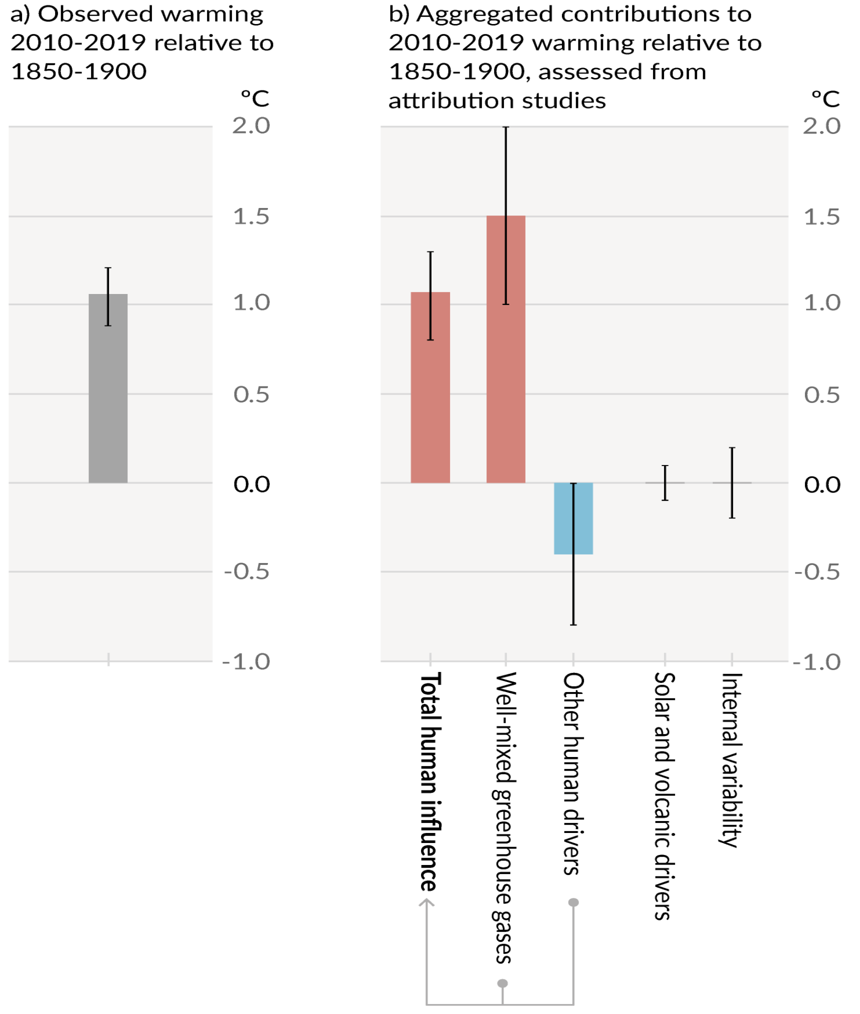
ATMOSPHERIC SCIENCE & CLIMATE CHANGE (IEK-8 PROJECTS)

Andreas Wahner, Forschungszentrum Jülich GmbH, Institut für Energie und Klima: IEK-8 Troposphäre, Germany; GGSB 26.06.2023

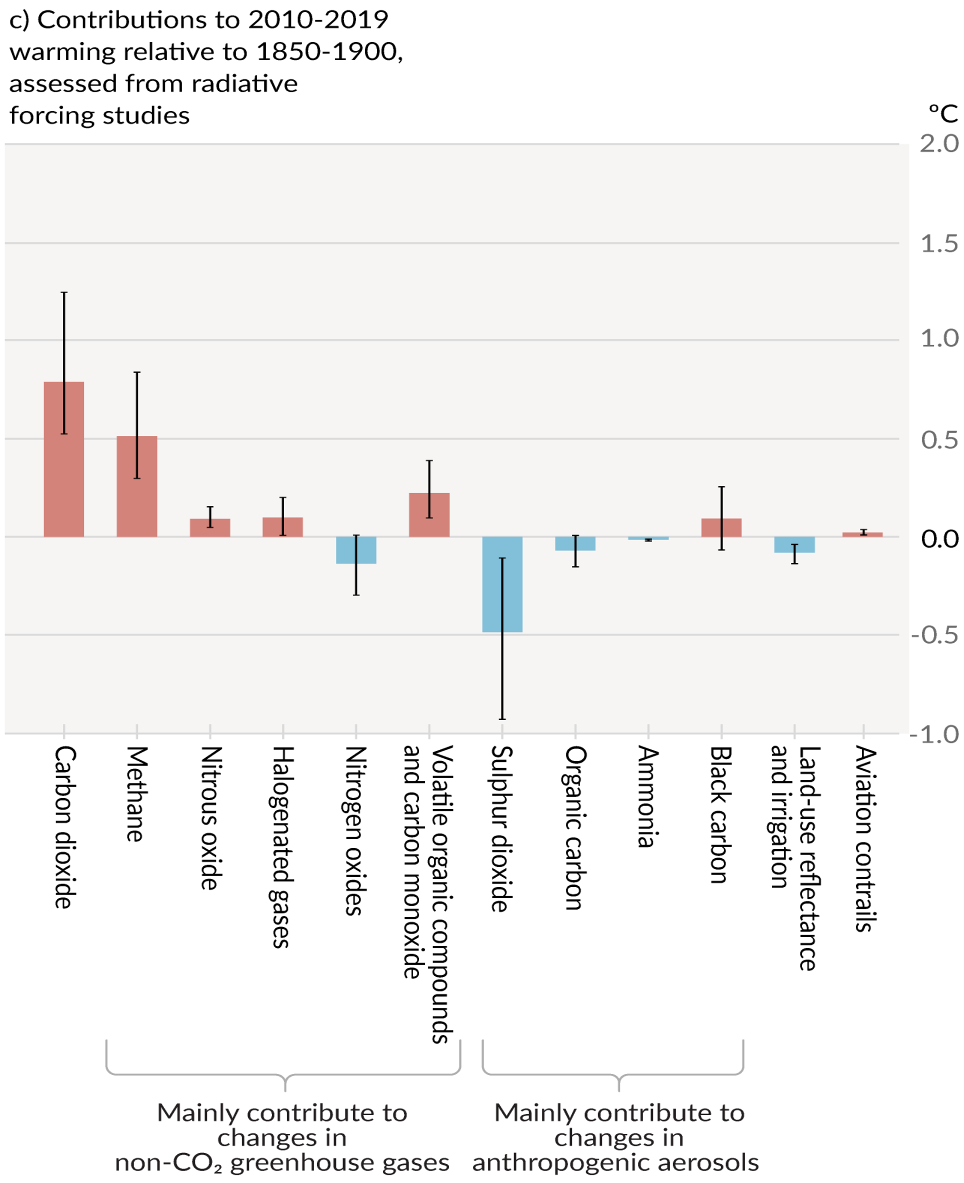


We currently observe a warming of 1.09°C compared to pre-industrial times.

