PMAp v.2 .2
Aerosol Optical Properties operational retrieval at global scale

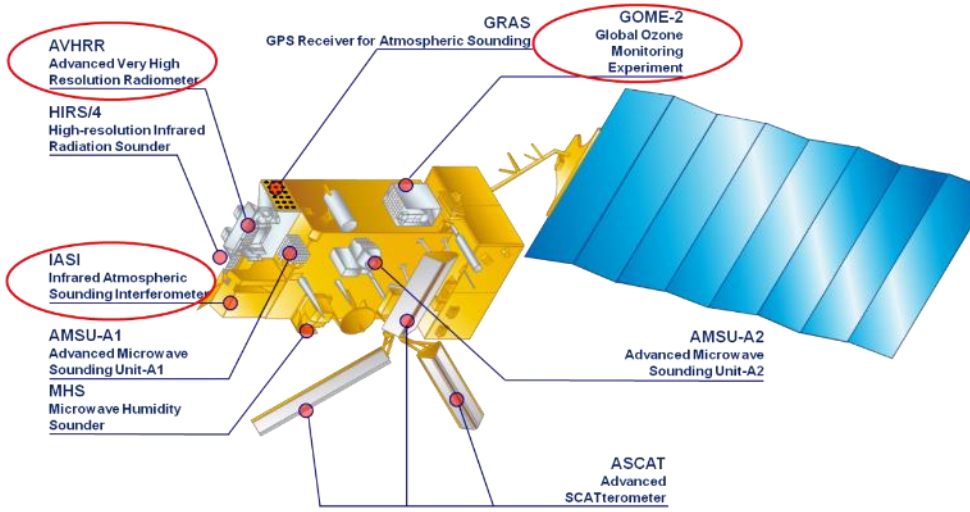
R. Lang, A. Cacciari, A. Holdak, M. Grzegorski, R. Munro, B. Fougnie J. Chimot, R. Lindstrot, G. Poli, R. Huckle, N. Hao, S. Gimeno Garcia

OUTLINE

- Sensors' characteristics and PMAp Aerosol product
- PMAp retrieval algorithm: current operational version 2.1
- New release: version 2.2
  - Impact of the new features
    - IASI IR spectral information for improved ash and dust detection
    - degradation correction for GOME-2 PMD radiances
  - AERONET Validation outcome
- What's next

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

- AOD @550nm over land & water 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

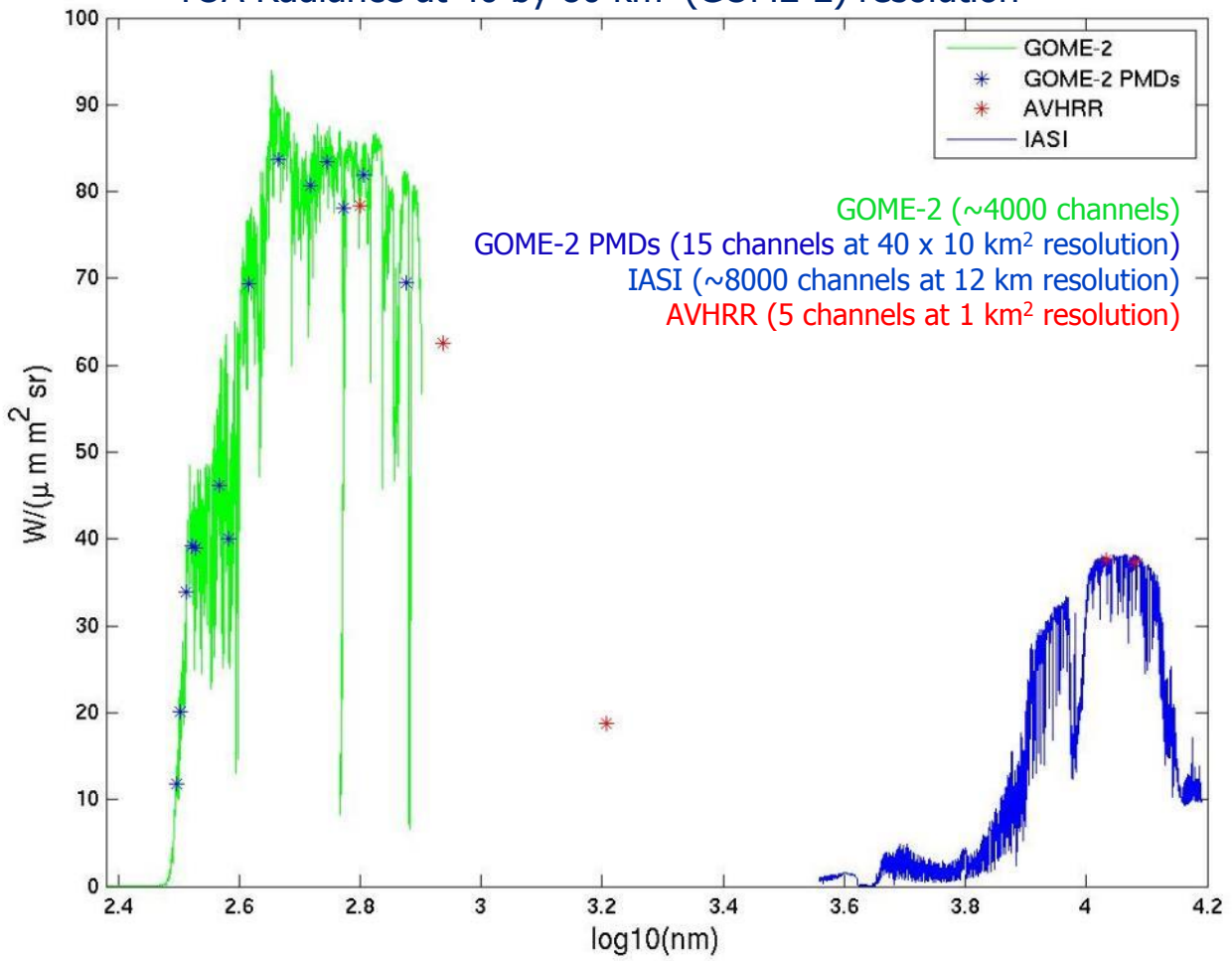


PMAp/A & PMAp/B v2.1 over ocean and land assimilated by CAMS

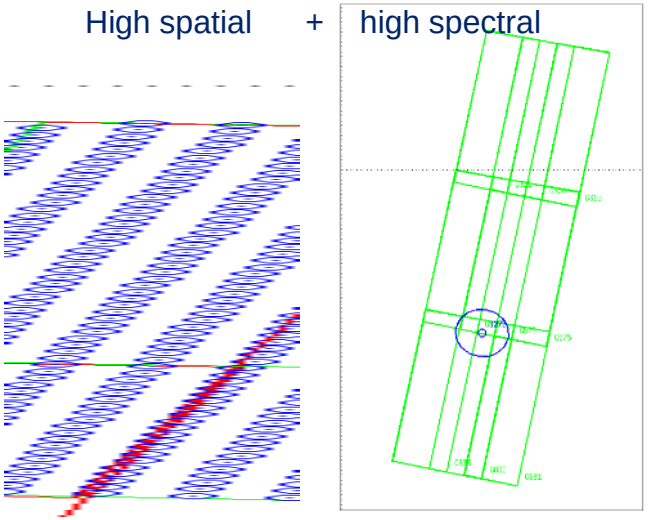
PMAp: creating a hyper-instrument

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

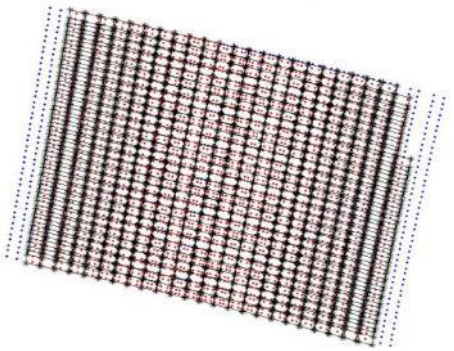
TOA Radiance at 40 by 80 km^2 (GOME-2) resolution



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 input data

➢ METOP Level-1 data

Instrument	Spatial resolution	Spectral range	comments
GOME PMD	10 x 40 km Metop-B 5 x 40 km Metop-A	311nm-803nm, 15 bands	AOD, aerosol type, AAI Stokes fraction (polarization)
AVHRR	1.08 x 1.08 km	580nm-12500nm, 5 bands	Clouds, scene heterogeneity, dust/ash
IASI	12km (circular)	3700–15500nm, resolution 0.5 cm^{-1}	volcanic ash, desert dust, aerosol heights

➢ Auxiliary data & static DB

Data		Pourpose	comments
ECMWF forecast	- Wind speed - Surface pressure	- ocean reflection parameterization - Rayleigh scattering over land	temporal interpolation
Surface Reflectance DB GOME2 LER DB (angular dependent)		- over land retrieval	Minimum LER (from G.Tilstra, KNMI)
Surface elevation DB E-TOPO5		- over land retrieval	
RT data LUT - TOA Reflectance and Stokes fraction for 28 aerosol models		- RT calculation interpolation	Hasekamp et al., 2008

PMAp AOP retrieval algorithm design

v 2.1 current operational release

Cloud / Aerosol Discrimination

- **Volcanic Ash Detection**
  10 set of thresholds tests AVHRR + IASI BTDs tests → Ash presence

- **Clouds' Detection & Correction**
  clouds detection and cloud fraction calculation (CF)
  cloud free PMD Reflectance .OR. PMD Reflectance Correction (for CF < 0.65; partly cloudy pixels)

- **Preliminary Aerosol Type**
  if Ash presence → aerosol type = ash
  VIS/NIR test for Coarse/Fine mode determination

} list of preselected aerosol types

Retrieve AODs

- AODs retrieval for all aerosol models in the LUT
  over water PMD 12 (617.867 - 661.893 nm)
  over land PMD 8 (399.581 - 428.585 nm) or PMD 7 (380.186 - 383.753 nm)

best fit selection

- Microphysics fit : $\chi 2$ minimization of the AODs
  if cloud free: list of preselected aerosol types
  if partly cloud: all aerosol models

