Gas-Programme @ Jungfraujoch

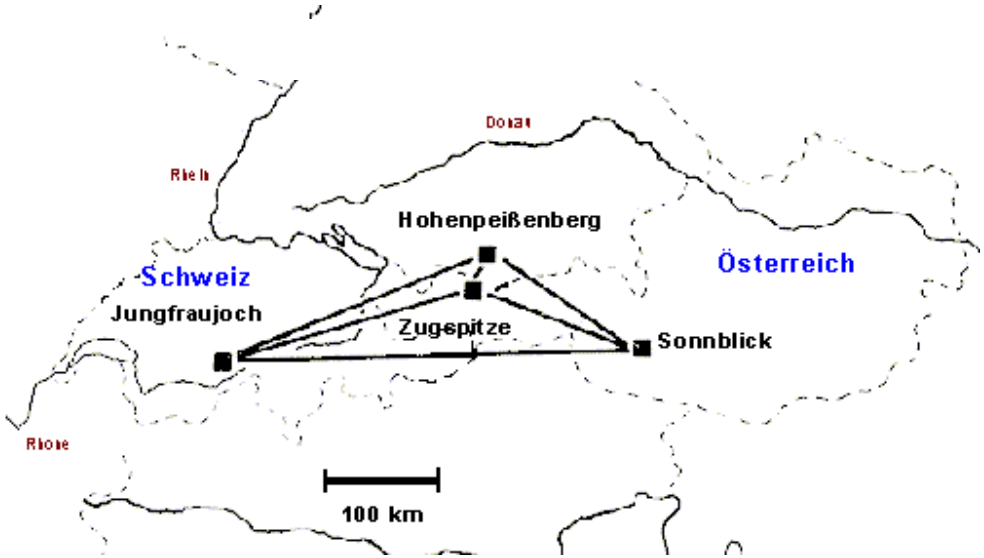
Trend Analysis, Early Warning, Benefit for International Treaties and Programmes

Brigitte Buchmann

Air Pollution / Environmental Technology

EMPA

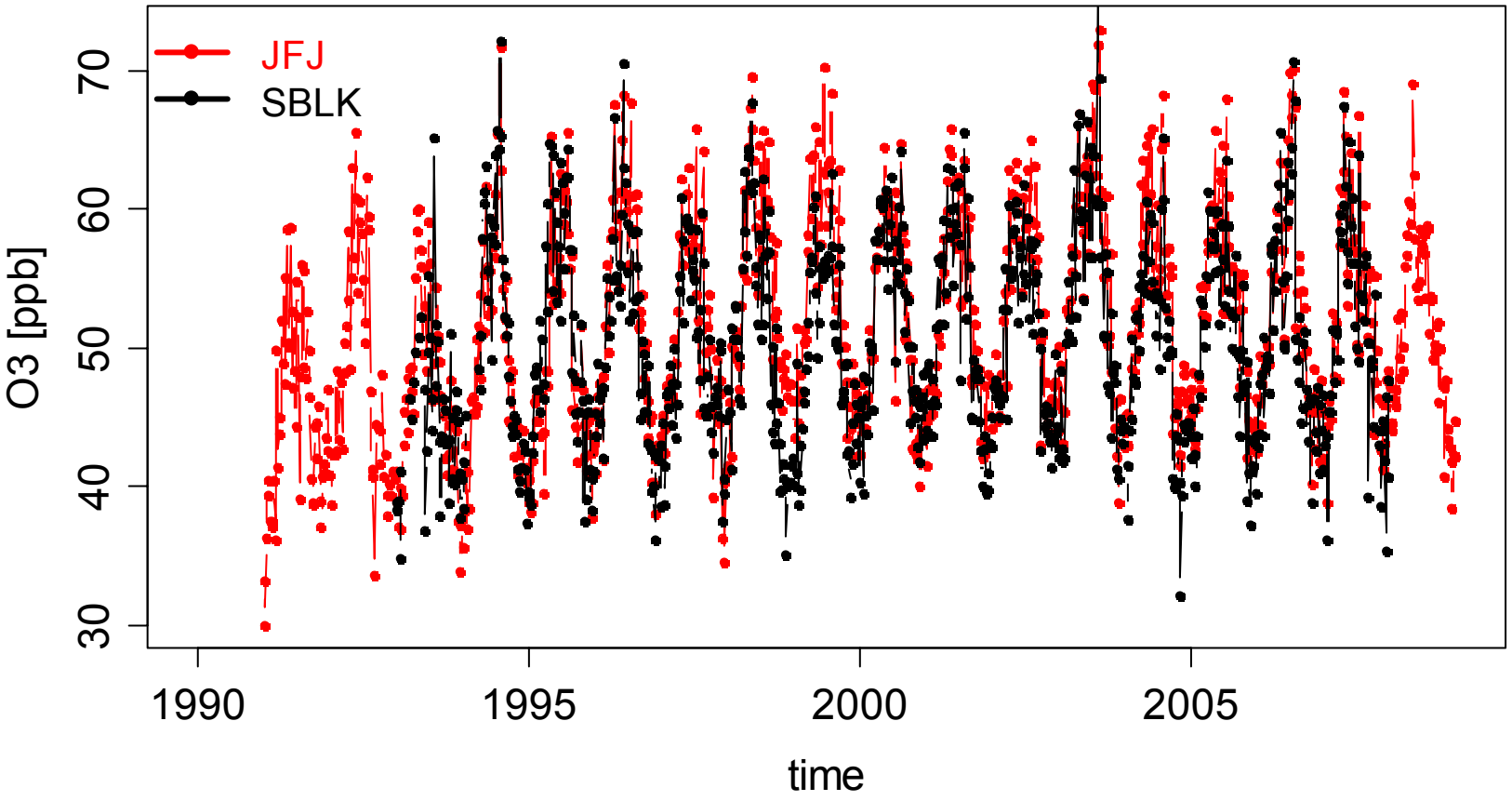
DACH: A NETWORK OF ALPINE SITES




Jungfraujoch
3500 m
Sphinx
Observatory
1937
Top of Europe
Restaurant
Research Station
1931

Ozone @ Jungfraujoch and @ Sonnblick

weekly averages



Overview

- *Measurement Programme @ Jungfraujoch*
- *Examples of results*

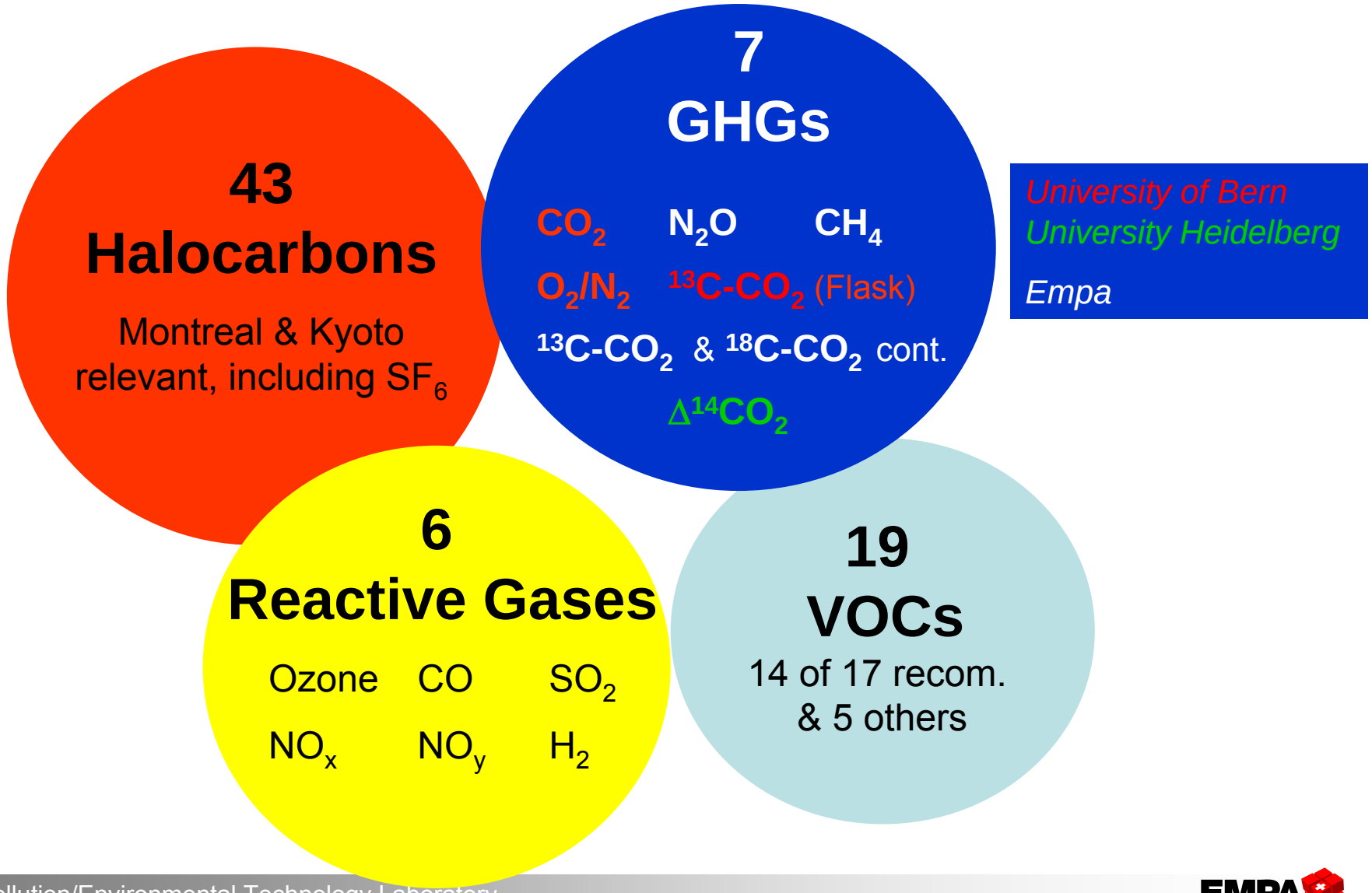
  - Detection of Trends / success of reduction measures

