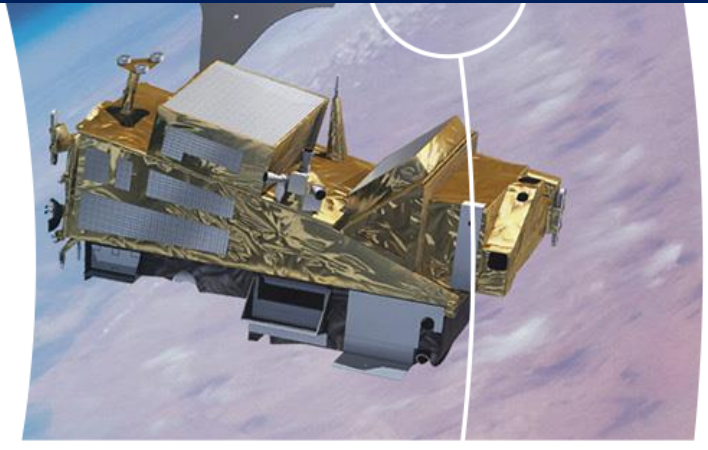
Advanced aerosol products from polarimetric missions: 3MI/EPS-SG and POLDER-3/PARASOL – intercomparison with models

Soheila Jafariserajehlou[1], Bertrand Fougnie[1], David Huerta Valcarce[1,2], Samuel Rémy[3], Bojan Bojkov[1]

1) EUMETSAT, 2) STARION, 3) Hygeos

ICAP 2026, Bonn, Germany

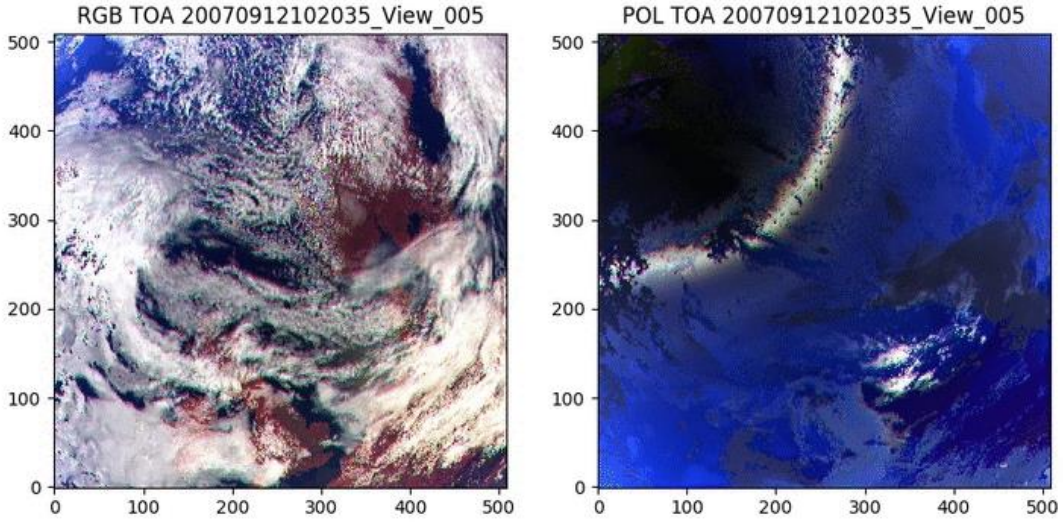
Acknowledgments to 3MI project and GRASP S.A.S

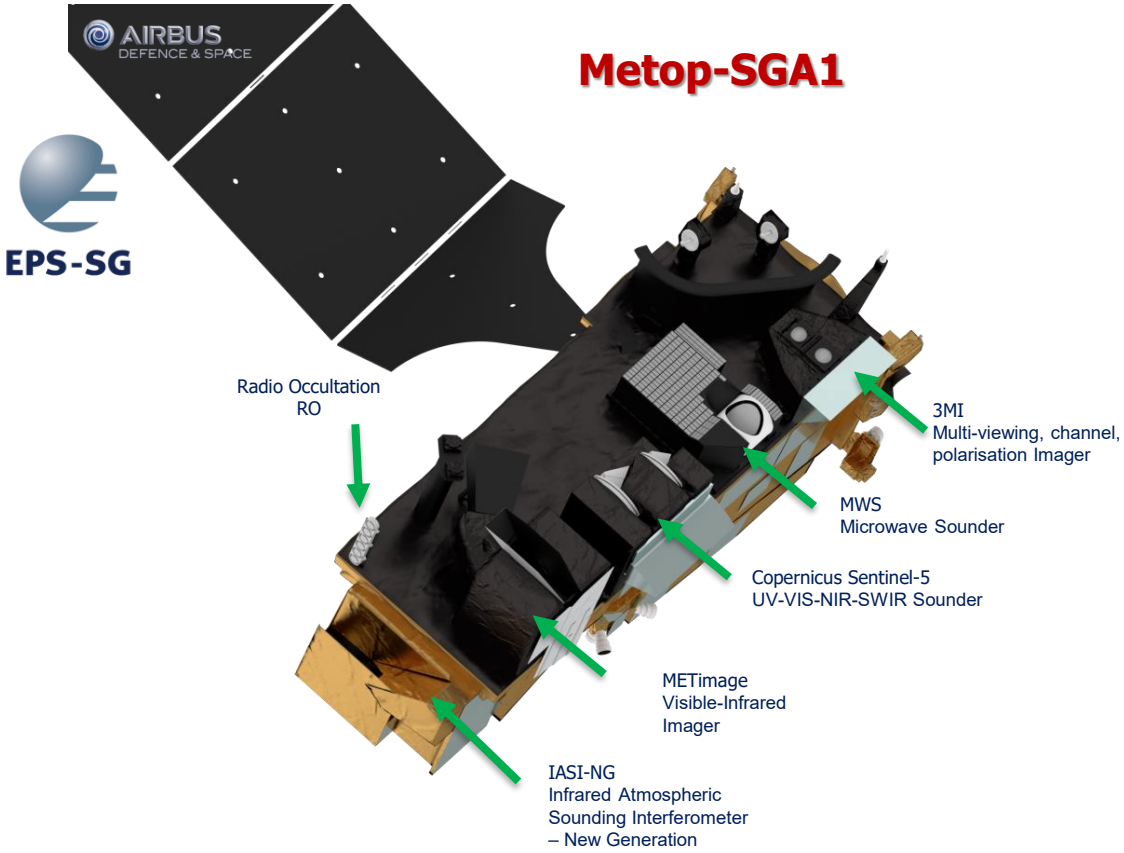


3MI

A mission-driven sensor, with a core mission to understand atmospheric aerosols

3MI :
Multi-viewing Multi-channel Multi-polarisation imager





EPS-SG : Polar orbit at 09:30
3 redundant platforms, 25 y of operation

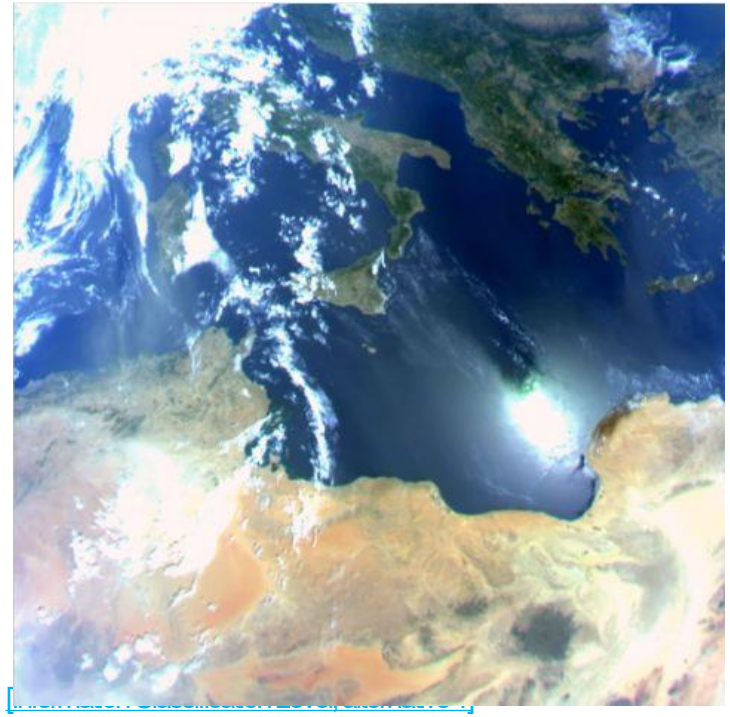
Launched in August 2025
Ongoing commissioning

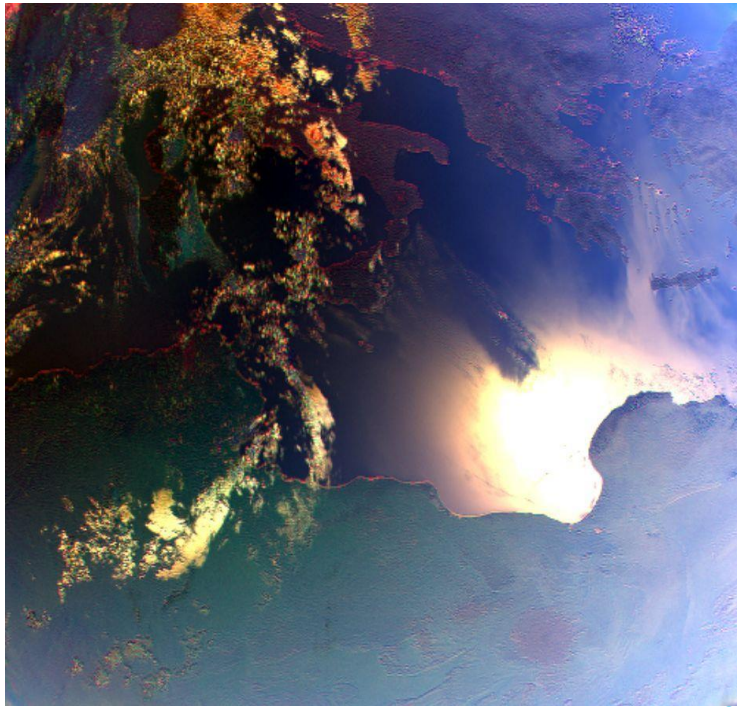
n Level, alternative 1]