} → best {AOD, aerosol type}

- Estimation of error on AOD

PMAp AOP retrieval algorithm design

towards v2.2 – next operational release

Cloud / Aerosol Discrimination

- Volcanic Ash Detection

10 set of thresholds tests AVHRR + IASI BTDs tests → Ash presence

- Desert Dust Detection

IASI dust index → Dust presence

- Clouds' Detection & Correction

clouds detection and cloud fraction calculation (CF)

cloud free PMD Reflectance .OR. PMD Reflectance Correction (for CF < 0.65; partly cloudy pixels)

- 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 for all aerosol models in the LUT

over water PMD 12 (617.867 - 661.893 nm)

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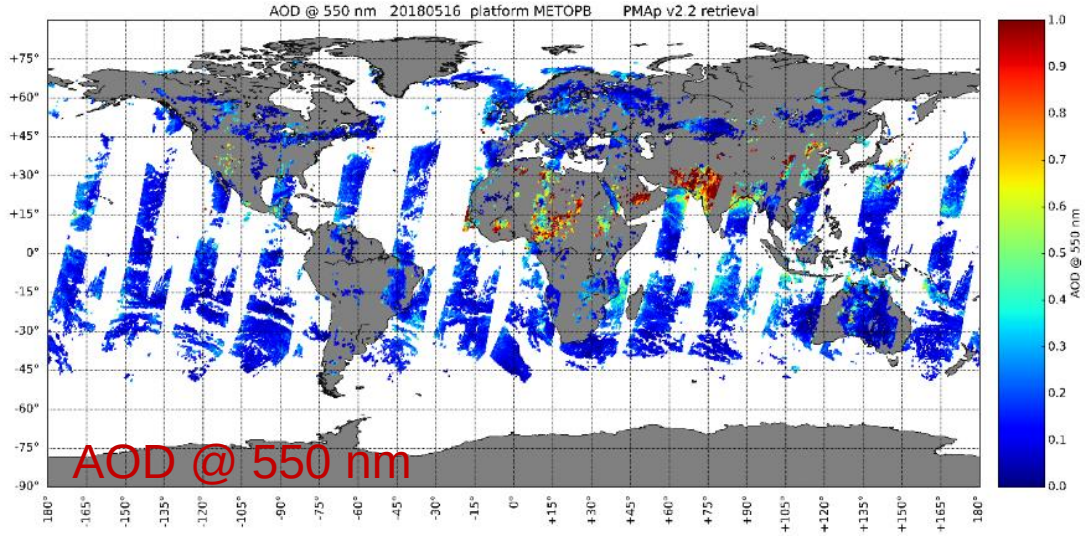
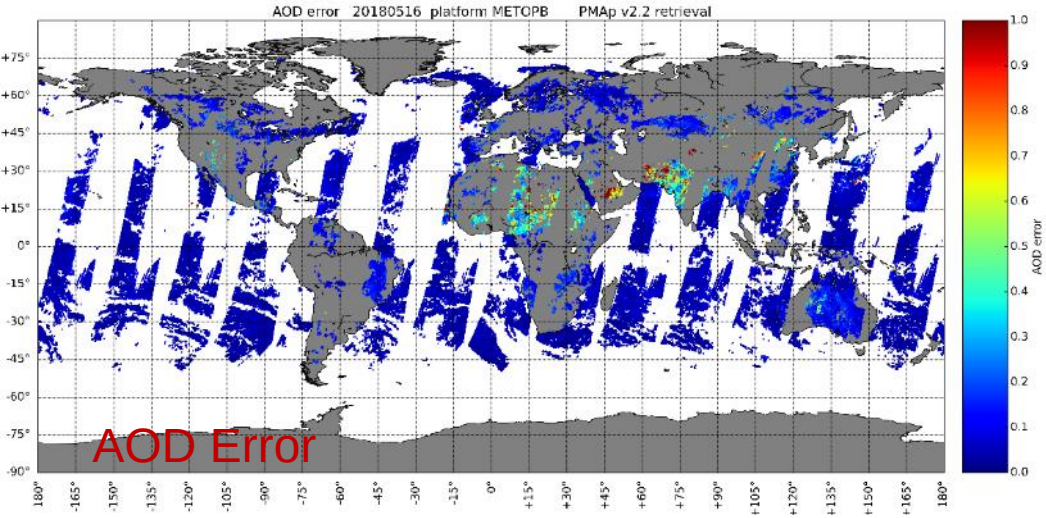
- Estimation of error on AOD

The Polar Multi-sensor Aerosol Product

Operational near-real time products from EPS/Metop

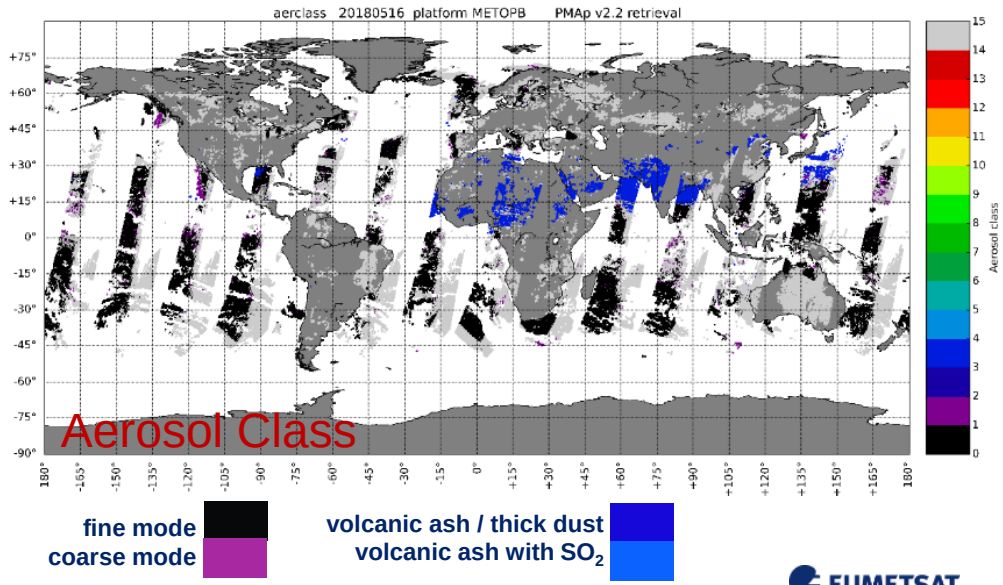
16 05 2018 MetopB





Product delivery features

- **NRT 3 minutes granules**: maximum 3 hours after sensing time - *Available via EUMETCast in netcdf4.*
- **Full orbit offline data** - *Available from the EUMETSAT archive EPS native and netcdf4.* http://archive.eumetsat.int



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PMAp v.2.2 AOP retrieval

Dust detection scheme

PMAp AOP retrieval
desert dust detection

Unified approach to detect aerosol type exploiting the IR spectral range

Distance approach

Atmos. Chem. Phys., 13, 2195–2221, 2013
www.atmos-chem-phys.net/13/2195/2013/
doi:10.5194/acp-13-2195-2013

Atmospheric Chemistry and Physics
Open Access

A unified approach to infrared aerosol remote sensing and type specification

L. Clarisse[1], P.-F. Coheur[1], F. Prata[2], J. Hadji-Lazaro[3], D. Hurtmans[1], and C. Clerbaux[3,1]

Set of 'polluted' spectra
ash, dust, same aerosol type

μ_p mean spectra
by RTM simulation $\mu_p = K + \mu_c$
or measured

Set of clear spectra
not affected by aerosol

μ_c mean spectra
S_c clear covariance matrix

$$R_N = \frac{(\mu_p - \mu_c)^T S^{-1}}{\sqrt{(\mu_p - \mu_c)^T S^{-1} (y - \mu_c)}} (y - \mu_c) \geq \text{threshold}$$

Y = measured spectra
G = f (λ, surf_type)
C = bias correction; f (lon,lat)
threshold to be manually tuned

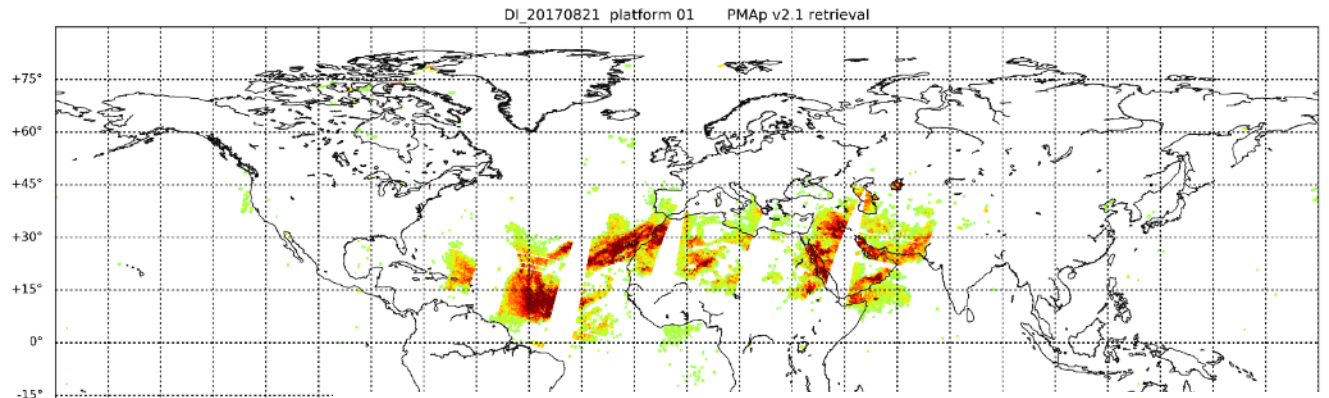
$$R_N = G\ (y - \mu_c) + C \geq \text{threshold}$$