The observed warming is driven by emissions from human activities.

The warming from greenhouse gases is partly masked by the cooling effect of aerosols.

Abb. SPM.2



We currently observe a warming of 1.09°C compared to pre-industrial times.

Methane is the second most important greenhouse gas after CO2 and has contributed 0.5°C to warming so far.

The sum of short-lived greenhouse gases and soot contribute to warming in the same order of magnitude as CO2.

Abb. SPM.2

[Credit: Evgeny Nelmin | Unsplash]

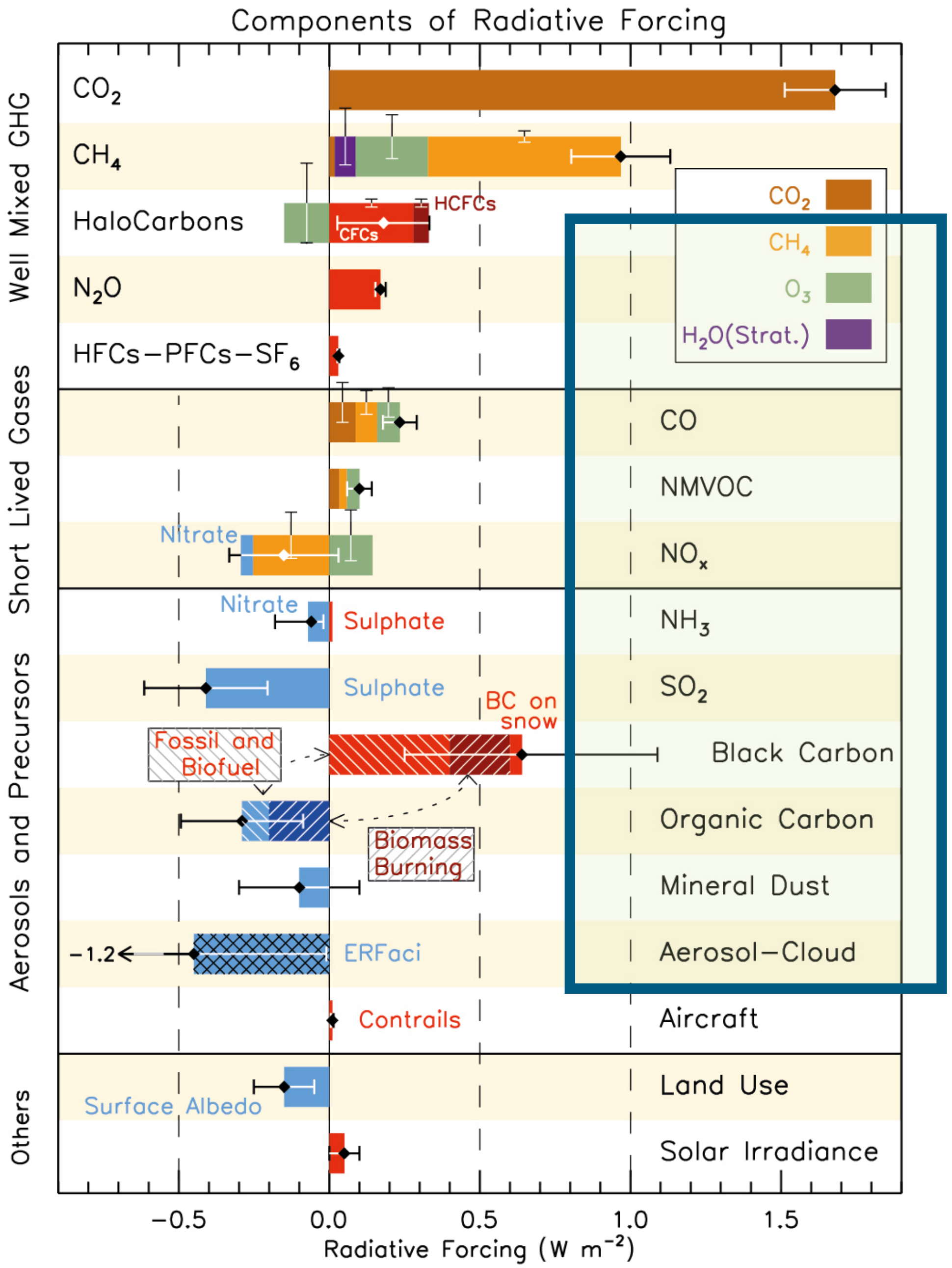
"

To limit global warming, strong, rapid, and sustained reductions in CO2, methane, and other greenhouse gases are necessary.

This would not only reduce the consequences of climate change but also improve air quality.

