3MI

Operational monitoring of aerosols from EPS-SG

J. Riedi - LOA

Paris Aerosols/Clouds Workshop - 14/09/2011

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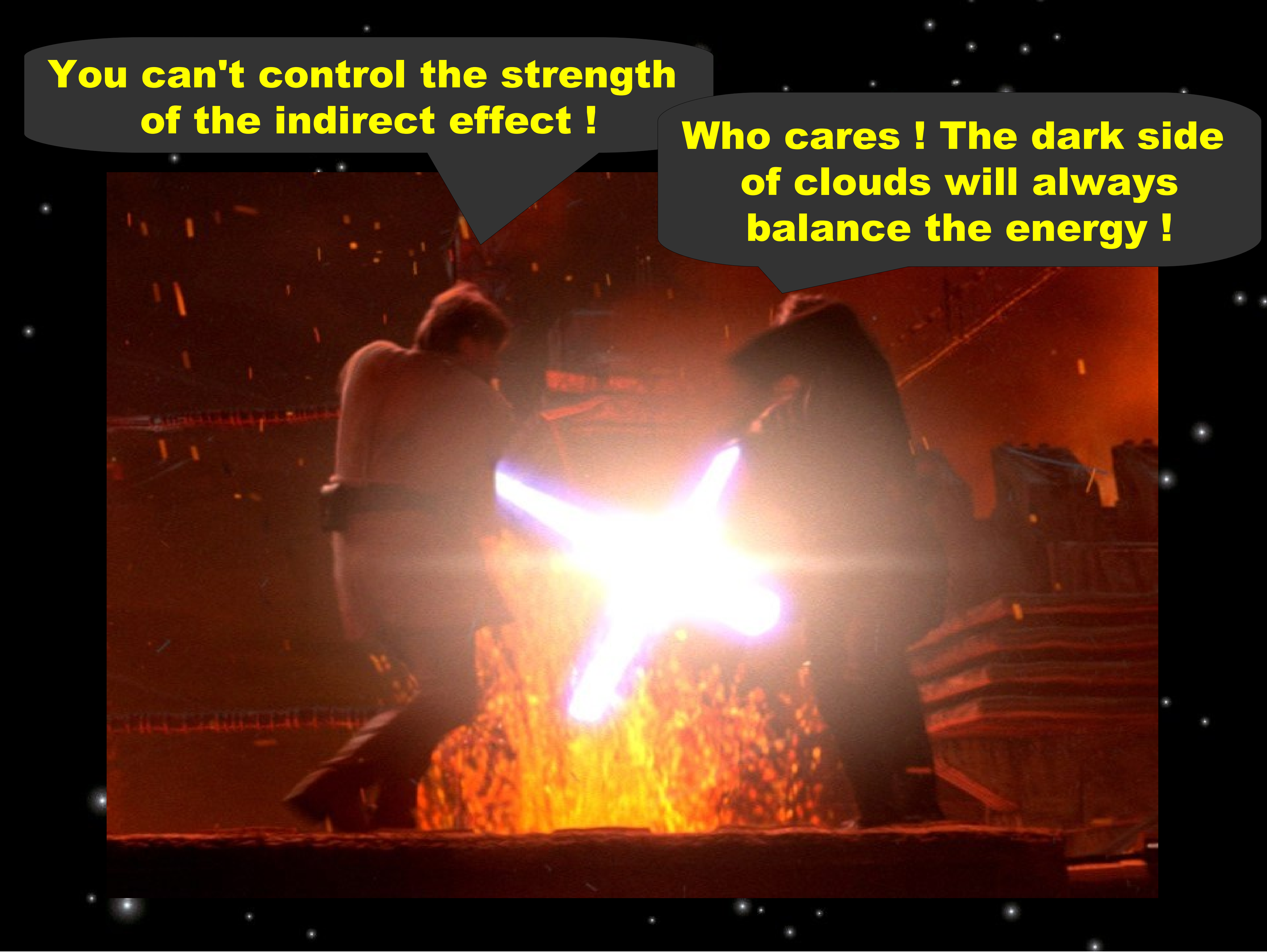
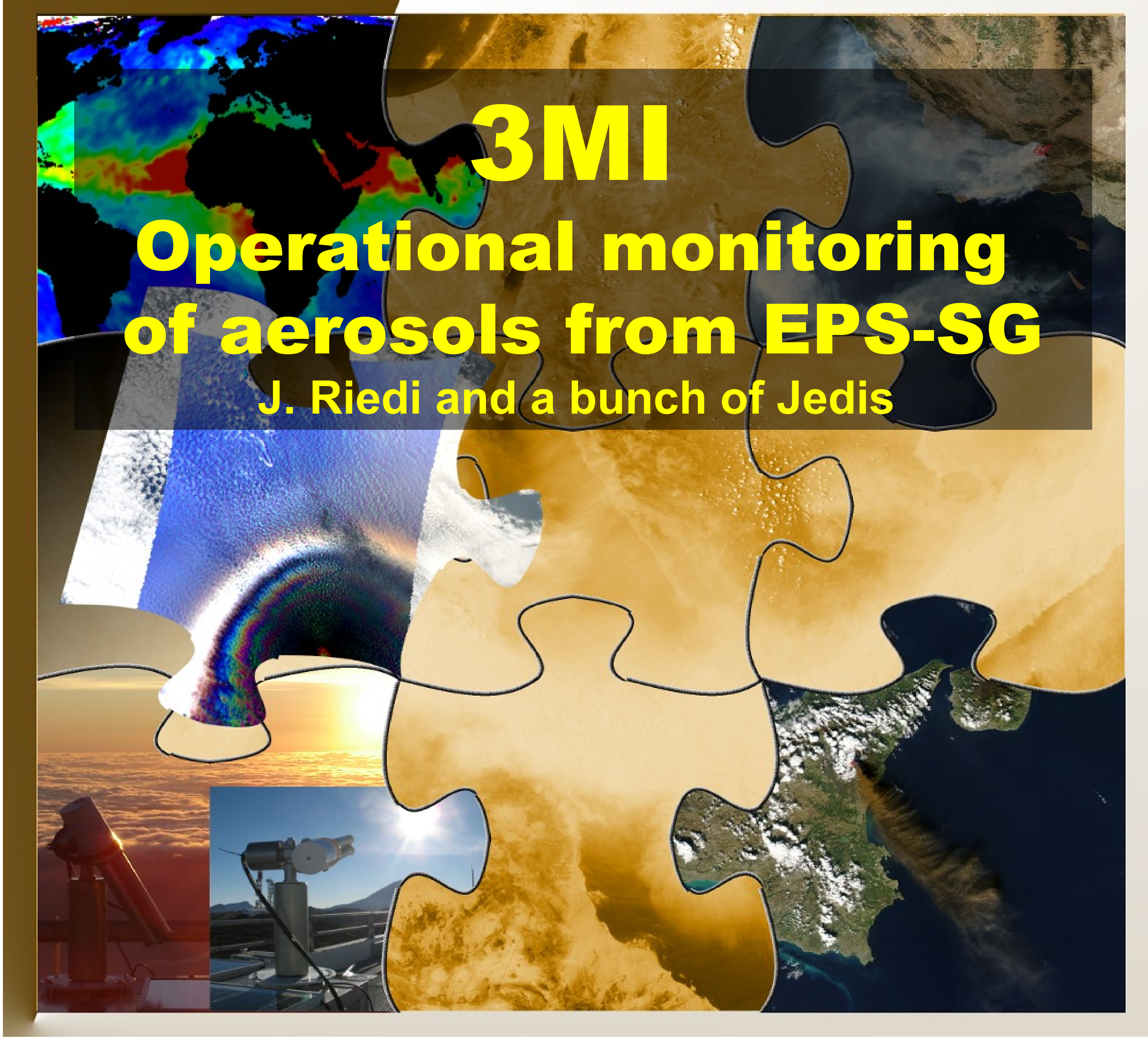
A LITTLE WHILE AGO

IN A NOT SO FAR

REMOTE SENSING LABORATORY ...

