Validation of satellite-based aerosol products; The lesser-known Aerosol Layer Height

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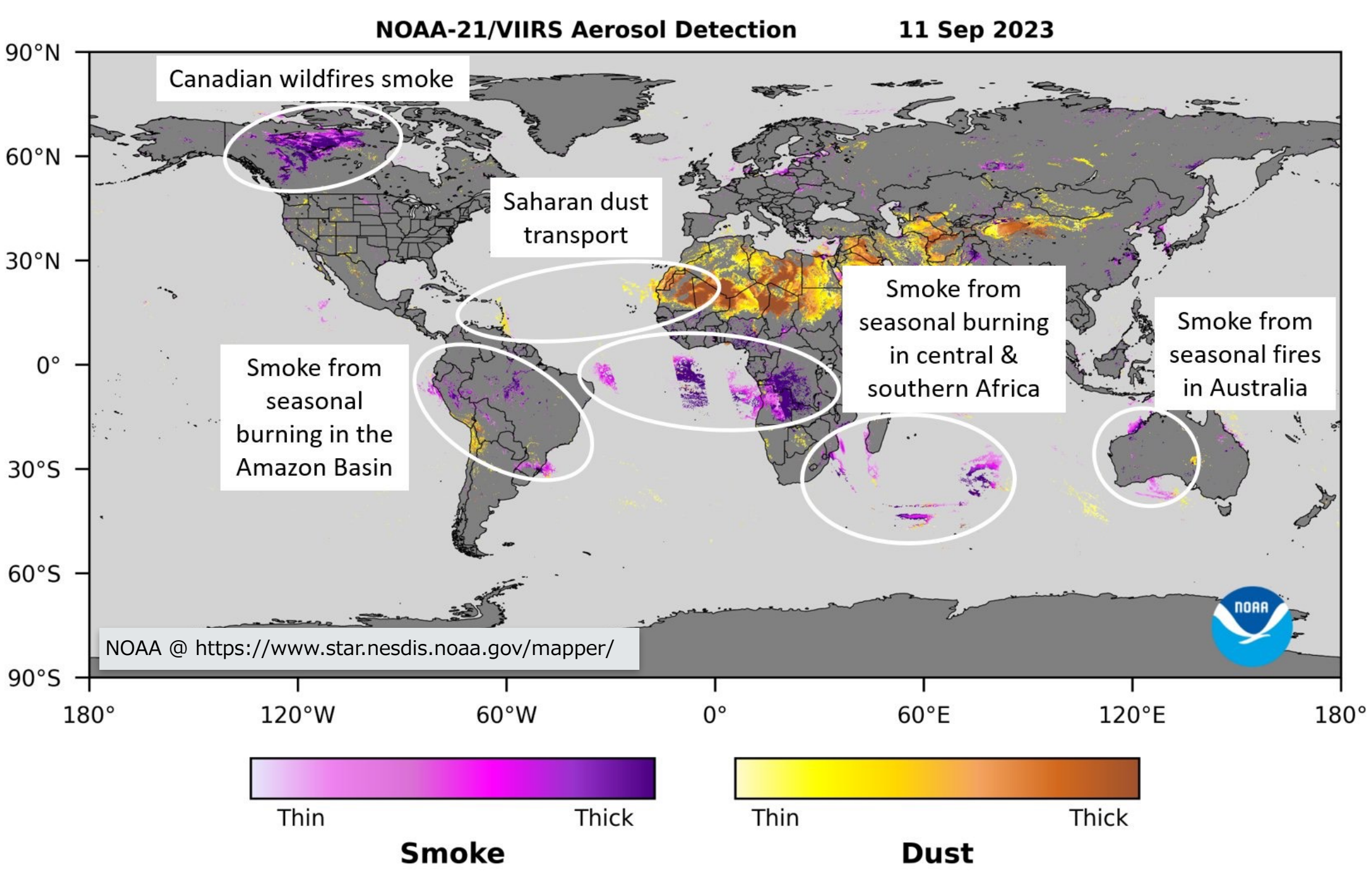
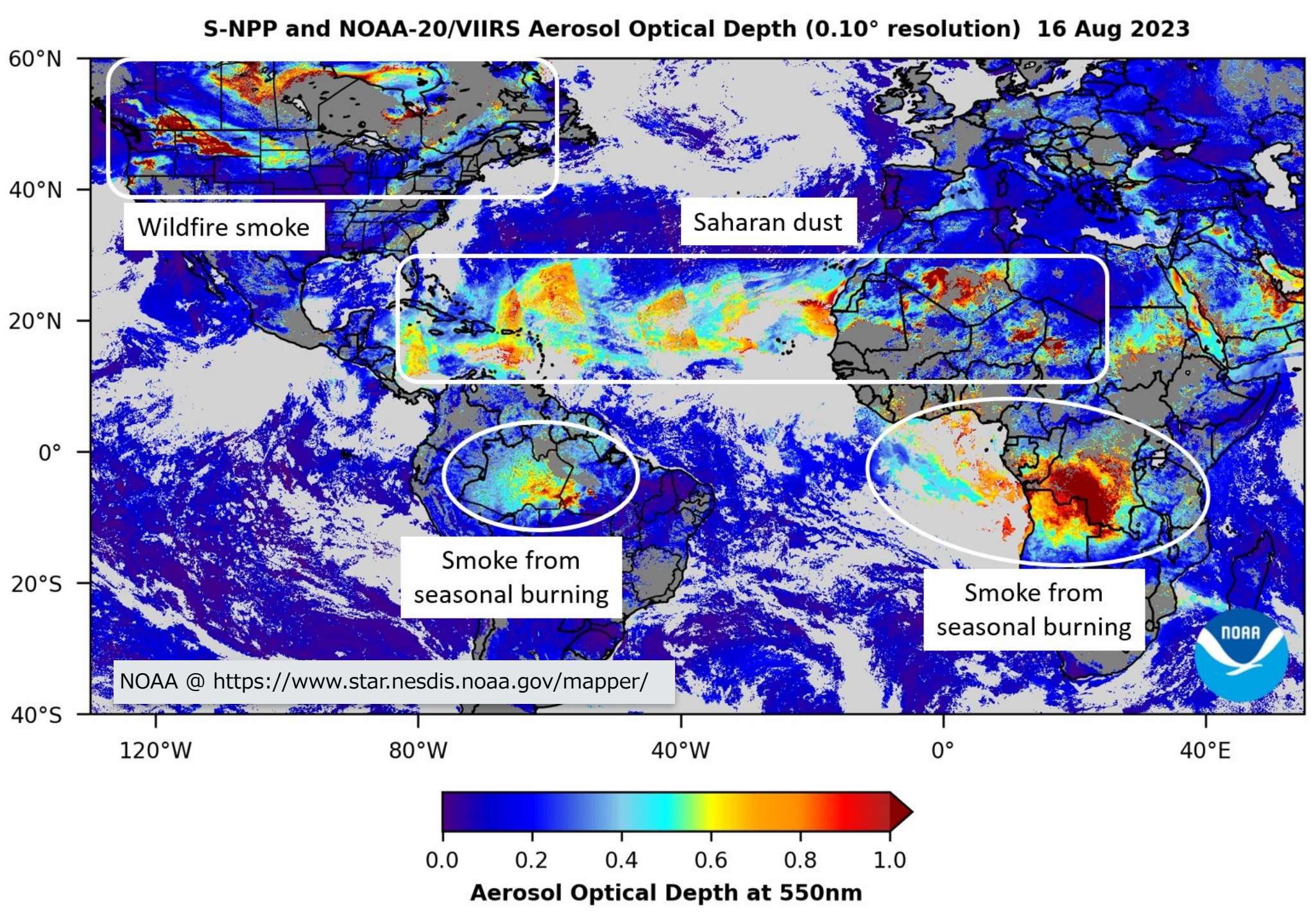
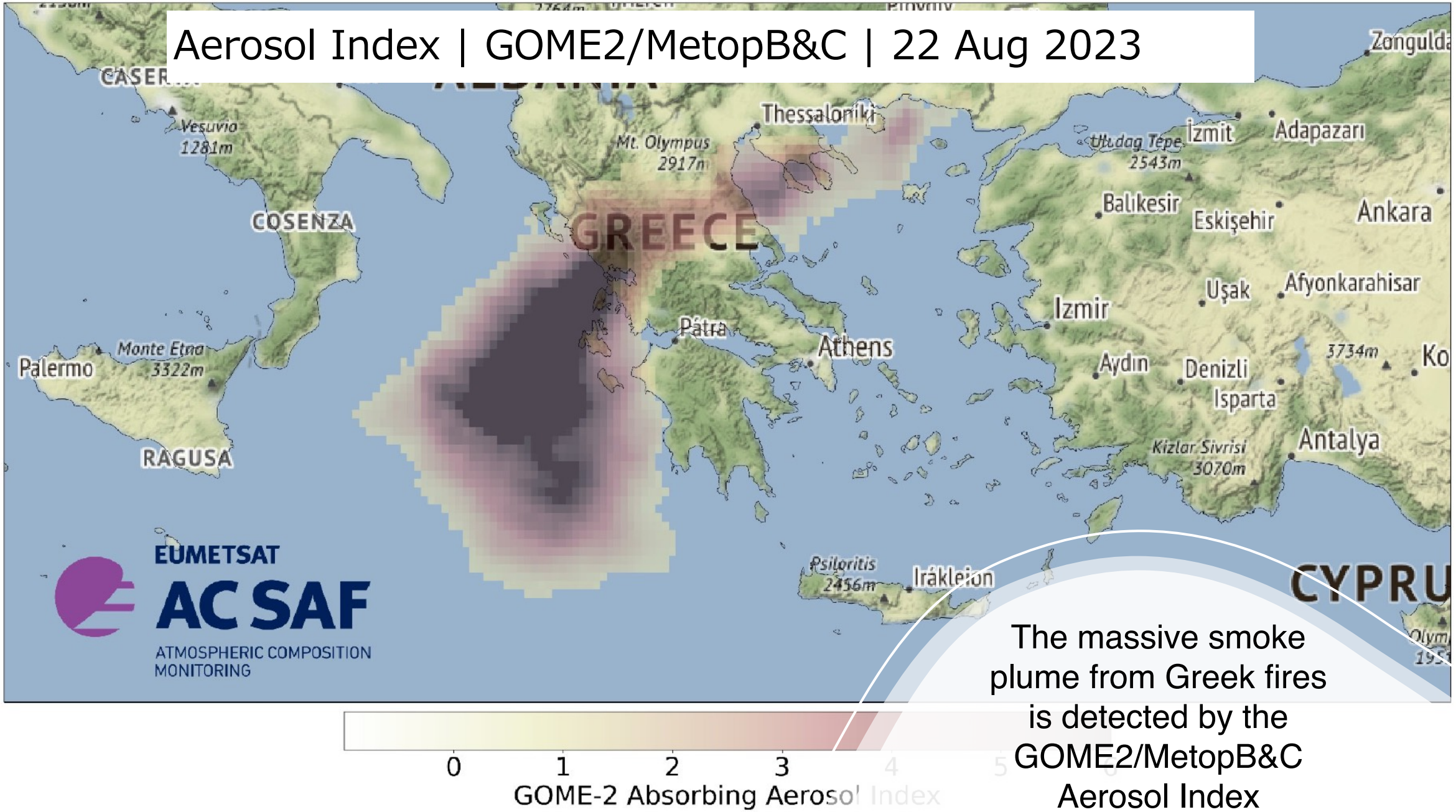
Aristotle University of Thessaloniki


