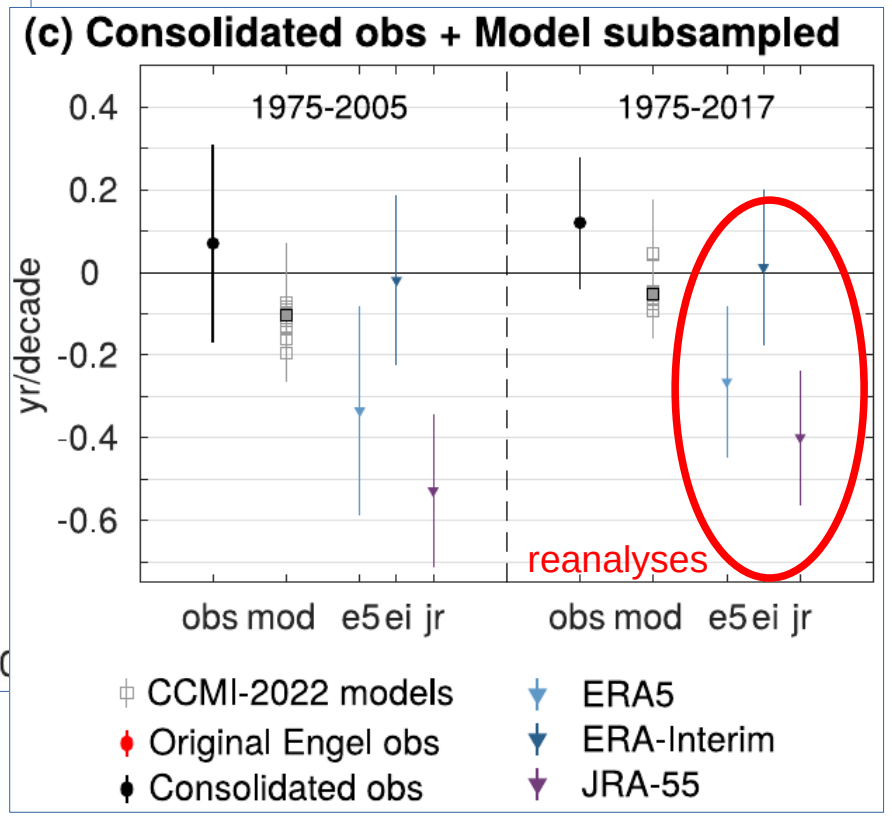


- Climate models simulate BDC strengthening with global warming
- Observations show no indication for such BDC strengthening so far (Garny et al., 2024)

→ Need better observational constraints for BDC!

Long-term trends of BDC remain uncertain





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→ Need better observational constraints for BDC!

Objectives of WP3400

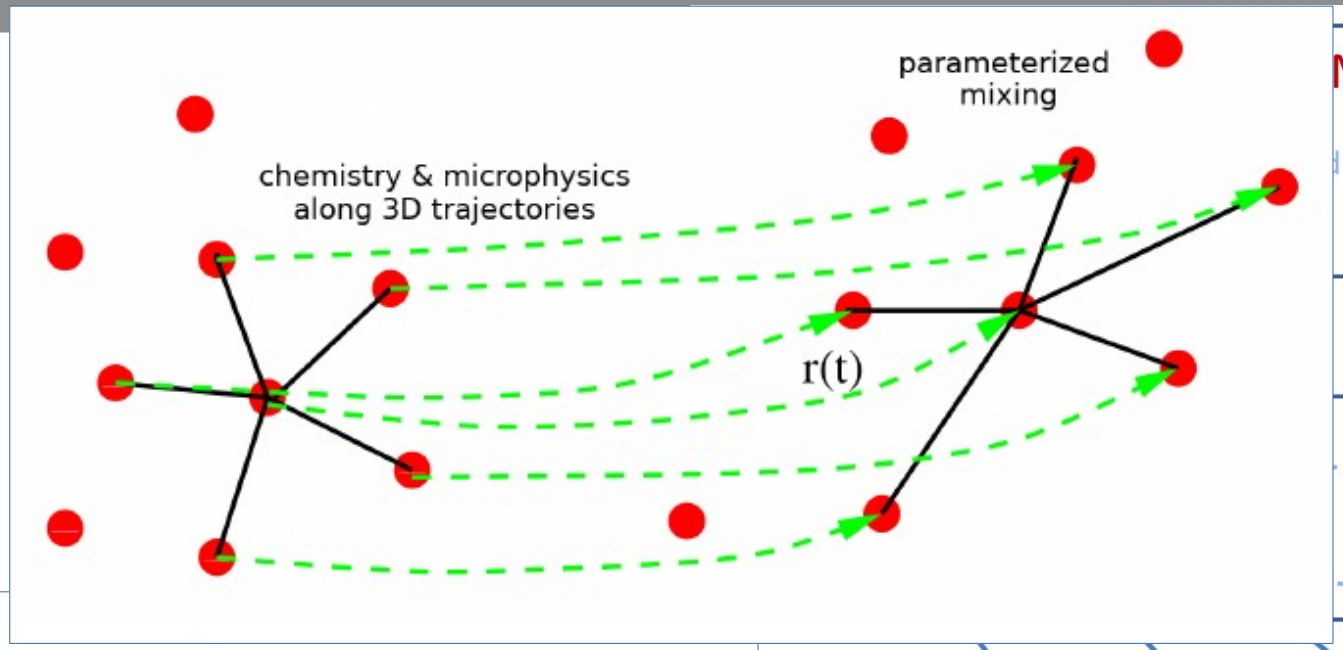
Perform and provide **model simulations** which will enable:

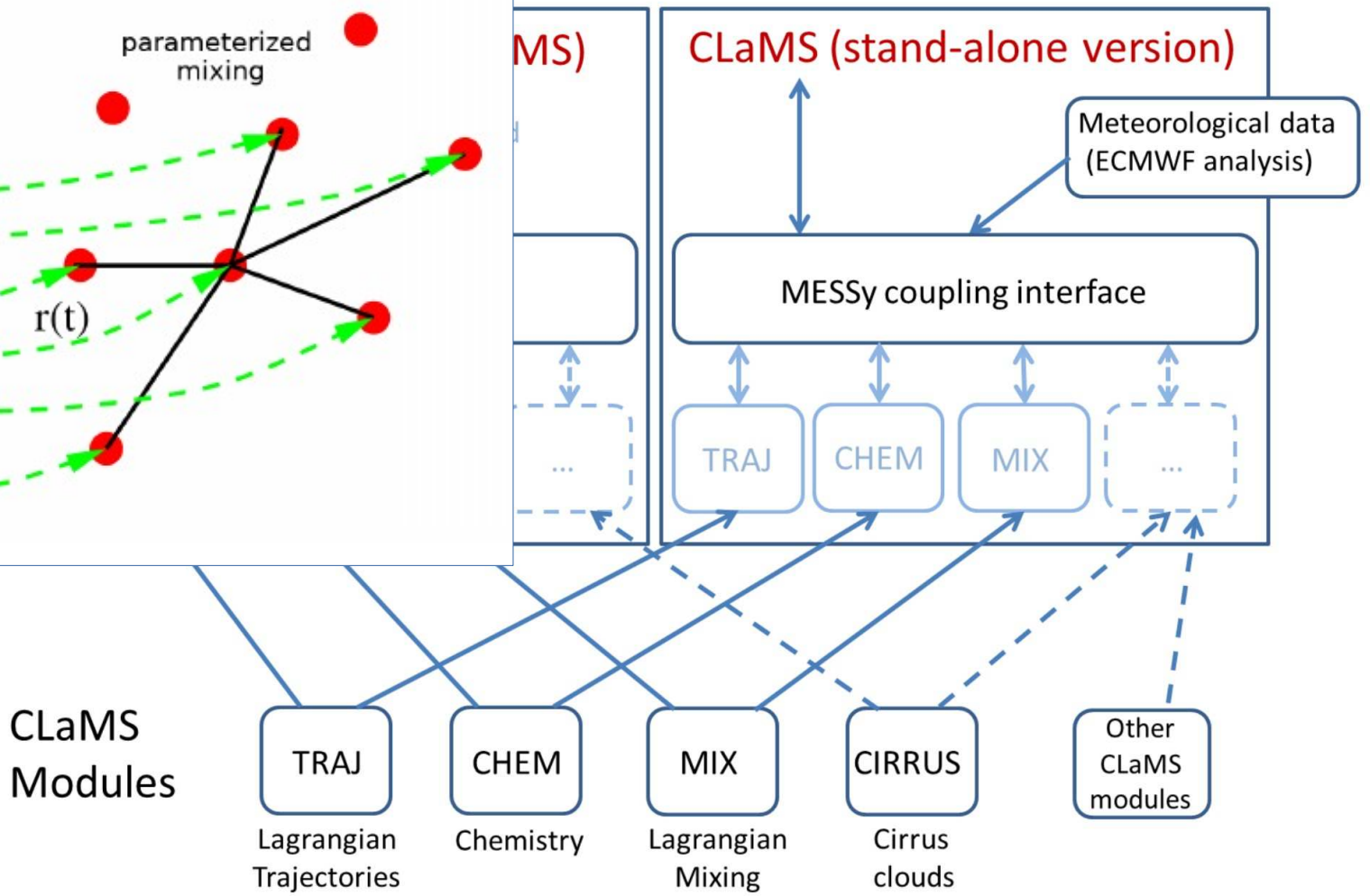
- Enhancing understanding of the effects of changes in the stratospheric circulation on the observed distributions of long-lived trace gases.
- Inferring stratospheric circulation changes from observed changes in long-lived trace gases.
- Evaluating the uncertainty in the representation of the stratospheric circulation and simulations of long-lived trace gases in current reanalysis data sets in comparison with observations.

