IASI MAPIR dust profiles

The IASI Mineral Aerosol Profiling from Infrared Radiances algorithm
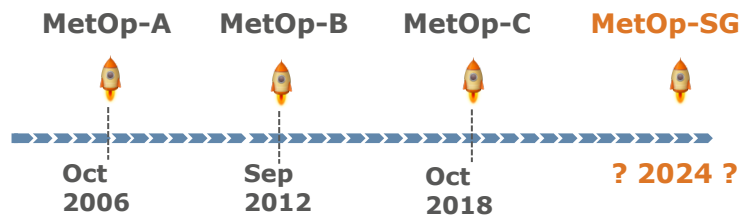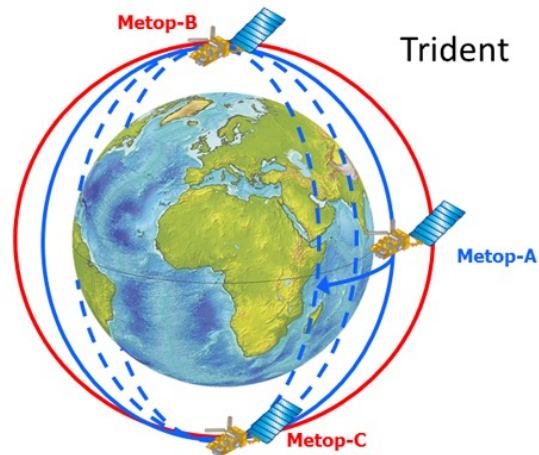
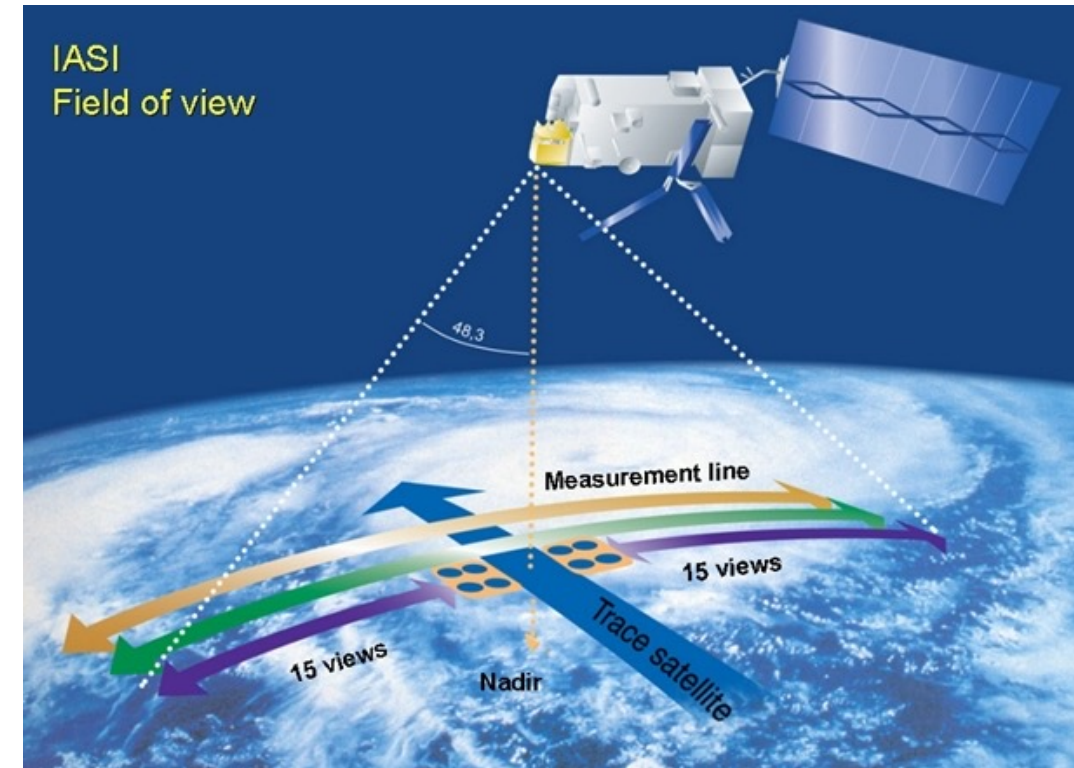Sophie Vandenbussche, Martine de Mazière

IASI

Orbital characteristics:

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

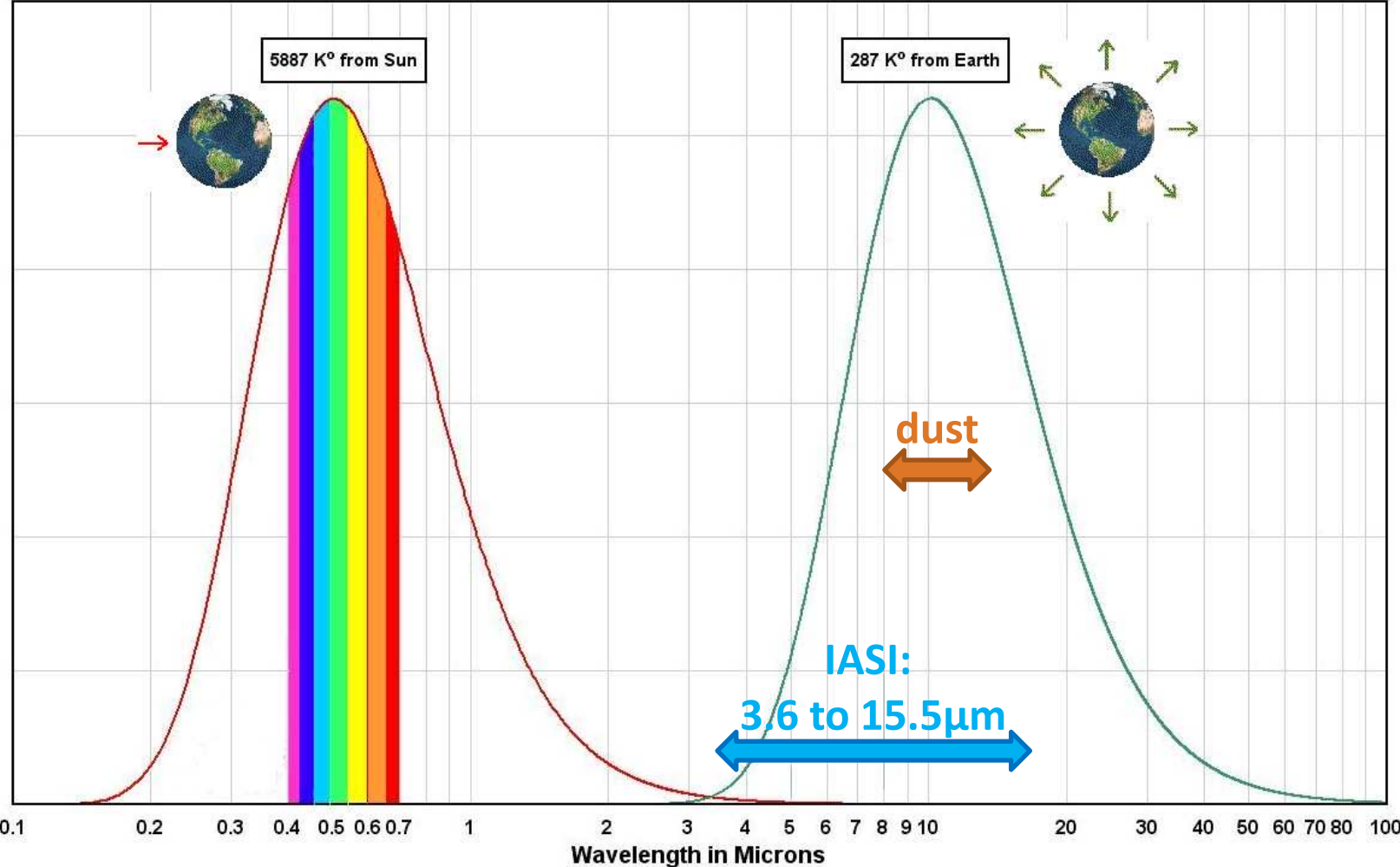## Observation technique:

