CAIRT mission and possible synergies with IASI-NG

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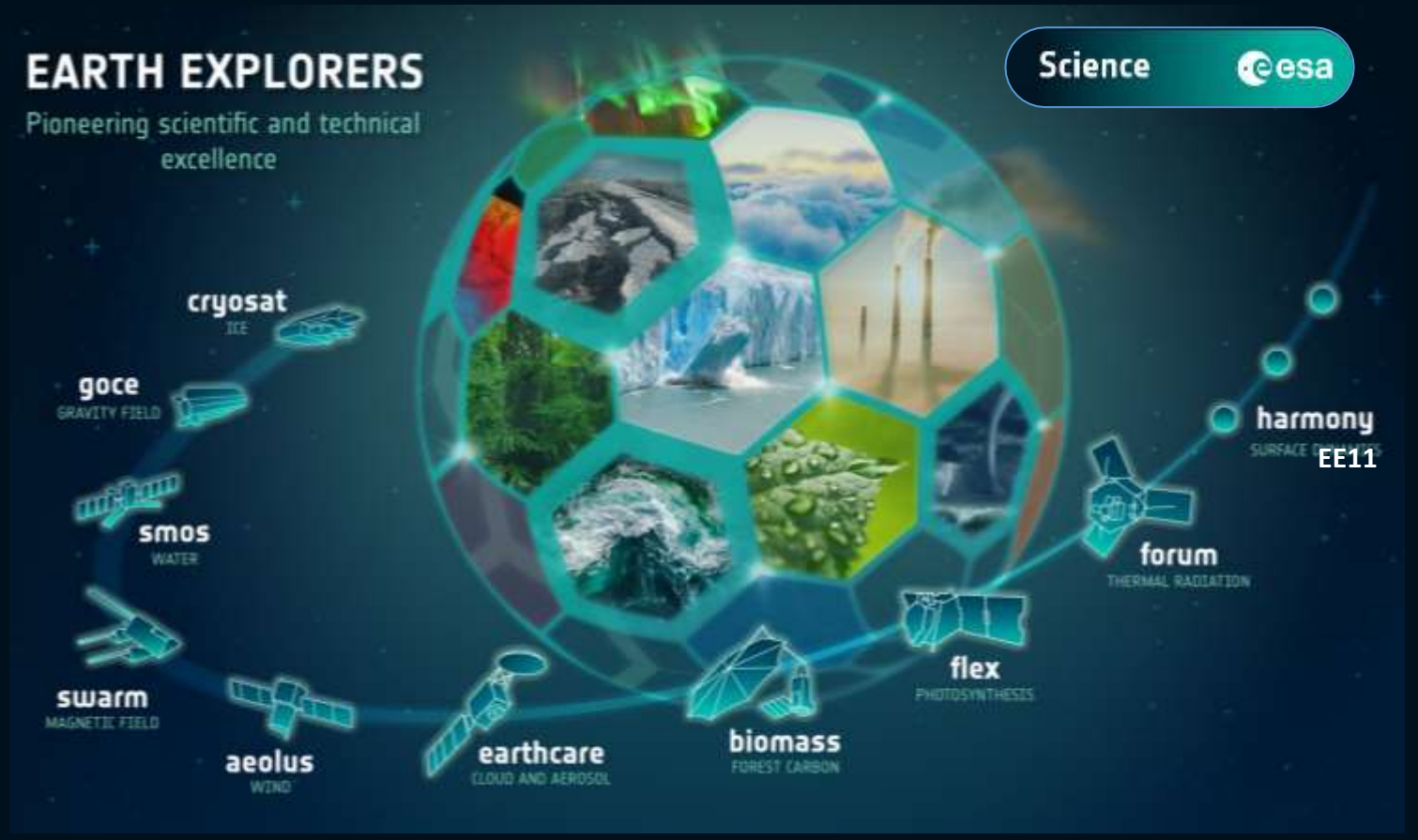
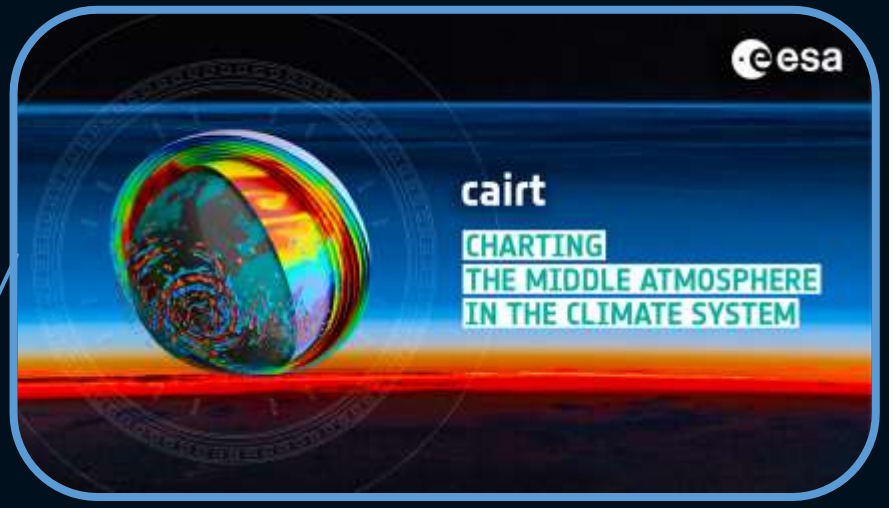
Earth Explorer 11 mission candidates

