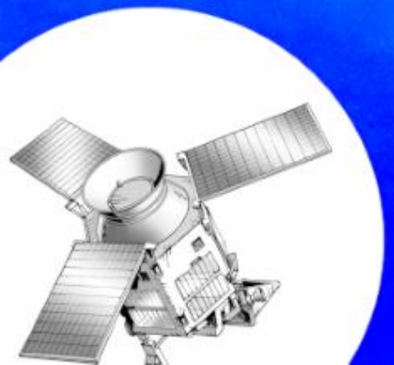
What can we see using the IASI infrared remote sensor

Cathy Clerbaux

Fourth Joint School on Atmospheric Composition

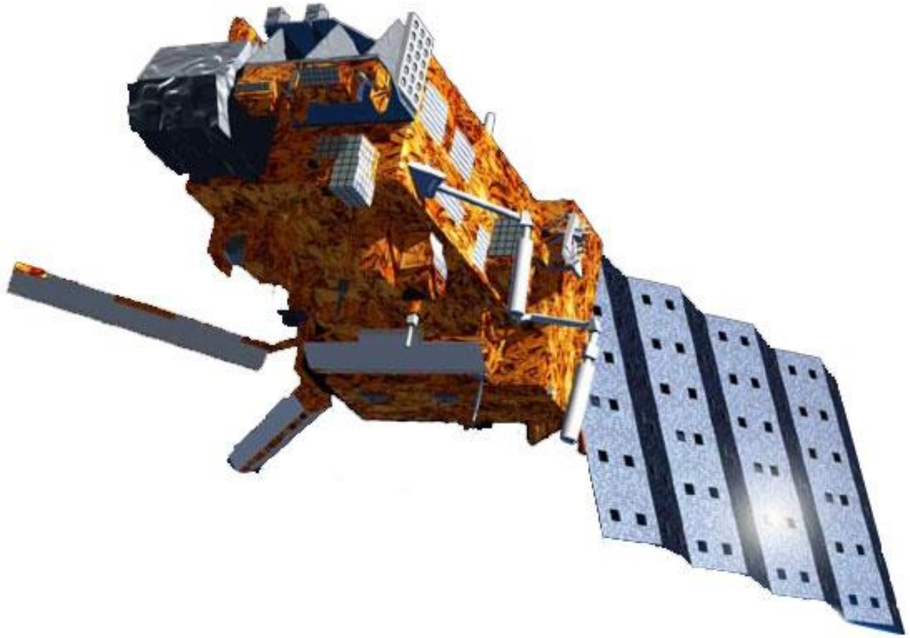
28 Sept – 6 October 2022



Copernicus Europe's eyes on Earth · ECMWF · Atmosphere Monitoring Service atmosphere.copernicus.eu · EUMETSAT · esa

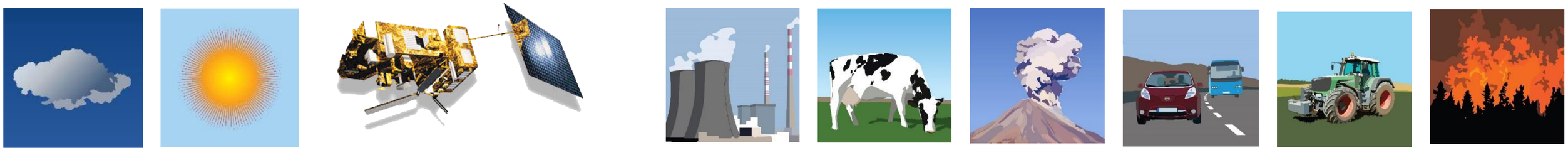
Cathy Clerbaux
cathy.clerbaux@latmos.ispl.fr

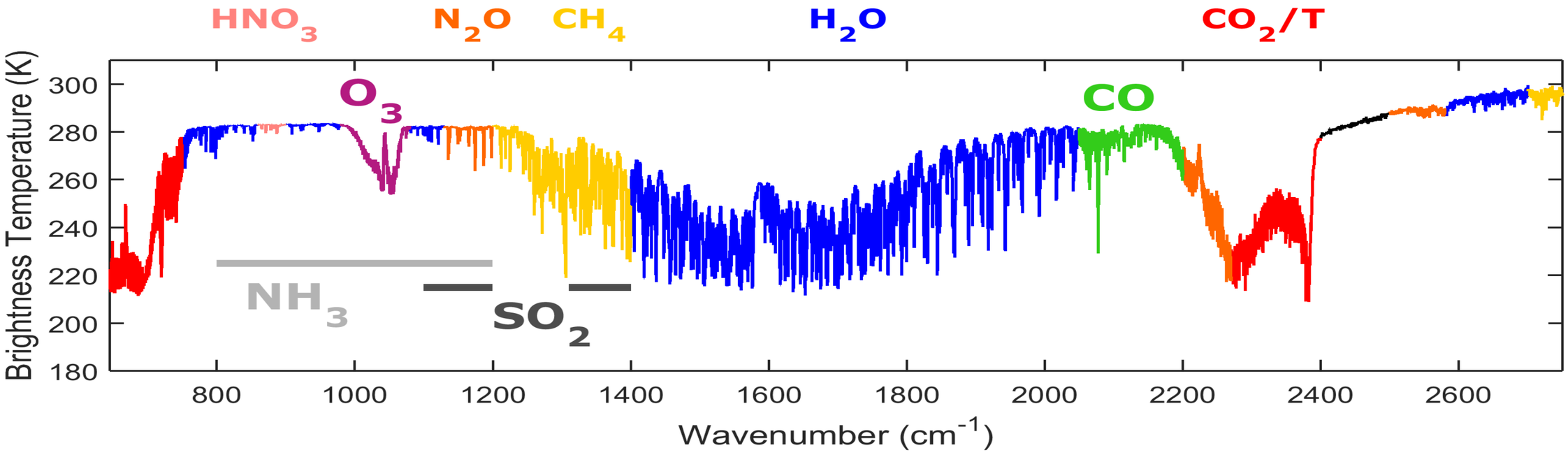
Senior Scientist at LATMOS/IPSL in Paris
Prof at Université Libre de Bruxelles



1. Short intro
2. Trace gaz measurements : CO, O_3, SO_2 and NH_3

ULB EUMETSAT LATMOS cnes





Now 33 species measured or *detected* by IASI

Greenhouse gases and ozone-related substances (13)	H_2O, CO_2, CH_4, N_2O, O_3, HNO_3, CFC-11, CFC-12, HCFC-22, CF_4, *SF_6*, *CCl_4*, *HFC-134a*
Air quality and VOCs (12)	CO, CH_3OH, HCOOH, CH_3COOH, CH_3COCH_3, C_2H_2, C_2H_4, NH_3, HCN, PAN, SO_2, OCS
Concentrated plumes (6)	HCl, H_2S, C_3H_6, C_4H_4O, HONO, *HCHO*

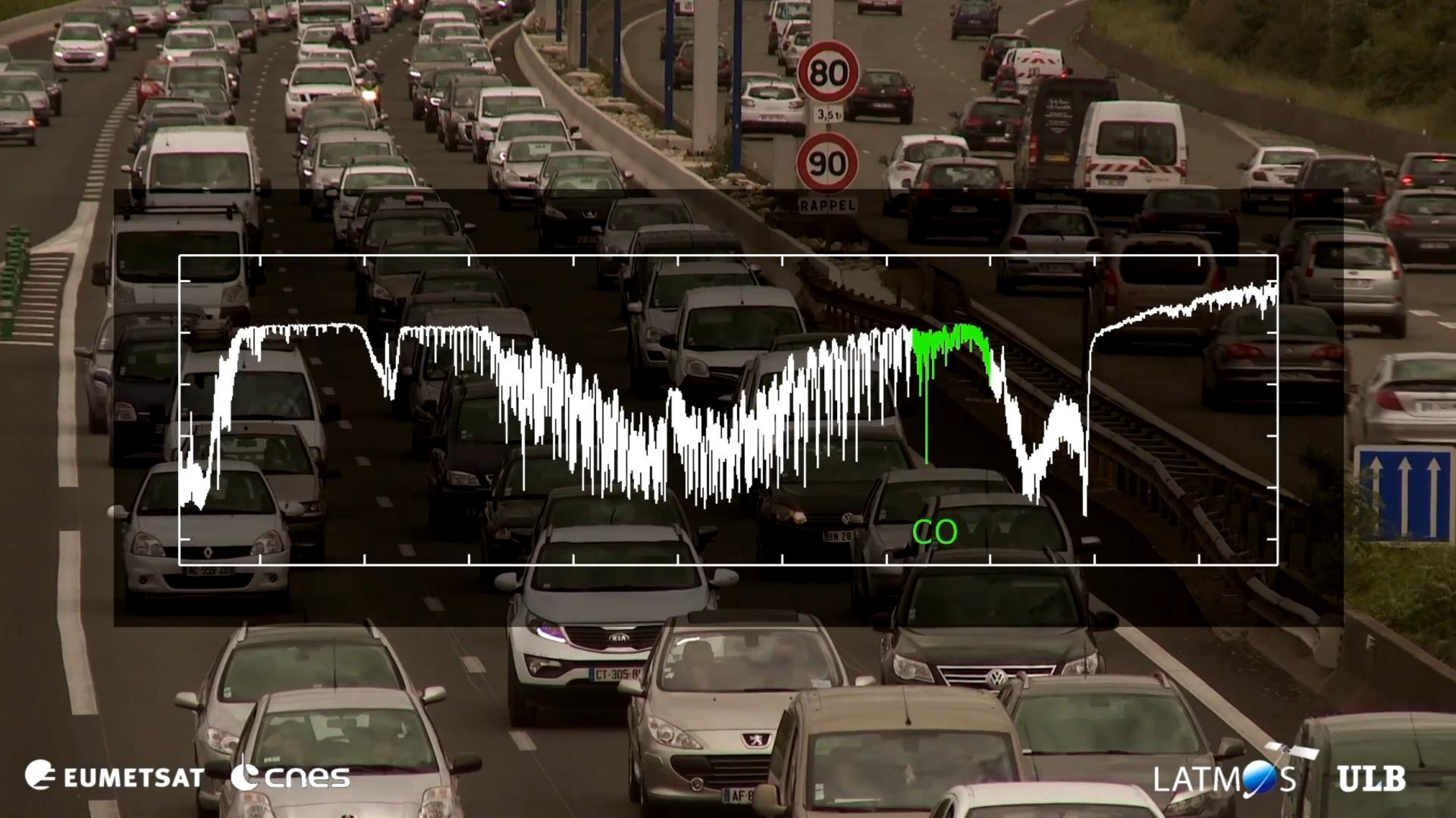
Carbon monoxide (CO)

Ozone (O_3)

Sulfur dioxide (SO_2) and ash

Ammonia (NH_3)

Carbon monoxide (CO)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3,5 t
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RAPPEL
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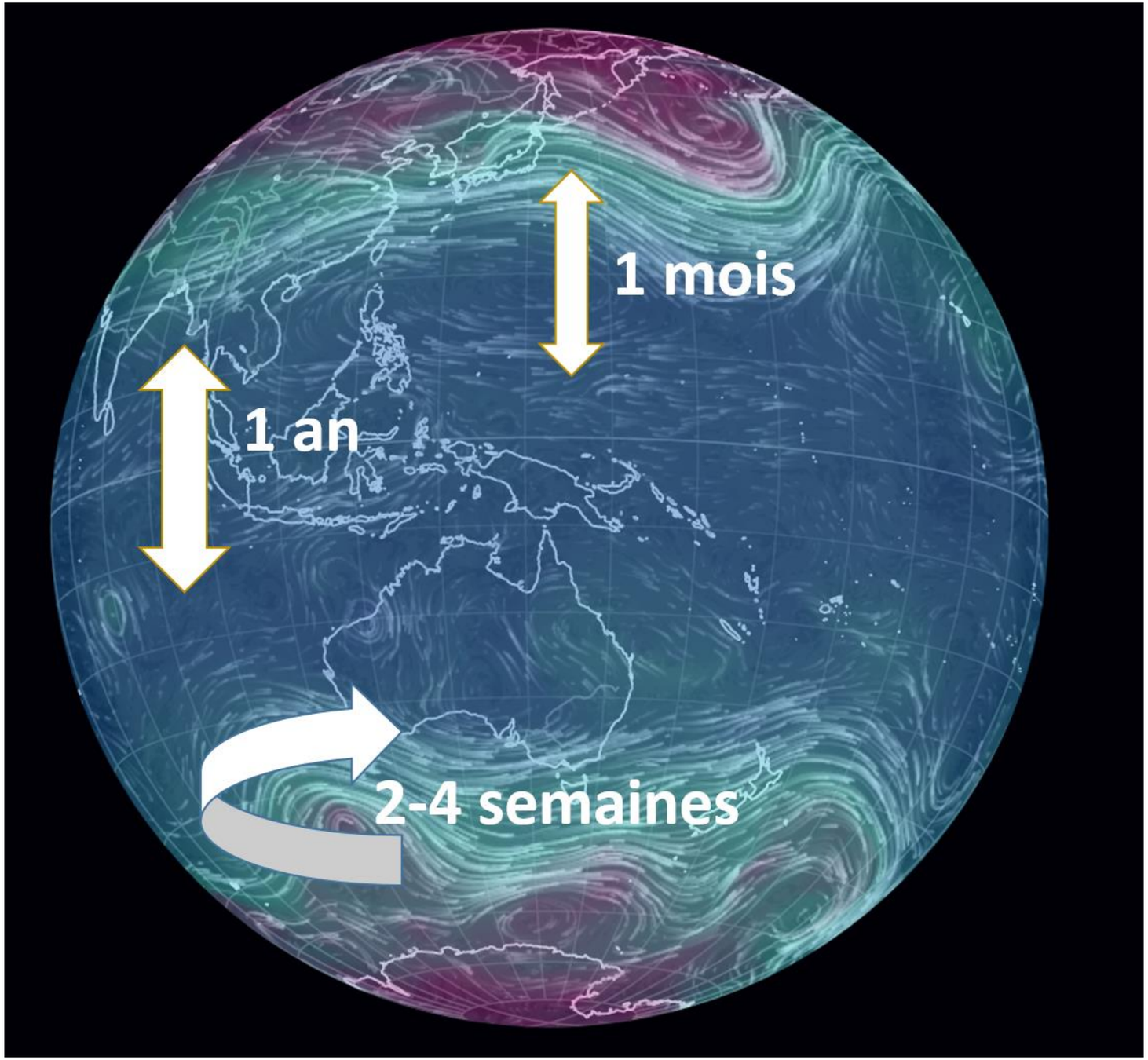
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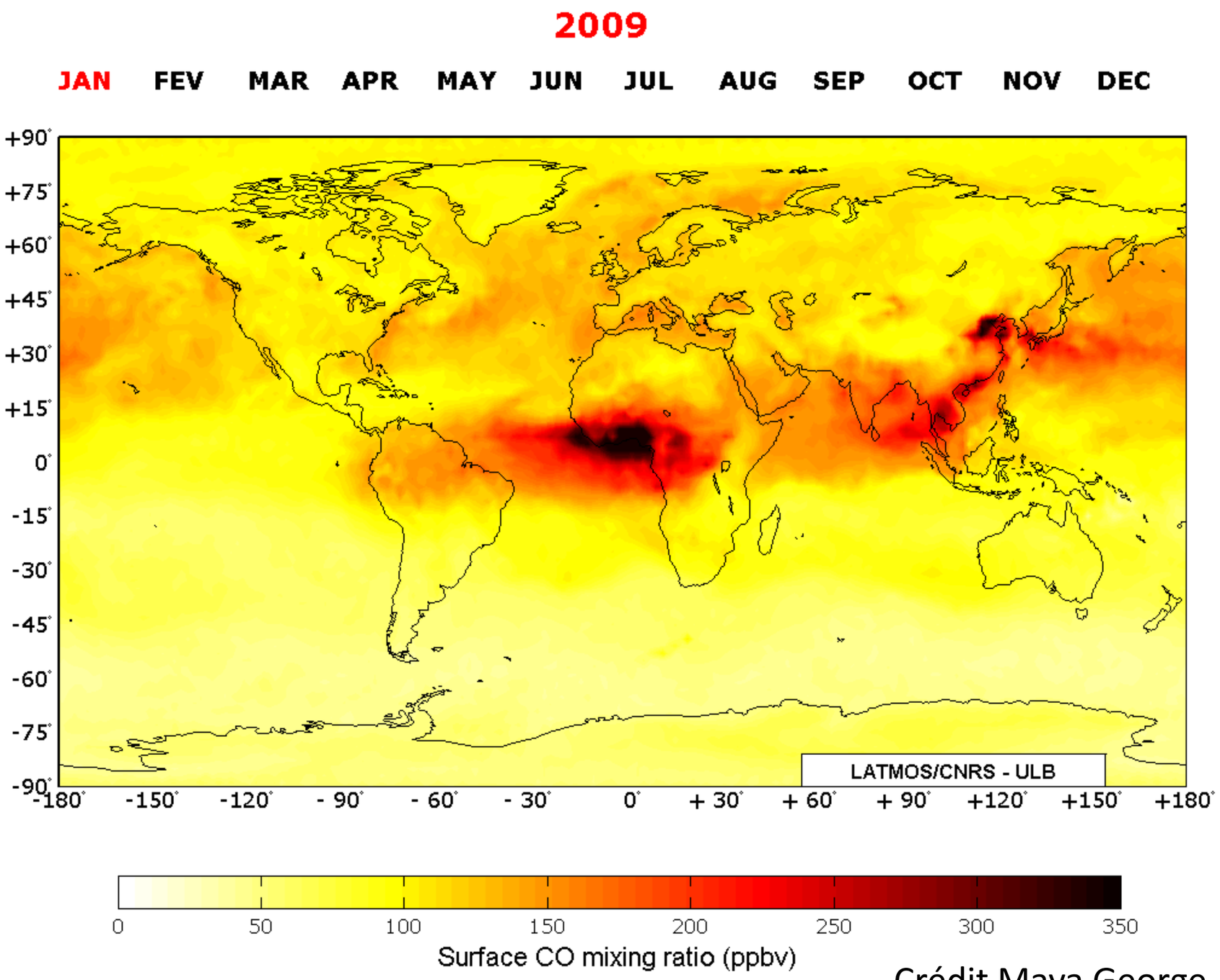
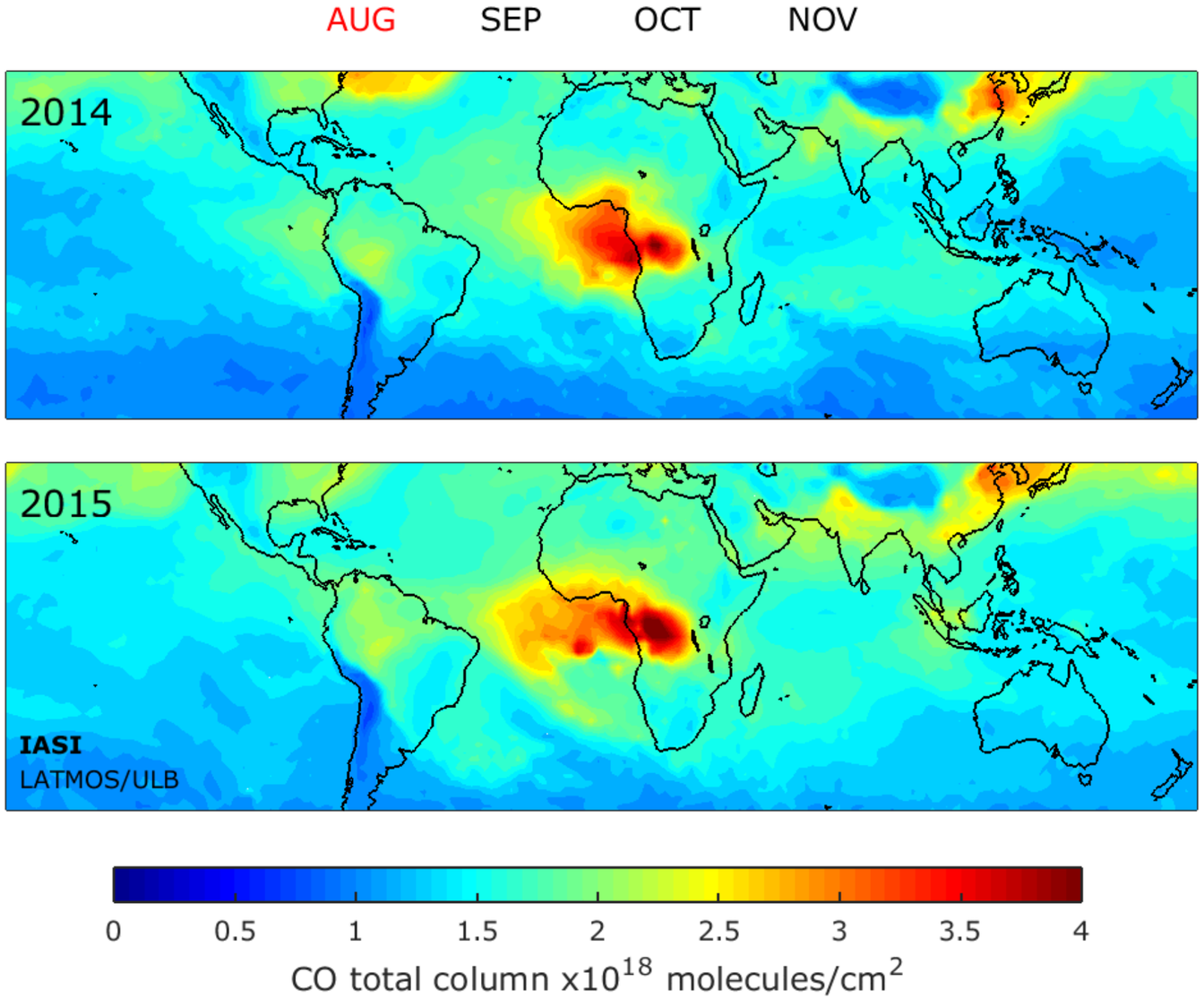