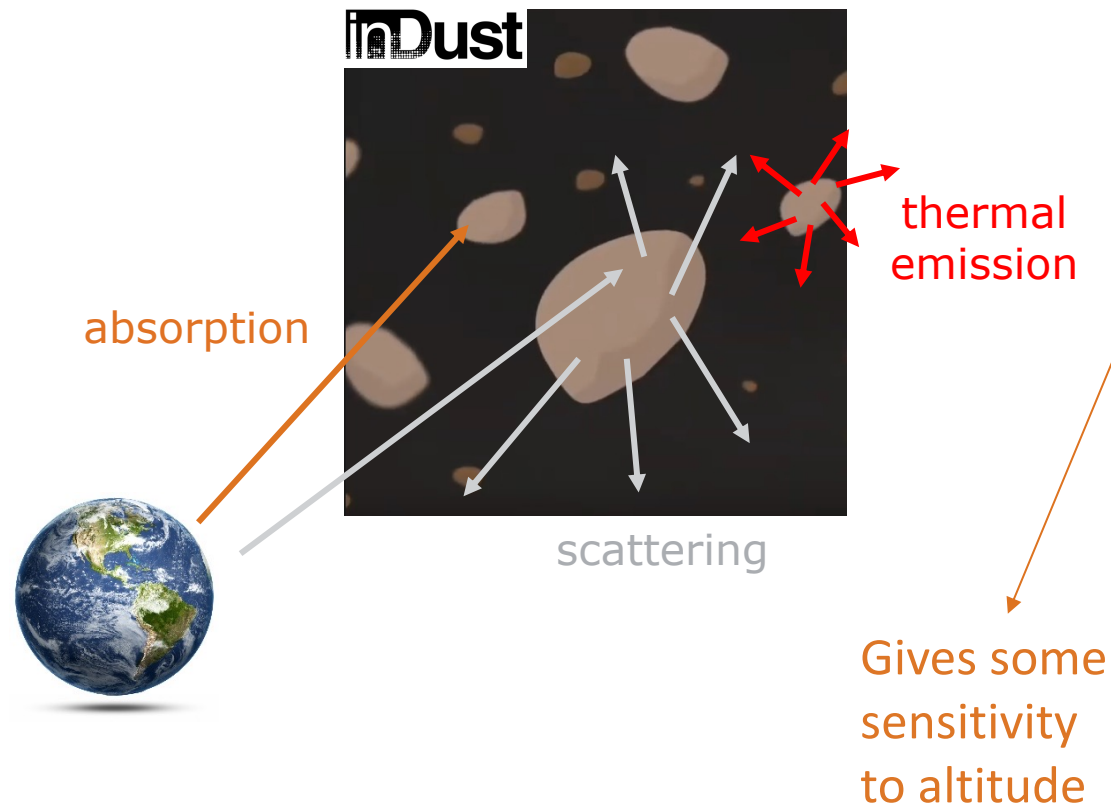- Nadir, across path scanning, FTIR
- 12km diameter pixels (at nadir)

Spectral ranges

Specificities of the TIR

thermal emission

absorption

scattering

Gives some sensitivity to altitude

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
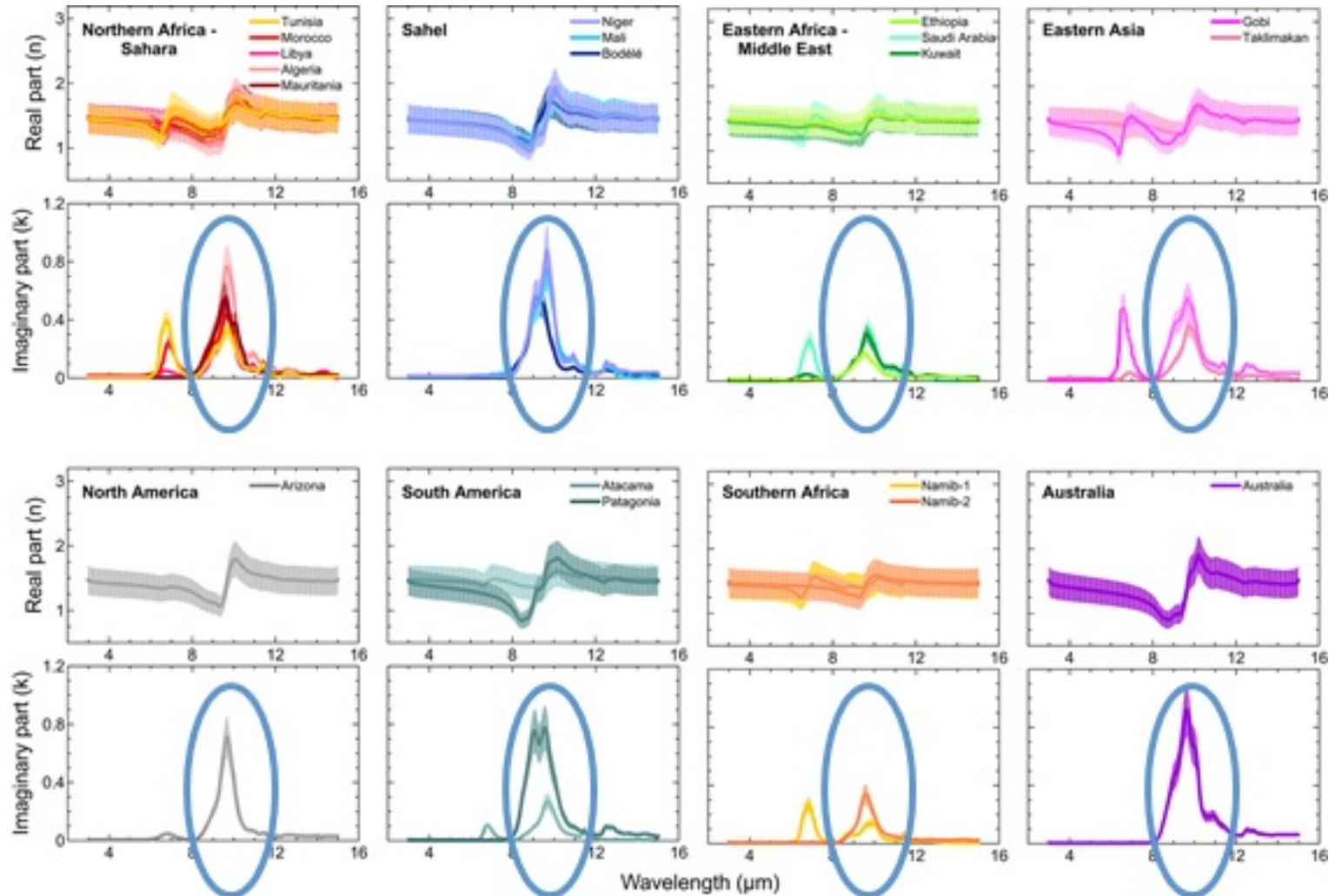- No solar light needed -> day & night

