# Quantifying Atmospheric ECVs

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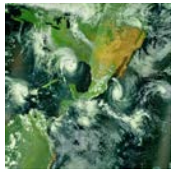
# Climate Change Initiative - Atmospheric ECVs

## Greenhouse Gases (GHGs – $CO_2$, $CH_4$)

Primary driver of Climate Change

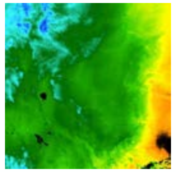
## Aerosols

Most uncertain climate forcing constituent



## Clouds

Cloud feedback in a changing climate is a major uncertainty of climate change predictions

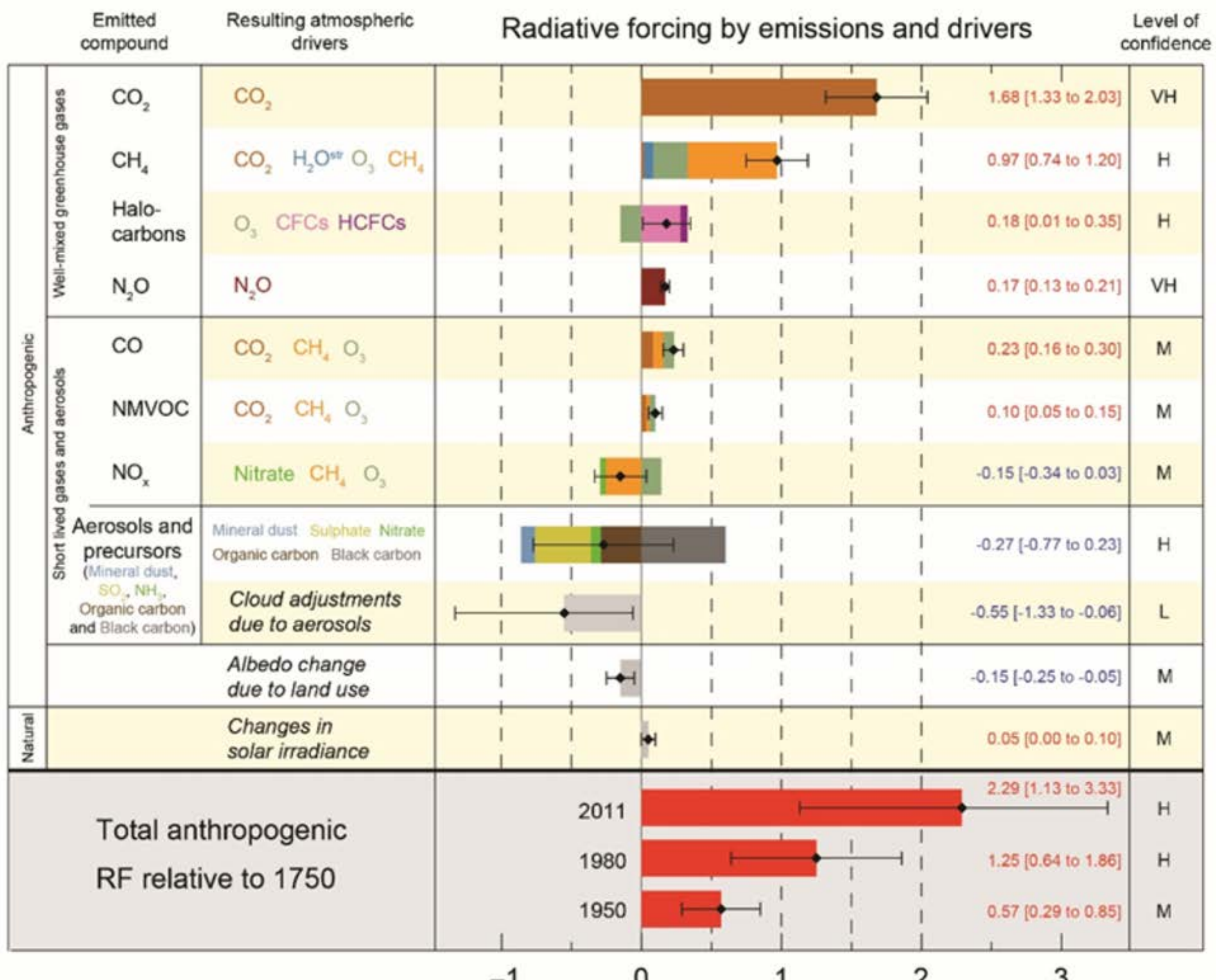


## Water Vapour

Strongest natural GHG. Critical for climate projections due to its positive feedback to $CO_2$-induced warming.