NOAA-21/VIIRS Aerosol Detection 11 Sep 2023
Canadian wildfires smoke
Saharan dust transport
Smoke from seasonal burning in central & southern Africa
Smoke from seasonal fires in Australia
Smoke from seasonal burning in the Amazon Basin
NOAA @ https://www.star.nesdis.noaa.gov/mapper/
90°N
60°N
30°N
0°
30°S
60°S
90°S
180°
120°W
60°W
0°
60°E
120°E
180°
Thin
Thick
Smoke
Thin
Thick
Dust

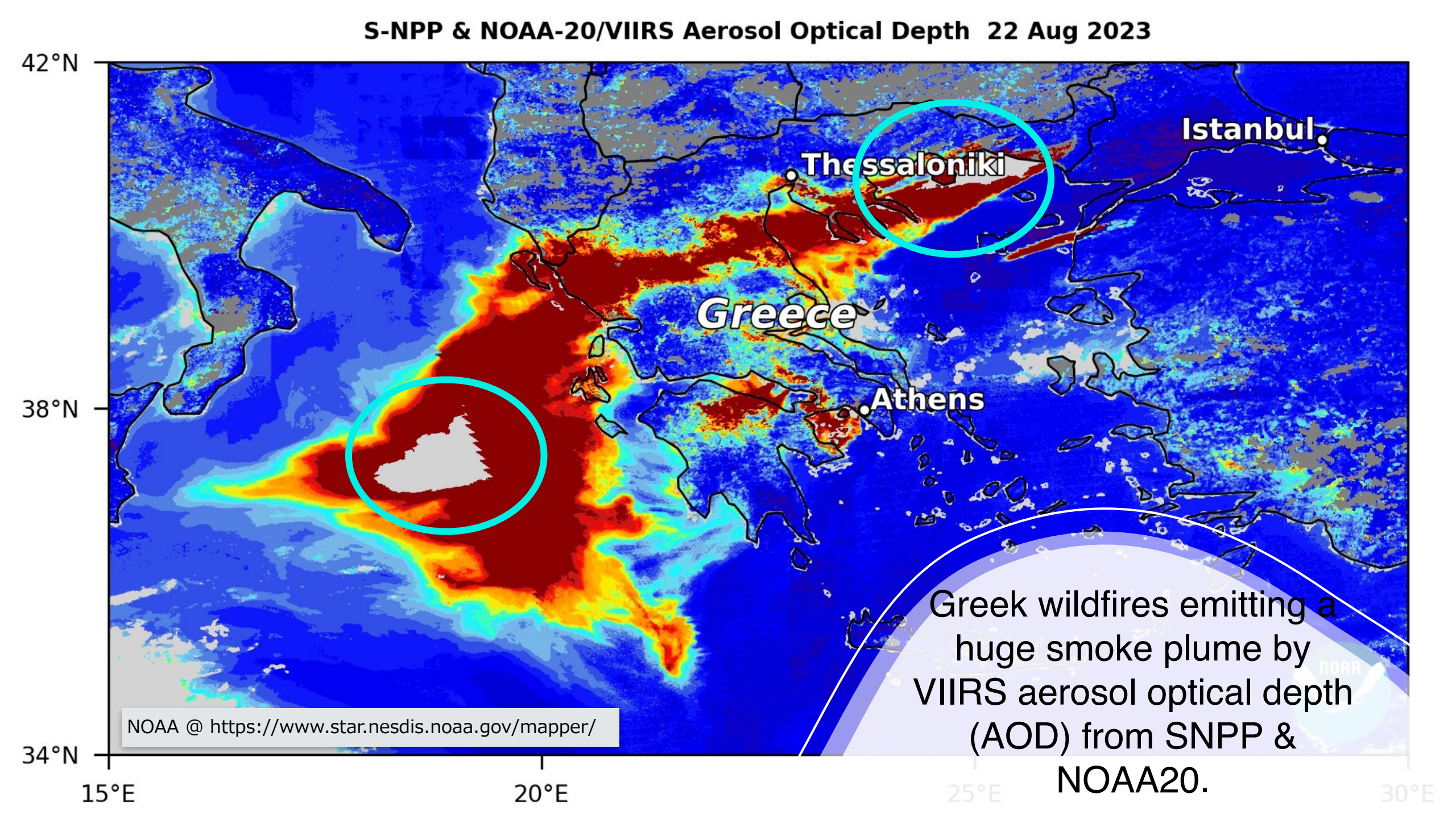

S-NPP and NOAA-20/VIIRS Aerosol Optical Depth (0.10° resolution) 16 Aug 2023
60°N
40°N
20°N
0°
20°S
40°S
120°W
80°W
40°W
0°
40°E
Wildfire smoke
Saharan dust
Smoke from seasonal burning
Smoke from seasonal burning
NOAA @ https://www.star.nesdis.noaa.gov/mapper/
NOAA
0.0
0.2
0.4
0.6
0.8
1.0
Aerosol Optical Depth at 550nm

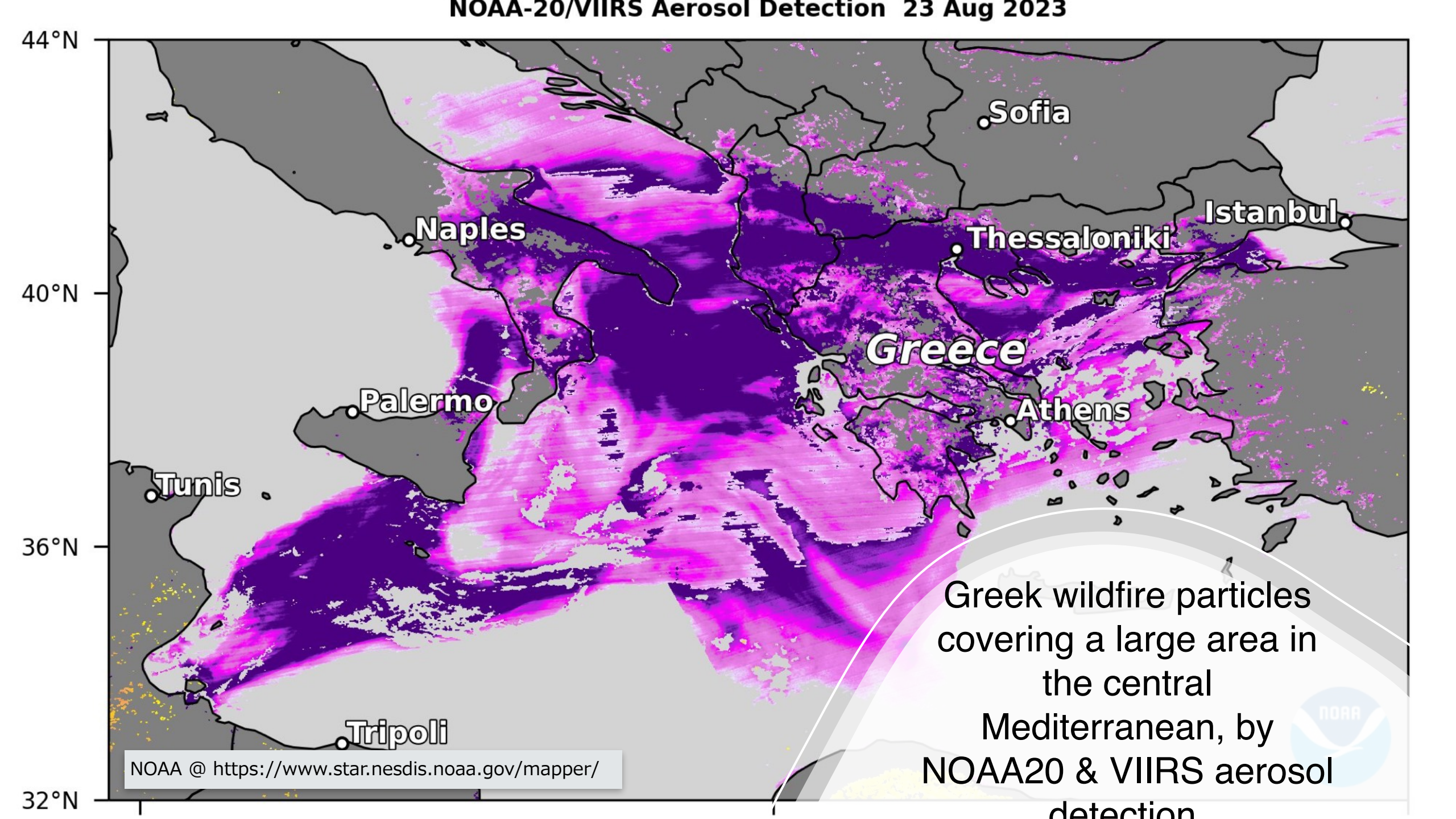
Aerosol Index | GOME2/MetopB&C | 22 Aug 2023

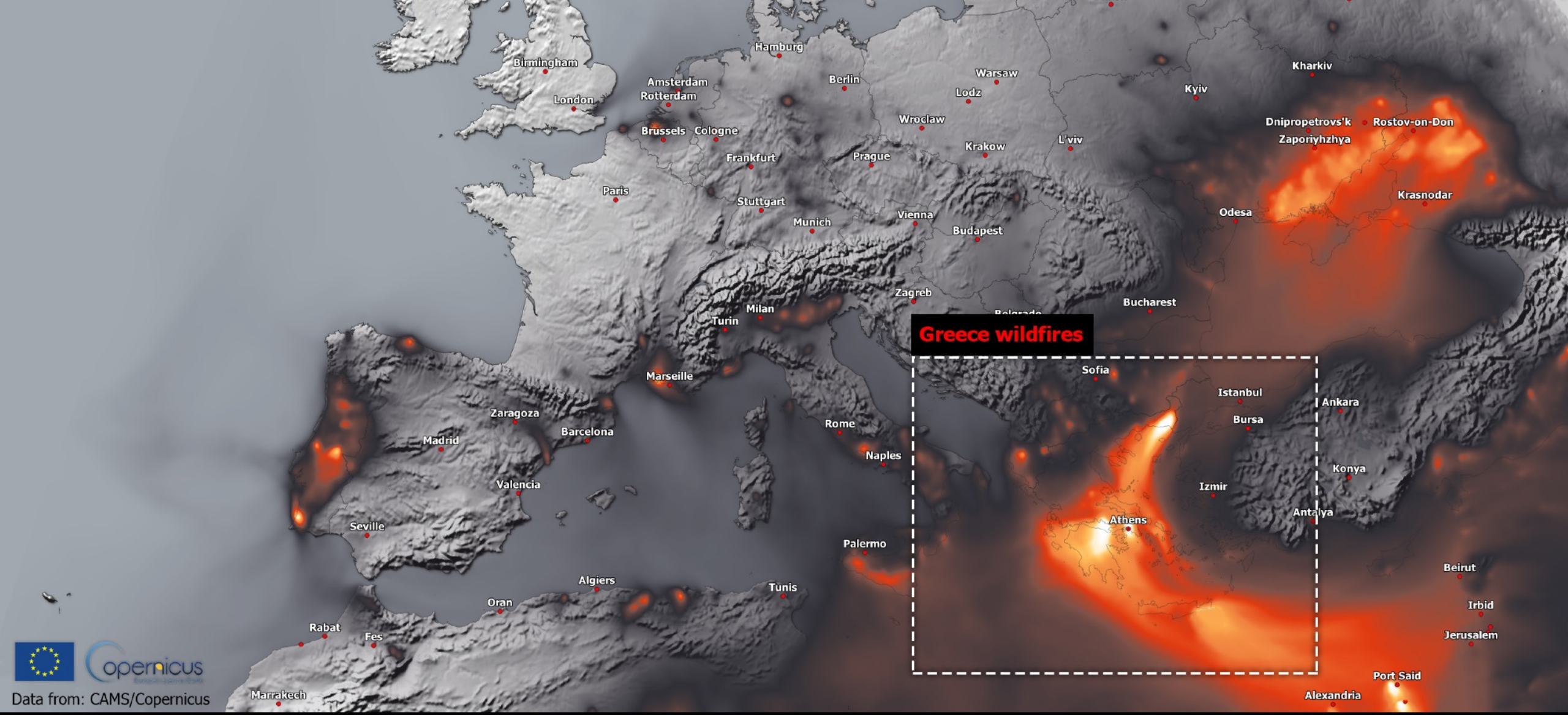


The massive smoke plume from Greek fires is detected by the GOME2/MetopB&C Aerosol Index

https://acsaf.org/


S-NPP & NOAA-20/VIIRS Aerosol Optical Depth 22 Aug 2023
42°N
38°N
34°N
15°E
20°E
25°E
30°E
Istanbul
Thessaloniki
Greece
Athens
NOAA @ https://www.star.nesdis.noaa.gov/mapper/
Greek wildfires emitting a huge smoke plume by VIIRS aerosol optical depth (AOD) from SNPP & NOAA20.


