The Network for the Detection of Atmospheric Composition Change

Status, recent contributions to ozone research, and perspectives.

M. De Mazière[1], I. Petropavlovskikh[2,3], J. D. Wild[4,5], A. M. Thompson[6,7], and the NDACC community[8]

[1]Royal Belgian Institute for Space Aeronomy (BIRA-IASB), Brussels, Belgium; [2]CIRES, University of Colorado, Boulder, CO, USA; [3]NOAA, Global Monitoring Lab, Boulder, CO, USA; [4]CISESS, University of Maryland, College Park, MD, USA; [5]NOAA/NESDIS/STAR, College Park, MD, USA; [6]NASA/Goddard Space Flight Center (Emeritus), [7]University of Maryland – Baltimore, [8] www.ndacc.org,

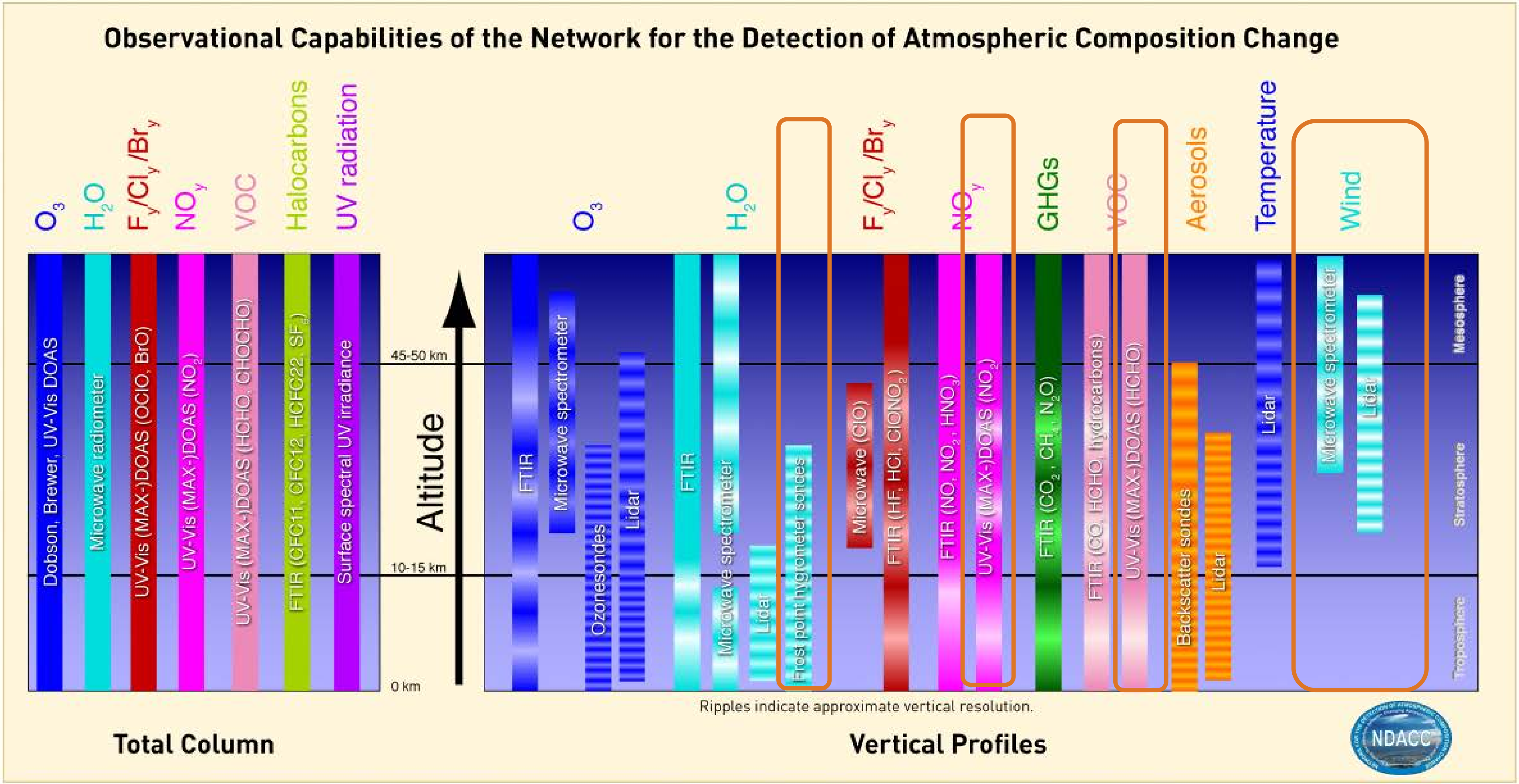
More info ? martine.demaziere@aeronomie.be
www.ndacc.org

Answers to ORM11 recommendations:

- Key systematic observations

Current status of NDACC (ndacc.org)

- Observational capabilities

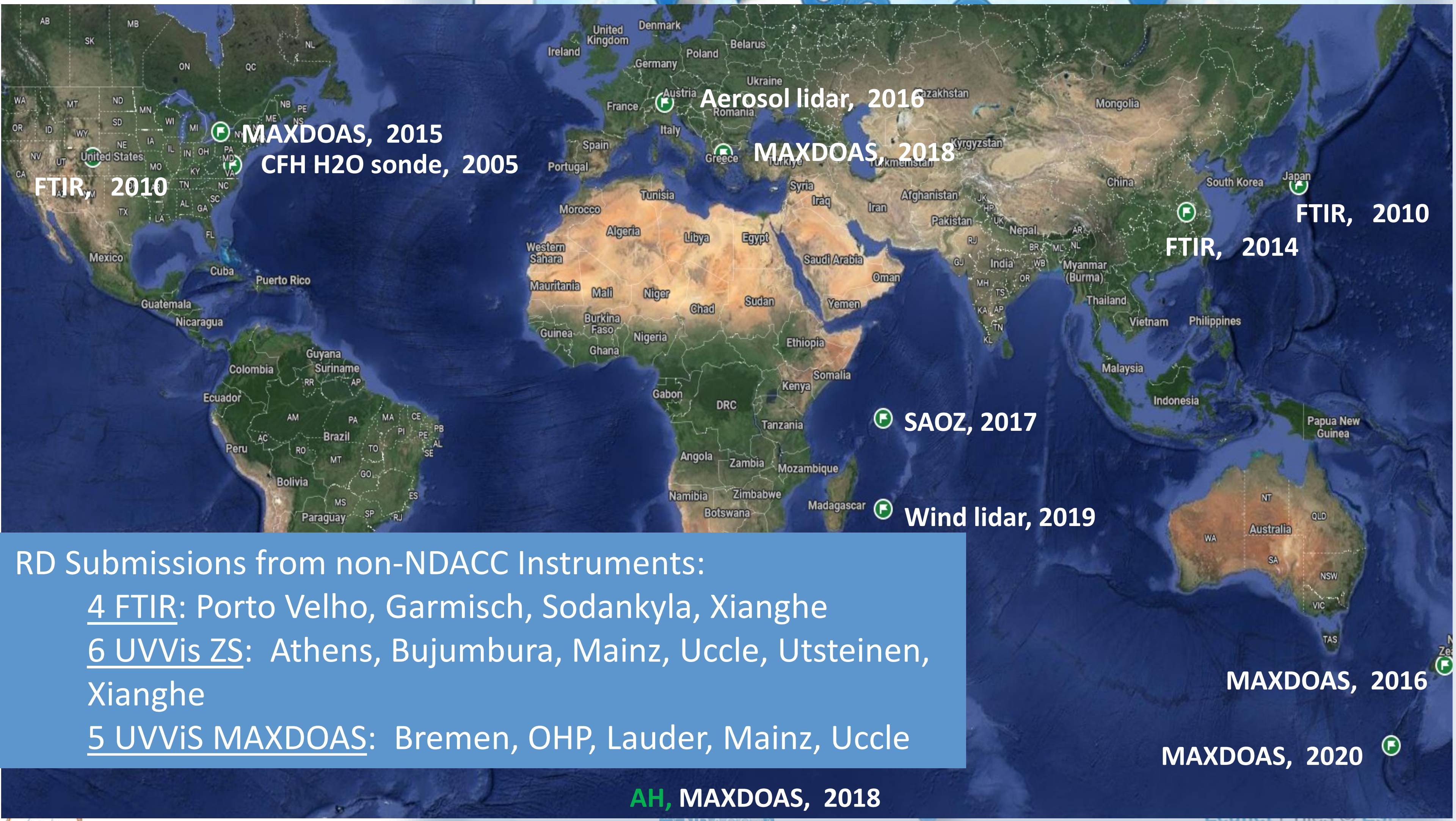


Key variables for investigating ozone, ODS and feedbacks with climate change

Expanding capabilities…

Current status of NDACC (ndacc.org)