## Ozone

Our shield against harmful UV-radiation. Important to understand chemistry-climate interactions.




IPCC, AR5

# Science Questions

## Quantifying emissions

Can we using global satellite observations provide a detailed inventory of the natural and anthropogenic sources of greenhouse gases, which are the main drivers of the global warming?

## Role of particles

The contribution of aerosols to radiative forcing remains highly uncertain to complex counterbalancing effects of different particle types. Can we better characterise particles from space and help constraining their radiative effect?

## Feedbacks and interactions

The atmosphere is a complex environment. Forcing due to climate change induce many feedbacks, as a result of interactions involving a range of dynamical, chemical or microphysical processes. Can we, based on satelllite observations, track and identify such feedbacks and contribute to a better understanding of the climate system?

**Impact** Can we maintain and improve the impact of our research on the international scene? (e.g. IPCC)

# Observational challenges

**Understanding climate change requires long-term observations of high-quality, well-characterised uncertainty, and high stability.**

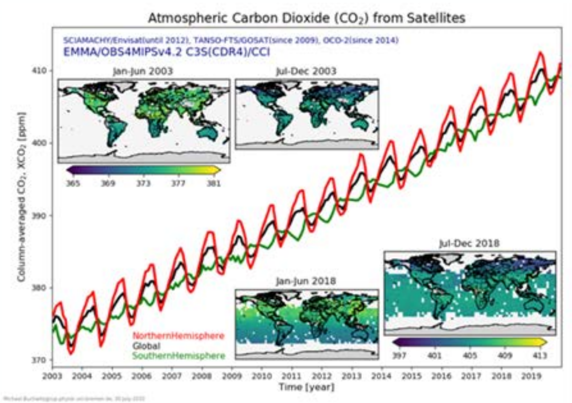
## Key challenges

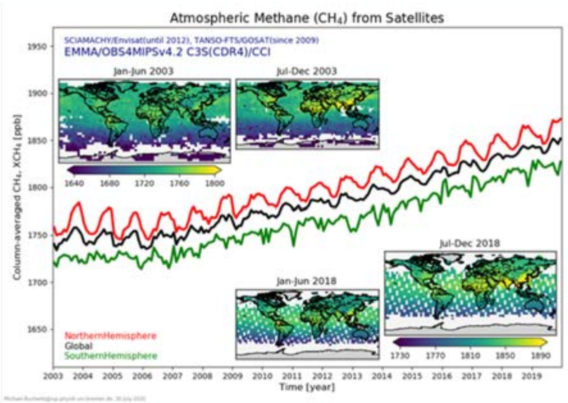
- How can we make sure that our observations reach the **accuracy, precision and stability** as defined by GCOS?
- Do observations reach a sufficient level of internal and mutual (across-ECV) **consistency**?
- Are we able to extract **all the needed variables** from satellite data?
- Do we account properly enough for the **3-dimensional nature** of the atmosphere?
- How can we improve the **sampling** of our satellite measurements, in particular the **temporal sampling** of the diurnal cycle?
- Can we build and maintain efficient links between **R&D** and **operational** processing?

# Greenhouse gases (GHG) – M. Buchwitz (IUP-B)

**Focus:** R&D to generate new $XCO_2$ and $XCH_4$ ECV products from OCO-2, Sentinel-5 Precursor (S5P), GOSAT-2 and TanSat

Past products from SCIAMACHY, GOSAT and IASI are generated operationally within C3S




