



Satellite Monitoring of Dust

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EUMETSAT
AC SAF
ATMOSPHERIC COMPOSITION
MONITORING



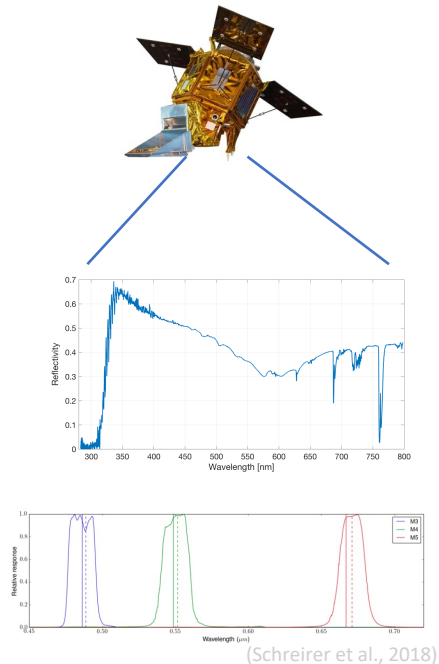
Contents of the lecture

- Basic concept of passive satellite measurements
- True color RGB images and RGB composites
- Aerosol Optical Depth
- Absorbing Aerosol Index

Basic concept of passive satellite retrievals

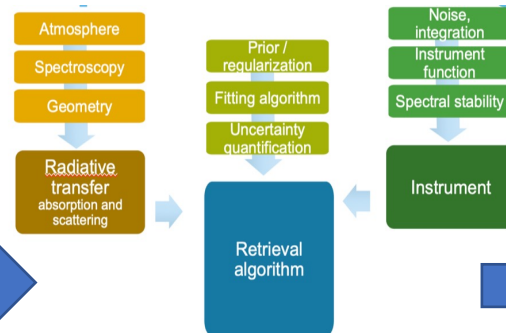
- Passive satellite instruments measure reflected radiation at selected wavelengths
- The key is the “fingerprint” that different gases and aerosols leave on the measured radiation

Level 1b data



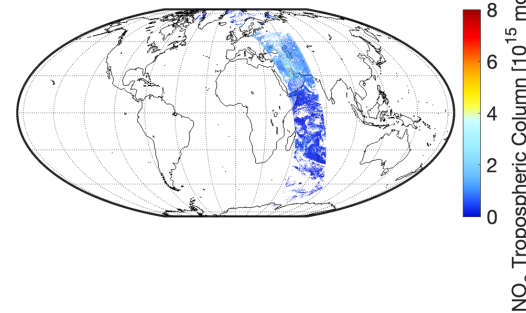
- Products containing geolocated and calibrated spectral radiance and solar irradiance data.

Retrieval algorithm



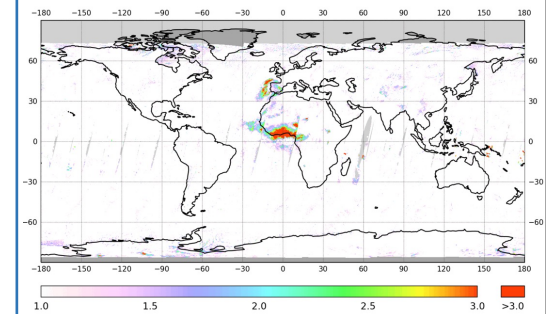
Level 2 data

Atmospheric parameters



- Atmospheric products retrieved from the L1B product.
- Near real time (NRT) or “offline”
- Use of L2 data requires knowledge, especially on quality filtering

Level 3 data



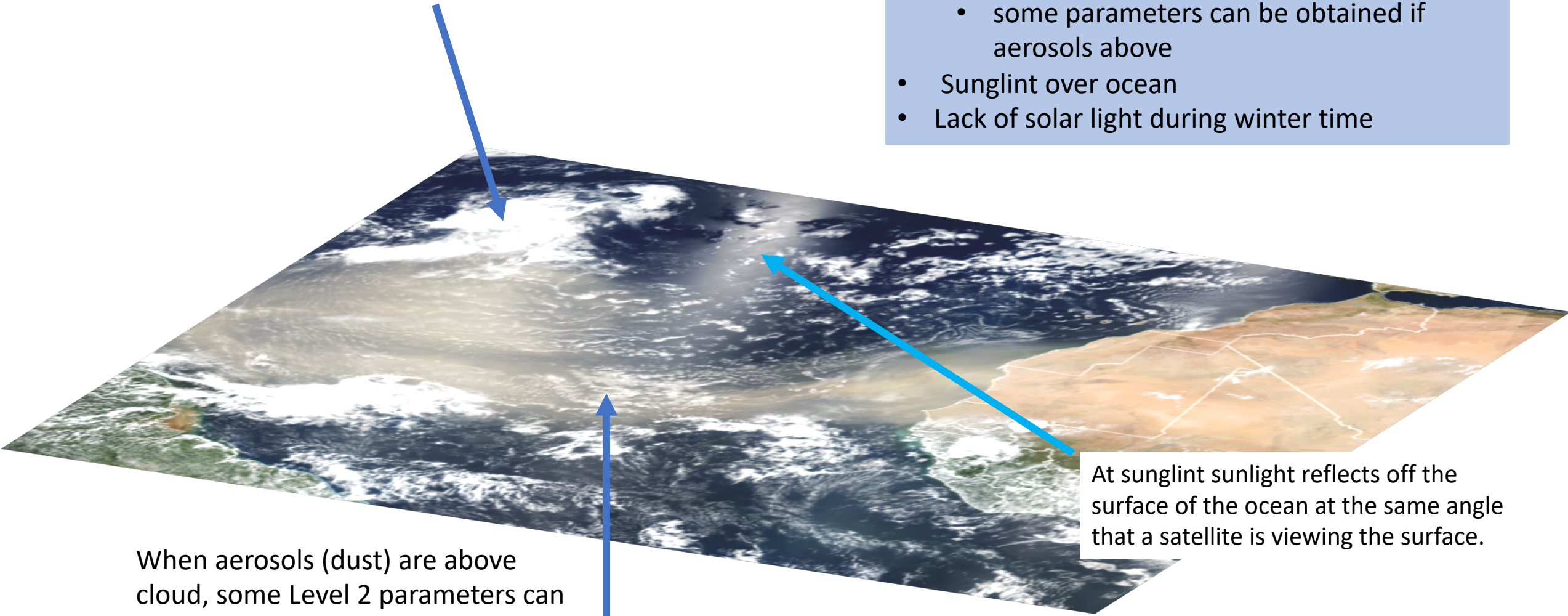
- Data gridded into a regular grid (often global)
- Typically daily or monthly products
- Quality filtered