Dust

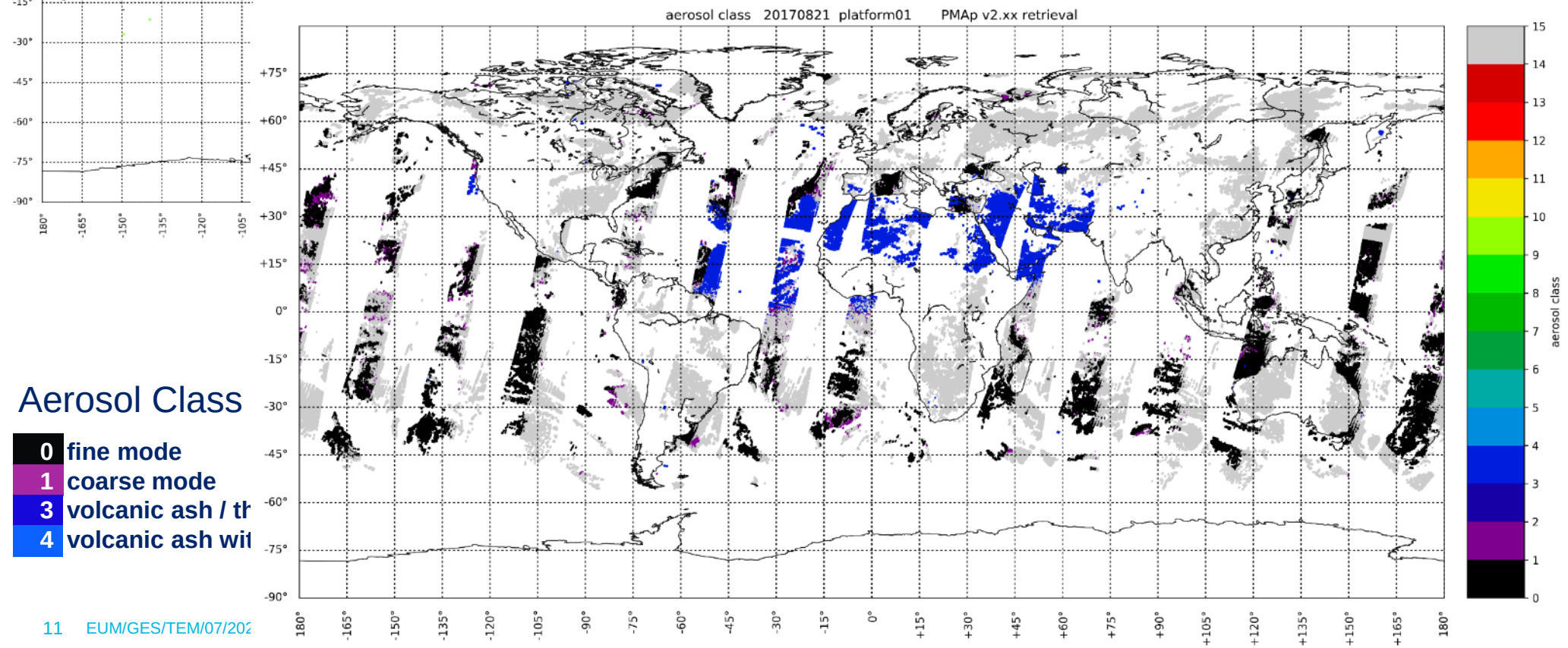
PMAp AOP retrieval

desert dust detection

21 08 2017 MetopB



Dust Index

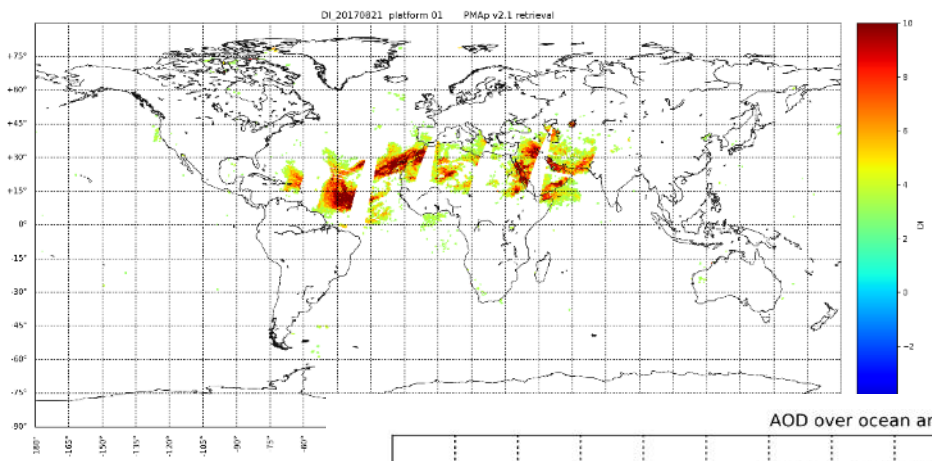


Aerosol Class

0	fine mode
1	coarse mode
3	volcanic ash / th
4	volcanic ash wit

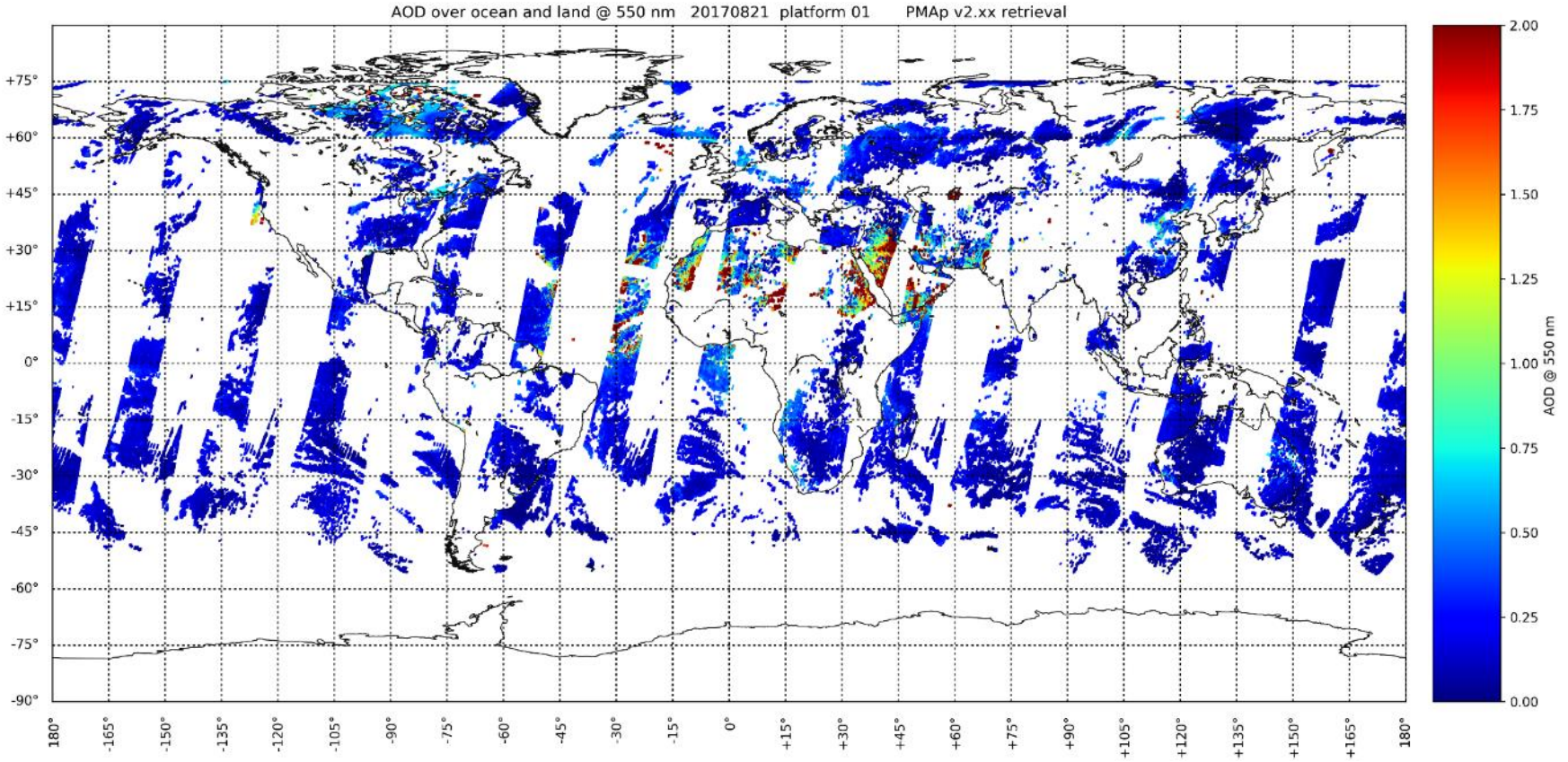
PMAp AOP retrieval
desert dust detection

