Studies of halogenated species using the Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS) on SCISAT

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ACE on SCISAT

Atmospheric Chemistry Experiment (ACE) Satellite Mission

Mission to measure atmospheric composition: profiles of trace gas species, cloud and aerosol extinction and temperature/pressure

Focusing on investigating:

- Distribution of ozone in upper troposphere and stratosphere
- Effects of biomass burning on the troposphere
- Relationship between atmospheric chemistry and climate change

Size: 1.12 m dia. x 1 m; 152 kg
Total power: 70 W (from single solar panel)
Launch date: August 12, 2003
Orbit: 74° inclined circular orbit at 650 km

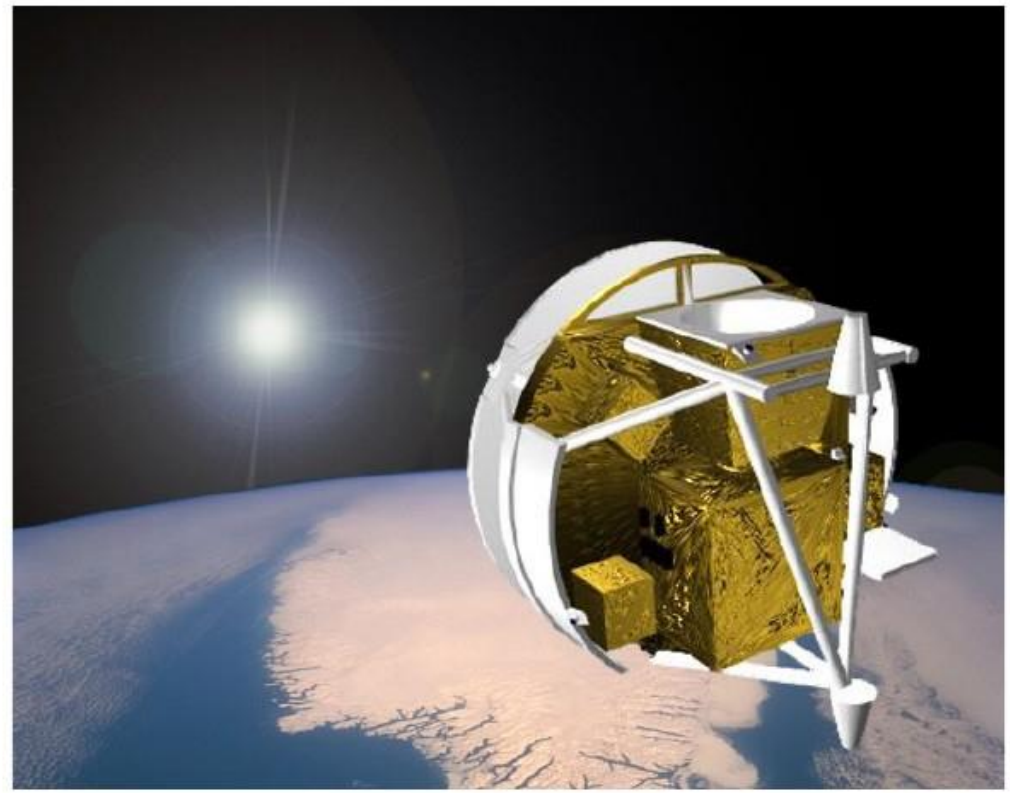
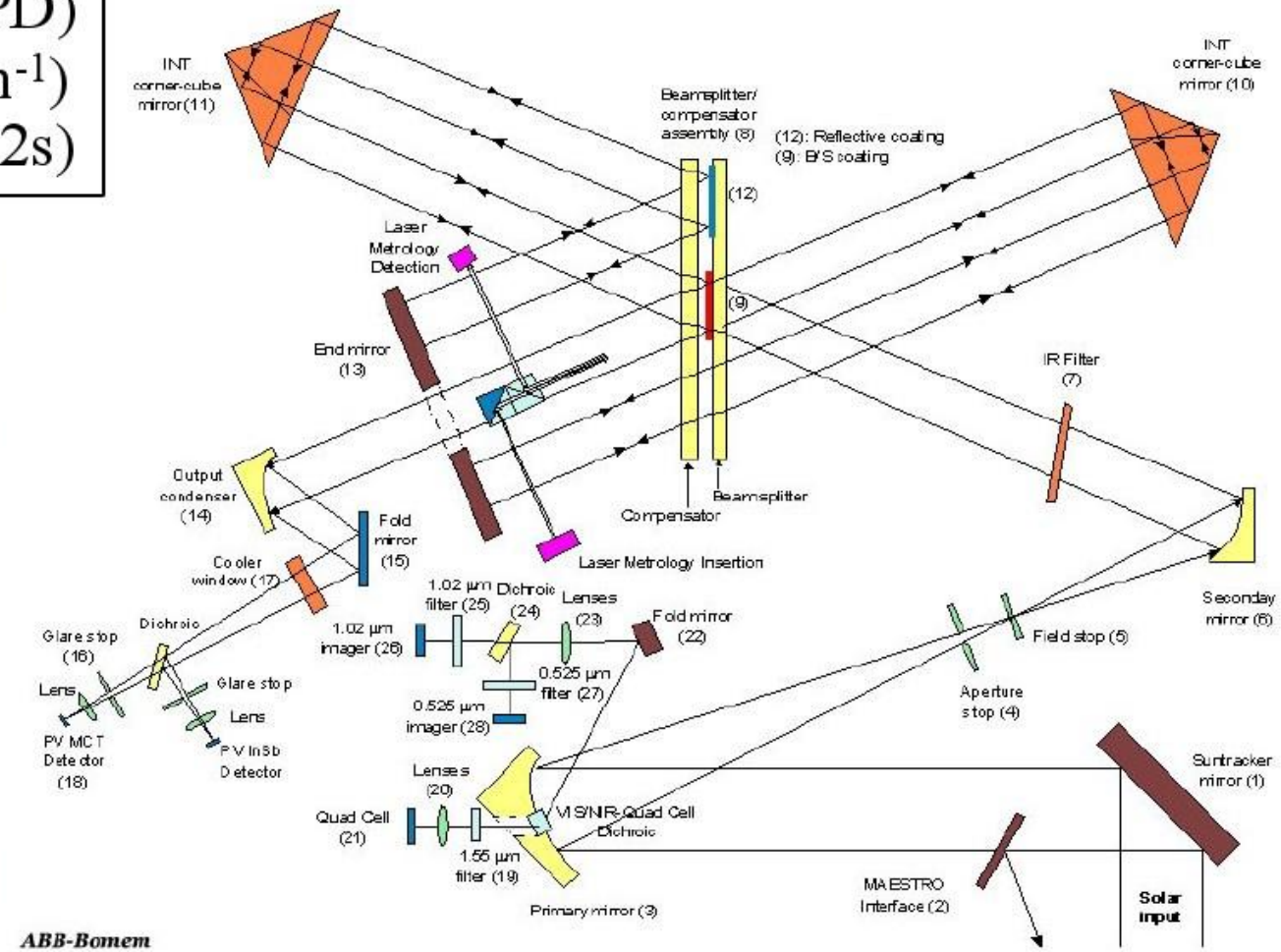


