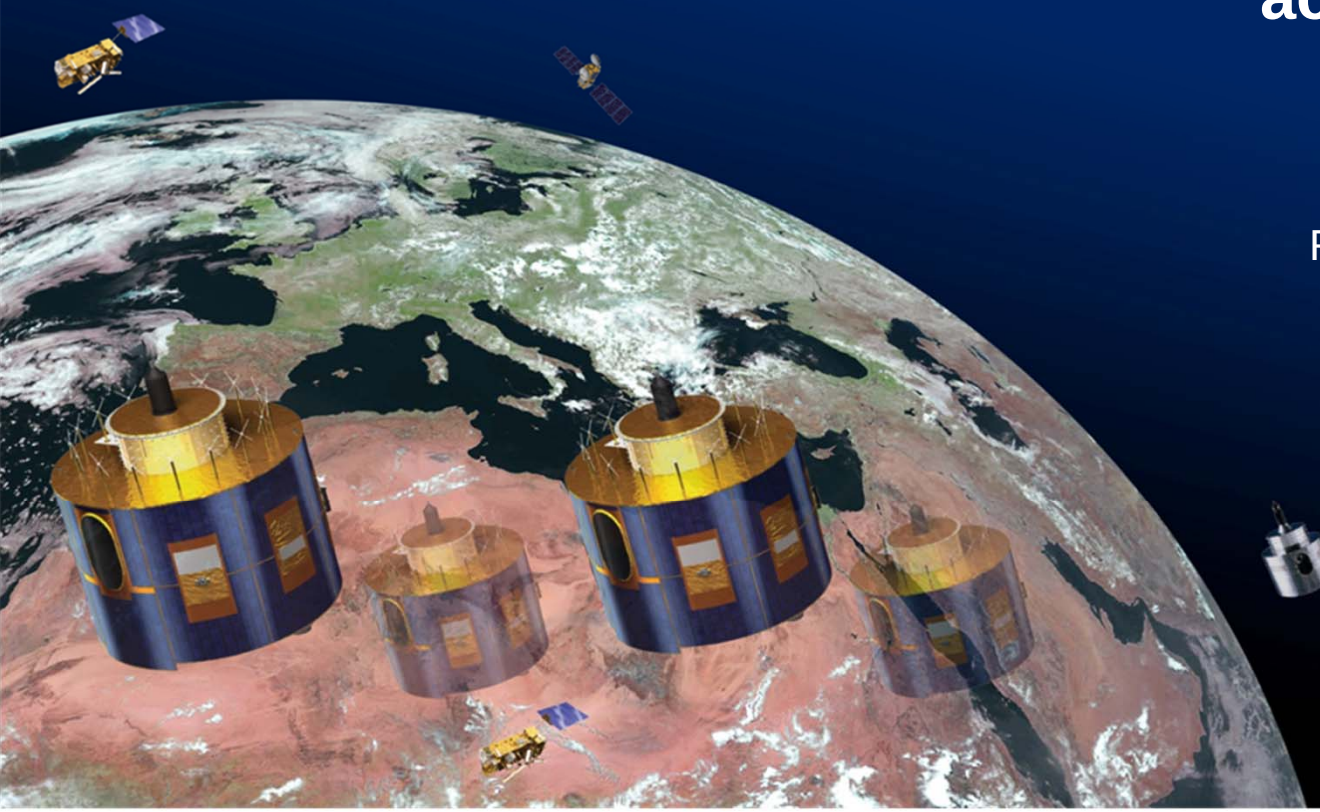
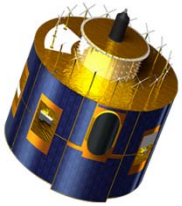
Aerosol monitoring related activities at EUMETSAT

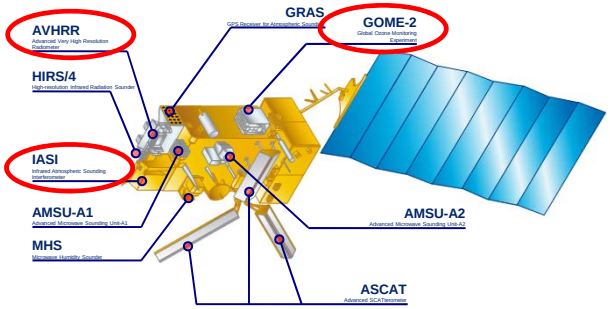
R. Lang, A. Cacciari, A. Holdak, A. Kokhanovsky, M. Grzegorski, R. Munro, C. Retscher, R. Lindstrot, G. Poli, R. Huckle, N. Hao, S. Gimeno Garcia,



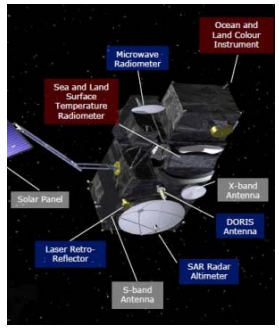
EUMETSAT Missions
Providing Aerosol, Trace-Gases and Cloud Products



Metop Multi-mission product (PMAp) (2014 - 2025)
Metop GOME-2, IASI (Metop-A/B/C 2007-2025)
MSG (Seviri 1997-2025)



Sentinel-3 OLCI, SLSTR (2015 -)

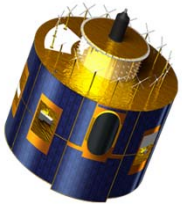


MTG UVN (Sentinel-4)
MTG FCI & IRS

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

EUMETSAT

EUMETSAT Missions
Providing Aerosol, Trace-Gases and Cloud Products



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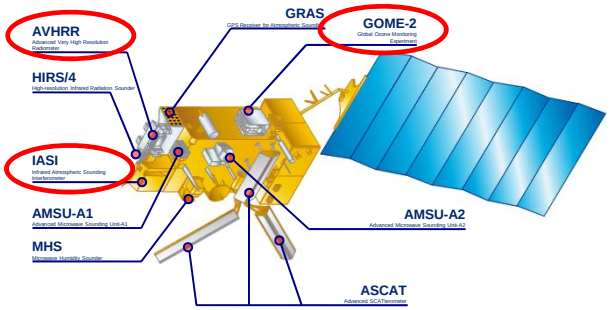
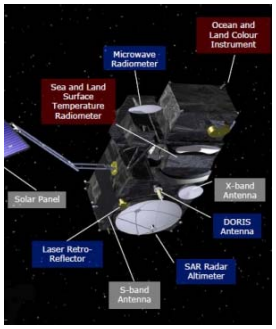


Sentinel-3 OLCI, SLSTR



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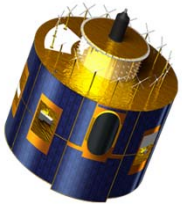
EUMETSAT Missions
Providing Aerosol, Trace-Gases and Cloud Products



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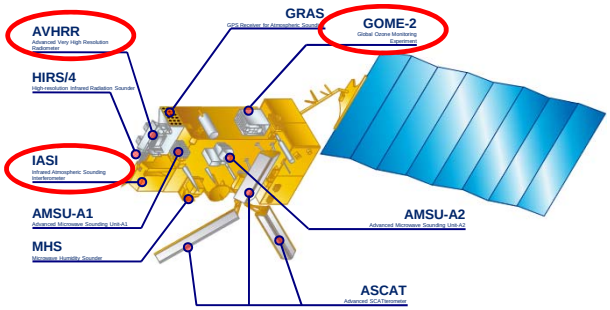
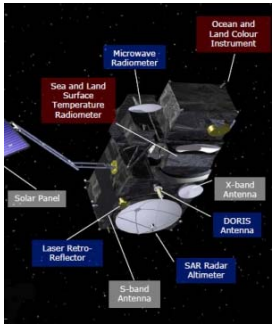


Sentinel-3 OLCI, SLSTR



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EUMETSAT

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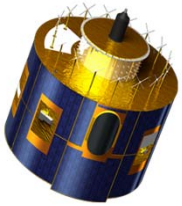
Providing Aerosol, Trace-Gases and Cloud Products



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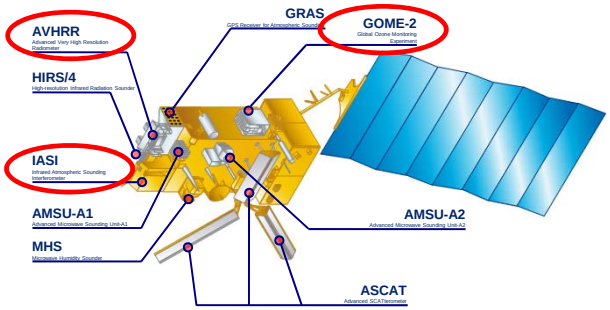
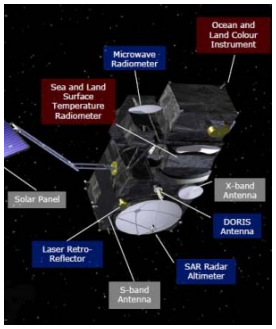


Sentinel-3 OLCI, SLSTR



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Sentinel-3 Atmosphere Products
AOD and FRP

Aerosol Optical Depth and Fire Radiative Power products

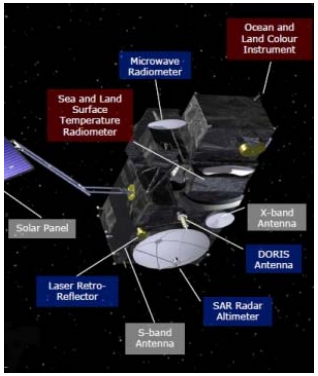
- Implementation of S-3 AOD and FRP products
  - Triggered in response to request from the EC User Forum in 2015
  - Change approved by the EC in early 2016

- The approach is for EUMETSAT to undertake the processing and the dissemination of the NRT Aerosol Optical Depth (AOD) & Fire Radiative Power (FRP) products, whereas ESA will undertake the processing and the dissemination of the NTC AOD & FRP products

- Implementation schedule under responsibility of ESA

- Deployment on the operational ground segment in Q4 2017/Q1 2018

- AOD & FRP NRT products will be disseminated over EUMETCast



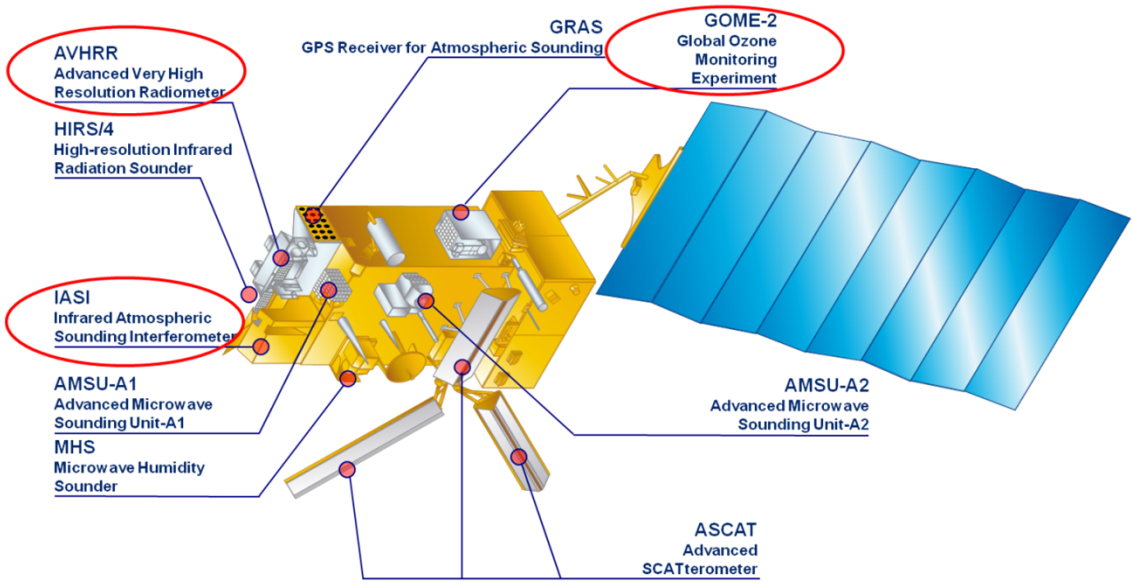
EUMETSAT

Sentinel-3 Atmosphere Products
AOD and FRP

Description	AOD - Aerosol Optical Depth	FRP - Fire Radiative Power
Resolution	SLSTR Aggregated “super pixel” ~4.5 km x 4.5 km	SLSTR native resolution (~500m/1km)
Coverage	Global	Global
Product Level	2	2
Timeliness	NRT (ESA is responsible for the corresponding NTC products)	
Availability	Q4 2017 (ESA MPC contract)	Q4 2017 (TBC) (ESA MPC contract)
Application Areas	Global aerosol monitoring and forecasting, regional air quality monitoring and forecasting, sand and dust storm warning and assessment, volcanic ash monitoring, climate change services and climate research.	Global emissions monitoring from biomass burning relevant to air quality and climate applications.
Motivation	Currently CAMS relies on MODIS aerosol data and is currently adding PMAp data. S3 global aerosol products will be an essential contribution.	CAMS uses FRP data from geostationary imaging missions and from polar orbit relies on MODIS data. MODIS FRP data may not be available in the future and the development of S3 FRP products is therefore essential.

The Polar Multi-sensor Aerosol Product
Operational near-real time AOD from EPS/Metop

PMAp: Polar Multi-sensor Aerosol product
(from GOME-2, AVHRR and IASI on Metop)



- AOD @550nm over land & water surfaces, aerosol type classification

- at GOME-2 PMD spatial resolution
10x40 km^2 Metop-B; 5x40 km^2 Metop-A

- Retrieval over water
fully operational product since October 2014

- Retrieval over water & land **PMAp version 2**
fully operational product since February 2017

The PMAp *operational* AOD product
what it is - and what it not is...

“PMAp aims at delivering *operational* aerosol optical depth information from *Metop* making use of the operational infrastructure available for EPS data processing at EUMETSAT”

What does *operational* mean:

- **Delivery of products in a robust and well controlled way within 3 hours of sensing (“near real time”)**
- **higher than 98% availability**
- **Most products arrive within 1.5 hours of sensing at EUMETCAST system/user (3 hours cut-off time).**
- **Continuous monitoring and quality control (24/7 controller handled system with 1 hour response time in cases of contingencies)**
- **User help desk (ops@eumetsat.int)**

The PMAp *operational* AOD product
what it is - and what it not is...

"PMAp aims at delivering *operational* aerosol optical depth information from *Metop* making use of the operational infrastructure available for EPS data processing at EUMETSAT"

What does AOD from *Metop* mean:

None of the Metop instruments is uniquely suitable for aerosols

- **Imagers (AVHRR) do not have enough channels,**
- **Hyper-spectral instruments (GOME-2 / IASI) do not have high enough spatial r**
- **Huge amount of spectral information from the UV/VIS/NIR to the TIR (GOME-2 / IASI)**
- **VIS/SWIR/TIR at high spatial resolution from AVHRR**
- **Some polarisation information (Q/I Stokes fractions) from GOME-2**
- **Continuous sensor cross-calibration capabilities.**

But...

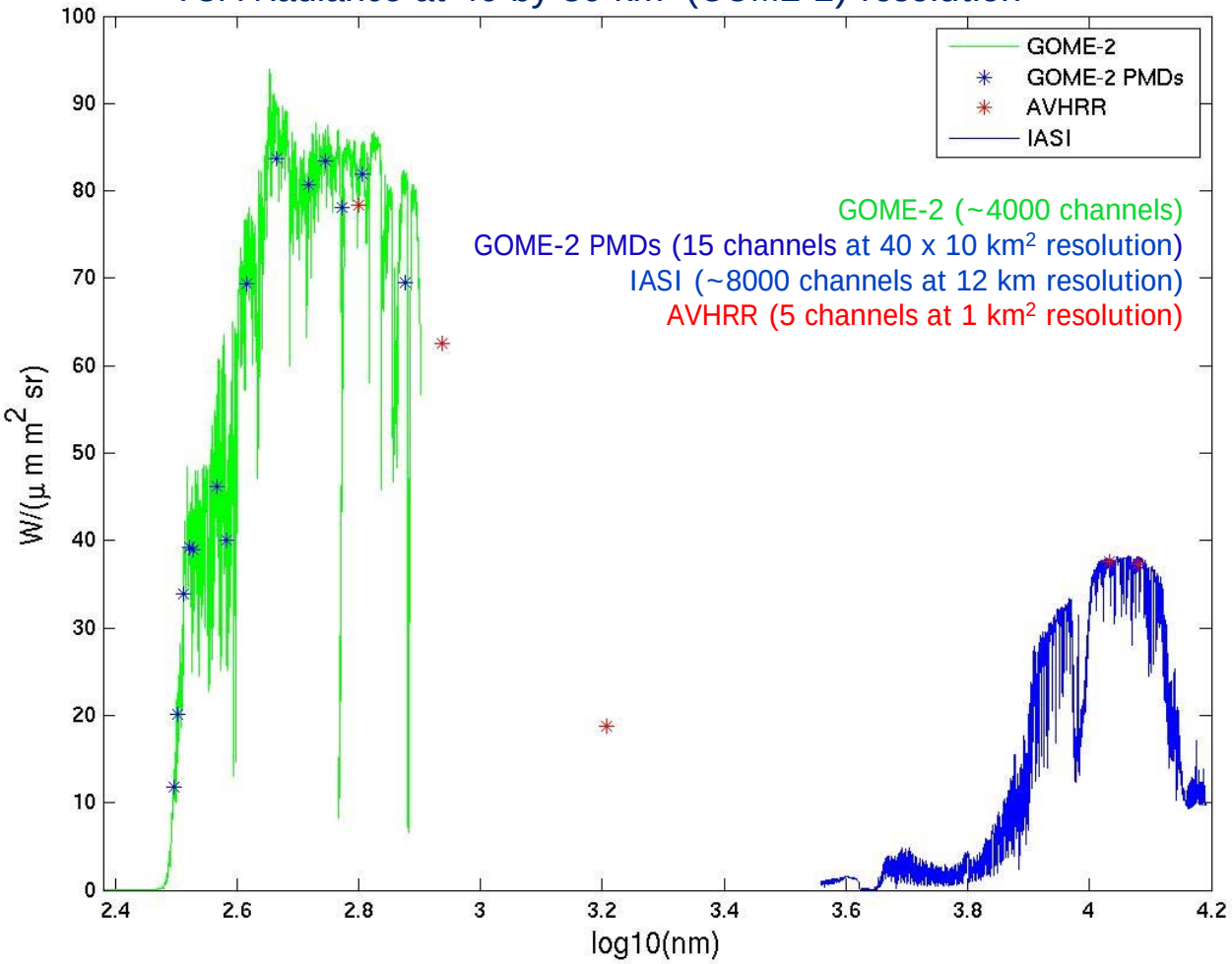
Pro: PMAp is the best AOD information we can get (including its potential) from *Metop*. And its *operational*.

Con: The PMAp product has less information content than products derived from dedicated aerosol missions like polarimeters or LIDAR, however no operational missions of this class are yet available (looking forward to 3MI on EPS-SG).

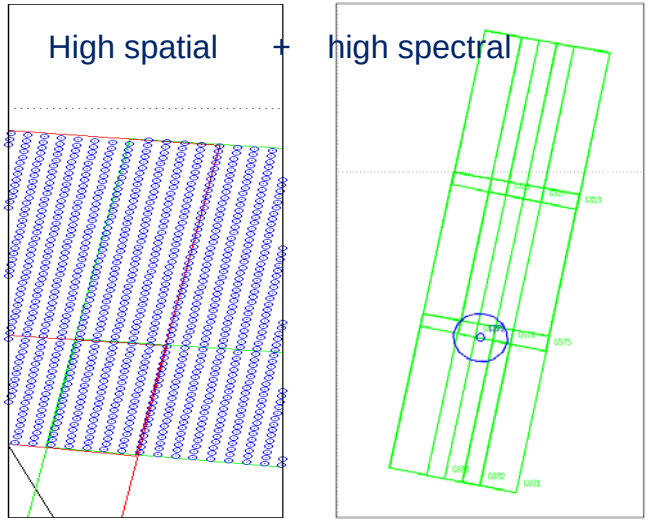
PMAp: creating a hyper-instrument

Merging spectral and spatial information from GOME-2 / AVHRR and IASI

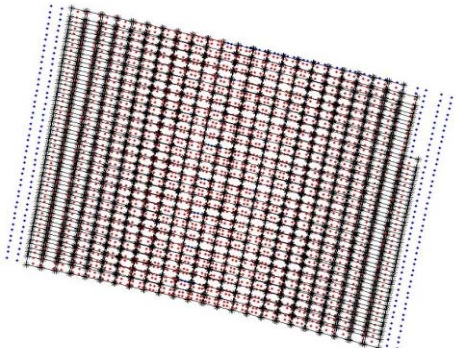
TOA Radiance at 40 by 80 km^2 (GOME-2) resolution



High spatial + high spectral



co-location



GOME-2 3-min sample footprint with co-located IASI states

➡ Combining hyper-spectral with hyper-spatial information in a new hyper-instrument

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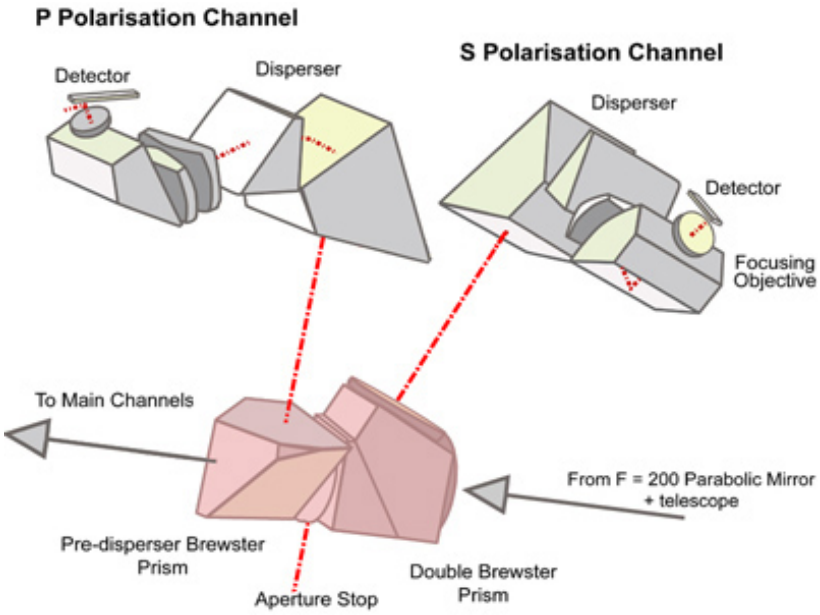
PMAp: the target instrument and its detectors

GOME-2 polarization measurement devices (PMDs)

Band-S				
No.	**pix1**	**pixw.**	**wav1**	**wav2**
1	22	5	311.709	314.207
2	30	4	316.762	318.720
3	37	12	321.389	329.139
4	50	6	330.622	334.443
5	57	6	336.037	340.161
6	84	17	360.703	377.873
7	102	4	380.186	383.753
8	117	19	399.581	428.585
9	138	27	434.083	492.066
10	165	18	494.780	548.756
11	183	2	552.474	556.262
12	187	11	568.070	612.869
13	198	9	617.867	661.893
14	218	4	744.112	768.269
15	224	2	794.080	803.072

- **Radiances & stokes fraction**
- **better spatial resolution**
- **stokes fraction s = Q / I**



PMAp: AOP retrieval algorithm design

Retrieval over land & water

Three steps retrieval:

Step1: Pre-classification (Multi-sensor: GOME-2,AVHRR, IASI)

- Clouds detection and cloud corrections, distinguish clouds/dust/ash
- Aerosol pre-classification (volcanic ash, dust, fine/coarse over sea)
- Results are inputs for the GOME-2 retrieval

Step2: Retrieval of a set of candidate AODs (PMD band)

- based on a set of aerosol models from LUT provided by O. Hasekamp (O3MSAF), model selection dependent on step 1.
- over water: Chlorophyll fitted for clear sky pixels (otherwise low chlorophyll assumption)
- over land: surface albedo a-priori (GOME-2 LER DB from G. Tilstra)

Step3: Selection of the best fit

- select the best result of step 2 using least-square minimization for all GOME-2 PMD bands (+ stokes fractions dependent on condition)

PMAp: AOP retrieval algorithm design

Retrieval over land & water

EUMETSAT

Polar Multi-Sensor Aerosol Product:
ATBD

Doc.No. : EUM/TSS/SPE/14/739904
Issue : v3C Draft
Date : 1 June 2016
WBS :

EUMETSAT
Eumetsat-Allee 1, D-64295 Darmstadt, Germany
Tel: +49 6151 807-7
Fax: +49 6151 807 555
http://www.eumetsat.int

Documentation:
www.eumetsat.int > Data > Technical documentation > Metop > PMAp

Three steps retrieval:

Step1: Pre-classification (Multi-sensor: GOME,AVHRR, IASI)