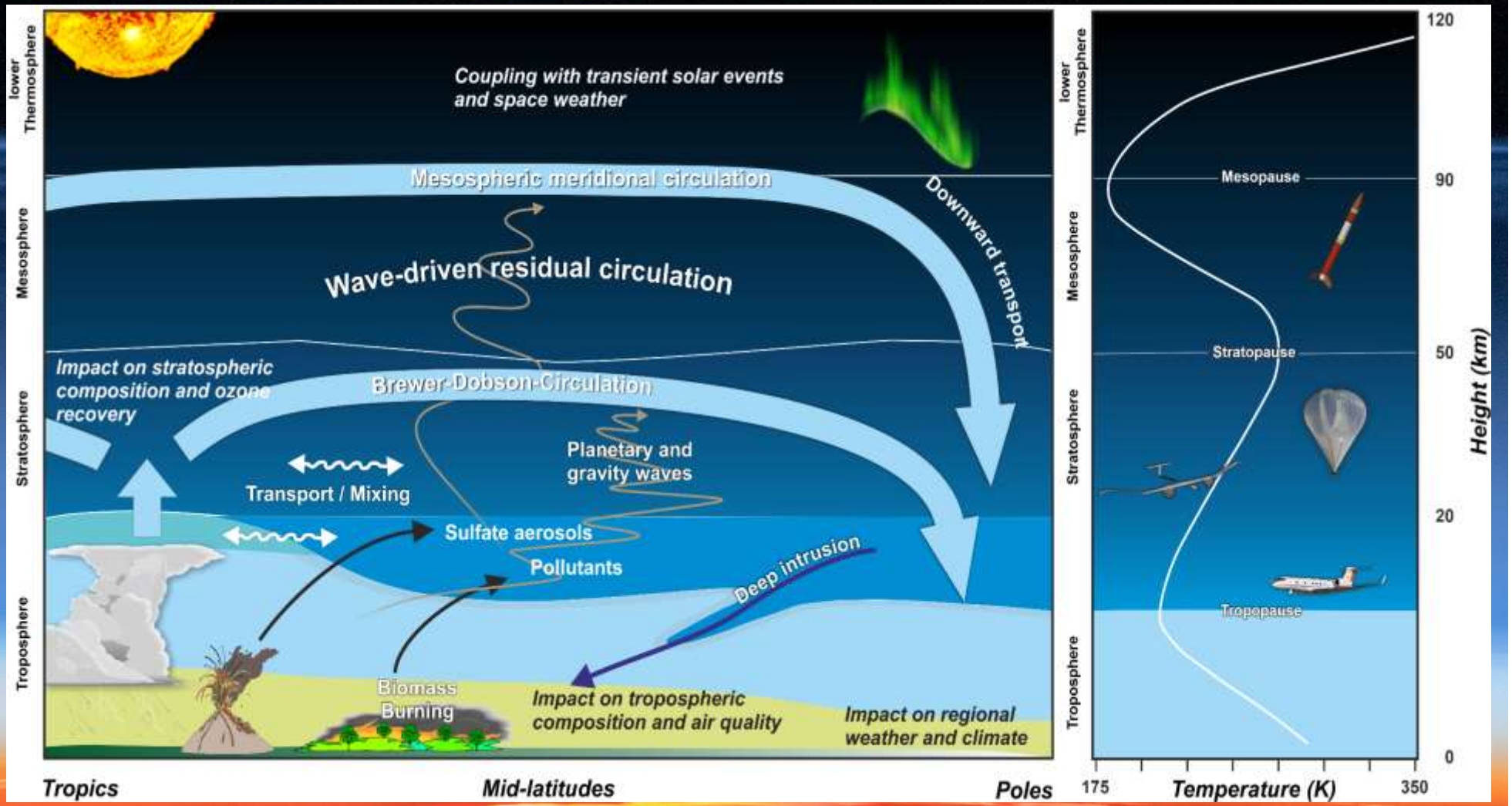




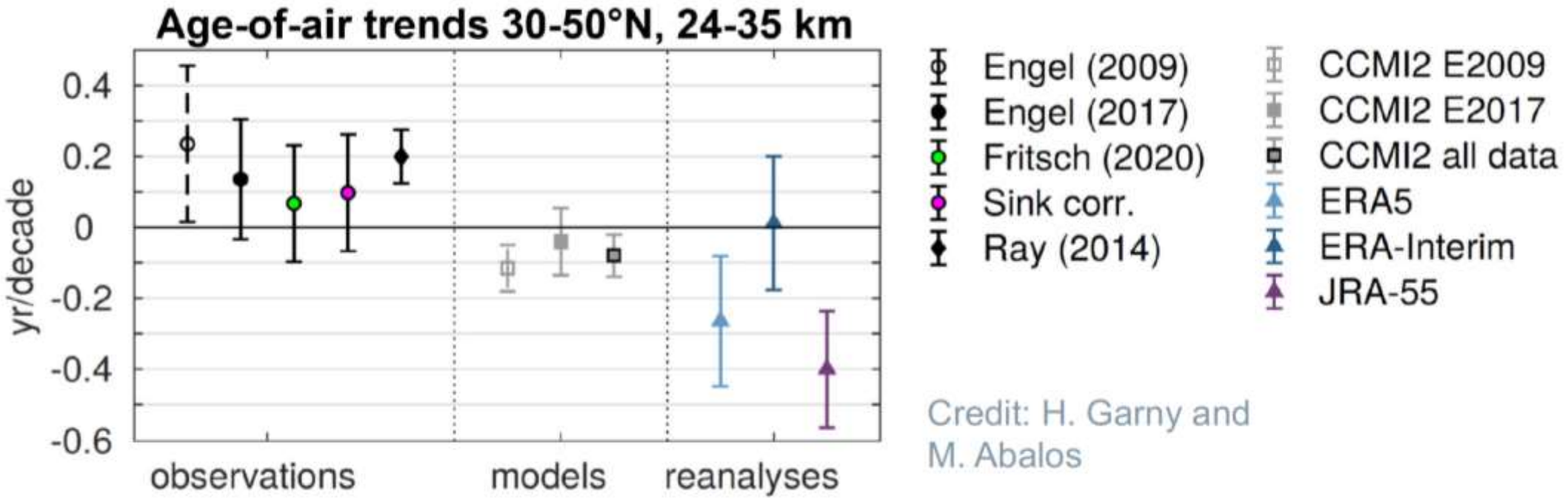
CAIRT is currently in Phase A
User Consultation Meeting in July 2025, followed by ACEO (**Advisory Committee for Earth Observation**) recommendations

The middle atmosphere in the climate system

- **How is the middle atmosphere circulation changing?**
- What is the wave driving of the circulation?
- What is the coupling with the upper atmosphere?
- What is the input by biomass burning and volcanic eruptions?
- What is the coupling between composition, circulation and climate?



The need to better constrain circulation and age of air

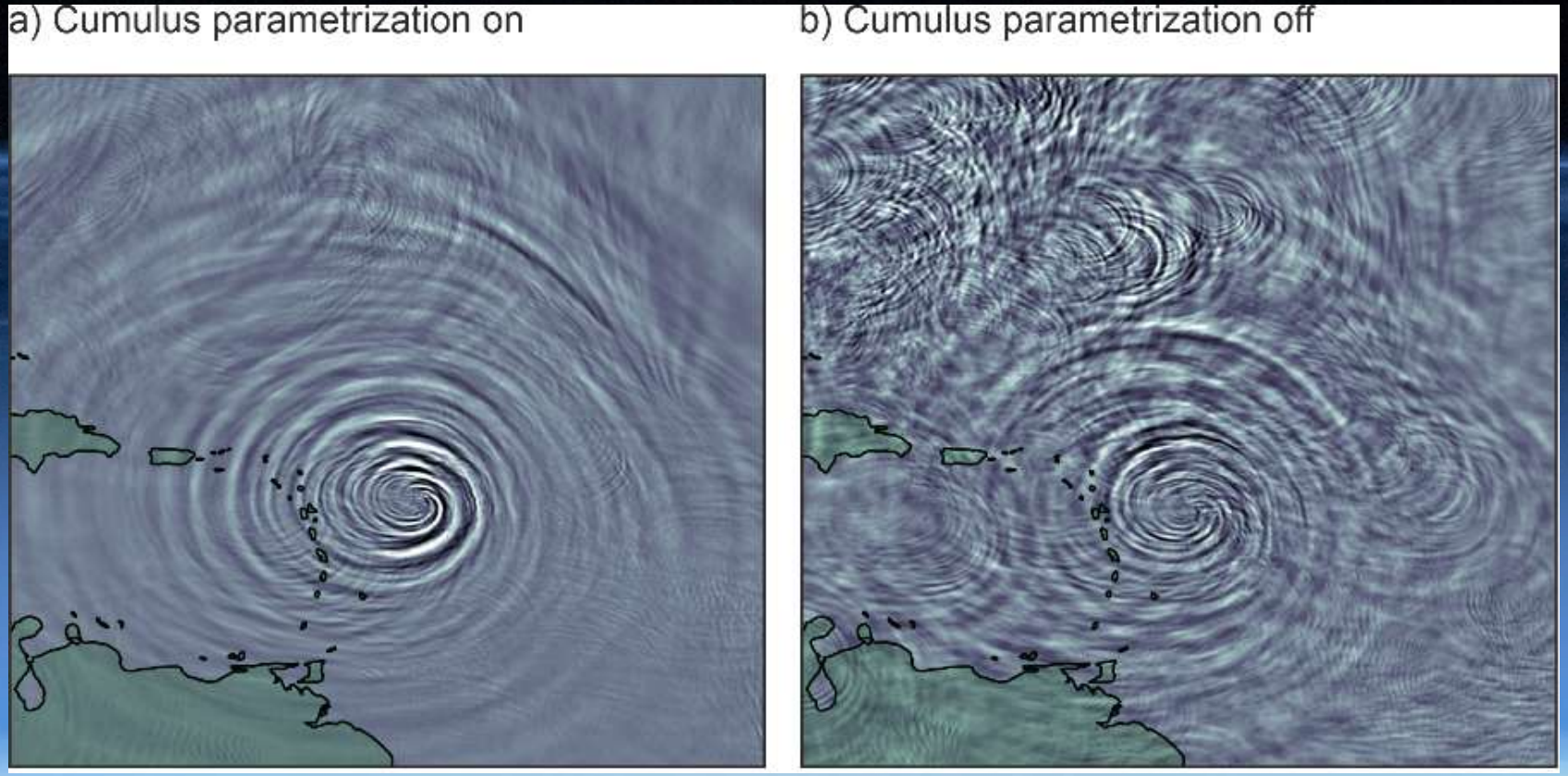


Changes in middle atmosphere circulation and age-of-air will have profound implications for:

- Surface climate
- Stratospheric ozone recovery
- Lifetime of greenhouse gases such as CH_4, N_2O and CFCs

CAIRT will provide age-of-air at scales of O(100 km) and with uncertainty (≤0.5 years) globally, available to date only through in-situ observations with very limited coverage