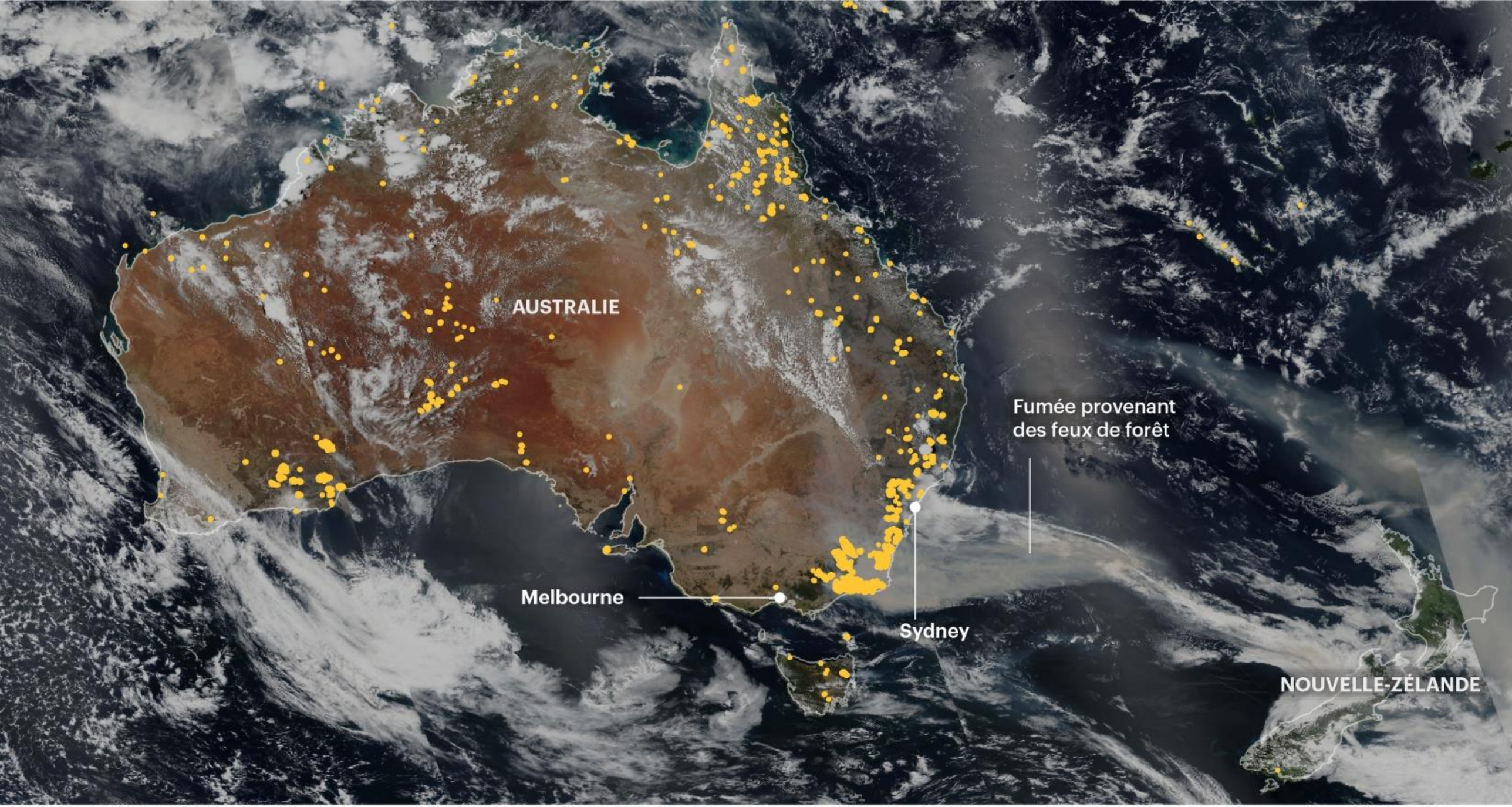
Crédit Maya George, LATMOS

Exceptional and “usual” fires



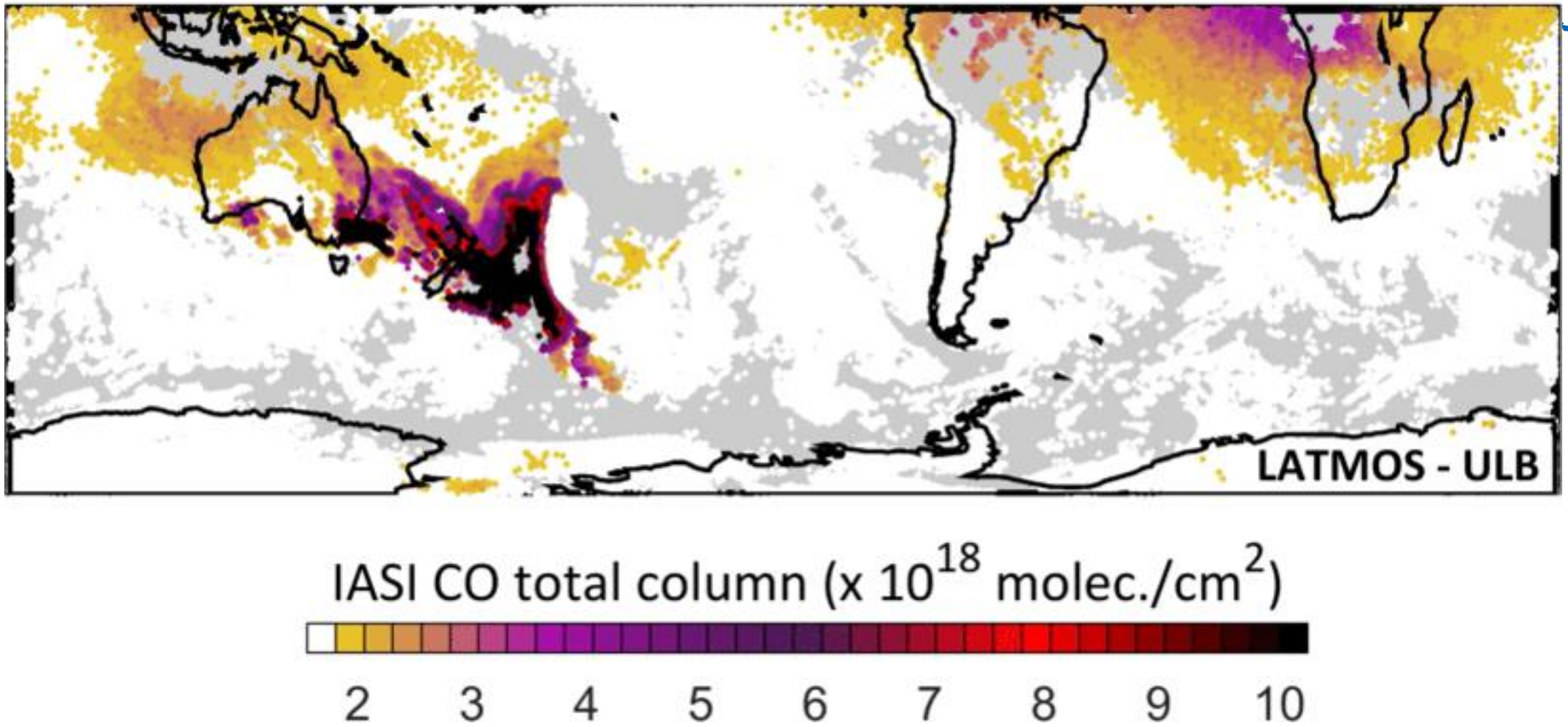
Credit M. George/ C. Clerbaux (LATMOS)

Janvier 2020 : Australia



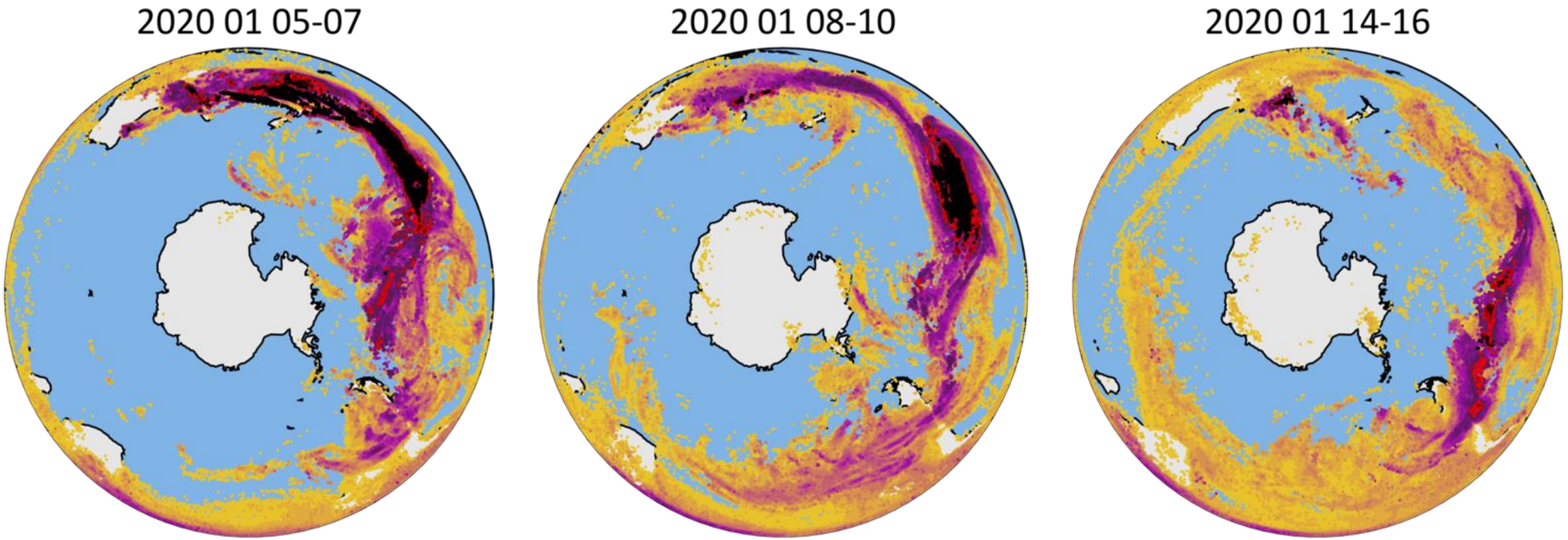
Foyers d'incendie dans les 24 dernières heures

20200101



Credit M. George/ C. Clerbaux (LATMOS)

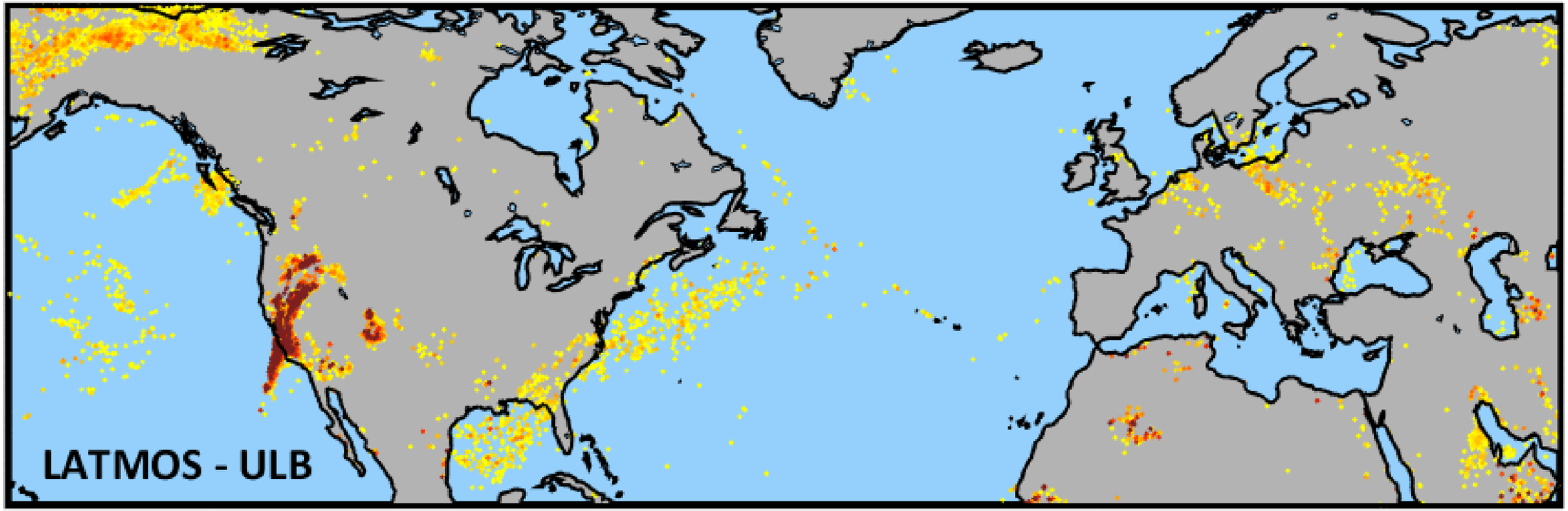
Fires plumes have circumnavigated around the globe



Credit M. George/ C. Clerbaux (LATMOS)

