



EUMETSAT

AC SAF

ATMOSPHERIC COMPOSITION
MONITORING



EUMETSAT

Satellite Ozone Monitoring and the EUMETSAT Contribution

Federico Fierli

on behalf of EUMETSAT teams



EUMETSAT is an intergovernmental organisation with 30 Member States and 1 Cooperating State

Member States



AUSTRIA



BELGIUM



BULGARIA



CROATIA



CZECH REPUBLIC



DENMARK



ESTONIA



FINLAND



FRANCE



GERMANY



GREECE



HUNGARY



ICELAND



IRELAND



ITALY



LATVIA



LITHUANIA



LUXEMBOURG



THE NETHERLANDS



NORWAY



POLAND



PORTUGAL



ROMANIA



SLOVAK
REPUBLIC



SLOVENIA



SPAIN



SWEDEN



SWITZERLAND



TURKEY



UNITED KINGDOM

Cooperating States



SERBIA



EUMETSAT's mission

To **establish, maintain** and **exploit** European **operational** meteorological satellite systems, while considering the recommendations of **WMO** as much as possible

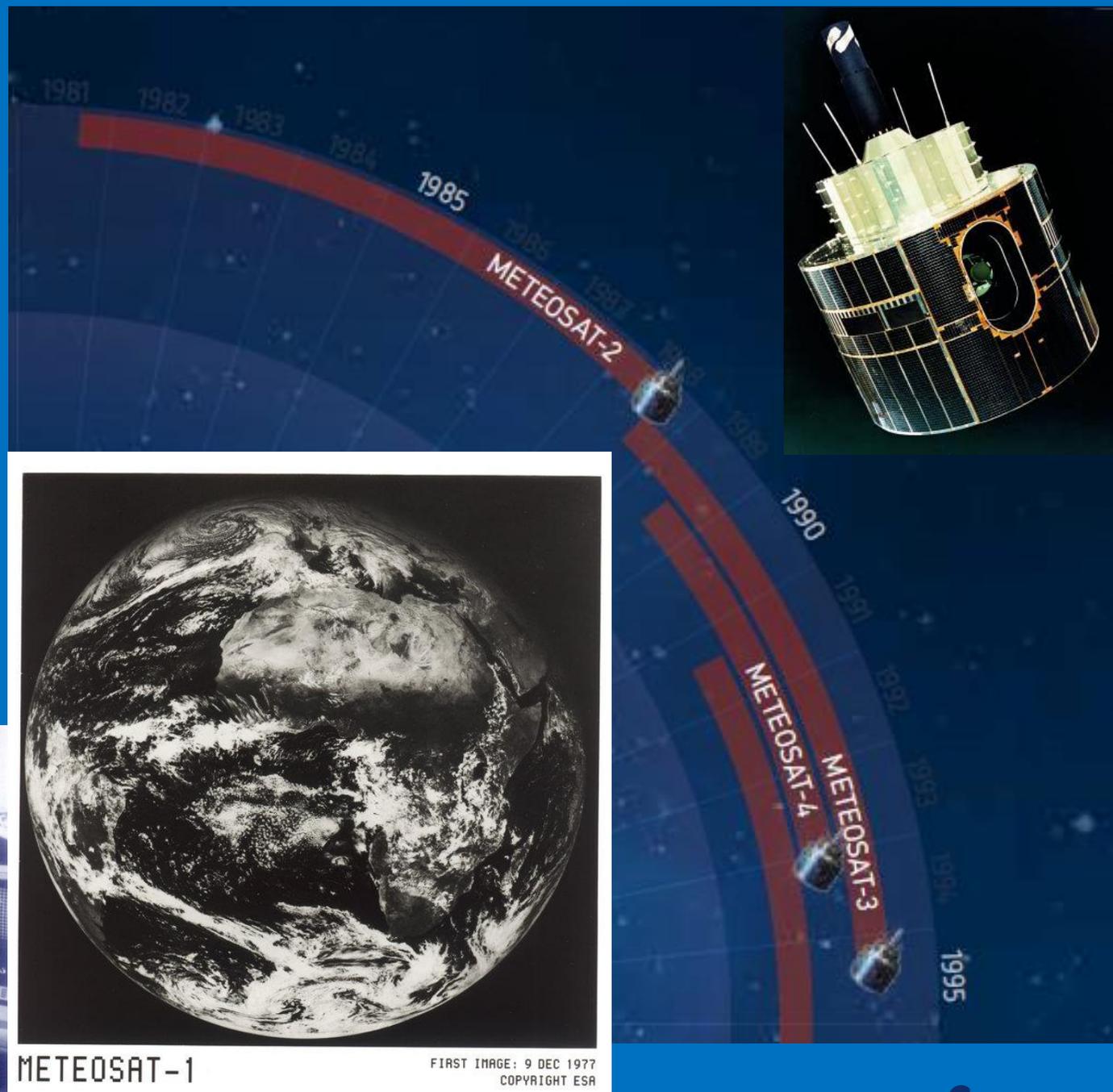
A further objective is to contribute to **operational climate monitoring** and detection of **global climatic changes**

By fulfilling these objectives, contribute to **environmental monitoring**, where **interactions** with the **ocean** and the **atmosphere** are involved

EUMETSAT satellites history

Meteosat first generation

- 1 sensor
- 3 channels



EUMETSAT satellites presence

Meteosat first generation

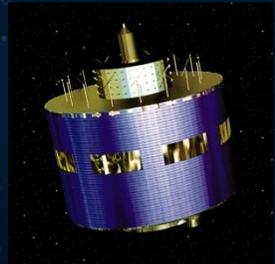
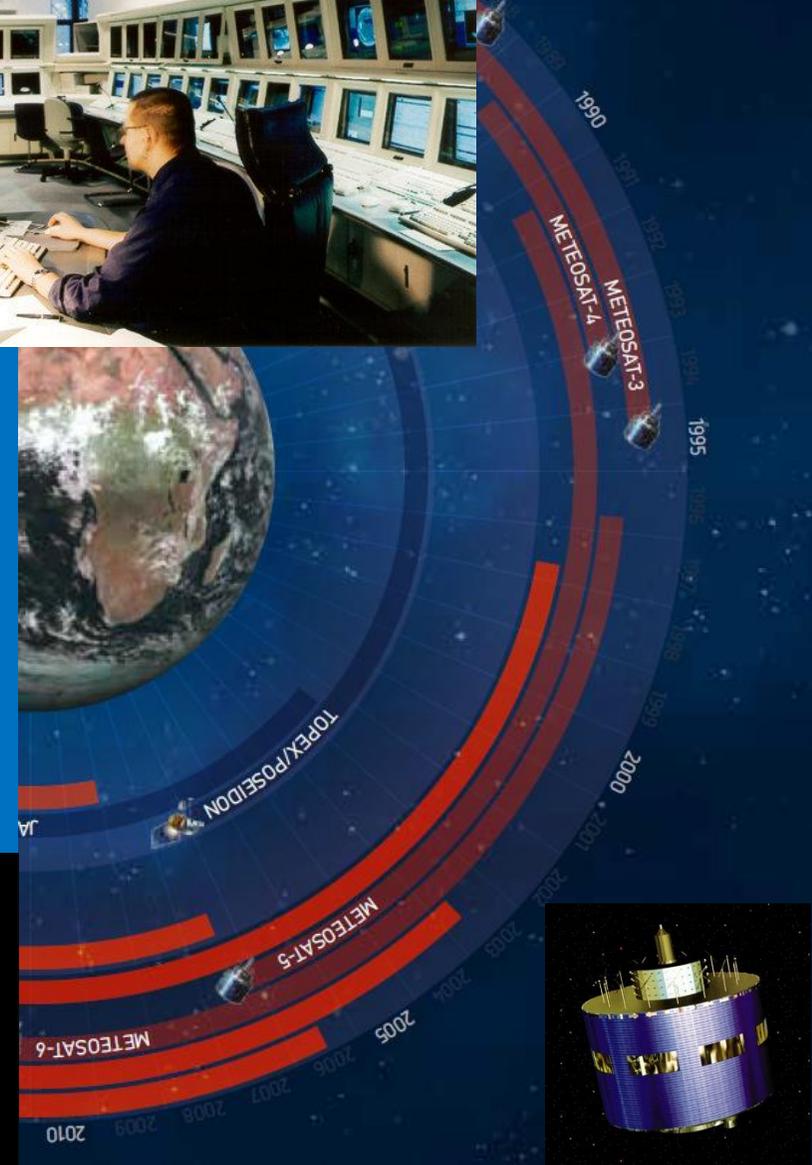
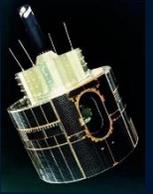
- 1 sensor
- 3 channels

Second Generation of Meteosat (MSG)

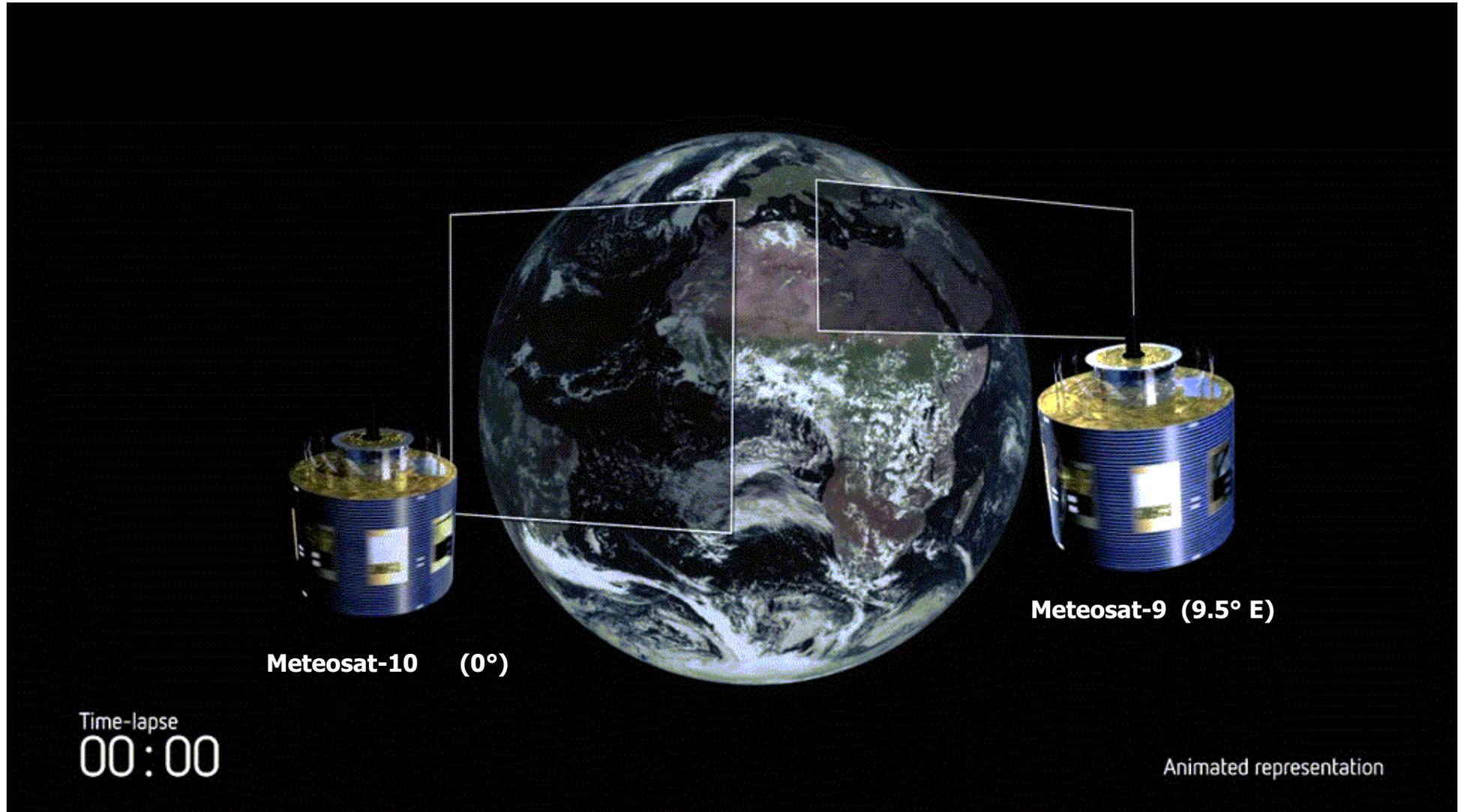
- 2 sensors
- 12 channels

Metop

- 10 sensors
- 500+ channels



(almost) 40 years Meteosat in geostationary orbit



The current EUMETSAT satellite fleet

METOP -A /B/C (Launched Nov 2018)

