Atmospheric observations for wildfire monitoring

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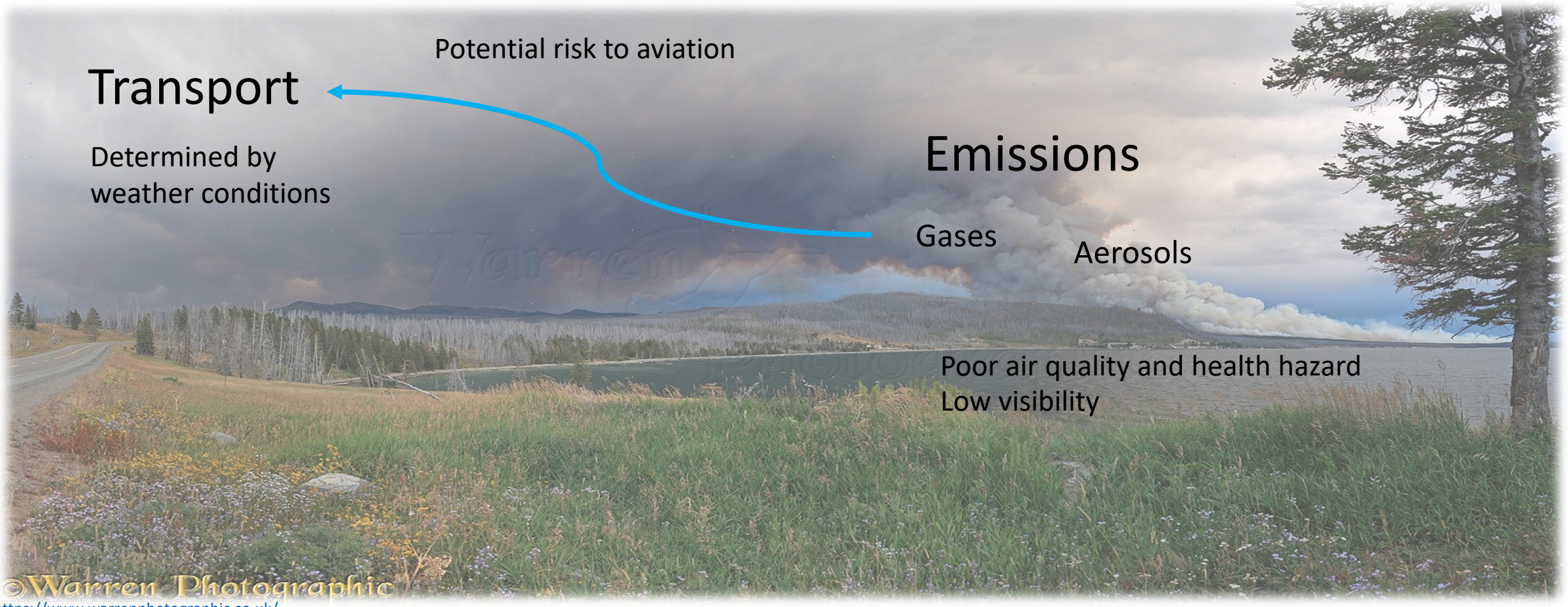
Earth Observation Products for Wildfires Monitoring and Forecast 2022
18.-20.10.2022, Lisbon

@Atmospheric_SAF

EUMETSAT
AC SAF
ATMOSPHERIC COMPOSITION MONITORING

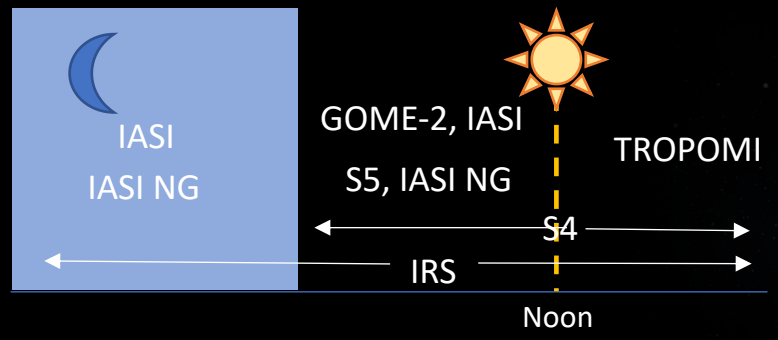
Fire emissions in the atmosphere



https://www.warrenphotographic.co.uk/

Satellites observing atmospheric composition

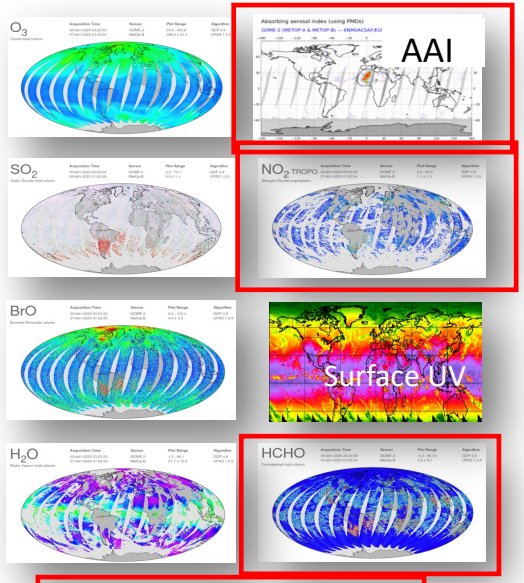
- **EUMETSAT METOP A (2006-2021), B (2012->) and C (2018->)**
  - GOME-2 (UV-VIS)
  - IASI (Thermal IR)
- Copernicus Sentinel 5p (2017->)
  - TROPOMI (UV-VIS + Shortwave IR)
- **Metop Second Generation (Metop-SG (EPS-SG))**
  - Sentinel 5 (UV-VIS)
  - IASI NG (Thermal IR)
- **Meteosat Third Generation (MTG)**
  - Sentinel 4; Ultraviolet, Visible and Near-Infrared instrument (UVN)
  - IRS; InfraRed Sounder



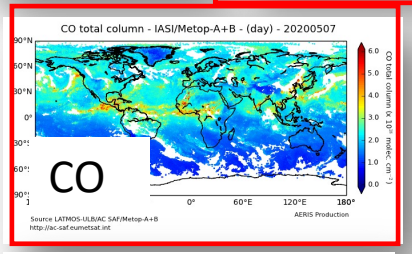
An overview of the atmospheric composition products relevant for wildfire monitoring