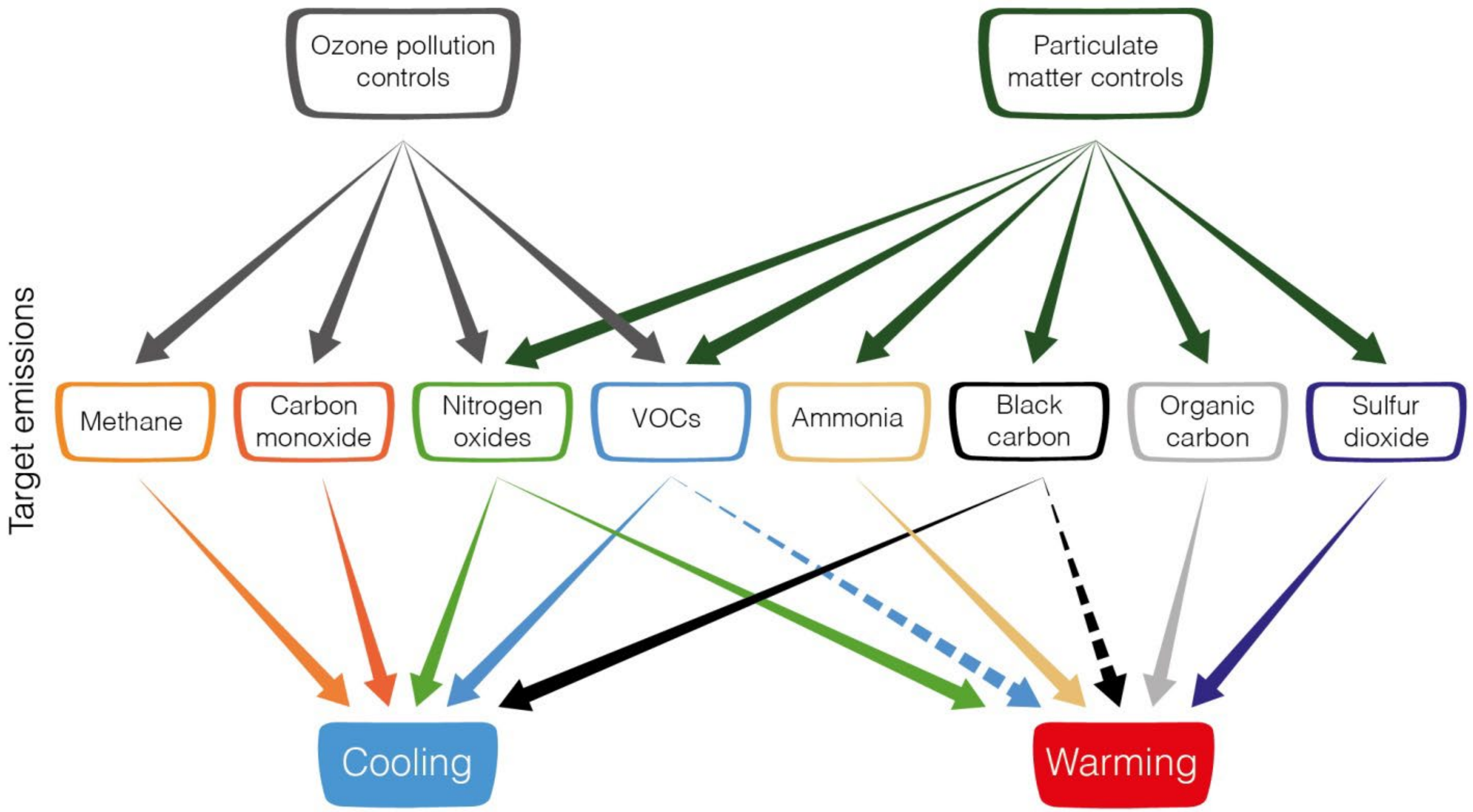
INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP



Climate change depend on short lived climate pollutants (SLCPs)

Air Quality Controls on SLCPs Impact Global Warming



[Credit: Peter John Maridable | Unsplash]

"Unless there are immediate, rapid, and large-scale reductions in greenhouse gas emissions, limiting warming to 1.5°C will be beyond reach.