(LOW-EARTH, SUN – SYNCHRONOUS ORBIT)

EUMETSAT POLAR SYSTEM/INITIAL JOINT POLAR SYSTEM

Sentinel -3a

(LOW-EARTH, SUN-SYNCHRONOUS ORBIT)

Copernicus Global Marine and Land Environment Mission
Operated by EUMETSAT

JASON-2, -3

(LOW-EARTH, 63° INCL. NON SYNCHRONOUS ORBIT)

OCEAN SURFACE TOPOGRAPHY MISSION

METEOSAT SECOND GENERATION -9, -10, -11

(GEOSTATIONARY ORBIT)

TWO-SATELLITE SYSTEM:

- METEOSAT-11: IN-ORBIT BACKUP
- METEOSAT-10: FULL DISK IMAGERY MISSION AT 0° (15 MN)
- METEOSAT-9: RAPID SCAN SERVICE OVER EUROPE AT 9.5°E (5 MN)

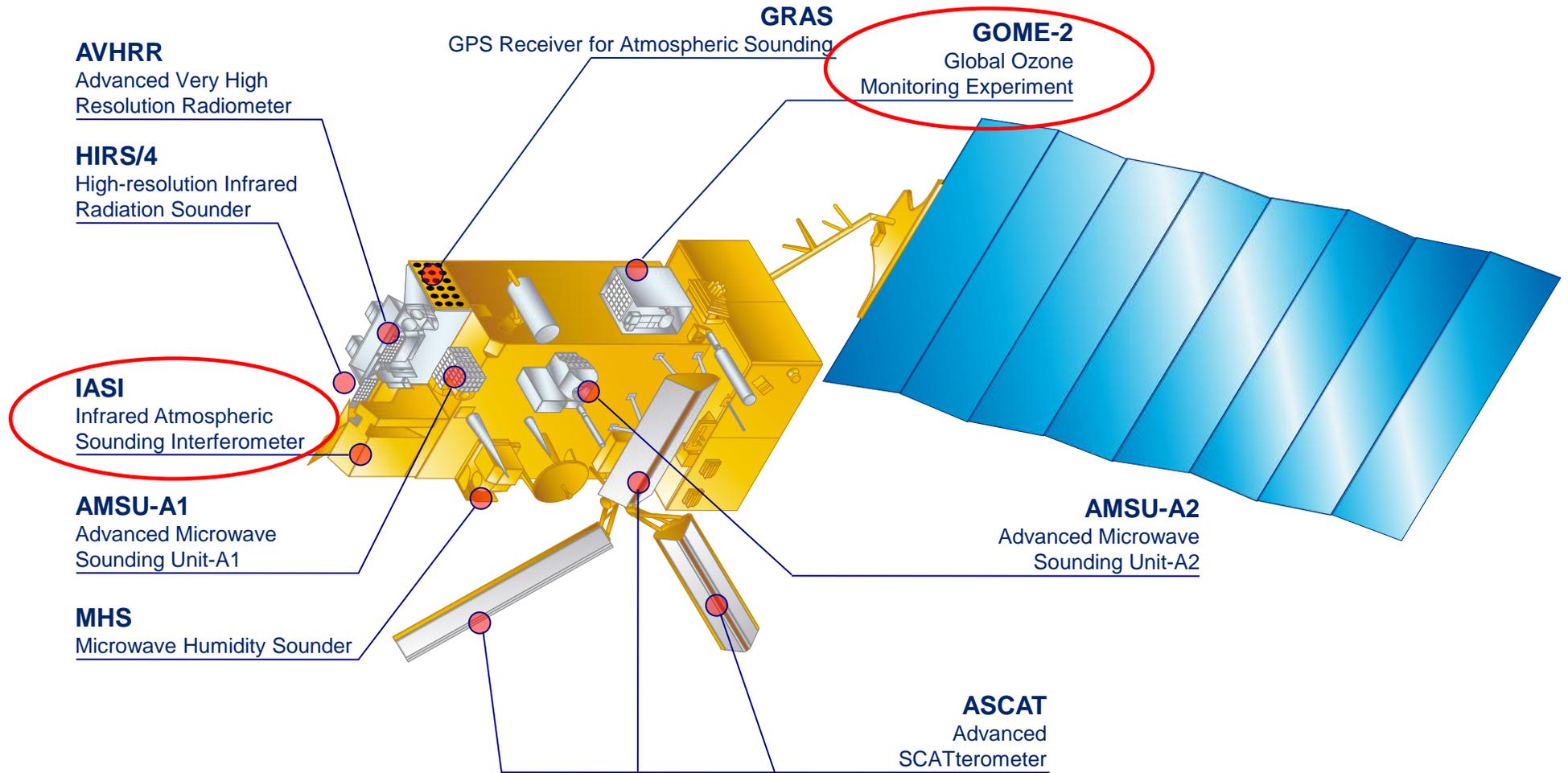
METEOSAT-8 (2nd GENERATION)

(GEOSTATIONARY ORBIT)

INDIAN OCEAN DATA COVERAGE MISSION
AT 40° E (TBD June 2016)

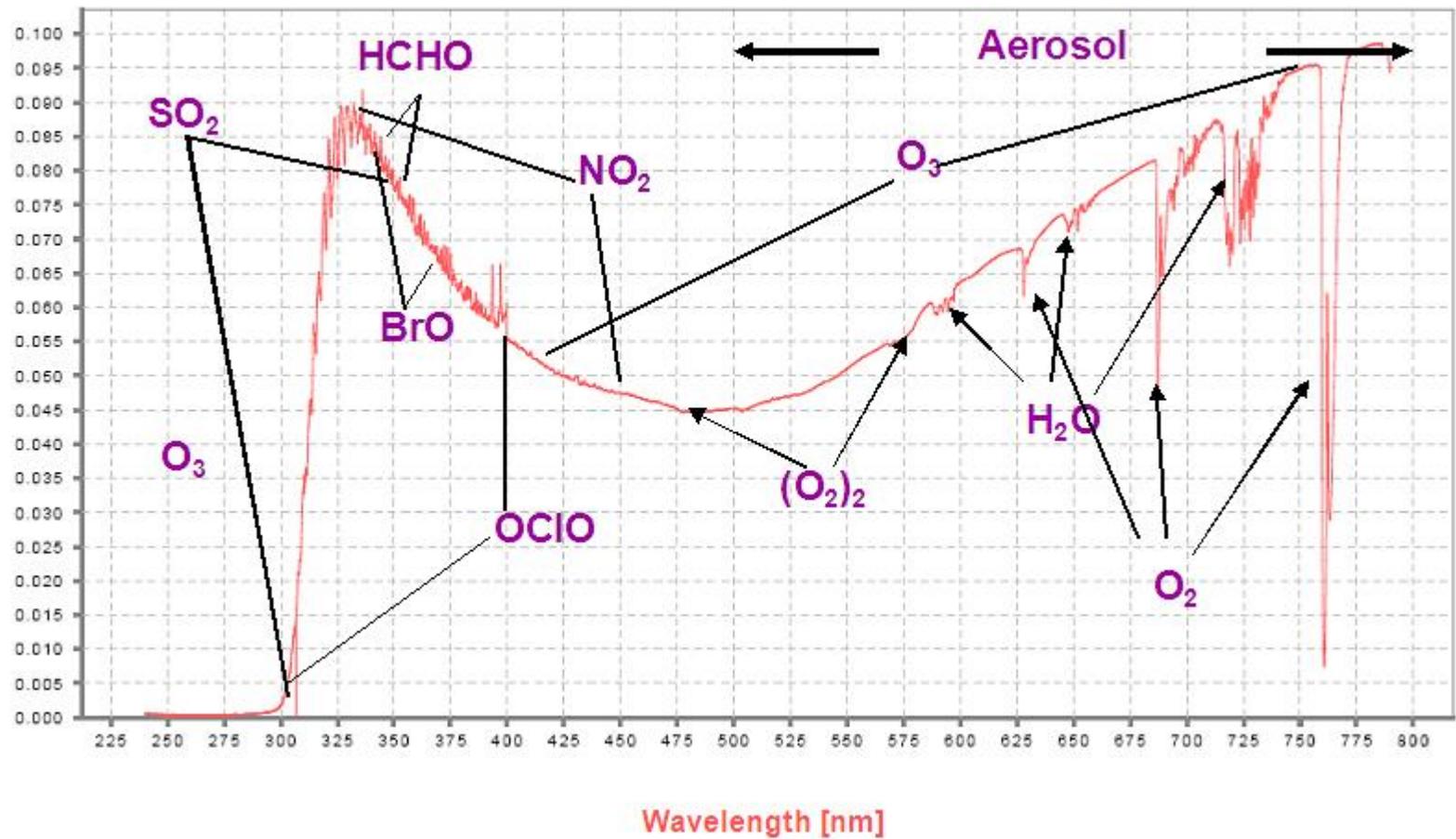


Metop and its instrument suite



How GOME-2 works ...

