ACCROSS Project: Investigating the impacts of circulation changes on stratospheric tracers

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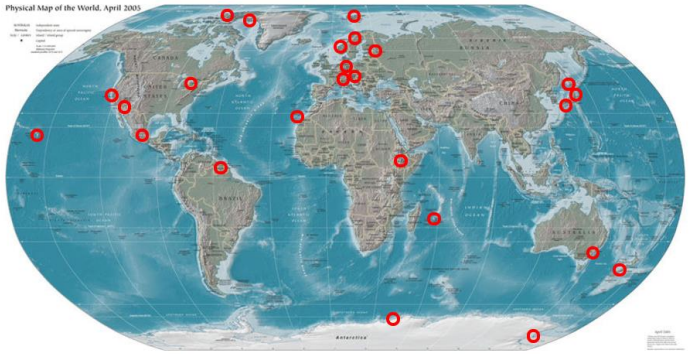
ACCROSS Project

- 3 main goals to improve our understanding of the circulation changes in the stratosphere during the past three decades:
  - Characterize the long-term trends and impact of stratospheric circulation changes on three reference long-lived tracers (HF, N_2O, CH_4).
  - Evaluate and compare the representation of the trends and circulation changes in at least three leading meteorological reanalyses (ERA-Interim, MERRA-2, JRA-55). In this comparison the BASCOE CTM will be used as a transfer tool to model the changes of the tracers stratospheric abundances.
  - Evaluate the ability of a state of the art climate model, WACCM, to simulate the observed changes of the stratospheric circulation.

Characterize the long-term trends and impact of stratospheric circulation changes on three reference long-lived tracers

- Exploitation of two main data sources:
  - Ground-based FTIR NDACC data
  - Satellite data
    - HALOE (1991→ 2005)
    - ACE (2004 → …)

    + GOZCARDS merged time series



https://www2.acom.ucar.edu/irwg/sites

https://www.jungfrau.ch/fr-ch/jungfraujoch-top-of-europe/

http://www.ace.uwaterloo.ca/

https://www.nasa.gov/centers/langley/news/factsheets/Haloe.html

Evaluate and compare the representation of the trends and circulation changes in at least three leading meteorological reanalyses

- The Chemistry-Transport Model (CTM) BASCOE
  - Belgian Assimilation System for Chemical ObsErvations
  - Four dimensional variational assimilation + **3D CTM**
  - Driven by *wind and pressure* from reanalyses
  - Originally 60 chemical species and ~200 reactions (gas-phase, photodissociation and heterogeneous)
  - New feature: reading historical greenhouse gas concentrations from Meinshausen *et al.* (GMDD 2016) as boundary condition

In progress: setting up BASCOE

- *Closing* the fluorine and chlorine budgets

In BASCOE sb15

Not in BASCOE sb15

Data from Meinshausen *et al.* (GMDD 2016)

Fluorine budget

	1984-12	**2014-12**
cfc12	48.57%	32.81%
hcfc22	8.12%	14.54%
hfc134a	0.00%	10.41%
cf4	15.00%	10.25%
cfc11	13.44%	7.35%
cfc113	7.21%	6.85%
hfc23	1.10%	2.58%
hfc125	0.00%	2.49%
cfc114	3.34%	2.06%
sf6	0.55%	1.59%
hfc143a	0.04%	1.44%
hcfc142b	0.10%	1.37%
cfc115	0.97%	1.33%

Chlorine budget

	1984-12	2014-12
cfc12	25.68%	31.69%
cfc11	21.29%	21.30%
CH3Cl	18.73%	16.32%
CCl4	13.69%	10.10%
hcfc22	2.15%	7.02%
cfc113	3.81%	6.63%
ch2cl2	1.33%	2.20%
hcfc141b	0.00%	1.46%
cfc114	0.88%	0.99%
chcl3	1.22%	0.93%
hcfc142b	0.03%	0.66%
ch3ccl3	11.04%	0.32%
cfc115	0.10%	0.26%
halon1211	0.05%	0.11%

  - → Adding of 2 *hcfc* and 4 *hfc* + corresponding reactions in BASCOE
- Update the reaction rates and photodissociation parameters of all cfc, hcfc, hfc and halons (JPL2015)

In progress: Investigating the HF stratospheric long-term trends

- Context: Mahieu *et al.*'s paper (Nature 2014) on HCl:

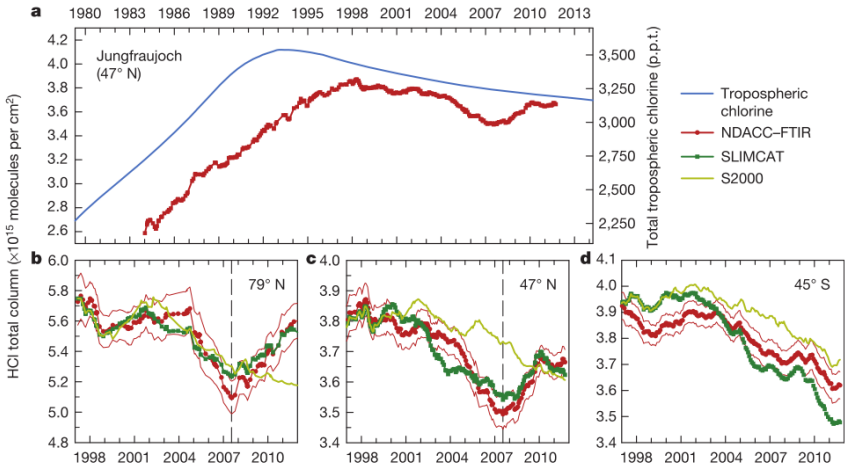
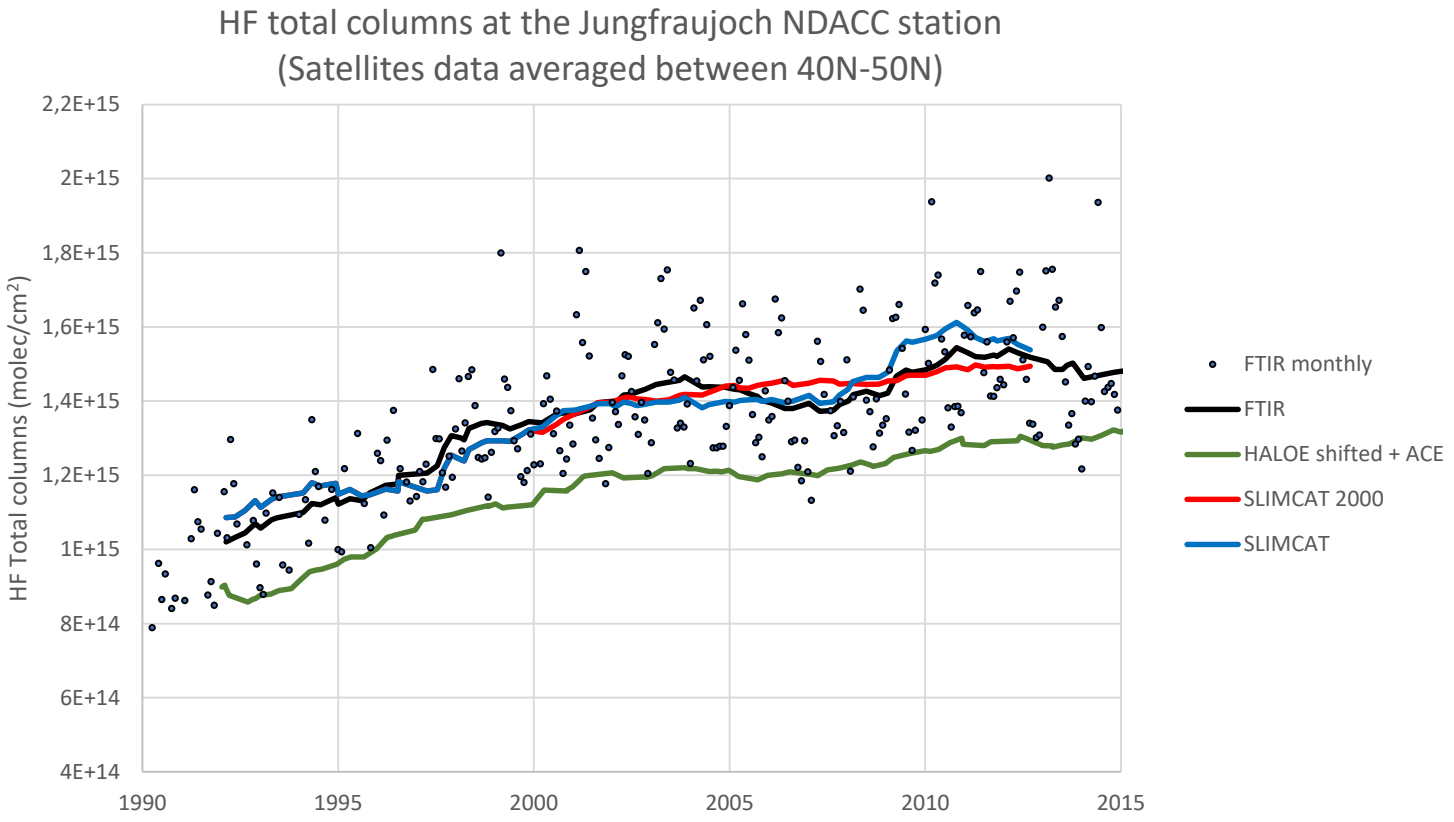


Figure 1 | Evolution of HCl in the Earth's atmosphere. a, The long-term total column time series of HCl at Jungfraujoch (running average with a 3-yr integration length, step of 1 month; in red, left scale) and the global total tropospheric chlorine volume mixing ratio (blue curve, right scale, in parts per trillion, p.p.t). The lower panels display the running average total column time series (1997–2011) of HCl at Ny-Ålesund (**b**), Jungfraujoch (**c**) and Lauder (**d**), derived from the NDACC–FTIR observations, and the standard (green) and S2000 (light green) SLIMCAT simulations. The thin red lines correspond to the ±2 standard error of the mean range. Minimum columns are observed in July 2007 at the Northern Hemisphere sites (dashed lines).

