Aerosol Information from the 3MI polarimeter and EPS-SG sensors

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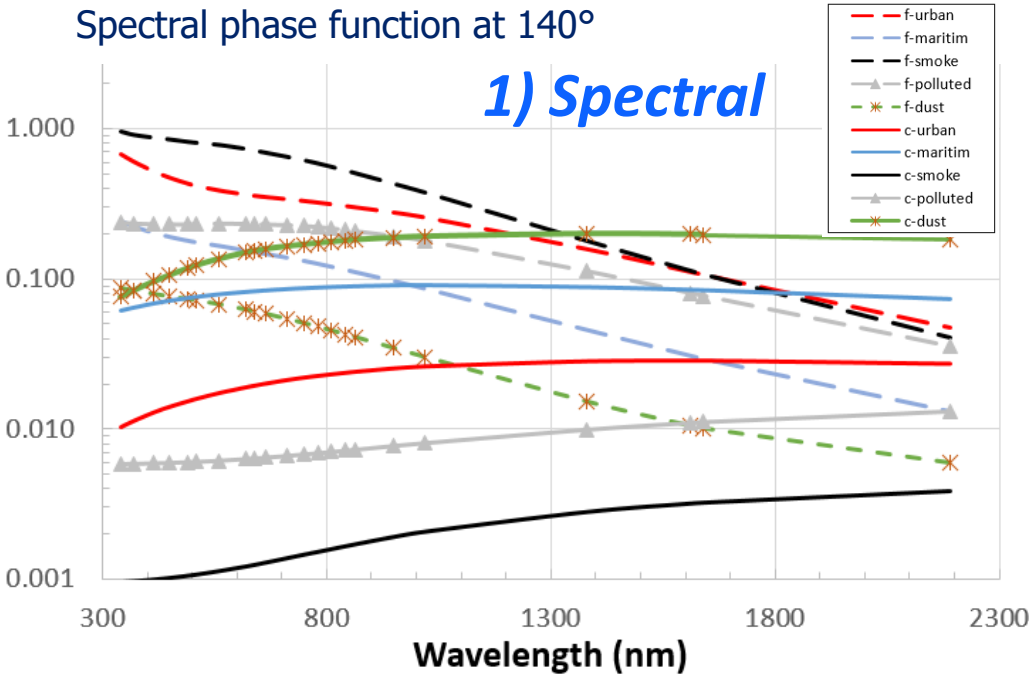
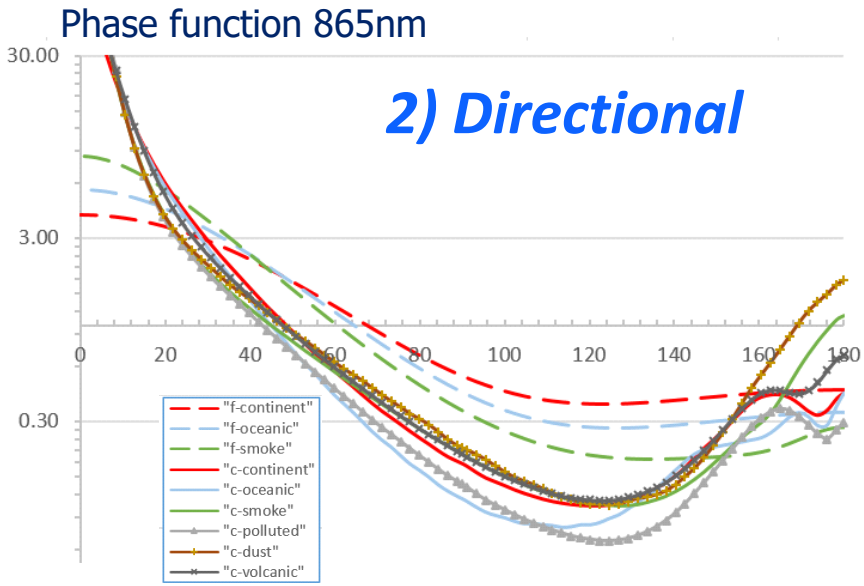
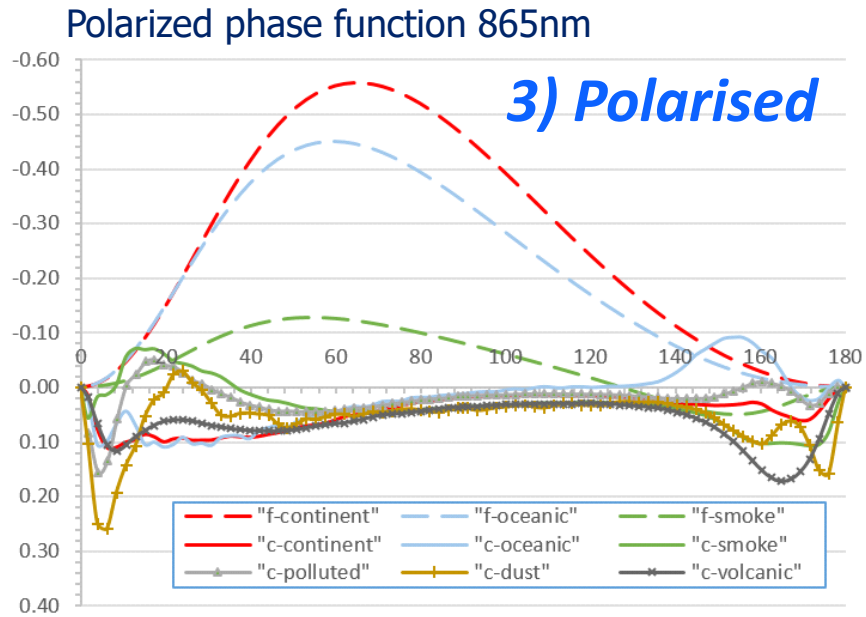
What's the challenge ?