GOME-2 main channel transmittance



Extending EUMETSAT: The SAF Network

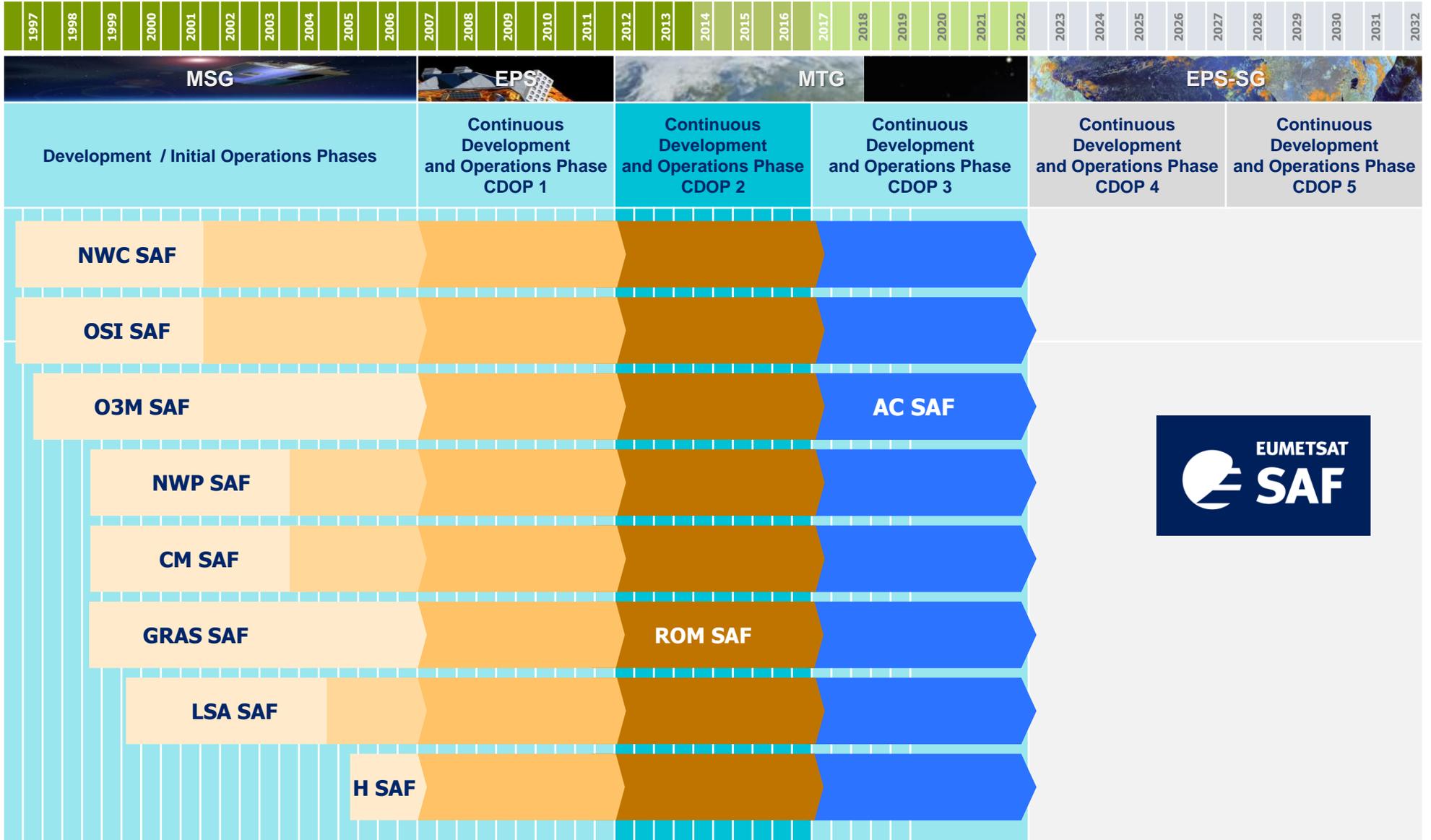


- SAF = **Satellite Application Facility**
- part of the EUMETSAT application ground segment
- providing **operational** products and services to users
- specialised on topics and themes
- complement production of standard meteorological products at EUMETSAT Secretariat
- located at Weather Services in EUMETSAT Member and Co-operating States
- developed and operated by consortium of partners

EUMETSAT Network of Satellite Application Facilities



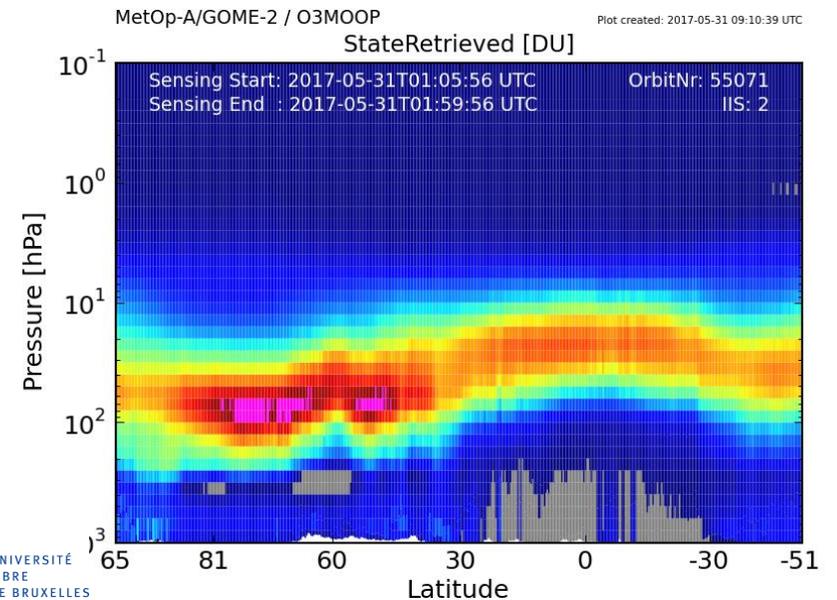
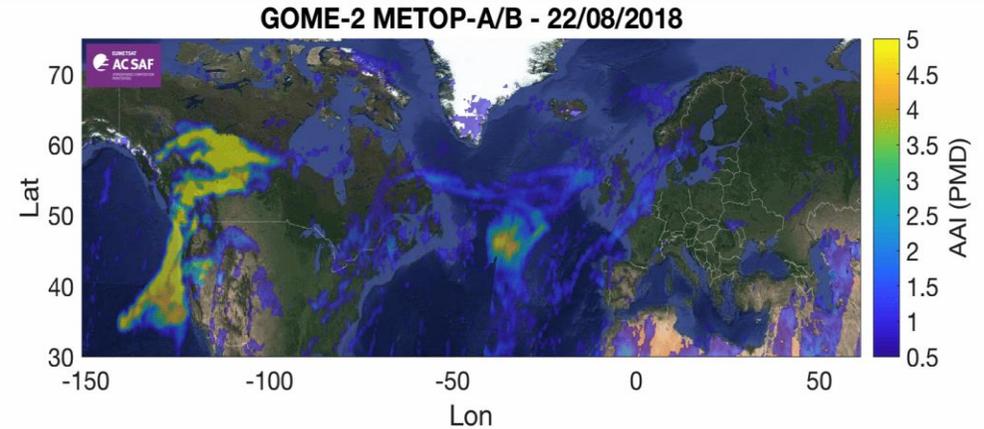
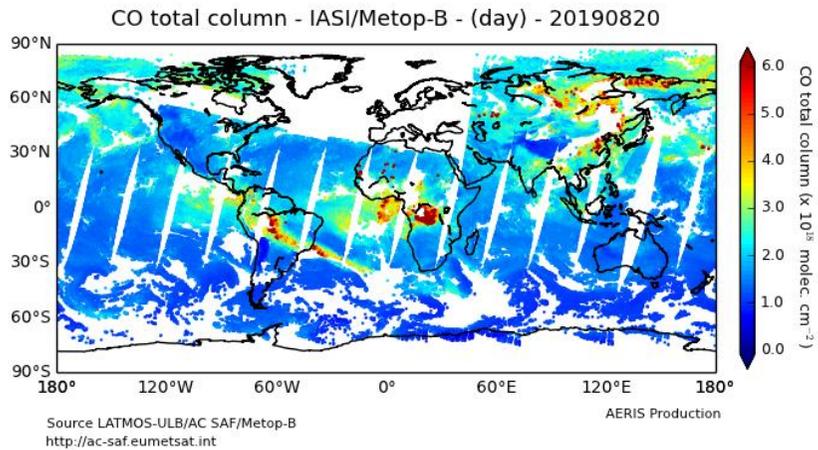
35 years of SAF Development and Operations



The SAF on Atmospheric Composition Monitoring

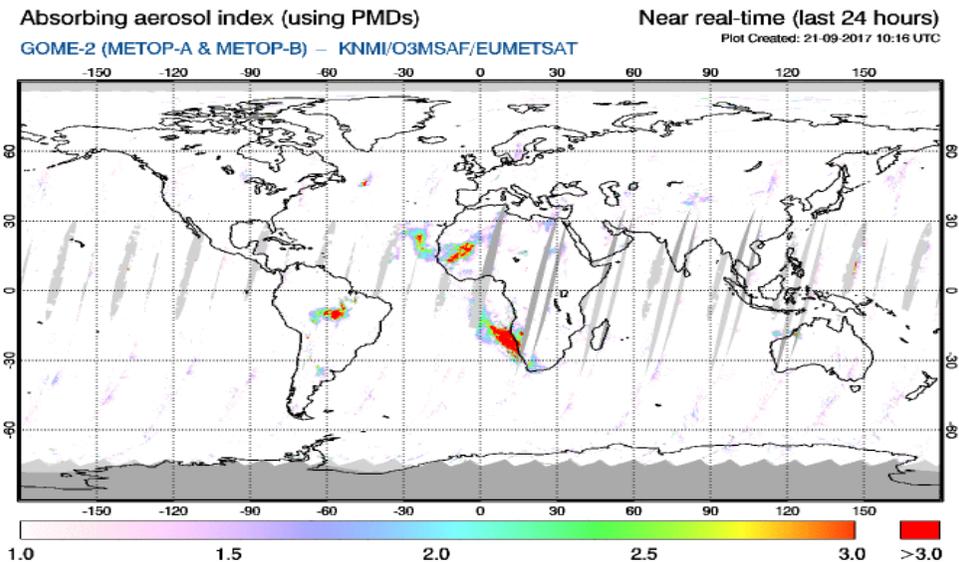
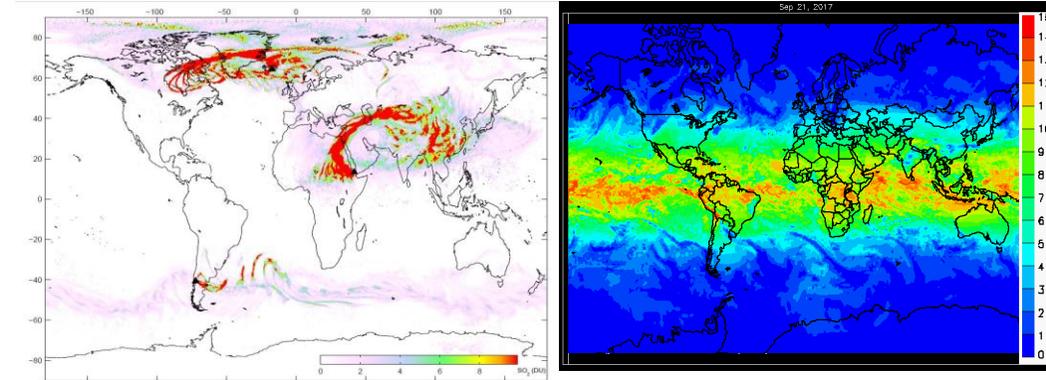
Ozone, trace gases, aerosols UV