Passive satellite instrument
can't see below clouds -> no
Level 2 observations



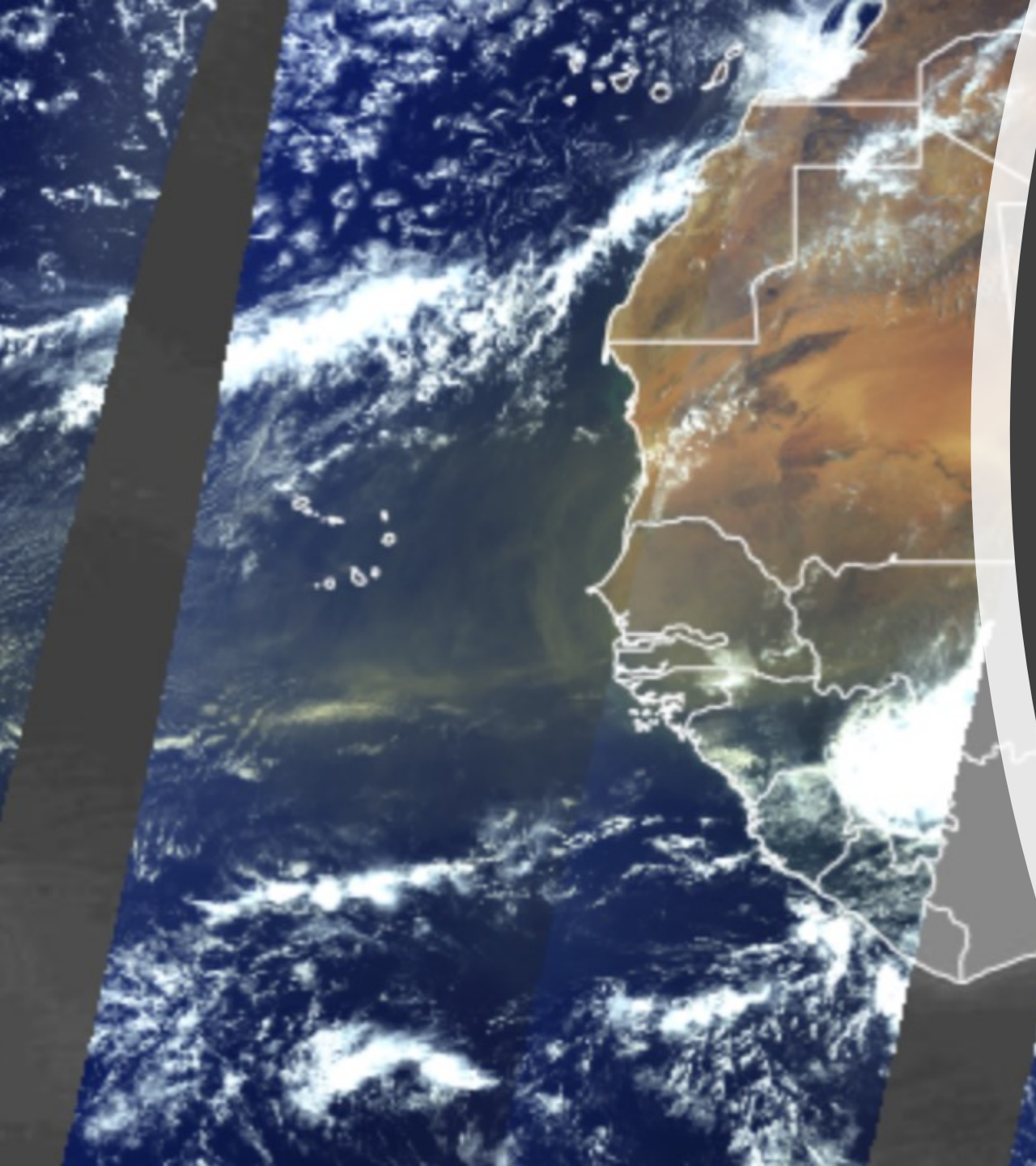
Some limitations of passive satellite aerosol observations:

- Clouds, snow and ice
 - some parameters can be obtained if aerosols above
- Sunlint over ocean
- Lack of solar light during winter time



When aerosols (dust) are above
cloud, some Level 2 parameters can
be retrieved

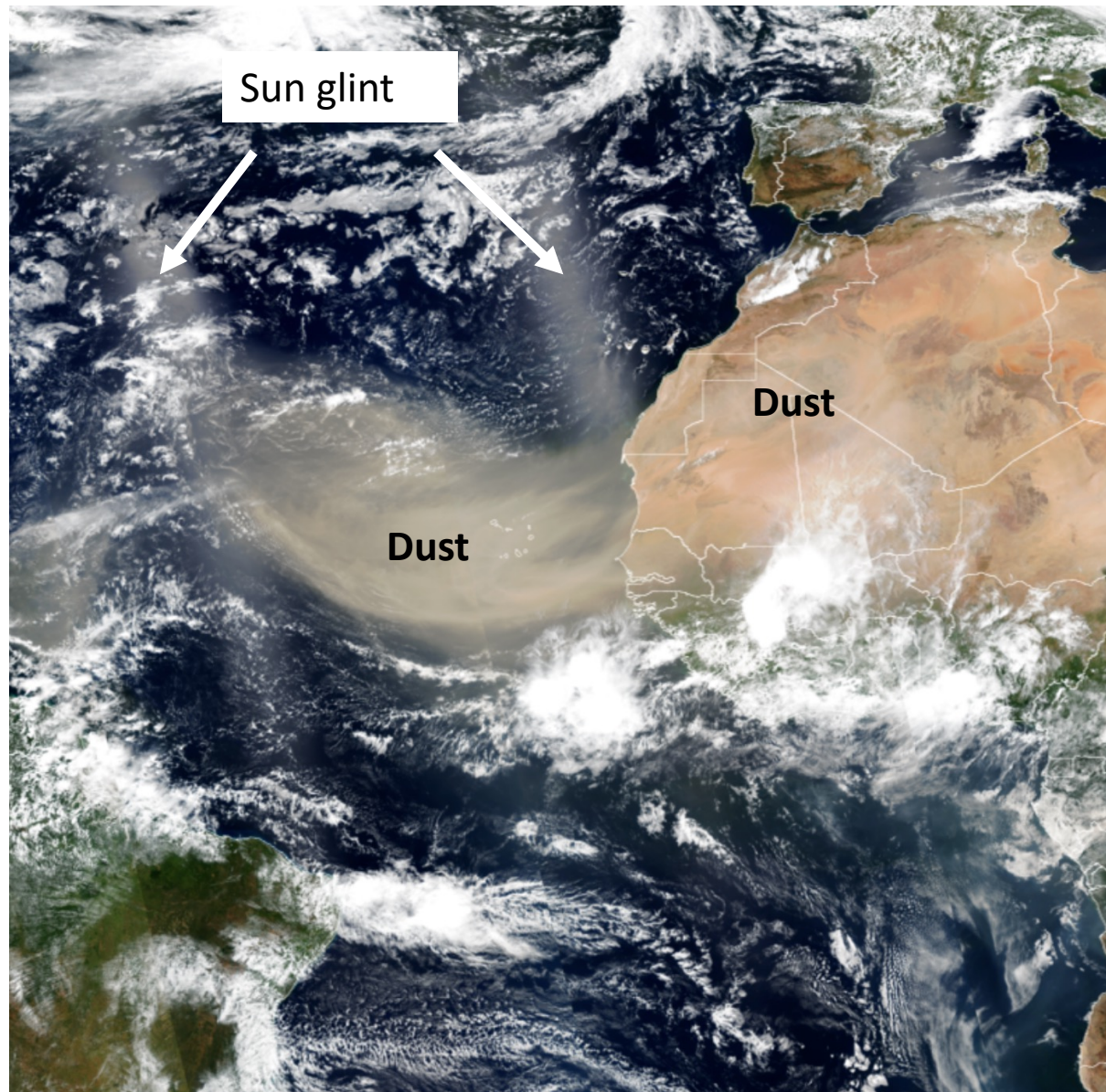
At sunlint sunlight reflects off the
surface of the ocean at the same angle
that a satellite is viewing the surface.



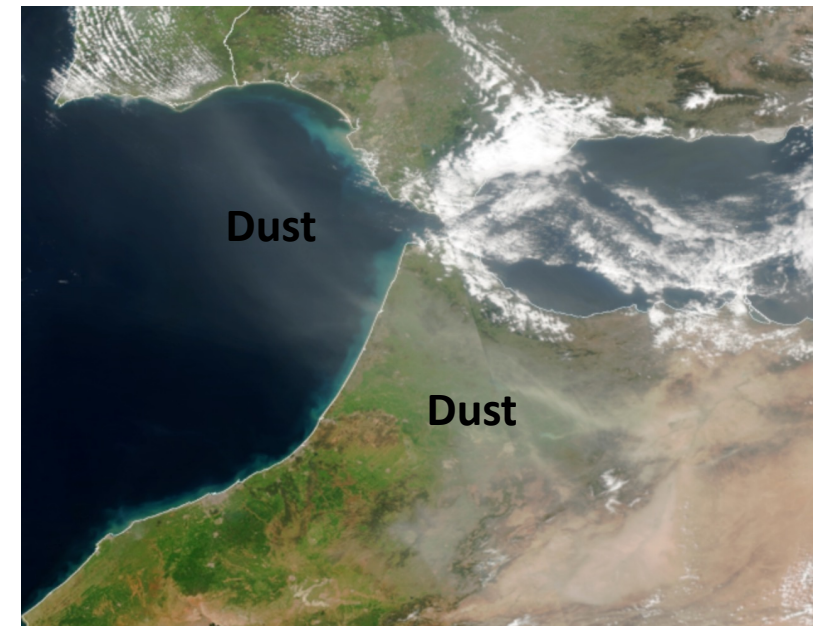
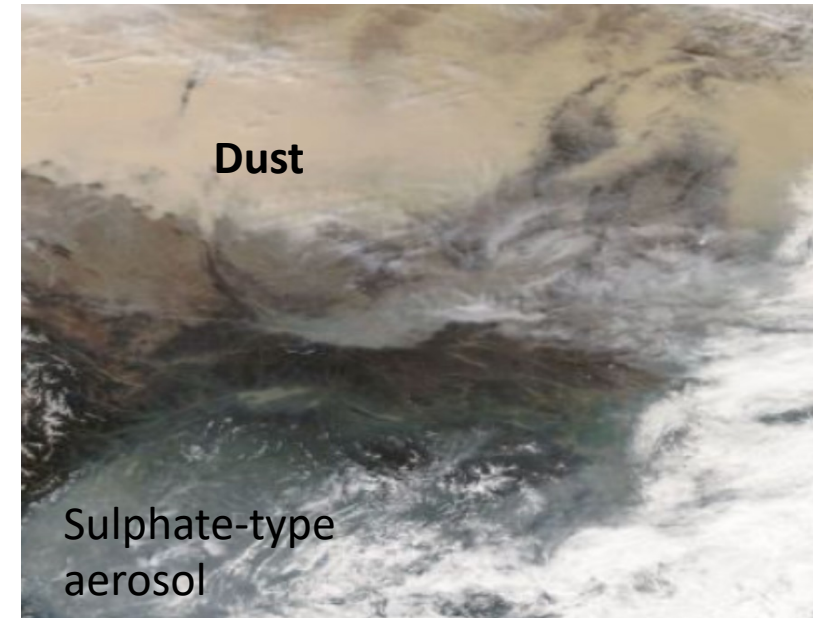
True color RGB
images and RGB
composites from
L1 data