NOAA-20/VIIRS Aerosol Detection 23 Aug 2023
44°N
40°N
36°N
32°N
Sofia
Istanbul
Naples
Thessaloniki
Greece
Palermo
Athens
Tunis
Tripoli
NOAA @ https://www.star.nesdis.noaa.gov/mapper/
Greek wildfire particles covering a large area in the central Mediterranean, by NOAA20 & VIIRS aerosol detection



Total PM10 - wildfires only

Fair Poor Very poor Extremely poor

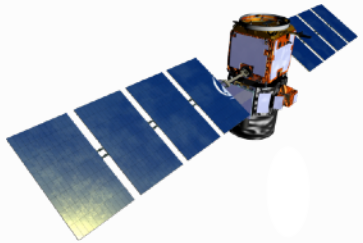
Total PM10 - Wildfires only

August 2023

The aerosol layer height

Polar orbiting satellites measuring global aerosol load

Cloud-Aerosol Lidar with Orthogonal Polarization



CALIOP/ CALIPSO

2006-2023

Vertically-resolved signature of aerosol and clouds

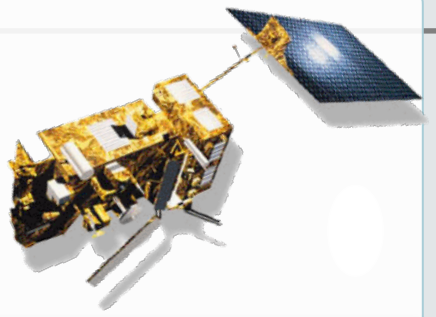
Channels: 532, 1064nm

Narrow footprint (~100m)

Rep. cycle 16d

High horizontal & vertical res.

Global Ozone Monitoring Experiment-2



GOME-2/MetOp

Since 2006

MetOp-A, -B, -C

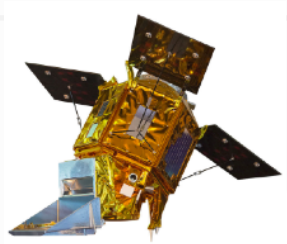
Daily global coverage

~09:30LT

Swath ~ 1920 km

Spatial res. (40 x 80km)

TROPOspheric Monitoring Instrument



TROPOMI/S5P

Since 2017

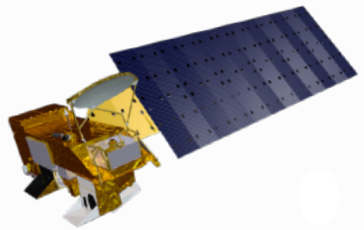
Daily global coverage

Cross. Time~13:30LT

Swath ~2600 km

Spatial res. (5.5 x 3.5km)

Moderate Resolution Imaging Spectroradiometer



MODIS-Aqua/Terra

Since 1999

Terra & Aqua

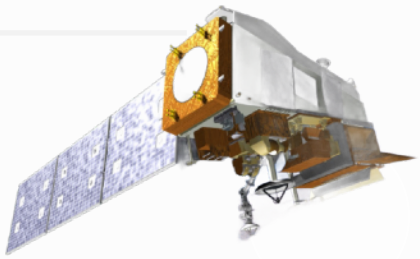
Daily global coverage

~10:30 & 13:30 LT

Swath ~ 2330 km

Spatial res. (200 – 1000m)

Visible Infrared Imaging Radiometer Suite (VIIRS)



VIIRS / Suomi-NPP

Since 2011

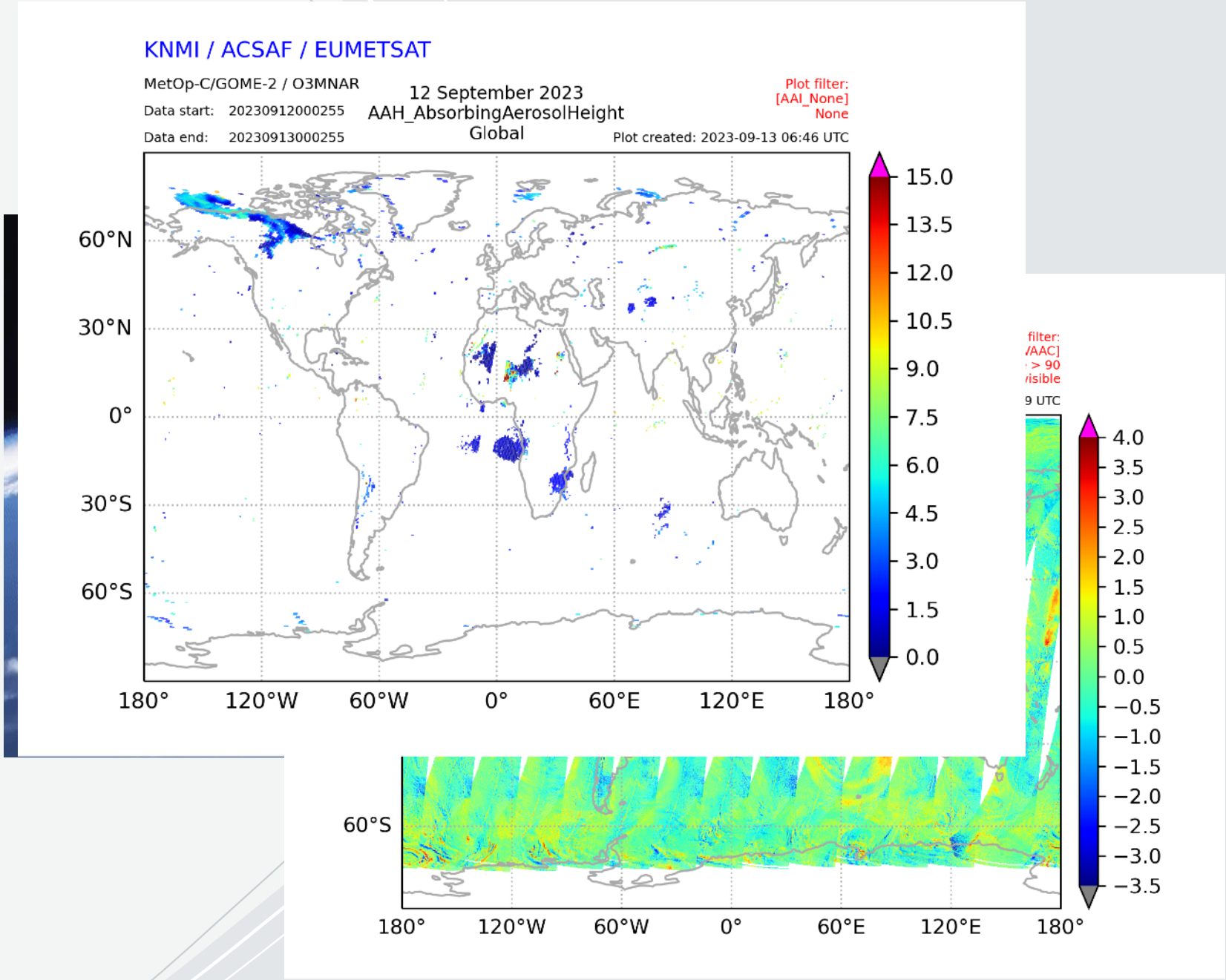
Daily global coverage

Cross. Time~13:30LT

Swath ~3000 km

Spatial res. (750m)

GOME-2/Metop Absorbing Aerosol Height

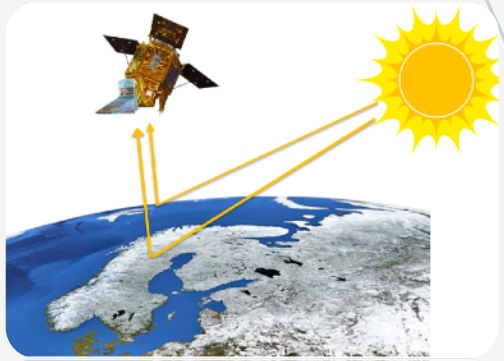


- GOME-2 Absorbing Aerosol Height (AAH): operational AC SAF EUMETSAT product.
- The algorithm uses the GOME-2 Absorbing Aerosol Index (AAI) product to identify scenes containing sufficient amounts of absorbing aerosol (Tilstra et al., 2012)
- The fast FRESCO+ cloud retrieval algorithm is used, which produces an effective height for optically thick aerosol plumes (Wang et al., 2012).