3MI / EPS-SG

Airbus, 2024

First 3MI image, 2025

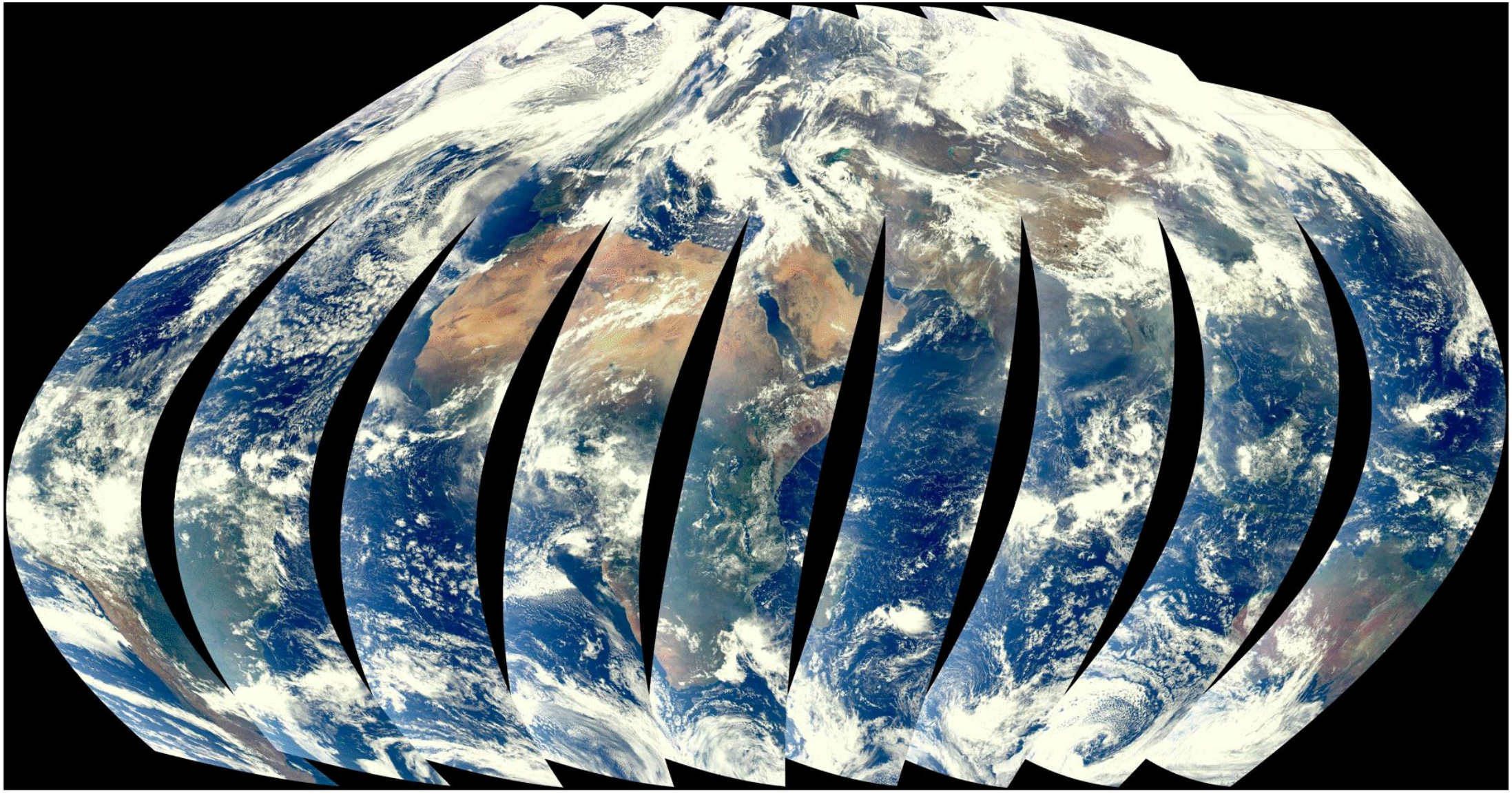




Observing a Polarised World with 3MI

EUMETSAT

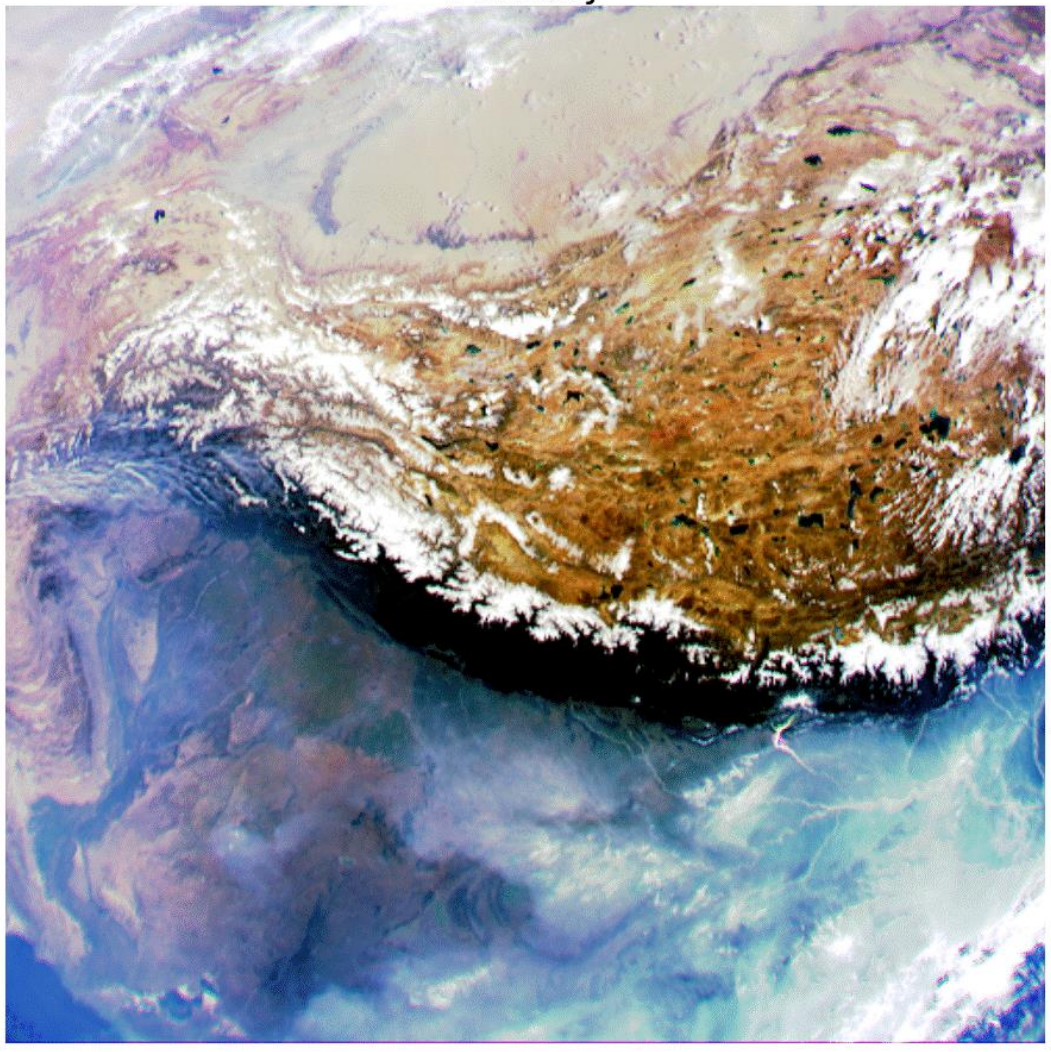
EPS-SG/3MI – 29th March 2026 (RGB) Intensity



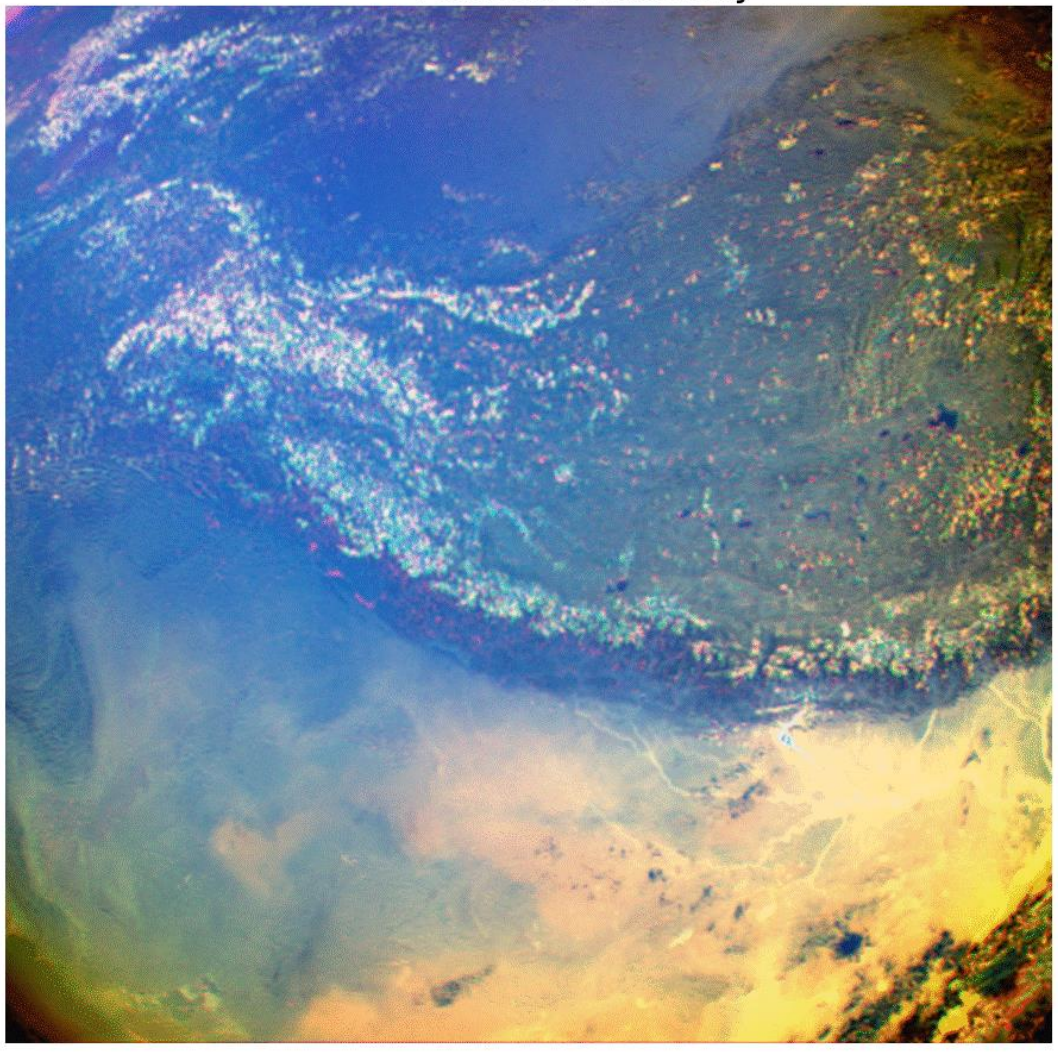
A month beneath the veil of aerosols, North India

EPS-SG/3MI - Xinjiang Province, Tibet & India – 19th October 2025

Intensity



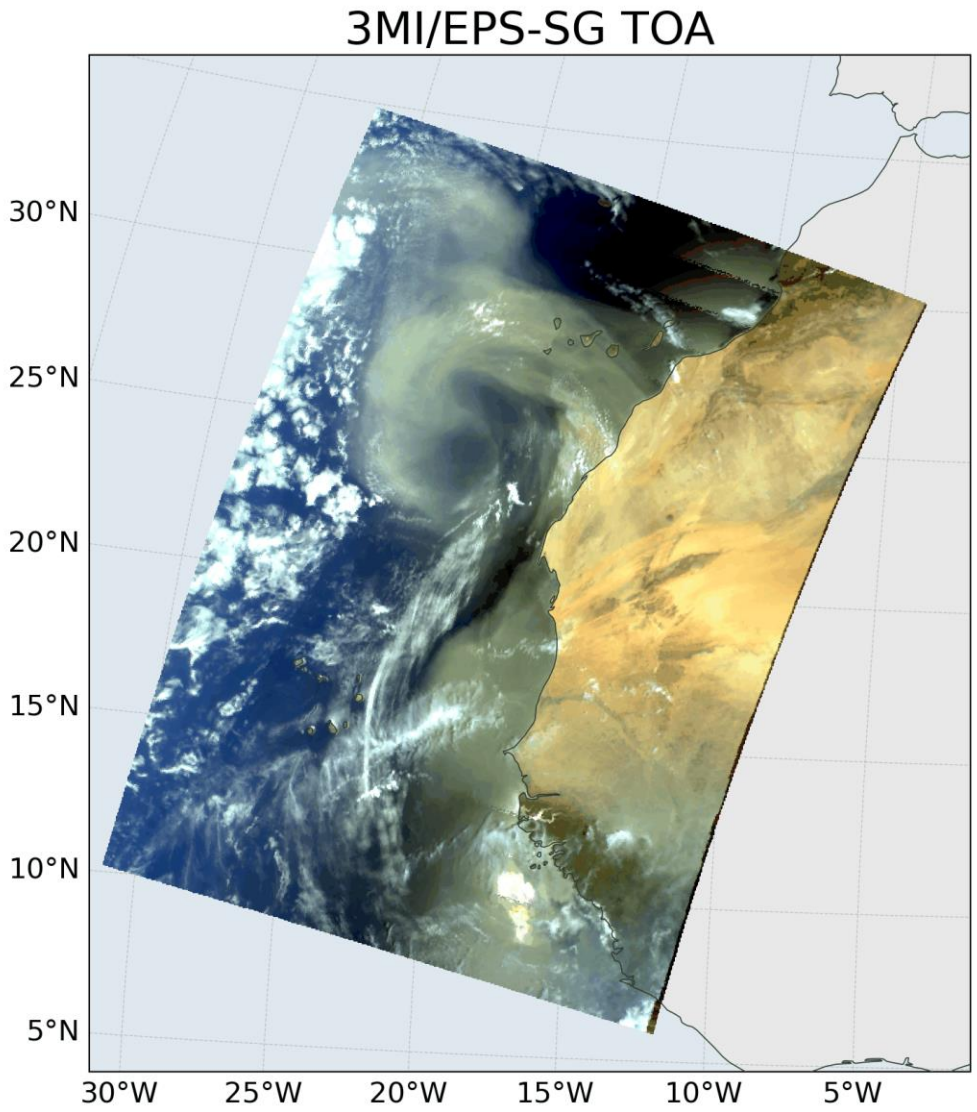
Polarised Intensity



L1B

First 3MI aerosol retrieval

EUMETSAT



Latest Status and ongoing updates

L1B reaching a reasonable level of maturity

- For polarisation, calibration and geometry,
- Ongoing fixing for SWIR.

L1C waiting for the coming geometrical calibration

- To be updated soon to be consistent with L1B.

L2 Aerosol under testing **since January 2026**

- No major aerosol-related anomaly yet,
- But full quality and validation only after the end of L1 Cal/Val, summer 2026.
- Technical preparation with CAMS to prepare readers of 3MI aerosol in IFS-COMPO in March 2026, and soon the buffer template for WMO.
- Demonstrational sample to be provided Q1 2027.

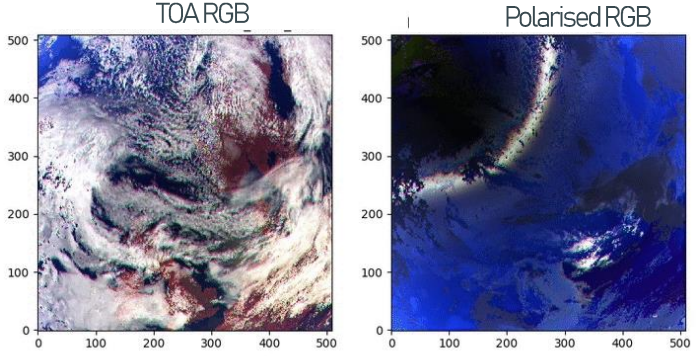
Aerosol Characterization with 3MI

Preflight demonstration

Extensive validation using POLDER-3

3MI Aerosol Processor, Operationalisation and Product

3MI : Multi-viewing Multi-channel Multi-polarisation Imager



L1C

- Radiances and polarization (8 bands)
- 10-14 viewing directions

⇩

240 – 336 measurements

⇩ 3MI L2 Aerosol Processor: a customised version of GRASP: Generalized Retrieval of Aerosol and Surface Properties

GRASP *In principle, yes!*

L2 Aerosol

Retrieved parameters
(more linked to GRASP optimisation)
&
Derived parameters
(more linked to user needs)

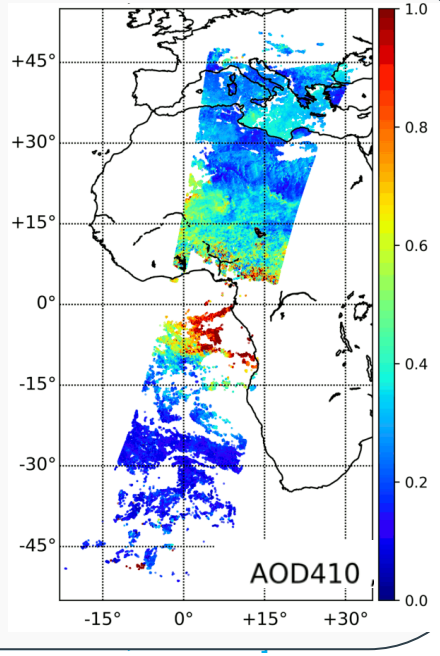
AEROSOL

- Size distribution
- Fraction of chemical components
- Sphericity fraction
- Aerosol layer height
- Spectral AOD (fine and coarse)
- Spectral Absorbing AOD
- Angstrom Exponent
- Spectral SSA
- Spectral index of refraction (8 wavelengths)

