

EUMETSAT Operational Aerosol Processors – Last Updates

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EUMETSAT Remote Sensing & Products / *Cloud & Aerosol* (RSP/CLA)

1) EUMETSAT 2) Starion Systems GmbH

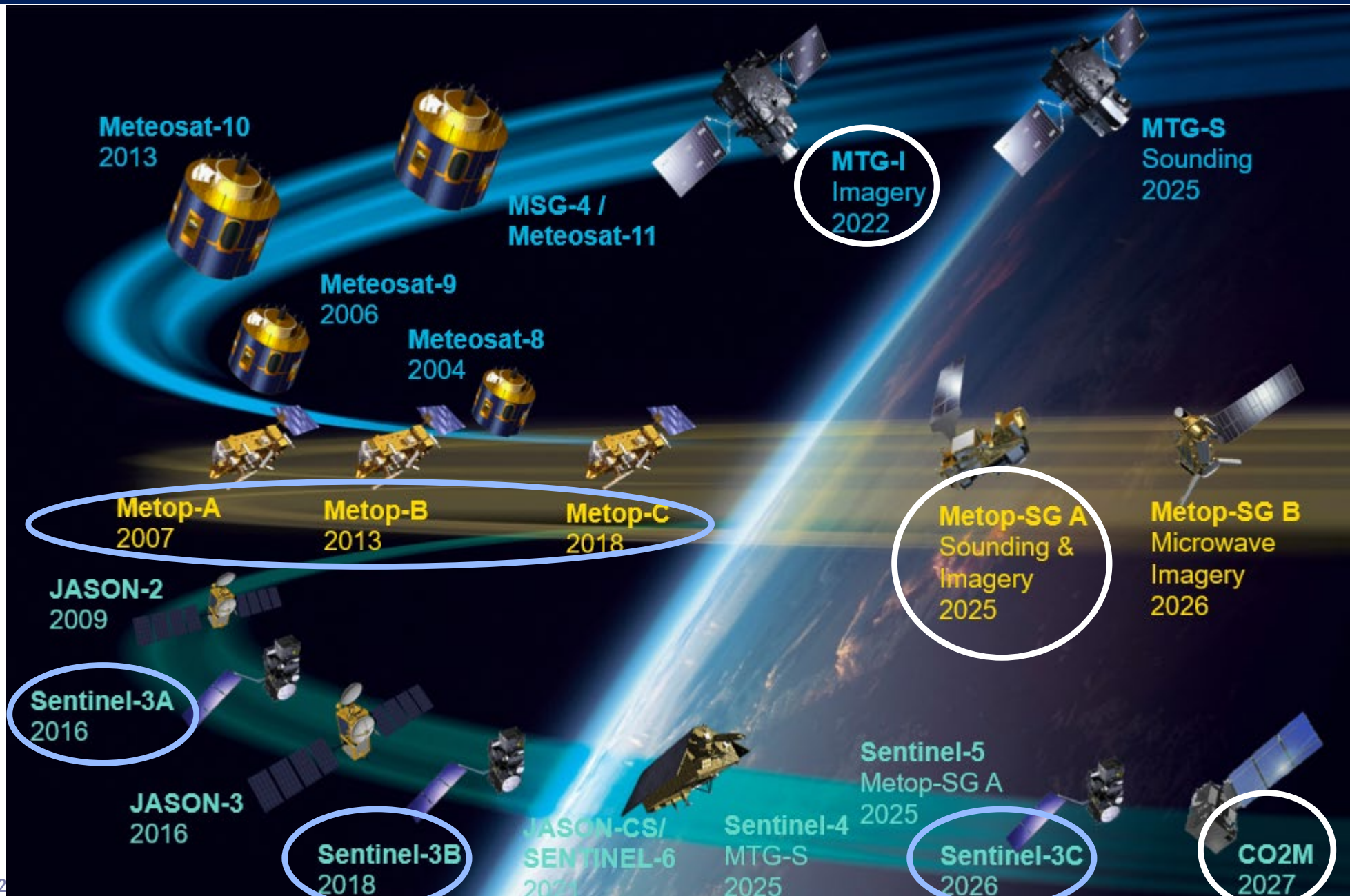
June 2026



- Introduction - Aerosol Operational Processors in EUMETSAT
- **Updates - Operational processors EPS/PMAp**
- **Updates - Operational processors S3/OSSAR-CS3**
- Fire Detection - S3 & MTG
- Processor under development for Geostationary - Plan for FCI
- **Advanced products from Polarimetry**
- Summary & Conclusion



EUMETSAT Missions – *Current and Future*





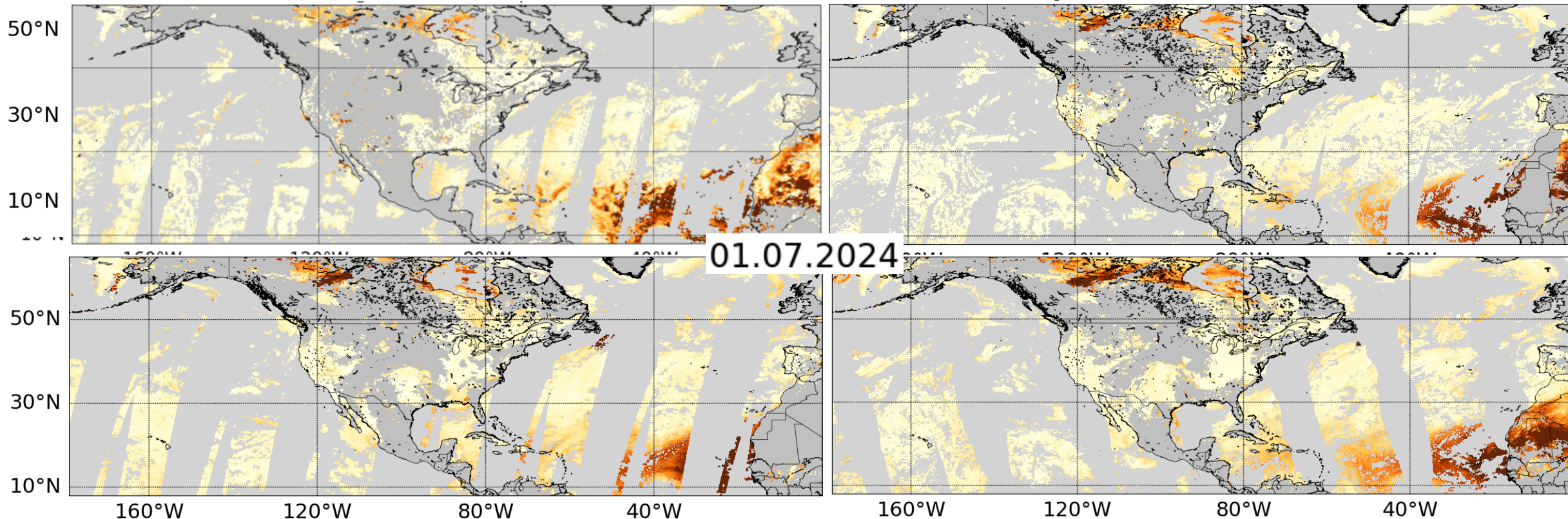
EUMETSAT Operational Aerosol Products

www.eumetsat.int

Metop B+C
PMAP V2.2.6

North-America wildfires

Sentinel-3 A+B
Coll 3.1 – OSSAR-CS3



MODIS Terra
NASA Merged Dark Target / Deep Blue

VIIRS NOAA-20
NASA Deep Blue

Aerosol Optical Depth (550 nm)



Operational NRT EPS processor

PMAp



Operational: EPS/PMAp - Polar Multi-sensor Aerosol Product

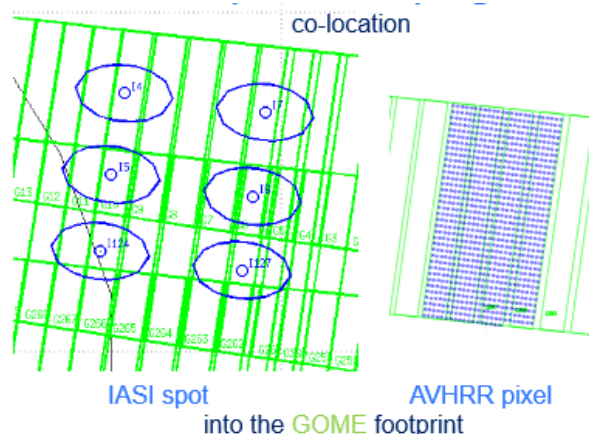
PMAp retrieval : Synergy between GOME-2, AVHRR and IASI

- EPS : Polar orbit at 09:30 ECT – A/2006, B/2012, C/2018
- 3 redundant platform/instrument → 25 y. of operation

Combined Spectral information

Sensor	Channel	CWL (µm)	Wavelength (µm)
GOME2	PMD-4	0.3381	
GOME2	PMD-5	0.3694	
GOME2	PMD-6	0.3821	
GOME2	PMD-7	0.4143	
GOME2	PMD-8	0.4633	
GOME2	PMD-9	0.5220	
GOME2	PMD-10	0.5546	
GOME2	PMD-11	0.5908	
GOME2	PMD-12	0.6403	
GOME2	PMD-13	0.7568	
GOME2	PMD-14	0.7992	
AVHRR	1	0.630	
GOME2	PMD-12	0.6403	
GOME2	PMD-13	0.7568	
GOME2	PMD-14	0.7992	
AVHRR	2	0.865	
AVHRR	3a	1.610	
IASI	3		3.62–5.00
AVHRR	3b	3.740	
IASI	2		5.00–8.26
AVHRR	4	10.800	
AVHRR	5	12.000	
IASI	1		8.26–15.50

Spatial sampling



- Product = AOD @550nm + aerosol type classification
- Operational product since Oct'14 (over ocean)
- Version 2 since Feb'17 (ocean & land)
- **Version 2.2.5 released Feb'23**
- **Fully operational product since Feb'23 for land and ocean**

Cloud / Aerosol Discrimination

- Volcanic Ash Detection
10 set of thresholds tests **AVHRR + IASI** BTDs tests → Ash presence
 - Desert Dust Detection
IASI dust index → Desert dust presence
 - Clouds' Detection & Correction
clouds detection and cloud fraction calculation (CF)
cloud free PMD Reflectance .OR. PMD Reflectance Correction (if partly cloudy)
 - Preliminary Aerosol Type
if Ash presence → aerosol type = ash
if Dust presence → aerosol type = dust
VIS/NIR test for Coarse/Fine mode determination
- } list of preselected aerosol types

Retrieve AODs

- AODs retrieval from **GOME2** for all possible aerosol models in the LUT
over water PMD 12 (640 nm)
over land PMD 7 (414 nm) or PMD 8 (463 nm)

best fit selection – model then AOD

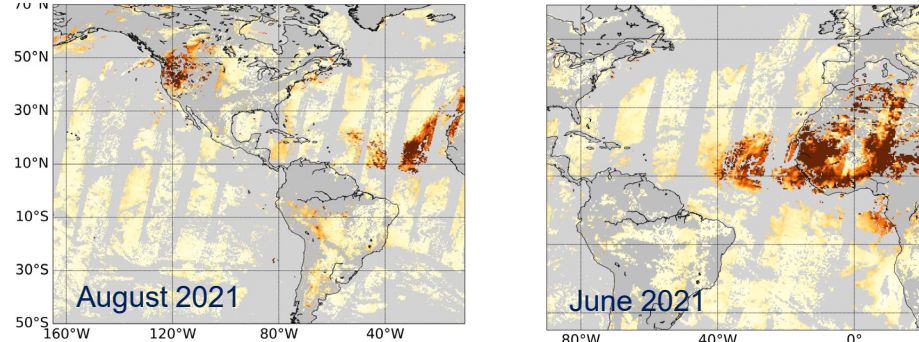
- Microphysics fit : χ^2 minimization of AODs and Models using Reflectance & Q fraction for bands 414-799nm
if cloud free: list of preselected aerosol types } → best {AOD, aerosol type}
if partly cloud: all aerosol models
- Estimation of error on AOD

detailed in Grzegorski et al., Remote Sensing, 2022

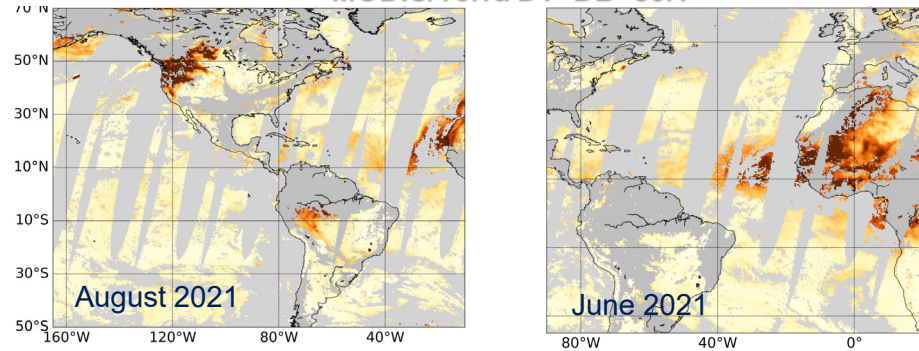
Operational: EPS/PMAp - Validation

Comparison of PMAp to satellite AOD products

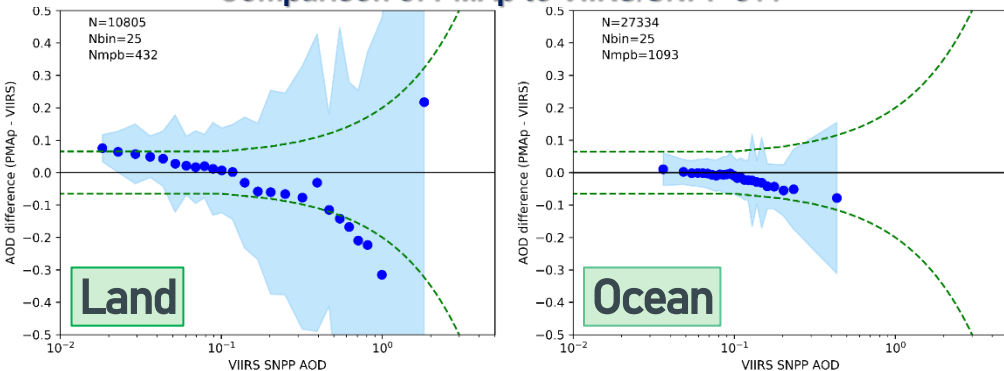
Metop (A+B+C), PMAp v 2.2



MODIS/Terra DT+DB c6.1

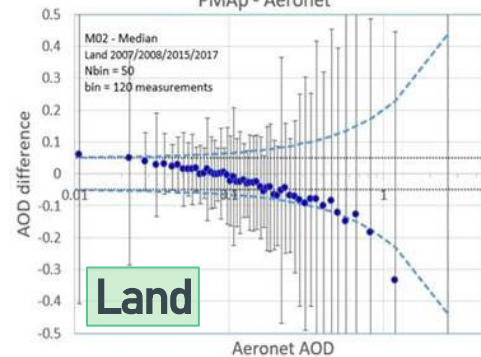
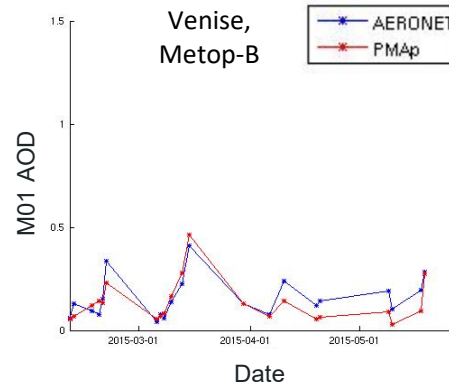
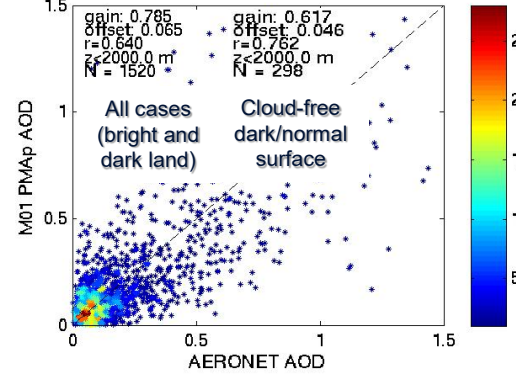