## Highlight:

Oil & gas fields


Atmos. Chem. Phys., 20, 9169–9182, 2020
https://doi.org/10.5194/acp-20-9169-2020


Atmospheric Chemistry and Physics EGU

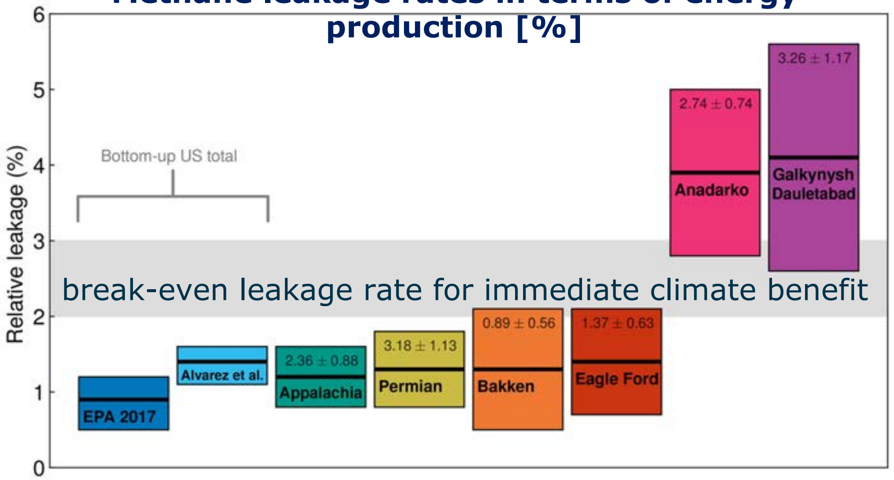
Schneising et al, ACP, 2020

**Remote sensing of methane leakage from natural gas and petroleum systems revisited**

**Oliver Schneising, Michael Buchwitz, Maximilian Reuter, Steffen Vanselow, Heinrich Bovensmann, and John P. Burrows**

Institute of Environmental Physics (IUP), University of Bremen FB1, Bremen, Germany

**Methane leakage rates in terms of energy production [%]**




Likely short-term climate benefit relative to coal?

No

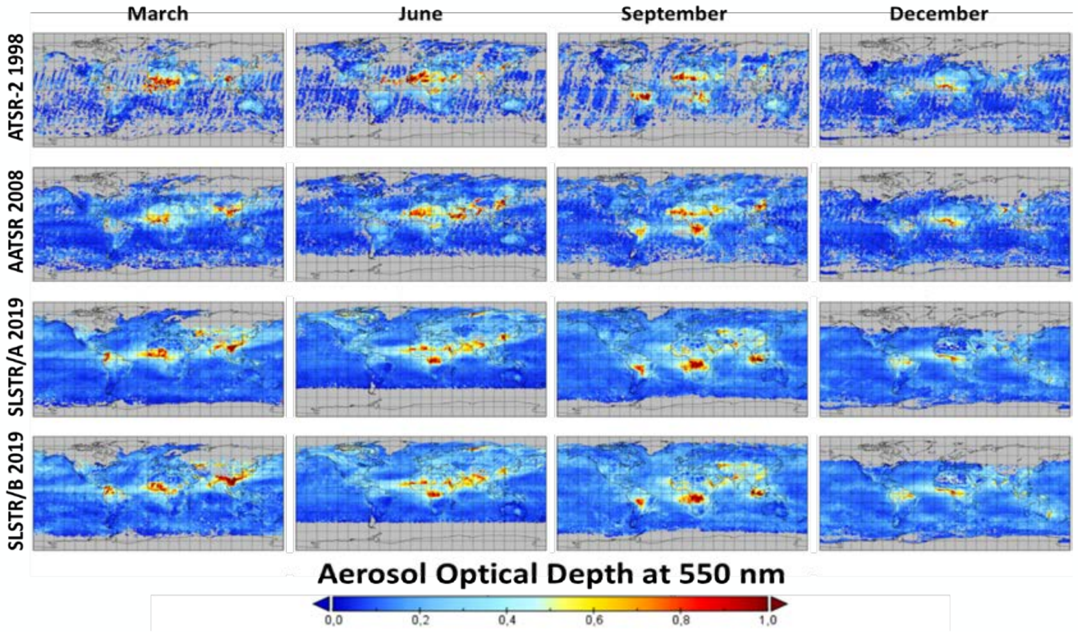
Yes

Universität Bremen · SRON Netherlands Institute for Space Research · University of Leicester · aeronomie.be · DLR · Max-Planck-Institut für Biogeochemie