  - Emission Estimations

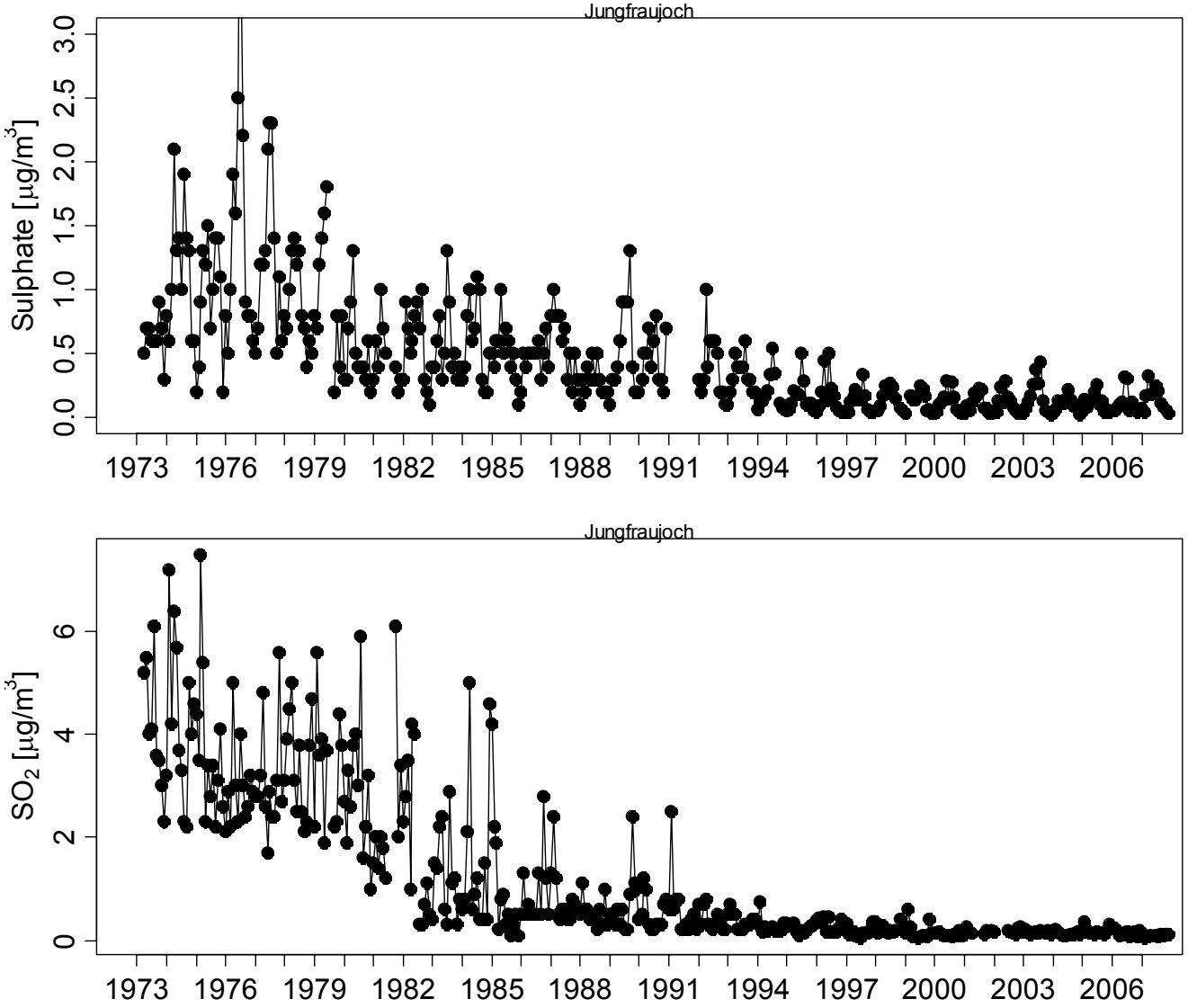
  - Analysis of Global Change impacts / Early warning
- *Future Activities*

Gas – Programme @ Jungfraujoch

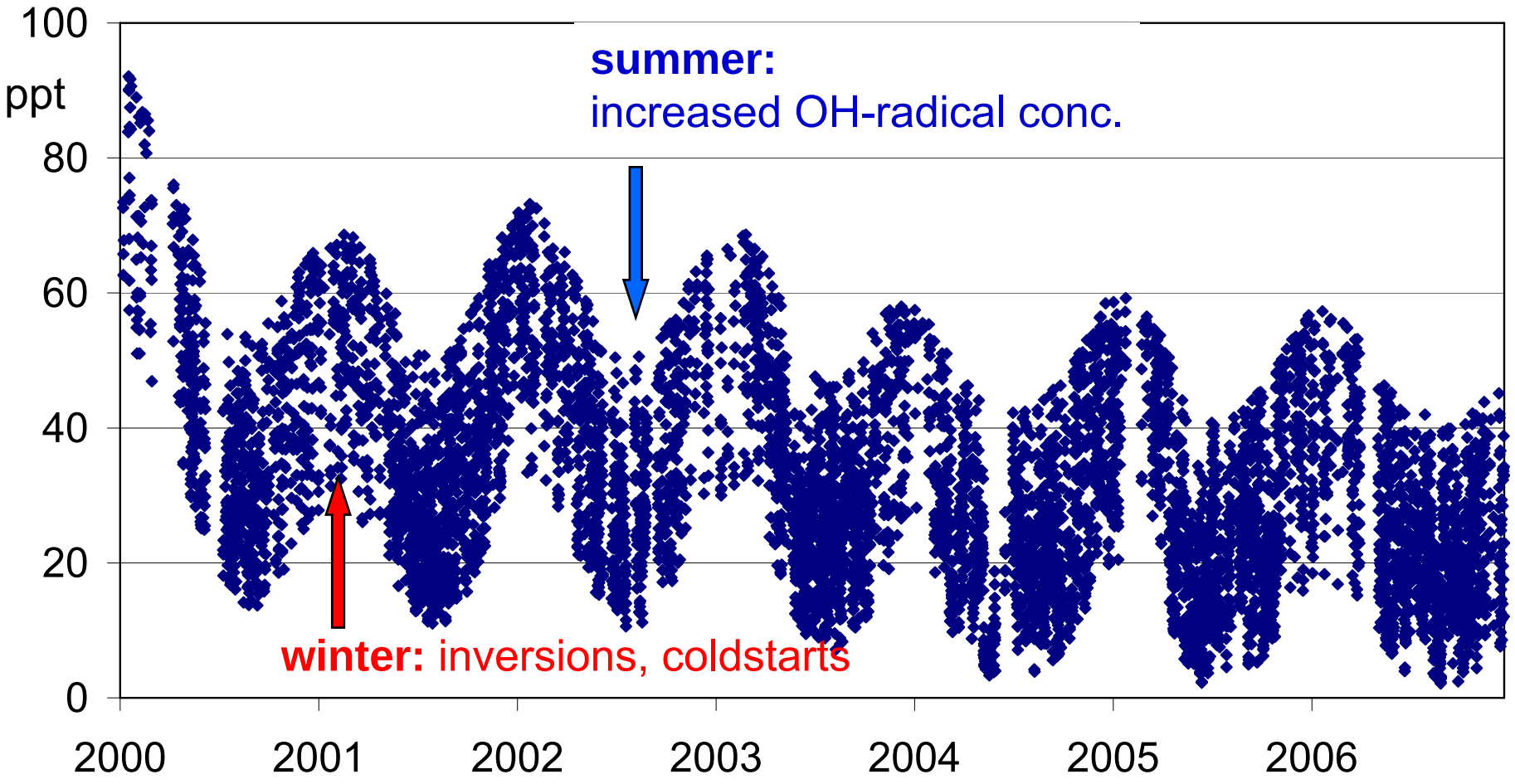
Reactive Gases and Greenhouse Gases



Longest records at JFJ



Benzene Background at Jungfraujoch



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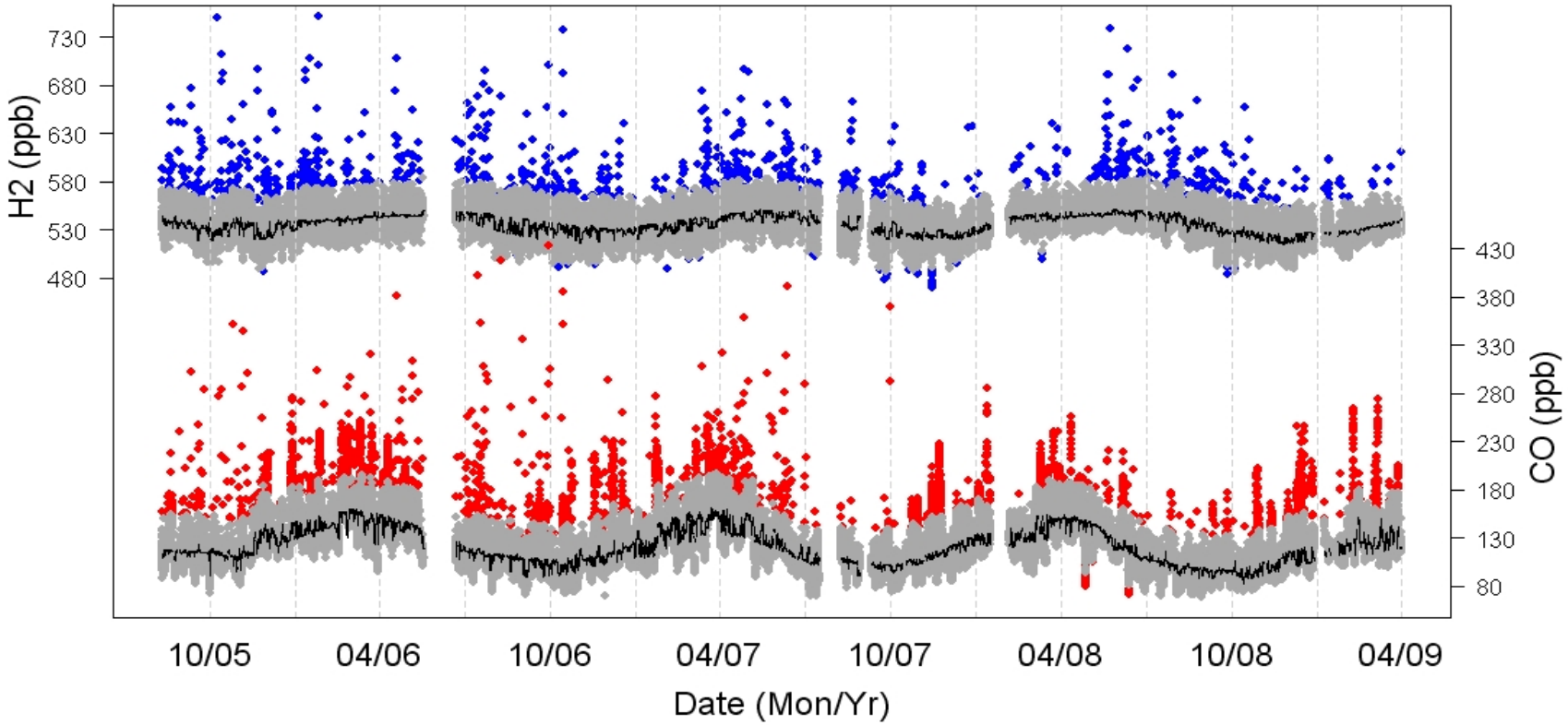
Hydrogen H_2