September 2020 : California

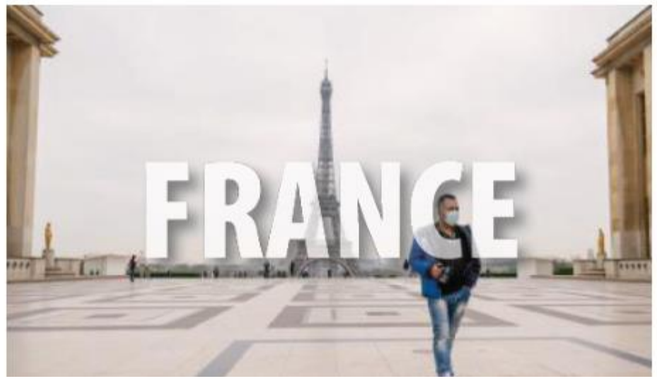
2020 08 19



IASI CO total column (x 10^{18} molec./cm^2)

Air pollution during the COVID-19 pandemic as seen by satellite

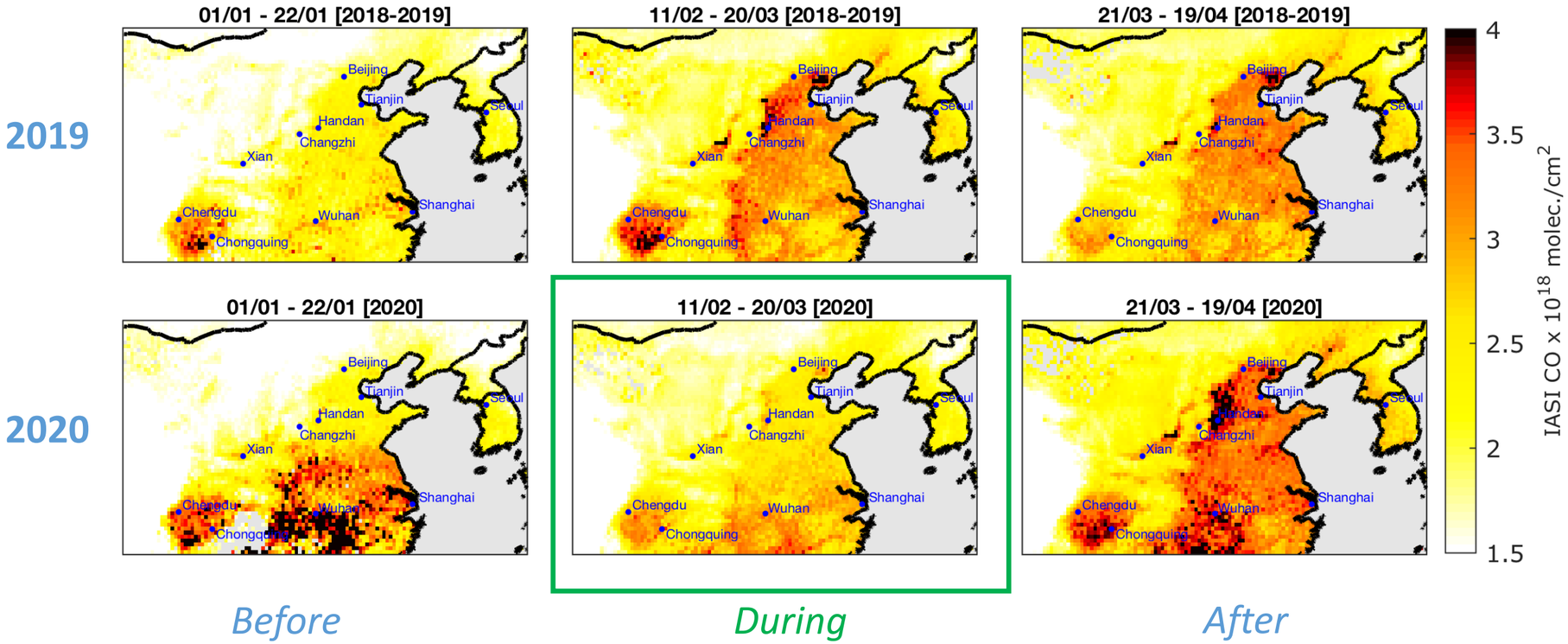
Click to see the impact of the lockdown on pollutants



Anthropogenic air pollution reduction during 2020 lockdown

IASI remote sensing observation

Carbon monoxide - China

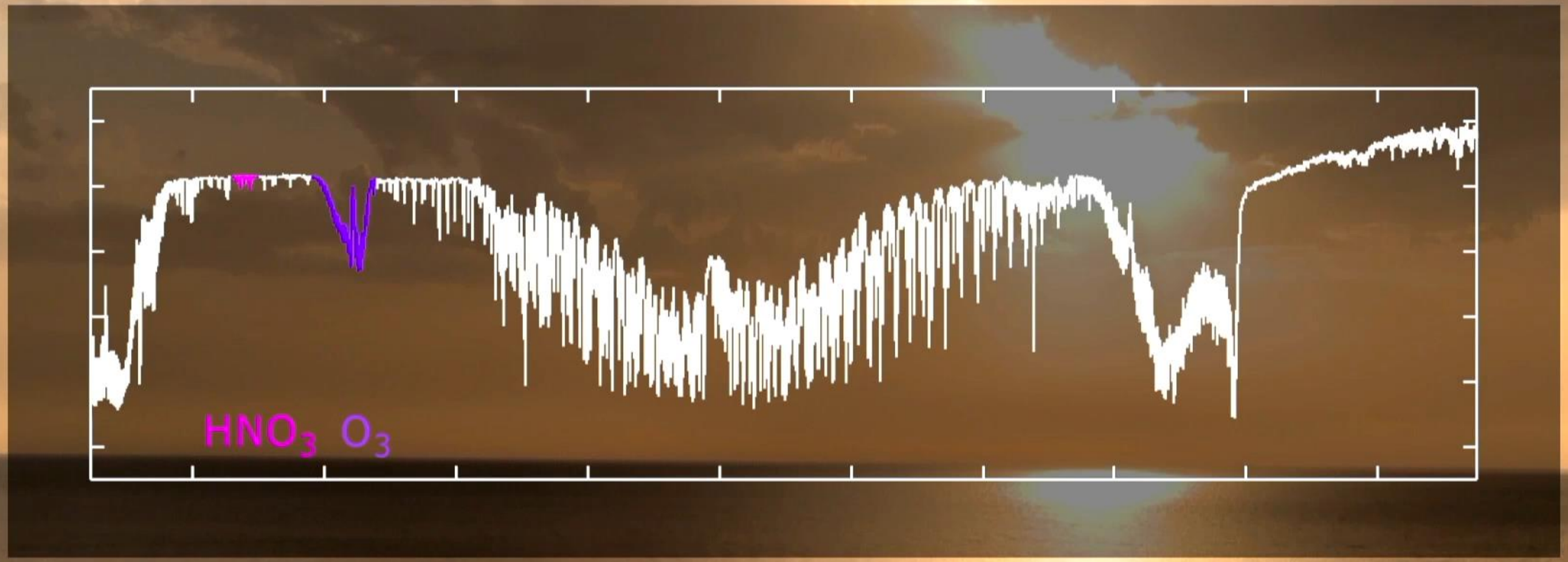


Before *During* *After*

https://iasi-ft.eu/covid-19/europe-air-pollution/

Carbon monoxide (CO)

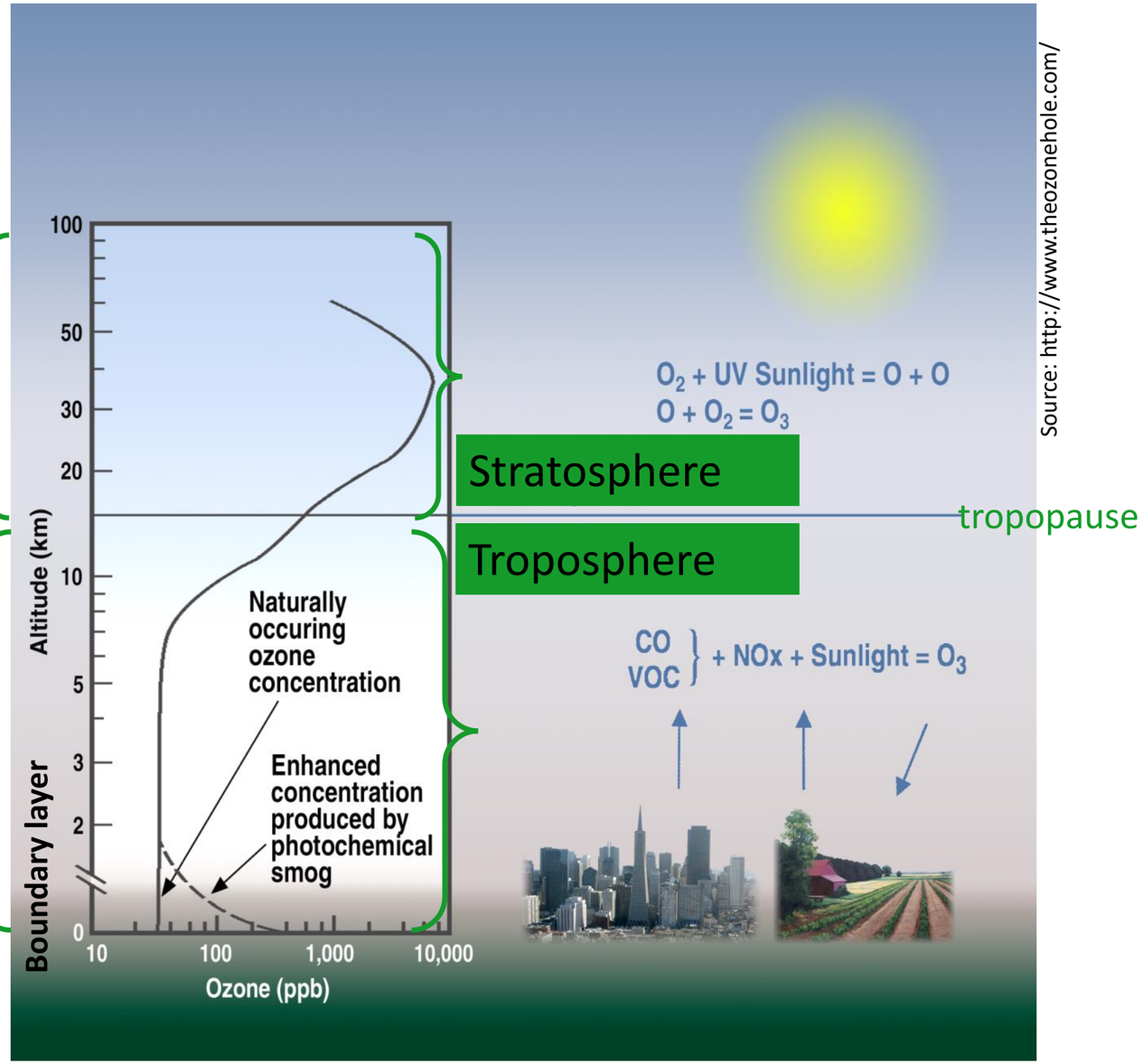
Ozone (O_3)


HNO_3 O_3

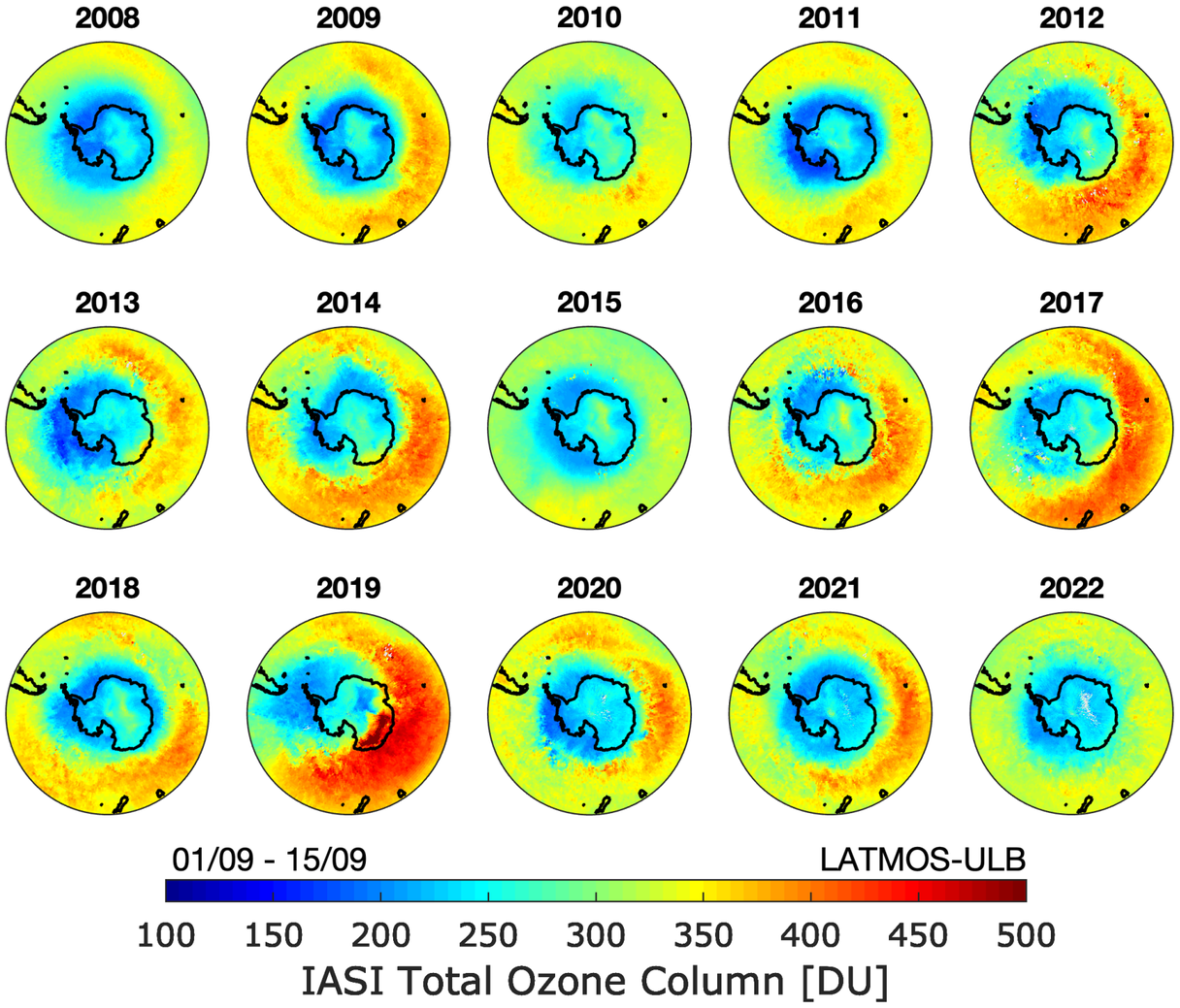
Vertical Profile of Ozone: Good or Bad?

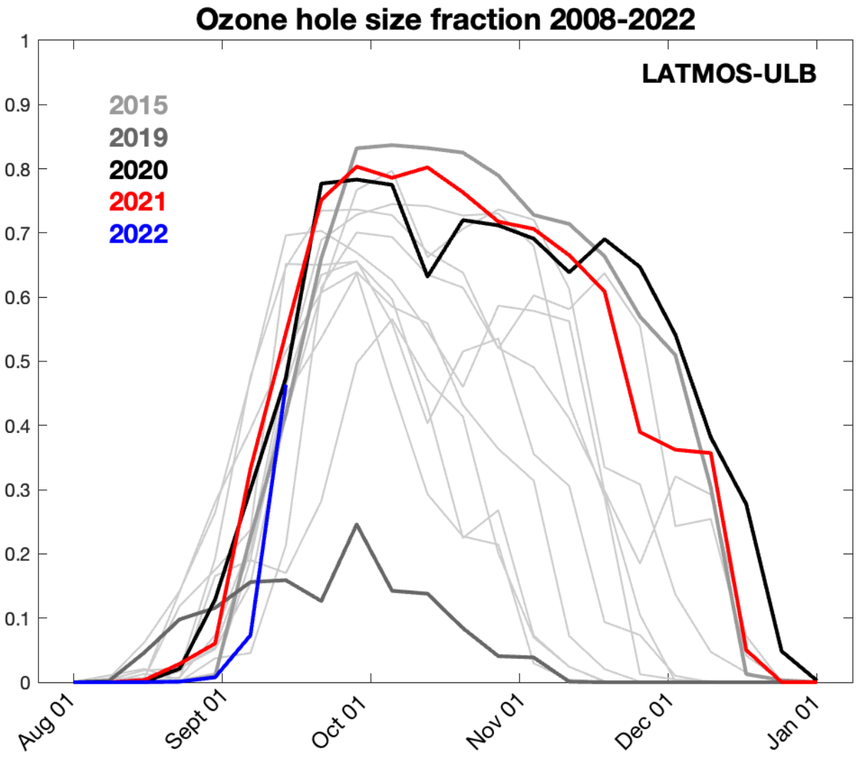
Good ozone:
UV shield

Bad ozone:
pollution



Source: http://www.theozonehole.com/


2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
01/09 - 15/09
LATMOS-ULB
100 150 200 250 300 350 400 450 500
IASI Total Ozone Column [DU]