EUMETSAT AC SAF
ATMOSPHERIC COMPOSITION MONITORING

TROPOMI/S5P Aerosol Layer Height

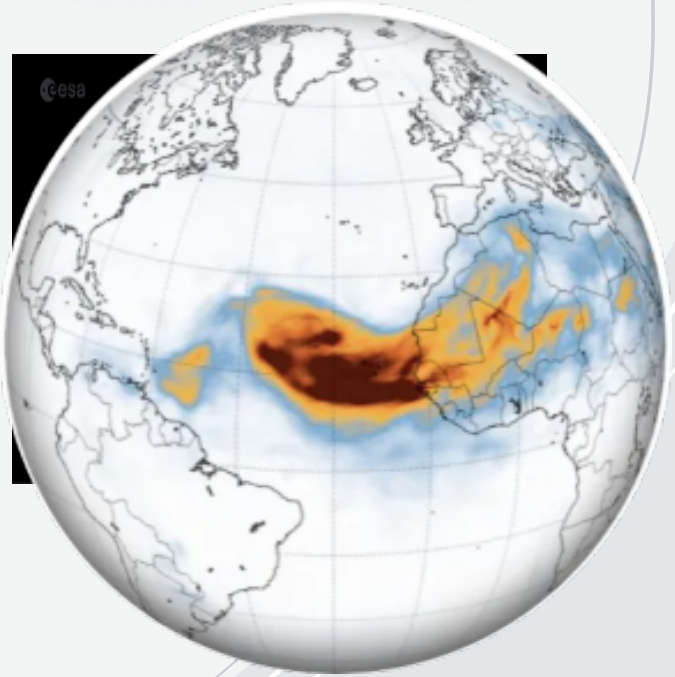
sentinel-5p https://scihub.copernicus.eu/ esa

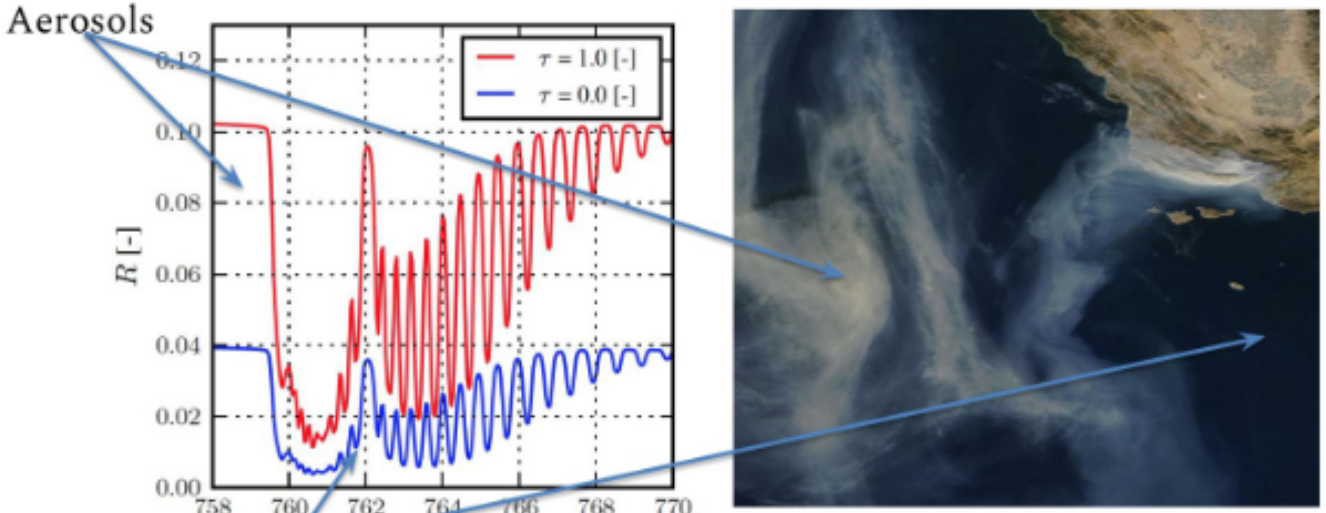


Sentinel-5P

- The reported satellite ALH is the height of a single aerosol layer (Dust, Biomass burning or Volcanic Ash) for the entire atmospheric column within the scene measured by TROPOMI (Nanda, S., et al., 2019) .

- Aerosols are assumed to be uniformly distributed in a single layer. The TROPOMI ALH indicate the 'effective' height (the altitude where aerosol extinction is strongest) for dominant aerosols layers.



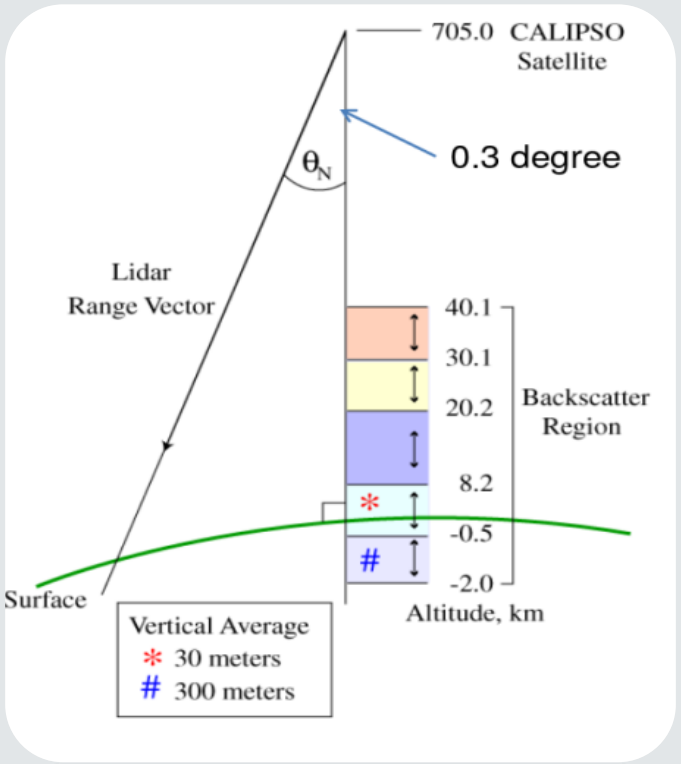


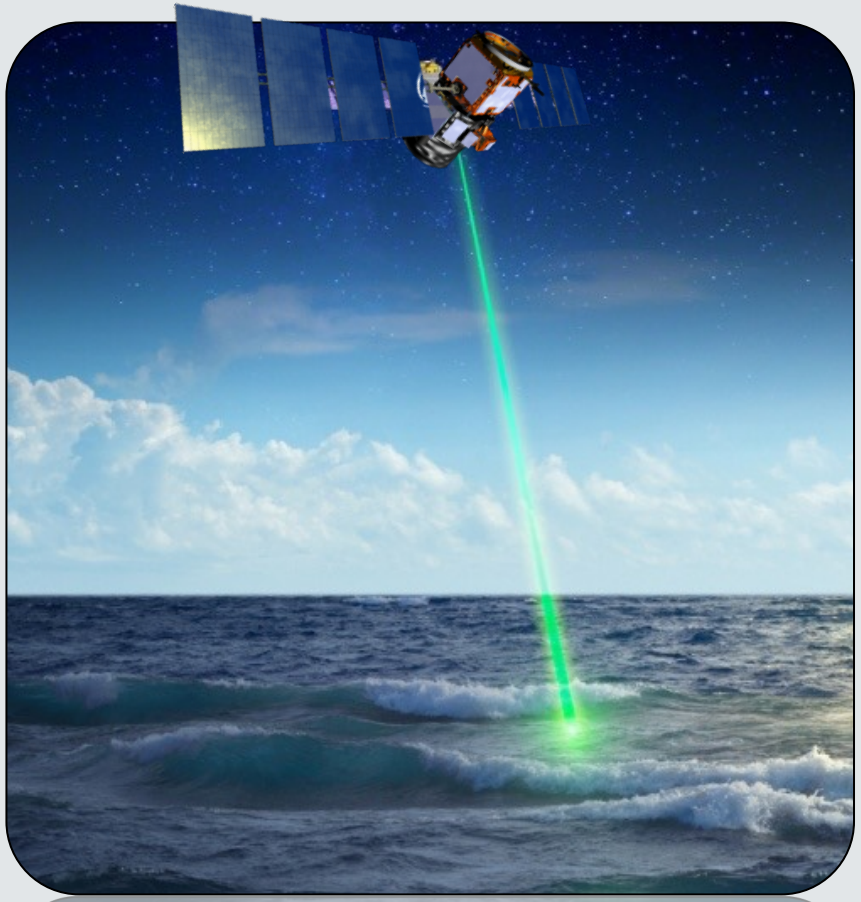
(Courtesy of Nanda et al. presentation ATMOS18)

Aeolus

CALIOP/CALIPSO Observations

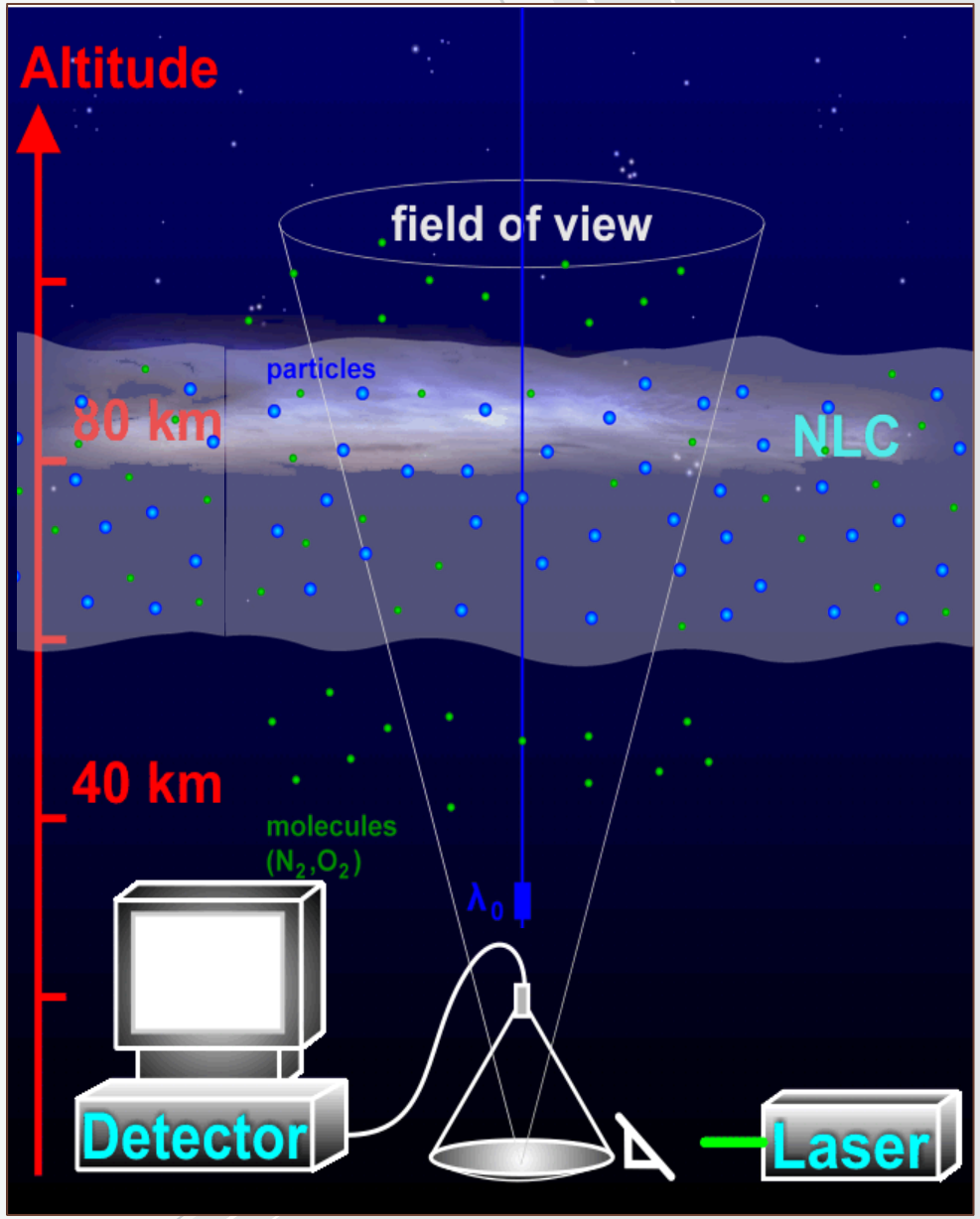
- CALIOP provides unique vertical profile measurements of the Earth's atmosphere on a global scale (Winker et al., 2010).
- CALIPSO has a narrow swath (point measurement) and a very limited global coverage. Small footprint of CALIOP measurements (~100m).
- A dual-wavelength (532, 1064nm) elastic backscatter lidar with the capability of polarization observations at 532nm.
- Level 2 products consist of the full resolution vertical feature mask, cloud and aerosol layer products reported at several different spatial resolutions, and profile products reported at a uniform 5-km horizontal resolution.
- Determines the locations of layers within the atmosphere, discriminates aerosols from clouds and **categorizes aerosol layers.**