RGA data

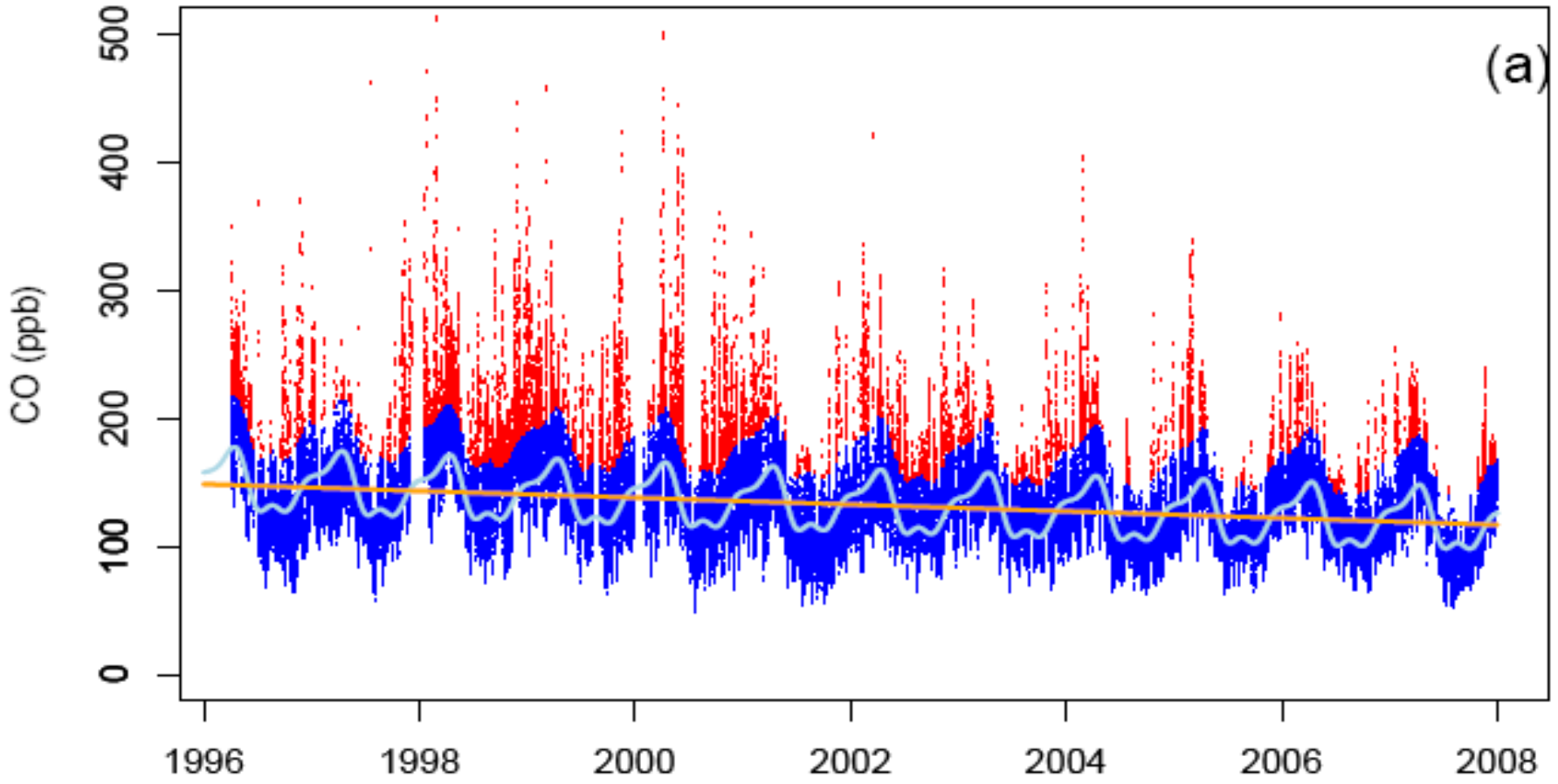


H2 (blue) and CO (red) datasets for the period August 2005 – March 2009 at Jungfraujoch. The calculated baseline fits are depicted by the black lines through the background data. Background mixing ratios are depicted by grey shaded areas, while pollution and depletion events border either side of the background measurements.

Steinbacher et al.

Carbon Monoxide Trend at Jungfraujoch

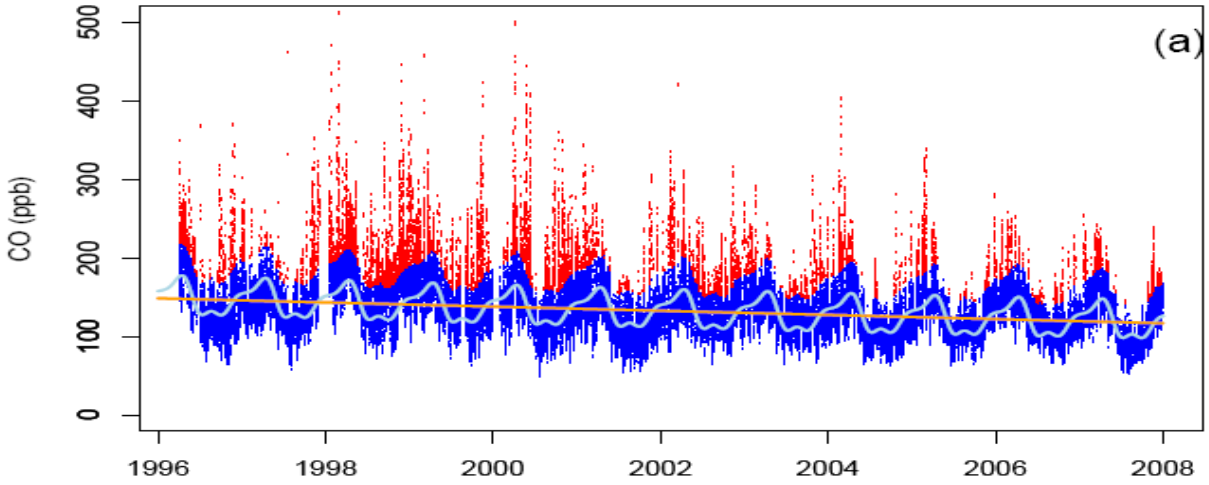
JFJ CO time series (one hourly data) from 1996 to 2007



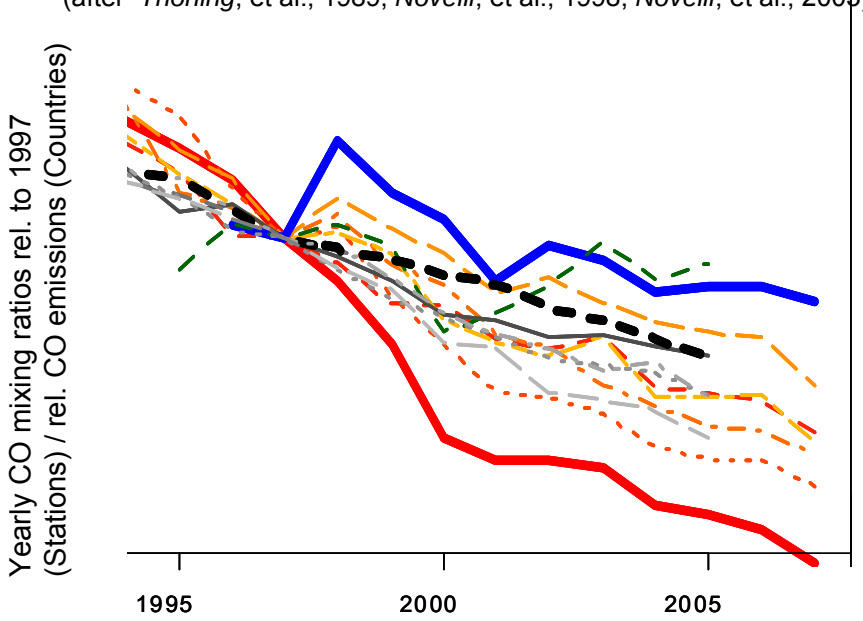
Zellweger et al., ACP, 2009

Carbon Monoxide Trend at Jungfraujoch

JFJ CO time series (one hourly data) from 1996 to 2007



The light blue curve represents a fitted baseline and the orange line the trend
(after *Thoning*, et al., 1989, *Novelli*, et al., 1998; *Novelli*, et al., 2003)



