



Mineral dust



Satellite observations in the thermal infrared

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From the Mad Max movie



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→ thermal infrared (TIR)

→ IASI

Existing IASI data

→ description, where to find?

→ comparisons, examples

Recap & take-home messages

→ links



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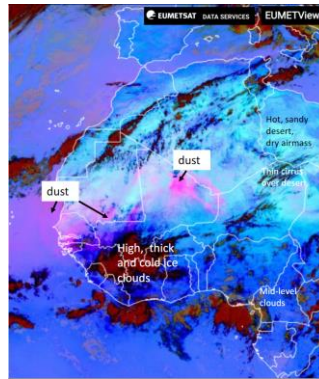


Introduction

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)**

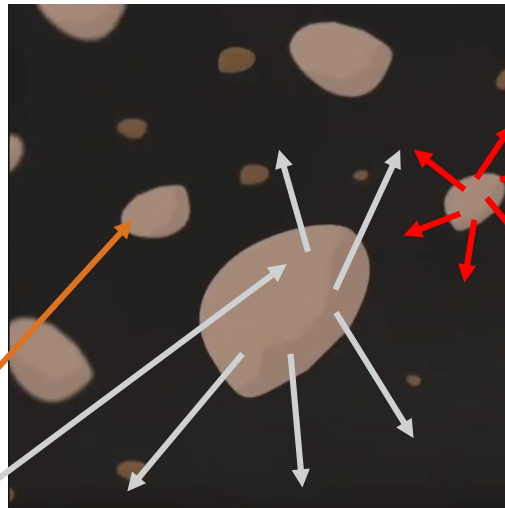


e.g. SEVIRI Dust RGB using the TIR bands
Red: IR12 – IR10.8
Green: IR10.8-IR8.7
Blue: IR10.8

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



Specificities of the Thermal Infrared



absorption

thermal
emission

scattering

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 »



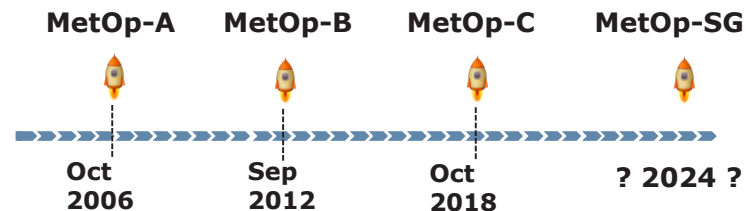
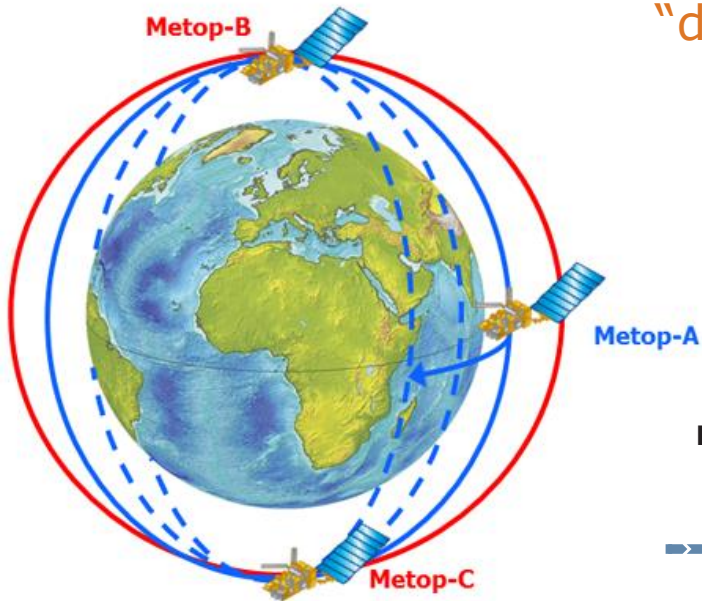
The Infrared Atmospheric Sounding Interferometer

Orbital characteristics:

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

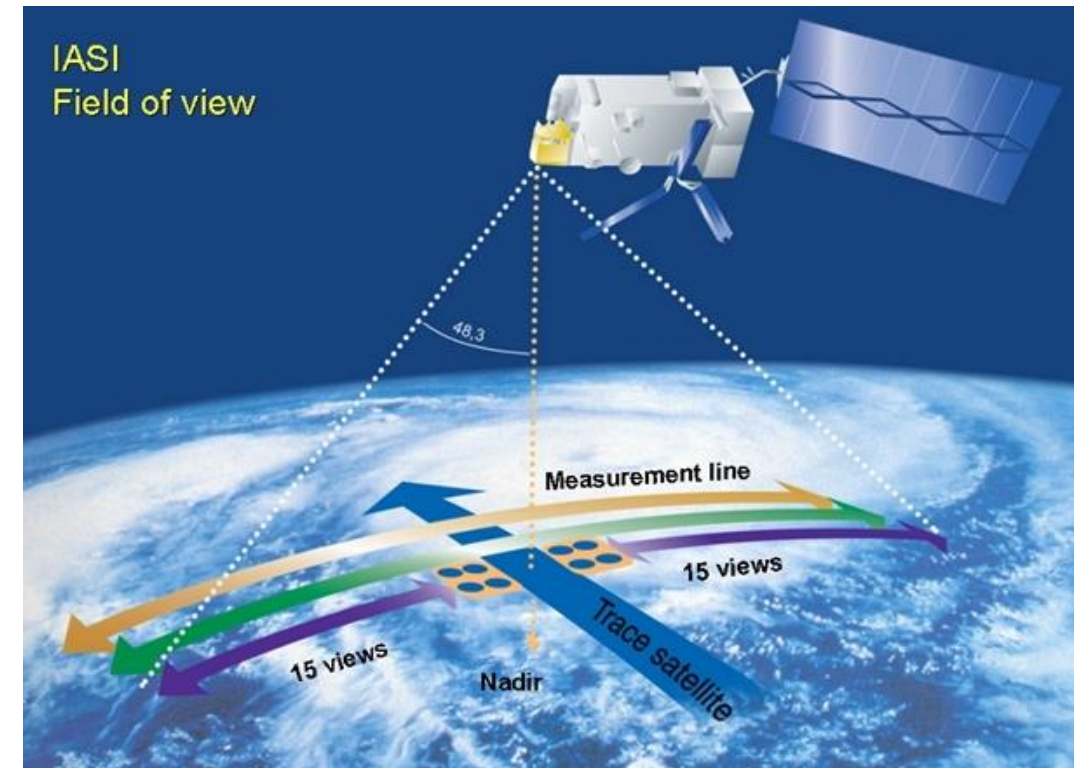


"descending" - "ascending"