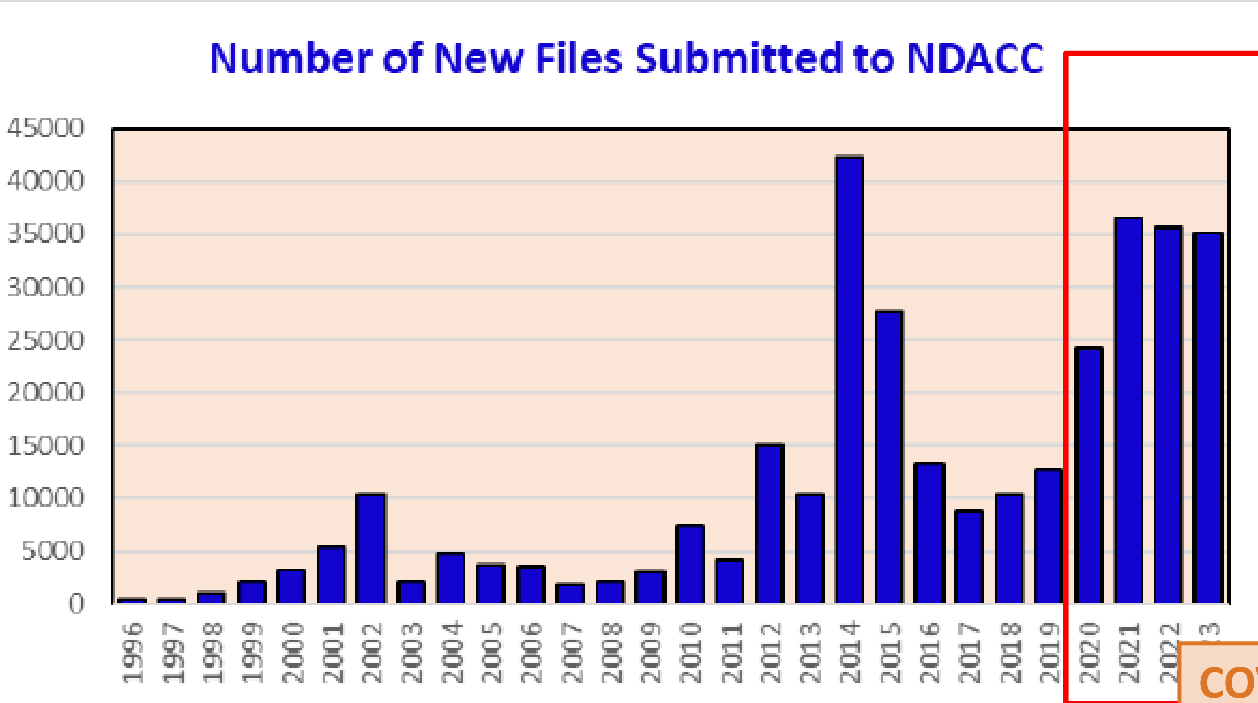
- About 117 stations worldwide, of which 80 active including 151 active instruments
- Expanding: new (since ORM11) instruments/stations



RD Submissions from non-NDACC Instruments:

- 4 FTIR: Porto Velho, Garmisch, Sodankyla, Xianghe
- 6 UVVis ZS: Athens, Bujumbura, Mainz, Uccle, Utsteinen, Xianghe
- 5 UVViS MAXDOAS: Bremen, OHP, Lauder, Mainz, Uccle

Evolution 2020-2023



Number of files in database			
2020	2021	2022	2023
180041	233850	292956	299816

From **165** active long-term measurements in **2020** to
to **172** active long-term measurements in **2023**

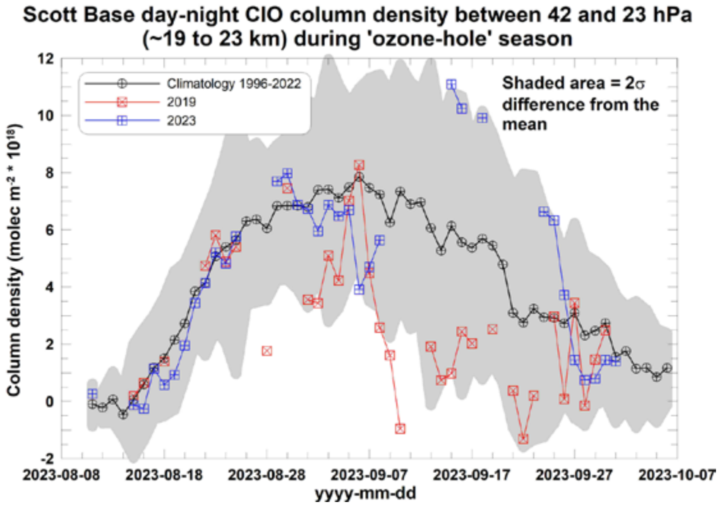
COVID impact on data acquisition in 2020-2022, especially for remote locations, due to travel restrictions and therefore problematic to maintain/repair H/W.

Large Impact of **Mauna Kea eruption** in Nov. 2022 ⇒ til now…

Instrument upgrades - example

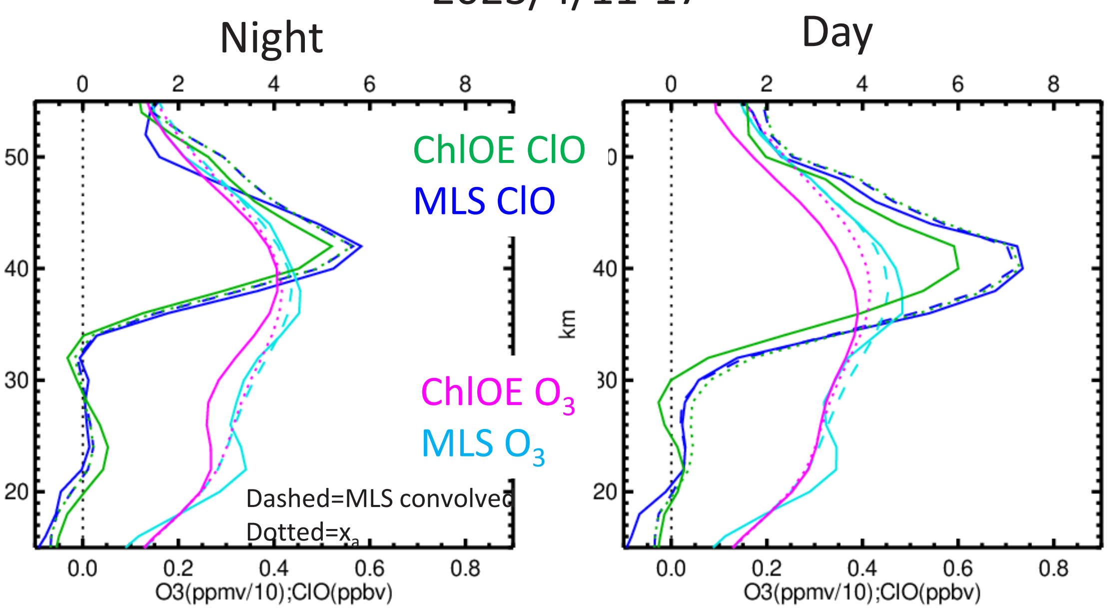
In March 2023 a new microwave ClO instrument was successfully installed at Scott Base, Antarctica

ChlOE4 replaces the ChlOE1 instrument which has been measuring ClO at Scott Base during the ozone hole season since 1996.



