The Multi-Viewing, -Channel, -Polarisation Imaging (3MI) Mission of the EUMETSAT Polar System - Second Generation (EPS-SG) dedicated to aerosol characterisation

Thierry Marbach and Peter Schlüssel

EUMETSAT

Outline

3MI: Introduction

3MI: Calibration

3MI: Geophysical Products

3MI: Benefits

3MI: Synergy with other EPS-SG Instruments

Outline

3MI: Introduction

3MI: Calibration

3MI: Geophysical Products

3MI: Benefits

3MI: Synergy with other EPS-SG Instruments

EPS-SG: EUMETSAT Polar System - Second Generation

- Follow the EUMETSAT Polar System (EPS)
- 2020-2040 timeframe
- Contribute to the Joint Polar System being jointly set up with NOAA
- Two-satellite configuration: Metop-SG-A and -B flying in the same orbit, separated by 180°
- Metop-like orbit: sun synchronous
  low earth orbit at 832 km mean altitude
  09:30 local time of the descending node

EPS versus EPS-SG

Metop payload	Metop-SG payload	Metop-SG satellite
IASI: Infrared Atmospheric Sounding Interferometer	**IASI-NG**: Infrared Atmospheric Sounding Interferometer – New Generation	A
AVHRR: Advanced Very High Resolution Radiometer	**METimage**: Visible-Infrared Imager	A
AMSU-A: Advanced Microwave Sounding Unit A **MHS**: Microwave Humidity Sounder	**MWS**: Microwave Sounder	A
GOME-2: Global Ozone Monitoring Experiment 2	**Sentinel-5**: UV-VIS-NIR-SWIR Sounder	A
ASCAT: Advanced Scatterometer	**SCA**: Scatterometer	B
GRAS: Global Navigation Satellite System Receiver for Atmospheric Sounding	**RO**: Radio Occultation	A and B
-	**MWI**: Microwave Imager	B
-	**ICI**: sub-mm wave Ice Cloud Imager	B
-	**3MI**: Multi-viewing, -channel, -polarisation Imager	A

3MI: Multi-View, -Channel, -Polarisation Imager

- Dedicated to aerosol characterisation for:
  - Climate monitoring
  - Air quality monitoring and forecasting
  - Numerical Weather Prediction

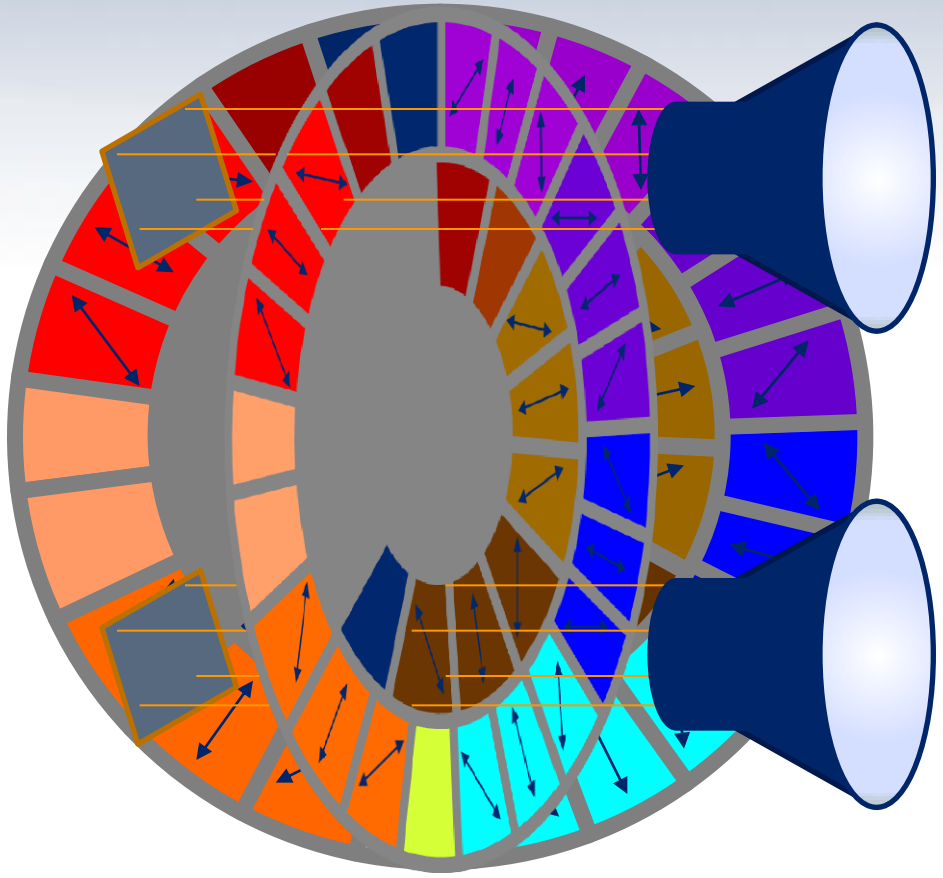
- 2D Push-broom radiometer (2200 km swath, 4 km pixel at nadir)

