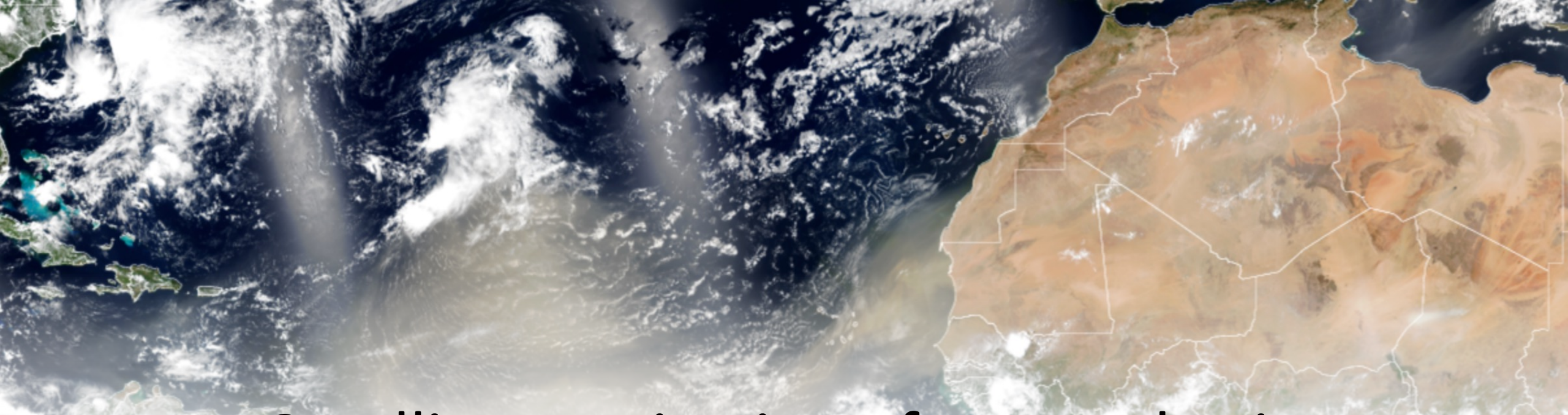

# Satellite monitoring of atmospheric composition and air quality

Anu-Maija Sundström, Elli Suhonen, Seppo Hassinen
Earth and Space Observation Centre, Finnish Meteorological Institute

Contact: anu-maija.sundstrom@fmi.fi

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Contact Team

Overview Product info Validation & QA Data access Documents Links

# EUMETSAT Satellite Application Facility on Atmospheric Composition Monitoring – AC SAF

- **Develop algorithms** and methods to retrieve atmospheric composition data from polar orbiting Metop- A, -B, and –C satellites.
- Carry out the **validation** for the AC SAF products
- **Disseminate** the data
- Training on atmospheric composition and air quality

Leading entity

FMI

Co-operating entities

DLR KNMI LATMOS KMI DMI

Sub-entities

ULB s[&]t

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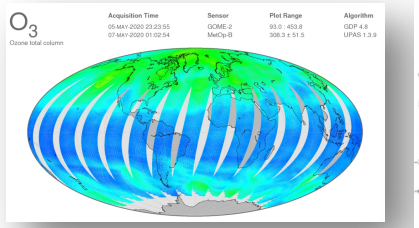
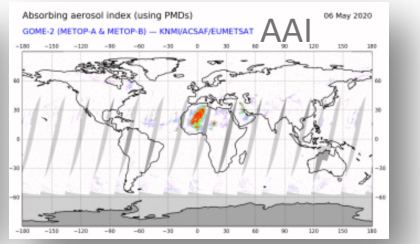
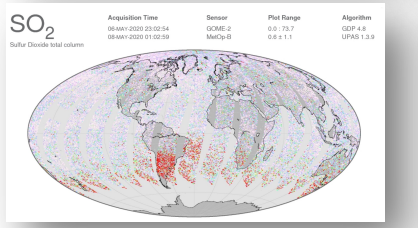
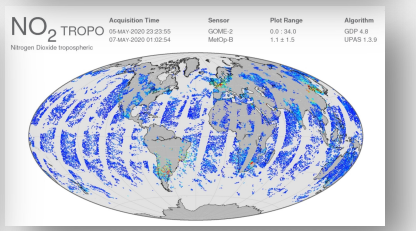
# An overview of the AC SAF products (Metop A/B/C)

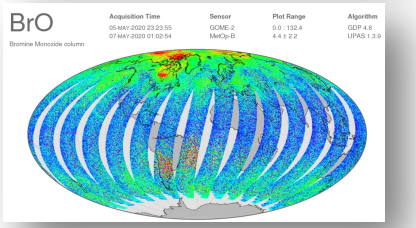
## GOME-2

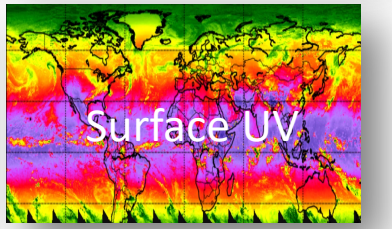


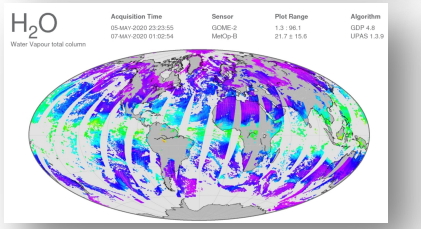



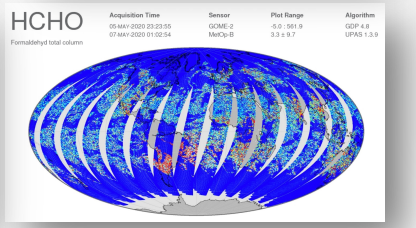



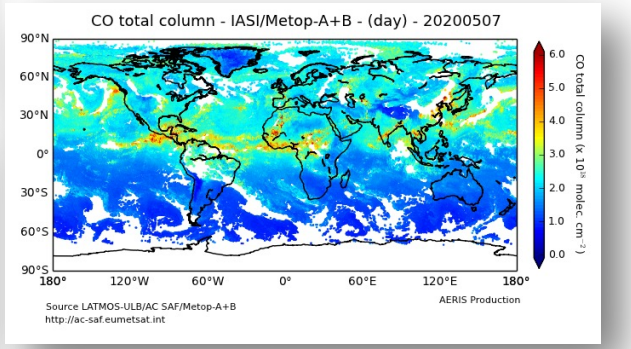



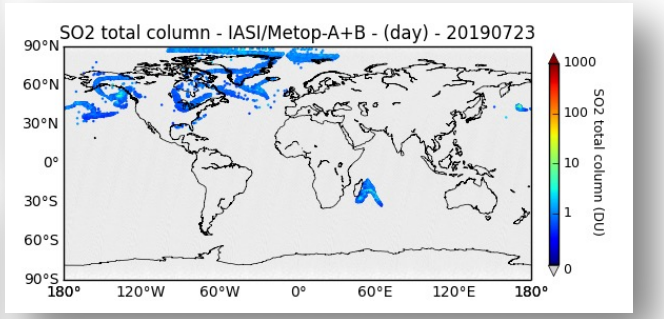




## IASI

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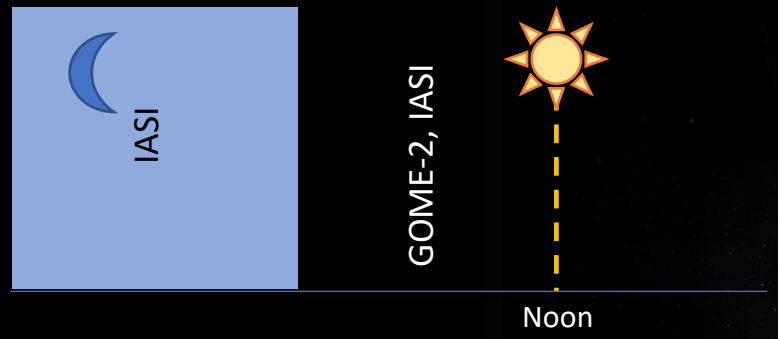
- Reactive gases, $H_2O$
- Aerosols
- Surface UV radiation

# AC SAF satellite instruments

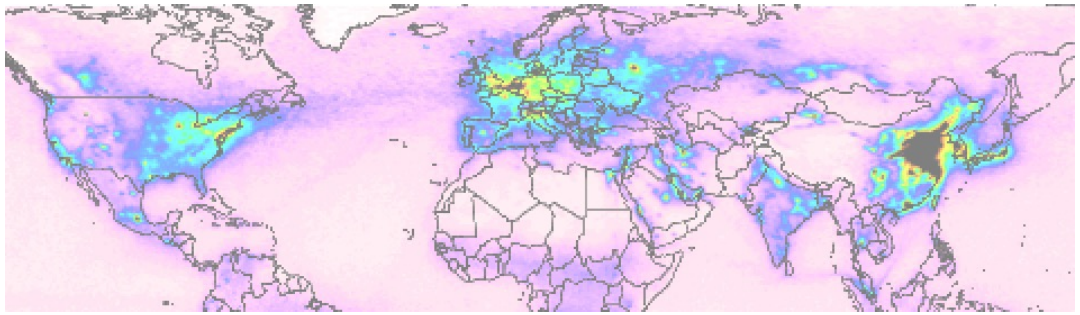
- EUMETSAT METOP A (2006->2021), B (2012->) and C (2018->)
  - Instruments:
    - GOME-2 (UV-VIS)
    - IASI (Thermal IR)
- Polar orbit, overpass time about 9:30 local time.



- AC SAF observations of reactive gases and aerosols are relevant for montoring atmospheric composition and assessing air quality.