Global Ozone Monitoring Experiment (GOME-2) and IASI on EPS (Metop)



AC SAF product portfolio

- Ozone:
 - total column
 - Profile
- Ozone chemistry products
 - BrO, HNO₃
- Air quality products
 - NO₂, Formaldehyde, Glyoxal, CO, NH₃, SO₂
- Volcanic products
 - SO₂, Volcanic ash
- Aerosol products
- UV radiation products

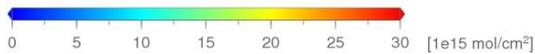
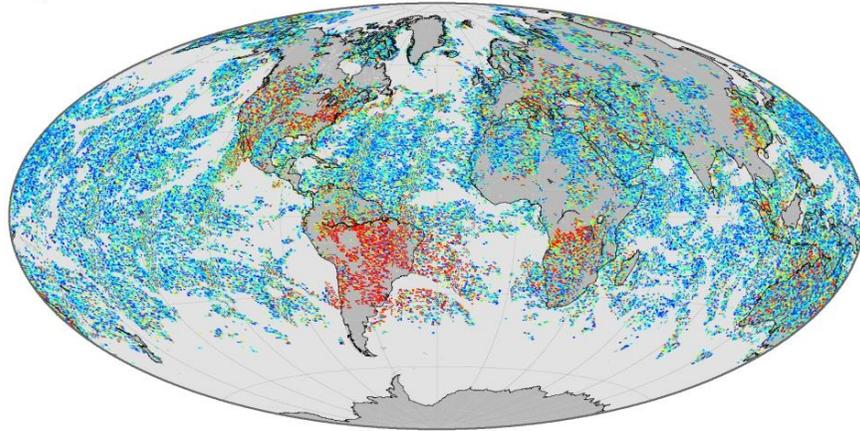


2019 Stories on Fires

HCHO

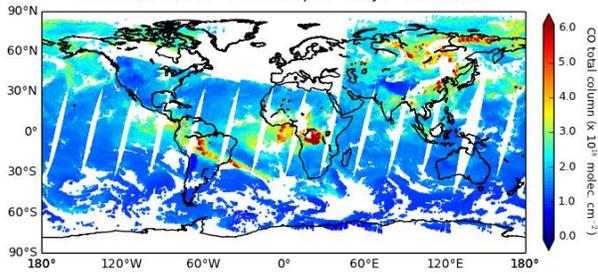
Formaldehyd total column

Acquisition Time	Sensor	Plot Range	Algorithm
19-AUG-2019 23:02:28 21-AUG-2019 01:02:57	GOME-2 MetOp-AB	0.0 : 411.1 13.6 ± 13.2	GDP 4.8 UPAS 1.3.9



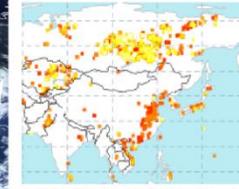
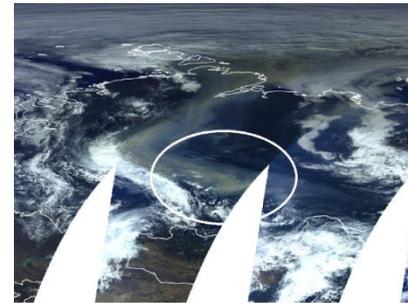
<http://atmos.eoc.dlr.de/oome2ab>

CO total column - IASI/Metop-B - (day) - 20190820

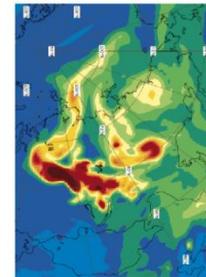


Source LATMOS-ULB/AC SAF/Metop-B
<http://ac-saf.eumetsat.int>

AERIS Production



Fire radiative power [W/m²]
(provided by CAMS, the Copernicus Atmosphere Monitoring Service)



Total column of carbon monoxide [10¹⁸ molecules/cm²]
(provided by CAMS, the Copernicus Atmosphere Monitoring Service)



Sentinel 3
Greenland, Jul_Aug 2019

IASI CO and Formaldehyde – Amazon data

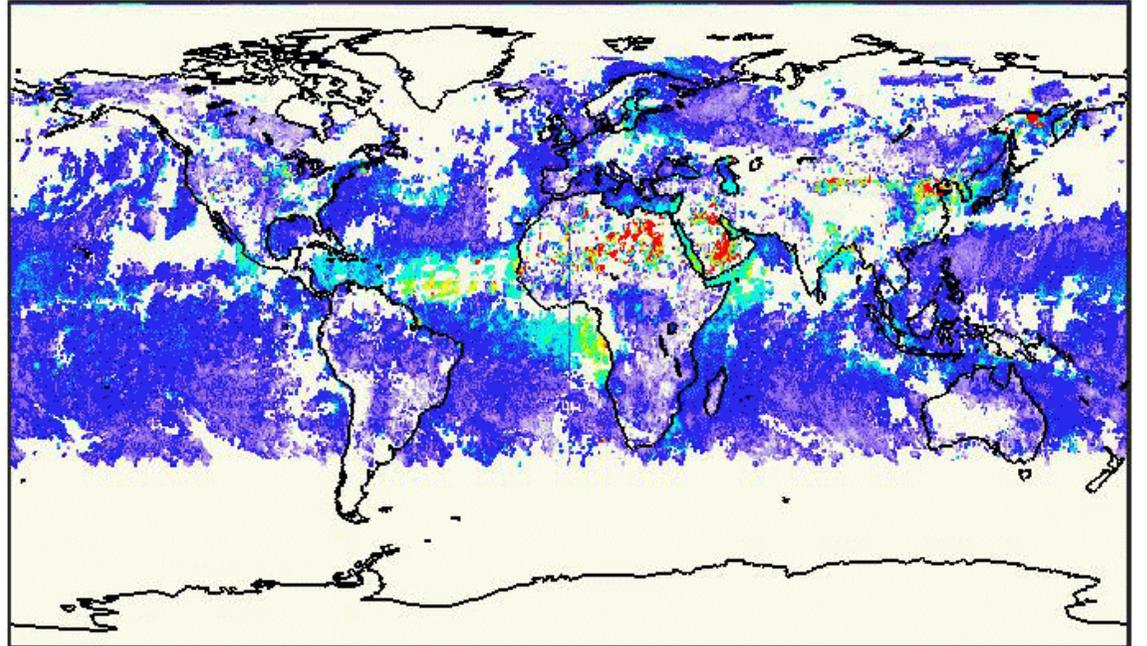
The advantage of multiple observations

Check internal consistency with different instruments

Stability in time

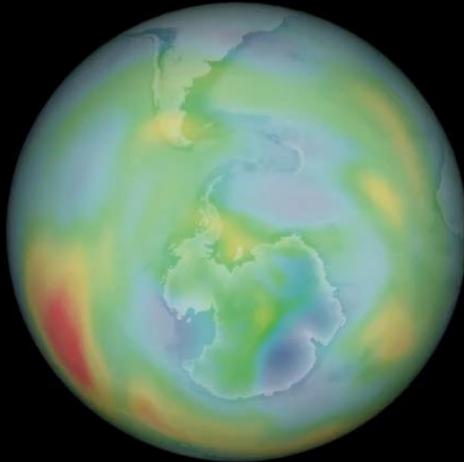
Super observations

PMAp L3 (0.50x0.50) Aerosol Optical Depth 02-Jun-2013

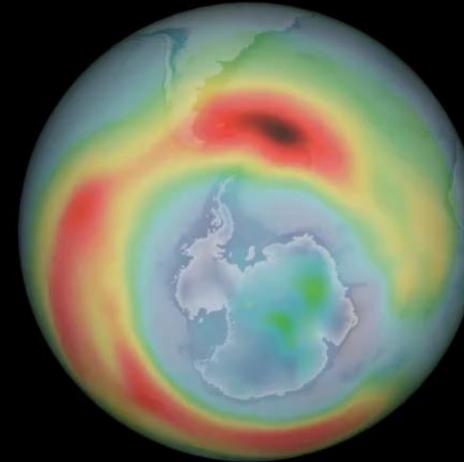


2015-2018 Ozone holes

GOME-2 / MetOp
ANALYSED TOTAL
OZONE COLUMN
15-08-2015



GOME-2 / MetOp
ANALYSED TOTAL
OZONE COLUMN
15-08-2016



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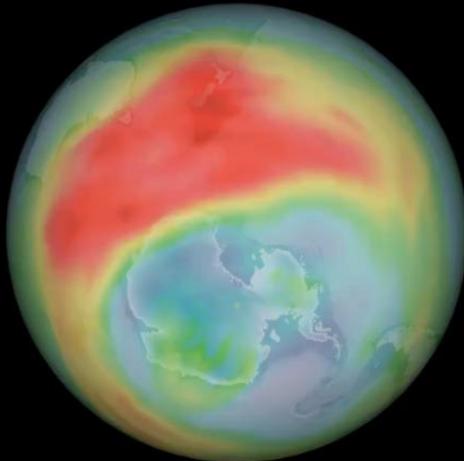
AC SAF



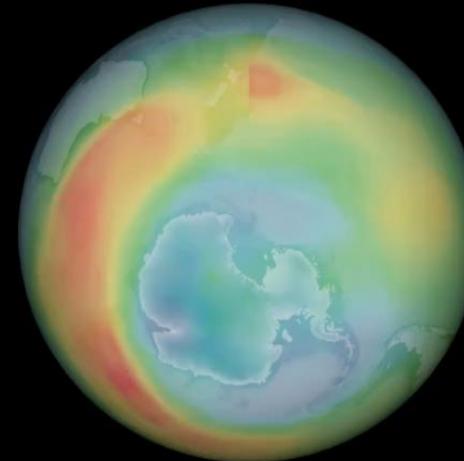
DLR - Earth Observation Center (EOC)

DLR - Earth Observation Center (EOC)