The aerosol optical properties







→ **all depend on :**

- **Aerosol model (type f/c, microphysics, size distribution, shape, absorption…)**
- **Aerosol load (optical thickness)**

What's the challenge ?

The measurement

→ **all signatures are mixed in the observed signal**

At first order :

$$R_{aerosol}(\lambda, view) \sim \boxed{\omega_o(\lambda).\tau(\lambda).P_{aerosol}(\lambda, view)}$$

where

ω_o	Single scattering albedo
τ	Optical thickness
$P_{aerosol}$	Phase function

Challenge = disentangle the contributors to retrieve aerosol parameters

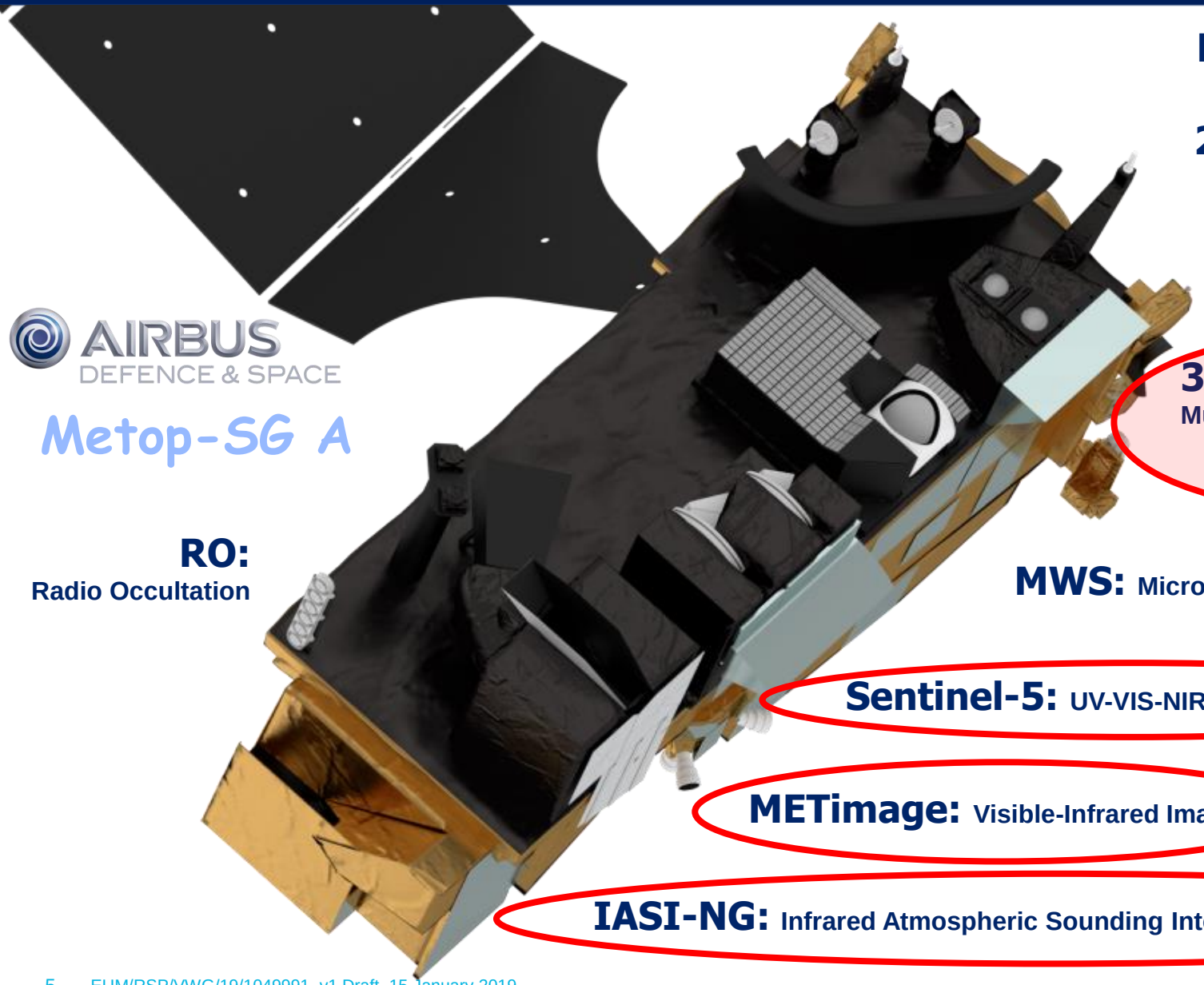
→ **The analysis of the information content is a prerequisite**
→ **This includes how the sensor/system is able to sample the spectral, the geometrical, and polarisation information**
→ **The larger, the better… but not only !**

Introduction

- The observed TOA signal is a combination of various terms:
  - The spectral variation
  - The bidirectional variation
  - The polarized contribution
- All are influenced by the aerosol type (nature, microphysics, size distribution…) and aerosol load (optical thickness)
- A proper aerosol retrieval includes:
  - The analysis of the information content
  - The associated identification of the constraints to be added on the retrieval (if and where needed)
  - The identification of the aerosol parameters to be retrieved and their expected validity range
- The information content analysis is crucial:
  - 3MI provides:
    - 12 bands, 3 polarisations, and 14 views
  - EPS-SG provides in addition:
    - the full spectral range (reflective and thermal) with high-resolution bands
    - a sub-pixel information
- 3MI and EPS-SG sensors are key-elements for the aerosol retrieval