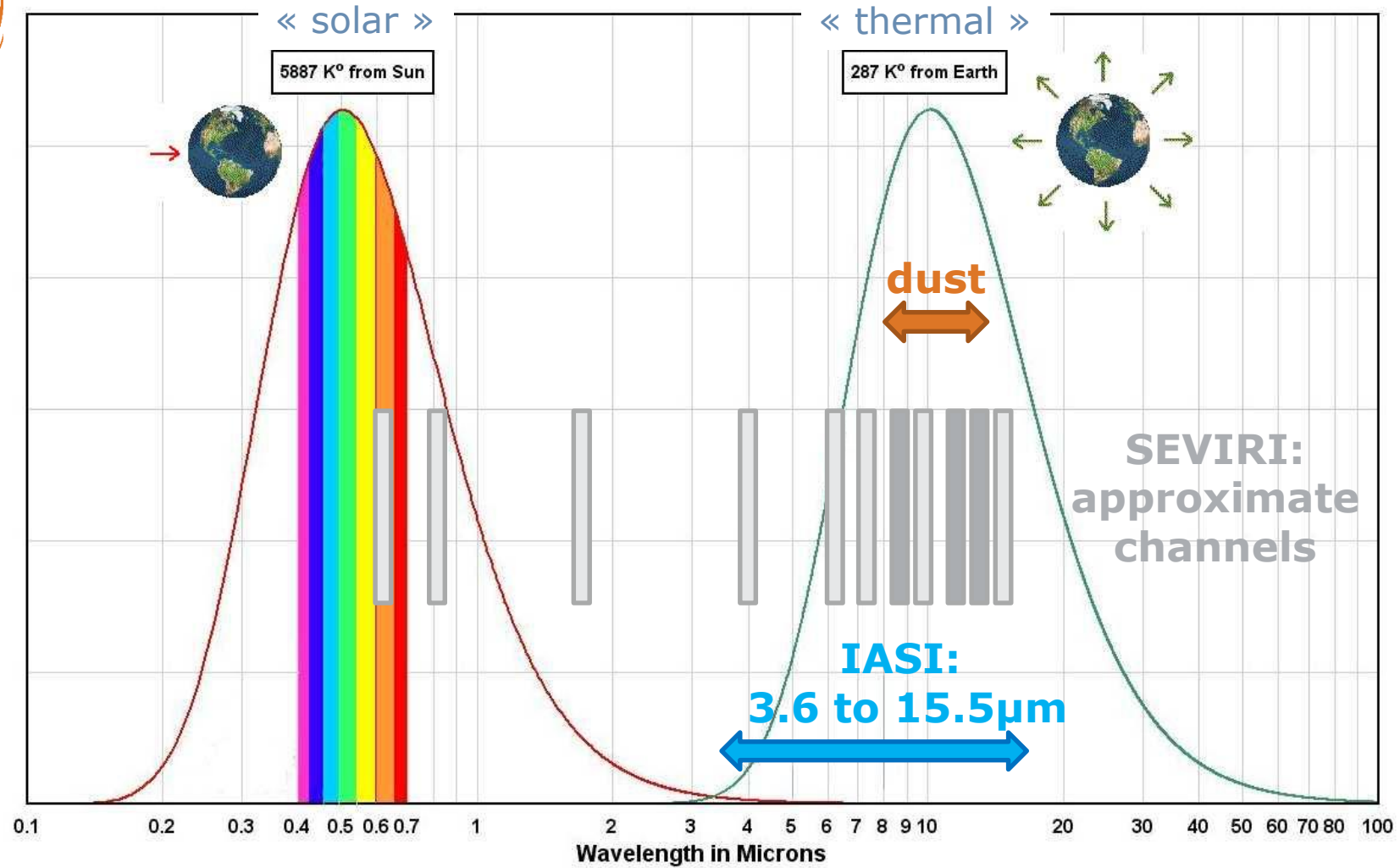
Observation technique:

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





Spectral ranges

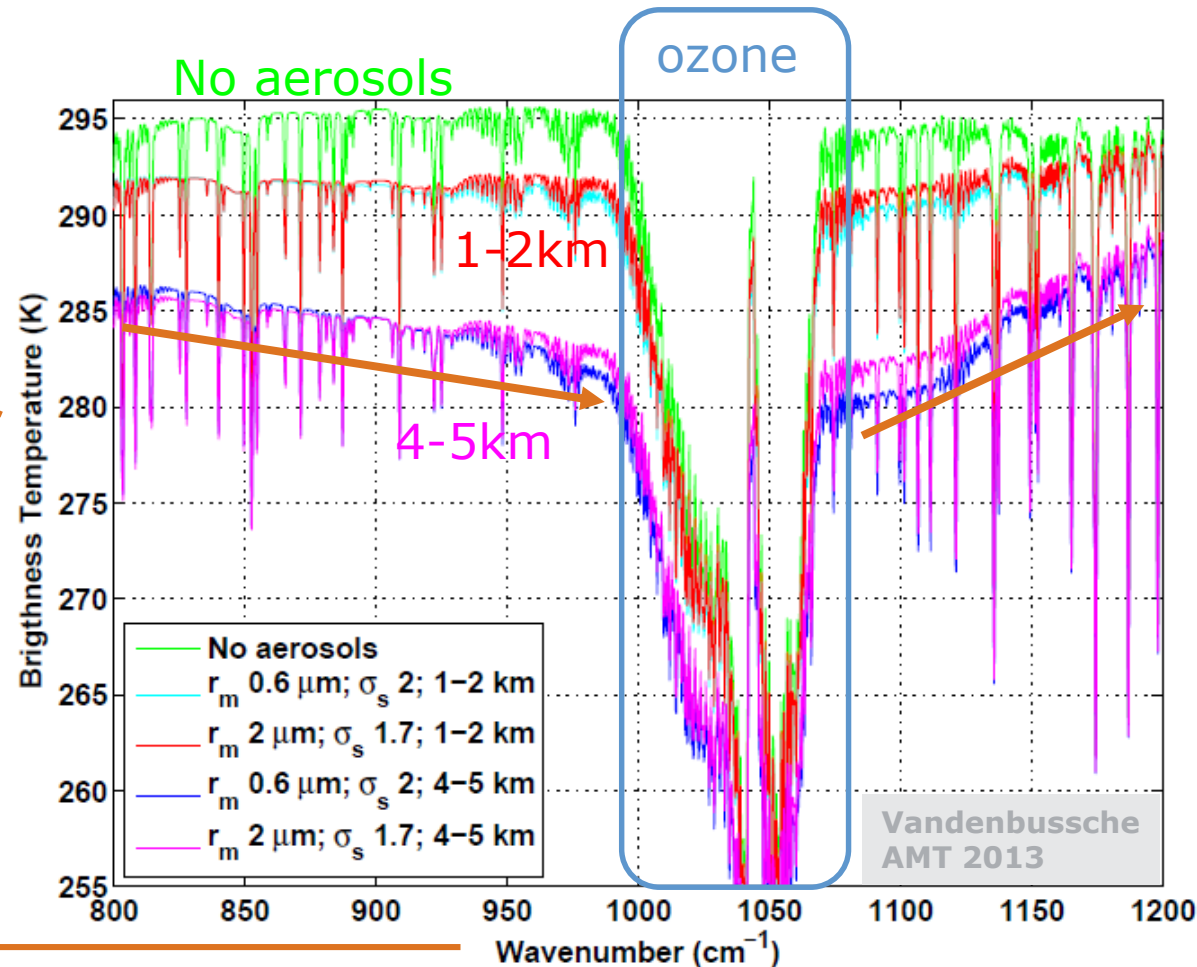




IASI dust observations

Brightness temperature: a way to measure radiance / energy

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



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

Welcome to the Climate Data Store

Dive into this wealth of information about the Earth's past, present and future climate.

It is freely available and functions as a one-stop shop to explore climate data. [Register for free](#) to obtain access to the CDS and its Toolbox.

We are constantly improving the services and adding new datasets. For latest announcements, watch the posts on the [C3S forum](#).

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

Overview **Download data** Quality assessment Documentation View

Time aggregation ?

At least one selection must be made

☐ Daily average ☐ Monthly average ☐ 5-daily composite

Variable ?

- ☐ Aerosol optical depth
- ☐ Fine-mode aerosol optical depth
- ☒ Dust aerosol optical depth
- ☐ Single scattering albedo
- ☐ Aerosol layer height
- ☒ Dust aerosol layer height
- ☐ Aerosol extinction coefficient

Select all Clear all





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

Sensor on satellite ?

At least one selection must be made

- | | | |
|--|---|--|
| ☐ AATSR on ENVISAT | ☐ ATSR2 on ERS2 | ☐ SLSTR on SENTINEL 3A |
| ☐ SLSTR on SENTINEL 3B | ☐ POLDER on PARASOL | ☐ MERIS on ENVISAT |
| ☐ IASI on METOPA | ☐ IASI on METOPB | ☐ IASI on METOPC |
| ☐ OLCI on SENTINEL 3A | ☐ GOMOS on ENVISAT | |

Algorithm ?

At least one selection must be made

- ☐ AERGOM (Algorithm for stratospheric Aerosol extinction retrieval from GOMOS observations)
- ☐ ADV (AATSR dual view)
- ☐ ENS (Product based on an ensemble of algorithms)
- ☐ GRASP (General Retrieval of Aerosol and Surface Properties)
- ☐ IMARS (Infrared Mineral Aerosol Retrieval Scheme)
- ☐ LMD (Laboratoire de Météorologie Dynamique)
- ☐ MAPIR (Mineral Aerosol Profiling from thermal Infrared Radiances)
- ☐ ORAC (Optimal Retrieval of Aerosols and Clouds)
- ☐ SDV (SLSTR dual view)
- ☐ SWANSEA (Swansea University)
- ☐ S4M (SeaWiFS algorithm for MERIS sensor)
- ☐ S4O (SeaWiFS algorithm for OLCI sensor)
- ☐ ULB (Université Libre de Bruxelles)
- ☐ XBAER (Extensible Bremen Aerosol Retrieval)

Overview

Download data

Quality assessment

Documentation

View

Time aggregation ?

At least one selection must be made

- ☐ Daily average ☐ Monthly average

Variable ?

