CAIRT

The Changing-Atmosphere Infra-Red Tomography Explorer

An Earth Explorer 11 candidate

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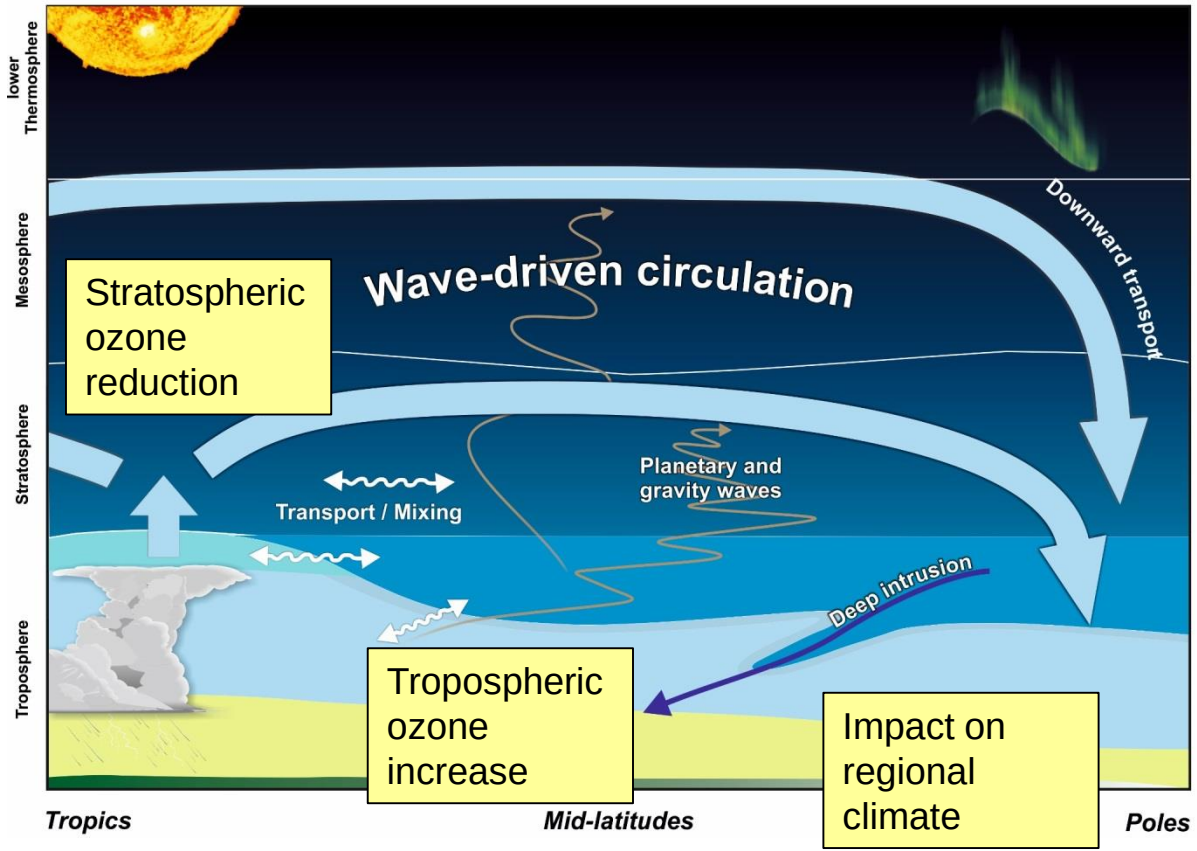
Circulation, composition and regional climate change

CAIRT



Evidence for profound changes in

- Atmospheric circulation
- Wave driving
- Transport and mixing
- Impact on
  - atmospheric composition
  - surface climate

ARTICLES
https://doi.org/10.1038/s41561-019-0456-x
nature geoscience

Australian hot and dry extremes induced by weakenings of the stratospheric polar vortex

Eun-Pa Lim[1*], Harry H. Hendon[1], Ghyslaine Boschat[2,3], Debra Hudson[1], David W. J. Thompson[4], Andrew J. Dowdy[1] and Julie M. Arblaster[2,3,5]