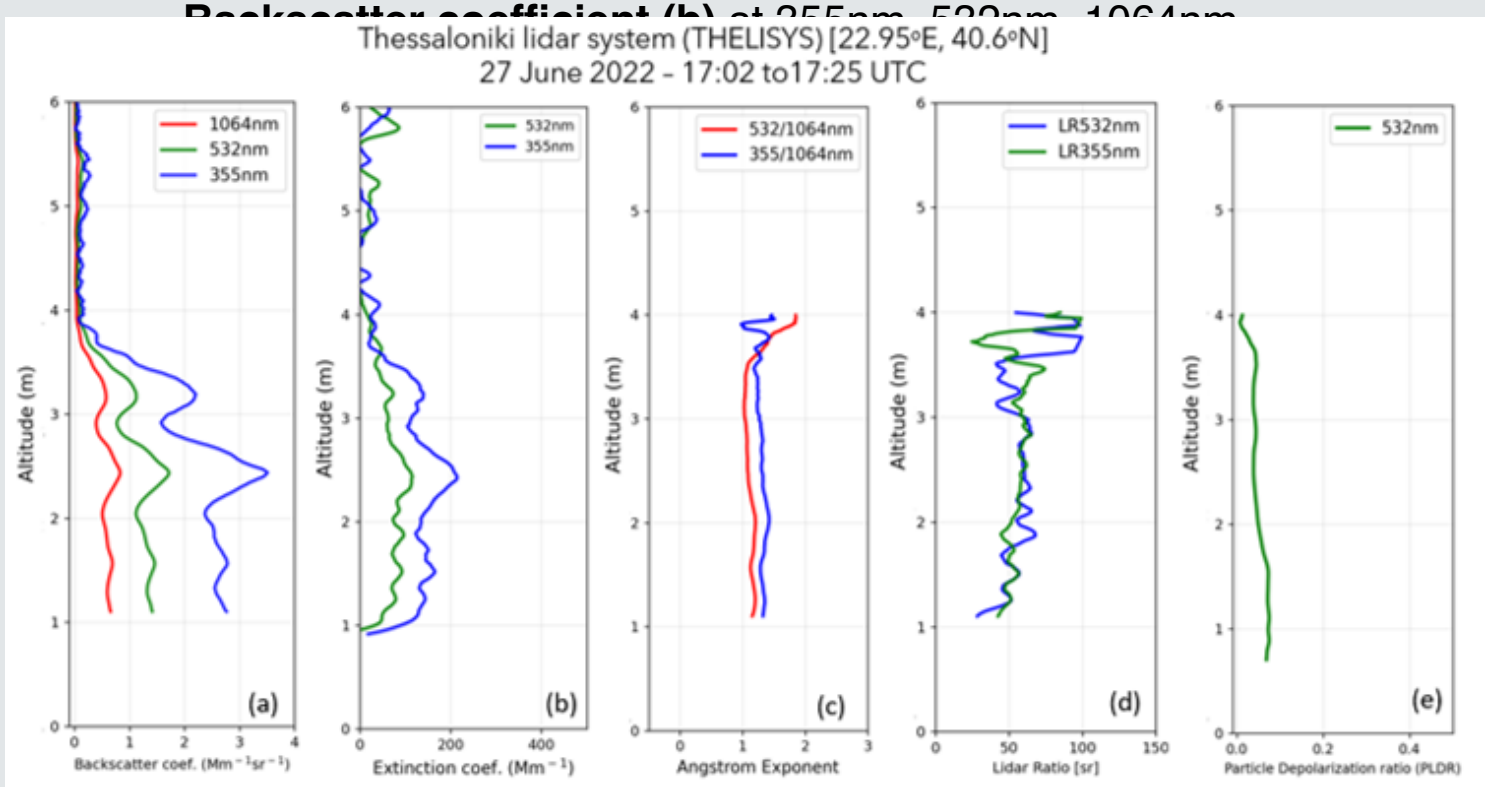
https://asdc.larc.nasa.gov/project/CALIPSO

Light Detection and Ranging (LIDAR)



Lidar Vertical profiles of:

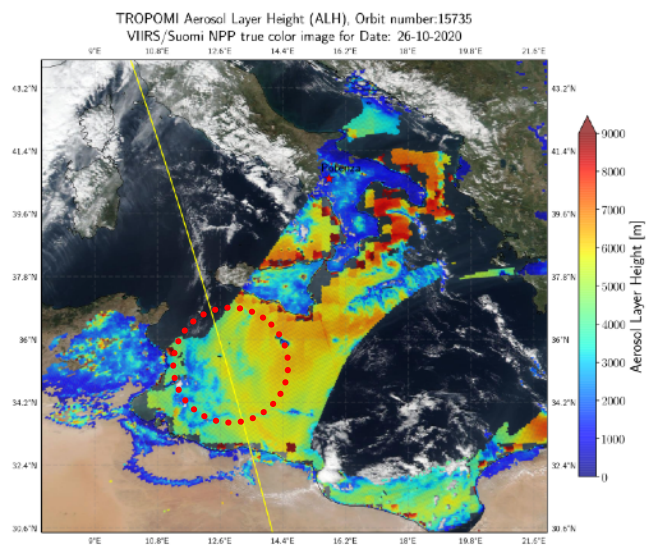
Backscatter coefficient (b) at 355nm, 532nm, 1064nm