Tasks of WP3400

- CLaMS simulations of long-lived trace gases (N2O, CH4, CFC-11, CFC-12, SF6) over the past 40 years,
- Simulations driven by different reanalyses (ERA5, ERA-Interim, JRA55, MERRA-2)
- Control model version v1.0 for all reanalyses, improved mixing and convection parameterizations in v3.1 for ERA5.
- Compilation of model-based long-lived trace gas monthly zonal mean data files
- Publication of these files in suitable data archive (https://zenodo.org/records/17357000)
- Comparison between model-fields and long-lived trace gas climatologies
- Technical report

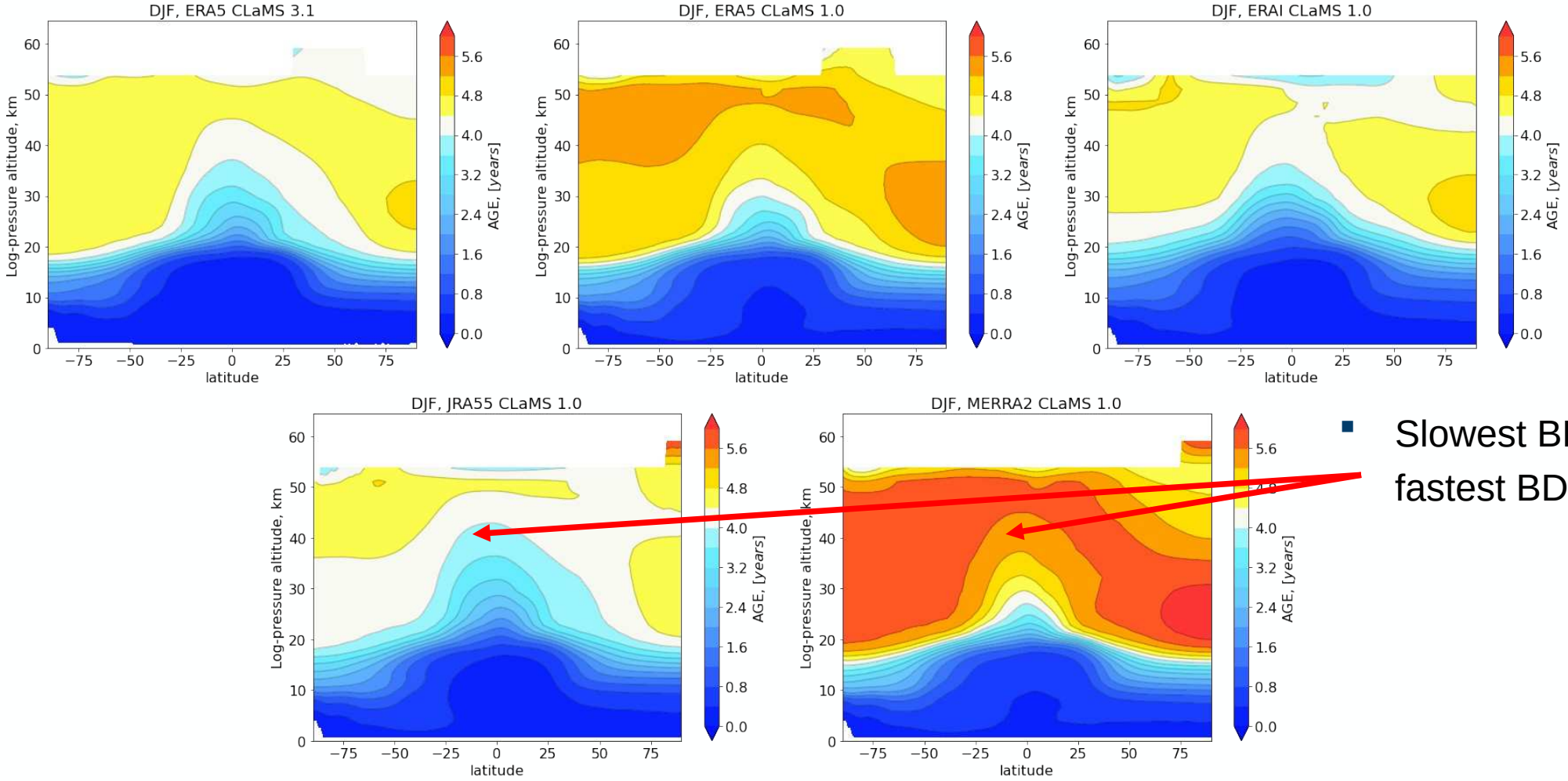
Chemical Lagrangian Model of the Stratosphere (CLaMS)





- **Our „tool“**: Lagrangian CTM, offline-driven by reanalysis data
- Advantageous for simulating gradients and structures in stratospheric composition

CLaMS simulations for age of air (proxy for BDC)