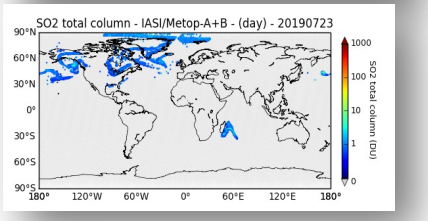
Current operational data

GOME-2



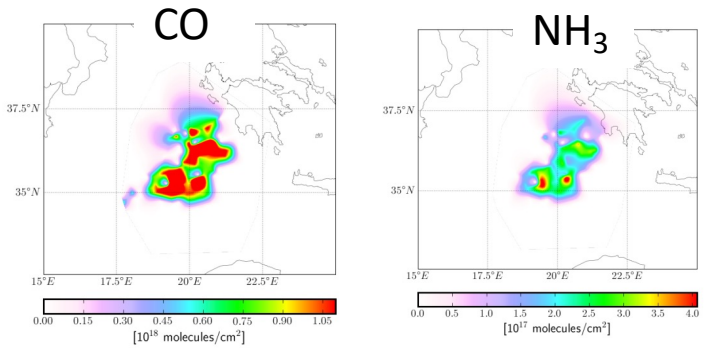
IASI





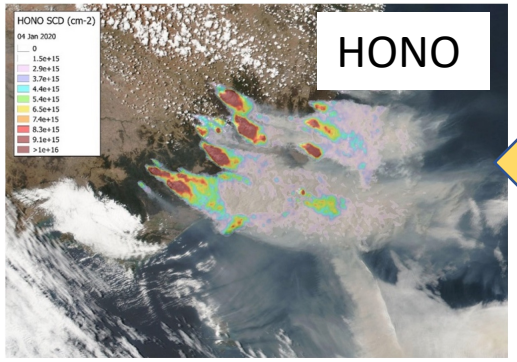
Upcoming data

IRS & IASI NG



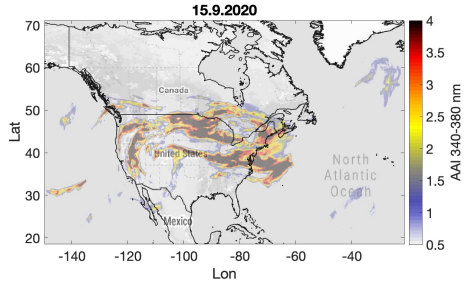
Example images from IASI, P. Coheur et al., ACP, 2009

Sentinel 5



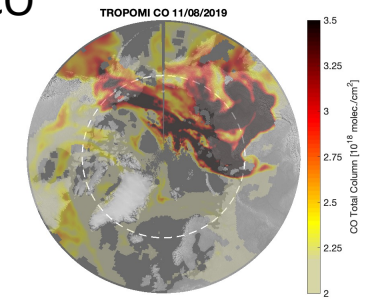
Sentinel 5p / TROPOMI

AAI

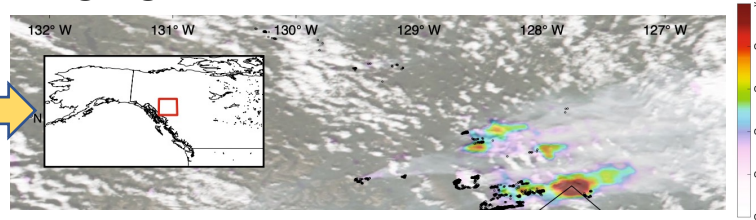


CO

NO_2
HCHO
AOD



HONO

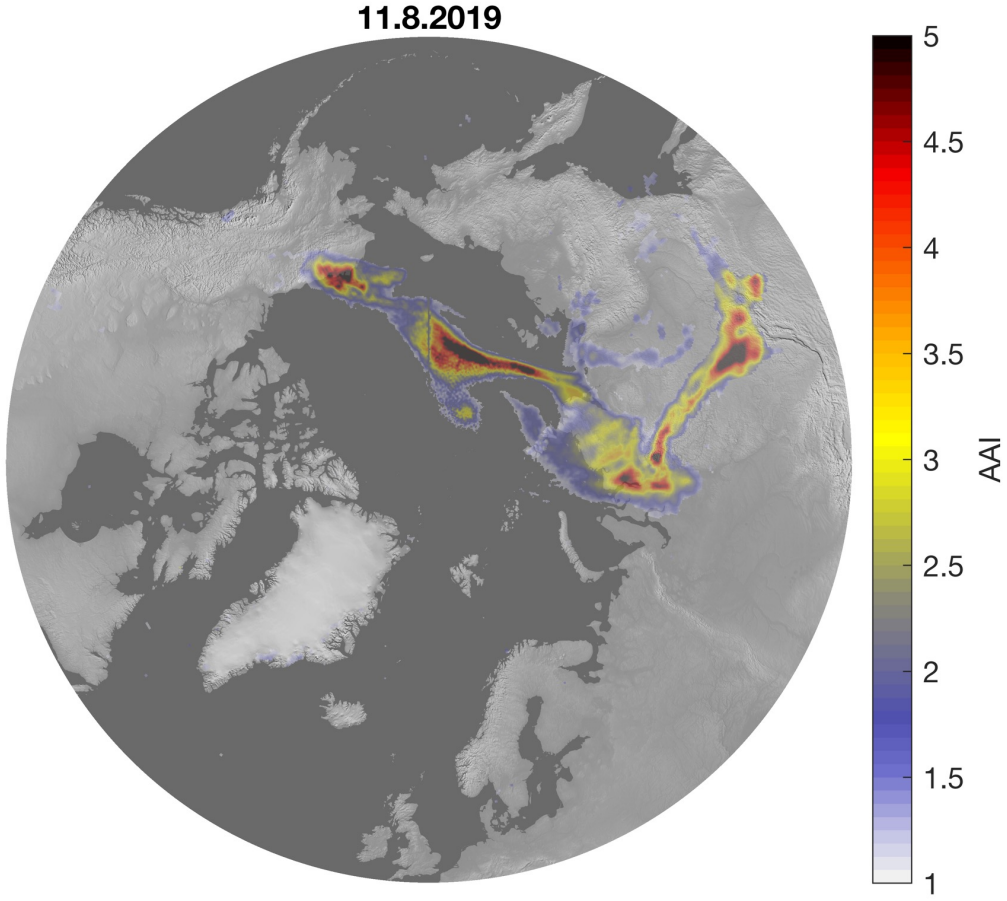


Theys et al., 2020

Absorbing Aerosol Index and Carbon Monoxide as Tracers of Atmospheric Fire Plumes