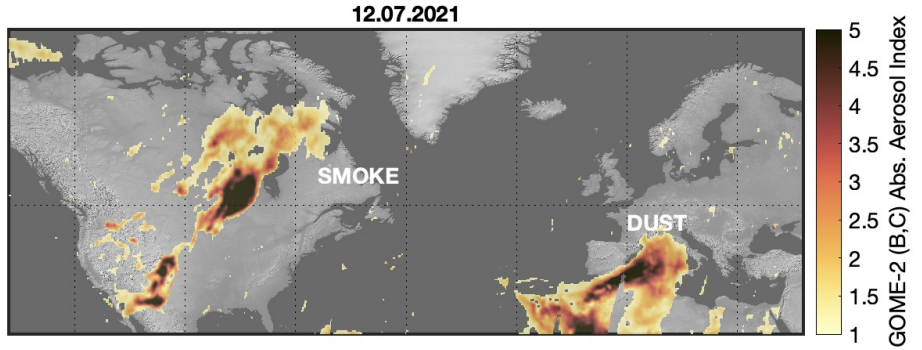
## Nitrogen dioxide $NO_2$

- E.g. traffic & fuel combustion, industrial emissions, forest fires



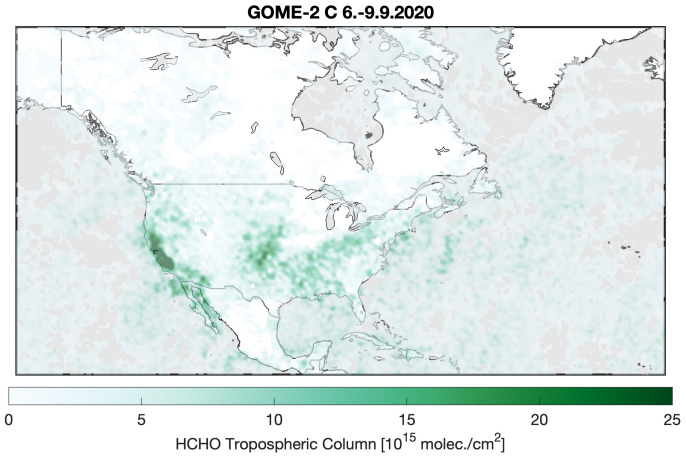
## Absorbing Aerosols

- Forest fires, dust storms, volcanic ash



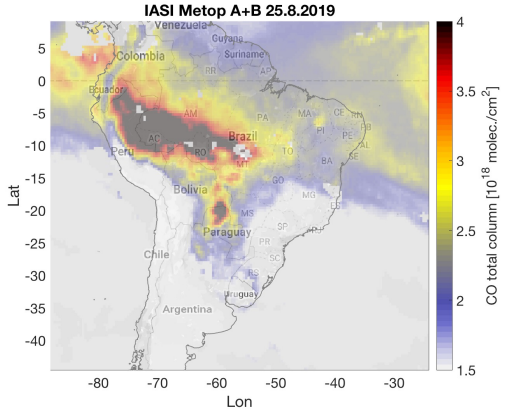

## Formaldehyde HCHO

- E.g. forest fires, industrial emissions, fuel combustion.



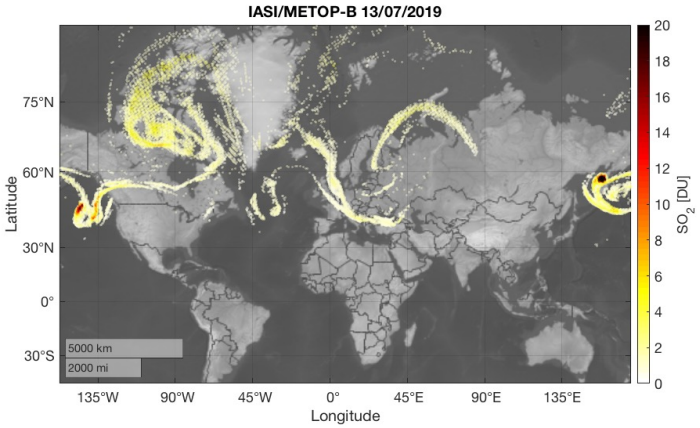

## Carbon monoxide CO

- Traffic, industry, forest fires, fuel combustion




## Sulphur dioxide $SO_2$

- Volcanoes, fossil fuel combustion, industrial emissions



- Information on strong and sudden air quality episodes are important, as they can have significant effect on the environment and society (e.g. aviation)

- Sudden events can be e.g.:
  - Wildfires (CO, smoke aerosols)
  - Volcanic eruptions ($SO_2$, ash aerosols)
  - Dust storms (dust aerosols)

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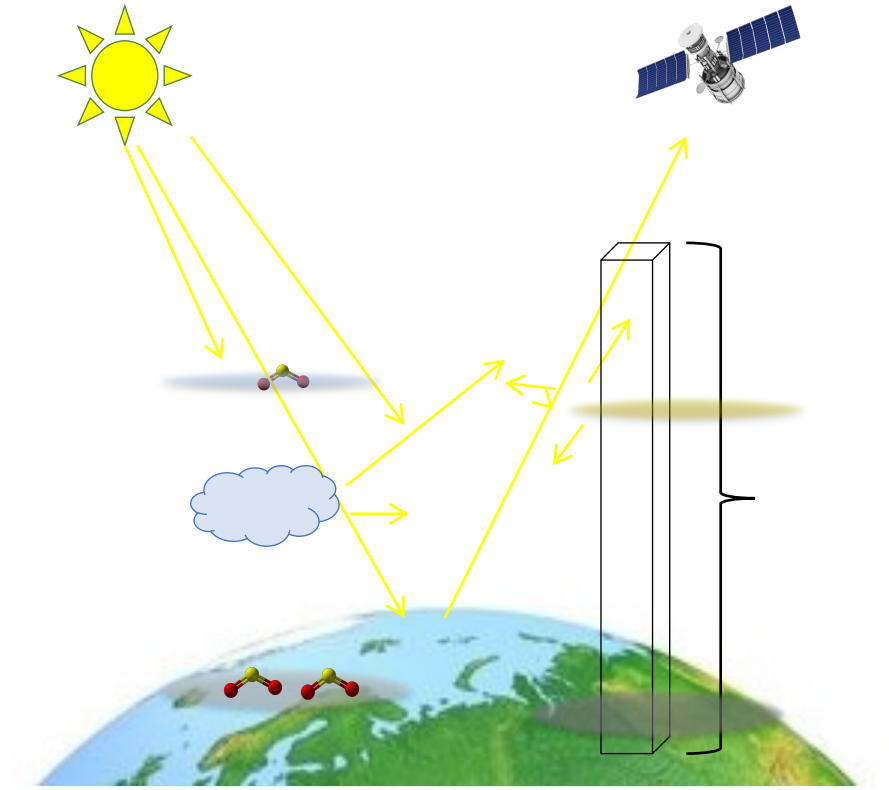

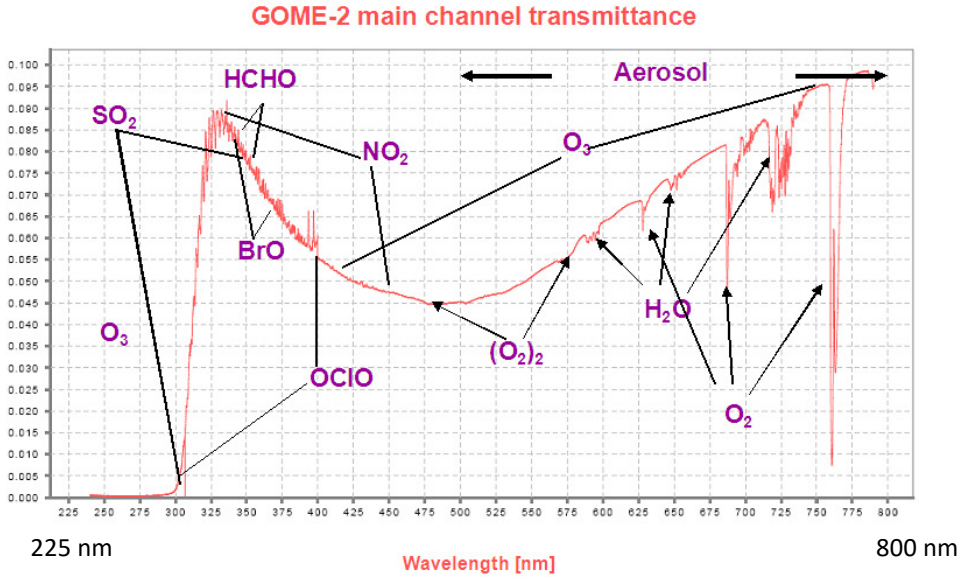


- Satellites provide amount of specific gas in total column / tropospheric column
- Satellite observation ≠ surface concentration
- Even though satellites have limited sensitivity close to surface concentrations, to a high degree satellites tell “the same story” as surface measurements.
- Observations can be limited by cloudiness and or polar winter (UV-VIS)
- Wind information is often very useful when analysing the data

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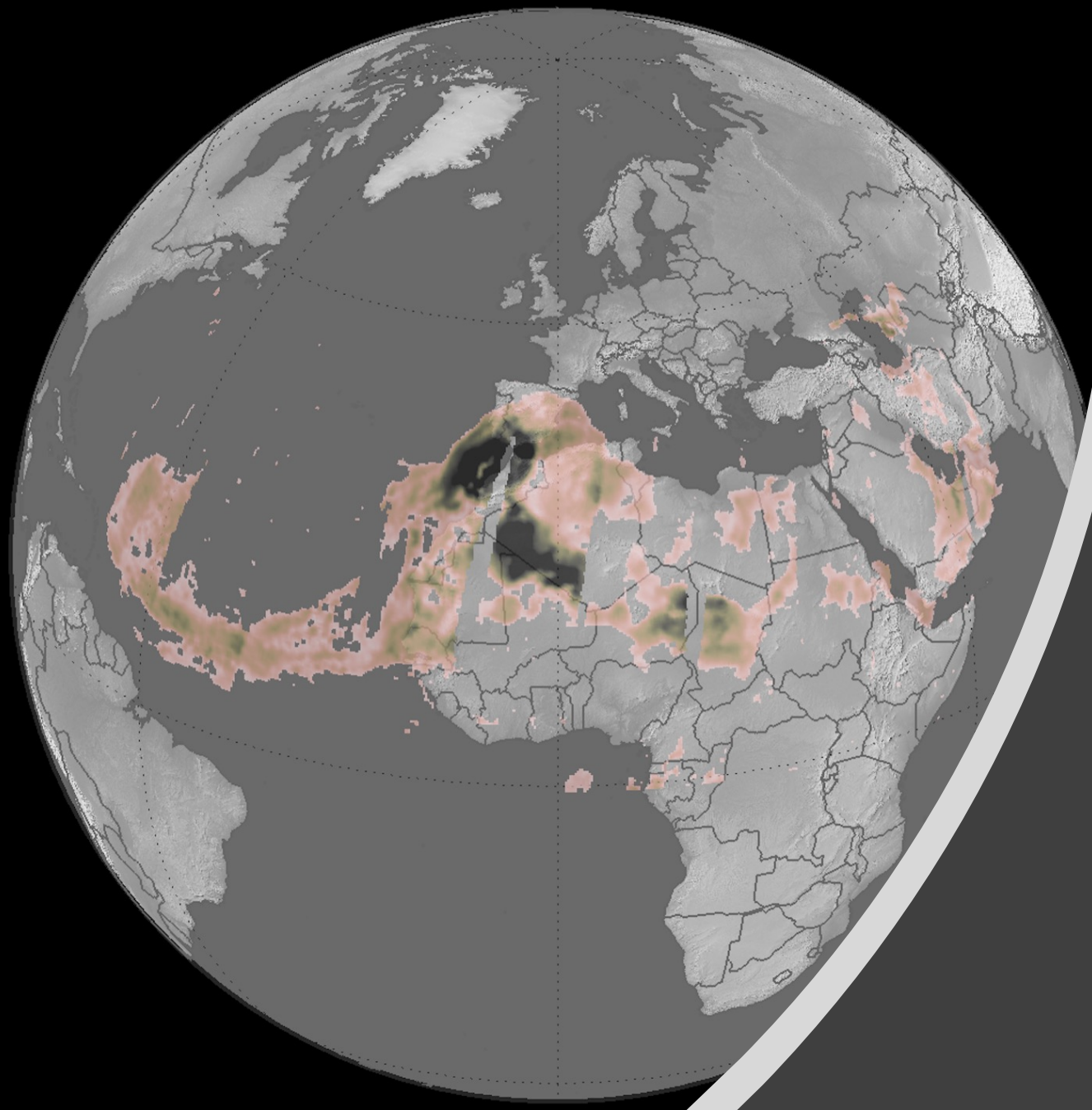