- ☐ Aerosol optical depth
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- ☒ Dust aerosol optical depth
- ☐ Single scattering albedo
- ☐ Aerosol layer height
- ☒ Dust aerosol layer height
- ☐ Aerosol extinction coefficient

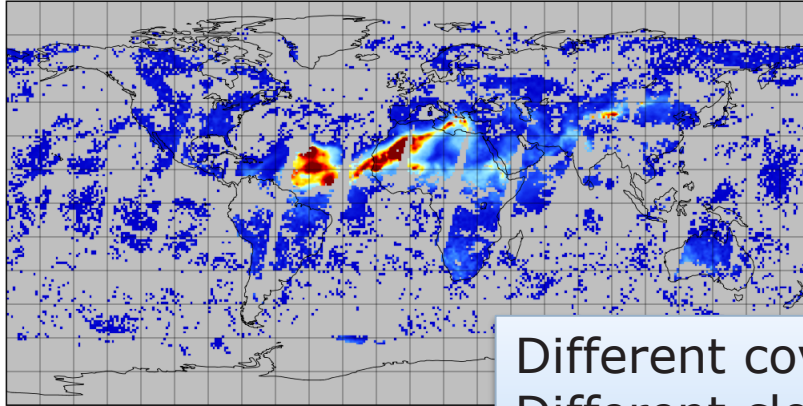


IASI dust observations

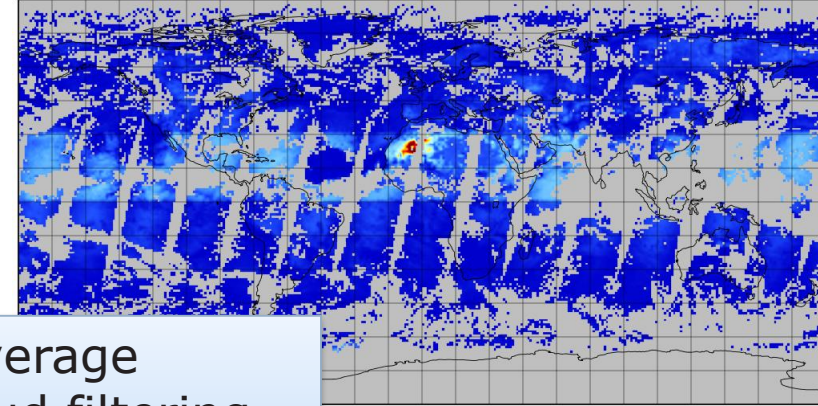
Example: « Godzilla » storm, 20 June 2020 9h30 LST – **10 μ m AOD**

(last version available, for each algorithm)

