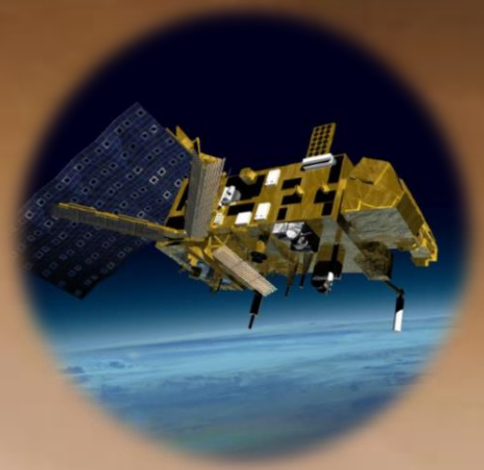

From the Mad Max movie

Mineral dust

Satellite observations in the thermal infrared

Sophie Vandenbussche

Royal Belgian Institute for Space Aeronomy

BIRA·IASB

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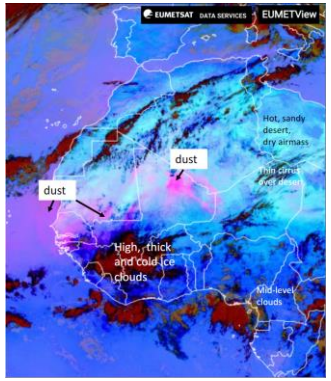
Introduction

Yesterday: full introduction on dust observations from space using UV, visible, infrared observations

Today: a specific case of satellite observations, providing different and targeted information on dust aerosols (**intrinsic selectivity** linked to the spectral range of the observations)

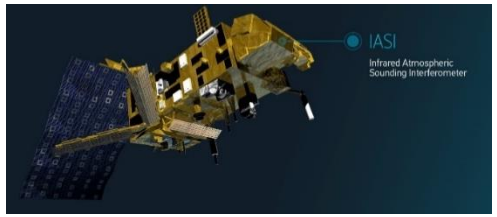
→ the thermal infrared (TIR)

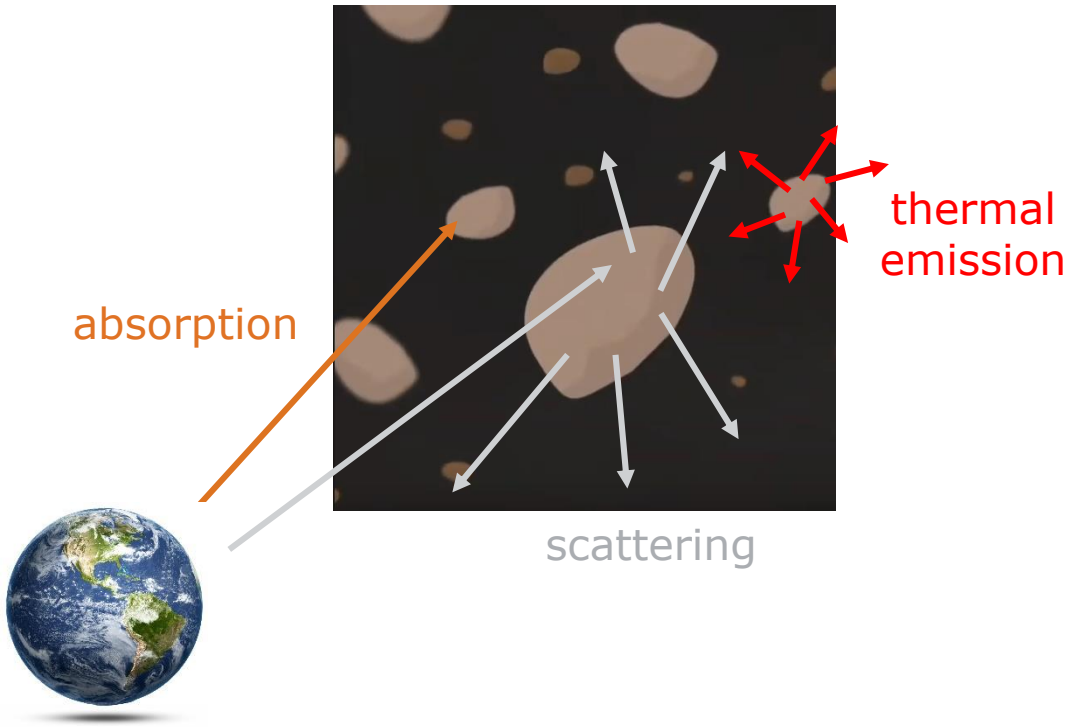


e.g. SEVIRI Dust RGB using the TIR bands
Red: IR12 – IR10.8
Green: IR10.8-IR8.7
Blue: IR10.8

→ hyperspectral observations in the TIR bring additional **quantitative** information
→ **Dust AOD, altitude, radius, composition** (including at **night**)

Specificities of the Thermal Infrared





Thermal Infrared radiative considerations

- Surface as source: temperature, emissivity
- Atmosphere as source: gases, aerosols, clouds (and their temperature)
- Atmosphere as sink: absorption and scattering by gases, aerosols, clouds

Aerosol signature

- Absorption/emission → minerals → **dust and ash**
- Scattering → coarse mode (**large particles**)

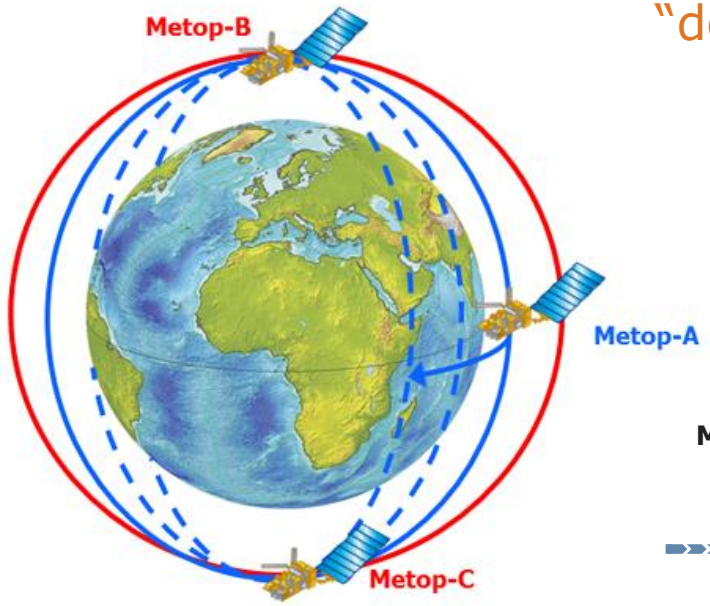
Clouds have to be « removed »

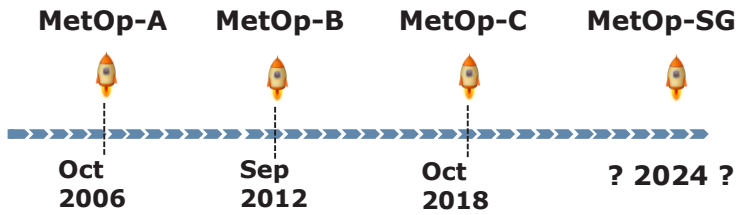
The Infrared Atmospheric Sounding Interferometer

Orbital characteristics:

- Sun-synchronous
- Overpass at local solar time: ~9h30 and 21h30

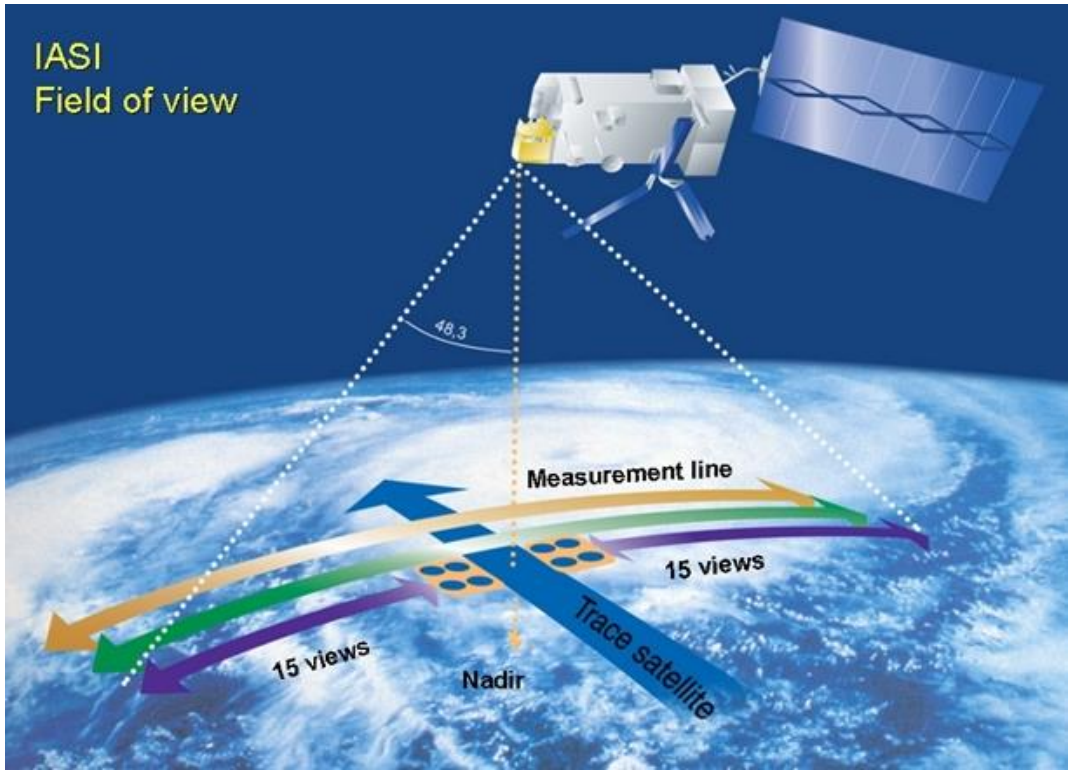
"descending" - "ascending"



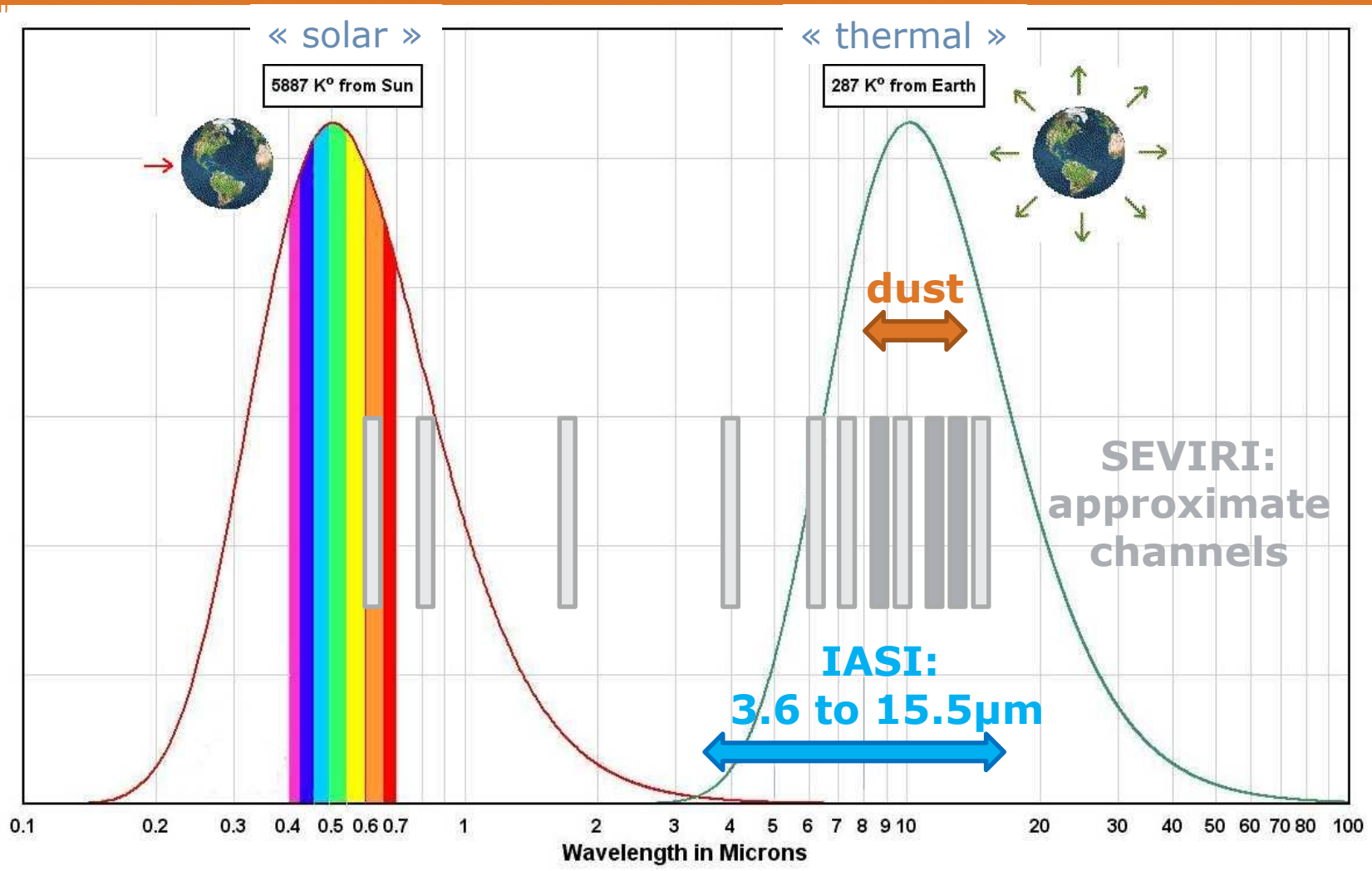


Observation technique:

- Nadir, across path scanning, FTIR
- 12km diameter pixels (at nadir)