EUMETSAT Polar System - Second Generation

Metop-like orbit 9:30
Launch Nov-2023
25 years of operation



AIRBUS DEFENCE & SPACE

Metop-SG A

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

RO:
Radio Occultation

MWS: Microwave Sounder

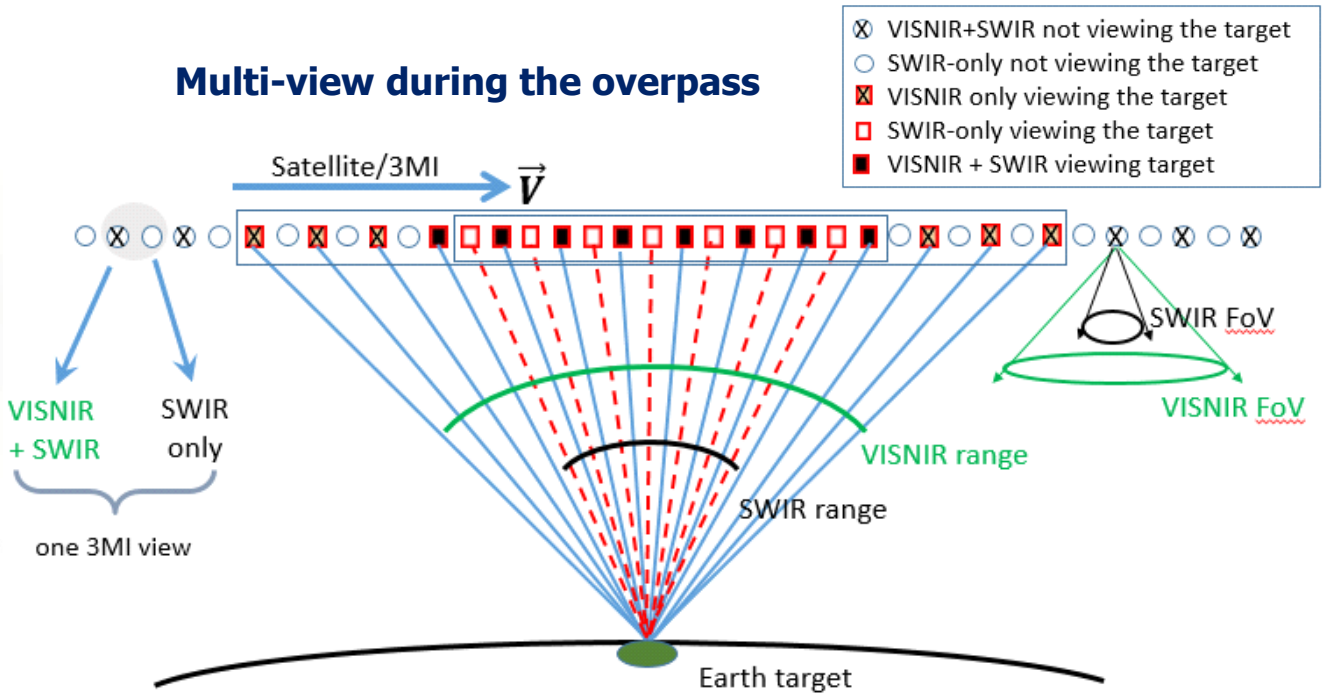
Sentinel-5: UV-VIS-NIR-SWIR Sounder

METimage: Visible-Infrared Imager

IASI-NG: Infrared Atmospheric Sounding Interferometer – New Generation

3MI on an nutshell