INTERGOVERNMENTAL PANEL ON climate change

Temperature change due to emissions of one year (2014) after 10 and 100 years

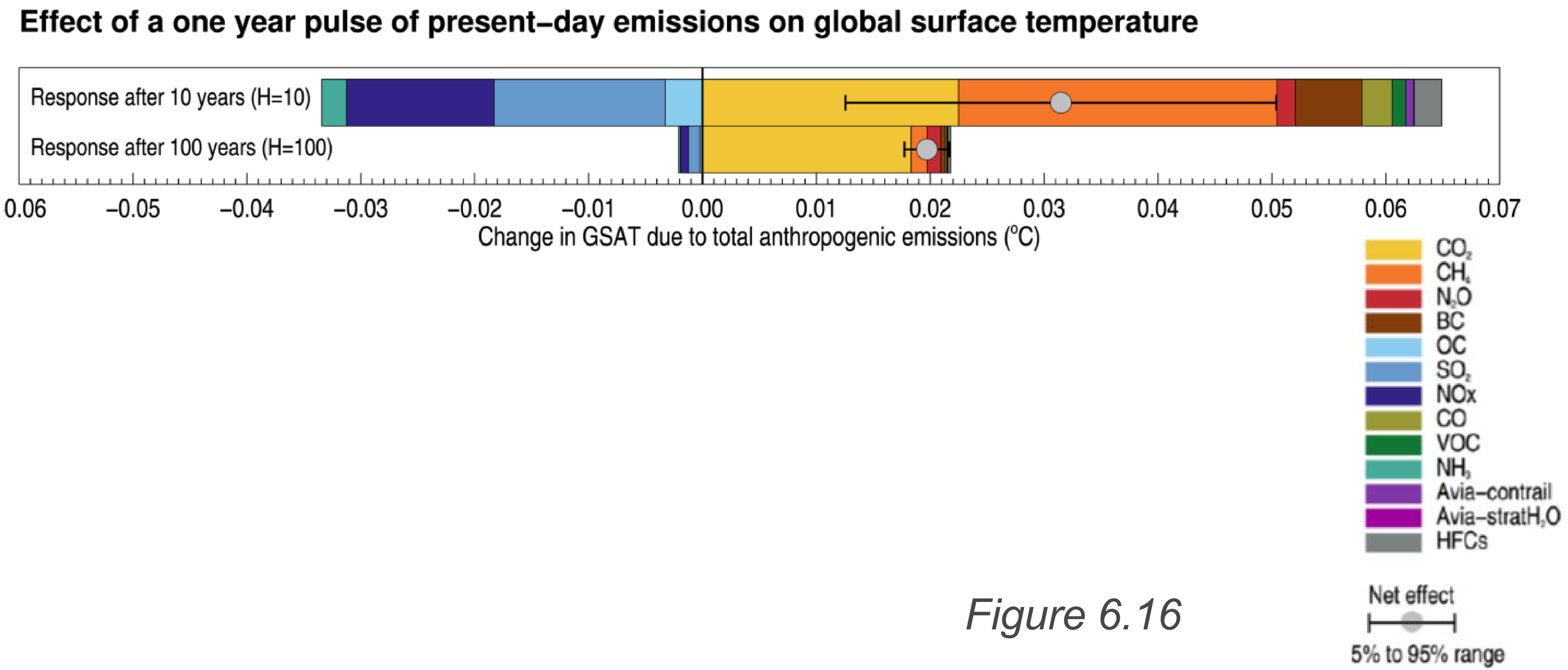
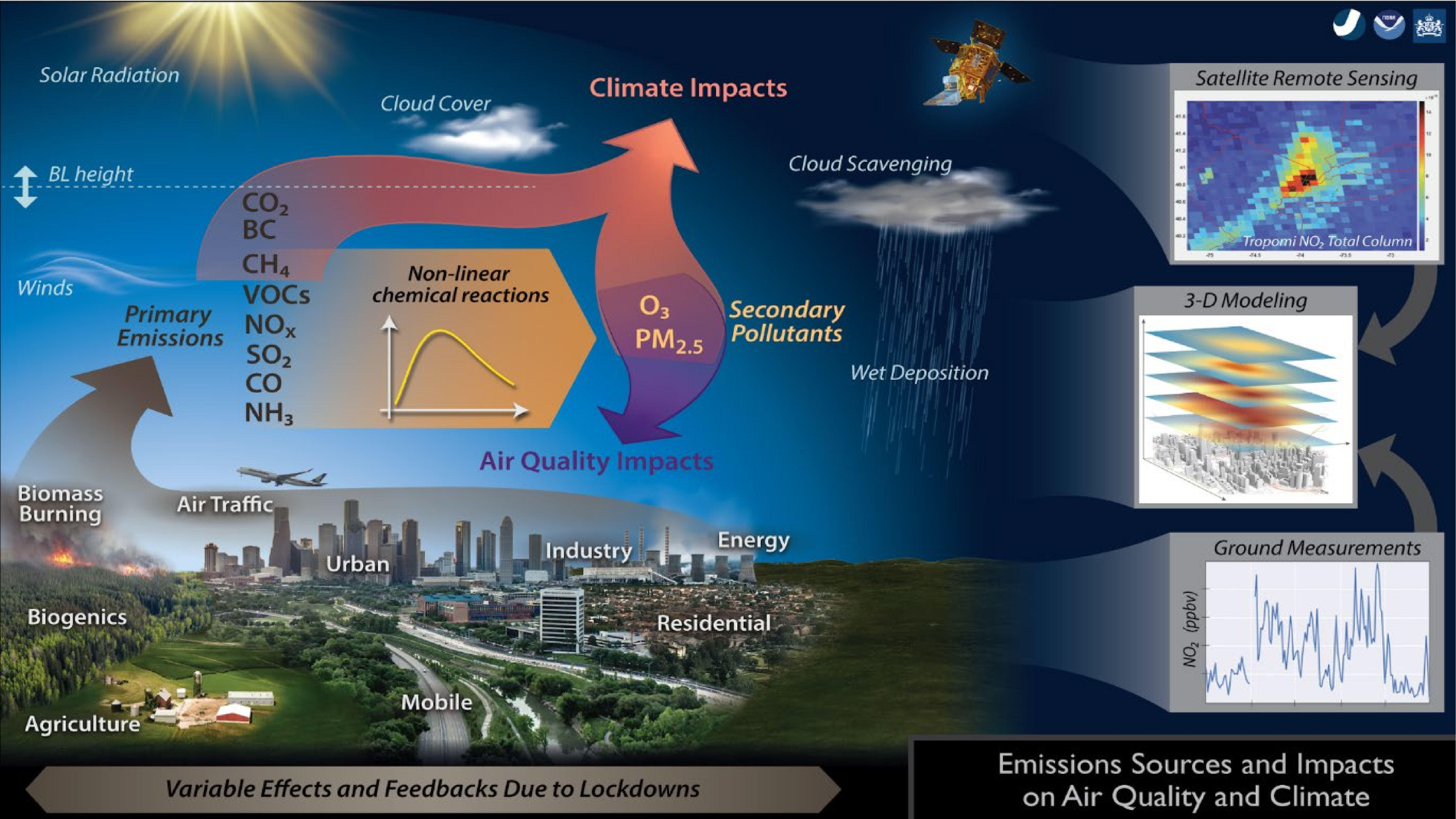