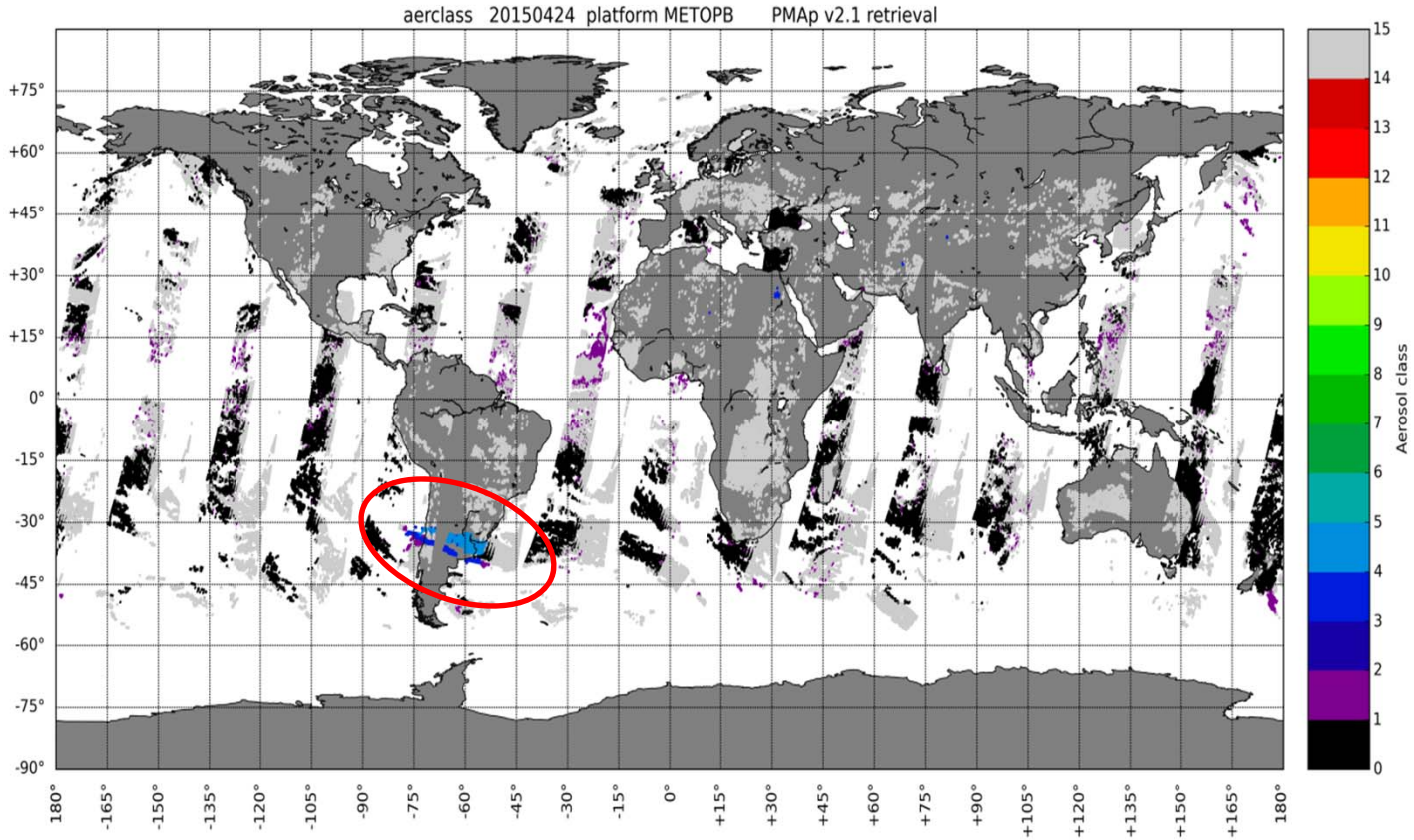
- Clouds detection and cloud corrections, distinguish clouds/dust/ash
- Aerosol pre-classification (volcanic ash, dust, fine/coarse over sea)
- Results are inputs for the GOME retrieval

	Class	***Characterization***
0	**No dust/fine mode** (ocean only)	BTD ash tests negative and strong wavelength dependency of the measured signal between 0.6µm and 1.6 µm.
1	**coarse mode** (ocean only)	Desert dust, ash or coarse mode sea-salt without significant BTD signal but weak wavelength dependency in VIS/NIR
2	**Thick biomass burning**	Over ocean: UV index indicate UV absorbing aerosol, coarse mode tests negative, TIR dust/ash tests negative. Over land: Stokes fraction and UV index tests positive.
3	**Thick dust/volcanic ash**	Volcanic ash or thick dust, BTD in TIR indicate dust/ash, weak wavelength dependency in VIS/NIR (ocean) or UV index indicate absorbing aerosol
4	**Volcanic ash with SO_2**	Volcanic ash, IASI ash test positive (including tests with SO2 TIR channels) confirmation by AVHRR VIS/NIR or GOME-2 UV tests
15	No classification	

PMAp: AOD retrieval
Retrieval over land & ocean

24 April 2015

aerosol type



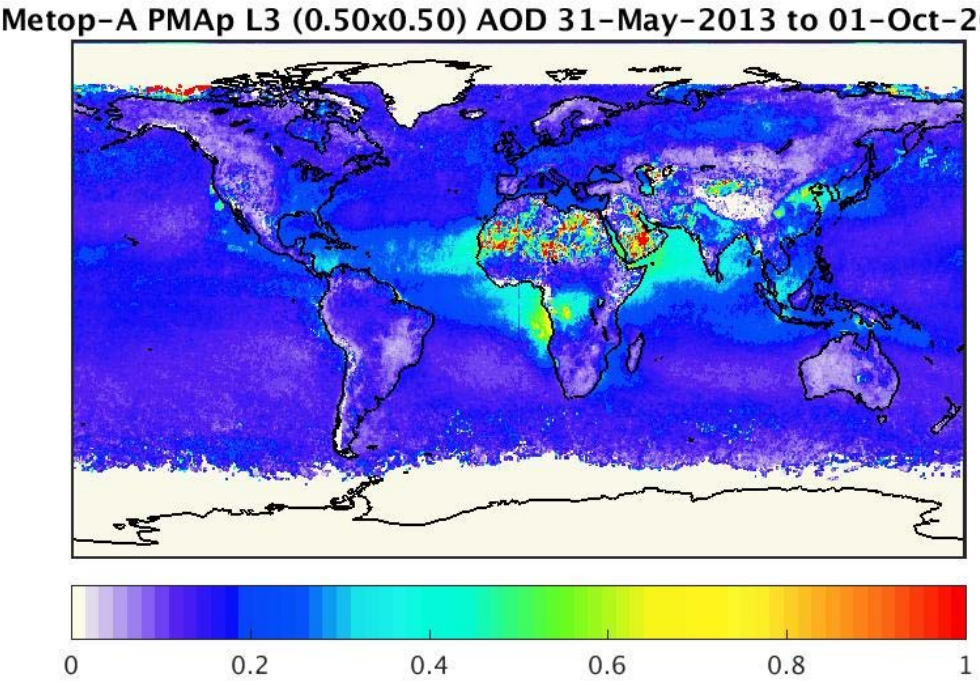
0 **fine mode**
1 **coarse mode**
3 **volcanic ash / thick dust**
4 **volcanic ash with SO_2**

Calbuco volcano (South Chile)
eruption begun on 22 April 2015

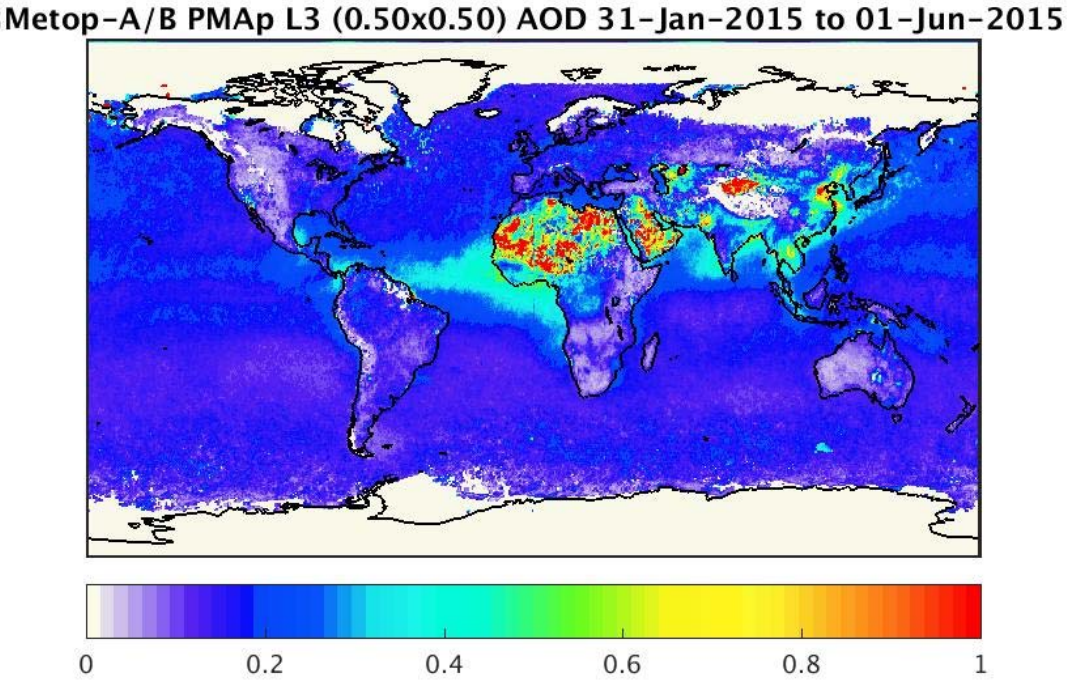
PMAp AOD results

Version 2 L3 gridded results – Summer 2013 and Winter 2015 – Metop-A&B

Summer 2013

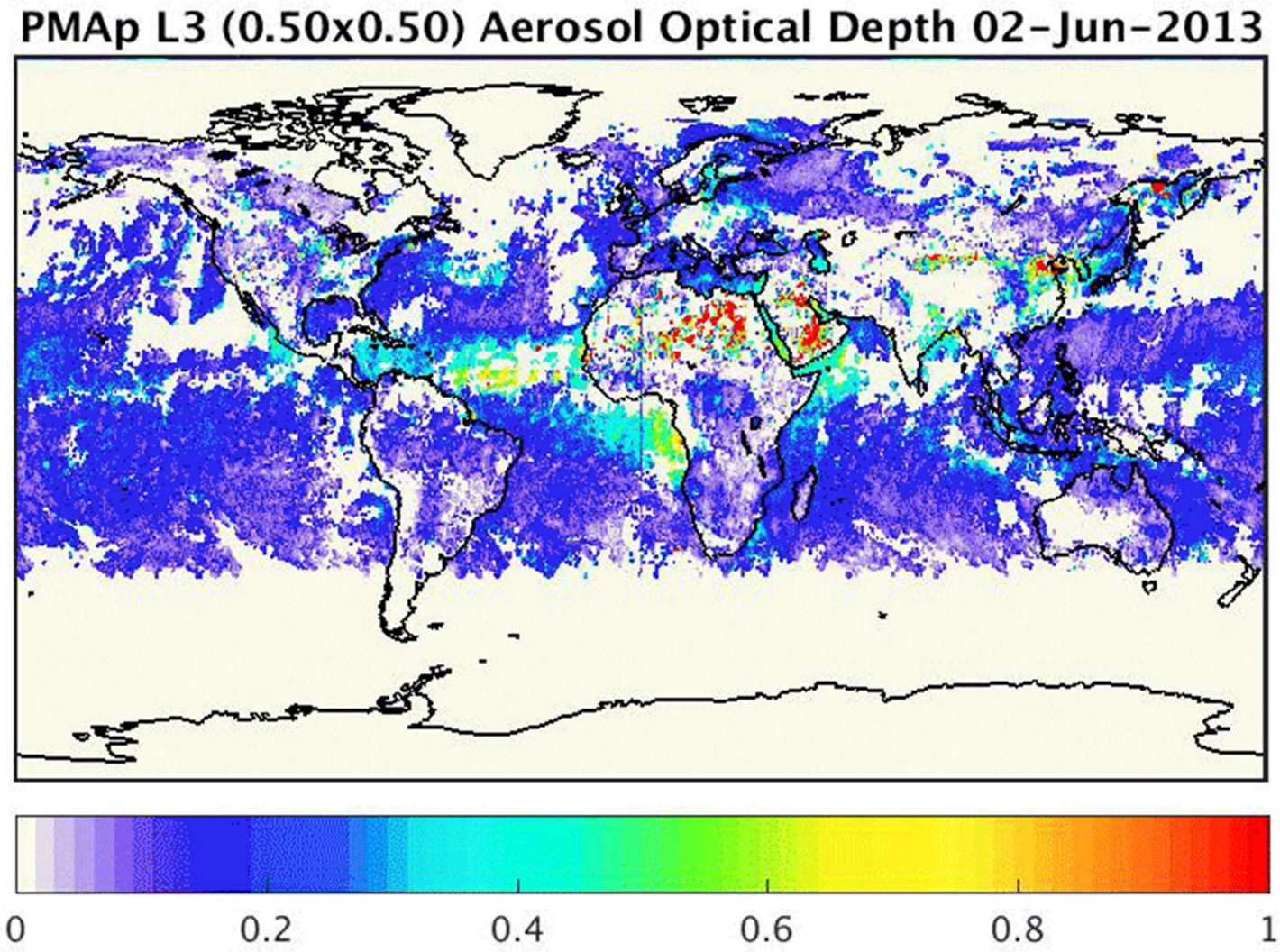


Winter 2015



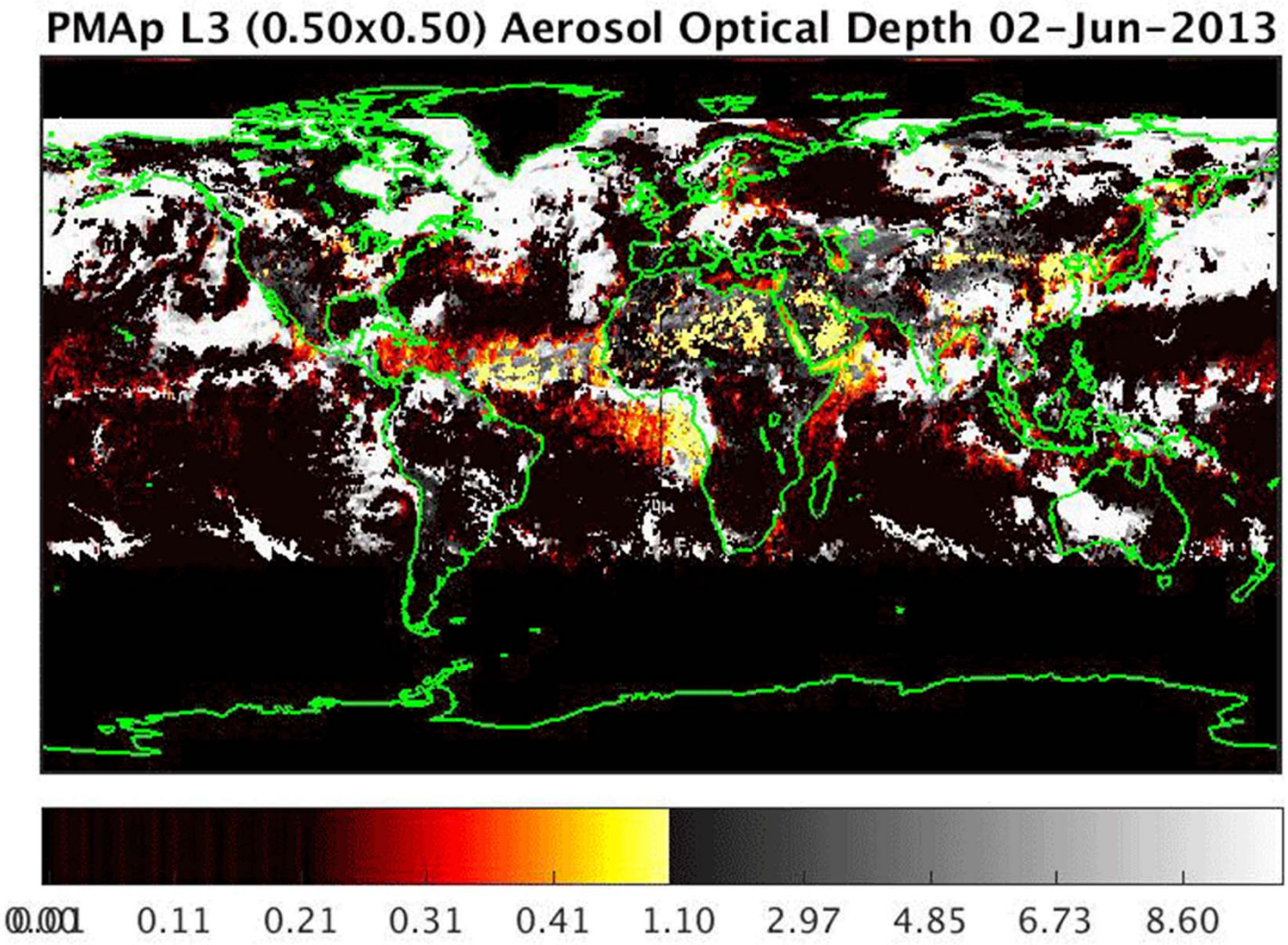
PMAp AOD results

Version 2 L3 gridded results – Summer 2013 – Metop-A&B



PMAp AOD results + COD

Version 2 L3 gridded results – Summer 2013 – Metop-A&B

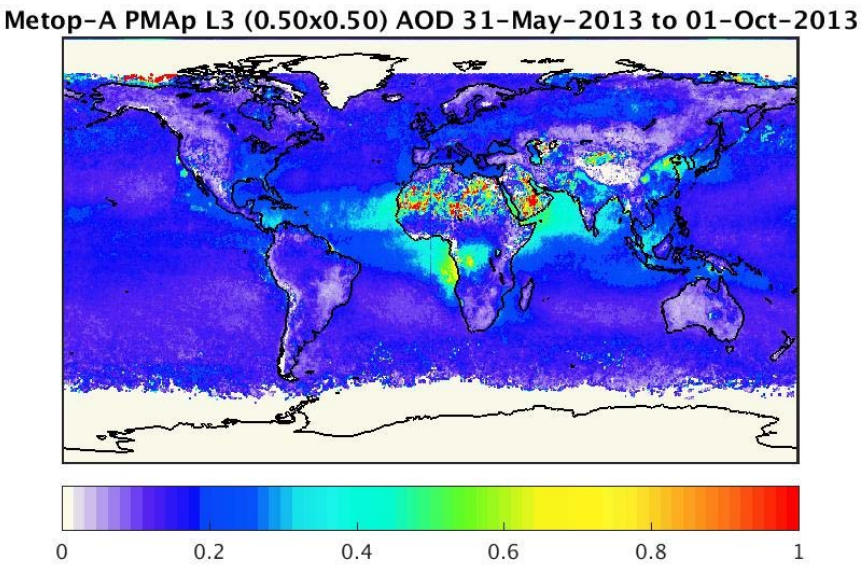


COD is demonstrational auxiliary parameter!!!!!

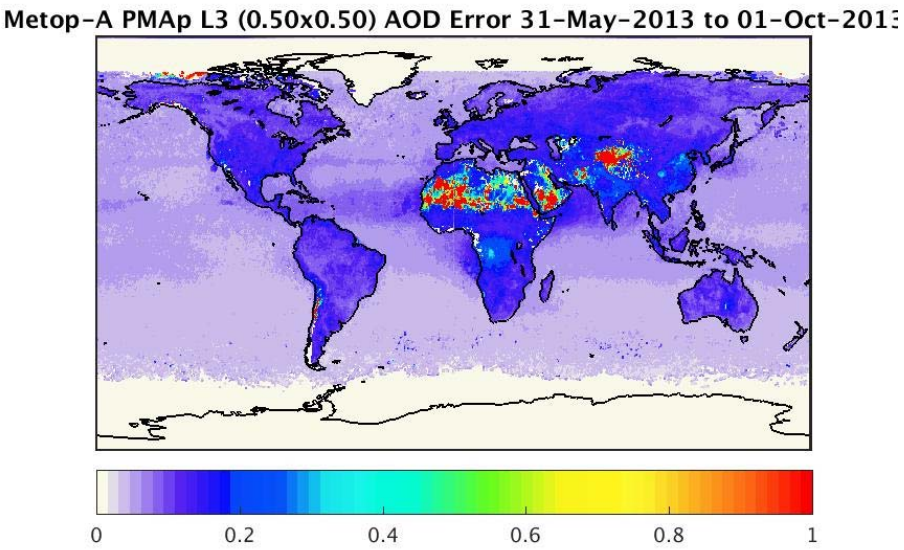
PMAp AOD results and error estimates

Version 2 L3 gridded results – Summer 2013 and Winter 2015 – Metop-A

Version 2.1 AOD



Version 2.1 AOD Error

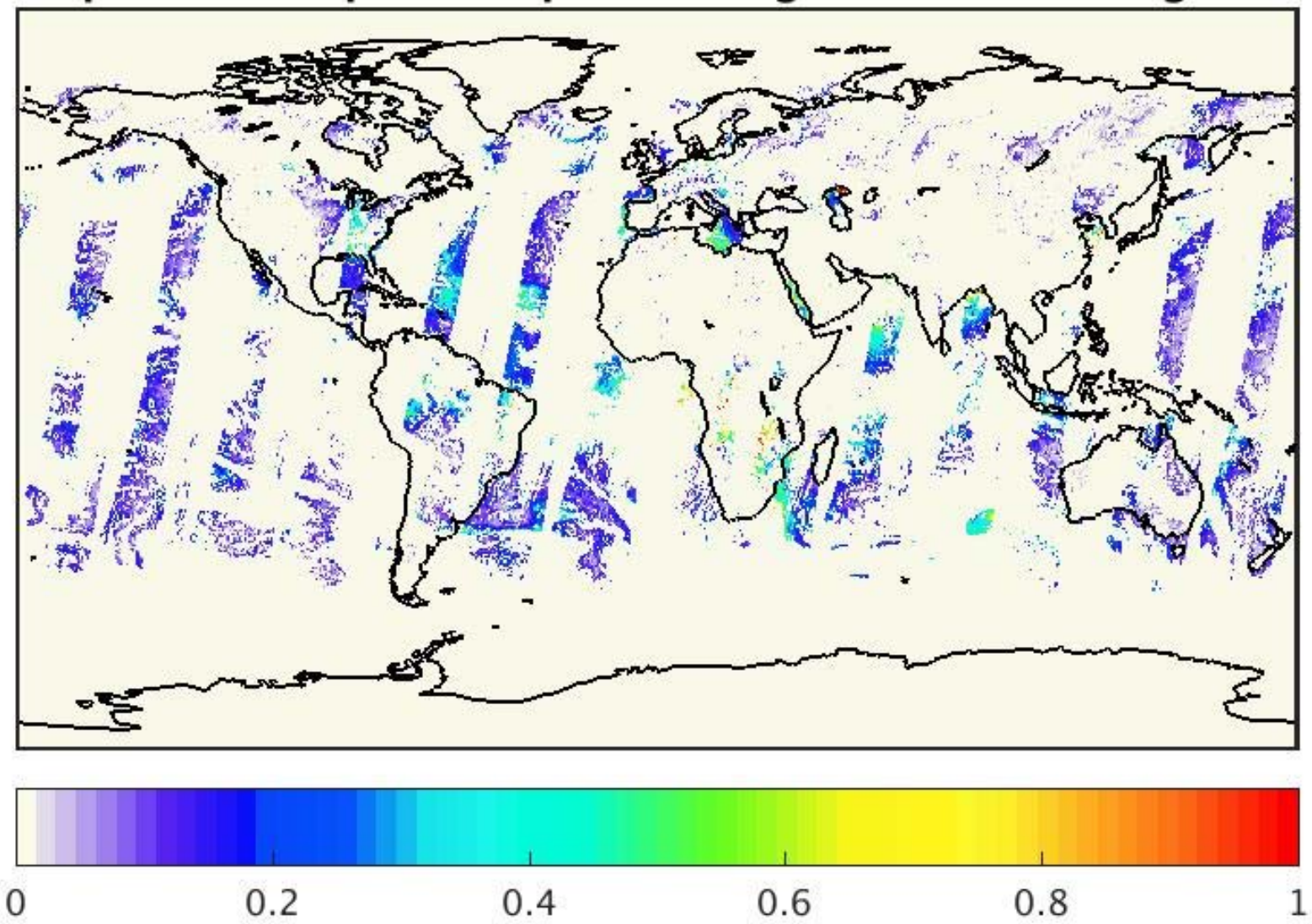


- PMAp does not use optimal estimation methods
  - A set of AOD is calculated using simplified inversion by varying **aerosol type, surface albedo, cloud correction**
  - A standard deviation of these AODs is calculated
  - PMAp calculates a randomized error