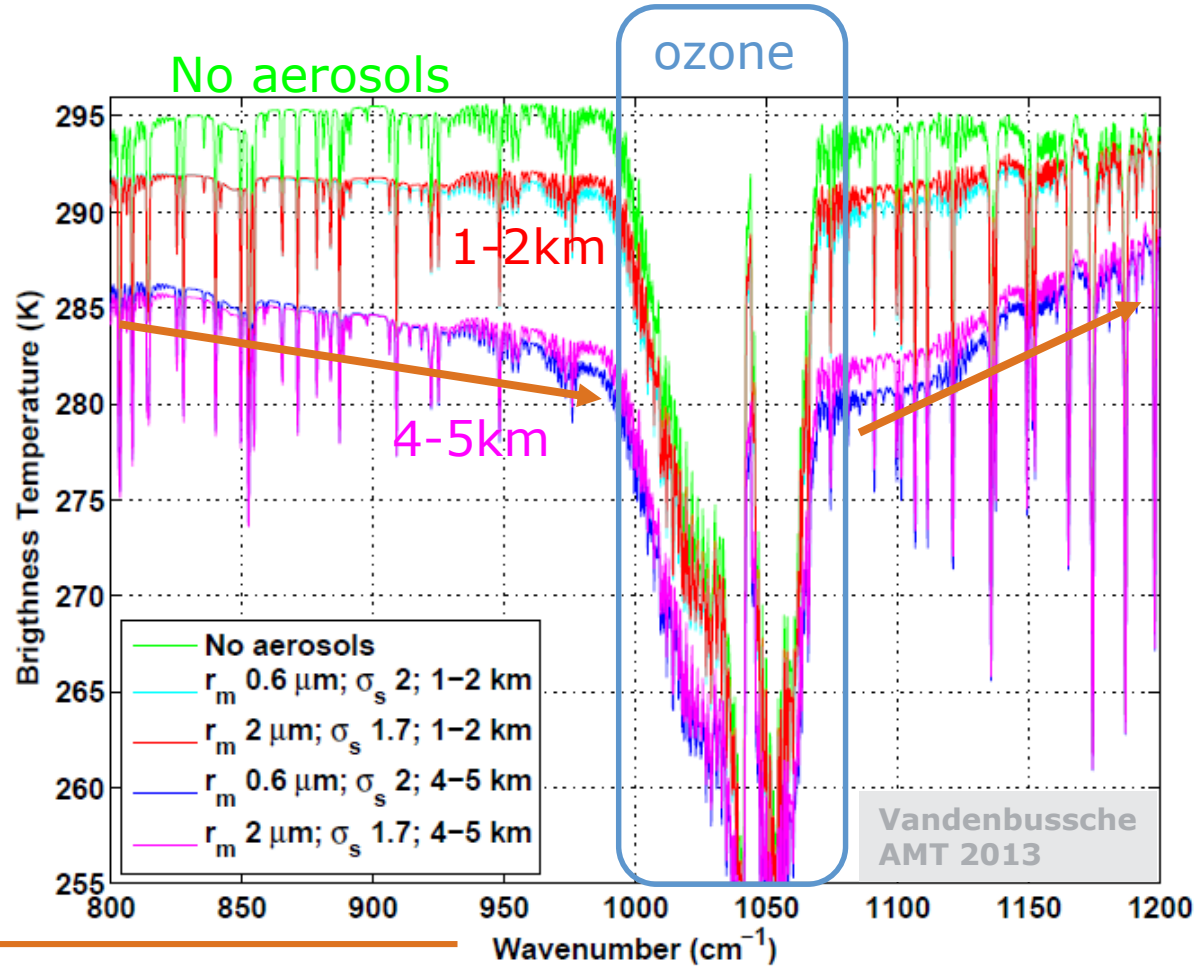
Spectral ranges



IASI dust observations

Brightness temperature: a way to measure radiance / energy

$$wavenumber = \frac{1}{wavelength}$$



Sensitivity to (from highest to lowest)

- Total amount – AOD (green vs other)
- Altitude (mag vs red)
- Size and composition (blue vs mag and cyan vs red)

!! Only **large particles**
!! Need **cloud-free**

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IASI dust observations

4 very different algorithms provide full data sets

ULB Dust

Dust index converted to AOD through NN

Parameters: dust AOD - dust index

Availability: CDS (level 3) - EUMETSAT and (level 2) https://www.aeris-data.fr

Infrared Mineral Aerosol Retrieval Scheme (IMARS)

Probabilistic estimations (dust/ice)

Parameters: dust AOD and layer T, dust size and composition

Availability: CDS (level 3)

LMD Dust

Lookup tables (3 steps)

Parameters: dust AOD and mean altitude, dust effective radius (not public)

Availability: CDS (level 3, not the radius) and (level 2) https://www.aeris-data.fr

Mineral Aerosol Profiling from Infrared Radiances (MAPIR)

Optimal estimation

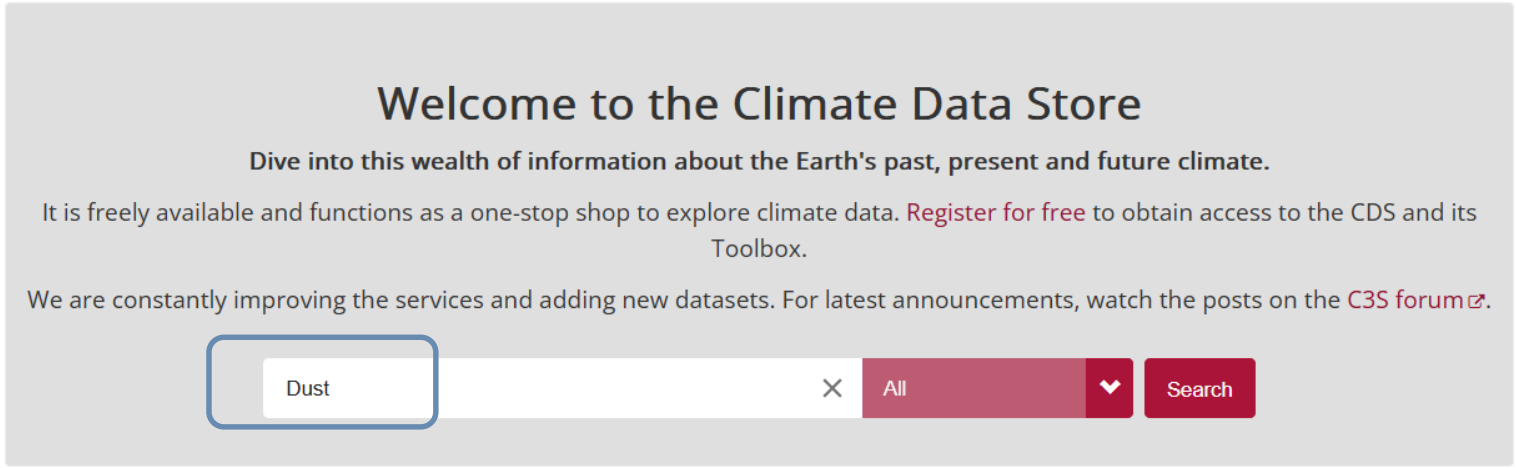
Parameters: dust AOD, mean altitude, vertical profile

Availability: CDS (level 3, not the profiles) and (level 2) https://iasi.aeronomie.be

IASI dust observations

Access through the Climate Data Store https://cds.climate.copernicus.eu

Dust AOD and mean altitude level 3: daily / monthly, day / night / both



Showing 1-3 of 3 results for **Dust** x

→ Aerosol properties gridded data from 1995 to present derived from satellite observations