Aerosol signature

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

Clouds have to be « removed »
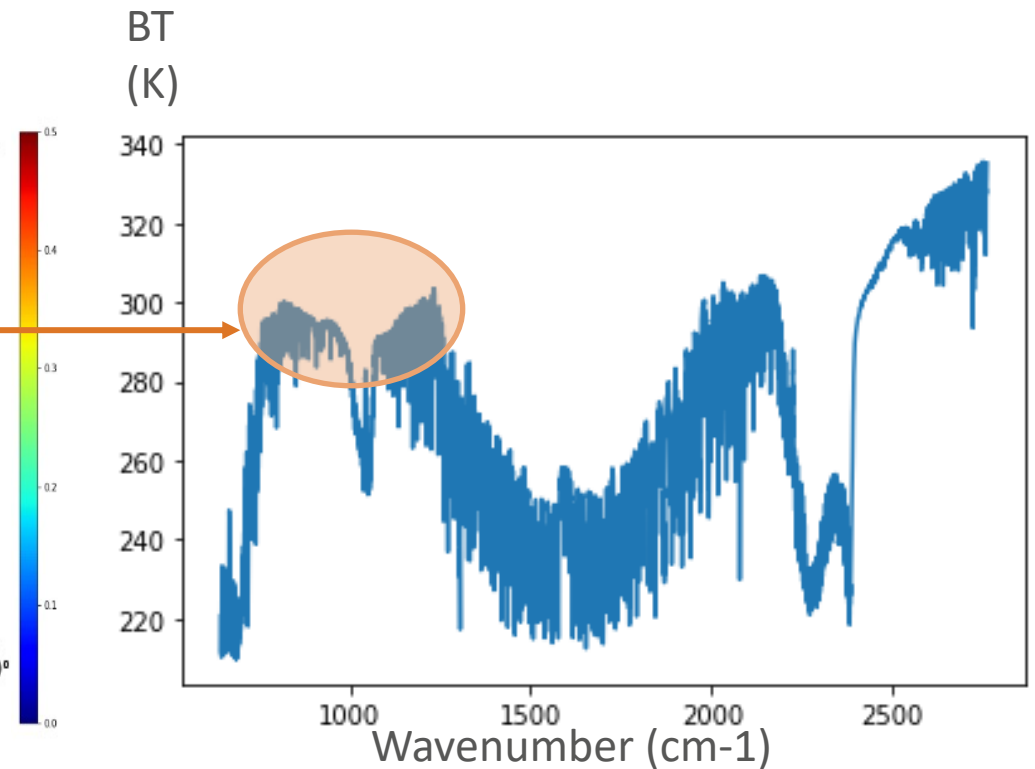
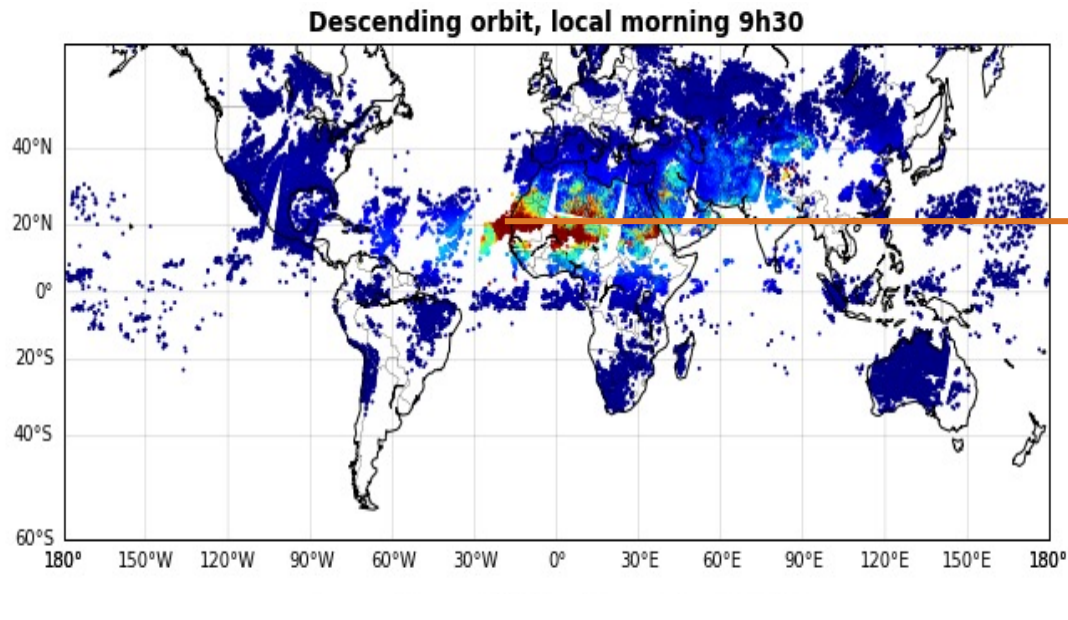# Dust refractive index (longwave)

Di Biagio, ACP 2017

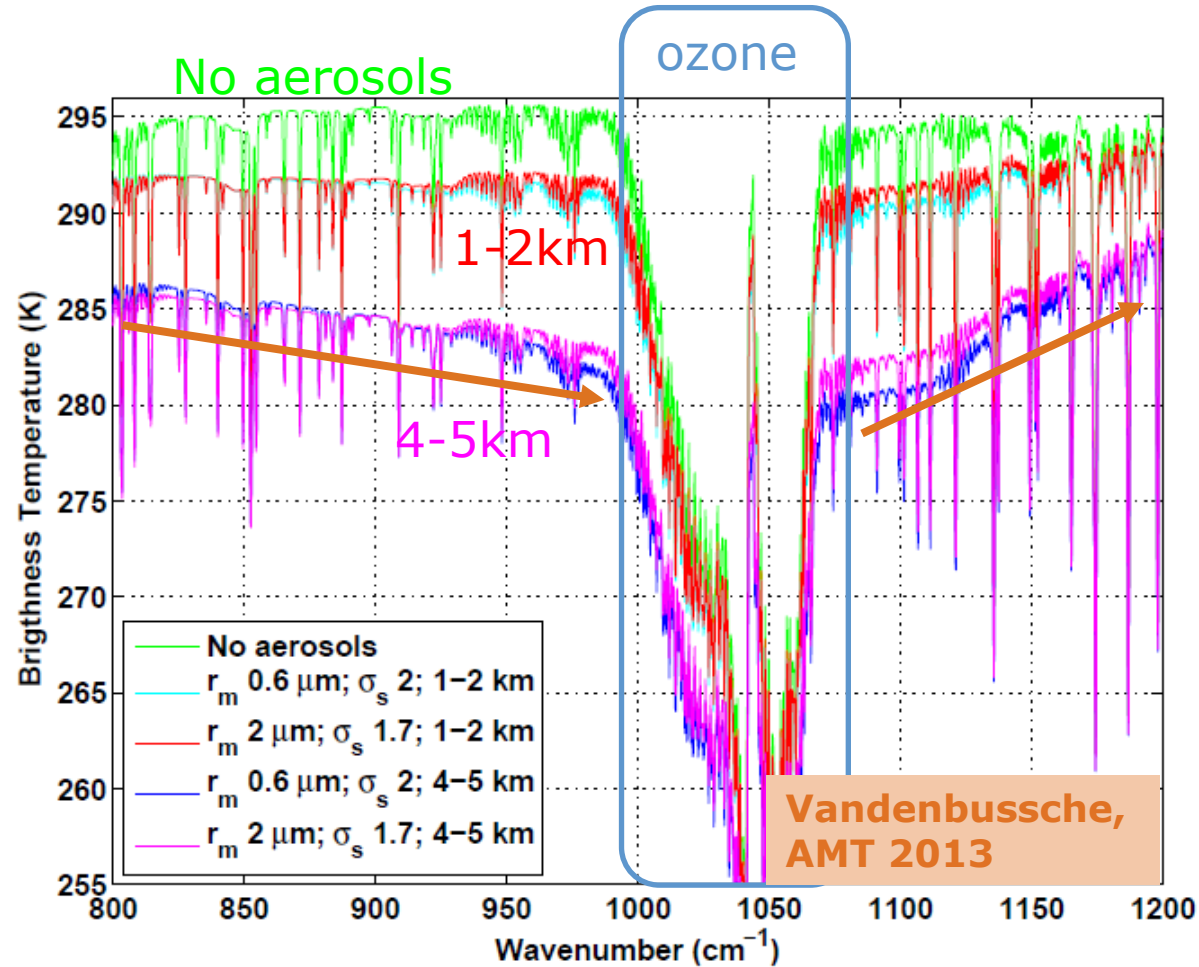# Typical spectral signature

Godzilla dust storm, June 2020
15/06/2020
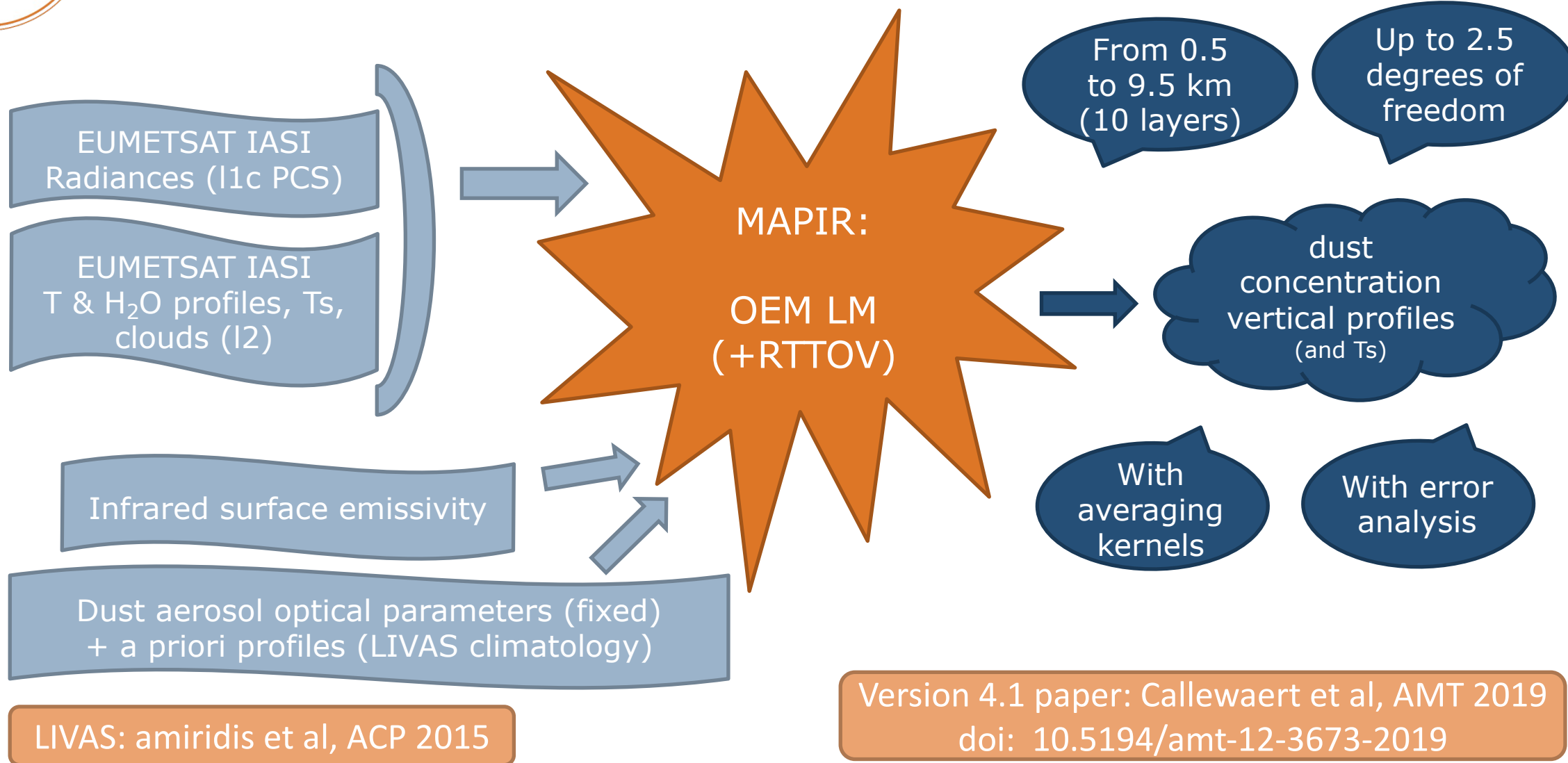local morning DOD at 10μm