Image: T. Doherty.

ACE-FTS Instrument Details

Spectral resolution: 0.02 cm^{-1} (±25 cm OPD)
Spectral range: 2-13 microns (750-4400 cm^{-1})
Vertical resolution: ~3 km (measures every 2s)

Interferometer-side Input optics-side



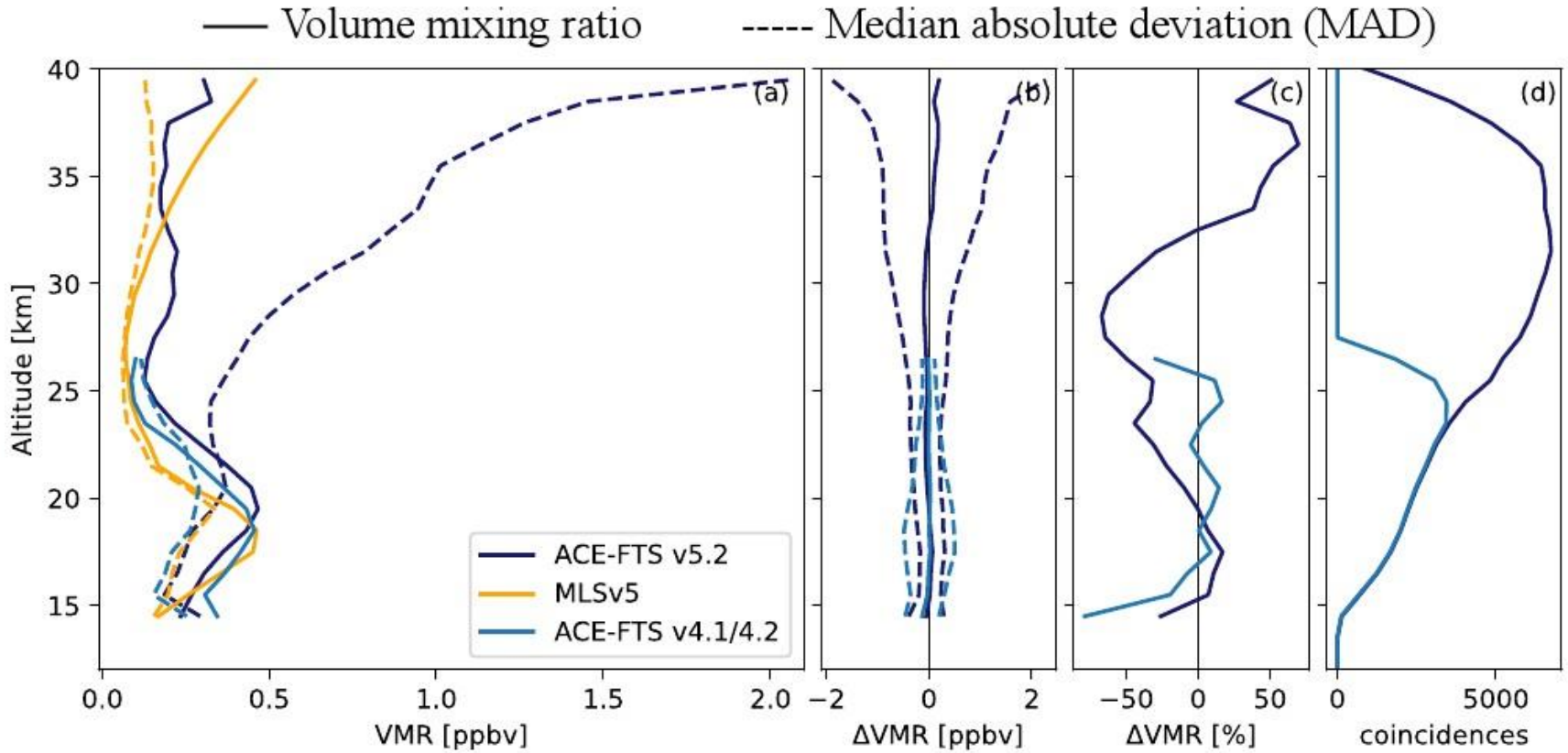
Images: ABB-Bomem

ACE Data Products

- ACE-FTS profiles (newest version 5.2; previous version 4.1/4.2; baseline species):
  - Tracers: H_2O, O_3, N_2O, NO, NO_2, HNO_3, N_2O_5, H_2O_2, HO_2NO_2, N_2, SO_2
  - Halogen-containing gases: HCl, HF, $ClONO_2$, CFC-11, CFC-12, CFC-113, ClO, COF_2, $COCl_2$, COFCl, CF_4, SF_6, CH_3Cl, CCl_4, HCFC-22, HCFC-141b, HCFC-142b, HFC134a, HFC-23, HOCl, HFC-32 (plus several more HFCs being developed as research products)
  - Carbon-containing gases: CO, CH_4, CH_3OH, H_2CO, HCOOH, C_2H_2, C_2H_4, C_2H_6, OCS, HCN acetone, CH_3CN, peroxyacetyl nitrate (PAN), CO_2 (5-18 km and >60 km), pressure / temperature from CO_2 lines
  - Isotopologues: Minor species of H_2O, CO_2, O_3, N_2O CO, CH_4, OCS, NO_2, HNO_3
- MAESTRO profiles (newest version 4; previous version 3.13):
  - O_3, NO_2, optical depth, and water vapor (v31) – aerosol extinction to come
- IMAGERS profiles (current version v5.0; previous version 4.1/4.2):
  - Atmospheric extinction & aerosol extinction at 0.5 and 1.02 microns

Halogenated species validation: ClO (Aura-MLS)

- New ACE-FTS v5.2 retrieval extended profiles to higher altitude (39 km vs. 27 km for v4)
- Good agreement in magnitude of ClO peak MLS v5 vs. v5.2/v4.1/4.2
- MAD comparable between MLS v5 and v4.1/4.2; increases above ~23 km for v5.2
- Similar comparisons with MIPAS and SMILES