Error Estimation

Surface

- BRDF (3 Spectrally dependent parameters) and BPDF

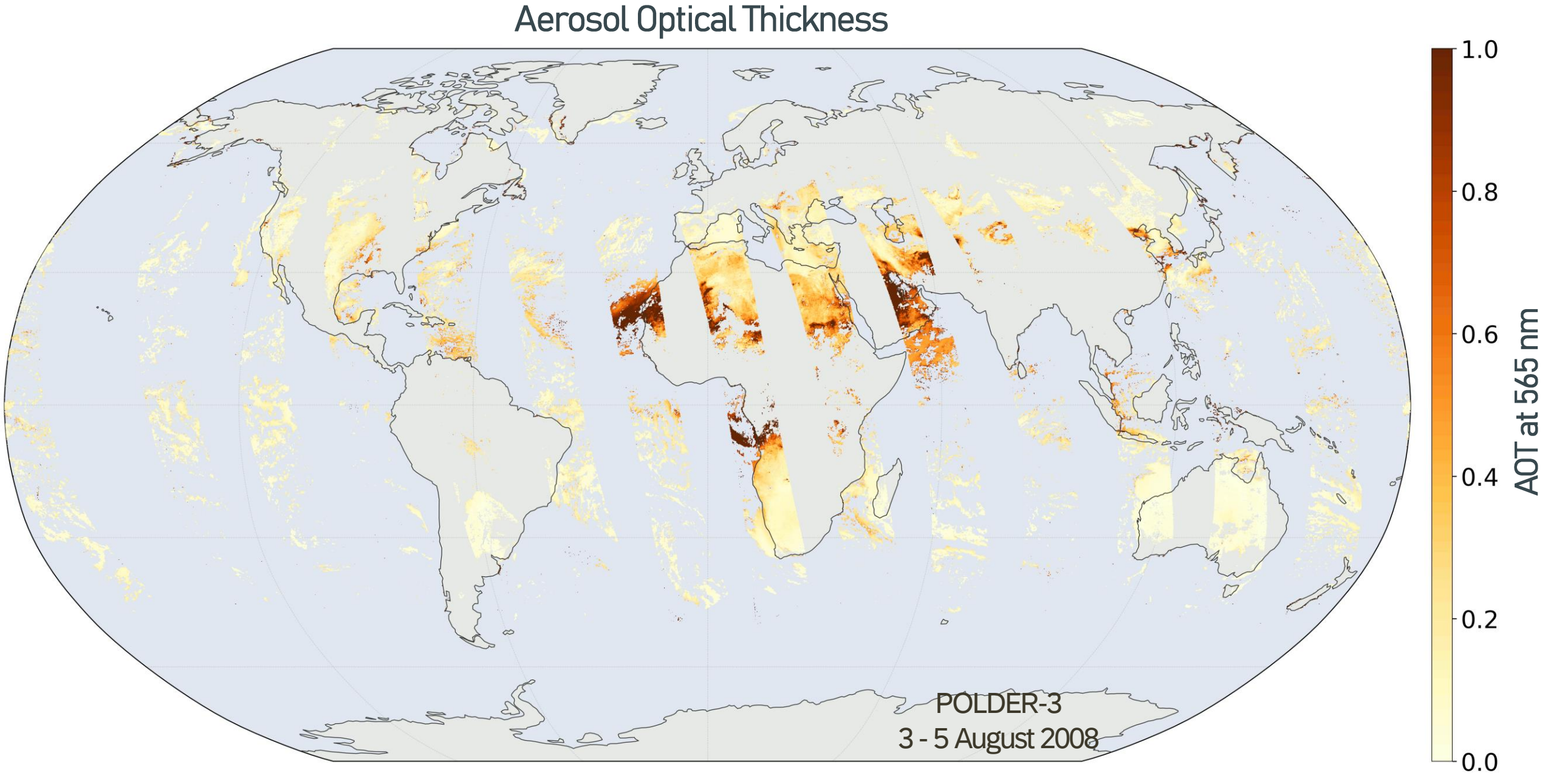


⇨

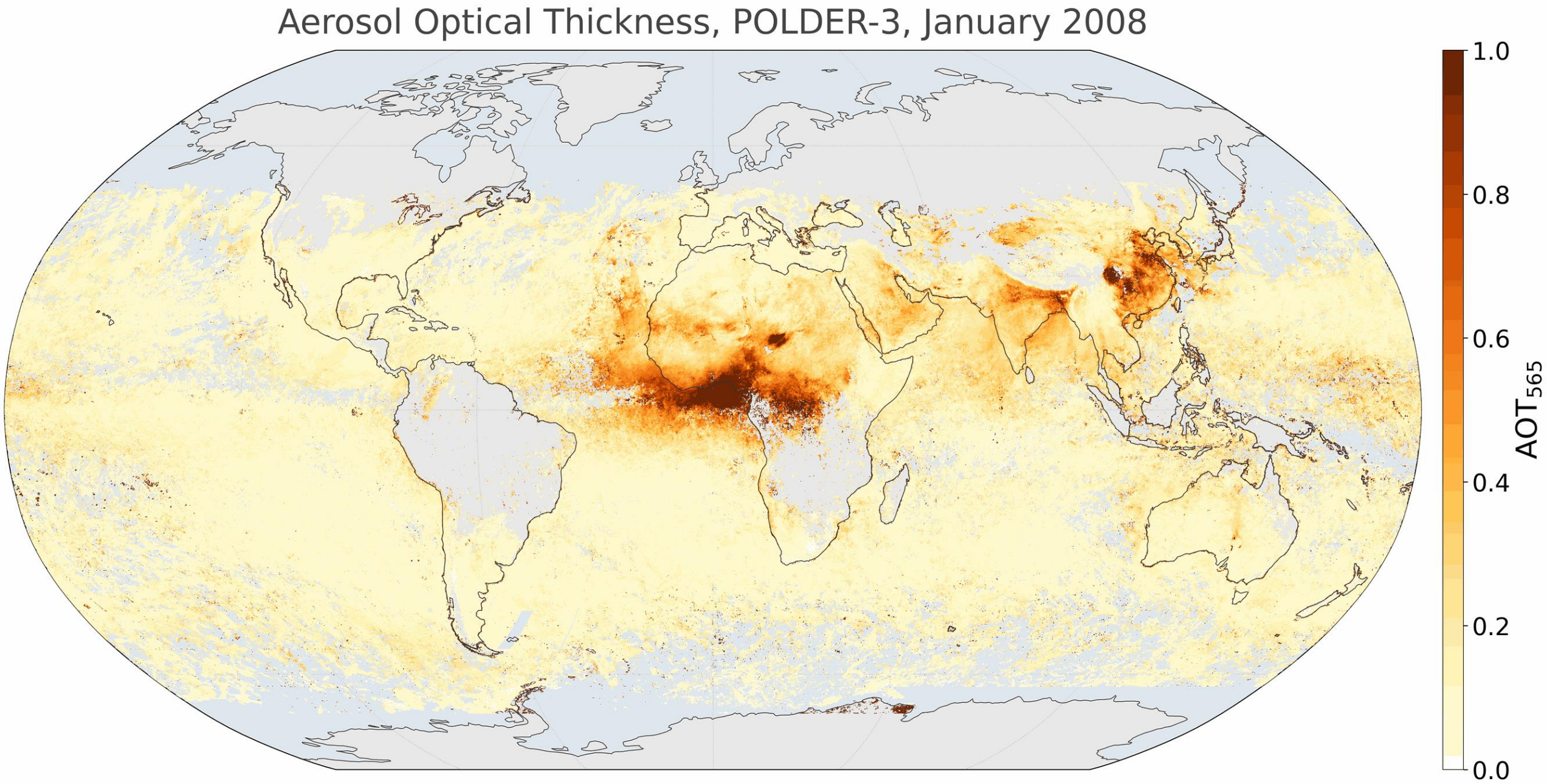
Proposed Architecture for the operationalisation of GRASP

- Product to be tailored to user requirement in term of product content and accuracy
- Regular interaction with users and collection of feedback needed.