Dust in RGB images

Polar orbiting satellites



Observation time always at about same local time
(sun synchronous)



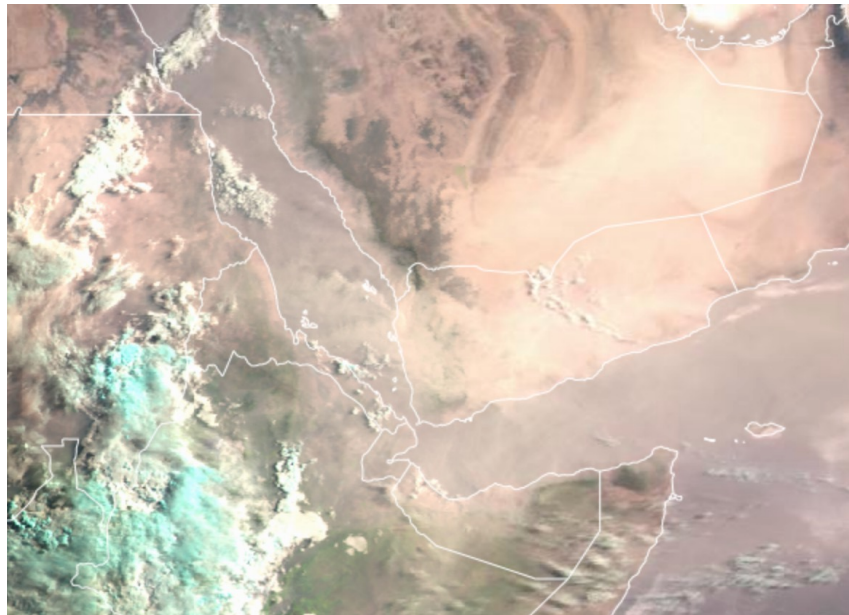
Dust in RGB images

Geostationary satellite

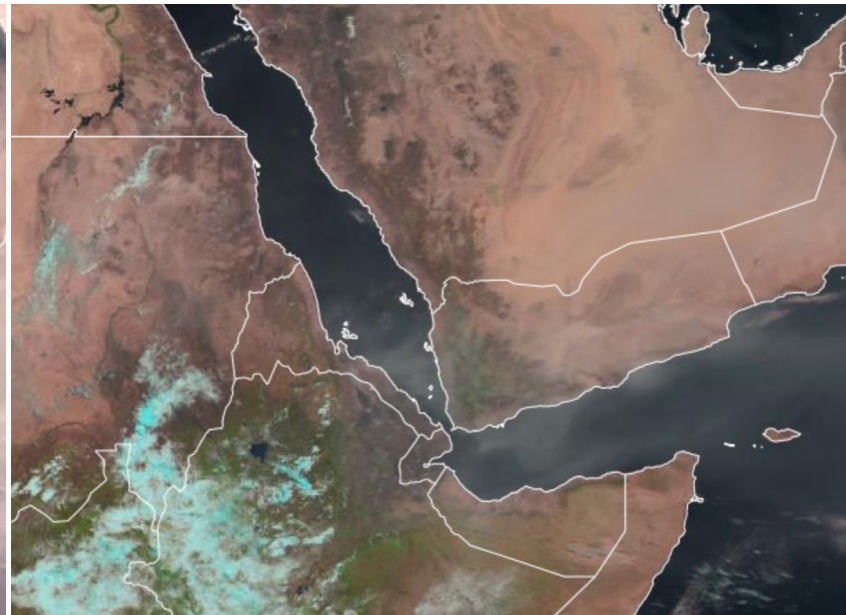
Example: MSG Seviri RGB True color product

Observation time changes -> solar angle change

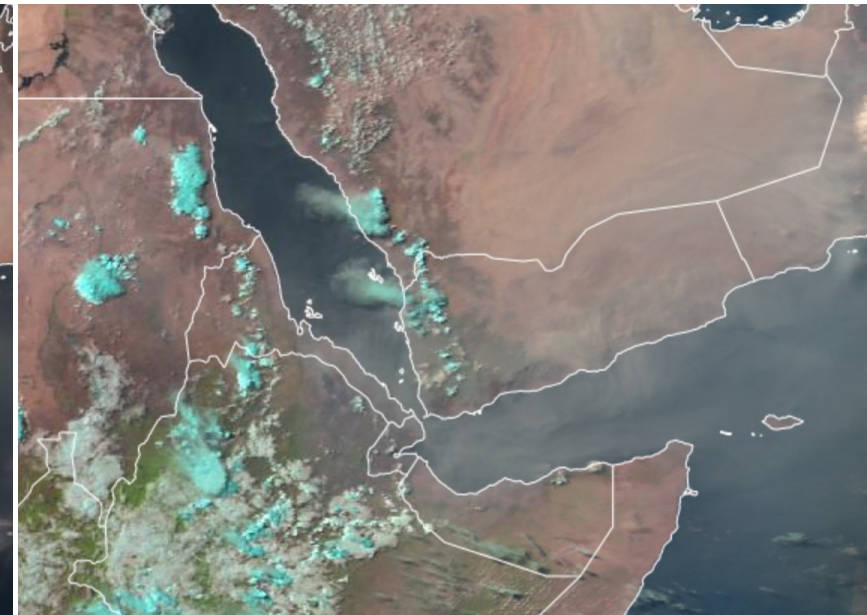
“Early morning”



“Close to noon”