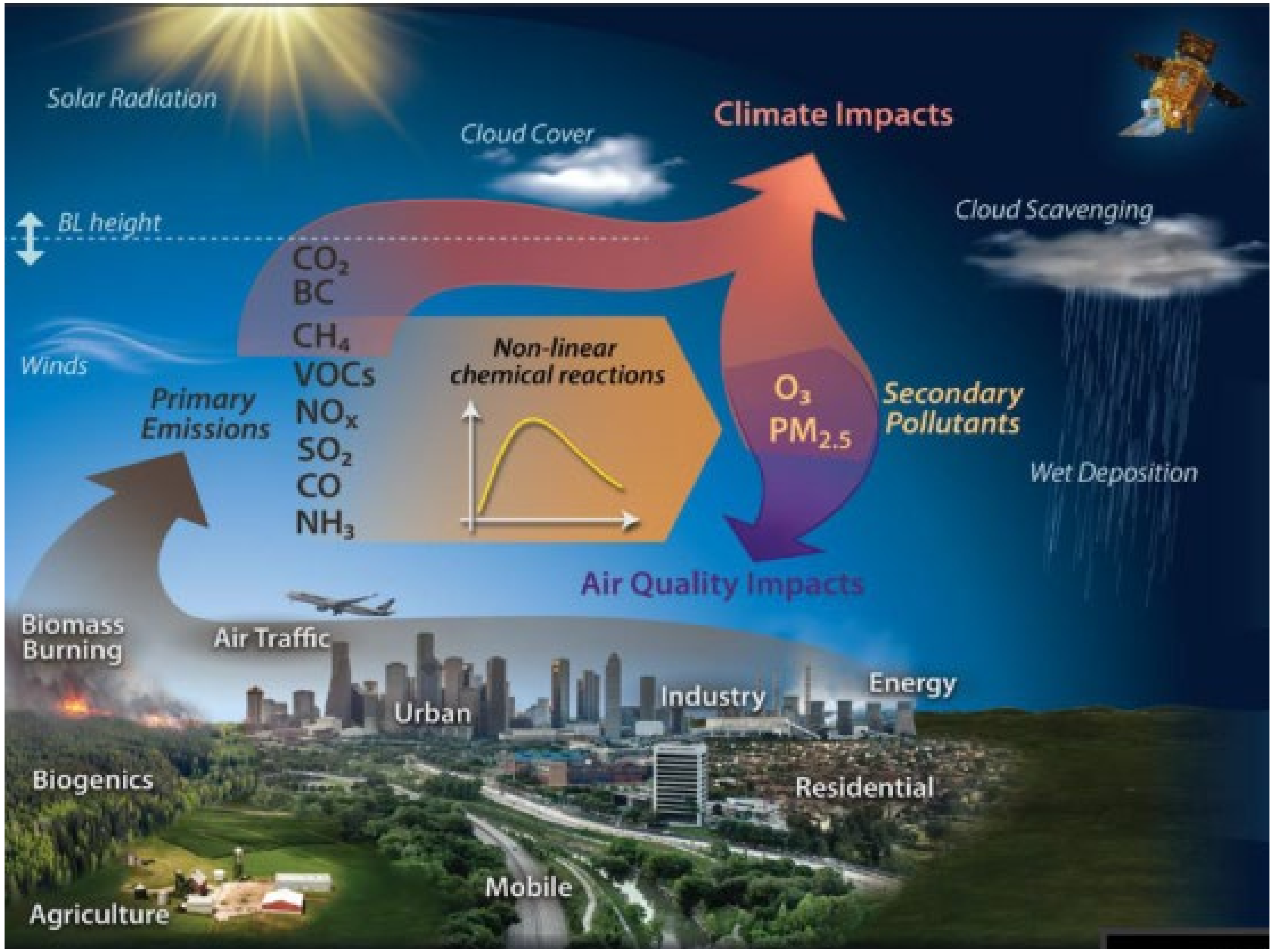
Figure 6.16



Solar Radiation
Cloud Cover
Climate Impacts
BL height
CO_2
BC
CH_4
VOCs
NO_x
SO_2
CO
NH_3
Winds
Primary Emissions
Non-linear chemical reactions
O_3
$PM_{2.5}$
Secondary Pollutants
Air Quality Impacts
Cloud Scavenging
Wet Deposition
Satellite Remote Sensing
Tropomi NO_2 Total Column
3-D Modeling
Ground Measurements
NO_2 (ppbv)
Biomass Burning
Air Traffic
Urban
Industry
Energy
Biogenics
Residential
Mobile
Agriculture
Variable Effects and Feedbacks Due to Lockdowns
Emissions Sources and Impacts on Air Quality and Climate

Iek-8: troposphere

Chemistry – Climate – Air Quality Interactions



The atmospheric chemsitry processes leading to secondary pollutant formation (O3, aerosol) are **highly non-linear** and depend on **precursor mixture and concentration**, and e.g. temperature and humidity

Trace compounds impact climate and air quality – with SLCF contributing in the same order maginitude to global warming as CO_2 and **aerosols posing the global number one environmental health risk**

European green deal, Energiewende, Verkehrswende and other policy interventions **to curb climate change and improve air quality** lead to new technology with changed and/or emerging new emissions

Institute IEK-8: Troposphere

observation > process understanding > simulation > societal options

unresolved questions

- *self-cleaning of the troposphere;*
- *interaction of biogenic and anthropogenic emissions;*
- *tropospheric ozone production;*
- *formation and aging of aerosol;*
- *night-time chemistry; …*