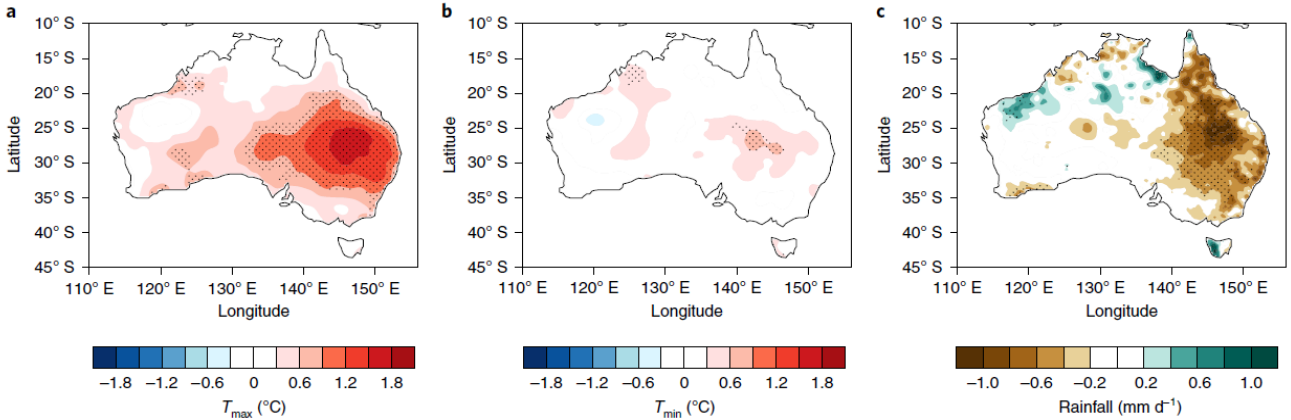


Photo: worldweatherattribution.org

The 2019/20 Australian wildfires generated a persistent smoke-charged vortex rising up to 35 km altitude

COMMUNICATIONS EARTH&ENVIRONMENT

https://doi.org/10.1038/s43247-020-00022-5

Sergey Khaykin[1✉], Bernard Legras[2], Silvia Bucci[2], Pasquale Sellitto[3], Lars Isaksen[4], Florent Tencé[1], Slimane Bekki[1], Adam Bourassa[5], Landon Rieger[5], Daniel Zawada[5], Julien Jumelet[1] & Sophie Godin-Beekmann[1]