PMAp AOD results

Version 2 L2 satellite grid results – 1 day Metop-A - 30 August 2013

Metop-B PMAp Aerosol Optical Depth 30-Aug-2013 to 31-Aug-2013

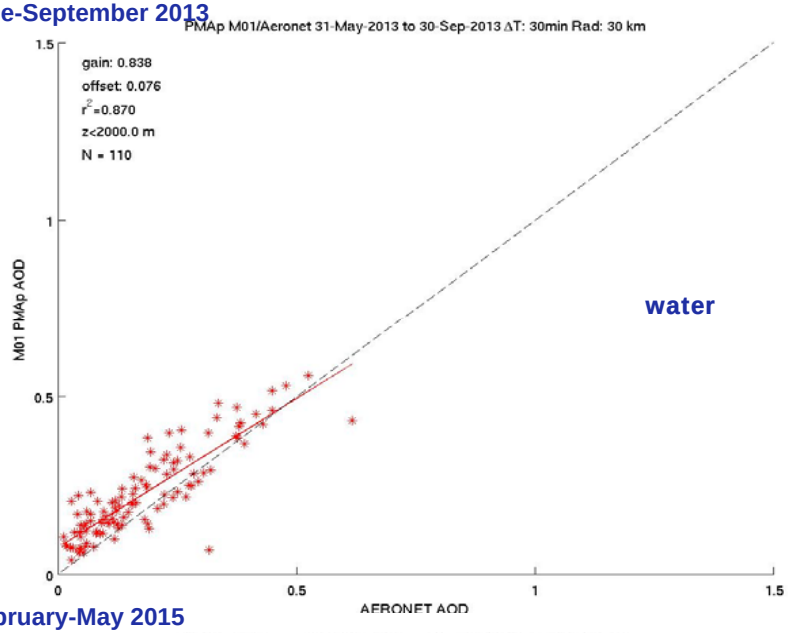


TSAT

PMAp version 2 validation at EUMETSAT

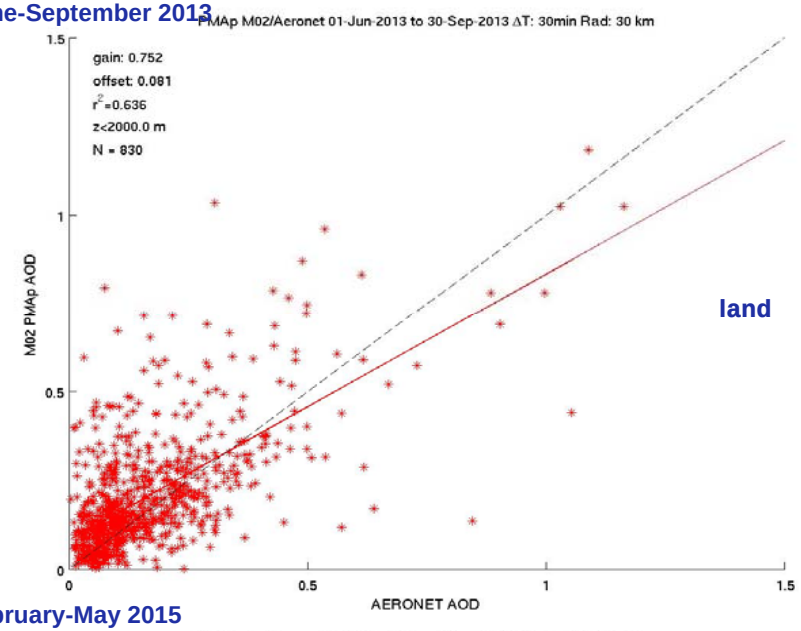
Operational validation with AERONET 1.5 weekly data

June-September 2013



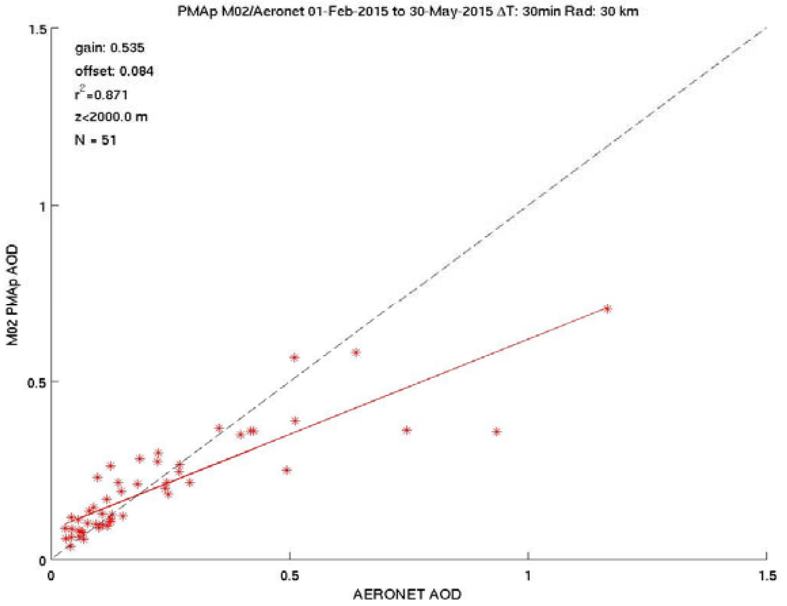
water

June-September 2013

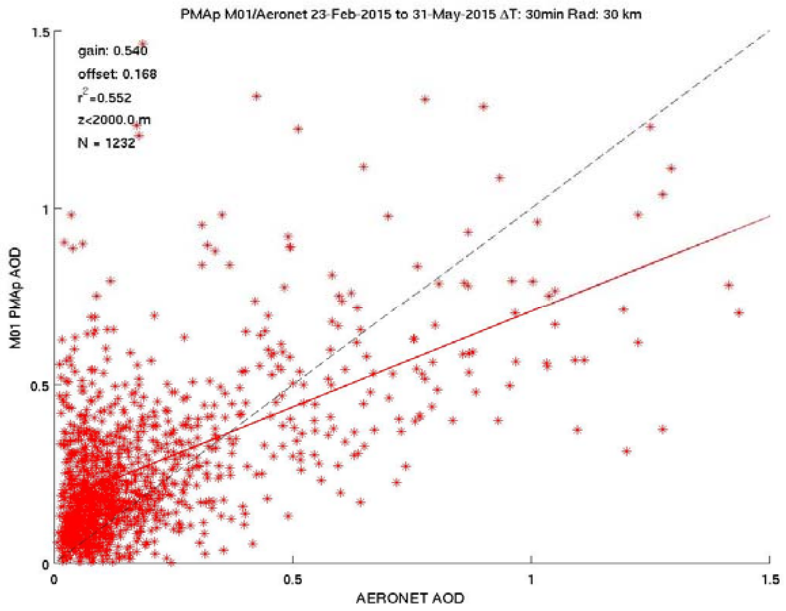


land

February-May 2015



February-May 2015

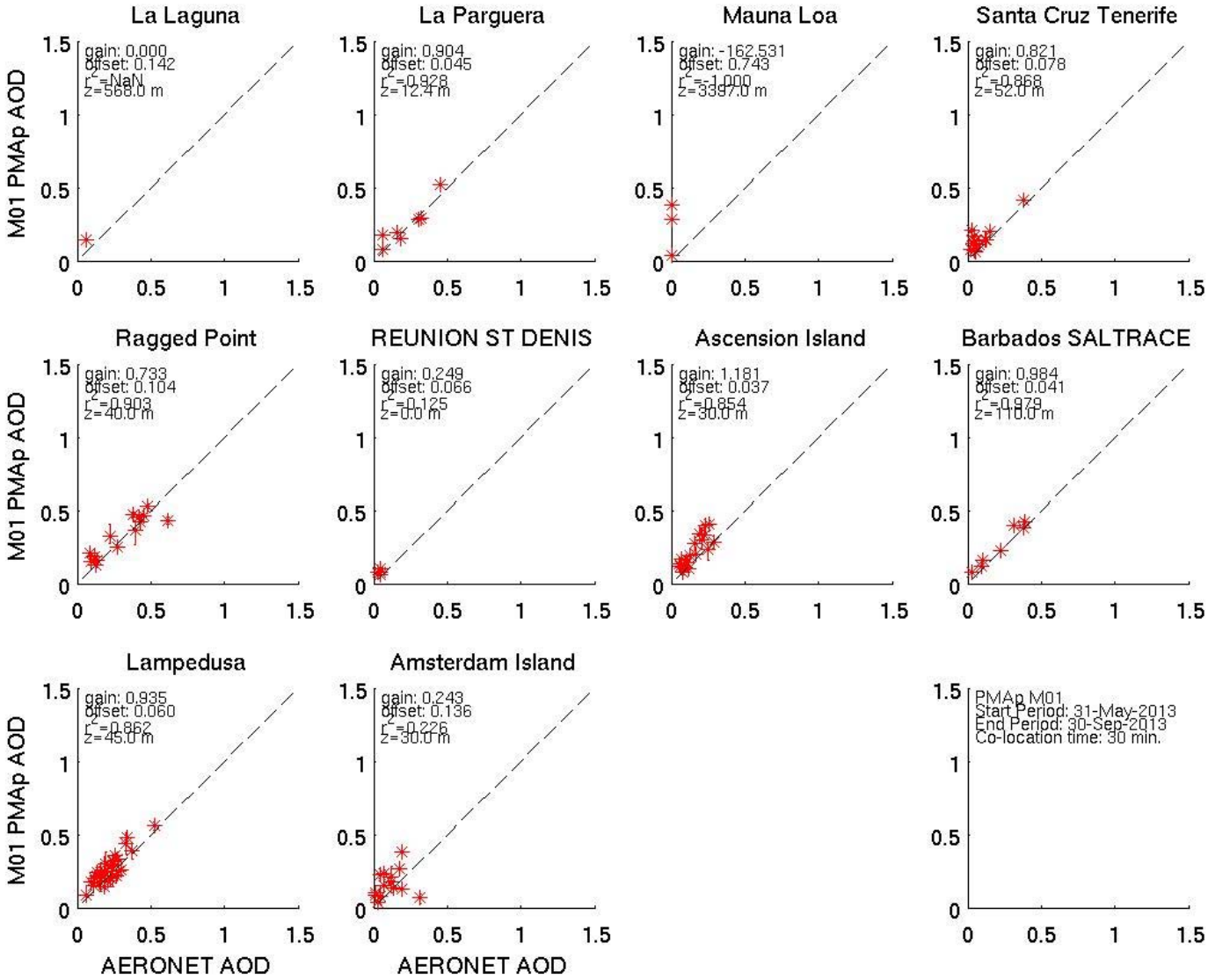


PMAp version 2 validation at EUMETSAT

Operational validation with AERONET 1.5 weekly data

June-September 2013

ocean

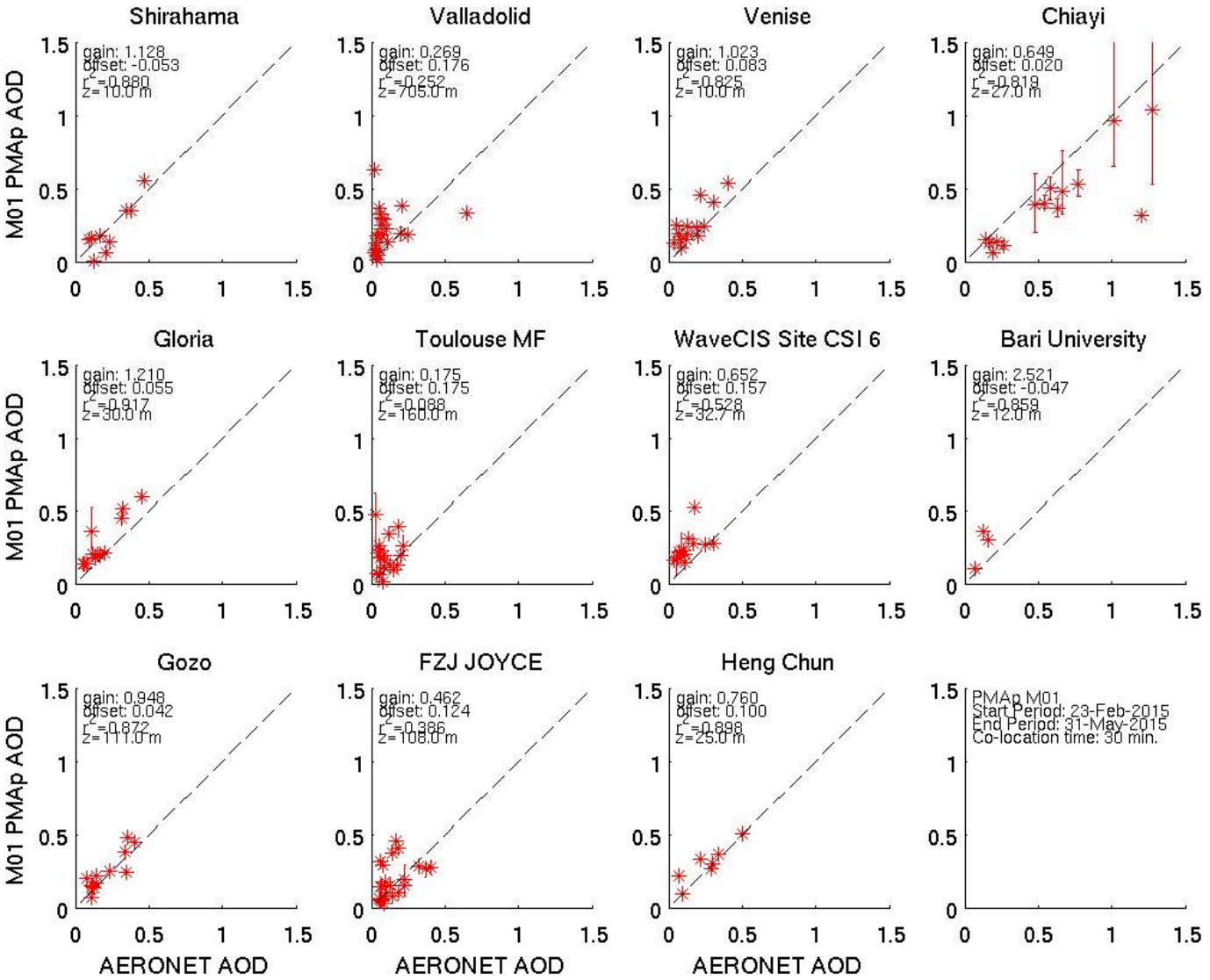


PMAp version 2 validation at EUMETSAT

Operational validation with AERONET 1.5 weekly data

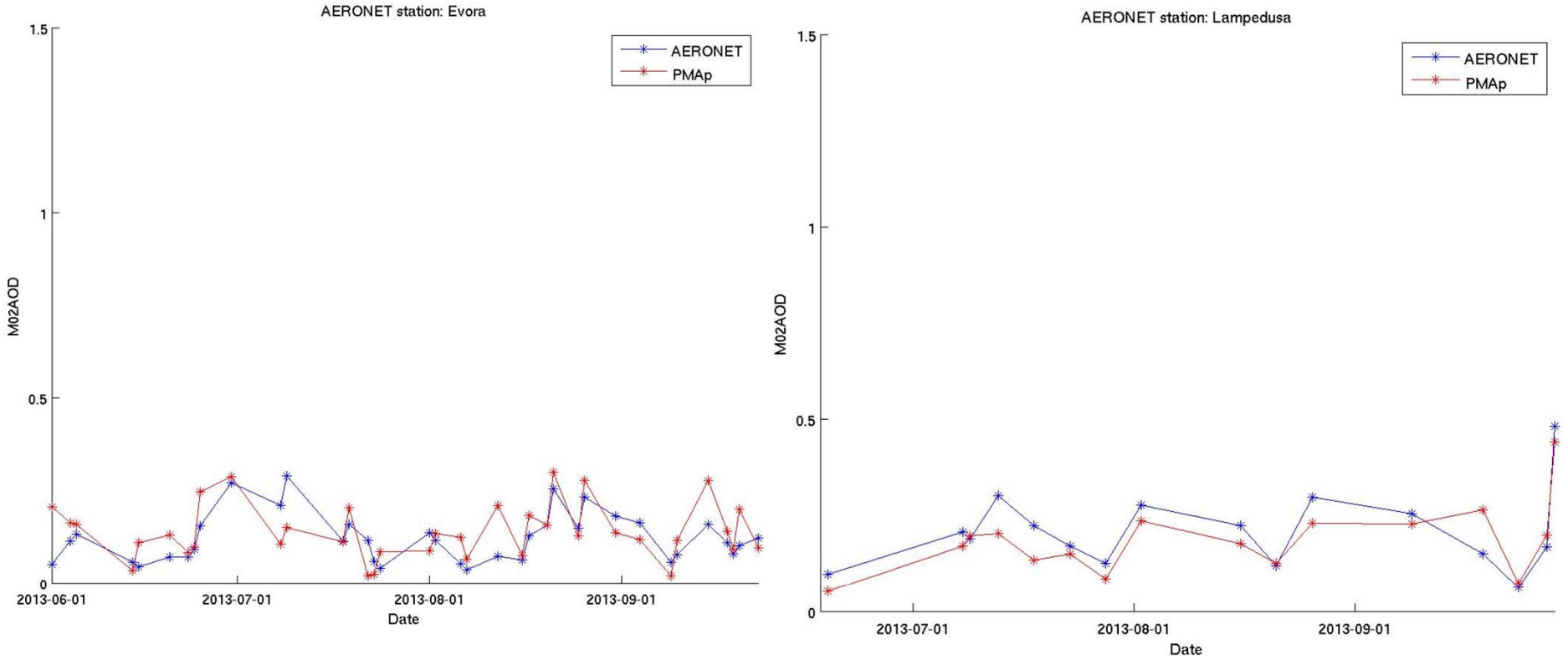
February-May 2015

land



PMAp version 2 validation at EUMETSAT

Operational validation with AERONET 1.5 weekly data



Time series of the AOD at 550 nm for validation period 1 at the Evora AERONET site (left panel) and at the Lampedusa AERONET site (rigth panel) compared to the AOD retrieved from METOP-A.

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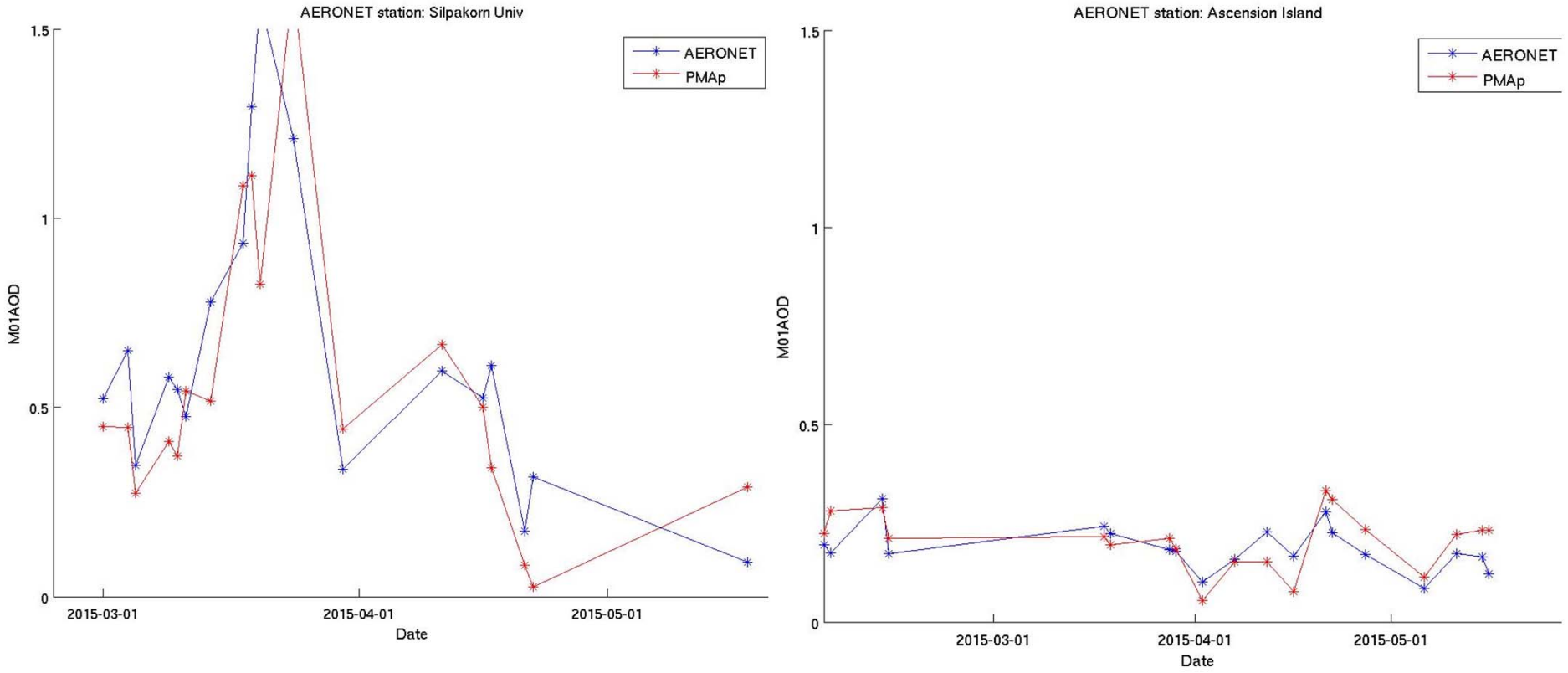
PMAp version 2 validation at EUMETSAT

Operational validation with AERONET 1.5 weekly data



Time series of the AOD at 550 nm for validation period 2 at the Silpakorn University AERONET site (left panel) site and at te Ascension Island AERONET site (right panel) compared to the AOD retrieved from METOP-B.

PMAp version 2 validation at EUMETSAT

Operational validation with AERONET 1.5 weekly data

PMAp vs Aeronet Lev2 Over Ocean

	June - Sept 2013		Feb-May 2015	
	MetopB	**MetopA**	**MetopB**	**MetopA**
gain	0.838	0.783	0.493	0.535
bias	**0.076**	**0.045**	**0.115**	**0.084**
correlation	**0.932**	**0.914**	**0.881**	**0.933**
N	110	90	22	51

PMAp vs Aeronet Lev2 Over Land

	June - Sept 2013		Feb-May 2015	
	MetopB	**MetopA**	**MetopB**	**MetopA**
gain	0.597	0.752	0.540	0.503
bias	**0.113**	**0.081**	**0.168**	**0.158**
correlation	**0.767**	**0.797**	**0.742**	**0.782**
N	906	830	1232	1000

Aerosol_CCI

ADV/ASV (AATSR Dual/Single View),
ORAC ((Oxford Ral Aerosol and Cloud Retrieval)
SU (Swansea University)

Metric	Algorithm					
	ADV/ASV		ORAC		SU	
	V1.0	V2.3	V1.0	V3.02	V1.0	V4.21
Over Ocean						
number of points	75	64	65	102	13	52
bias	0.04	0.02	0.07	0.10	0.06	−0.002
RMSE	0.16	0.09	0.15	0.16	0.08	0.06
correlation	0.58	0.89	0.81	0.93	0.89	0.86
GCOS fraction (%)	17	66	46	31	15	58
Over Land						
number of points	306	185	262	262	138	343
bias	−0.005	−0.05	0.03	−0.002	−0.001	−0.01
RMSE	0.16	0.13	0.16	0.08	0.08	0.11
correlation	0.59	0.66	0.59	0.86	0.72	0.82
GCOS fraction (%)	37	54	40	51	46	62

(Popp et al. 2016)

PMAp version 2 validation
MPI for Chemistry study

Comparison of Metop PMAp Version 2 AOD Products using Model Data

Final Report
EUMETSAT ITT 15/210839

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With contributions from:

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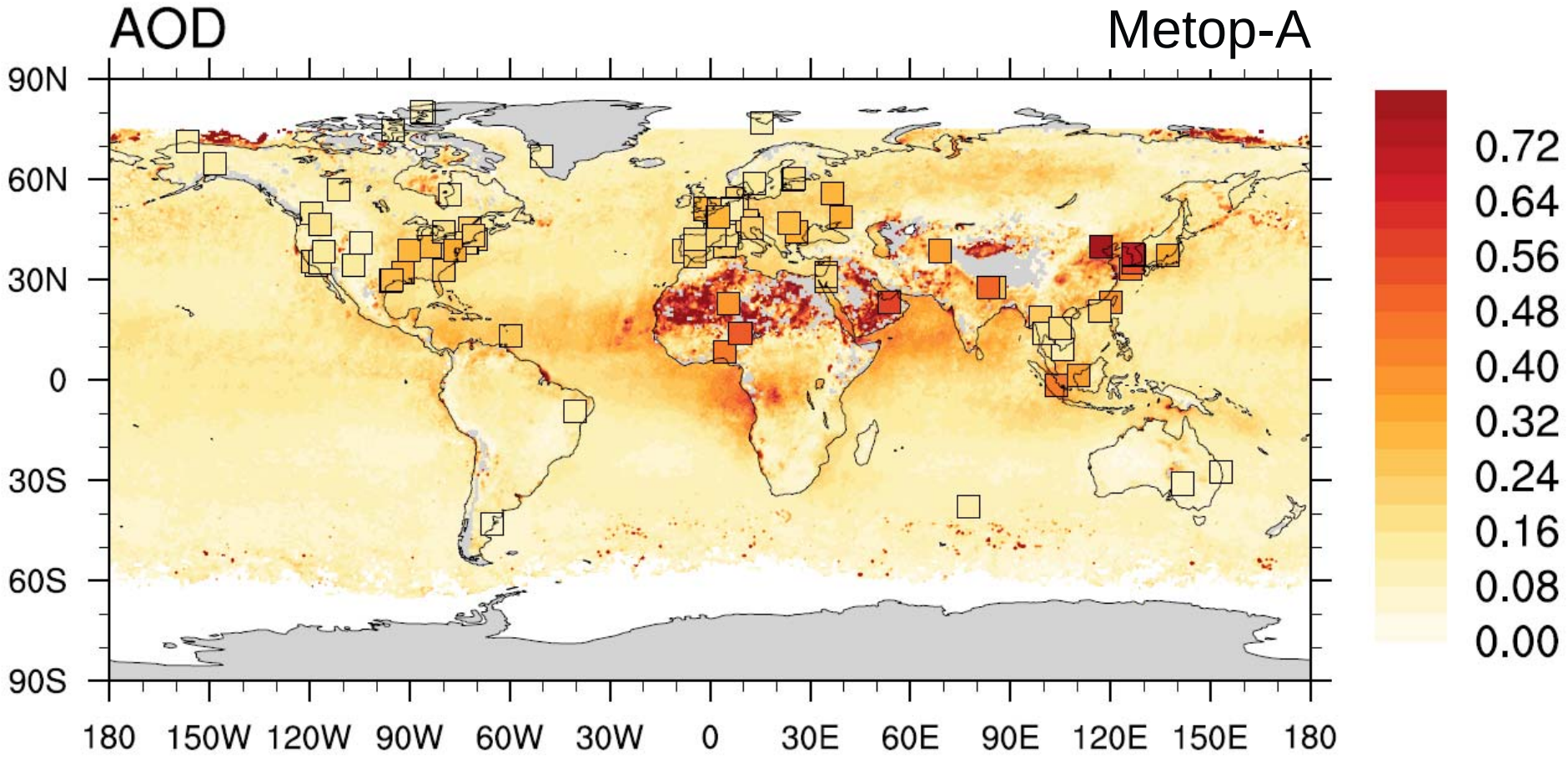
Documentation:
www.eumetsat.int > Data > Technical documentation > Metop > PMAp