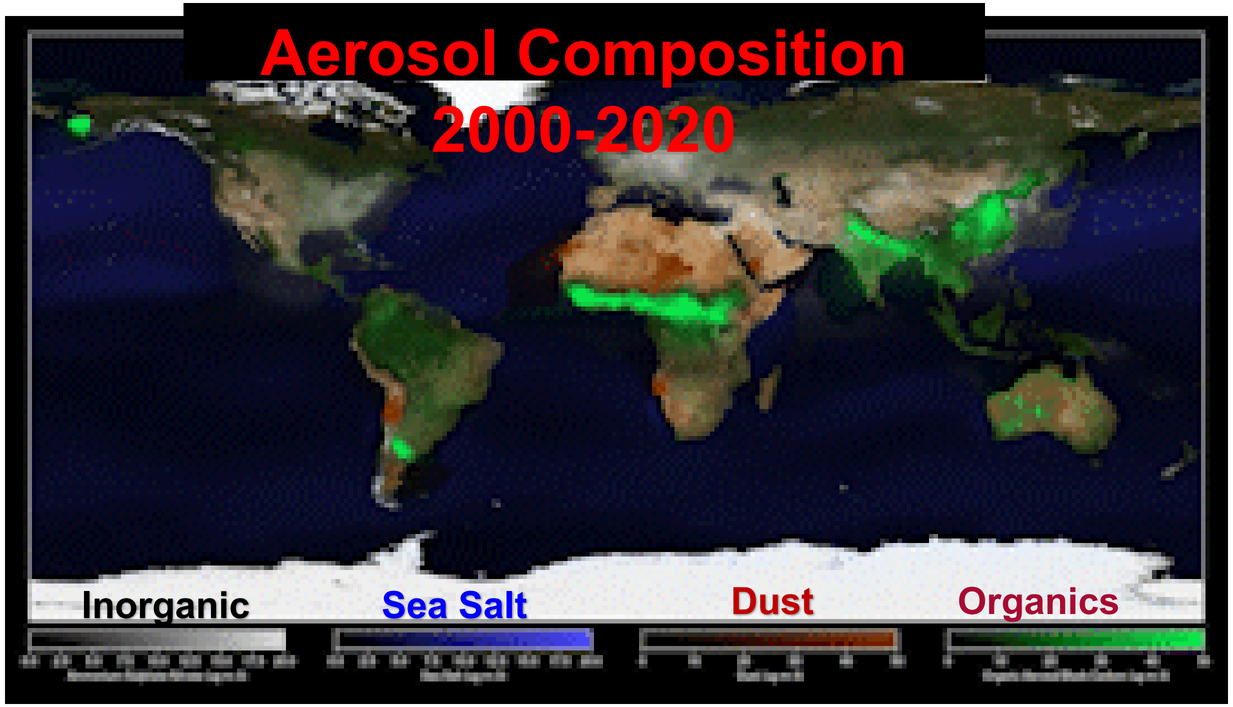
observation and simulation

- *long-term tropospheric observations*
- *ground based, airborne measurements (Zeppelin NT, drones, Mobilab, …);*
- *atmosphere simulation chamber SAPHIR, SAPHIR**
- *plant chamber SAPHIR+ …*

process understanding

parameterization of chemical, dynamical and micro-physical processes

global and regional simulations and predictions



IAGOS
GEO Group on Earth Observations
GEM-AQ
Copernicus Europe's eyes on Earth
WMO
ACTRIS
IPCC
Cams Copernicus Atmosphere Monitoring Service
ENVRI community
DestinE AQ

IEK-8 research foci

Emission ⟷ **atmospheric transformation** ⟷ **Air Quality Climate**

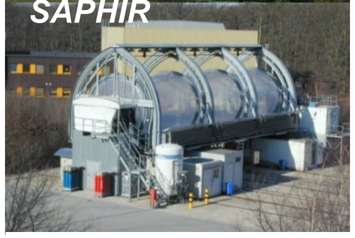
Focus:

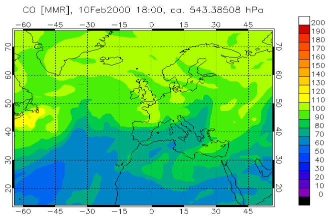
- **Long term observations of tropospheric composition change:** passenger aircraft as part of a global earth observation system
  → **European research infrastructure IAGOS AISBL**
- **Radical chemistry and atmospheric oxidation processes in the lower troposphere:** oxidation capacity and trace gas degradation under changing emissions; Actris National Facility; Actris Calibration Centers (NOx, VOC)
  → **Process understanding, Air Quality**
- **Gas to particle conversion, particle formation, and ageing:** quantifying of aerosol processes and chemistry-climate links
  → **Anthroposphere – Biosphere – Atmosphere interaction, Air Quality**
- **Global and regional impacts of atmospheric processes on tropospheric composition and climate:** operational chemical weather forecast, from science to service
  → **Copernicus Atmospheric Service, DestinE AQ, GEO, WMO, IPCC**