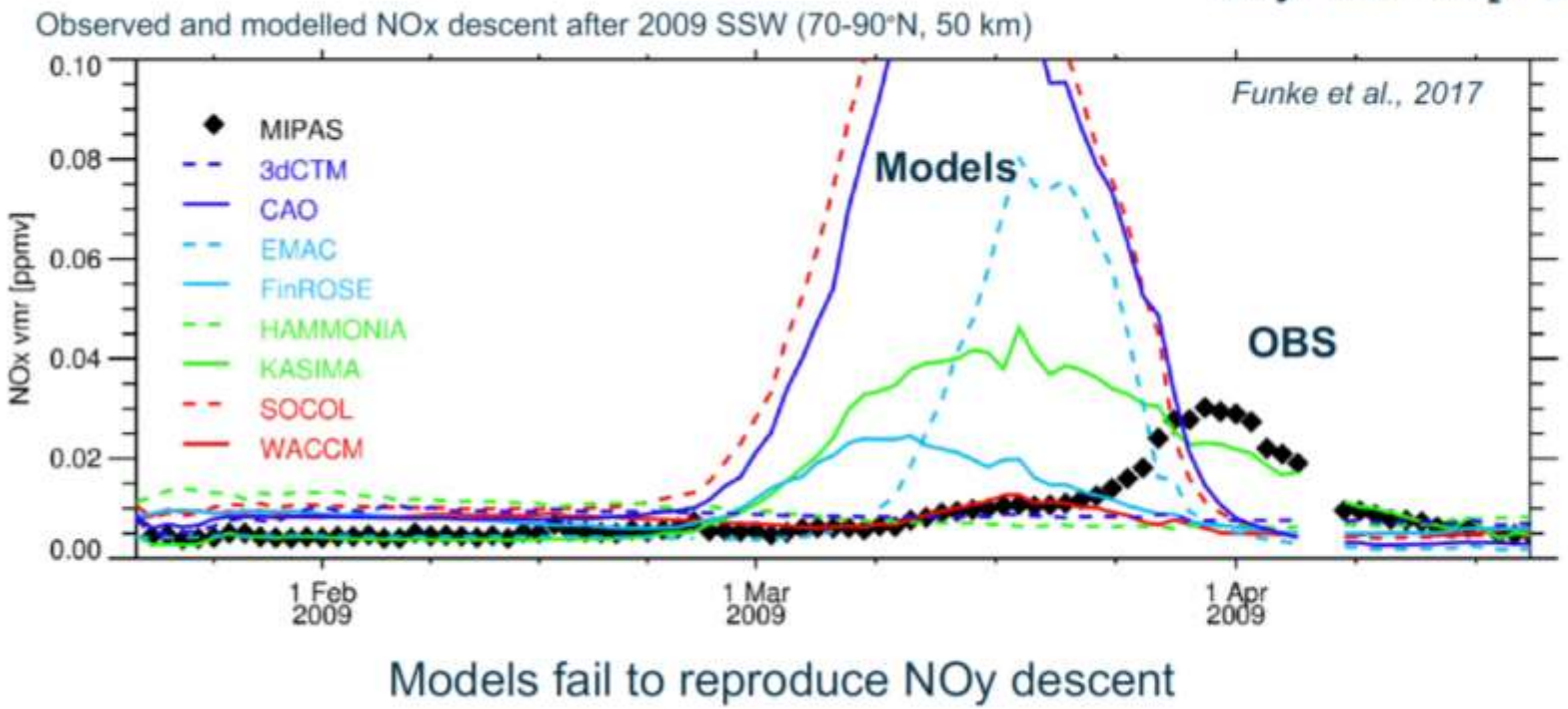
The need to better constrain gravity waves, driving the circulation



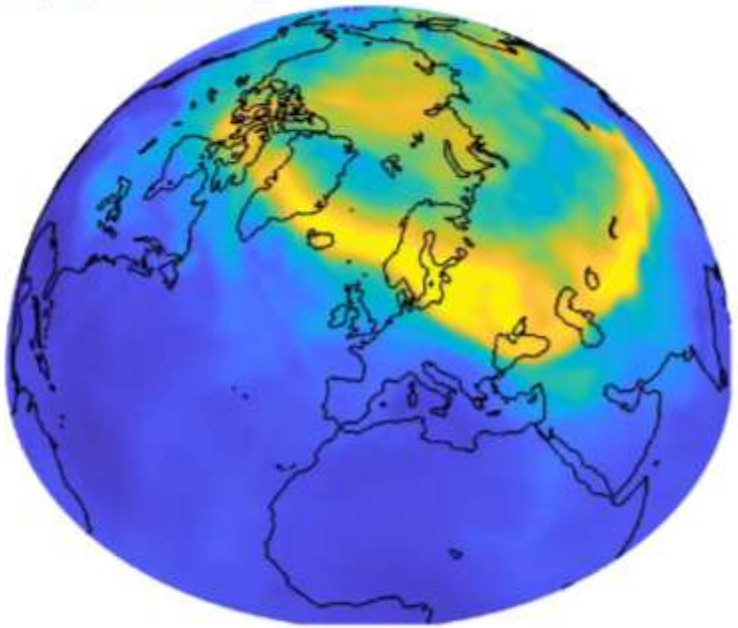
CAIRT will resolve gravity waves (momentum flux, phase speed, and direction) to test high-resolution models and to guide model development

The need to observe NOy throughout the atmosphere

$NOy = NO + NO_2 + HNO_3 + 2\,N_2O_5 + ClONO_2$



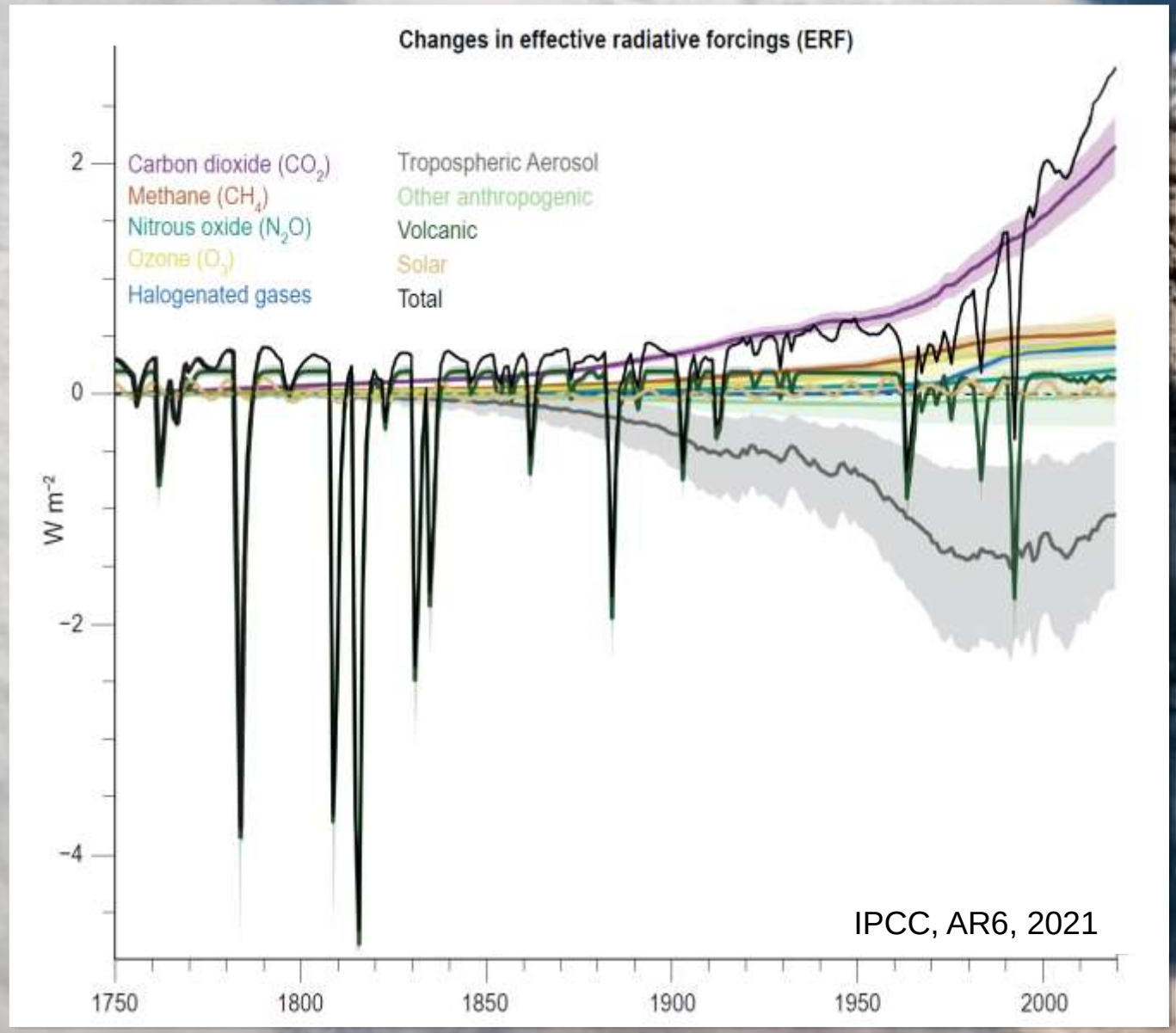
Models fail to reproduce NOy descent



Lack of spatially NOy observations in the mesosphere and lower stratosphere

CAIRT will provide spatially resolved measurements of reactive nitrogen (NOy) from the lower thermosphere down to the stratosphere