# Monitoring of sudden air quality episodes

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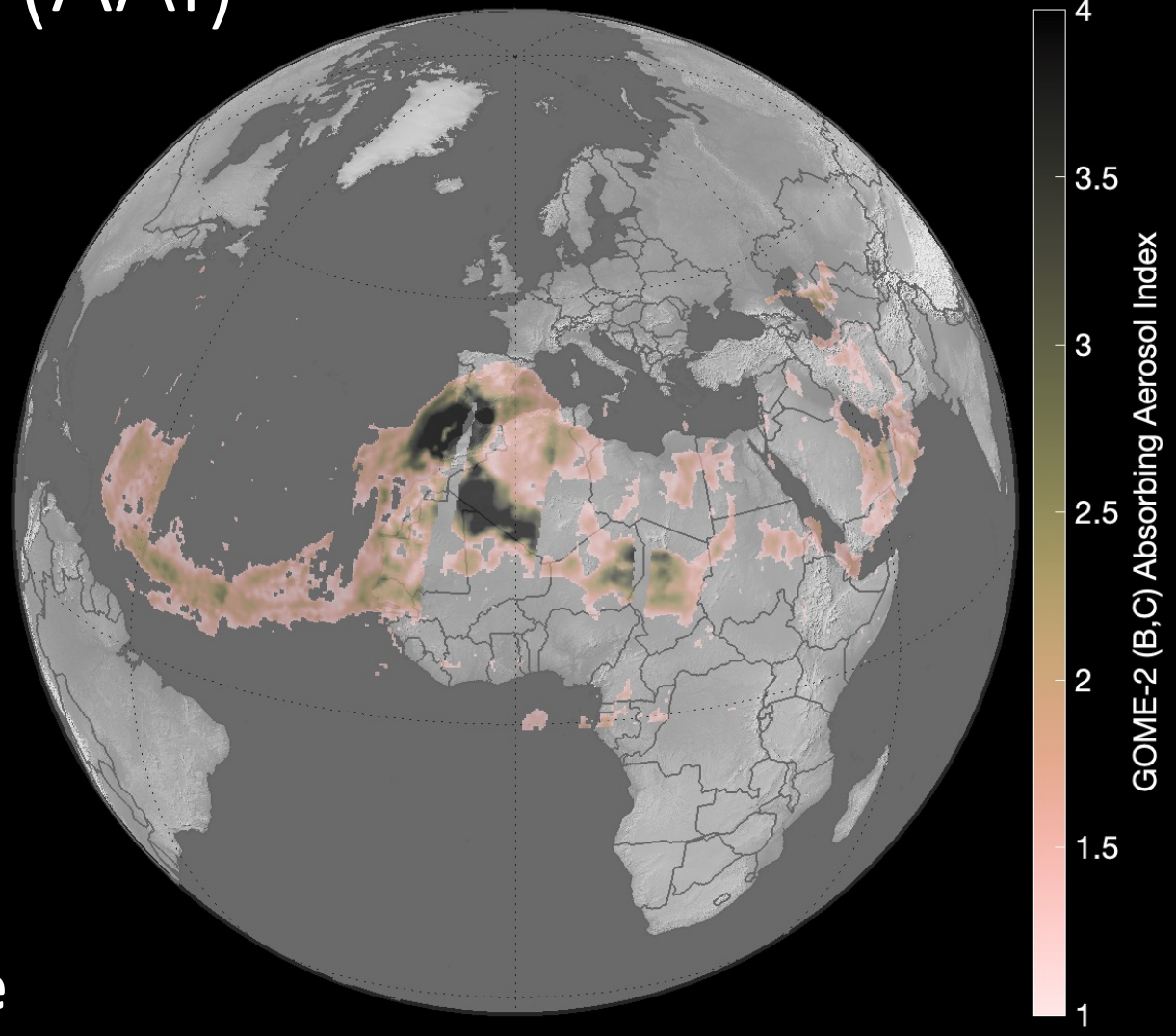
# Absorbing Aerosol Index (AAI)

- Also known as UV Aerosol Index (UVAI)
- Defined using UV-wavelengths (typically 340 – 380 nm)
- Sensitive to **absorbing** aerosols: smoke, volcanic ash, desert dust
- Elevated positive AAI (>1) indicates presence of smoke, ash or dust
- Can be obtained also for cloudy scenes, when aerosols are on top of clouds.

**AAI is a good tracer for long range transport of dust, smoke and volcanic ash**

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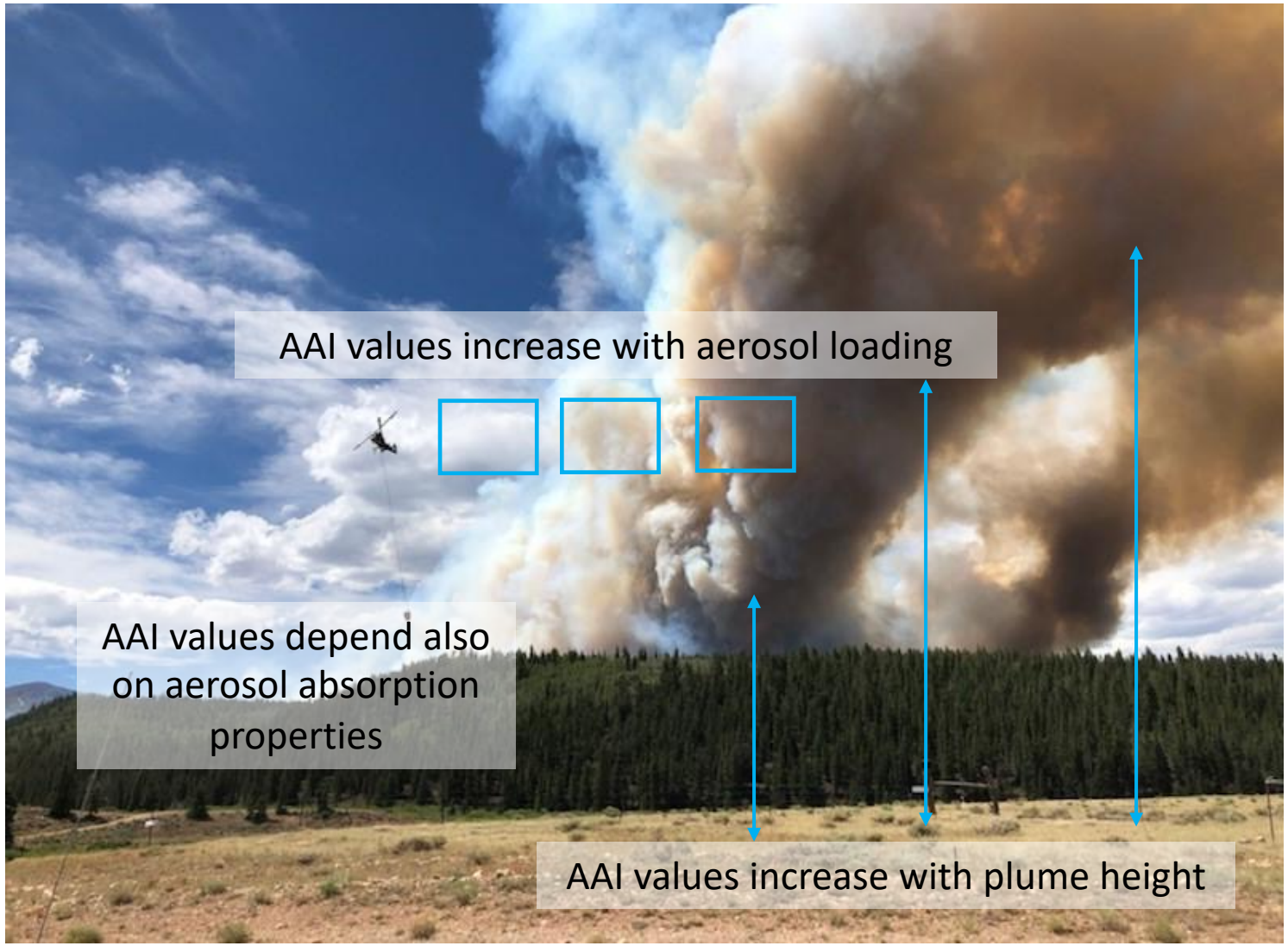
# Interpreting AAI




https://en.wikipedia.org/wiki/File:Weston_Pass_Fire_smoke_plume.jpg

- AAI values depend on various factors
  - Comparing cases is not straightforward!
- AAI is not a ”direct” measure of aerosol loading
  - I.e. larger AAI does not necessarily mean more aerosols!
- With AAI you typically ”see” an elevated plume
  - For assessing air quality at the surface, additional information (model, in situ) is recommended.
- Information on prevailing winds can help analyzing the plume extent (both horizontal and vertical)