Episode III
The revenge of the 60th


You can't control the strength of the indirect effect !
Who cares ! The dark side of clouds will always balance the energy !



3MI

Operational monitoring of aerosols from EPS-SG

J. Riedi and a bunch of Jedis

Rationale for operational monitoring/forecasting of aerosols

- Climate record

- Meteorological application

- Air quality monitoring and forecasting

- Extreme events (dust, volcanoes, fires)

- Policy control : which part of the total aerosol can be attributed to emission from one country ?

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Requirements for operational monitoring/forecasting of aerosols

- Climate record
  → continuity and global coverage
- Meteorological application
  → near real time
- Air quality monitoring and forecasting
  → detailed aerosol properties over land and ocean
- Extreme events – security (dust, volcanoes, fires)
  → near real time and details size/composition
- Policy control : which part of the total aerosol can be attributed to emission from one country ?
  → Scientist should be well paid to avoid corruption

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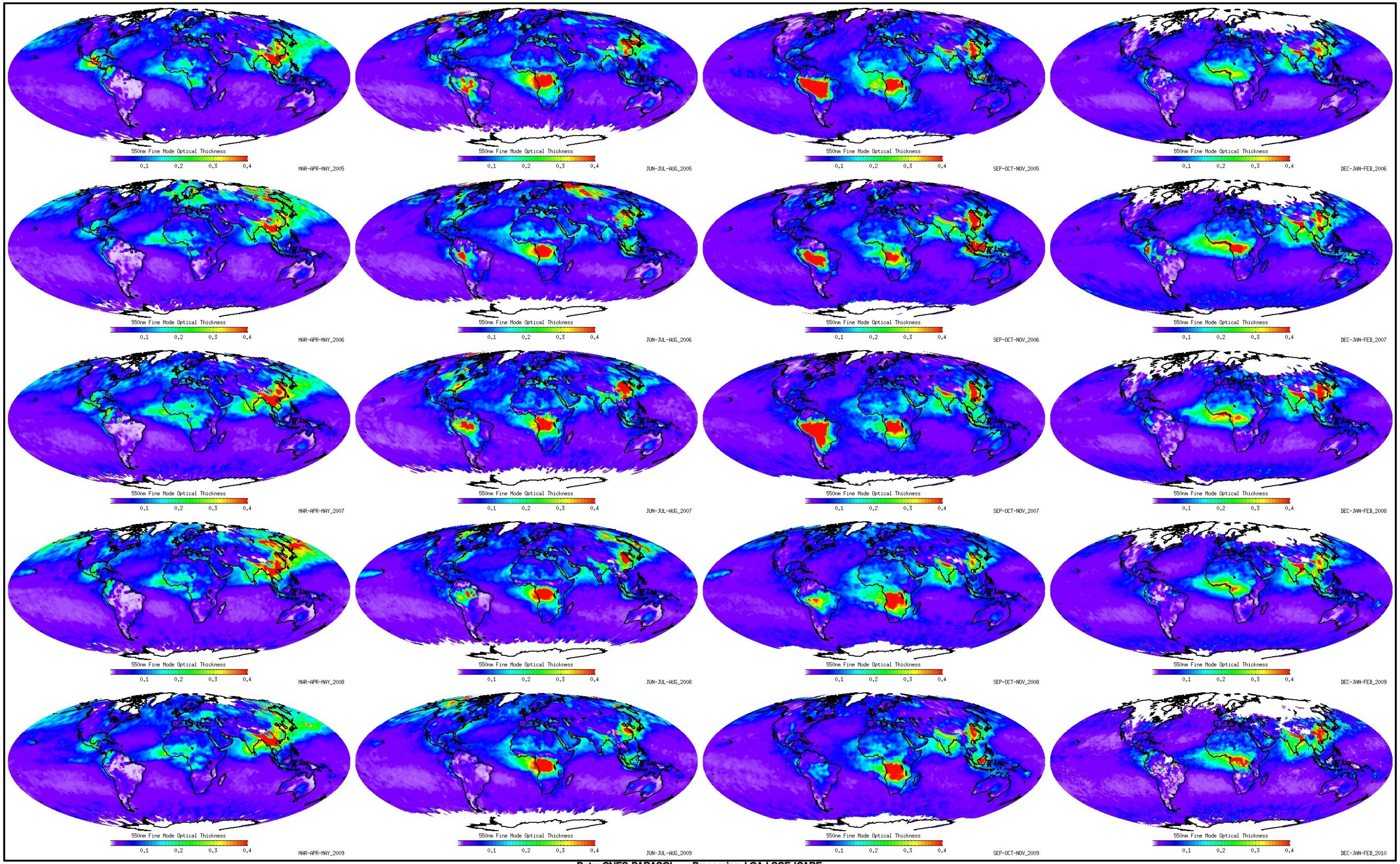
POLDER Heritage
AOT of fine mode land/ocean