Comparison of PMAp to VIIRS/SNPP c11

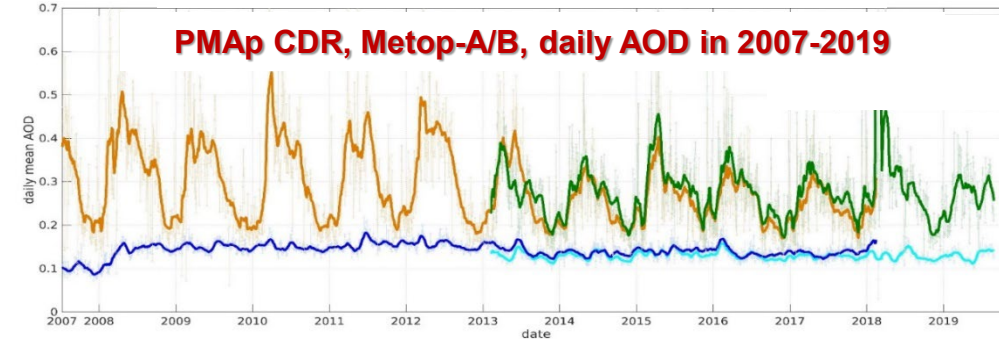
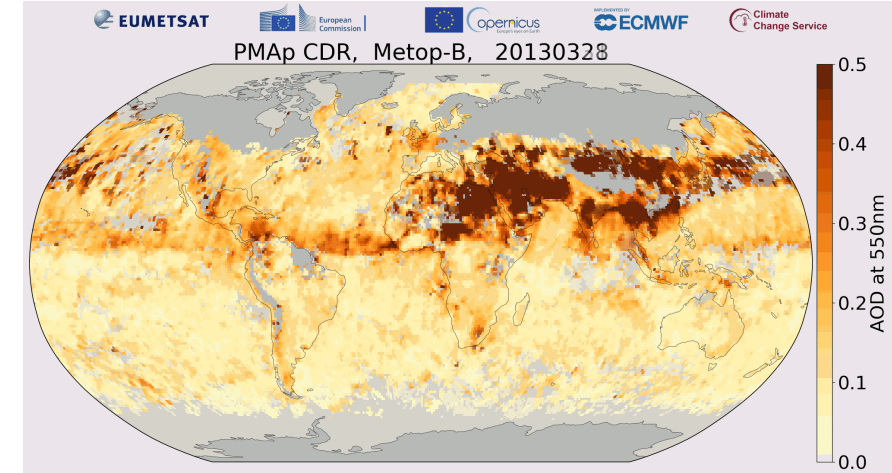


Validation of PMAp vs AERONET

PMAp M01/Aeronet 01-Feb-2015 to 30-May-2015 ΔT: 30min Rad: 30 km

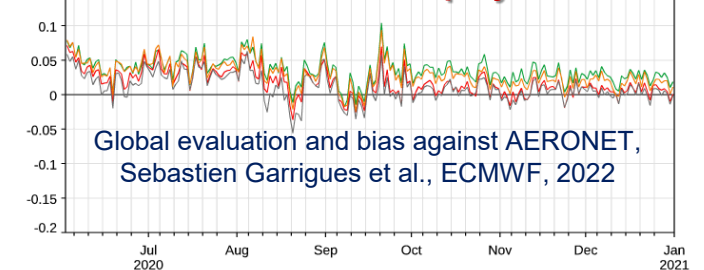


Reprocessing PMAp to create a climate data record (CDR) in the context of Copernicus Climate Change Service (C3S)



PMAp CDR, Metop-A/B, daily AOD in 2007-2019

Assimilation of PMAp by CAMS



Global evaluation and bias against AERONET, Sebastien Garrigues et al., ECMWF, 2022

- On-going improvements:
 - Released in 2025: updated GOME-2 degradation correction + Surface reflectance (GOME-2 LER v4.0)
 - Q1-2026: Solar gap in GOME-2 calibration + upgrade of AVHRR calibration
- Under preparation (tentatively Q3 2026):
 - Improved sub-pixel cloud correction in case of dust event.
 - Revised implementation of GOME-2 Absorbing Aerosol Index (AAI).
- CDR version 2 under discussion
- The overall performance of PMAp fulfils the technical and scientific requirements of operational users (PMAp over ocean assimilated by CAMS since 2017)
- Follow-on: The operational service will be continued by next generation of products from EPS-SG:
 - **3MI** = Version 1 of the follow-on product
 - major improvement in terms of performance + provision of new parameters
 - **MAP** = Version 2 of the follow-on product (= 3MI + Metimage + UVNS + IASI-NG)
 - Improved performance

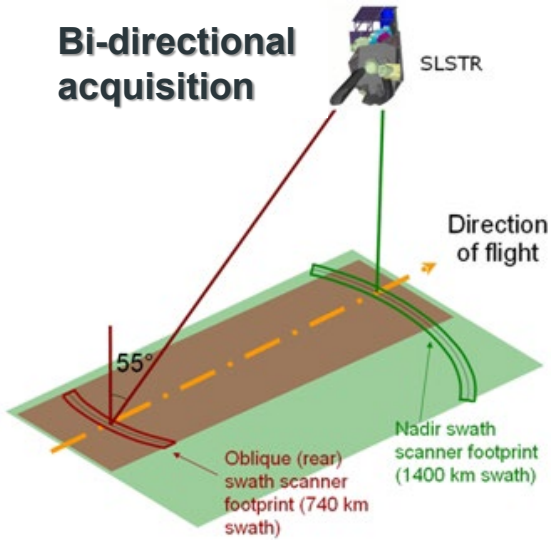
Operational NRT Sentinel-3 processor

SLSTR / OSSAR-CS3



Operational: OSSAR-CS3 from Sentinel-3/SLSTR

- OSSAR-CS3 = Optimised Simultaneous Surface Aerosol Retrieval from Copernicus Sentinel-3
- First **operational** aerosol product from Sentinel-3/SLSTR instrument
 - Nadir & oblique view with spectral VIS, SWIR, & TIR → spectral combined with dual-view



- Joint surface & aerosol retrieval weighted by the actual Information Content (ICA)
- Internal cloud & aerosol mask
- **Ocean:**
 - Dual-view retrieval with ocean surface pre-computed (not retrieved)
- **Land:**
 - Dynamic ICA per pixel = $f(\text{dual scattering angle, land cover type})$
 - Land surface reflectance 1st guess: spectral model built upon AFRI vegetation index & Red-SWIR spectral matching
 - Weighted joint aerosol-land surface: high weight for unfavourable dual-view geometry & vegetation
- Aerosol types (35 mixtures interpolated between dust, sea salt, weakly & strongly absorbing)
- A posteriori diagnostic Quality Indicators (including AOD spatial uniformity, spectral residuals (sediments, melted ice, missed polar stratospheric clouds), bright deserts)

Spectral acquisition

Sensor	Channel	CWL (μm)	
SLSTR	S-1	0.555	
SLSTR	S-2	0.659	
SLSTR	S-3	0.868	
SLSTR	S-4	1.375	
SLSTR	S-5	1.613	
SLSTR	S-6	2.250	
SLSTR	S-7	3.742	
SLSTR	S-8	10.854	
SLSTR	S-9	12.022	

➤ Version 2.0 Aug'20 1st dissemination
 ➤ Version 3.1 released July'24

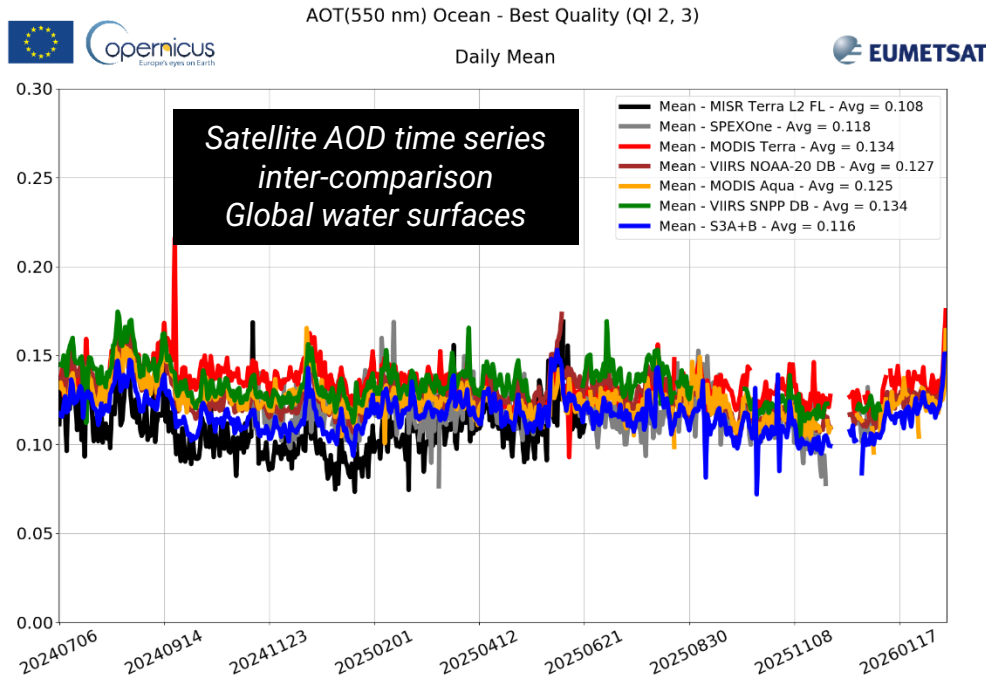
- Includes: better cloud mask for ocean, more representative oceanic surface (climato), inclusion of all VIS bands in the retrieval, update of calibration (VIS)



Recent developments

- **Baseline Collection 3.1 since July 2024.**
 - Enhanced oceanic contribution – AOD improved over all water
 - Stable performance over all water and land surfaces.
- **Updated Collection 3.2 (end May 2026):**
 - Update of calibration directly in L1B
 - Further improvement in Antarctic & Arctic oceans.
 - improved oceanic contribution (hybrid EUMETSAT / NASA OLCI)

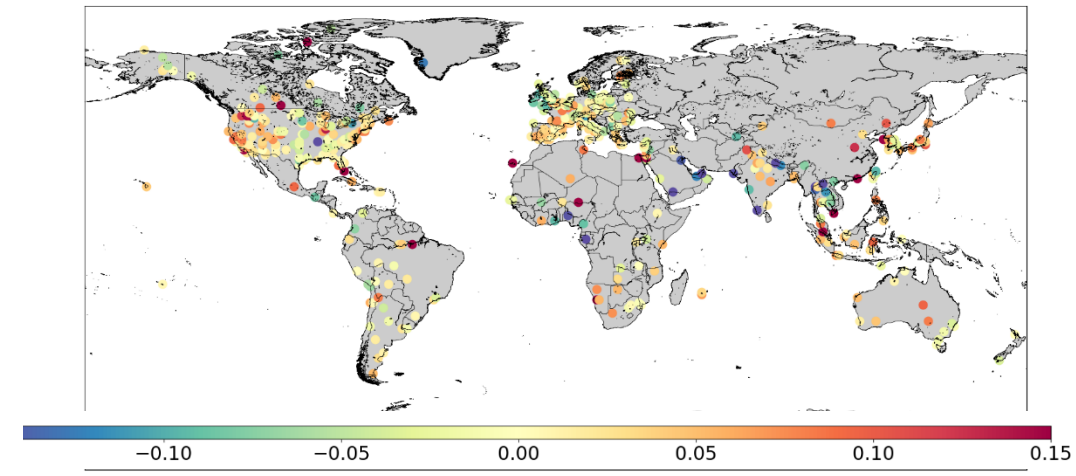
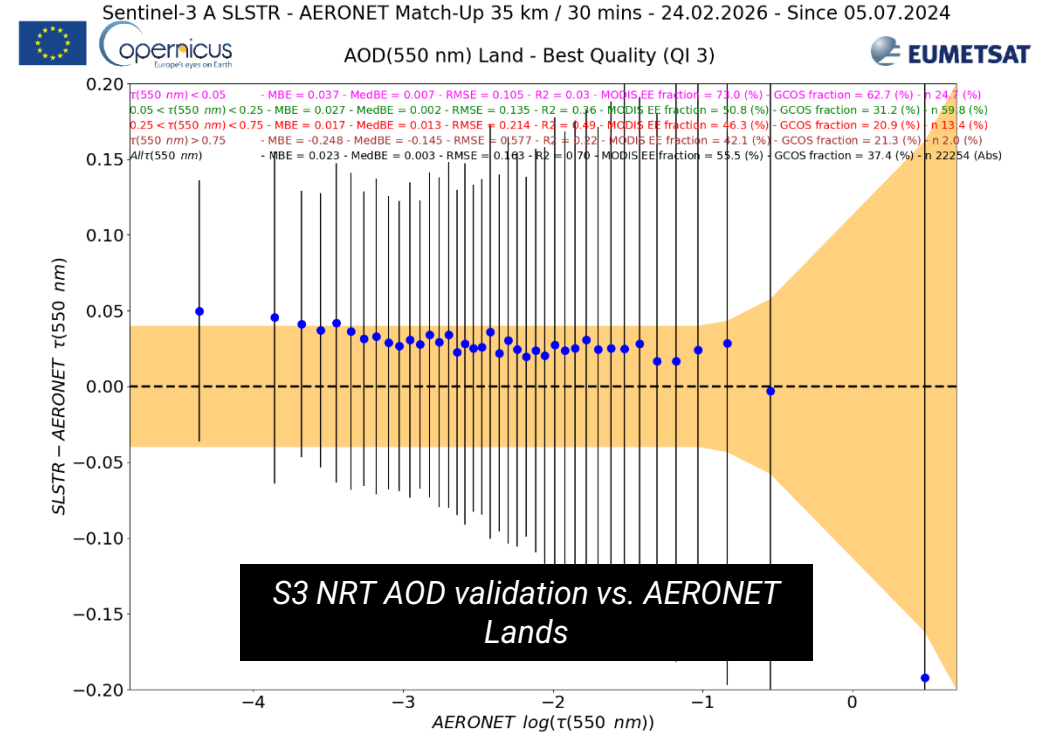
Constellation Sentinel-3 A+B SLSTR - 17.02.2026 - Since 05.07.2024



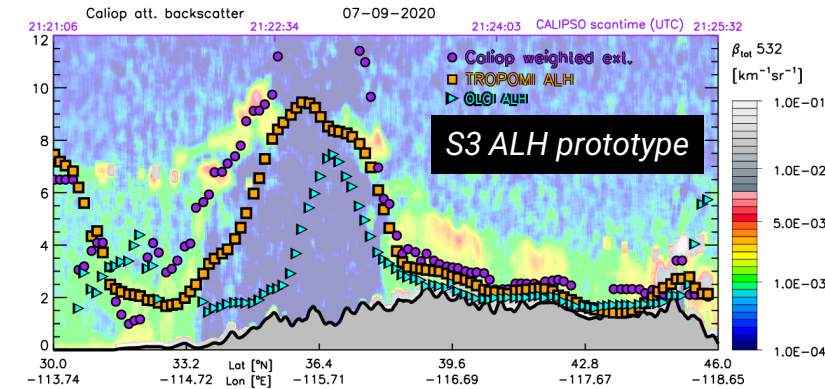
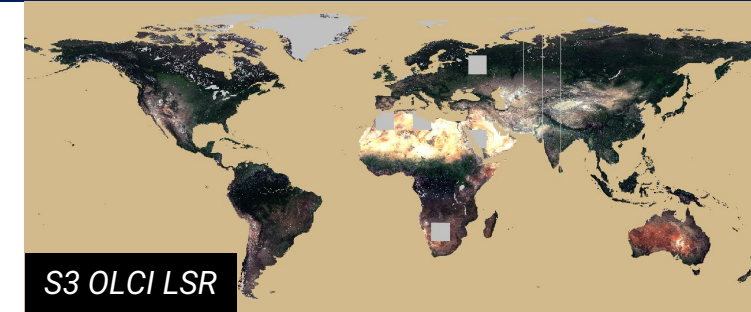
NRT Sentinel-3
MODIS Terra/Aqua

VIIRS SNPP Deep Blue (NASA)
VIIRS NOAA-20 Deep Blue (NASA)

PACE / SPEX One (NASA)
MISR Terra (NASA)