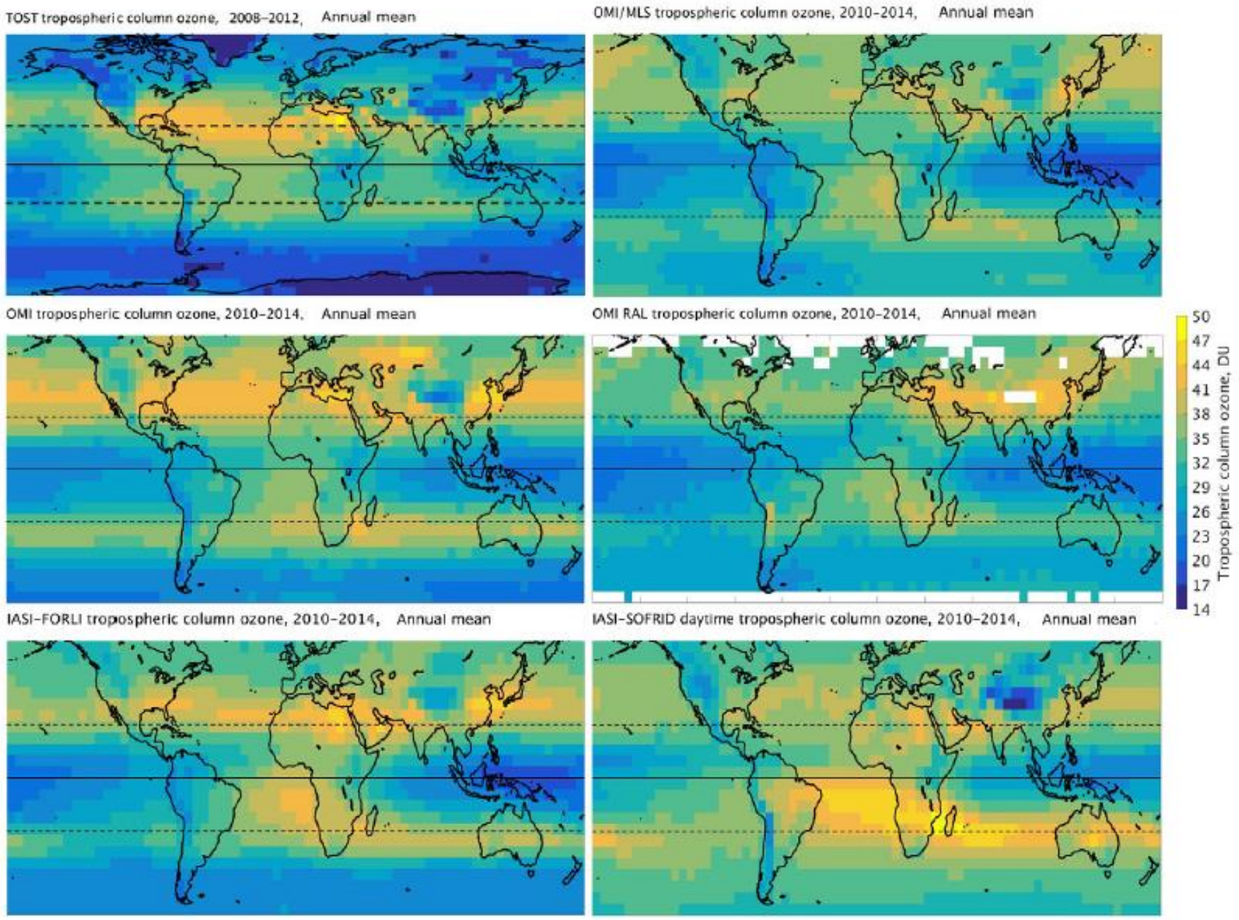

Ozone hole size fraction 2008-2022
LATMOS-ULB
2015
2019
2020
2021
2022
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Aug 01
Sept 01
Oct 01
Nov 01
Dec 01
Jan 01

ELEMENTA
Science of the Anthropocene

Gaudel, A, et al. 2018. Tropospheric Ozone Assessment Report: Present-day distribution and trends of tropospheric ozone relevant to climate and global atmospheric chemistry model evaluation. *Elem Sci Anth*, 6: 39. DOI: https://doi.org/10.1525/elementa.291

RESEARCH ARTICLE

Tropospheric Ozone Assessment Report: Present-day distribution and trends of tropospheric ozone relevant to climate and global atmospheric chemistry model evaluation



EUMETSAT
AC SAF

ozone cci

TOAR
tropospheric ozone assessment report

Climate Change

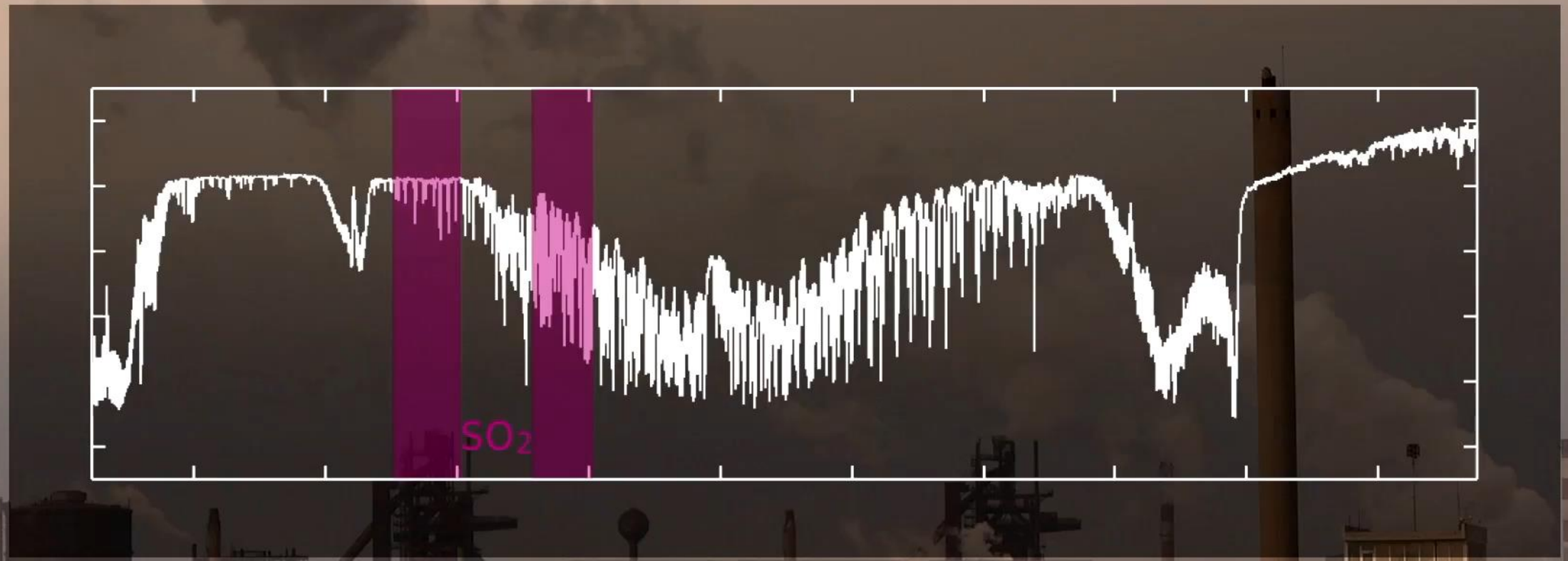
C3S_312a_Lot4 Ozone

Service Readiness Review n°1 – 19 April 2017

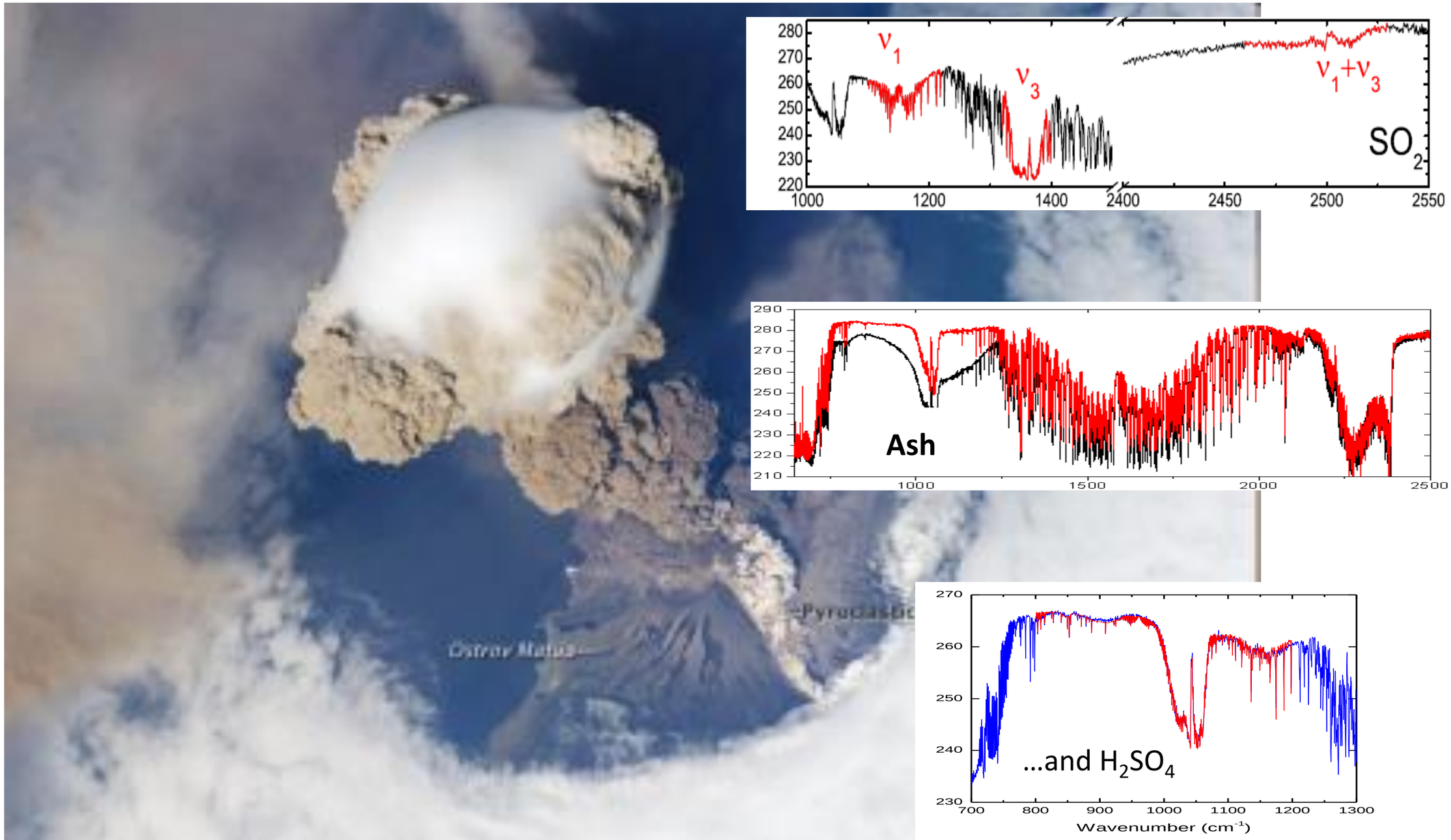
Carbon monoxide (CO)

Ozone (O_3)