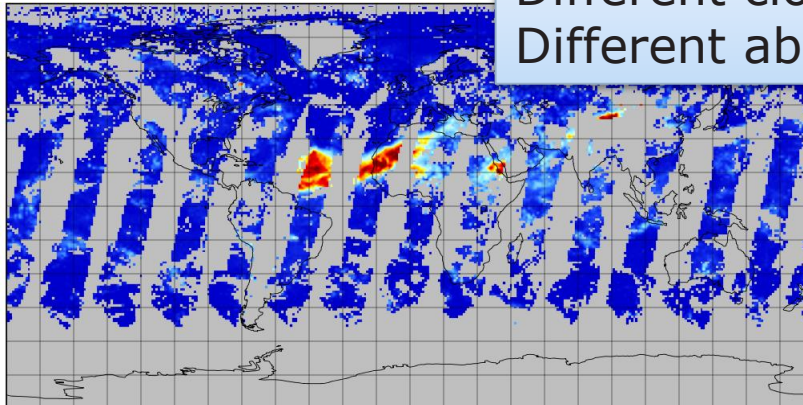
ULB



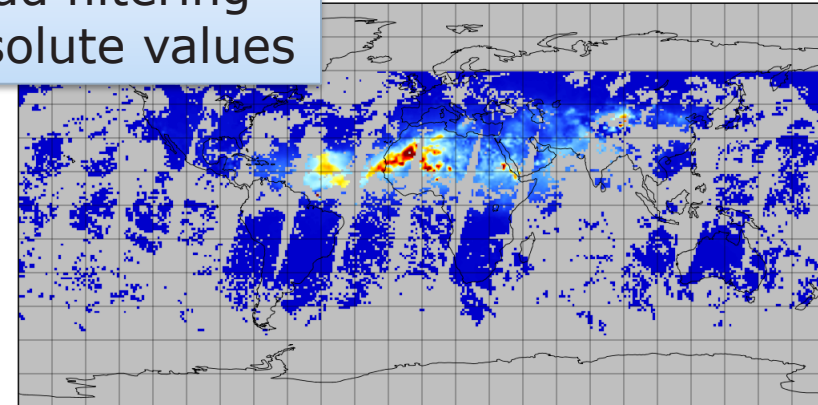
IMARS



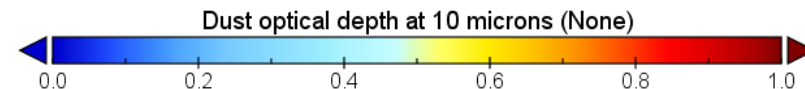
LMD



MAPIR



Different coverage
Different cloud filtering
Different absolute values



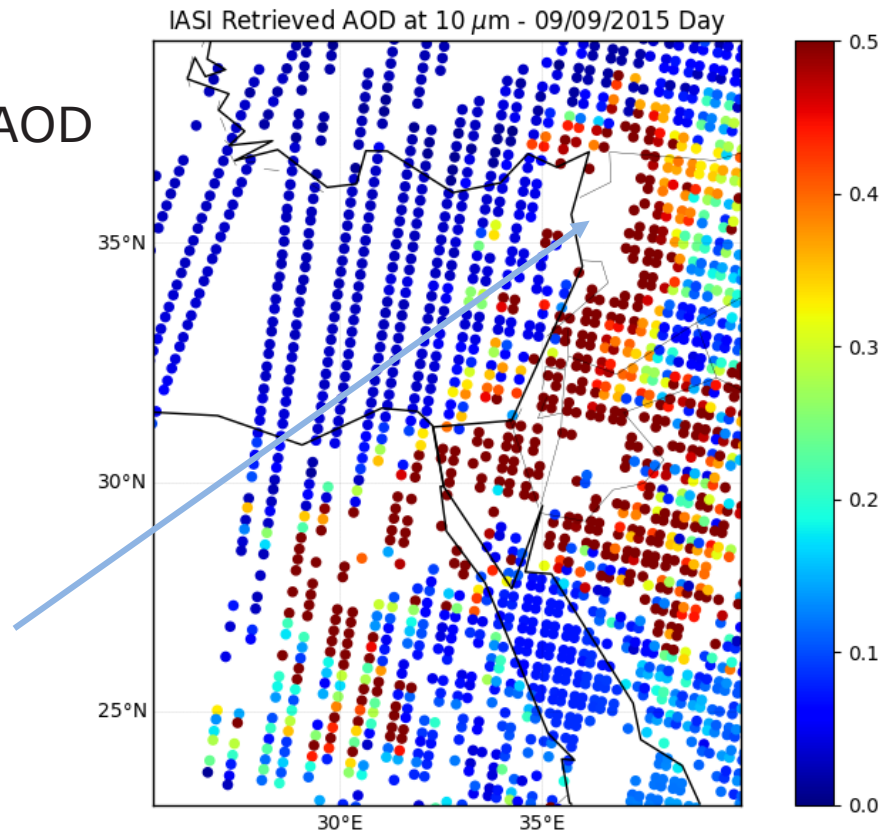


IASI dust observations: clouds ...

Big dust storm over Middle East 09/09/2015

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

Wrongly
classified as
cloud



Terra/MODIS
08:50 UTC



IASI dust observations

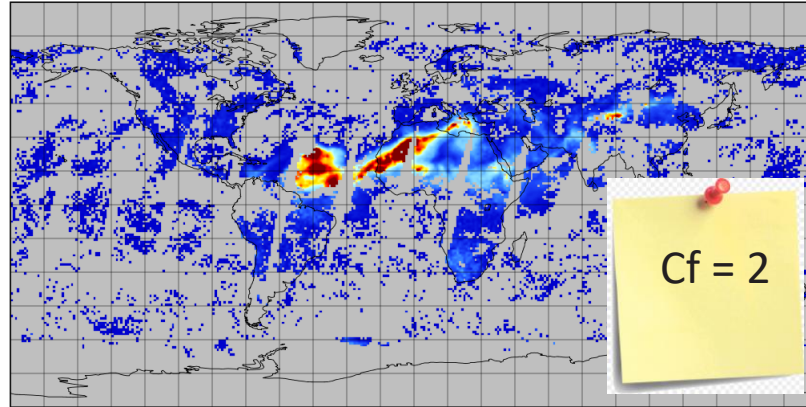
Example: « Godzilla » storm, 20 June 2020 9h30 LST – **550nm AOD**

(last version available, for each algorithm)