- **Redesign of the L2 NRT Aerosol algorithm:**
 - Extended coverage to full SLSTR swath (not only dual view)
 - Towards higher spatial resolution
 - Enhanced surface constraints
 - **Land Surface Reflectivity (LSR) auxiliary product:** Completed and validated for OLCI – In progress for SLSTR.
 - Benefiting from the OLCI-SLSTR synergy
 - NRT LIC-syn version 3.2.0 (prototype) available in Wekeo – under evaluation
 - Increase of the set of aerosol parameters: Aerosol Layer Height (ALH), aerosol typing (dust, smoke, ash), Single Scattering Albedo (SSA).
 - **ALH prototype** finalised
 - Improved retrieval by assuming more physical aerosol chemical components
 - **Aerosol chemical component** under specification



Proposed roadmap	Model 1 Based on CAMS	Model 2 Based on GRASP chemical component	Model 3 CCI-based model with Stefan Kinne's AEROCOM climatology and coarse dust	Model 4 Based on full Chemical Component approach (3MI, CO2M, HARP, SPEX)
Number of component	5 External mixture: BC, OM, Soluble_fine, Dust, Soluble_coarse	5 External mixture: BC/BrC1, BC/BrC2, Soluble_fine, Dust, Soluble_coarse	5: 4(CCI) + 1 (coarse dust) External mixture	2 modes, 5 aerosol species Internal + external mixture Aerosol species climatology: - Fraction of chemical component per each mode - SD climatology per mode depending
$Re(m)$ <RH=50%> or depends on RH	$Re(m_k)$	$Re(m_k)$???	
$Im(m)$ <RH=50%> or depends on RH	$Im(m_k)$	$Im(m_k)$???	
$\tau_m^{>RH=50\%}$ or depends on RH	$\tau_m^{v(k)}$	$\tau_m^{v(k)}$???	
σ <RH=50%> or depends on RH				
Clim				From PARASOL, 3MI

New aerosol components for S3 – under final specification



- **Current version:**
 - Performance monitored and interesting comparison to other reference sensors (VIIRS NOAA-20)
 - Assimilation in CAMS: under activation over ocean (fall 2025), coming over land
- **S3 NRT AOD now actively assimilated (over ocean) by CAMS within IFS-COMPO new cycle 50r1 (12th May 2026, ECMWF)**
 - Land under testing
- **Launch S3C in Sept'26**
 - Decommissioning of S3A after commissioning of S3C
 - Continuity shall be secured
- **Day-2 under preparation for SLSTR in synergy with OLCI**
- **Preparation of S3-NGO: MRD under finalisation – improved capabilities for aerosol detection and typing**

Operational NRT Fire processors

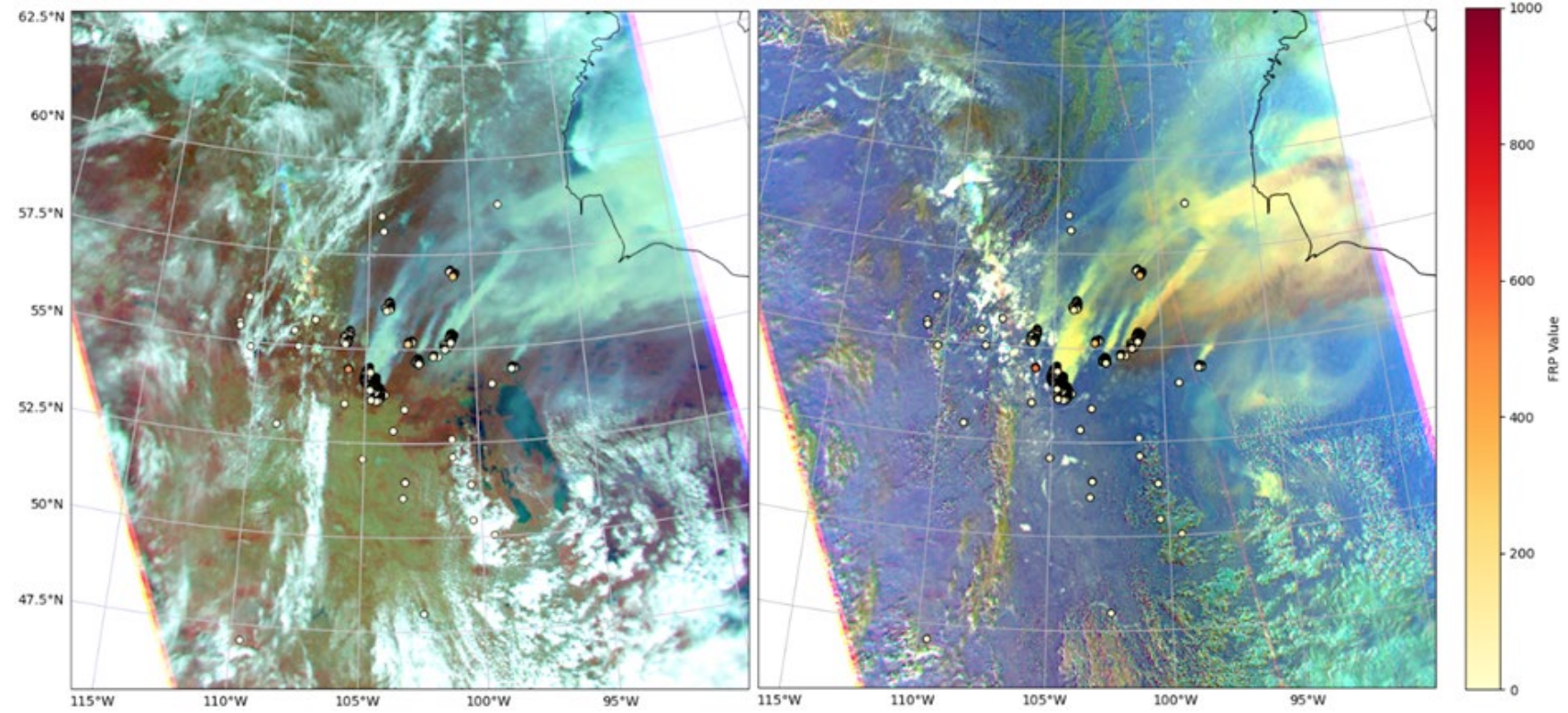
Sentinel-3 & MTG



- Operational NRT FRP product from SLSTR (S3) & FCI (MTG) and soon VII (EPS-SG)
 - Provides identification of sources for smoke prediction (morning orbit)
 - Consistency with aerosol signature from imagers & polarimeters



1-km [SLSTR](#) FRP [MW]
RGB Composite from [OLCI](#)



1-km [SLSTR](#) FRP [MW]
RGB Composite from [HARP2](#) (left=natural + right=polarised)

- **Detection and Power**
 - Operational with Sentinel-3 and MTG (EPS-SG coming)

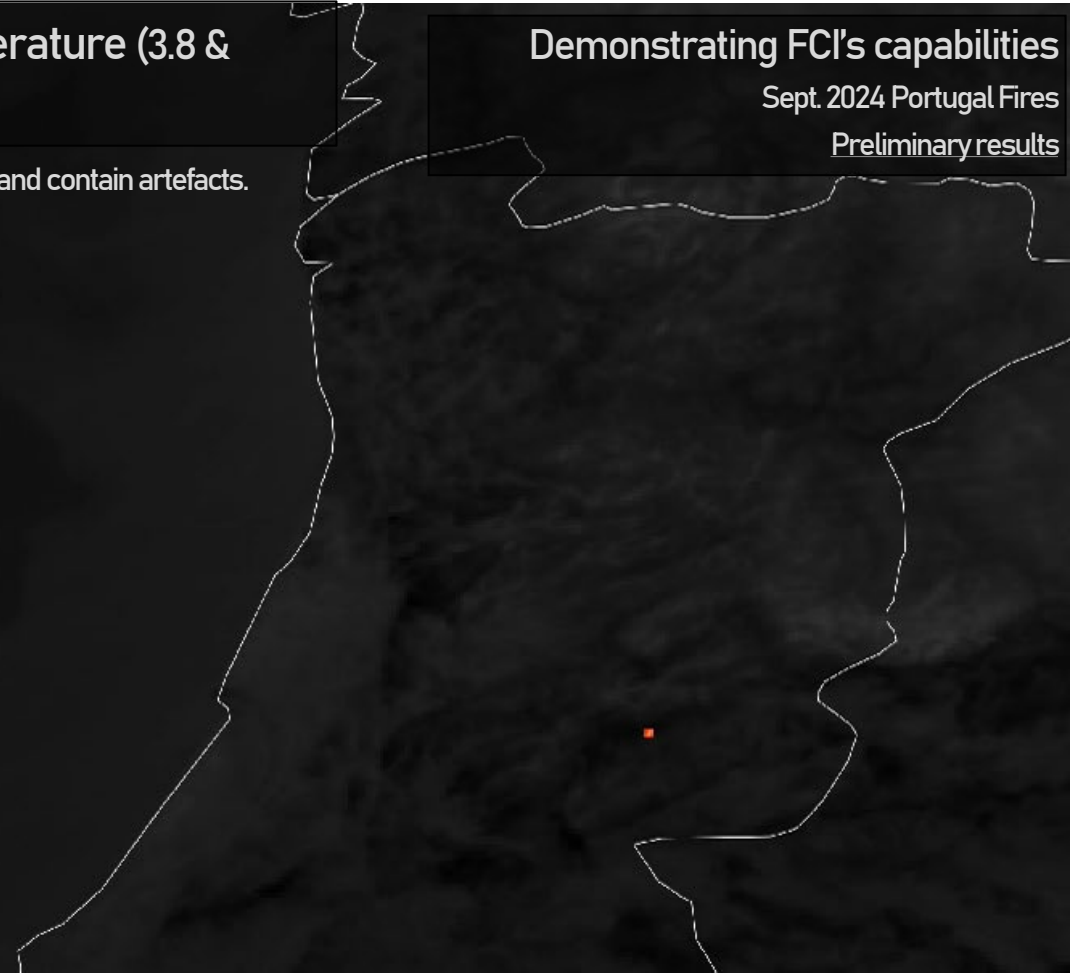


1-km [SLSTR](#) FRP [MW]
RGB Composite from [OLCI](#)

FCI 0.5km True Color & Fire Temperature (3.8 & 2.2 μ m)
16.09.2024 00:00 - 18.09.2024 18:00
Note: simple fire mask applied - may miss smaller fire and contain artefacts.

Demonstrating FCI's capabilities
Sept. 2024 Portugal Fires
Preliminary results

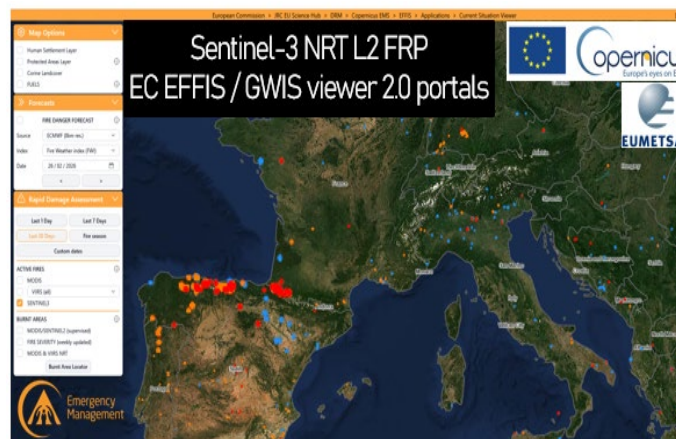
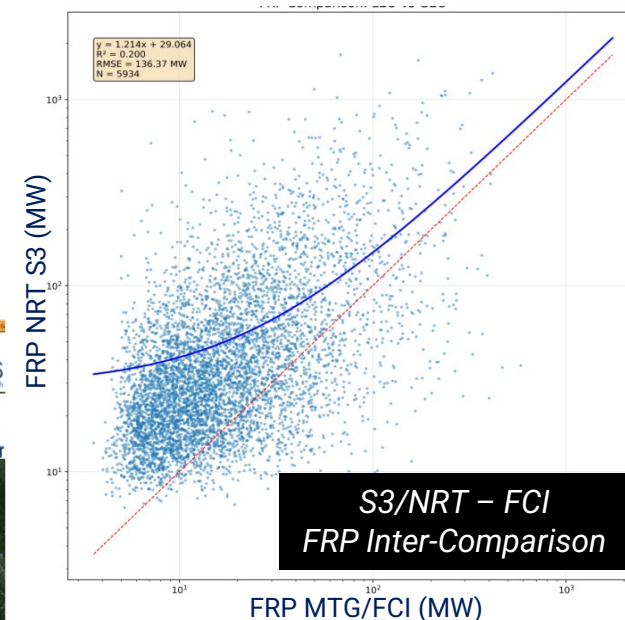
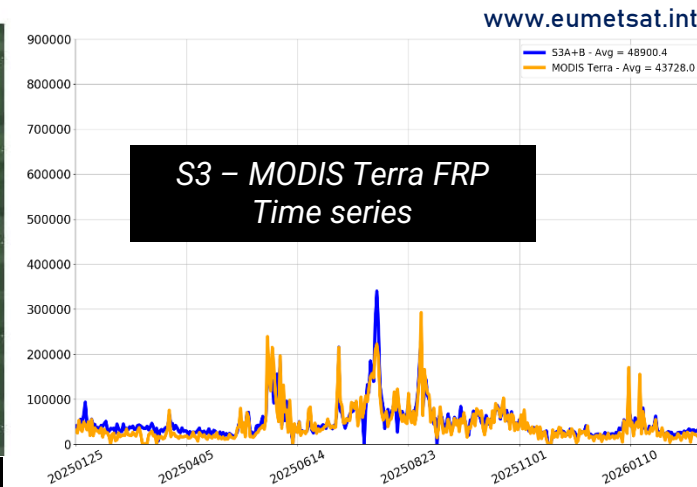
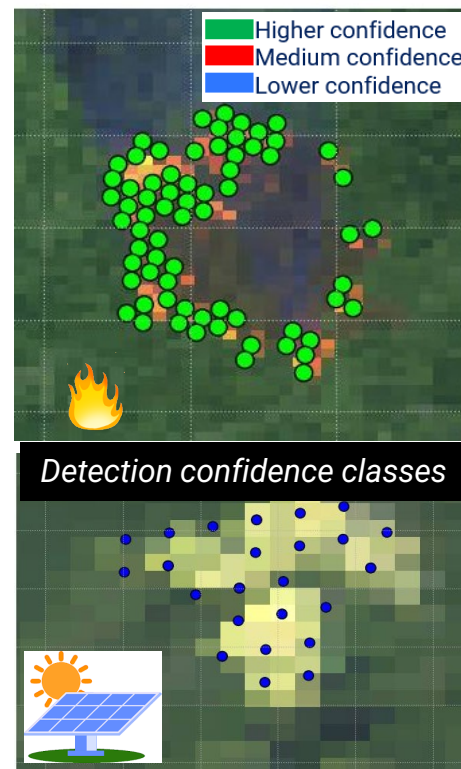
2024-09-16
00:00 UTC





S3 NRT FRP – Status

- **Baseline Collection 3.1 since January 2025.**
 - New product format (mini files, CSV fire convention).
 - Improved day-time algorithm, reduced outliers in large solar zenith angle.
- **Last update Collection 3.2 (end May 2026):**
 - **Further product optimization:**
 - Large geodetic grid moved to a dedicated place.
 - Only mini fire files in the core product.
 - **Further improved quality detection:**
 - **Removed Bright clouds in twilight high latitude.**
 - **New detection schemes of bright reflective targets:** solar panels, cloud edges.
 - **Detection confidence classes per pixel**
 - **First definition of a “non fire” detection**
- **Automatized GEO-LEO Fire inter-monitoring system**
 - Evolution from MSG/SEVIRI to MTG/FCI.
- **Feeds EFFIS (CEMS), CAMS ingestion test into GFAS**
- **Development of the “Fast-FRP” with improved timeliness**
 - Down to 30/15 mins





Development with GEO MTG/FCI



❖ Interest

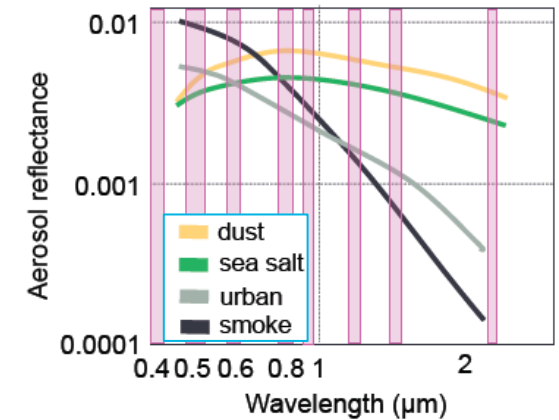
- AOD available with high temporal revisit (up to 10 mins)