GOME-2 / MetOp
ANALYSED TOTAL
OZONE COLUMN
15-08-2017



GOME-2 / MetOp
ANALYSED TOTAL
OZONE COLUMN
15-08-2018



EUMETSAT

AC SAF



EUMETSAT

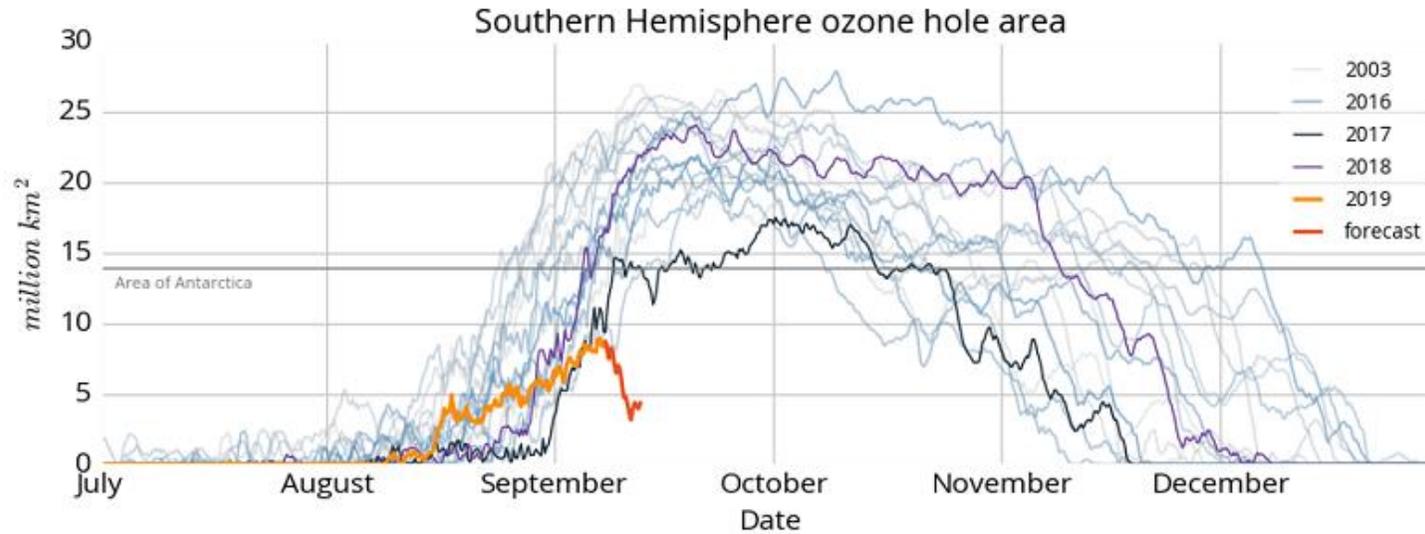
AC SAF



DLR - Earth Observation Center (EOC)

DLR - Earth Observation Center (EOC)

Ozone Today



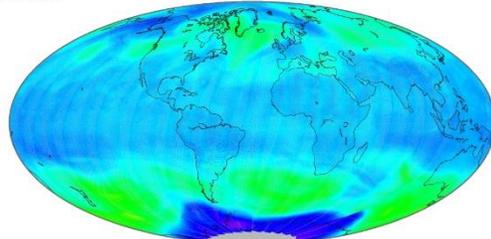
Last update: 2019-09-09T11:05Z

@CopernicusECMWF



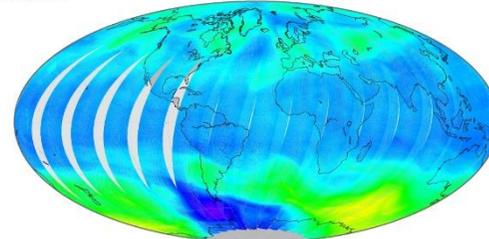
O₃
Ozone total column

Acquisition Time	Sensor	Plot Range	Algorithm
10-SEP-2018 23:39:14	GOME-2	84.8 : 634.8	GDP 4.8
12-SEP-2018 01:50:07	MetOp-AB	295.0 ± 40.0	UPAS 1.3.9



O₃
Ozone total column

Acquisition Time	Sensor	Plot Range	Algorithm
08-SEP-2019 23:17:54	GOME-2	68.8 : 611.4	GDP 4.8
10-SEP-2019 01:27:17	MetOp-AB	302.2 ± 56.1	UPAS 1.3.9

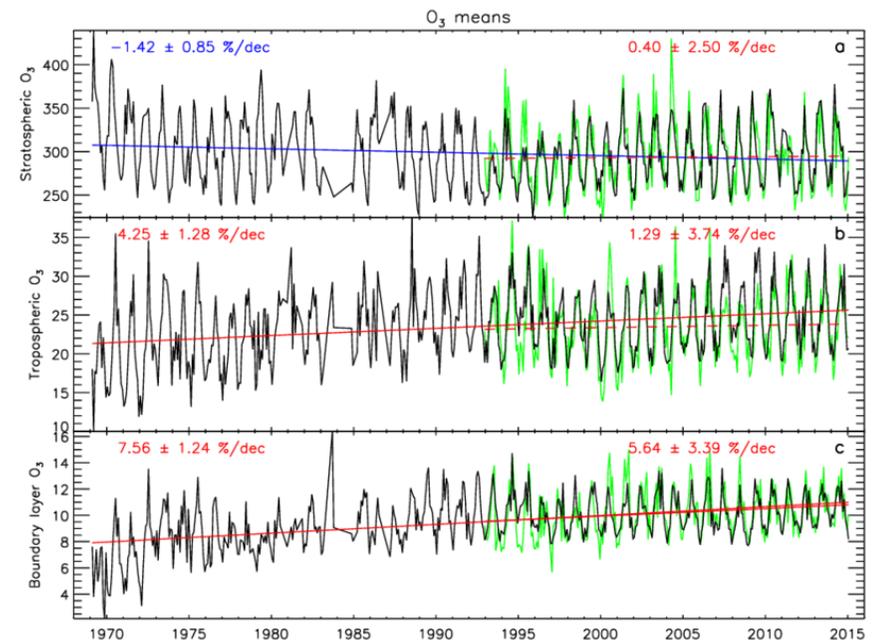
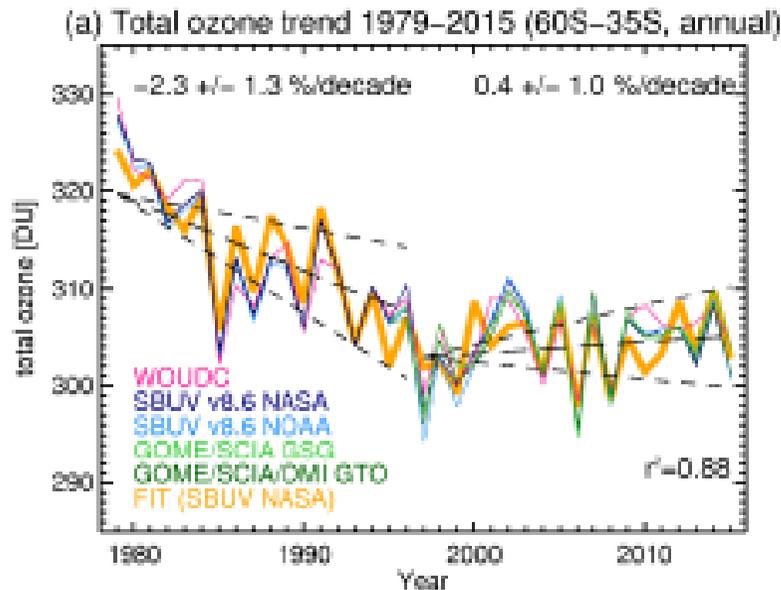


Good reasons to celebrate

50 years of ozone observations at Uccle
33 years of EUMETSAT
32 years of Montreal Protocol
40 years of Meteosat
21 years of AC SAF
13 years of METOP

A story of continuous support of EUMETSAT programmes and EUMETSAT user community

Thank you! DOI: 10.5194/amt-2015-341Atmos. Meas. Tech., DOI:10.5194/amt-2015-341

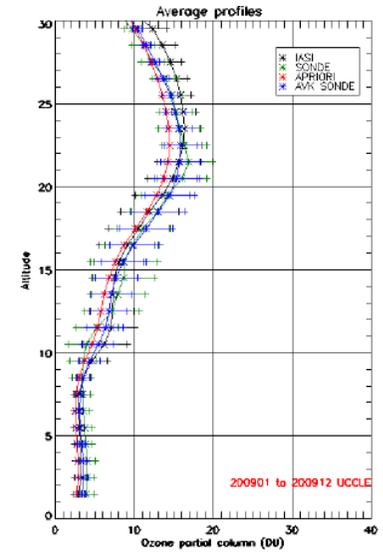
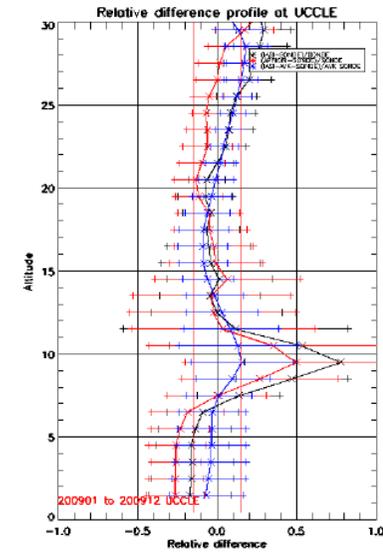
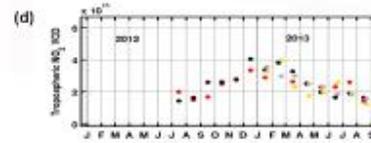
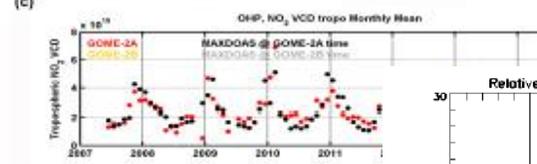
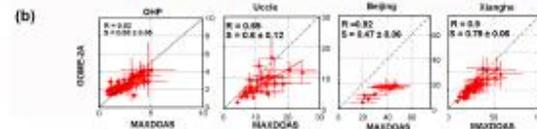
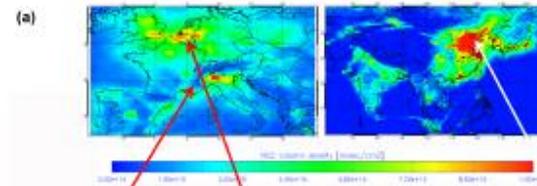
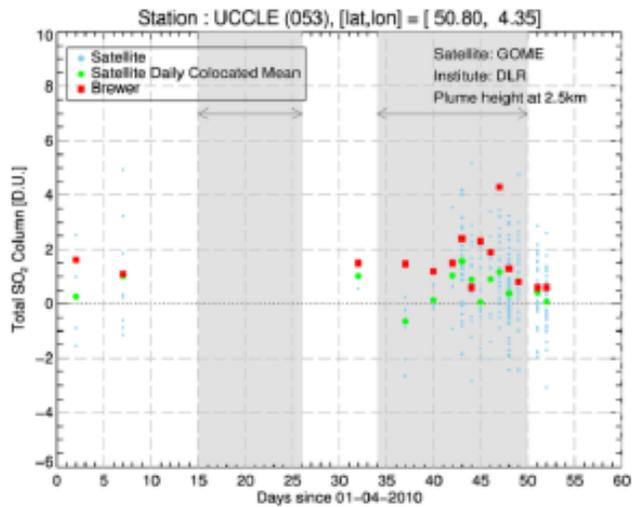