Decrease 21.3%

1.78% / year

2.66 ppb / year

JFJ influenced

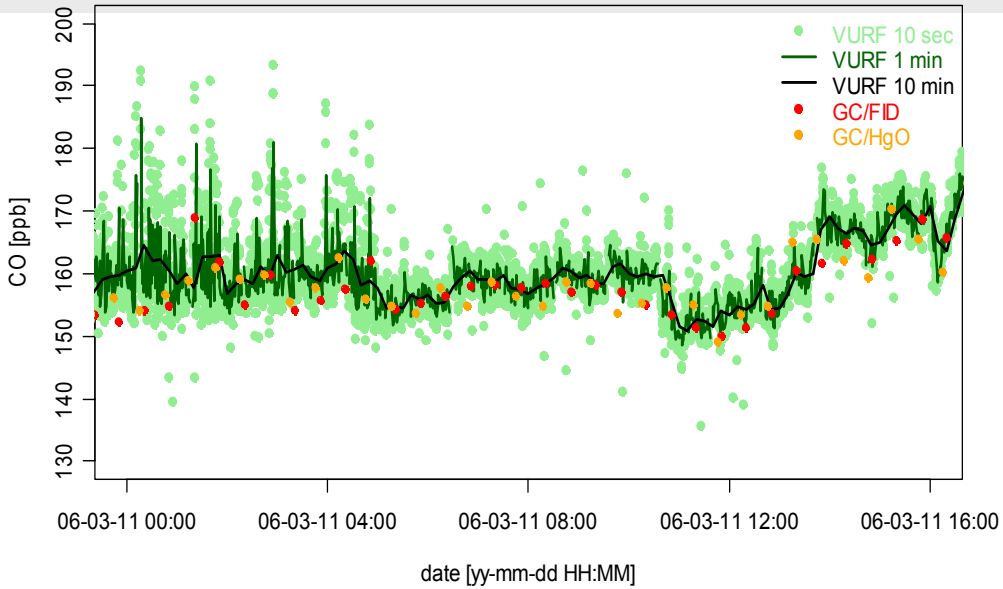
by long-range transport

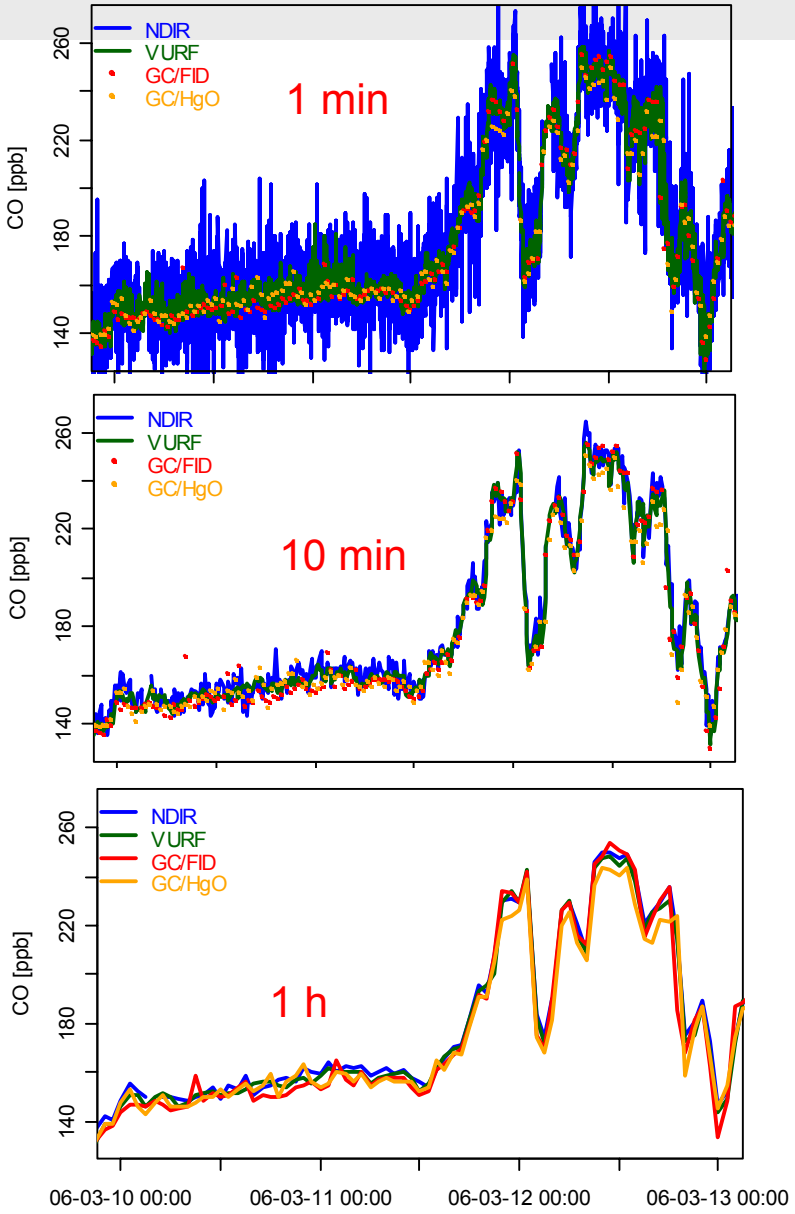
by global scale events

JFJ is well situated to study both large-scale changes and regional air quality aspects

Zellweger et al., ACP, 2009

CO inter-comparison JFJ





- Good agreement between techniques
- All instruments are able to detect fast changes in the mixing ratios
- NDIR (Horiba instrument) performs well when averaging interval is long enough

Zellweger et al., ACP, 2009

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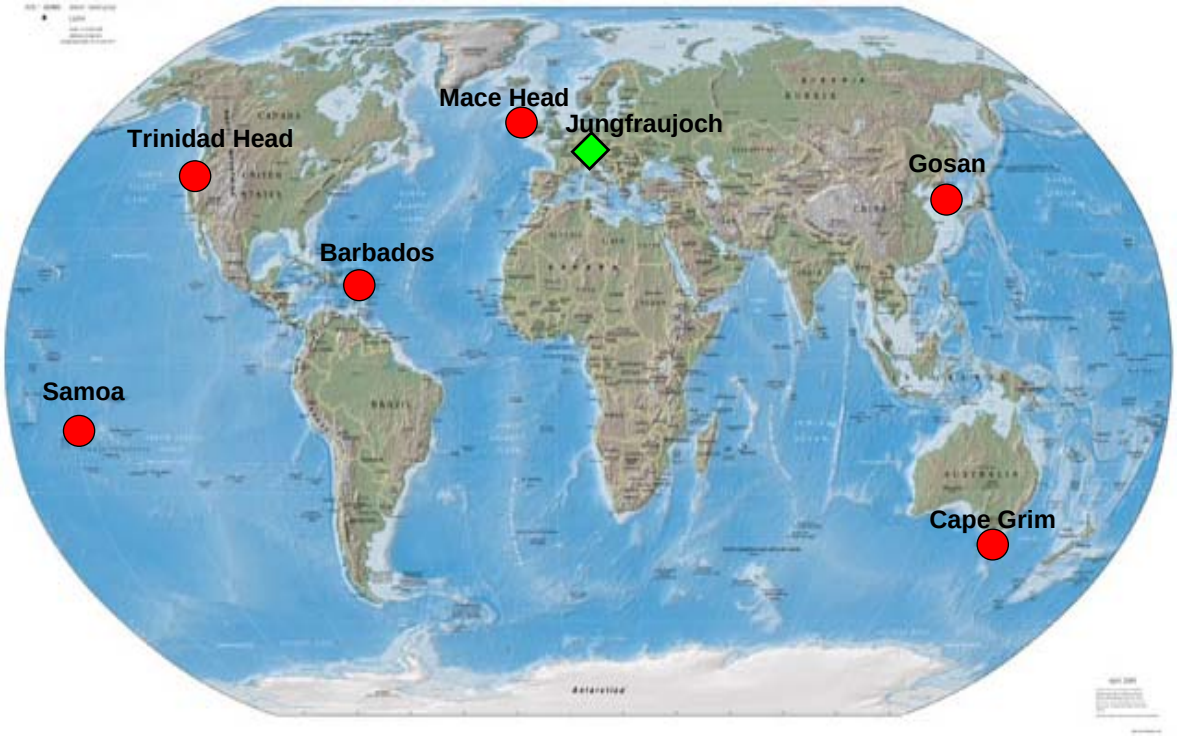
Advanced Global Atmospheric Gas Experiment
Network for Halogenated Hydrocarbons

mit einer MEDUSA

Core-Partners:

Massachusetts Institute of Technology

University of BRISTOL



MEDUSA, the instrument for halocarbon

cold head 1
HFCs
CFCs
SF_6
C_2F_6
VOC

cold head 2
CF_4

In cooperation with AGAGE, SCRIPPS, University Bristol

Non - CO_2- Greenhouse Gases (since 2008)

43 Halocarbons

Montreal Protocol

- **CFCs: Fluorochlorocarbons (6)**
  CFC-11 CFC-12, CFC-13
  CFC-113 CFC-114 CFC-115

- **HCFCs: Hydrofluorochlorocarbons (4)**
  HCFC-141b HCFC-124 HCFC-22
  HCFC-142b