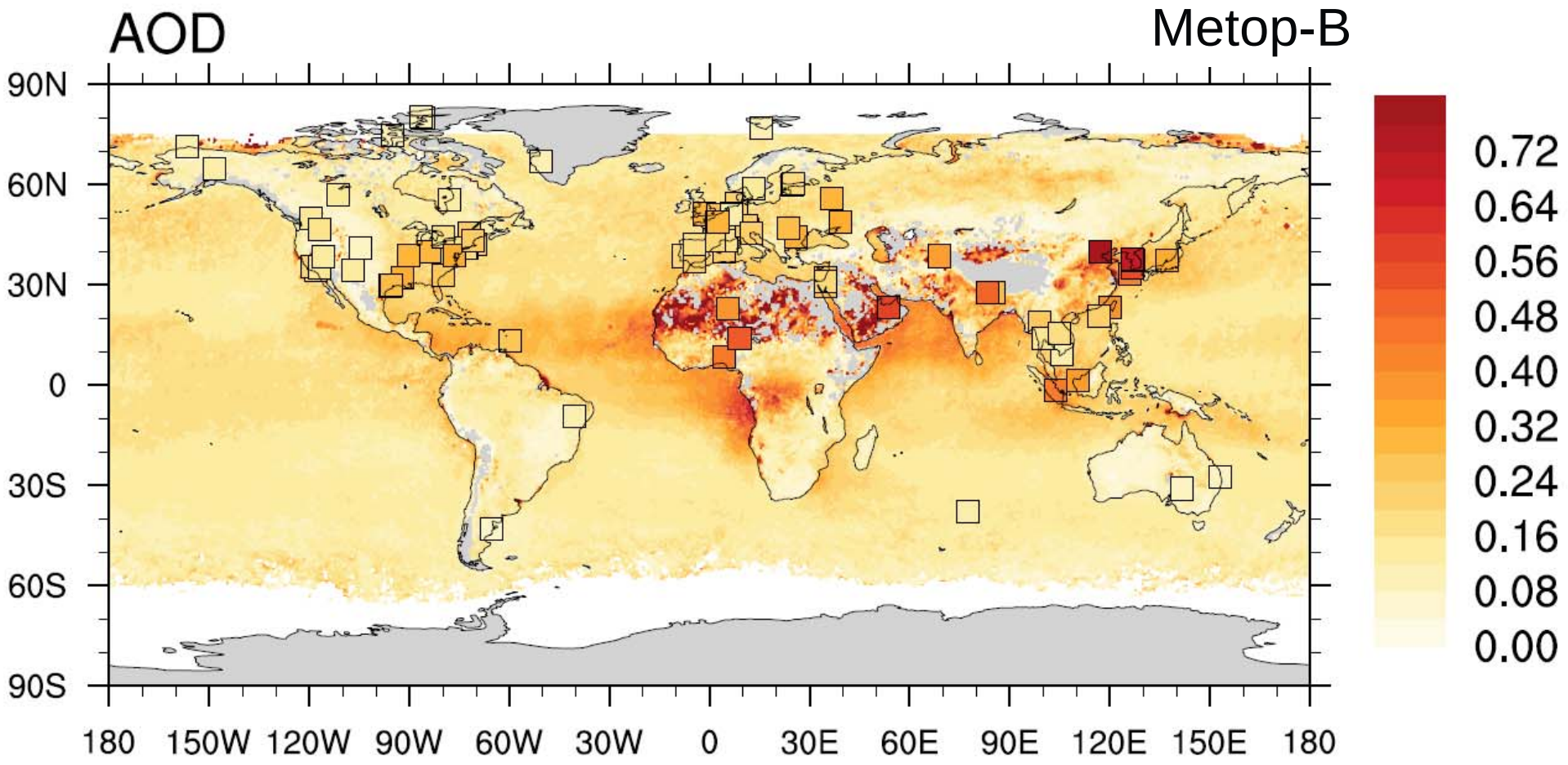
PMAp version 2 validation – MPI Chem.

Validation against Aeronet 2.0 – Metop-A – June to Sep 2013



PMAp version 2 validation – MPI Chem.

Validation against Aeronet 2.0 – Metop-B – June to Sep 2013



PMAp version 2
Outlook

Whats next?

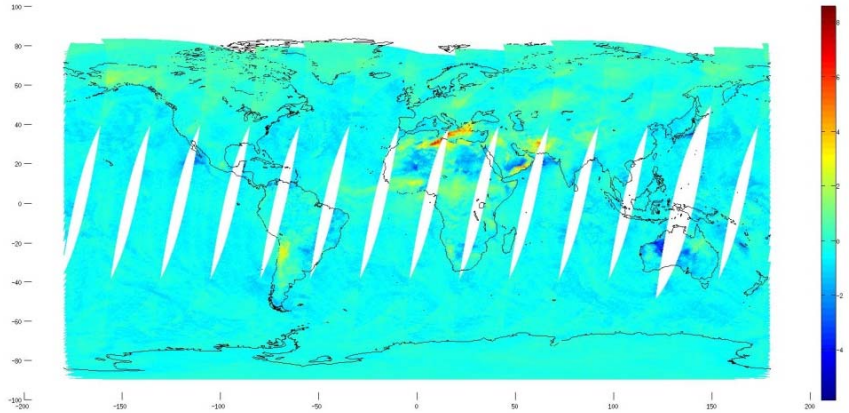
PMAp version 2.2 – release planned for Q1 2018

- Improved dust/ash detection using IASI (Clarisse et al.)

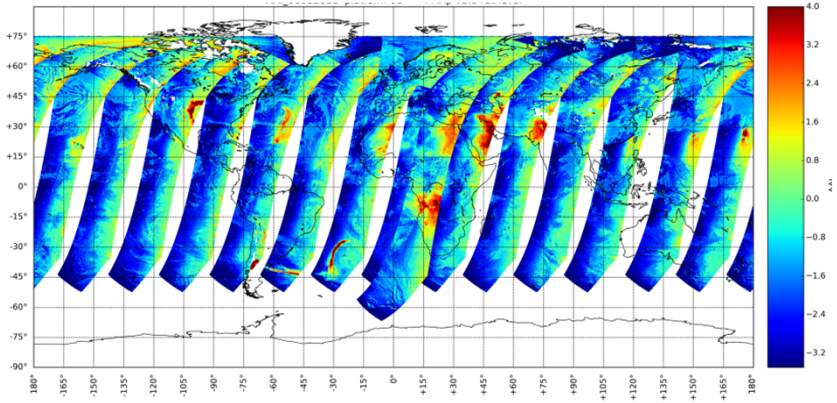
- Include UV information for additional absorbing aerosol detection

- Provide a level-3 gridded daily AOD product (offline TBC)
  - ➢ 0.5x0.5, gap-filled, quality controlled

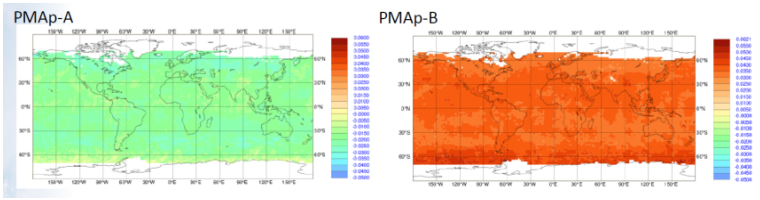
- Degradation correct PMD radiances
  - ➢ reduce overall biases and the biases between Metop-A and B



IASI Dust flag, Clarisse et al, AC SAF



UV absorbing radiances vs background



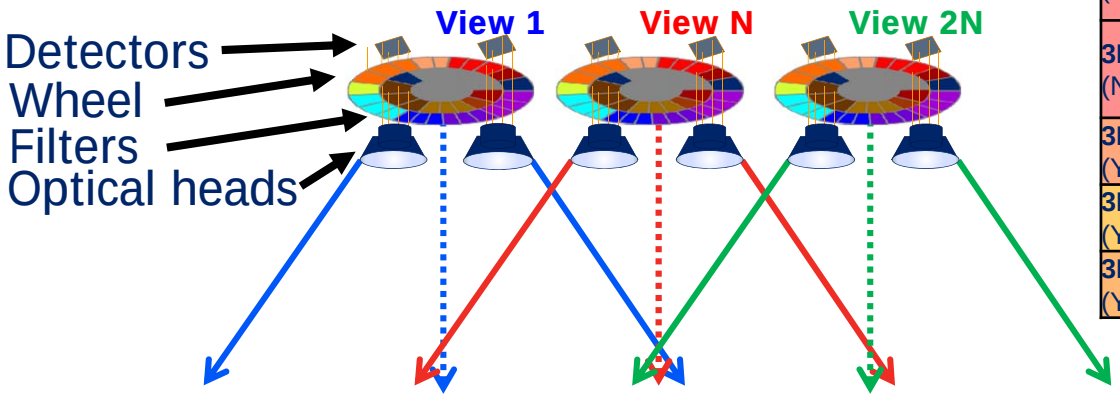
Ades et al., ECMWF

EPS-SG: 3MI observation concept

3MI - Multi Angle, Multi Spectral, Multi Polarisation

IASI-NG
VII
3MI
Sentinel 5
MWS
RO

EPS-SG
Platform A
2021-....



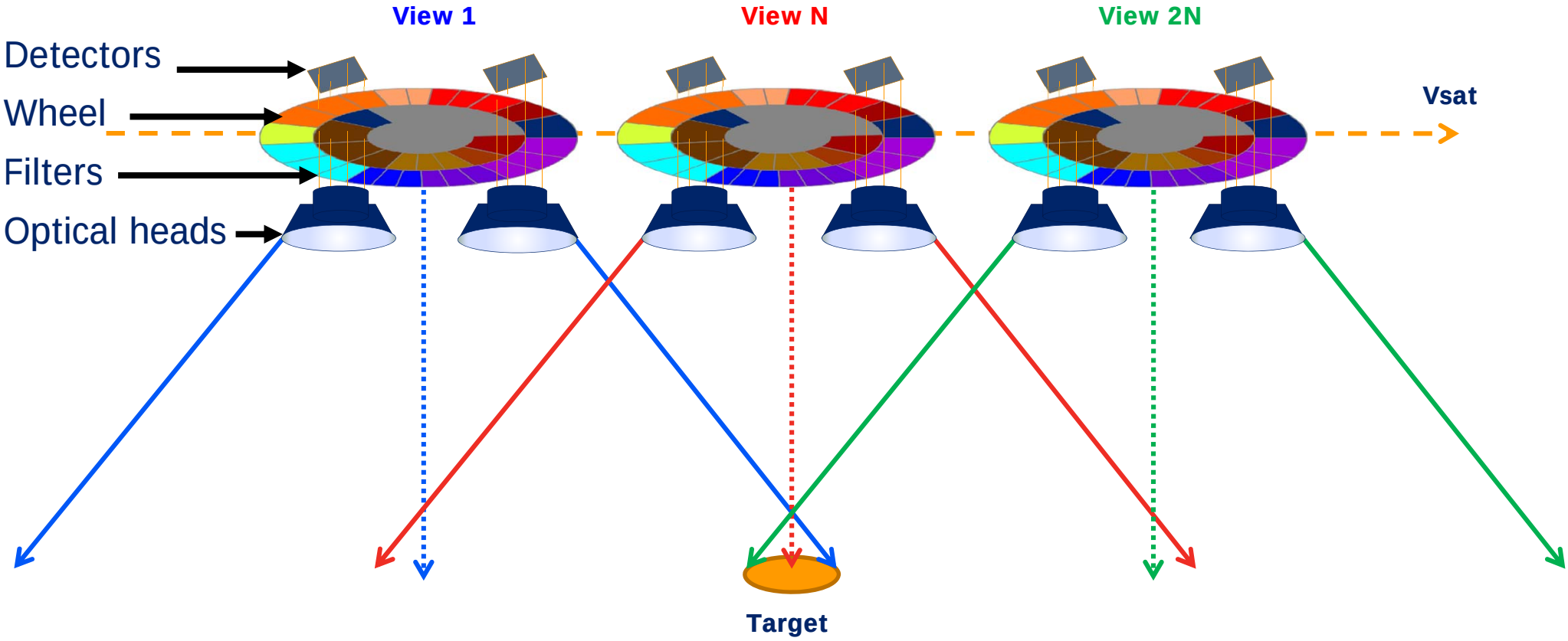
Channel (Polarisation)	*Channel centre* (channel width)	*Channel index k*	*Optical head*	*Applications*
3MI-2b (Yes)	**410 nm** (20 nm)	1	VNIR Optical head (h=1)	Absorbing aerosol and ash cloud monitoring
3MI-3 (Yes)	**443 nm** (20 nm)	2		Aerosol absorption and height indicators
3MI-4 (Yes)	**490 nm** (20 nm)	3		Aerosol, surface albedo, cloud reflectance, cloud optical depth
3MI-5 (Yes)	**555 nm** (20 nm)	4		Surface albedo
3MI-6 (Yes)	**670 nm** (20 nm)	5		Aerosol properties
3MI-7 (No)	**763 nm** (10 nm)	6		Cloud and aerosol height
3MI-8 (No)	**765 nm** (40 nm)	7		Cloud and aerosol height
3MI-9 (Yes)	**865 nm** (40 nm)	8		Vegetation, aerosol, clouds, surface features
3MI-9a (No)	**910 nm VNIR** (20 nm)	9		Water vapour , atmospheric correction
3MI-9a (No)	**910 nm SWIR** (20 nm)	10	SWIR Optical head (h=2)	Water vapour , atmospheric correction
3MI-10 (Yes)	**1370 nm** (40 nm)	11		Cirrus clouds, water vapour imagery
3MI-11 (Yes)	**1650 nm** (40 nm)	12		Ground characterisation for aerosol inversion
3MI-12 (Yes)	**2130 nm** (40 nm)	13		3MI-11 + Cloud microphysics at cloud top, Vegetation, fire (effects)