❖ Resuming the development in EUMETSAT

- MTG/FCI in orbit and Level-1 data operationally available & disseminated
 - 8 spectral bands in 440-2100nm, 10' min resolution, 1km nadir
- Kick off in Jan'25 of the Scientific Framework with Météo-France on the development of the algorithm + processor

❖ Strategy

- Heritage = instantaneous retrieval from MSG/SEVIRI (demonstrational product in ICARE)
 - Surface retrieval (Kalman filter) with previous days
- Upgrade to FCI capabilities – Collaboration with Meteo-France
- Provision of an advanced prototype
 - Transformation into a IPF in hosting (TBD) ground-segment + dissemination
 - Optimisation processing time (RTM)
- Demonstrational tests for the added-value in Chemistry Transport Model (AROME)
- **Definition of the product:** spatial resolution, temporal resolution (hourly?)
 - Other feedbacks welcome
- Mid-term target: early demonstrational samples > end 2027





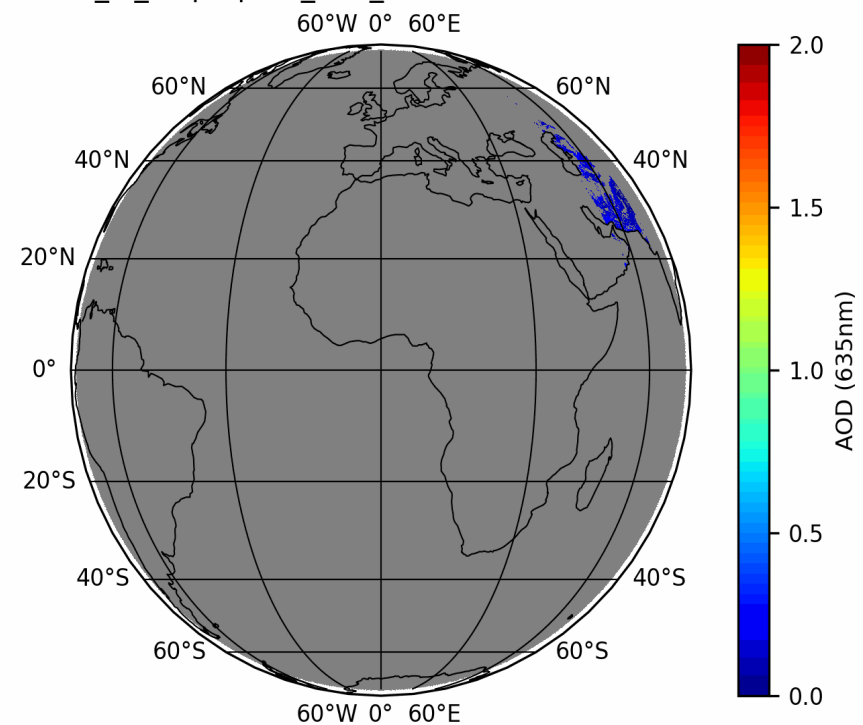
Transition to MTG/FCI

i-AERUS-GEO algorithm – *Instantaneous Product*

- Instantaneous AOD every 15mins (daily surface BRDF at 0.64 μm) – Ceamanos *et al.* (AMT 2023)
- Progressive upgrade in algorithm: transition from SEVIRI to FCI (similar band)
- Activation of the FCI Blue band

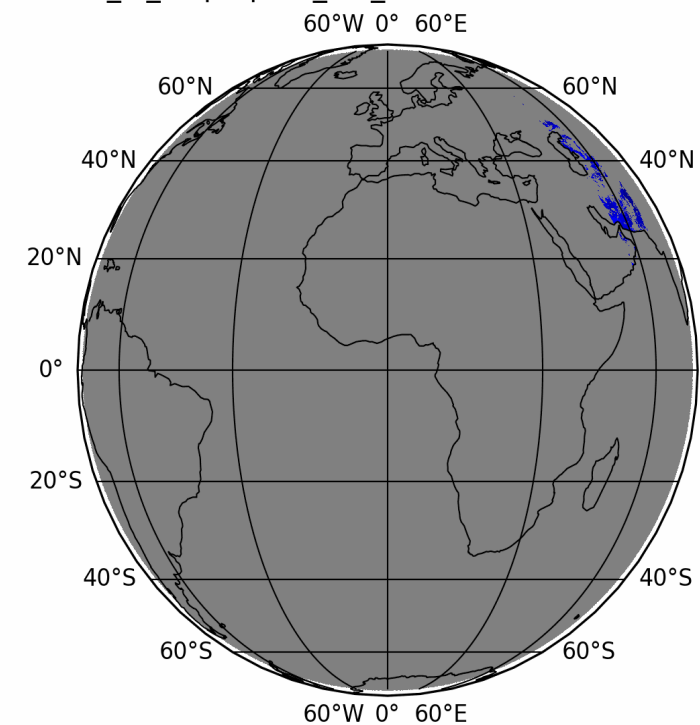
MSG/SEVIRI
(670nm)

i-aerus_l3_fci-prep-tol_SEV_FLT - 2025-04-25T03-00-00



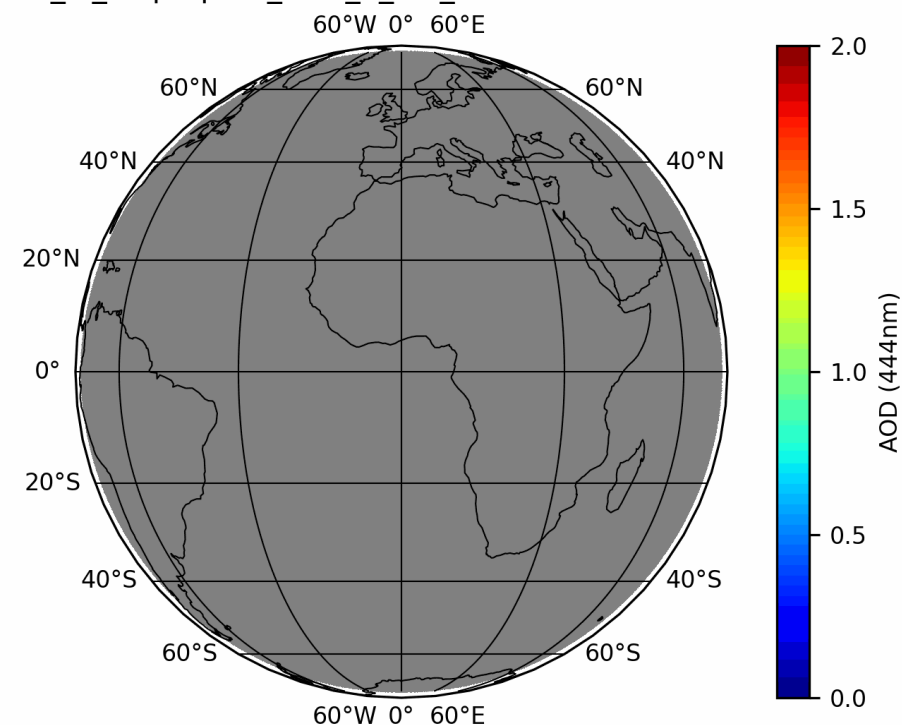
MTG/FCI
(670nm)

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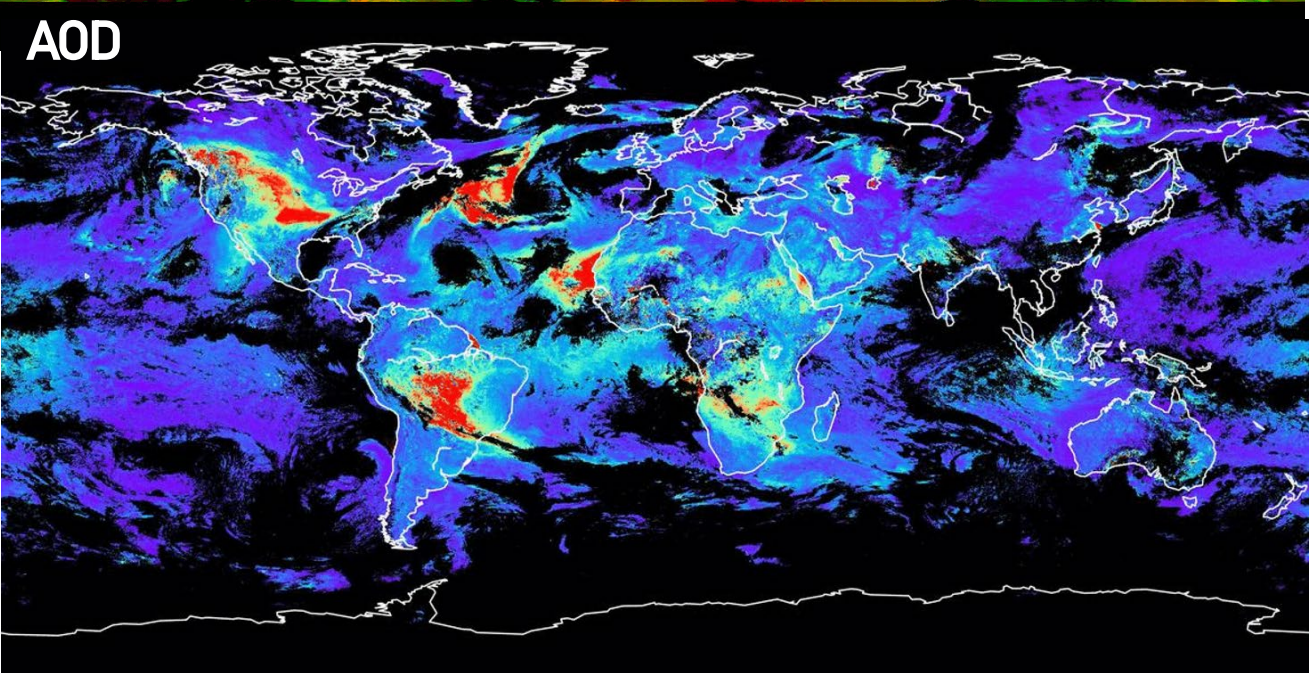
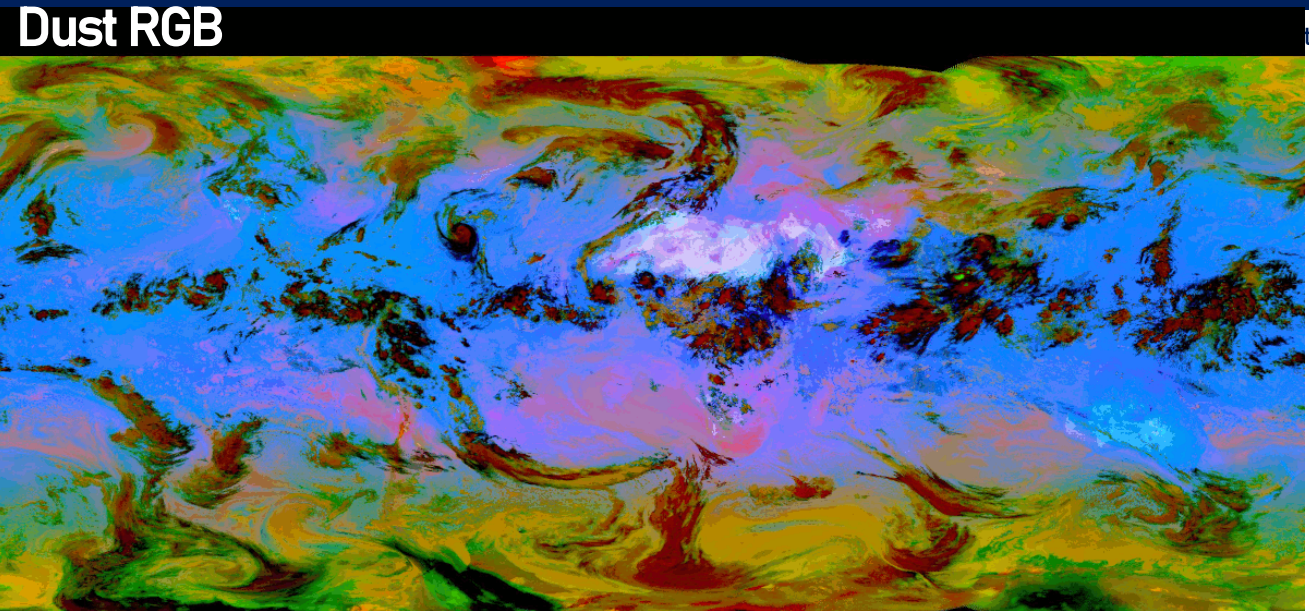


MTG/FCI
(440nm)

i-aerus_l3_fci-prep-tol_blue_0_FCI_FLT - 2025-04-25T03-00-00



- Toward GEO-ring
 - Himawari-9, GOES-16/18, Meteosat-8/11
 - Dust-RGB and iAerus-AOD
 - Demonstration already done for a “SEVIR-like” version of the products (data & tools are available)
 - Targeted option: implementation in ICARE



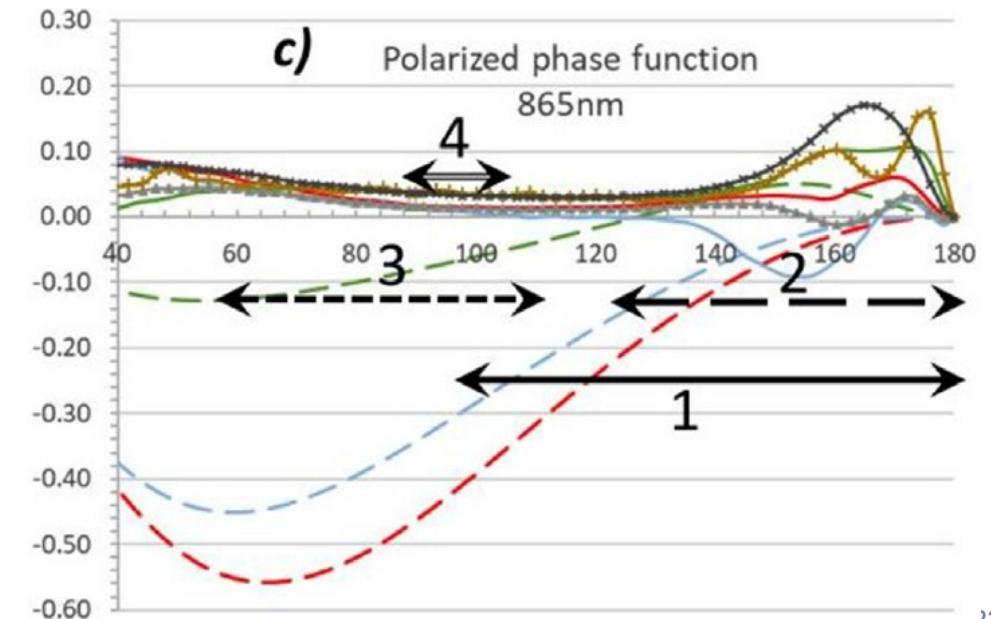
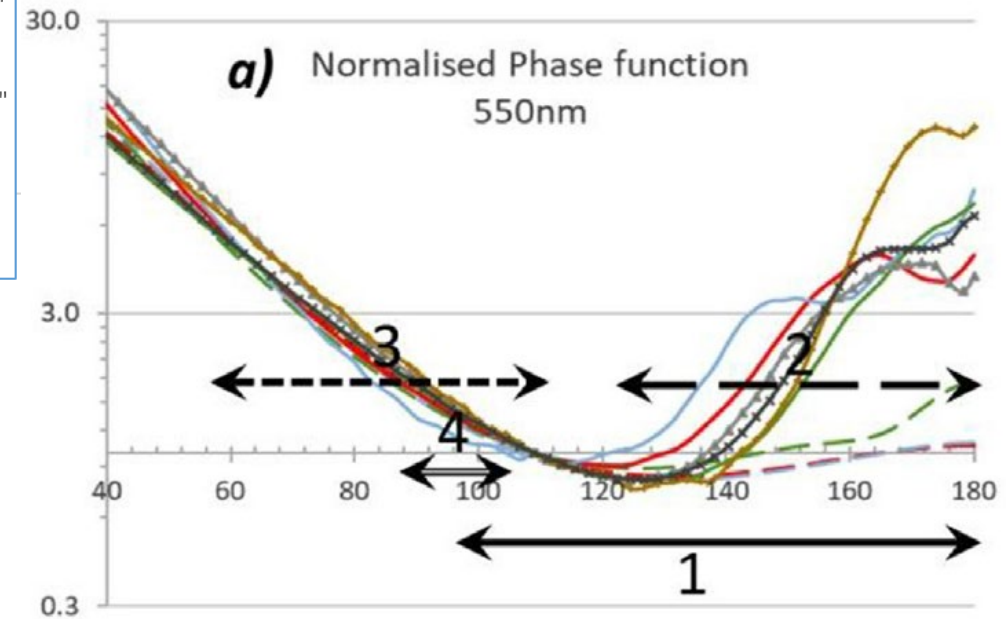
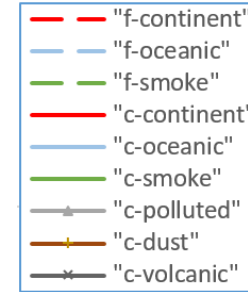
Courtesy www.icare.univ-lille.fr