- Provide images of the Earth TOA outgoing radiance using:
  - Multi-view (10 to 14 views; angular sampling in the order of 10°)
  - Multi-channel (12 channels from 410 to 2130 nm)
  - Multi-polarisation (9 channels with -60°, 0°, +60° polarisers)

- POLDER heritage

3MI Channels

Channel centre and width	**Polarisation**	**Optical head**
410 nm 20 nm	**Yes**	**VNIR Optical head**
443 nm 20 nm	**Yes**	
490 nm 20 nm	**Yes**	
555 nm 20 nm	**Yes**	
670 nm 20 nm	**Yes**	
763 nm 10 nm	**No**	
754 nm 20 nm	**No**	
865 nm 40 nm	**Yes**	
910 nm VNIR 20 nm	**No**	
910 nm SWIR 20 nm	**No**	**SWIR Optical head**
1370 nm 40 nm	**Yes**	
1650 nm 40 nm	**Yes**	
2130 nm 40 nm	**Yes**	



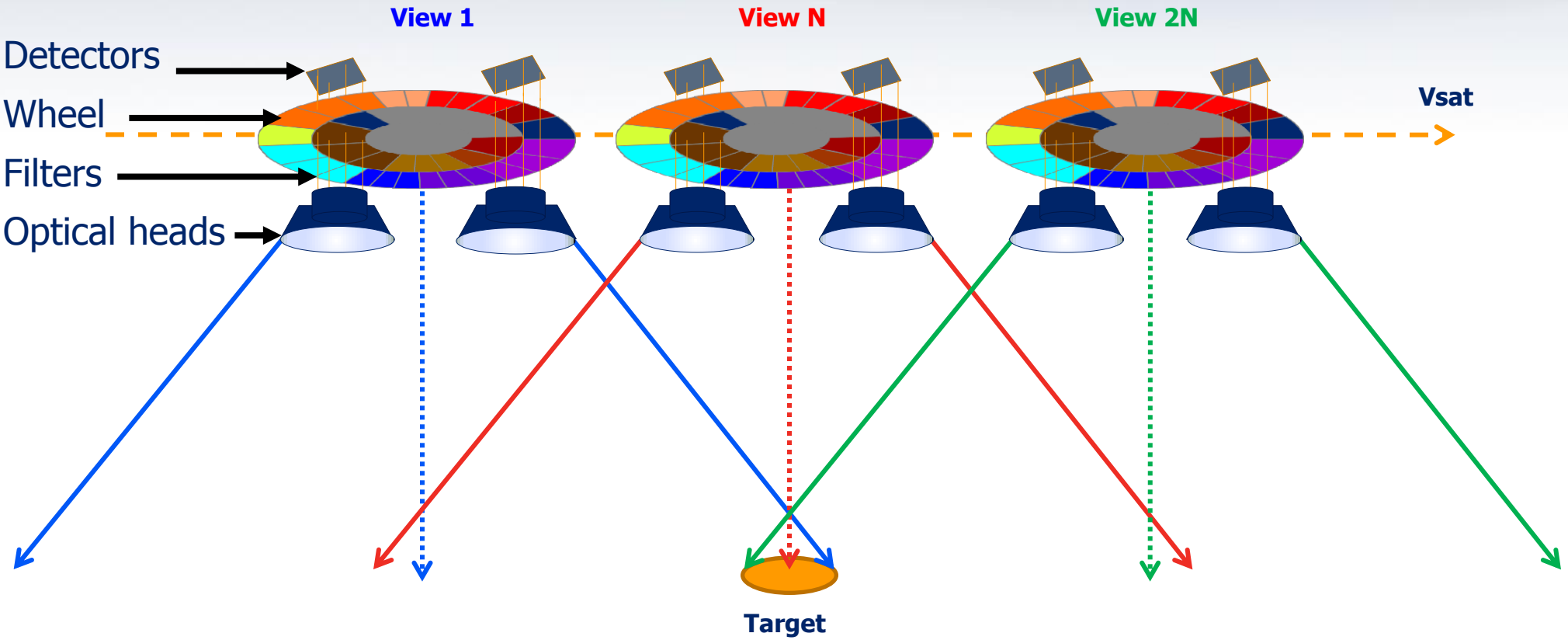
EUMETSAT

3MI Channels

Channel centre and width	**Polarisation**	**Optical head**	**Primary Use**
410 nm 20 nm	**Yes**	**VNIR Optical head**	Absorbing aerosol and ash cloud monitoring
443 nm 20 nm	**Yes**		Aerosols absorption and height indicators
490 nm 20 nm	**Yes**		Aerosol, surface albedo, cloud reflectance, cloud optical depth
555 nm 20 nm	**Yes**		Surface albedo
670 nm 20 nm	**Yes**		Aerosols properties
763 nm 10 nm	**No**		Cloud and aerosols height
754 nm 20 nm	**No**		Cloud and aerosols height
865 nm 40 nm	**Yes**		Vegetation, aerosol, clouds, surface features