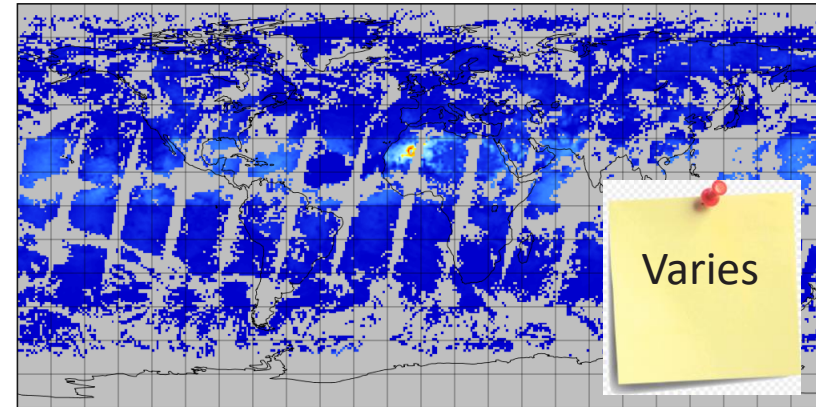
ULB

Conversion
factor:
from $10\mu\text{m}$
to 550nm

LMD

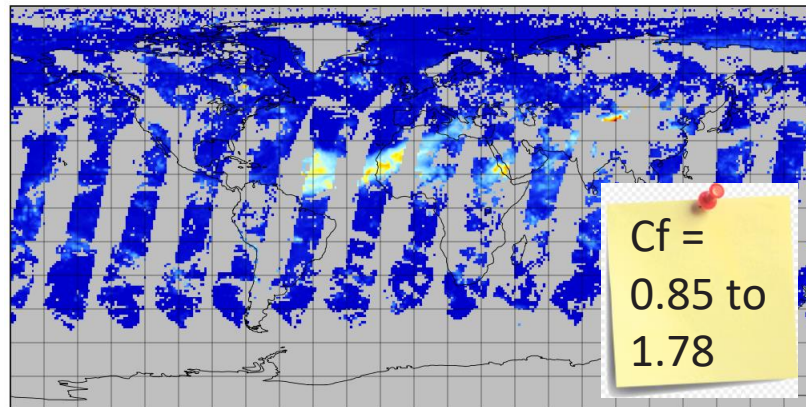


$C_f = 2$

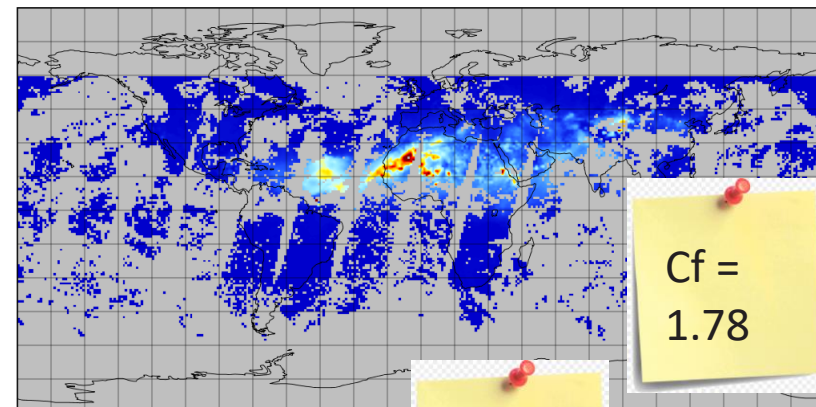


Varies

IMARS

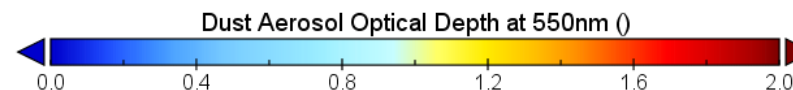


$C_f =$
0.85 to
1.78



$C_f =$
1.78

MAPIR



Scale
x 2

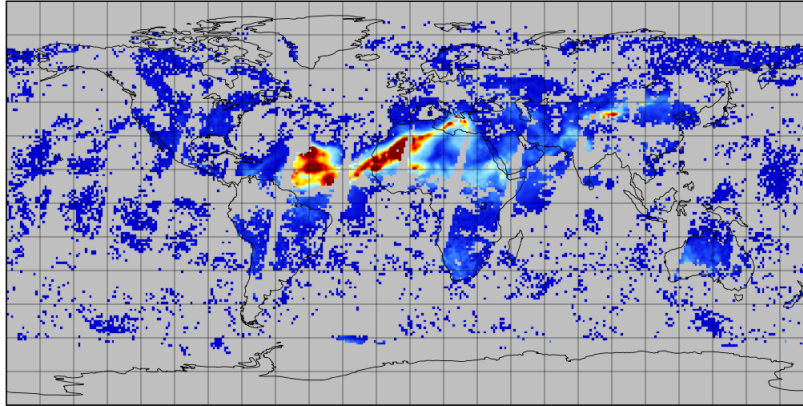


IASI dust observations

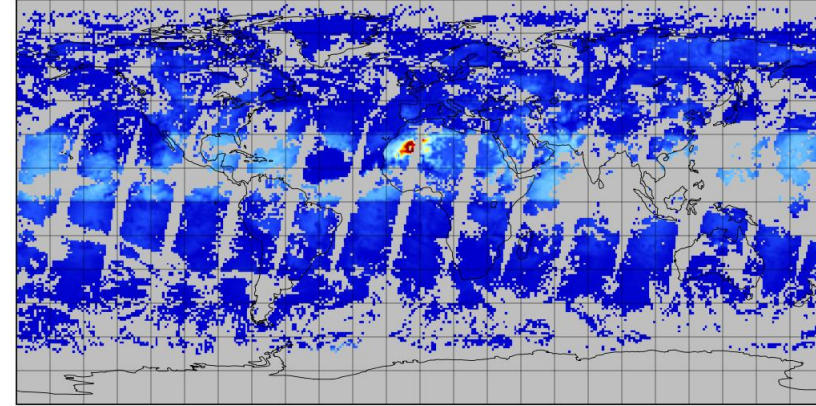
Example: « Godzilla » storm, 20 June 2020 9h30 LST – **10 μ m AOD**

(last version available, for each algorithm)

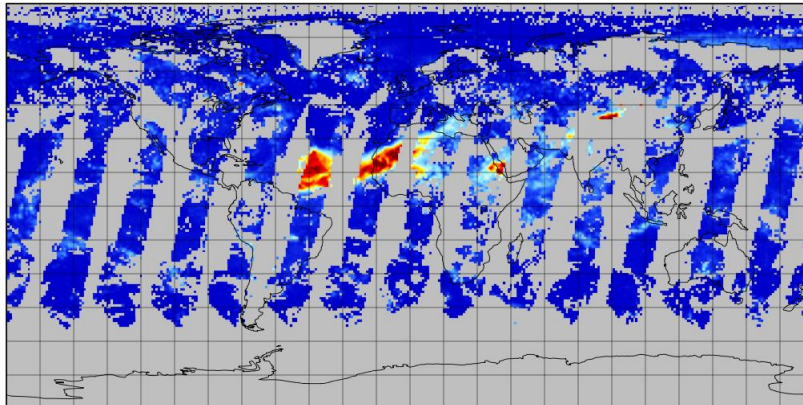
ULB



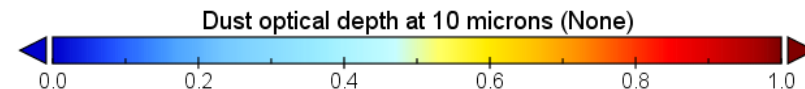
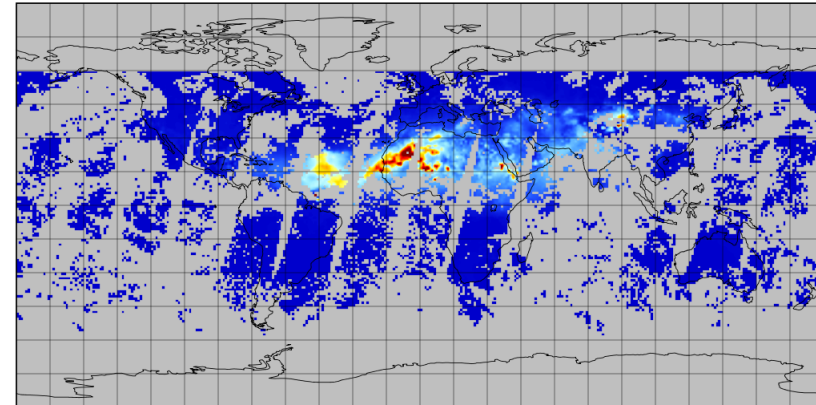
IMARS



LMD



MAPIR





Important note on conversions!!