Sensitivity

Sensitivity to
(from highest to lowest)

- Total amount (AOD)
- Altitude
- Size and composition

!! Only **large particles**
!! **Clouds** are an issue

MAPIR algorithm – new version 5.1

EUMETSAT IASI Radiances (l1c PCS)

EUMETSAT IASI T & H_2O profiles, Ts, clouds (l2)

Infrared surface emissivity

Dust aerosol optical parameters (fixed) + a priori profiles (LIVAS climatology)

MAPIR:

OEM LM (+RTTOV)

From 0.5 to 9.5 km (10 layers)

Up to 2.5 degrees of freedom

dust concentration vertical profiles (and Ts)

With averaging kernels

With error analysis

LIVAS: amiridis et al, ACP 2015

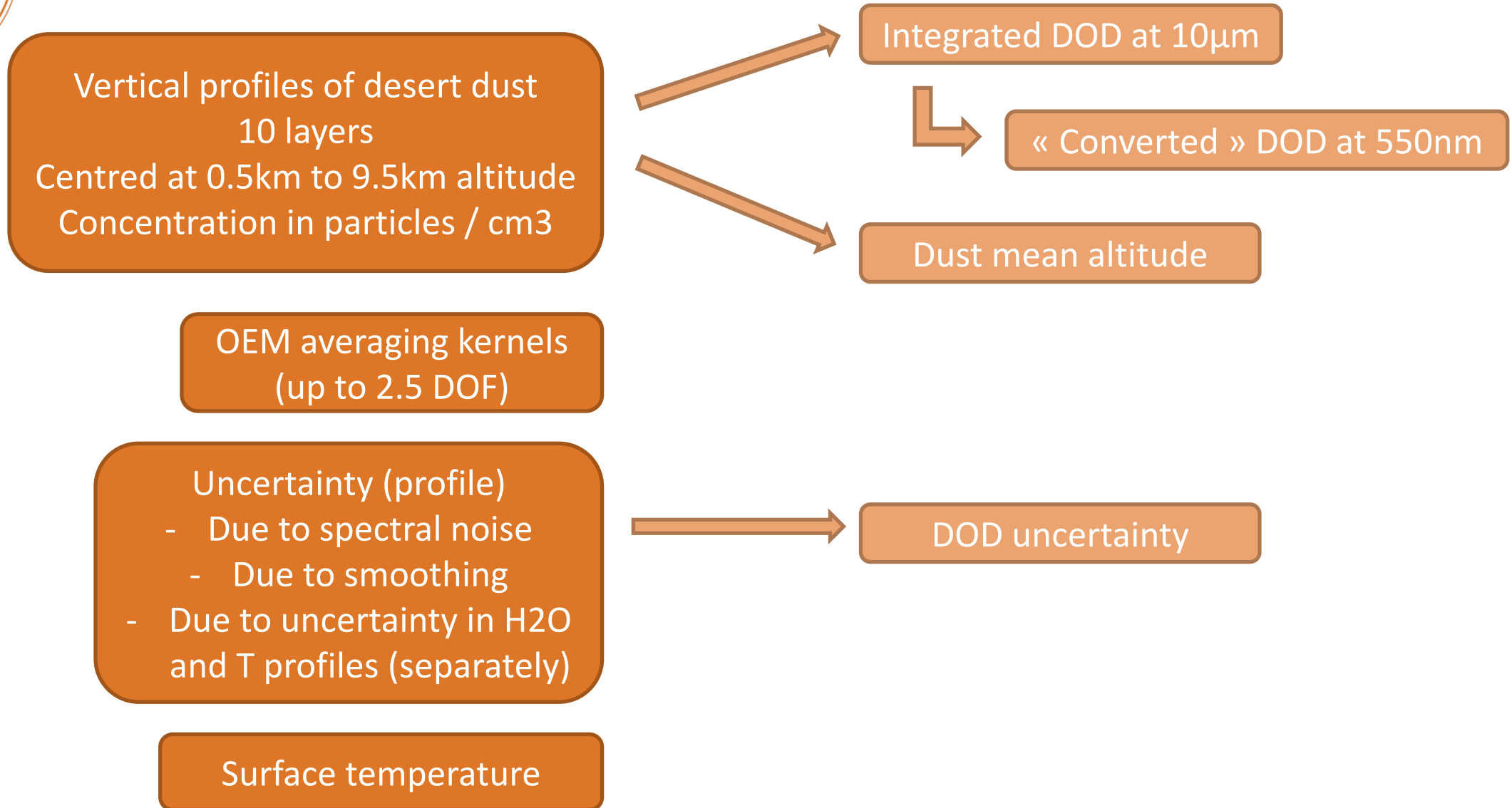Version 4.1 paper: Callewaert et al, AMT 2019
doi: 10.5194/amt-12-3673-2019

New in version 5.1

- **All scenes** processed (including clouds) + **global** coverage (used to be the Tropical belt + up to 60° latitude with additional pre-filters that were far from perfect)

- DOM solver (scattering) reduced to **4 streams** (used to be 8)

- **Emissivity** now from the RTTOV **CAMEL** climatology for land (used to be from Daniel Zhou), **IREMIS** for sea (used to be fixed from literature Newman)

- **RTTOV** updated to version **13** (used to be version12)

- Altitude range **up to 10km** (used to be 7km)

- **Uncertainty** now contains propagation of T and H2O profiles uncertainty

- Spectral noise in OEM reduced (less noise inflation)

- Minimum dust concentration in a priori increased to 2 part/cm³ (used to be 0.1 part/cm³)

- Std dev on Ts a priori reduced to 5K over land (used to be 15K)

MAPIR outputs in more details

**Vertical profiles of desert dust
10 layers
Centred at 0.5km to 9.5km altitude
Concentration in particles / cm3**

→ Integrated DOD at 10μm

↳ « Converted » DOD at 550nm

→ Dust mean altitude

**OEM averaging kernels
(up to 2.5 DOF)**

Uncertainty (profile)
- Due to spectral noise
- Due to smoothing
- Due to uncertainty in H2O and T profiles (separately)