- Slowest BDC in MERRA-2, fastest BDC in JRA55

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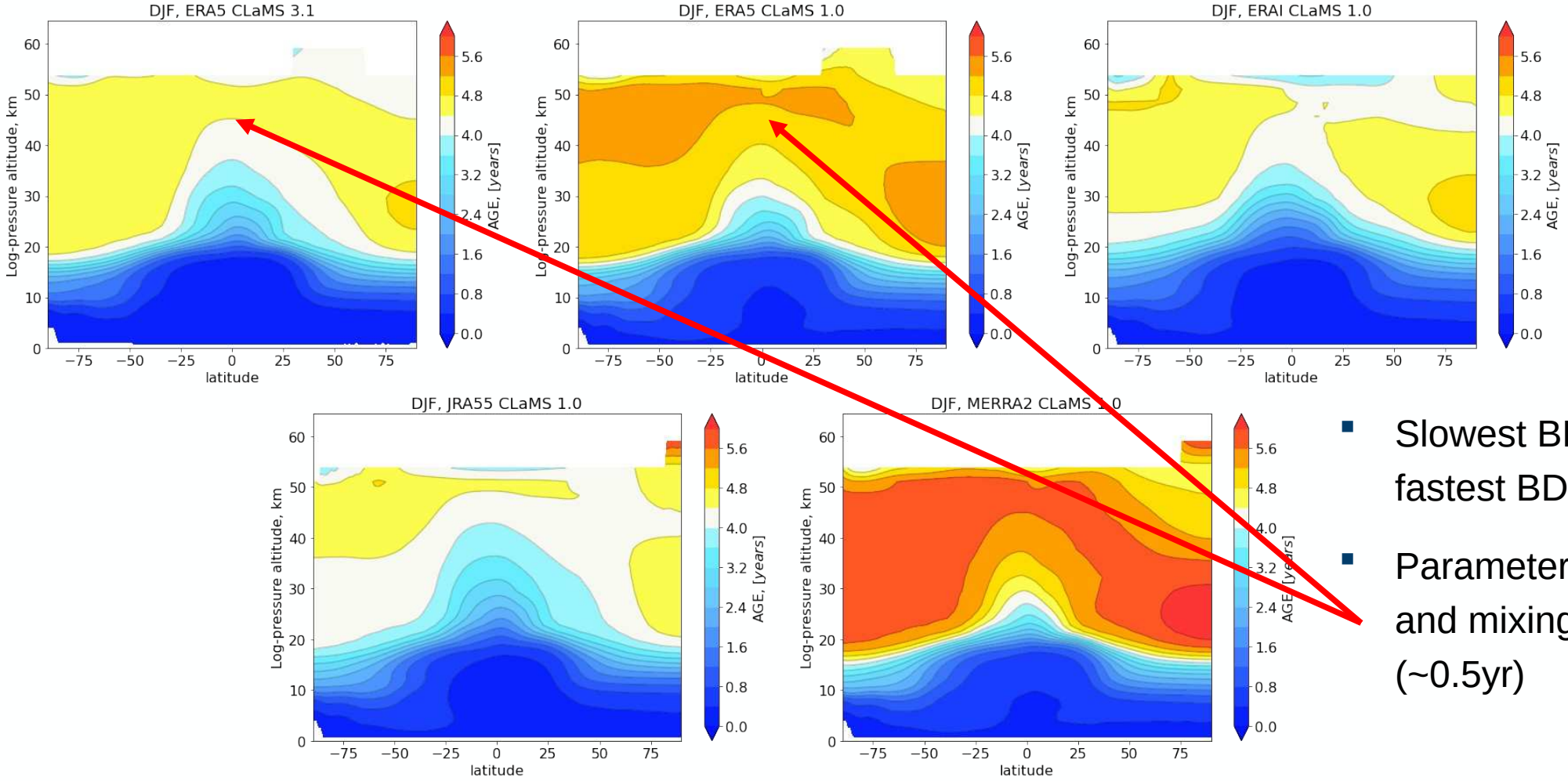
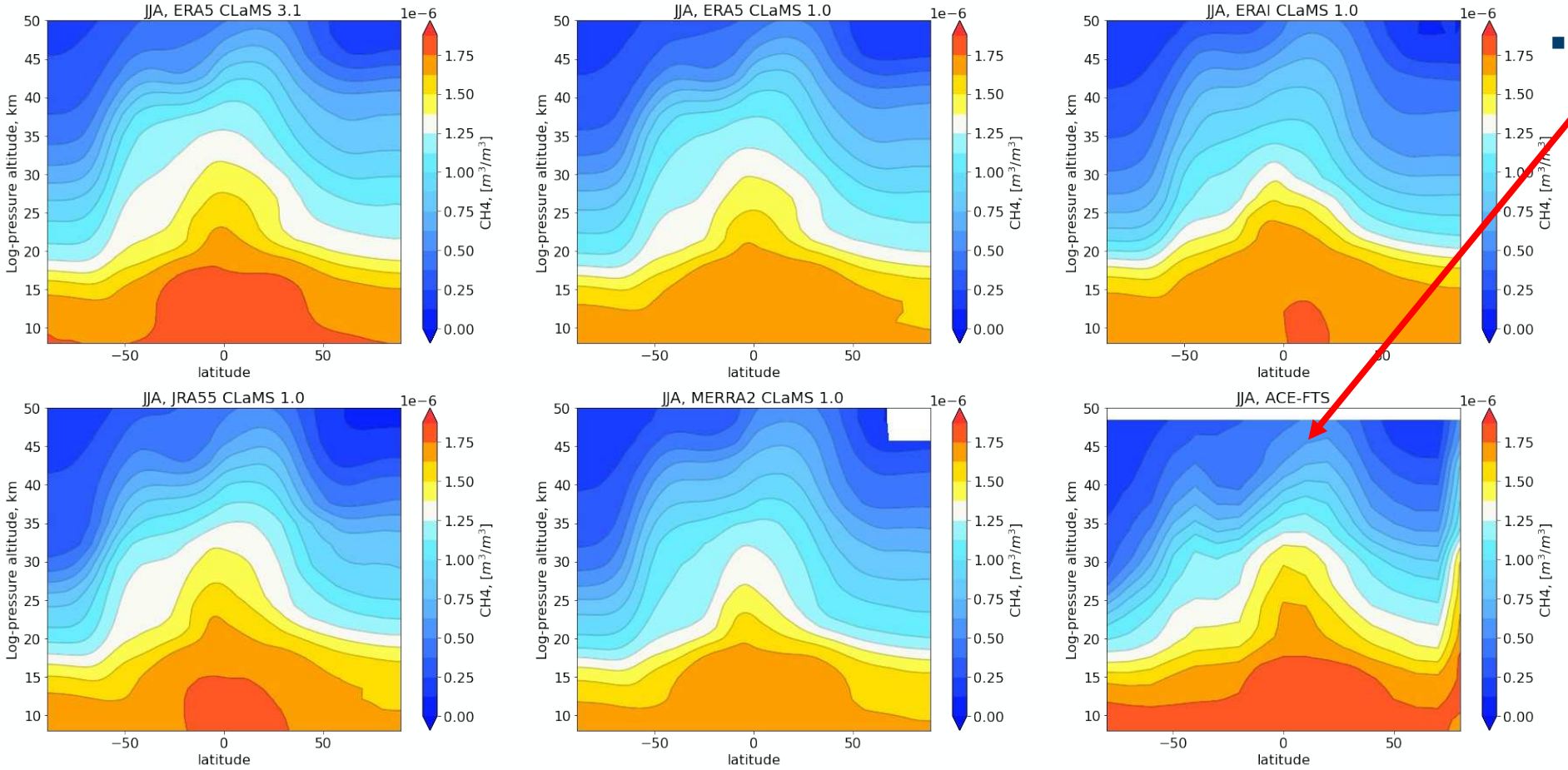


- Slowest BDC in MERRA-2, fastest BDC in JRA55 (>=1yr)
- Parameterized convection and mixing make air younger (~0.5yr)

Trace gas climatologies from CLamS (here CH4)



- ACE-FTS observations for comparison (here CH4)