Ground-based and Satellite – Sweets and Lowdown

SACS-2/SMASH – VALIDATION REPORT ON THE EYJAFJALLAJÖKULL & GRIMSVÖTN ERUPTIONS

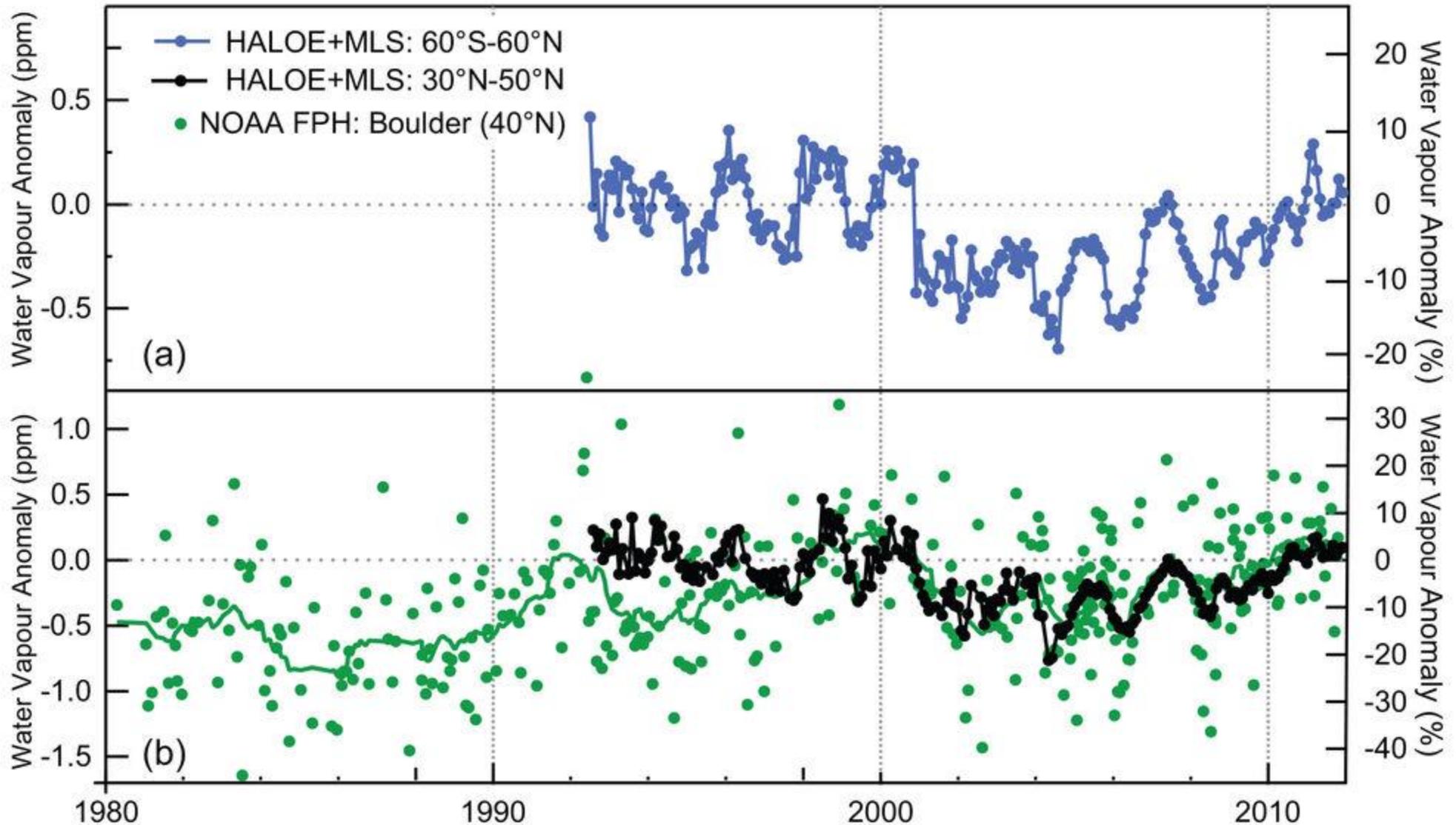
Overview of the O3M SAF GOME-2 operational atmospheric composition and UV radiation data products and data availability

S. Hassinen¹, D. Balis², H. Bauer³, M. Begoin³, A. Delcloo⁴, K. Eleftheratos⁵, S. Gimeno Garcia³, J. Granville⁶, M. Grossi⁷, N. Hao³, P. Hedelt⁸, F. Hendrick⁹, M. Hess¹, K.-P. Heue², J. Hovila¹, H. Jönck-Sørensen⁸, N. Kalakoski¹, A. Kauppi¹, S. Kiemle¹, L. Kins¹, M. E. Koukoulis¹, J. Kujanpää¹, J.-C. Lambert⁶, R. Lang¹⁰, C. Lerot⁶, D. Loyola¹, M. Pedergnana¹, G. Pinardi⁶, F. Romahn³, M. van Roozendael⁶, R. Lutz¹, I. De Smedt⁶, P. Stammes⁶, W. Steinbrecht⁷, J. Tamminen¹, N. Theys¹, L. G. Tilstra², O. N. E. Tuinder², P. Valks², C. Zerefos², W. Zimmer², and I. Zyrichidou²



Ground-based and Satellite – Sweets and Lowdown

Stratospheric Water Vapour IPCC AR5, 2017



Ground-based and Satellite – Sweets and Lowdown

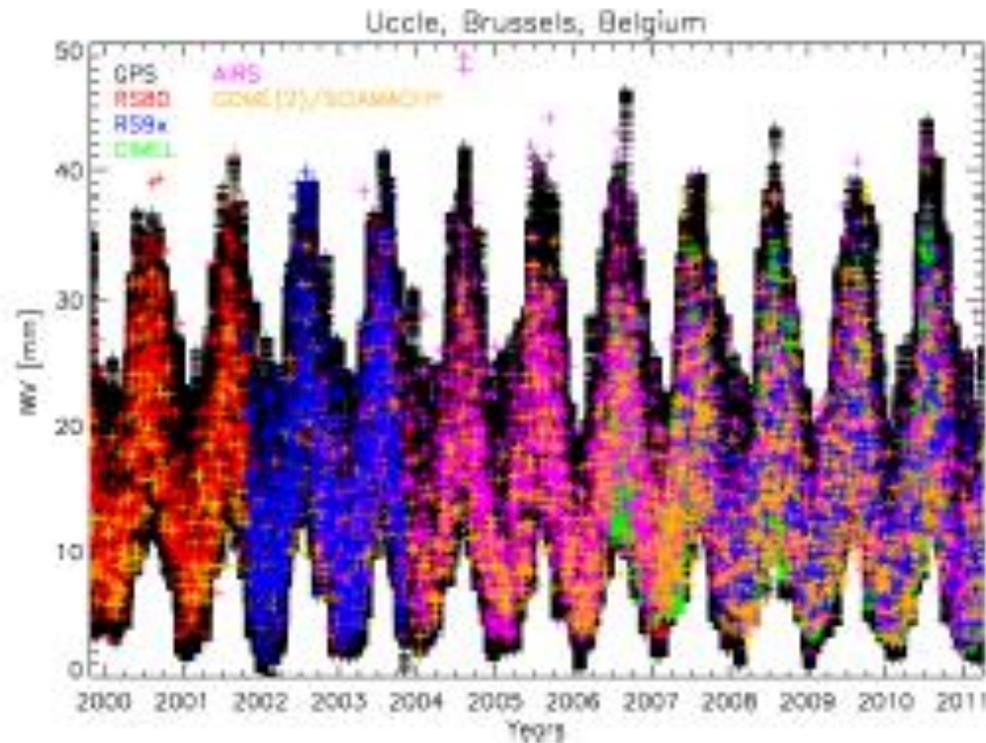


Figure 4. Overview of all IWV data available at Uccle, Brussels, Belgium.

2498

R. Van Malderen et al.: A multi-site IWV intercomparison

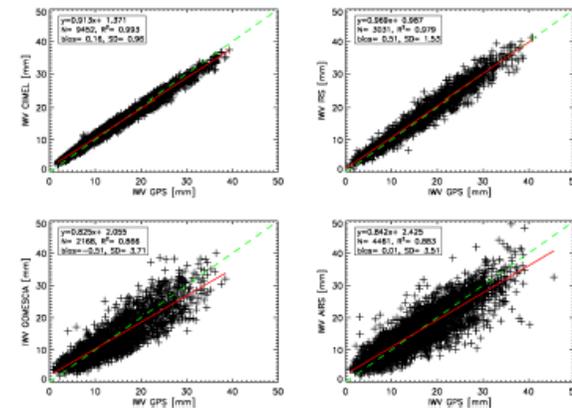


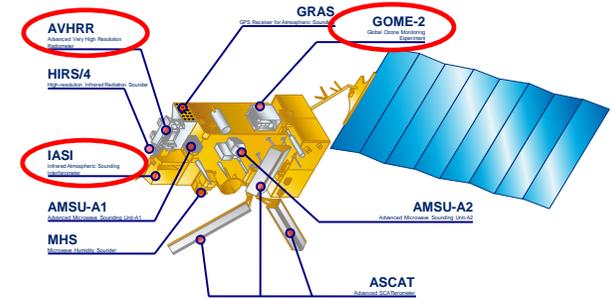
Figure 5. Scatter plot of coincident IWV measurements of the different instruments with the GPS device at Uccle, Brussels, Belgium.

New EUMETSAT Missions

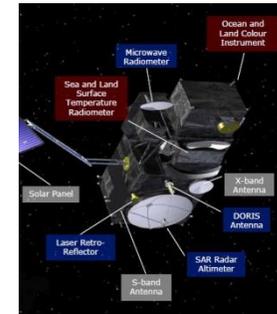
Providing Aerosol, Trace-Gases and Cloud Products



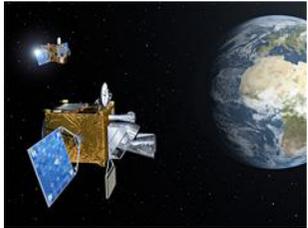
Metop Multi-mission product (PMAp)
Metop GOME-2, IASI (Metop-A/B/C 2007-2025)
MSG (Seviri 1997-2025)



Sentinel-3 OLCI, SLSTR



MTG UVN (Sentinel-4)
MTG FCI & IRS



EPS-SG 3MI
EPS-SG UVNS (Sentinel-5)
EPS-SG VII
EPS-SG IAS

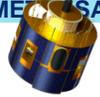


EUMETSAT programmes overview

YEAR... 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

METEOSAT FIRST GENERATION

METEOSAT-7



METEOSAT SECOND GENERATION

METEOSAT-8 ...Extended lifetime

METEOSAT-9 ...Extended lifetime

METEOSAT-10 ...Extended lifetime ...