EUMETSAT

3MI Co-registration concept – L1B temporal dimension II

3MI Multi Viewing Angle Acquisition

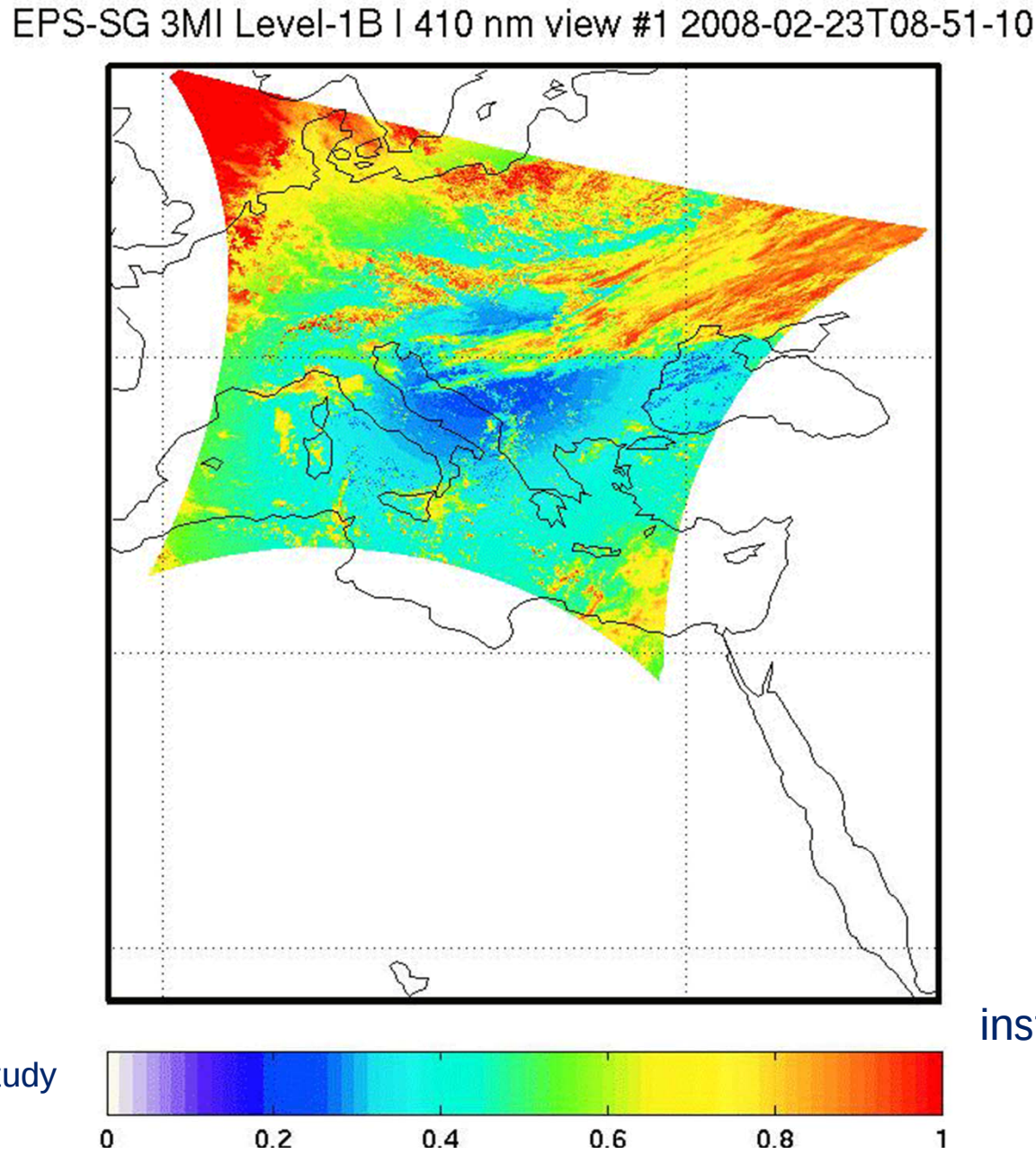
up to 14 views: N = 7



EUMETSAT

3MI L1C proto-type results

L1C EUM proto-type output – Reflectance $\pi/\cos(\Theta)$ I/R_0 – version 1

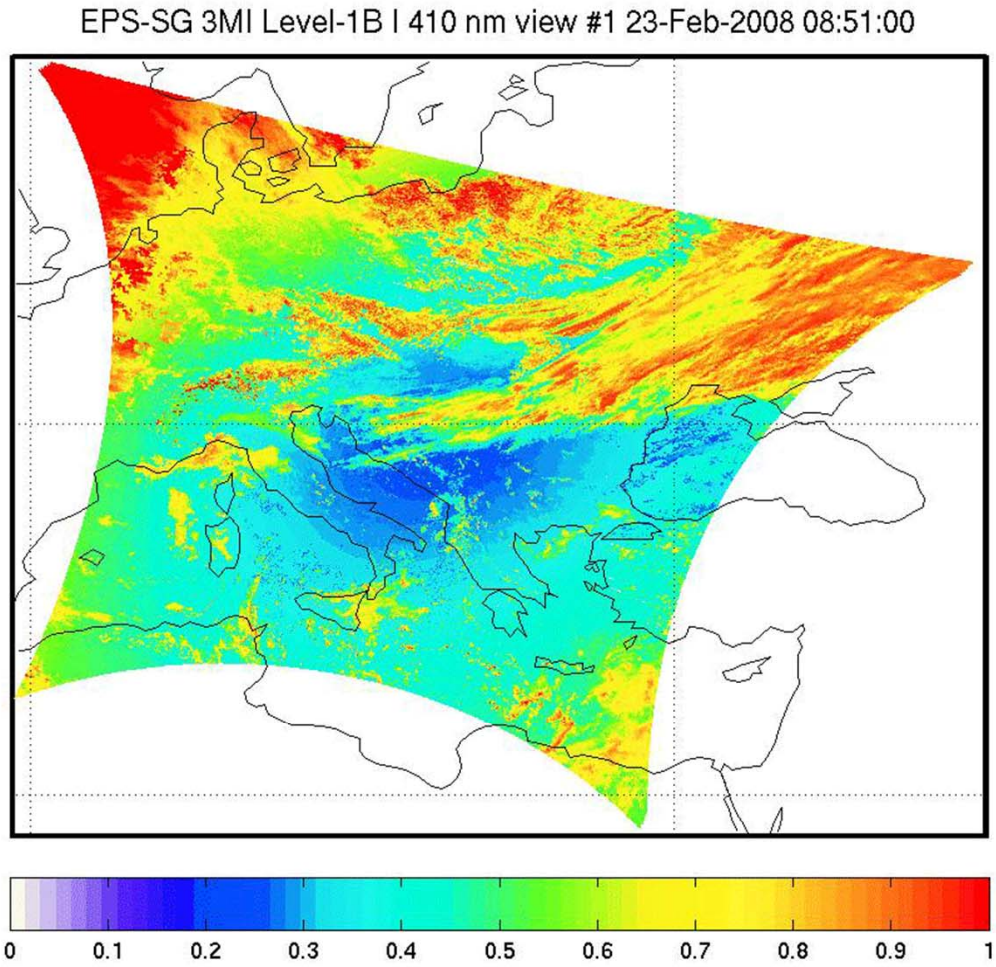


LOA, Riedi et al.
3MI TOA EUM test-data study

Level 1B
instrument resolution

3MI L1C proto-type results

L1C EUM proto-type output – Reflectance $\pi/\cos(\Theta)$ I/R_0 – version 1



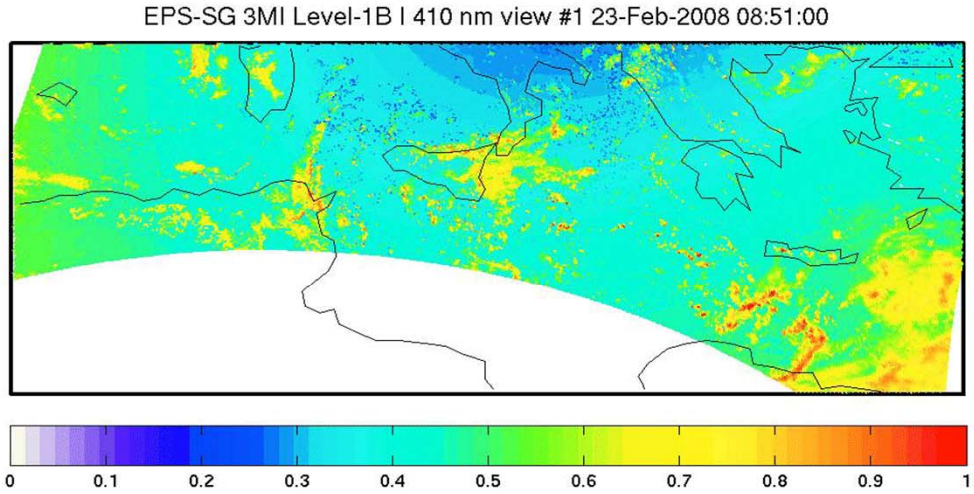
Level 1B
instrument resolution

LOA, Riedi et al.
3MI TOA EUM test-data study

EUMETSAT

3MI L1C proto-type results

L1C EUM proto-type output – Reflectance $\pi/\cos(\Theta)$ I/R_0 – version 1



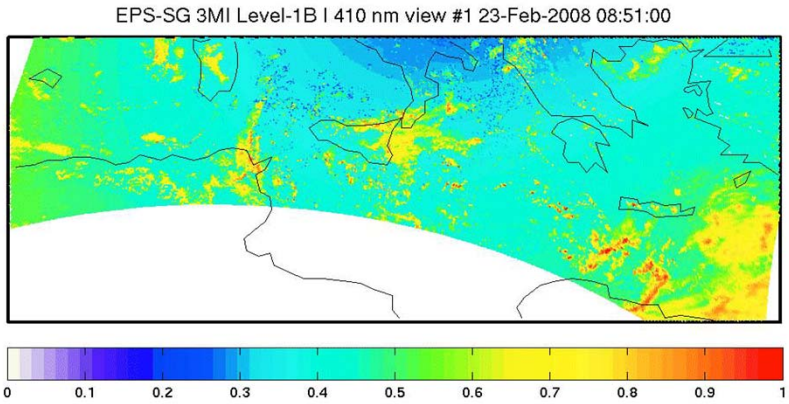
Level 1B
instrument resolution

LOA, Riedi et al.
3MI TOA EUM test-data study

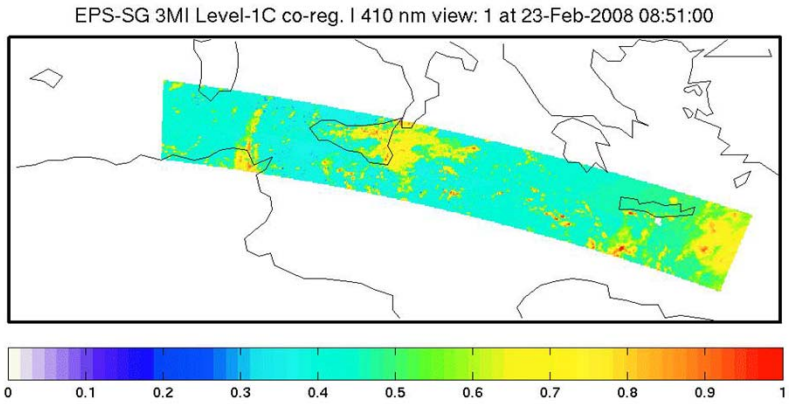
EUMETSAT

3MI L1C proto-type results

L1C EUM proto-type output – Reflectance $\pi/\cos(\Theta)$ I/R_0 – version 1



Level 1B
instrument resolution

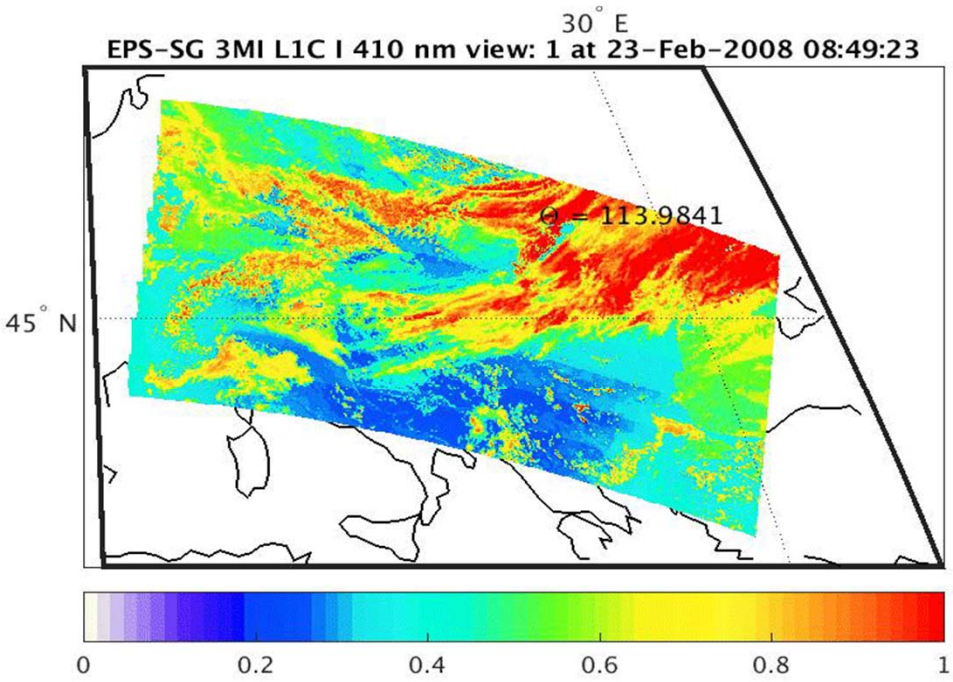


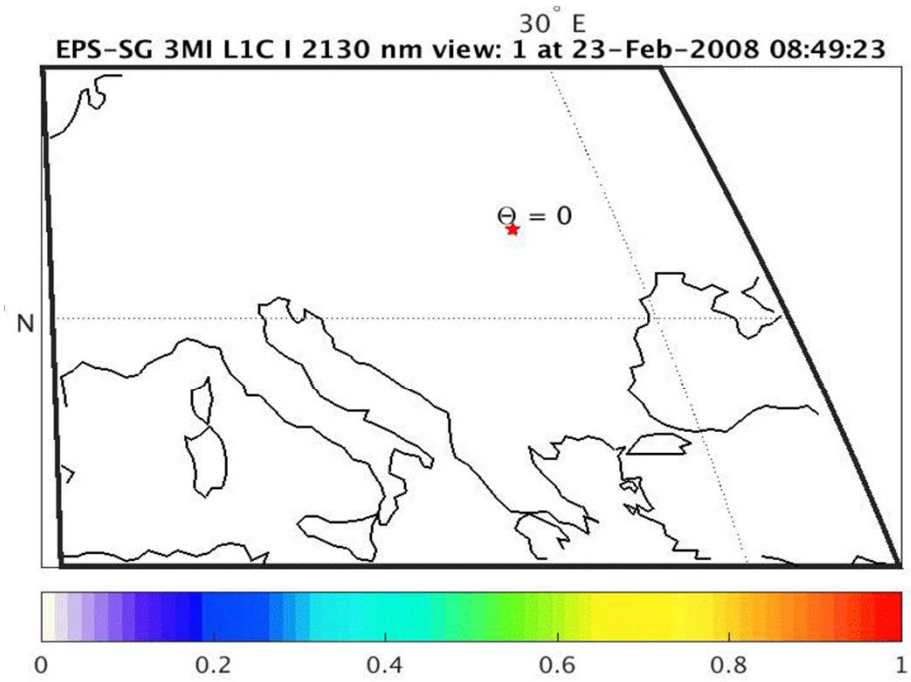
Level 1C
fixed sinusoidal grid

EUMETSAT

3MI L1C proto-type version2 results

L1C EUM proto-type v2 – VNIR/SWIR co-registration – I (410/2130 nm)

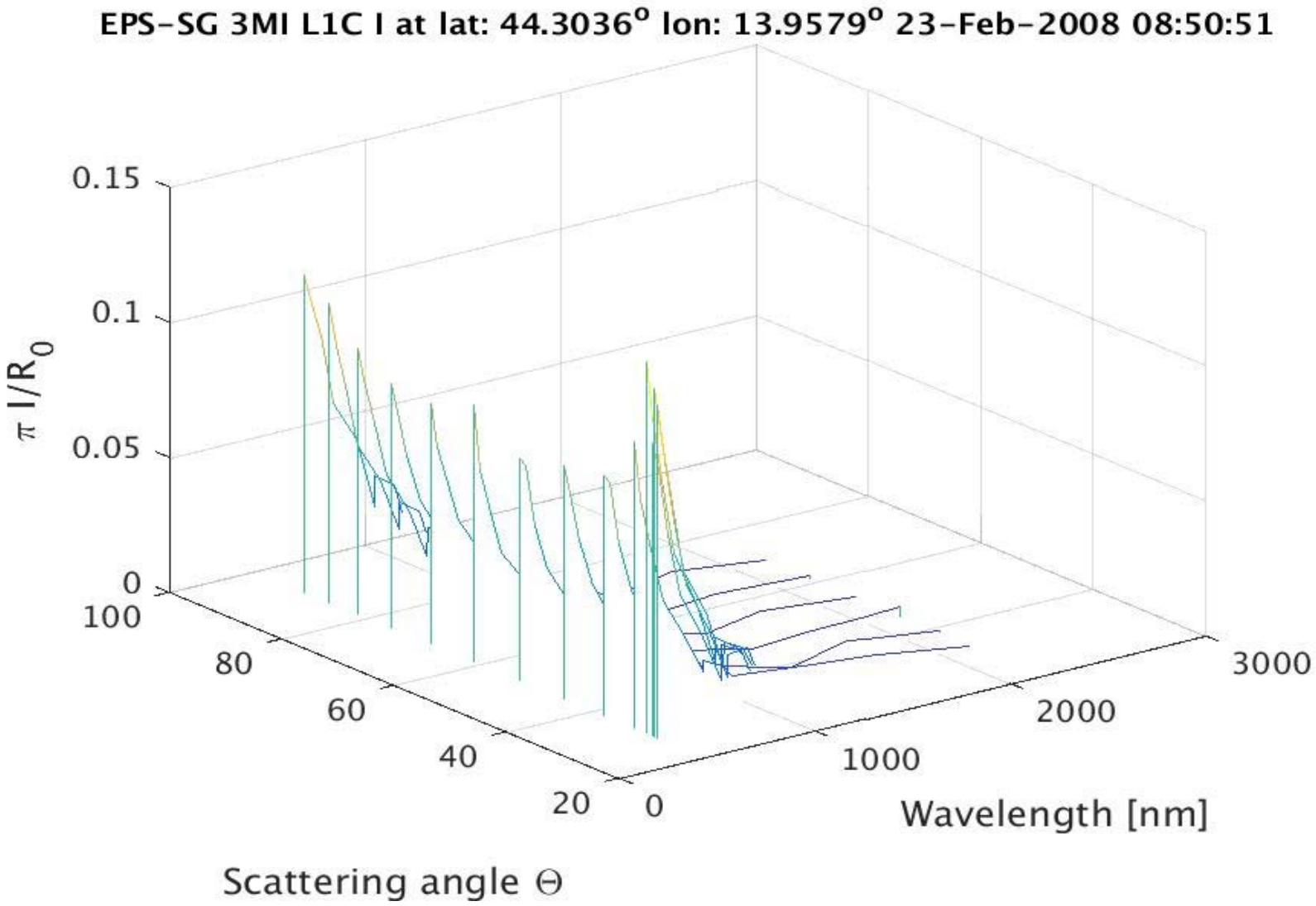




EUMETSAT

3MI L1C proto-type version2 results

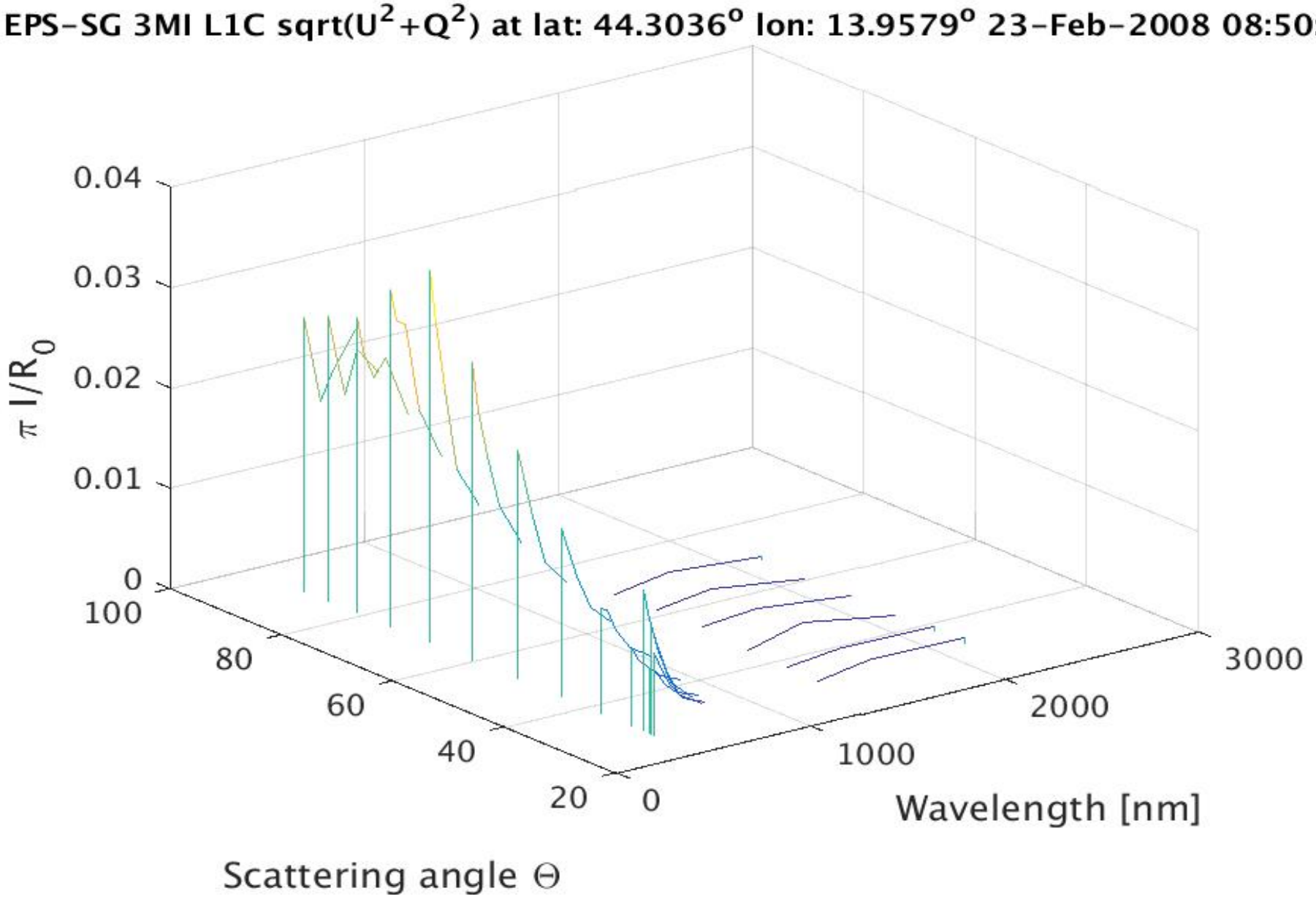
L1C EUM proto-type v2 – VNIR/SWIR co-registration – I All views All channels



EUMETSAT

3MI L1C proto-type version2 results

L1C EUM proto-type v2 – VNIR/SWIR co-registration – Q/U All views All channels



3MI Co-location/Co-registration concept – Spatial overlap

3MI Multi Viewing Angle Acquisition – with VII nadir viewing co-location

IASI-NG
VII
3MI
Sentinel 5
MWS
RO

EPS-SG
Platform A
2021-....

VII

VII

VII

View 1

View N

View 2N

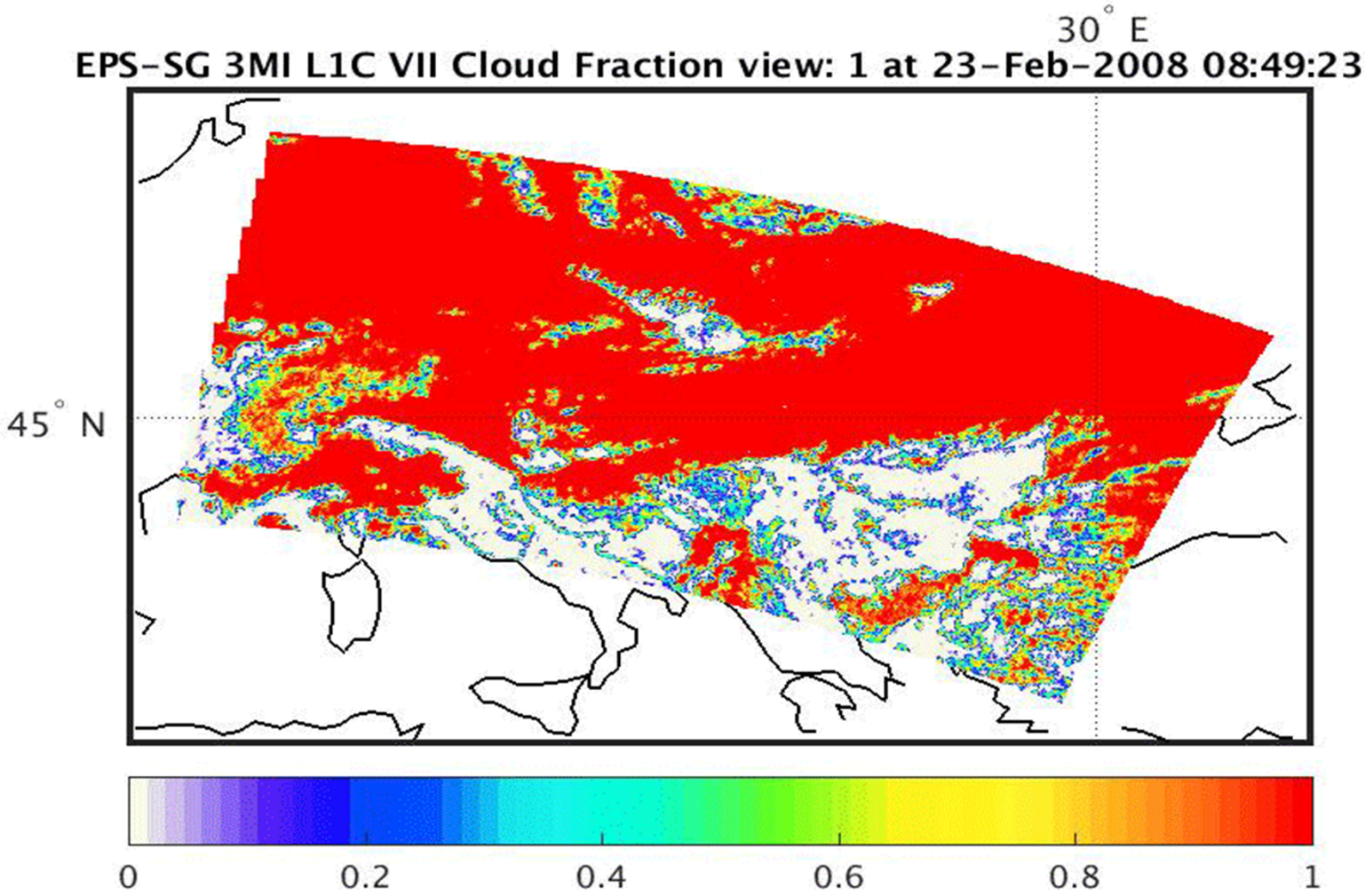
Vsat

Target

EUMETSAT

3MI L1C proto-type version2 results

Co-located VII cloud-information - CFR



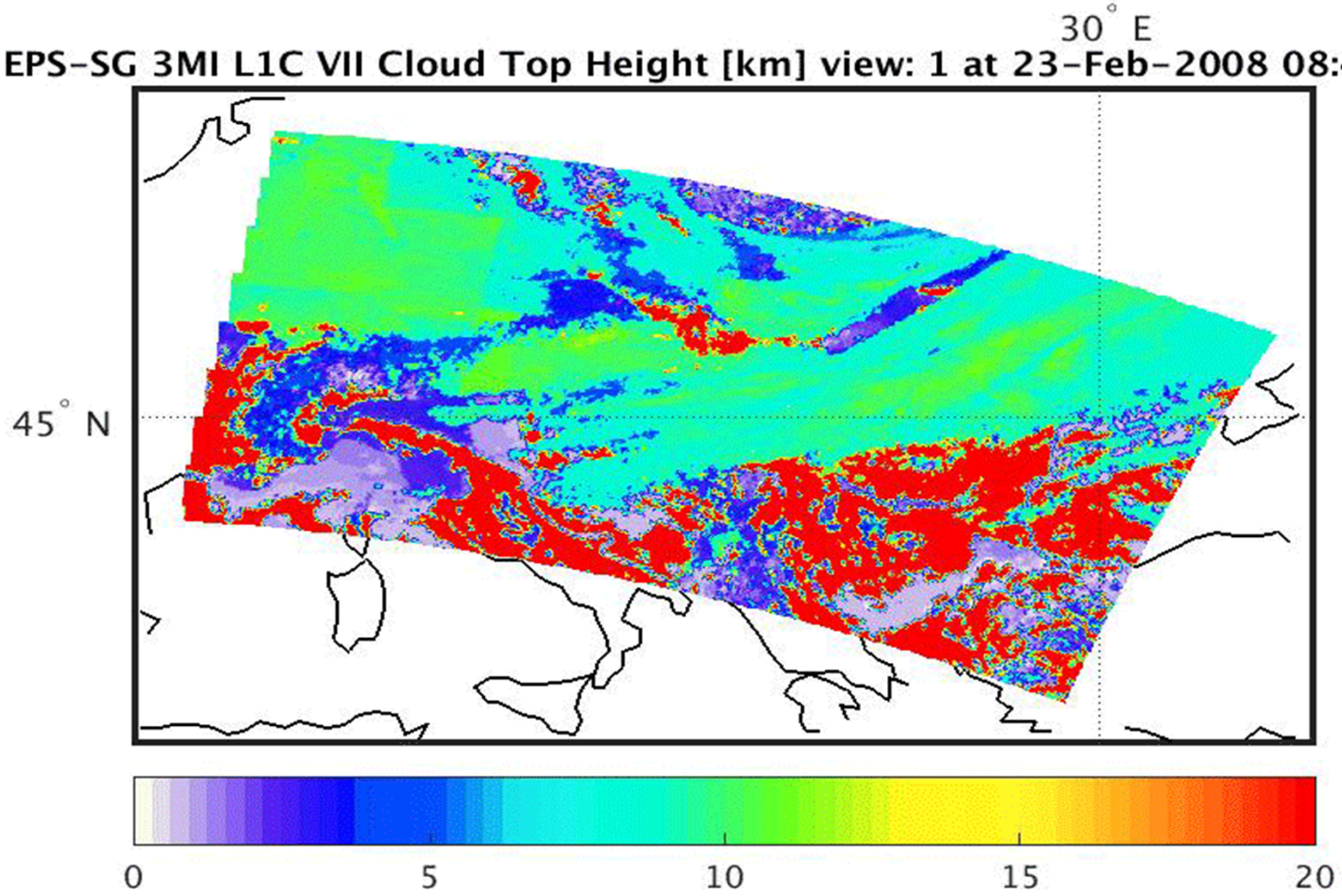
1st option:

Co-located on the 3MI detector grid per view (14 views of CFR) – presented here!

EUMETSAT

3MI L1C proto-type version2 results

Co-located VII cloud-information - CTH



Preliminary. Still a problem with the cloud-free numbers!

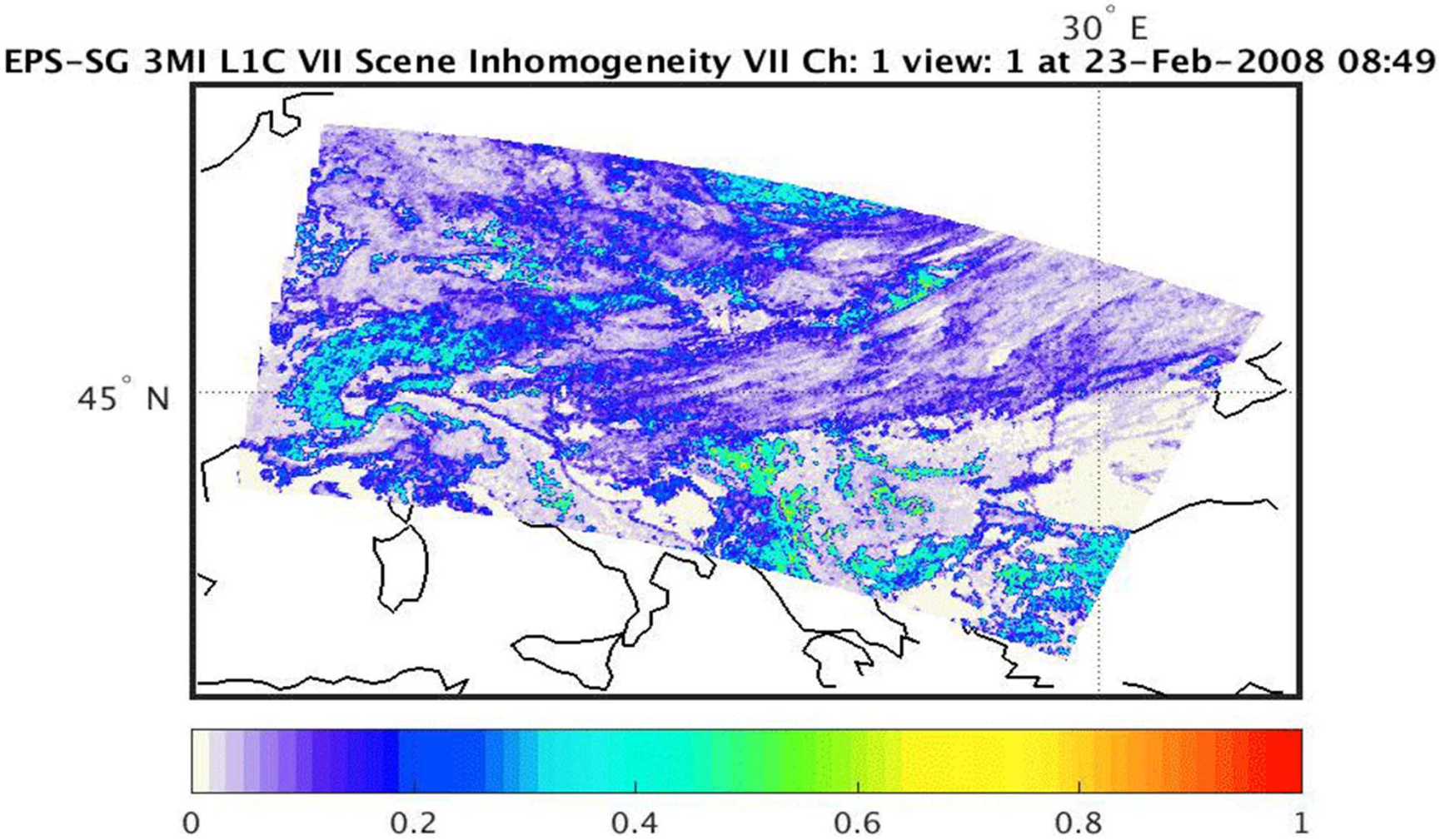
1st option:

Co-located on the 3MI detector grid per view (14 views of CFR) – presented here!

EUMETSAT

3MI L1C proto-type version2 results

Co-located VII cloud-information – scene in-homogeneity VII at 555 nm



1st option:

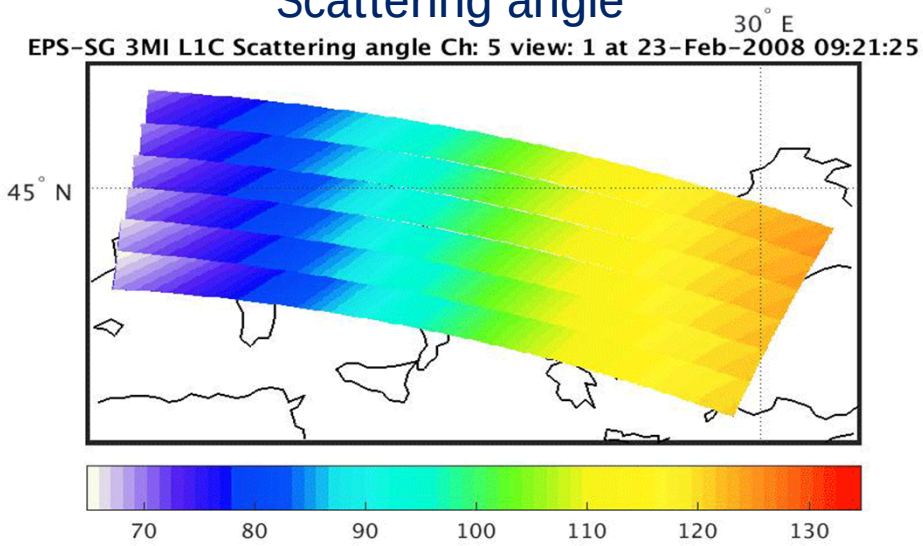
Co-located on the 3MI detector grid per view (14 views of CFR) – presented here!