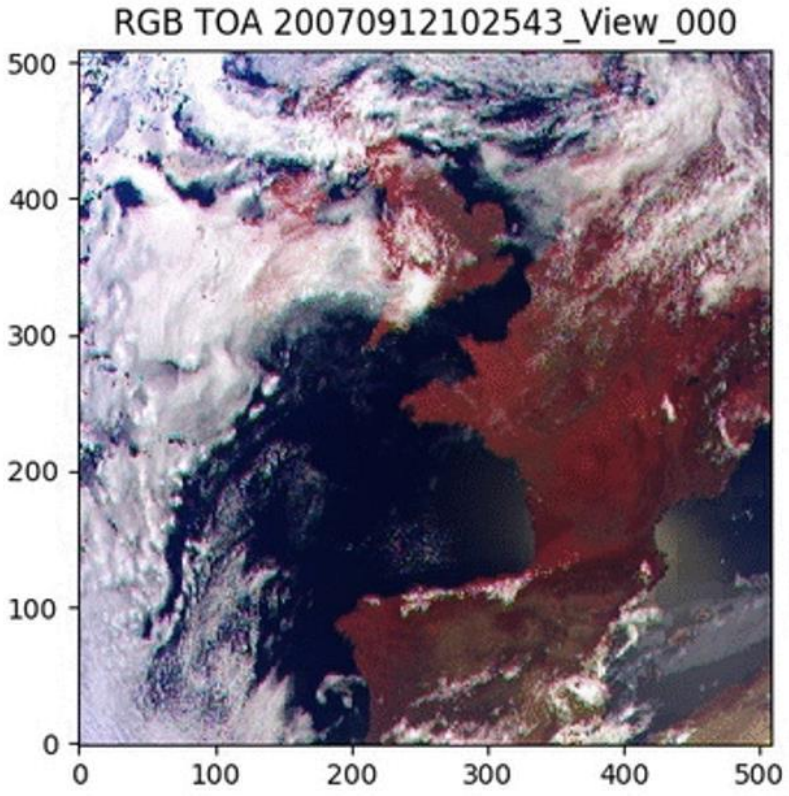
- The instrument relies on a very simple concept
  - 2 wide field-of-view optics (VISNIR + SWIR)
  - 2D detectors at focal planes (CCD for VISNIR, and CMOS for SWIR)
  - 1 filter wheel inc. polarizer (12 bands from 410 to 2130nm with I/Q/U)

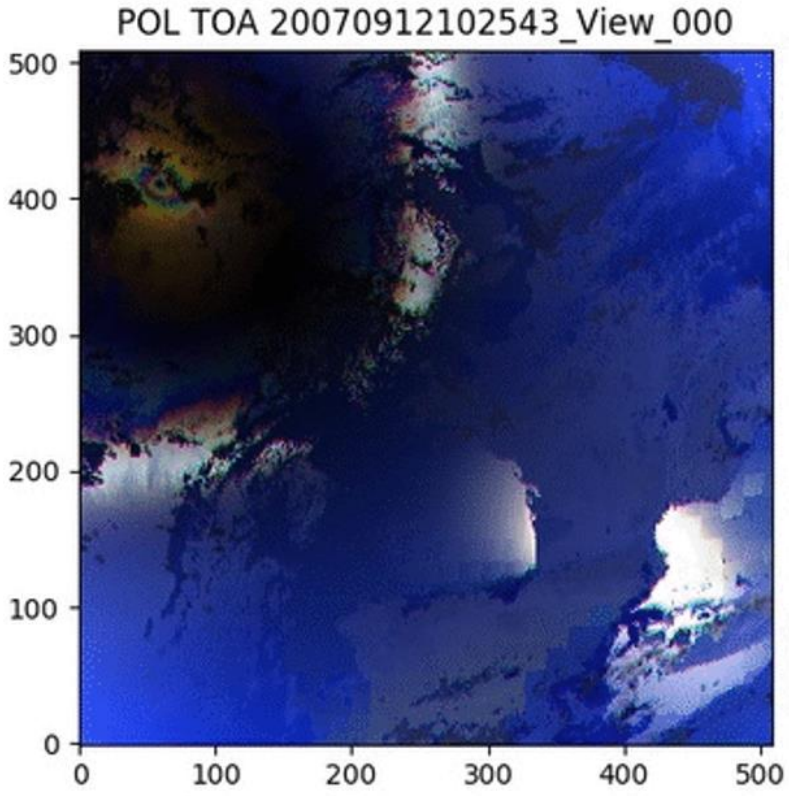


See Fougnie et al., 2018 in JQSRT APOLO'17

Why polarisation is a key-element for the observation of atmospheric scatterers ?