- **Halones: (containing bromo) (3)**
  H-1301 H-1211 H-2402

- **Halogenated Solvents (3 + 6)**
  1,1,1-Trichloroethane CCl_4 CH_3Br

CH_3Cl CH_3I $CHCl_3$
CH_2Cl_2 CCl_2CHCl CCl_2CCl_2

Kyoto Protocol

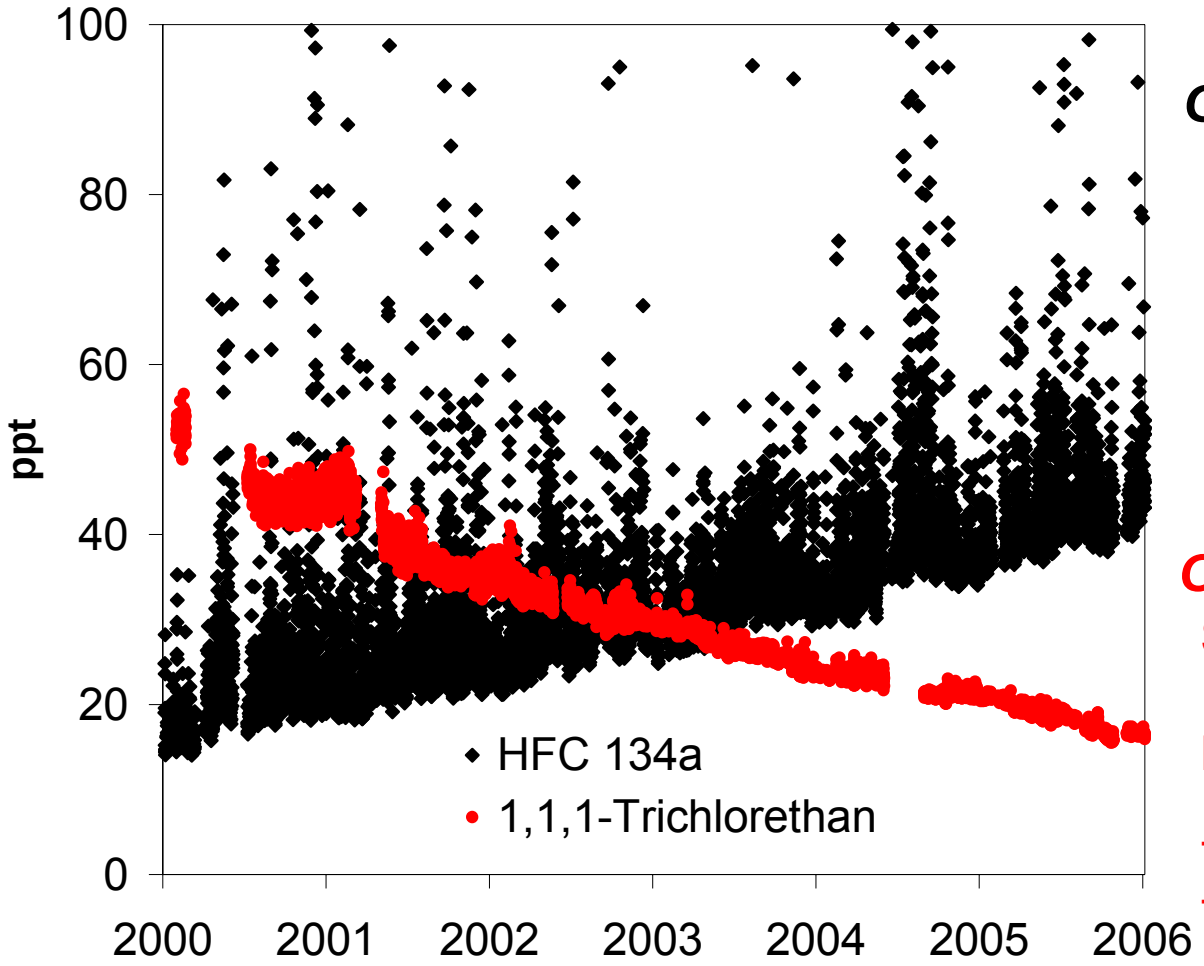
- **HFCs: Hydrofluorocarbons (10)**
  HFC-32 HFC-23
  HFC-125 HFC-134a
  HFC-152a HFC-227ea
  HFC-143a HFC-236fa
  HFC-365mfc HFC-245fa

- **PFCs: Perfluorocarbons & SF_6 (7)**
  CF_4 C_2F_6 $CF_3CF_2CF_3$
  C_4F_{10} $c\text{-}C_4F_8$ CF_3CF_3
  SF_6

- **Others (4)**
  SO_2F_2 $C_4Cl_2F_6$ C_2ClF_3
  CH_2Br_2

Control of success of reduction measures

Early warning of change in atmospheric composition



GHG Global Warming

Cooling Agents
HFC 134a
Kyoto Protocol regulated

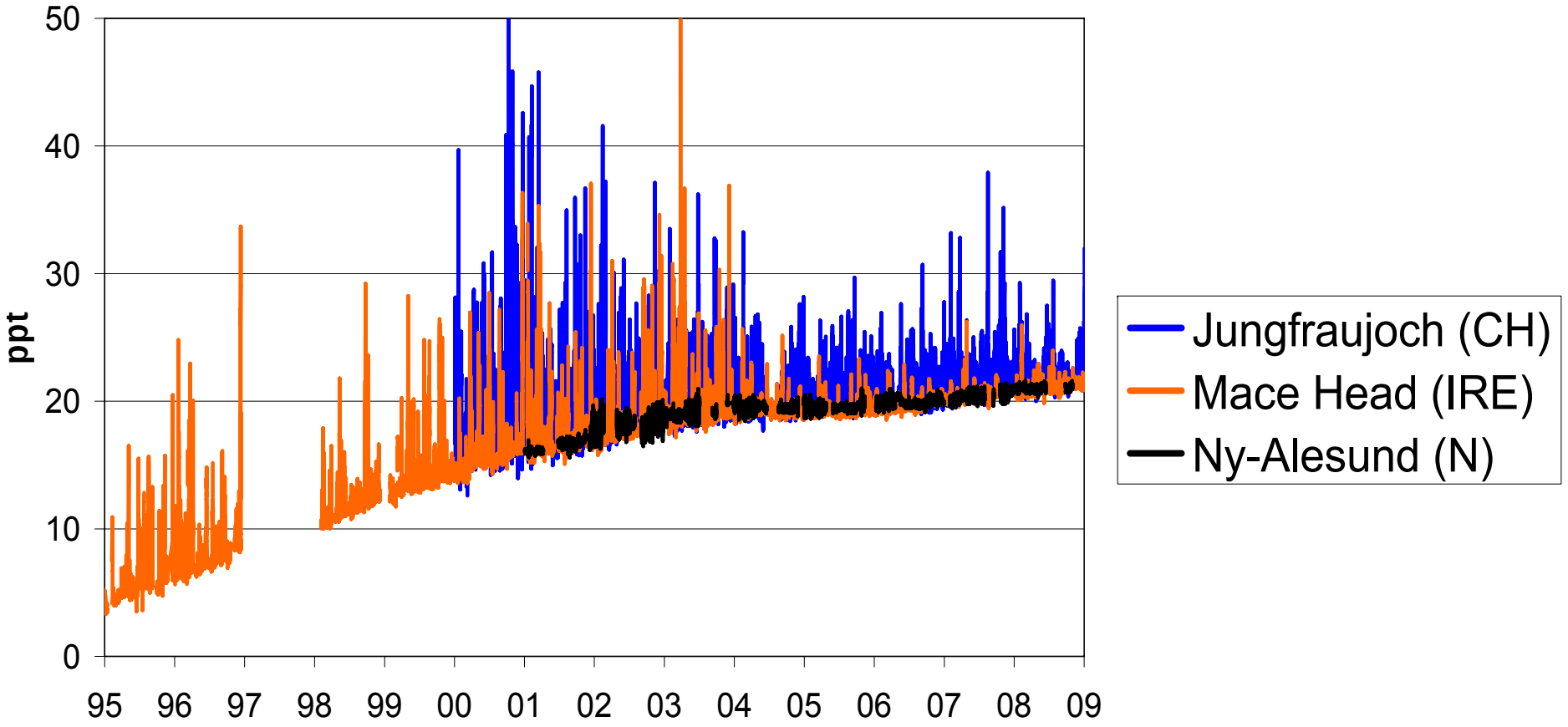
+ 5 ppb y^{-1}
+ 0.71 $mWm^{-2}y^{-1}$

CFCs Ozone Depletion

Solvent
1,1,1-Trichloroethane
Montreal Protocol; forbidden

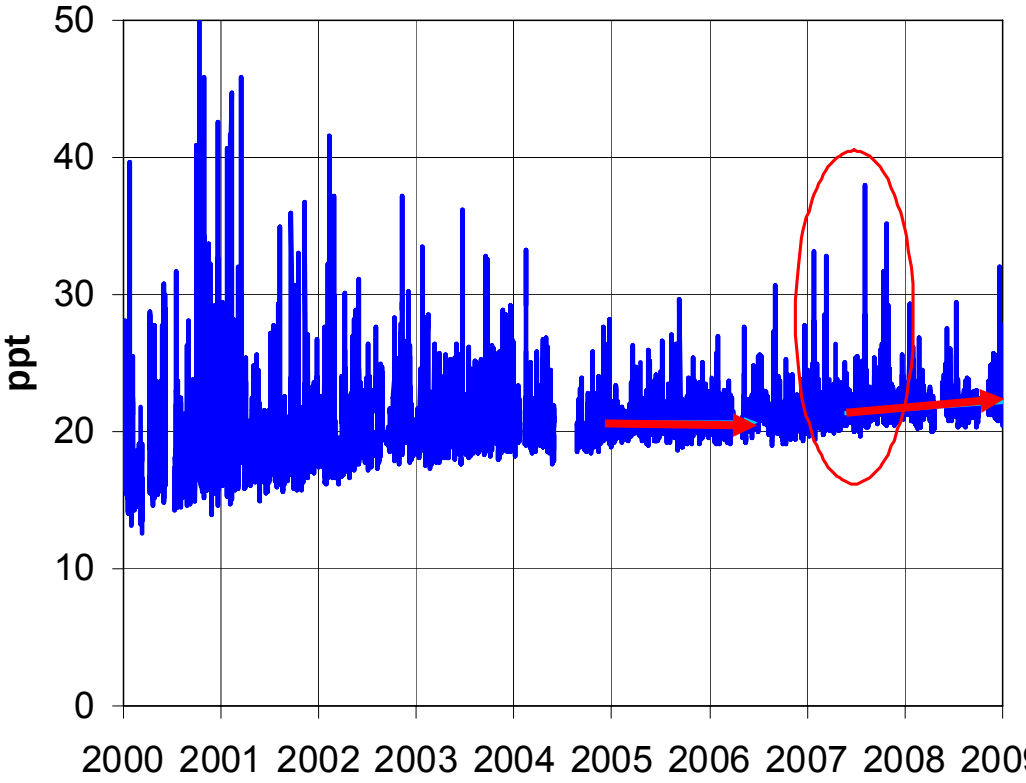
- 2.5 ppb y^{-1}
- 0.21 $mWm^{-2}y^{-1}$

HCFC (141b) regulated in the Montreal Protocol



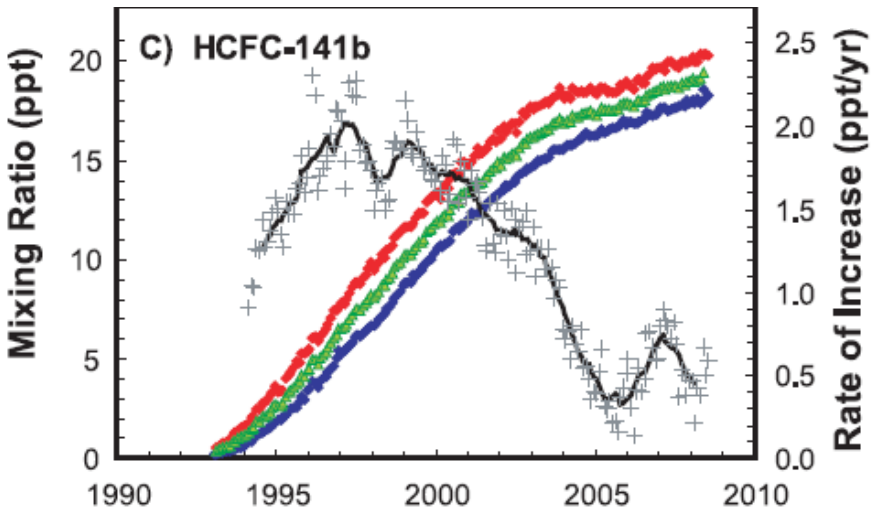
HCFC (141b) regulated in the Montreal Protocol