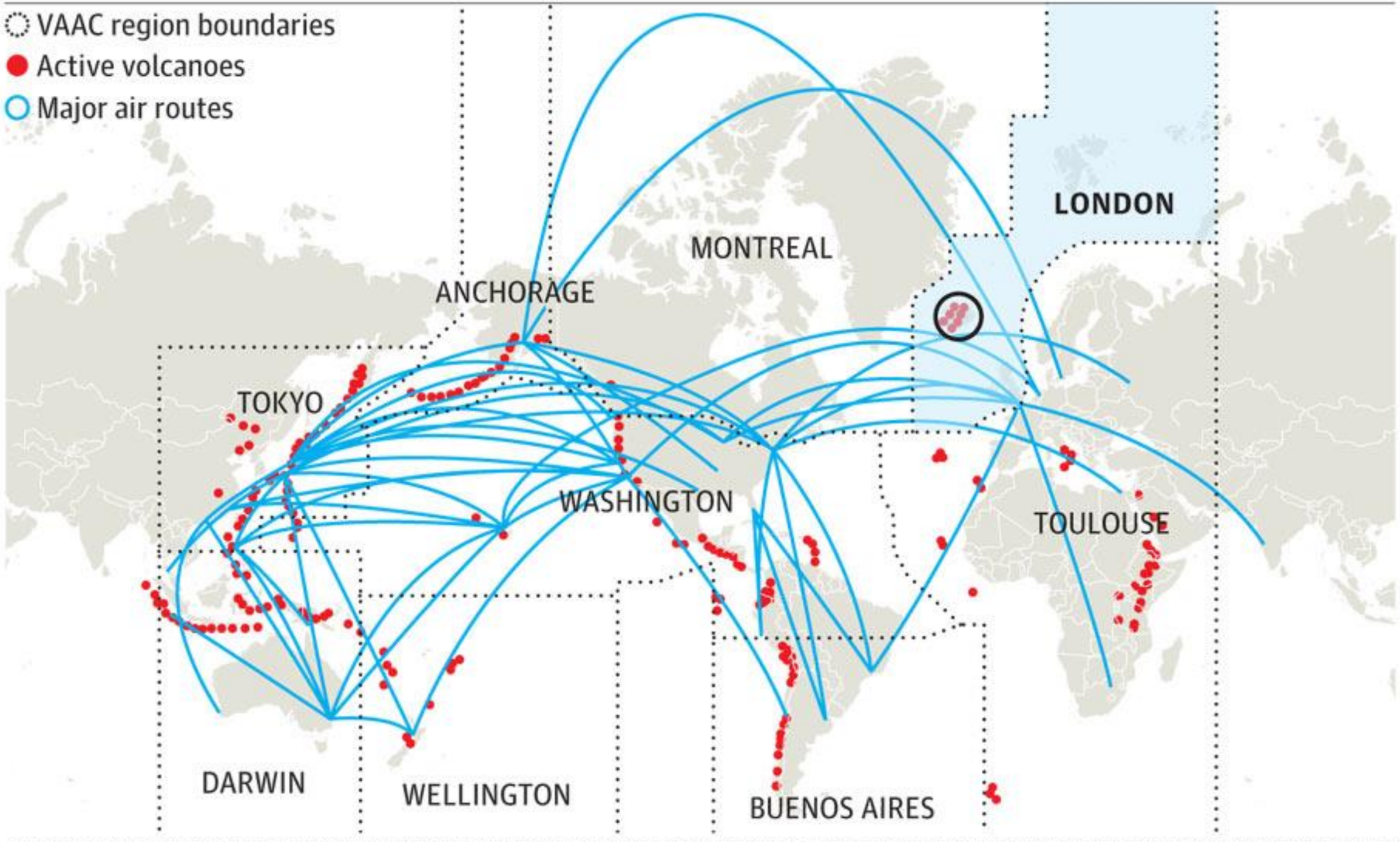
Sulfur dioxide (SO_2) and ash

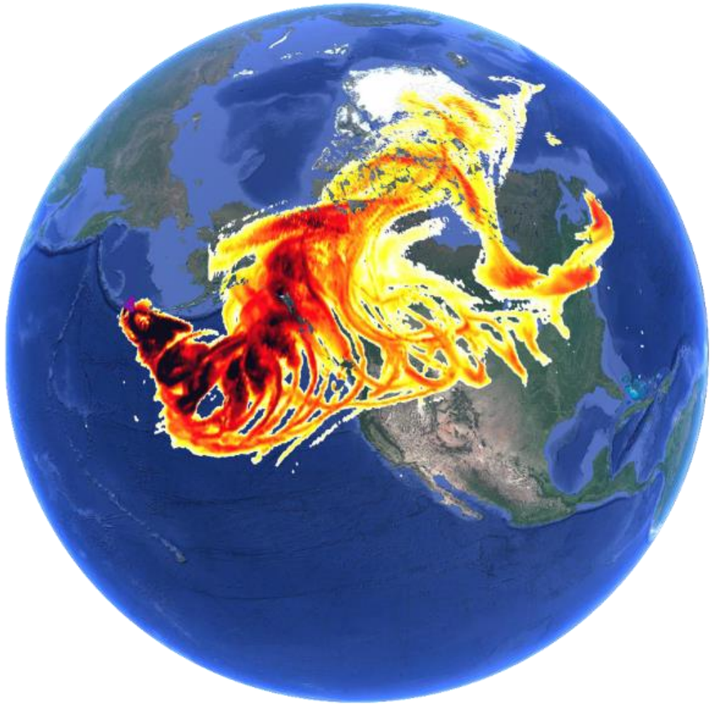

SO2

IASI SO_2, ash and H_2SO_4

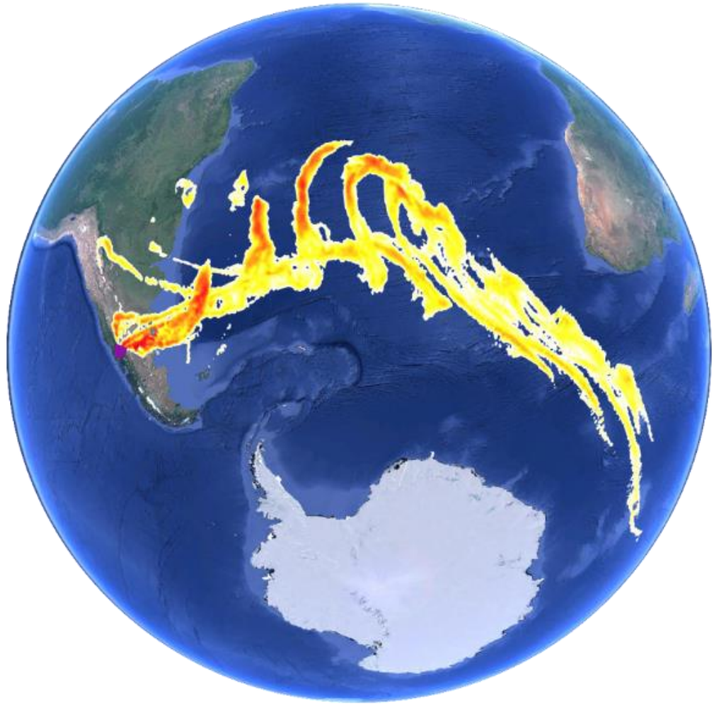


How the world's flight routes traverse volcanic risks

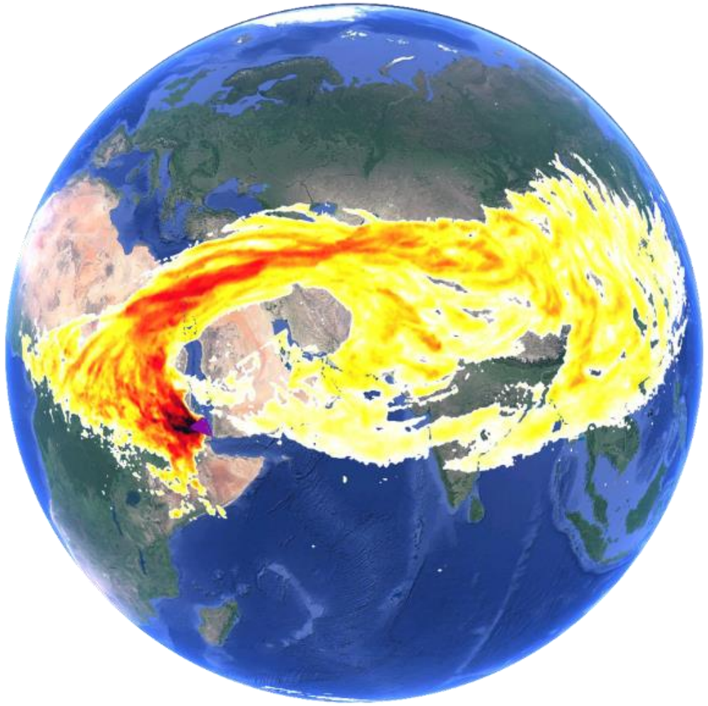




Kasatoshi
Aug. 2008



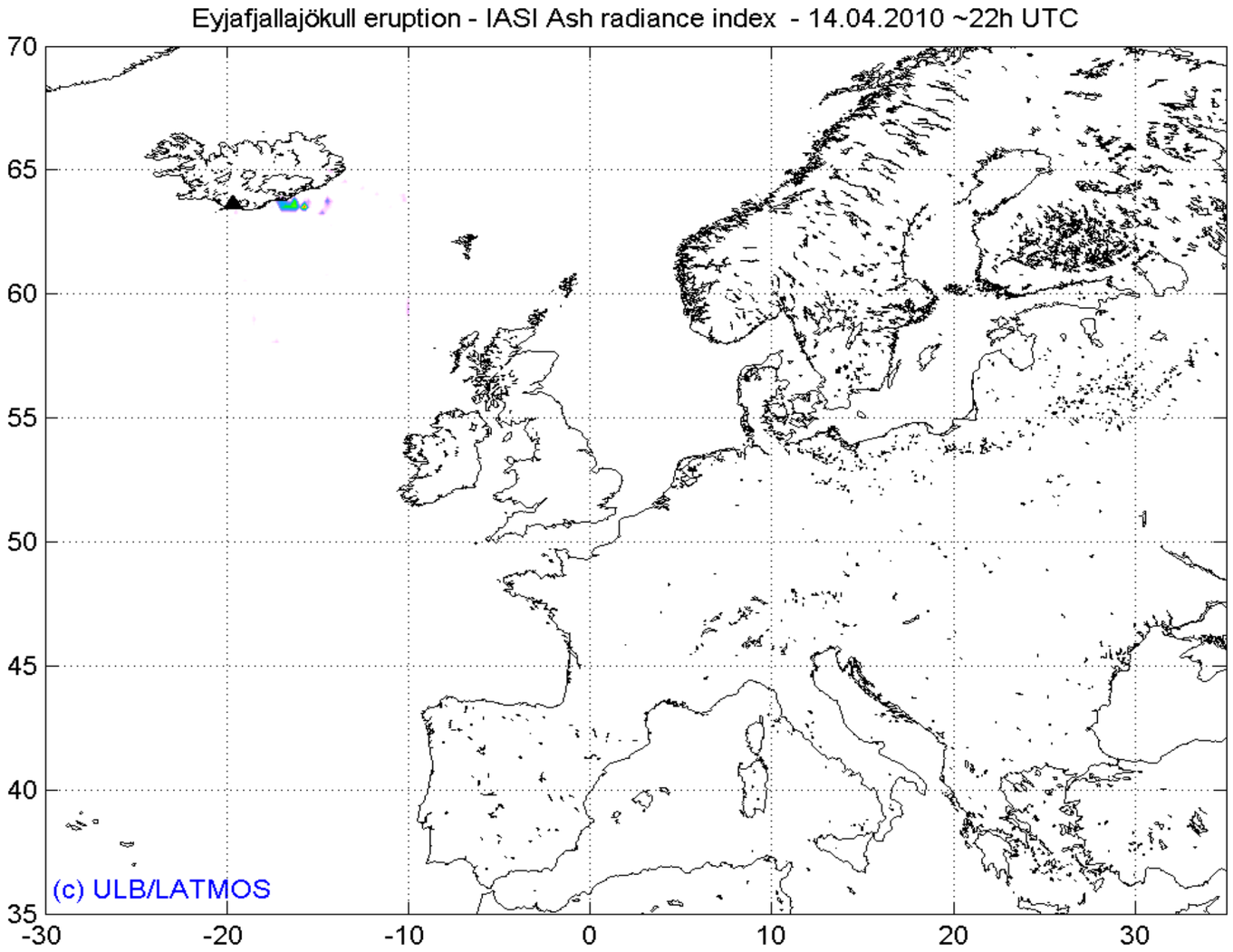
Puhehue
June 2011



Nabro
June 2011

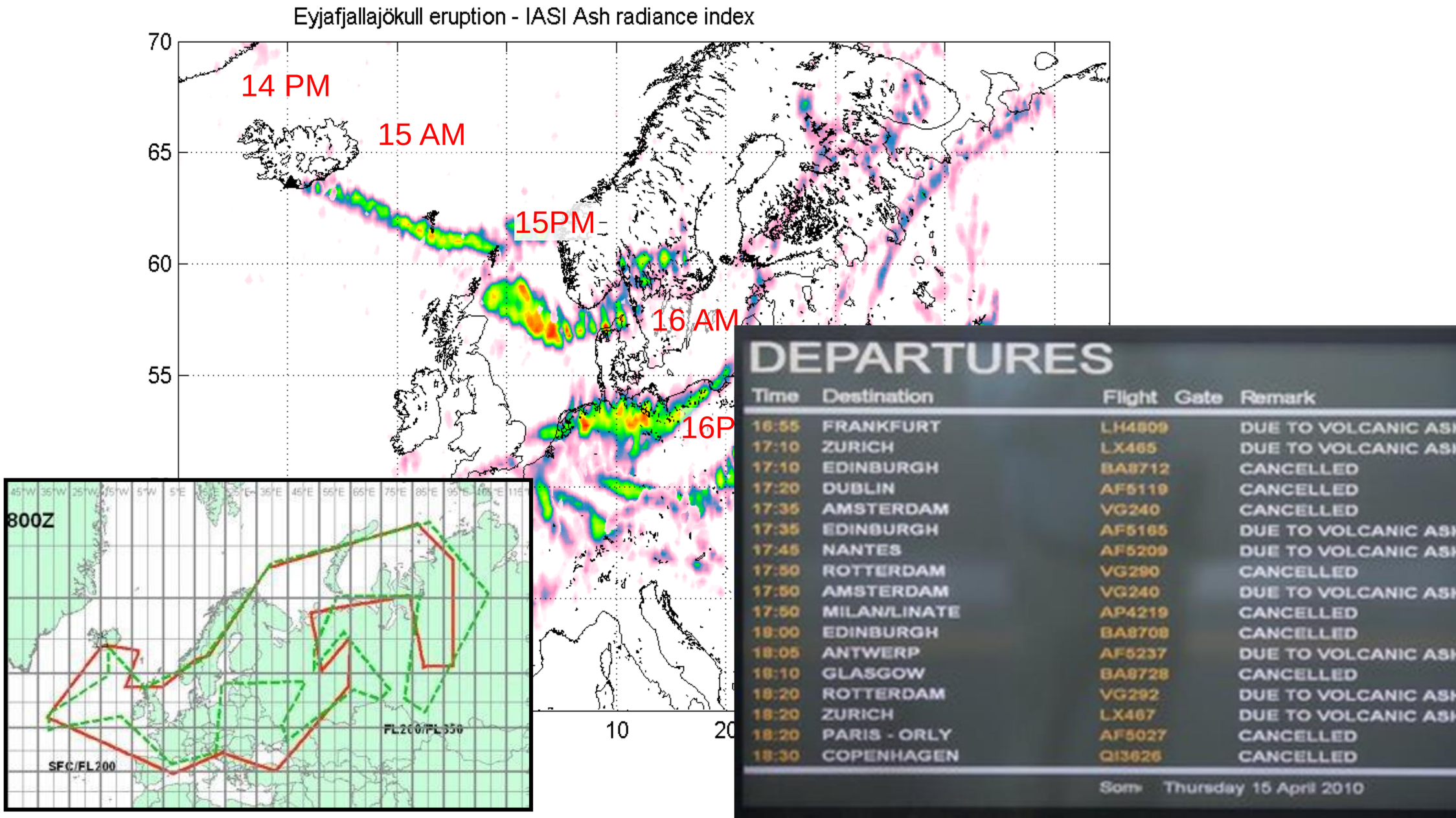
Eyjafjallajökull
(2010)

Eruptions volcaniques : Eyjafjöll avril-mai 2010



Credit L.Clarisse, ULB

Eruptions volcaniques : Eyjafjöll avril-mai 2010



Hunga – Tonga Island
(01/2022)