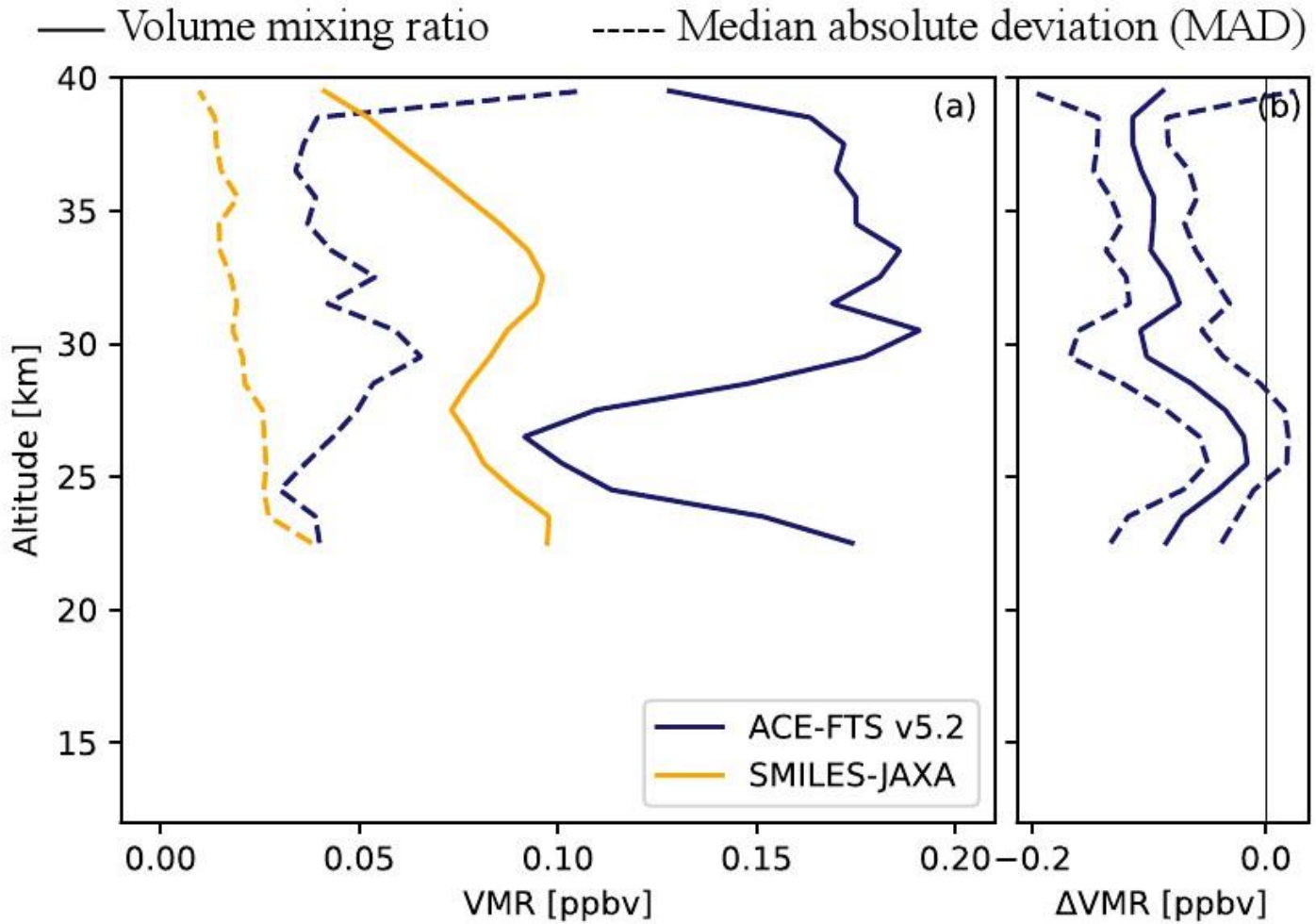
Coincidence criteria: within 12h and 300km, and on same side of polar vortex edge

L. Saunders, N. Ryan, et al., in preparation.

Halogenated species validation: HOCl (SMILES)

Newly retrieved species in v5.2, chlorine reservoir HOCl

- Comparison of all coincident profiles Oct. 2009 – Apr. 2010
- ACE-FTS reports more HOCl than SMILES (both JAXA and NICT products) and Aura-MLS
- Contributes additional species to Cly family calculations using ACE-FTS results