# Aerosol properties – T. Popp (DLR)

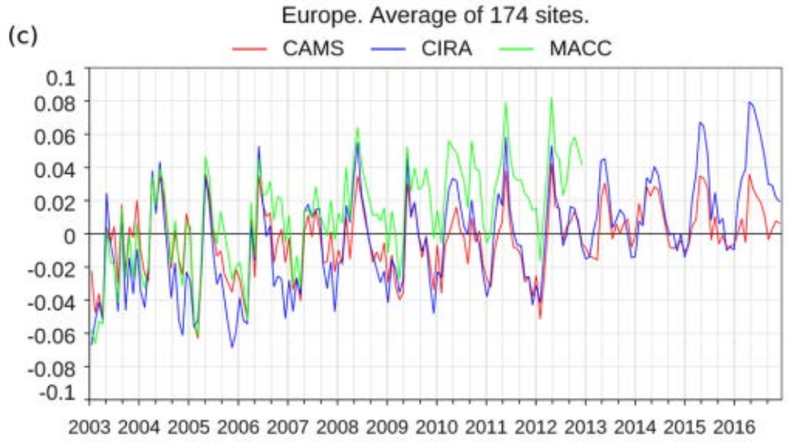
**Focus:** R&D to create consistent aerosol records (Total AOD, Fine Mode AOD) from **dual view sensors** (SLSTR, AATSR, ATSR-2)

A mature algorithm qualified in previous phase is further improved (reduced limitations, advanced uncertainties)

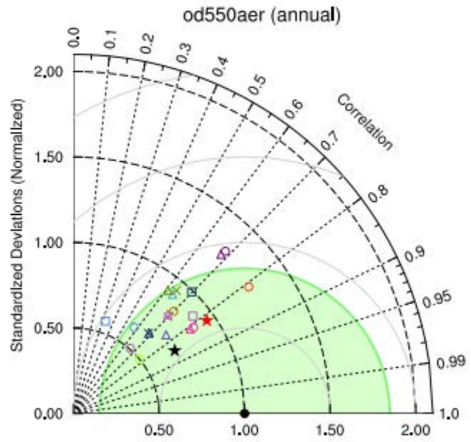



**Highlights:**

(1) CAMS AOD re-analysis confronted to AERONET (Inness et al., 2019)



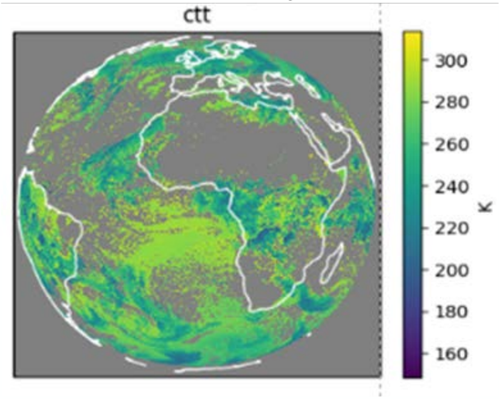

(2) Satellite AOD data used to benchmark CMIP-5 model (Lauer et al., 2017)



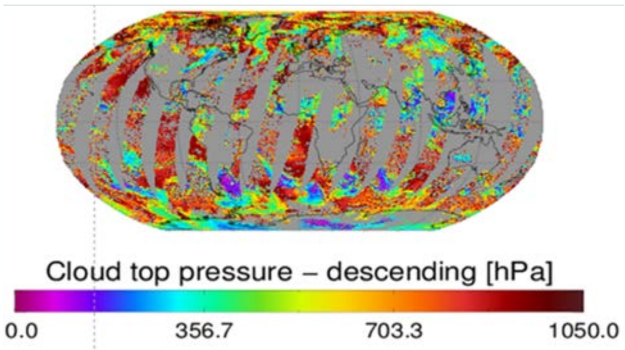
# Cloud properties – M. Stengel (DWD)

**Focus:** R&D to transfer and improve developments done for long-term datasets based on AVHRR-heritage information to the enhanced sensors SEVIRI and SLSTR making use of their enhanced temporal and spatial resolution as well as spectral information. Enhance consistency of cloud properties between GEO and LEO sensors.