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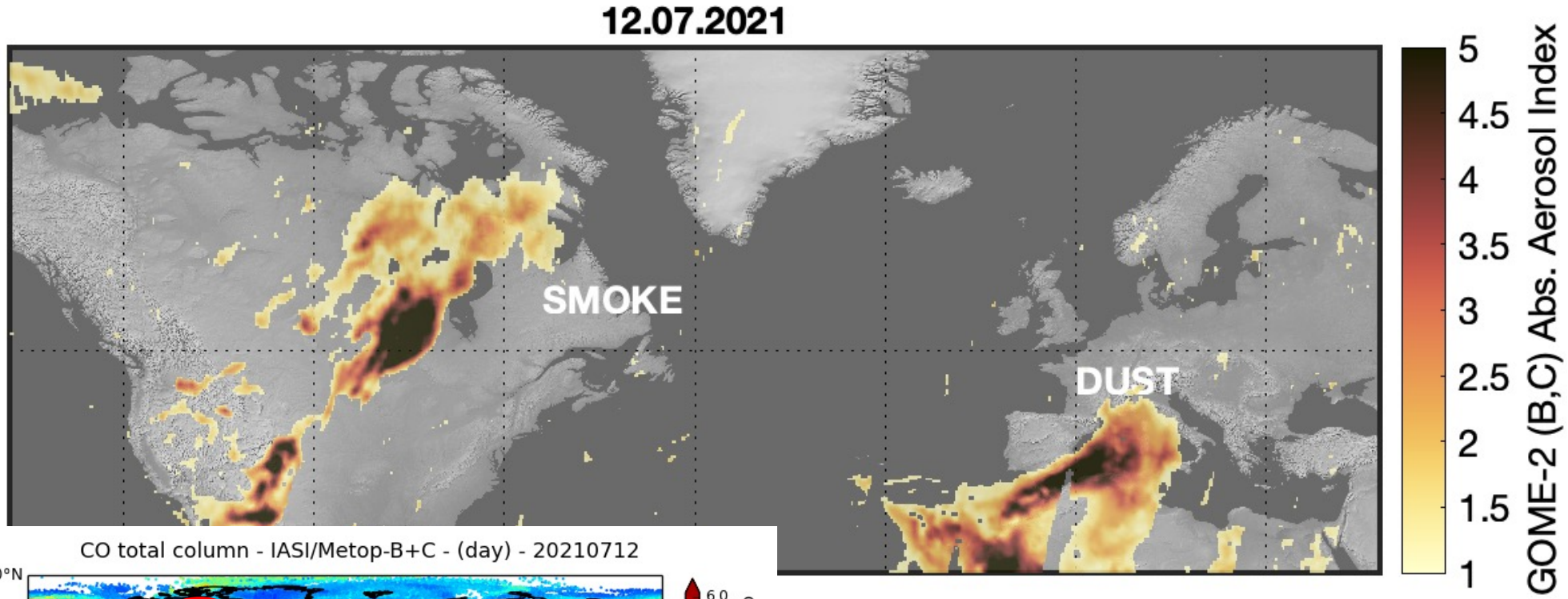
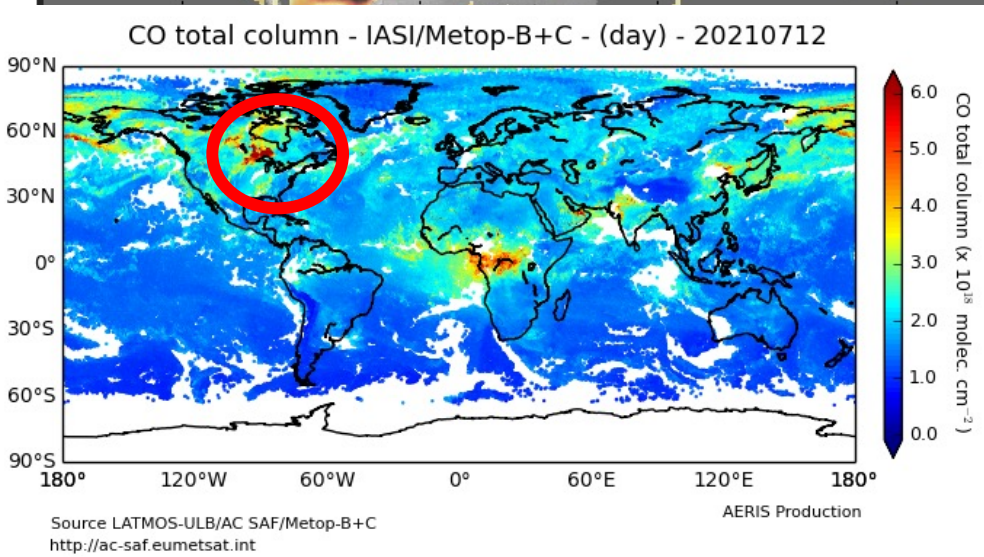
- AAI value itself does not tell about the absorbing aerosol type, other observations and/or analysis of sources/ transport are needed




- Smoke often accompanied with elevated CO concentration
- Volcanic ash often associated with elevated $SO_2$
- Plume over Southern Europe originates from Sahara,

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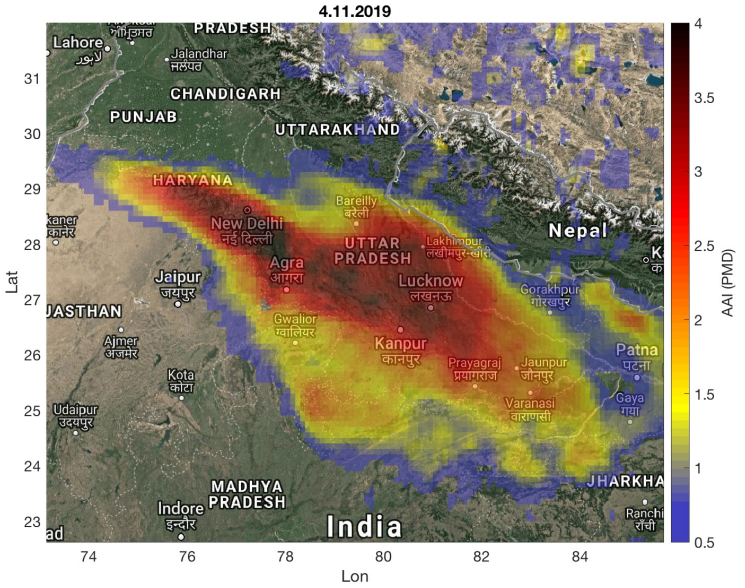
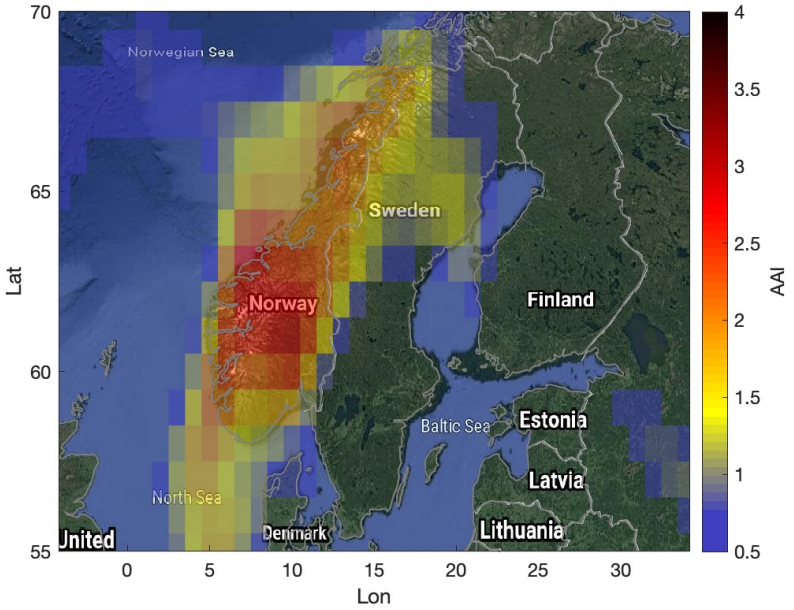
## Smoke pollution build up over Northern India

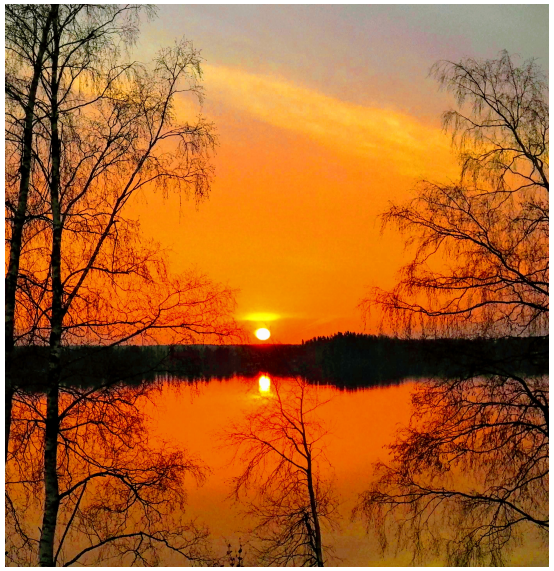
- Clear plume of absorbing aerosols visible in satellite observations
  - Highest AAI values vary between 3-4
- Weak wind conditions, pollution stays close to surface (0-3 km) - > hazardous air quality




## Smoke transport from Canadian fires to Europe

- Elevated values of AAI over Norway show similar values than in India (3-4)
- The signal is related to long range transport of smoke from Canadian forest fires
- Smoke was at about 7-10 km height
- Did not affect air quality at surface



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# Examples of major smoke transport episodes

(AAI from GOME-2 instruments)