EUMETSAT

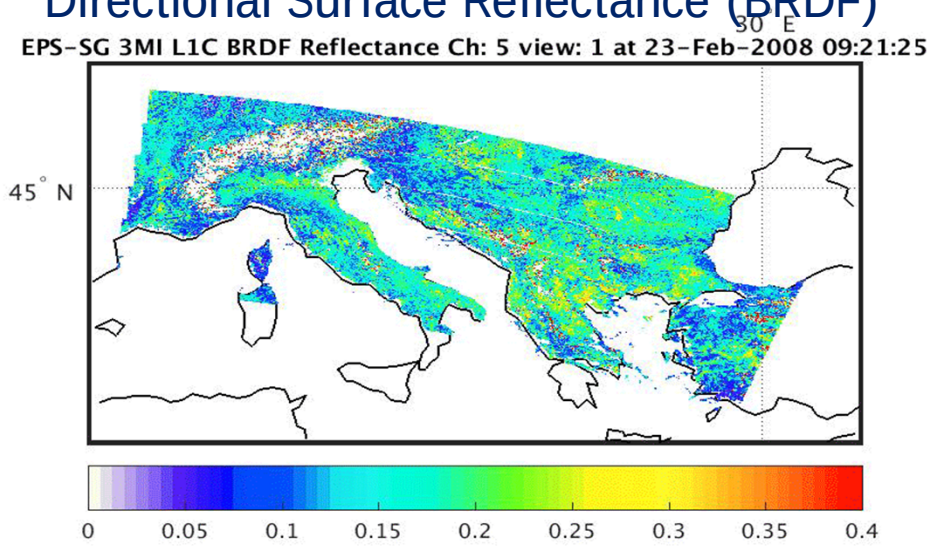
3MI level 2 surface (BRDM) product

RSP – AC team prototyping activities – Breon and Maignon EUM study

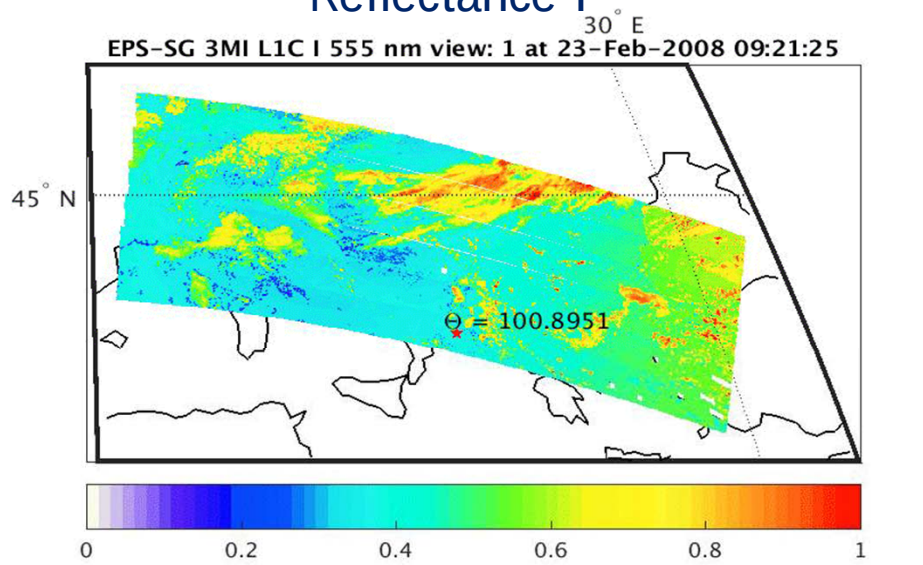
Scattering angle



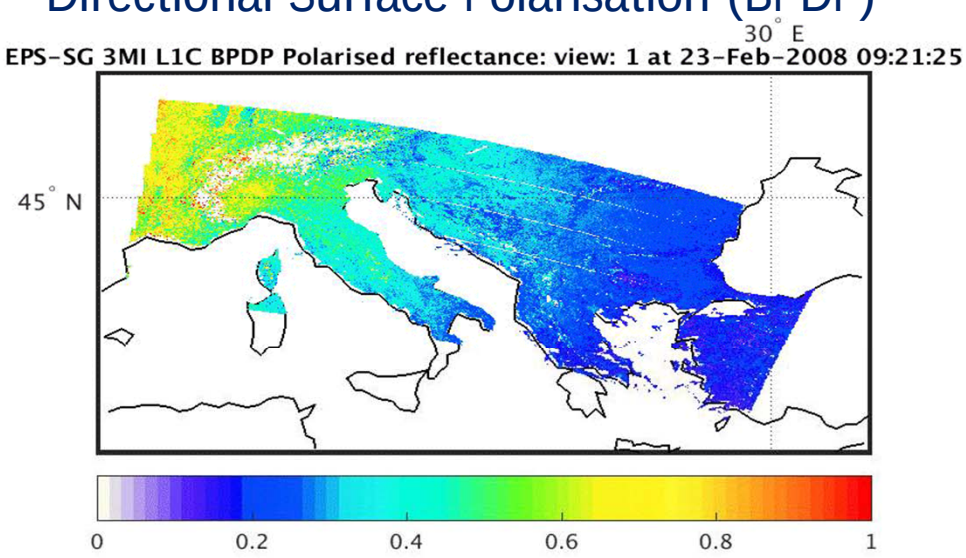
Directional Surface Reflectance (BRDF)



Reflectance I



Directional Surface Polarisation (BPDF)



3MI Level 1C proto-type results, v2

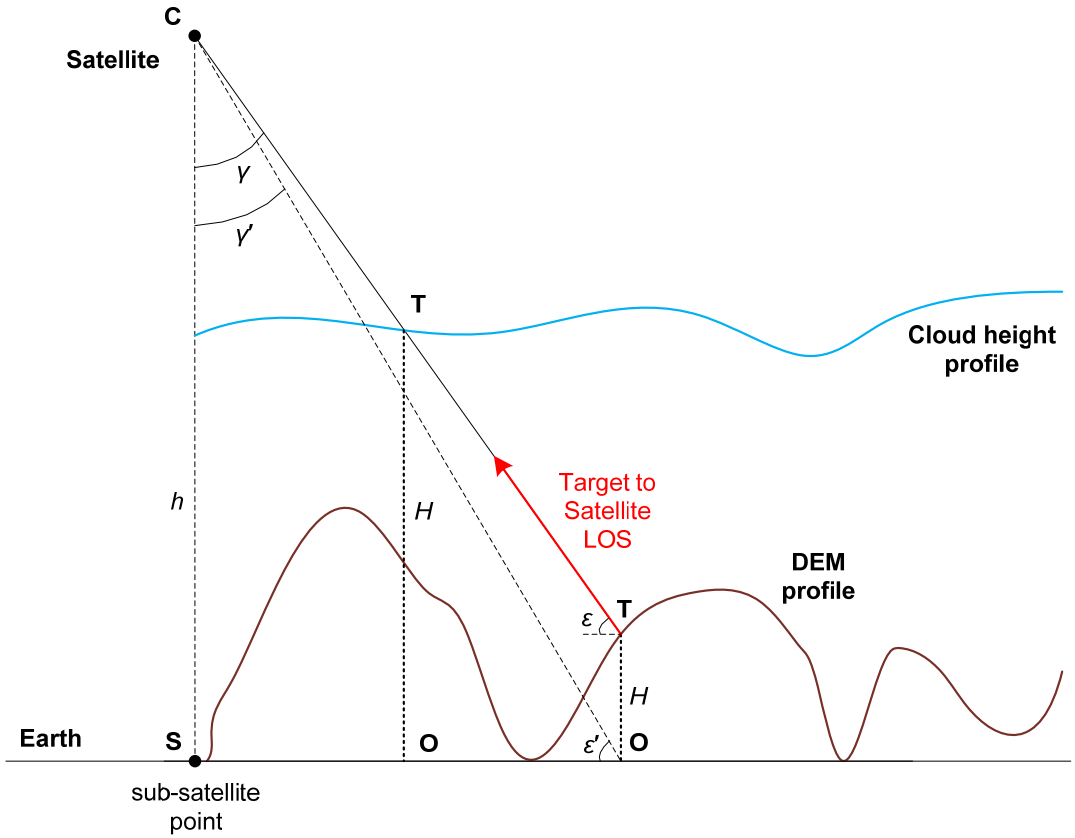
3MI Level 2 BRDM proto-type results, v2

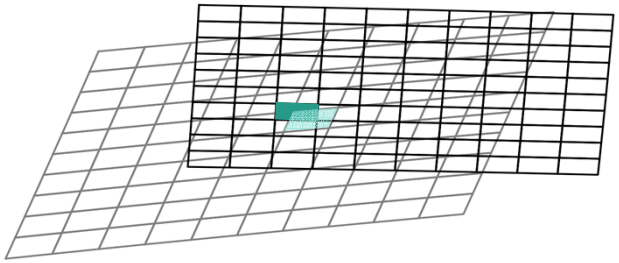
3MI L1C proto-type version2 results
Parallax correction

Parallax correction is done using VII ch. 555, 865 and 2300 radiance and cloud mask information:

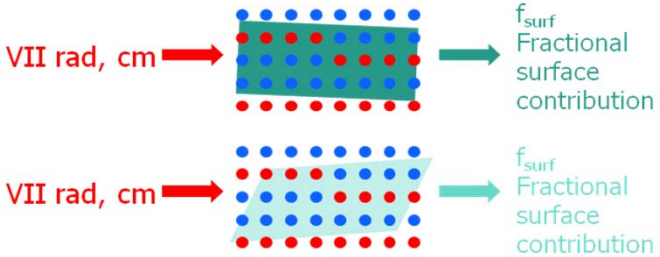
Calculation of dominant signal surface/cloud in 3MI pixel (threshold 50%; default)

3MI to VII ch mapping as for inhomogeneity is [0 0 0 0 1 1 1 2 2 2] (default)





Input:
VII radiance and cloud mask information



Fractional surface contribution of signal per 3MI ground pixel

If f_{sub} < 50% use CTH
If f_{sub} > 50% use DEM

EUMETSAT

3MI L1C proto-type version2 results
Parallax correction

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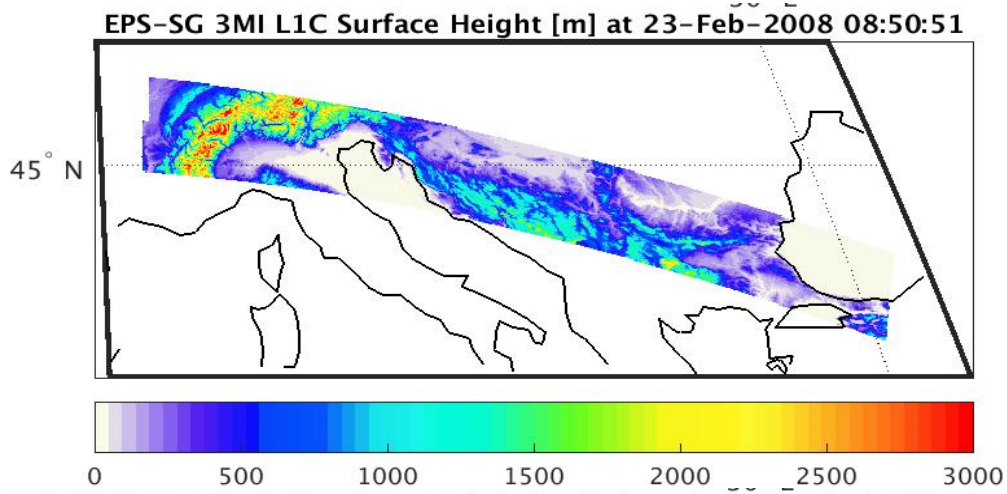
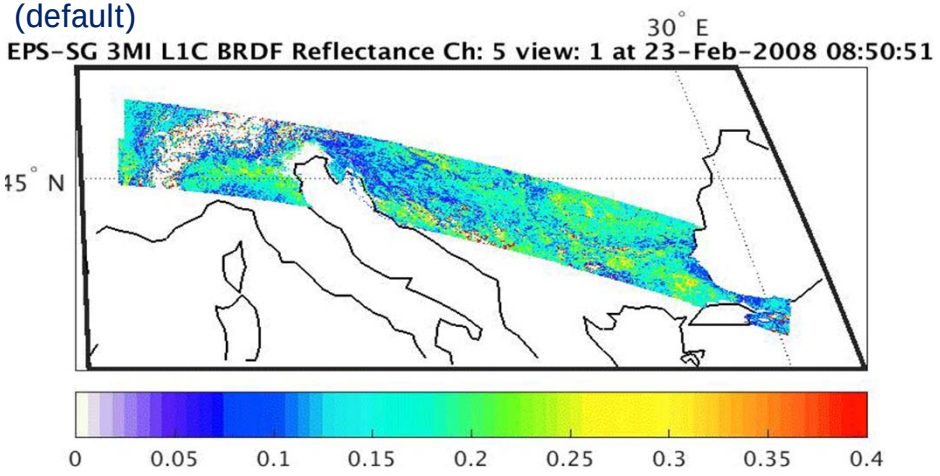
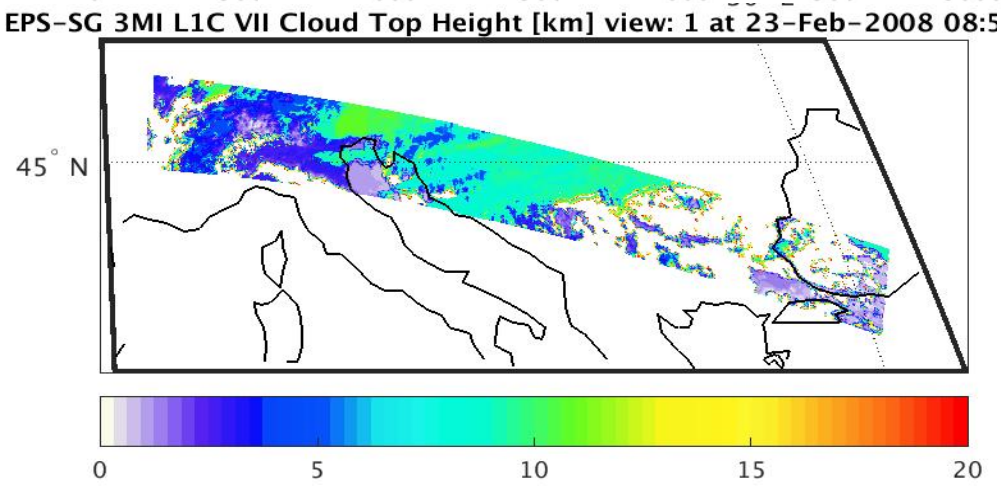
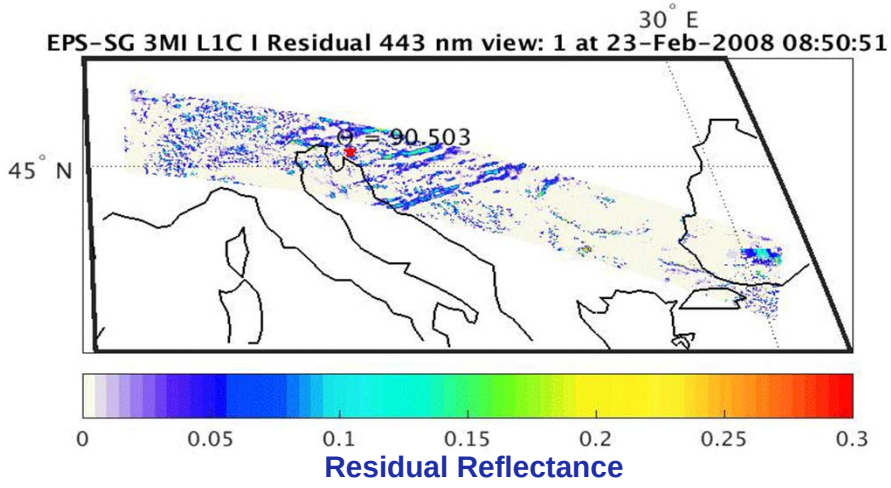


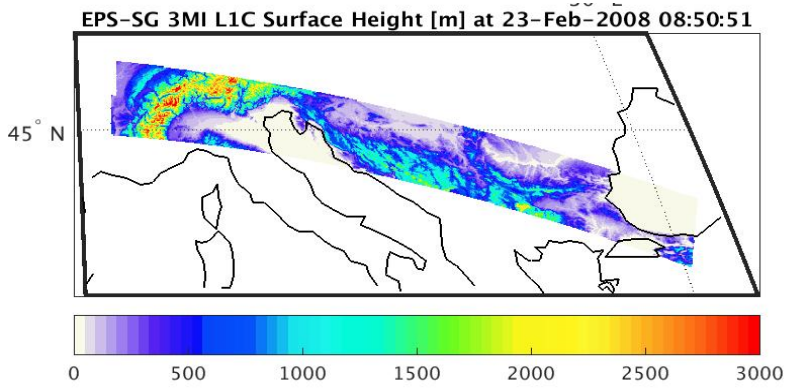


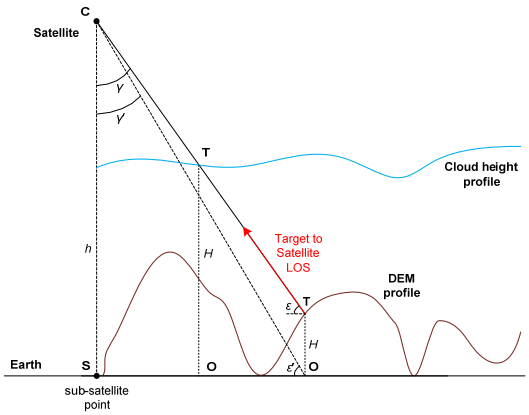




3MI L1C proto-type version2 results

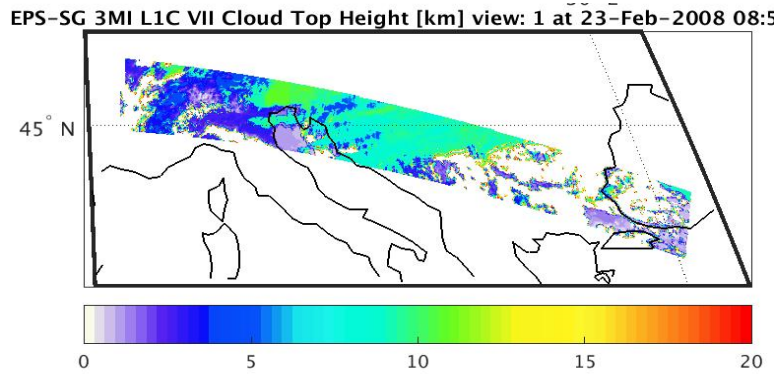
Parallax correction

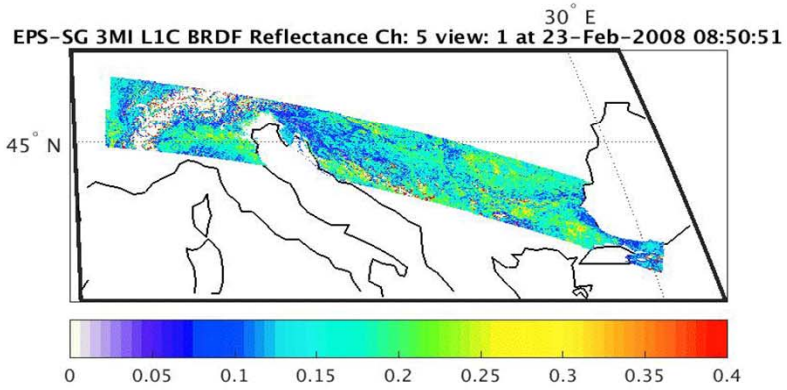


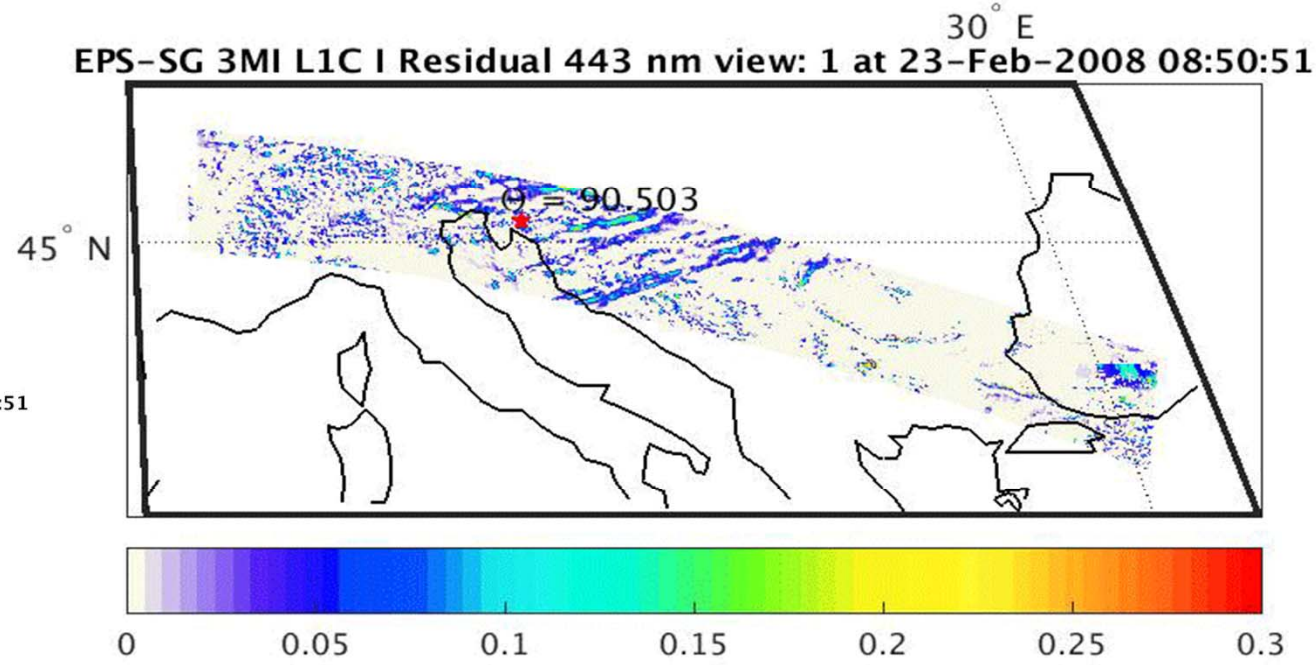


Fractional surface contribution of signal per 3MI ground pixel using VII radiances and cloud mask information

If f_{sub} > 50% use CTH
If f_{sub} < 50% use DEM







Residual Reflectance

EPS-SG: Towards an EPS-SG hyper-instrument

3MI/S5/IASI-NG/VII -

Combining co-locations of VII/Sentinel5/IASI-NG observations with co-registered multi-viewing observations (3MI) on 3MI multi-viewing fixed grid.