The need to better constrain aerosols and sulfur budget

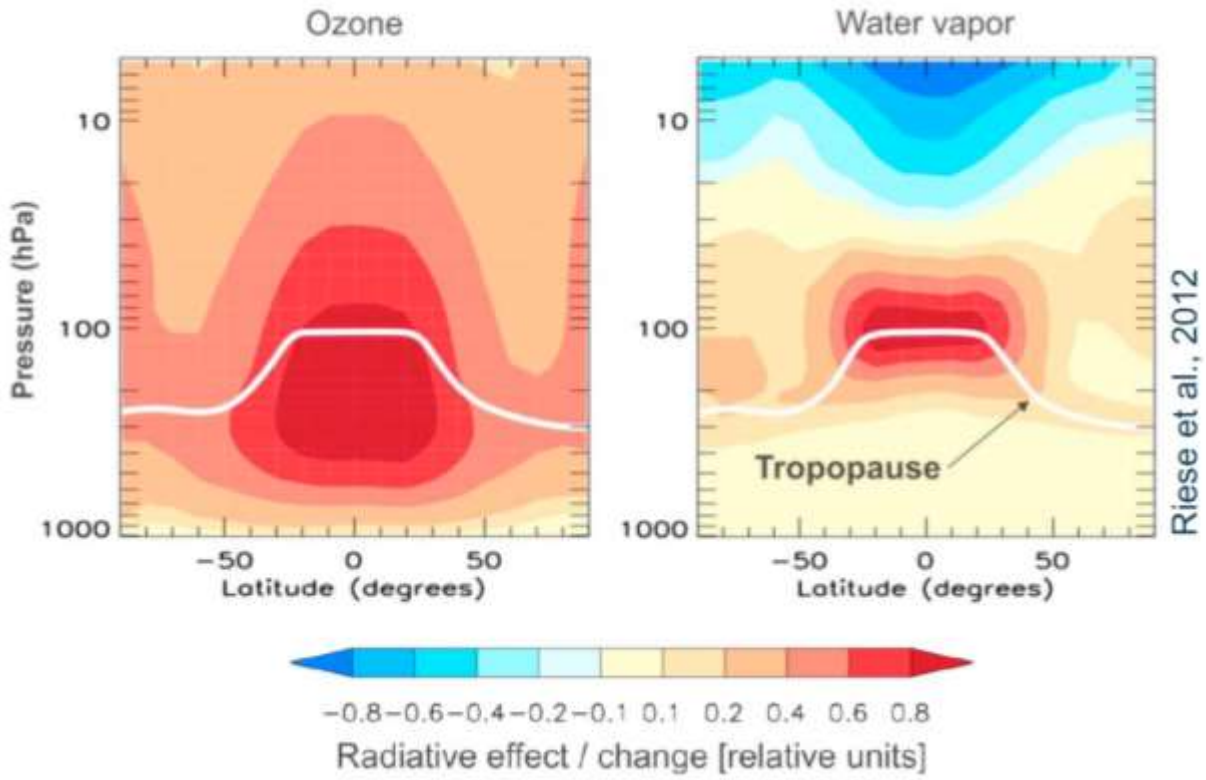


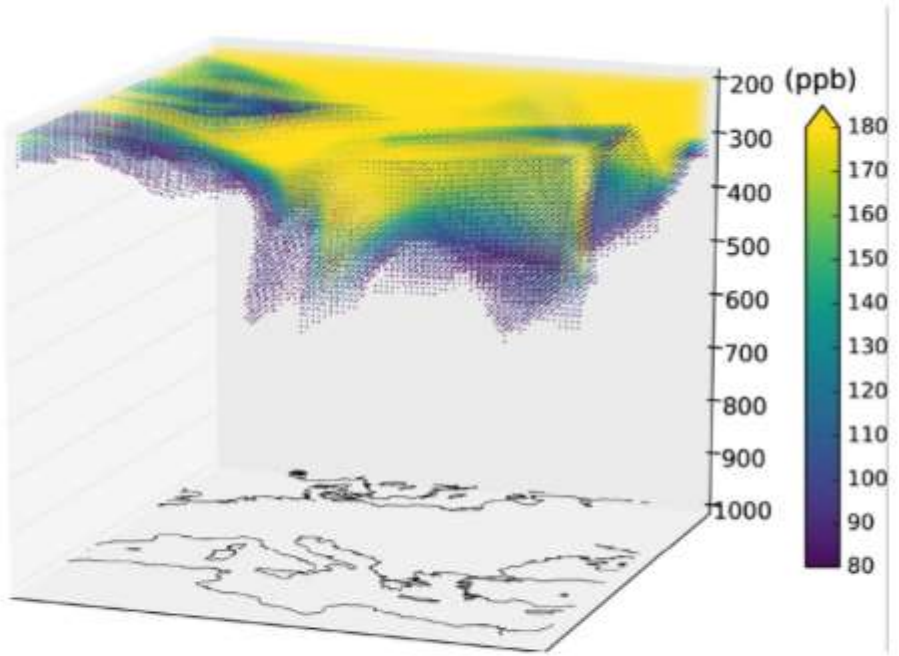
Dimming of solar radiation by stratospheric aerosols following volcanic eruptions can dominate climate forcing

There is a need to better understand the constantly changing background of stratospheric aerosols

CAIRT prepares us to detect possible climate engineering

The need to resolve gradients and fluxes in the UTLS

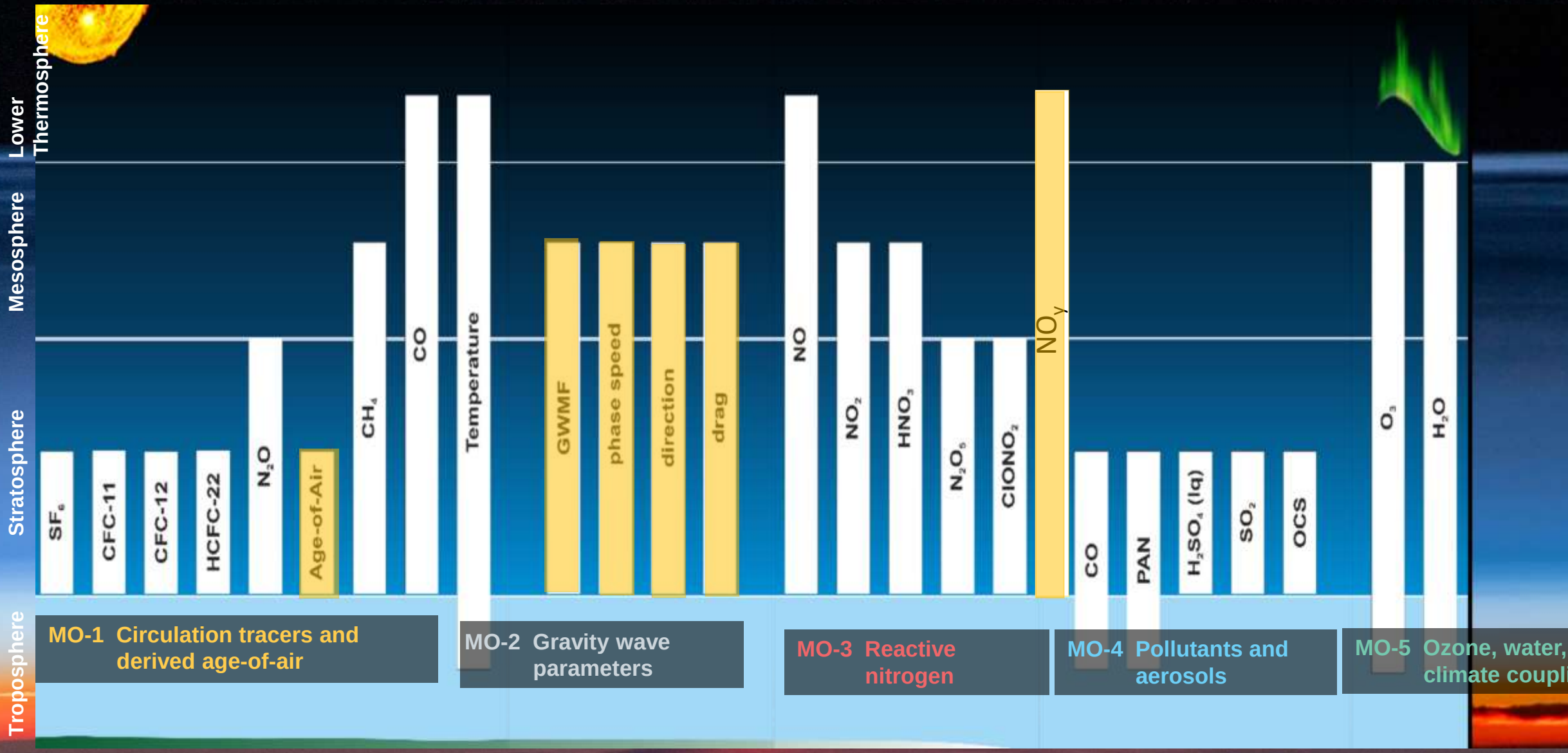




CAMS ozone during tropopause fold
Akritidis et al., ACP, 2018

CAIRT will resolve the flux of climate relevant gases like ozone and water vapour across the tropopause