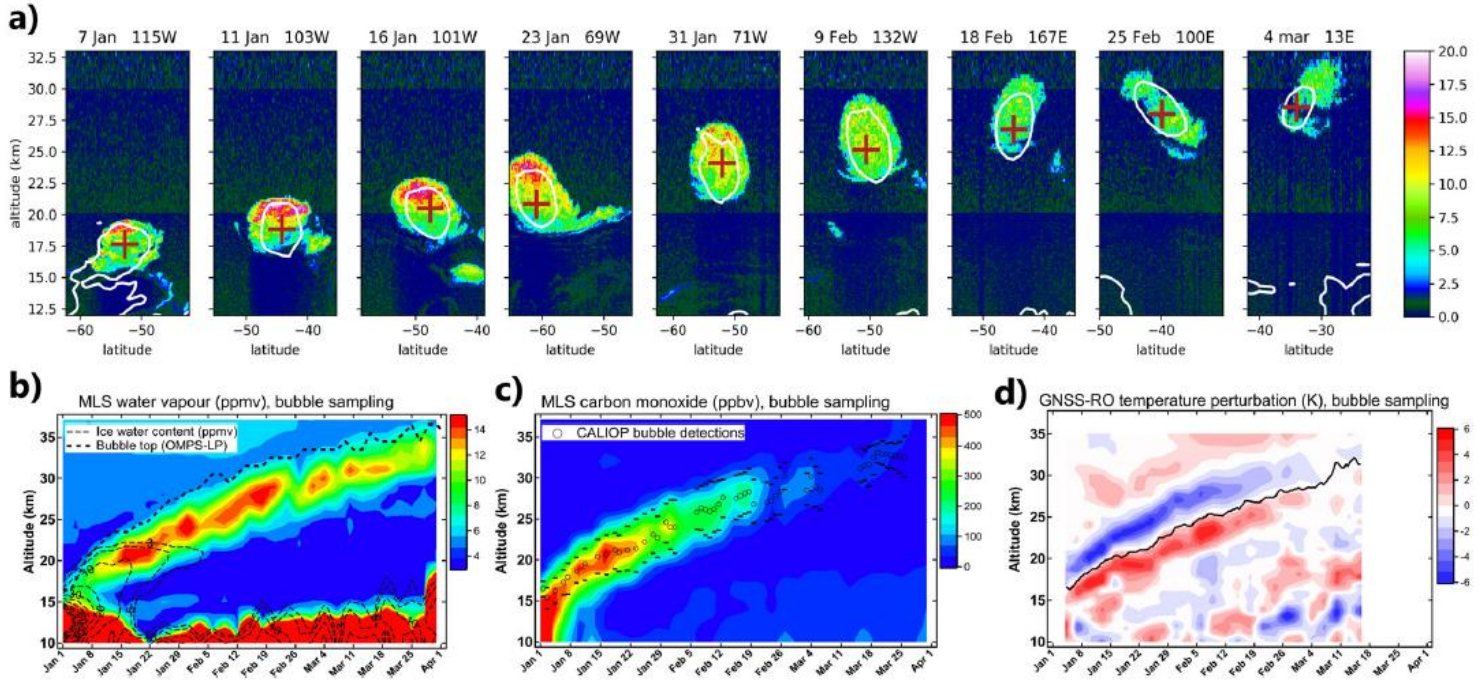
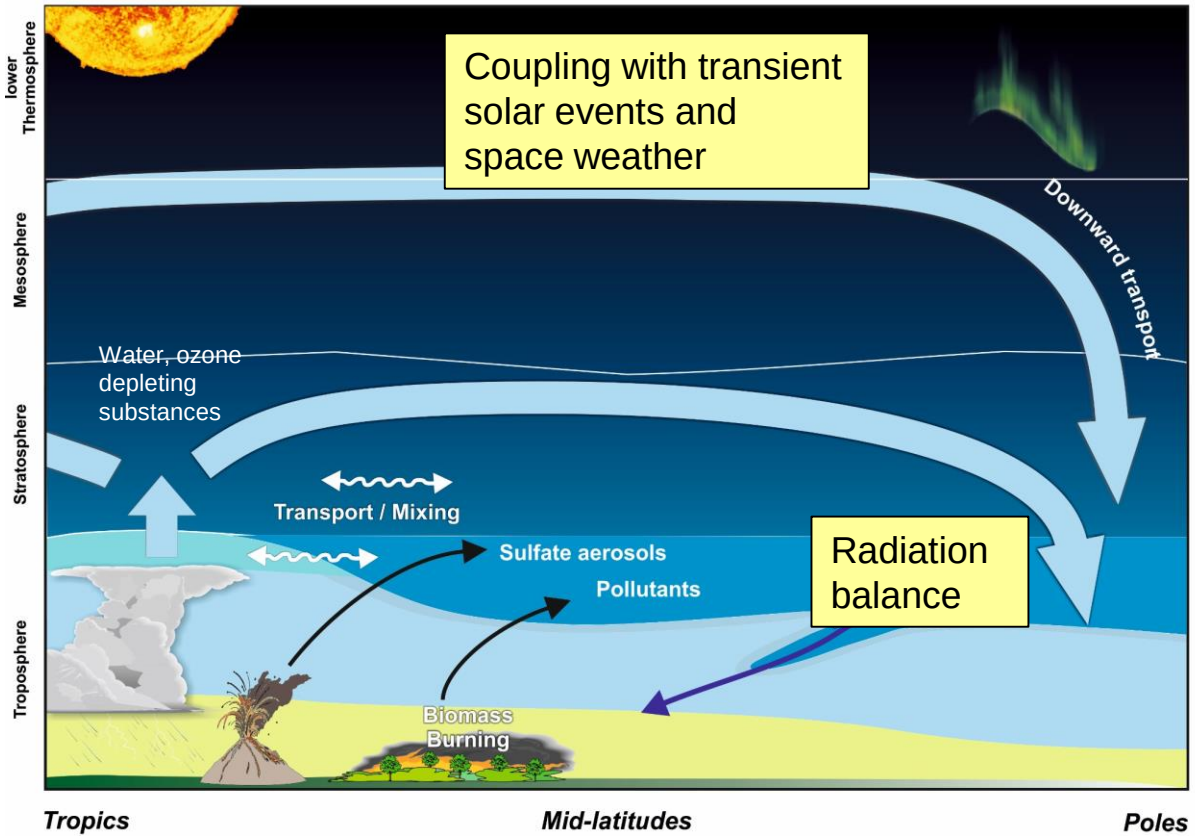


Photo: worldweatherattribution.org

Circulation, composition and regional climate change

CAIRT



Evidence for profound changes in

- Atmospheric circulation
- Wave driving
- Transport and mixing
- Impact on
  - atmospheric composition
  - surface climate
- Stratospheric aerosol budget
- Coupling with upper atmosphere / space weather
- Radiative balance

Objective A: Quantify the **middle-atmosphere circulation** from the upper troposphere to the lower thermosphere by providing accurate and high-resolution observations of age-of-air, temperature and long-lived trace gases