EPS-SG Platform

Sentinel-5
UV-Vis-SWIR hyper spectral sounder

IASI-NG
IR hyper spectral sounder

VII
Very high spatial resolution,
multi channel imager

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

Co-location and co-registration

EPS-SG hyper-instrument

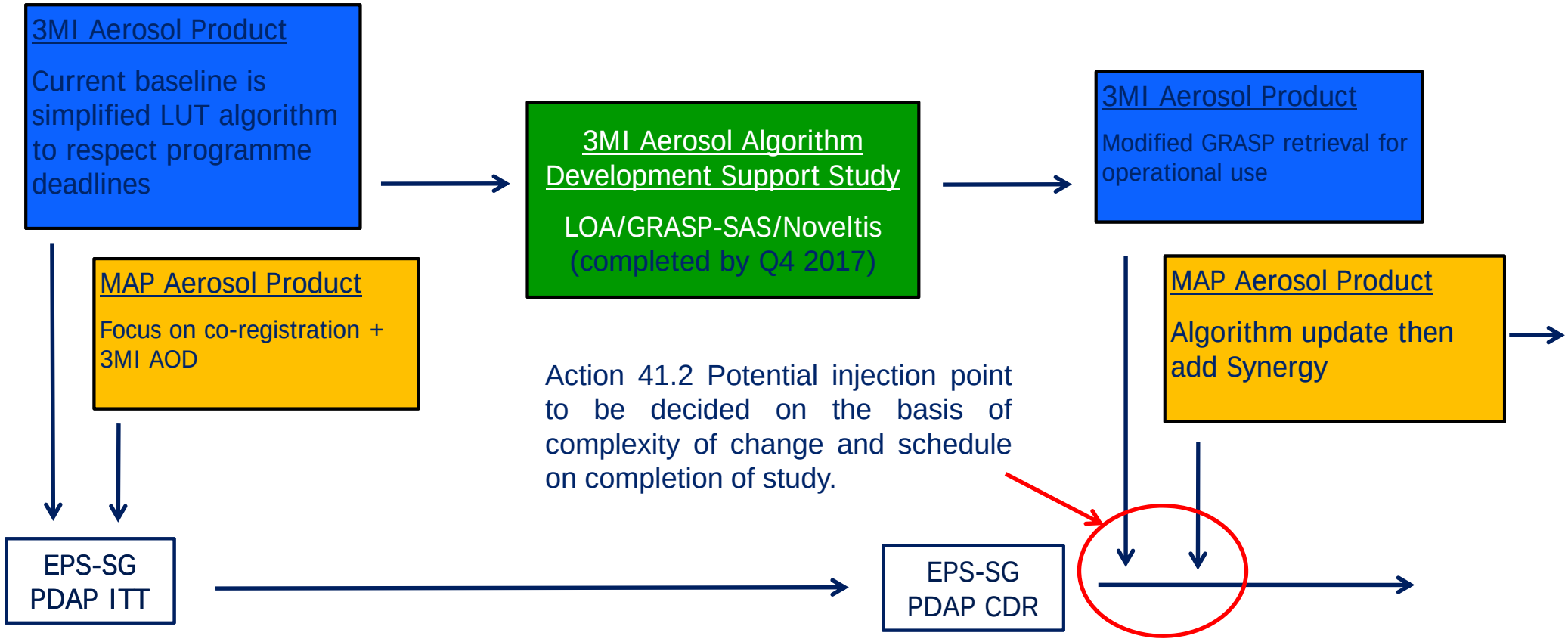
0.29 – 15μm
0.5 – 7 km^2
~ 19000 channels

Initial product: Multi-sensor Aerosol product (MAP)

AC team overall aerosol road-map (presented to STG/SWG, March 17)

Polarimeter & Multi-mission 3MI (*and MAP*)

- Strong POLDER heritage with the GRASP algorithm well adapted to POLDER
- GRASP has not been used for NRT production of POLDER data
- 3MI has higher spatial resolution and a much larger swath (and therefore data rate) than POLDER
- Adaptation needed



Thank you

Product delivery features:

- Near real time 3 minutes granules, maximum 3 hours after sensing time

→ *Available via EUMETCast in netcdf4.*

- Full orbit offline data. Available from the EUMETSAT archive

→ http://archive.eumetsat.int *EPS native and netcdf4.*

- AOD, volcanic ash flag

Version1 (water only)
Start of dissemination:
29th April 2014
Version 2.0 (water and land)
Start of dissemination:
17th April 2016
Version 2.1 (water and land)
Start of dissemination:
23rd February 2017

Documentation (user guide):
www.eumetsat.int > Data > Technical documentation > Metop > PMAp

EPS-SG UVNS Sentinel-5

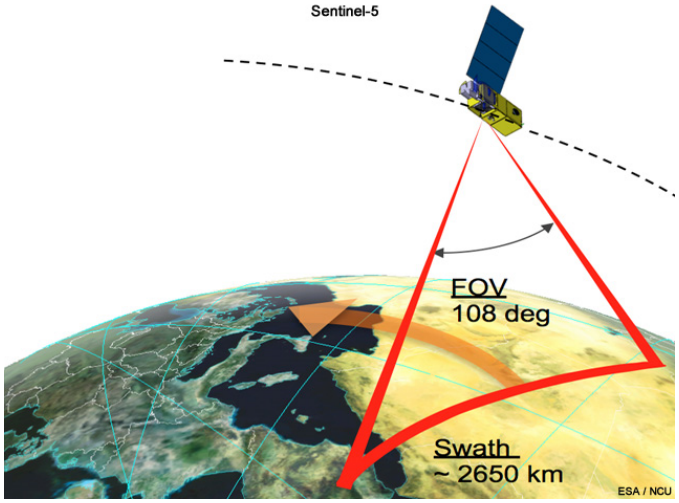
UV-NIR-SWIR hyper spectral instrument from low-earth polar orbit

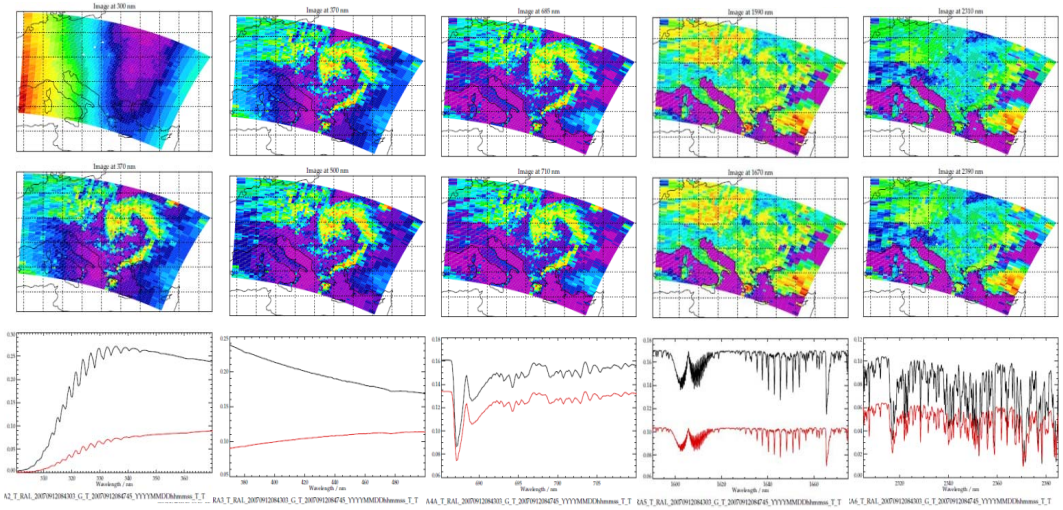
- Sentinel-5 will build on the heritage from the GOME/SCIAMACHY/GOME-2/OMI series of instruments and will provide continuity with these instruments

- The spatial resolution will be significantly improved compared to previous missions (~ 7 x 7 km at SSP), which is important to support development of air quality applications

- Sentinel-5 level 1 and 2 products will be produced operationally by EUMETSAT

- Products: O3, NO2, SO2, HCHO, CH4, CO, CHOCHO, UV, AAI, AOD, ALH, CLD, HSC, SUR





EUMETSAT

MTG-S UVN Sentinel-4

UV-NIR hyper spectral instrument from geostationary orbit

- Sentinel-4 has heritage from the GOME/SCIAMACHY/GOME-2/OMI series of instruments
- Primary focus is the monitoring of air quality in the European domain with high spatial and temporal resolution
- The spatial resolution will be ~ 8 x 8 km with hourly temporal resolution
- Sentinel-4 level 1 and 2 products will be produced operationally by EUMETSAT
- Products: O3, NO2, SO2, HCHO, (CHOCHO), UV, AAI, AOD, ALH, FCI support, CLD, HSC, SUR

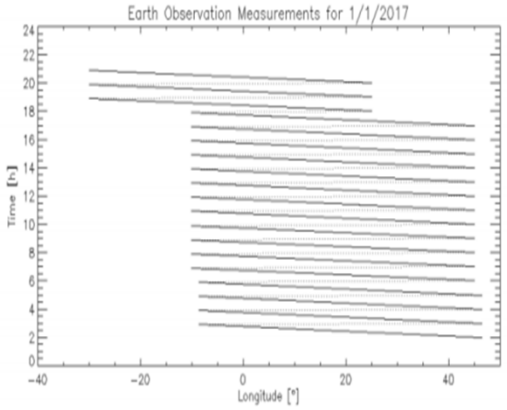
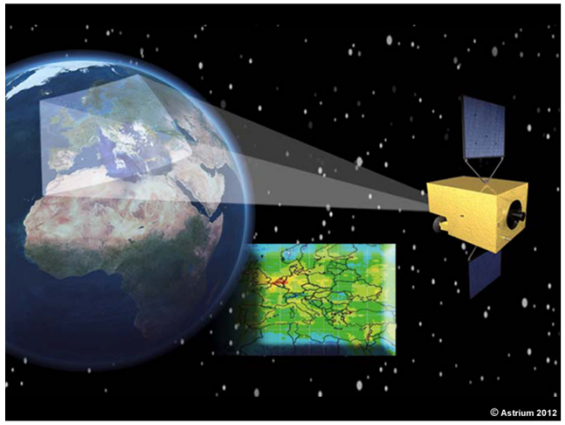


Figure 9-2: Possible UVN scanning scheme



An example of a single scan line is provided in Figure 4-13.

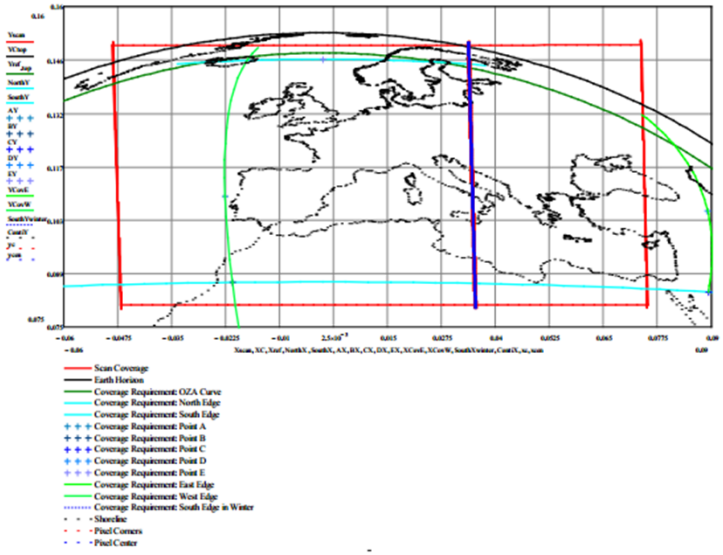


Figure 4-13: Scan coverage (red) and a single scan line (at an x-coordinate of about 0.035, corners: red, center: blue) in normalized GEOS projection.

EUMETSAT

PMAp: AOD retrieval
Volcanic ash detection

Algorithm 1 - AVHRR & GOME-2

over OCEAN & LAND

- **BT(10.8 µm – BT(12 µ) < - 2.2 °K**
  coarse absorbing particles

over OCEAN

- **R(AVHRR_chVIS) / R(AVHRR_chNIR) > ths**
  relative spectral flatness

over LAND (in-progress)

- GOME UV Absorbing index

Algorithm 2 - IASI

over OCEAN & LAND

BT(10µm) – BT(12µm) < - 1.0 °K

AND

BT(IASI_bckg ch) – BT(IASI_ν_3 SO_2 abs ch) > 2.0 °K

volcanic ash / thick dust

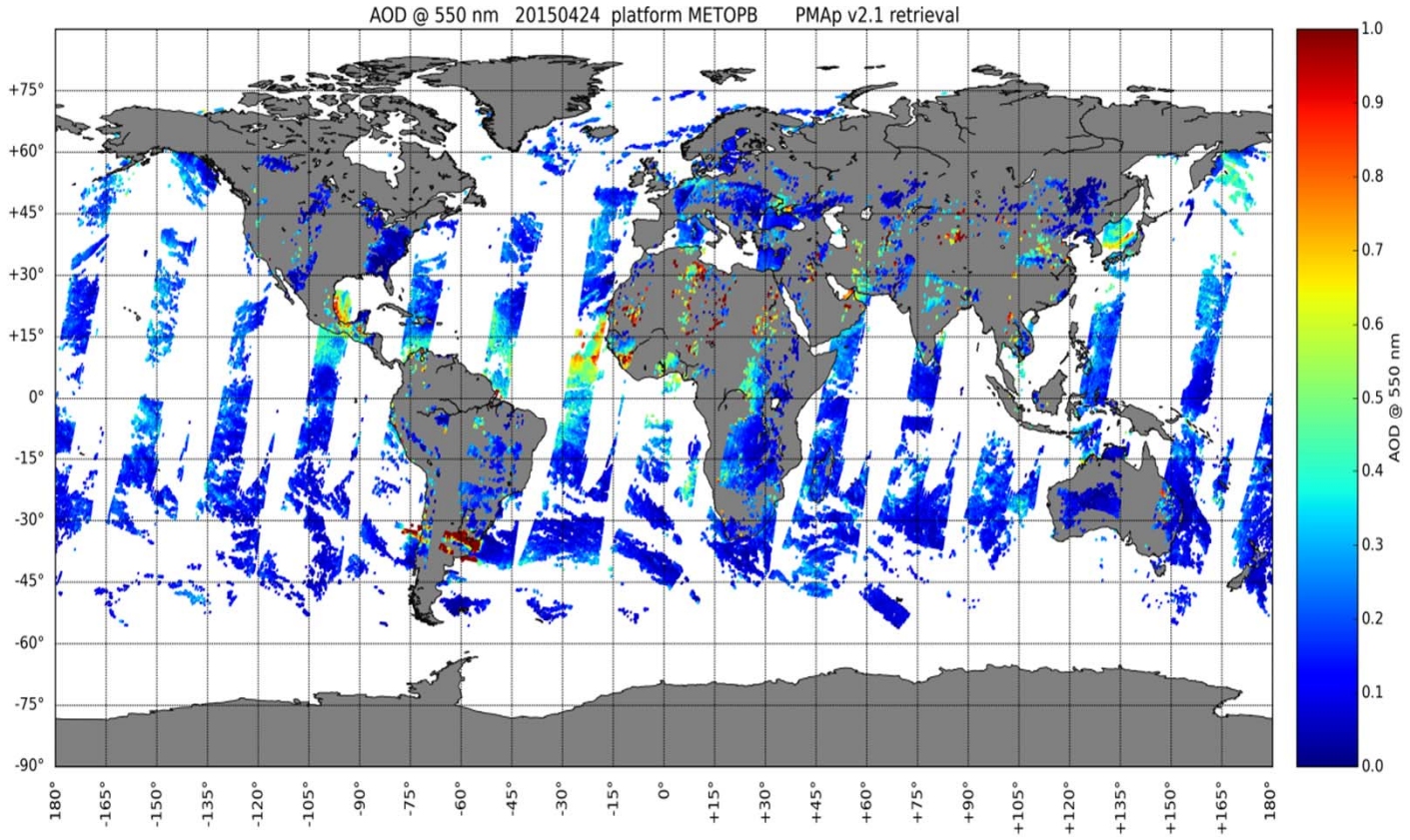
volcanic ash with SO_2

Flag ASH

PMAp: AOD retrieval
Retrieval over land & ocean

24 April 2015

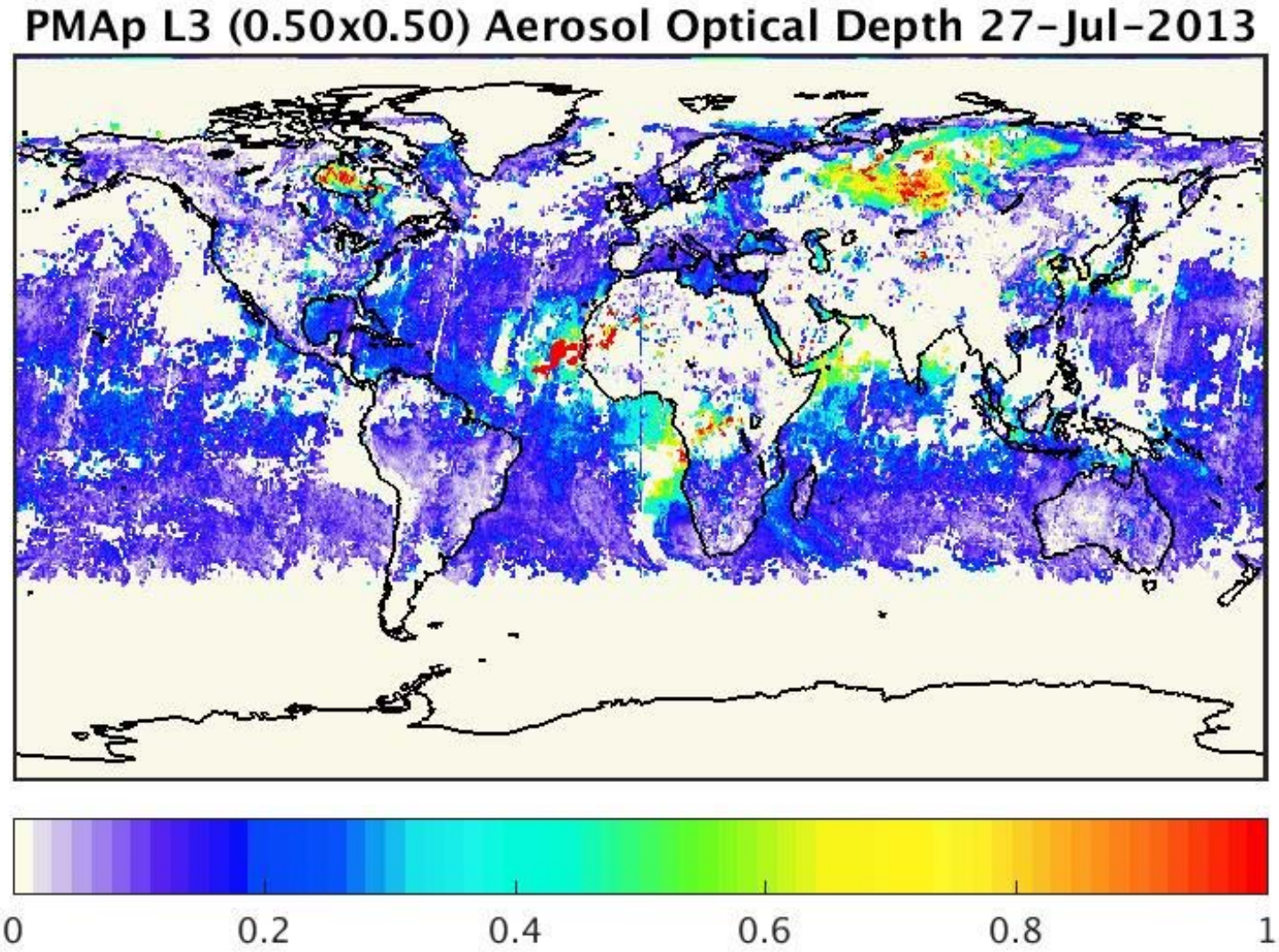
AOD @ 550 nm



Calbuco volcano (South Chile)
eruption begun on 22 April 2015

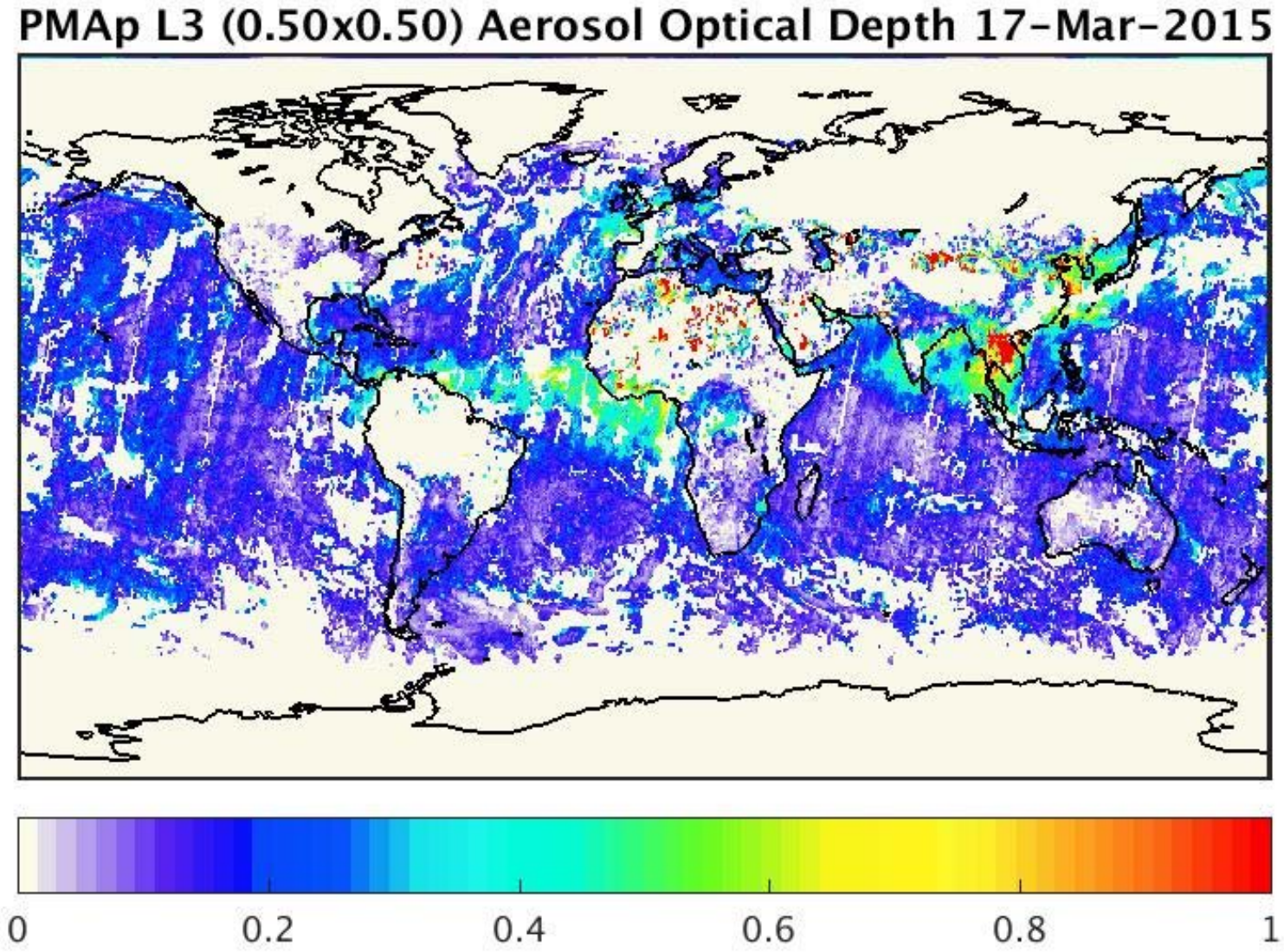
PMAp AOD results

Version 2 L3 gridded results – 1 day Metop-A & B



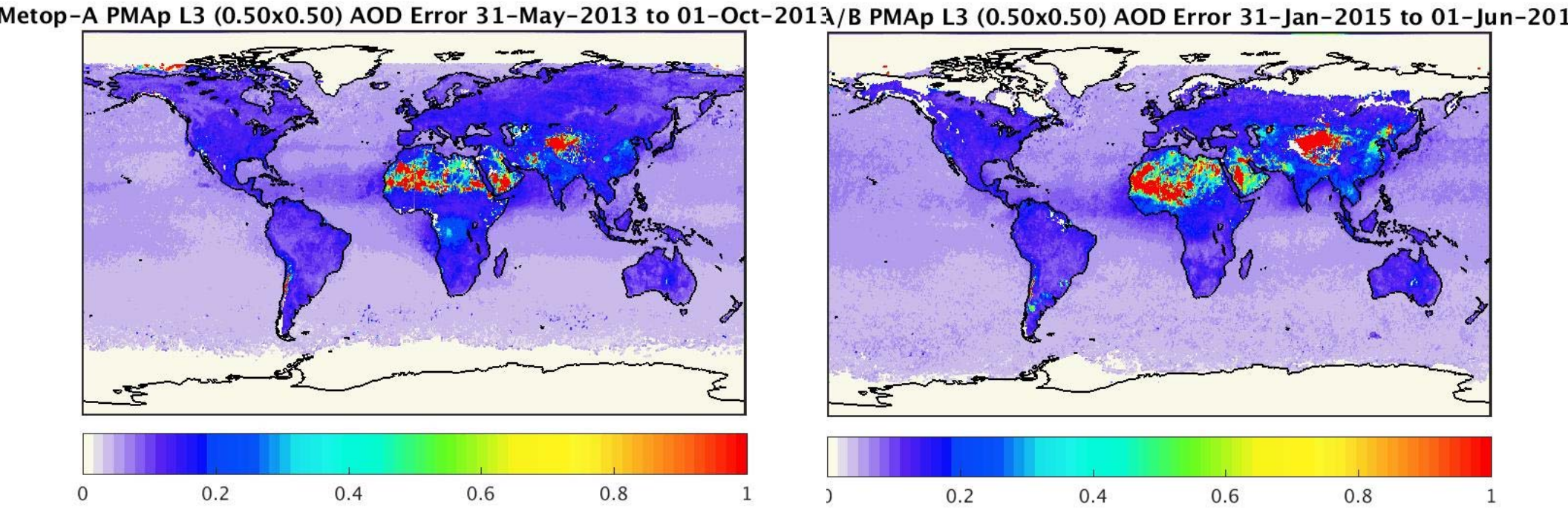
PMAp AOD results

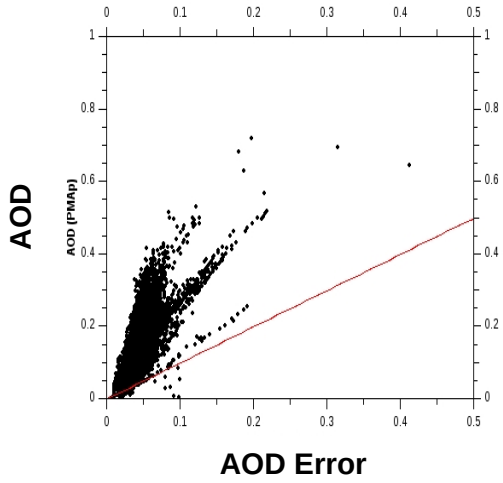
Version 2 L3 gridded results – 1 day Metop-A & B