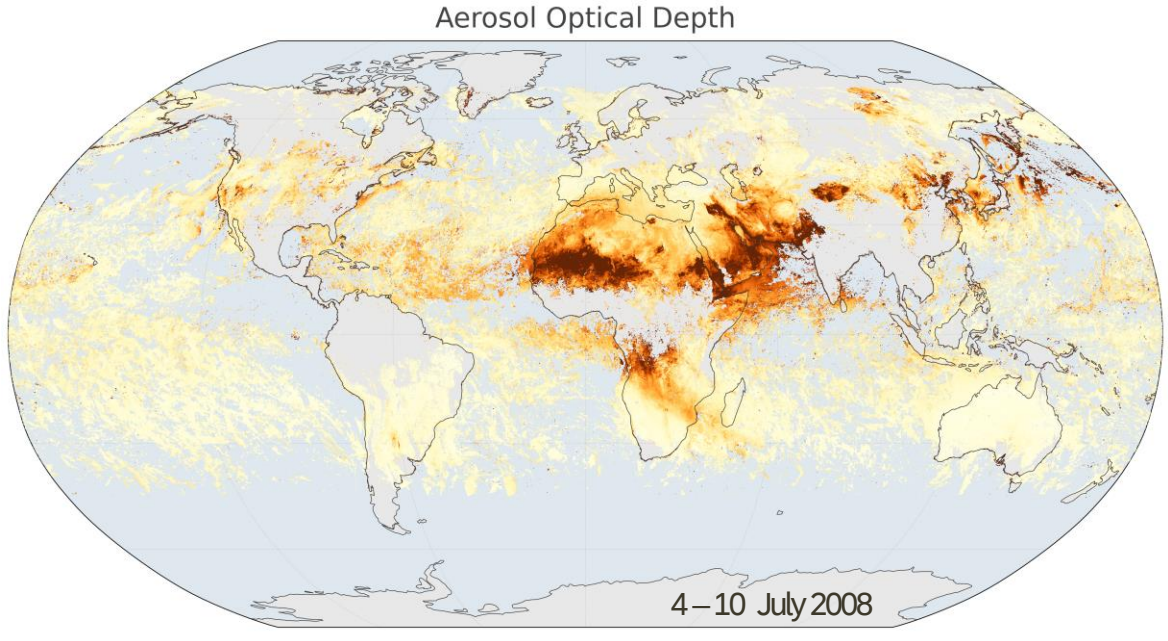
POLDER-3 AOD using 3MI NRT processor

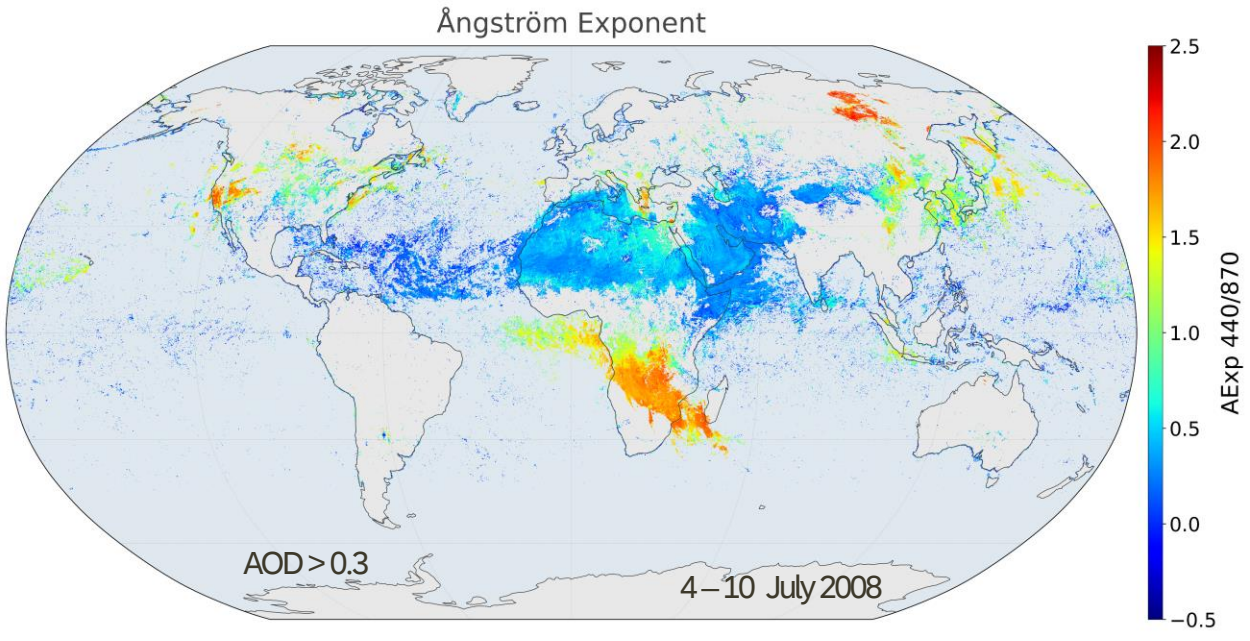


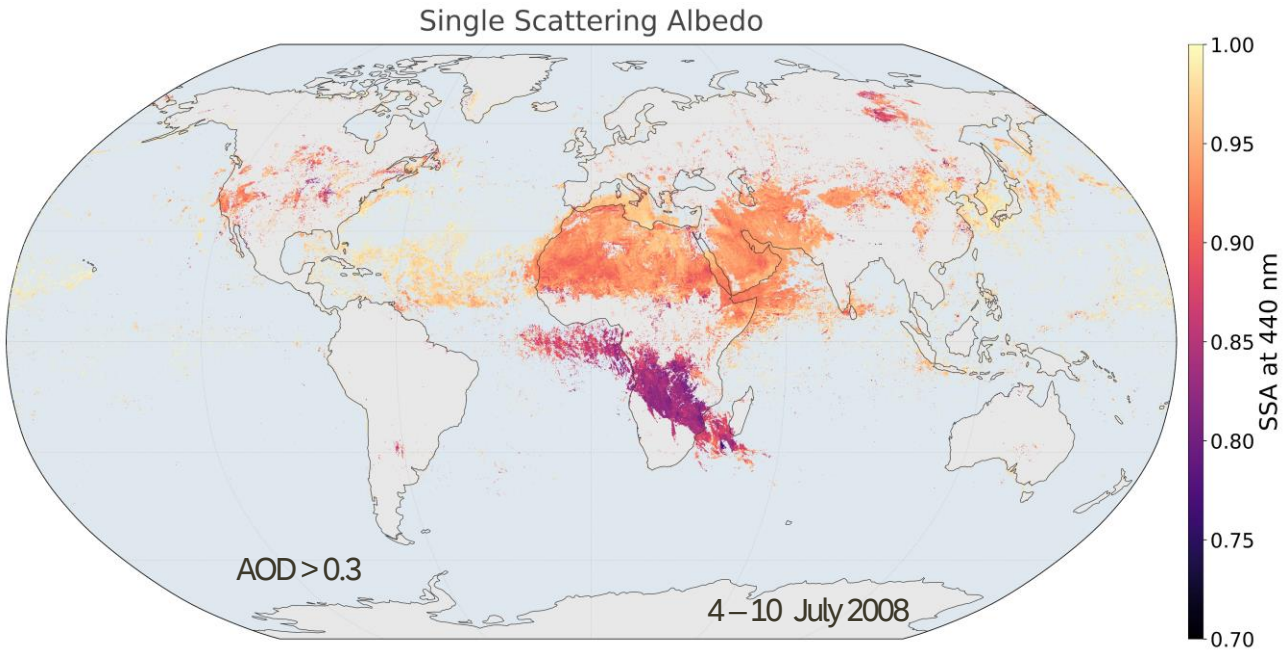
Monthly mean AOT

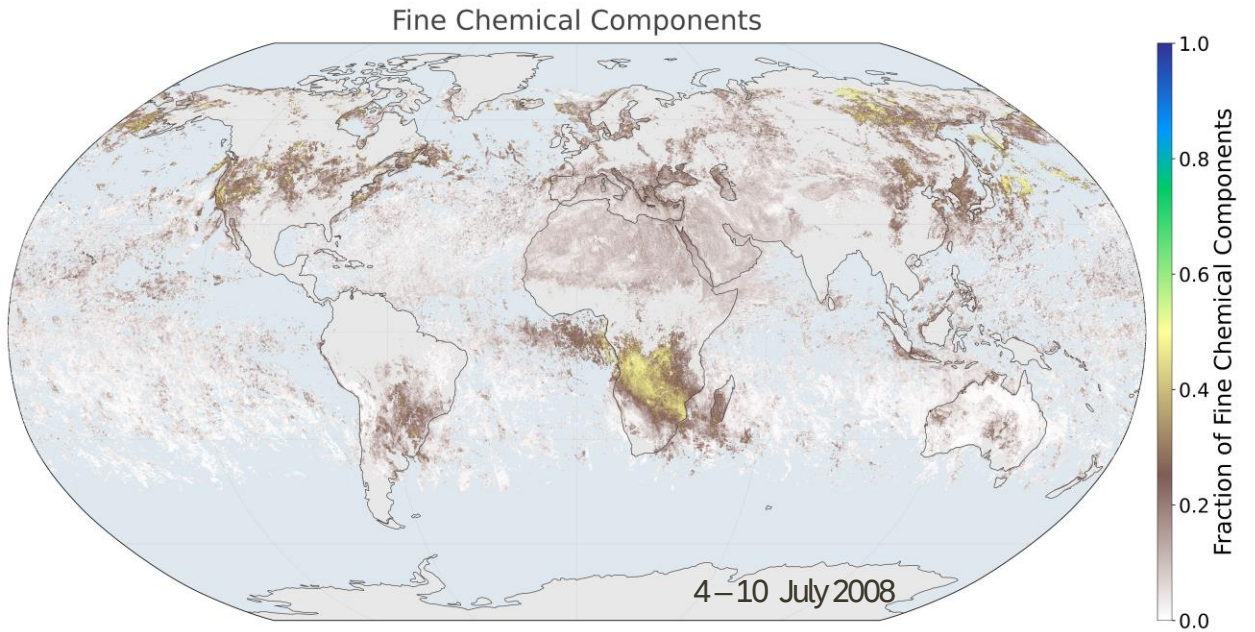


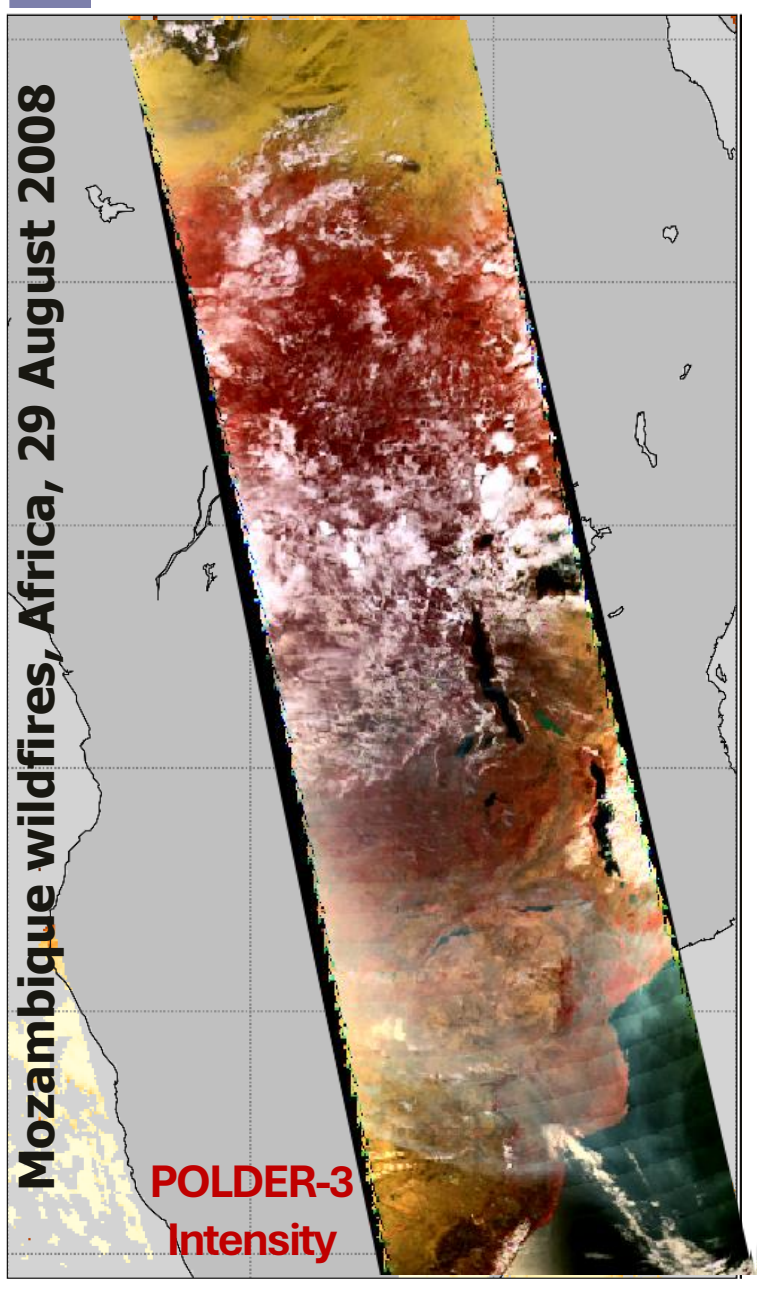
POLDER-3 Aerosol characterization using 3MI NRT processor