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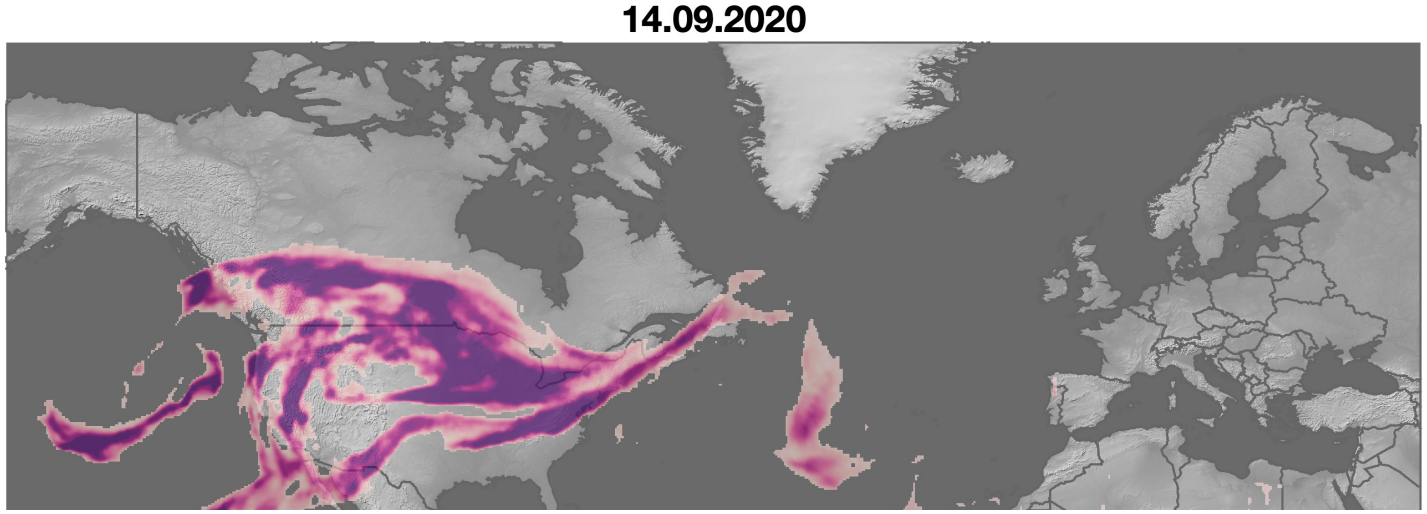
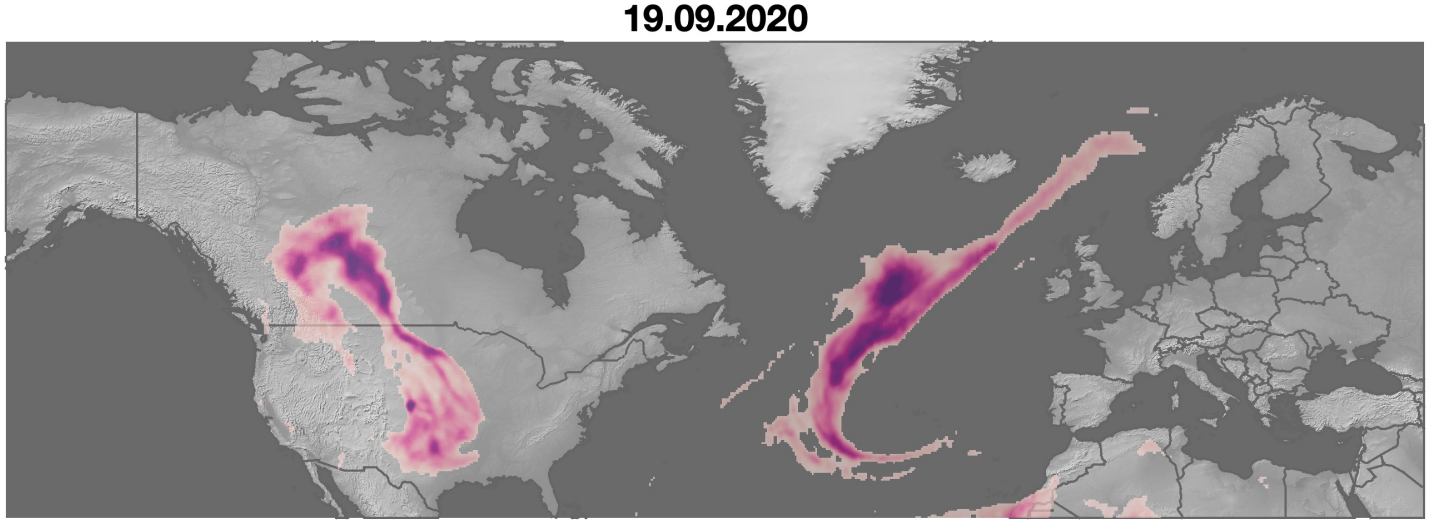
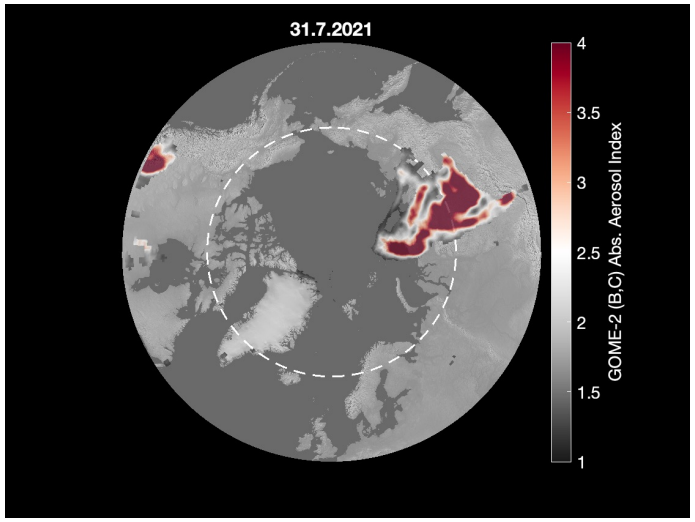
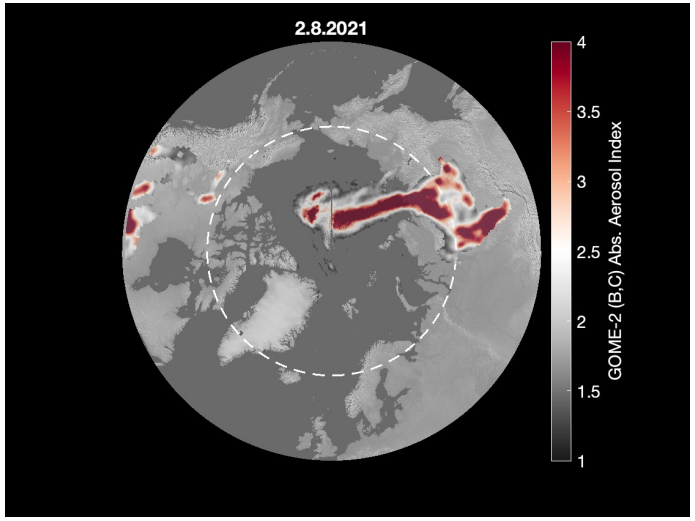
California fires Sept. 2020