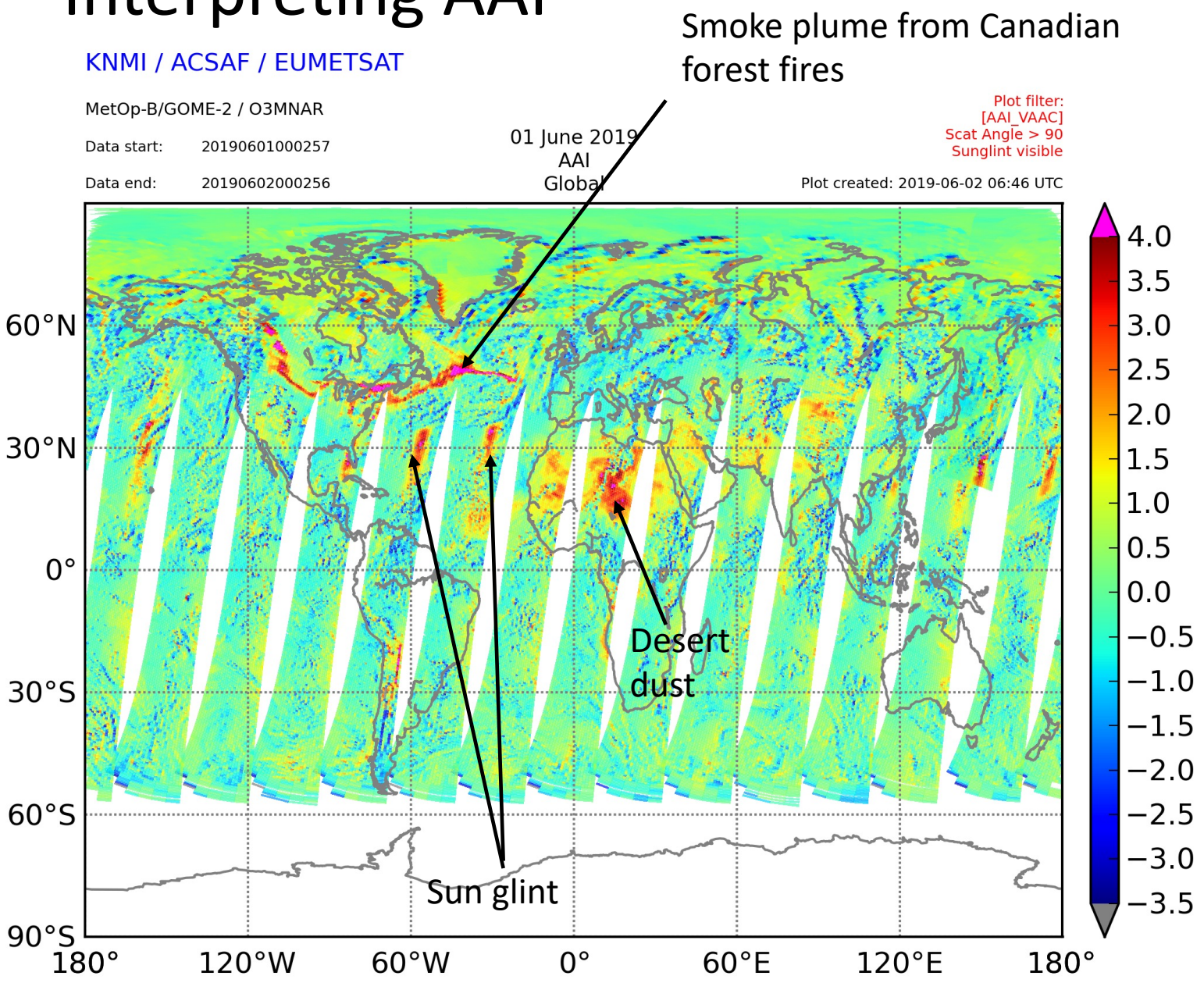
Absorbing Aerosol Index (AAI)

- Also known as UV Aerosol Index (UVAI)
- Defined using UV-wavelengths (**GOME-2, TROPOMI**, OMI, OMPS, S5)
- Sensitive to absorbing aerosols: smoke, volcanic ash, desert dust
- AAI separates the spectral contrast at two UV wavelengths caused by aerosol extinction from that of other effects (e.g. molec. scattering)
- Clouds do not “prevent” the observation