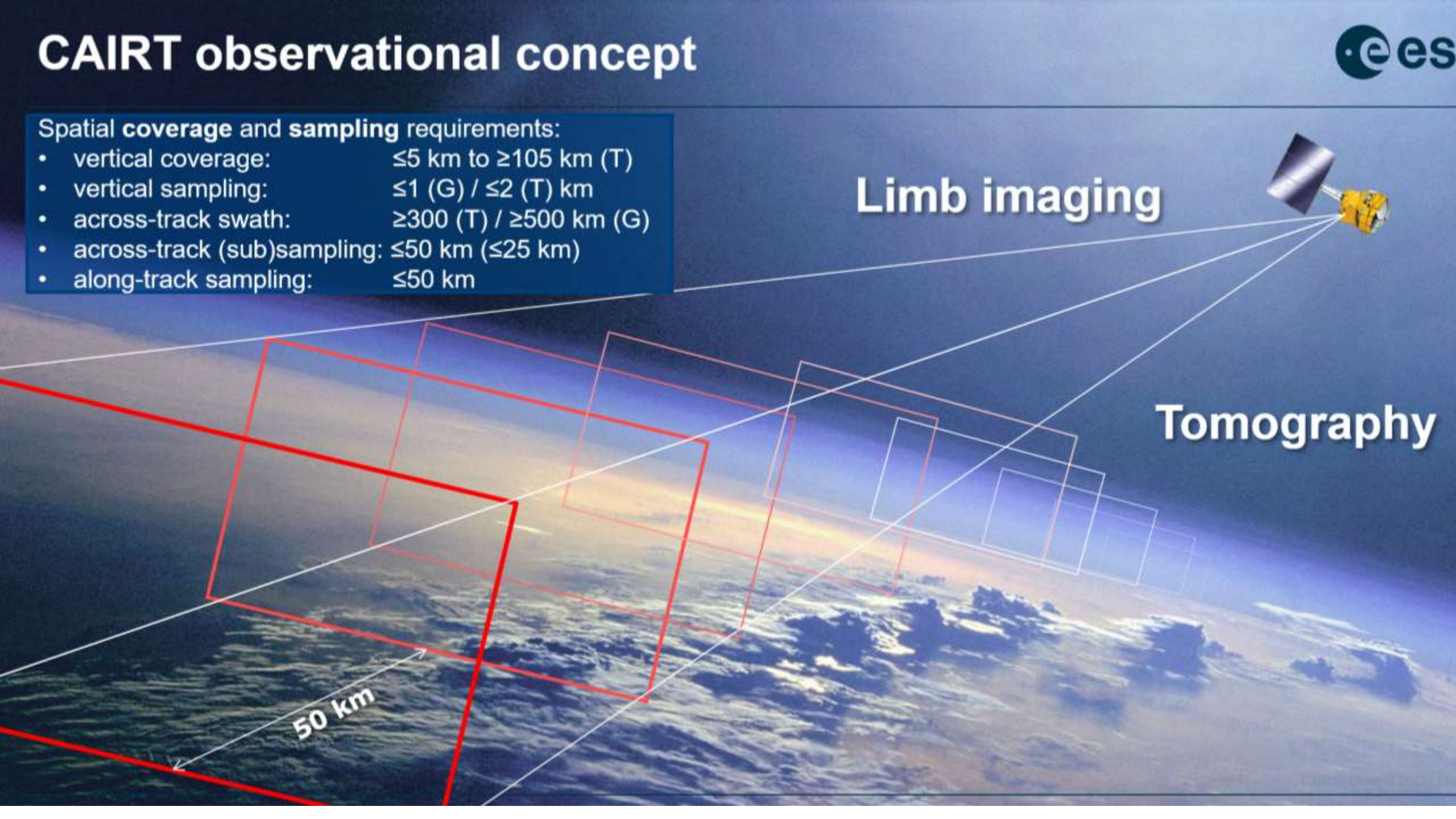
CAIRT primary observational data products



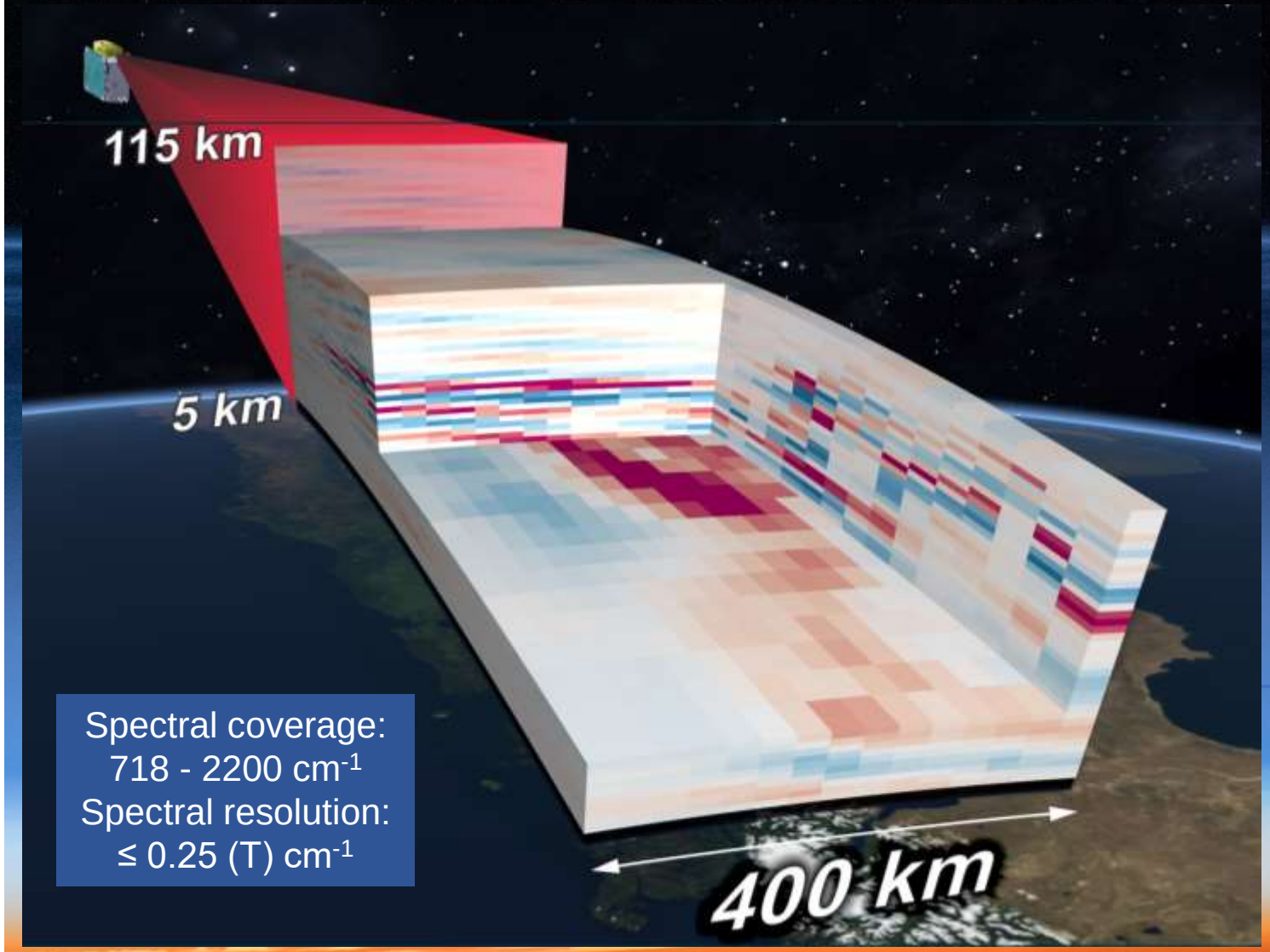
CAIRT observational concept

Spatial **coverage** and **sampling** requirements:

- vertical coverage: ≤5 km to ≥105 km (T)
- vertical sampling: ≤1 (G) / ≤2 (T) km
- across-track swath: ≥300 (T) / ≥500 km (G)
- across-track (sub)sampling: ≤50 km (≤25 km)
- along-track sampling: ≤50 km

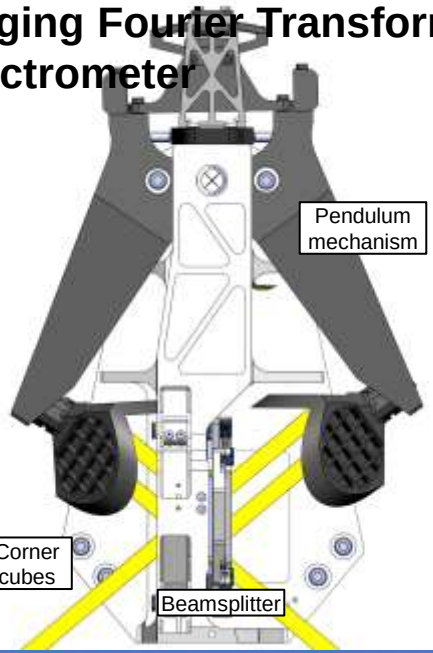


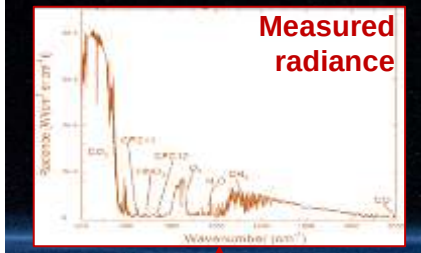
Observing principle and measurement technique



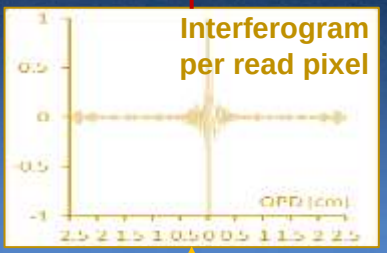
Spectral coverage:
718 - 2200 cm^{-1}
Spectral resolution:
≤ 0.25 (T) cm^{-1}

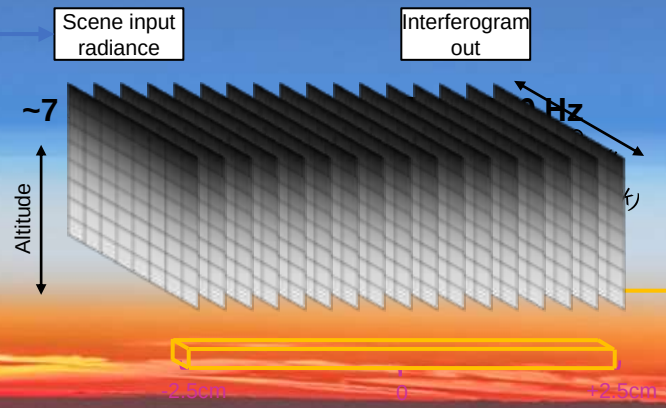
imaging Fourier Transform Spectrometer



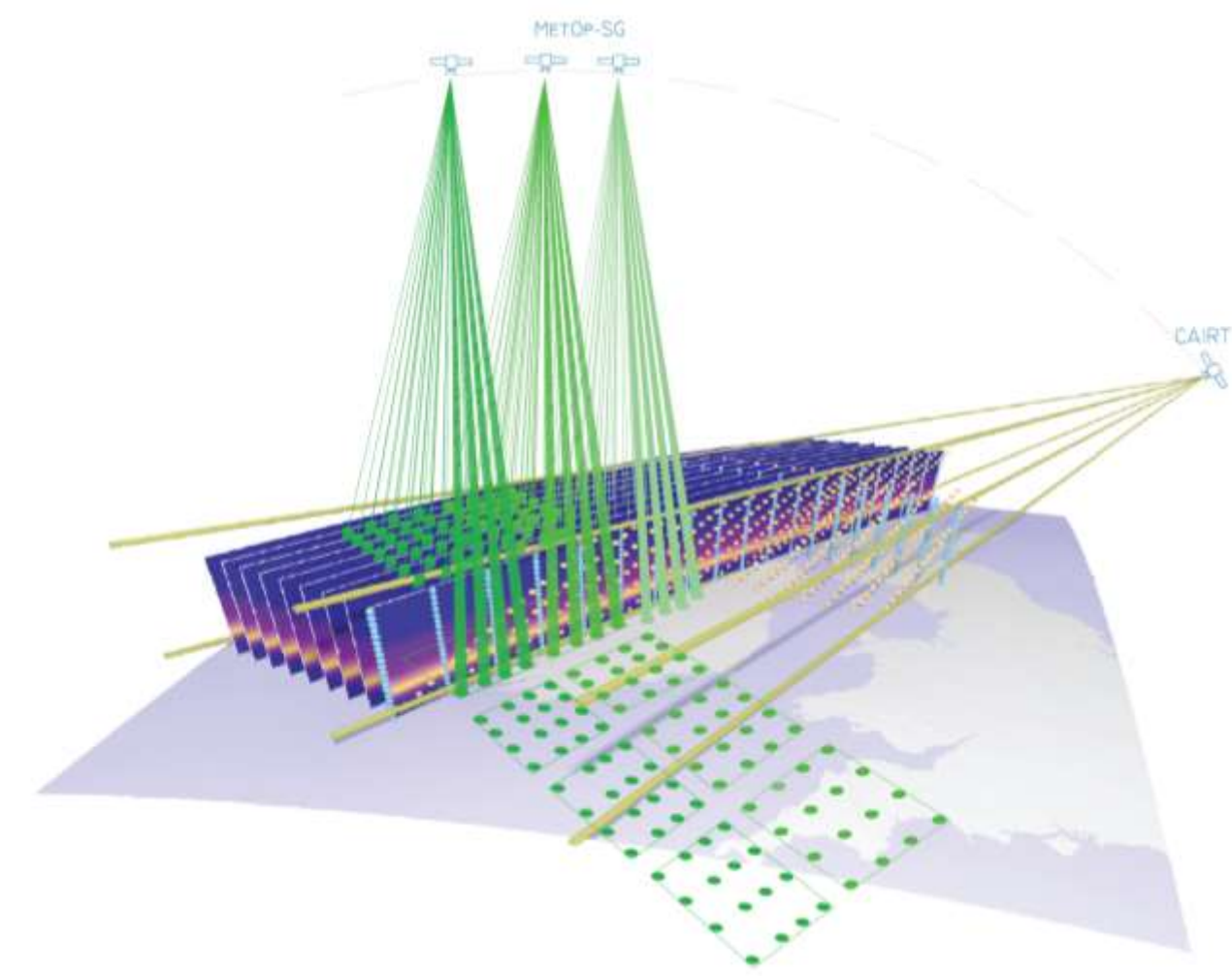


Fourier Transform & calibration





CAIRT in loose-formation with MetOp-SG-A



Concurrent limb and nadir (from MetOp-SG-A) viewing allows to extend CAIRT measurements to the lower troposphere, to further constrain the horizontal variability and to exploit the synergy.

Among the different nadir instruments on MetOp-SG, IASI-NG assumes a special role for CAIRT since they have very similar characteristics.