Objet **Automated SO2 Alert - Extended version 20220113.214536**
De Automated SO2 Alert <daniel.hurtmans@ulb.be>
À Undisclosed recipients:
Date 2022-01-14 00:42

```
Maximum Brightness Temperature difference:
==========================================
Location                > -177.221 -20.2703
Value                   > 9.30142 K
#Pixels above threshold > 22

Maximum Partial Column:
=======================
Location                > -176.498 -19.1573
Value                   > 12.0275 DU at 15 km

#Pixels in plume        > ~47

File     > W_XX-EUMETSAT-Darmstadt,SOUNDING+SATELLITE,METOPC+IASI_C_EUMR_20220113214456_16535_eps_o_l1.bin
Link:    > http://cpm-ws4.ulb.ac.be/Alerts/index.php?
NewYear=2022&NewMonth=01&sel_day=13&AlertList=SO2_iasi_20220113_214456_metopc_16535_eps_o.png
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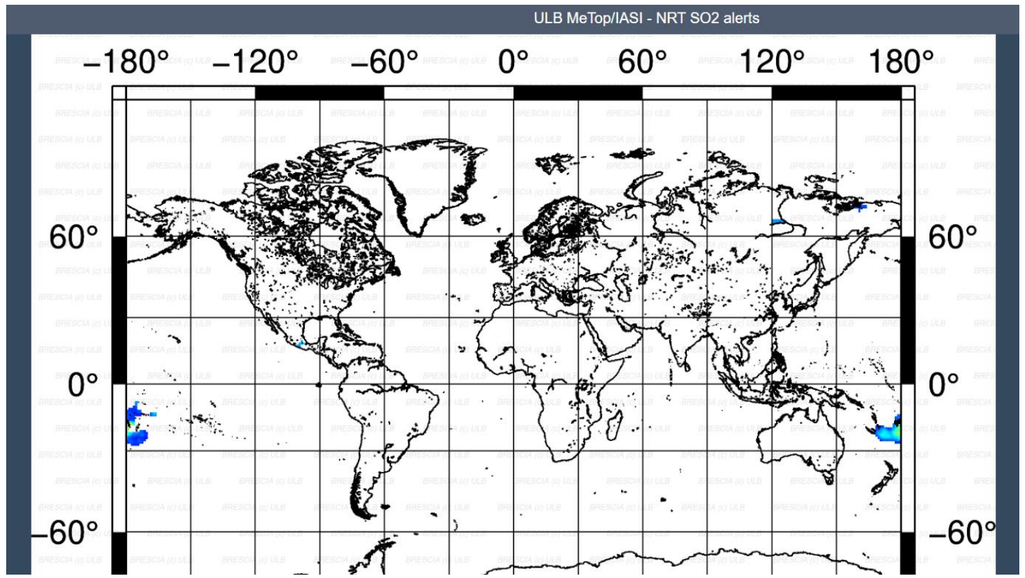
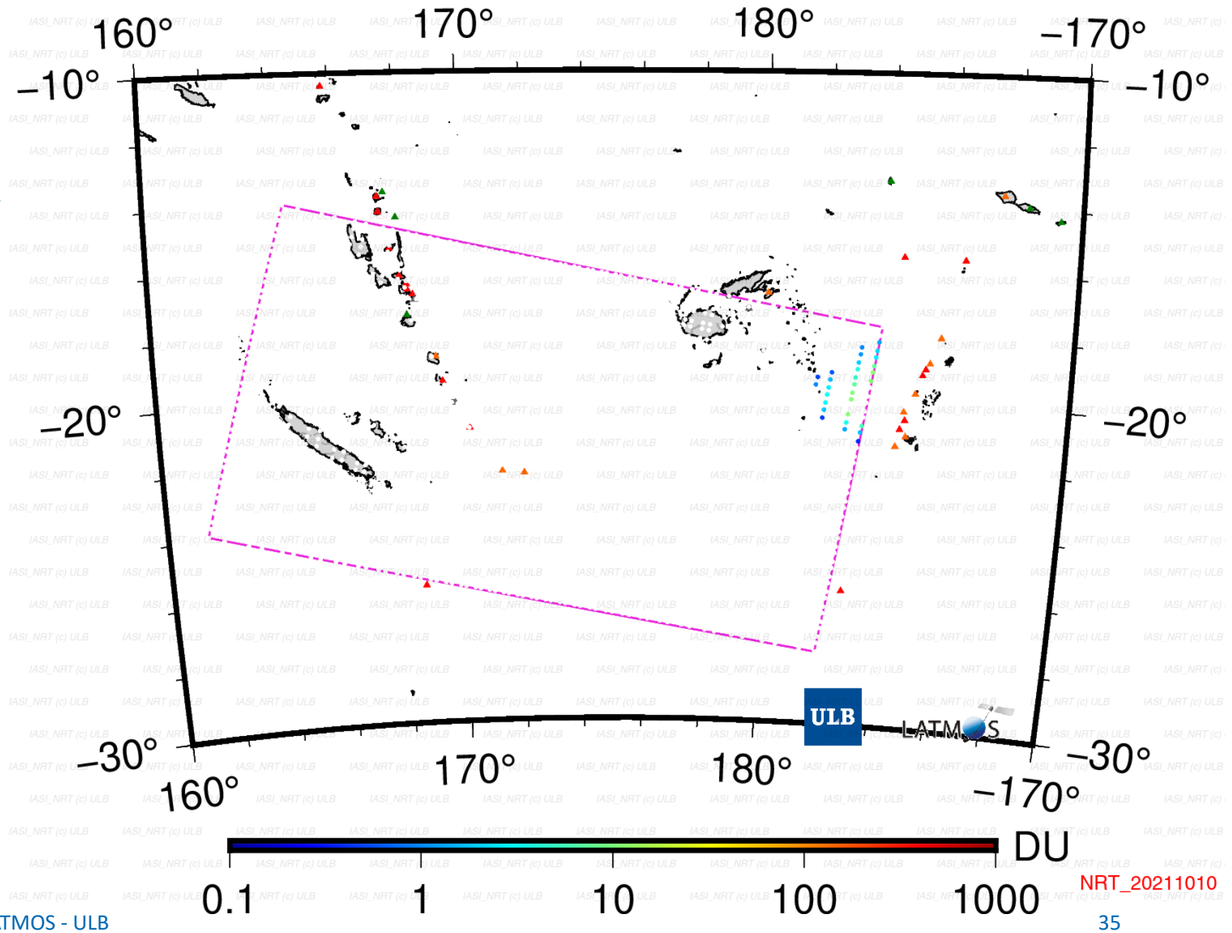
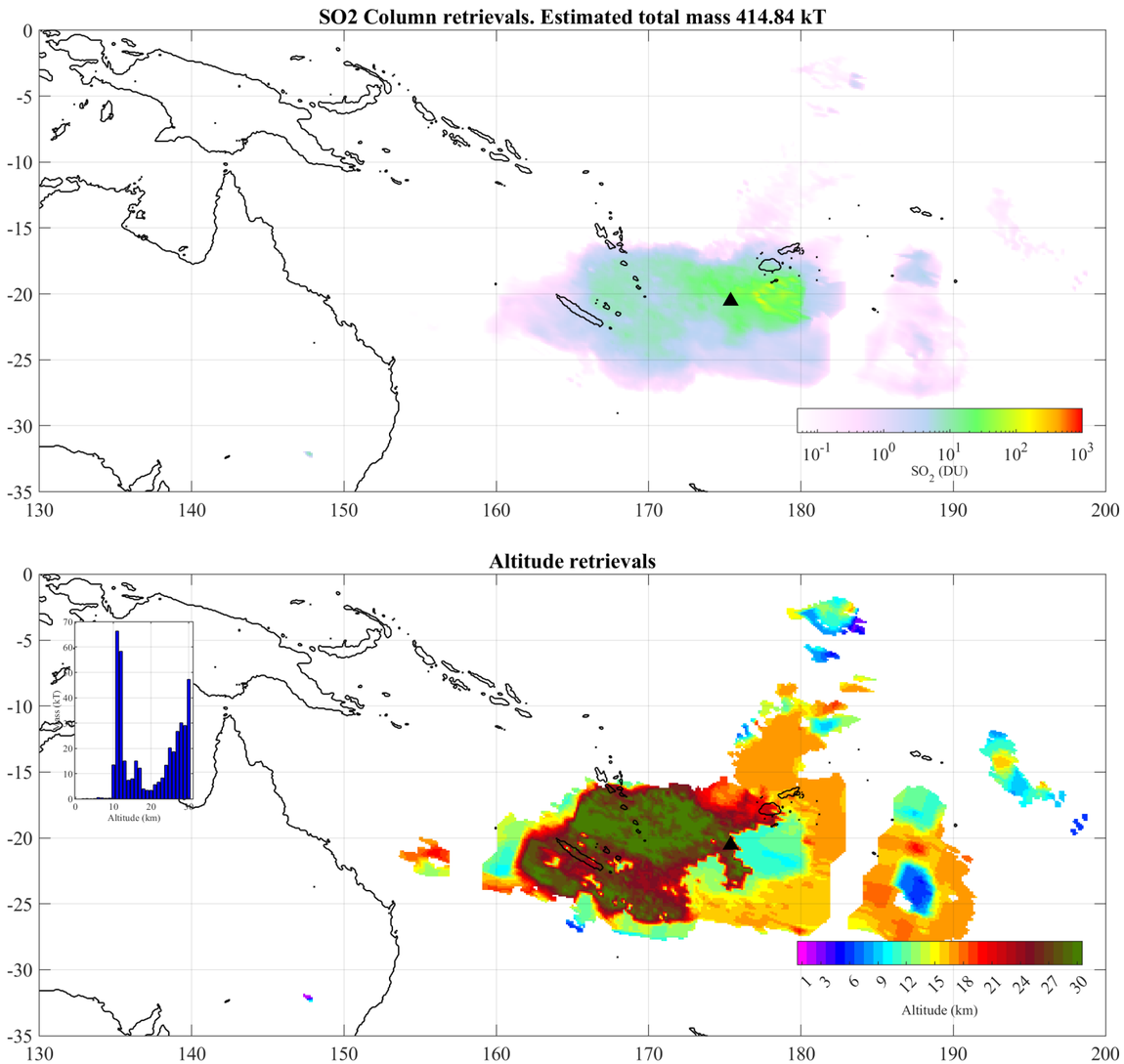
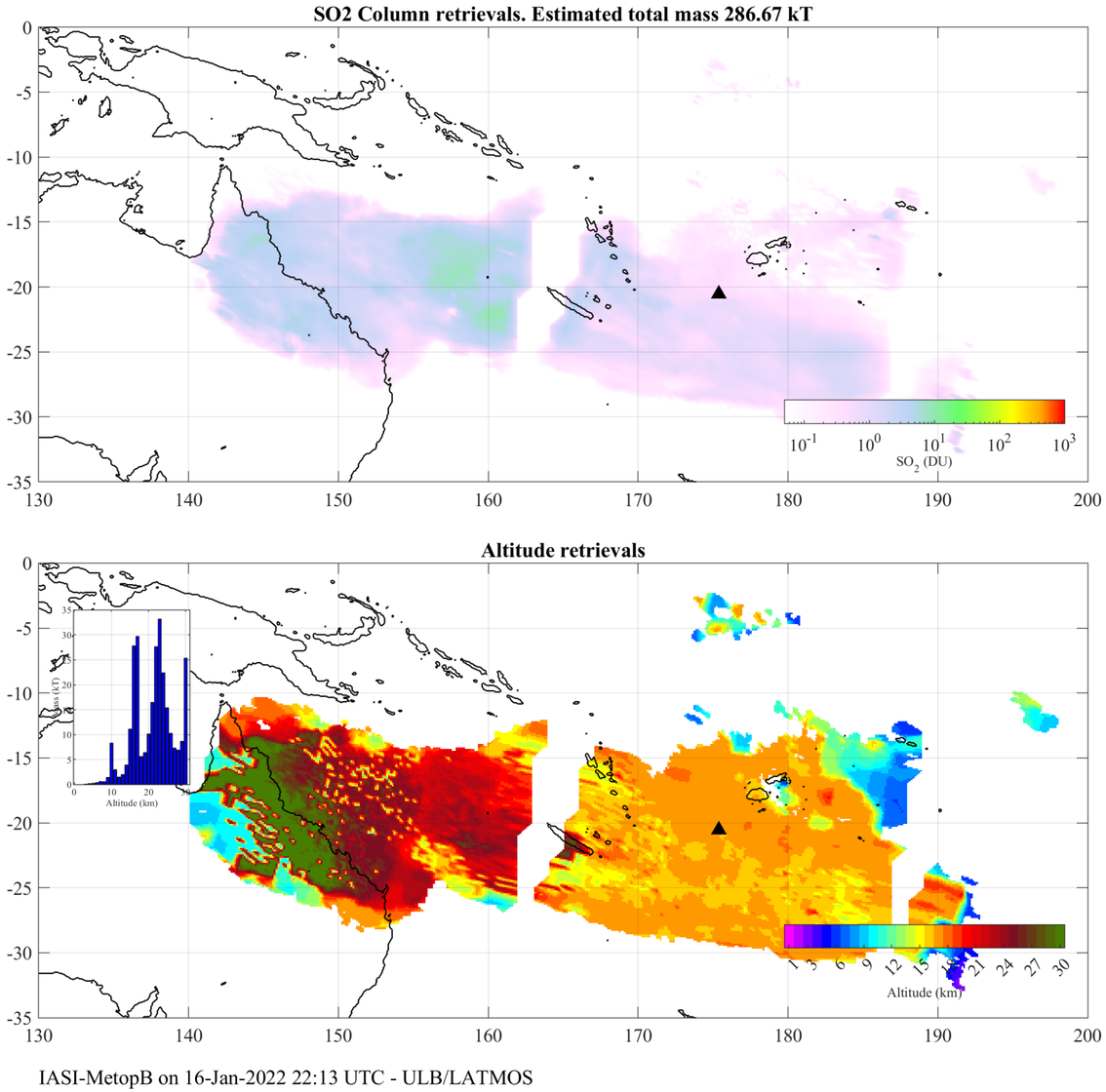


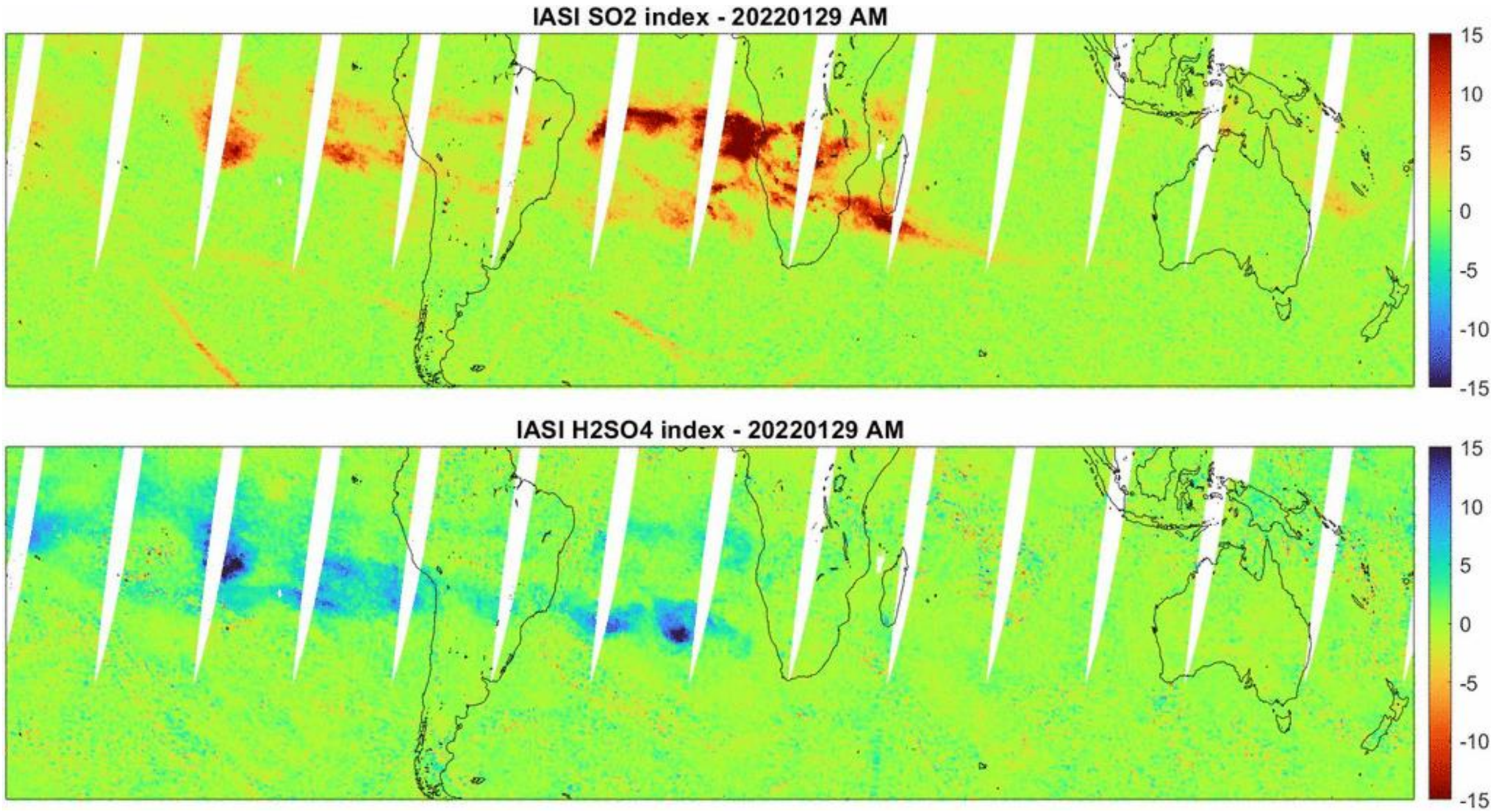
SO_2 Alert 20220113.214456 (c 16535) PC



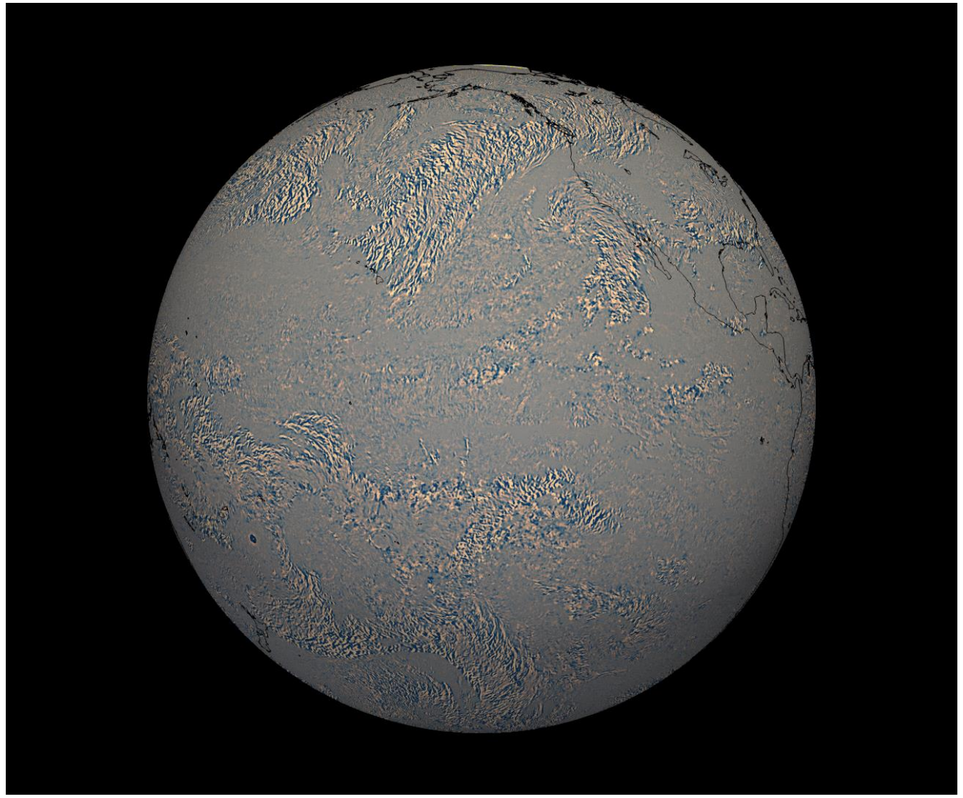




Courtesy Lieven Clarisse (ULB)



Courtesy Lieven Clarisse (ULB)



Courtesy Mathew Barlow (University of Massachusetts Lowell).
Images taken by NOAA's GOES-West satellite (BT band 13, IR)

https://doi.org/10.5194/amt-2021-302