Development with polarimetry EPS-SG/3MI



New Generation of Enhanced Aerosol Products

- Why multi-directional and/or polarisation ?
 - 1 aerosol = 1 phase function
 - Mixture = combination
 - Mono-view = Observation for one variable scattering angle
 - Multi-view = A variable range of scattering angle available
 - Discrimination of some aerosols types
 - Better discrimination of the surface
 - Polarisation = Additional dimension of the phase function
 - Higher discrimination of aerosol (especially fine mode)
 - Better discrimination of the surface (especially in NIR/SWIR)
- **Asset:** Combination Spectral, Directional and Polarisation offers an extended information content for the characterisation of aerosol components and properties

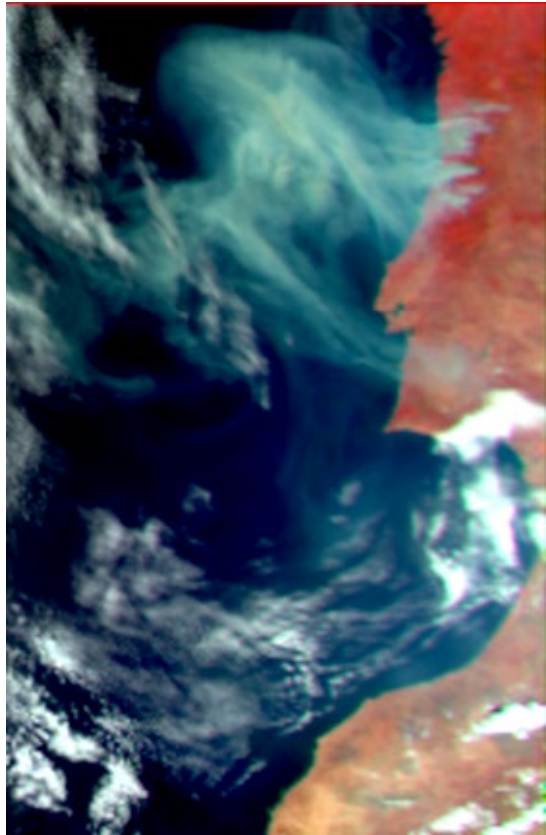




What can one see with polarisation?

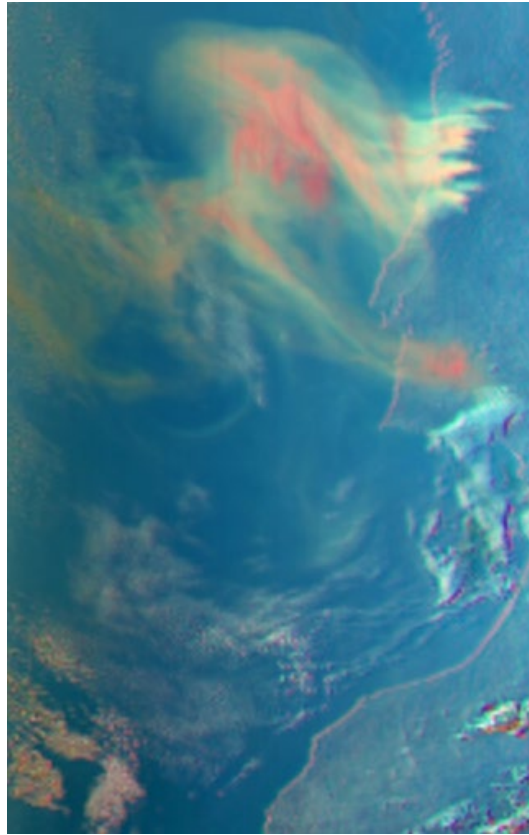
16th September 2024 Portugal

Intensity



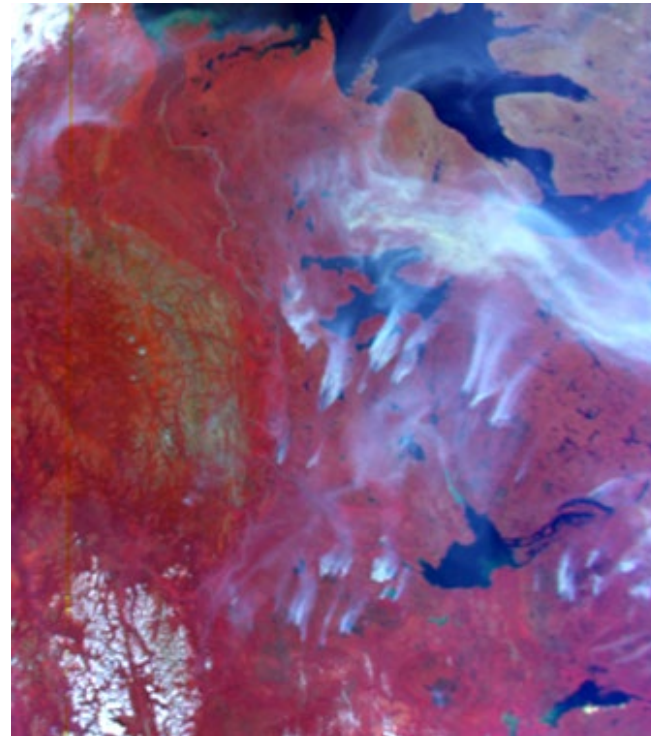
RGB = 865/550/440nm

Polarised Intensity



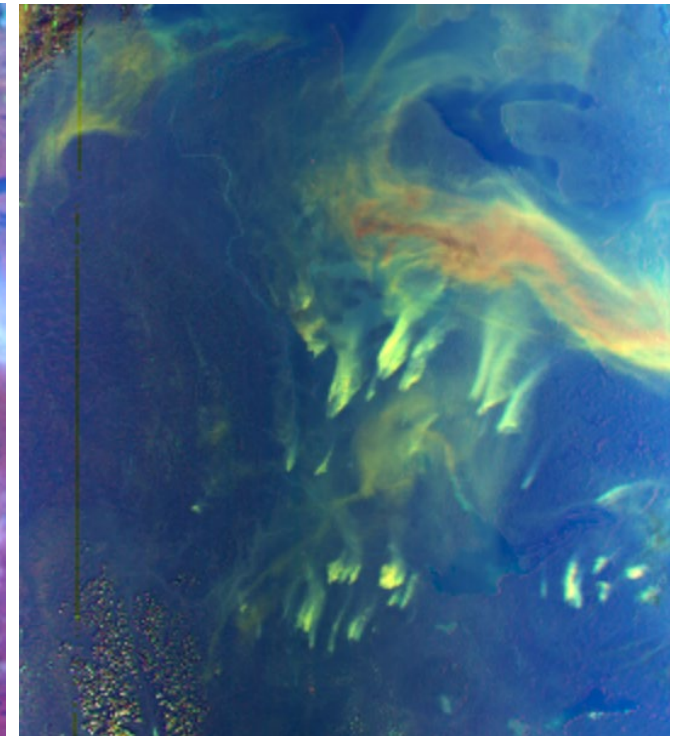
8th August 2024 Canada

Intensity



RGB = 865/670/440nm

Polarised Intensity



Data: HARP-2, PACE, NASA
Courtesy: Bertrand Fougnie, EUMETSAT

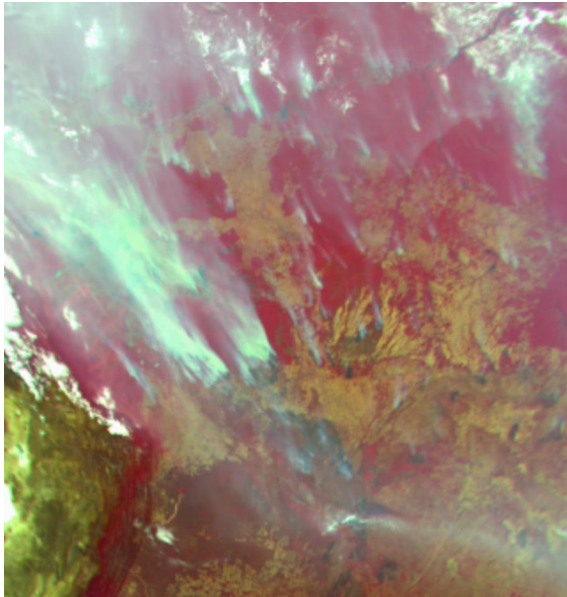


What can one see with directional polarisation?

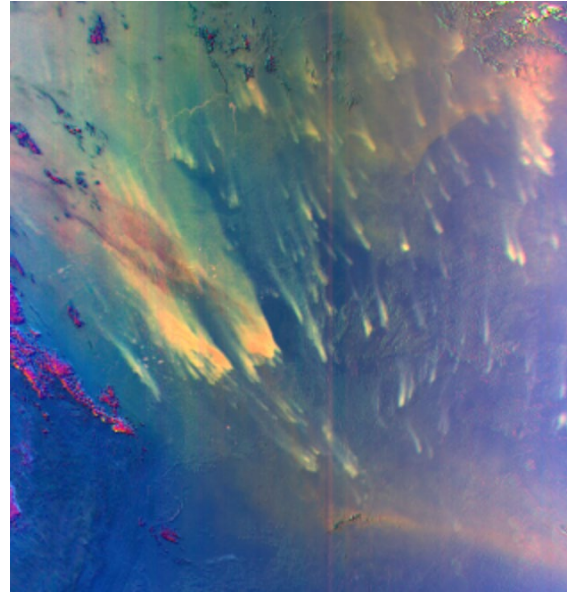
Amazonia

26th August 2024

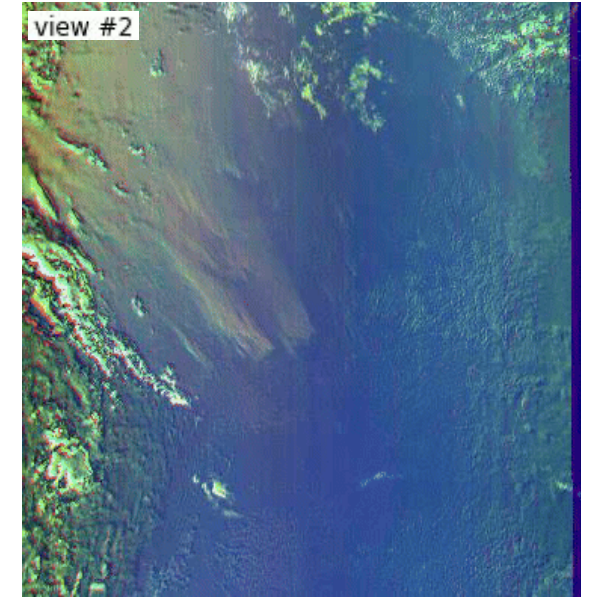
Intensity



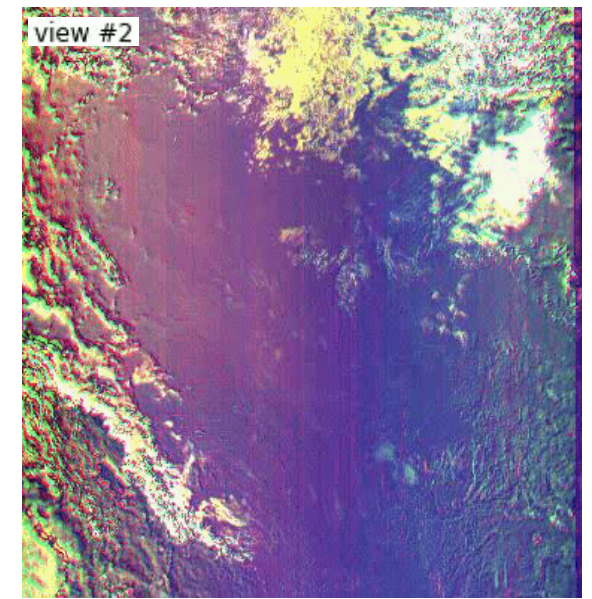
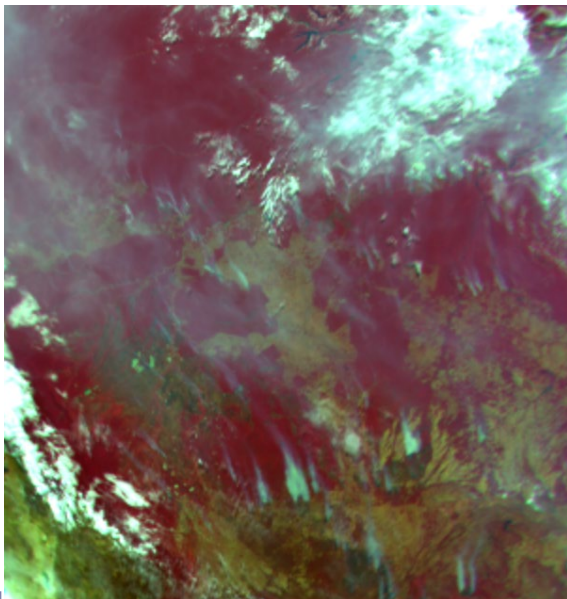
Polarised Intensity