MSG-4/METEOSAT-11

METEOSAT THIRD GENERATION

MTG-I-1 : IMAGERY

MTG-S-1: SOUNDING

MTG-I-2: IMAGERY

MTG-I-3: IMAGERY

MTG-S-2: SOUNDING

MTG-I-4: IMAGERY

Mandatory Programmes



EUMETSAT POLAR SYSTEM (EPS)

METOP-A ...Extended lifetime

METOP-B ...Extended lifetime

METOP-C ...Extended lifetime

METOP SECOND GENERATION

METOP-SG-A1

METOP-SG-B1

METOP-SG-A2

METOP-SG-B2

METOP-SG-A3

METOP-SG-B3



Operational Development

JASON

JASON-2

JASON-3

JASON CONTINUITY OF SERVICE (JASON-CS)

COPERNICUS

SENTINEL-3a/Sentinel-3b (Q2/2018)

SENTINEL-4 ON MTG-S

SENTINEL-5 ON EPS-SG



Optional and Third Party Programmes

YEAR... 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

Meteosat Third Generation (MTG): Mission overview

▪ Imagery missions (MTG-I):

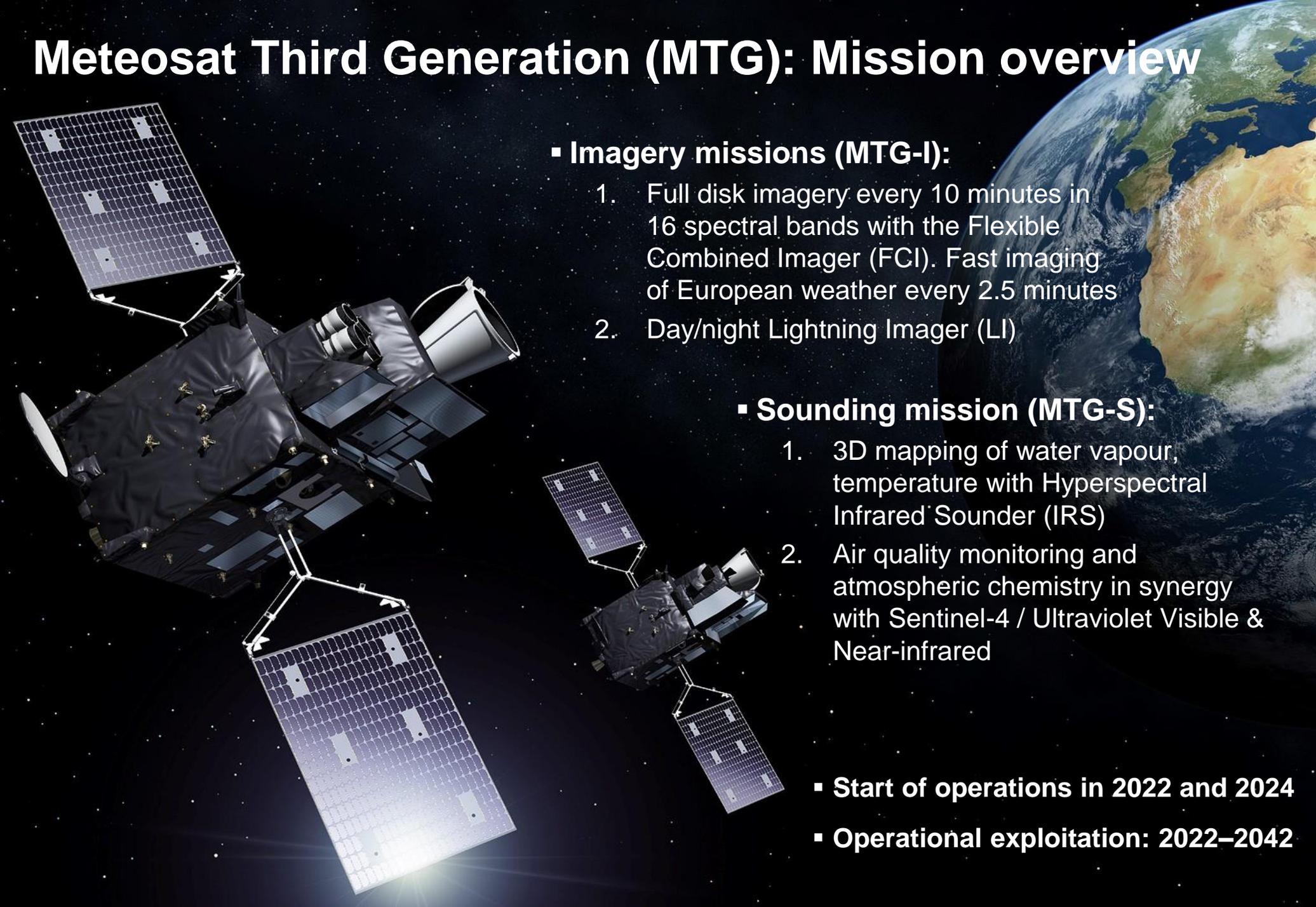
1. Full disk imagery every 10 minutes in 16 spectral bands with the Flexible Combined Imager (FCI). Fast imaging of European weather every 2.5 minutes
2. Day/night Lightning Imager (LI)

▪ Sounding mission (MTG-S):

1. 3D mapping of water vapour, temperature with Hyperspectral Infrared Sounder (IRS)
2. Air quality monitoring and atmospheric chemistry in synergy with Sentinel-4 / Ultraviolet Visible & Near-infrared

▪ **Start of operations in 2022 and 2024**

▪ **Operational exploitation: 2022–2042**



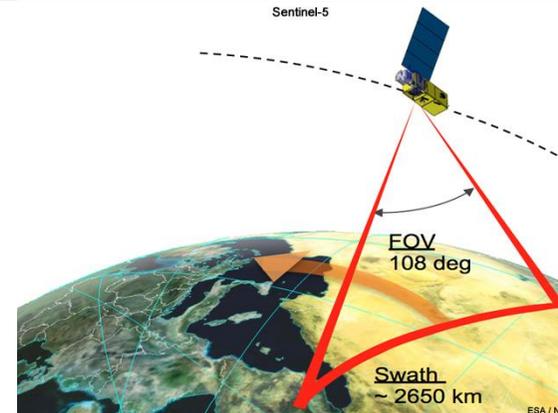
Metop-SG A

- 1. IASI-NG**
Infrared Atmospheric Sounding
- 2. MWS**
Microwave Sounding
- 3. METImage**
Visible-Infrared Imaging
- 4. RO**
Radio Occultation
- 5. 3MI**
Multi-viewing, -channel, -
polarisation Imaging
- 6. Copernicus Sentinel-5**
UN/VIS/NIR/SWIR Sounding

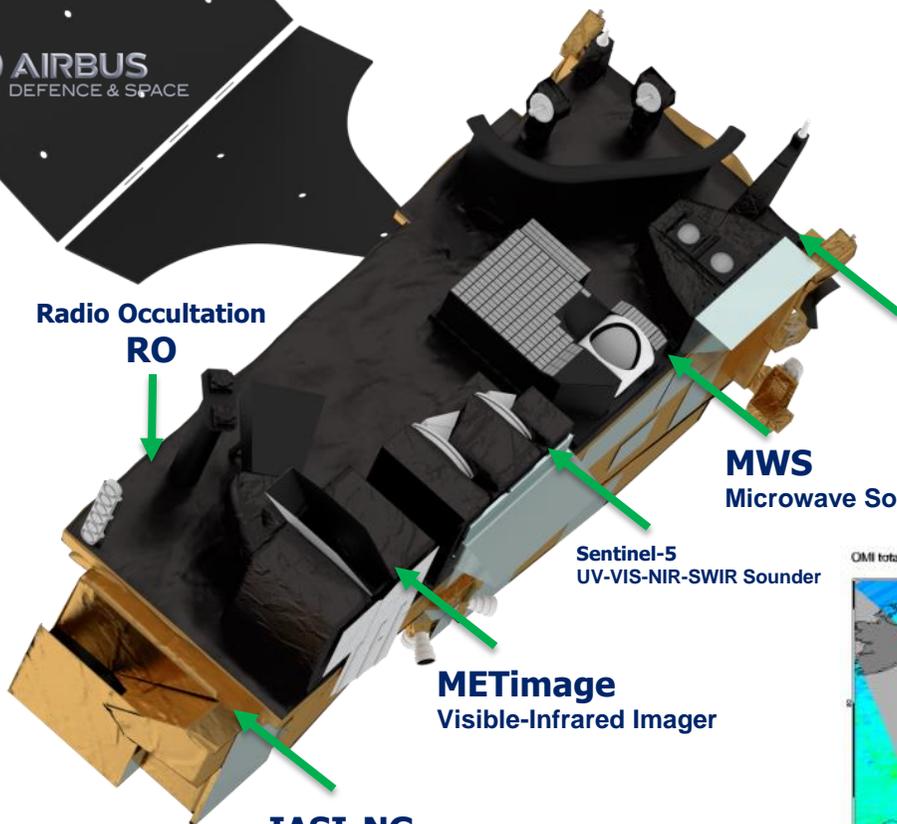


METOP (EPS-SG) – Sentinel 5

Operational : 2023-2035



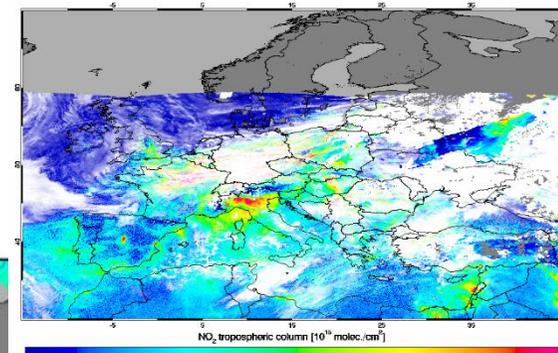
AIRBUS
DEFENCE & SPACE



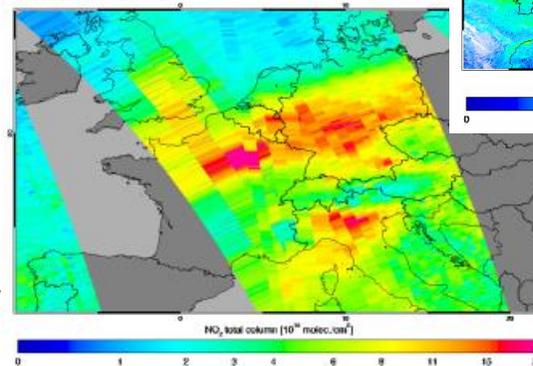
IASI-NG
Infrared Atmospheric Sounding Interferometer
– New Generation