HCFC-141b at Jungfraujoch



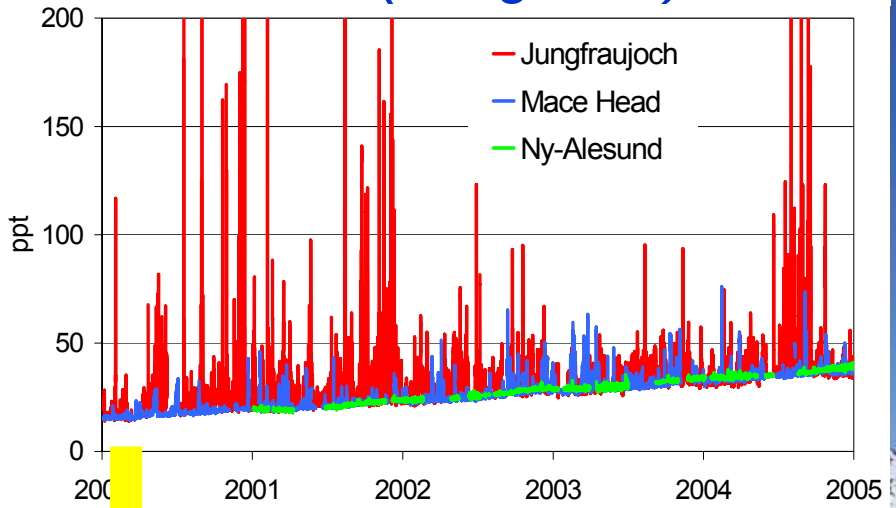
HCFCs at global background sites (NOAA)

Montzka et al., GRL, 2009

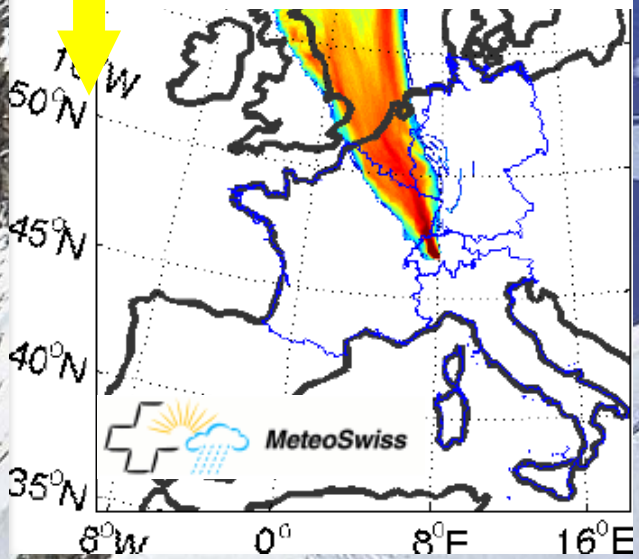


Allocation of European Emission

F134a (refrigerant)



NWP models



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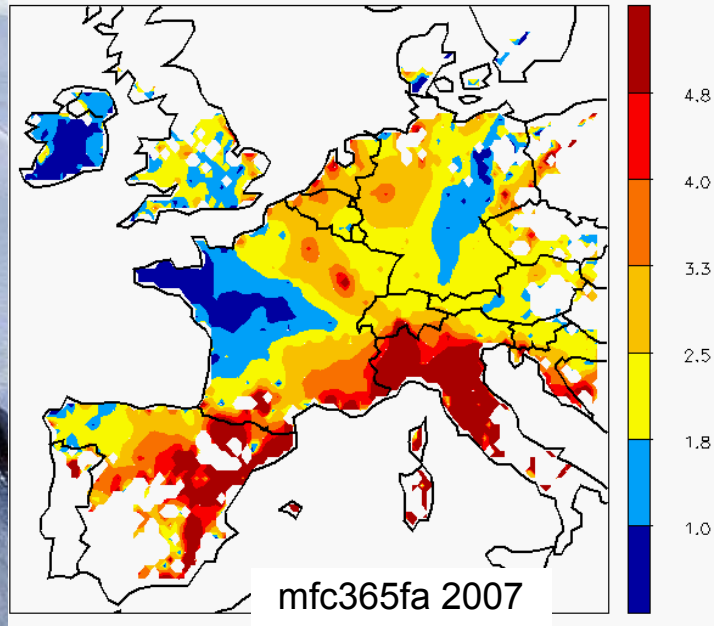
Materials Science & Technology