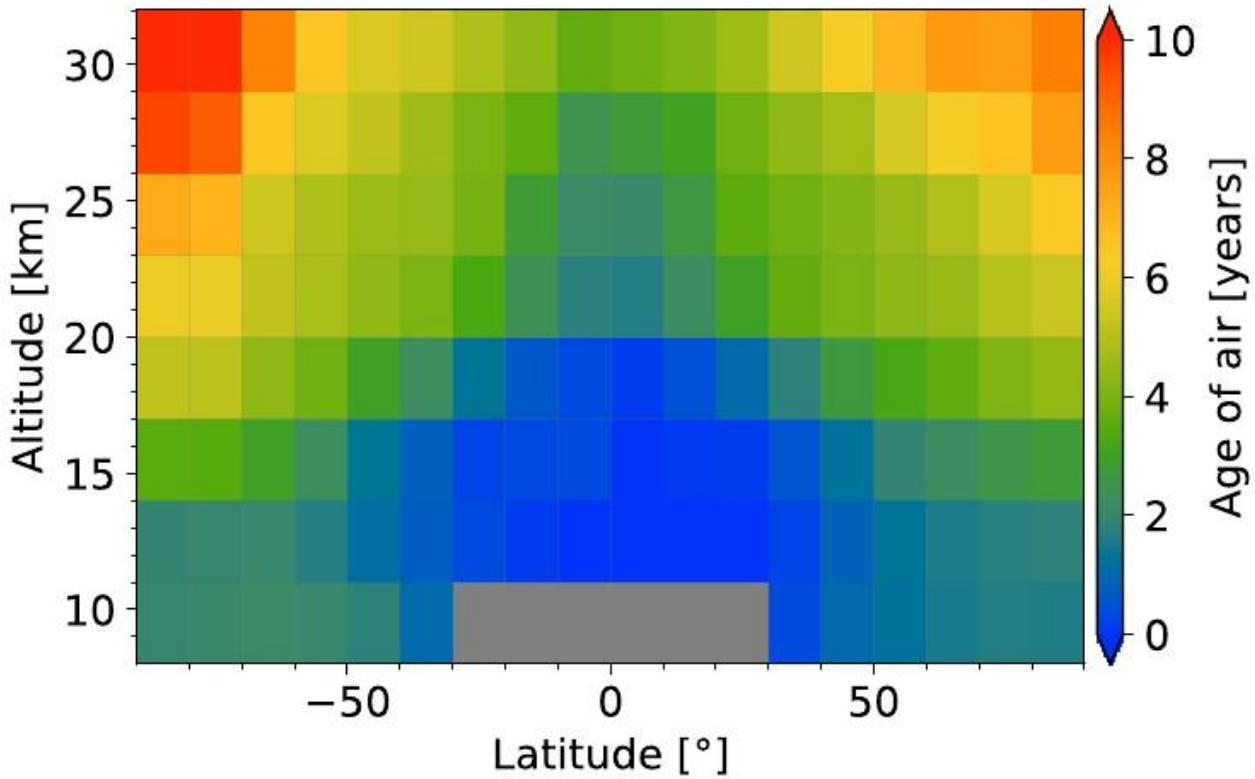


Coincidence criteria: within 12h and 300km, and within polar vortex

L. Saunders, N. Ryan, et al., in preparation.

Stratospheric age of air (AoA) derived from SF_6

Multi-year (2004-2021) mean zonal mean AoA from ACE-FTS



Using SF_6 as a clock tracer, stratospheric age of air for ACE-FTS (v3.5/3.6) and MIPAS (V5R)

- Age increases with distance from the tropical tropopause
- Air in the upper stratosphere appears older due to a mesospheric SF_6 sink

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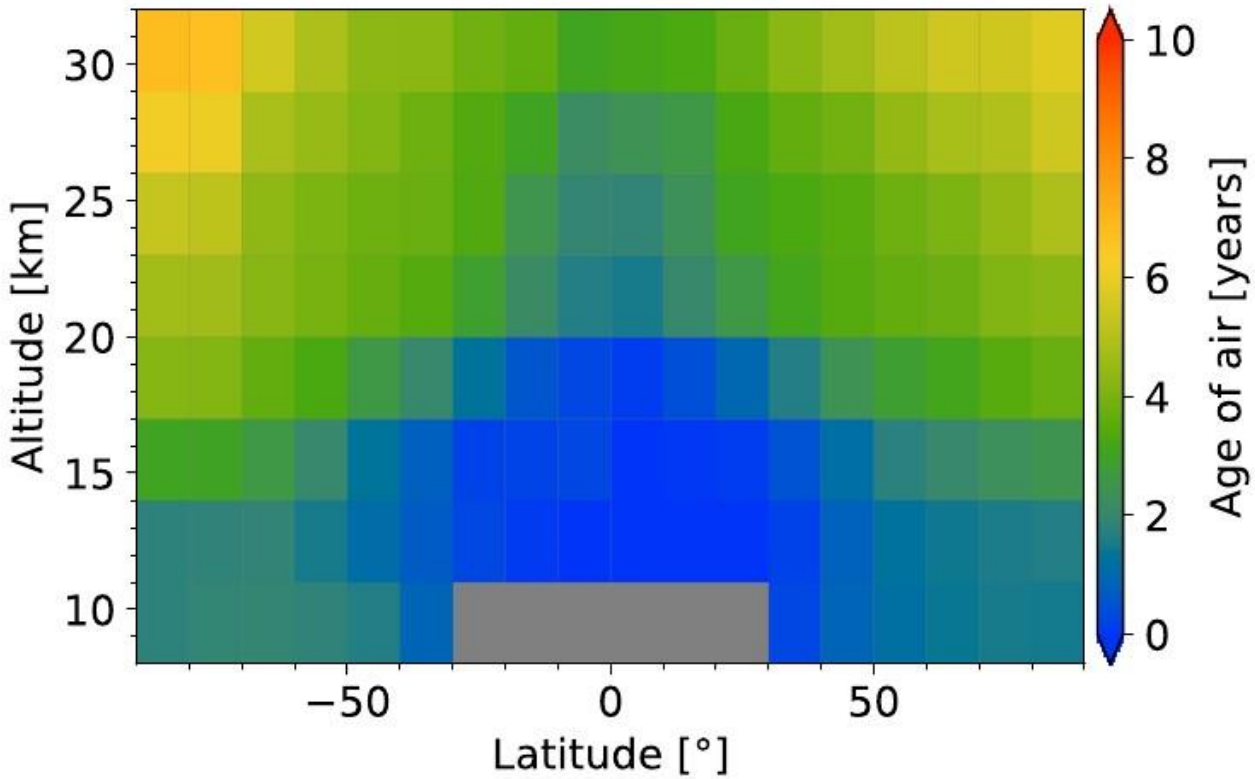