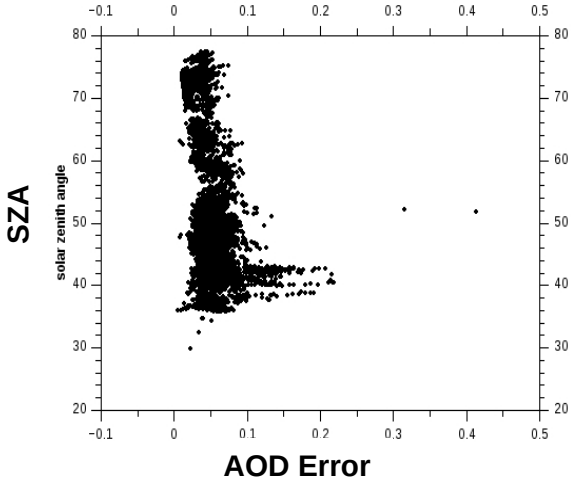


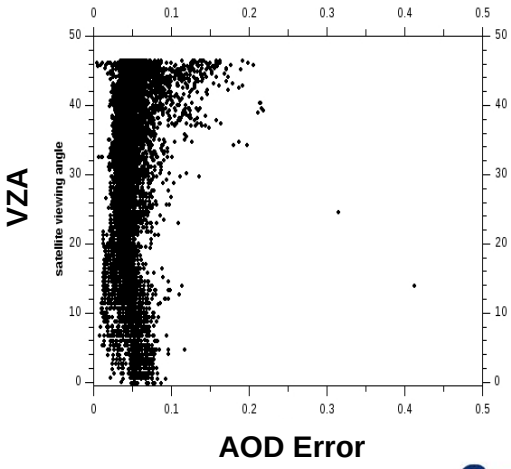
PMAp AOD randomized error estimates

Version 2 L3 gridded results – Summer 2013 and Winter 2015 – Metop-A





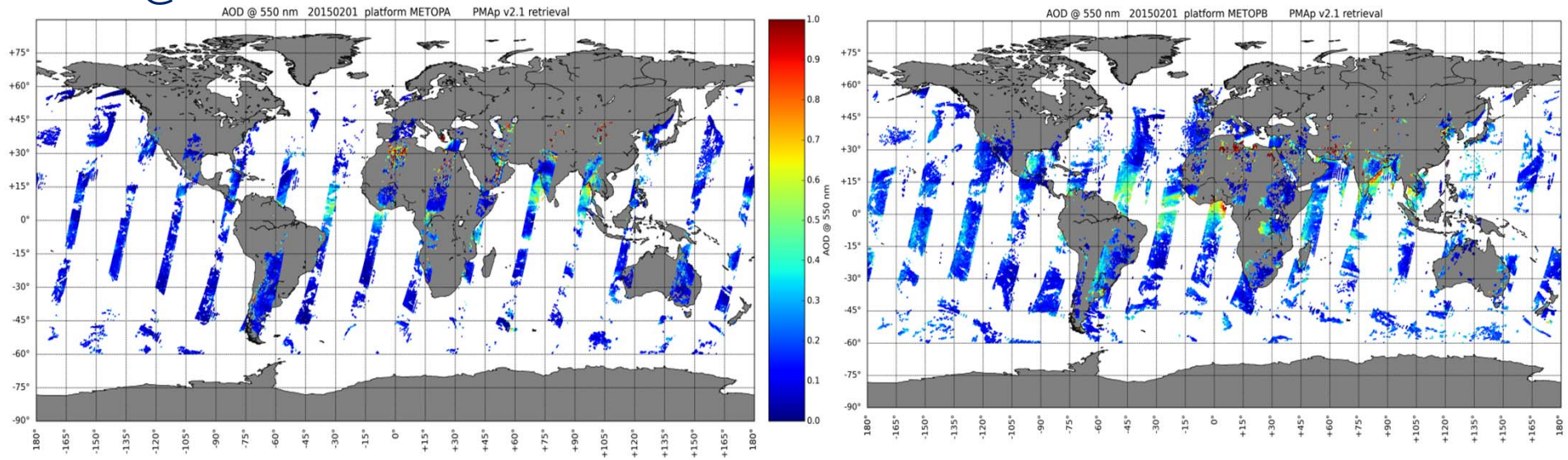




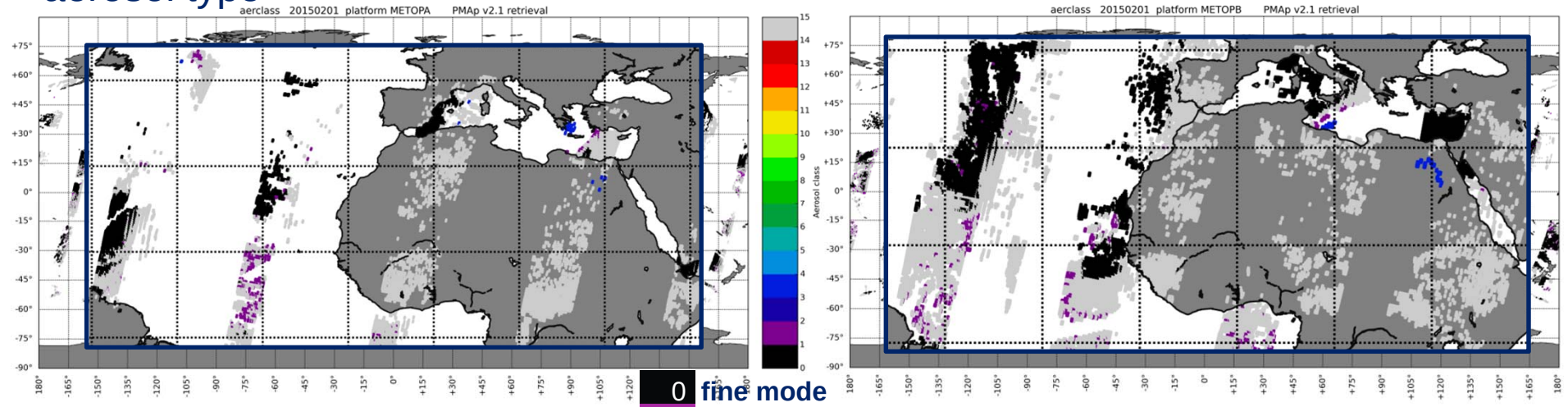
PMAp: AOD retrievals
Aerosol type

AOD @ 550 nm

1st February 2015



aerosol type

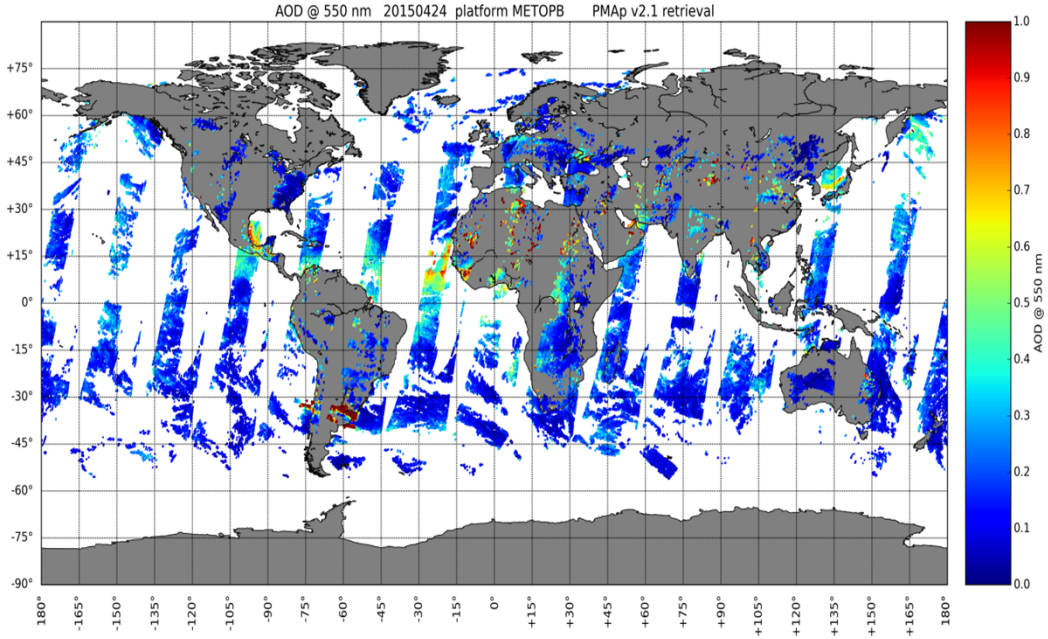


0 **fine mode**
1 **coarse mode**
3 **volcanic ash / thick dust**

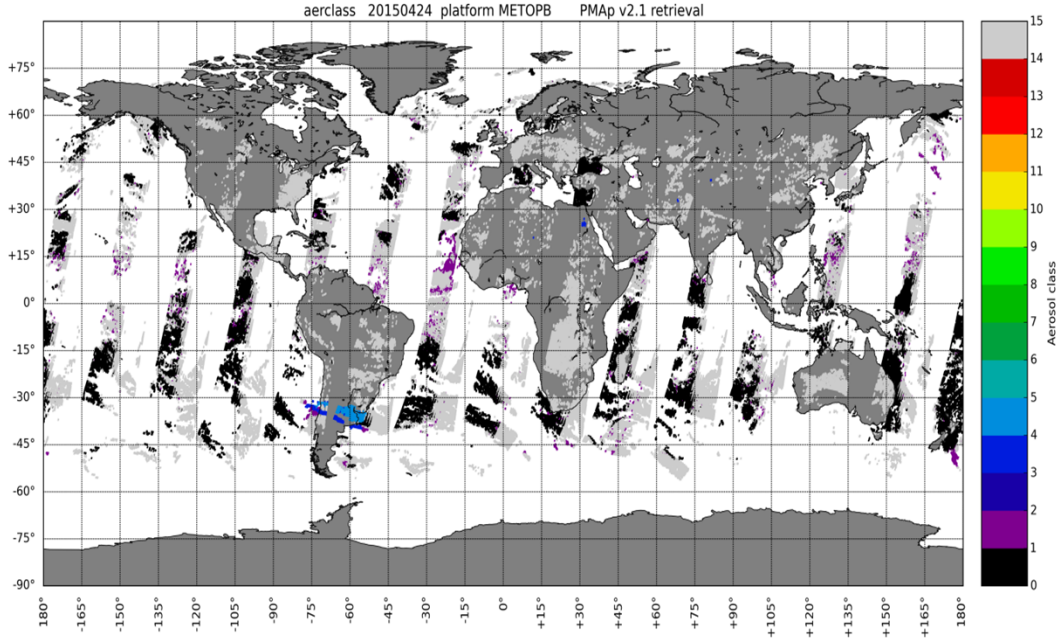
PMAp: AOD retrievals
Aerosol type

AOD @ 550 nm

April 24, 2015



aerosol type



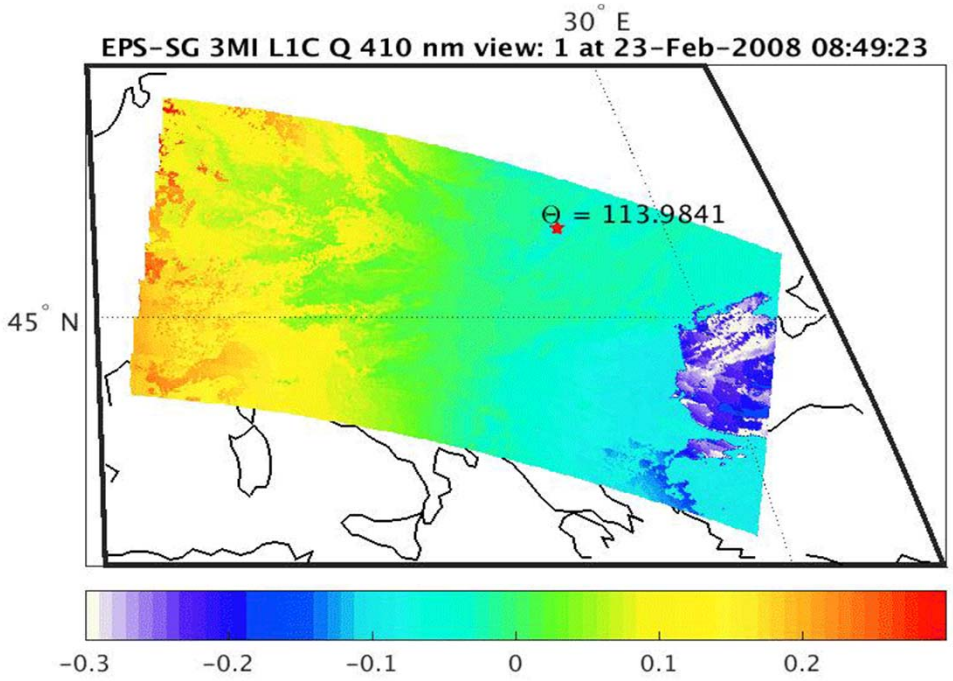
Calbuco volcano (South Chile)
eruption begun on April 22, 2015

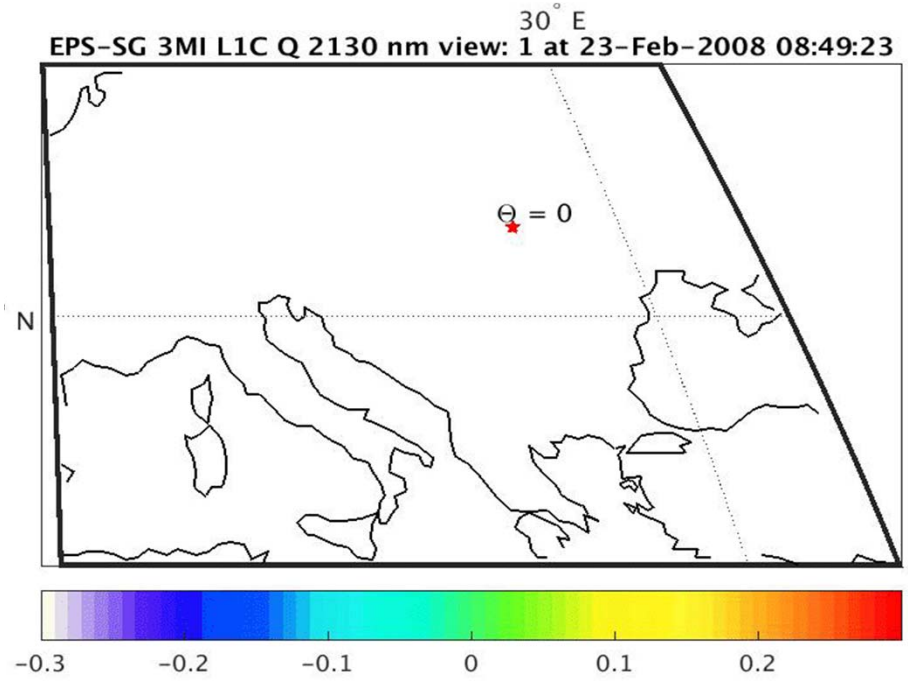
0 fine mode
1 coarse mode
3 volcanic ash / thick dust
4 volcanic ash with SO_2

EUMETSAT

3MI L1C proto-type version2 results

L1C EUM proto-type v2 – VNIR/SWIR co-registration – Q (410/2130 nm)

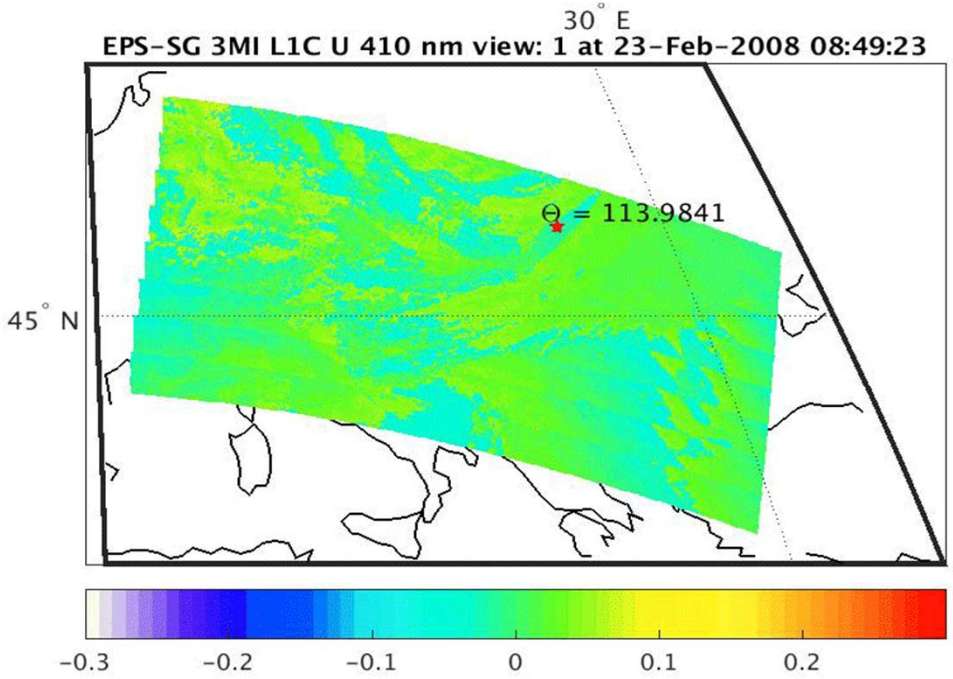


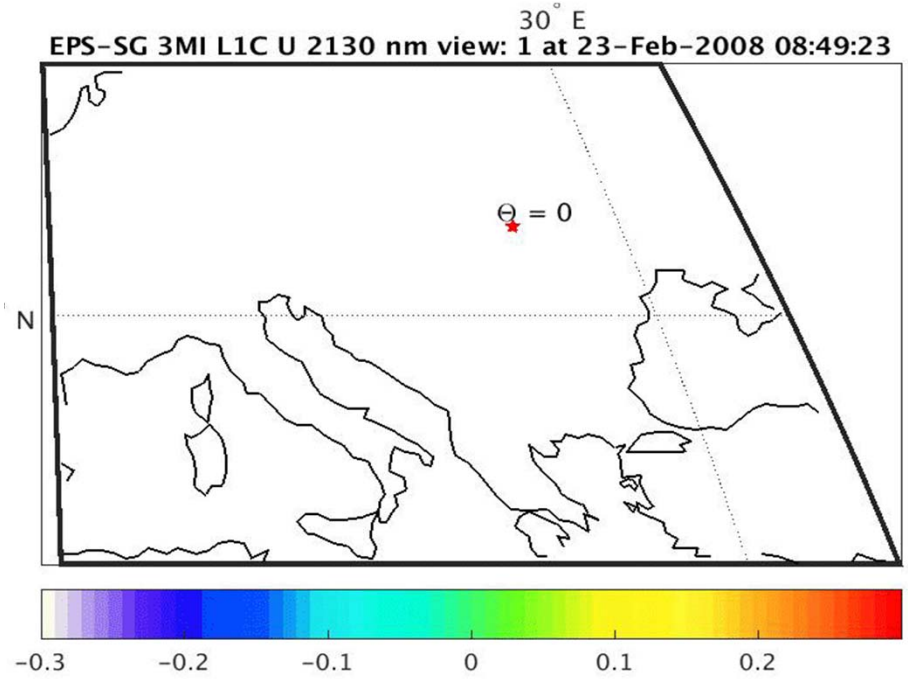


EUMETSAT

3MI L1C proto-type version2 results

L1C EUM proto-type v2 – VNIR/SWIR co-registration – U (410/2130 nm)

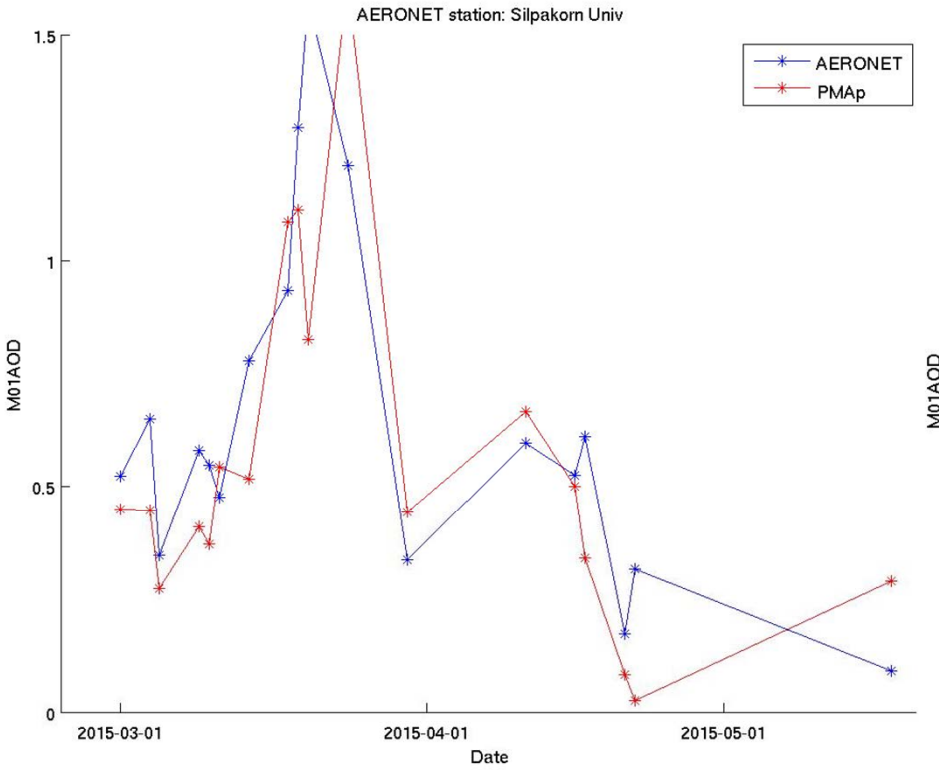




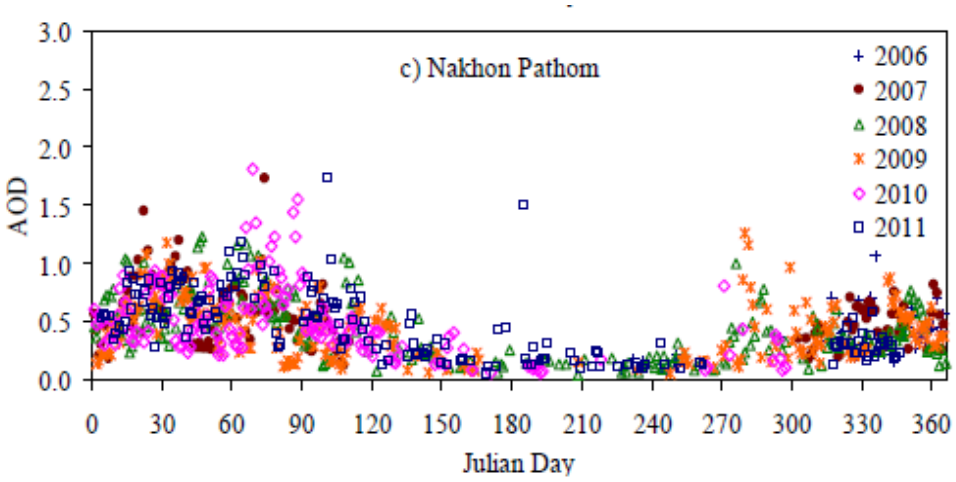
EUMETSAT

PMAp version 2 validation at EUMETSAT

Operational validation with AERONET 1.5 weekly data



Time series of the AOD at 550 nm for valid AERONET site (left panel) site and at te Asc compared to the AOD retrieved from METOP-B.



the Silpakorn University, the AOD has a strong seasonal dependence with maxima in the dry season - from November to April – and minimum values from May to October. This is mainly due to the typical biomass burning activities carried out in the northern part of the country from January to April combined with the northeasterly winds dominating the measurements area
[Bridhikitti and Overcamp, 2011; Janjai et al. 2012].

PMAp version 2 LUT

Developed by O. Hasekamp / AC SAF – SRON/KNMI

Aerosol model	*Eff. Radius liquid*	*Eff. Radius solid*	*Eff. Variance small*	*Eff. Variance large*	f_l	m_r	m_i	*Aerosol type*
1	0.11	0.84	0.65	0.65	1.53e-2	1.40	-4.0e-3	oceanic
2	0.12	2.19	0.18	0.81	4.36e-4	1.40	-4.0e-3	industrial
3	0.13	2.24	0.50	0.81	4.04e-4	1.40	-4.0e-3	industrial
4	0.21	2.50	0.18	0.81	8.10e-4	1.45	-4.0e-3	industrial
5	0.14	2.15	0.22	0.62	7.00e-4	1.45	-1.2e-2	industrial
6	0.15	2.26	0.22	0.62	6.84e-4	1.45	-1.2e-2	industrial
7	0.18	2.69	0.22	0.62	6.84e-4	1.45	-1.2e-2	industrial
8	0.12	2.43	0.20	0.87	1.70e-4	1.50	-1.0e-2	biomass
9	0.15	2.70	0.20	0.87	2.06e-4	1.50	-1.0e-2	biomass
10	0.20	3.42	0.20	0.87	2.94e-4	1.50	-1.0e-2	biomass
11	0.11	2.52	0.17	0.70	2.07e-4	1.50	-2.0e-2	biomass
12	0.12	2.67	0.17	0.70	2.05e-4	1.50	-2.0e-2	biomass
13	0.14	3.28	0.17	0.70	1.99e-4	1.50	-2.0e-2	biomass
14-18	0.10	1.60	0.32	0.42	4.35e-3	1.53	See Figure 2	dust
19-28	Same as model 7-16 with altitude 3-4km (model 0-18: altitude 1-2km)							