SEVIRI example

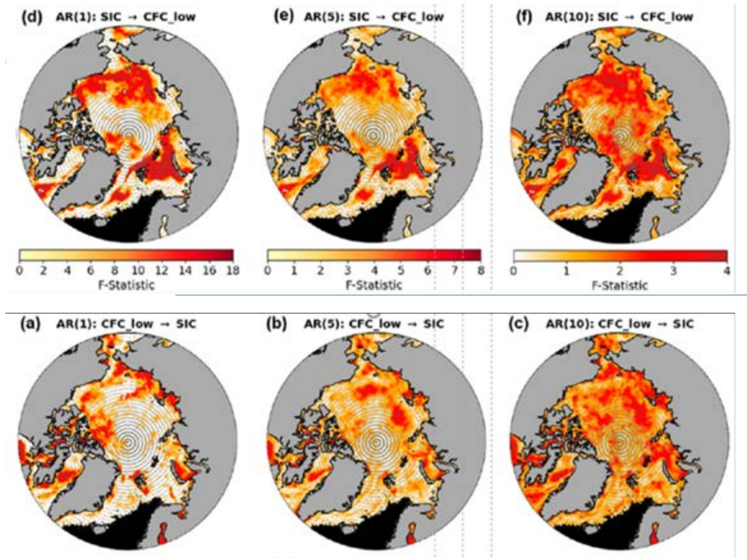



SLSTR example




**Highlight:**

Cloud_cci was able to reveal **strong evidence** for a **positive cloud – sea-ice feedback** in the **Arctic** with the capability to contribute to autumnal Arctic amplification




Less Arctic sea-ice
→ More low-level clouds

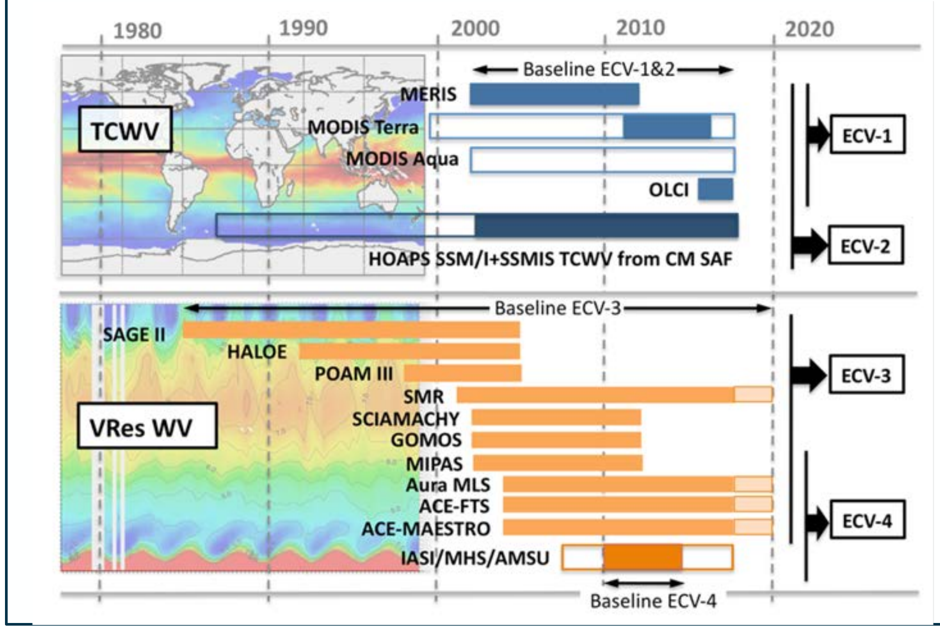
More low-level clouds
→ Less Arctic sea-ice

Philipp et al., J. Climate, 2020

# Water vapour – M. Hegglin (University of Reading)

**Focus:** to develop four new water vapour CDRs (total column and vertical distribution) using nadir and limb sensors.

New ECV in CCI+ → achievements to date: established user requirements, near-final data versions, uncertainty characterisation and validation.