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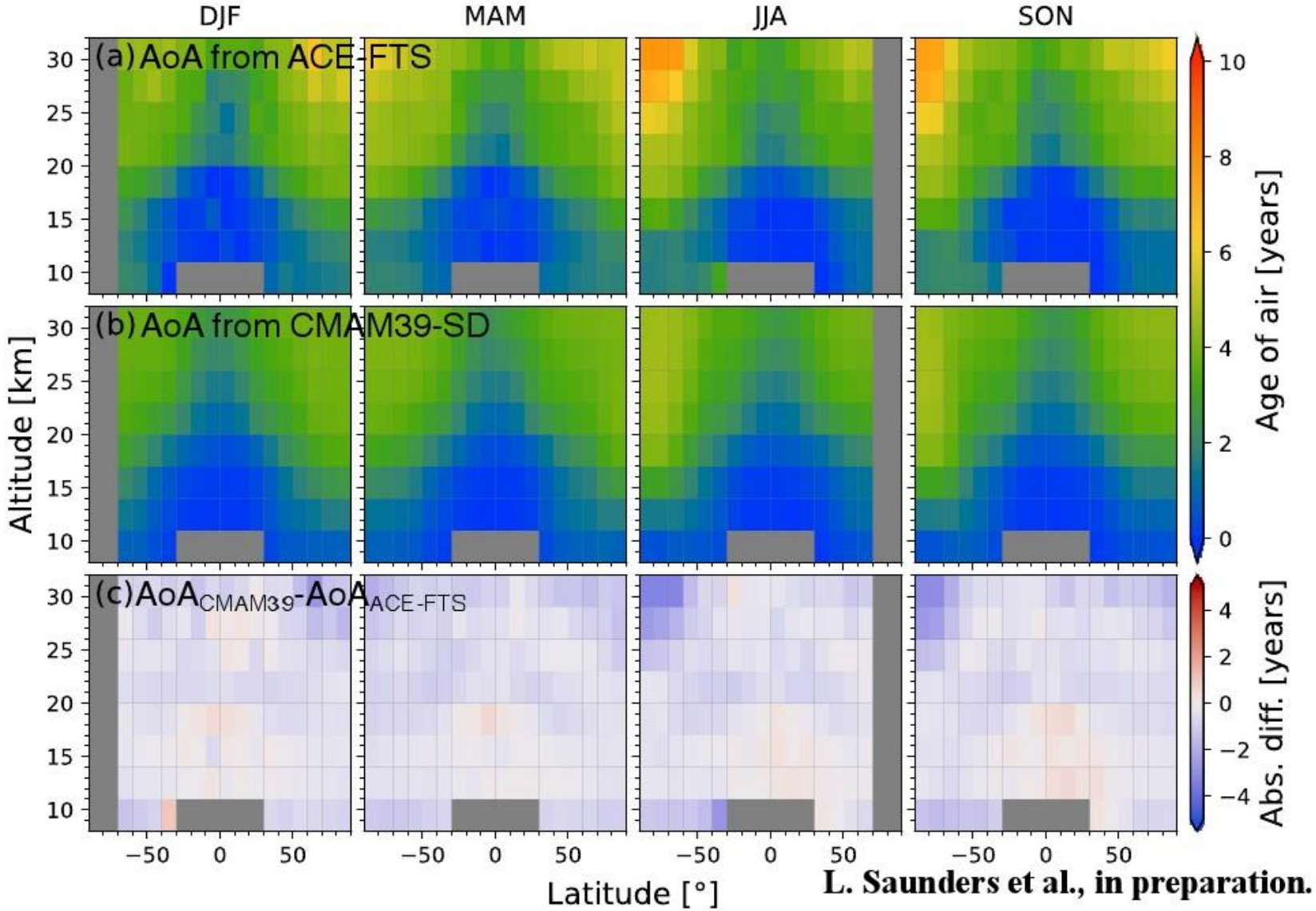
- Age increases with distance from the tropical tropopause
- Air in the upper stratosphere appears older due to a mesospheric SF_6 sink
- A correction scheme developed by H. Garny was implemented to account for this – applied here