Courtesy: G. Nedoluha, NRL

ChlOE4 measurements
2023/4/11-17

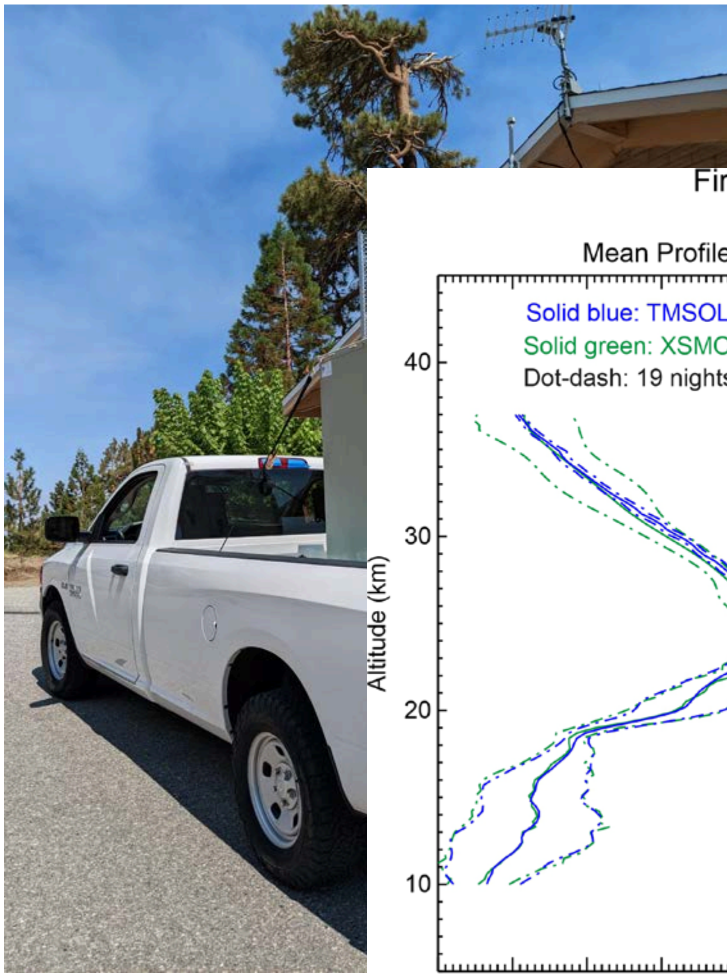


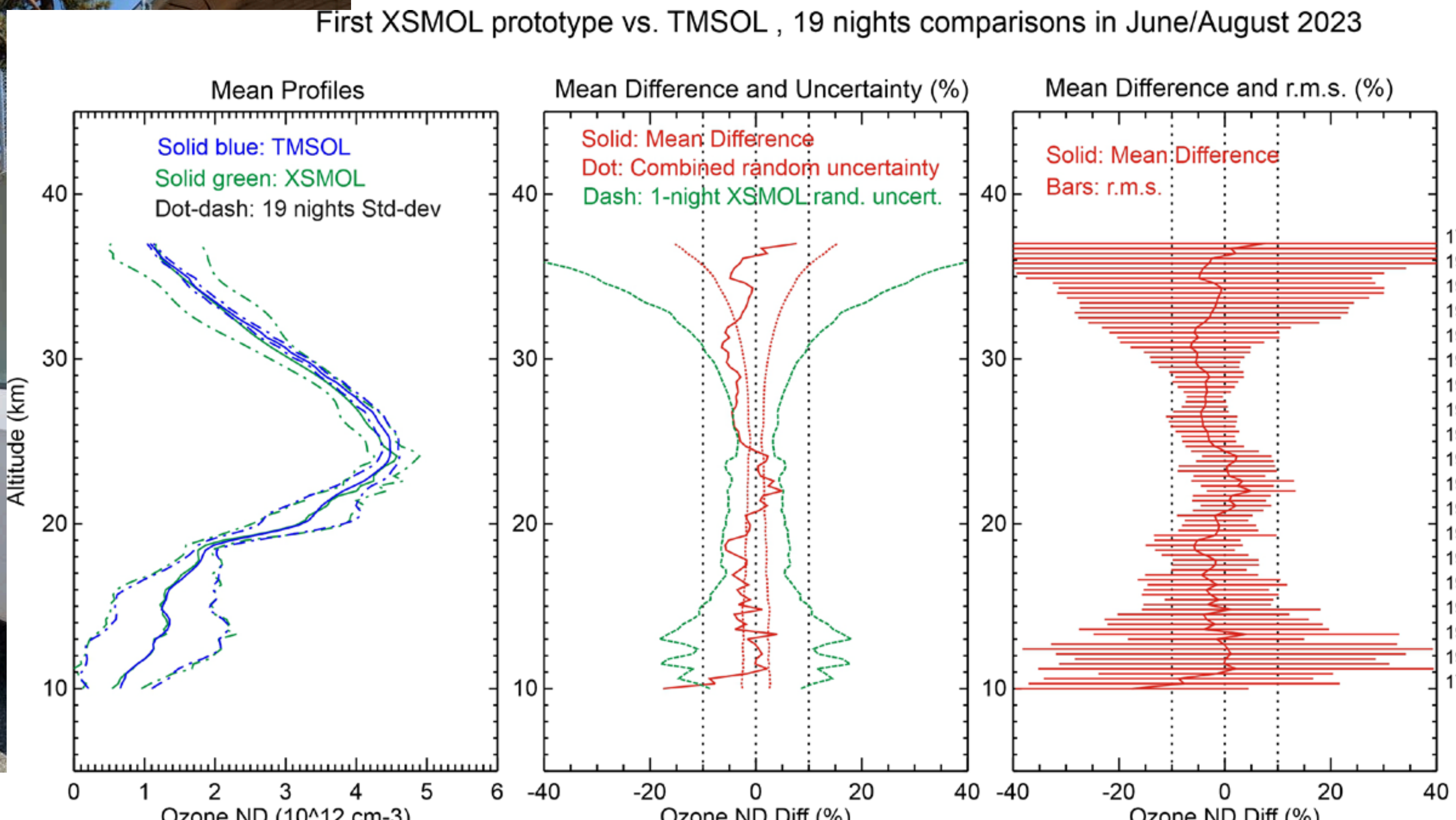
Move towards more compact, cheaper, mobile, automated, …

- More mobile, compact, cheaper and automated instruments

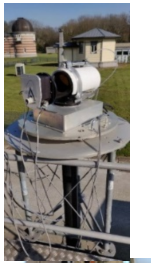
From SMOL – Small Mobile Ozone Lidar- to xSMOL – eXtended-range Small Mobile Ozone Lidar

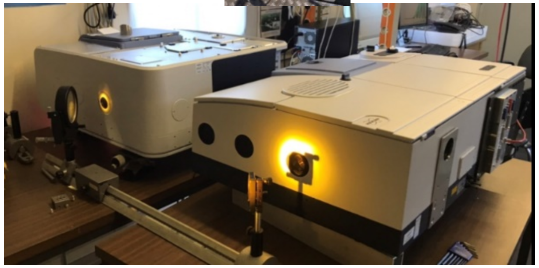
Courtesy: T. Leblanc et al.,JPL

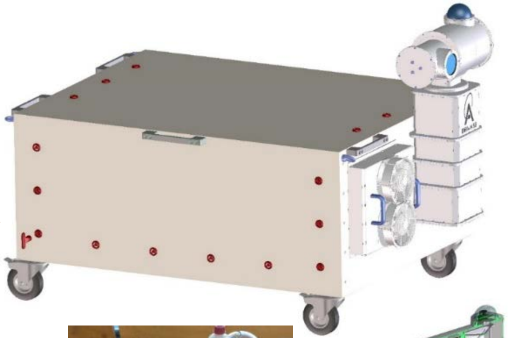


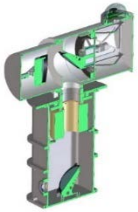


Move towards more compact, cheaper, mobile, automated… : traveling standard

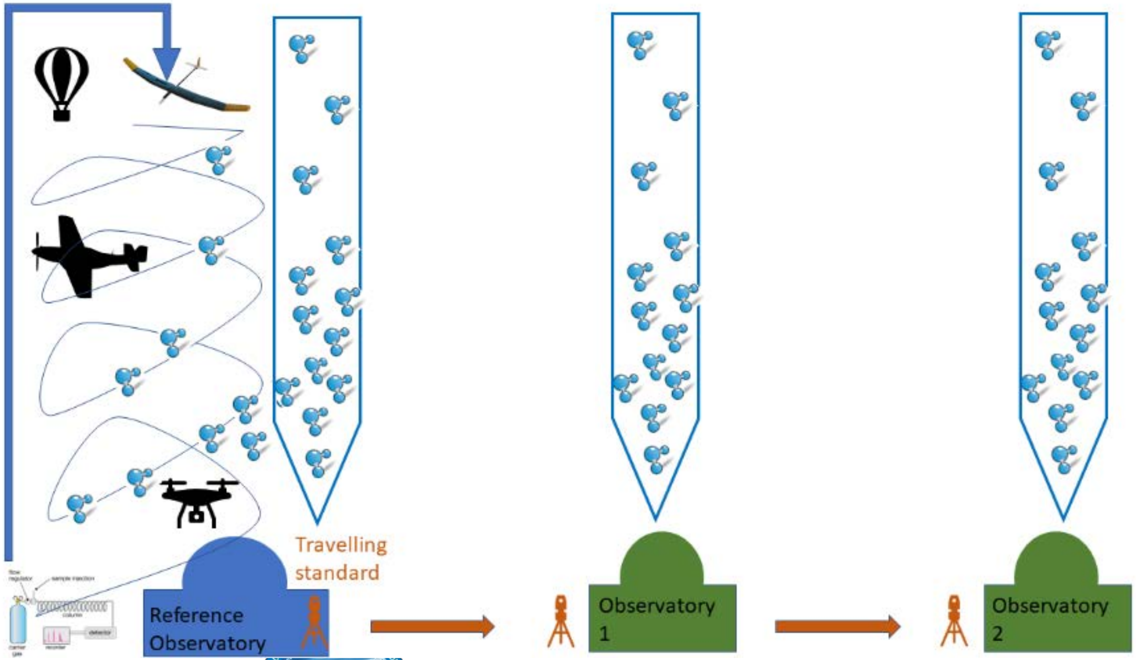








- ❑ Concept of travelling standard



Answers to ORM11 recommendations:

- observations, data analyses and curation of data related to ozone depletion

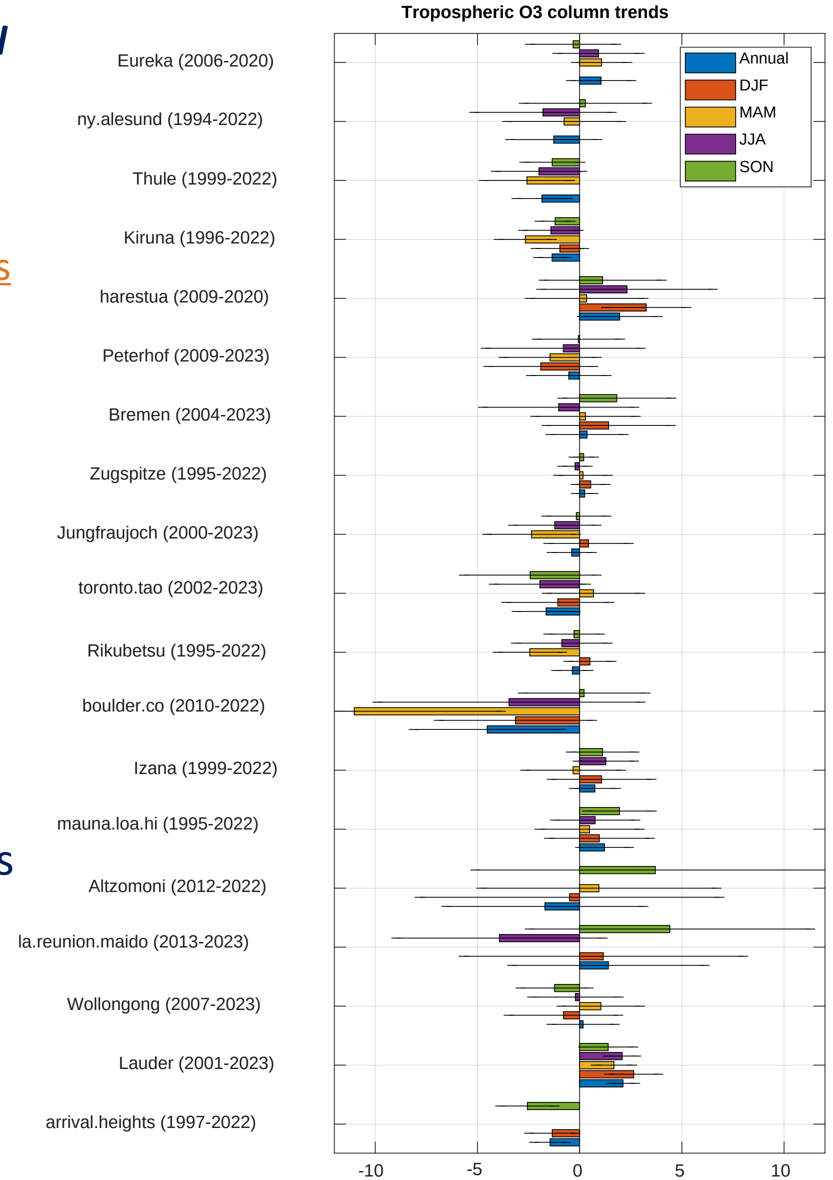
NDACC & international initiatives

- NDACC has become a key data provider for ***operational*** services
  - Copernicus Atmosphere Monitoring Service (CAMS)
  - Mission Performance Centres for Sentinel missions (ATM-MPC)
  - CO2M in future

- NDACC long-term climate data records for O_3, NO_2, HCHO, CO and CH_4 are ready for being included in the Copernicus Climate/Atmosphere Data Store (C3S)

  aiming at enhanced visibility and usage in combination with other climate-relevant data

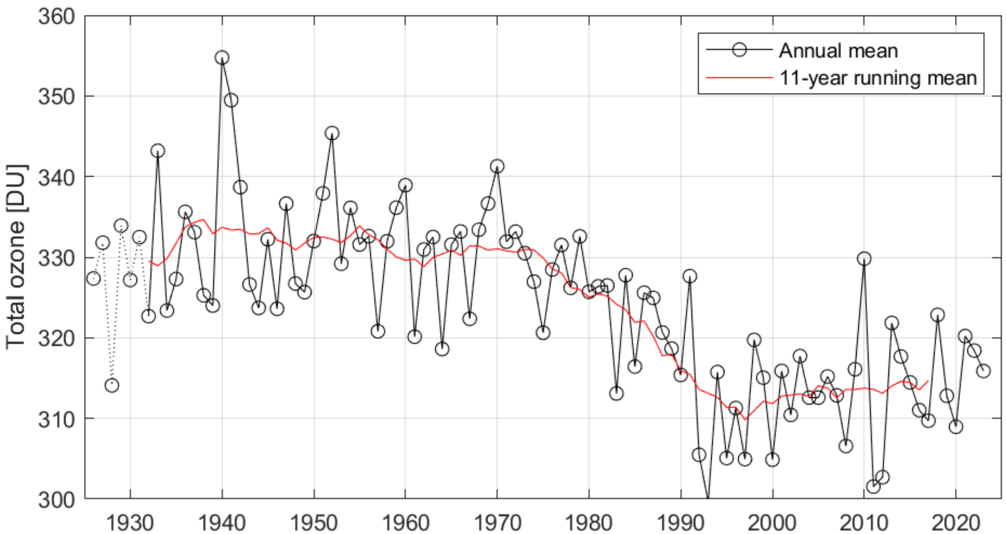
- NDACC supports international ***research*** initiatives focusing on Ozone and its precursors :
  - LOTUS and TOAR-II →
  - ESA Climate Change Inititiatives on O_3, O_3 and aerosol precursors, GHG, H_2O, …



Courtesy: C. Vigouroux, BIRA-IASB ppbv/decade

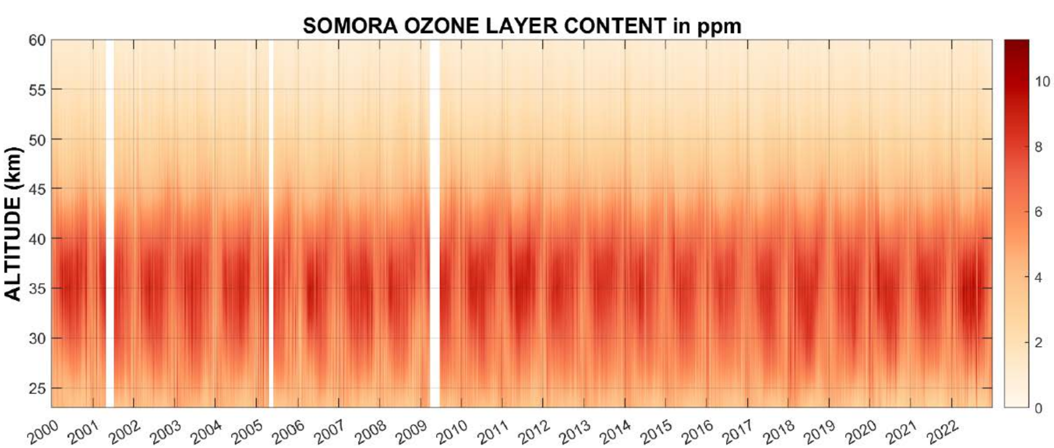
Curation and harmonization of historical data

Dobson Total Column Ozone timeseries: «Arosa/Davos»



Timeseries is composed of datasets from 3 Dobson instruments, with a simultaneous measurement period at each transition. Homogenisation has been performed back in 1998 by Staehelin et al, and harmonisation is in progress in the light of a recent result about agreement between Brewer and Dobson TCO (paper Gröbner et al, AMT, 2021). The determination of TCO is implying the new ozone absorption cross-section.
Digitalization of raw data is under process in order to recalculate the TCO using the new absorption cross section.

Ozone microwave radiometry at Payerne, Switzerland



The Bern and the Payerne microwave radiometer (MWR) instruments observe the 142 GHz ozone emission line and have similar design, sensitivity and viewing angle. However, the 2 datasets showed significant discrepancies leading to long-term trends differences. The 2 MWR calibration procedures and retrievals are now similar and the 2 timeseries have been reconciled.

Courtesy: E. Maillard Barras, MeteoSwiss

Answers to ORM11 recommendations

- data archiving and stewardship

Sustainability of NDACC DHF: move from NOAA to NASA LaRC

To ensure the sustainable long-term archiving of NDACC data, NDACC DHF was moved from NOAA/NCEP/CPC to NASA LaRC, starting end 2020 - early 2021

1. Phase 1 – duplicate DHF functionality at LaRC
   - Format check & Mirror of data
   - Data ingest
   - Data download
   - External mirrors and downstream databases, metadata sharing
2. Phase 2 – Establish full relational database at LaRC
   - Enable search engines
   - Enable NDACC data tools
3. Phase 3 – Relocate NDACC website

- The transition of the **DHF** was completed successfully on April 13, 2022

⇒ Website for NDACC DHF at LaRC: https://www-air.larc.nasa.gov/missions/ndacc/data.html

- The transition of the NDACC **Webpages** was completed successfully in 2023

⇒ see ndacc.org

Progressing towards FRM status and FAIR data access

- NDACC DHF synchronizes data/metadata with several other datacentres, in particular with WOUDC, EVDC and ACTRIS ; data are provided in several formats - metadata standards (NASA AMES; GEOMS HDF; NetCDF_CF; …). NASA Ames is getting phased out..