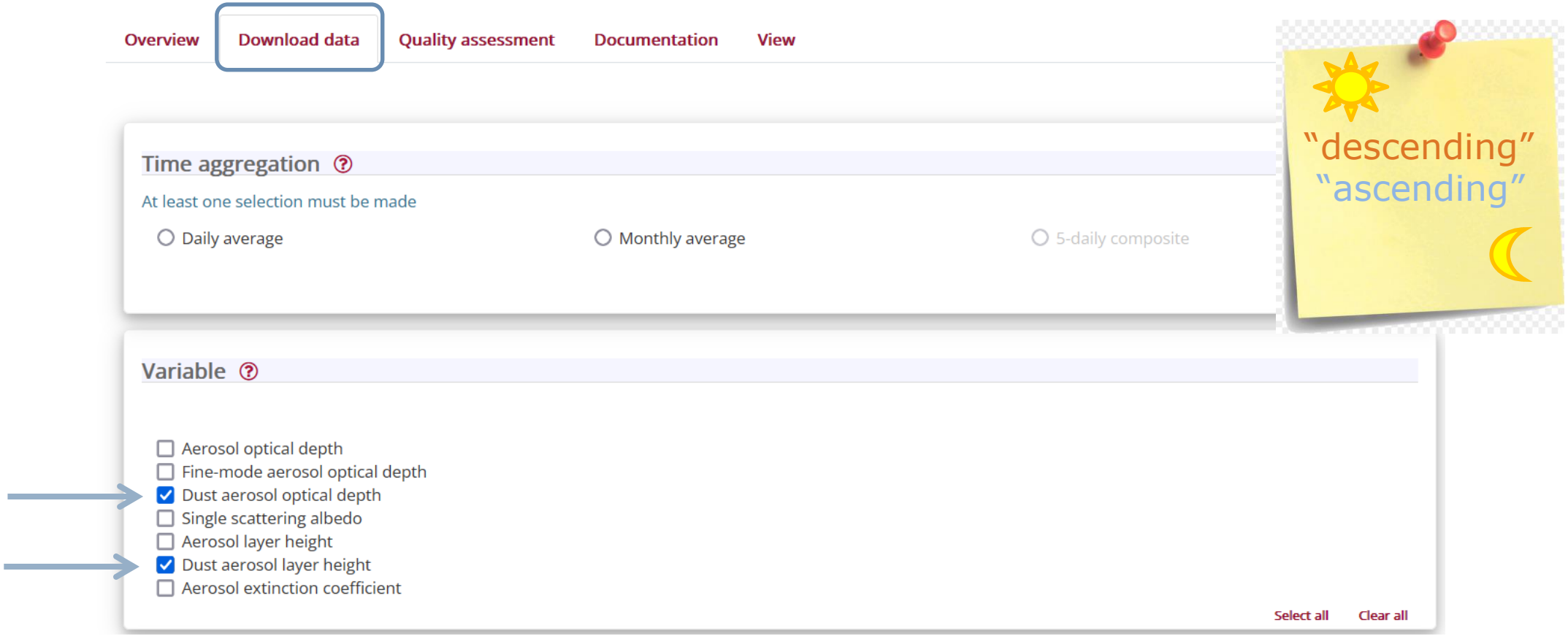
Dataset | Global | Atmosphere (composition) | Satellite observations

mode aerosol optical depth, **dust** aerosol optical depth, single scattering albedo, aerosol layer height

IASI dust observations

Access through the Climate Data Store https://cds.climate.copernicus.eu

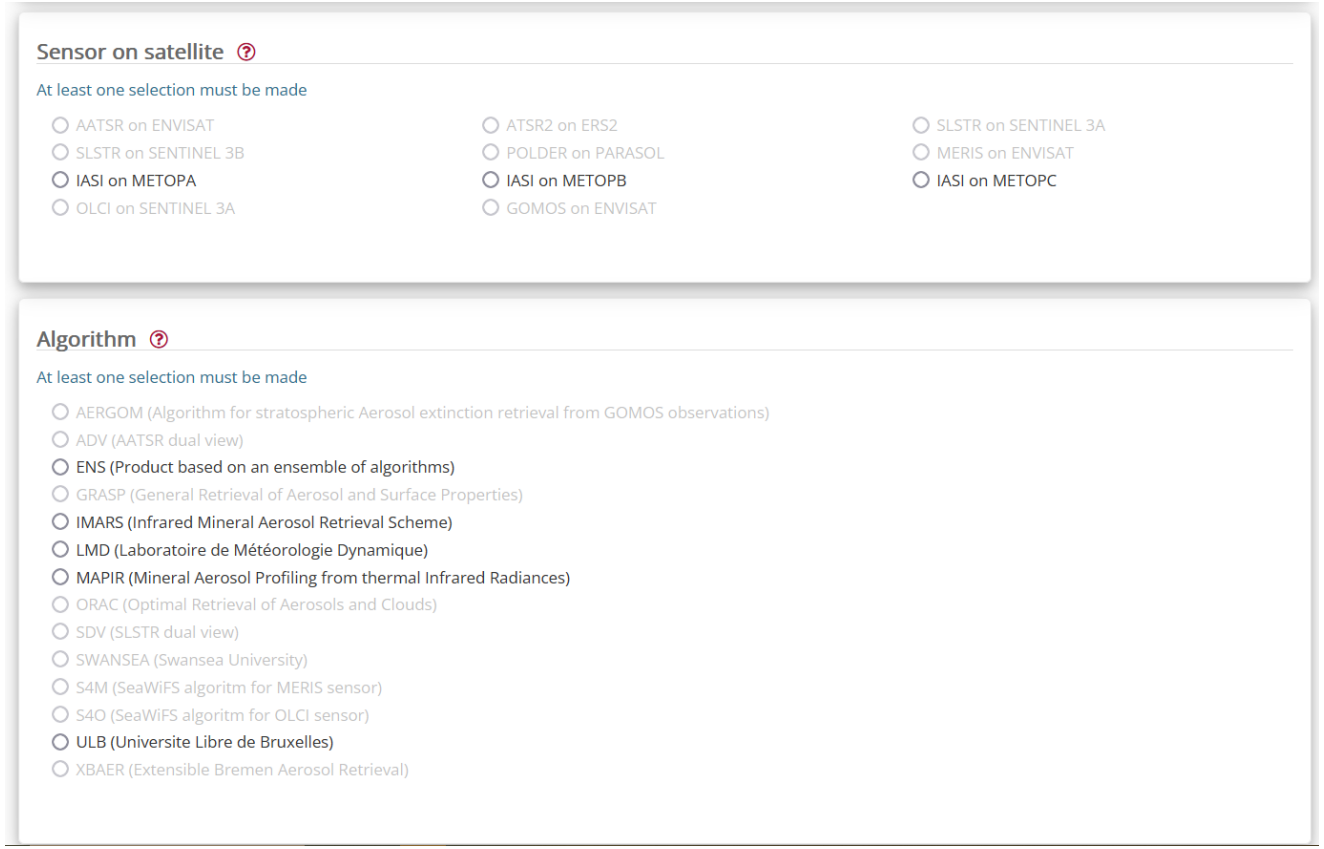
Dust AOD and mean altitude level 3: daily / monthly, day / night / both