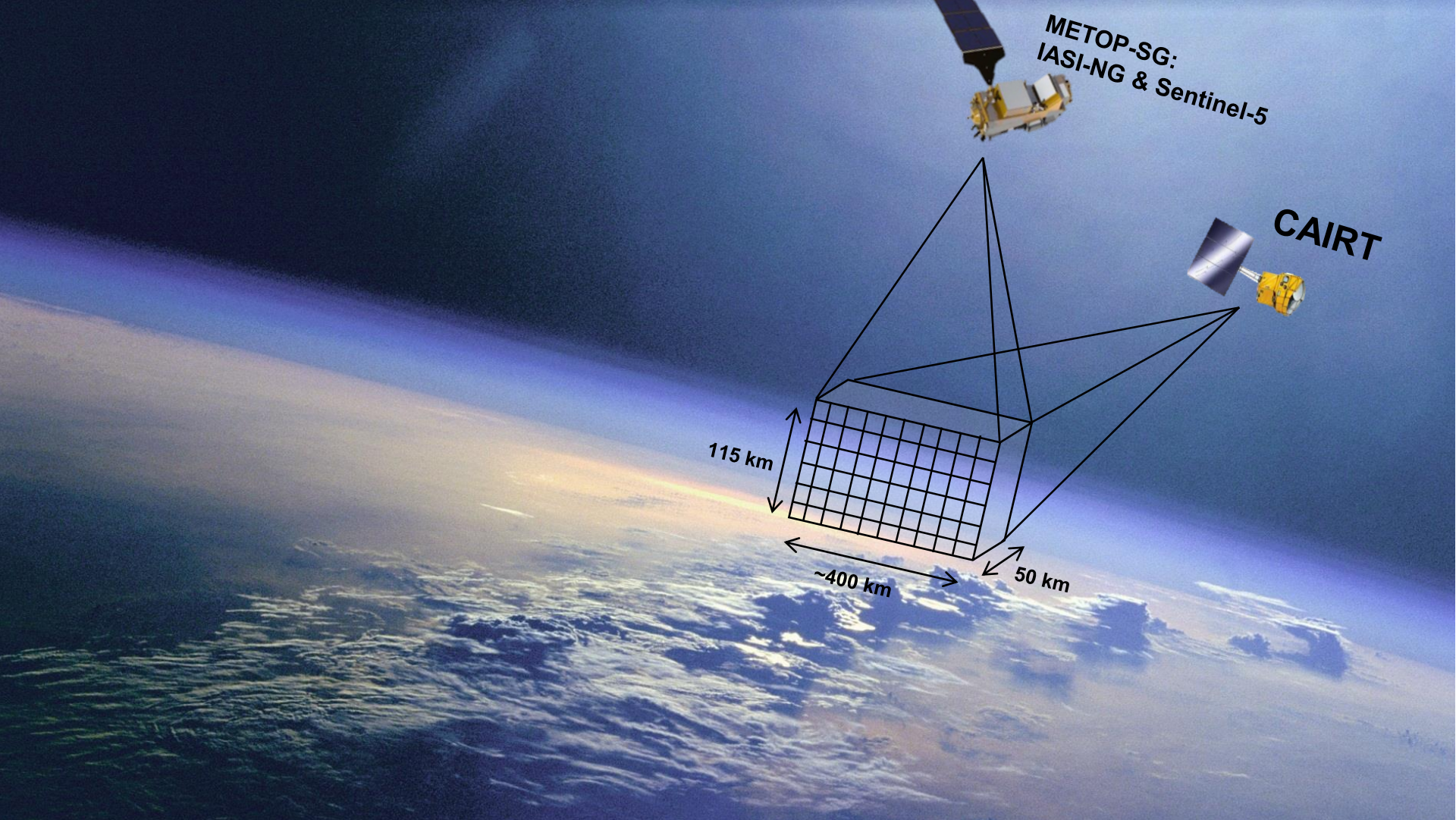
Objective B: Quantify the atmospheric **gravity wave momentum flux** and wave driving through temperature observations at unprecedented scales

Objective C: Attribute changes in stratospheric ozone due to **circulation and chemistry** by providing observations of the relevant chemical species

Objective D: Quantify the flux of reactive nitrogen species from the upper atmosphere into the stratosphere to improve our understanding how **transient solar events and space weather** affect stratospheric ozone and natural climate variability