Directional Polarised Intensity



12th August 2024



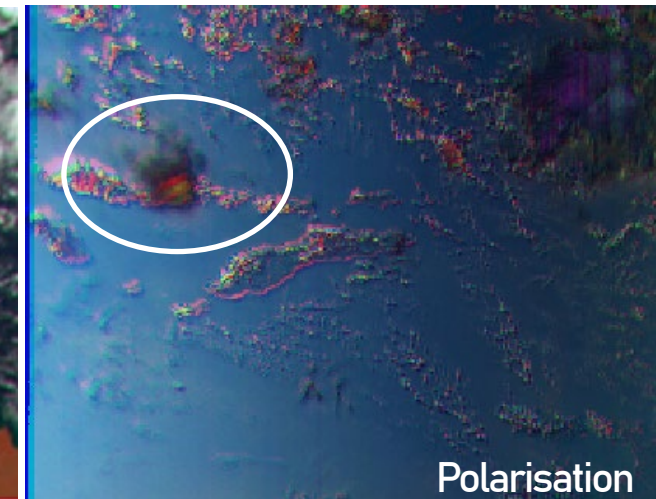
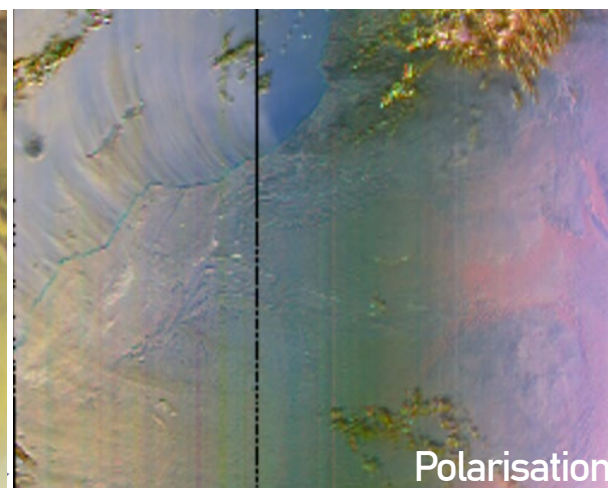
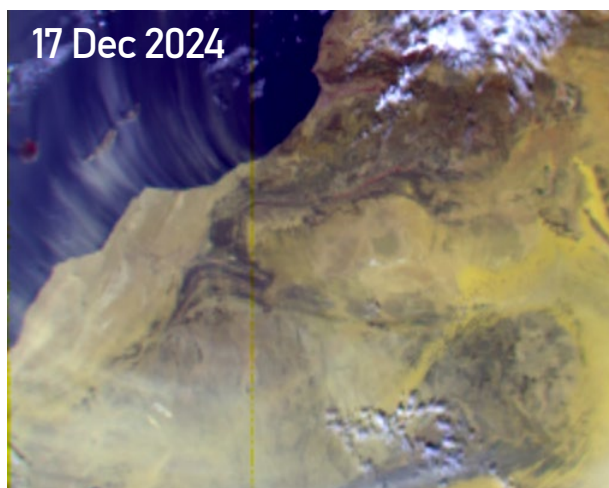
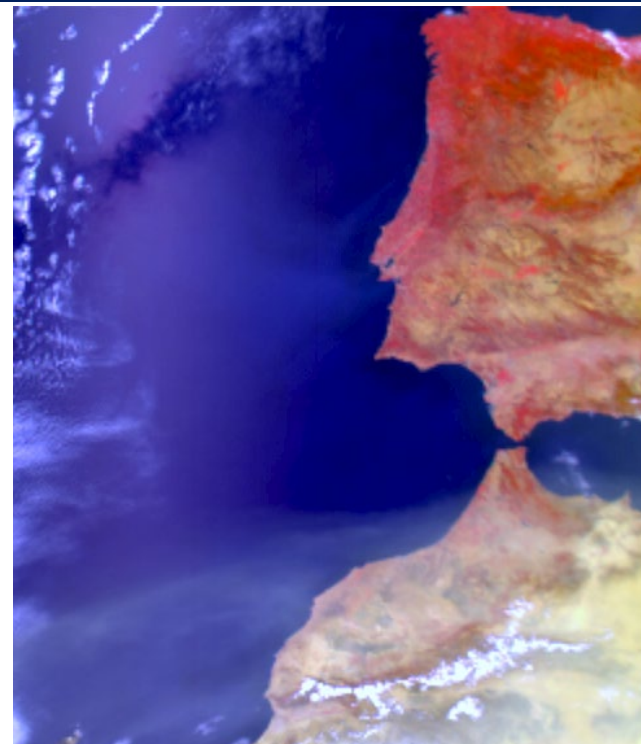
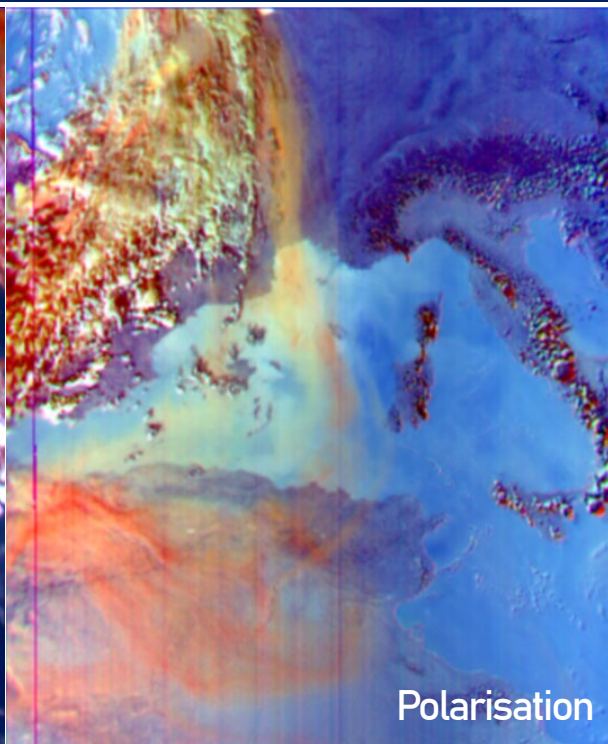
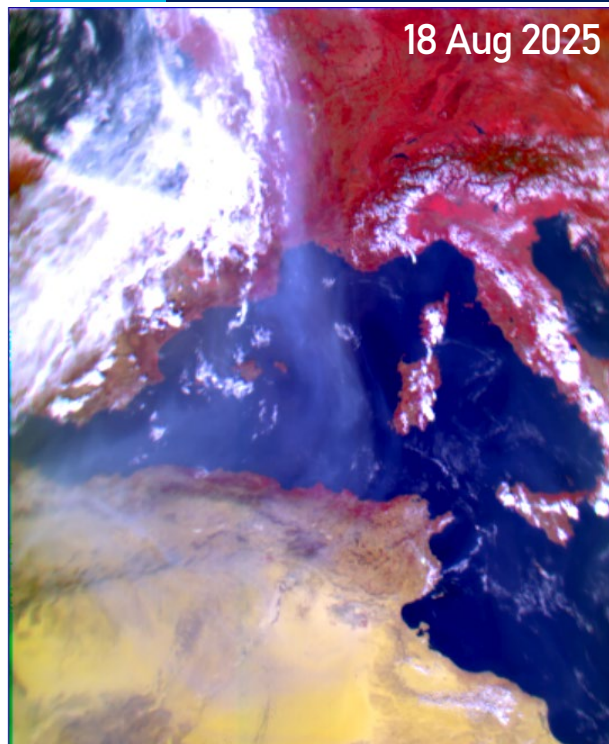
Data: HARP-2, PACE, NASA

Courtesy: Bertrand Fougnie, EUMETSAT

November 2025



Combining Spectral, Directional and Polarisation



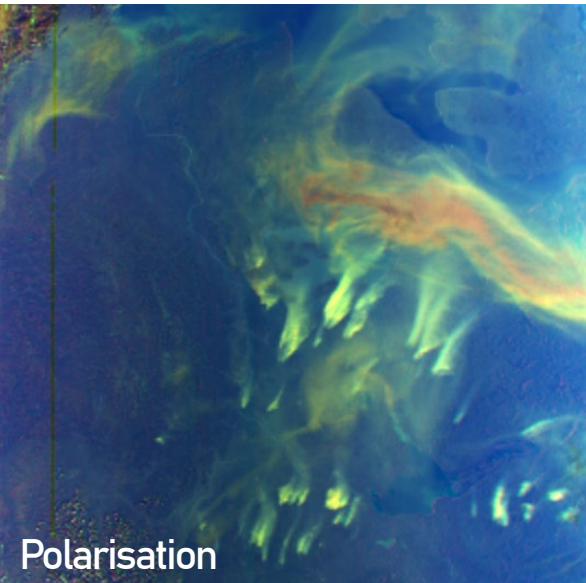
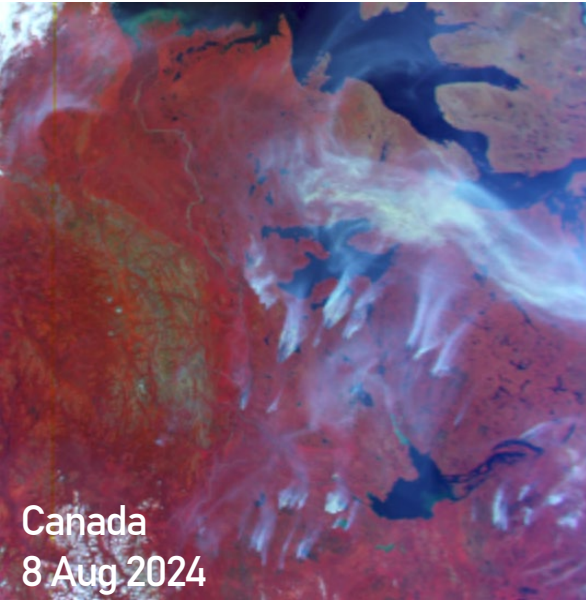


Observation & Characterisation of Smoke with Polarimetry

From PACE/HARP2

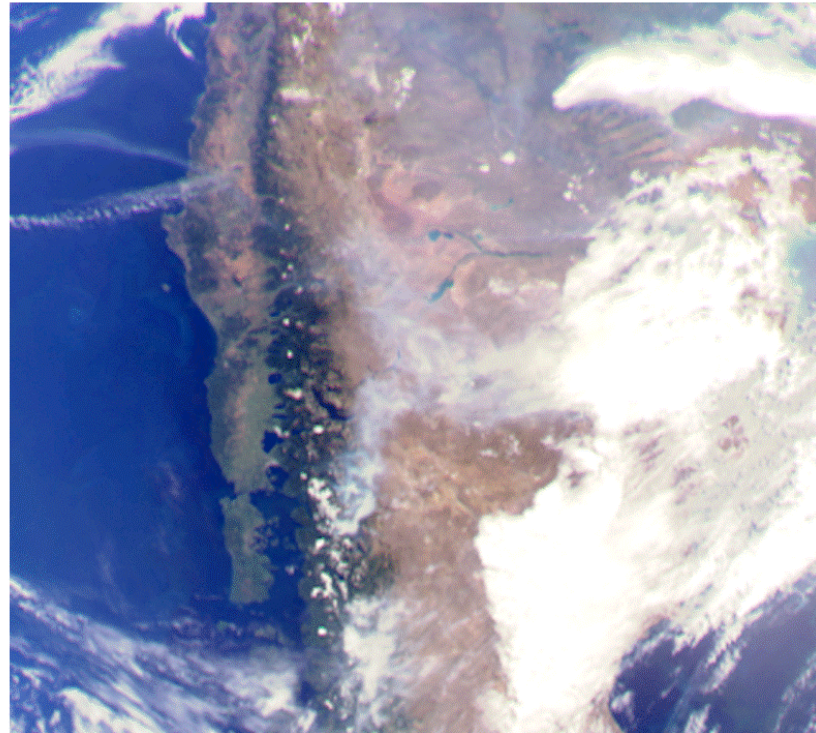
Multi-angular and spectral polarimetry

- Smoke → small particles → large polarisation
- Polarisation → reduced surface contribution
- Multi-view → sampling of the phase function → nature of particle