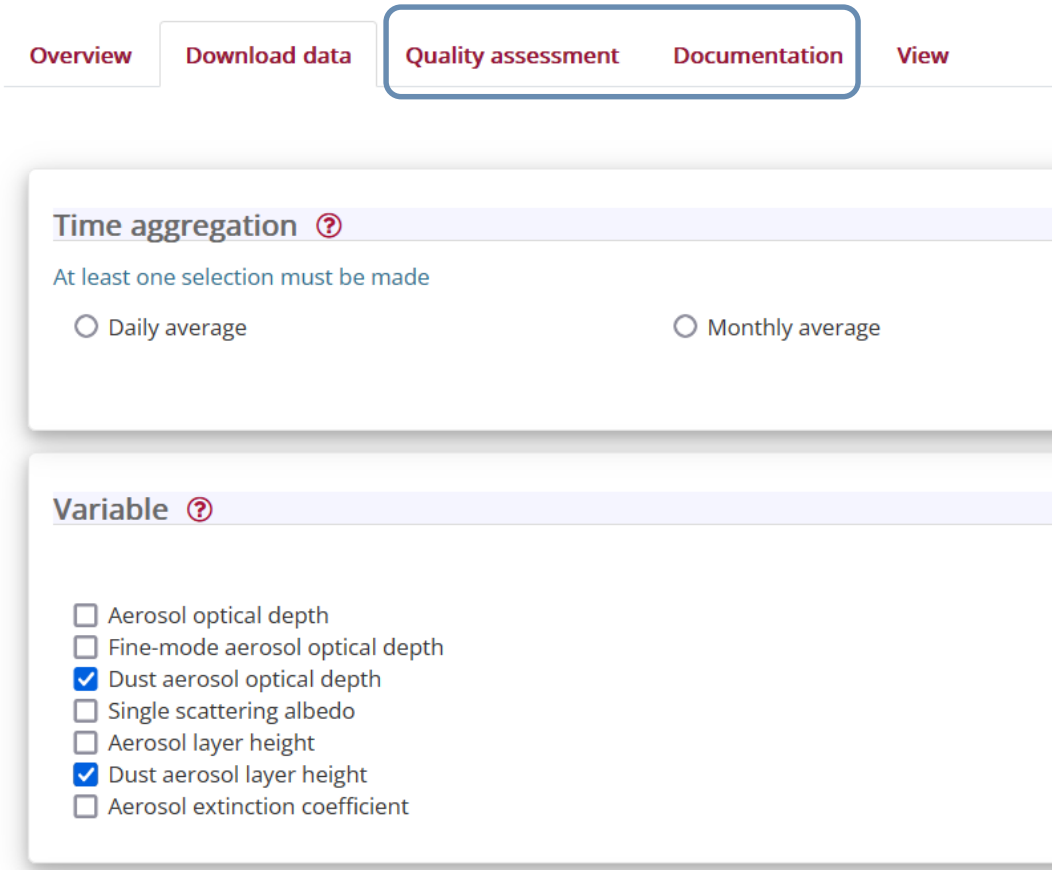


IASI dust observations

Access through the Climate Data Store https://cds.climate.copernicus.eu

Dust AOD and mean altitude level 3: daily / monthly, day / night / both





IASI dust observations

Example: « Godzilla » storm, 20 June 2020 9h30 LST – **10µm AOD**

(last version available, for each algorithm)

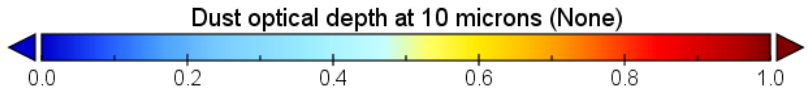
ULB

IMARS

Different coverage
Different cloud filtering
Different absolute values

LMD

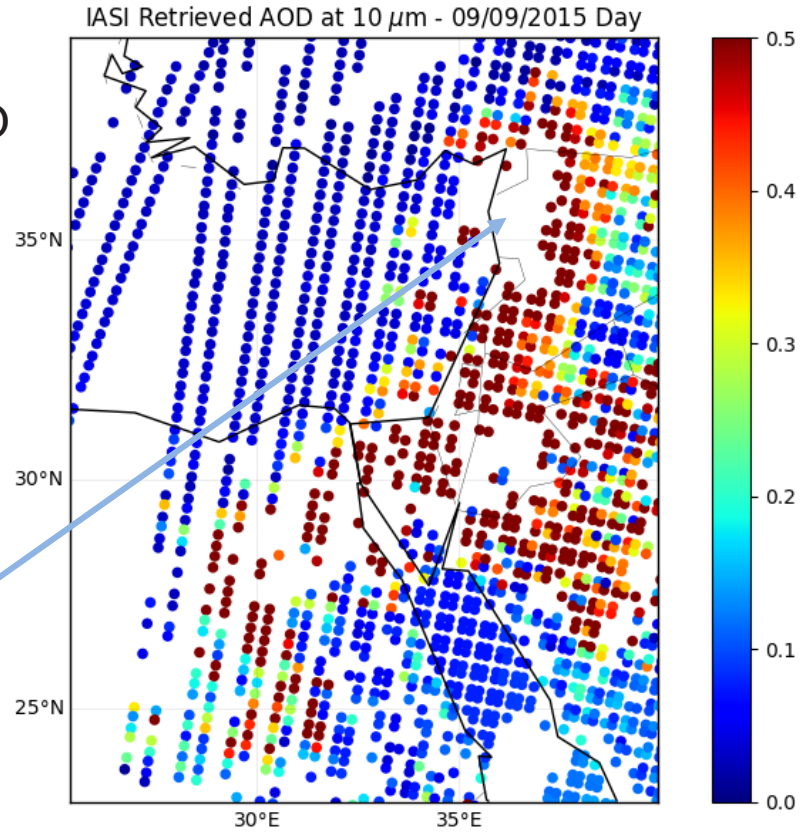
MAPIR



IASI dust observations: clouds …

Big dust storm over Middle East 09/09/2015

MetOp-A/IASI
MAPIR 10µm AOD
Level 2
~07:12 UTC



Wrongly classified as cloud

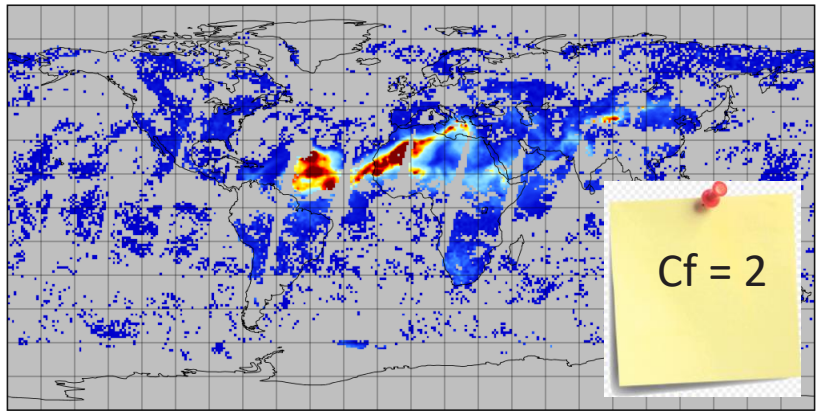
Terra/MODIS
08:50 UTC

IASI dust observations

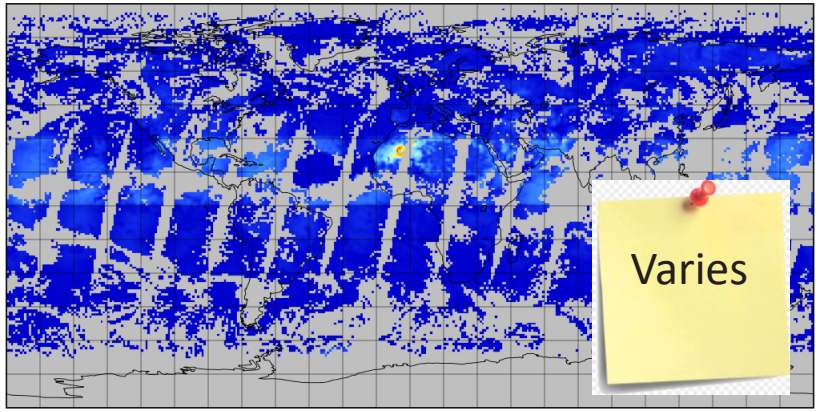
Example: « Godzilla » storm, 20 June 2020 9h30 LST – **550nm AOD**