L. Saunders et al., in preparation.

Evaluation of AoA from Sampled CMAM39-SD

CMAM39-SD is the newest specified dynamics version of the Canadian Middle Atmosphere Model, a chemistry climate model, for 1980-2018

- Model's age of air is based on an idealized SF_6 tracer
- CMAM modelled air is generally too young, especially at higher latitudes, compared to ACE-FTS SF_6 AoA



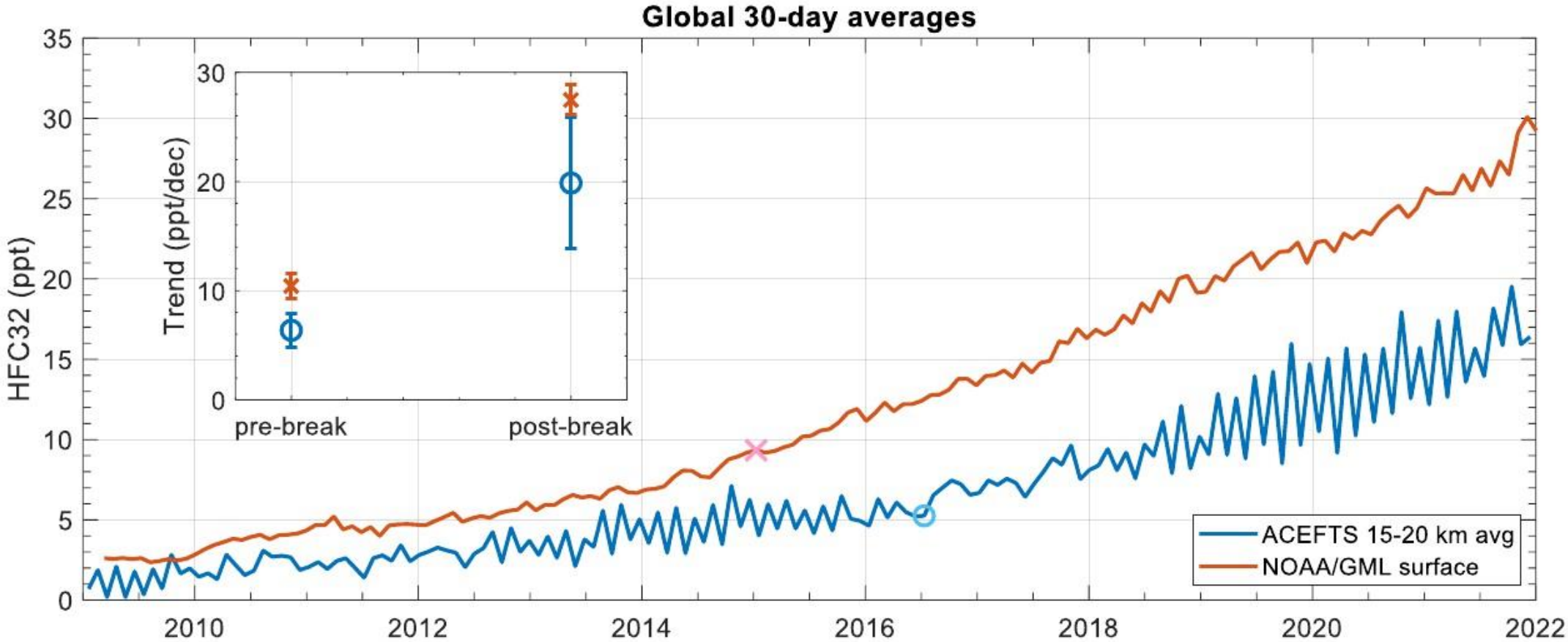
L. Saunders et al., in preparation.