IASI data : TIR, dust coarse mode AOD obtained at $\sim 10\mu\text{m}$ (1000cm^{-1})

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



Dust AOD conversion $10\mu\text{m} \rightarrow 550\text{nm}$

- Requires assumptions on particle optical properties
 - Increases the uncertainty
- Converts only what is observable at $10\mu\text{m}$

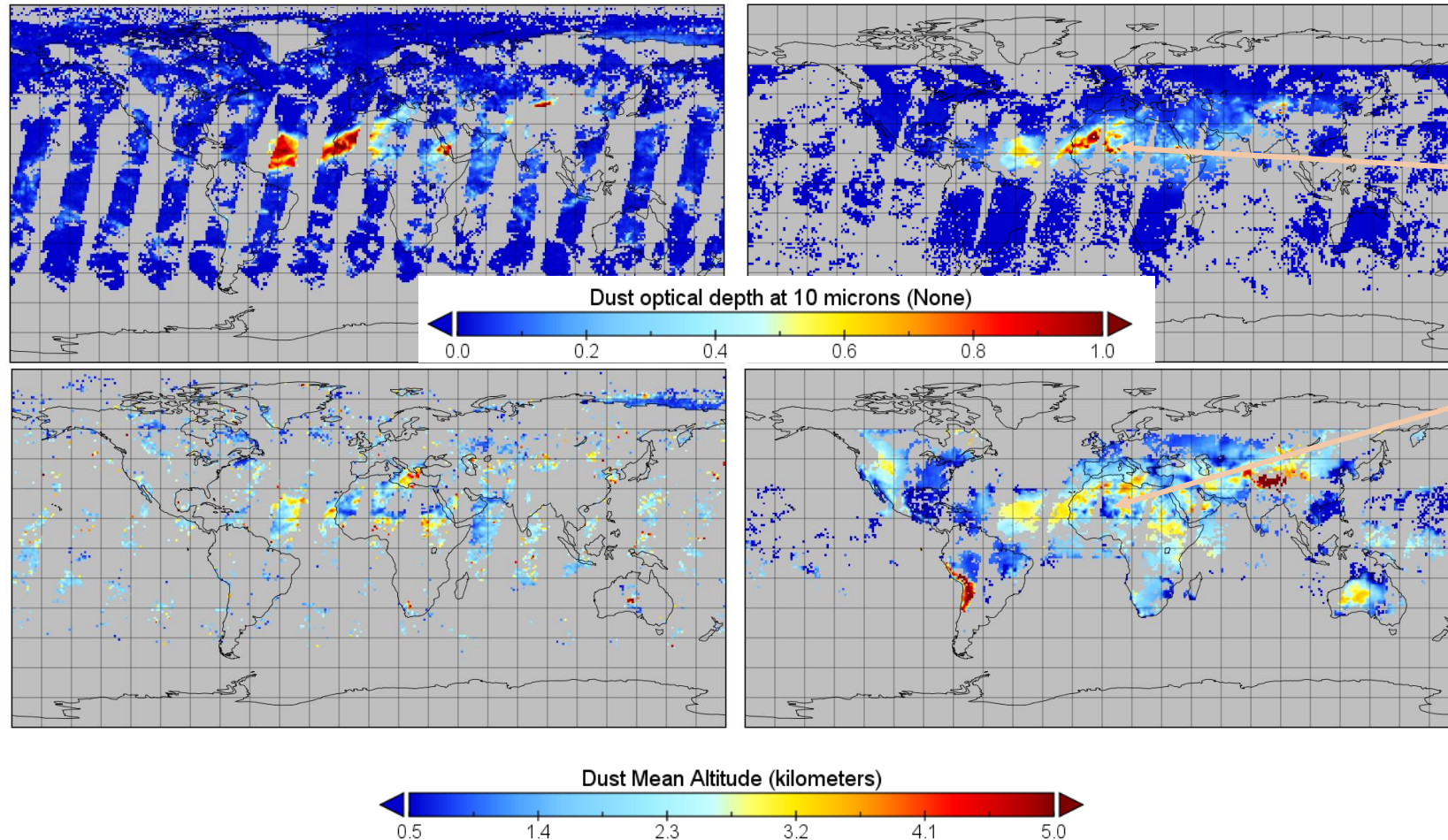
Reminder:

Day and night
observations



IASI dust observations

Example: « Godzilla » storm, 20 June 2020 9h30 LST – **mean altitude**
(last version available, for each algorithm)



LMD

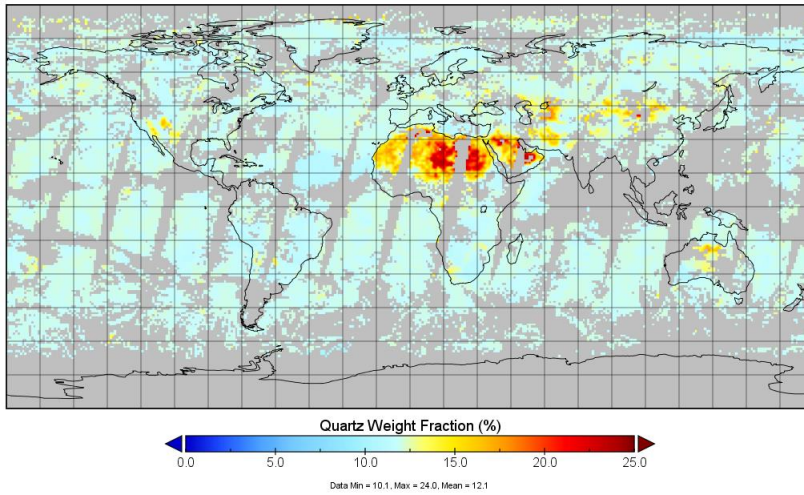
MAPIR



IASI dust observations

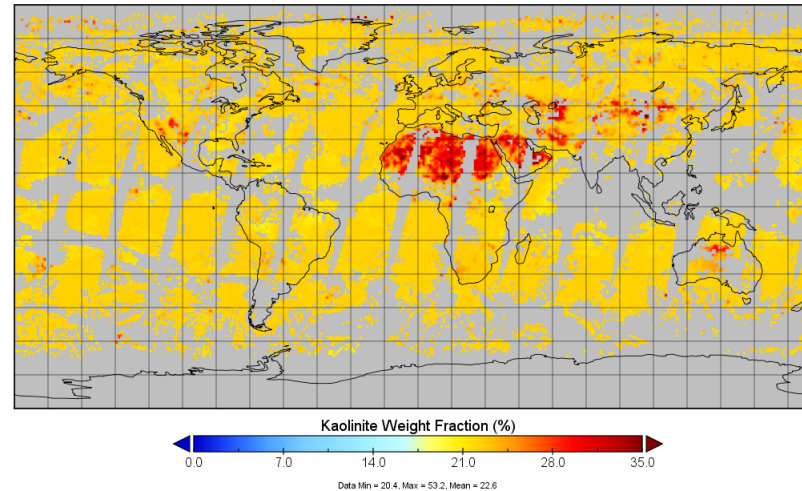
Example: « Godzilla » storm, 20 June 2020 9h30 LST – **other ...**