→ HCl starts to increase in 2007 in the Northern hemisphere whereas a constant decreasing of the source gases in the troposphere is seen since the early 1990s

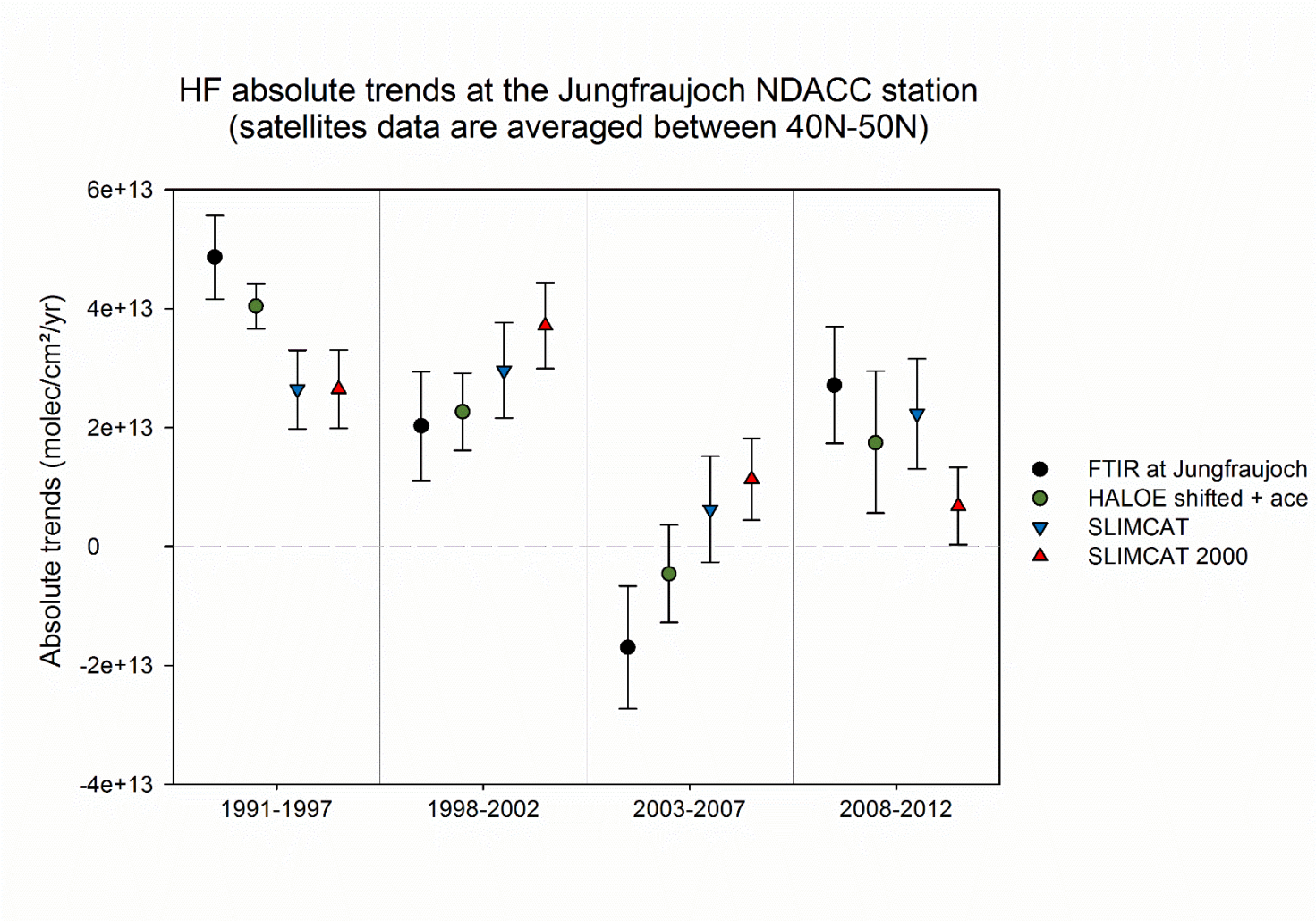
→ Circulation (Brewer-Dobson) slow down in the Northern Hemisphere

In progress: Investigating the HF stratospheric long-term trends First results



* FTIR, satellites and SLIMCAT series are smoothed with a 3yr integration length and a step of 3 month.
* Due to a well known bias between HALOE and ACE (Mahieu *et al.*, ACP 2008), HALOE is shifted up in order to fit the ACE observations
* Models output are sampled as the ground-based FTIR observations.

In progress: Investigating the HF stratospheric long-term trends First results



What's coming up next ?

- BASCOE
  - Complete the long run configuration
  - launch the long simulations (1985 → near present)
  - Compare with WACCM (in specified dynamics mode) outputs
- Impact of circulation changes on tracers
  - Include other NDACC sites to investigate the hemispheric asymmetry in circulation changes