→ DOD uncertainty

Surface temperature

The biggest problem: the clouds
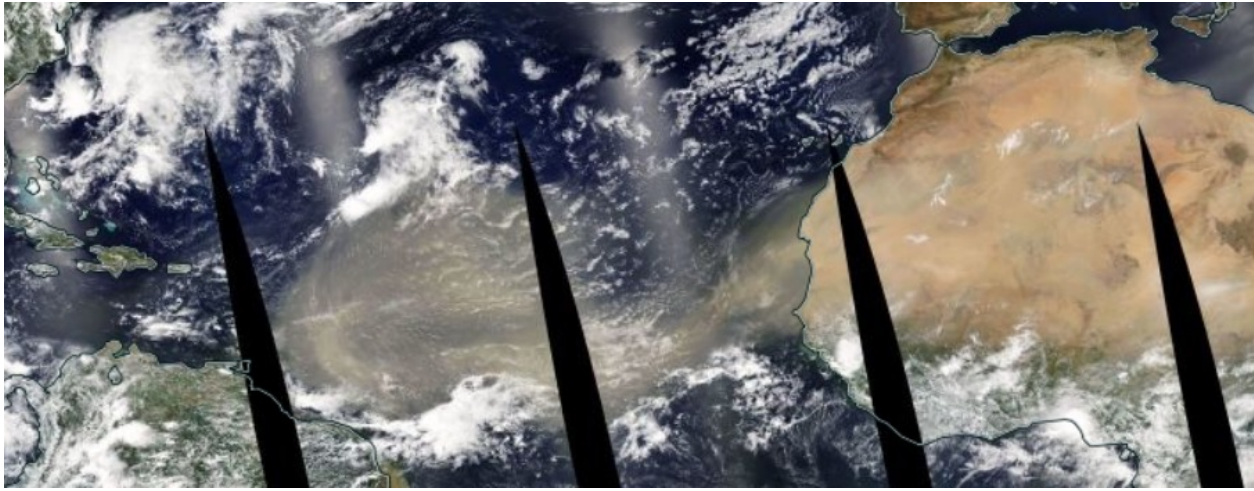
Filter before

↓

Use some cloud flags

↓

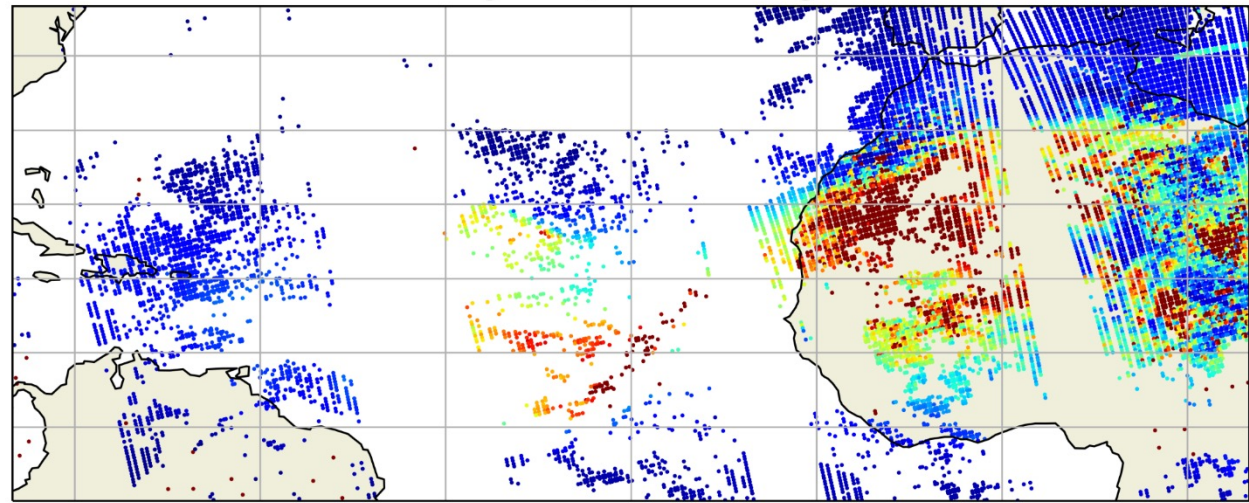Reduced data to be treated
+ Depends on cloud flag quality:
- Usually misses the most intense dust plumes
- Possibly leaves small cloud contamination

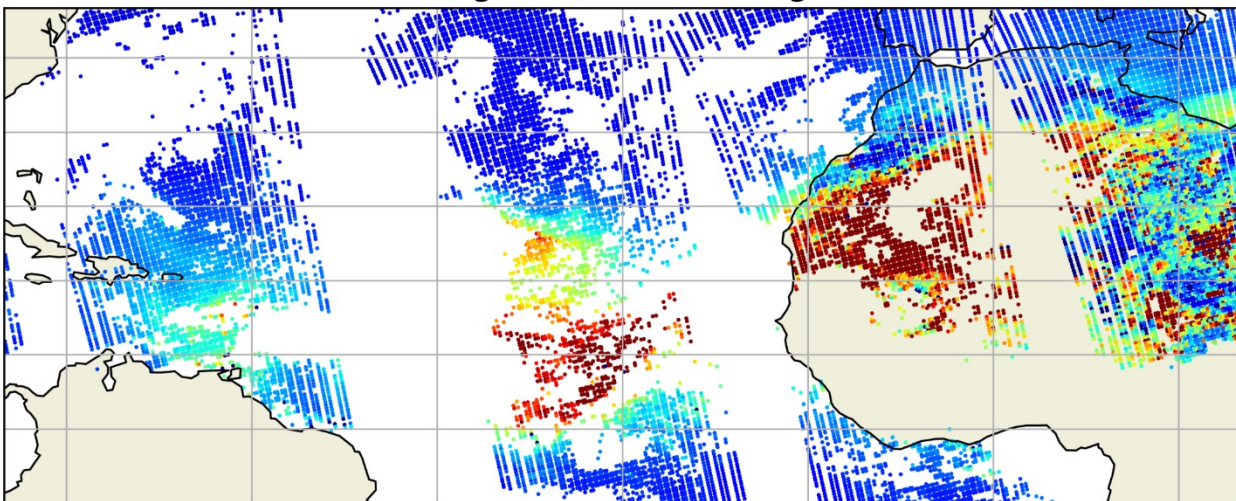# « Godzilla » 20/06/2020 21h30 (AOD 10µm – scale up to 0.5)
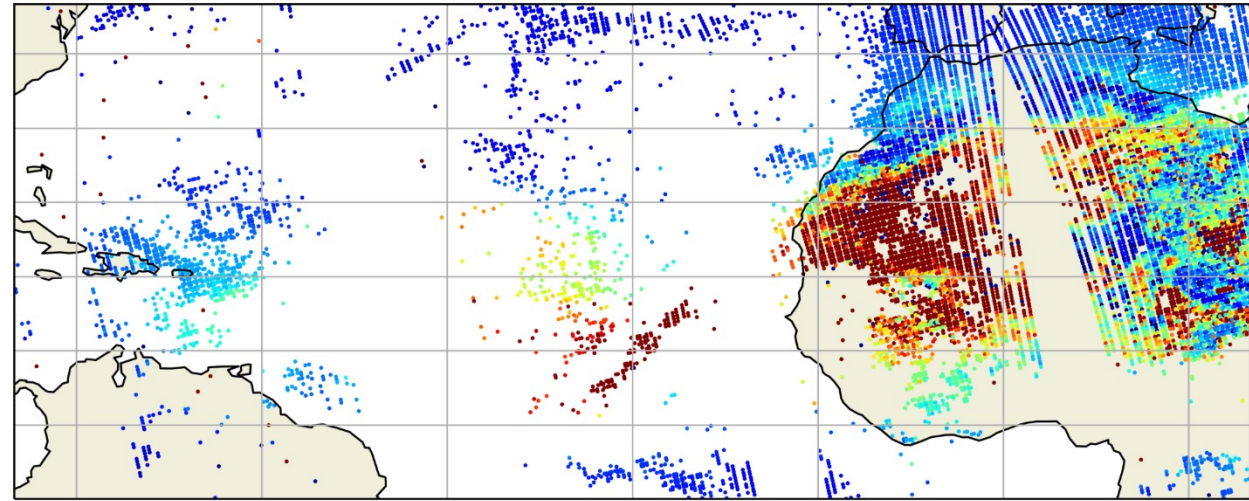

MODIS / Aqua True Color (NASA Worldview)

NRT flag + cloud fraction – MAPIR v4.1 no post filter
Ascending orbit, local evening 21h30

RPRO cloud fraction – MAPIR v5.0 no post filter
Ascending orbit, local evening 21h30

ULB cloud fraction – MAPIR v5.0 no post filter
Ascending orbit, local evening 21h30

The biggest problem: the clouds

Filter before

↓

Use some cloud flags

↓

Reduced data to be treated
+ Depends on cloud flag quality:
- Usually misses the most intense dust plumes
- Possibly leaves small cloud contamination