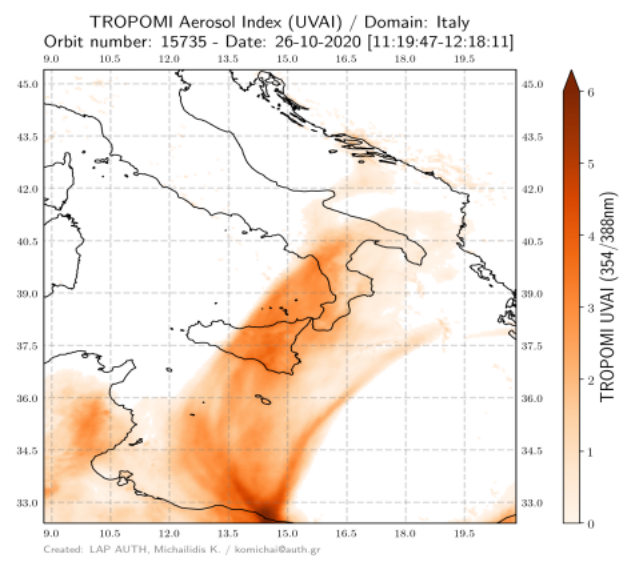


https://earlinet.org/

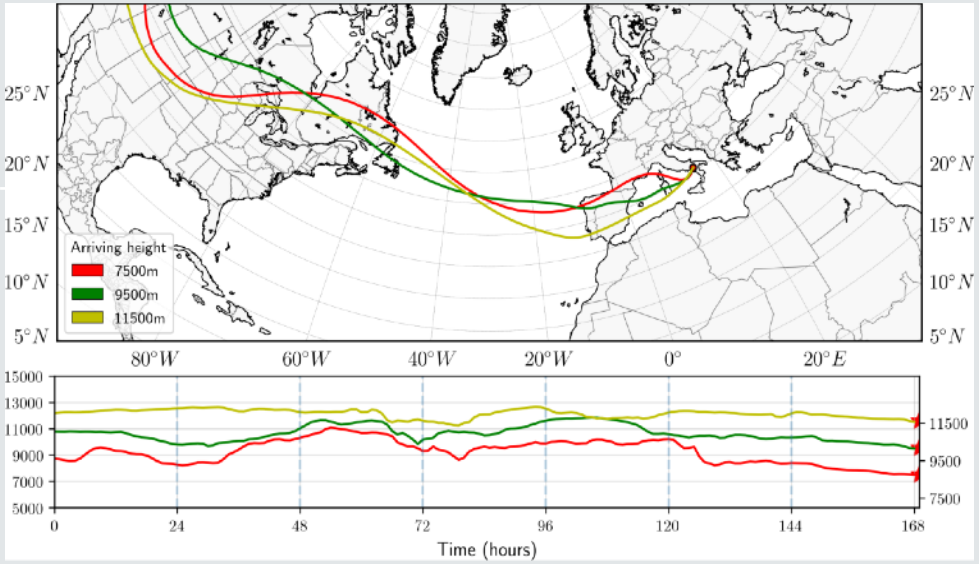
Severe dust and wild fire events

Elevated smoke plumes detected over Italy

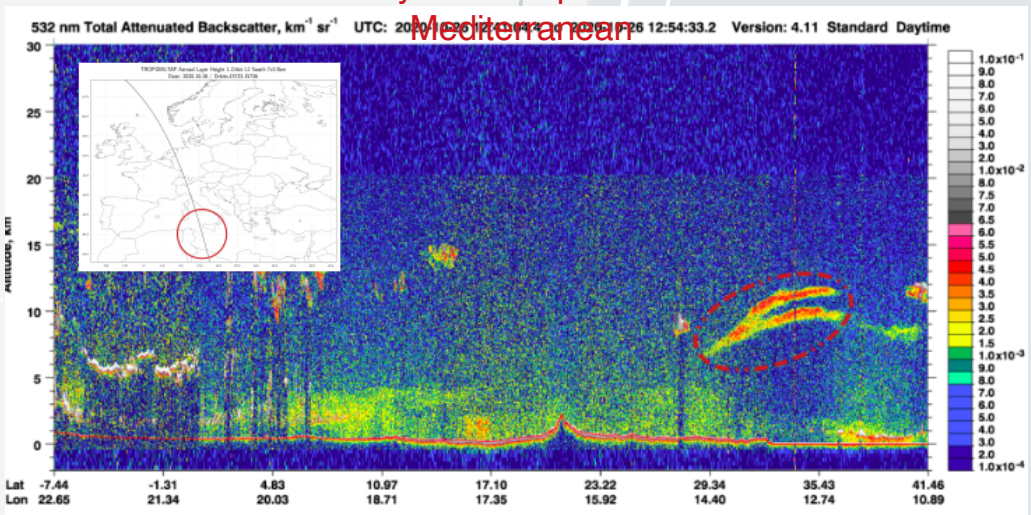


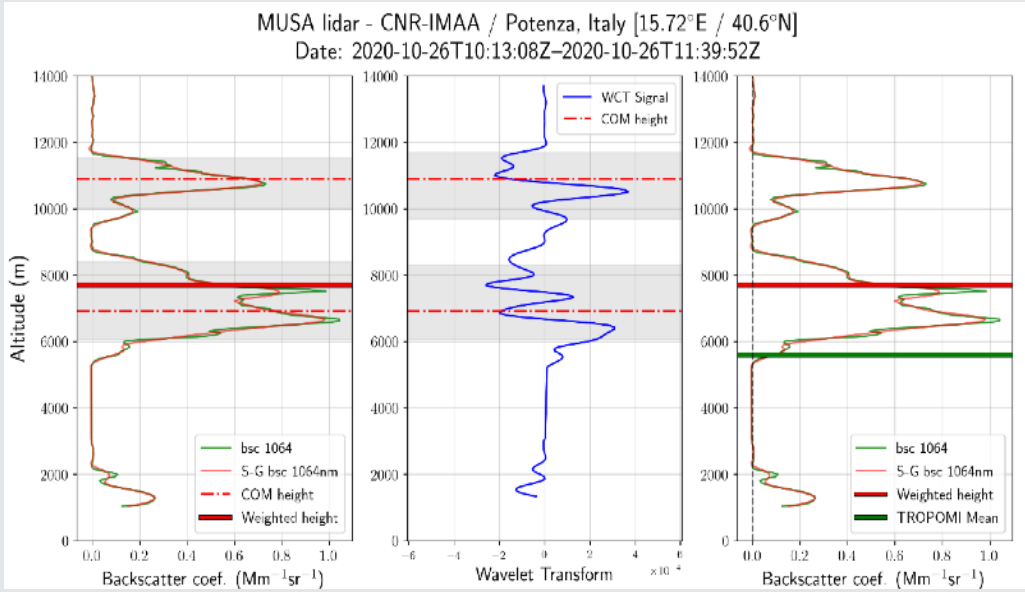


7-day HYSPLIT back-trajectories at Potenza, Italy on 26 Oct. 2020

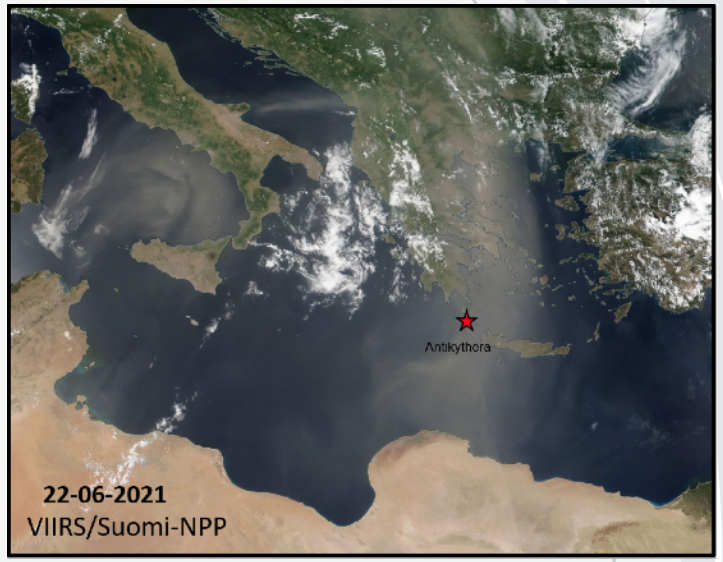


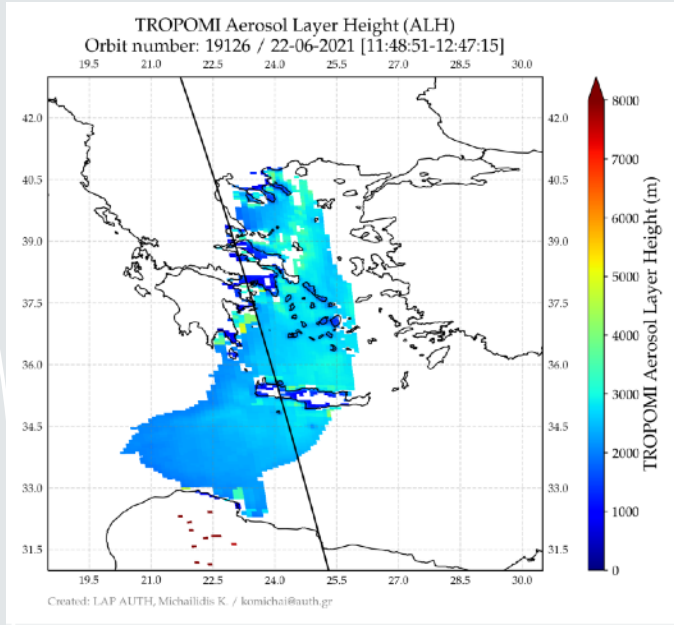
CALIPSO daytime overpass across the C. Mediterranean