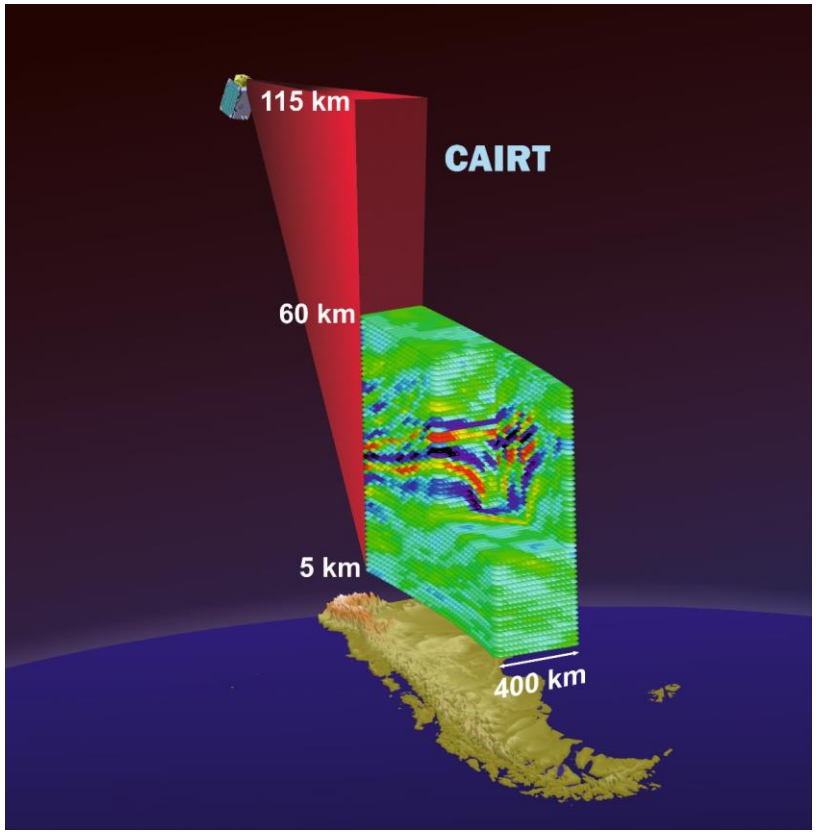
Objective E: Quantify the upper troposphere and lower stratosphere (UTLS) **aerosol composition and precursor gases**

Objective F: Quantify UTLS variability, **stratosphere-troposphere exchange** and its impact on tropospheric composition and air quality