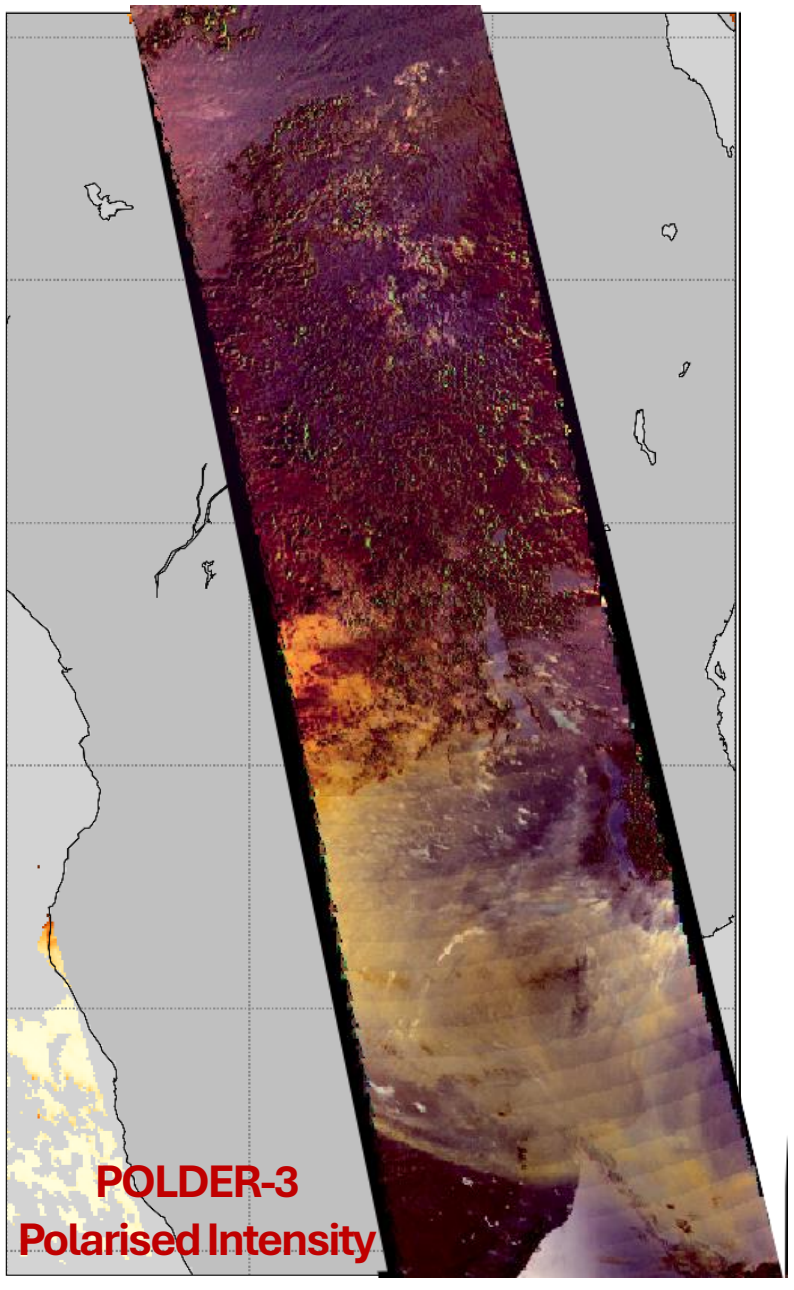


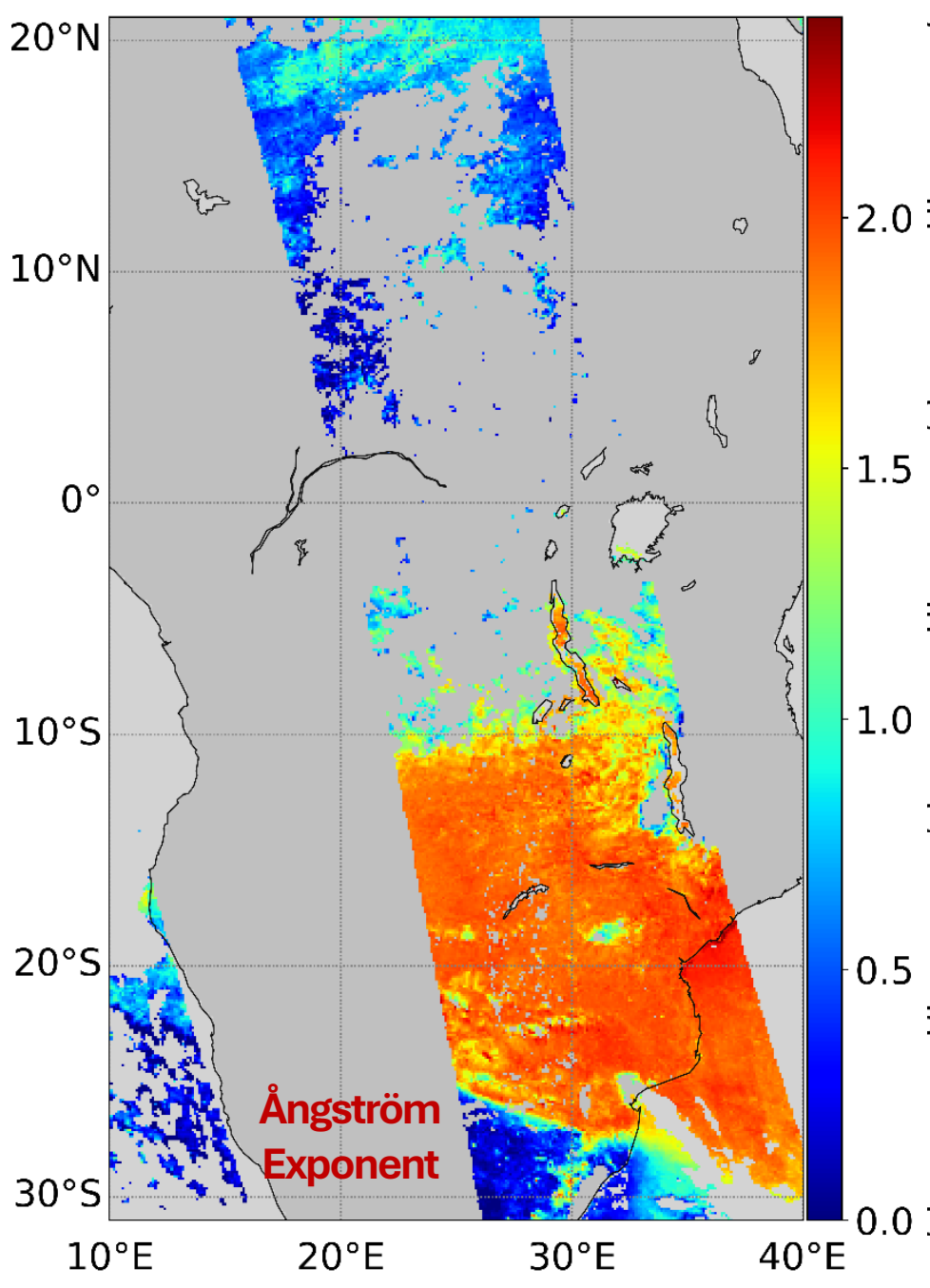




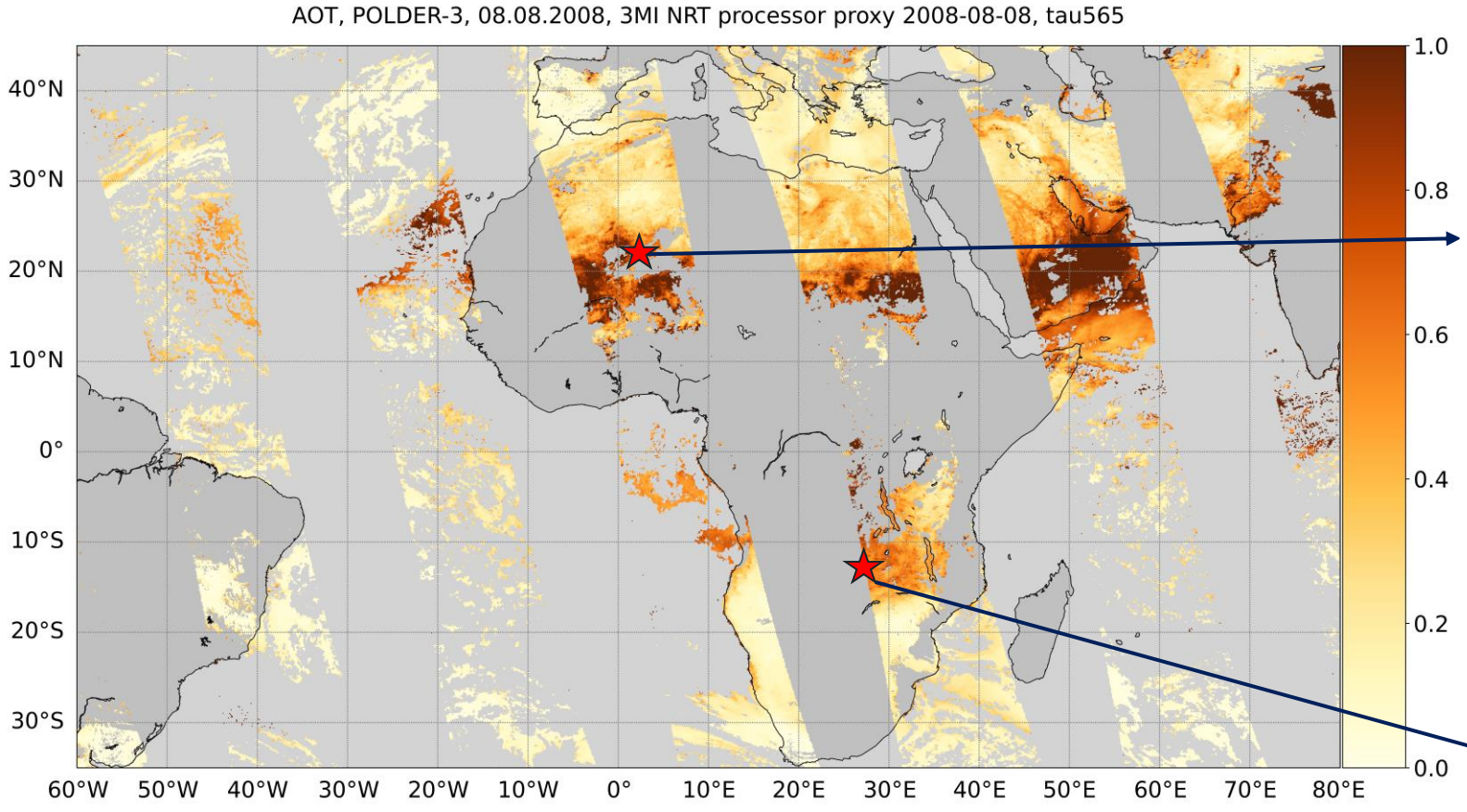


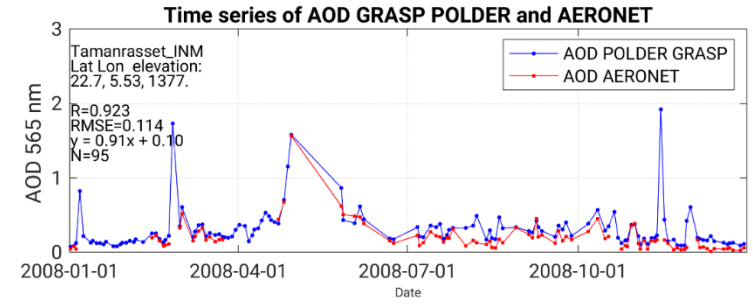

Mozambique wildfires, Africa, 29 August 2008
POLDER-3
Intensity

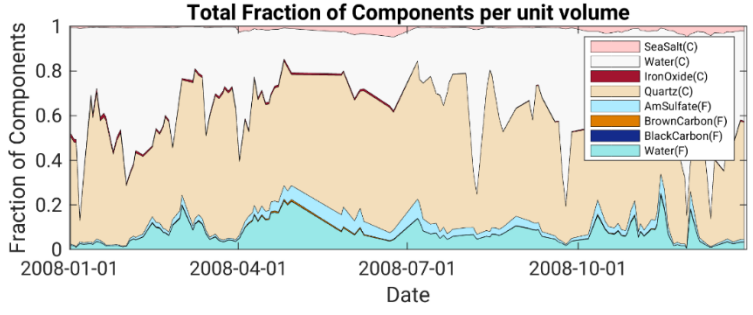

POLDER-3
Polarised Intensity

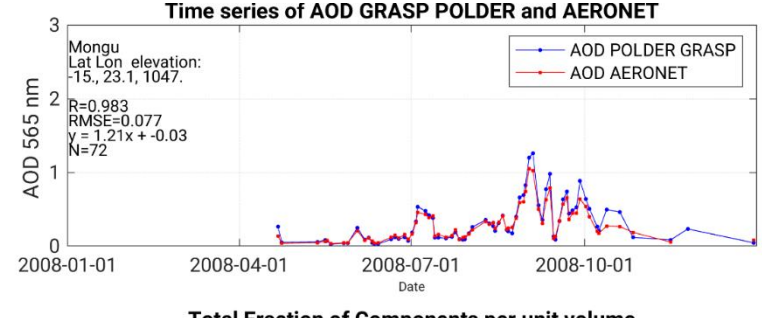

20°N
10°N
0°
10°S
20°S
30°S
10°E
20°E
30°E
40°E
2.0
1.5
1.0
0.5
0.0
Ångström
Exponent

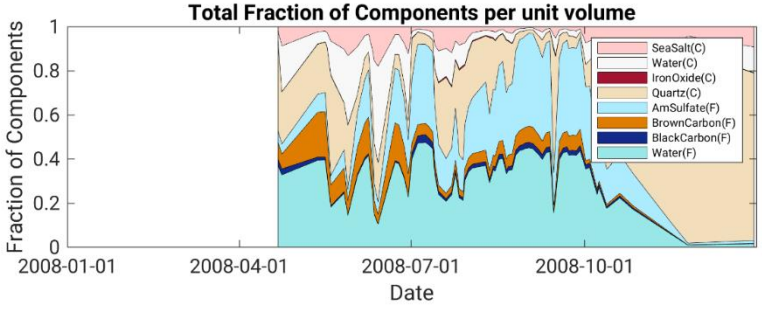
Validation vs. AERONET



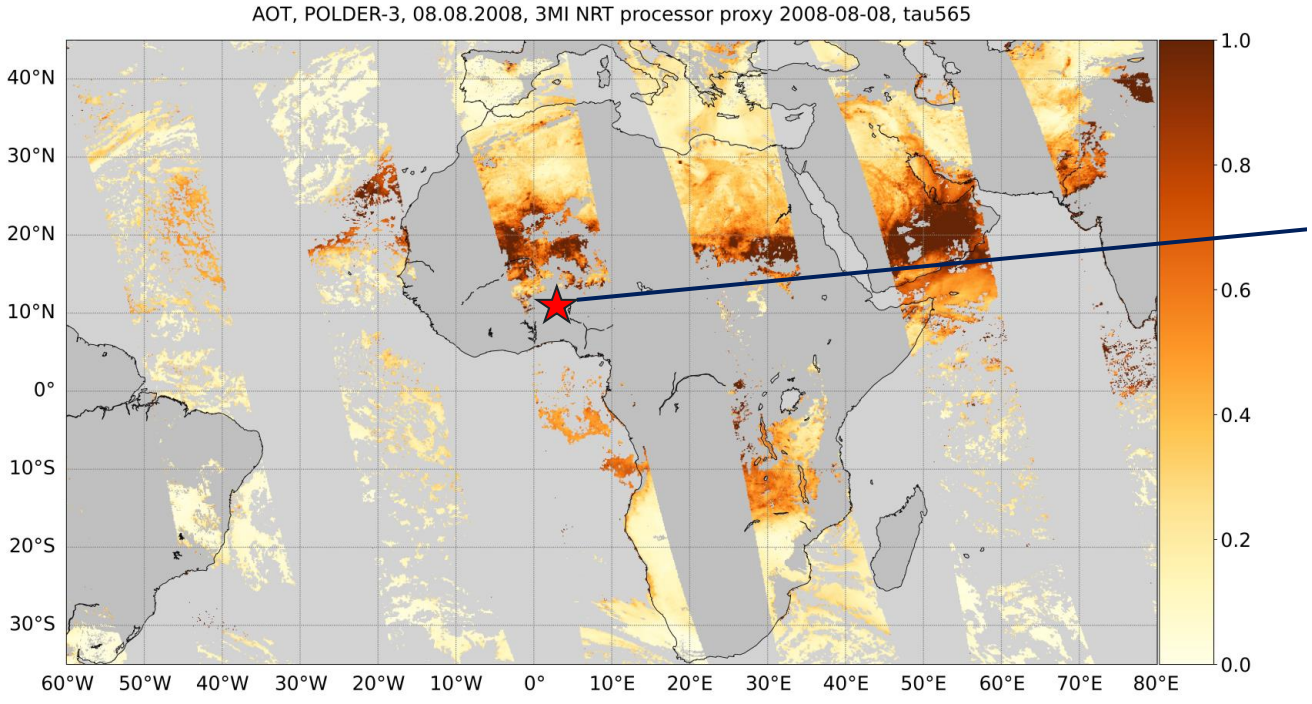


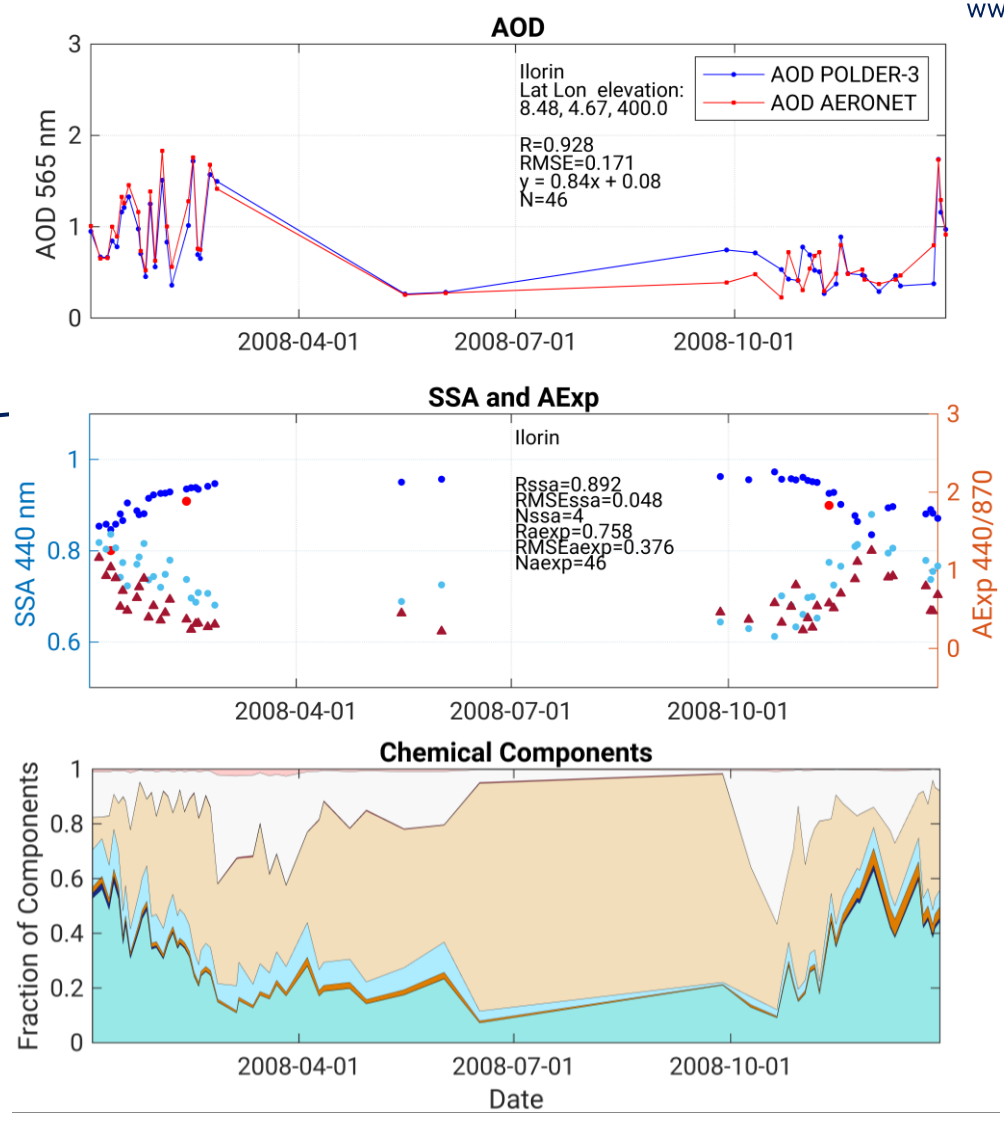






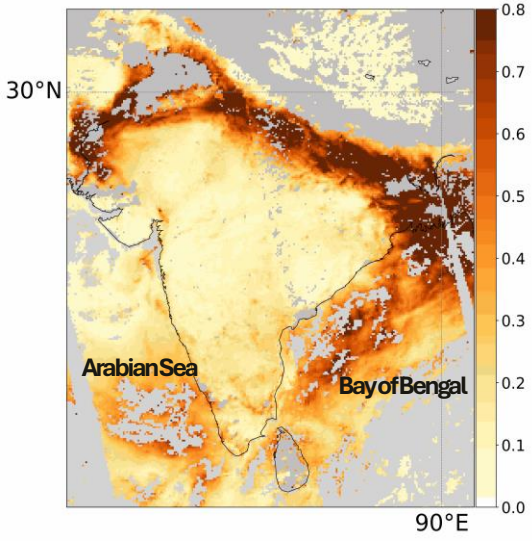
Validation vs. AERONET



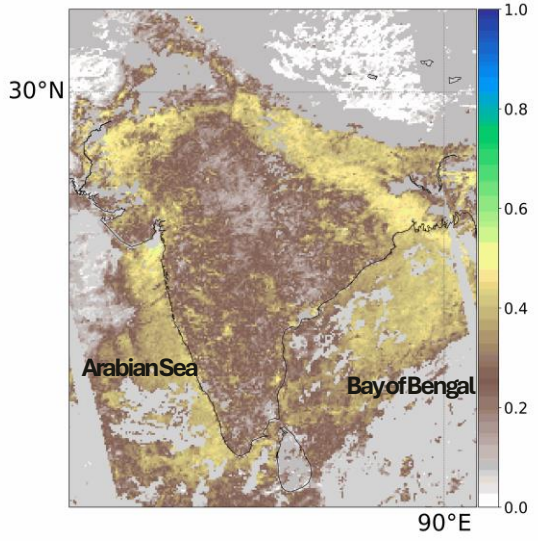


India – Aerosol, Elevation and wind

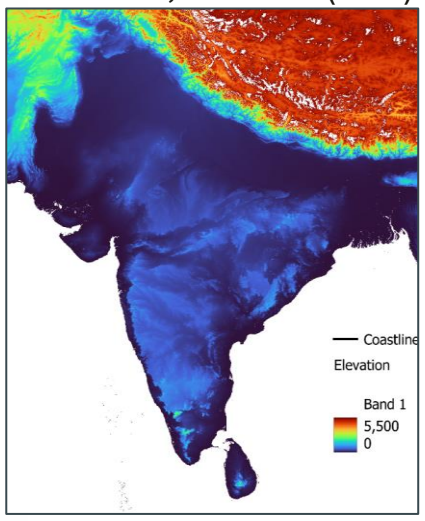
AOT 565nm, POLDER-3, 2008-12-26
3MI NRT processor proxy



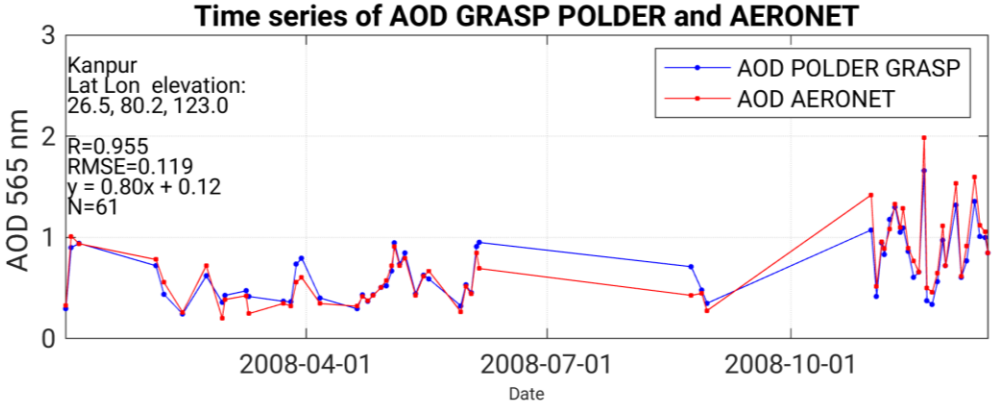
Fine Chemical Components, POLDER-3, 2008-12-26
3MI NRT processor proxy