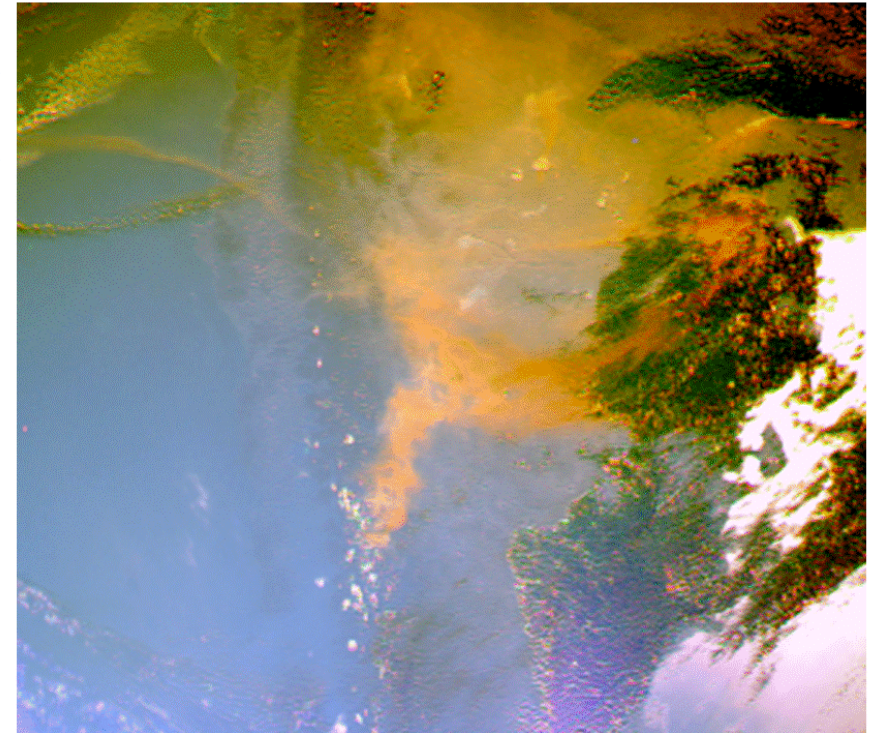


EPS-SG/3MI – 7th January 2026 – Wildfire El Hoyo, Patagonia, Chile

Intensity

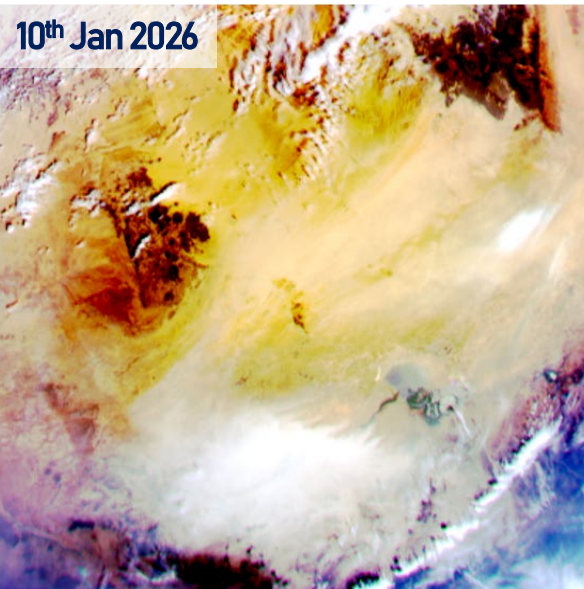


Polarised Intensity

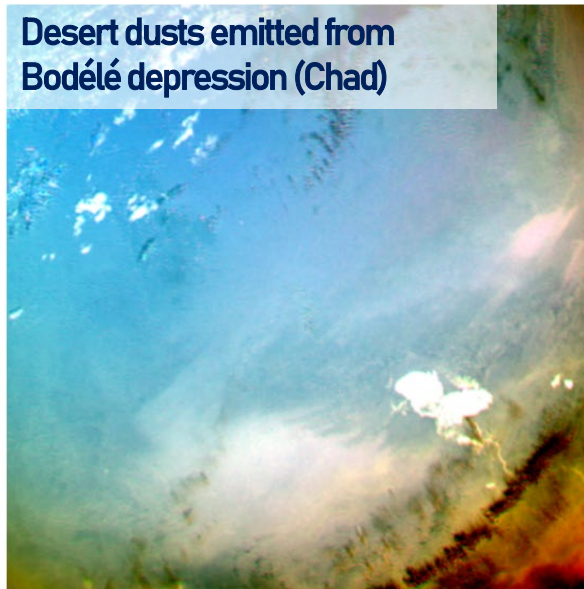


Aerosol events captured by 3MI

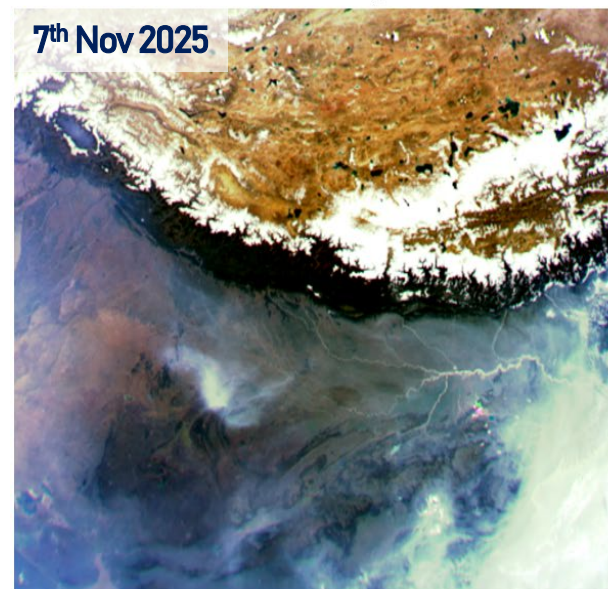
Intensity



Polarised Intensity



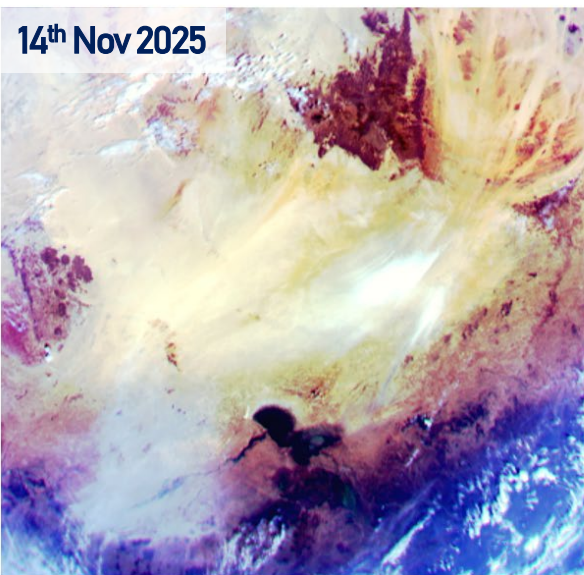
Intensity



Polarised Intensity



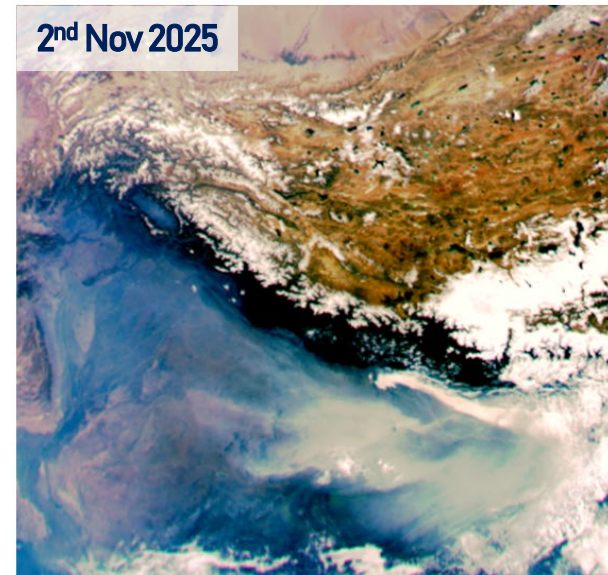
Intensity



Polarised Intensity



Intensity



Polarised Intensity

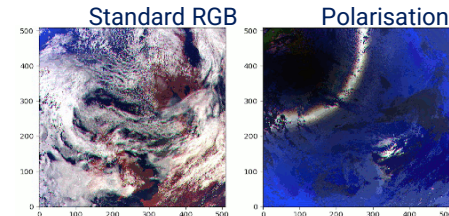




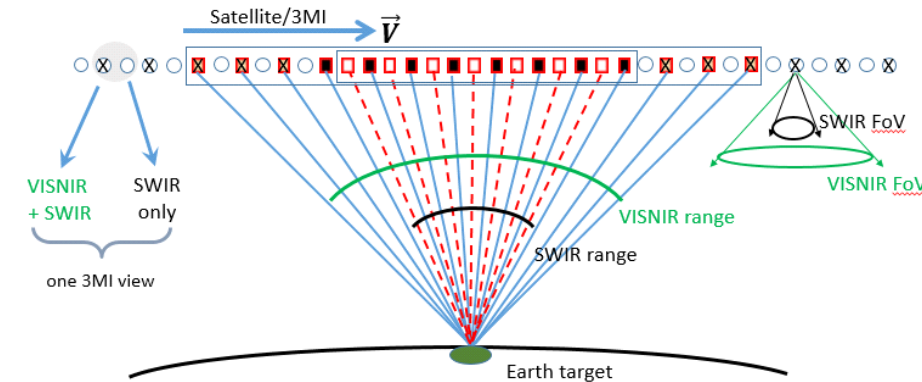
EPS-SG/3MI in a nutshell



Launched 12th August 2025
First image 28th August 2025



- Multi-angle polarimeter
- Very extensive information content with spectral/directional/polarisation
 - 14 views [-50° backward / +50° forward]
 - 12 spectral bands [410 to 2130nm] for 3 polarisations [I, Q, U]
 - Potentially 420 information per pixel feeding the retrieval
 - Very large information content



- Commissioning of Level-1 on-going
 - L1B mostly mature
 - L1C started
 - Preoperational L1 – Sep'26
- Optimised 3MI NRT instantiation of GRASP
 - Enhanced aerosol characterisation
 - Performance tested on PARASOL 2005-2013
 - Now activated on some 3MI acquisitions

Retrieved parameters
(linked to GRASP optimisation)

&

Derived parameters
(linked to user needs)

AOD410

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

Error Estimation

Surface

- BRDF + BPDF (3 Spectral parameters)



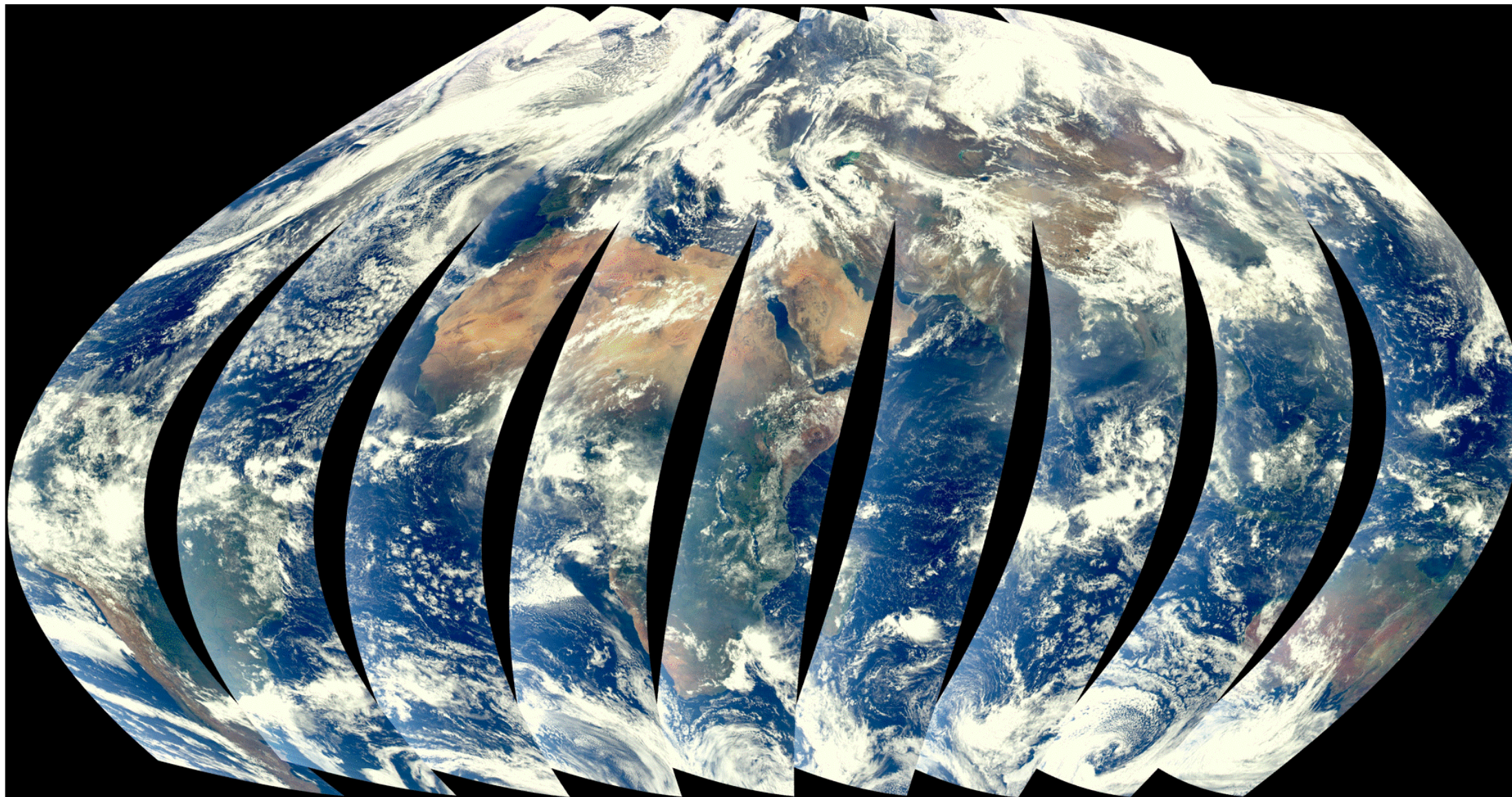
Observing a Polarised World with 3MI

www.eumetsat.int

 **EUMETSAT**

EPS-SG/3MI – 29th March 2026

(RGB) Intensity





3MI L2 Aerosol Processor – New era of Product

- Aerosol components external mixture in **3 modes** (internal mixture by **Linear Volume Mixture**)
- **Refractive index** from **literature review** (publications 1979–2007)



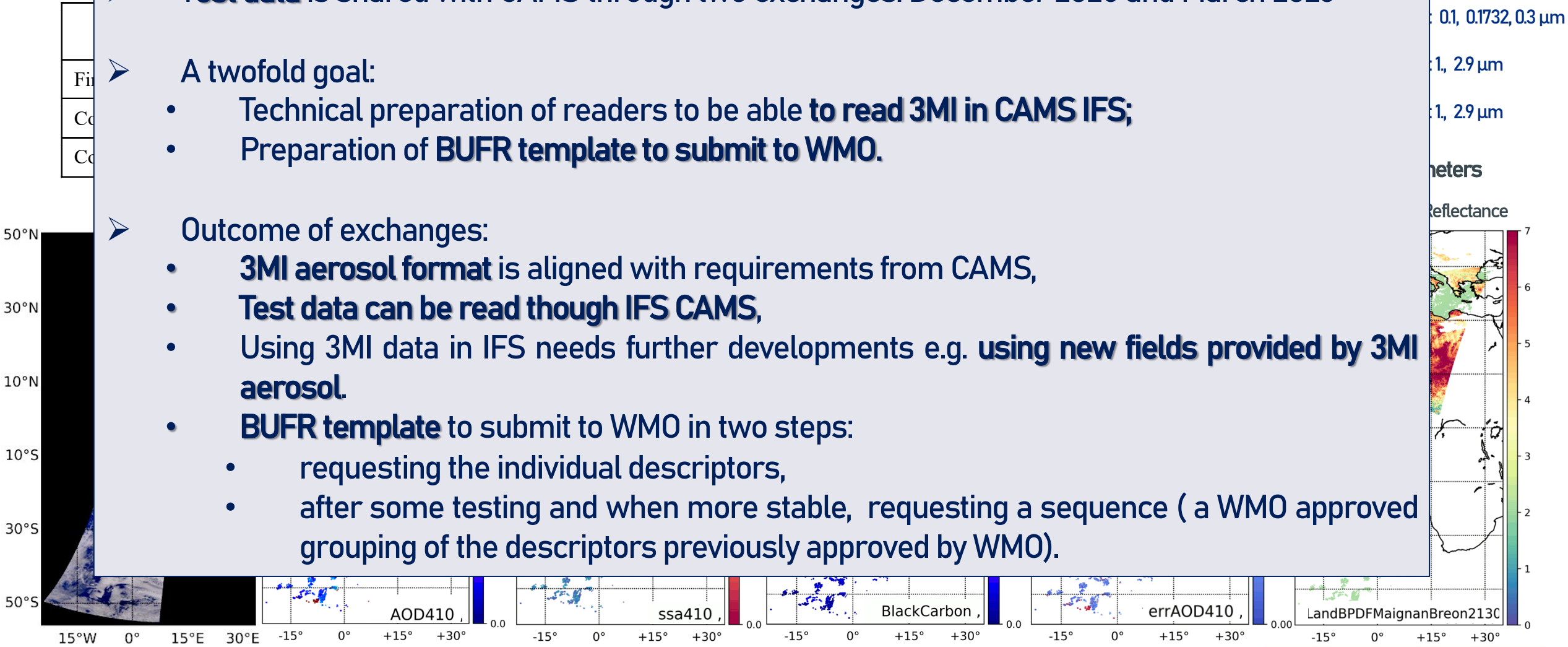
➤ **Test data** is shared with CAMS through two exchanges: December 2025 and March 2026

➤ A twofold goal:

- Technical preparation of readers to be able to read **3MI in CAMS IFS**;
- Preparation of **BUFR template to submit to WMO**.

➤ Outcome of exchanges:

- **3MI aerosol format** is aligned with requirements from CAMS,
- **Test data can be read though IFS CAMS**,
- Using 3MI data in IFS needs further developments e.g. **using new fields provided by 3MI aerosol**.
- **BUFR template** to submit to WMO in two steps:
 - requesting the individual descriptors,
 - after some testing and when more stable, requesting a sequence (a WMO approved grouping of the descriptors previously approved by WMO).

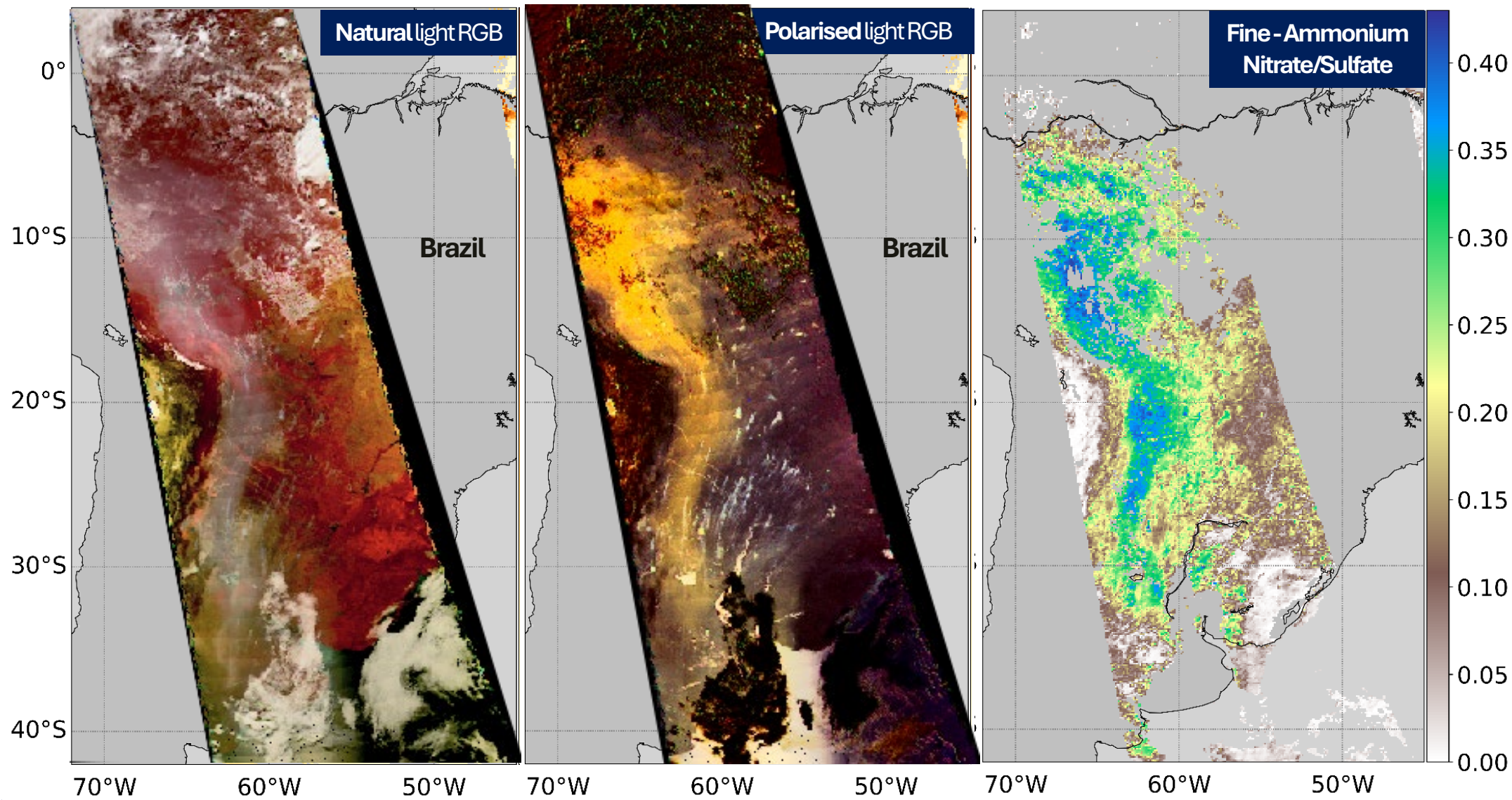




Case – Advanced Characterisation of a Smoke Plume

3MI processor – POLDER3 data
Argentina fires, 26 August 2008

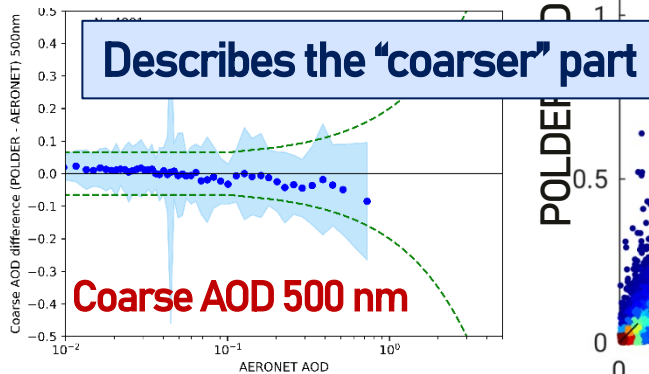
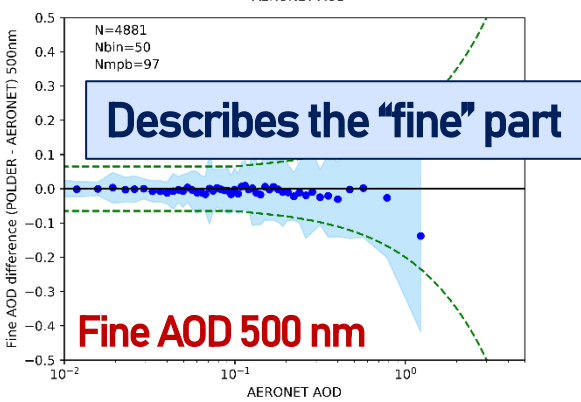
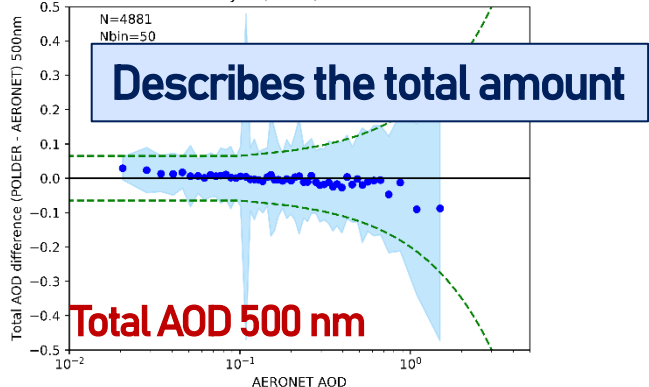
www.eumetsat.int