Source regions

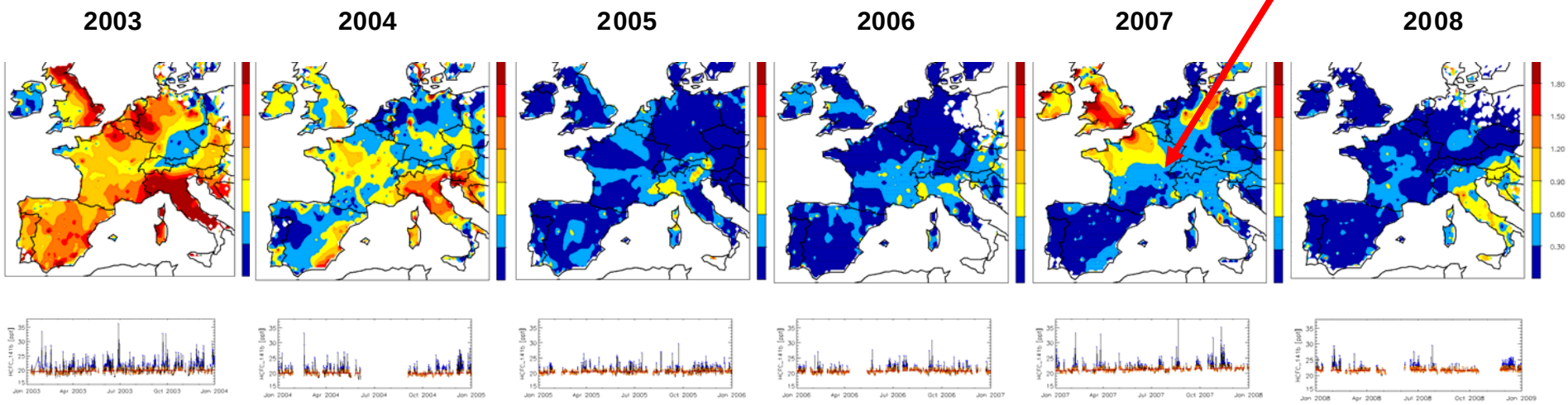


mfc365fa 2007

HCFC (141b) regulated in the Montreal Protocol Source Regions

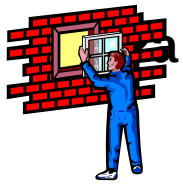
HCFC-141b at Jungfraujoch

Plant: Tavaux

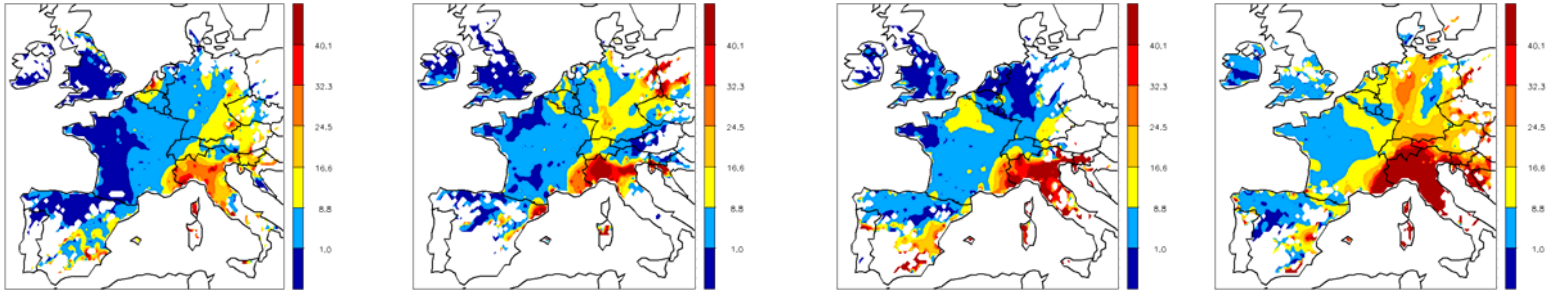


banned in Europe since 2003

Foam blowing agent HFC-152a: Emissions from Europe



2004 2005 2006 2007

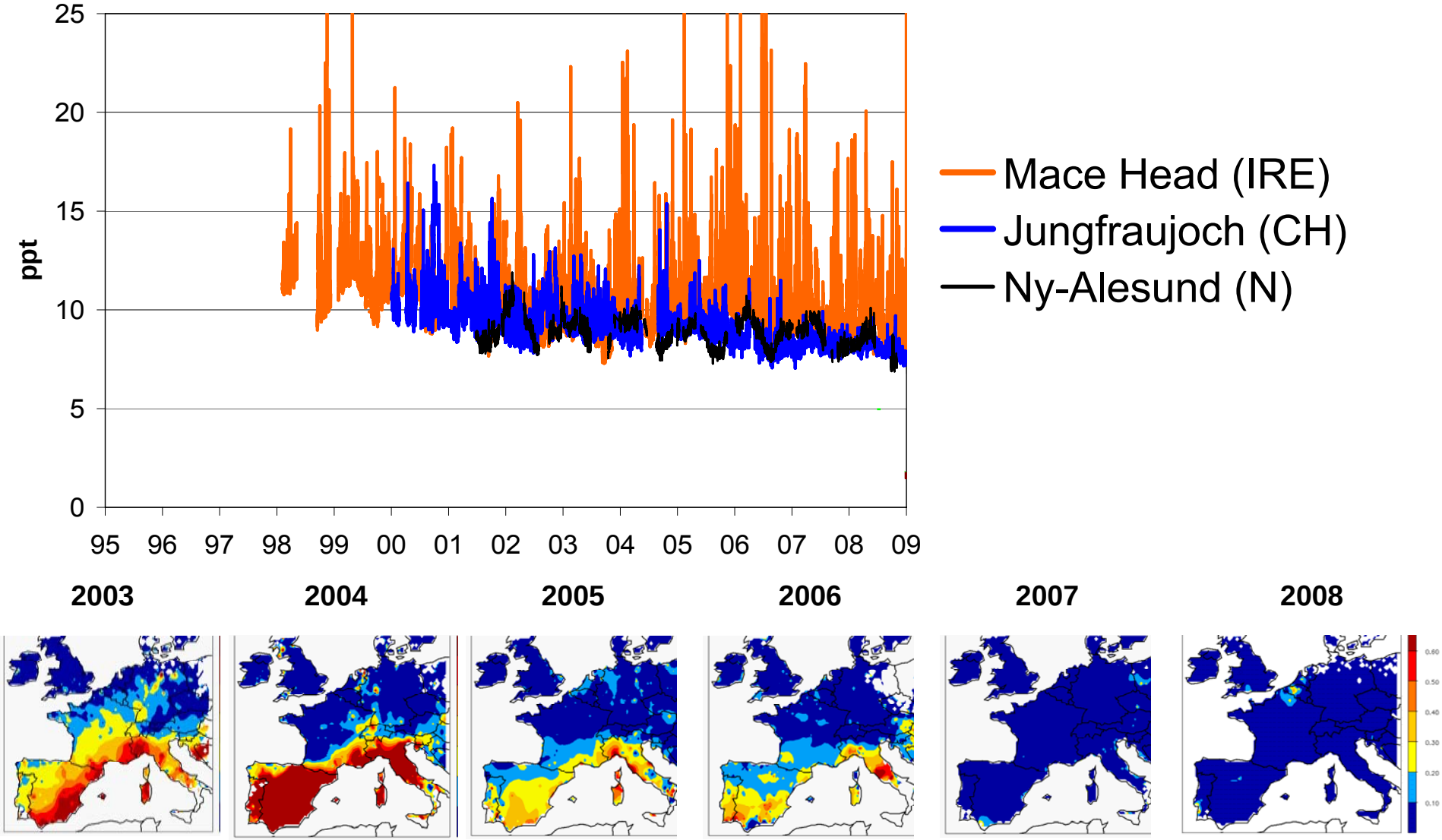


2007

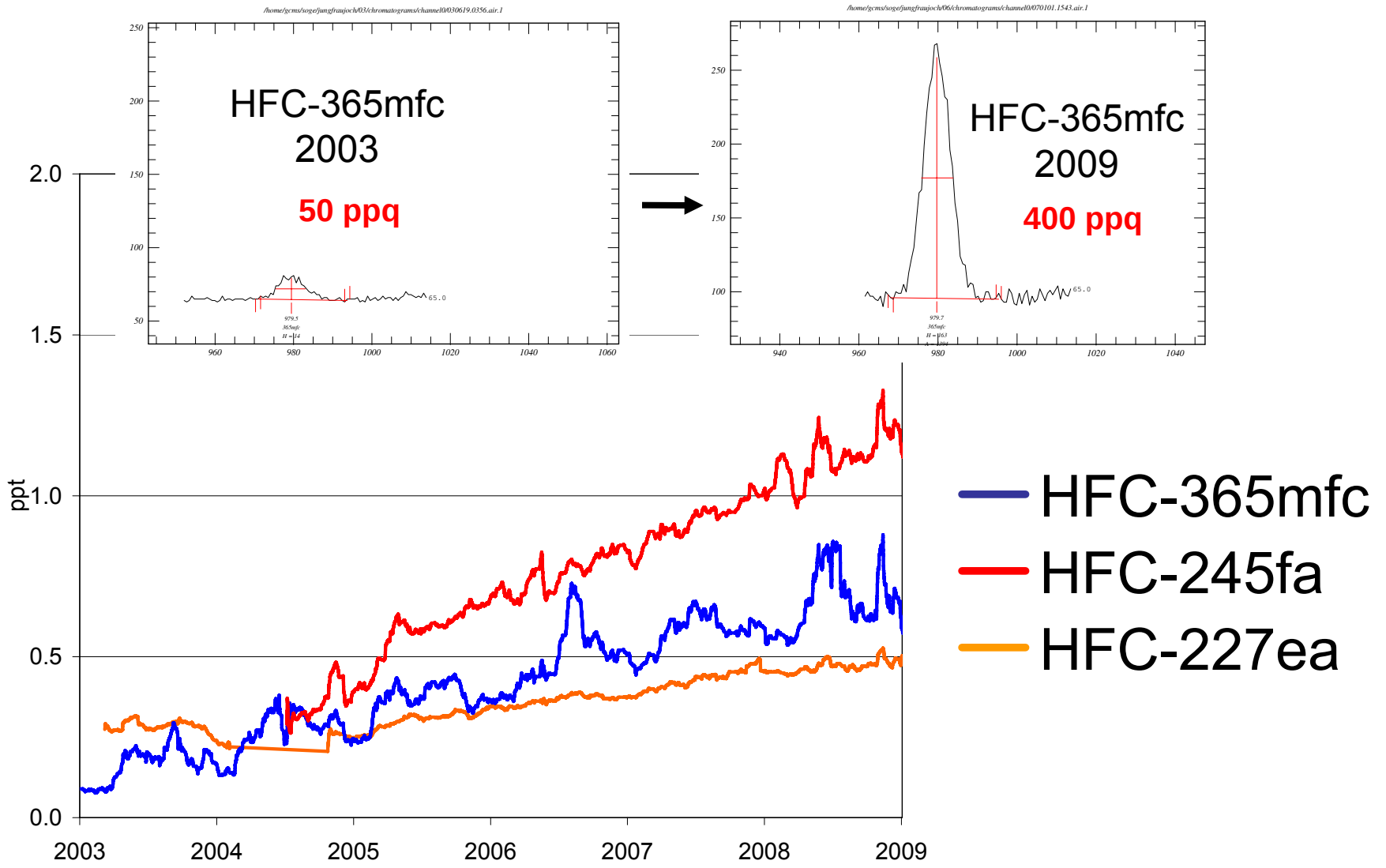
National Communications to UNFCCC

	2003	2004	2005	2006
Austria	520 t	529 t	574 t	416 t
Belgium	330 t	288 t	204 t	208 t
Germany	1880 t	1333 t	781 t	669 t
France	460 t	297 t	313 t	318 t
Italy	- t	- t	- t	- t
Spain	177 t	187 t	170 t	113 t

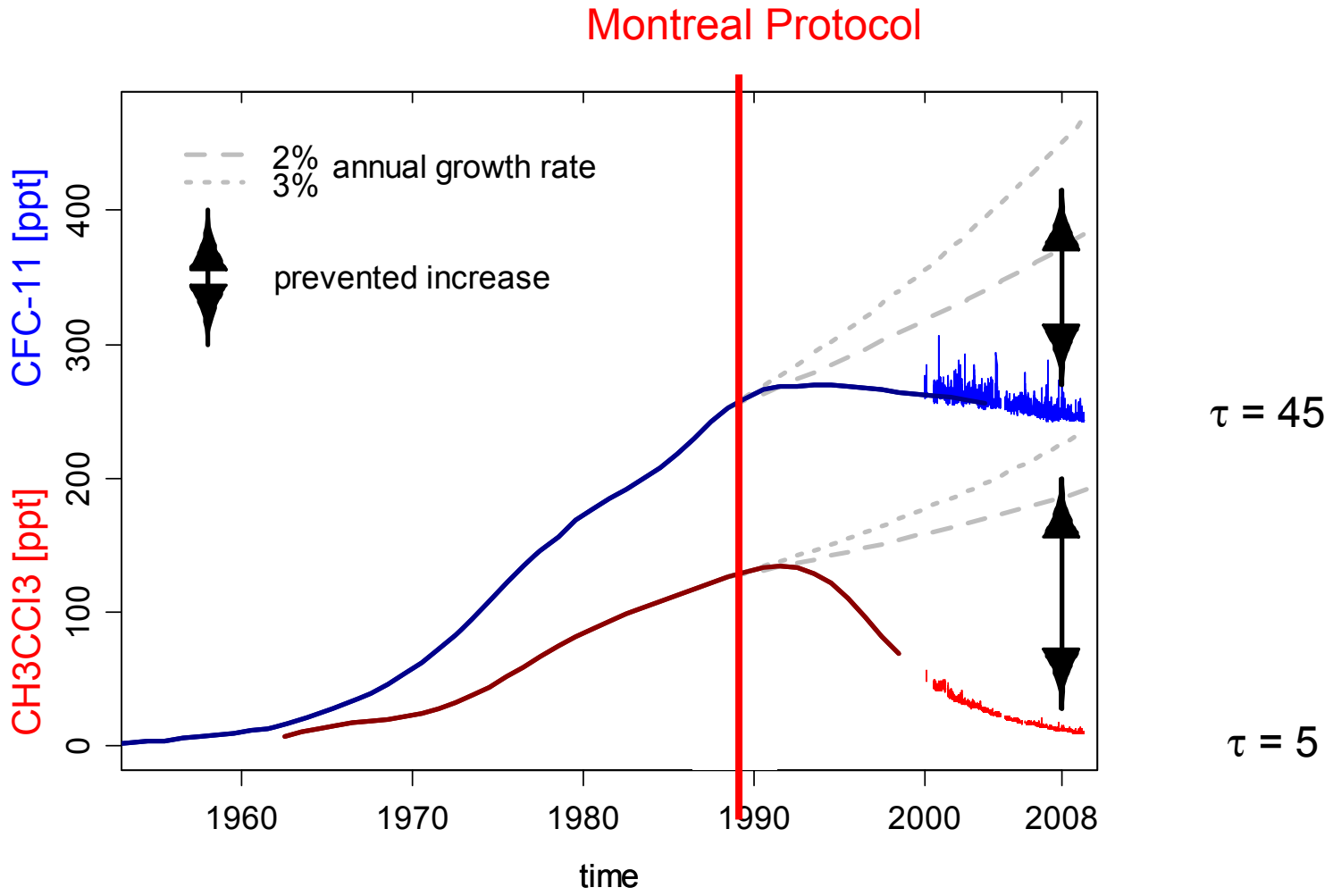
Methylbromide (CH_3Br)