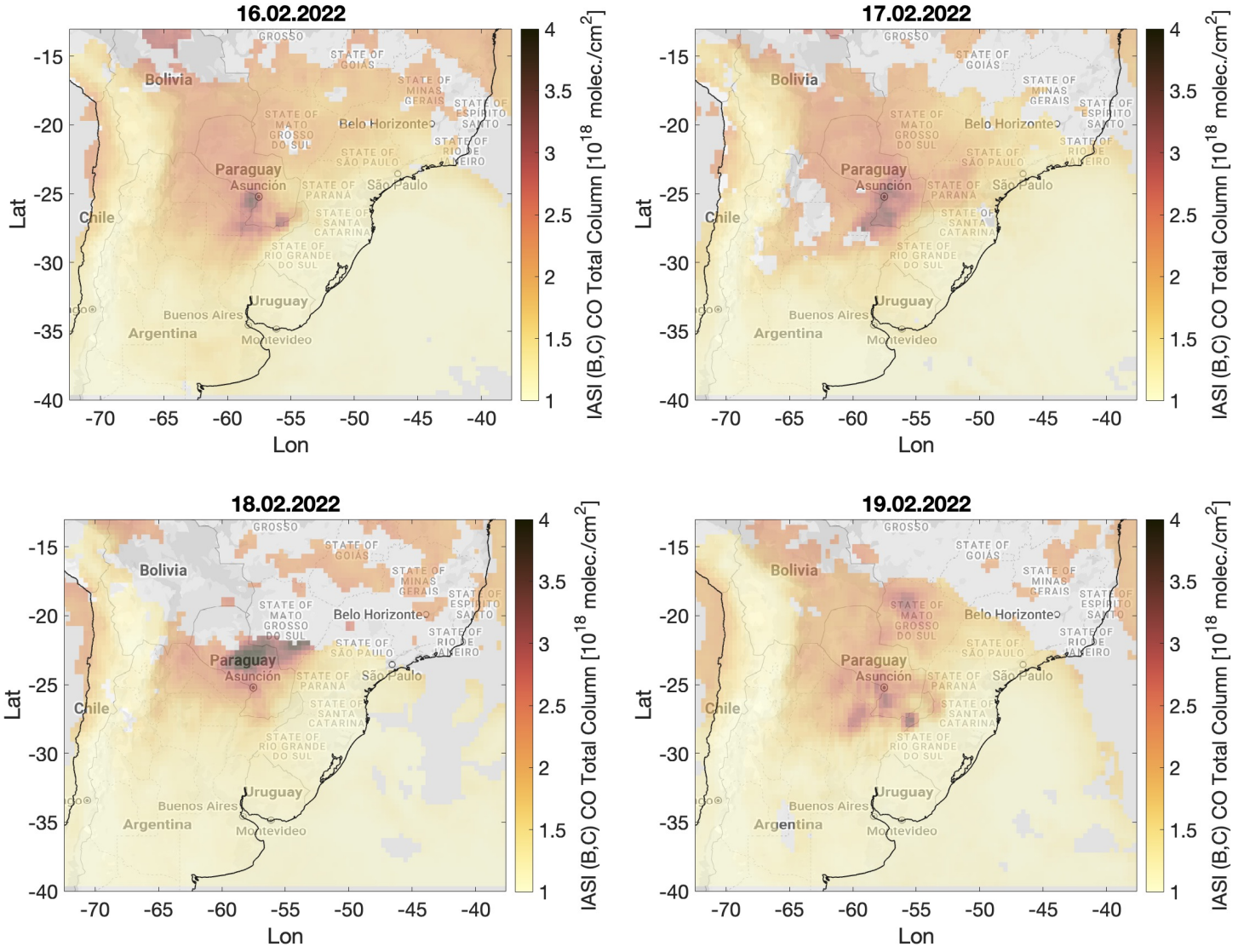

Siberian Fires July 2021



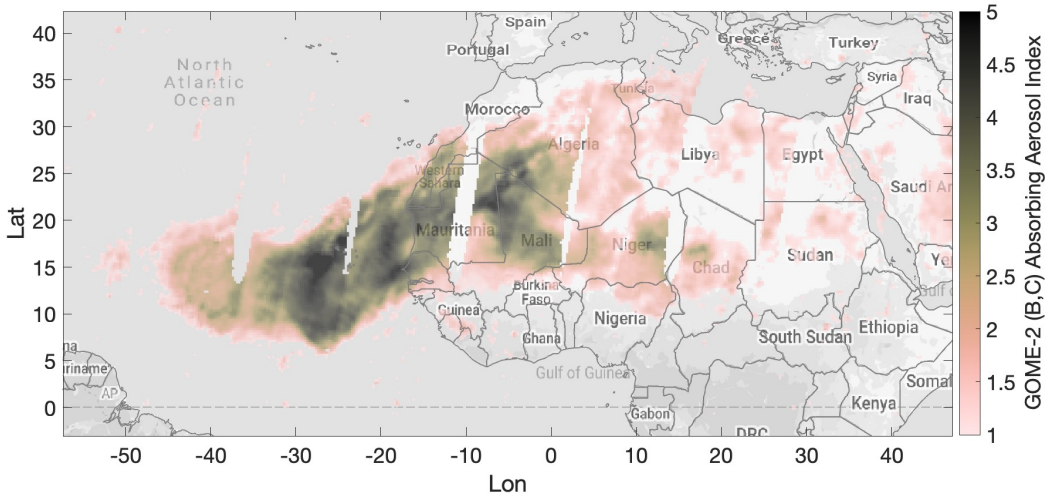
# South America wildfires

- Daily gridded Carbon Monoxide (CO) measurements by IASI instrument onboard Metop-B & C, 16. – 19.02. 2022
- A long-lasting heathwave and drought in South America resulted into widespread wildfires during Jan-Feb 2022
- CO can be transported long distances from the sources because of its relatively long lifetime in the atmosphere

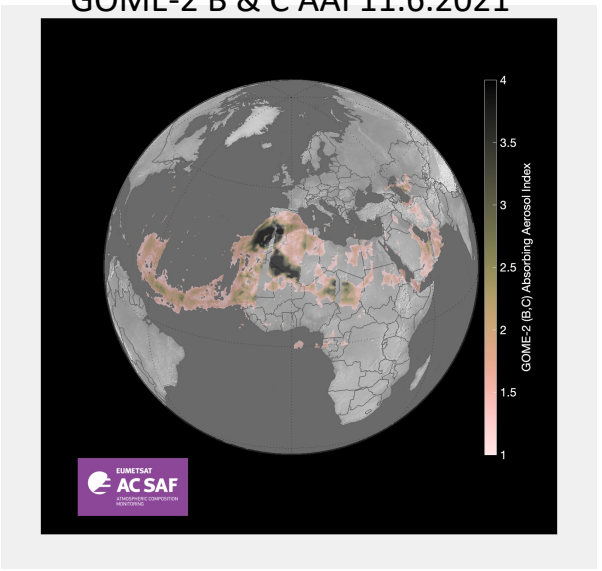


# Examples of dust episodes

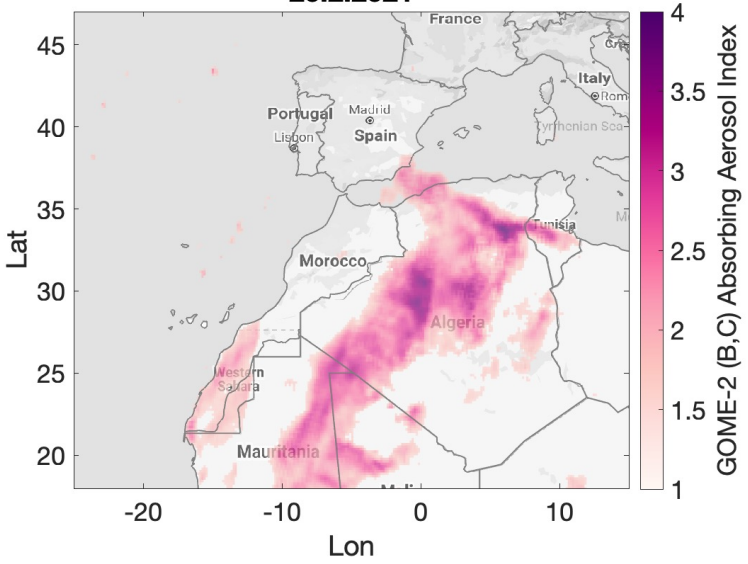
GOME-2 B & C AAI 7.6.2021



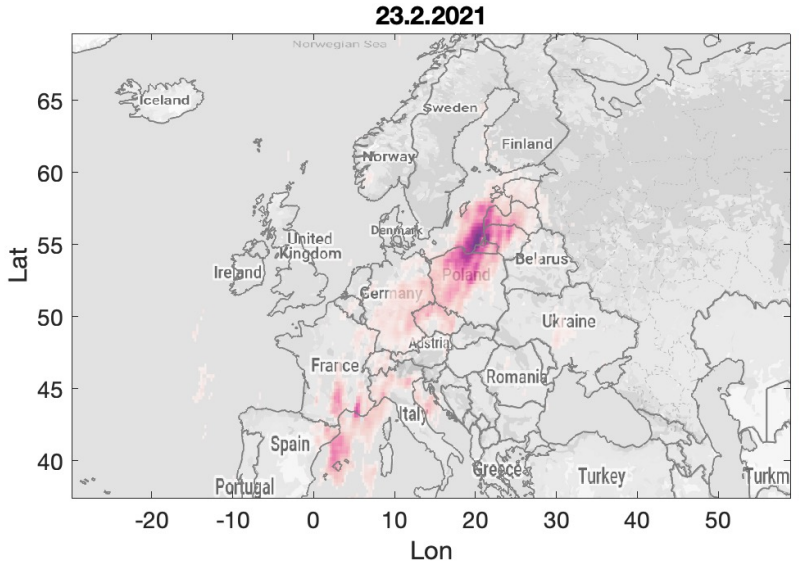

GOME-2 B & C AAI 11.6.2021




**20.2.2021**




**23.2.2021**

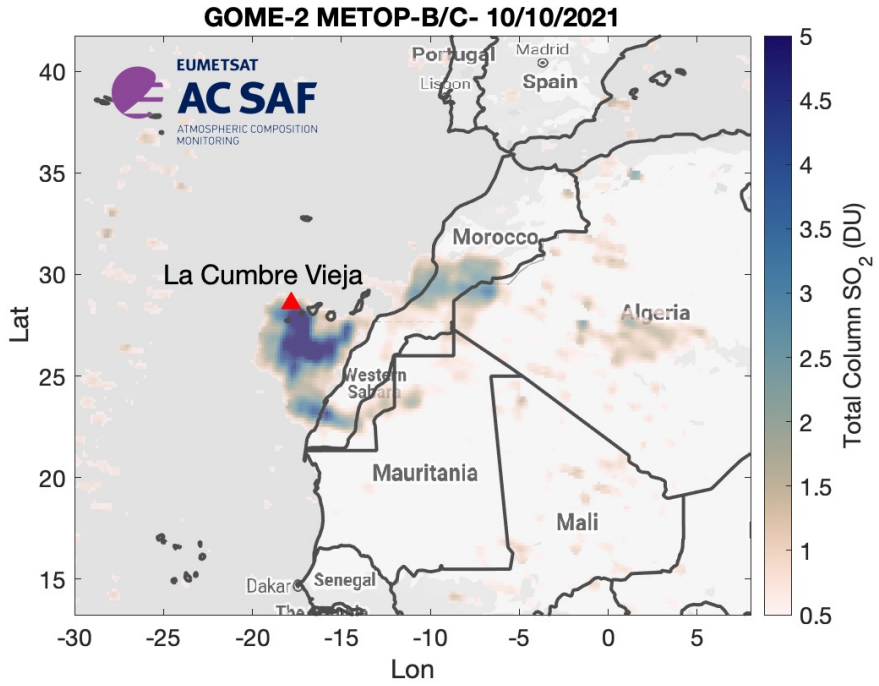



Finland 23.2.2021:
Dust “falling” down, snow colored brown

Yle.fi

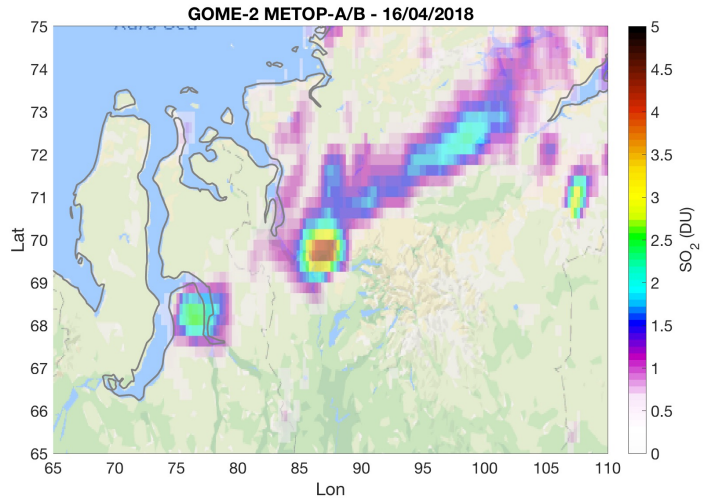
# $SO_2$ total colum concentrations

- In AC SAF $SO_2$ observations are provided by GOME-2 (UV VIS) and IASI (thermal) instruments
- IASI also provides an estimate on $SO_2$ plume height
- These satellite observations are most sensitive to volcanic plumes.
- Some execptionally strong anthropogenic $SO_2$ sources can ocassionally be visible in the observations.
- The lifetime of $SO_2$ molecules in the troposphere is a few days, and in the stratosphere even several weeks




La Cumbre Vieja Volcano

Norilsk smelters

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# Examples of major volcanic eruptions