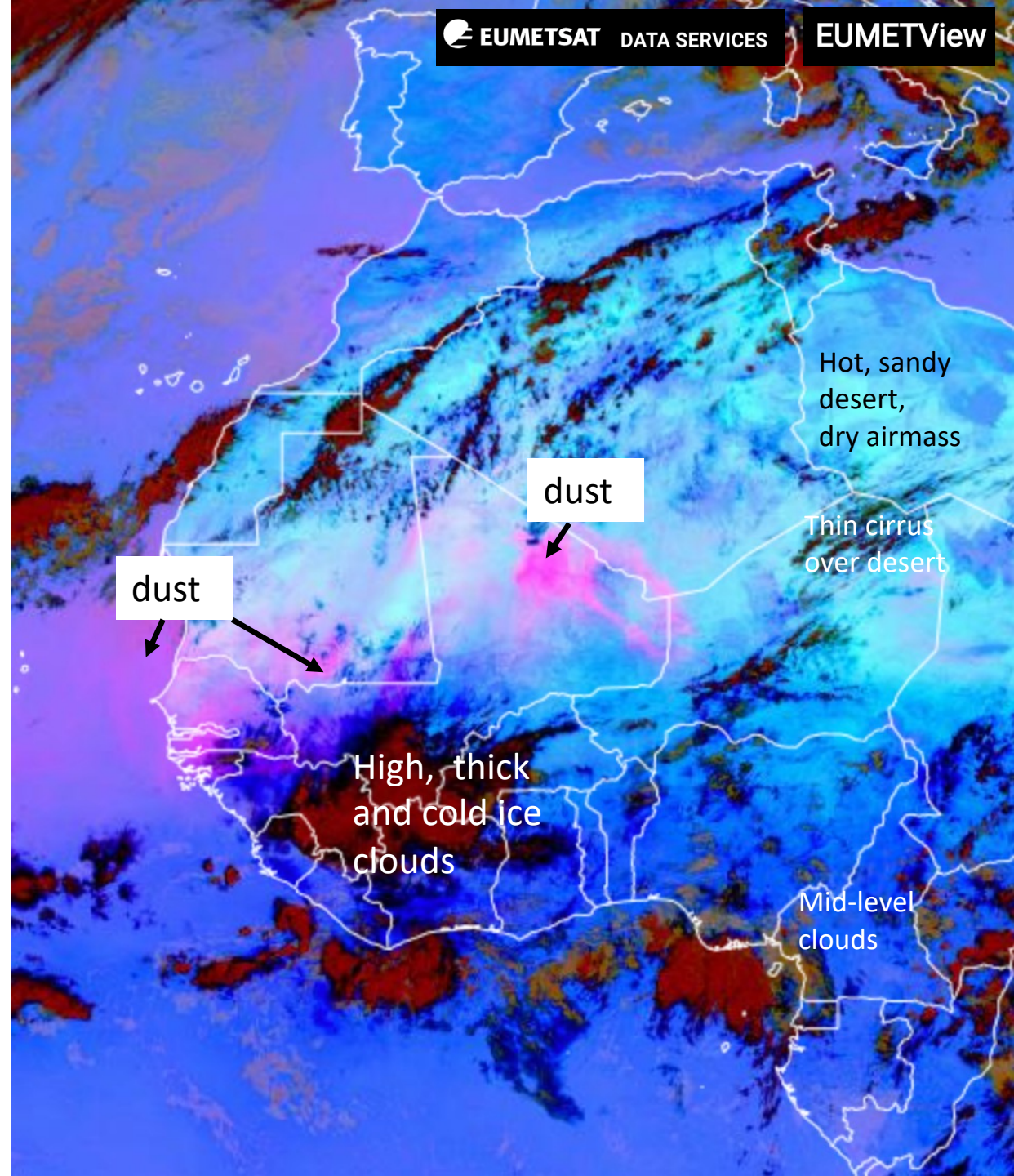


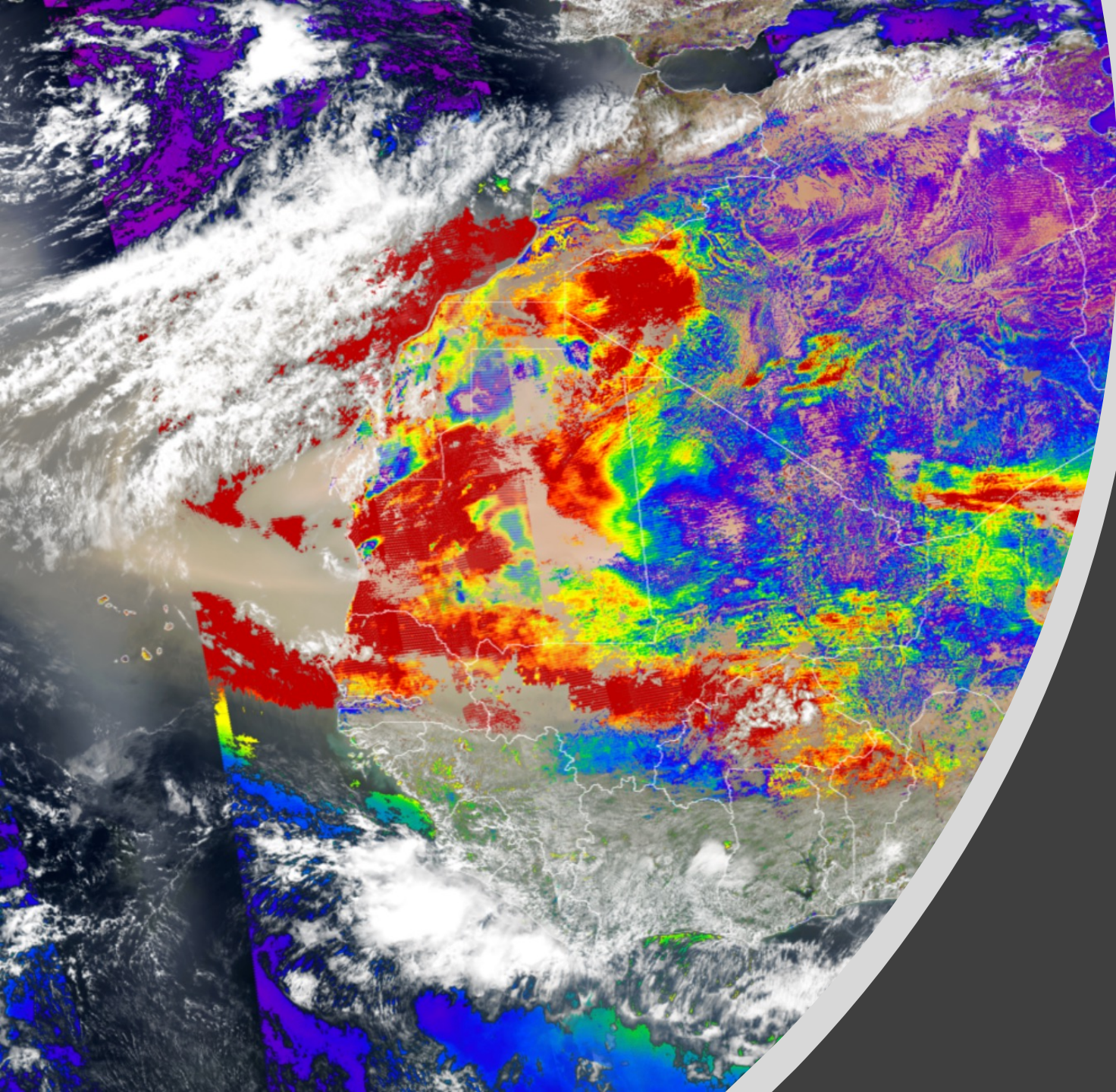
“Late afternoon”



MSG Seviri Dust RGB composite product

- Based on combining measurements from three different *infrared* channels:
 - Red: IR12 – IR10.8
 - Green: IR10.8-IR8.7
 - Blue: IR10.8
- Benefits:
 - Available night and day at 15 min temporal resolution near real time
 - Easy and quick to use in EUMETSAT online services
 - Additional info on cirrus clouds or dry/humid air masses
- Limitations:
 - Dust RGB doesn't indicate the concentration or height of the dust plume
 - Color shades can vary, interpretation not always straightforward
 - Thin or low level dust over ocean difficult to detect
 - For more detailed analysis with dust RGB recommended to use other satellite products
- Interpretation (roughly):
 - **Pink/violet** : Dust
 - **Orange/brown**: thick high/mid-level clouds
 - **Black/ dark green**: thin cirrus