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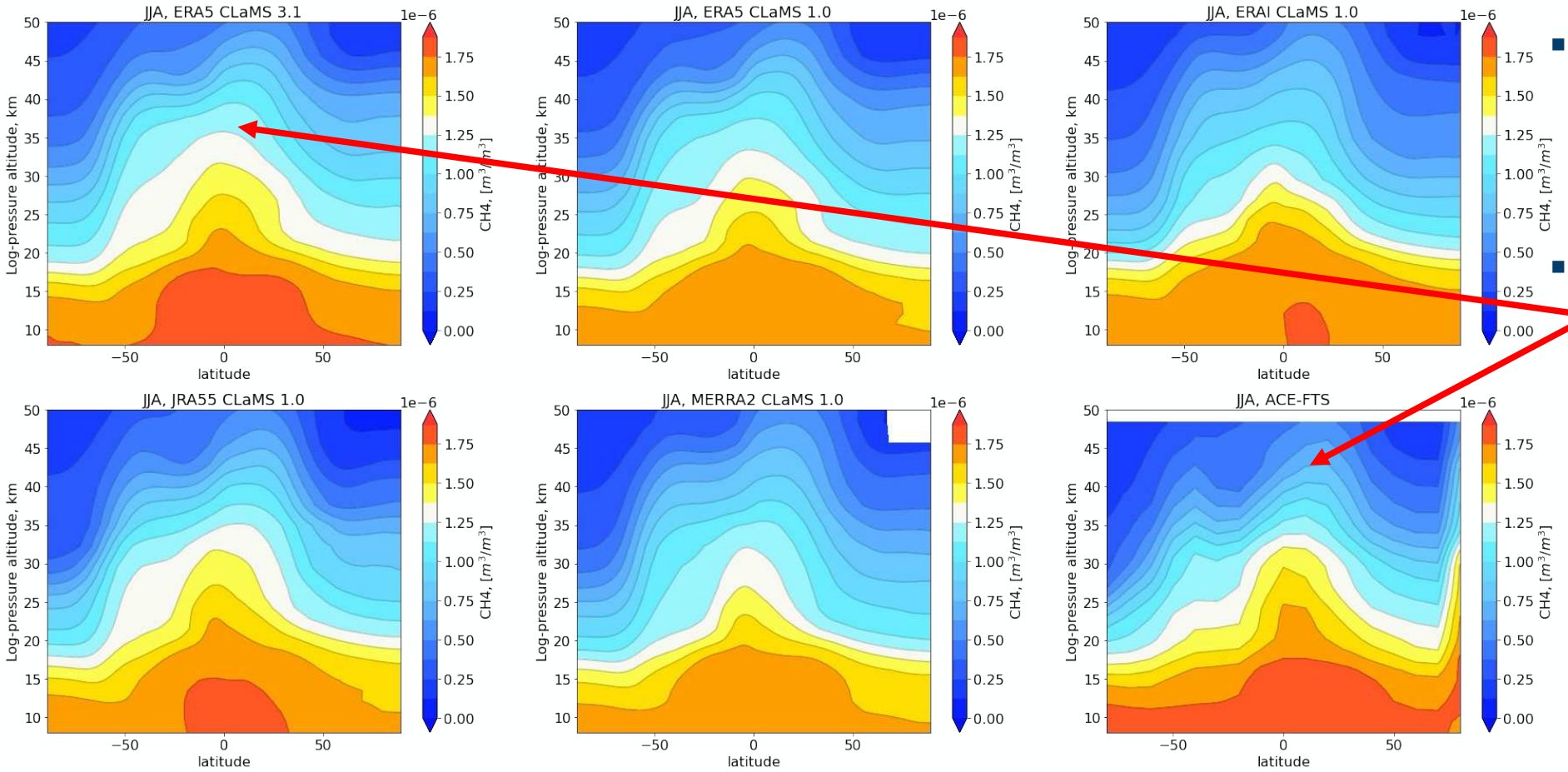
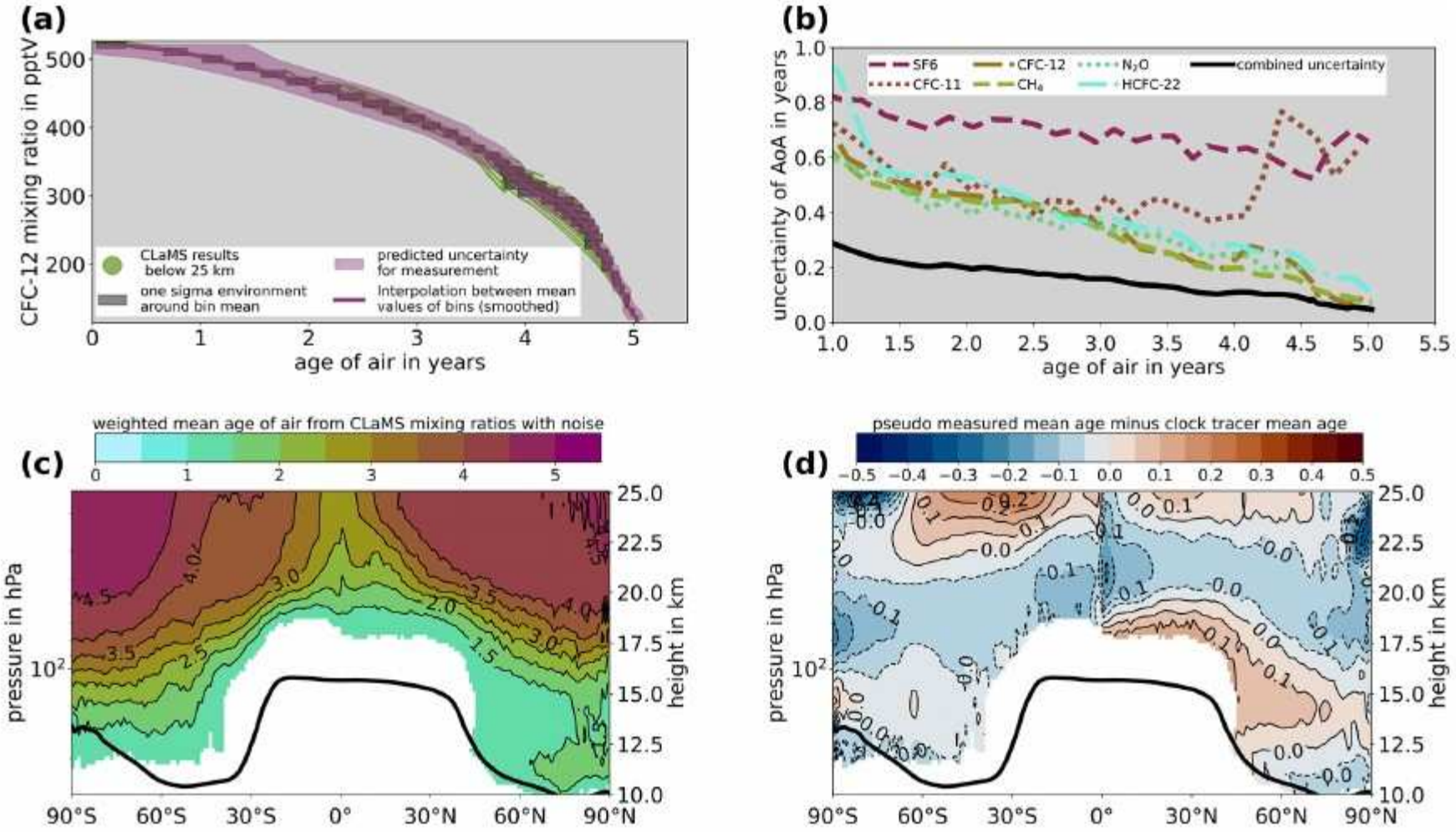