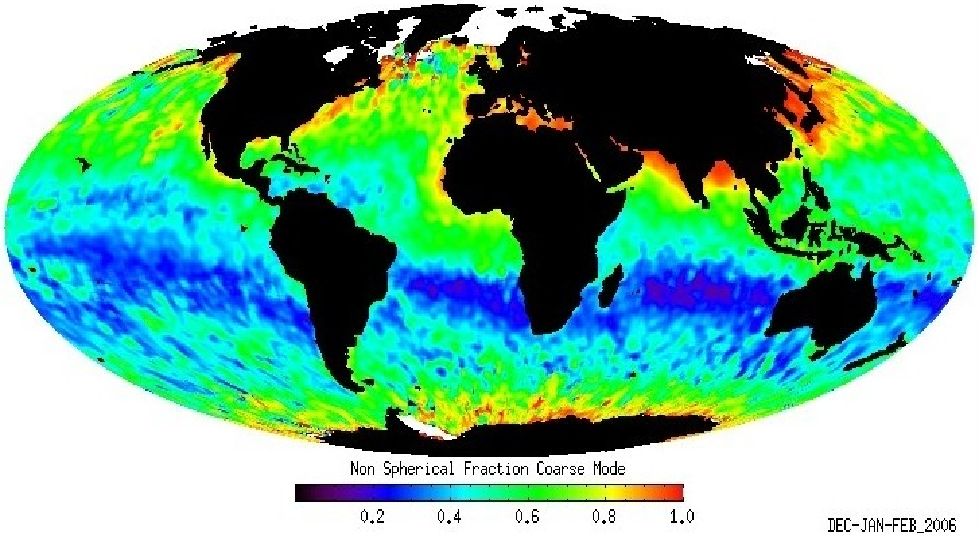


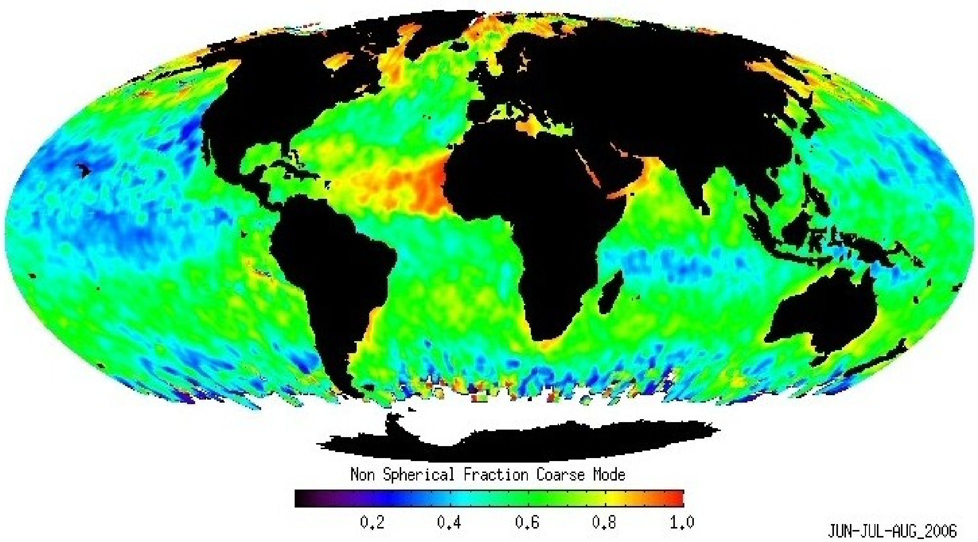
Data: CNES-PARASOL   Processing: LOA-LSCE-ICARE