AAI is a good tracer for smoke plumes

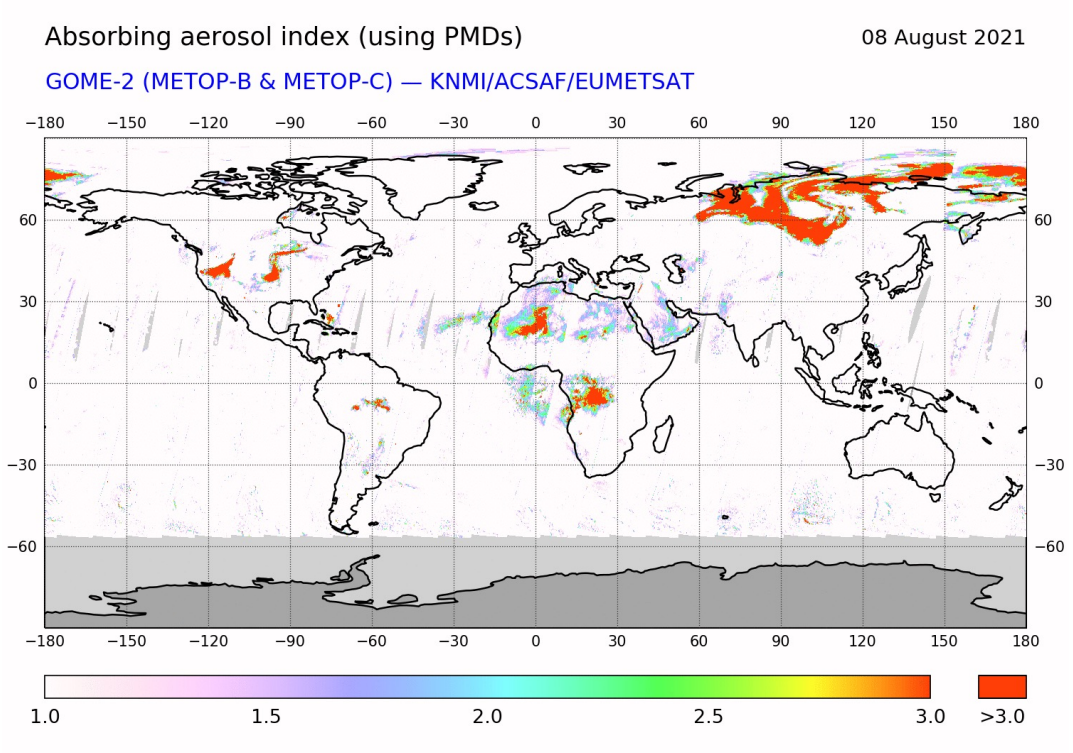
Interpreting AAI

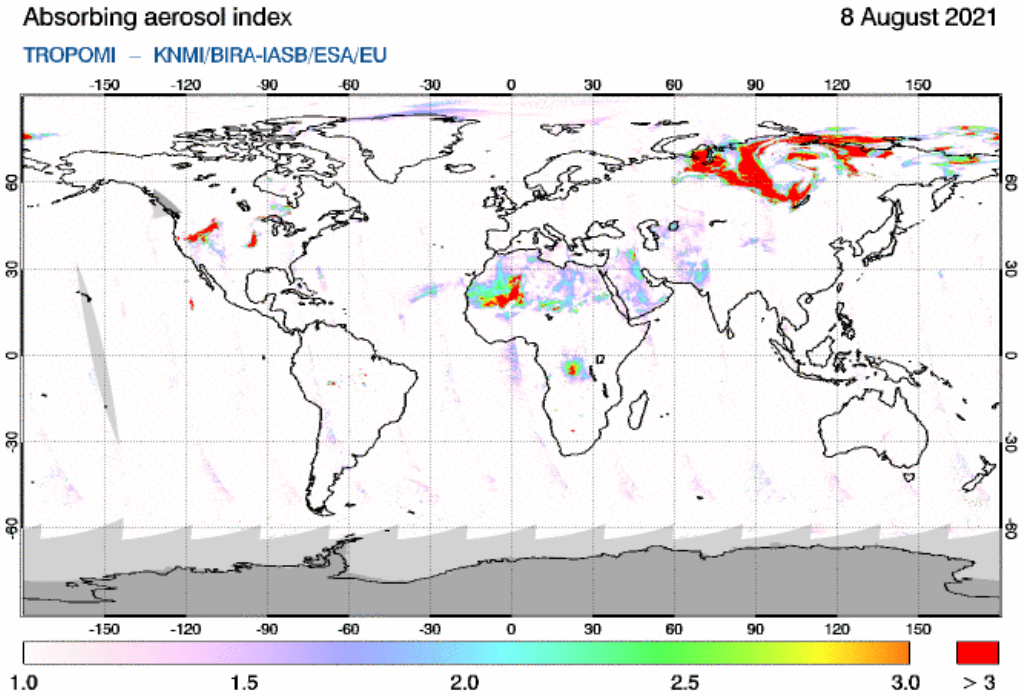


- **Positive values** indicate presence of absorbing aerosols
  - For clouds (or scattering aerosols) AAI is close to zero or negative
  - Positive values can also be other aerosols than smoke!
  - Also sunglint over ocean causes positive values but that is often filtered out from the data.
- For (smoke) plumes typically AAI > 1.0
  - Typical background slightly positive
  - AAI is a function of several parameters (aerosol load, type, height) => not always ”direct” indicator of aerosol amount
  - Sensitive to elevated aerosol layers

GOME-2 & TROPOMI AAI quicklook at SACS

https://sacs.aeronomie.be/nrt/





- The AAI values often somewhat differ between GOME-2 and TROPOMI; this can be explained with different observation time, also possible differences related to instrument
  - Comparison of exact values is not straightforward
- TROPOMI has much higher spatial resolution (5.5 km x 3.5 km) than GOME-2 (10km x 40km), and therefore it can potentially detect smaller scale fires.

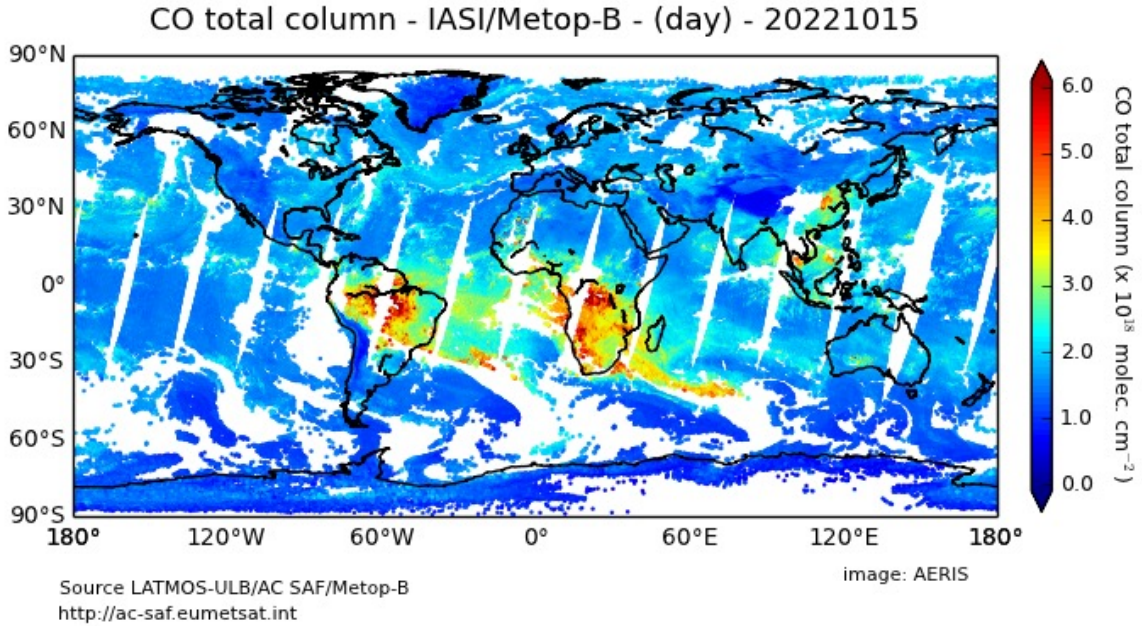
Accessing the AAI data

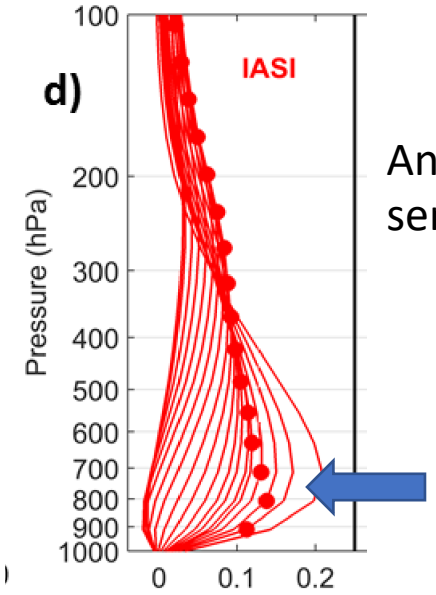
- GOME-2 AAI: FMI AC SAF data service
  - Register: https://acsaf.org/registration_form.html
  - Download: https://acsaf.org/offline_access.html