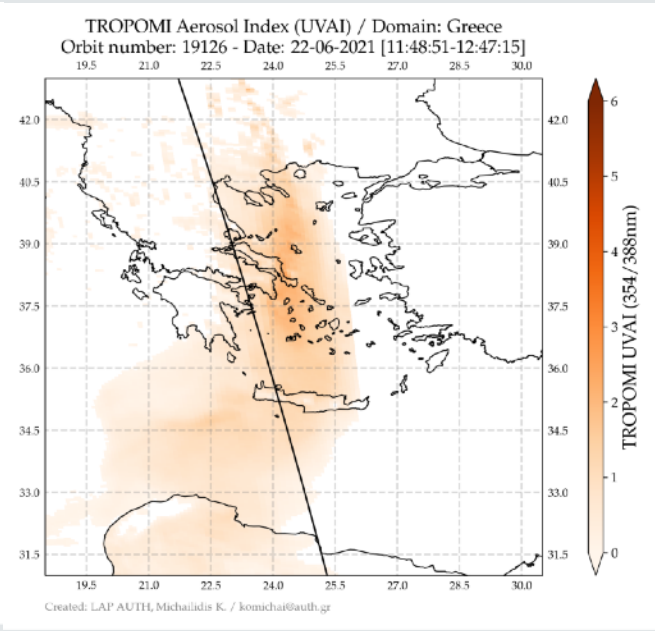


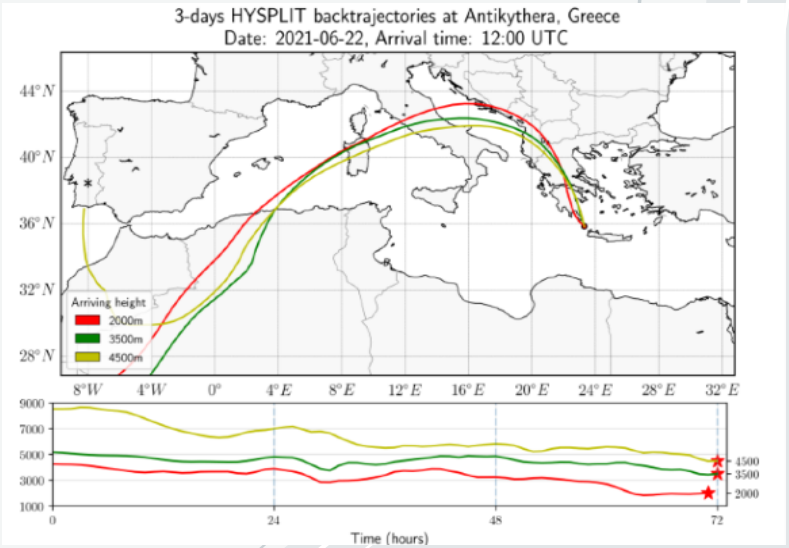


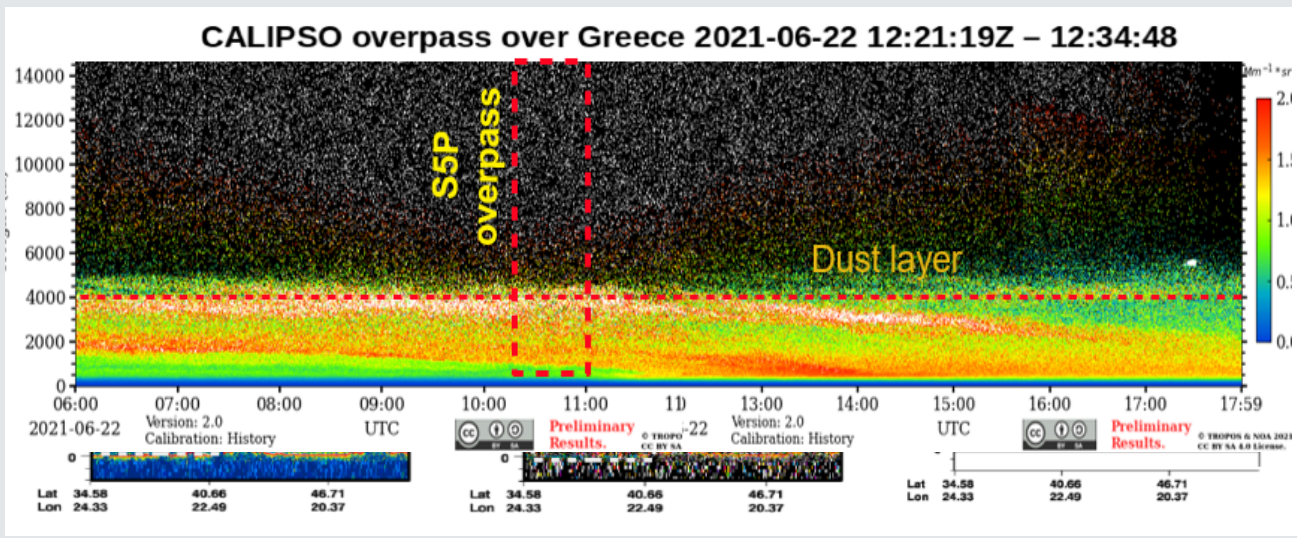
Dust case 22 June 2021 over Greece

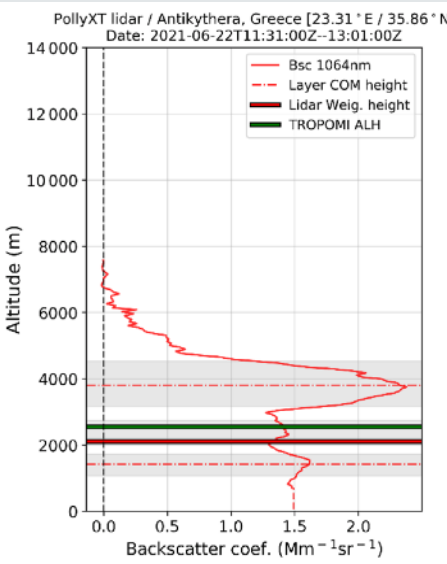




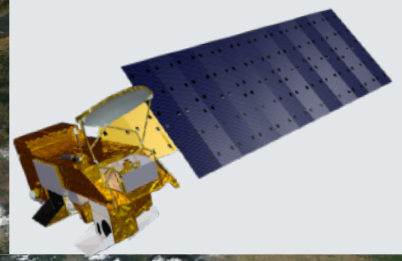


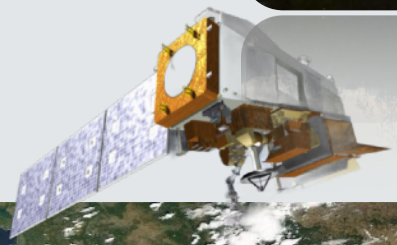


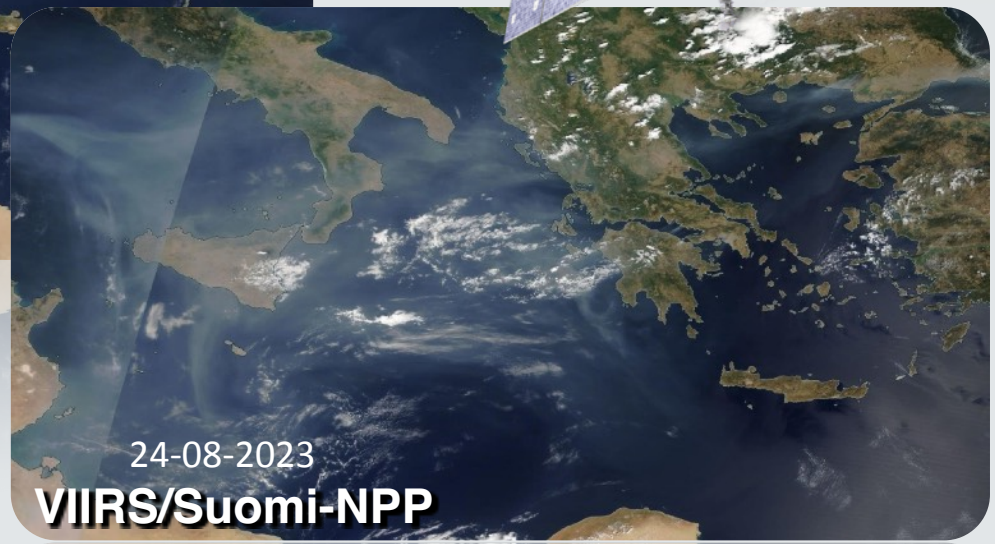




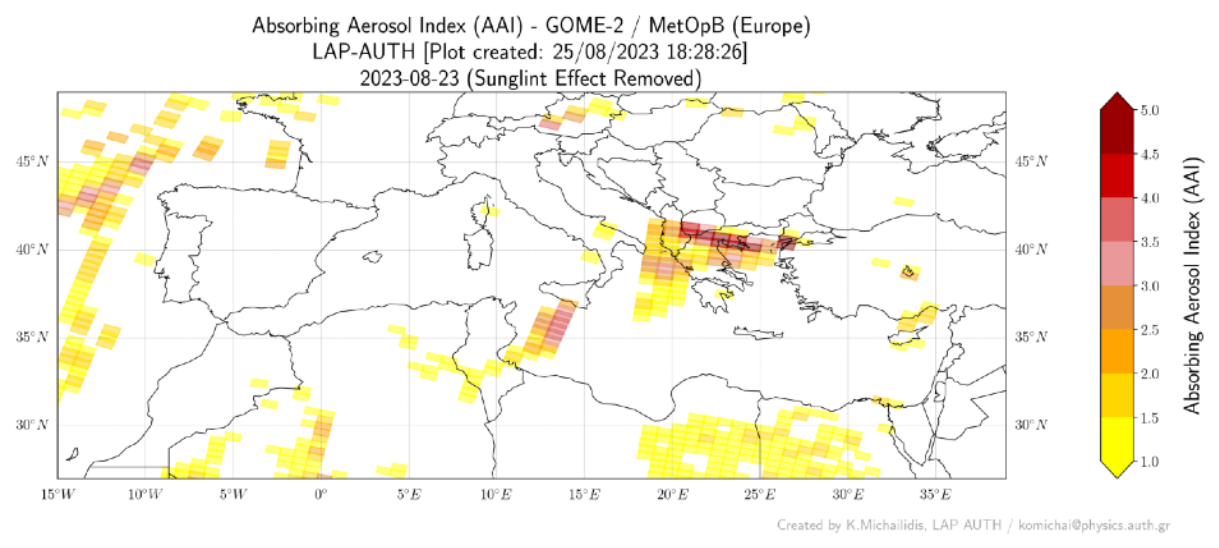
Demonstration case: Greek Fires, August 2023