910 nm VNIR 20 nm	**No**		Water vapour , atmospheric correction
910 nm SWIR 20 nm	**No**	**SWIR Optical head**	Water vapour , atmospheric correction
1370 nm 40 nm	**Yes**		Cirrus clouds, water vapour imagery
1650 nm 40 nm	**Yes**		Ground characterisation for aerosol inversion
2130 nm 40 nm	**Yes**		Ground characterisation for aerosol inversion, Cloud microphysics at cloud top, Vegetation, fire (effects)

3MI Acquisition

up to 14 views: N = 7



Outline

3MI: Introduction

3MI: Calibration

3MI: Geophysical Products

3MI: Benefits

3MI: Synergy with other EPS-SG Instruments

3MI Calibration

Calibration updated in-flight using vicarious calibration methods:

- Well characterised ground targets and atmosphere RT calculations
- Inter-calibration with other satellite instruments

Calculation of calibration coefficients is done offline and is fed recurrently into the operational processing that applies the calibration to the actual 3MI measurements.

Other pre-processing steps have to be completed:

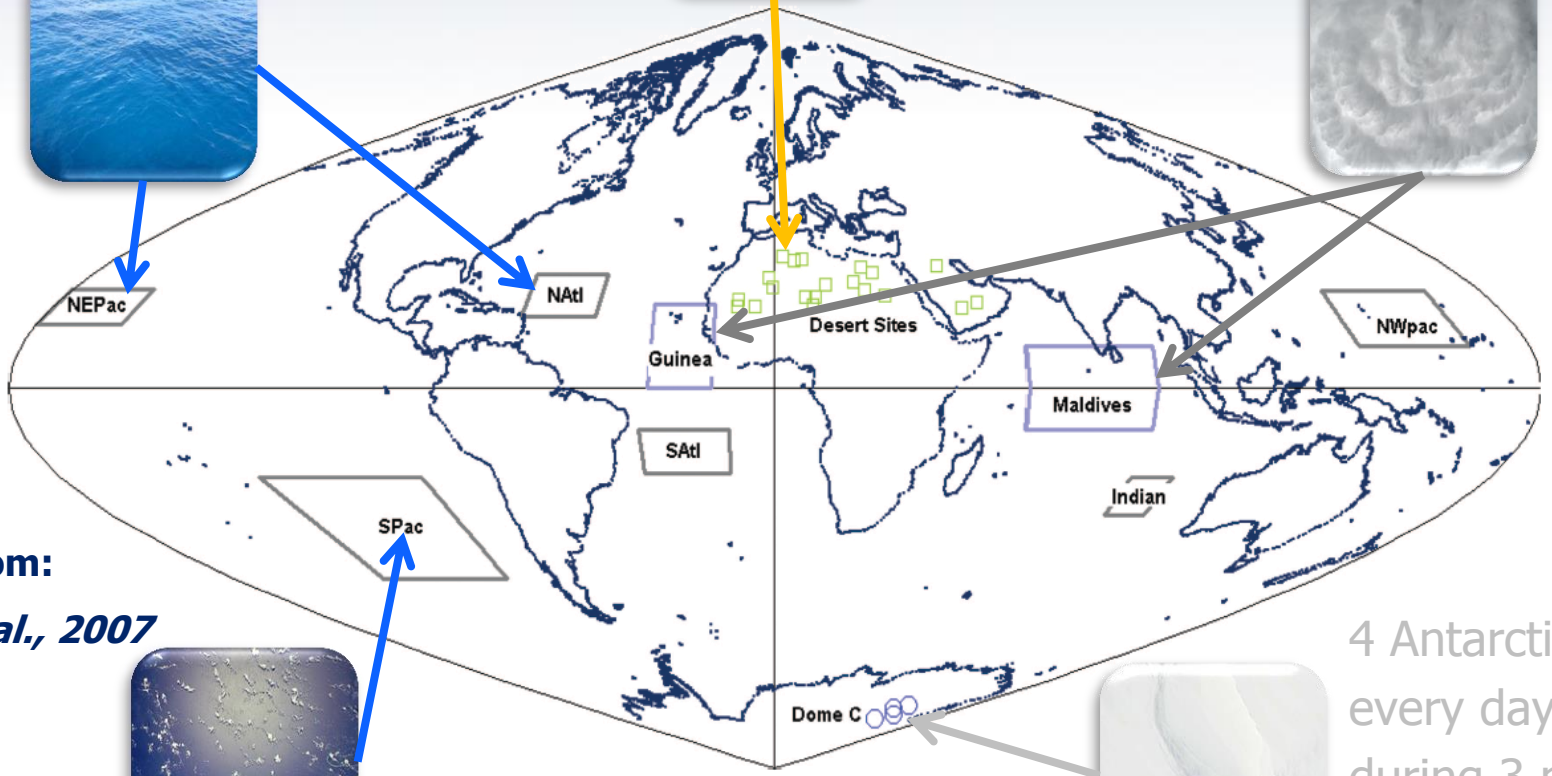
- Dark current, smearing, non-linearity and stray-light corrections
- For the retrieval of the Stokes vectors, the co-registration of:
  - of the polarisations (three polarisation acquisitions within 1s)
  - the different channels (within a wheel rotation of less than 7s)