- NDACC data archiving at NDACC DHF:
  - **L2 (geophysical data) mandatory** – with maximum latency of 1 year. Different versions are co-existing providing appropriate documentation and metadata
  - **L0/L1 data** (raw data/spectra): mandatory for NDACC-ACTRIS data providers in ACTRIS DC; recommended for all to NDACC DHF for long-term archiving (not publicly accessible; tools and metadata should be provided to make them 'useable' by experts)
  - Up-to-date **metadata**, including **data license** (mandatory for NDACC-ACTRIS data providers – with CC-BY-4.0 license; recommended for all)

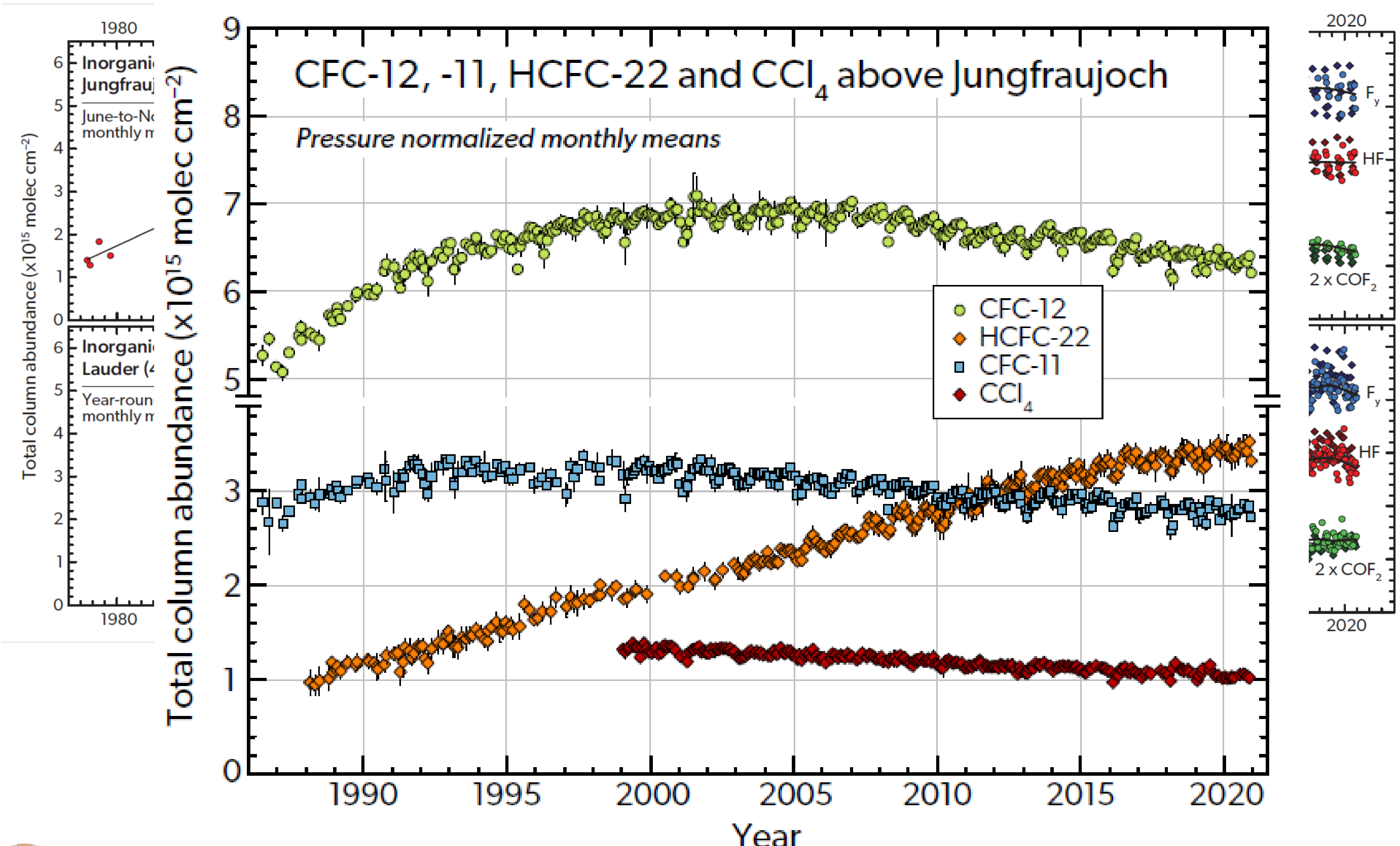
- Traceability:
  - **DOI**, not only for data but also for data processors; PID for instruments (in progress, supported through ACTRIS)
  - Assessment of FRM status according to Assessment Framework for CEOS-Fiducial Reference Measurements (FRMs)

Answers to ORM11 recommendations:

- research needs & gaps in monitoring of controlled substances

Evolution of ODS & related species

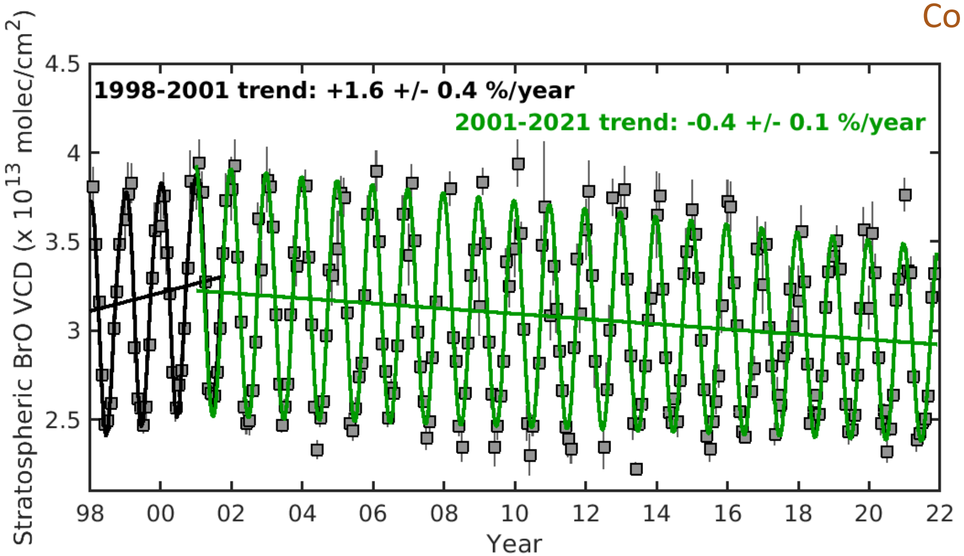
- Stratospheric chlorine and fluorine reservoirs – see WMO O_3 Assessment 2022



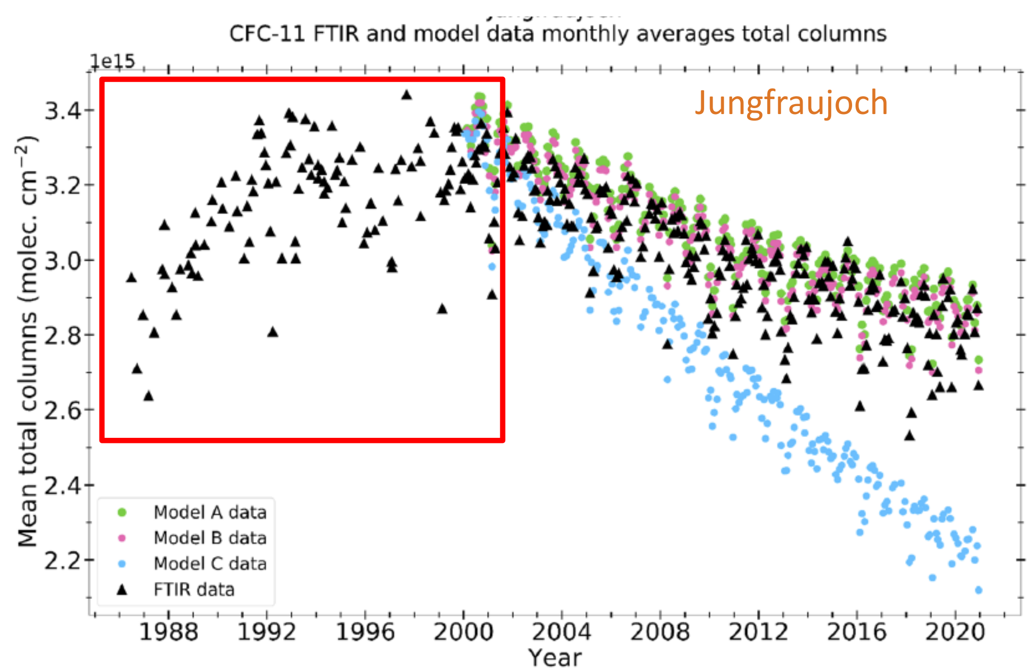
Detection of changes in global emissions of ODS