METOP-SG:
IASI-NG & Sentinel-5
CAIRT
115 km
~400 km
50 km

Tomography by Infra-Red Limb Imaging

CAIRT

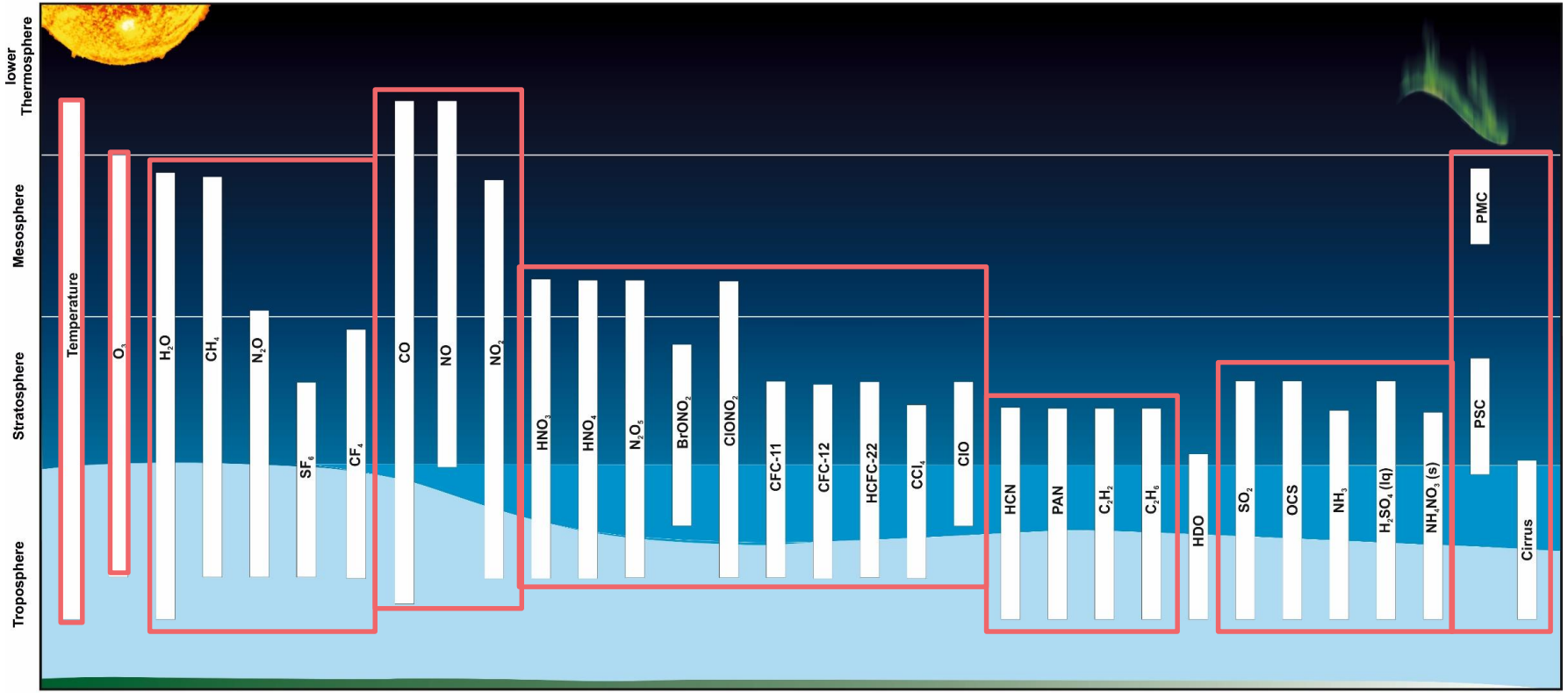


Mission characteristics

- Infrared limb imager
  - Nominal sampling 50 x 50 x 1 km
  - 5 – 115 km vertical coverage
  - 3D tomographic retrievals
- Spectral coverage
  - 710 cm^{-1} to 2200 cm^{-1} (4.5 µm to 14 µm) @ 0.1 cm^{-1} sampling
- Sun-synchronous orbit, 835 km
  - Formation with MetOp-SG (IASI-NG, Sentinel-5)