21 08 2017 MetopB



Dust Index

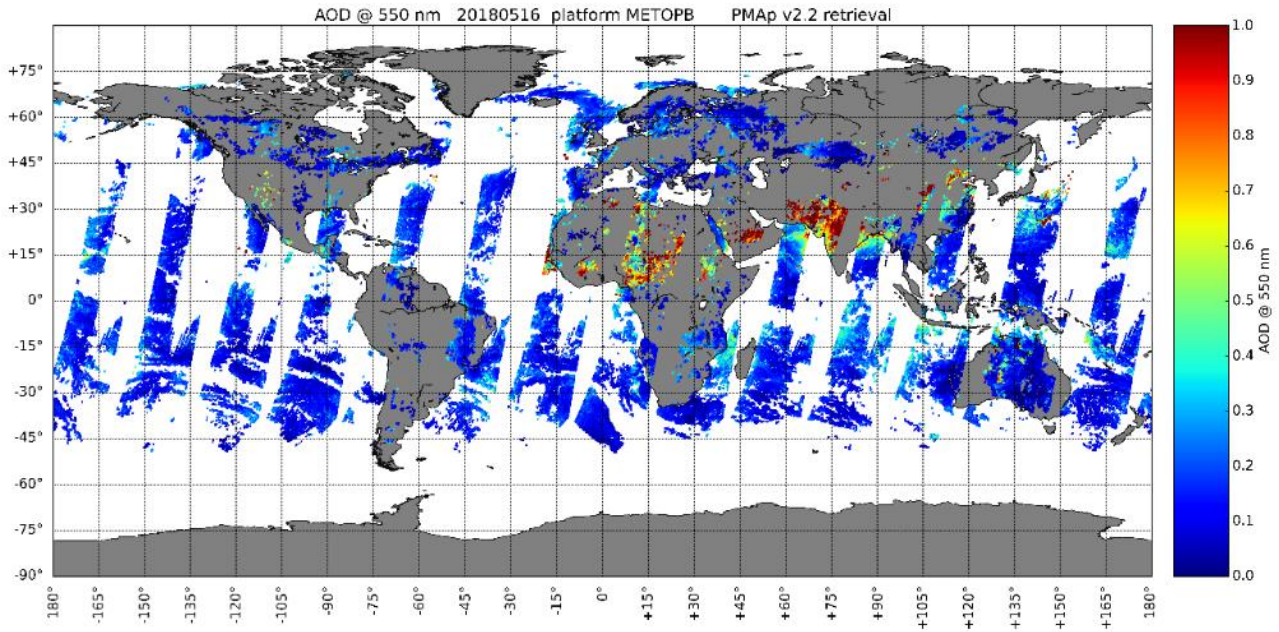
Aerosol Optical Depth @ 550 nm



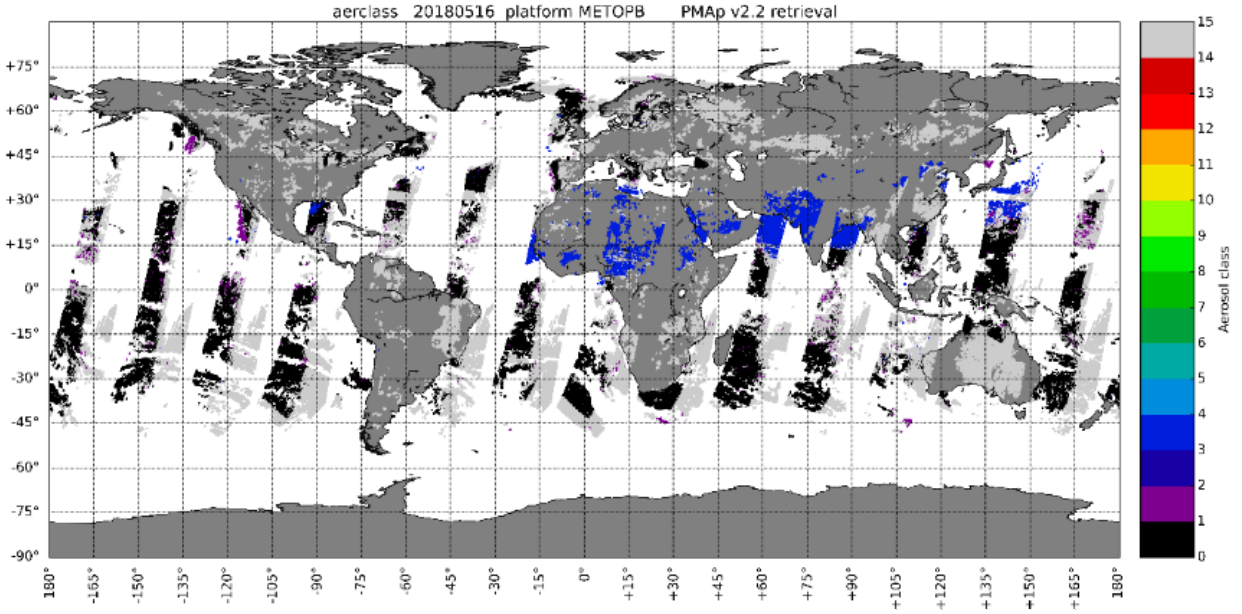
The Polar Multi-sensor Aerosol Product

Operational near-real time products from EPS/Metop

16 05 2018 MetopB



AOD @ 550 nm



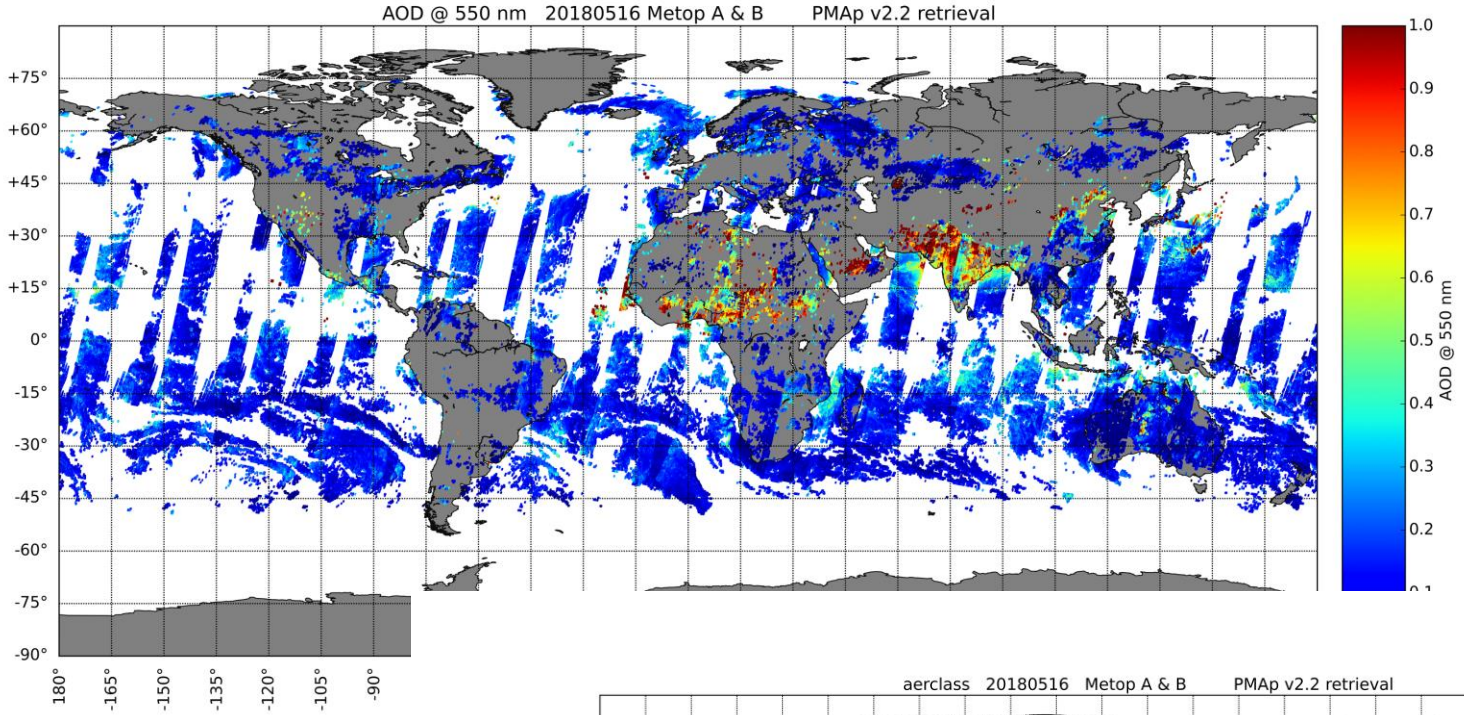
Aerosol Class

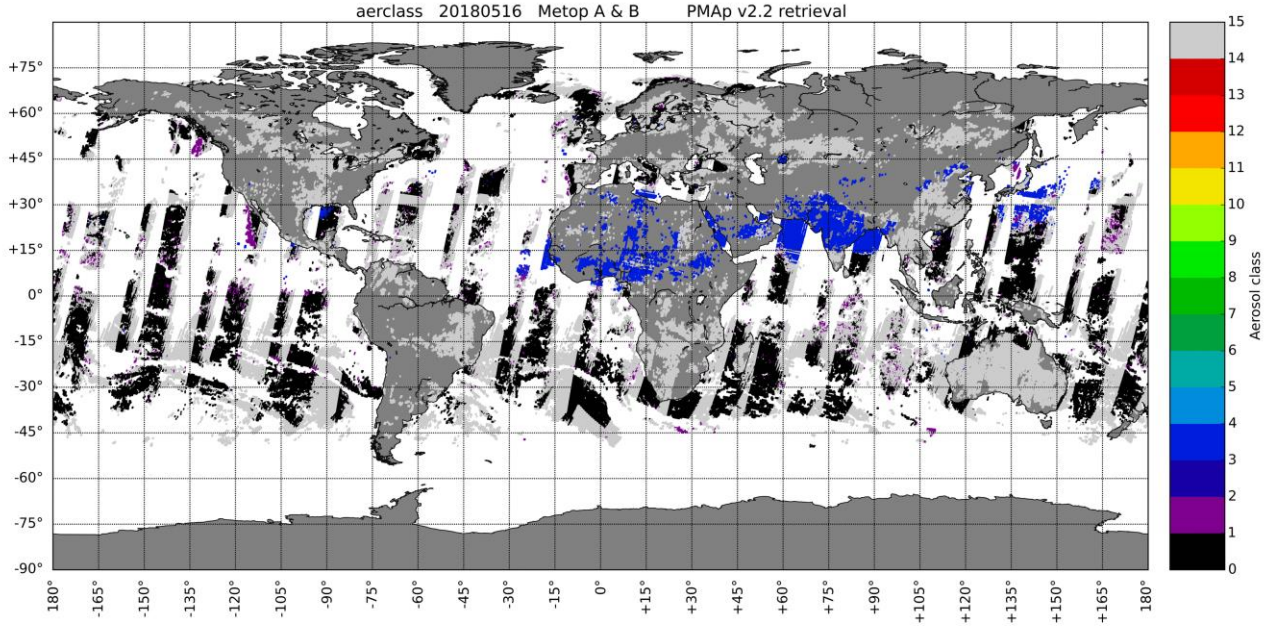
fine mode

coarse mode

volcanic ash / thick dust

volcanic ash with SO_2


AOD @ 550 nm 20180516 Metop A & B PMAp v2.2 retrieval
+75°
+60°
+45°
+30°
+15°
0°
-15°
-30°
-45°
-60°
-75°
-90°
180°
-165°
-150°
-135°
-120°
-105°
-90°
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
AOD @ 550 nm