- TROPOMI UVAI: Sentinel 5p pre-operations data hub
  - No registration needed, username and password: s5pguest
  - Download: https://s5phub.copernicus.eu/dhus/#/home

CO observations from IASI

- The IASI instrument (also IASI NG and IRS) observe CO using the Thermal InfraRed (TIR) spectral band.
  - CO retrieval is based on thermal contrast, typically lower sensitivity close to surtace
  - Observations are made twice a day: ”daytime”, ”nighttime”
  - IASI circular pixel corresponds to a 12 km diameter footprint
- CO is given as total column
  - Units are e.g. molec./cm^2
- Co-analysis with (daytime) IASI and GOME-2 can help to identify smoke plumes.





An example of IASI CO vertical sensitivity (averaging kernel)

George et al,AMT, 2015

Max. sensitivity at abt. 5-7 km height

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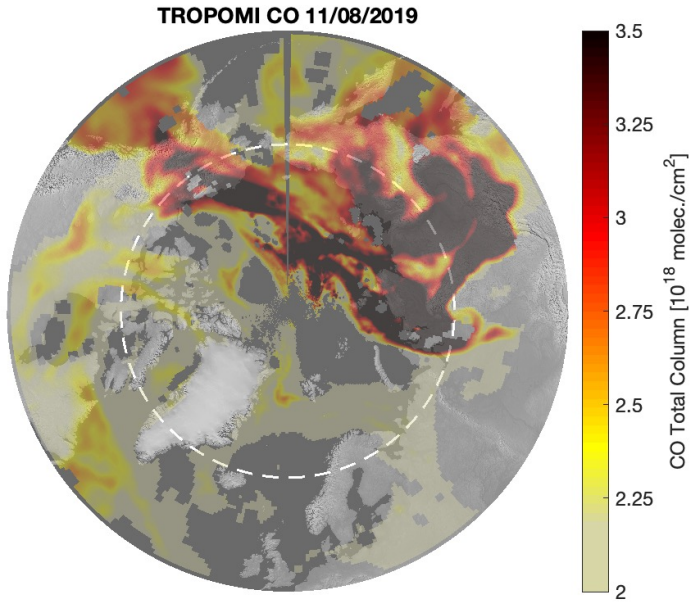
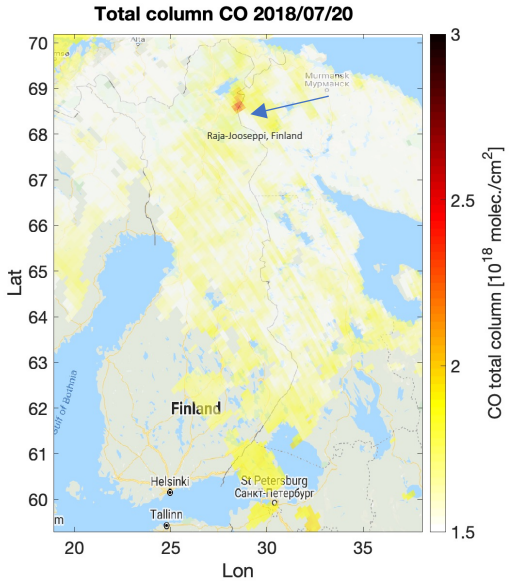
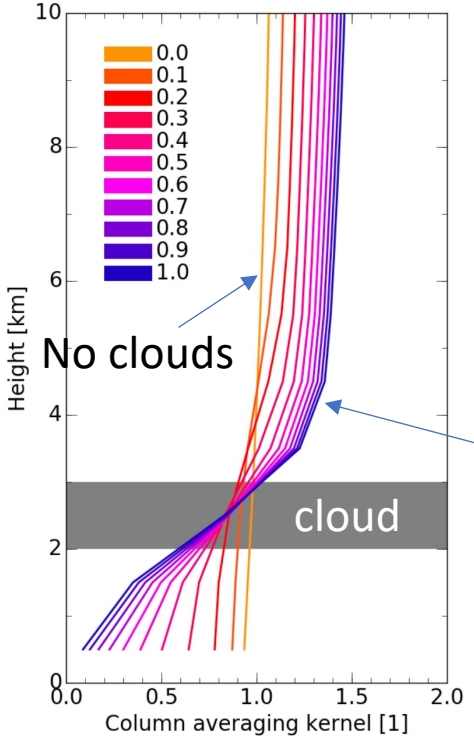
TROPOMI CO observations

- TROPOMI observes CO in the 2.3 µm spectral range of the shortwave infrared (SWIR)
  - Often more sensitive to boundary layer variations (in clear sky) than TIR instruments
  - For cloudy scenes partial column is obtained.
- Due to high spatial resolution (5.6 x 7 km^2) relatively small-scale fires can also be observed.



- Currently TROPOMI is the only instrument that provide both CO and AAI observations





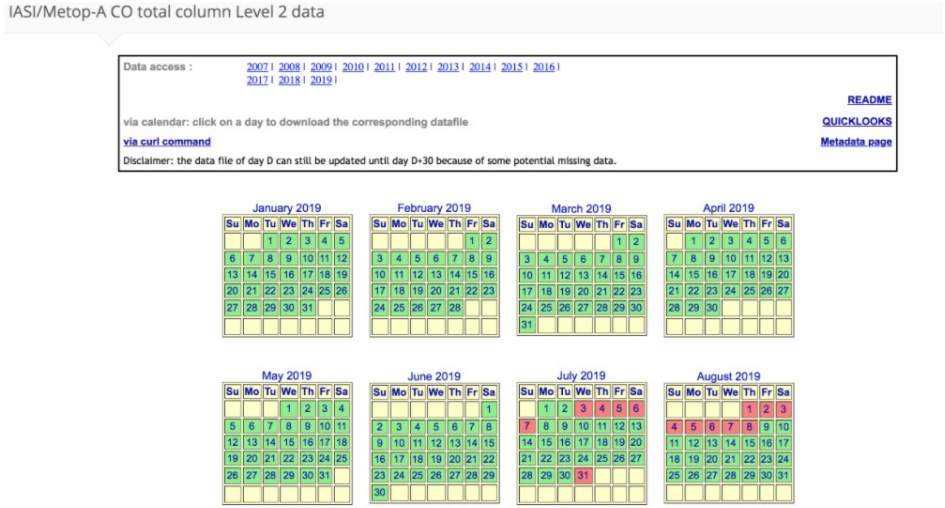
An example of TROPOMI CO vertical sensitivity (averaging kernel) for different cloud fractions