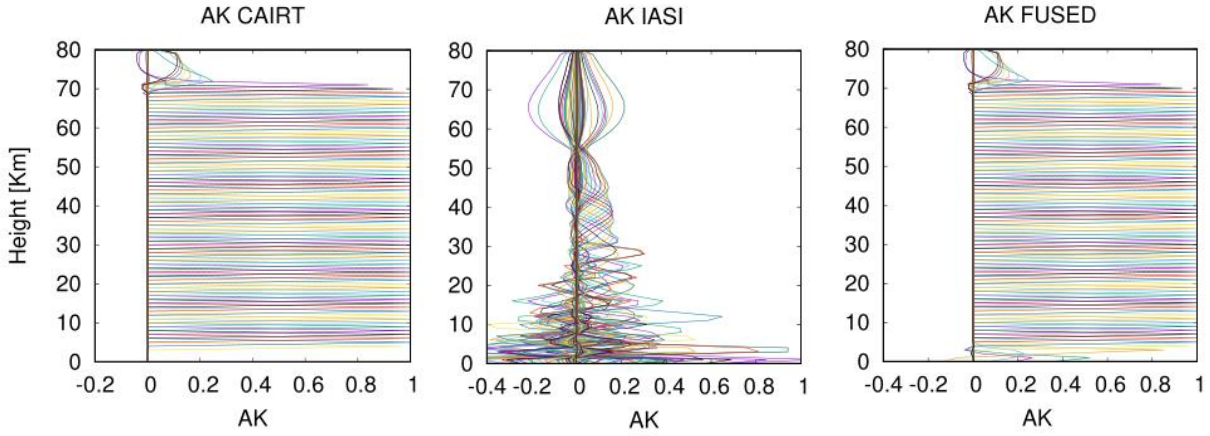
Level 2 products

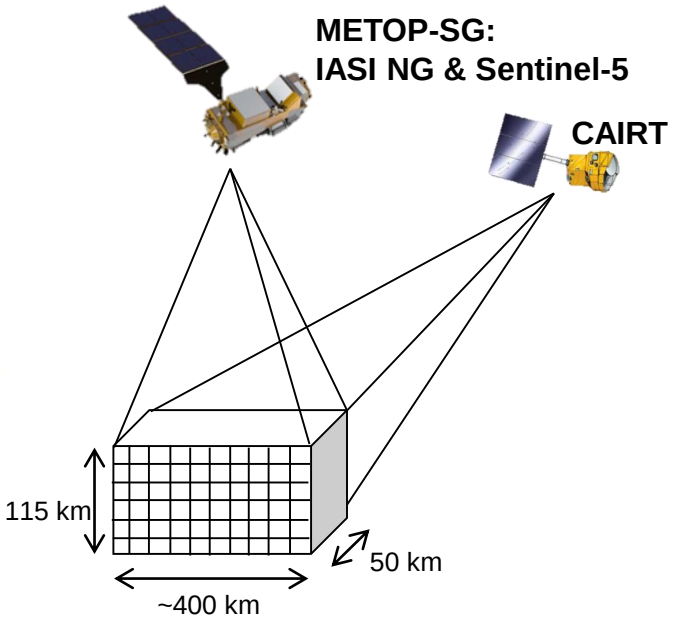
CAIRT



Limb / nadir matching with MetOP-SG

Example: Ozone data fusing CAIRT and IASI



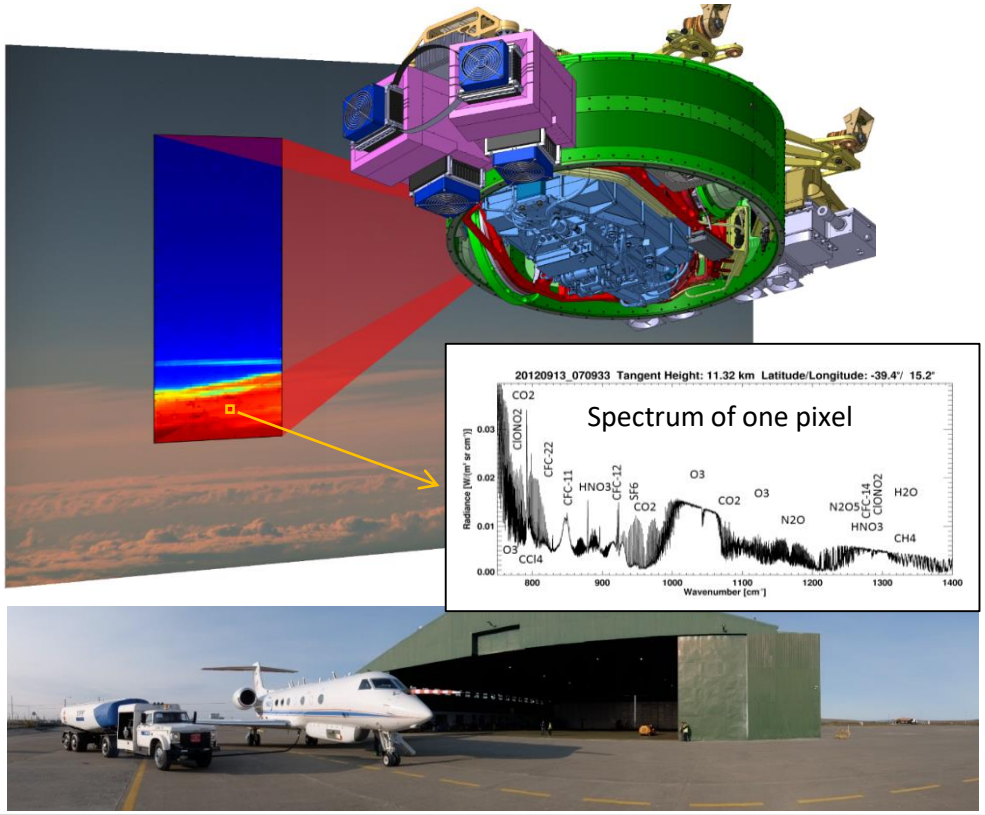


By combining collocated nadir and limb measurements it is possible to improve the knowledge of the troposphere achievable by a nadir only measurement and to increase the number of DOFs. (CAIRT retrieval considered here only up to 80km.)

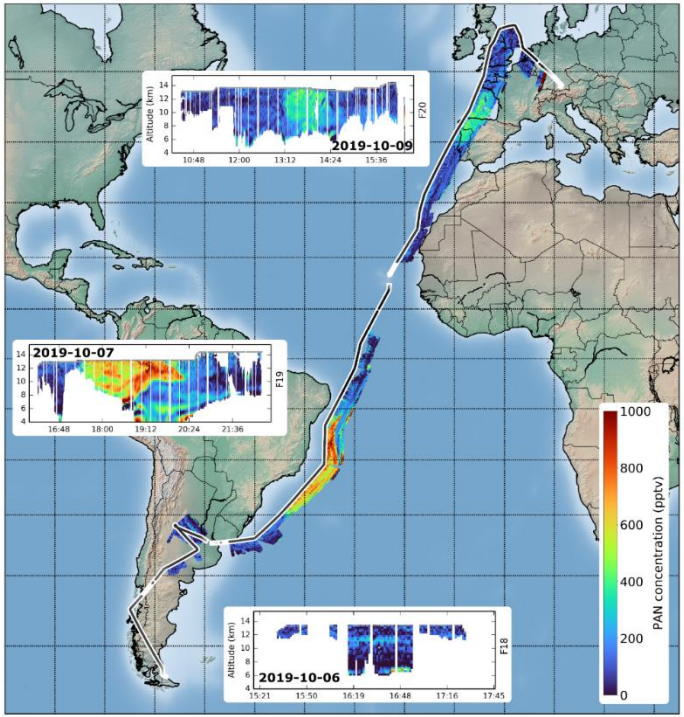
Reference: Simone Ceccherini, Bruno Carli and Piera Raspollini, Equivalence of data fusion and simultaneous retrieval, OPTICS EXPRESS 8476, 2015