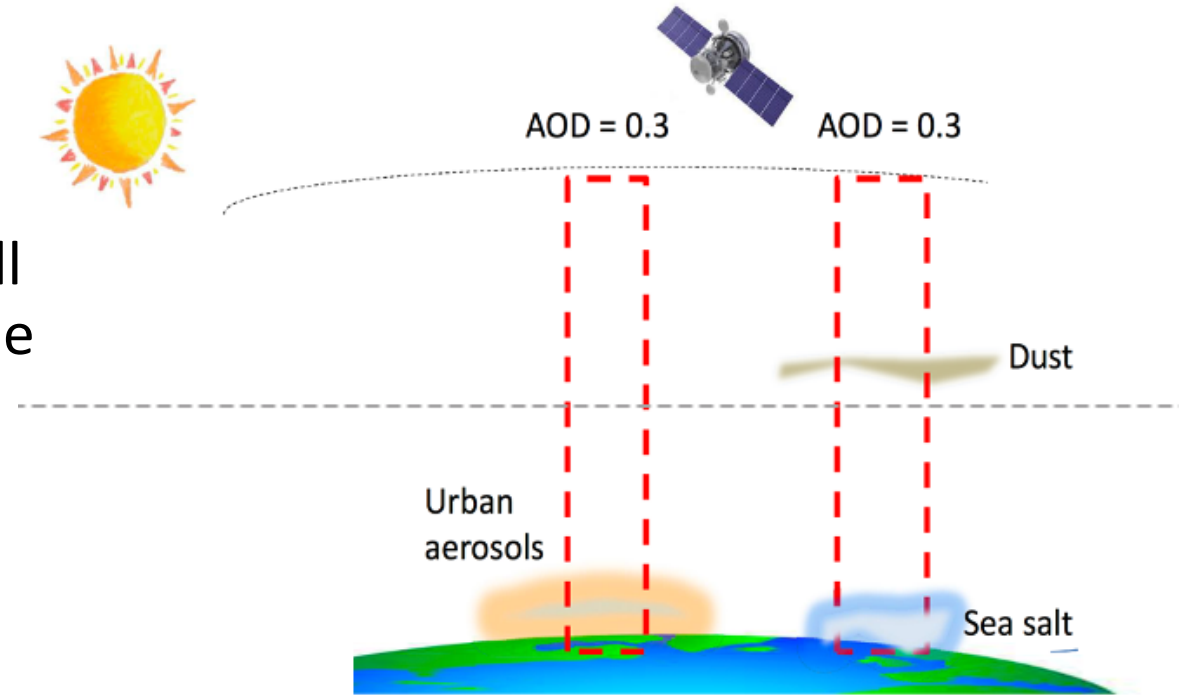




Aerosol Optical Depth

Aerosol optical depth (AOD)

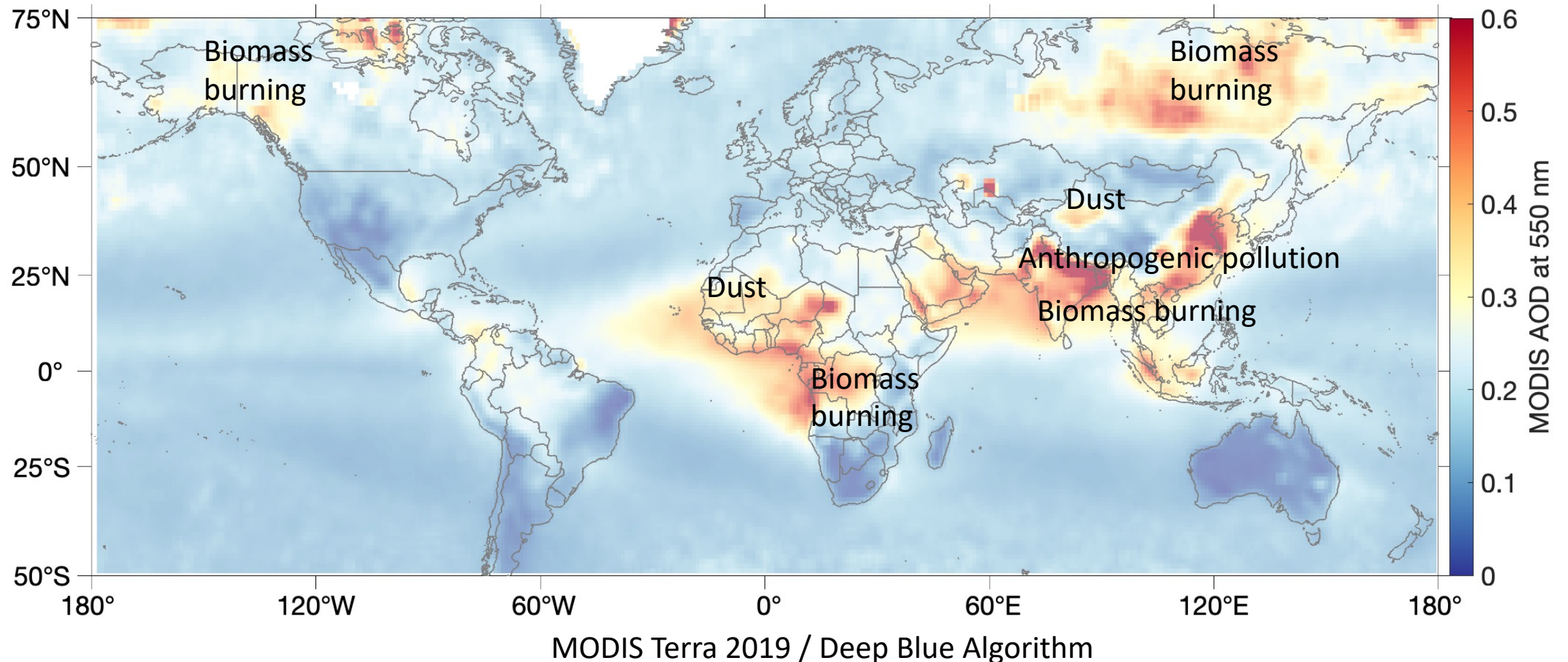
- Also known as aerosol optical thickness (AOT)
- AOD *is related to the amount* of (optically active) aerosols in the total atmospheric column.
 - AOD is the sum of aerosol extinction at all atmospheric levels, from surface up to the top of the atmosphere.
- AOD is **wavelength dependent**, often satellite products provide AOD at 550 nm
 - Typical range of values: 0.05-2.0
- AOD from passive satellite instruments doesn't indicate what is the vertical distribution of aerosols
- “same” AOD can be obtained for very different cases



$$AOD = \int_{surf}^{TOA} \beta_e(s) ds$$

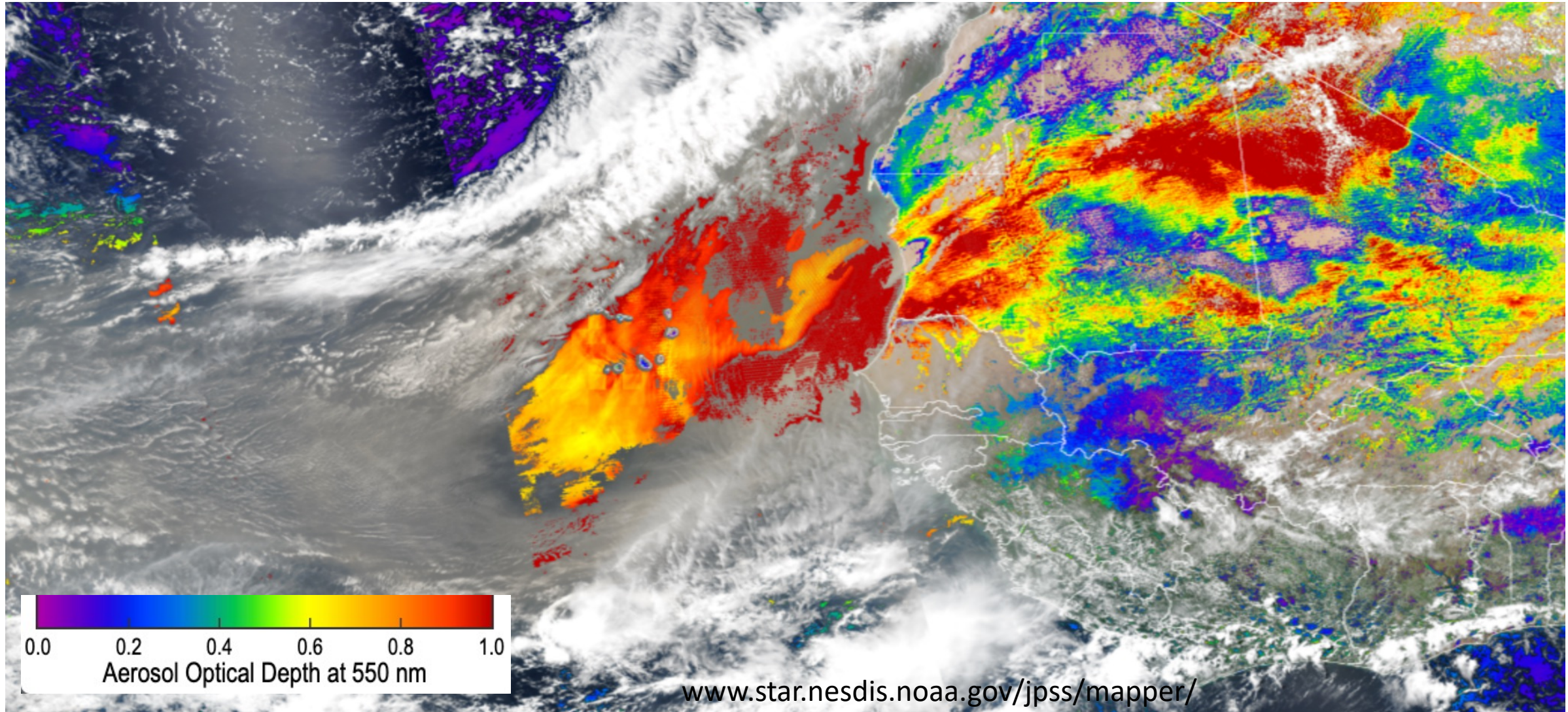
Satellite AOD is available from several instruments (and wavelengths), e.g.:

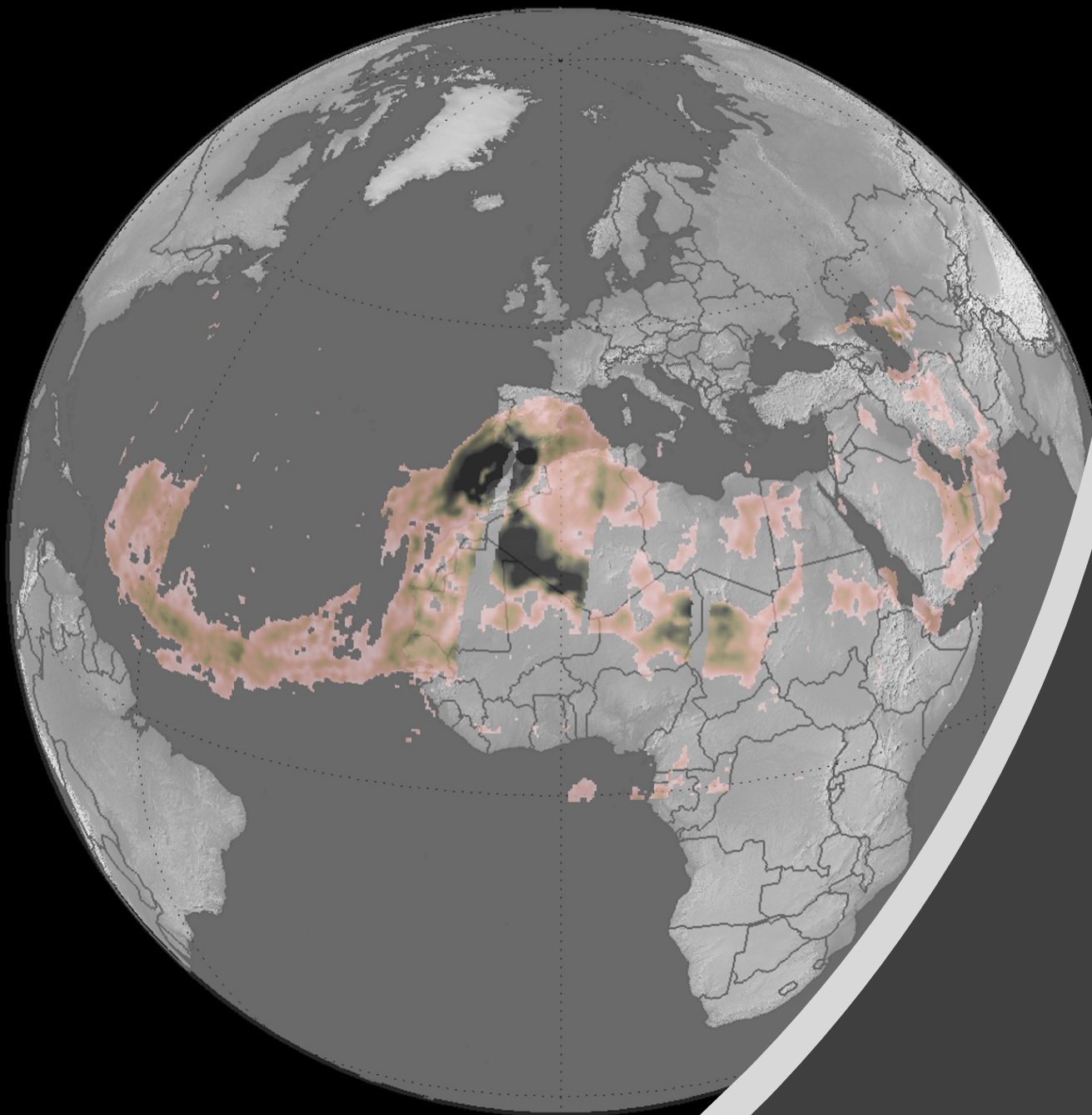
- OLCI, SLSTR (Sentinel 3), AATSR (Envisat, until 2012)
- E.g. MODIS (Aqua, Terra), MISR (Terra), VIIRS (Suomi NPP, NOAA 20), SeaWiFS,
- Multi-instrument products such as PMAp (combining information from GOME-2, AVHRR, IASI)



AOD at 550 from VIIRS instrument 7.6.2021

- AOD is not retrieved for cloudy pixels
 - thickest parts of dust plumes can be interpreted as clouds -> AOD is not provided
- AOD is not provided at sunglint

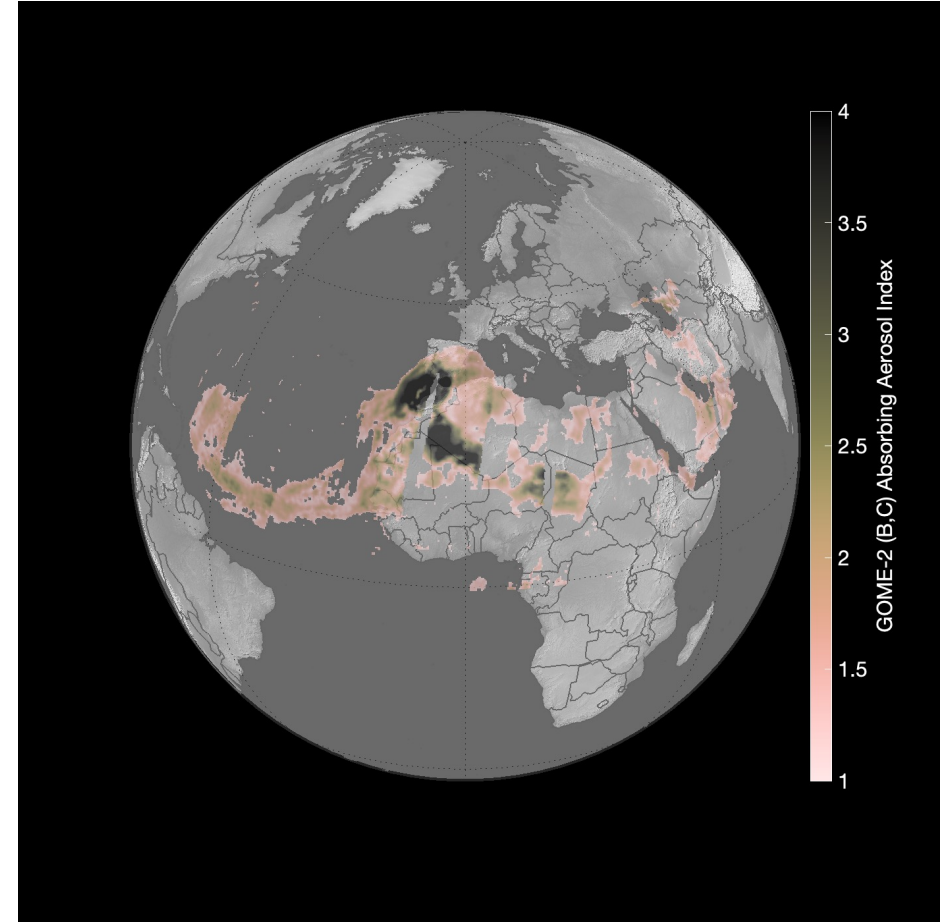




Absorbing Aerosol Index

Absorbing Aerosol Index (AAI)

- AAI, also referred as UVAI or AI is an **index** that indicates the presence of absorbing aerosols (**dust**, smoke, volcanic ash)
- AAI separates the spectral contrast at two **UV wavelengths** caused by aerosol extinction from that of other effects (e.g. molec. scattering)
- Can be obtained also for cloudy scenes, where aerosols are on top of clouds.