Fully cloudy

Landgraf et al., AMT

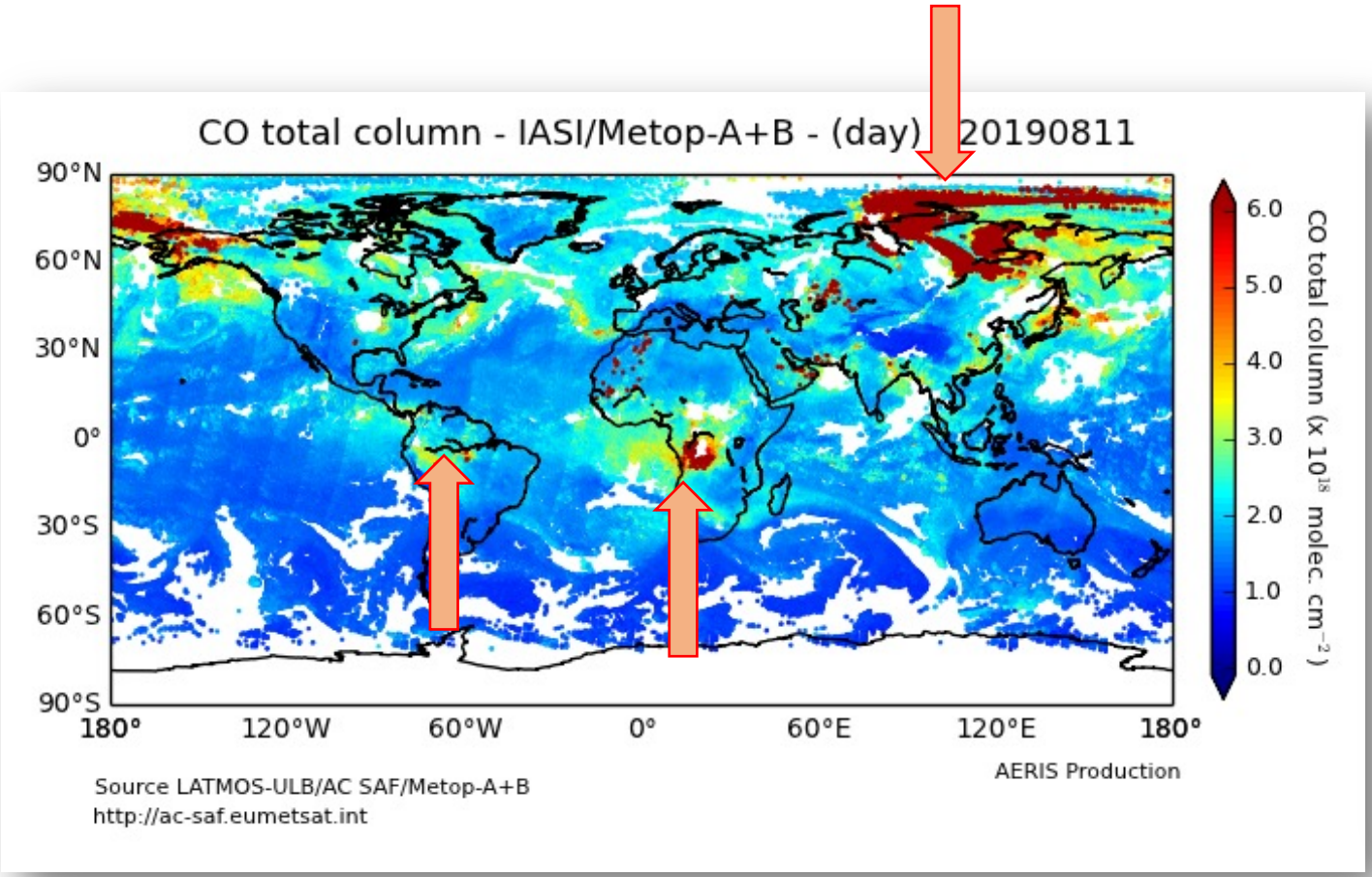
Accessing the CO data

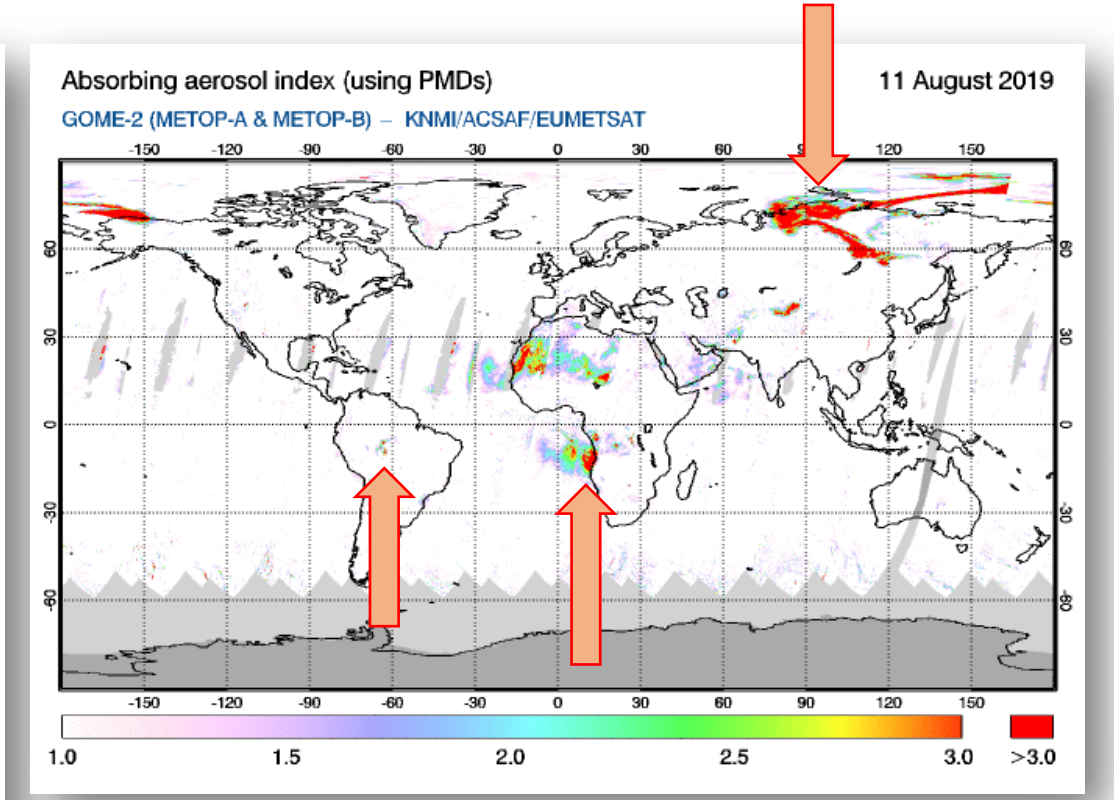
- IASI CO: AERIS data hub
  - Register and download: https://iasi.aeris-data.fr/CO_IASI_A_data/, https://iasi.aeris-data.fr/co_iasi_b_arch/
- TROPOMI CO: Sentinel 5p pre-operations data hub
  - No registration needed, username and password: s5pguest
  - Download: https://s5phub.copernicus.eu/dhus/#/home