Courtesy: F. Hendrick, BIRA-IASB

- BrO timeseries

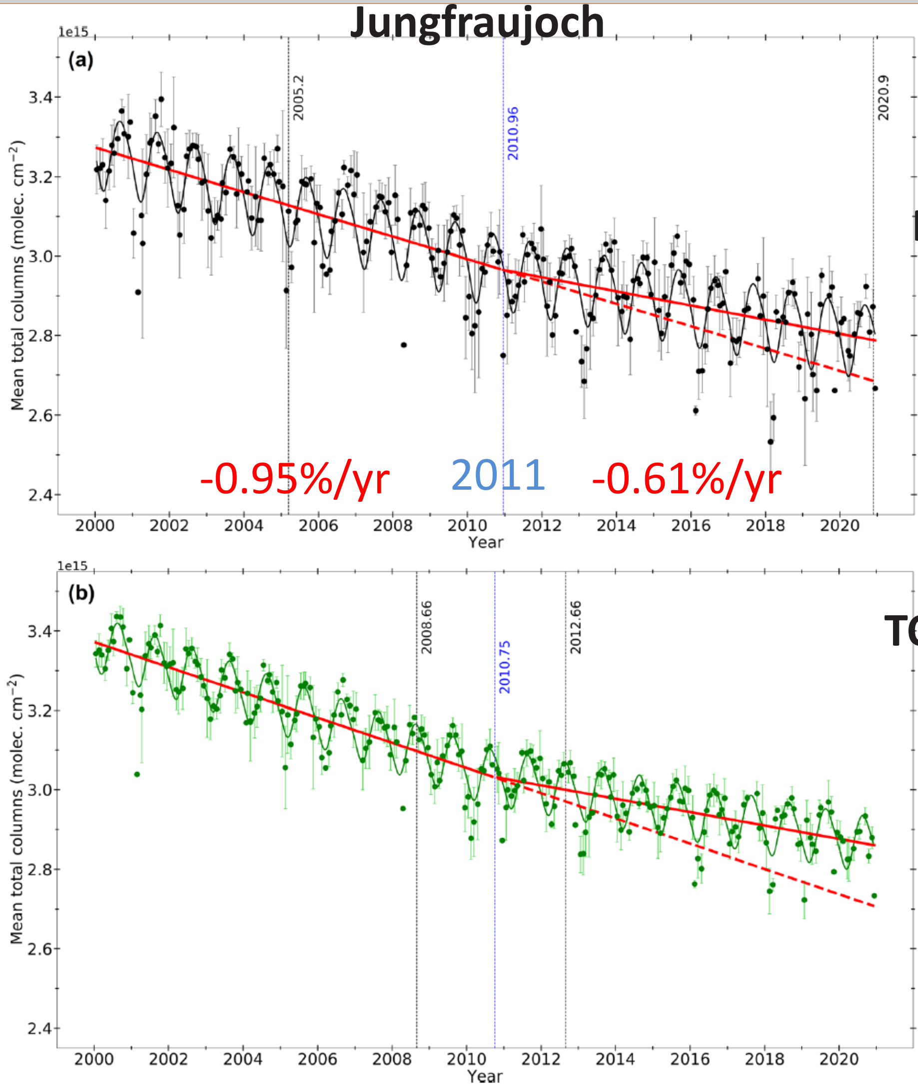


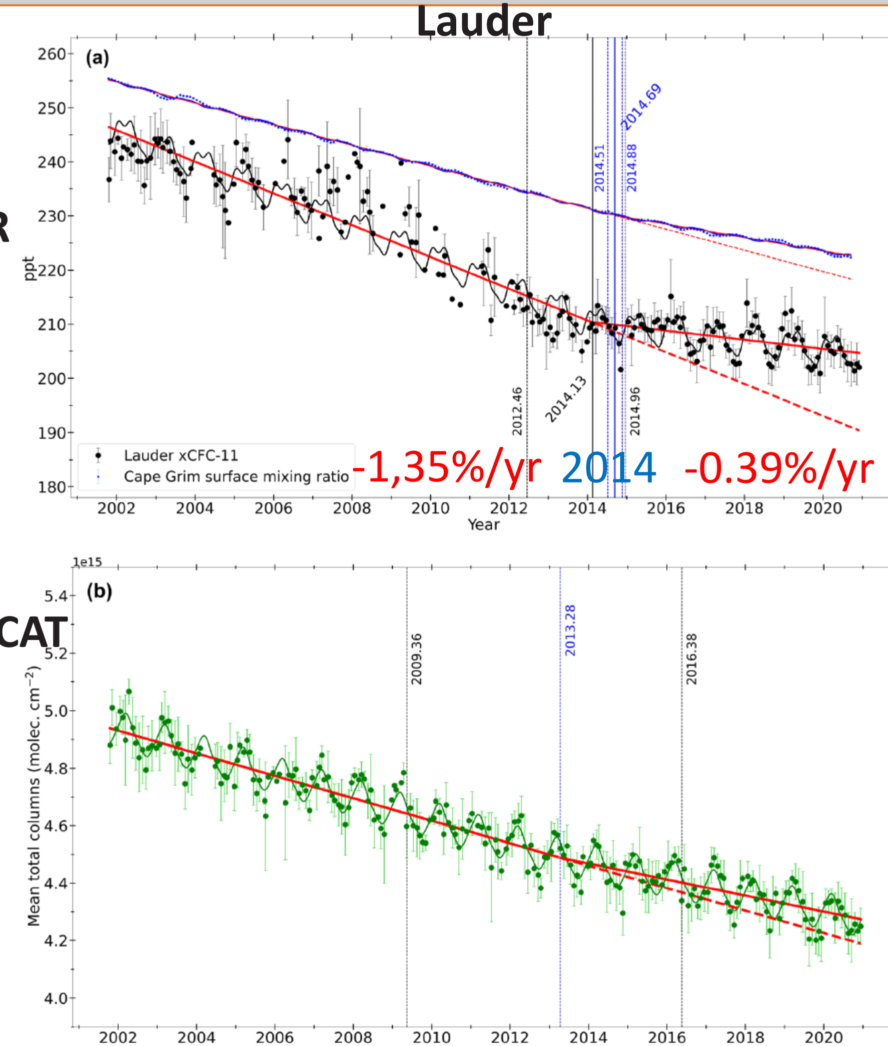
- CFC-11 and CFC-12 timeseries at Hefei and a few other NDACC stations (Zeng et al., 2022 https://doi.org/10.5194/amt-15-6739-2022
- Historical and harmonized timeseries of CFC-11 – at Jungfraujoch and Lauder and comparison with TOMCAT model (Pardo Cantos et al., 2022; https://doi.org/10.1039/D2EA00060A



A: best estimate of emissions and some realistic distribution
B: same total emissions as A but equal emissions at all lat/lon;
C: zero emissions since 2000 (simple decay).

Changes in emissions of CFC-11 & inter-hemispheric differences





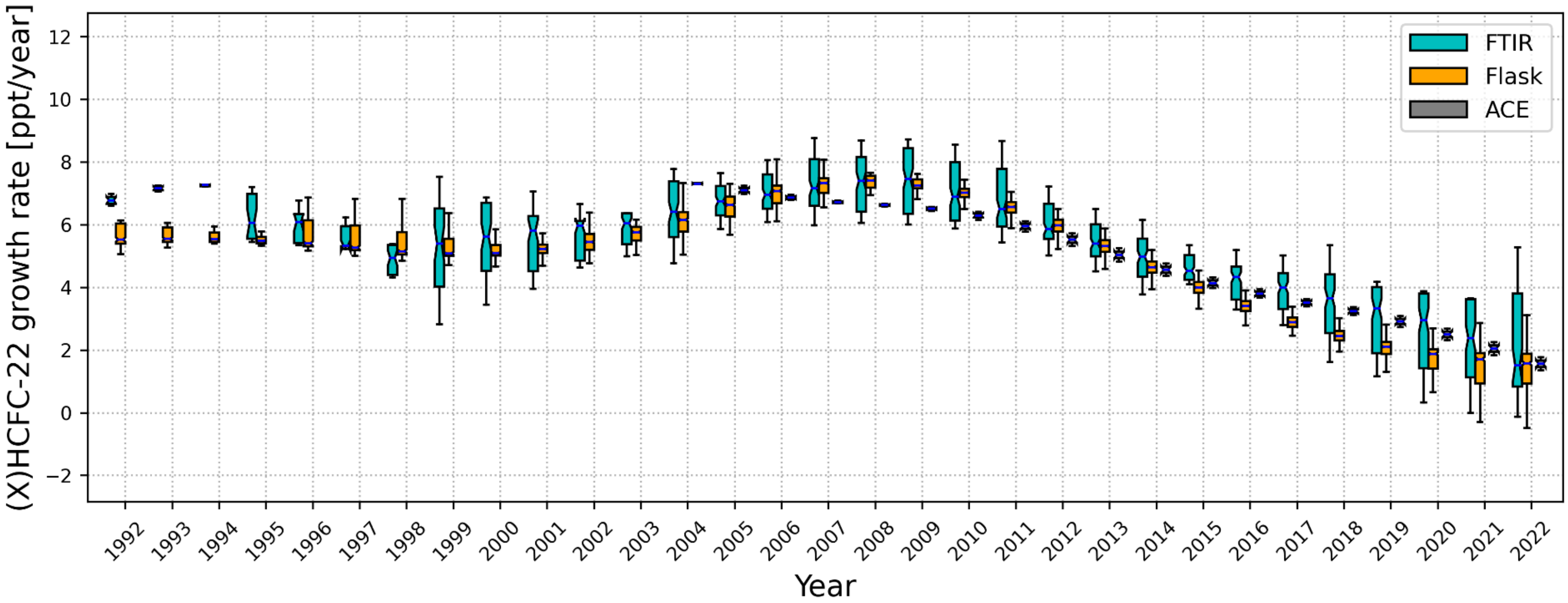
(a) FTIR and (b) TOMCAT monthly time series of CFC-11 total columns above Jungfraujoch. All vertical bars represent the standard deviations around the monthly means. (b) The "best estimation/realistic" simulation (tracer A) has been chosen.