Credits : ICARE Data and Services Center

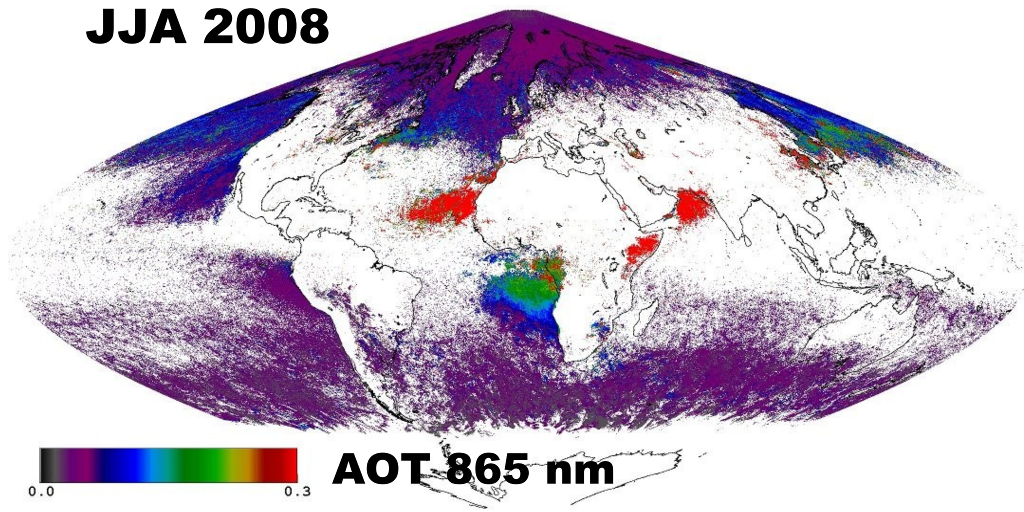
POLDER Heritage

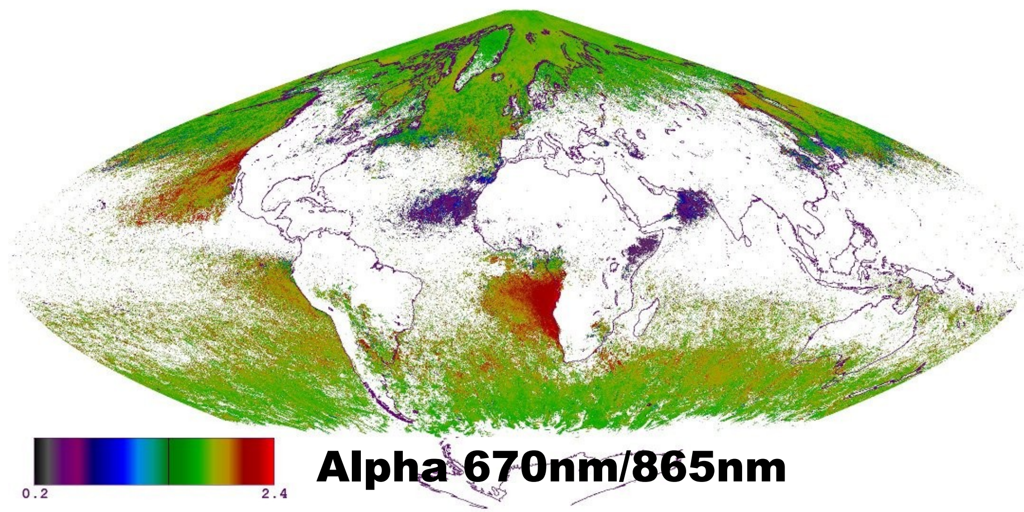
Non spherical fraction of coarse mode





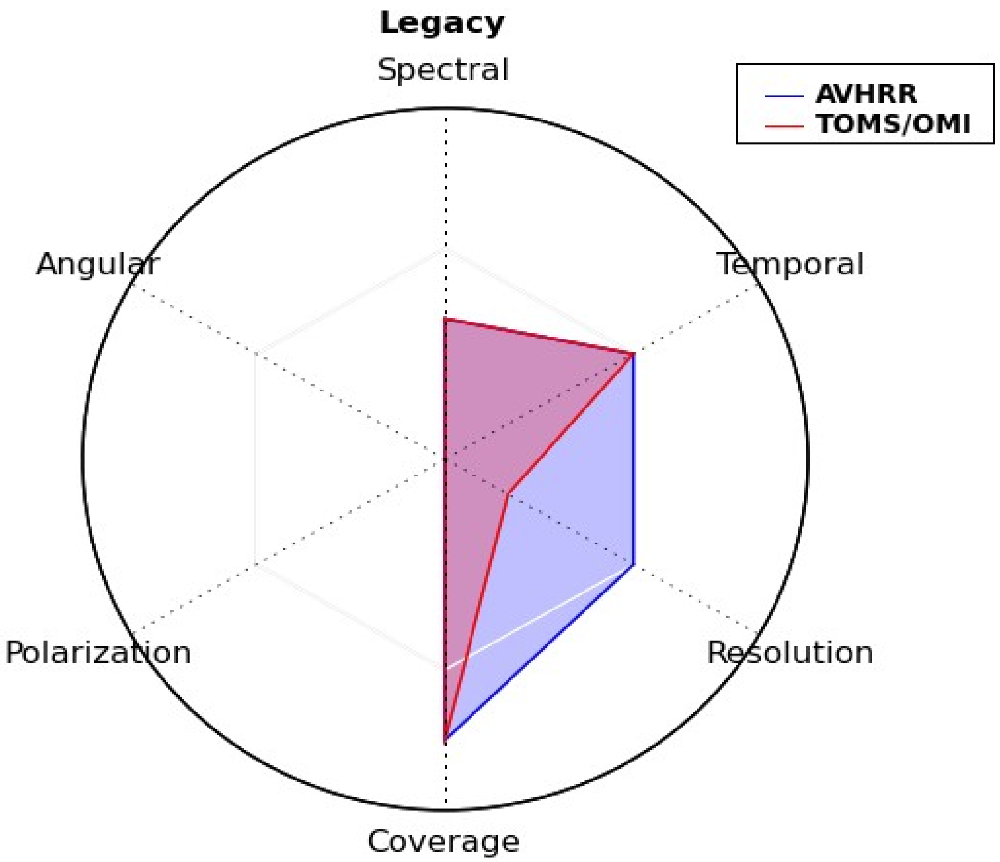
Aerosols above clouds

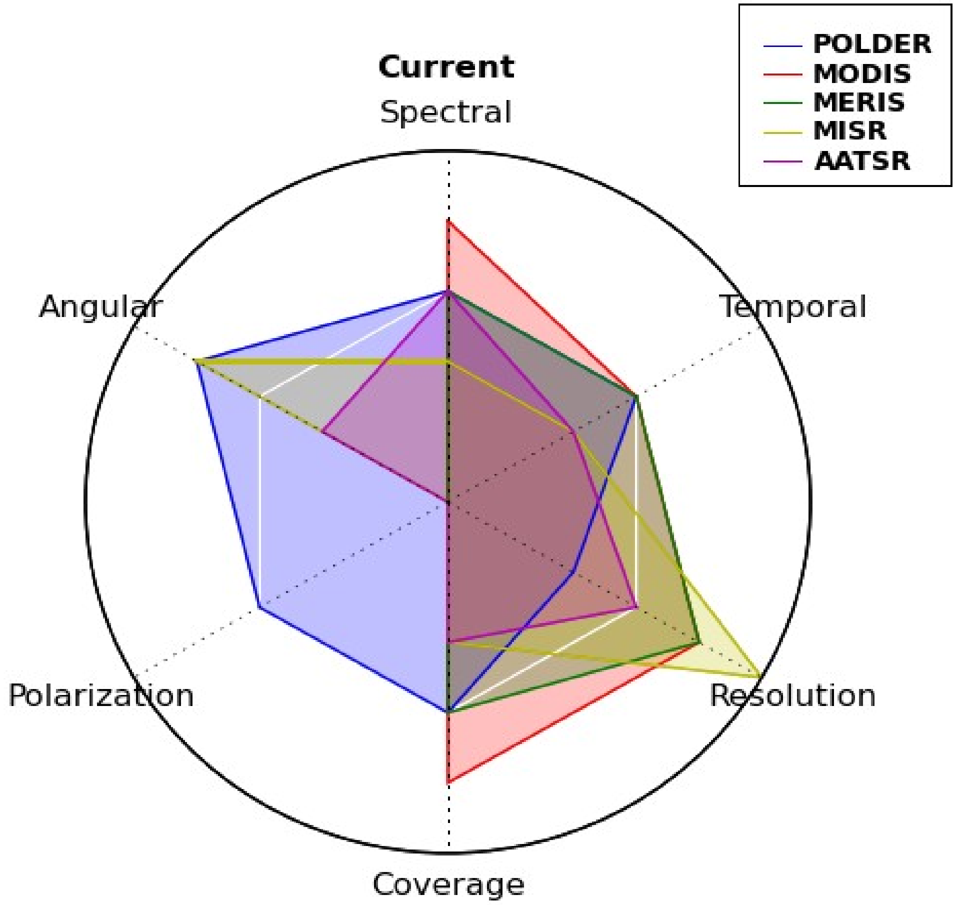




Waquet et al, 2011

Past and Present





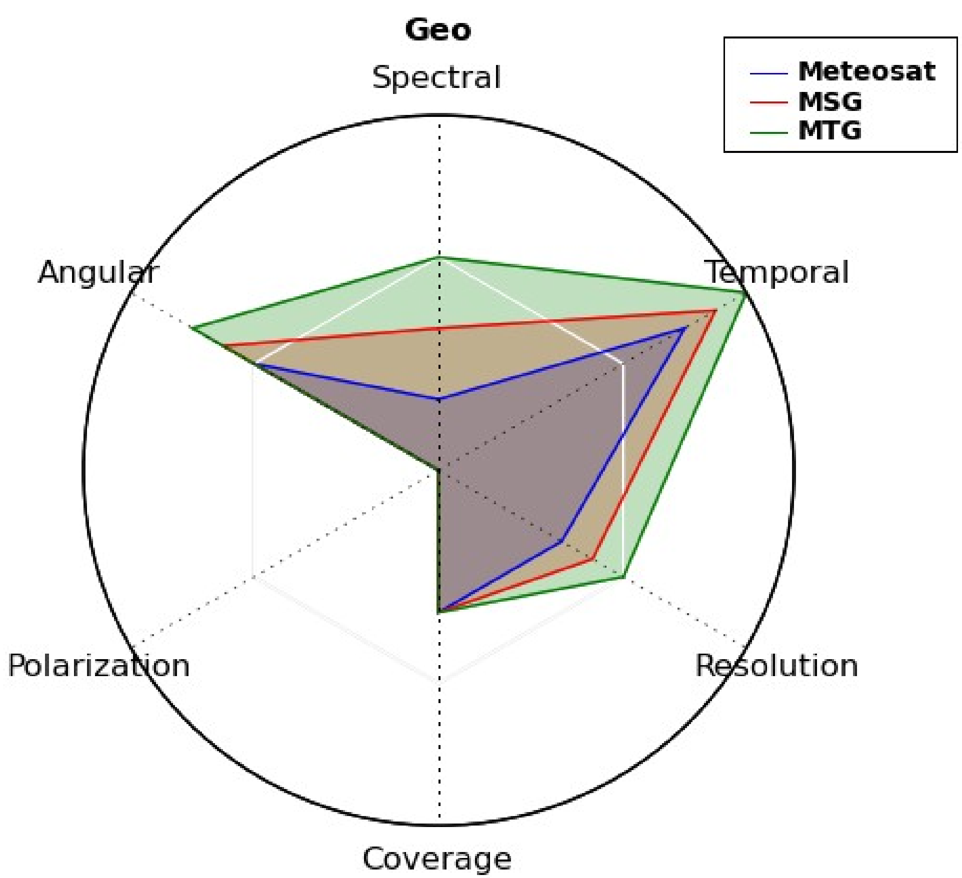
Going beyond POLDER
SCIENCE RATIONALE

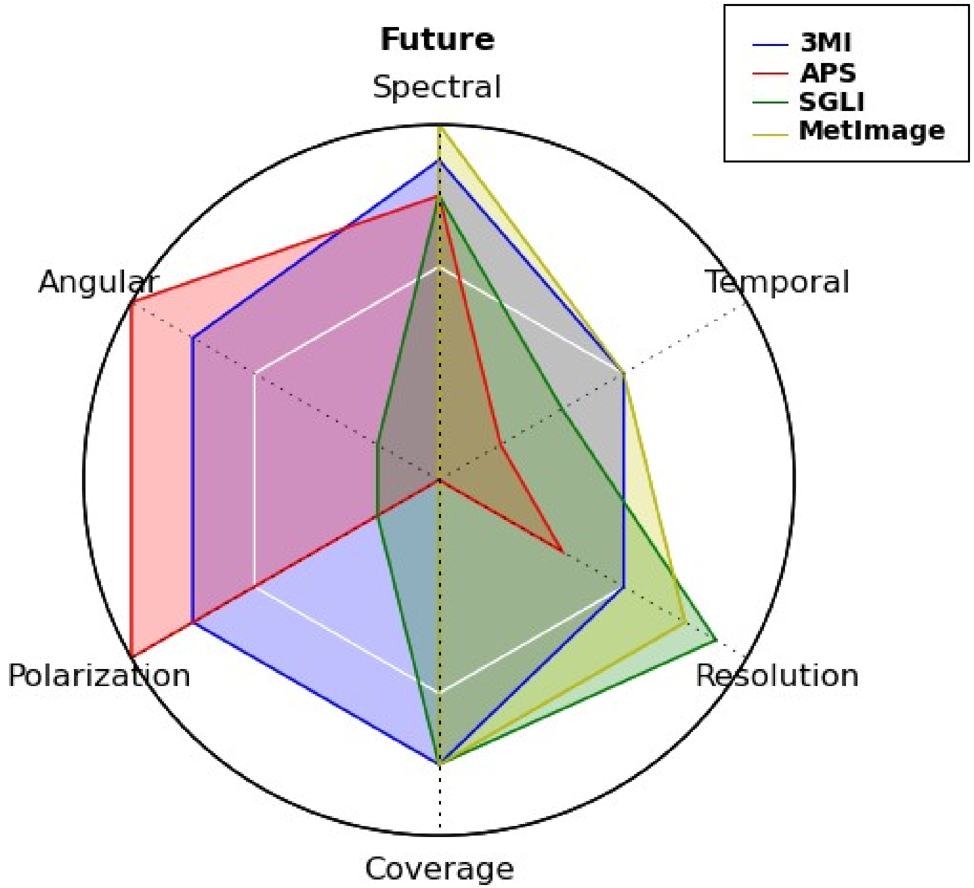
Significant uncertainties in aerosols (and clouds) remote sensing remain due to limited constraints we can impose on atmosphere models, not because of calibration accuracy.

→ operational observation systems are not adapted anymore to make progress in observation of aerosols/cloud properties : we need to rethink our observation strategy

→ an evolution of POLDER type Instrument providing Multiangle, Multispectral and Multipolarisation (3MI) observations may fulfill these requirements

Future


Geo
Spectral
Temporal
Resolution
Coverage
Polarization
Angular
Meteosat
MSG
MTG


Future
Spectral
Temporal
Resolution
Coverage
Polarization
Angular
3MI
APS
SGLI
MetImage

3MI : Lessons learned from POLDER
SCIENCE RATIONALE

POLDER has already provided strong basis for improved remote sensing of aerosols / clouds but clear improvements can be expected from evolutions of the initial concept :

Spectral and polarization coverage :
→ UV and SWIR extension

Spatial resolution :
→ aerosols and clouds do coexists in a continuum and we need to resolve what happens at this fuzzy frontier

Angular sampling :
→ new retrieval methodologies are available to infer surface and aerosol properties simultaneously : angular sampling can be improved both instantaneously and by temporal analysis

3MI : Lessons learned from POLDER SPECTRAL COVERAGE

The spectral coverage of POLDER has been a clear limitation

UV and SWIR will enable better characterization of aerosol properties for both the coarse and fine mode over land and ocean.

Performance studies of full retrievals (Dubovik, 2011) based on synthetic observations for various channels combinations showed that :

- SWIR extension is critical and improves retrieval of all parameters including (somehow surprisingly) layer altitude and spectral absorption because coarse mode is much better constrained

- UV extension is also critical for determination of absorption at shorter wavelength though we have not demonstrated the added value of a UV channel at 360nm for our retrieval framework