Observation

Process understanding

Simulation



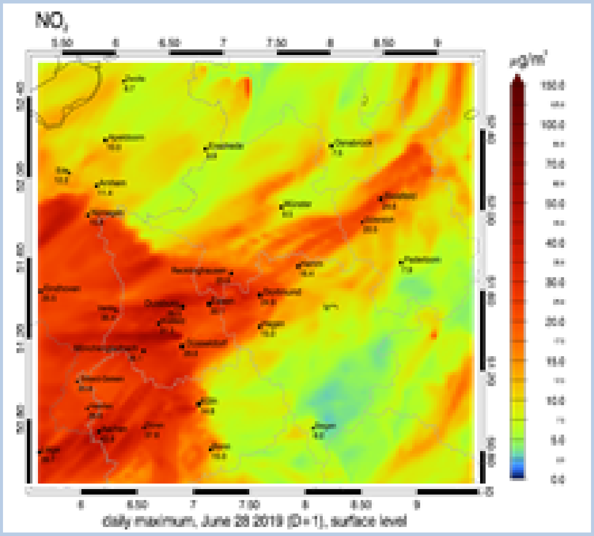


Service and Advice to Society

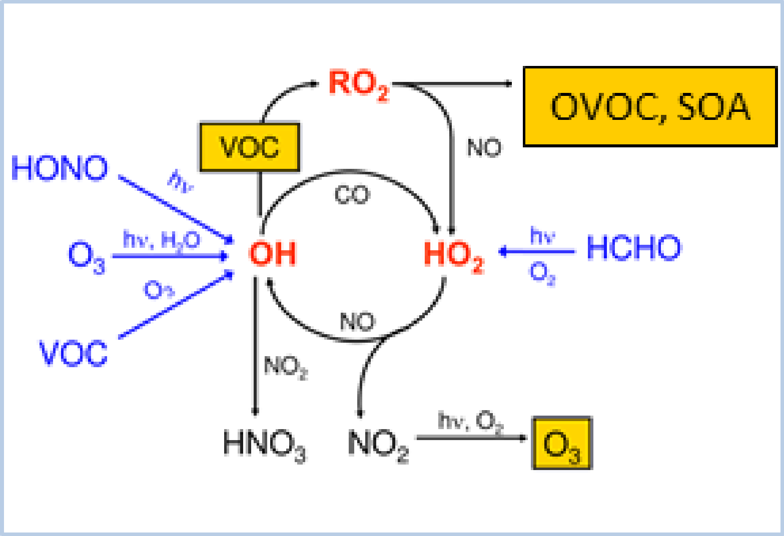
JÜLICH Forschungszentrum

IEK-8 research foci

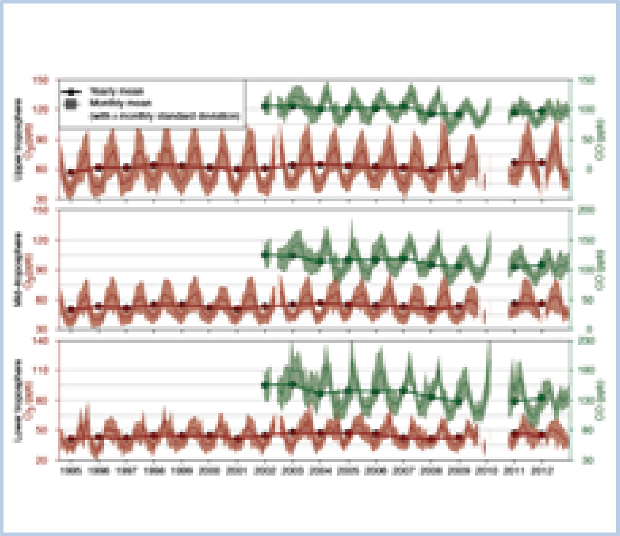
ST1.2: Air Quality



Urban air quality



Processes



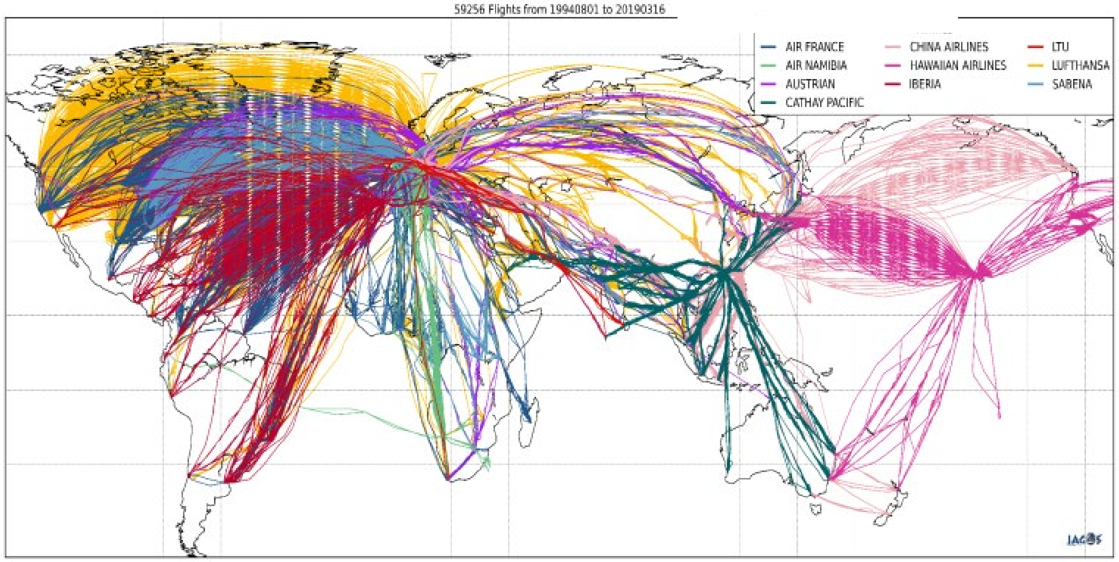
Long term trends

IAGOS

JÜLICH Forschungszentrum, cnrs, METEO FRANCE, MANCHESTER 1824, KIT Karlsruhe Institute of Technology, DLR, TROPOS

Lufthansa, AIRFRANCE, CHINA AIRLINES, CATHAY PACIFIC, IBERIA, HAWAIIAN AIRLINES

- In-Service Aircraft for a Global Observing System
- Operationel ESFRI Landmark, AISBL
- Continuous in situ global observation of essential climate variables: Temperature, H_2O, O_3, CO, NO_x, CO_2, CH_4, aerosols, clouds.
- Long-term operation (> 20 years)
- Currently, 8 long-range aircraft in operation for IAGOS
- Germany, France, England are partners
- Invest. Financing of the present setup: IAGOS-D by BMBF



- Open Data Policy
- Real-time data for Copernicus Atmospheric Service of the European Weather Forecast

Zeppelin – a unique plattform for tropospheric composition studies

- Targeted research flights with high payload
- Ability to maneuver with high precision in boundary layer
- Use of passenger flights for longer term trend analysis with automated instrumentation
- Flexible deployment → ad-hoc campaign 2020: Impacts of COVID-19 lockdown on regional air pollution

ACTRIS: Aerosol, clouds and trace gases research infrastructure

Vision and Mission

- pan-European research infrastructure
  - ✓ short-lived atmospheric constituents
- long-term trends and atmospheric processes
  - ✓ air pollution, aerosol-cloud interactions and climate change