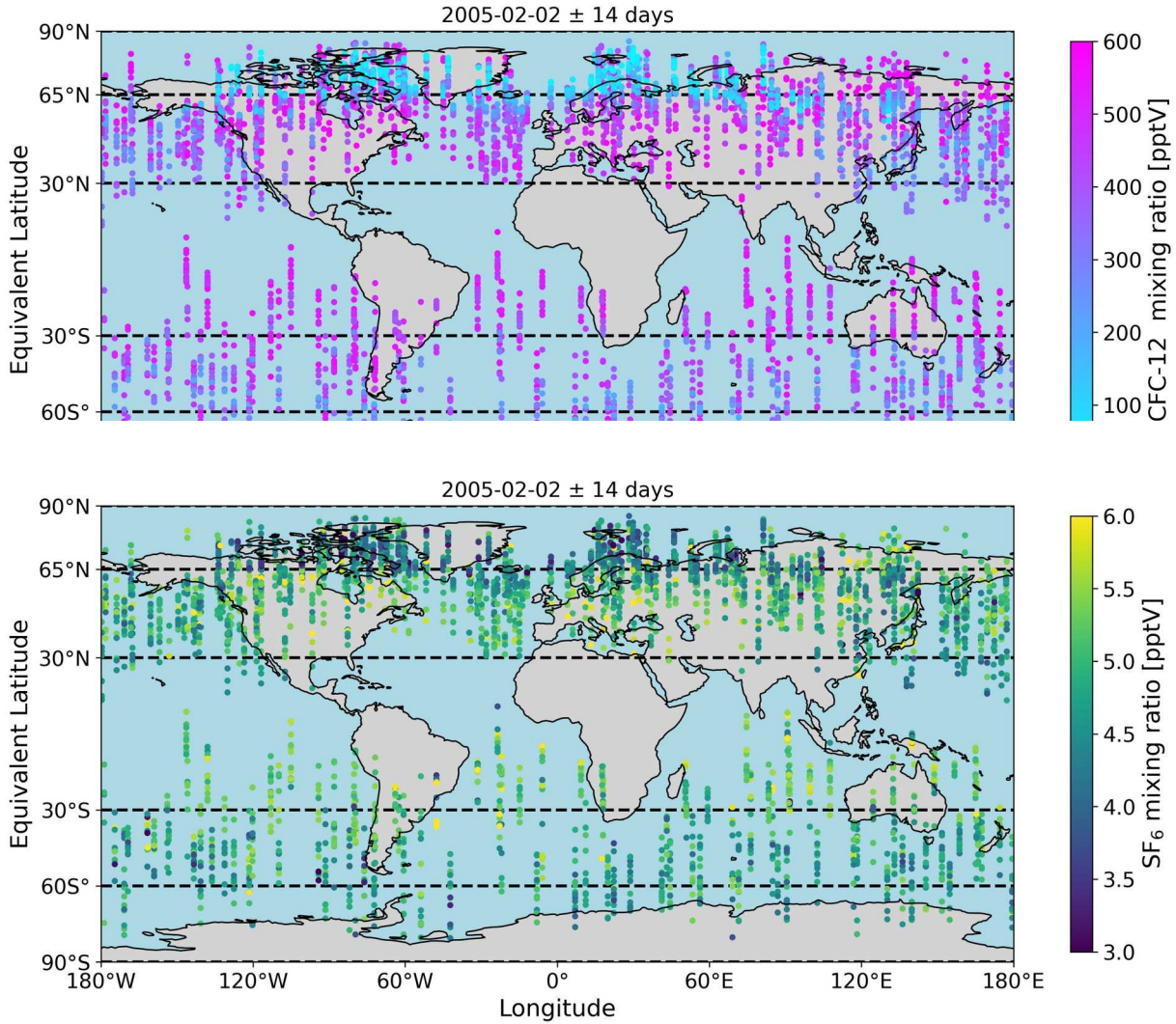
- ACE-FTS observations for comparison (here CH4)
- Closest agreement for ClaMS-ERA5 v3.1 (with parameterized convection and tropospheric mixing)

Mean age from multiple tracer mixing ratios (Voet et al., 2025, ACP)



- Mean age is proxy for BDC speed
- **Goal:** reduce uncertainty in mean age estimates from satellite observations by including multiple tracers
- “Proof of concept” for CLaMS model tracers (Voet et al., 2025)
- Now: apply this method to ACE-FTS observations
- → **improved age estimate**

Lookup Tables for AoA from ACE-FTS measurements



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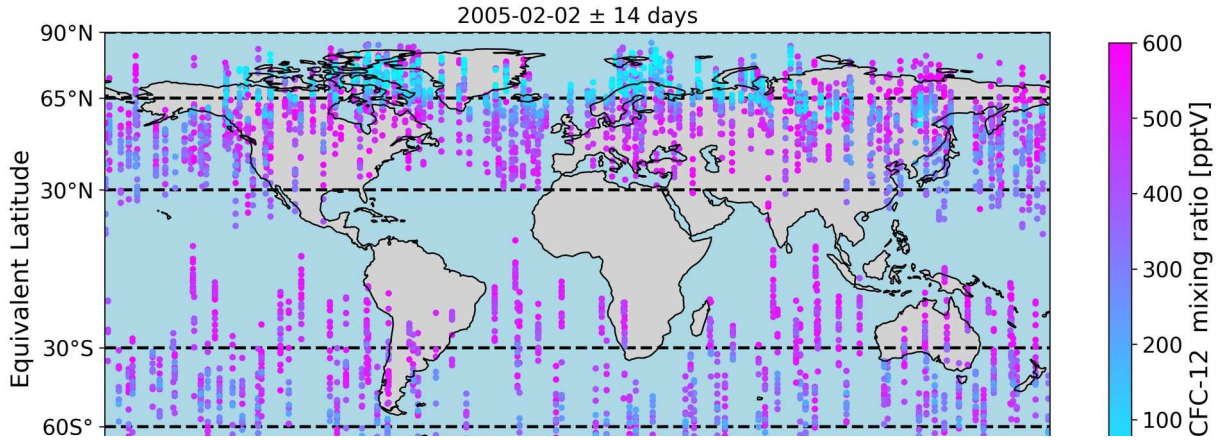