aerclass 20180516 Metop A & B PMAp v2.2 retrieval
+75°
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180°
-165°
-150°
-135°
-120°
-105°
-90°
-75°
-60°
-45°
-30°
-15°
0°
+15°
+30°
+45°
+60°
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+90°
+105°
+120°
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15
14
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12
11
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7
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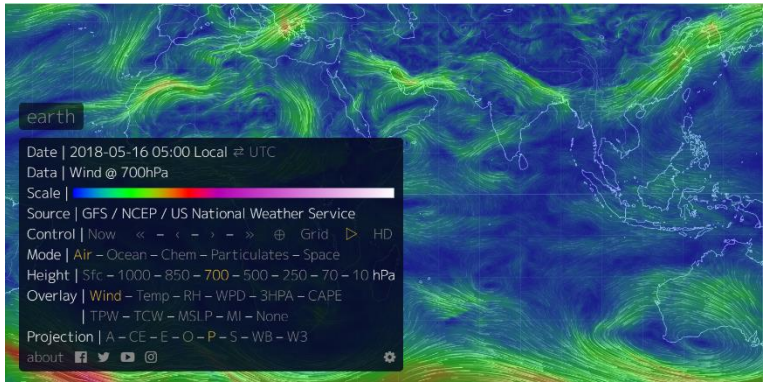
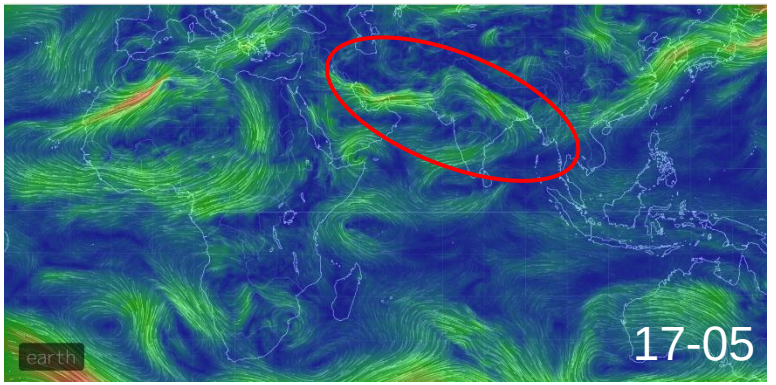
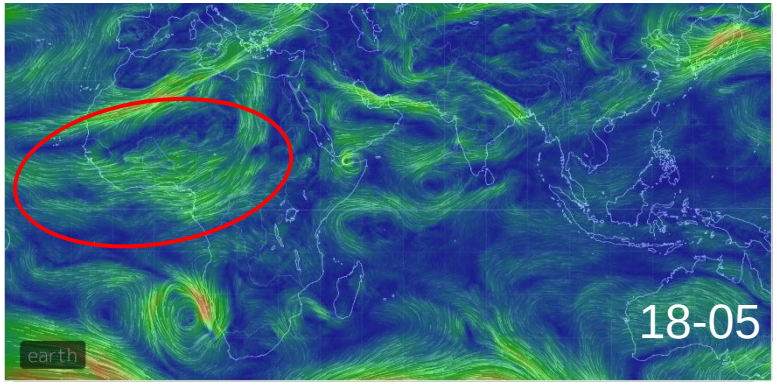
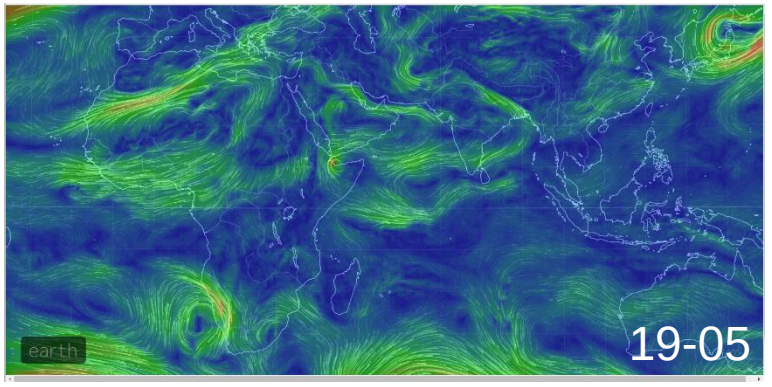
2
1
0
Aerosol class