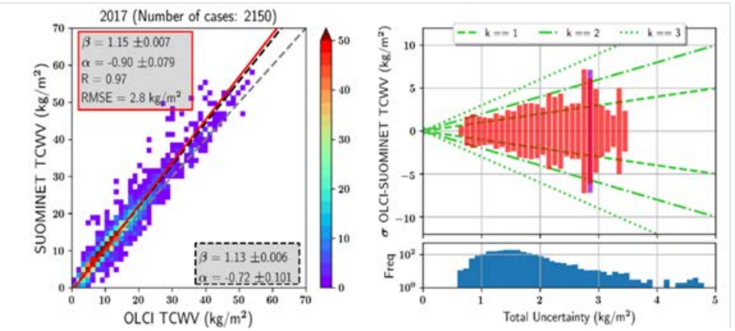



**Total Column Products**

**Vertically Resolved (Profile) Products** for stratosphere (2D) and upper troposphere/lower stratosphere (3D)

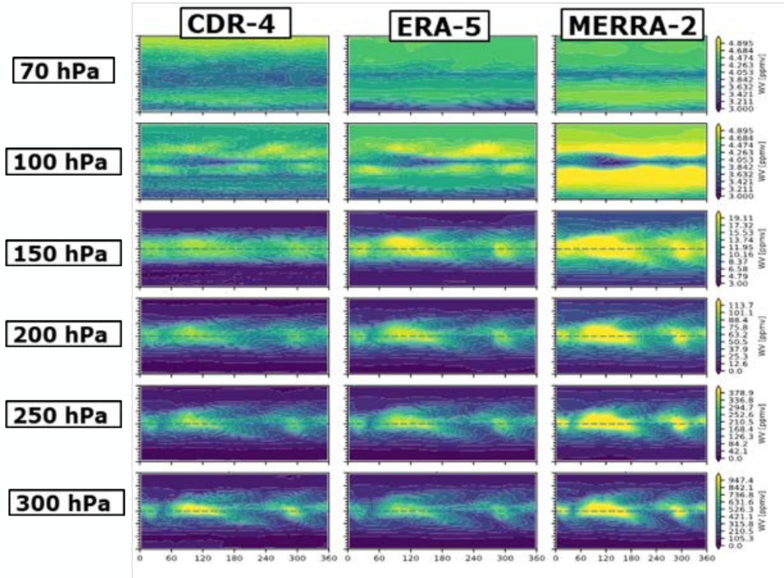
## Highlights:

TCWV, land coverage – CDR-1




CRD-1 validation using reference data from SuomiNet GNSS show good agreement.

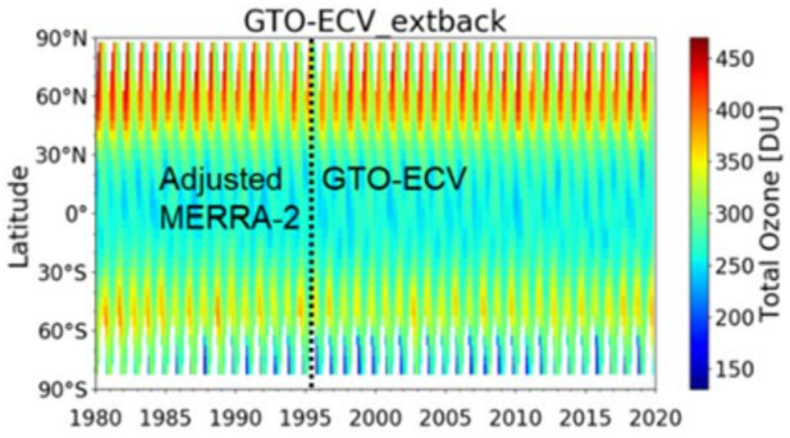
Comparison of CDR-4 with re-analyses exhibit the large uncertainties in our knowledge of water vapour in the upper troposphere /lower stratosphere.