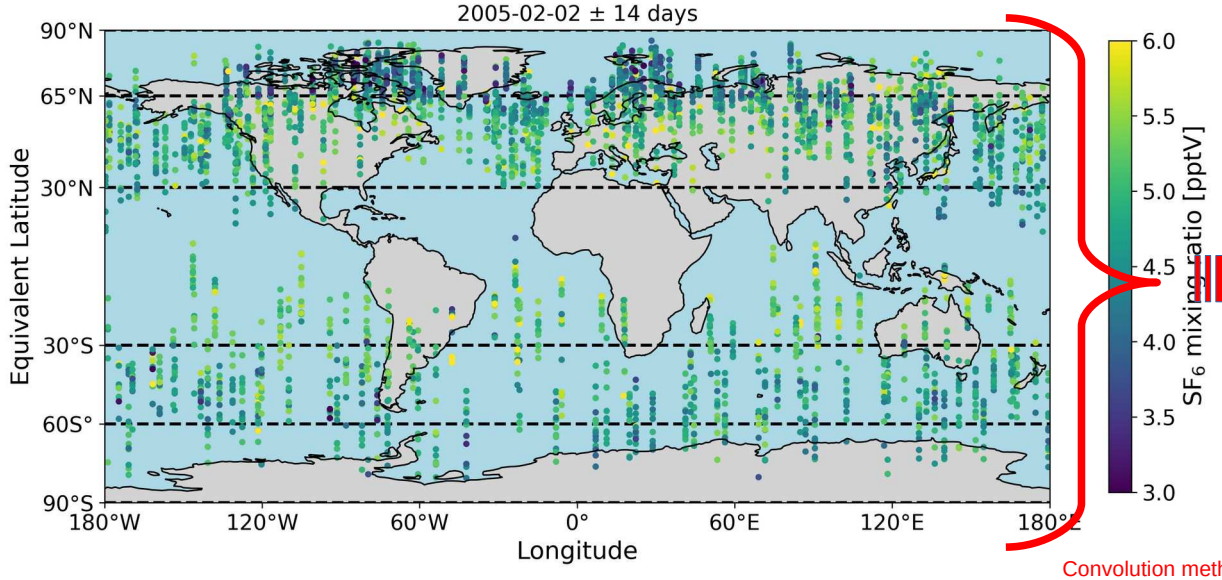

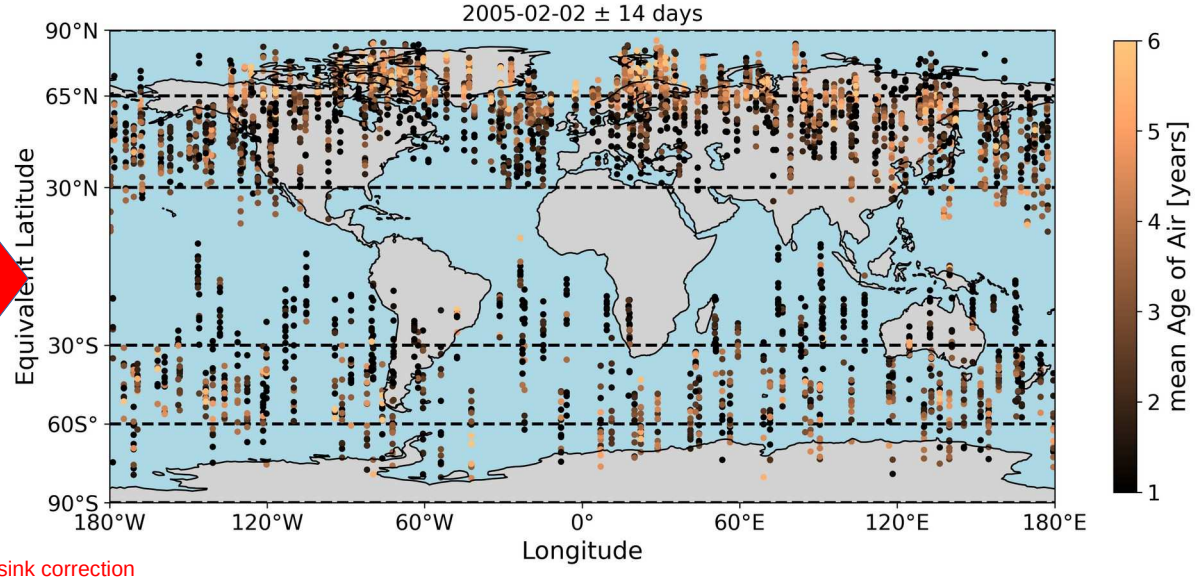

Convolution method + sink correction
(Garny et al. 2024a, 2024b)

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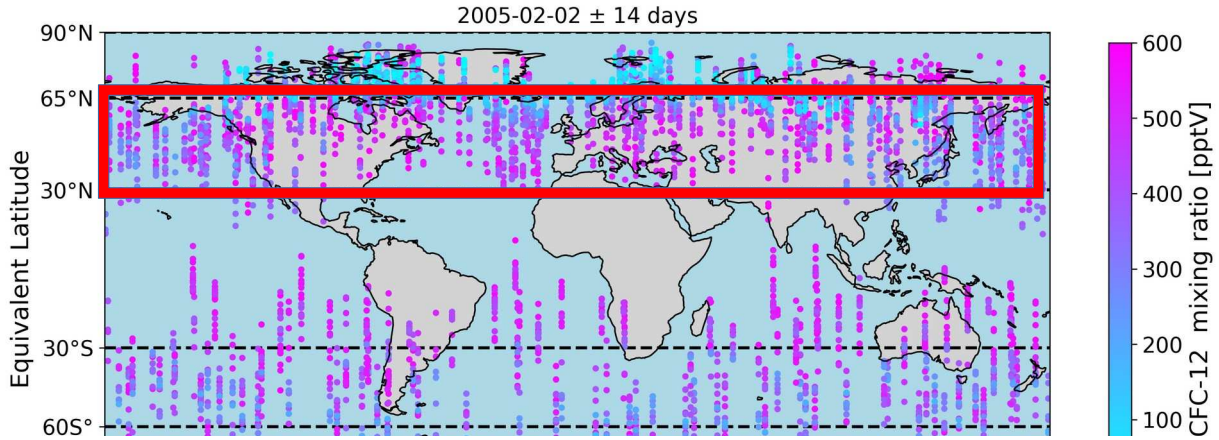