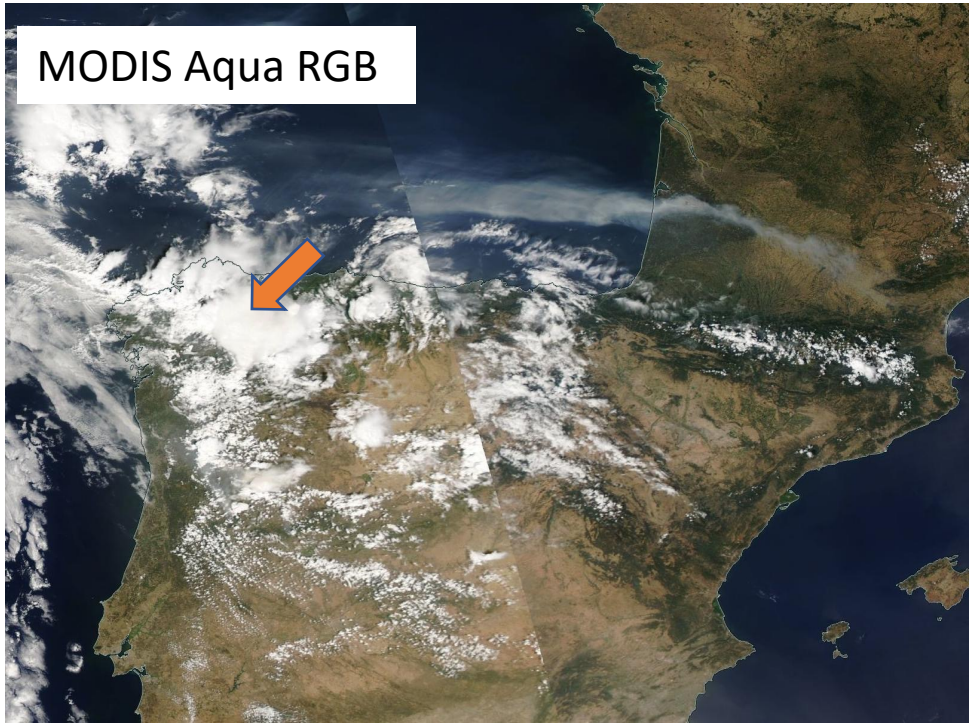
Identifying smoke plume: IASI CO and GOME-2 AAI from Metop-A and B