Comparison between CAIRT and IASI-NG

Requirements	CAIRT	IASI-NG
Spectral range	718 cm^{-1} - 2200 cm^{-1}	645 -2760 cm^{-1}
Spectral sampling	0.2 cm^{-1} [goal: 0.1 cm^{-1}]	0.125 cm^{-1}
Spectral resolution (FWHM of ISRF)	0.4 cm-1 [goal 0.2 cm-1] after apodisation	0.25 cm^{-1} after apodisation

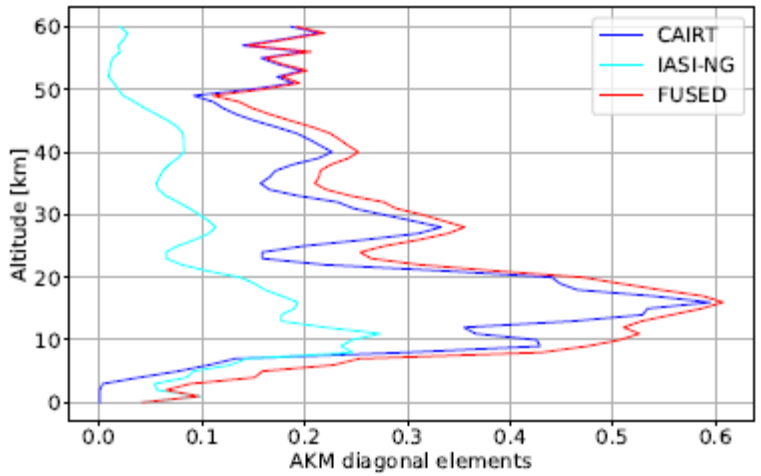
Possible advantages of the synergy

A rigorous approach has been finalised to assess the impact of the synergy between CAIRT and IASI-NG measurements with Complete Data Fusion (CDF) technique extended to 2D.

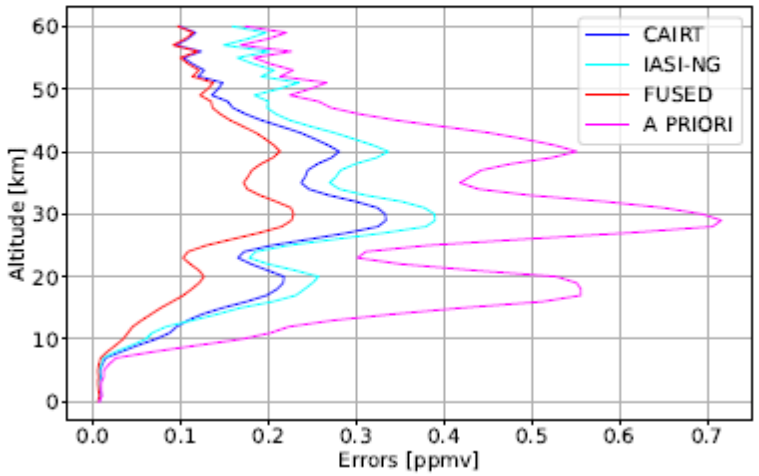
See poster S10-38
Tirelli et al.

Characteristics of Ozone profile for single instruments and combined one

Spatial resolution



Noise + smoothing error

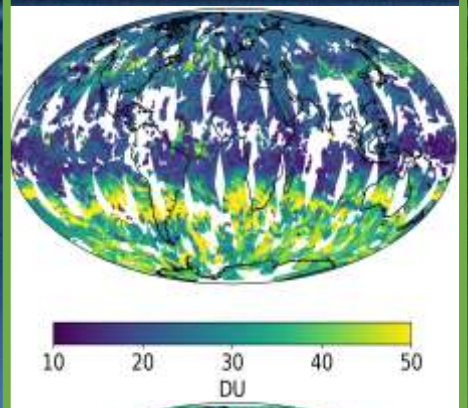
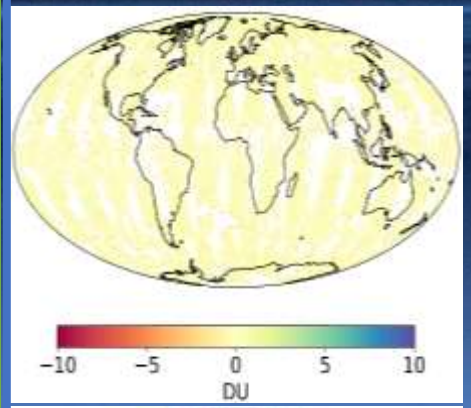
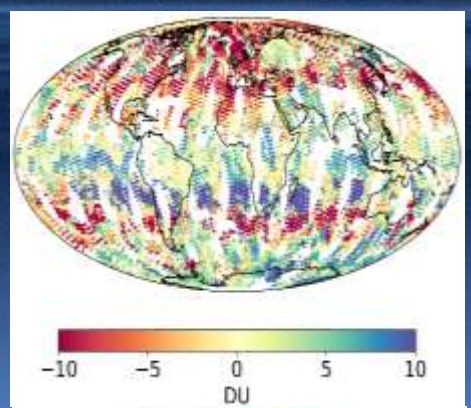
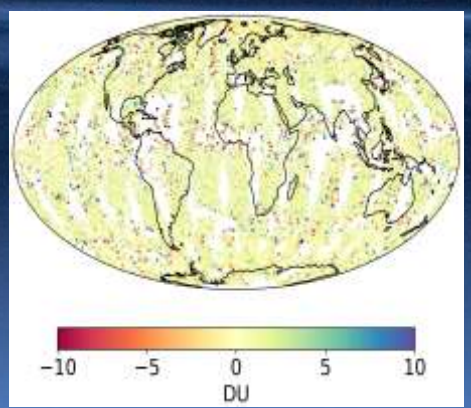
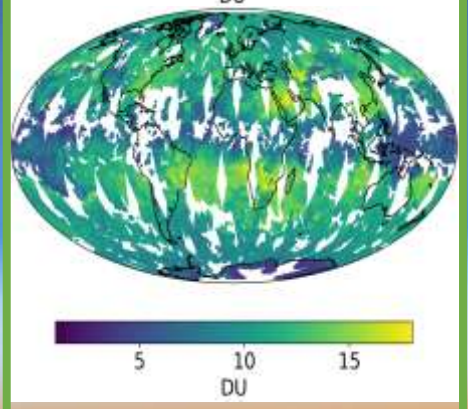
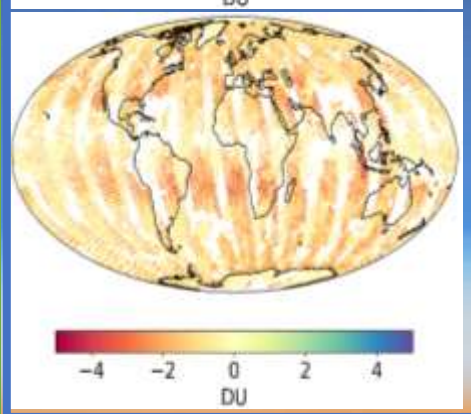
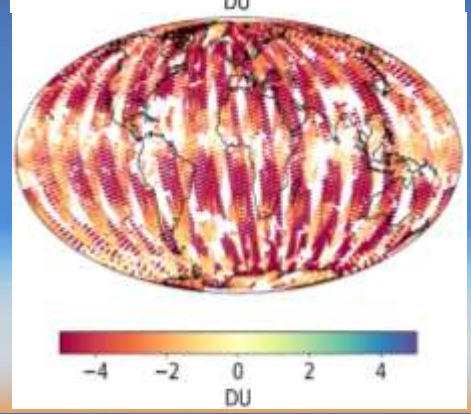


The result of the combination of CAIRT and IASI-NG is characterised by profiles with better spatial resolution and a smaller total (noise + smoothing) error

Impact of the synergy on Ozone partial column in the UTLS and in the lower troposphere

model

Difference: observation - model ($x_{retrieved} - x_{true}$)

ozone	CAIRT + IASI-NG + Sentinel-5	IASI-NG + Sentinel-5	CAIRT only
			
			no CAIRT-only observations in lower troposphere

Partial column: UTLS

Partial column: 0 – 5 km

More accurate UTLS and tropospheric ozone columns are obtained with the combination of CAIRT, IASI-NG and Sentinel 5