# Ozone ($O_3$) – M. Van Roozendael (BIRA-IASB)

**Focus:** R&D to improve ozone data products operationally generated in C3S, with a focus on (1) adding new sensors (S5P, Metop-C), (2) extend existing CDRs backward in time, and (3) improve the accuracy of profile data products

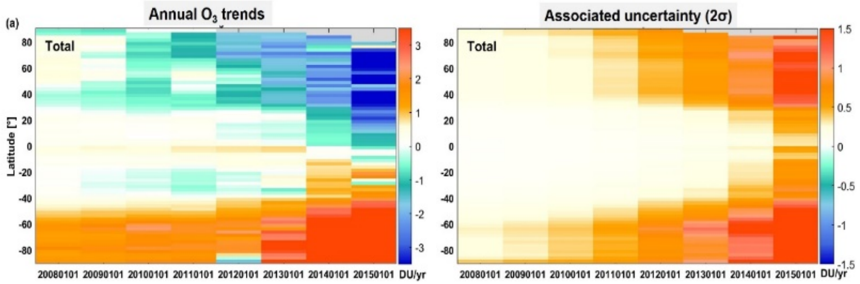
Example: extension of GTO-ECV CDR to early 1980 (pre-ozone-hole) by merging of European and NASA CDRs



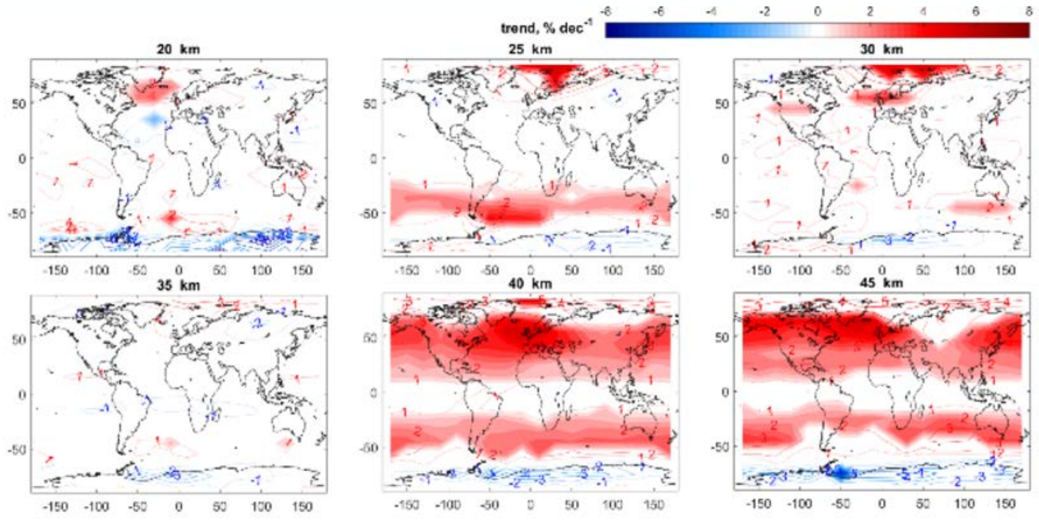

**Highlights:**

*Wespes et al., ACP, 2019*

Acceleration of the $O_3$ recovery detected by IASI




Regional trends in $O_3$ indicating changes in large scale circulation



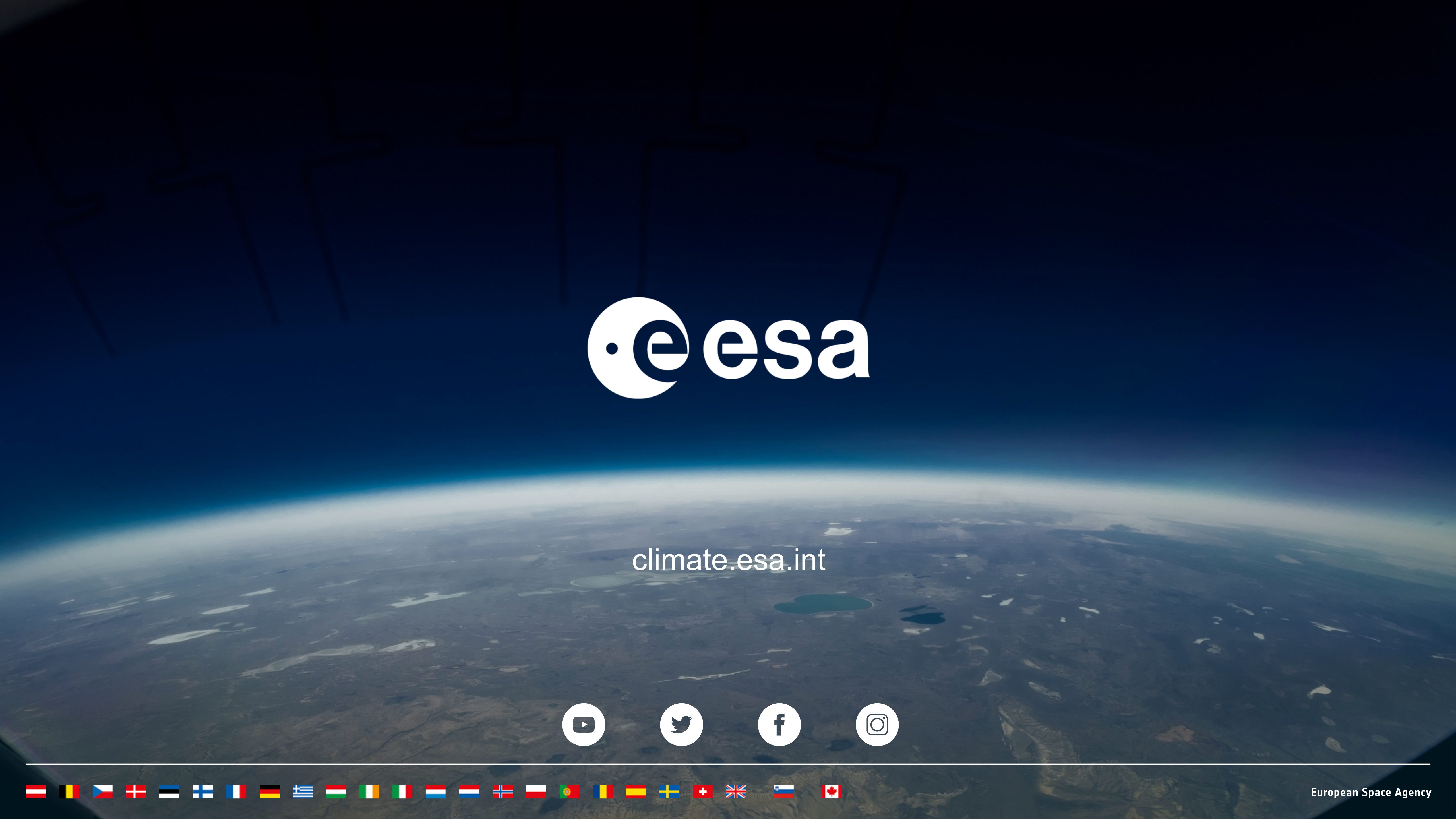

*Sofieva et al., ACP, 2020*

# Links and inter-connections

- **Radiative budget:** connects all atmospheric ECVs, e.g. GHGs warm the planet while aerosols cool it. The cooling induced by aerosols is itself adjusted due to cloud/aerosol interactions.
- **Chemistry:** aerosol and ozone concentrations are modulated by chemical reactions involving common precursors ($NO_x$, VOCs, CO, $NH_3$)
- **Microphysics:** water vapour, aerosol, clouds are directly linked through microphysical processes
- **Retrieval:** retrievals used for different ECVs have some common aspects. E.g. cloud masks (aerosol/cloud/water vapour), or aerosol corrections used in trace gas retrievals (GHG, ozone).
- **Earth system cycles:** Energy budget/balance, Carbon and Water cycles connect many ECVs. All-CCI consistency paper led by science leads of Aerosol, Water vapor and Cloud CCI projects.

# Priorities for CCI+ Phase-2

- Focus on generating ECV products relevant to the Paris Agreement, e.g. CO2 and CH4 from emission hot spots (in support to NDC)
- Exploit and/or prepare the exploitation of new sensors such as the future atmospheric Sentinels (including $CO_2$-M) and the latest Geo sensors as part of advanced Geo-ring constellation (GOES16/17, MSG/MTG, Kompsat, Himawari)
- Better use inter-sensor synergies to produce new value-added products (e.g. based on new multi-instrumented platforms combining imagers and spectral measurements)
- Continue and further develop R&D to improve existing CDRs (accuracy, resolution, time-covering, sampling, stability) against GCOS requirements and consolidate uncertainty propagation. This also implies the development of innovative retrieval approaches (e.g. using machine learning)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