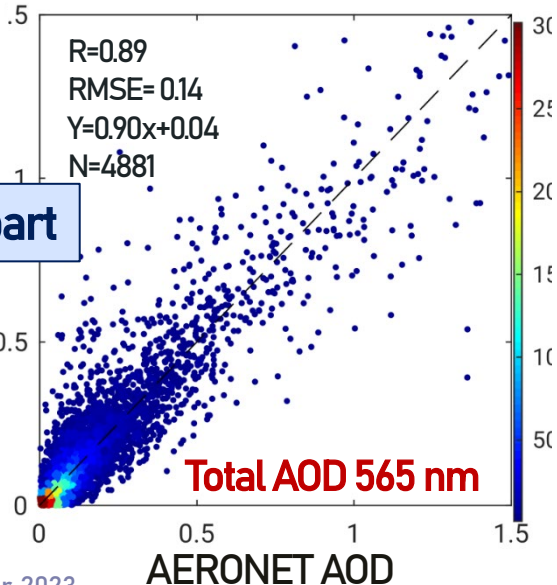
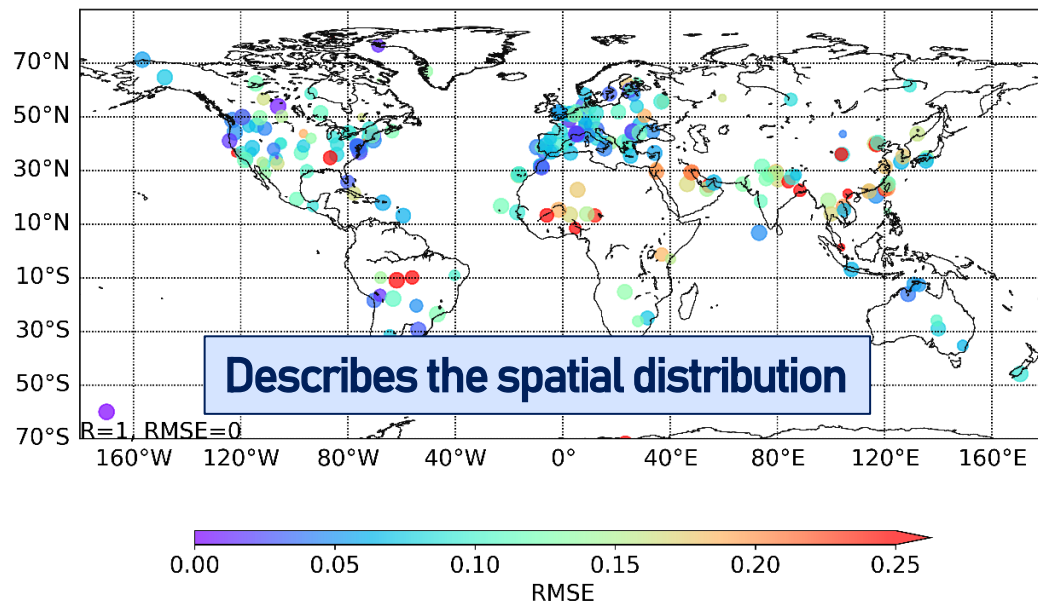


Scientific Validation of the Aerosol Properties

POLDER/PARASOL GRASP V1.1.5 Baseline component vs AERONET v3.0 - One year, 2008, Global land



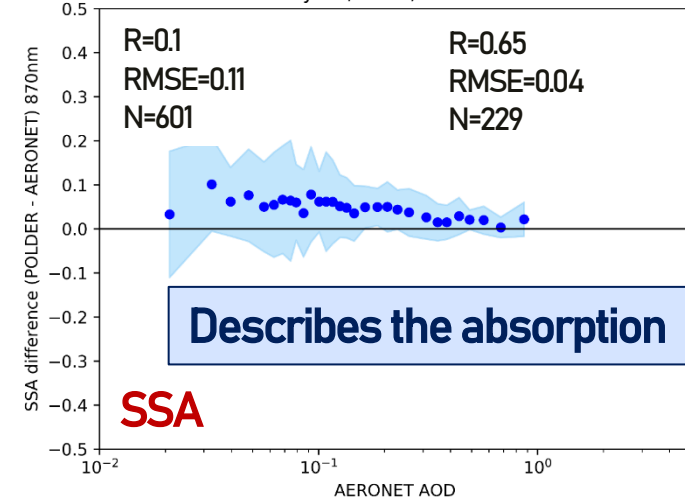
RMSE (colour) and R (radius) : 2009 POLDER vs AERONET AOD



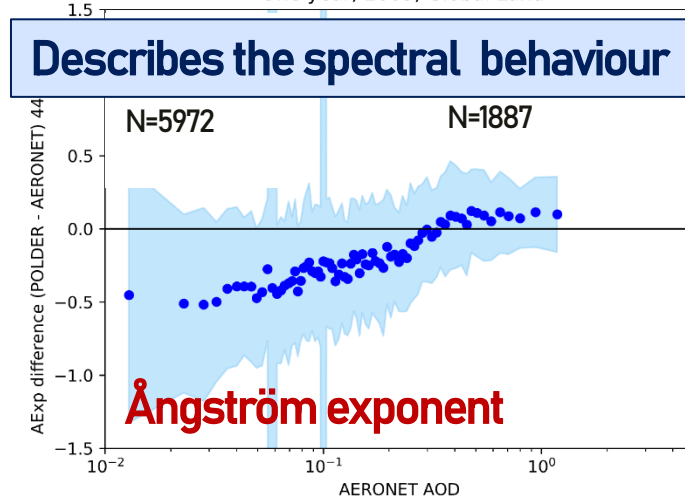
AOD retrieval shows an overall good performance with a better agreement for fine mode AOD.

AOD	R	RMSE
Fine mode	0.92	0.11
Coarse mode	0.78	0.12
Total	0.89	0.14

Comparison of POLDER/PARASOL GRASP V1.1.5 to AERONET v3.0 - One year, 2009, Global Land



Comparison of POLDER/PARASOL GRASP V1.1.5 to AERONET v3.0 - One year, 2009, Global Land



From early version of the processor (baseline)



Comparison Remote-Sensing vs Forecast: **AOD**

10-day POLDER/CAMS comparison

www.eumetsat.int

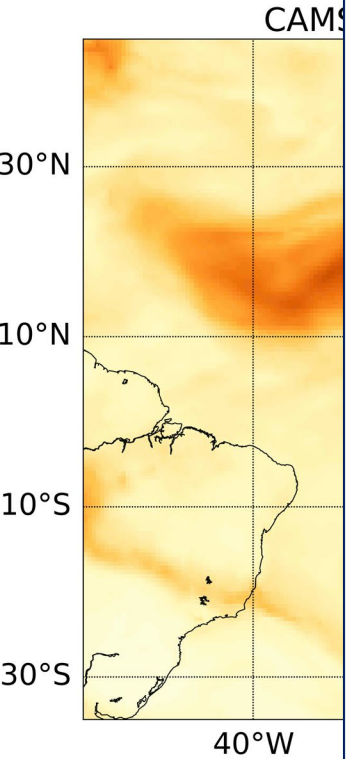
On-going activity: **Soheila Jafariseraiehlou (EUMETSAT) and**

➤ Updated and Improved

➤ Extended to many parameters: AOD, fine-AOD, coarse-AOD, SSA, chemical components...

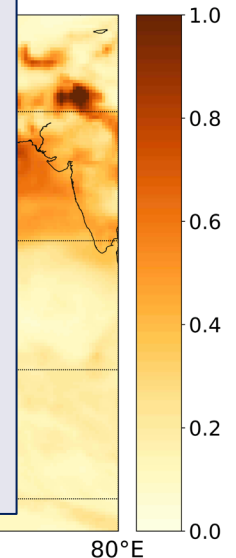
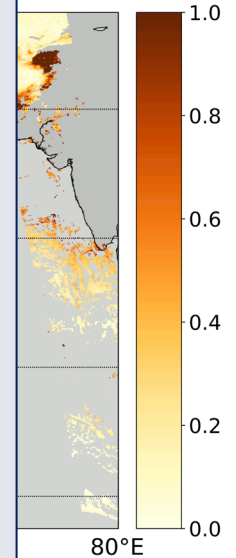
➤ Benefit both Remote Sensing / Retrieval and Models

➔ See the "Enhanced Aerosol Products & comparison to Model" talk



CAMS data

Data is from "Cyclo" conditions an ana from the previous

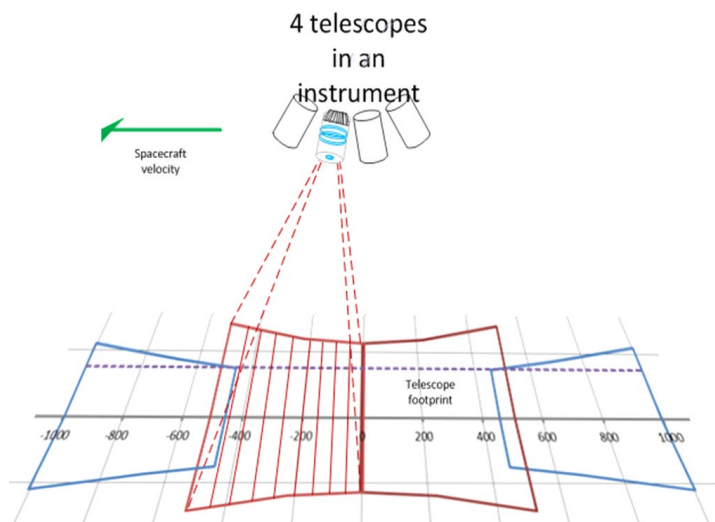




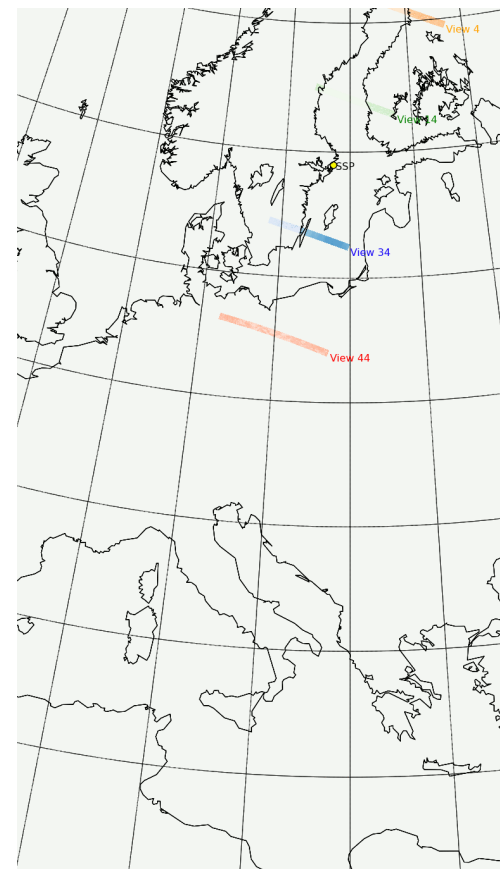
CO2M project – MAP polarimeter for atmospheric correction

- MAP Multi-Angle Polarimeter in VIS-NIR
- CO2M = synergistic use of 3 instruments CO2IS, MAP and CLIM
- Aerosol correction is needed to reach the performance for CO2 & CH4
- Challenge: aerosol contribution is needed in SWIR
- Similarly to 3MI, GRASP being optimised for MAP

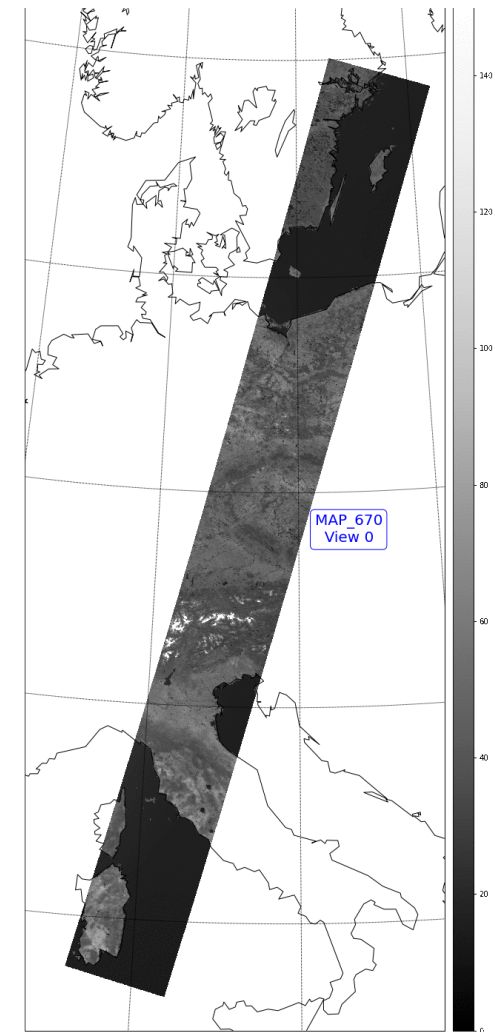
→ 45 views, I/Q/U in 7 bands (410–865nm)



MAP/CO2IS Channels	Central wavelength (nm) (BOLD denotes polarised)	Spectral width (nm)
MAP-1	410	20
MAP-2	443	20
MAP-3	490	20
MAP-4	555	20
MAP-5	670	20
MAP-6	753	9
MAP-7	865	40
CO2IS-1	1625	10
CO2IS-2	2040	10



CO2M MAP L1B



L1C MAP L1C

Coming in 2027

- Many aerosol processors under improvement / development
 - Operational: PMAp and S3 are regularly upgraded
 - S3 moving to Day-2 & 3, and preparing S3-NGO
 - EPS moving to EPS-SG, and preparing 3MI (later synergy MAP)
 - New developments with GEO/FCI and CO2M/MAP
- New generation of enhanced provided and improved characterisation
 - New parameters: SSA, fine mode, ALH
 - New characterisation: chemical components, size distribution, refractive index
 - New questions....
- High importance of the joint activity with Models
 - Demonstrational test of assimilation – definition, benefit, consolidation, preparation
 - Inter-comparisons strongly benefit to both developments (Remote Sensing and Model): definition, understanding
 - Support the harmonisation of the definition / assumption as much as we can (aerosol components, vertical shape...)



Thank you for your attention !