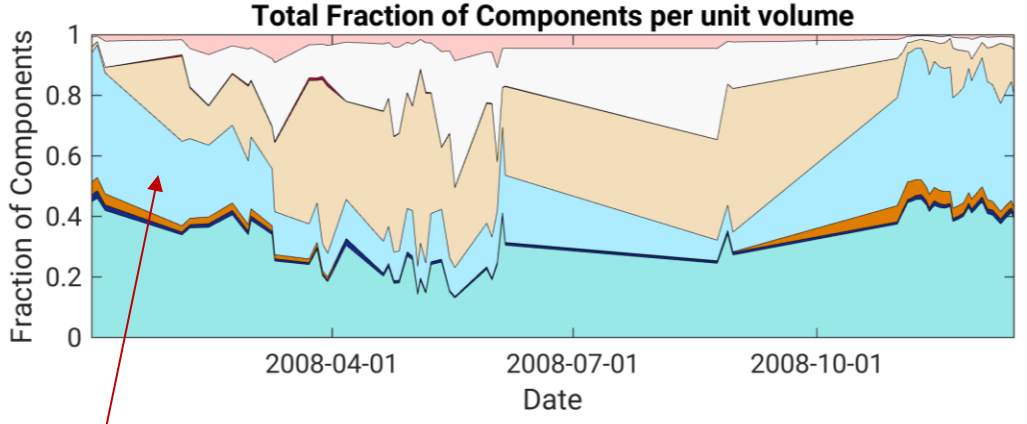


Elevation, SRTM GL3 (90 m)



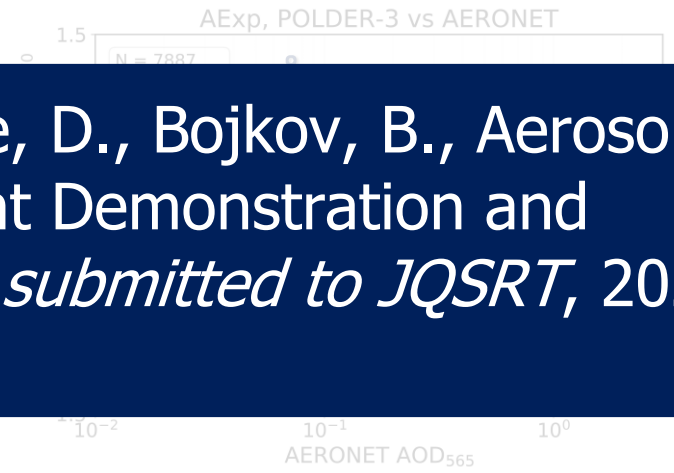
One-third of Delhi's PM2.5 is ammonium sulfate



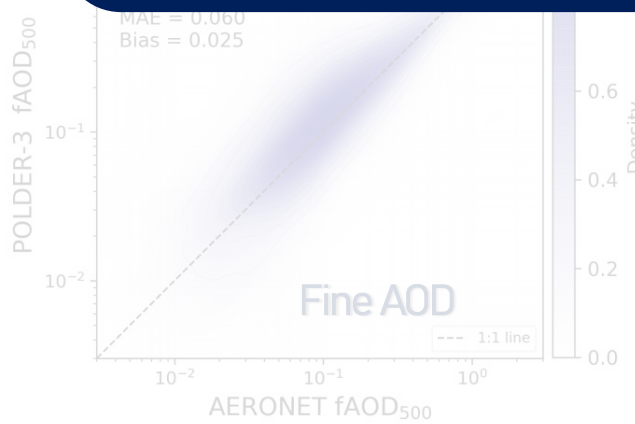


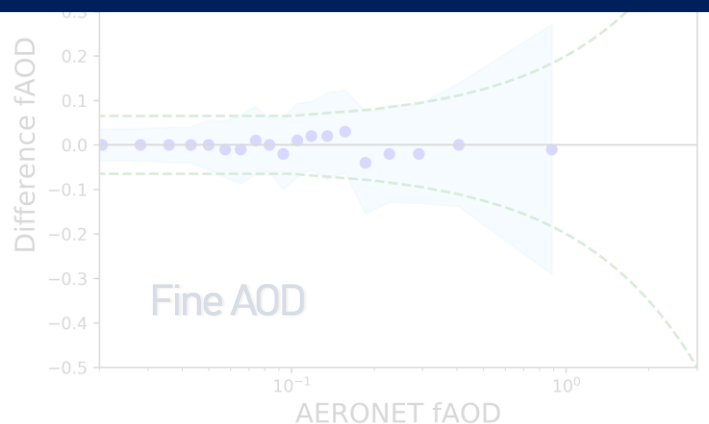
Notable seasonal increase of
Ammunium Sulfate and Brown carbon

Preflight Demonstration and Extensive Validation using PARASOL/POLDER-3



Jafariserajehlou, S., Fougnie, B., Huerta Valcarce, D., Bojkov, B., Aerosol Characterisation based on EPS-SG/3MI – Preflight Demonstration and Extensive Validation using PARASOL/POLDER-3, *submitted to JQSRT*, 2026.





AOD	R	RMSE	Bias
Fine mode	0.91	0.11	0.02
Coarse mode	0.71	0.13	0.03
Total	0.89	0.15	0.05

submitted to JQSRT, 2026

Bridging Modelling and Remote Sensing

Chemical components in 3MI aerosol processor

A study initiated by EUMETSAT in 2023, conducted by GRASP SAS, ongoing.

Baseline definition of chemical components

- External mixture in 2 modes
- Each mode internal mixture by Maxwell-Garnett
- Refractive index from literature review (1979–2007)

Aerosol components/types: what are they and how useful are they?
– Viewpoints from (a) modeler (in the spirit of MIRA)

Modeling team:	**Mian Chin, Huisheng Bian, Hongbin Yu, Dongchul Kim**	NASA GSFC, USA
Remote-sensing teams:	**Yevgeny Derimian, Oleg Dubovik, Pavel Litvinov, et al.**	U. Lille & GRASP, Franc
	Lei Li, Xindan Zhang, Huizheng Che, et al.	CAMS, China
	Brent Holben, Tom Eck, Pawan Gupta, Elena Lind, et al.	NASA GSFC, USA

Acknowledgment: NASA Earth Science programs for supporting modeling and analysis

Size
Radius:
mode 1:
bins: 0.1, 0.1732, 0.3 µm
mode 2:
bins: 1., 2.9 µm

Advanced definition of chemical components

a selected harmonization scheme among several scenarios

- External mixture in 3 modes
- Each mode internal mixture by Linear Volume Mixture
- Refractive index from literature review (1979–2007)
- Vertical profiling with aerosol concentration per mode (approximated by exponential one).

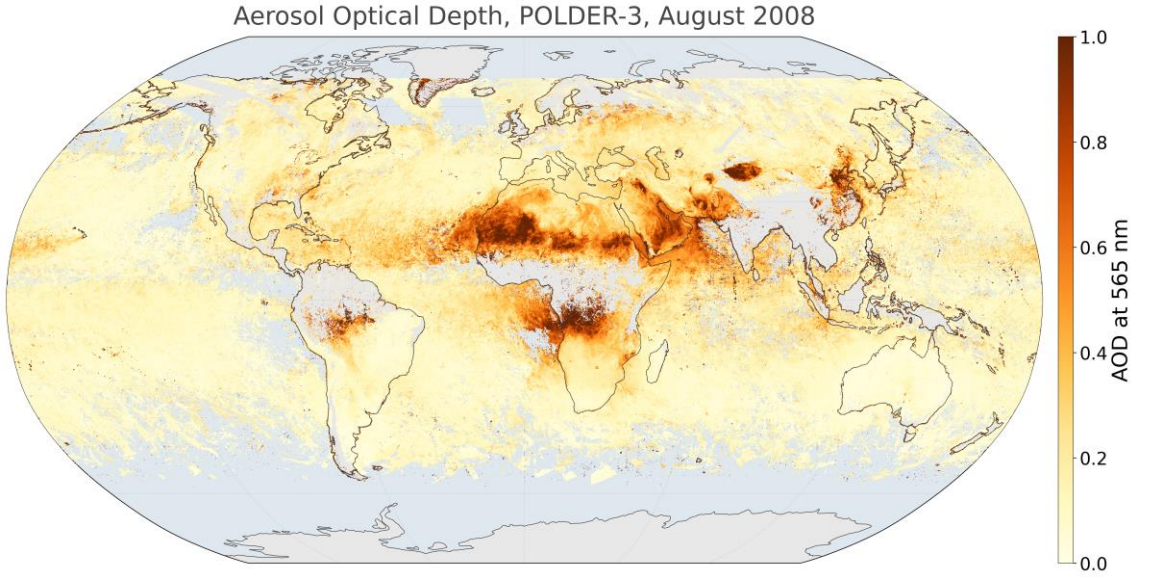
?

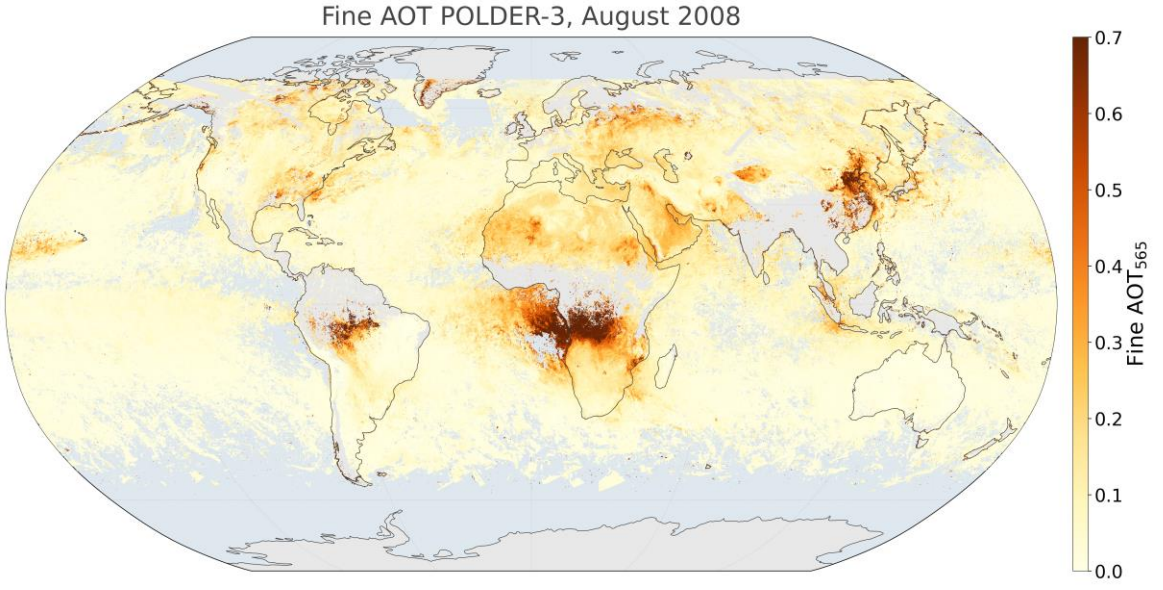
	Size distribution	Volume concentration	BC	BrC	Quartz	Iron oxide	Water	Sea salt
Fine mode	3 LN bins	✓	✓	✓	✓	✗	✓	✗
Coarse mode	2 LN bins	✓	✗	✗	✓	✓	✓	✗
Coarse mode	2 LN bins	✓	✗	✗	✗	✗	✓	✓

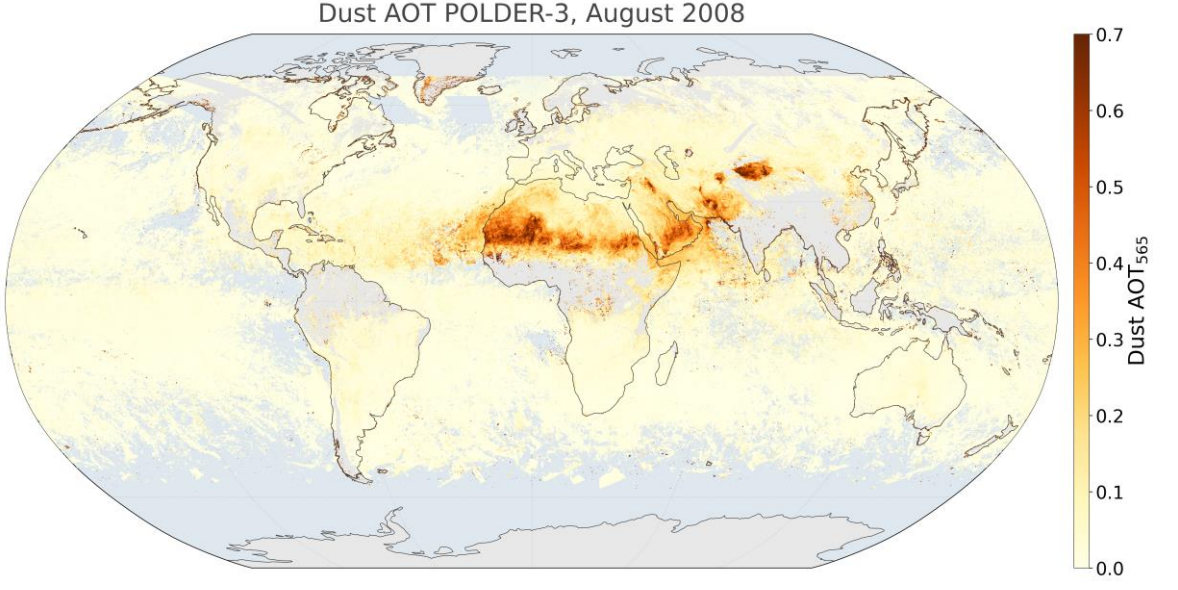
Global dataset processed at EUMETSAT
Extensive evaluation and Inter-comparison to model