(last version available, for each algorithm)

ULB

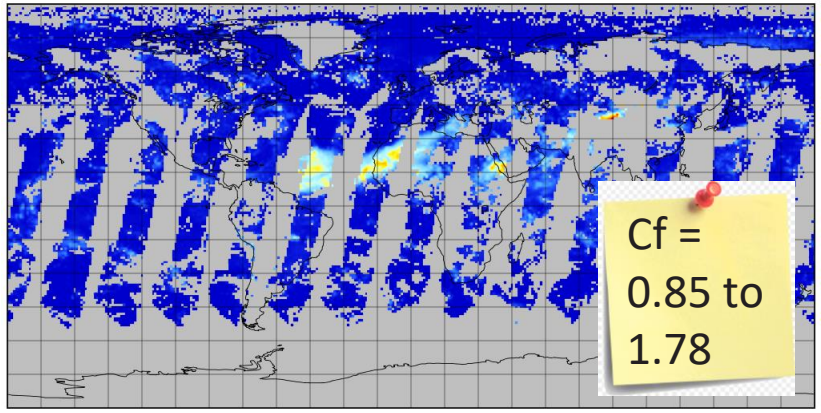


IMARS

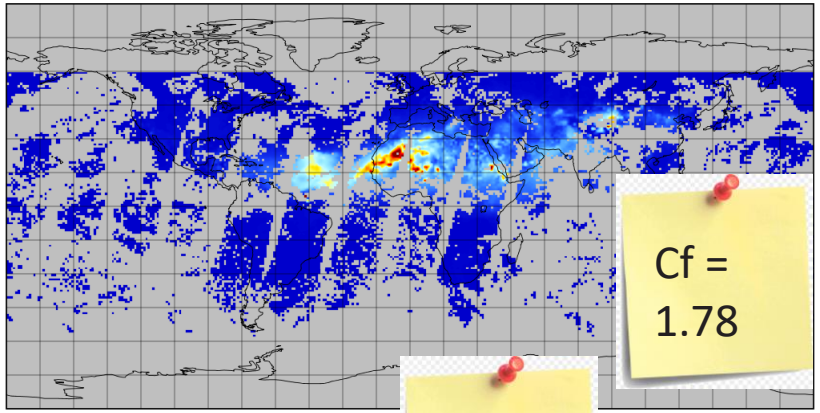


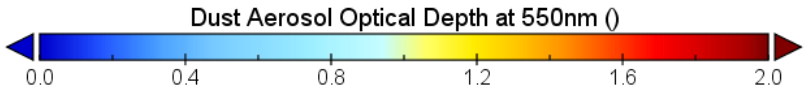
Conversion factor: from 10µm to 550nm

LMD



MAPIR





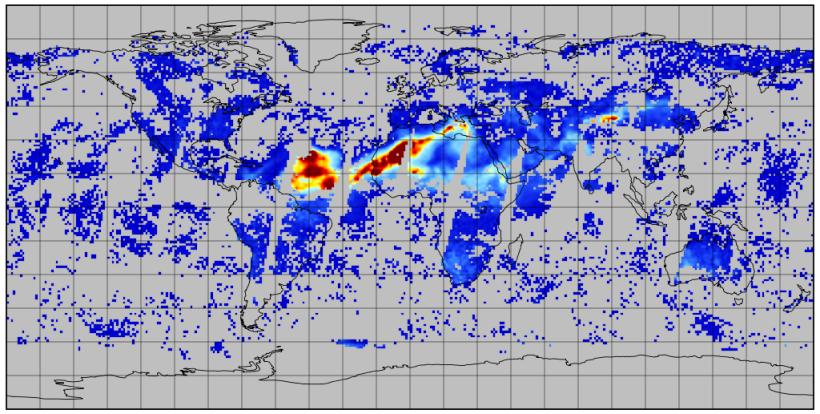
Scale x 2

IASI dust observations

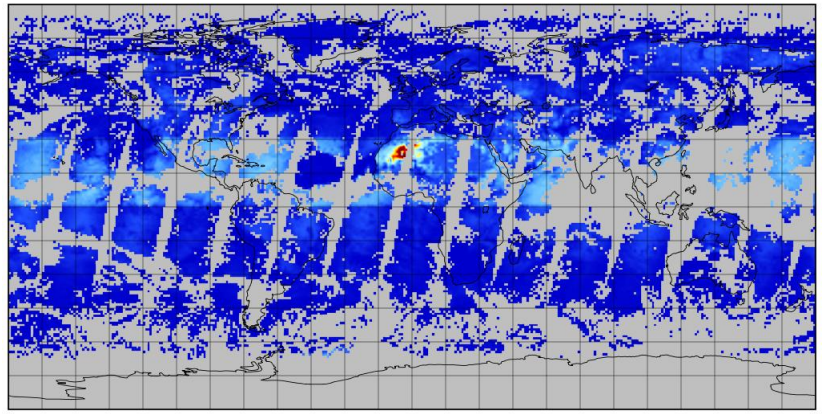
Example: « Godzilla » storm, 20 June 2020 9h30 LST – **10µm AOD**

(last version available, for each algorithm)

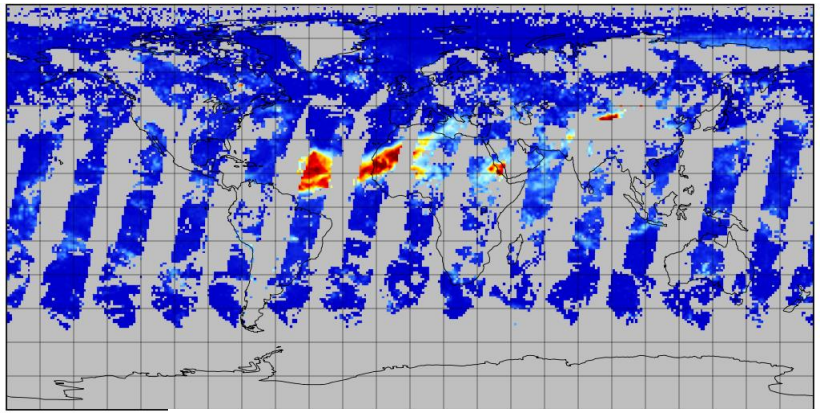
ULB



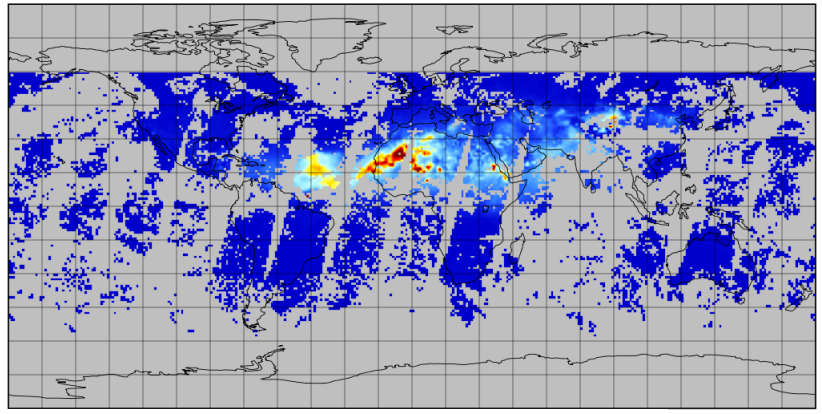
IMARS

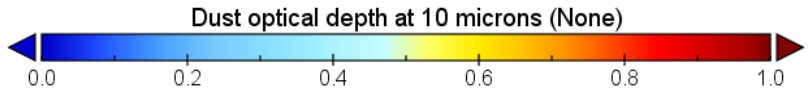


LMD



MAPIR





Important note on conversions!!