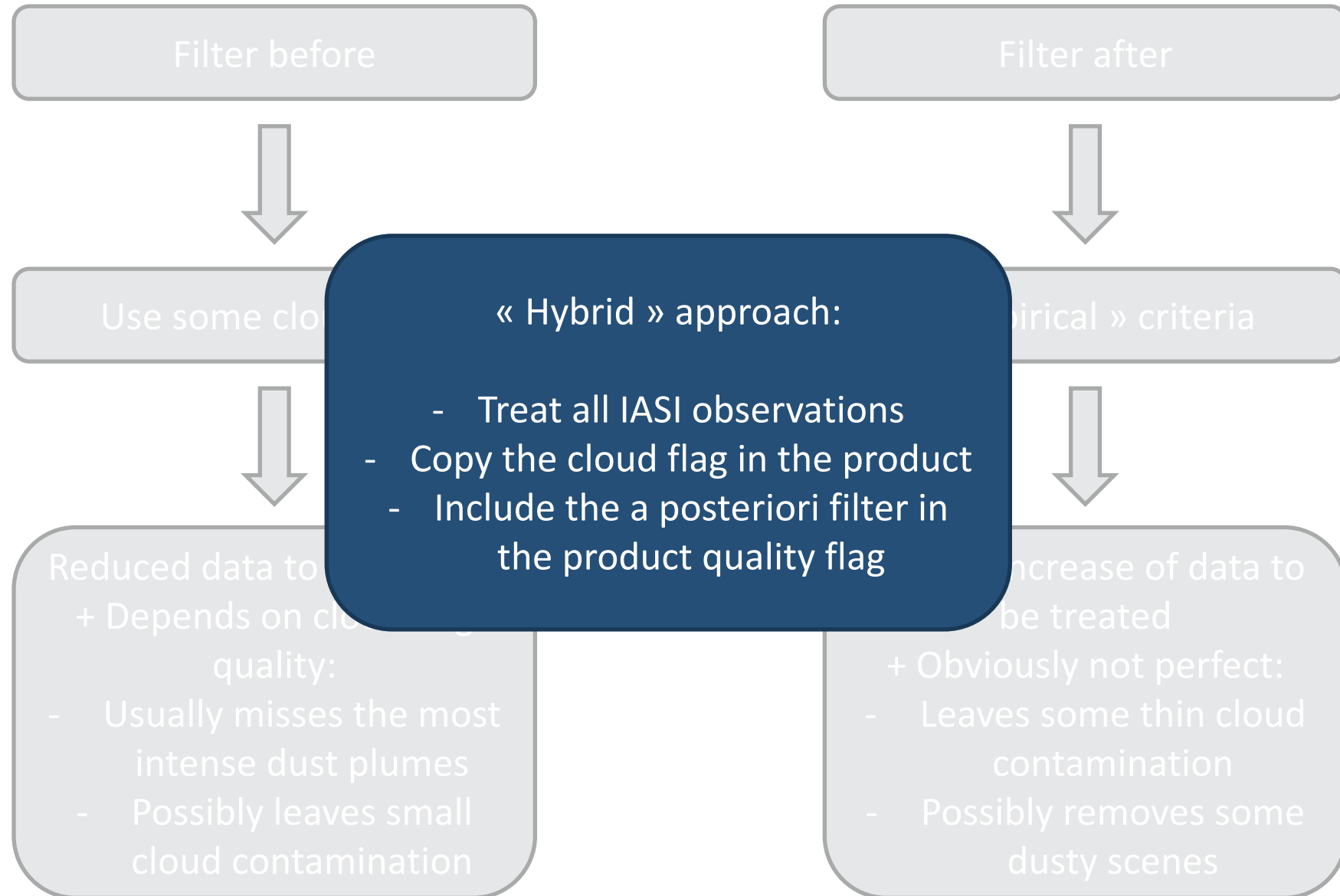**Filter after**

↓

« Empirical » criteria

↓

Serious increase of data to be treated
+ Obviously not perfect:
- Leaves some thin cloud contamination
- Possibly removes some dusty scenes
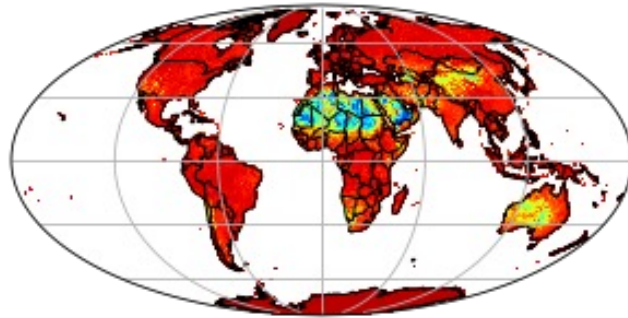
The biggest problem: the clouds

Filter before

Filter after

Use some clo...

...birical » criteria

Reduced data to...
+ Depends on clo...
quality:
- Usually misses the most intense dust plumes
- Possibly leaves small cloud contamination

...ncrease of data to be treated
+ Obviously not perfect:
- Leaves some thin cloud contamination
- Possibly removes some dusty scenes

« Hybrid » approach:

- Treat all IASI observations
- Copy the cloud flag in the product
- Include the a posteriori filter in the product quality flag

Another crucial input: land surface emissivity

Example for June

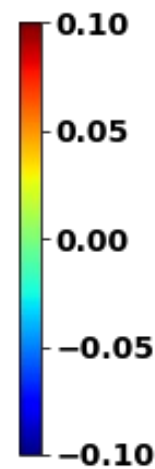Used in MAPIR v5.1   Used in previous versions (only land)
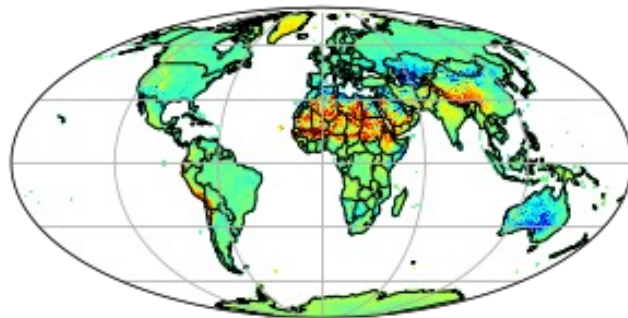

CAMEL 1115.00cm-1

Zhou 1115.00cm-1
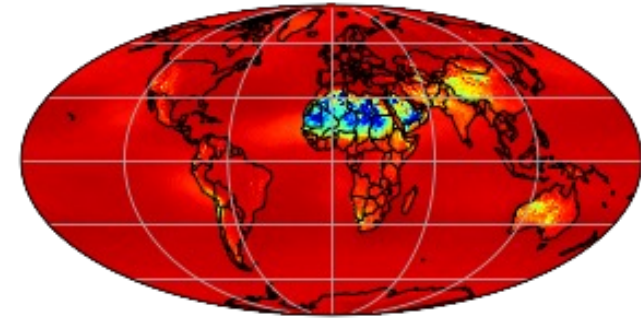
Zhou et al, IEEETGR 2015

CAMEL-Zhou
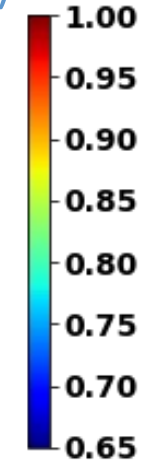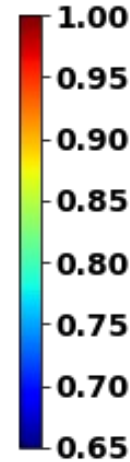
Different versions for NRT and RPRO

NRT
Goal: best possible data
at processing time

- Input: NRT IASI l1 PCS and l2 OEM
 - Cloud flag from IASI l2 OEM

RPRO
Goal: highest possible consistency
along time

- Input: RPRO IASI l1 PCS and l2
  PWLR3 (OEM not available)
- Cloud fraction from AVHRR / IASI l1
 (full flag not available)

Under evaluation / implementation as
EUMETSAT IASI NRT product

Will be delivered this month to
Copernicus climate data store

MAPIR v4.1 | 20 June 2020 | MAPIR v5.1

CALIOP - no smoothing, ext. only plotted for dust (orange) / polluted dust (light orange) / dusty marine (yellow)
IASI plotted for max 50km and 6h vs CALIOP; bottom IASI AOD plot is whole day

New !