3MI Calibration

6 main oceanic sites
10 days/month

20 desert sites
Every day

2 oceanic coudy sites
10 days/month



Modified from:

Fougnie et al., 2007

4 Antarctic sites
every day
during 3 months

EUMETSAT

3MI Calibration

3MI		METimage		Sentinel 5	
Channel	Bandwidth (nm)	Channel	Bandwidth (nm)	Channel	Bandwidth (nm)
3MI-2b	400-420			VIS	370-500
3MI-3	433-453	VII-4	428-458	VIS	370-500
3MI-4	480-500			VIS	370-500
3MI-5	545-565	VII-8	545-565		
3MI-6	660-680	VII-12	660-680		
3MI -7	758-768	VII-16	758-768	NIR-2	750-775
3MI -8	744-764	VII-15	747-757	NIR-2	750-775
3MI -9	845-885	VII-17	855-875		
3MI-9a	900-920	VII-20	904-924		
3MI -10	1350-1390	VII-23	1345-1385		
3MI -11	1630-1670	VII-24	1620-1640	SWIR-1	1590-1675
3MI -12	2110-2150				

Outline

3MI: Introduction

3MI: Calibration

3MI: Geophysical Products

3MI: Benefits

3MI: Synergy with other EPS-SG Instruments

Geophysical Products

Primary objectives: HQ imagery of aerosol variables over ocean and land

- AODs for accumulation, coarse and total modes at high horizontal resolution
- Aerosol particle size for accumulation, coarse and total modes.
- Aerosol type through Ångström exponent, refractive index, non-sphericity index
- Aerosol height index
- Aerosol absorption

Secondary objectives:

- Improved cloud characterisation through cloud imagery, COD, CTH, and cloud microphysics (phase and effective particle size)
- Land surfaces (surface albedo, BRDFs)
- Vegetation (e.g. Leaf area index, Vegetation type, Fraction of vegetated land)