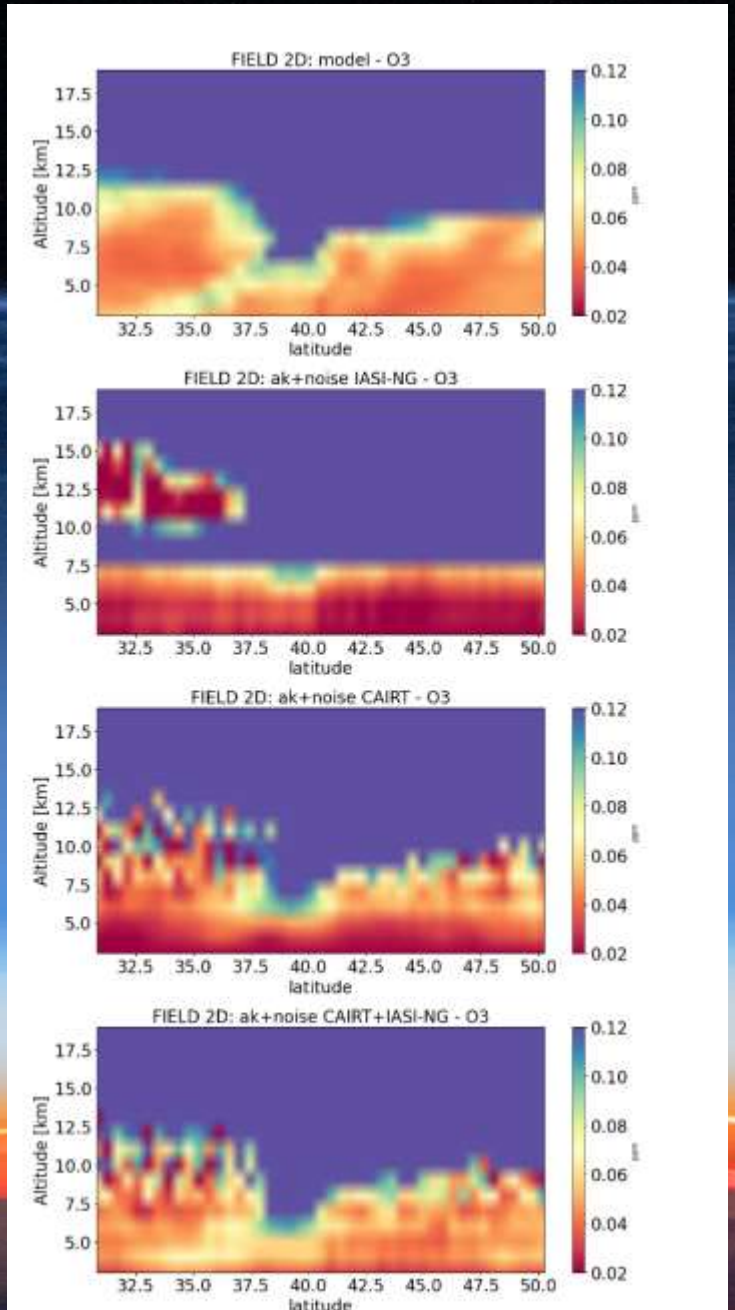
Resolving stratospheric intrusion (in clear sky conditions)

O3 CAMS model sampled at CAIRT grid – 15 Dec 2021

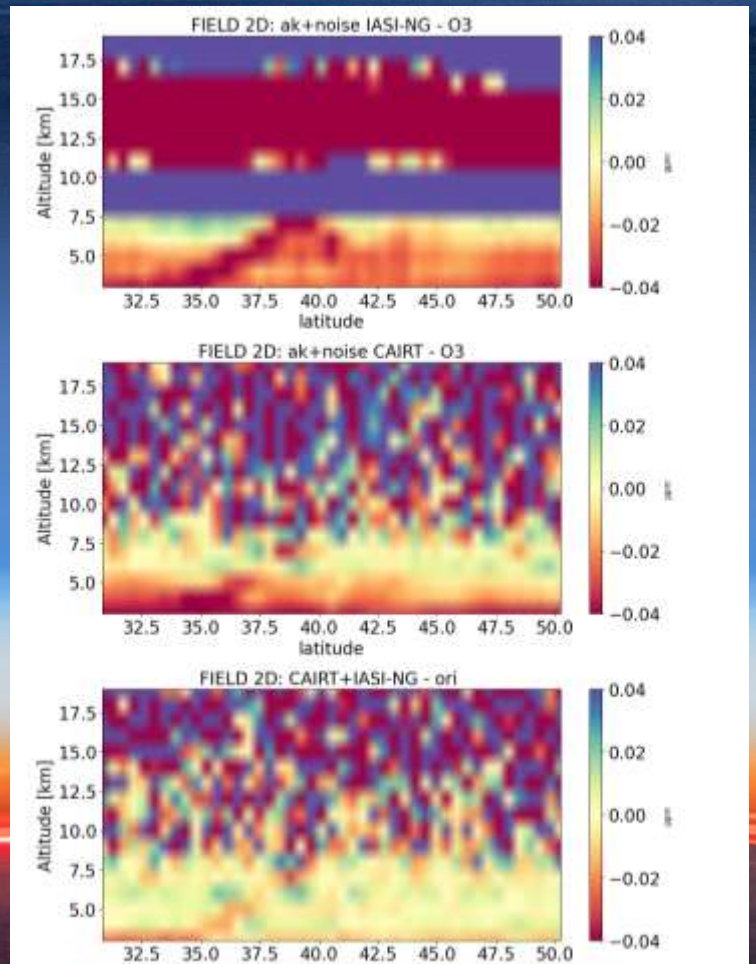
IASI-NG+ S5

CAIRT

CAIRT + IASI-NG+ S5



Difference: observation - model ($x_{retrieved} - x_{true}$)



In clear sky conditions, the combination of CAIRT, IASI-NG and Sentinel 5 measurements allows to resolve the stratospheric ozone reaching the lower troposphere

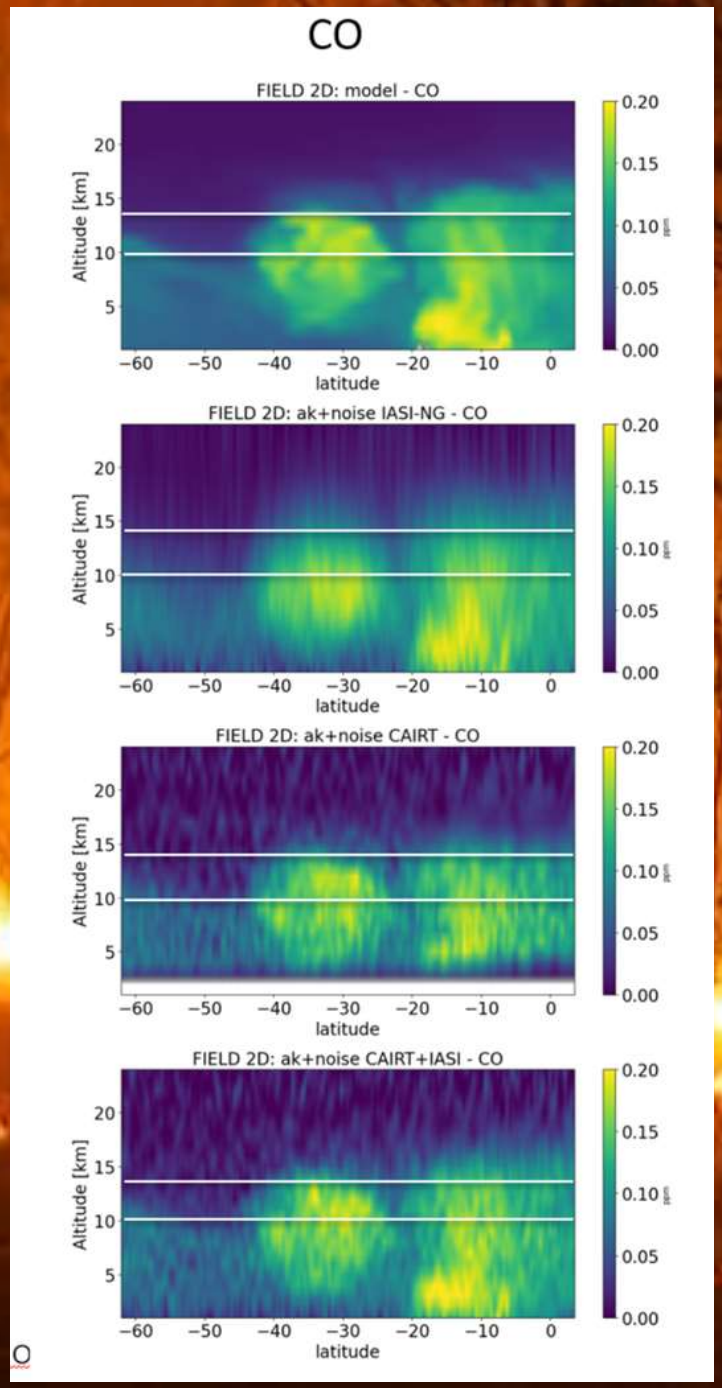
Biomass burning: CO

Model

IASI-NG

CAIRT

CAIRT +
IASI-NG



IASI-NG brings information on the total column amount and emission at the surface

CAIRT brings information mainly on the altitude of the plume

The combination of CAIRT and IASI-NG measurements allows to monitor emission and transport of pollution plumes

CAIRT – Community Engagement

Online survey

You are kindly invited to participate to the survey

More information:

www.cairt.eu