➡ **AAI is a good tracer for dust, smoke and ash plumes**

Interpreting AAI (1)

KNMI / ACSAF / EUMETSAT

MetOp-B/GOME-2 / O3MNAR

Data start: 20190601000257

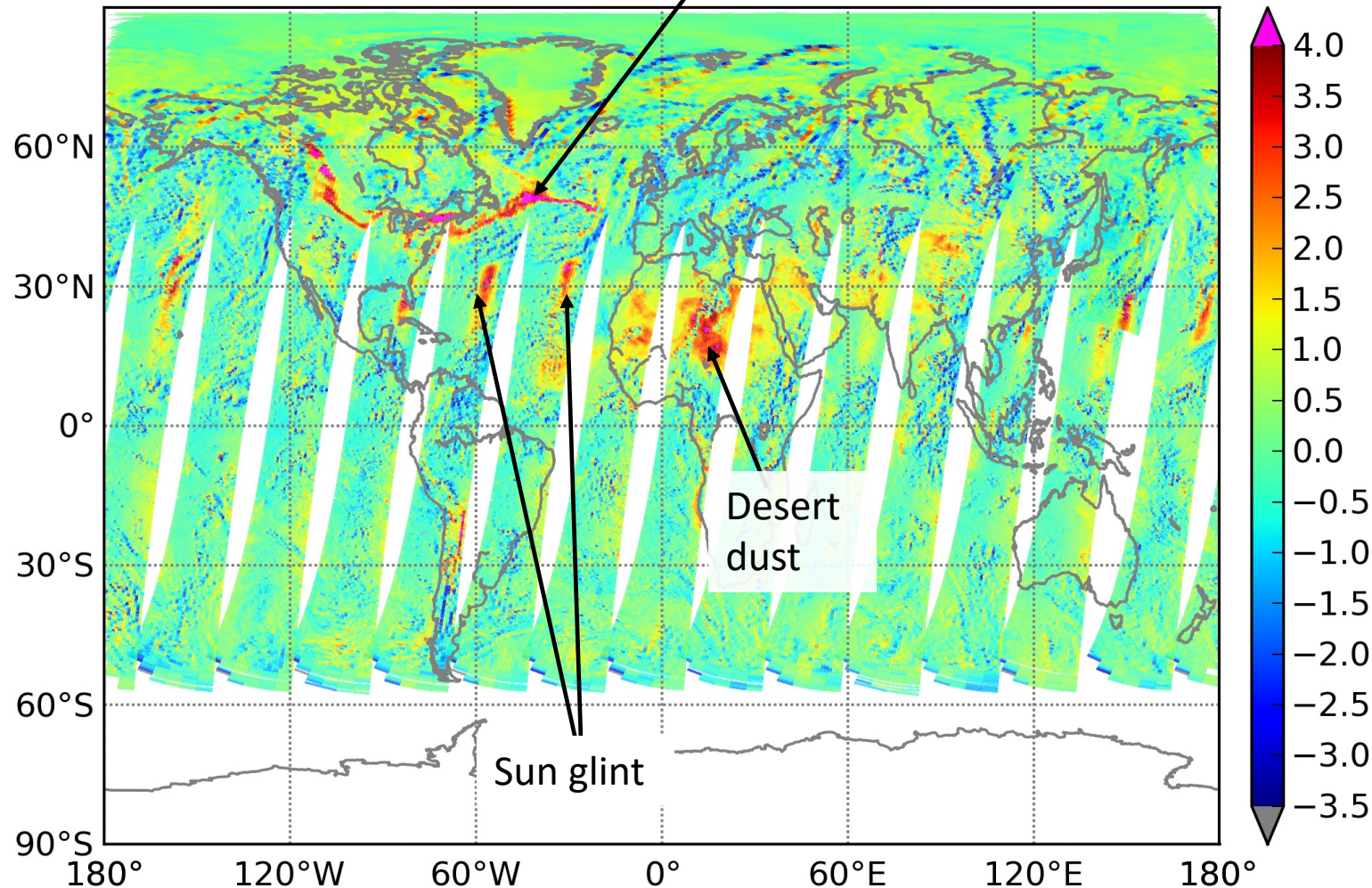
Data end: 20190602000256

Smoke plume from Canadian forest fires

01 June 2019
AAI
Global

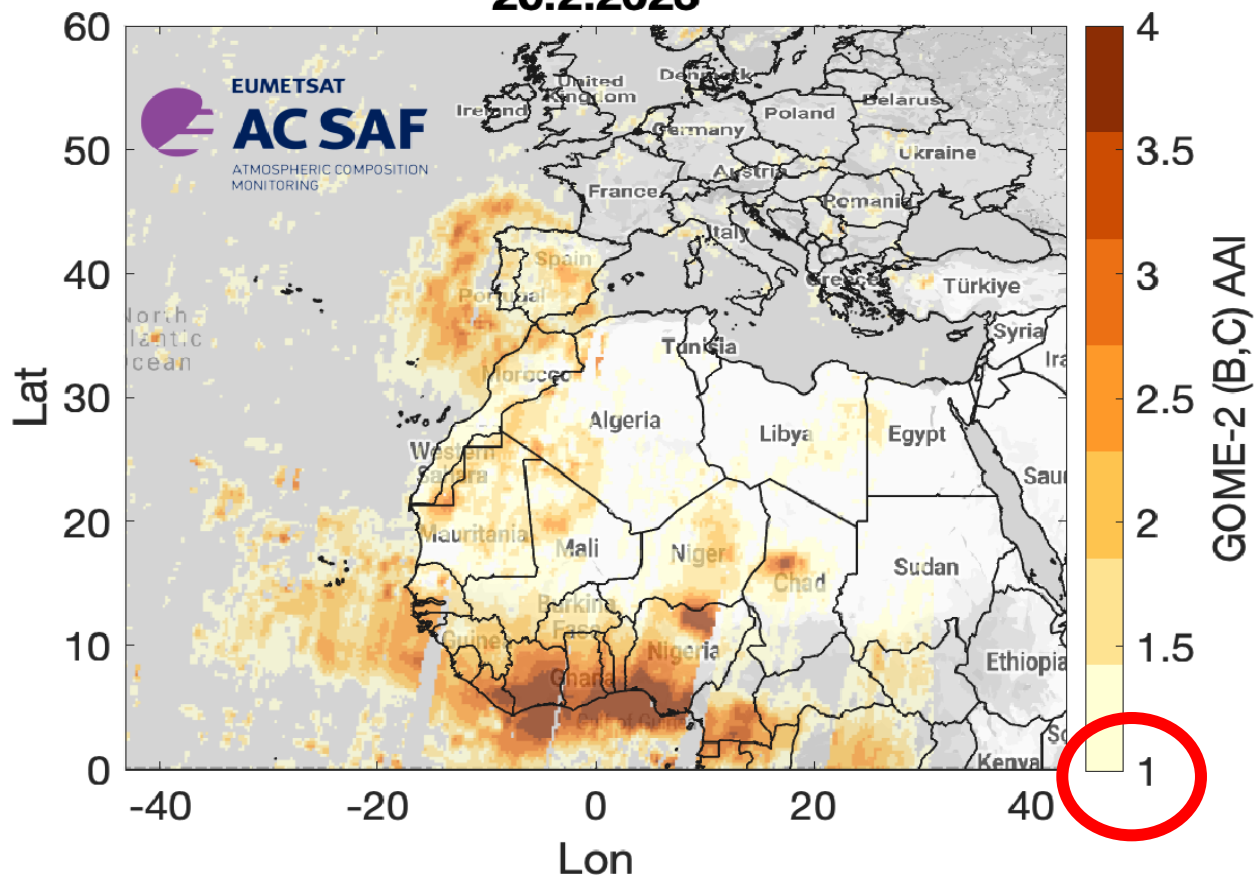
Plot filter:
[AAI_VAAC]
Scat Angle > 90
Sunglint visible