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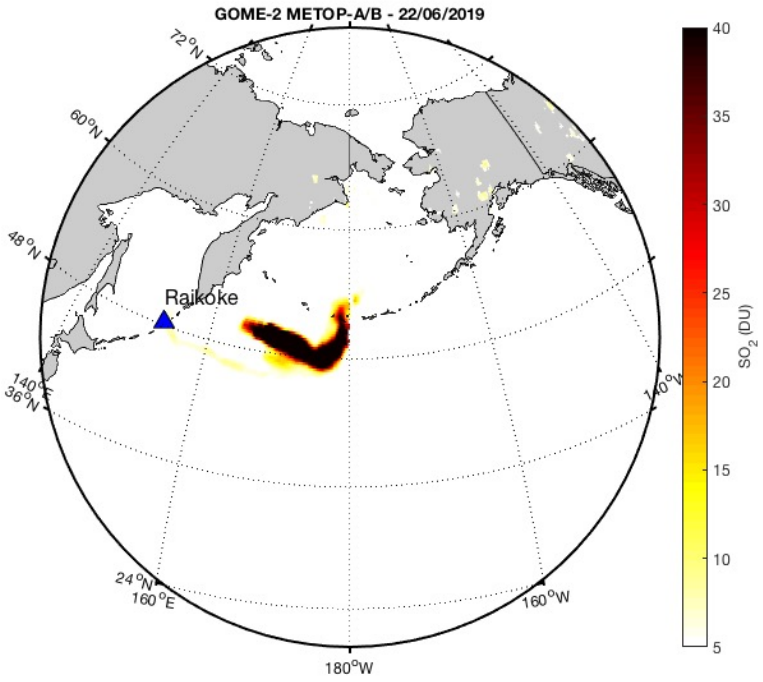
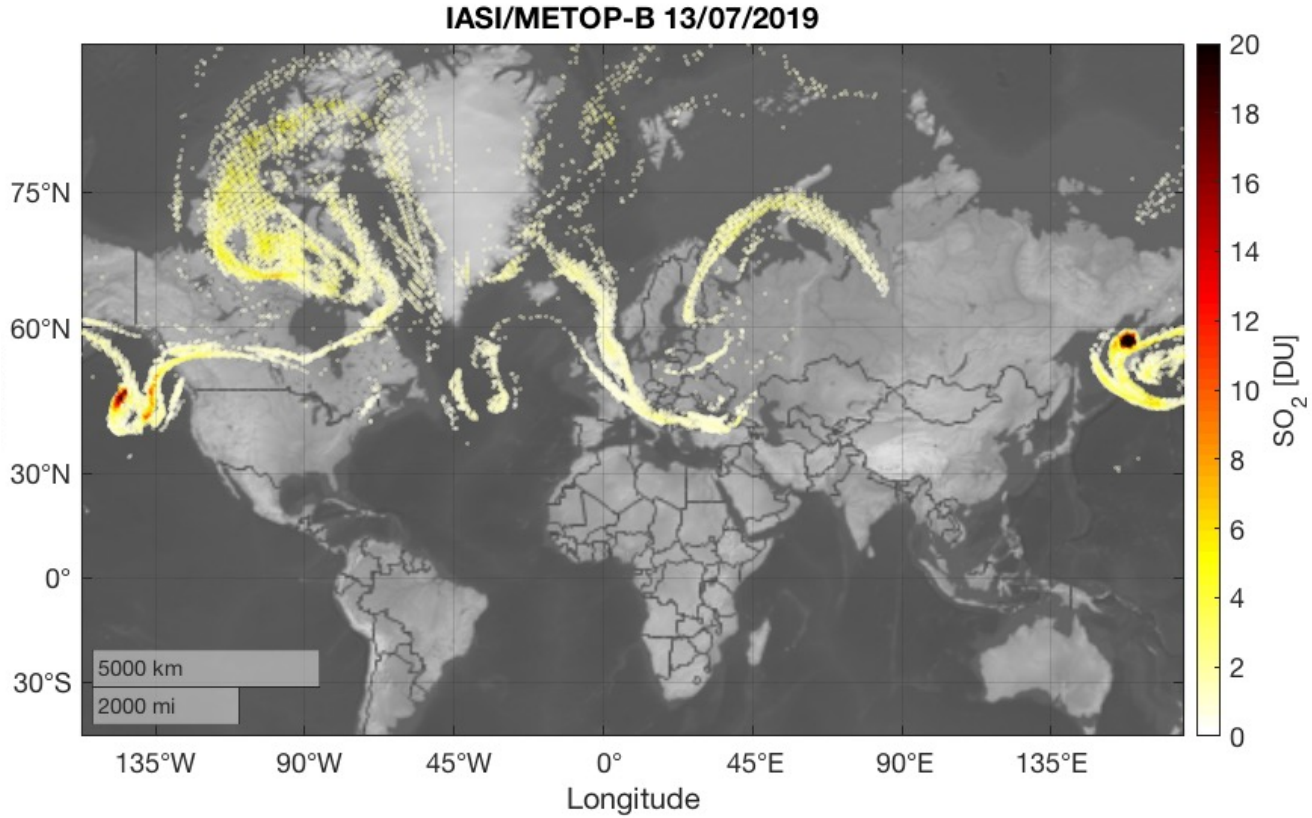
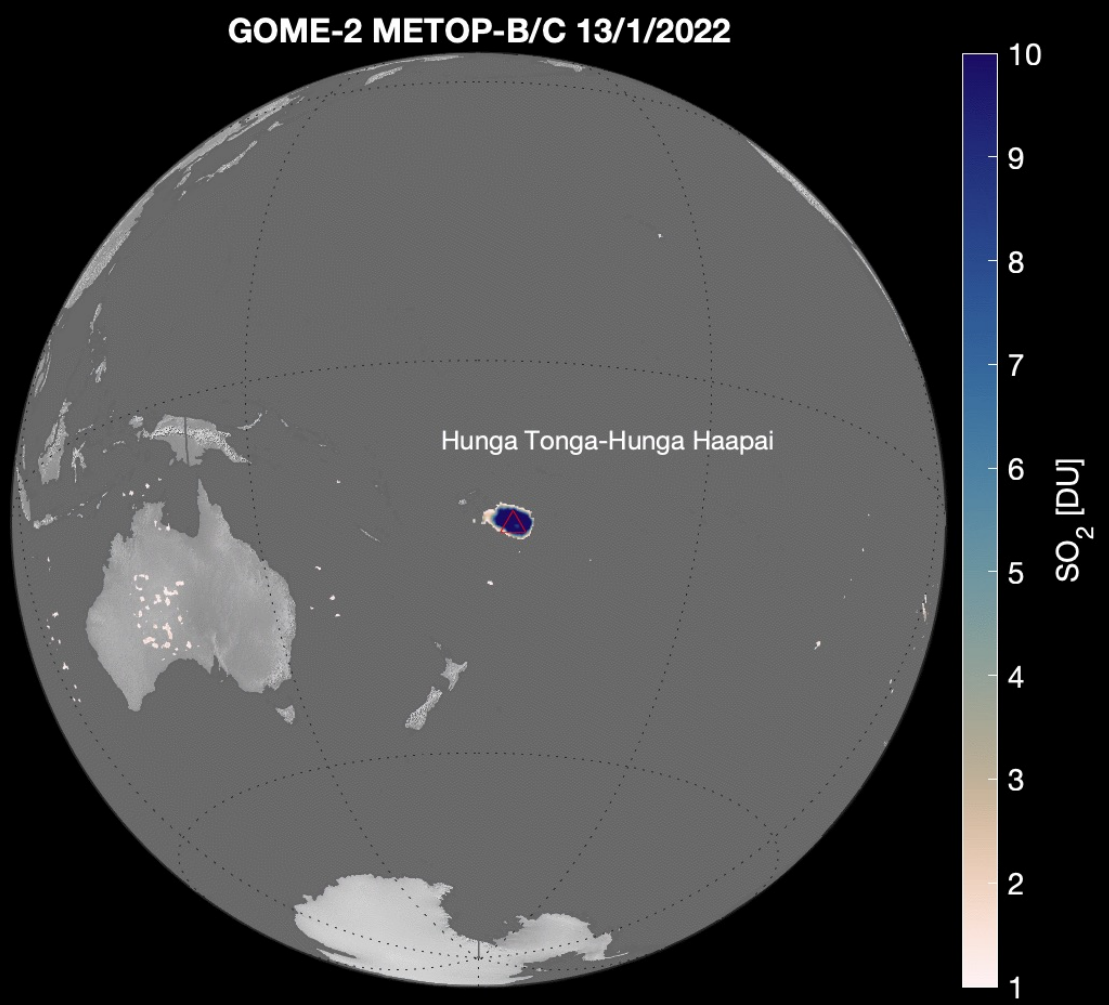
## Raikoke eruption in June 2019