Preprint. Discussion started: 27 October 2021
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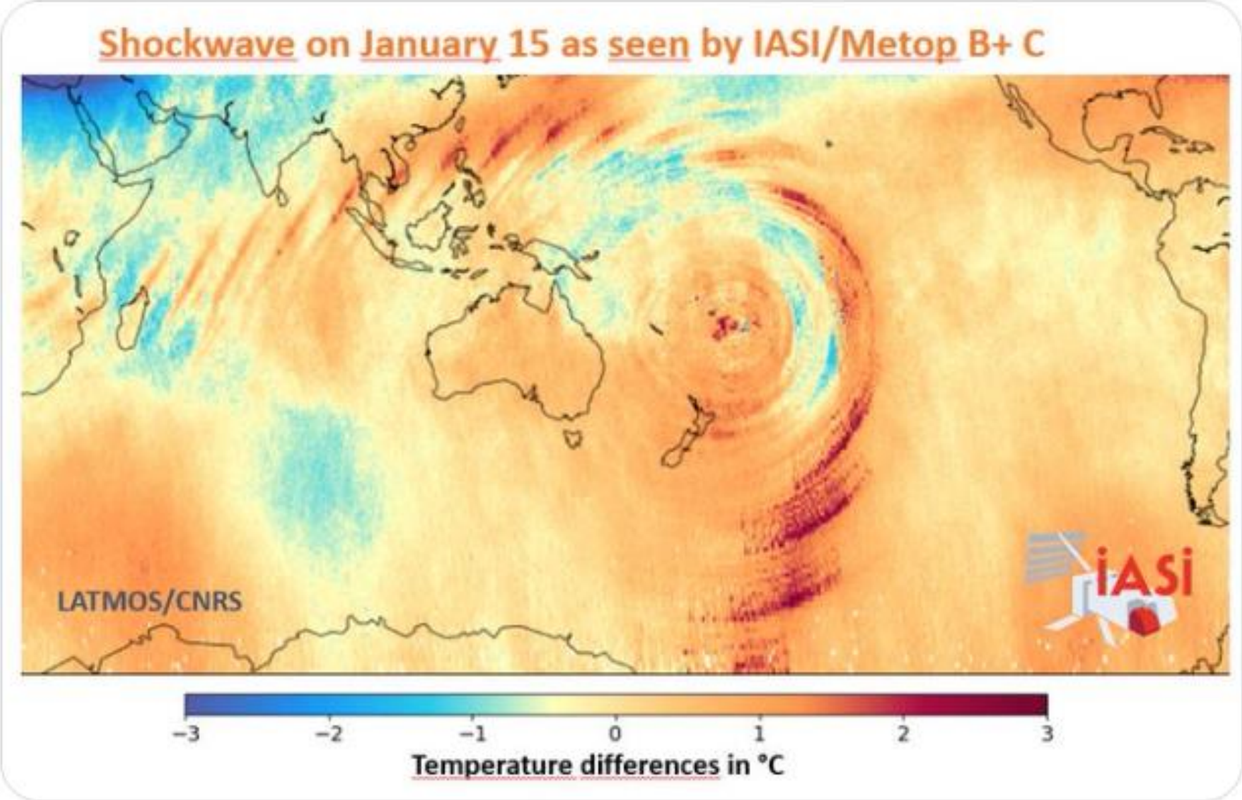
Atmospheric Measurement Techniques Discussions
Open Access
EGU

cathy clerbaux @CathyClerbaux · 19 janv.

Tonga volcano : This is shockwave as measured with the IASI satellite mission (temperature perturbation between the day of the eruption and the next day). First time we see this !



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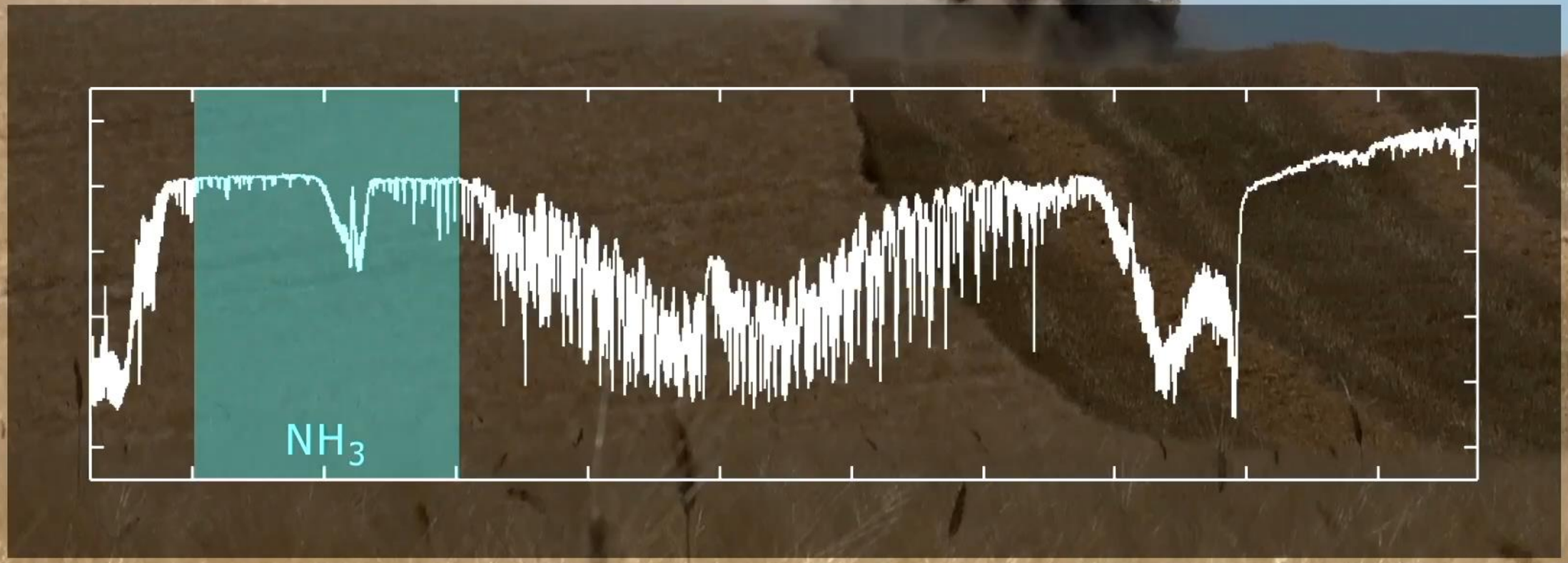
Carbon monoxide (CO)

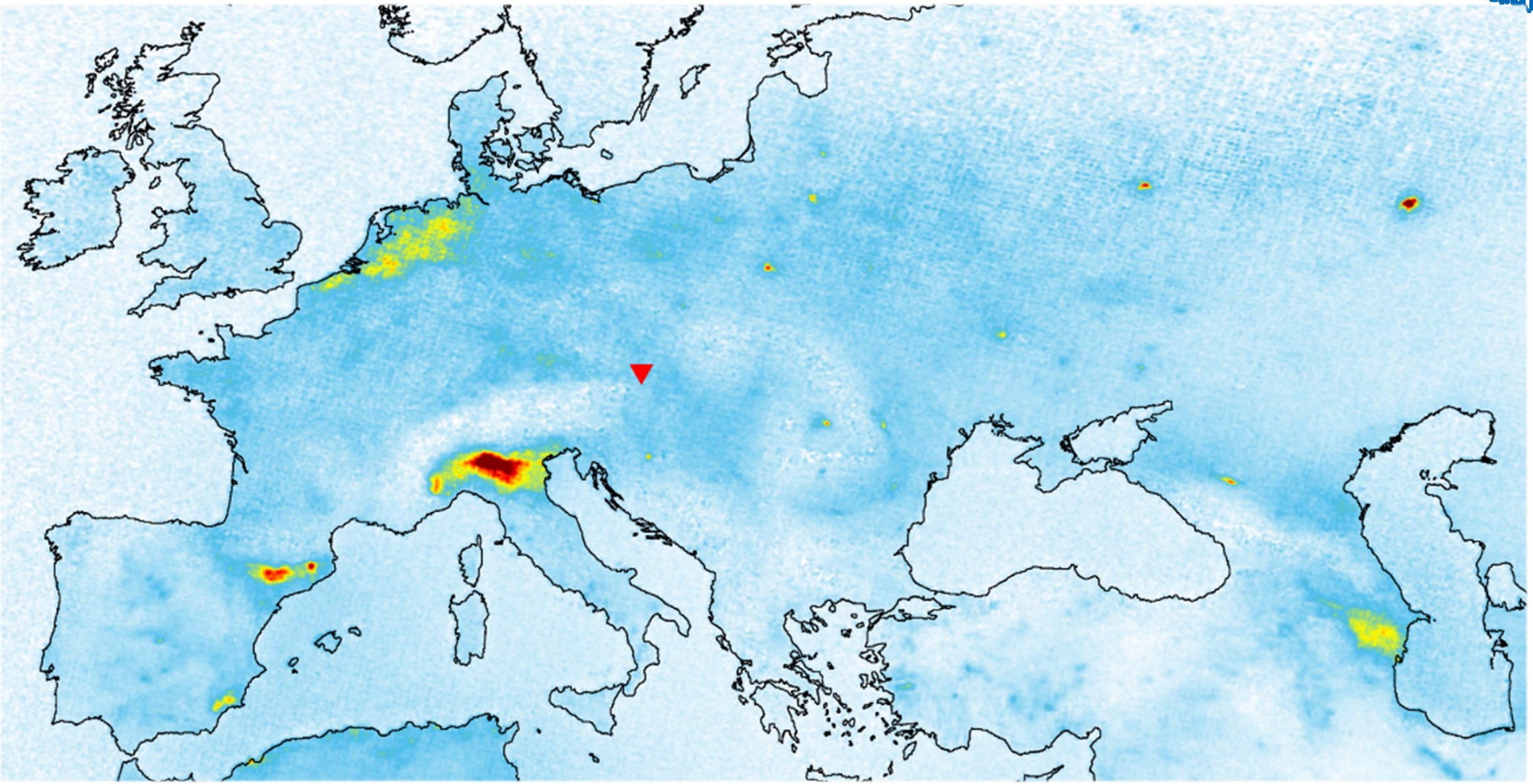
Ozone (O_3)

Sulfur dioxide (SO_2) and ash

Ammonia (NH_3)


NH_3

2009 : what is this signal in the IASI spectra?

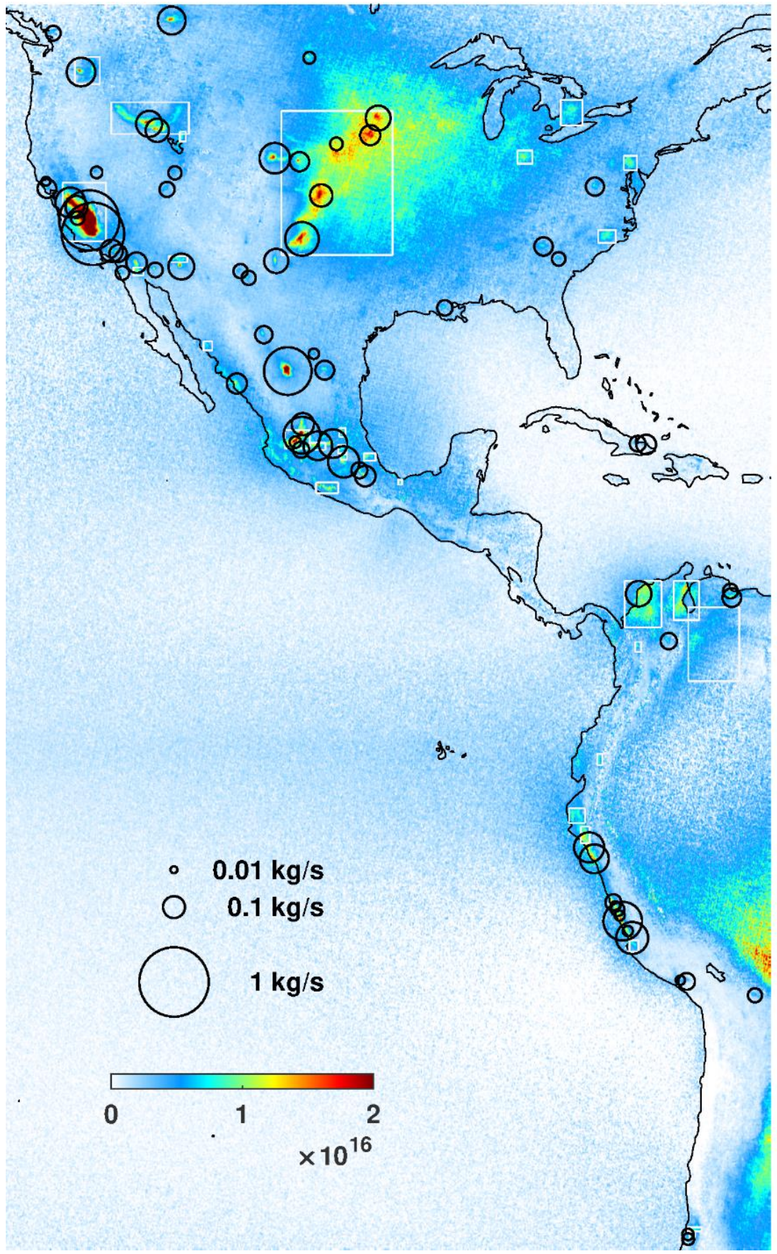


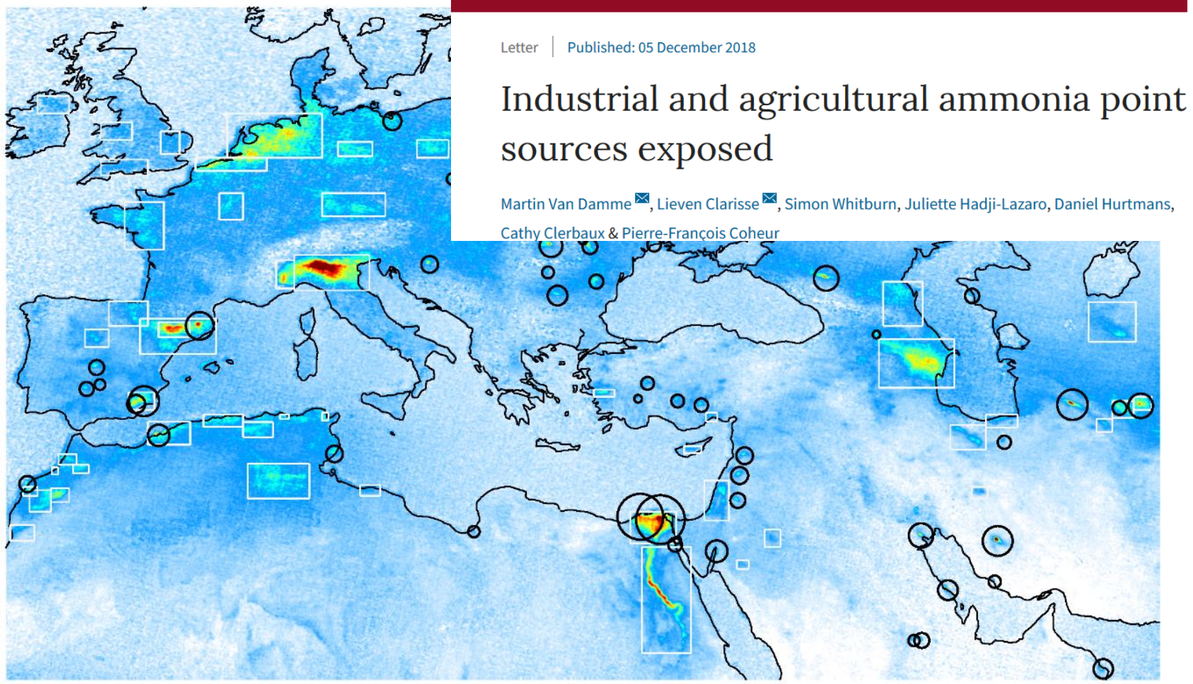
Ammonia (NH_3) – precursor of PM

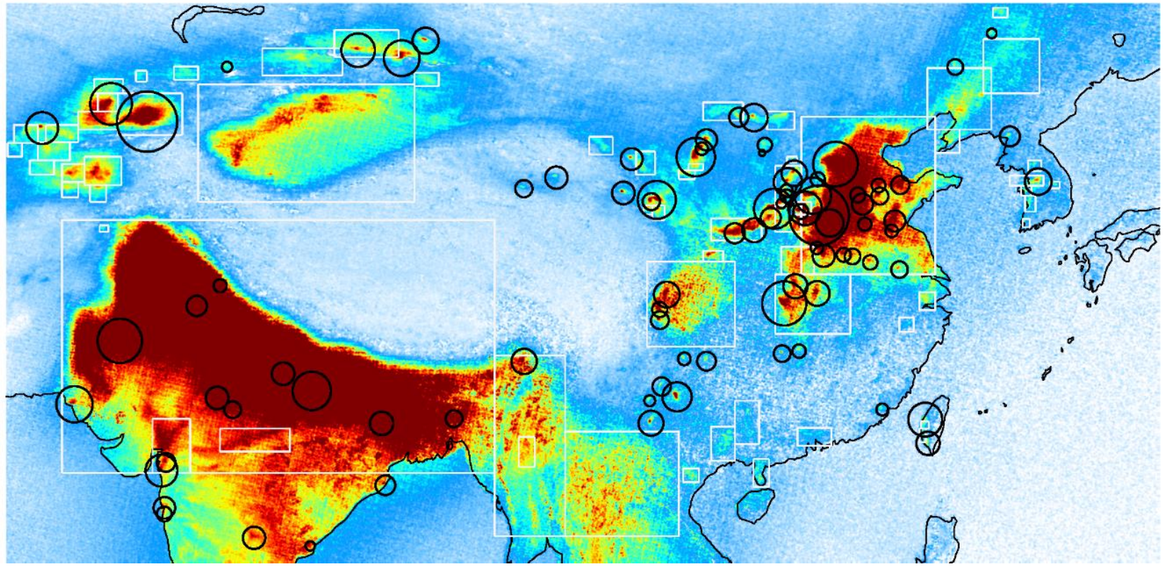
IASI-NH_3

2008-2016 oversampled (1 km^2) distribution:

- **>240 hotspots identified (+ >170 source regions)**
- 3 classes:
  - Agricultural (83)
  - Industrial (158)
  - Natural (1)
- Flux quantification







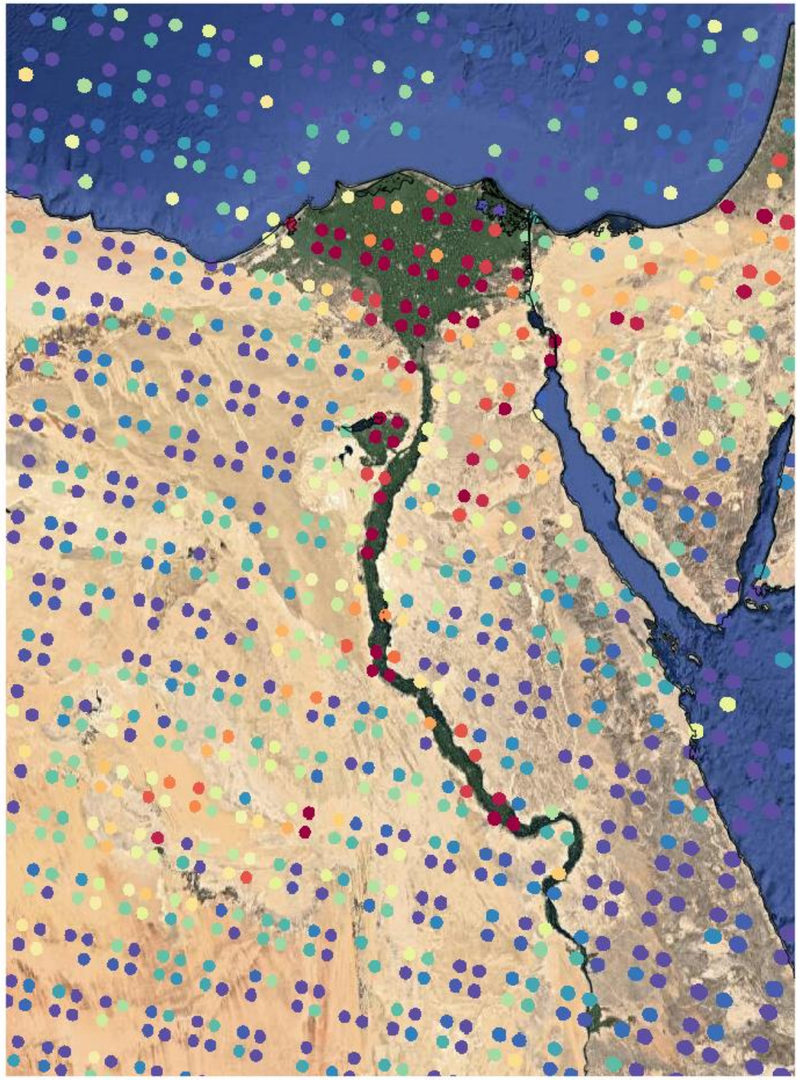
nature
International journal of science

Letter | Published: 05 December 2018

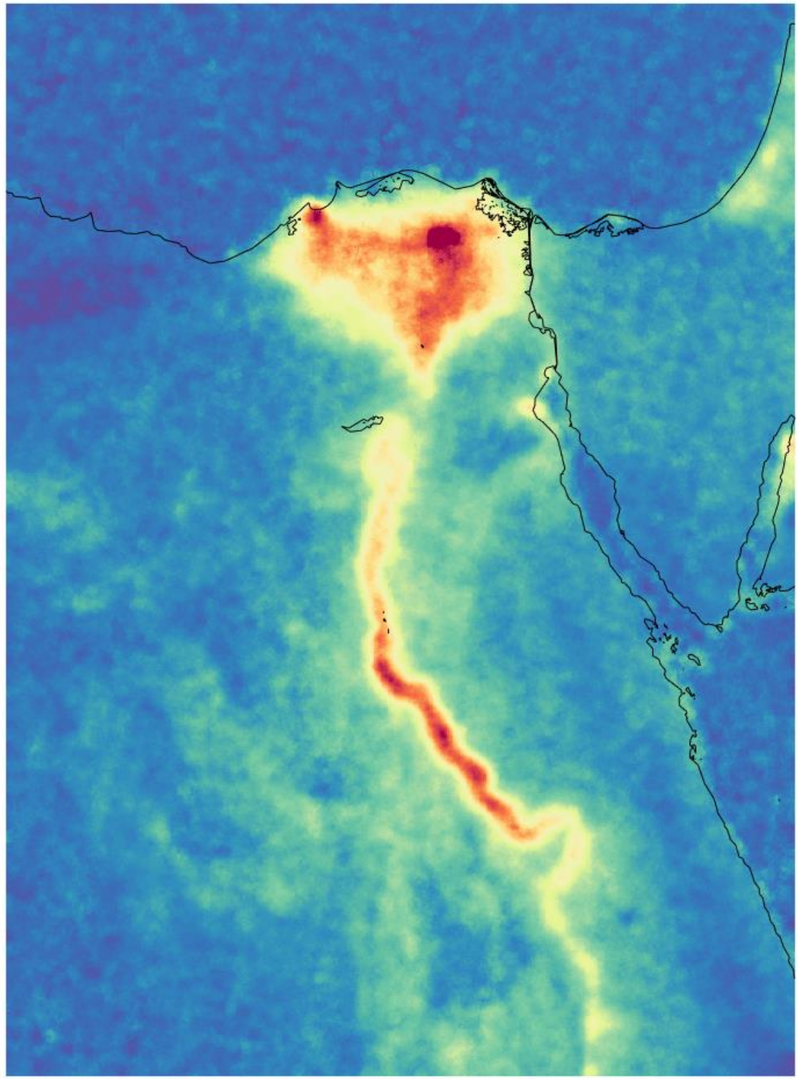
Industrial and agricultural ammonia point sources exposed

Martin Van Damme, Lieven Clarisse, Simon Whitburn, Juliette Hadji-Lazaro, Daniel Hurtmans, Cathy Clerbaux & Pierre-François Coheur