TROPOMI tropospheric NO₂ 11 Jan 2019

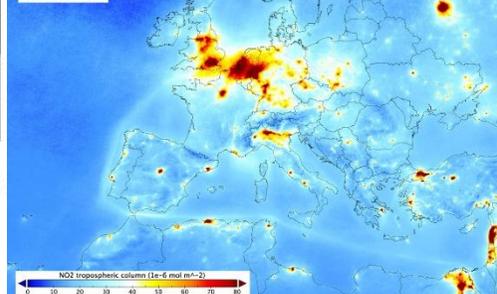
KNMI/ESA



OMI total NO₂ 11 Jan 2019



TROPOMI NO₂
April-September 2018
© KNMI / ESA



MTG-S Sounding Mission – Sentinel 4

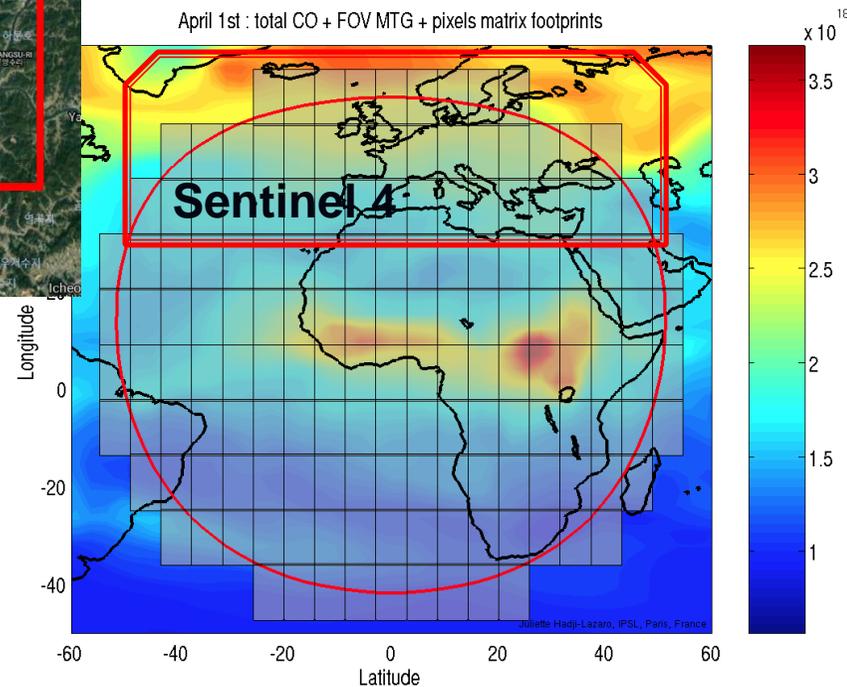
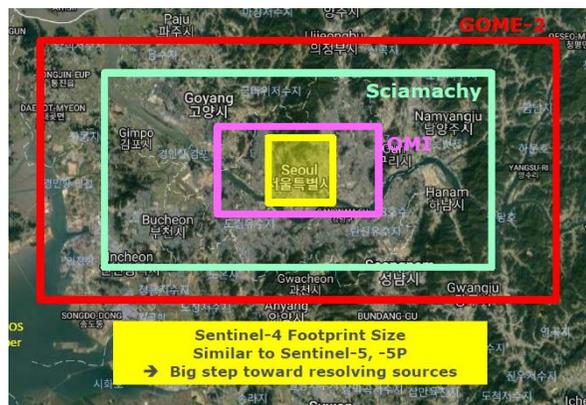
The spatial resolution ~ 8 x 8 km
with hourly temporal resolution

First Geostationary over EU

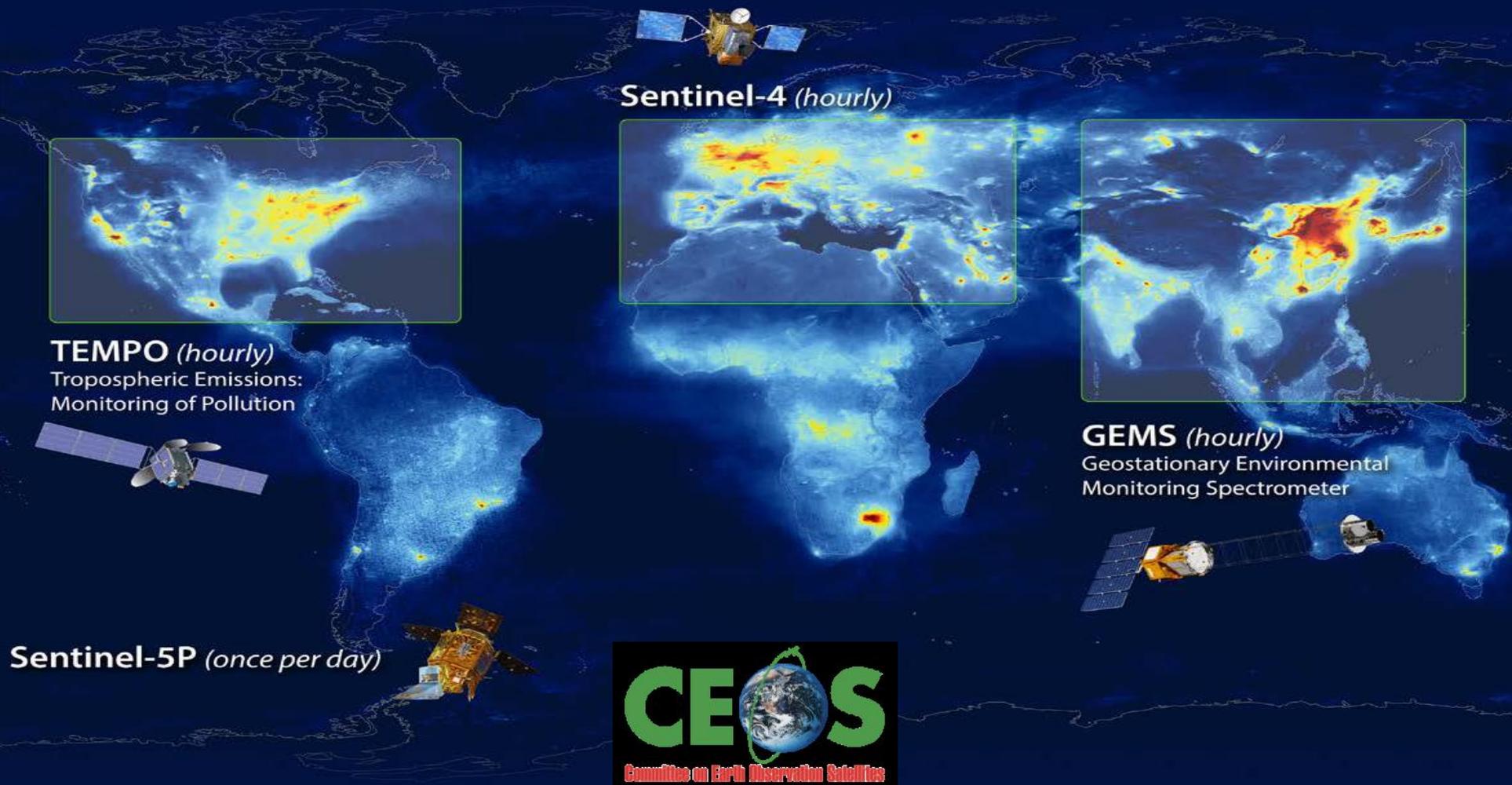
Focus on air quality with the
main data products being O_3 ,
 NO_2 , SO_2 , HCHO, and aerosol
optical depth.

Start of operations: 2023

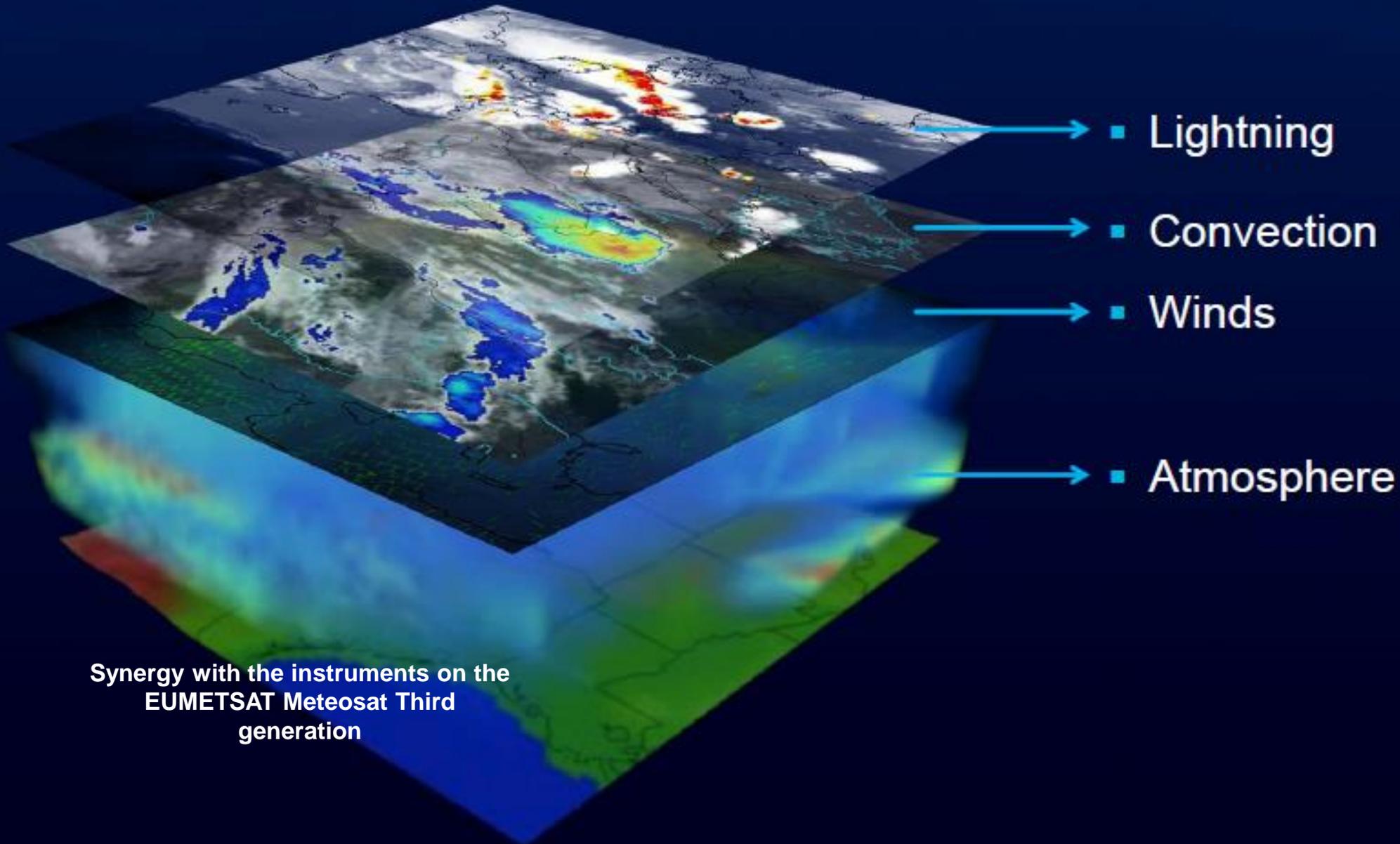
Operational : 2023-2042



Sinergy – Constellation for Air Quality



Sinergy – MTG Weather Cube

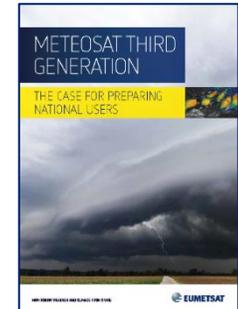


Users Needs & Shared Engagement program

Building the Copernicus community

Type Professionals in reg/nat/gvt : Service providers from SMEs: Academy & Research Large audiences	Expertise High to Mid High to Low High to Mid Low	Newcomers Starters
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Short courses and training
EGU 2019 and 2020
IGAC – ACAM 2019
Short term exchange

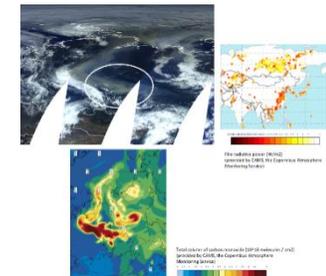
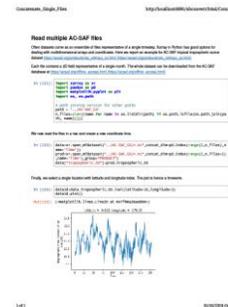


Massive on-line course 2019



User Preparation and consultation

Hackathon



Python Notebooks to handle / access / plots datasets
On WEKEO

<https://twitter.com/eumetsat>
Stories with short data animations and plots

FIRST JOINT TRAINING COURSE ON ATMOSPHERIC COMPOSITION