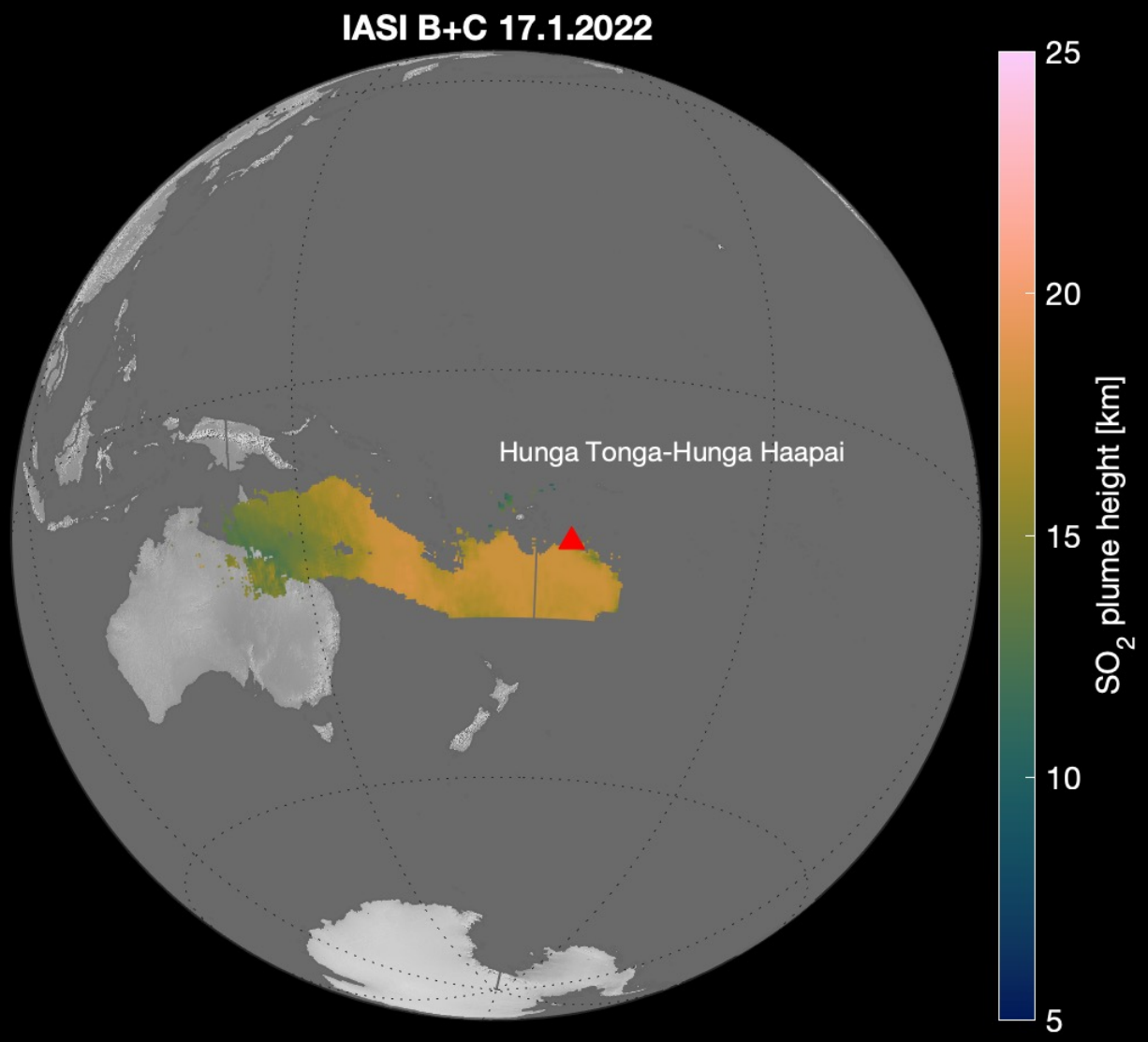



# Volcanic eruption at Tonga



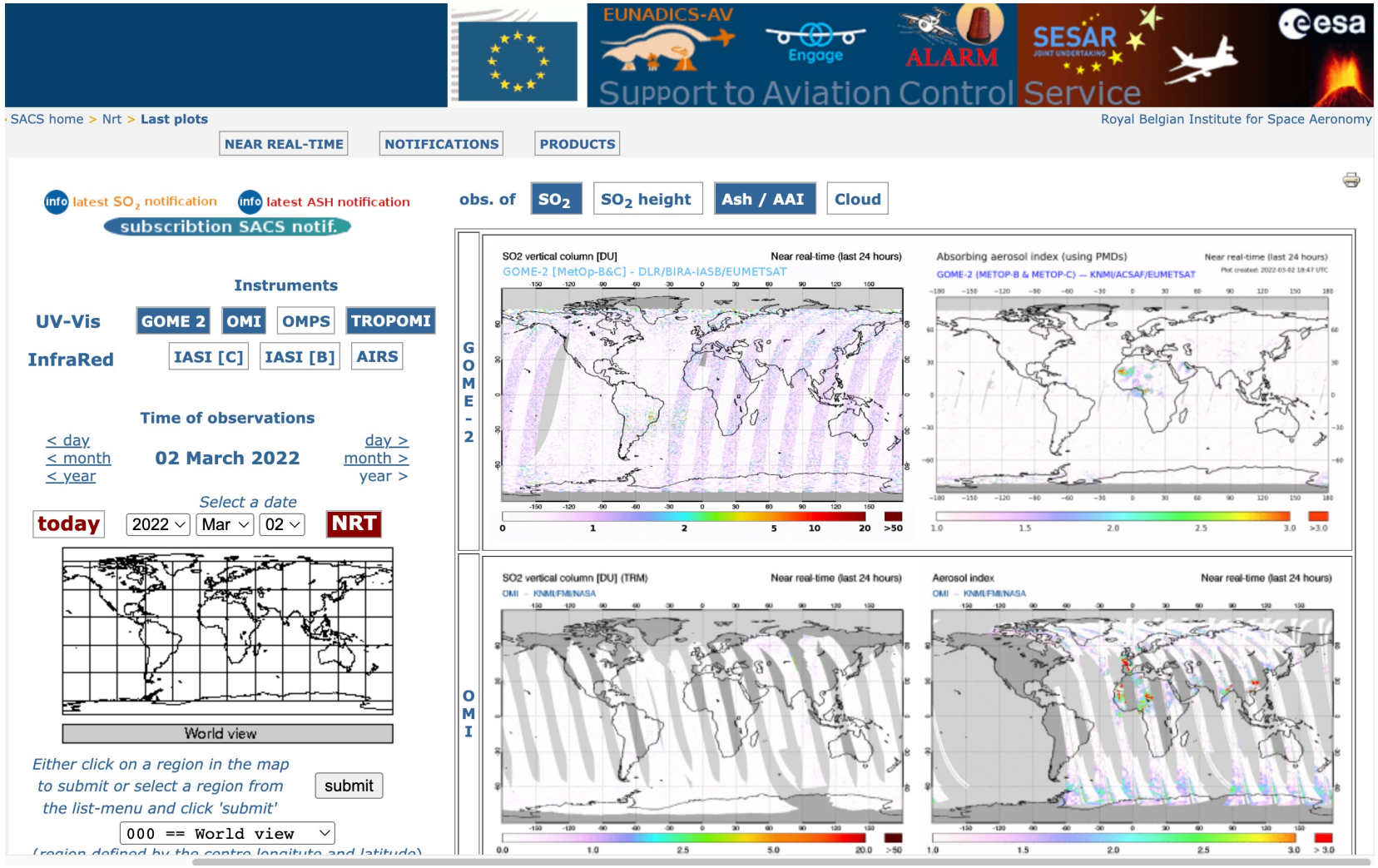
# Volcanic eruption at Tonga

$SO_2$ plume height from IASI



# SACS – Support to Aviation Control Service

https://sacs.aeronomie.be/




- free service that provides ash/$SO_2$ notifications in case of exceptional concentrations detected by satellite instruments.
- AC SAF products in SACS: GOME-2 AAI and $SO_2$, IASI $SO_2$

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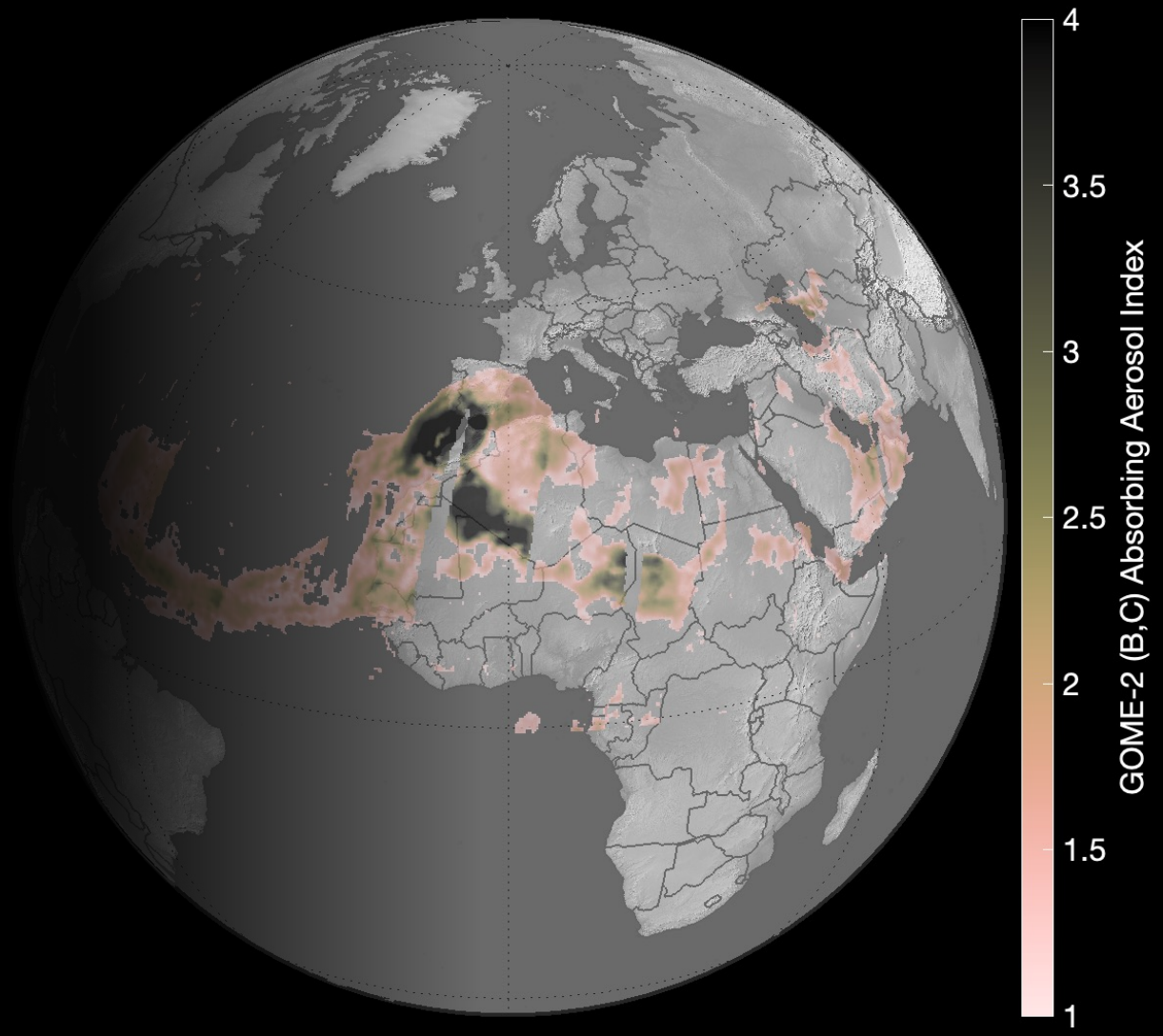
# Summary

- AC SAF provides observations on atmospheric composition
- Interpretation of observations from satellites is not always straightforward; often supporting observations is needed e.g. to asses air quality
- Future plans: to increase wider use of AC SAF products for monitoring purposes
  - New ways to present the data are needed; combinations of several parameters?
  - At FMI pilot project with forecasting meteorologists

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