In situ monthly CFC-11 at Cape Grim (in blue) and monthly xCFC-11 FTIR above Lauder (in black). (b) TOMCAT model monthly time series of CFC-11 total columns above Lauder. The "best estimation/realistic" simulation (tracer A) has been chosen.

https://doi.org/10.1039/D2EA00060A

Improve detection of ODS & related species

- Harmonized NDACC FTIR retrievals of HCFC-22 at 17 NDACC stations
  - ✓ Zhou et al., 2024; in preparation

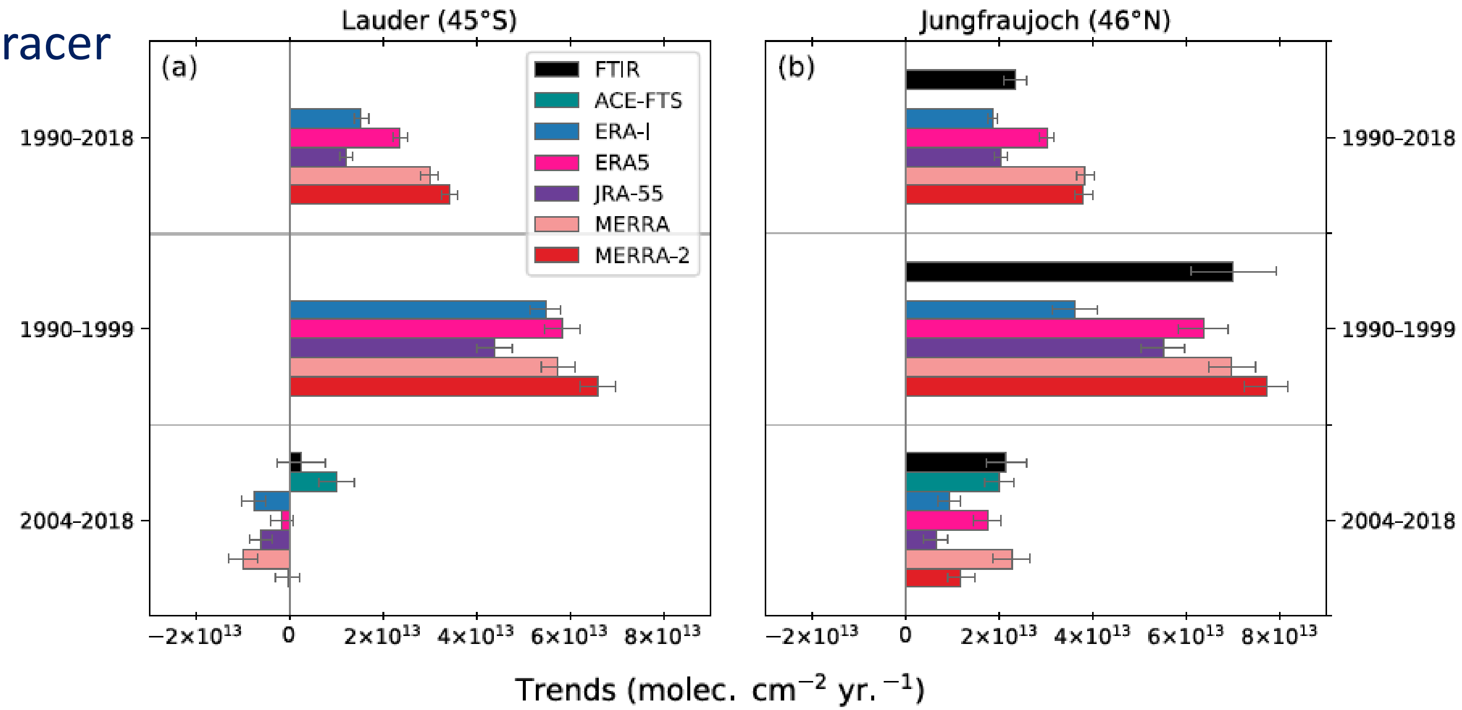


- Demonstration of NDACC capability for quantifying
  - HFC-23 - at Rikubetsu (Japan) and Syowa (Antarctica)
    - ✓ Takeda et al., 2021; https://doi.org/10.5194/amt-14-5955-202)
  - HFC-134a - at Jungfraujoch
    - ✓ Pardo Cantos et al., 2024; https://doi.org/10.1016/j.jqsrt.2024.108938)

Stratospheric ozone – climate coupling: BD circulation

- Atmospheric dynamics based on *Fy-tracer

M. Prignon et al., [10.1029/2021JD034995](10.1029/2021JD034995)



The long-term trends of inorganic fluorine analyzed in this research suggest that the mid-latitude lower stratosphere of the Southern Hemisphere is getting younger relative to that of the Northern Hemisphere during the first decades of the 21st century (2004–2018).
This result is in contrast with the CCM projections for the 21st century in response to the coupled increase of greenhouse gases and decrease of ODS and their impact on the Brewer-Dobson Circulation indicating a deceleration of BDC in the Southern hemisphere.

Consistent with Strahan et al. (2020) using global multidecadal observations of HCl and HNO_3.

Unexpected phenomena… - examples

Compared to long-term climatologies….

- COVID-19 pandemics
  - Anomalies in **O_3**, CO, C_2H_2, H_2CO and C_2H_6 in 2020 (e.g., I. Ortega, et al., https://doi.org/10.1525/elementa.2023.00015)
  - Reduction of free tropospheric ozone across N Hemisphere by about 7% (e.g., W. Steinbrecht et al., https://doi.org/10.1029/2020GL091987)

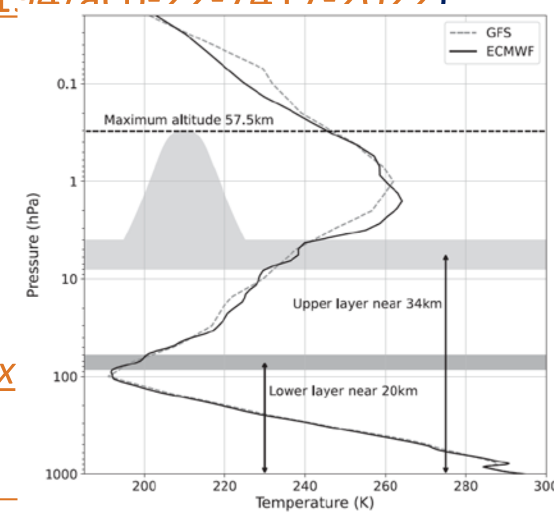
- 2019 Australian wildfires
  - chlorine repartitioning after Australian wildfires (S. Strahan et al., 10.1029/2022GL098290)
  - strato- ozone depletion (e.g., Y. Zhu et al., https://doi.org/10.5194/egusphere-2023-1334;

    K. Ohneiser et al., https://doi.org/10.5194/acp-22-7417-2022)

- Hunga Tonga eruption
  - Impact on stratospheric sulfate aerosol load
  - Impact on mesospheric & stratospheric water vapour