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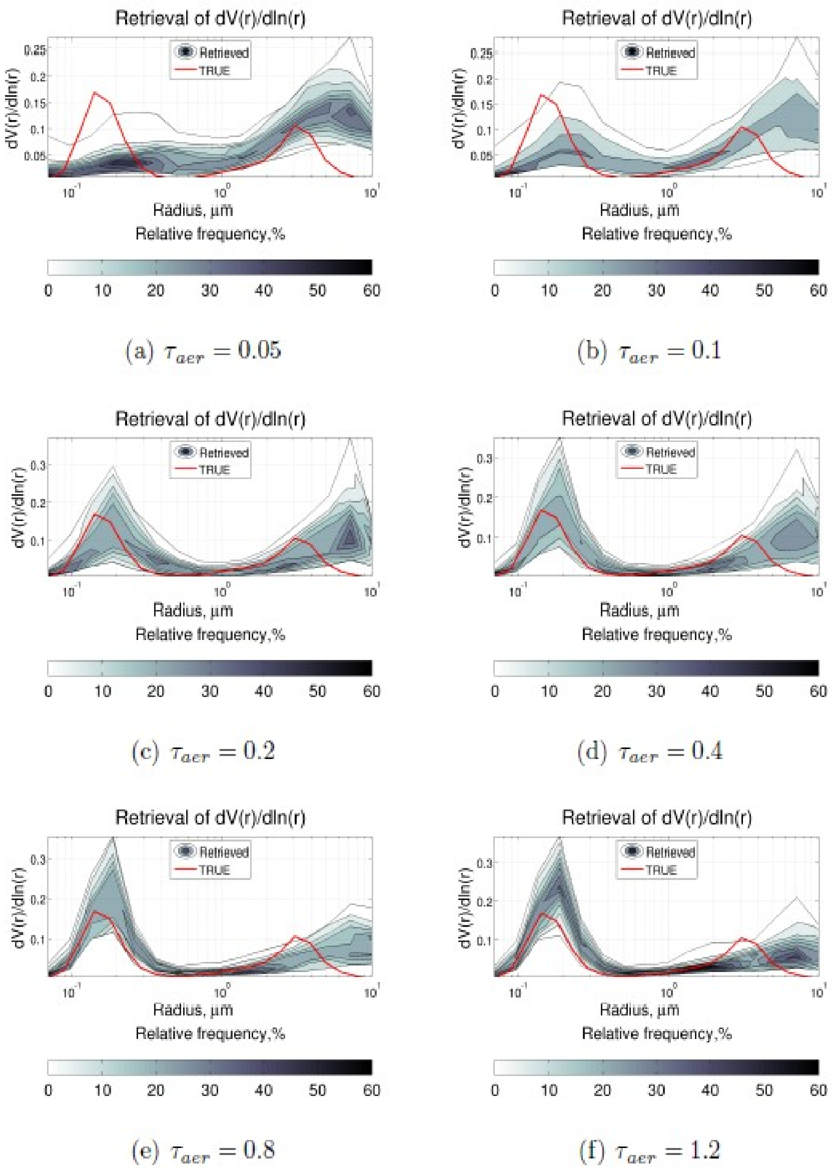
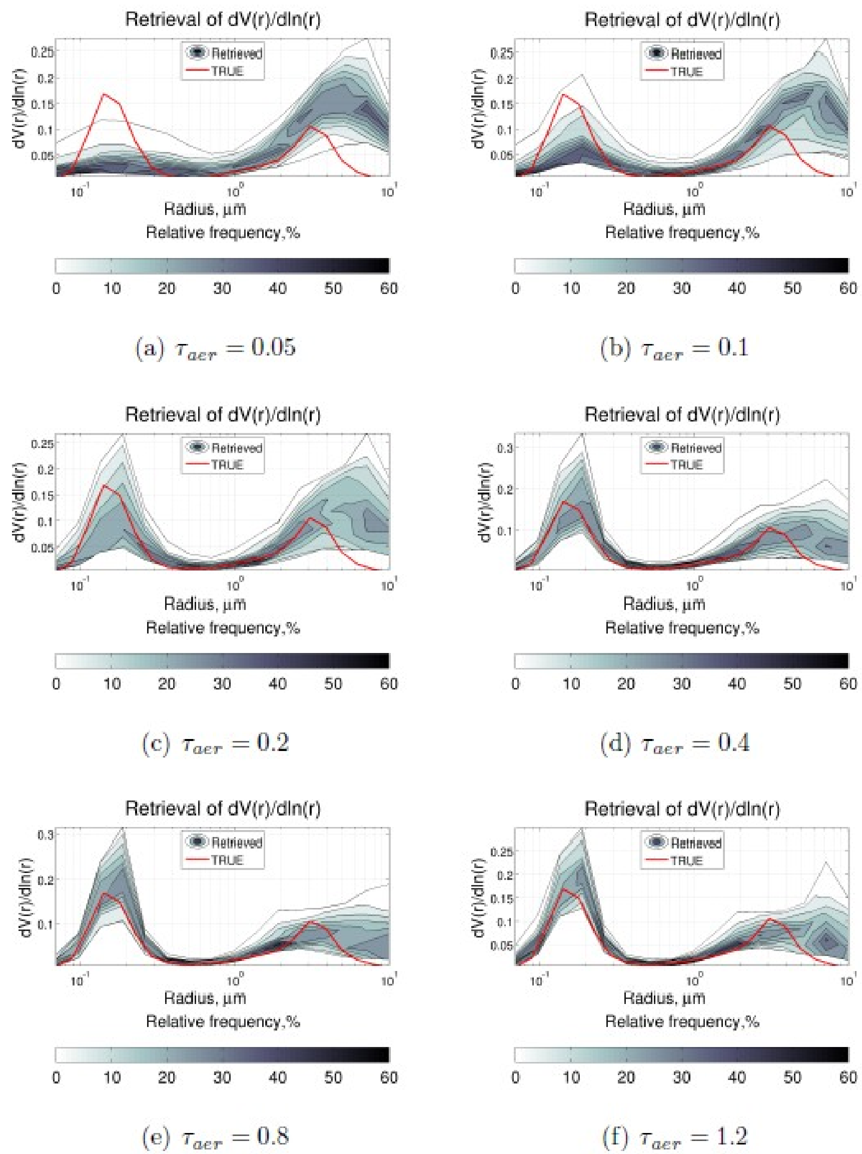


POLDER + UV

Figure 4.17: Retrieved and assumed Size Distribution for different aerosol layer optical thicknesses for combination POLDER base UV and 6 different optical thicknesses.



POLDER + SWIR

Figure 4.16: Retrieved and assumed Size Distribution for different aerosol layer optical thicknesses for combination POLDER base SWIR and 6 different optical thicknesses.

3MI : Lessons learned from POLDER
SPATIAL RESOLUTION

Rationale : Users requirements define the product resolution BUT the retrieval requirements define the instrument resolution

Resolution for 3MI must account for aerosols and clouds spatial variability scales

Aerosols and clouds do appear as a continuum :
- maximize the probability of getting clear sky (non cloudy) pixels
- allow for understanding processes at the transition zone

1) SWIR and VIS resolution need to be consistent
2) Higher res. in VIS would be useful in some bands
3) multiangle registration at layer altitude requires High. Res.

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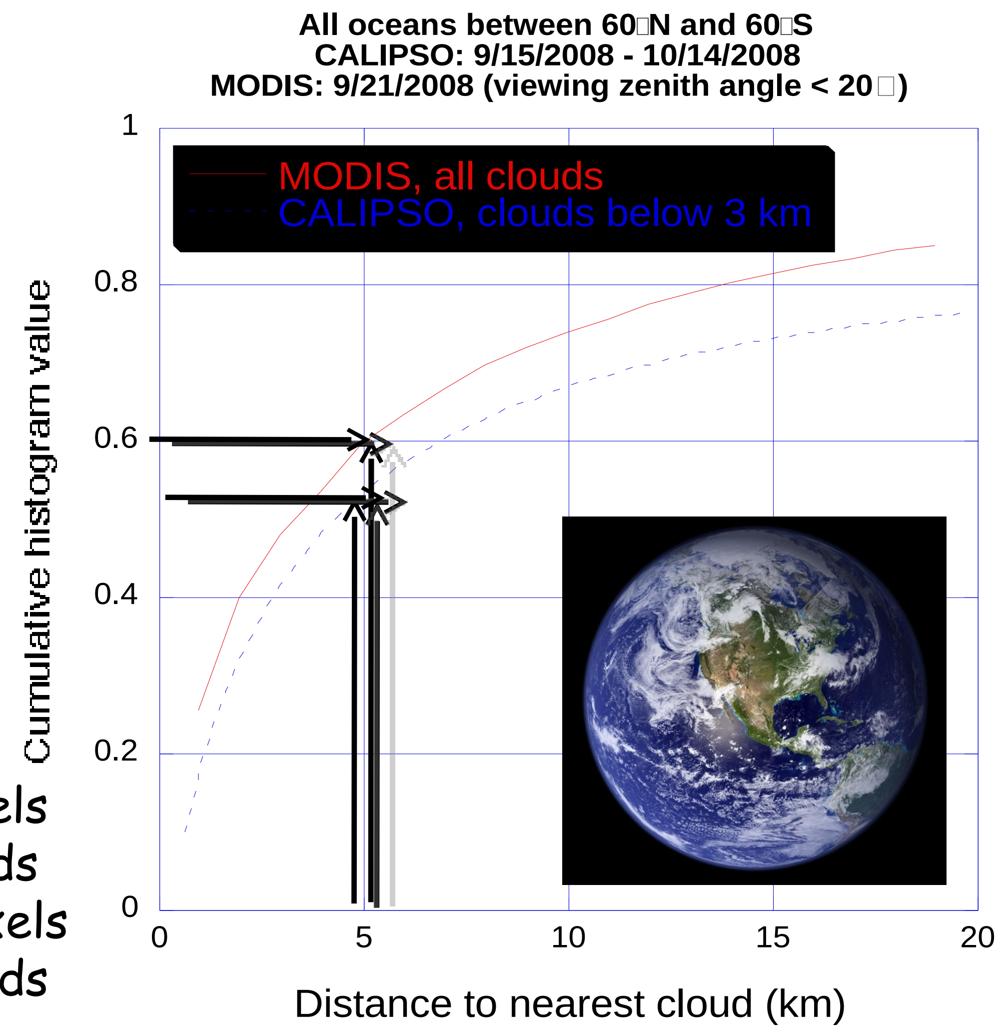
3MI : Lessons learned from POLDER SPATIAL RESOLUTION