Quartz Weight Fraction

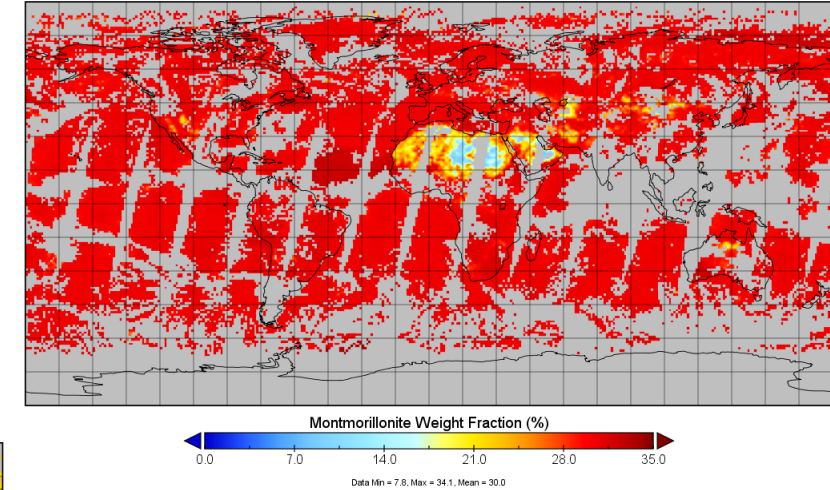


IMARS
« experimental »
dust composition

Kaolinite Weight Fraction



Montmorillonite Weight Fraction



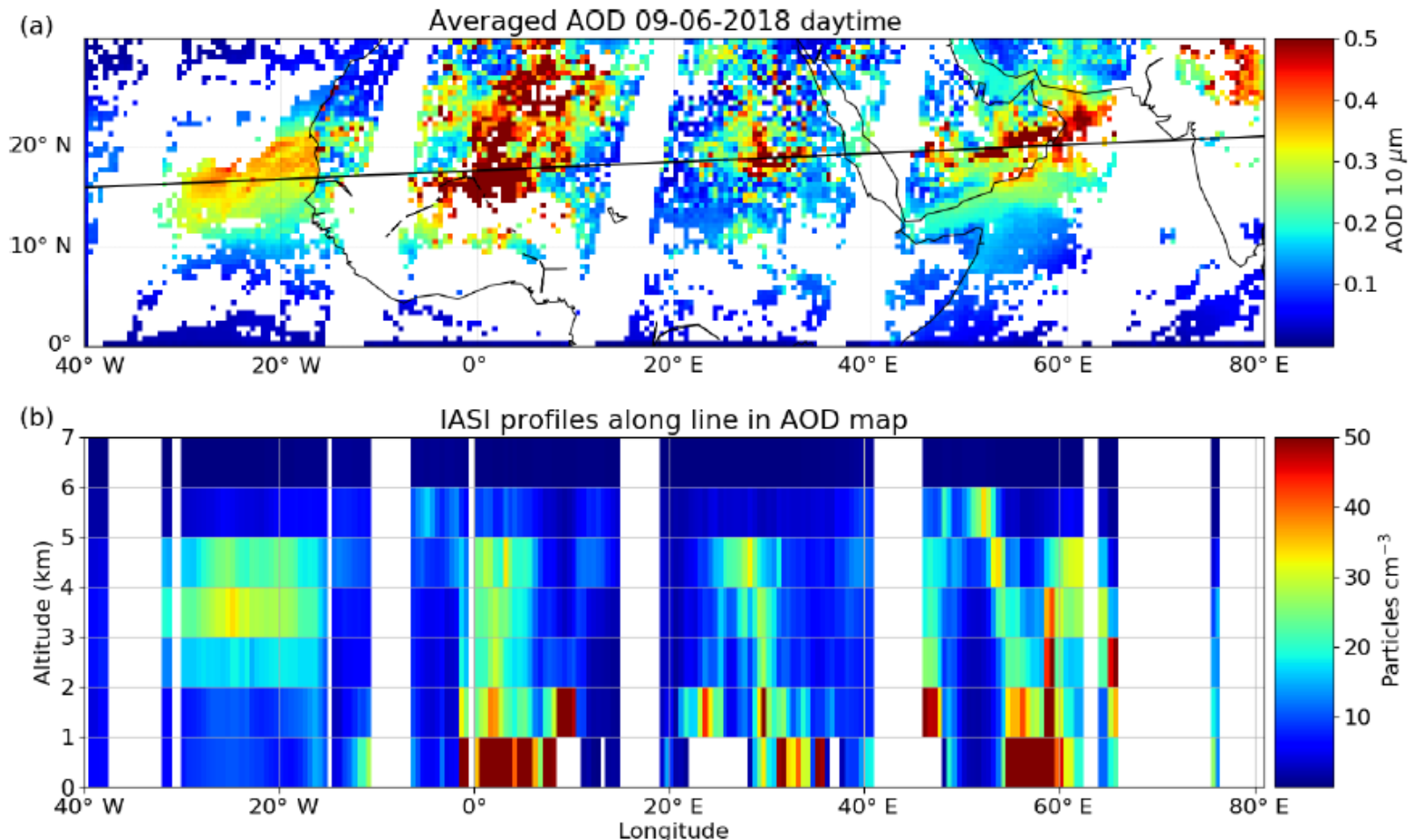


IASI dust observations: profiles

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 $\sim 10\mu\text{m}$**
→ **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>

“descending”
“ascending”





LET'S DISCUSS
A BIT...