Outline

3MI: Introduction

3MI: Calibration

3MI: Geophysical Products

3MI: Benefits

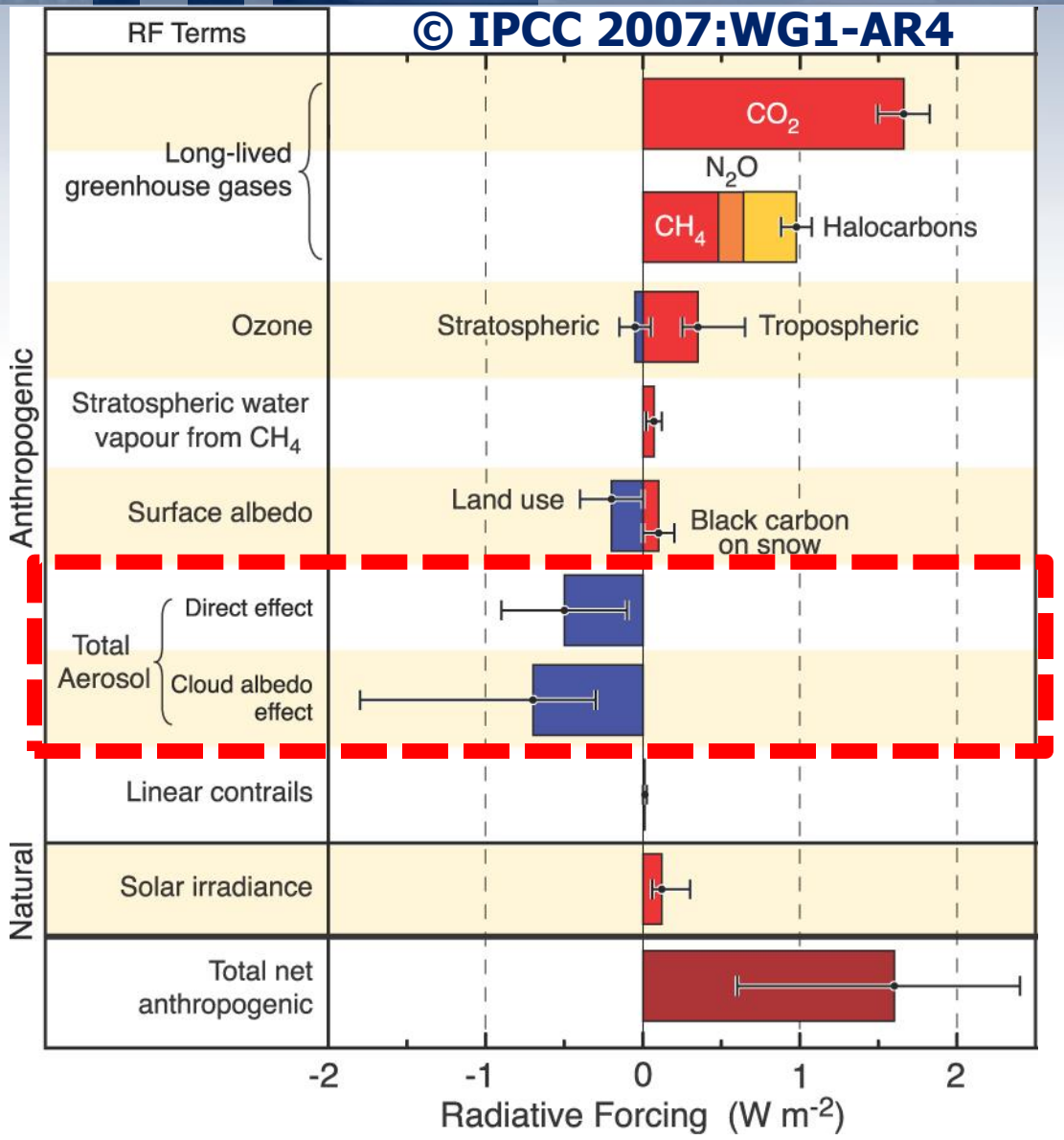
3MI: Synergy with other EPS-SG Instruments

3MI Benefits: Climate Monitoring

Improve knowledge on the aerosol constrain in the radiative forcing of Earth's atmosphere

Using particle size and spatial distribution to separate natural from anthropogenic aerosols

Improvement for model input parameters (e.g. aerosol, cloud, surface characterisation) → Beneficial for other IPCC parameters (e.g. greenhouse gas, albedo)



3MI Benefits: Numerical Weather Prediction (NWP)

- Identification of cirrus clouds, and cloud cover in general
- Correction of deficiencies in the model representation of radiative processes (anisotropy of scattering)
- Provision of surface BRDFs, essential for surface radiative variables (e.g albedo, vegetation indices)
- Constrain artefacts induced by scattering and polarisation in IASI-NG, METimage , and S-5 measurements

3MI Benefits: Air Quality Monitoring and Forecasting

- Monitoring of air quality index
- Measurement of particle concentration
  (PM2.5 and PM10 aerosol mass load)
- Observation of natural hazards, such as volcanic ash or fire plumes
- Measurement of land surface variables e.g.
  Leaf area index (LAI), Photosynthetically Active Radiation (PAR),
  Normalised Differential Vegetation Index (NDVI)