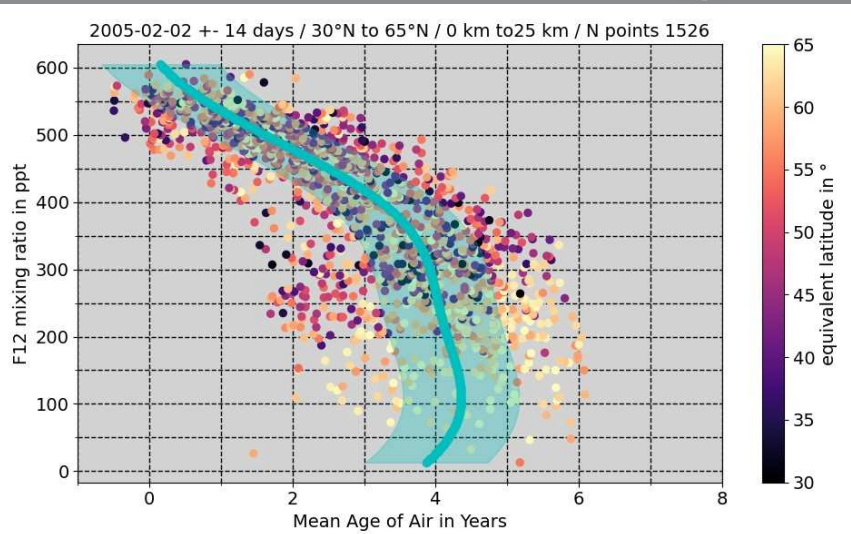

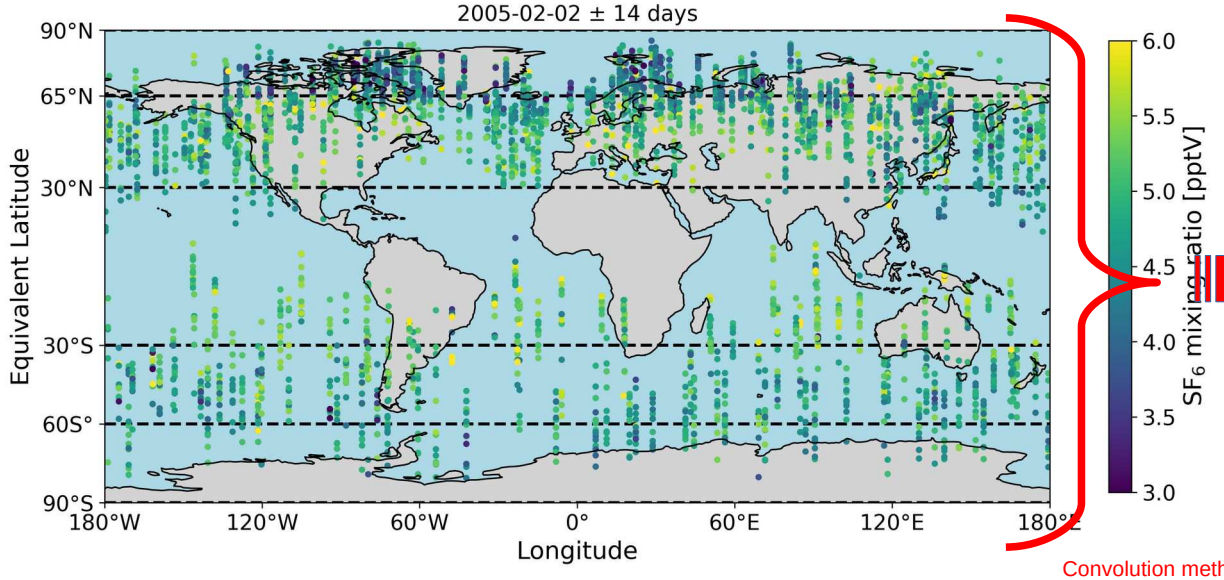

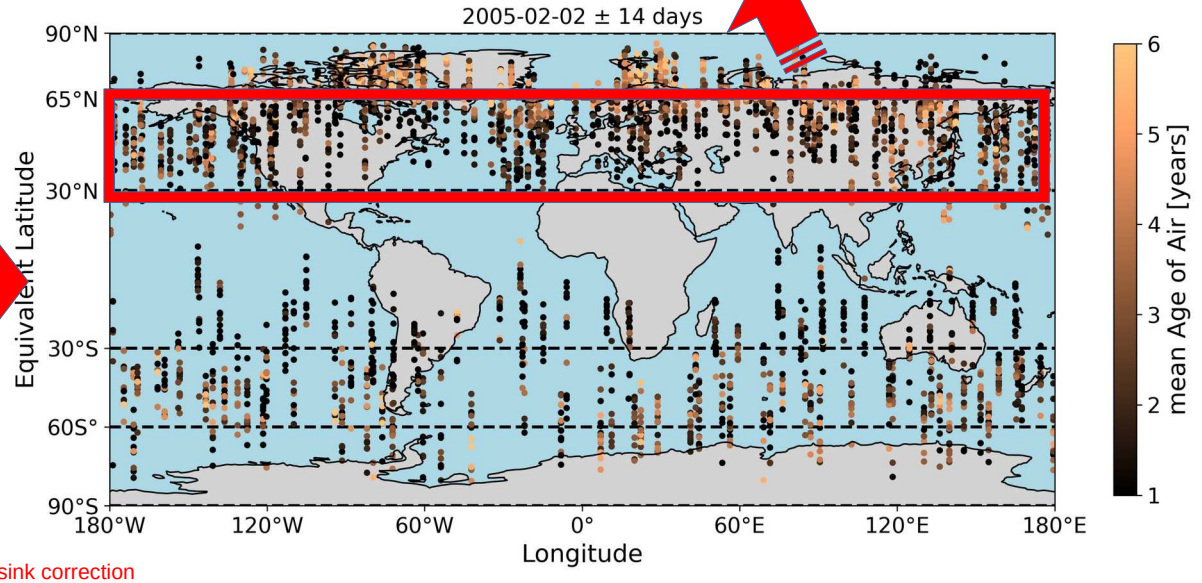

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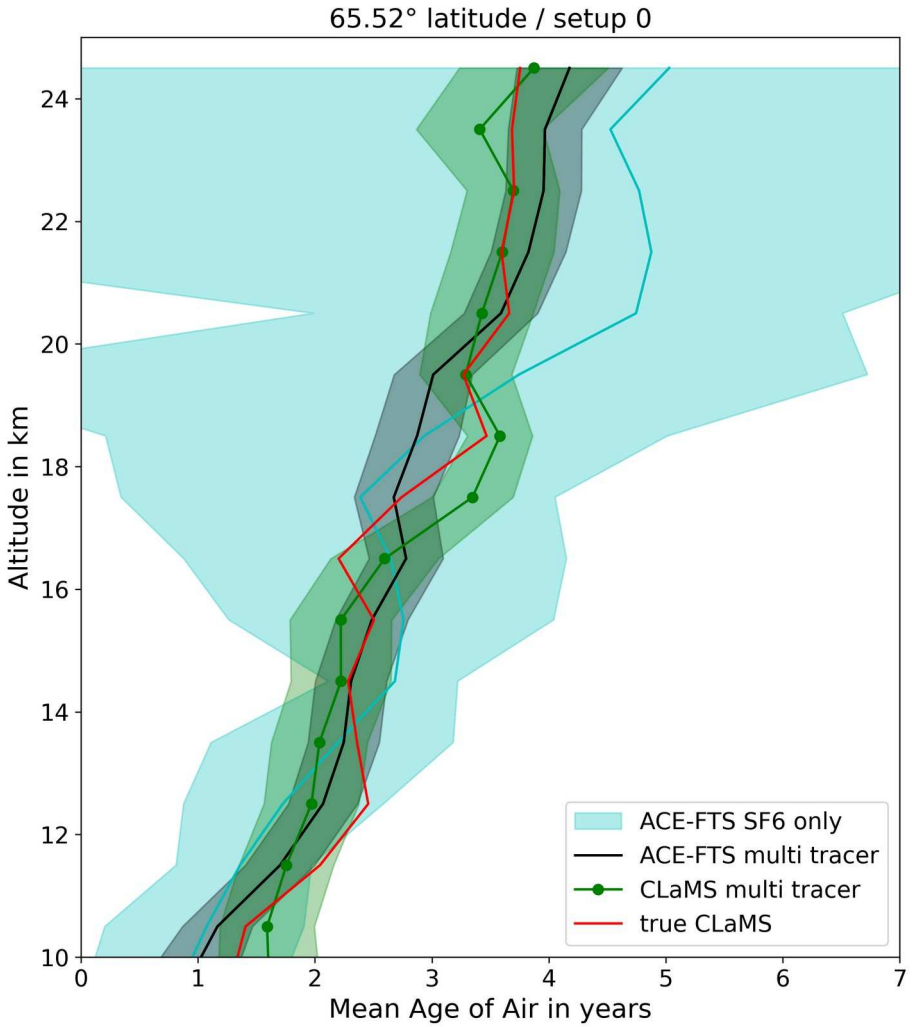
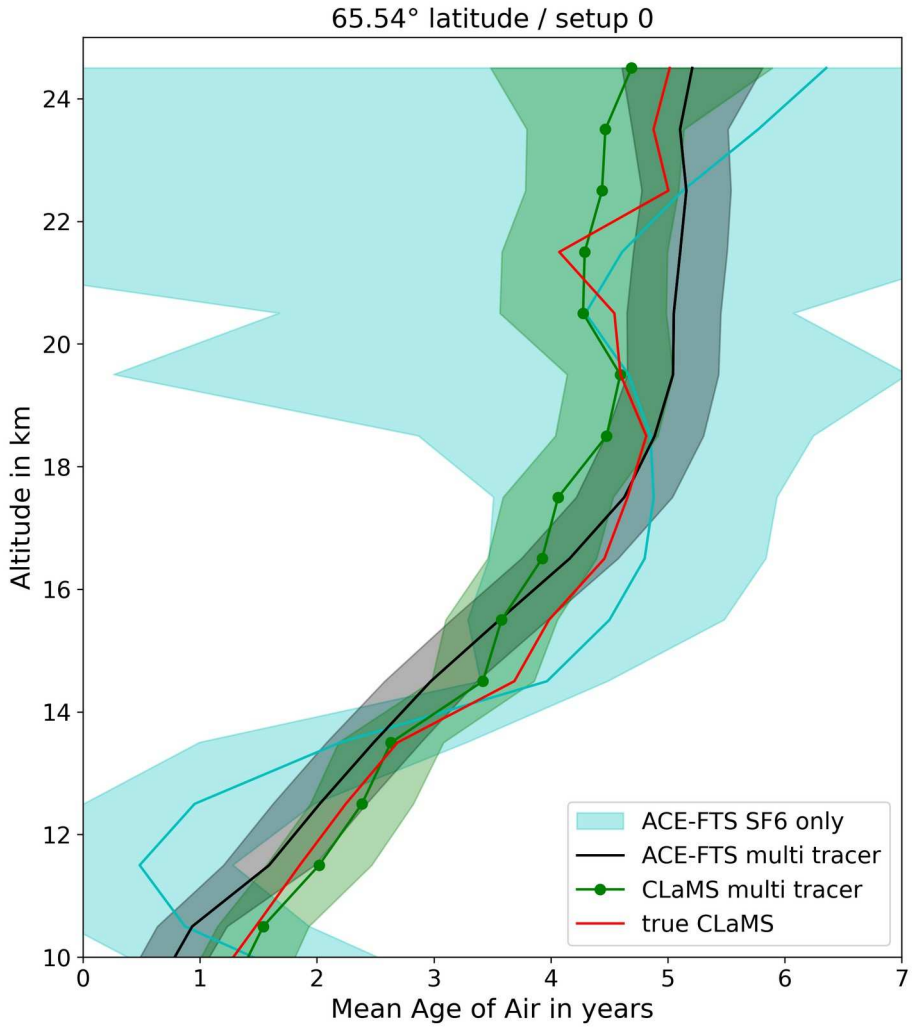
Example Mean Age of Air profiles (preliminary)