The MIPAS/ENVISAT
heritage
(2002 – 2012)

Airborne Limb-Imaging Demonstrator GLORIA

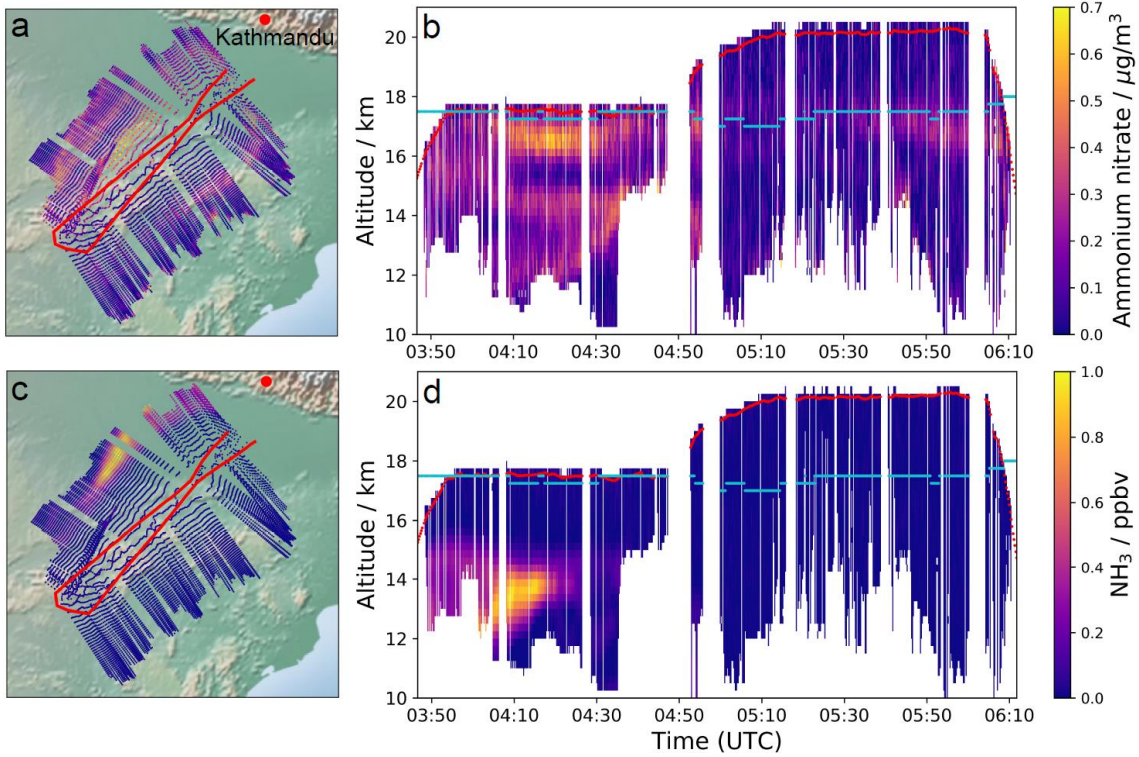


Example: Biomass burning



(Figure courtesy of S. Johansson)

GLORIA observations of ammonium nitrate aerosols in the Asian monsoon



StratoClim flight 31 Jul 2017

NH_4NO_3 aerosol mass density

NH_3 trace gas mixing ratio

Höpfner et al., Nat. Geosci. 10.1038/s41561-019-0385-8, 2019

- **Large concentrations of NH_3 observed at 14 km**
- **Enhanced ammonium nitrate in the vicinity of regions with enhanced NH_3**

Summary

CAIRT

- **CAIRT will be the first** imaging IR limb sounder in space
- First **comprehensive global 3D tomographic measurements** of the relevant processes from troposphere to lower thermosphere at ~ 50 x 50 x 1 km resolution
- High-resolution measurements of temperature will provide **momentum flux**, phase speed and direction of **atmospheric gravity waves**
- Long-lived tracers (**N_2O**, **CH_4**, **SF_6**, **CF_4, CO**) will provide information on **transport, mixing and circulation changes**
- Budget of stratospheric sulfur (**OCS**, **SO_2**, and **H_2SO_4** aerosols)
- UTLS aerosols (**NH_4NO_3**), precursors (**NH_3**) and reactive trace gases (e.g., **PAN**, **HCN**, **C_2H_2**)
- **Water vapour isotopologues** will help to constrain water vapour and cloud processes
- Flying in formation with Metop-SG will provide **synergies with IASI and Sentinel-5** for measuring tropospheric composition (e.g., **O_3**, **NO_2**, **CH_4**, **N_2O**)