Ammonia – averaging over different time scales



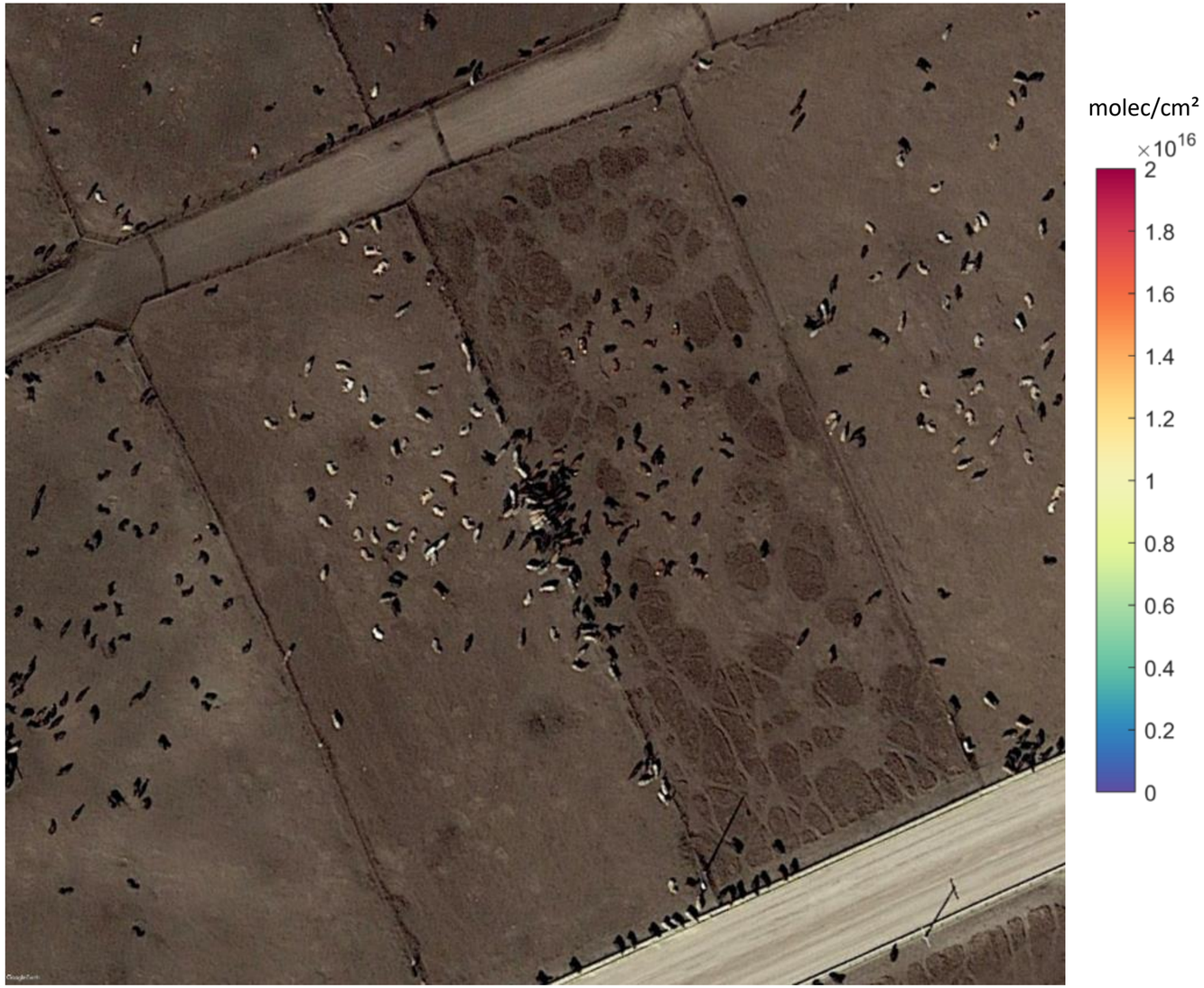
1 day



10 years

Credit Martin Van Damme, Lieven Clarisse (ULB)

Example 1: Agriculture



Picture: GoogleEarth

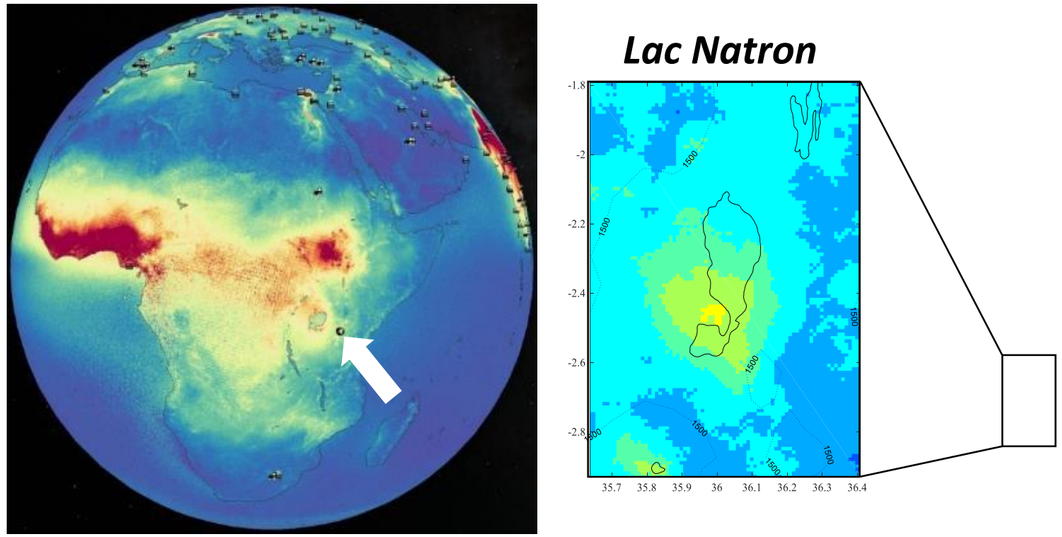
Credit Martin Van Damme, Lieven Clarisse (ULB)

Example 2: Industry

Picture: GoogleEarth

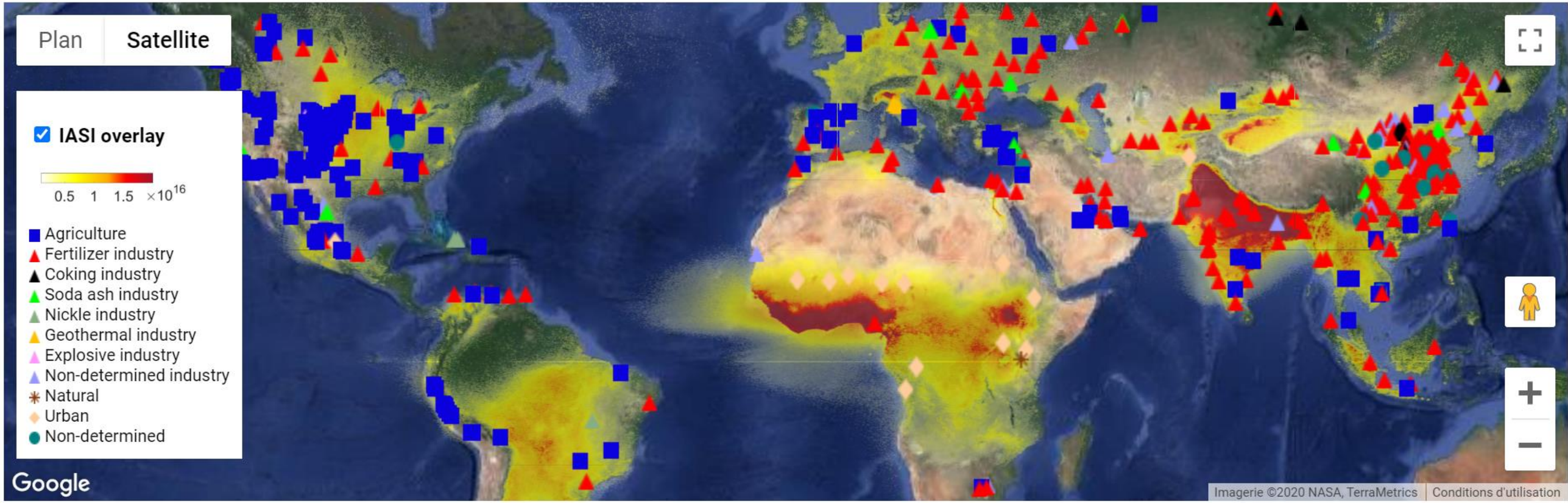
Credit Martin Van Damme, Lieven Clarisse (ULB)

Example 3:Pink flamingos



Picture: http://animalia-life.club/other/lesser-flamingo-lake-natron.html

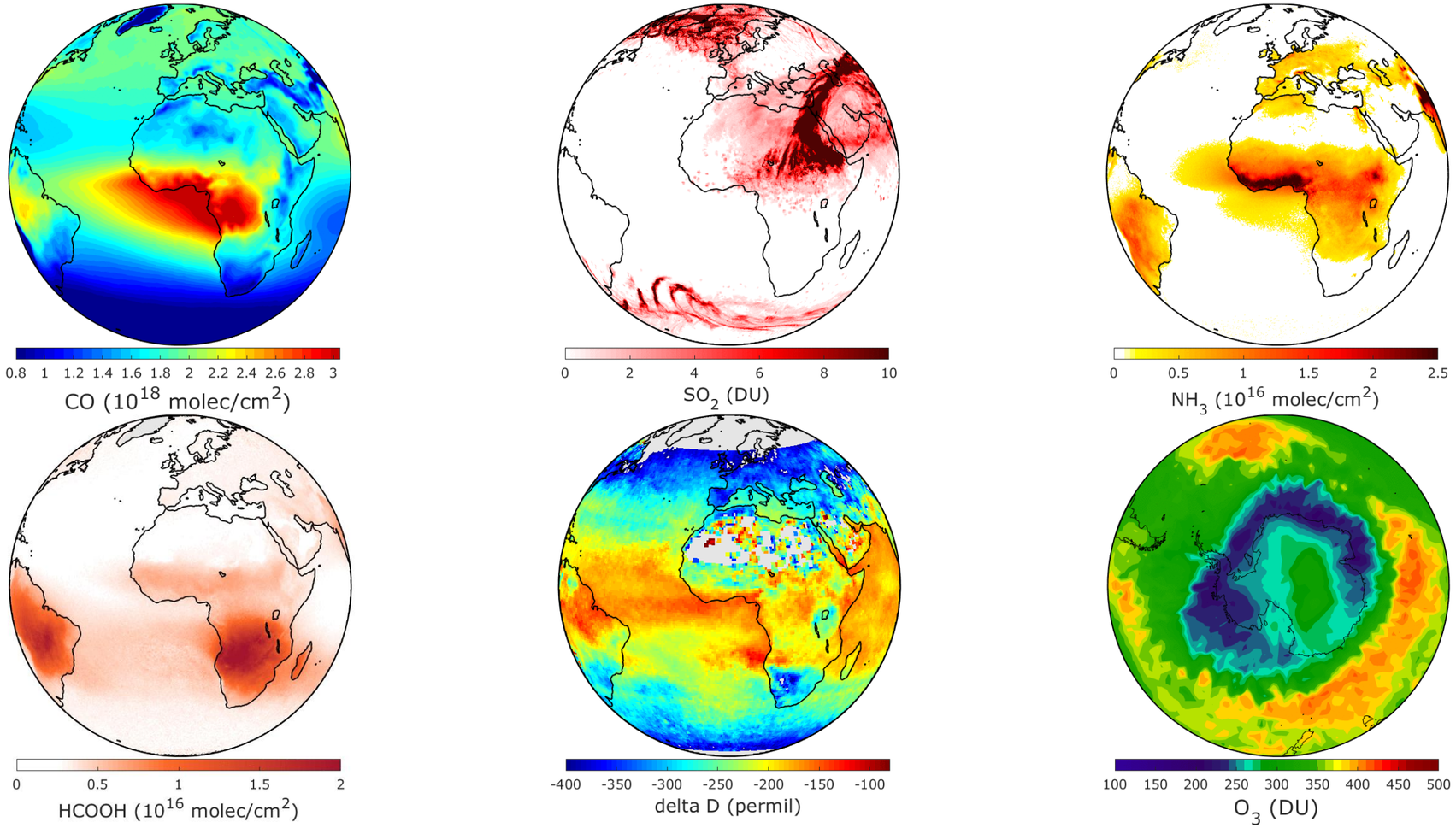
Clarisse et al., Sci. Rep. 2019



Global ammonia point sources as seen by IASI satellite instruments

https://www2.ulb.ac.be/cpm/NH3-IASI.html

Van Damme, M., Clarisse, L., Whitburn, S., Hadji-Lazaro, J., Hurtmans, D., Clerbaux, C., Coheur, P.-F. **Industrial and agricultural ammonia point sources exposed**. *Nature* **564**, 99-103, doi: 10.1038/s41586-018-0747-1, 2018



https://iasi.aeris-data.fr/

http://iasi.aeris-data.fr/CO/
http://iasi.aeris-data.fr/NH3/
http://iasi.aeris-data.fr/HCOOH/
http://iasi.aeris-data.fr/O3/
http://iasi.aeris-data.fr/SO2/

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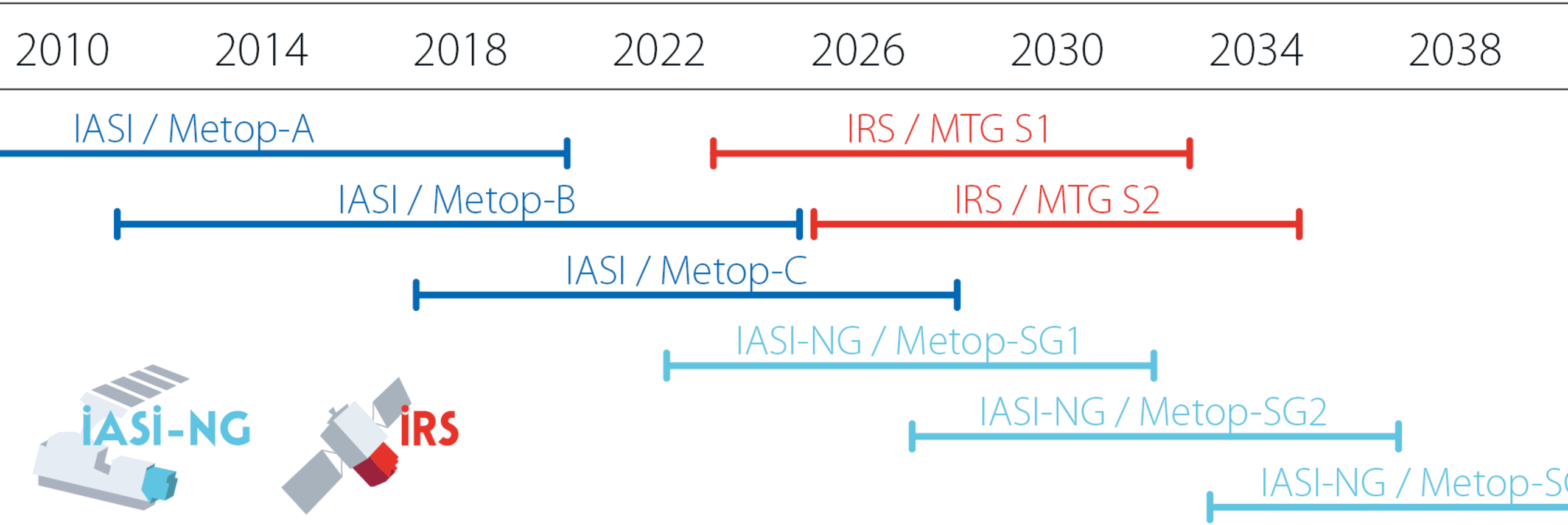

That’s all folks !

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