Outline

3MI: Introduction

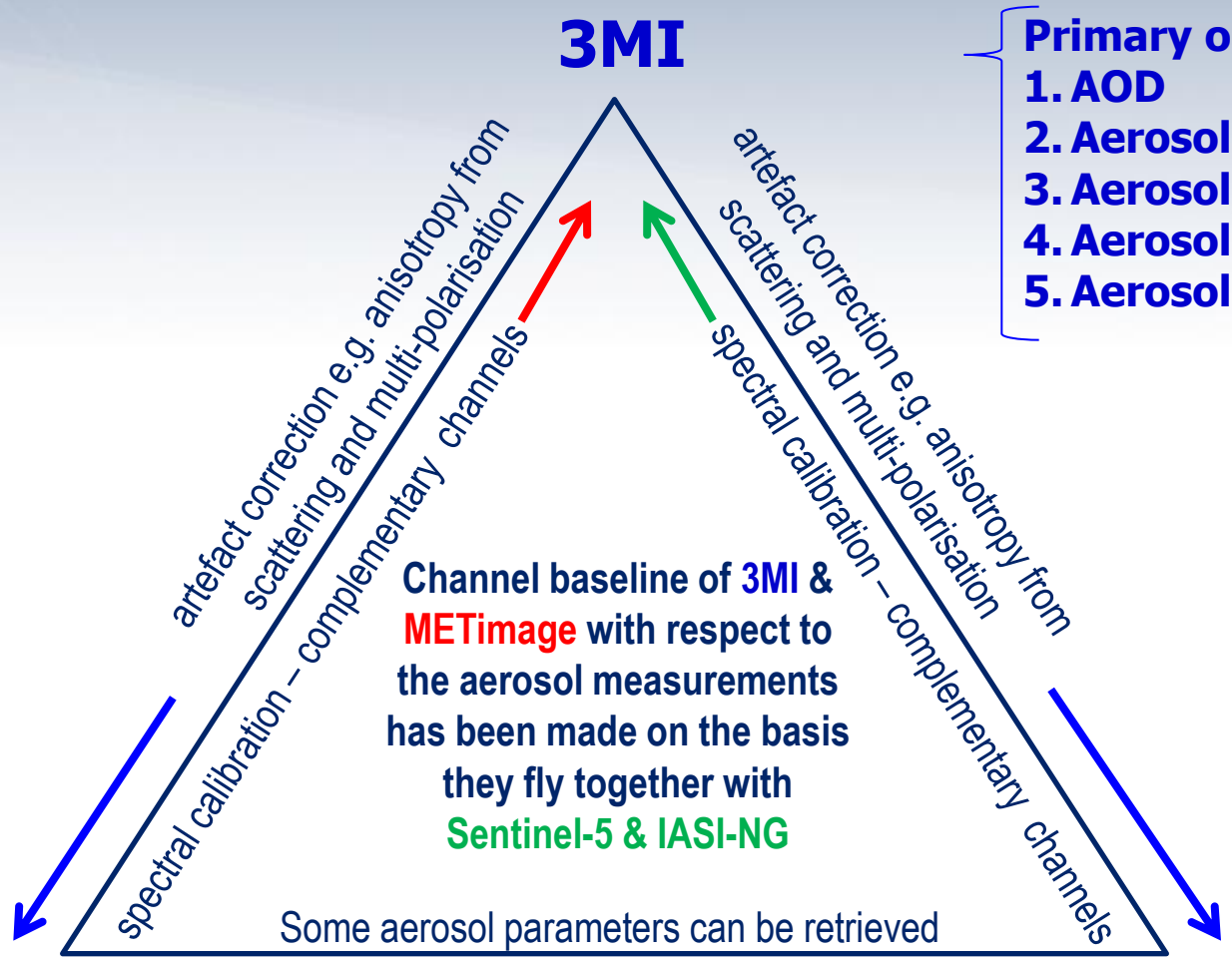
3MI: Calibration

3MI: Geophysical Products

3MI: Benefits

3MI: Synergy with other EPS-SG Instruments

Synergy with other EPS-SG Instruments



Primary objective:

1. **AOD**
2. **Aerosol particle size**
3. **Aerosol type**
4. **Aerosol height index**
5. **Aerosol absorption**

Thank you for your attention

More information:
http://www.eumetsat.int/website/home/Satellites/FutureSatellites/EUMETSATPolarSystemSecondGeneration/index.html

EPS-SG

EUMETSAT