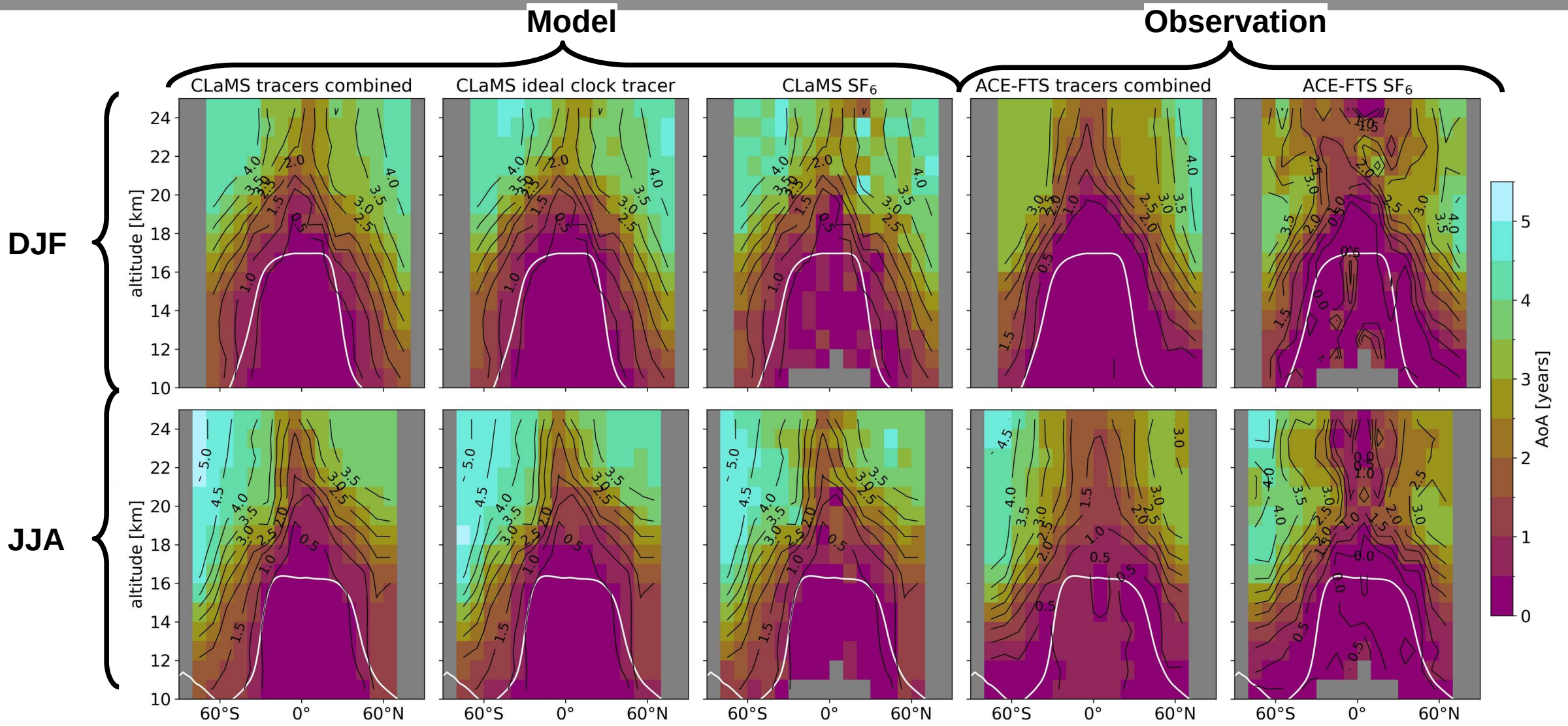




→ Significantly reduced uncertainty range for AoA from multiple trace gases

→ Model tracer derived AoA in good agreement with actual model AoA

Zonal Mean AoA for DJF/JJA 2005 (preliminary)

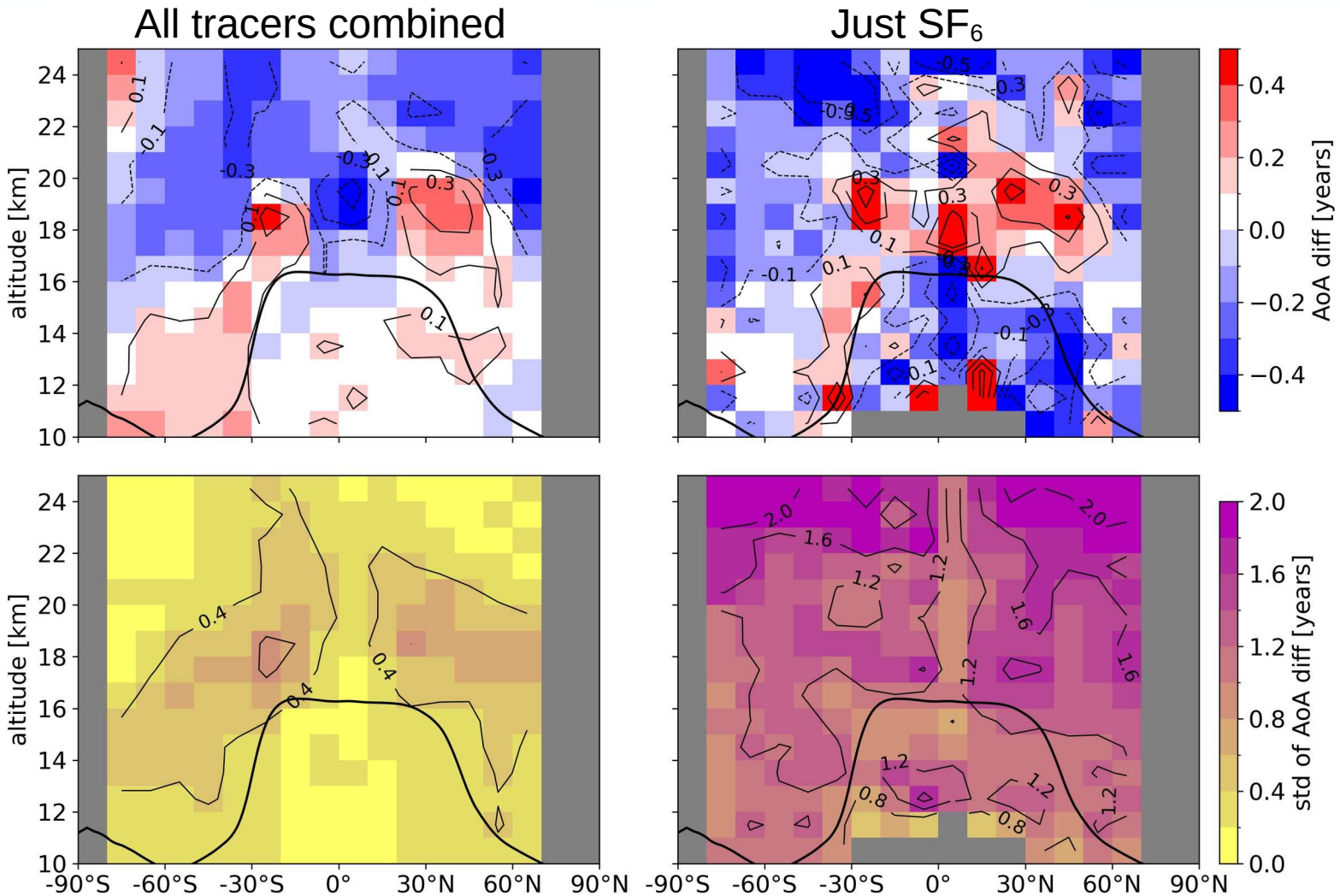


Uncertainties of AoA from SF_6 compared to all tracers in ClaMS for JJA 2005

Differences between actual model AoA and AoA from model tracers:

Averages in zonal direction

Standard deviations in zonal directions



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