Plot created: 2019-06-02 06:46 UTC

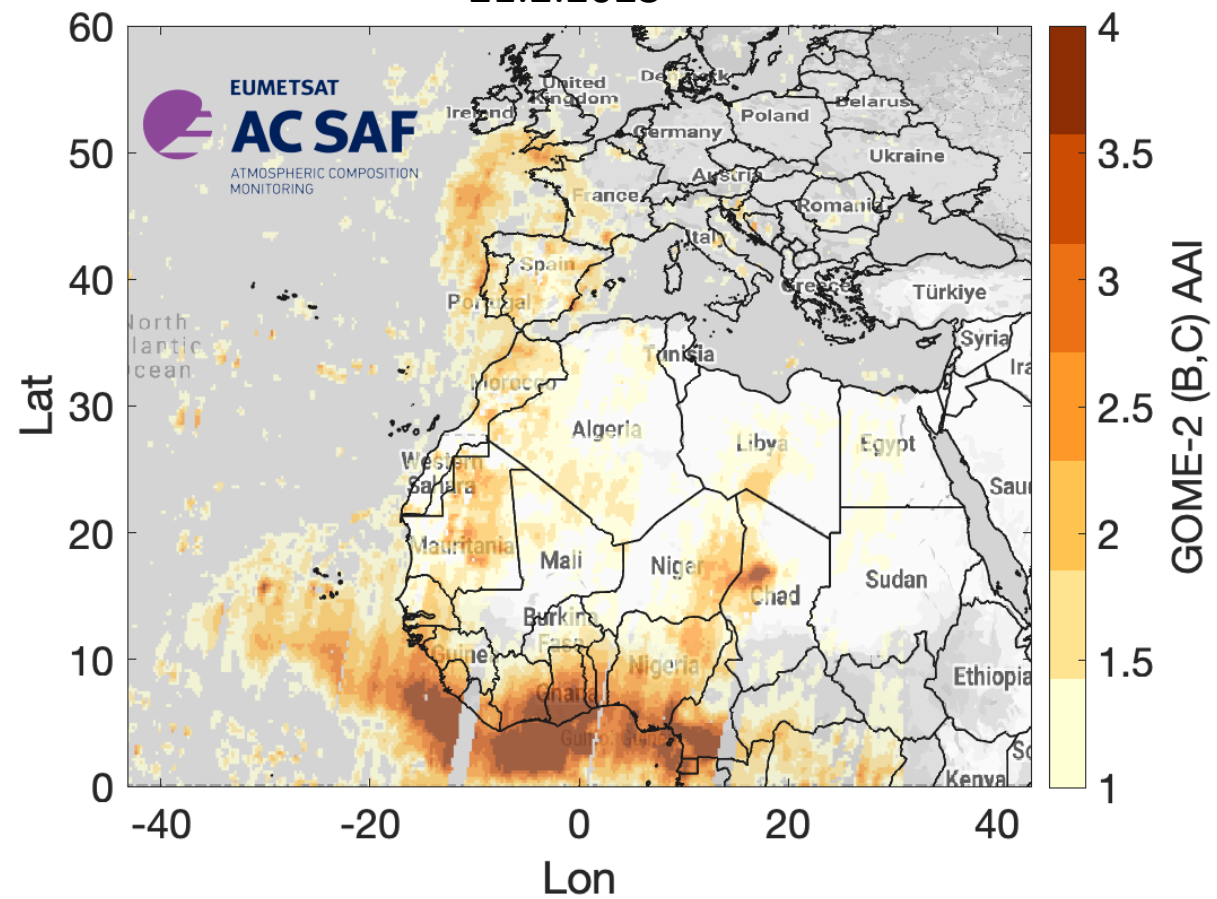


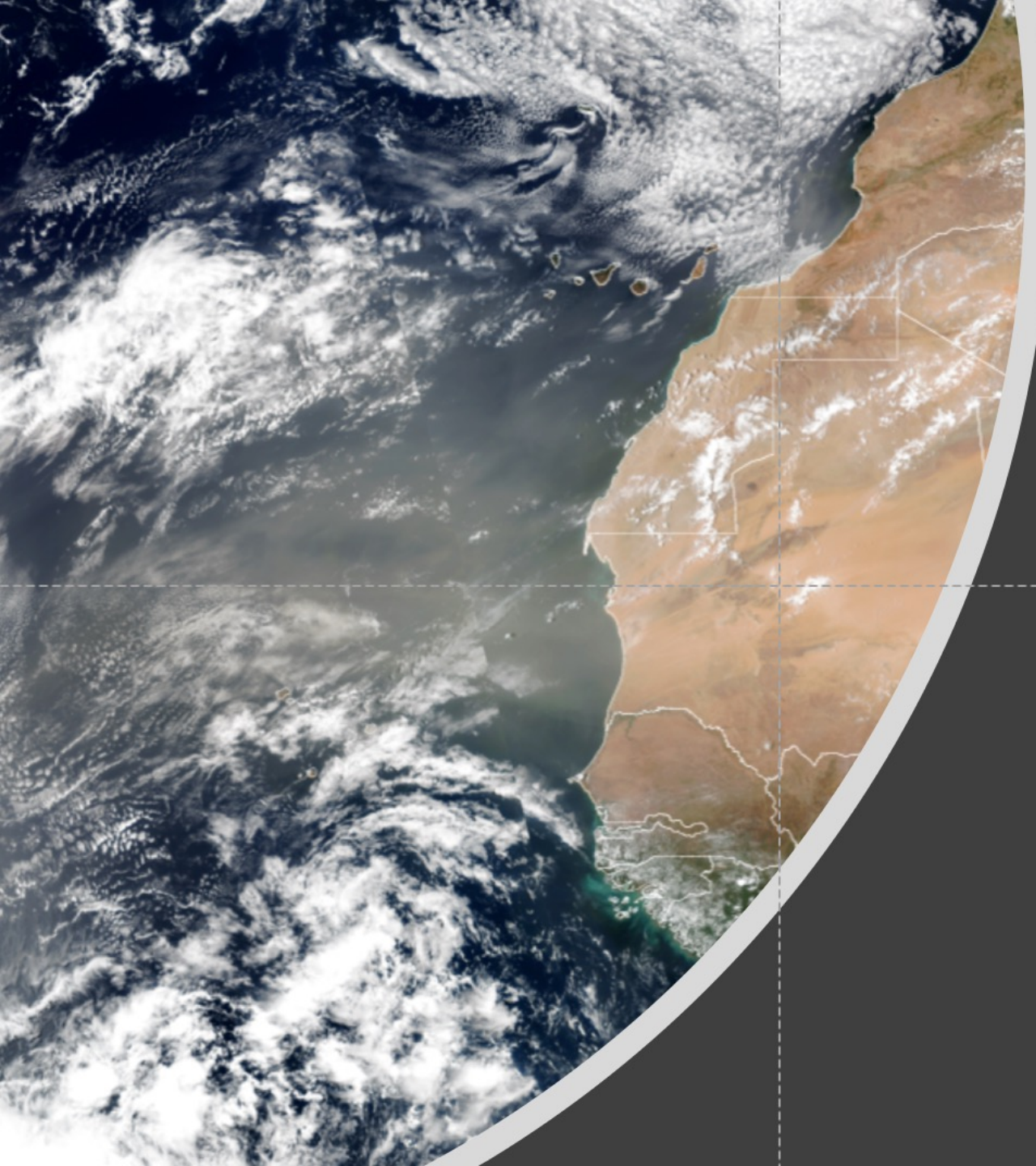
- **Positive AAI values indicate presence of absorbing aerosols**
 - For clouds (or scattering aerosols) AAI is close to zero or negative
 - Sun glint over ocean causes positive values but that is artifact and should be filtered out from the data.
- For absorbing aerosol plumes typically $AAI > 1.0$
 - Background slightly positive
- AAI is a function of many parameters and cannot be used as direct measure of aerosol amount.

20.2.2023



21.2.2023





Take home messages

- Passive satellite observations provide various parameters for monitoring dust events
- True color RGB and RGB composite images are available at several web-based services in near real time
 - Easy to use but interpretation not always straightforward
- Aerosol optical depth provides an estimate on aerosol loading of all aerosol types
- Absorbing Aerosol Index indicates the presence of absorbing aerosols (elevated plumes), including dust
- More comprehensive view on dust episodes can be obtained by combining observations from multiple sources (RGB, AOD, AAI)!