New HFCs being retrieved for ACE-FTS

- HFCs are significant greenhouse gases that are typically thousands of times more powerful than CO_2 in contributing to global warming
- In October 2016, the Kigali Amendment was completed to include the phase out of hydrofluorocarbons (HFCs) within the Montreal Protocol
  - In September 2024, it will be 37 years since the original Protocol was finalized
- ACE-FTS was the first to measure HFC-23 and HFC-134a from space
  - It is now the only satellite measuring vertically resolved profiles of HFCs
  - Currently, it measures CFC-11, CFC-12, CFC-113, HCFC-22, HCFC-141b, HCFC-142b, HFC134a, HFC-23, HFC-32 plus new research HFC products

Global view of HFC-32 (CH_2F_2) trend

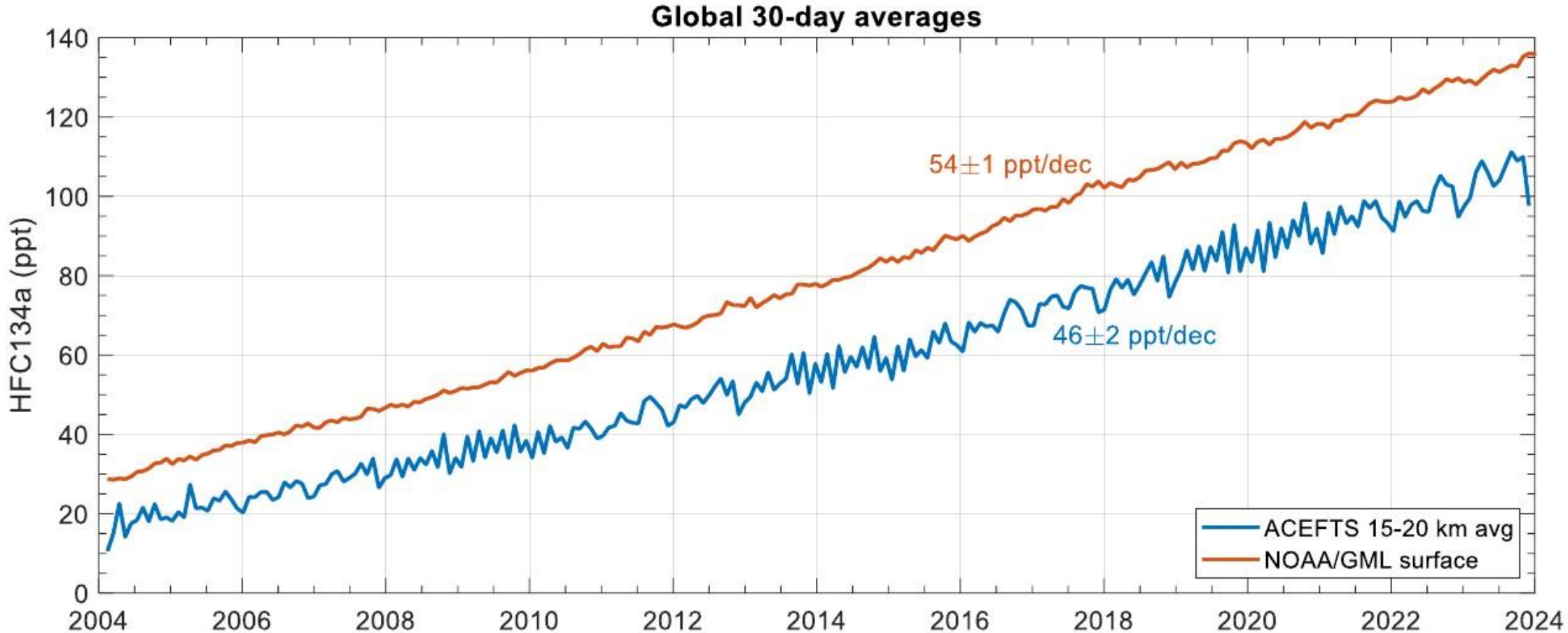
- Time period for analysis limited to time range of NOAA data availability
- Breakpoint where increase occurs in rate of HFC-32 increase – 2015-2016 range



Analysis by P. E. Sheese

Examining Global Trend in HFC-134a

- HFC-134a, tetrafluroethane (CF_3CH_2F), has GWP of >1,400
- In contrast to HFC-32, no significant breakpoint determined in ACE-FTS or NOAA



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Summary

- ACE has evolved from an ozone-focused mission to a climate-focused mission
  - Advantage of large number of species being measured simultaneously – including halogenated
  - Stability of ACE-FTS measurements useful for multi-year time series and trend analysis
- Data availability for ACE:
  - ACE-FTS (and MAESTRO) from https://databace.scisat.ca/level2 (registration required)
  - Data quality flags are being produced separately doi:10.5683/SP2/BC4ATC (ACE-FTS v5.2)
  - Zonal mean climatologies available through SPARC Data Initiative or talk to Kaley!

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