IASI data : TIR, dust coarse mode AOD obtained at ~10µm (1000cm^{-1})

Most other data : IV, VIS, Total AOD usually reported at 500-550nm

Dust AOD conversion 10µm -> 550nm

- Requires assumptions on particle optical properties
- Increases the uncertainty
- Converts only what is observable at 10µm

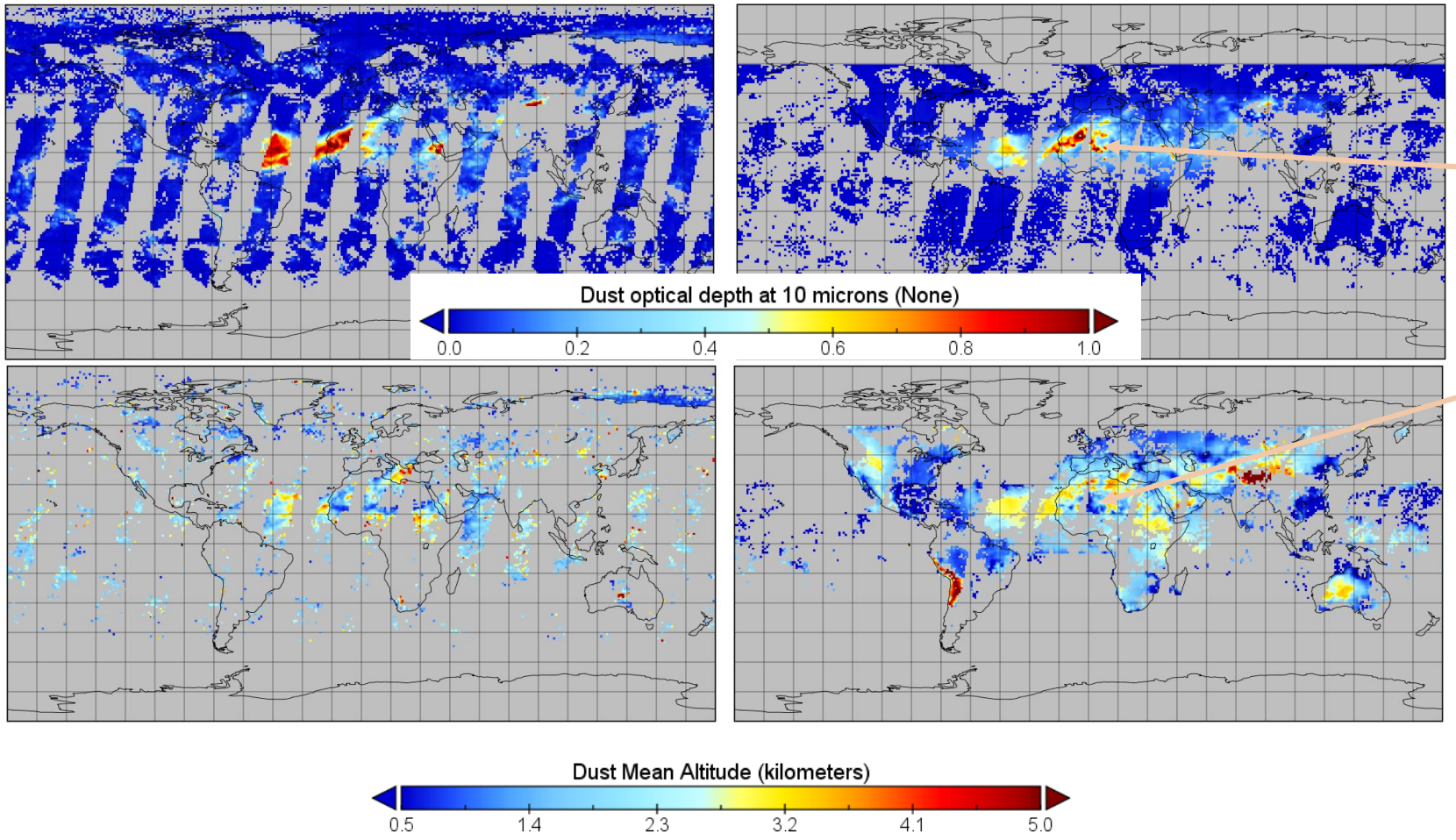
Reminder:

Day and night observations

IASI dust observations

Example: « Godzilla » storm, 20 June 2020 9h30 LST – **mean altitude**

(last version available, for each algorithm)



Probable source area

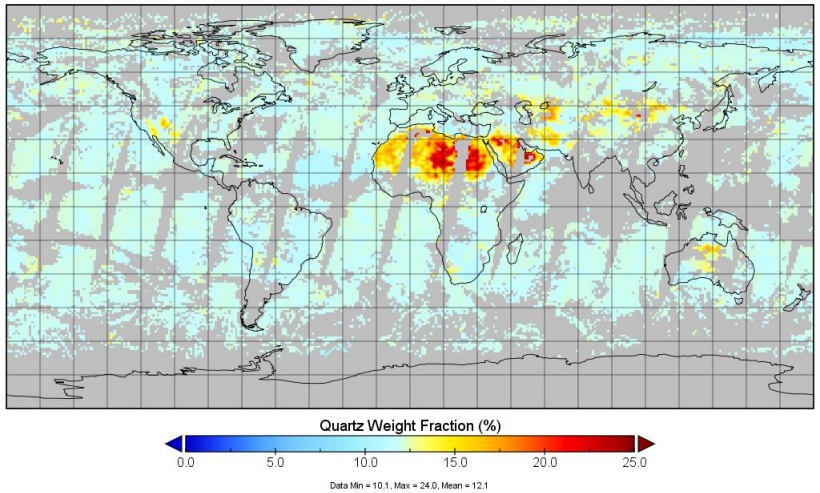
LMD

MAPIR

IASI dust observations

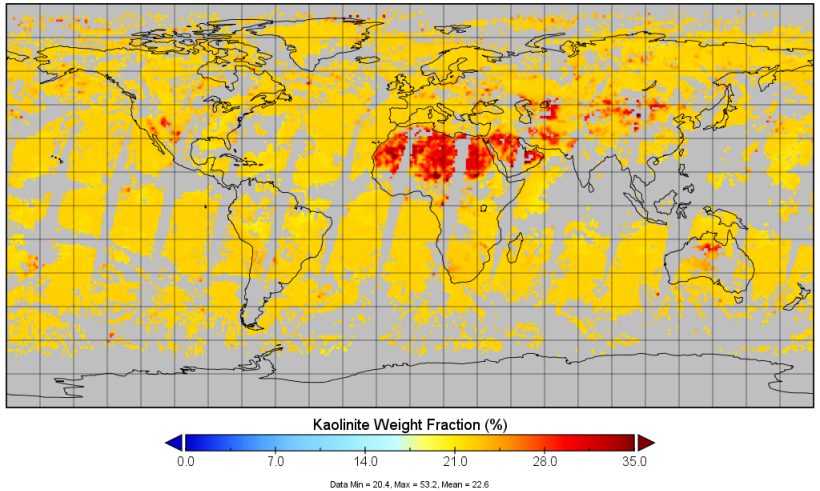
Example: « Godzilla » storm, 20 June 2020 9h30 LST – **other …**