  E.g., S. Khaykin et al., *https://doi.org/10.1038/s43247-022-00652-x*

  G.E. Nedoluha et al., *10.1029/2022JD037227*



Hunga-Tonga eruption

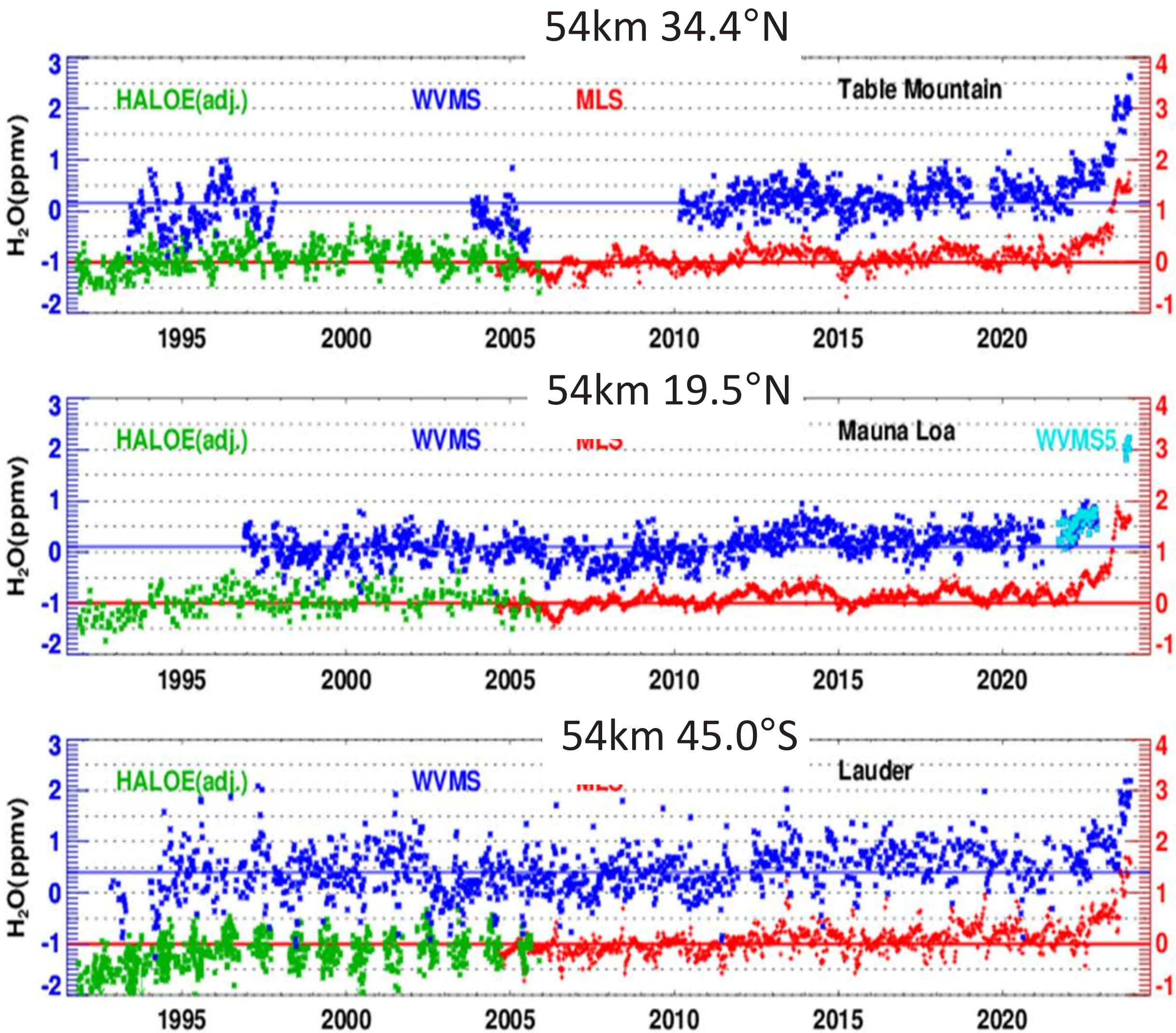
- Mesospheric H_2O anomalies

The Hunga Tonga volcano erupted in January 2022.

In 2023 H_2O values measured at 3 NDACC sites in the lower mesosphere were much larger than ever before measured.

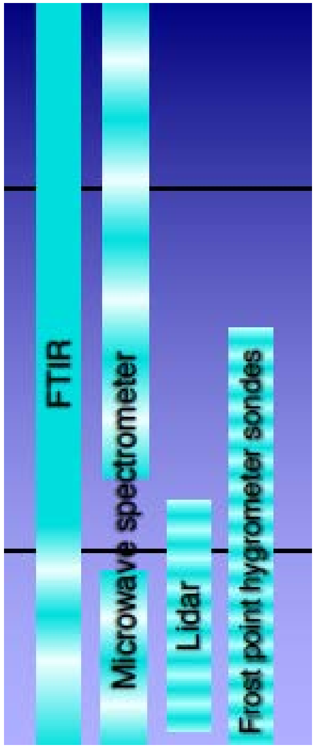
MLS (right-hand axis)
HALOE (bias-adjusted to match MLS)
Ground-based (WVMS)
Solar-powered backup at Mauna Loa (WVMS5)

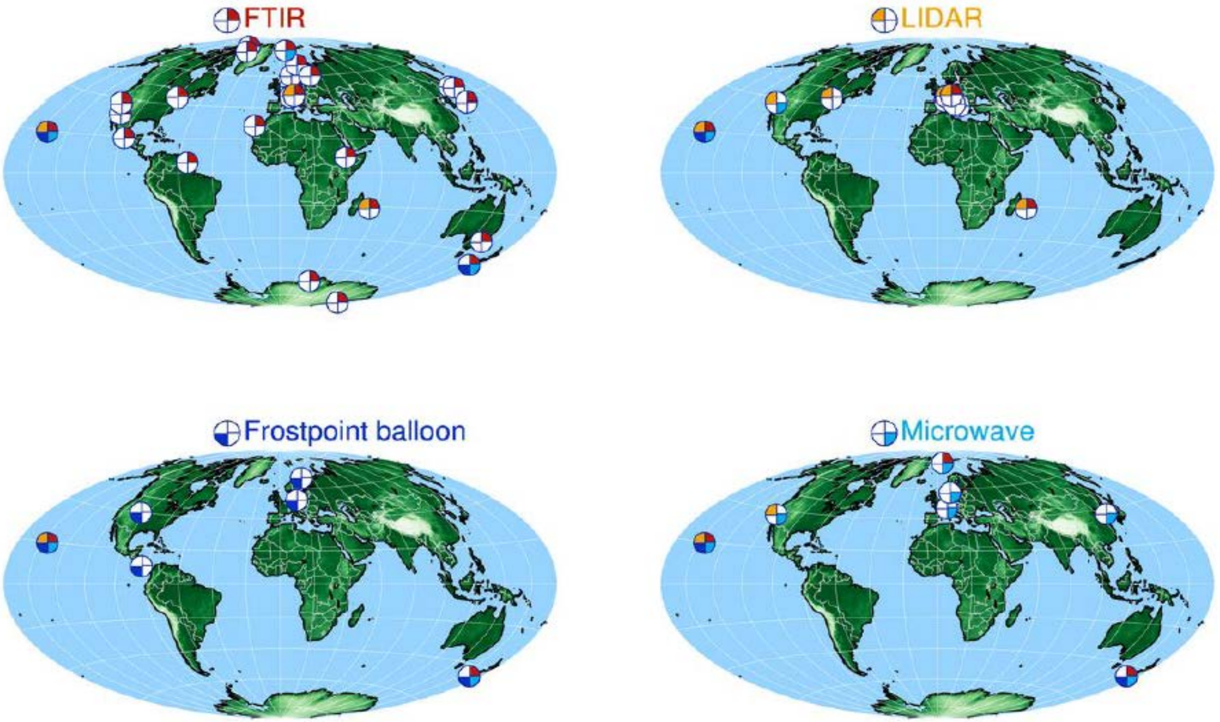
Nedoluha et al., JGR, in review



NDACC's water vapour strategy

- Water vapour is prominently connected with temperature and dynamical processes that impact ozone-depleting substances and greenhouse gases.





- Challenges ahead:
  - Instrument calibration and inter-comparisons
  - Uncertainty documentation; change management (e.g., change of refrigerant in FPH)
  - Observations frequency, schedule, spatial and temporal coverage
  - Synergistic observations

Courtesy: H. Vömel, et al., 2022

Conclusions
&
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NDACC strategy for next decade

- NDACC is keeping up with ORM recommendations, while growing and expanding its scope and looking forward
  - Maintaining long-term commitment remains an issue –

    E.g., lack of resources for operation or data submission since 2020
    - *Lidar O_3, T & aerosol at Eureka*
    - *Microwave O_3 at Ny Alesund*

- NDACC's 35th anniversary will be celebrated in 2025
  - NDACC Symposium in N. America – exact location TBD
  - Special Issue in AMT/ACP/EESD
  - Including ***NDACC Strategy Paper***

THANK YOU!

www.ndacc.org

martine.demaziere@aeronomie.be

With thanks to contributors and NDACC community:
E. Baillard
J. Hannigan
E. Mahieu
G. Nedoluha
C. Vigouroux
M. Zhou