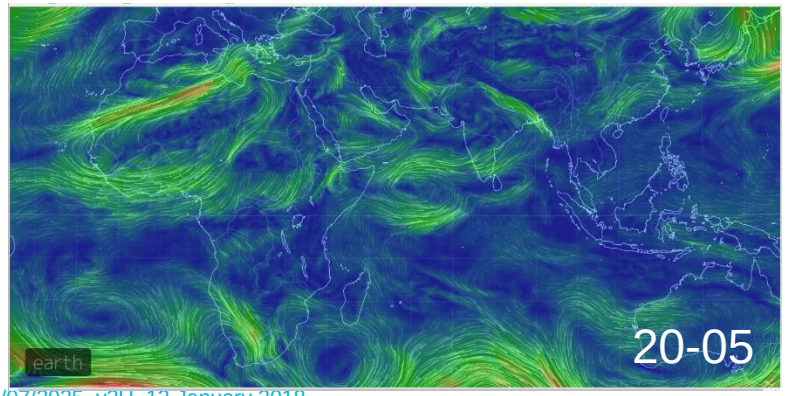
16 – 23 / 05
GFS/ NCEP / Wind @700hPa

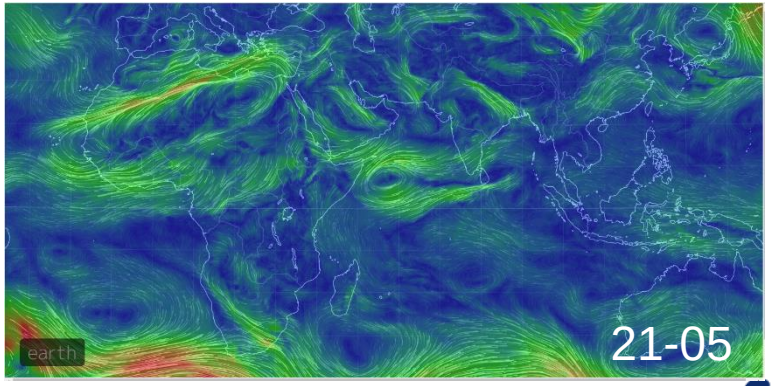






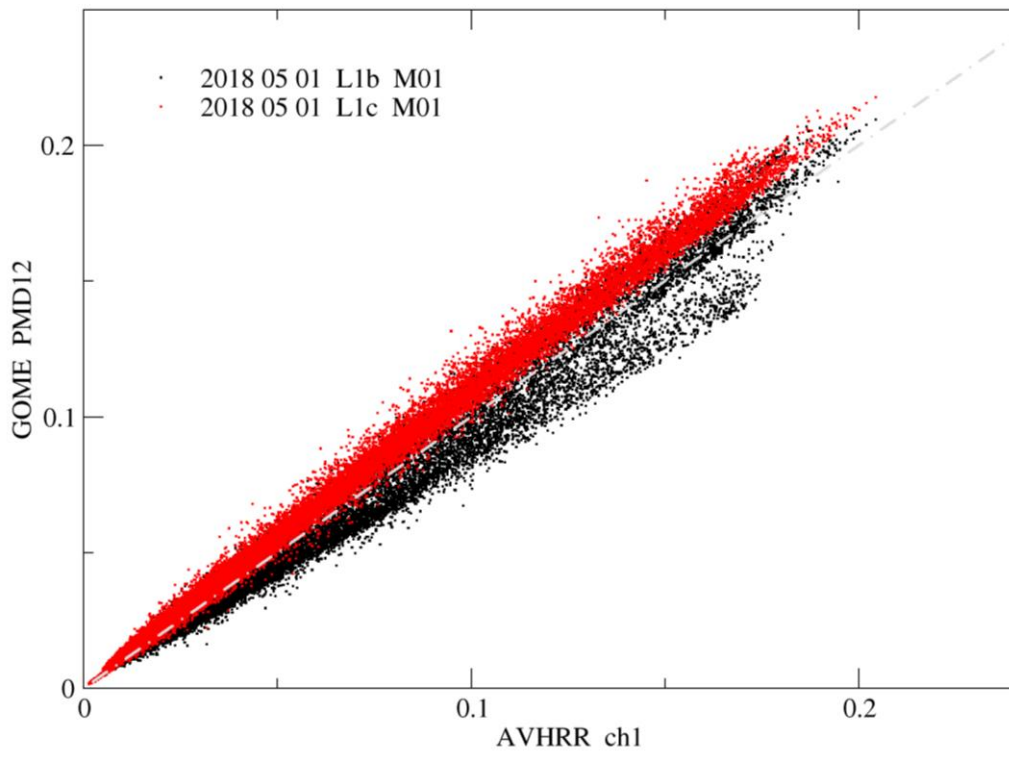


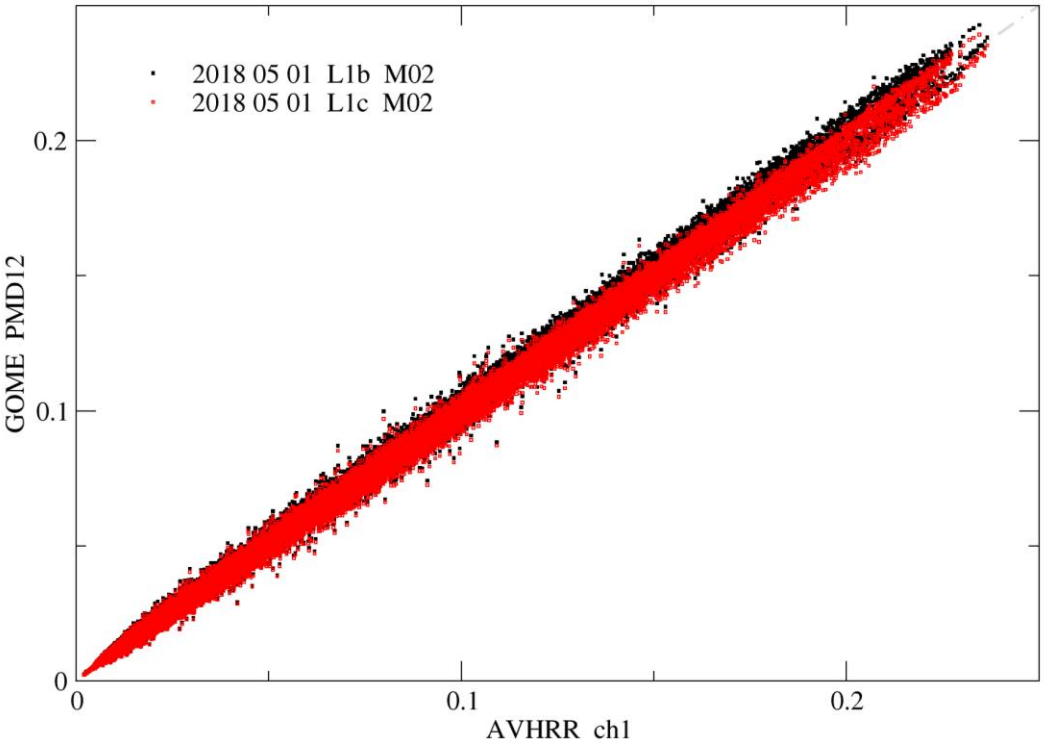




PMAp v2.2 AOP retrieval

Lev1B → Lev1C : impact on AOD retrieval



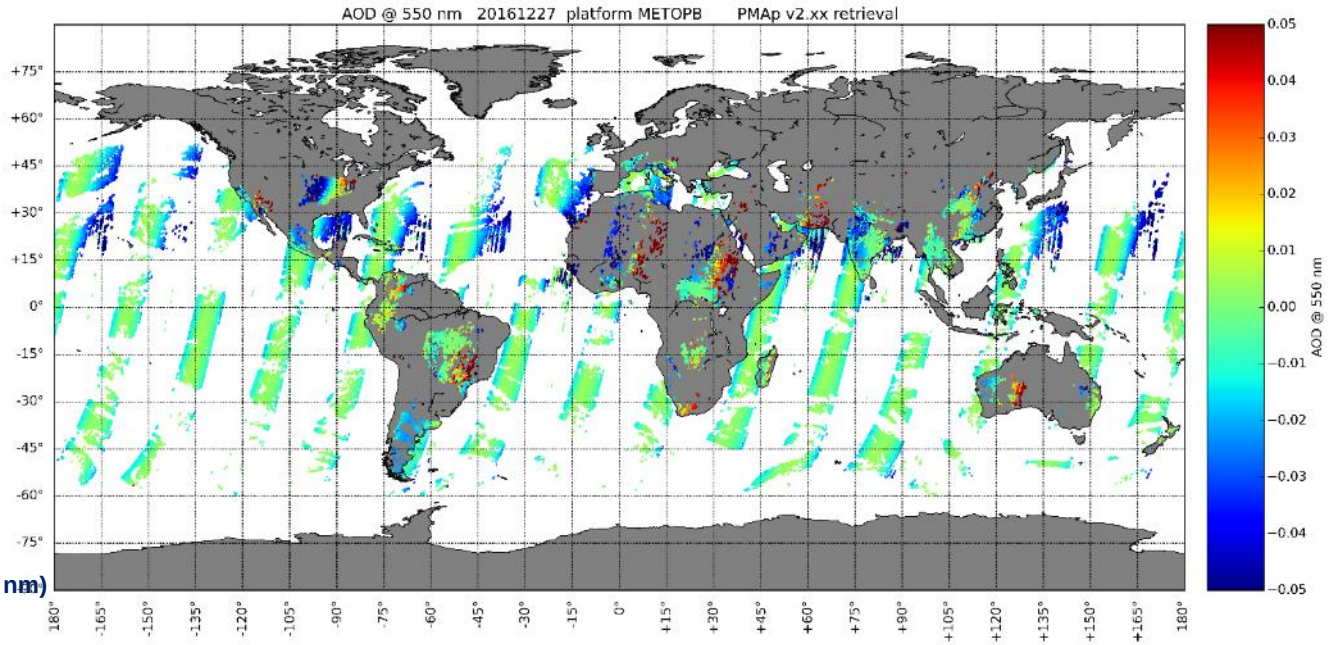


PMAp AOP retrieval

Lev1B → Lev1C : impact on AOD retrieval

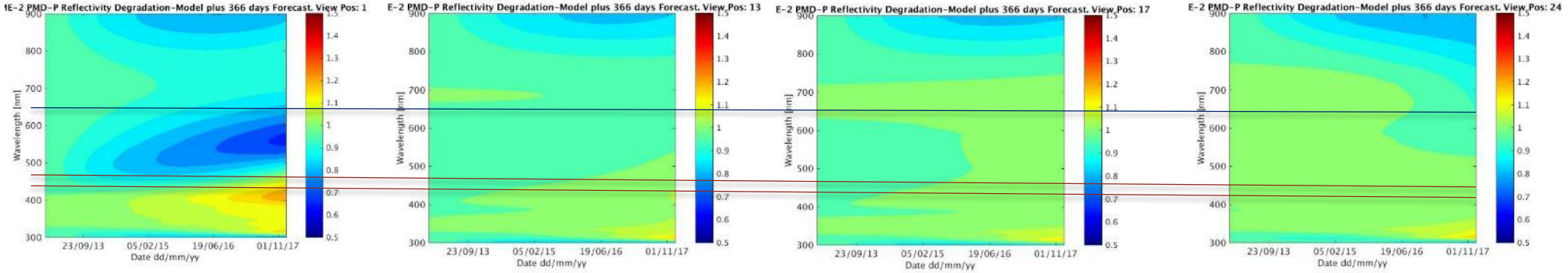
27 12 2016 MetopB

AOD_1B – AOD _1C



over water
PMD 12 (617.867 - 661.893 nm)

over land
PMD 8 (399.581 - 428.585 nm)
PMD 7 (380.186 - 383.753 nm)



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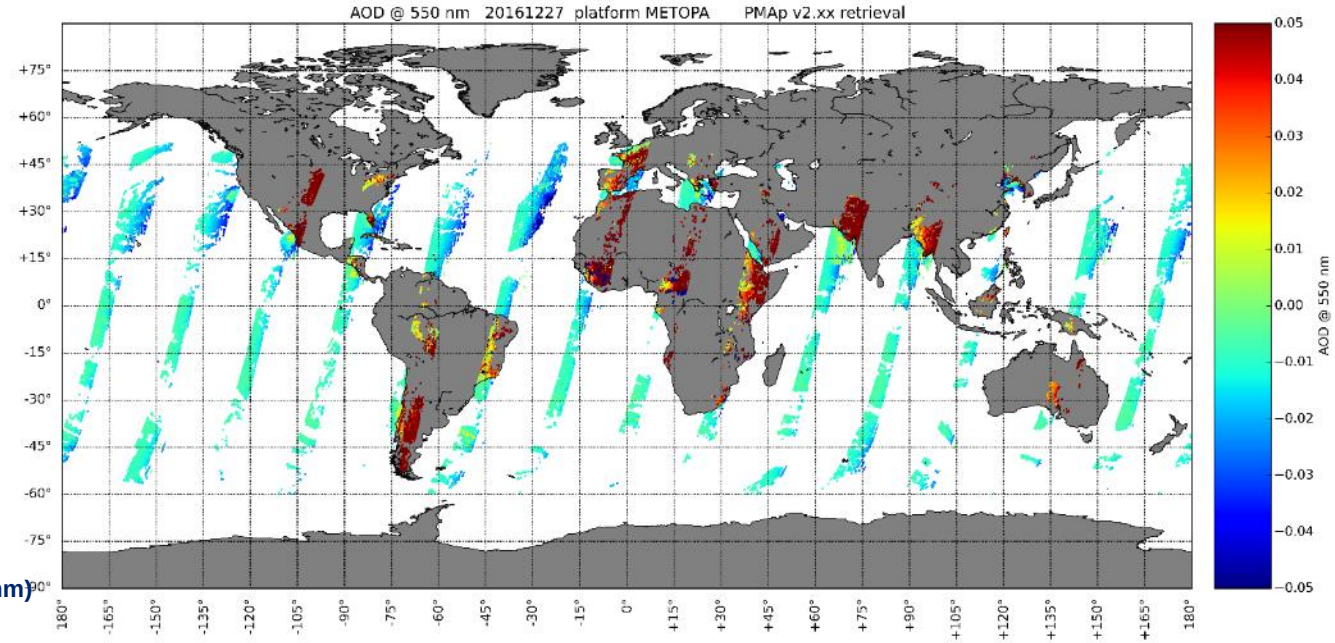
PMAp AOP retrieval

Lev1B → Lev1C : impact on AOD retrieval

27 12 2016 MetopA

AOD_1B – AOD _1C



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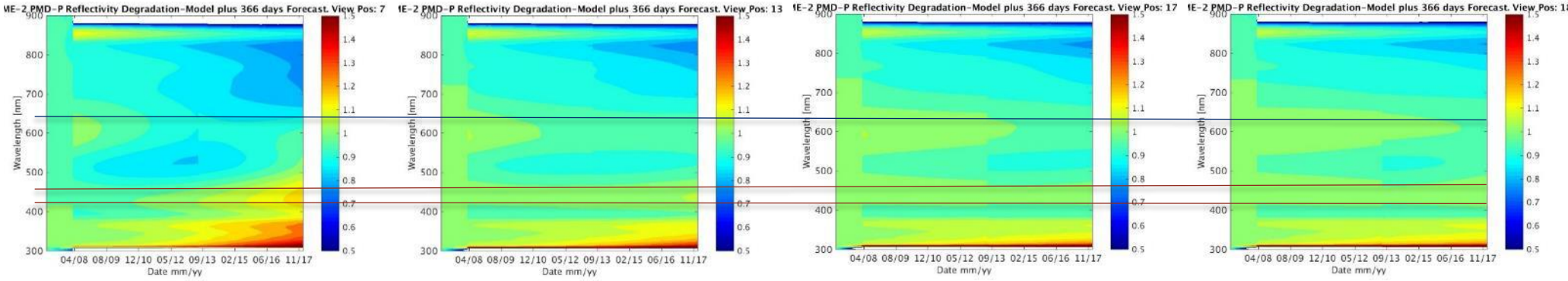