Level 1 TOA reflectance





Natural light

Polarized light

First overflight (simulated 3MI data)

Aerosol retrieval from 3MI

- Large information content:
  - 14 views : from -50° backward to 50° forward
  - 12 spectral bands: from 410 to 2130nm
  - 3 polarisations providing I, Q, and U (except for absorption bands)
  - → Potentially 420 information per pixel to feed the retrieval

- The aerosol retrieval will be based on an optimal simultaneous retrieval of the surface and aerosol
  - GRASP was adopted to be the best solver for this specific information
  - Configured to an Operational processor (product available 1:30 after sensing)
  - The simultaneous retrieval will be adjusted to optimise the performance of the aerosol retrieval

Aerosol retrieval from 3MI

- It is potentially possible to address the following aerosol properties:
  - Aerosol optical thickness
  - Angstrom coefficient
  - Fine/coarse fraction
  - Single scattering albedo
  - Absorbing aerosol optical thickness
  - Refractive indexes
  - Sphericity fraction
  - Aerosol height
- But it is unrealistic to retrieve all of them and everywhere
  - The geometry of acquisition and/or the surface type strongly influence the performance of the retrieval
- With respect to our user needs, the retrieval will be optimised to derive properly
  - AOD
  - Aerosol model
- Other parameters will be retrieved when/if possible

Aerosol characterization from EPS-SG sensors

- Information content = incredible collection of measurements from the same single platform

- Creating an hyper-instrument with many key-elements for a 4-km aerosol product: MAP (Multi-sensor Aerosol Product)
  - Extended spectral content: UV/VIS/NIR/SWIR/TIR
  - Improved spectral content: highly resolved in absorption lines
  - Sub-pixel radiometric characterisation
  - Multi-view and polarisation

Sensor	Spatial resolution	Swath	Spectral type	Spectral bands	Spectral range	Additional capabilities
3MI	4x4 km²	2200 x 2200 km²	VIS/NIR/SWIR	12 bands	410 to 2130nm	14 views Polarisation (I/Q/U)
METimage	0.5x0.5 km²	2670 km	VIS/NIR/SWIR TIR	11 bands 9 bands	443 to 2250nm 3.3 to 13.3µm	
S5-UVN	7.5x7.5 km² 50x50 km² (<300nm)	2670 km	UV/VIS/NIR/SWIR	1669 bands (0.25nm in SWIR to 1nm in UV)	270-300nm 300-370-500nm 685-710nm 755-773nm 1590-1675nm 2305-2385nm	
IASI-NG	12km spot	2000 km	TIR	16921 bands (0.25cm-1)	645 to 2760cm-1	

Aerosol characterization from EPS-SG sensors

- The MAP measurements will allow
  - A clear consolidation and improvement of the 3MI retrieval (the core aerosol mission)
  - An extension of the aerosol parameters to be retrieved

Characterisation		3MI	METimage	S5-UVN	IASI-NG
Cloud identification	CM	X	O		
Cloud decontamination			O		
Ash/Dust detection		X	O		O
Aerosol height	ALH	O	X	O	
Aerosol over clouds		O	X		O
Aerosol model		O	X	X	
Aerosol fine fraction	FMF	O			
Aerosol Optical Depth	AOD	O	X	X	
Aerosol absorption	AAI/SSA	O		O	

- The development will consider feedbacks from POLDER/PARASOL, MODIS, and EPS/PMAp (GOME, AVHRR, IASI)

Conclusion

- The polarimeter 3MI will provide spectral, bidirectional and polarised measurements allowing the provision of aerosol characterisation in a long-term operational framework

- Combining the sensors from the EPS-SG platform, the MAP synergistic product will also greatly contribute to the aerosol characterisation by extending the performance and the number of retrieved parameters

Thank you for your attention