- Climate studies (e.g., aerosol indirect effect) demand a precise separation of clear and cloudy air;
- Remote sensing retrievals of aerosol properties near clouds are not problem free;
- Excluding aerosols retrieved near clouds underestimates aerosol radiative forcing while including them may overestimate the forcing.



from **MODIS**: 60% of all clear sky pixels are located 5 km or less from all clouds
from **CALIPSO**: 50% of all clear sky pixels are located 5 km or less from low clouds
(e.g., Twohy et al., 2009)

Courtesy A. Marshak

3MI : Lessons learned from POLDER ANGULAR SAMPLING

First of all : there is no quantum effect in aerosol remote sensing ! Multiangle measurements are always better than single view because we can observe, quantify and understand the problems ...
Single view instrument sometimes don't appear to see as much problems but those exist regardless.

Angular sampling :
- the sampling will never be symmetrical
- we shouldn't even try to get constant angular sampling (ie MISR) because more information can be retrieved by combining neighboring pixels
- not all directions were created equals but 2 remains greater than 1
- High Res. angular sampling would be useful for some bands

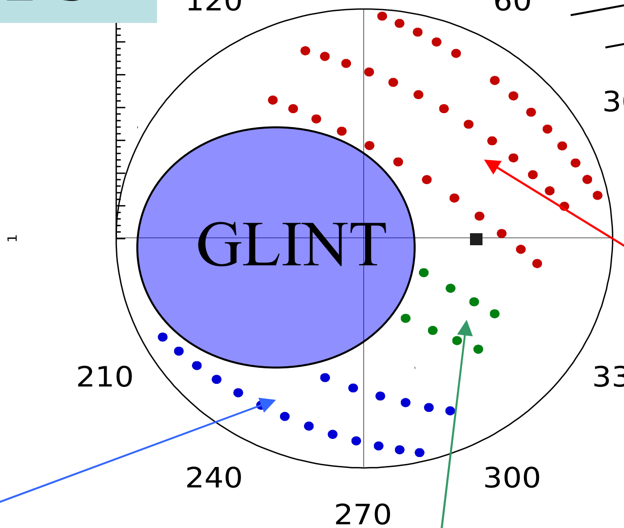
3MI : Lessons learned from POLDER ANGULAR SAMPLING

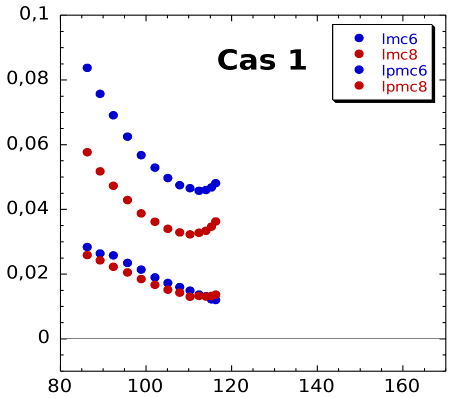
Over Ocean « Cases 1-2-3 »