PMAp v2.2 AOP retrieval
AOD Validation

PMAp Validation Data Set

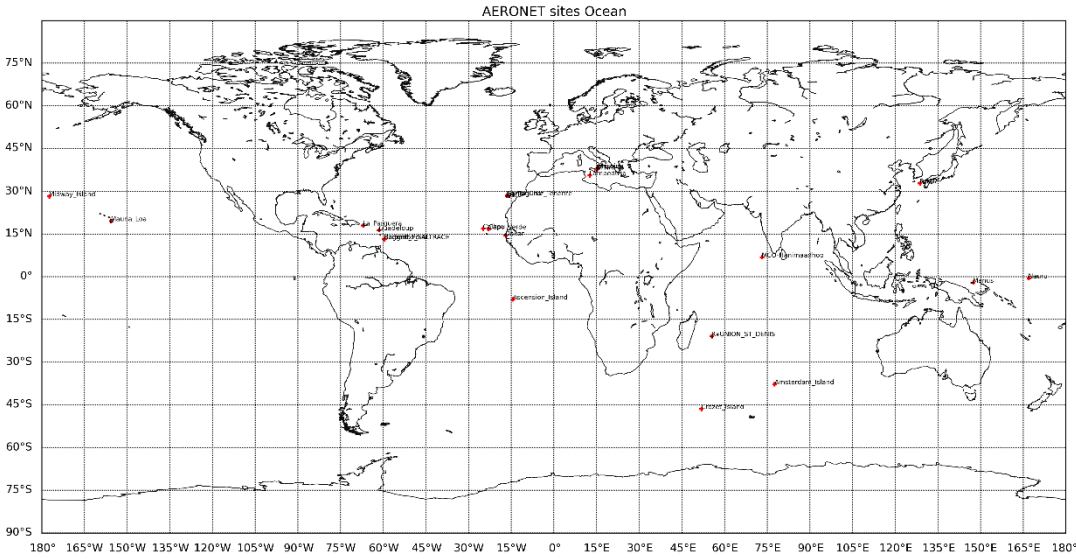
period 1. June - September 2013
period 2. February - May 2015

AERONET Data Set

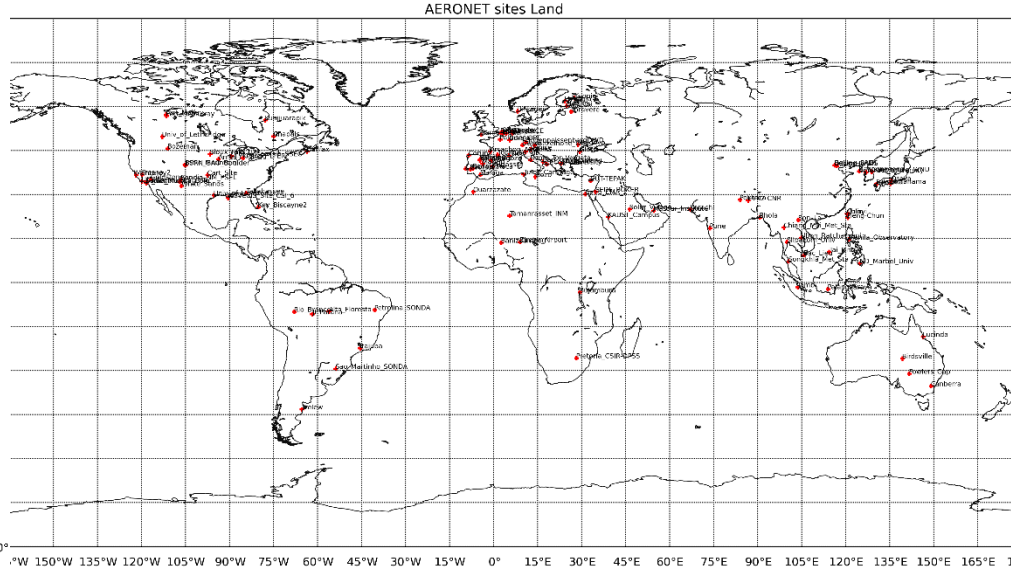
Co-located: 30 min & 30 km
AERONET AOD@ 550 nm

PMAp vs AERONET

Over Ocean *23 sites*



Over Land *121 sites*



PMAp v2.2 AOP retrieval

AOD Validation — Water surface

PMAp 2.1 vs Aeronet Lev2 Over Ocean

	June - Sept 2013		Feb-May 2015	
	METOP-B	METOP-A	METOP-B	METOP-A
gain	0.838	0.783	0.493	0.535
bias	0.076	0.045	0.115	0.084
correlation	0.870	0.836	0.777	0.871
N	110	90	22	51

PMAp 2.2 vs Aeronet Lev2 Over Ocean

	June - Sept 2013		Feb-May 2015	
	METOP-B	METOP-A	METOP-B	METOP-A
gain	0.949	0.922	0.836	0.744
bias	0.098	0.049	0.044	0.091
correlation	0.549	0.819	0.873	0.81
N	110	92	19	60

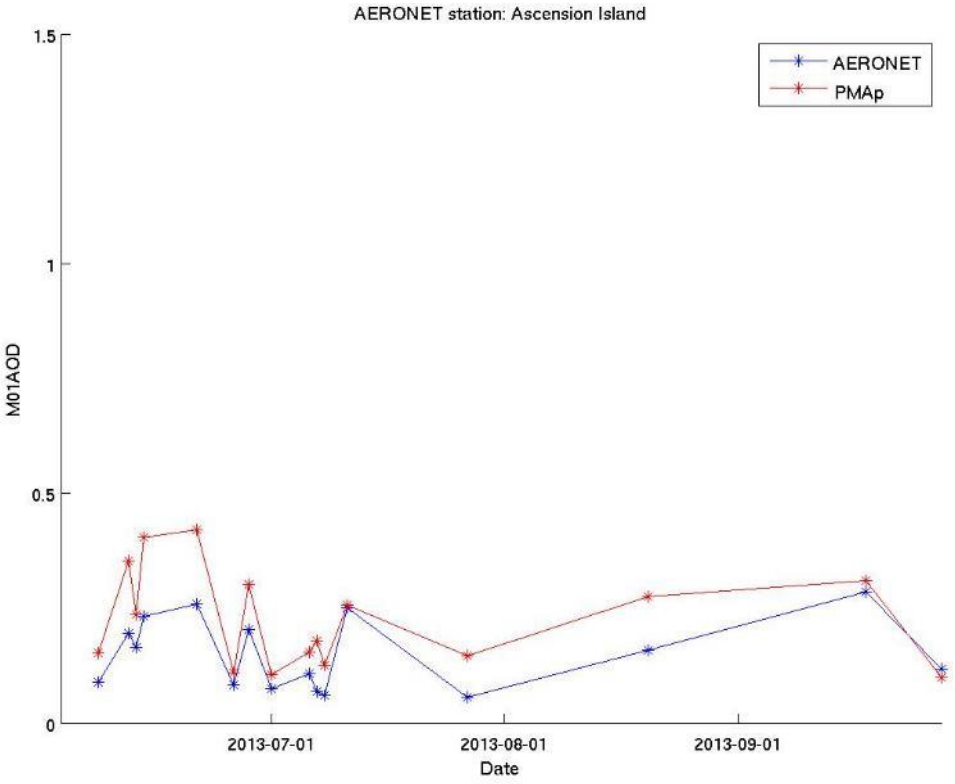
Metric	Algorithm					
	ADV/ASV		ORAC		SU	
	V1.0	V2.3	V1.0	V3.02	V1.0	V4.21
	Over Ocean					
number of points	75	64	65	102	13	52
bias	0.04	0.02	0.07	0.10	0.06	−0.002
RMSE	0.16	0.09	0.15	0.16	0.08	0.06
correlation	0.58	0.89	0.81	0.93	0.89	0.86
GCOS fraction (%)	17	66	46	31	15	58

(Popp et al. 2016)

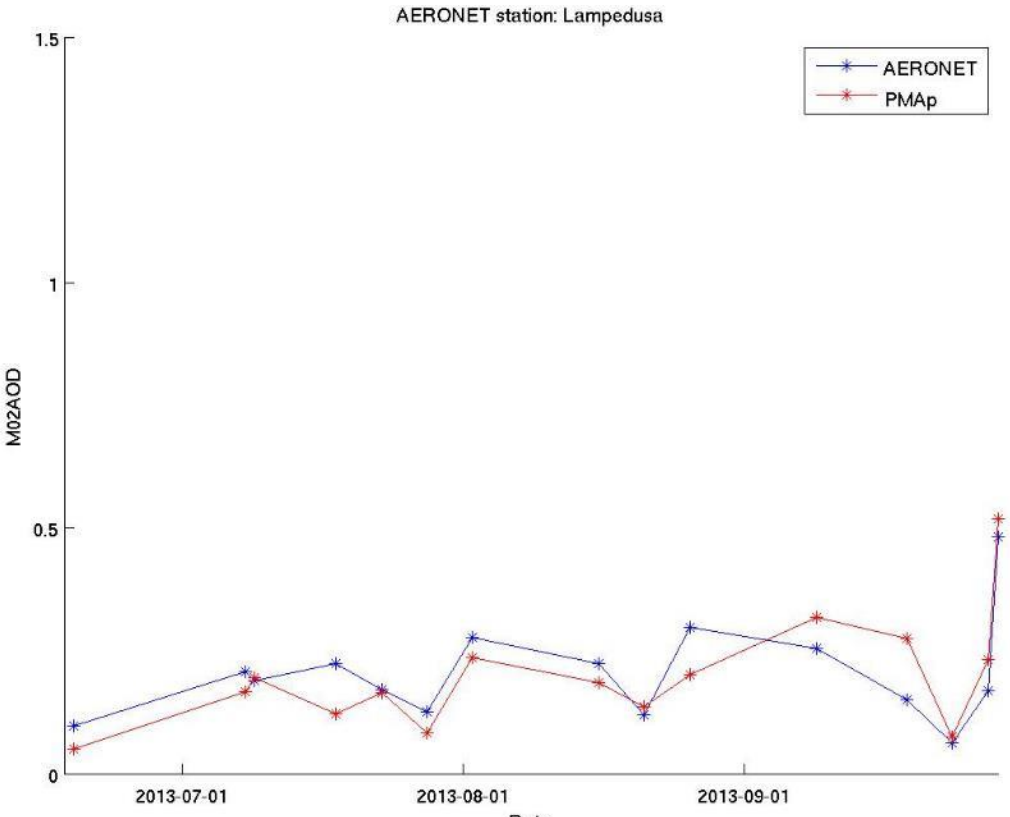
PMAp v2.2 AOP retrieval

AOD Validation Water surface

AOD @ 550 nm PMAp/METOP–B



AOD @ 550 nm PMAp/METOP–A



PMAp v2.2 AOP retrieval

AOD Validation Land surface

PMAp 2.1 vs Aeronet Lev2 Over Land

	June - Sept 2013		Feb-May 2015	
	METOP-B	METOP-A	METOP-B	METOP-A
gain	0.597	0.752	0.540	0.503
bias	0.113	0.081	0.168	0.158
correlation	0.589	0.636	0.552	0.612
N	906	830	1232	1000