Substitute Compounds for Forbidden Foam Blowing Agents



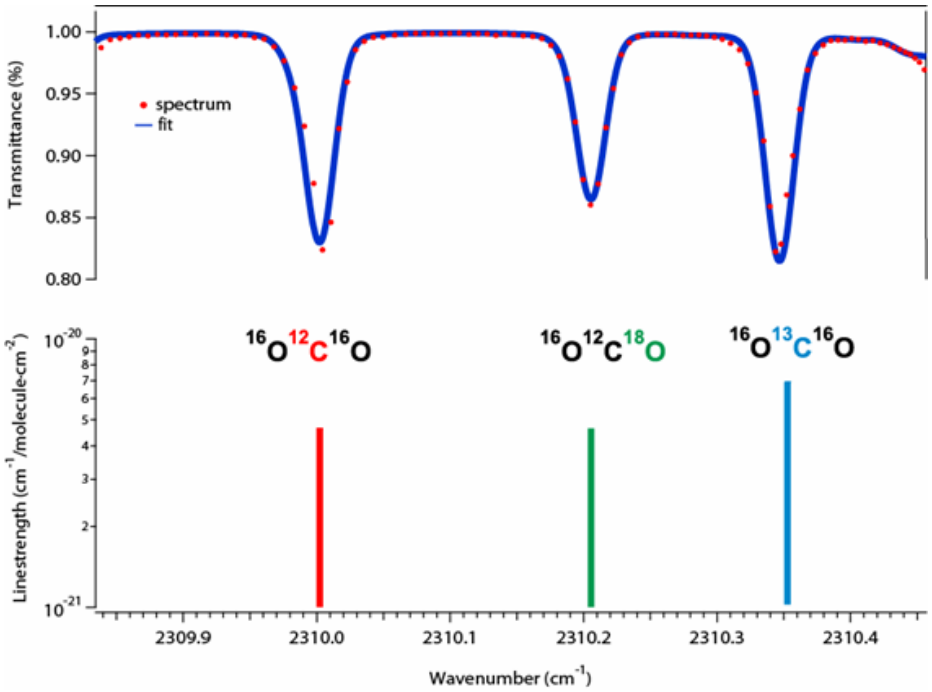
Influence of the Montreal-Protocol on Climate



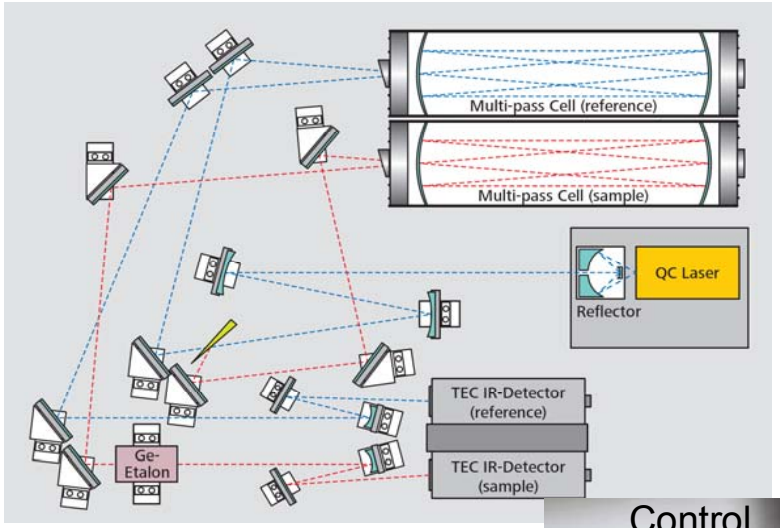
Steinbacher et al., 2008

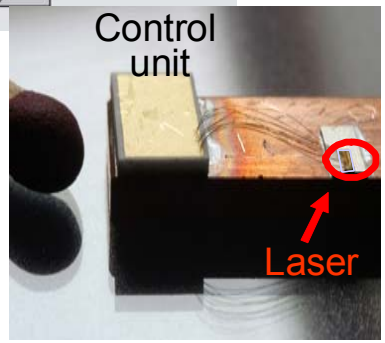
Future Activies: CO_2 isotopes ($\delta^{13}C$, $\delta^{18}O$) for source identification

Fast and high-precision (QCL) laser spectroscopy for CO_2-isotopes



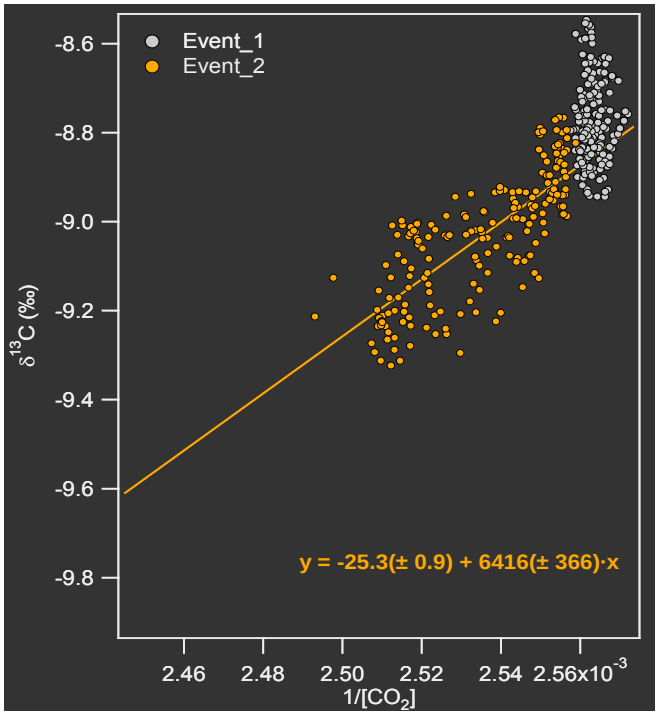
Tuzson et al., Infr. Phys. & Techn., (2008)

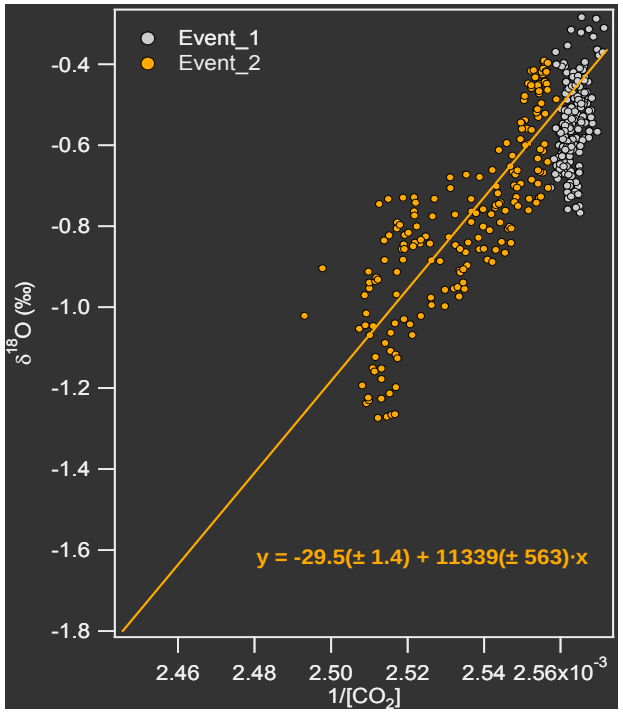




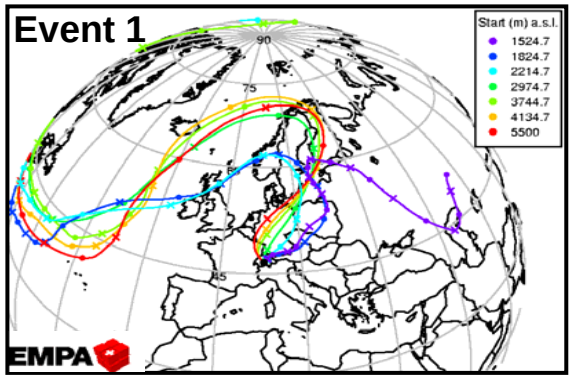
Identification and quantification *of biogenic and anthropogenic carbon dioxide* ***sources****, e.g. respiration vs. photosynthesis fossile vs. biogenic*

CO_2 isotopes ($\delta^{13}C$, $\delta^{18}O$) for source identification

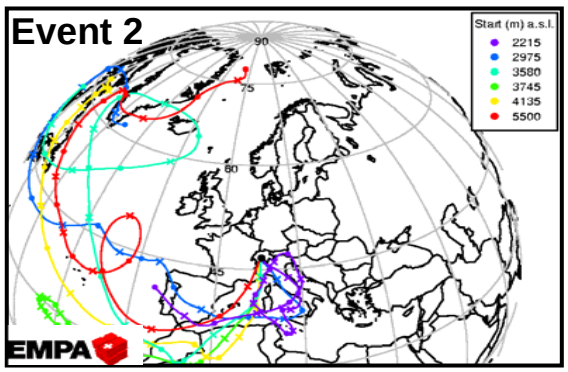




Event 1 background high trajectories



Event 2 polluted low trajectories



precision of ~ 0.05 ‰ for δ13C and δ18O with 100 s averaging

L. Emmenegger, B. Tuzson

Summary & Conclusions

- **Trend estimation** at background sites allows independent **verification of reduction measures**
- **Montreal Protocol** not only reduced the atmospheric chlorine content but also slowed **global warming**
- Global GAW sites (measurements combined with models) allow an **allocation** and **quantification** of pollution sources and thus **support international treaties** and protocols
- **Early detection** of new compounds (substitutes for forbidden substances) allow to **reduce environmental risks** to the society
- Extension of the measurement programme with **relevant new parameters** (e.g. continuous isotope measurement) enables **improved source identification**

Thanks to:

- S. Reimann, M.K. Vollmer, M. Hill
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- C. Hüglin, M. Steinbacher, B. Schwarzenbach
- L. Emmenegger, B. Tuzson

and

- International Foundation High Altitude Research Stations Jungfraujoch and Gornergrat

- MeteoSwiss
- BAFU

- AGAGE/NOAA team

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Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Umwelt BAFU

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Bundesamt für Meteorologie und Klimatologie MeteoSchweiz