CALIOP - no smoothing, ext. only plotted for dust (orange) / polluted dust (light orange) / dusty marine (yellow)
IASI plotted for max 50km and 6h vs CALIOP; bottom IASI AOD plot is whole day

New !
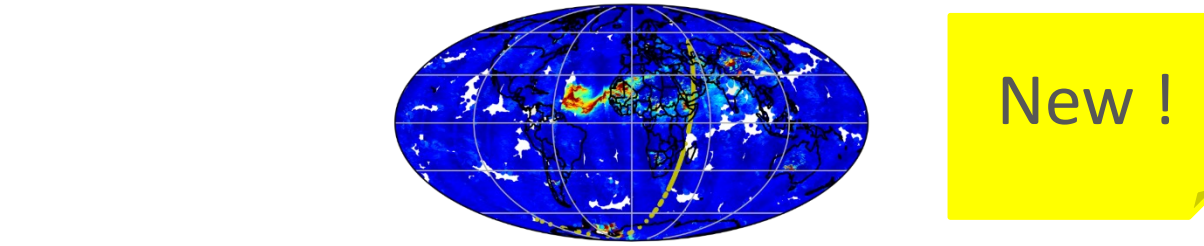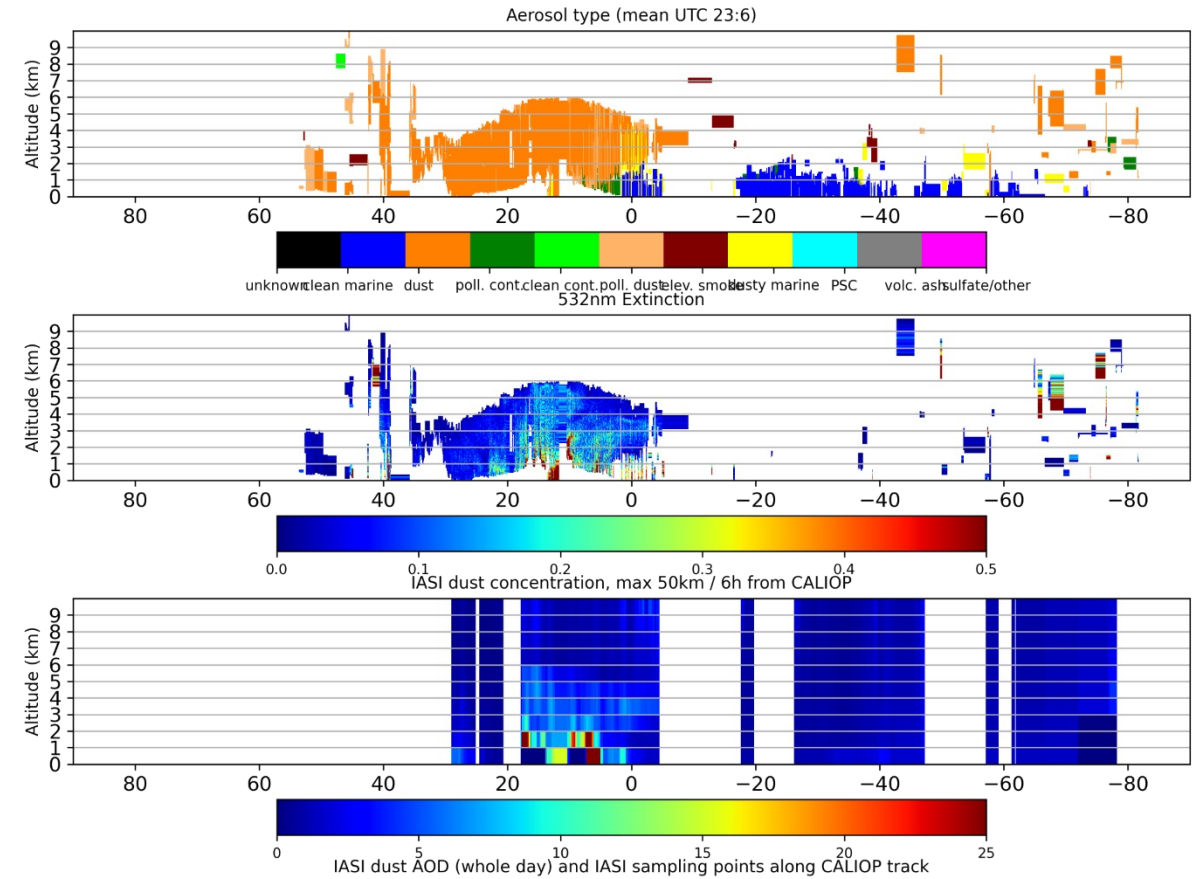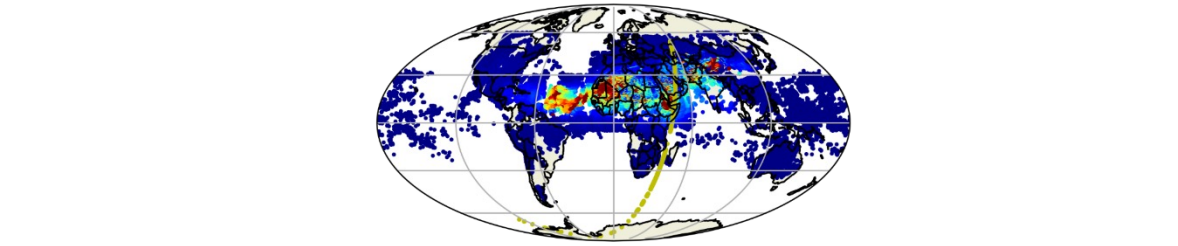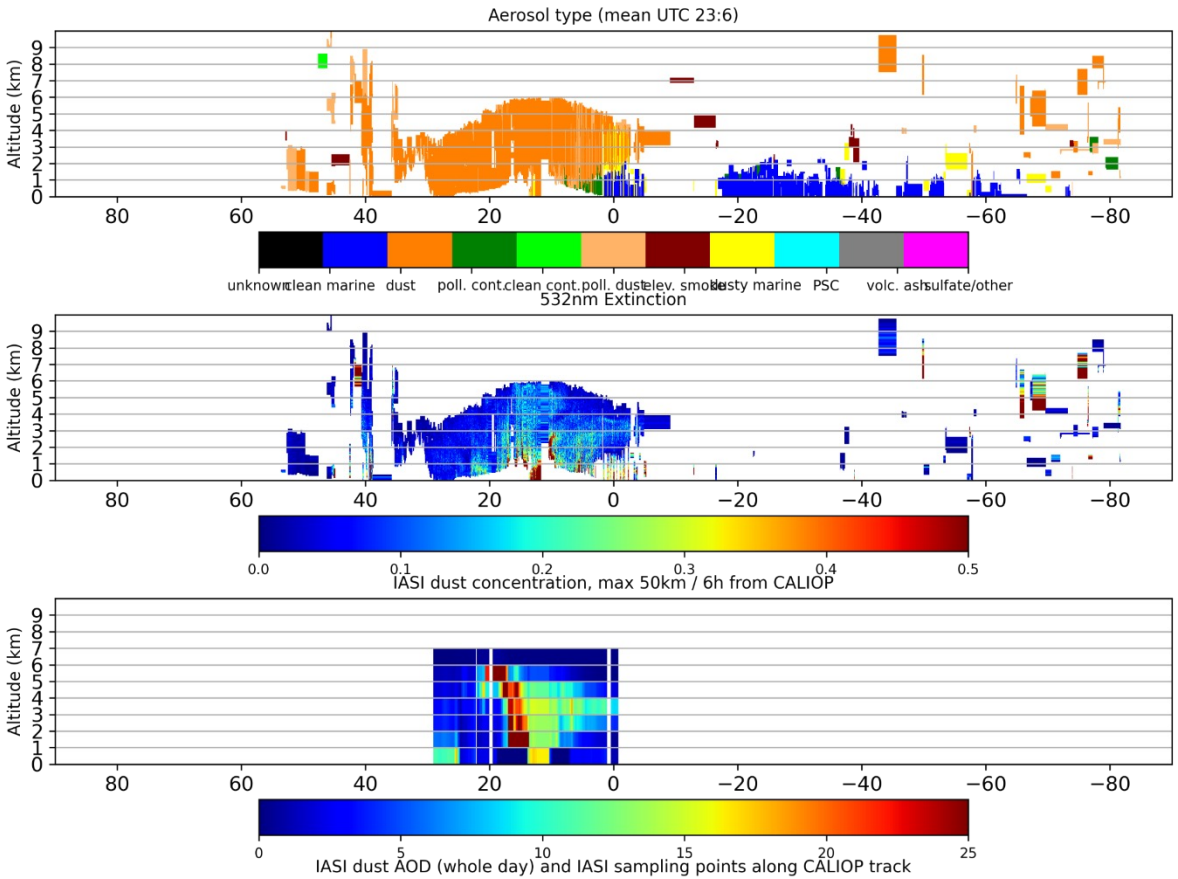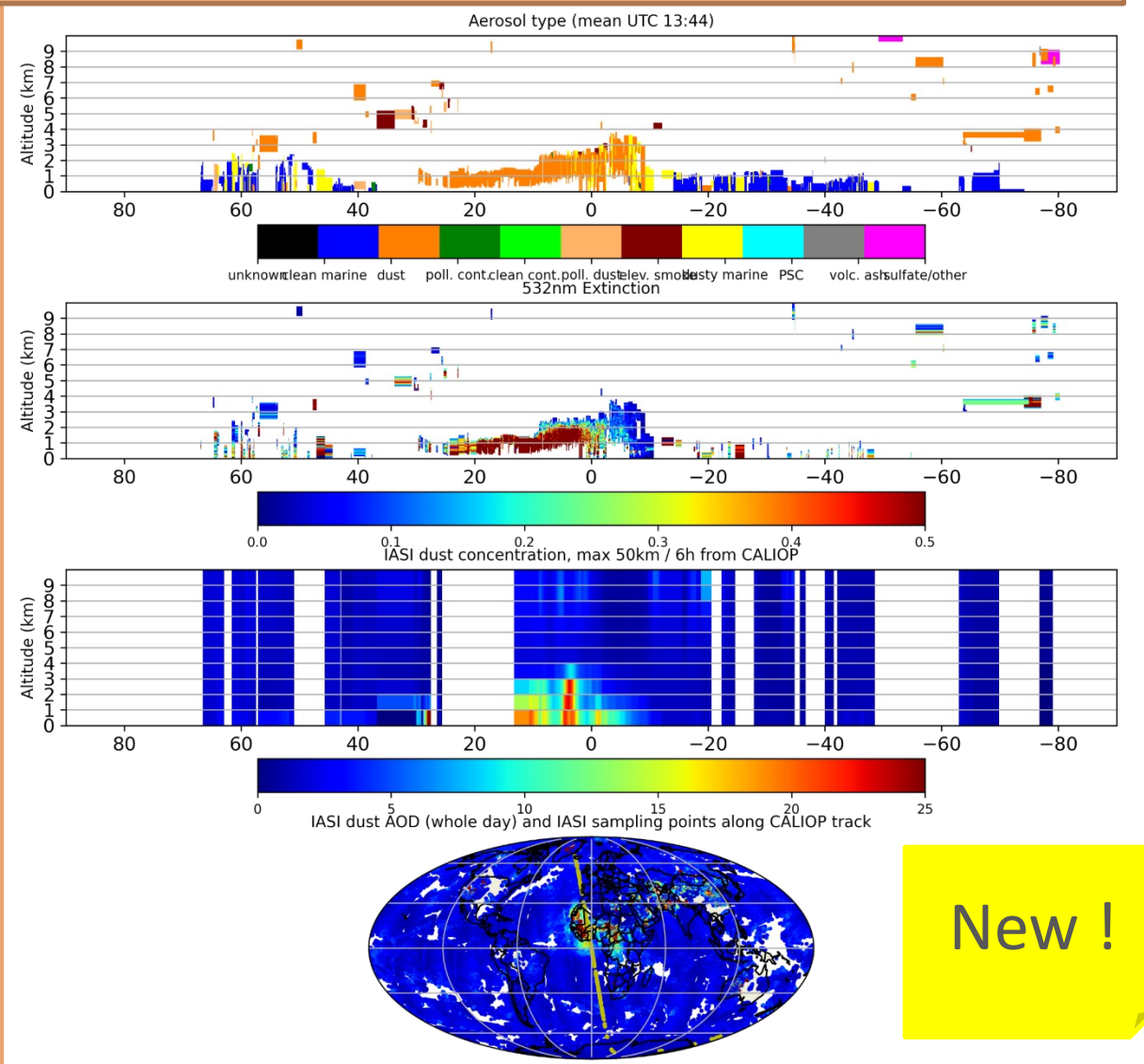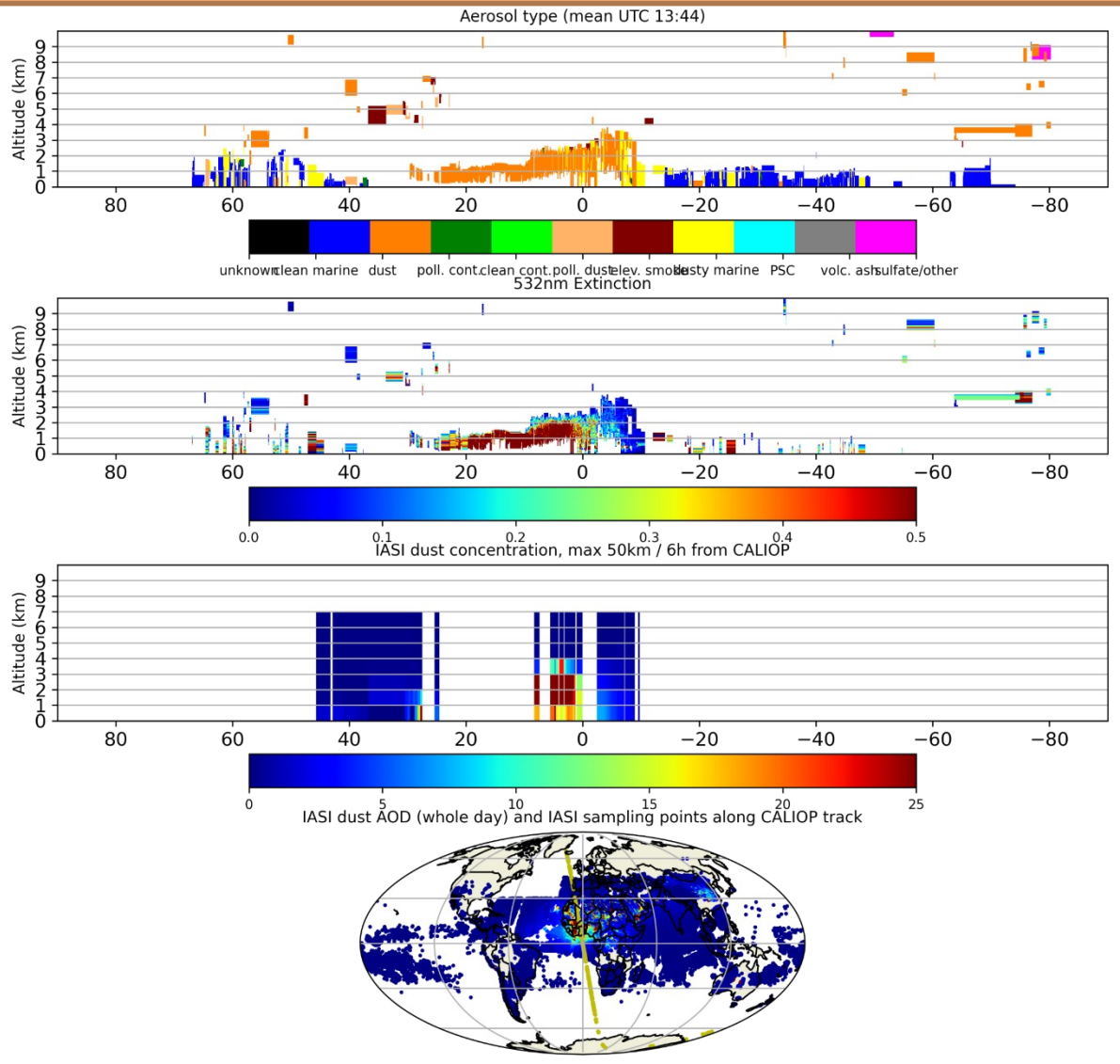
Summary, and upcoming

- Version 5.1 is brand new
  - CDR fully consistent since 2007
  - NRT to be implemented soon (ACSAF)
- « internal » validation of CDR
  - Look deeply at data (test cases were done before processing ;))
  - Converted AOD at 550nm versus AERONET coarse mode SDA AOD
  - Vertical profiles vs CALIOP, CATS, … (will be qualitative only, probably)
  - (maybe) mean altitude vs CALIOP mean altitude
- « external » validation
  - CDR: under Copernicus
  - NRT: under ACSAF (EUMETSAT)

Level 2 data access through our institute **iasi.aeronomie.be**
currently old version 4.1 !

Level 3 data on the CDS

Access through the Climate Data Store **cds.climate.copernicus.eu**
Dust AOD and mean altitude **level 3**: daily / monthly, day / night / both

"descending"
"ascending"

currently MAPIR old version 4.1 !

Additional take-home messages

The biggest issue: clouds…
- Sometimes difficult to discriminate
- 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

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

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

THANK YOU!

MORE INFO?

iasi.aeronomie.be

sophie.vandenbussche@aeronomie.be