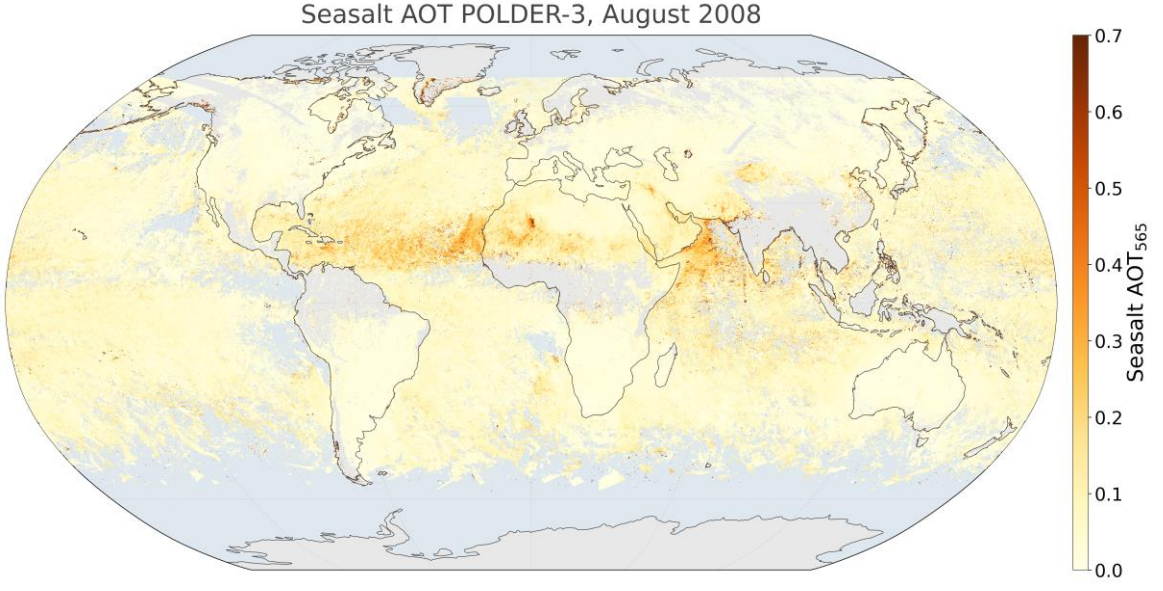
Size
Radius:
mode 1:
bins: 0.1, 0.1732, 0.3 µm
mode 2:
bins: 1., 2.9 µm
mode 3:
bins: 1., 2.9 µm

Total/Dust/Fine/Seasalt AOT



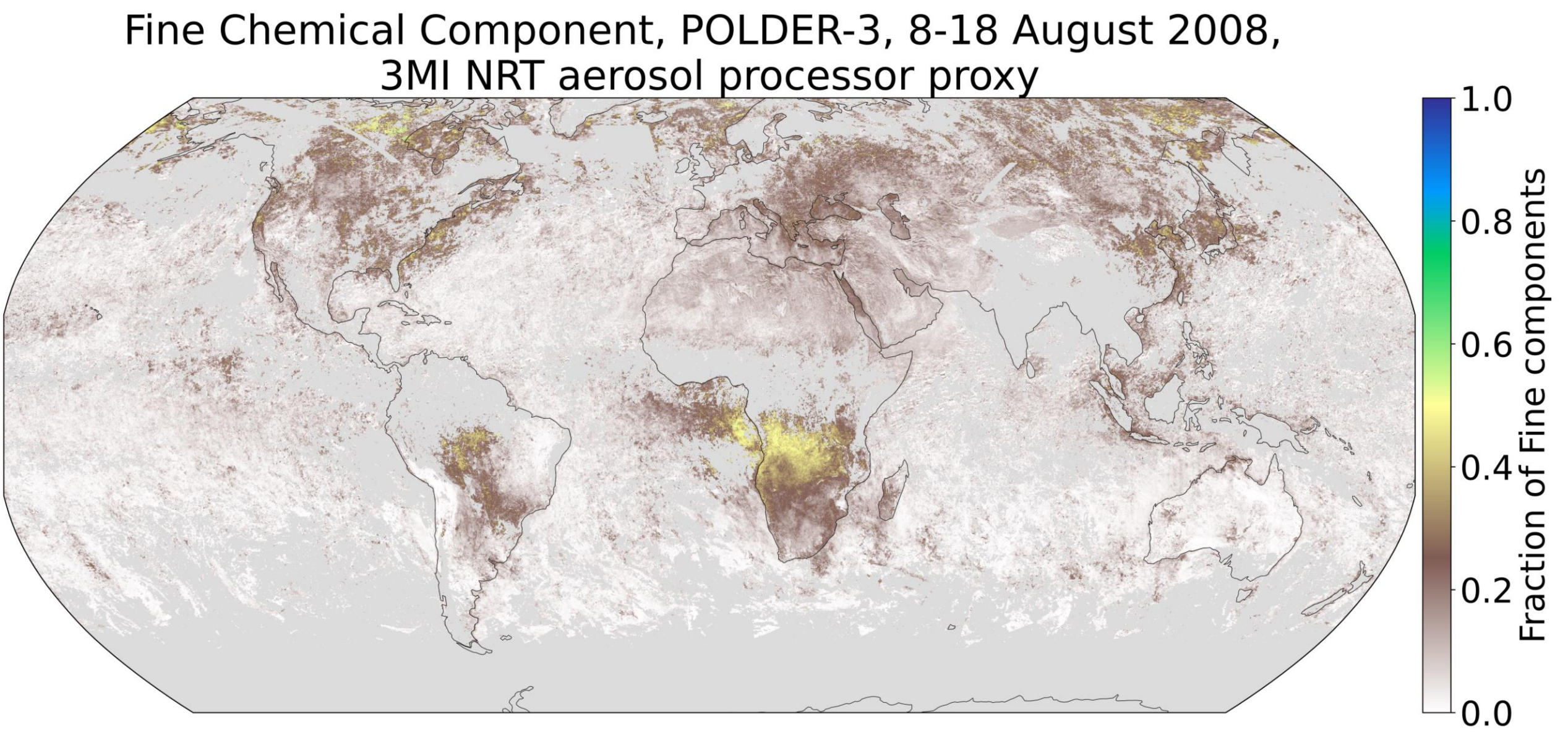




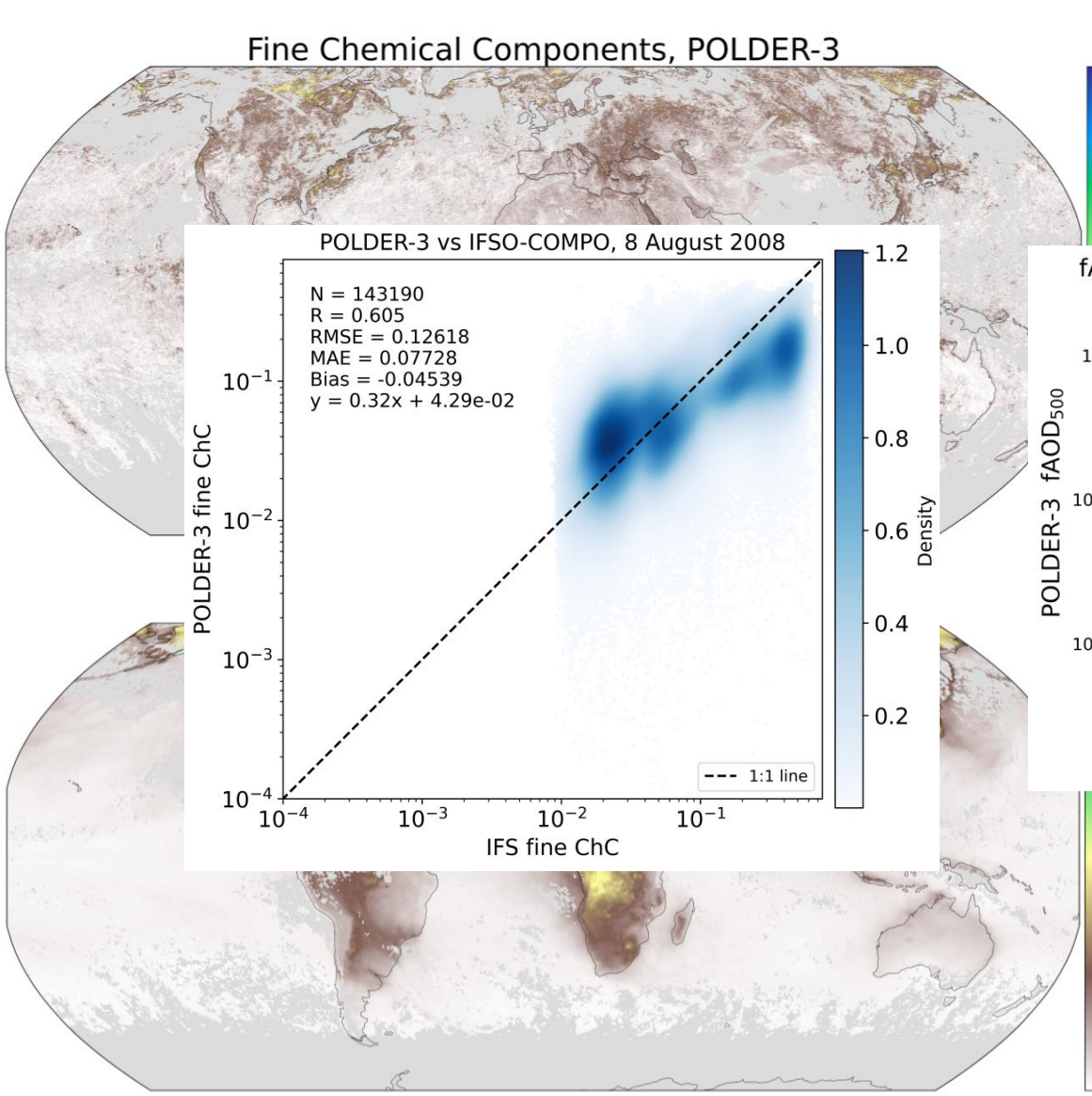


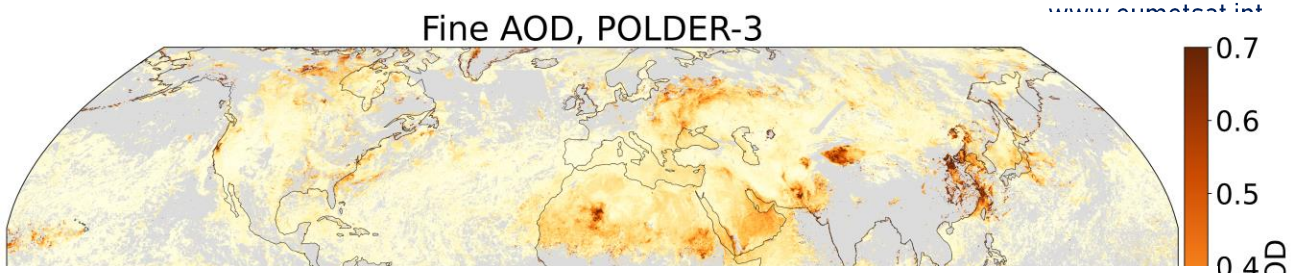
Advanced POLDER-3 Chemical Components: Fine

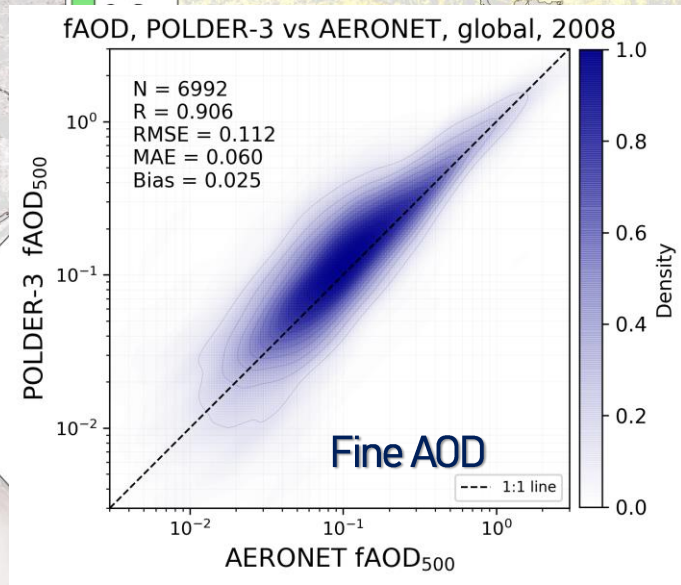
www.eumetsat.int

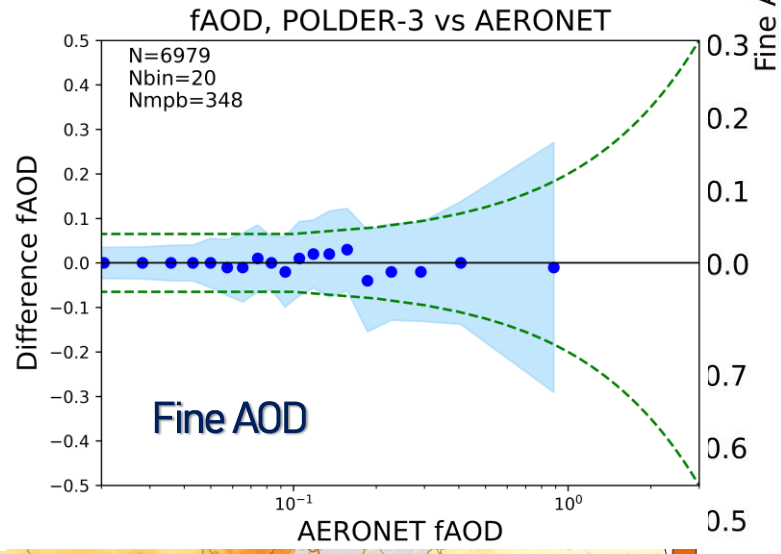


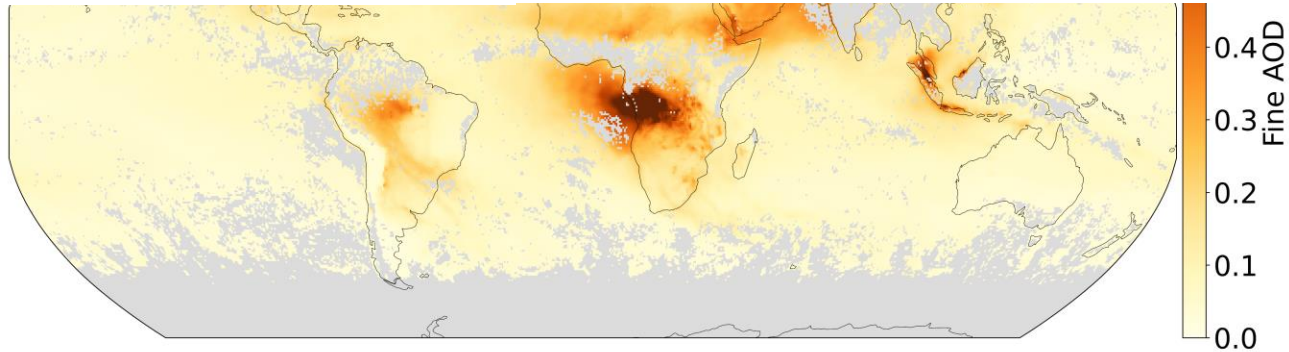
Inter-comparison of satellite data and models