PMAp 2.2 vs Aeronet Lev2 Over Land

	June - Sept 2013		Feb-May 2015	
	METOP-B	METOP-A	METOP-B	METOP-A
gain	0.762	0.979	0.839	0.615
bias	0.128	0.057	0.189	0.108
correlation	0.431	0.541	0.559	0.644
N	931	838	1675	1205

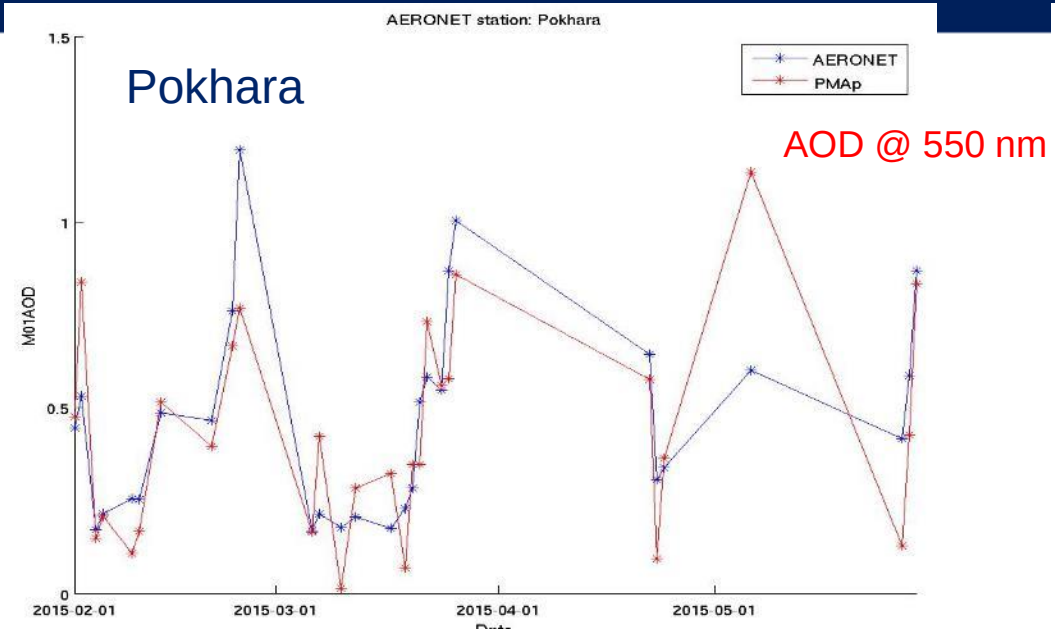
Metric	Algorithm					
	ADV/ASV		ORAC		SU	
	V1.0	V2.3	V1.0	V3.02	V1.0	V4.21
	Over Land					
number of points	306	185	262	262	138	343
bias	−0.005	−0.05	0.03	−0.002	−0.001	−0.01
RMSE	0.16	0.13	0.16	0.08	0.08	0.11
correlation	0.59	0.66	0.59	0.86	0.72	0.82
GCOS fraction (%)	37	54	40	51	46	62

(Popp et al. 2016)

PMAp v2.2 AOP retrieval

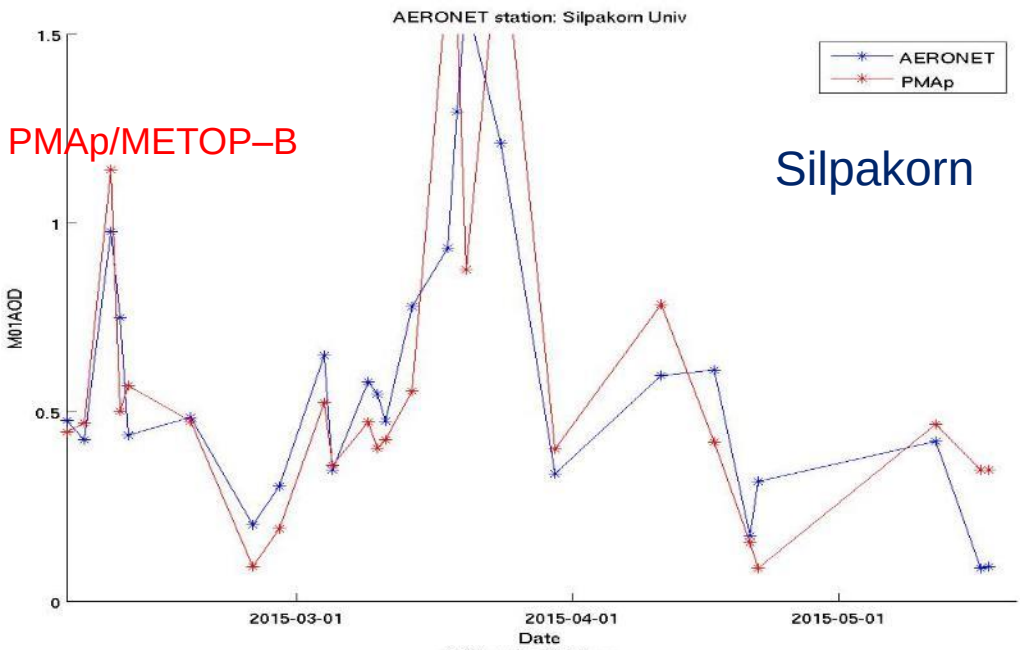
AOD Validation

Land surface

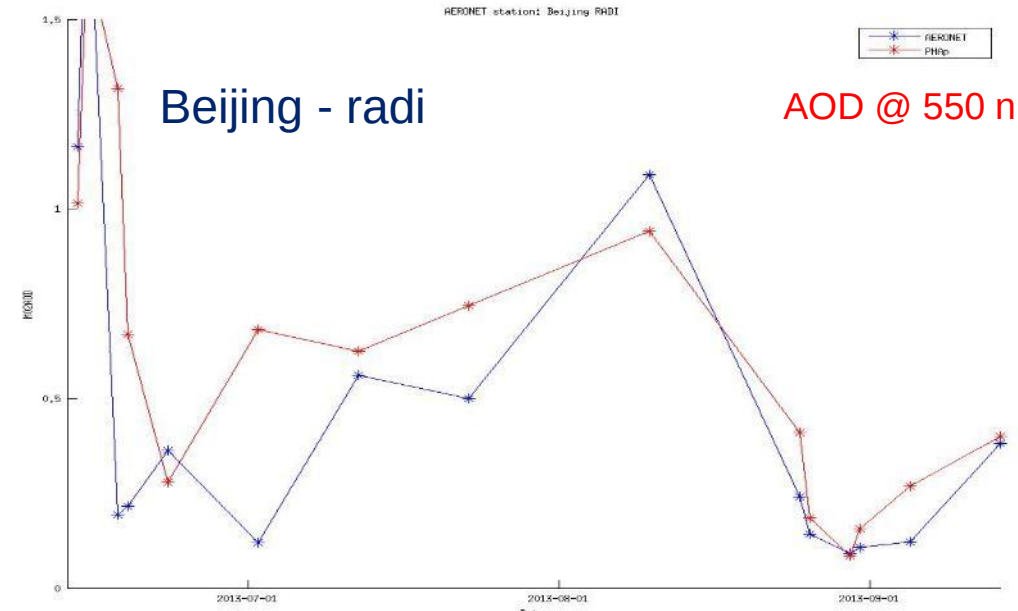


Pokhara

AOD @ 550 nm PMAp/METOP–B

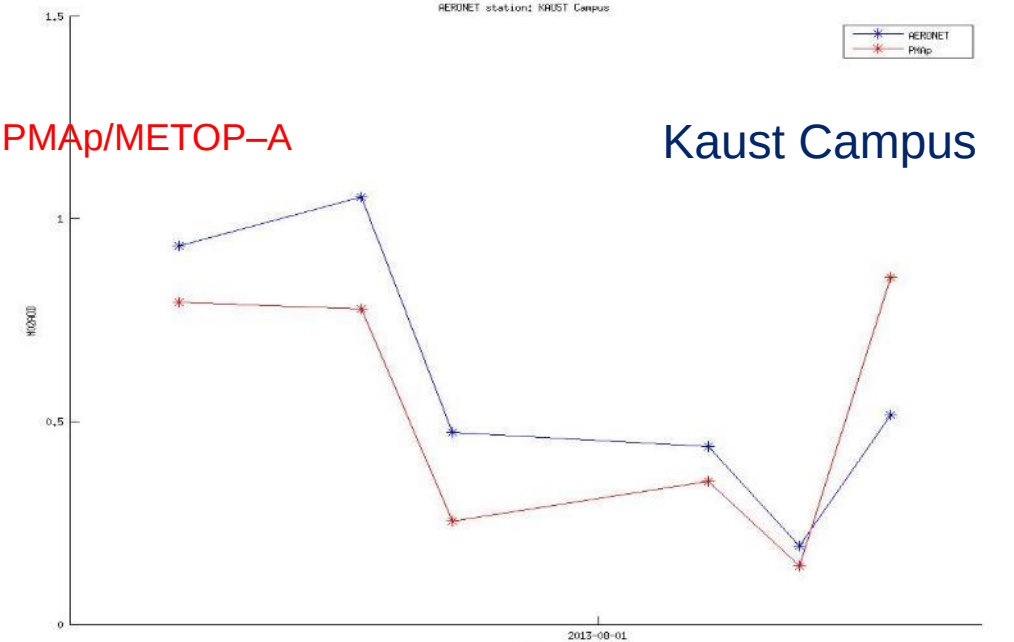


Silpakorn



Beijing - radi

AOD @ 550 nm PMAp/METOP–A



Kaust Campus

What comes next?

- *PMAp v.2.2 validation data set delivered to CAMS for evaluation*

  Internal Validation Review Board

  Product ready for dissemination by September 2018

  Metop-A and Metop-B

- *PMAp operational chain tests for Metop-C*

  launch scheduled on 21 September 2018

  extending the 2006 - 2017 data record to 2006 - 2027

Thank you