National Facilities

30 Observational Platforms

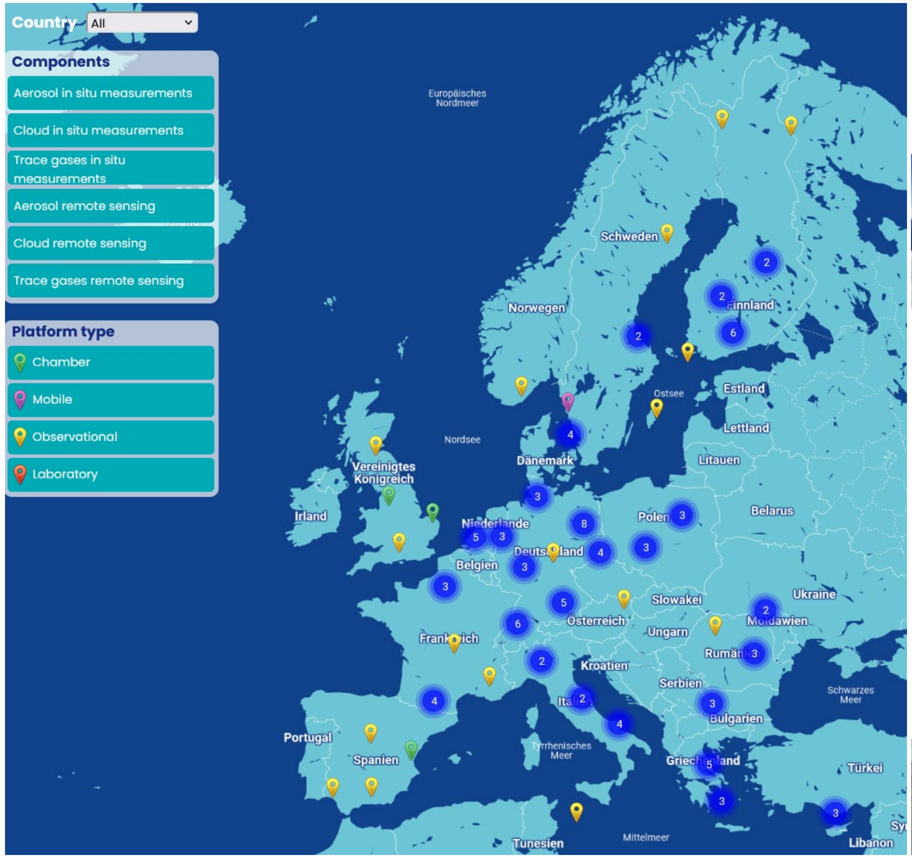
Long-term trends

16 Exploratory Platforms

Atmospheric processes

11 Chambers
5 Mobile Platforms

Observational platforms - reactive trace gases



Source Fig.: https://www.actris.eu/facilities/national-facilities

ACTRIS Calibration Centre for Reactive Trace Gases In Situ Measurements (Cigas)

State-of-the-art scientific and operational support

- Scientific and technological developments
- Measurement Guidelines
- Data QA/QC
- Regular audits
- Training and consultancy
- Linking with other communities

Andrea Marcillo
NMHCs
- TD-GC-MS/FID
- PTR-TOF-MS

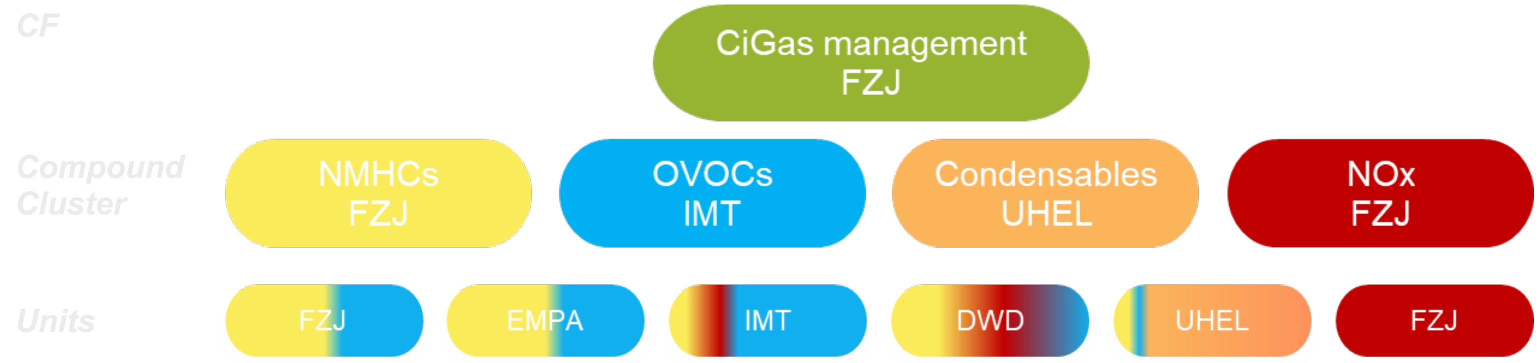
Hariprasad Alwe
OVOCs
- PTR-TOF-MS
- TD-GC-MS/FID

Achim Grasse
VOCs

Christian Wesolek
Instrument development + IT

Ralf Tillmann
VOCs
CiGas Lead

Organizational structure



Member of the Helmholtz Association

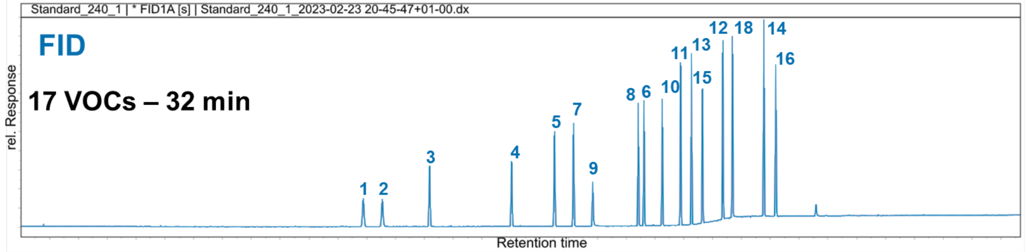
State-of-the-art methodology for NMHC measurement and calibration

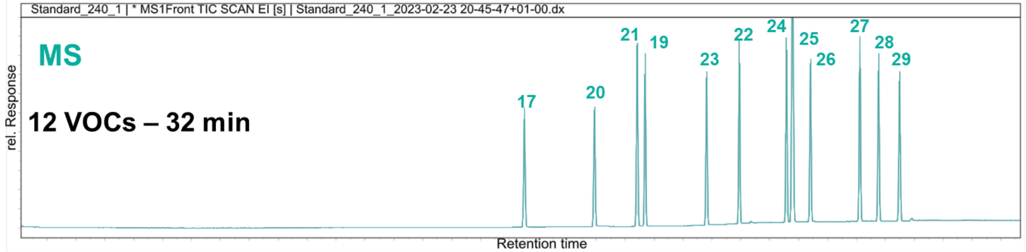
ACTRIS CiGas

OFF-LINE MONITORING

Automated analysis:
TD tubes, calibration standards, canisters

ON-LINE MONITORING





1 Ethane
2 Ethene
3 Propane
4 Propene
5 2-Methylpropane
6 n-Butane
7 Ethyne
8 1,3-Butadiene
9 But-1-ene
10 trans-but-2-ene
11 2-Methylbutane
12 n-Pentane
13 cis-but-2-ene
14 trans-pent-2-ene
15 Penta-1-ene
16 2-Methylpentane
17 n-Hexane
18 Isoprene
19 n-Heptane
20 Benzene
21 2,2,4-Trimethylpentane
22 n-Octane
23 Toluene
24 Ethylbenzene
25 m-Xylene + p-xylene
26 o-Xylene
27 1,3,5-Trimethylbenzene
28 1,2,4-Trimethylbenzene
29 1,2,3-Trimethylbenzene


Thank you
JÜLICH
FORSCHUNGSZENTRUM