Data from IFS-COMPO been produced from Cycle 50R1, "Cycling Forecast" numerical experiment

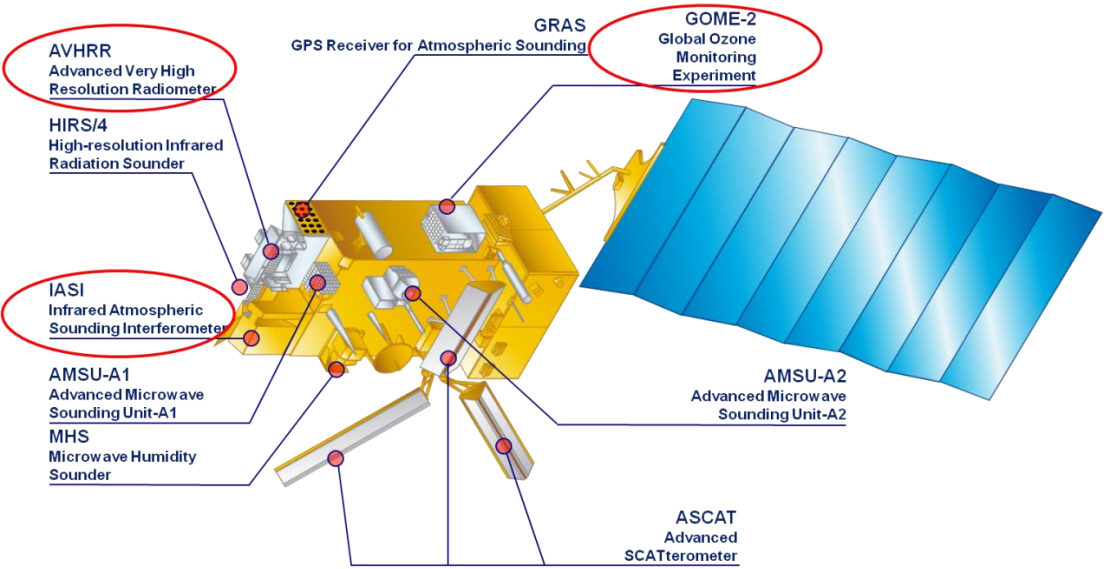
More examples of inter-comparison to models

Multi-sensor Aerosol Product
MAP
Next generation of EUMETSTAT aerosol synergy product

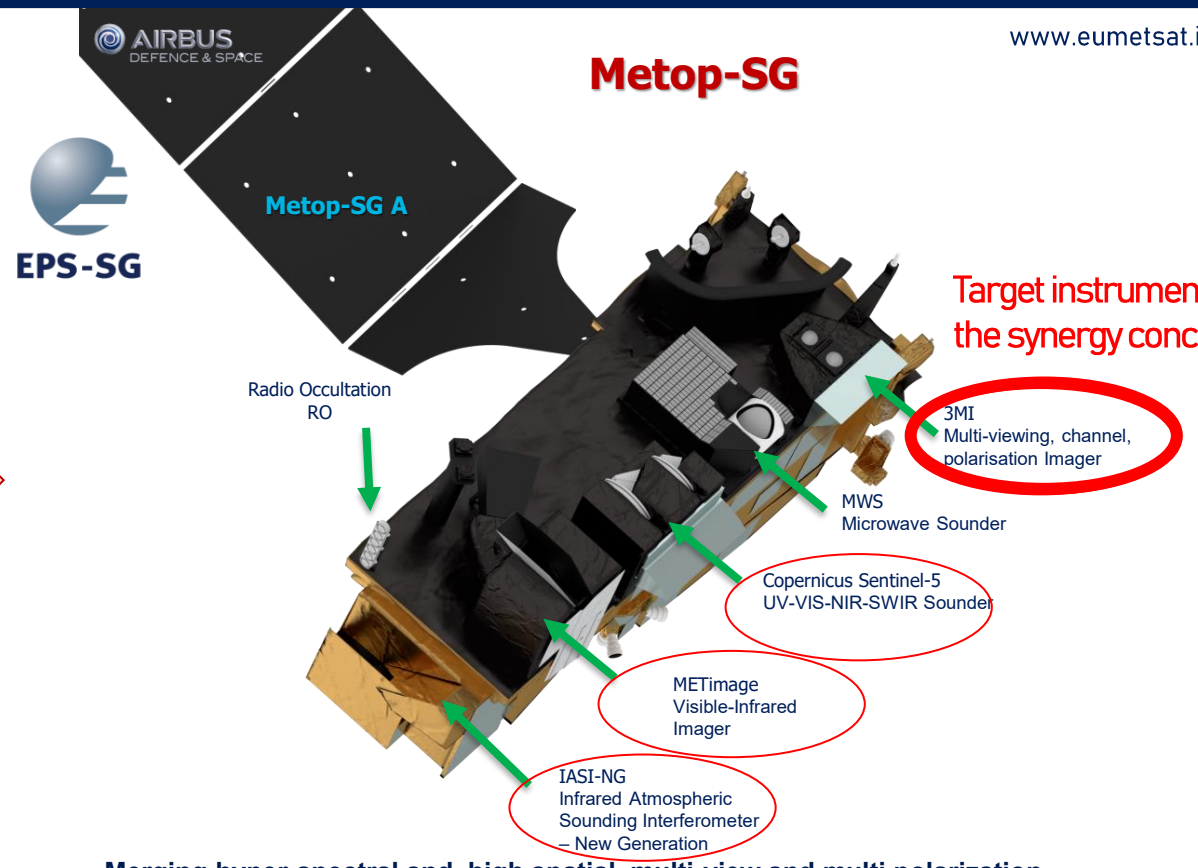
Increasing information content at satellite level
3MI, METimage, IASI-NG, Sentinel-5

PMAp to MAP

Metop



Metop-SG



Target instrument in the synergy concept

Merging hyper-spectral and high spatial information from GOME-2, AVHRR and IASI

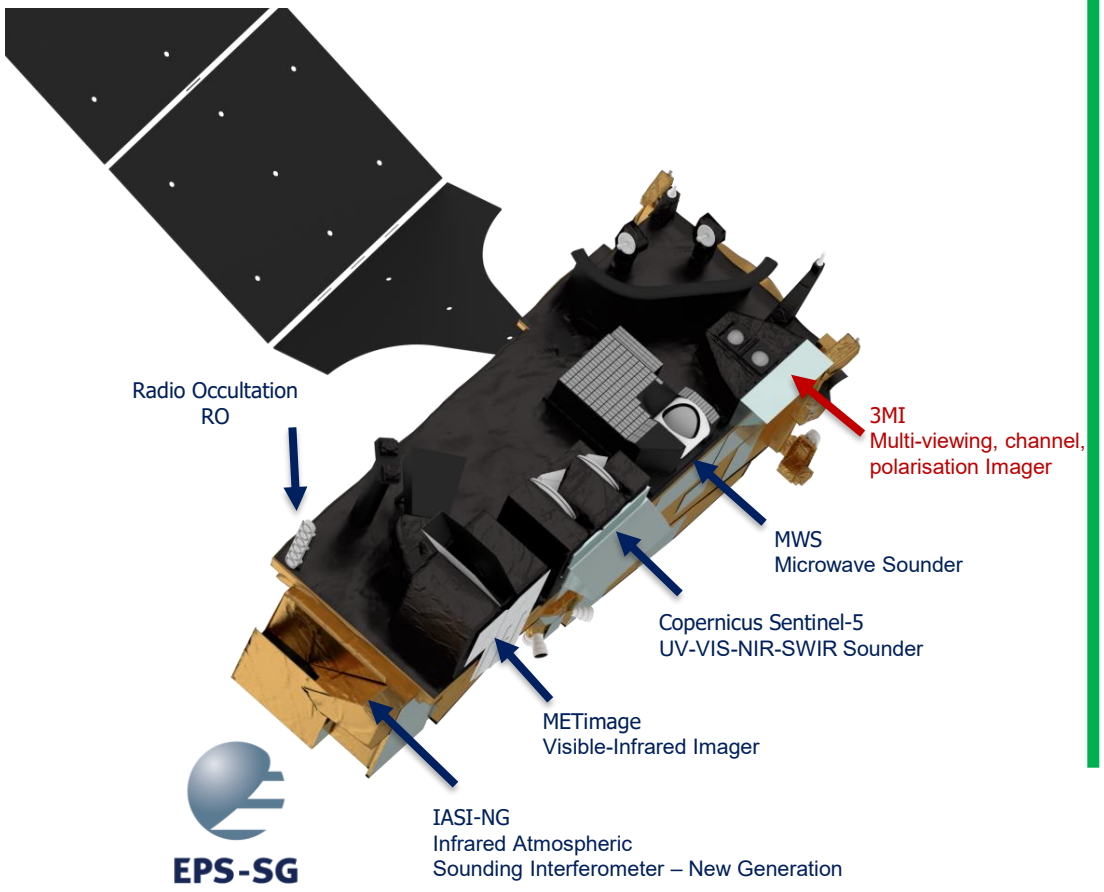
Instruments for L1 data	Spatial resolution	Spectral range
-	-	-
GOME-2 PMD	Metop B and C: 10×40 km^2 Metop A: 5×40 km^2	311 nm – 803 nm (15-? bands)
AVHRR	1.08 × 1.08 km^2	580 nm – 12500 nm (5 bands)
IASI	12 km (circular)	3700 nm – 15500 nm (resolution 0.5 cm^{-1})

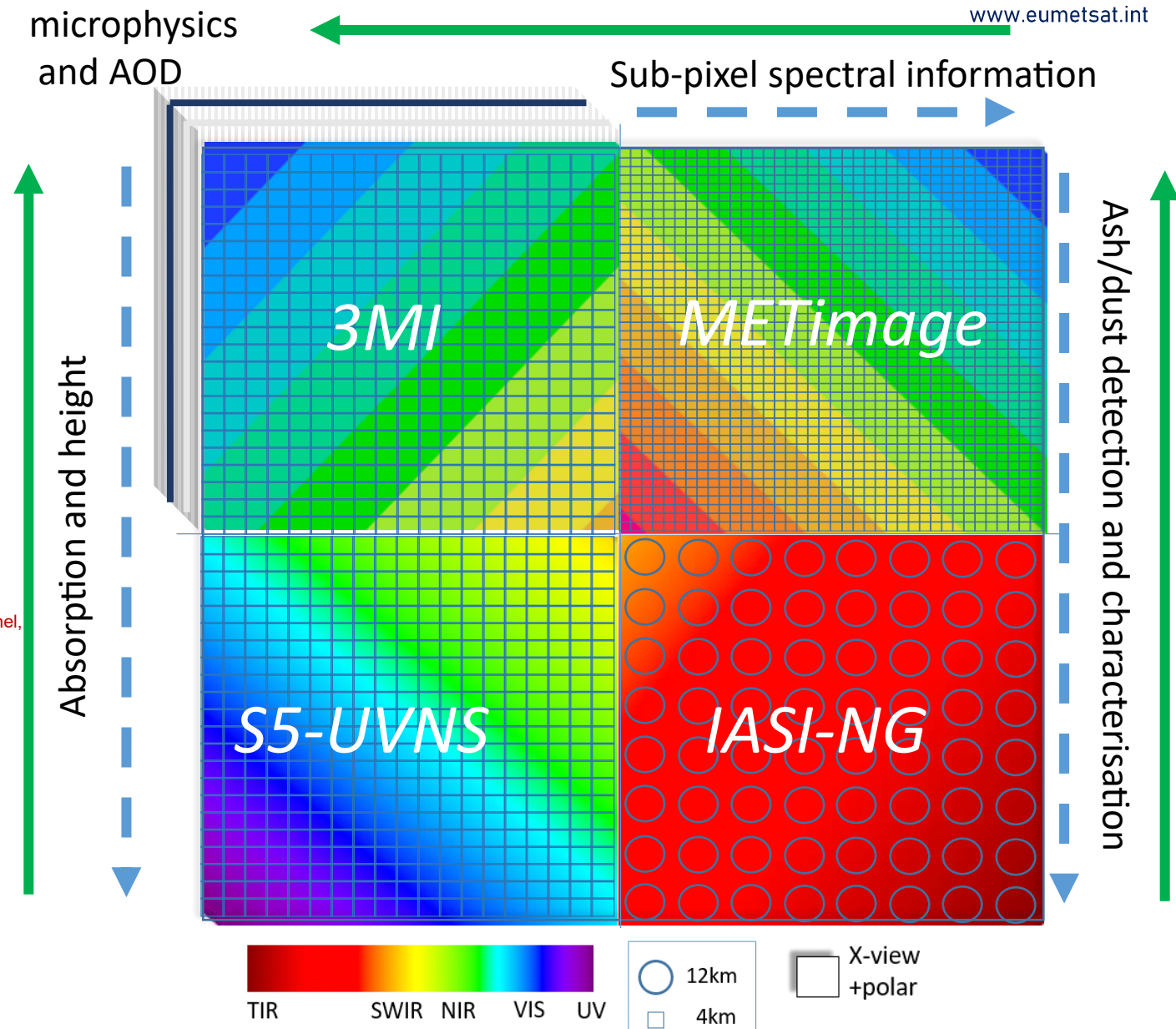
Merging hyper-spectral and high spatial, multi-view and multi polarization information from 3MI, METimage and IASI-NG and Sentinel-5

Instruments for L1 data	Spatial resolution	Spectral range
3MI	4×4 km^2	410 nm – 2130 nm (12 bands)
Sentinel-5	7.5×7.5 km^2 (<300nm) 50×50 km^2	270 nm – 2385 nm (1669 bands)
METimage	0.5 × 0.5 km^2	443 nm – 2250 nm (20 bands)
IASI-NG	12 km (circular)	645 nm – 2760 cm^{-1} (resolution 0.25 cm^{-1})

Multi-sensor synergy

Multi-instrument mission: Metop-SG





Summary

Current status

3MI aerosol processor under testing with real measurements, promising early results.

- Full quality retrieval will be assessed after end of L1 Cal/Val in Q4 2026 + full validation.
- New updates ongoing in the processor (GRASP) for Aerosol Layer Height, Chemical Components, Error estimation etc.

Inter- comparison with models

- Preliminary results show the high potential of new parameters e.g. SSA, Chemical components, Aexp, Fine/Coarse AOD.
- The results to be re-evaluated using 3MI aerosol.
- To be extended using other models e.g. AEROCOM diagnostics experiments.
- New questions for both satellite and modelling communities.

Future perspective

Synergy of multi sensors, satellite or in-situ/model/satellite

- EPS-SG, GEO+GEO (FCI+IRS+S4), GEO+LEO.

Challenges for synergies

- New scientific questions.
- Harmonisation and clarification on the scientific assumption.
- Harmonisation of the level 1 (calibration of radiometry and geometry).
- Technical complexities

Thank you!

Questions are welcome.