Fire plume ➡ Where both AAI and CO enhancements are observed

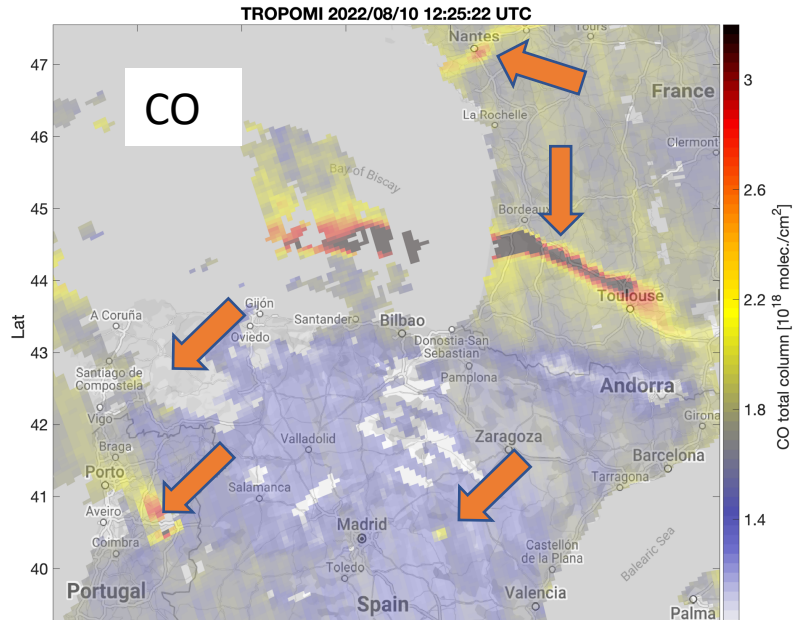


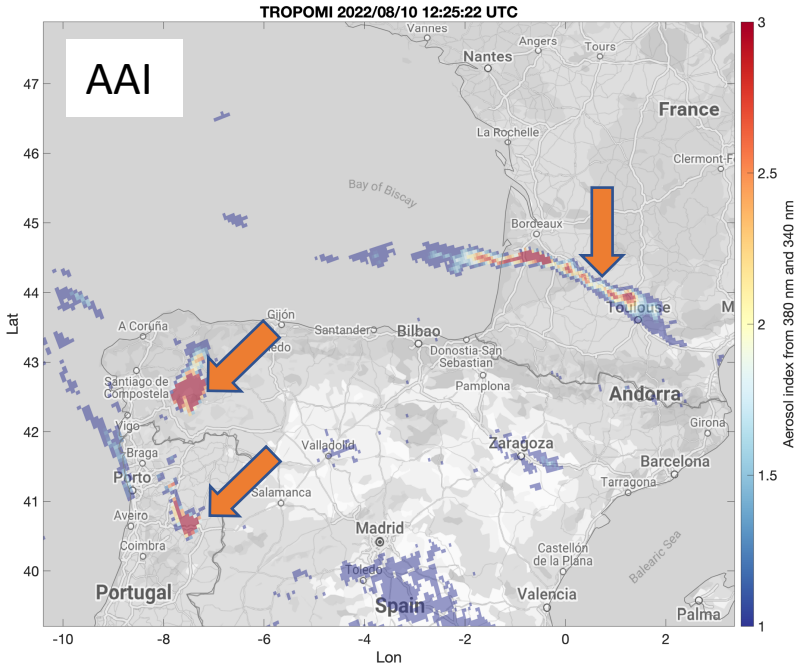


Example: TROPOMI observations on 10th August, 2022



TROPOMI





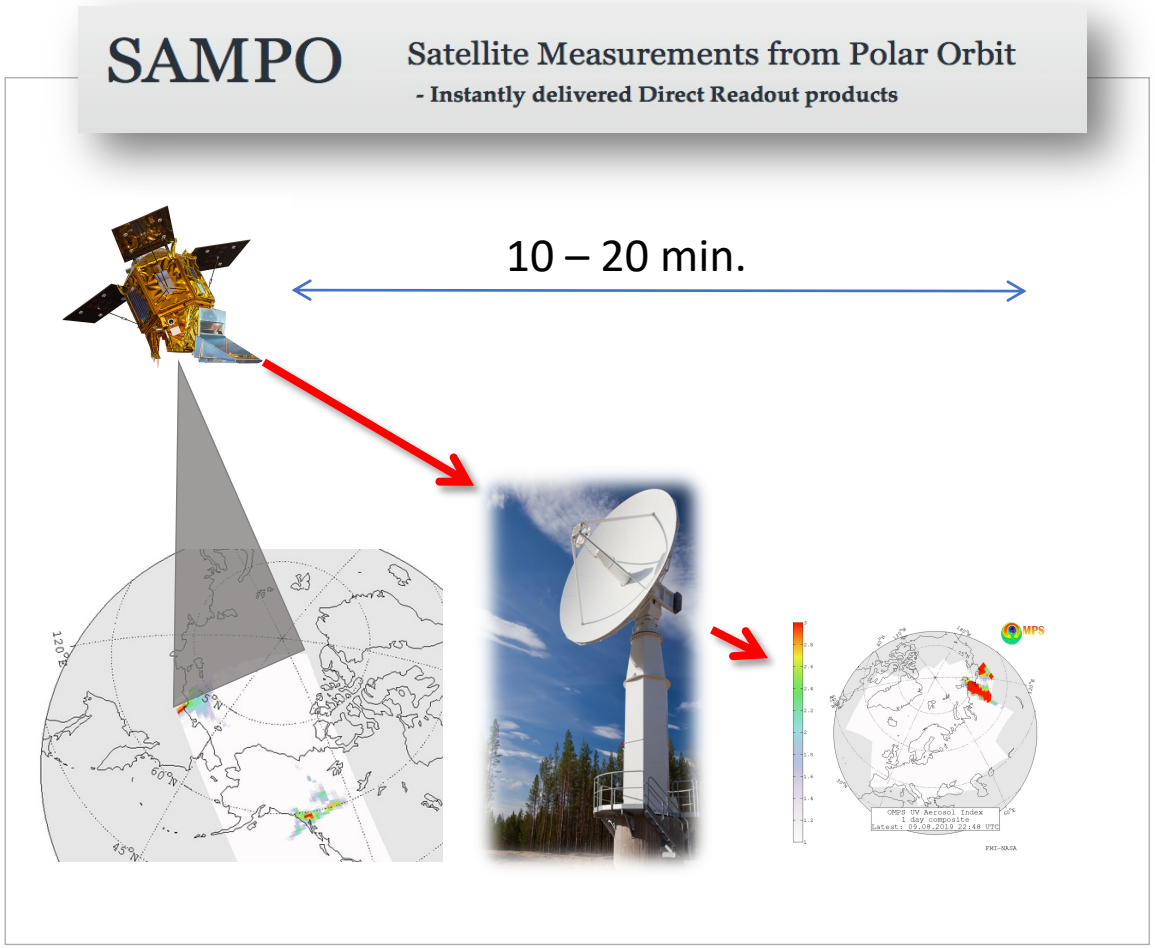
1. Fire plumes picked up by both AAI and CO
2. AAI shows elevated values, CO data missing due to clouds
3. Elevated CO values, no AAI signal. Source could be fires, but also e.g. industrial hot spots

Summary

- Satellites provide observations on several atmospheric parameters that are related to fire emissions
  - Fires emit multiple species, many gas concentrations are enhanced
  - For tracking the actual smoke plume, AAI and CO are useful parameters
  - There are also several challenges related to direct use of satellite data, such as:
    - Clouds
    - Vertical sensitivity and assesment of air quality
  - Best estimation of potential air quality hazard is obtained by combining all kind of available data: satellites, in situ and models

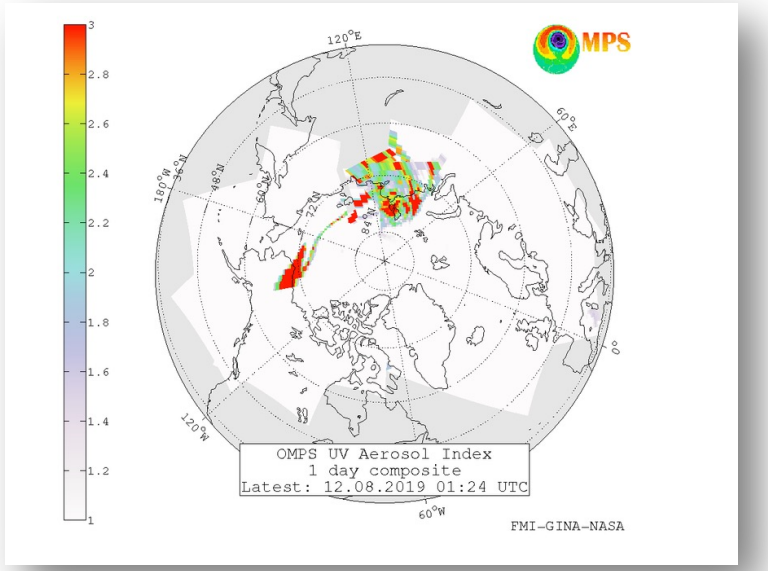
The SAMPO service (www.sampo.fmi.fi)

by Finnish Meteorological Institute



- NRT satellite service maintained by FMI for monitoring atmospheric composition in the Northern Hemisphere/ Arctic

- Receiving stations in Sodankylä and Alaska
  - Satellite-instruments: OMI, OMPS



SAMPO provides observations also on AAI