13 views of the same target

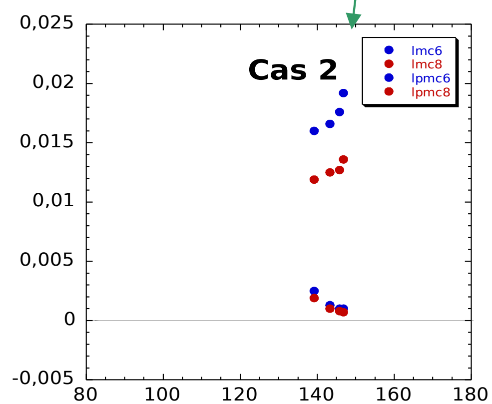
West

East

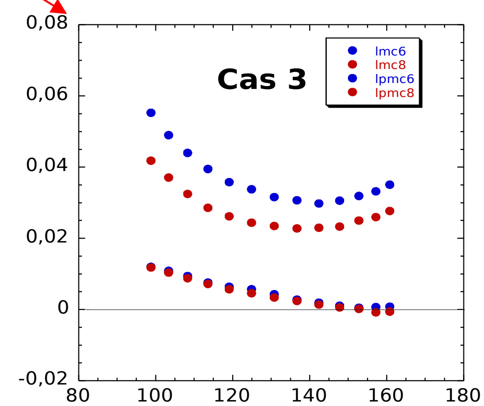




$\delta, \delta_{Acc}, r_{Acc}, m_{Acc}, \alpha$



$\delta, \delta_{Acc}, \alpha$

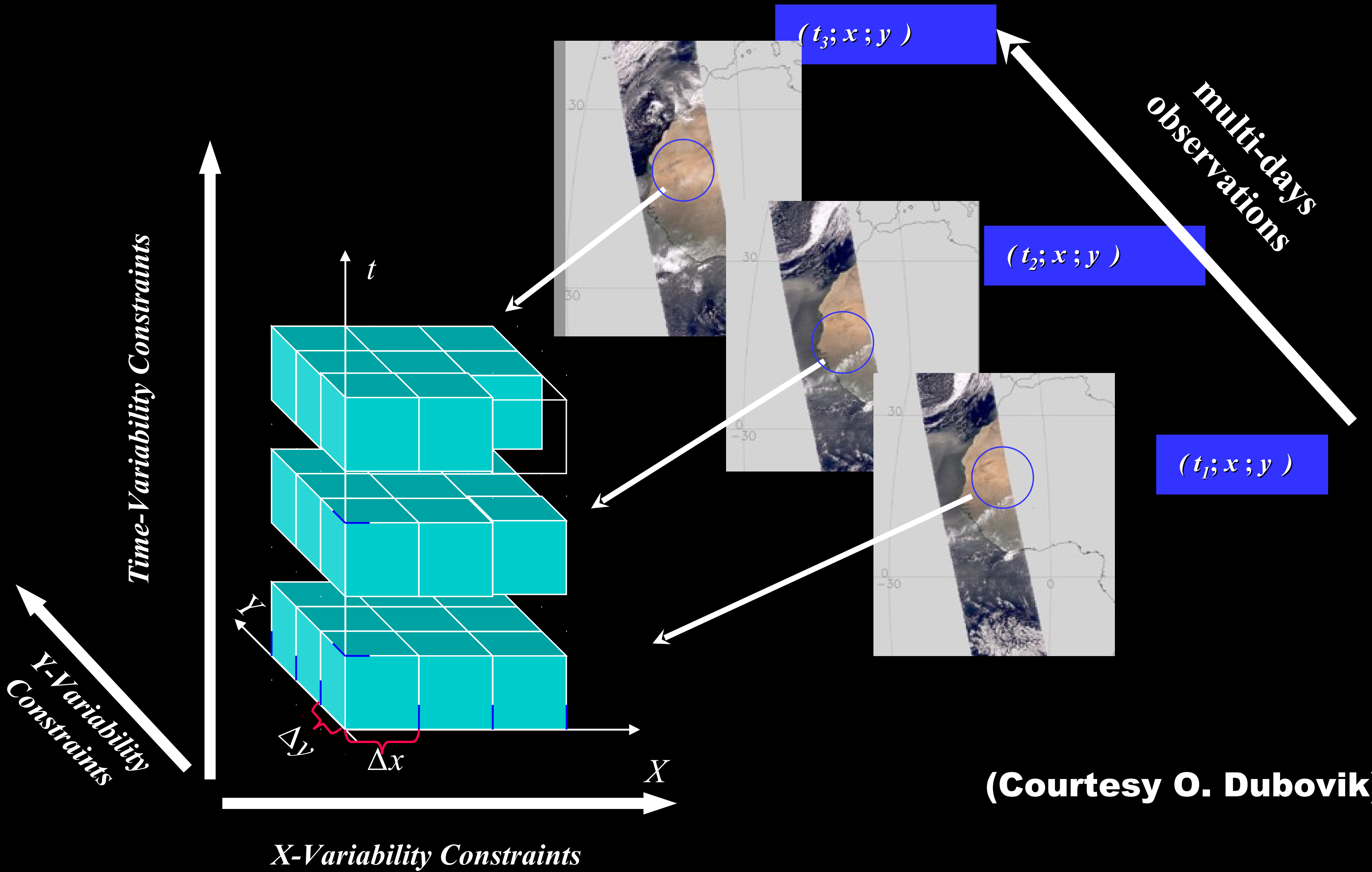


$\delta, \delta_{Acc}, r_{Acc}, m_{Acc}, m_{coarse}, \alpha$

$NSI = \delta_{ns}/(\delta_{cs}+\delta_{cns})$

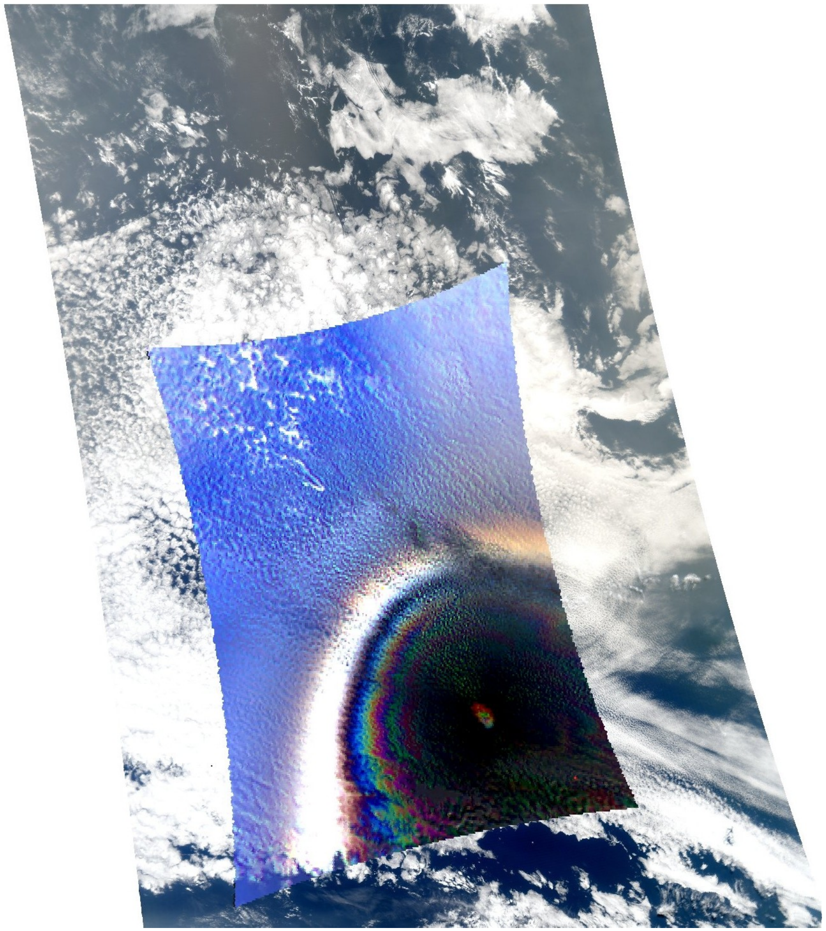
(Herman et al., J.G.R. 2005)

The concept of multi-pixel retrieval



(Courtesy O. Dubovik)

3MI : Lessons learned from POLDER and MODIS



POLDER has demonstrated clear potential for aerosol remote sensing for climate studies and air quality monitoring.

In addition, a number of studies from POLDER/MODIS led to innovative approaches for aerosols and clouds remote sensing :
- aerosol above clouds : Waquet et al, JAS, 2009, 2011
- cloud phase : Riedi et al, ACP, 2010, Zeng, 2011 (PhD)
- ice cloud microphysics : Zhang et al, ACP 2009
- cloud vertical struct. from O2 A-Band : Ferlay et al, JAMC 2010

All of which are of clear interest for meteorological purpose : radiative effect of aerosols over clouds, links between cloud phase, microphysics and precipitations, ...

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3MI Requirements in a nutshell

Instrument requirements

- large field of view of 114°
- 10 to 14 different angles per ground pixel
- 13 optical channels – 8 of them in 3 polarization → 29 channels
- Polarization sensitivity > 96% for polarized channels
- Polarization sensitivity < 5% for non polarized channels
- Bandwidth from 10 nm (UV) to 40 nm (SWIR)
- co-registration of ~7 sec max between all channels for one direction
- ground resolution between 2km (goal) and 6km (threshold) – current status being 4km for all channels

Mission band	Wavelength [nm]	FWHM [nm]	Polar.
3MI-1	354	10	Y
3MI-2	388	20	Y
3MI-3	443	20	Y
3MI-4	490	20	Y
3MI-5	555	20	N (T)
3MI-6	670	20	Y
3MI-7	763	10	N
3MI-8	765	40	N
3MI-9	865	40	Y
3MI-9a	910	20	N
3MI-10	1370	40	Y (G)
3MI-11	1650	40	Y
3MI-12	2150	40	Y

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3MI Requirements in a nutshell

The real color of UV is GREEN !!!

13033CS-U [RF] © www.visualphotos.com

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3MI-12	2150	40	Y

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Meeting the requirements

If we (Jedis) think that what we're doing is important, we need to convince our agencies (The Forces) to come up with multispectral fundings

Mission band	Wavelength [nm]	FWHM [nm]	Polar.
3MI-1	354	10	Y
3MI-2	388	20	Y
			Y
			Y
			N (T)
			Y
			N
			N
			Y
			N
			Y (G)
			Y
			Y

Join the Force !

Support 3MI !