Quartz Weight Fraction

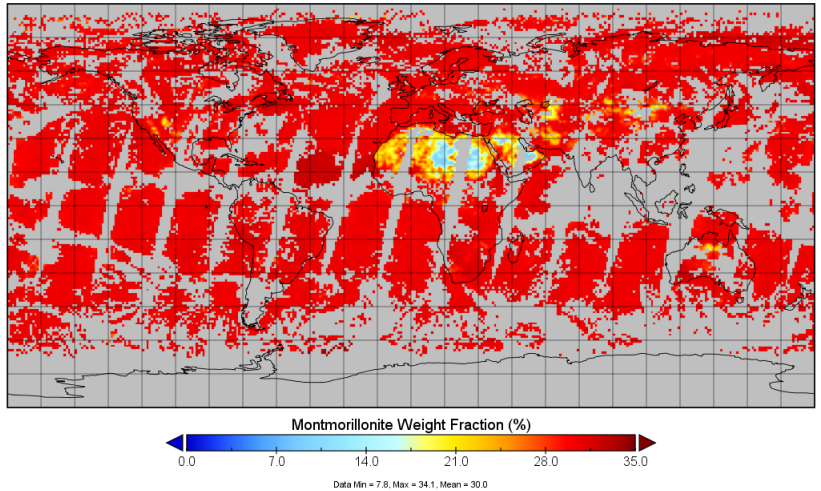


IMARS
« experimental »
dust composition

Kaolinite Weight Fraction



Montmorillonite Weight Fraction

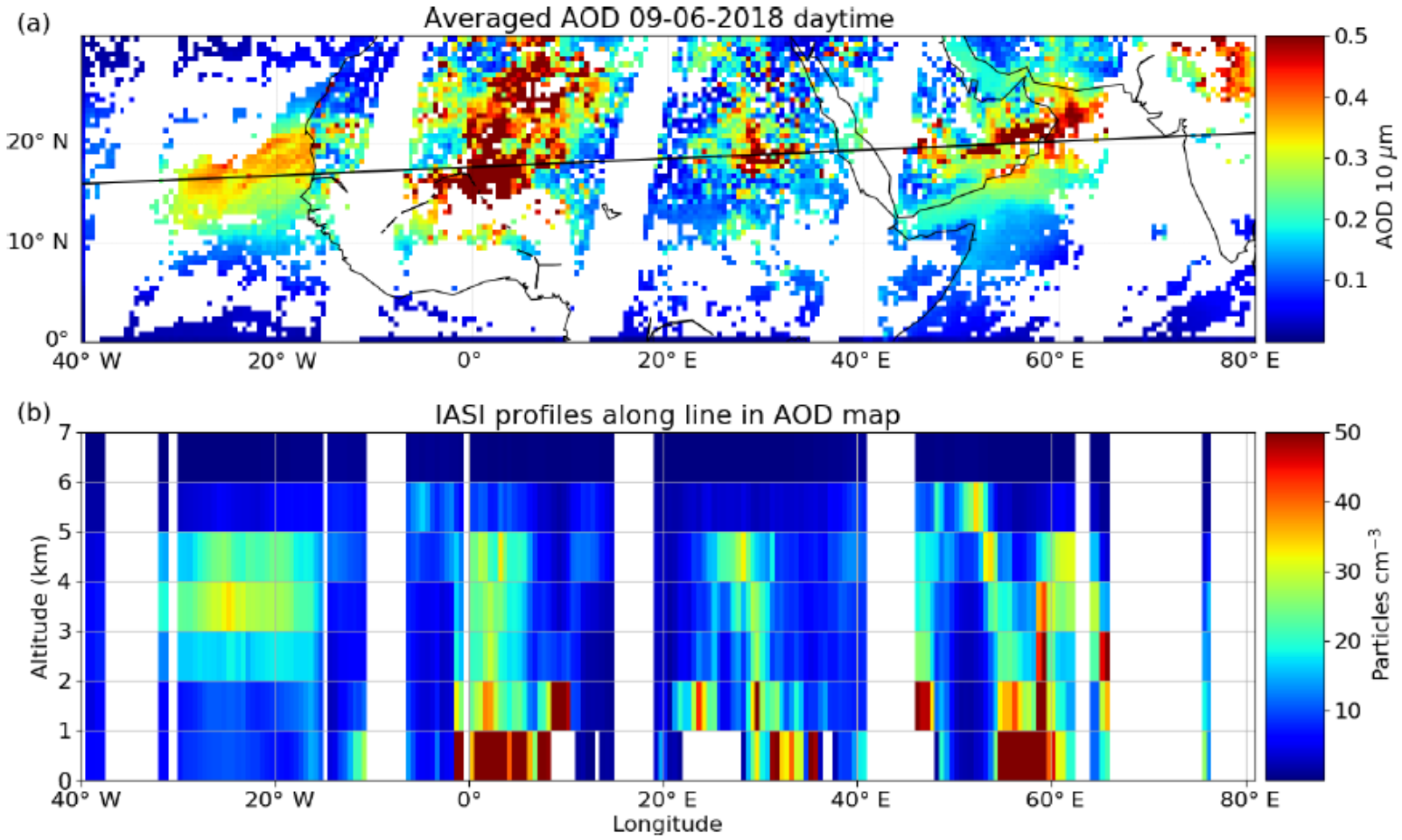


IASI dust observations: profiles

MAPIR contains profile information, can separate 2 distinct layers

Not in the CDS (technical reasons)

iasi.aeronomie.be



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IASI (TIR) dust observations

Four algorithms… results are similar overall but not in details…

The biggest issue: clouds…

- Wrong classification -> no retrieval…
- Dust is CCN and IN -> quite often mixed…

Difficult over cold surfaces and for low AOD (low sensitivity, higher uncertainty, noise, and lower information content)

« Mineral-specific » but actually requires silicates (local high-latitude dust not observed)

Thermal IR retrievals are « mineral –specific »… while other retrievals have a hard time separating different aerosol types

Night-time observations are available

Vertical sensitivity (limited) with global coverage

Also keep in mind …

Most aerosol products report **total AOD** (fine + coarse, all aerosol types)
→ IASI « sees » **coarse dust** AOD (DOD) only

IASI dust product is obtained **at ~10µm**
→ **Converting it to 550nm** requires assumptions and increases uncertainty

Links

Level 3: Gridded averaged data

Level 2: each satellite obs

Level 3 data (DOD, mean altitude, daily, monthly, morning / evening / combined), documentation and quality information: https://cds.climate.copernicus.eu

Level 2 data for LMD (with mean altitude) and ULB: https://www.aeris-data.fr

Level 2 data for MAPIR (with vertical profiles): http://iasi.aeronomie.be

Let's discuss a bit...