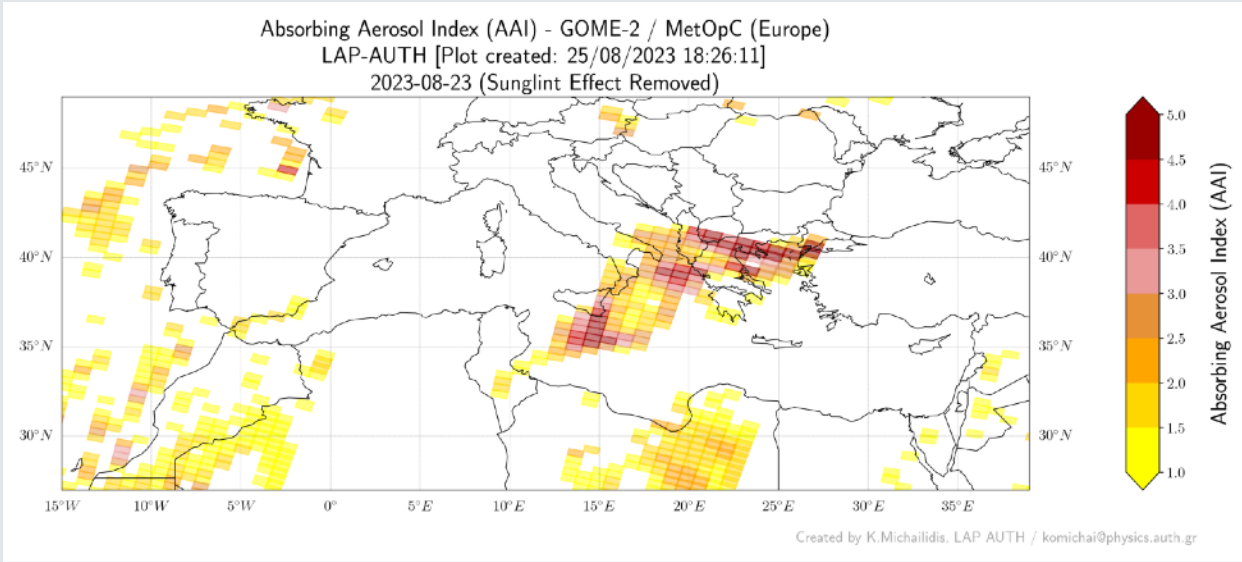


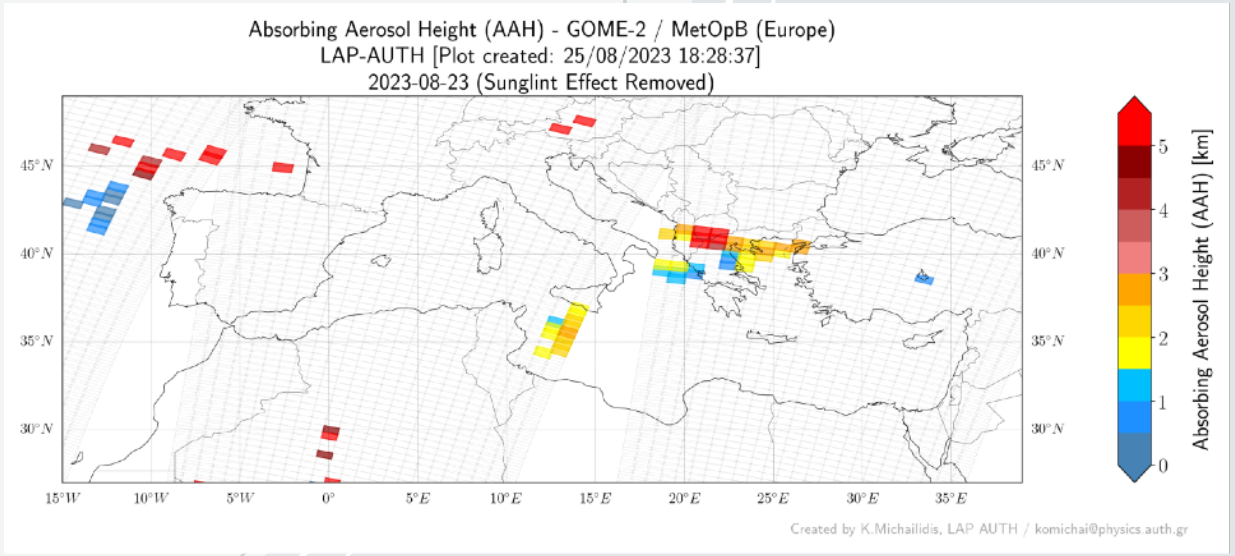


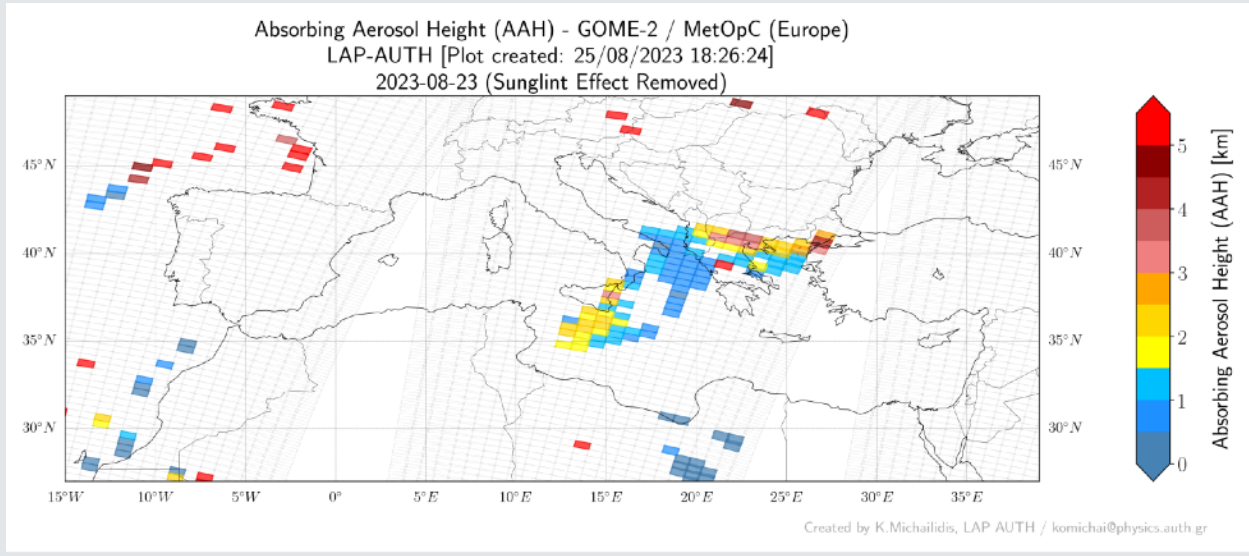


Demonstration case: Greek Fires, August 2023

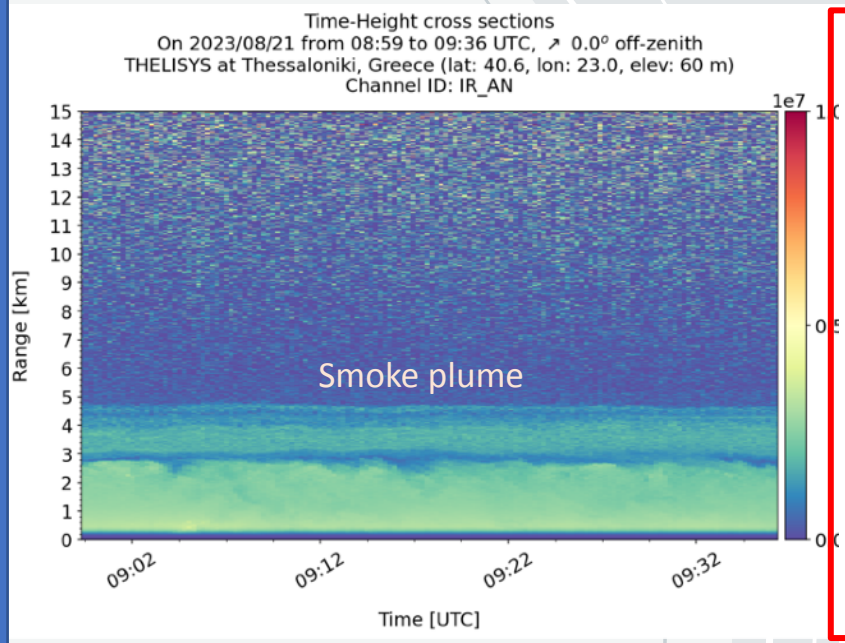


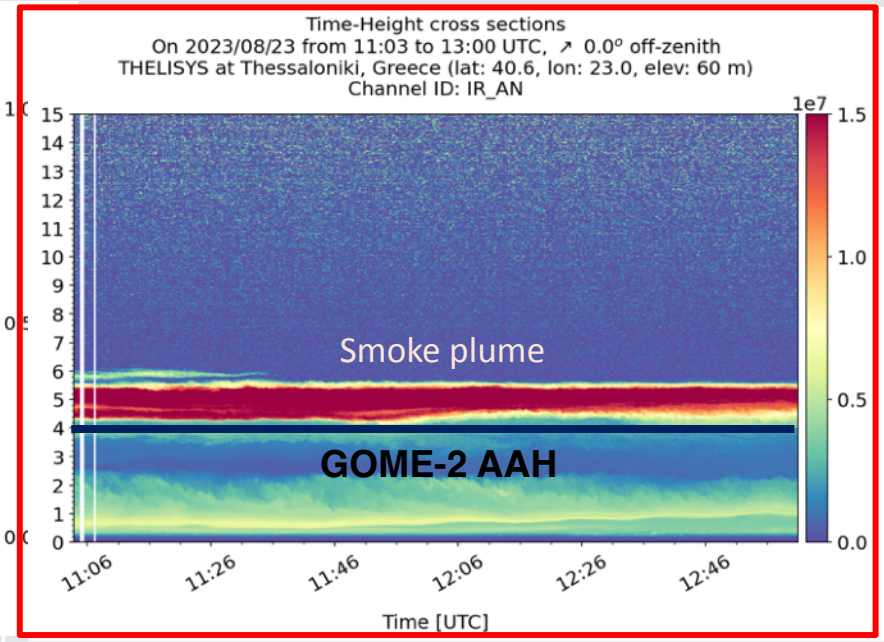


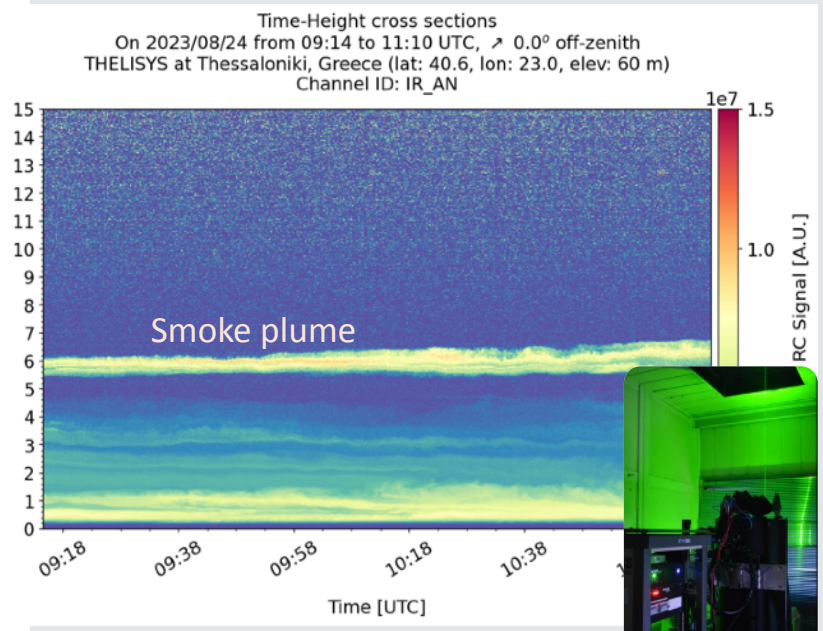


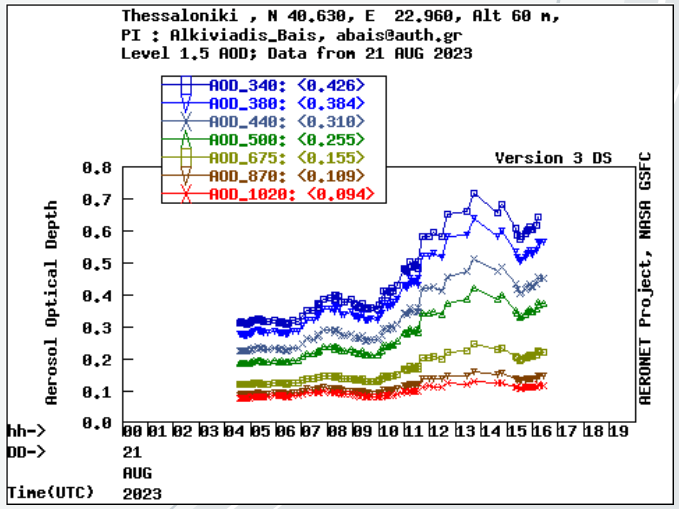


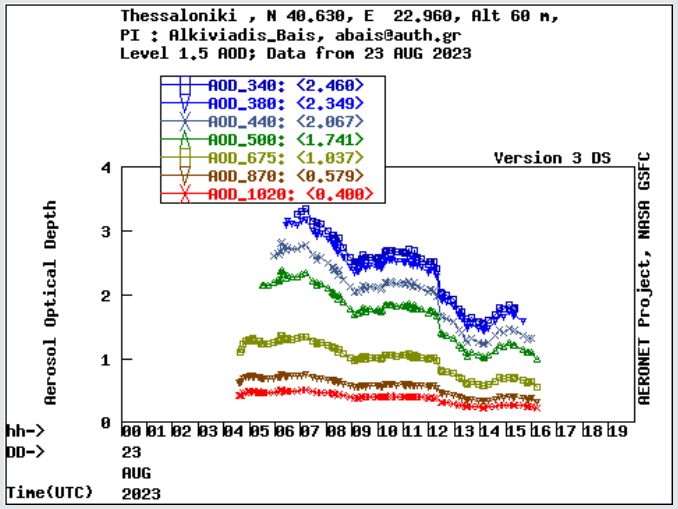
Demonstration case: Greek Fires, August 2023

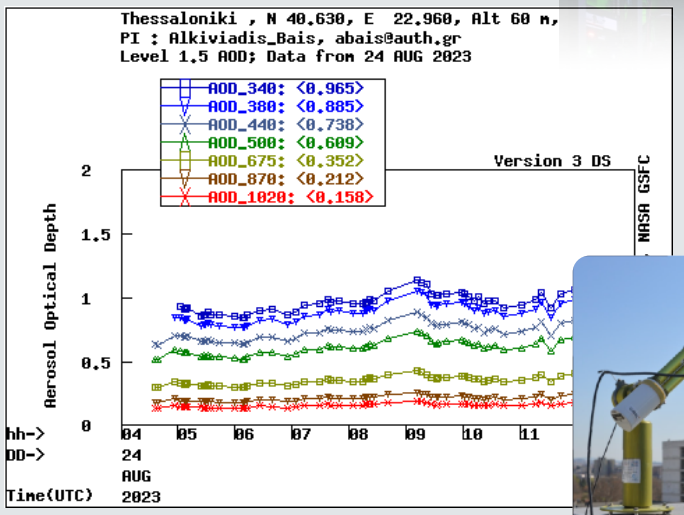






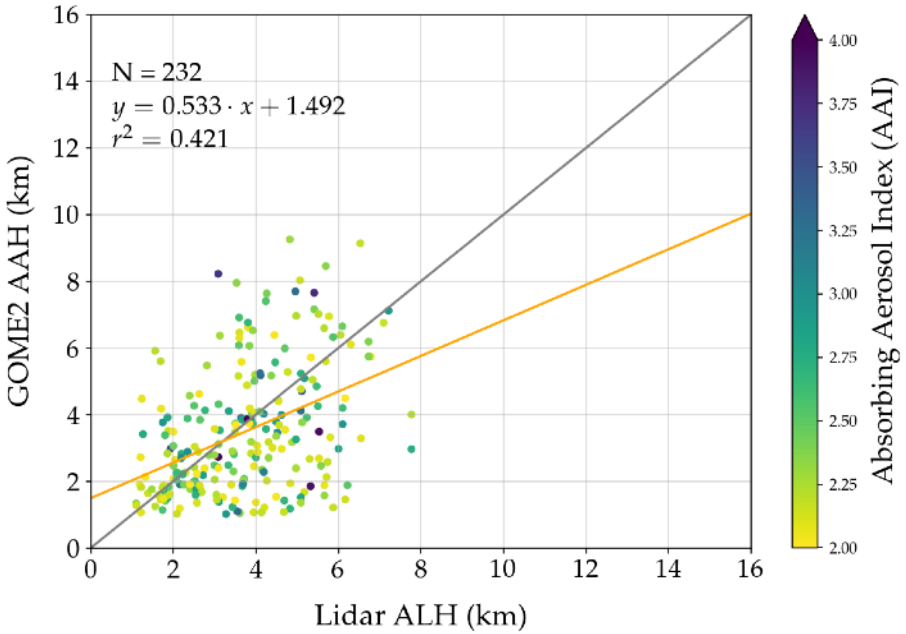


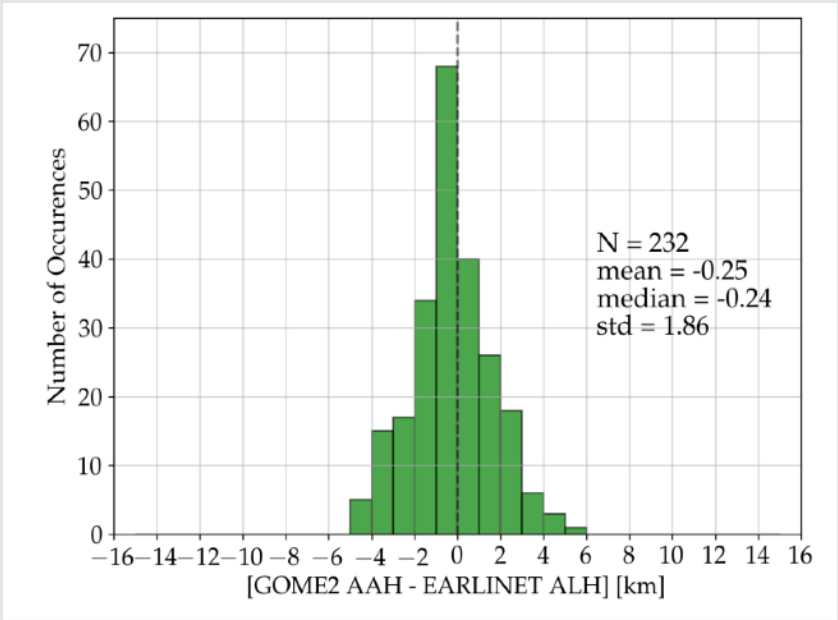


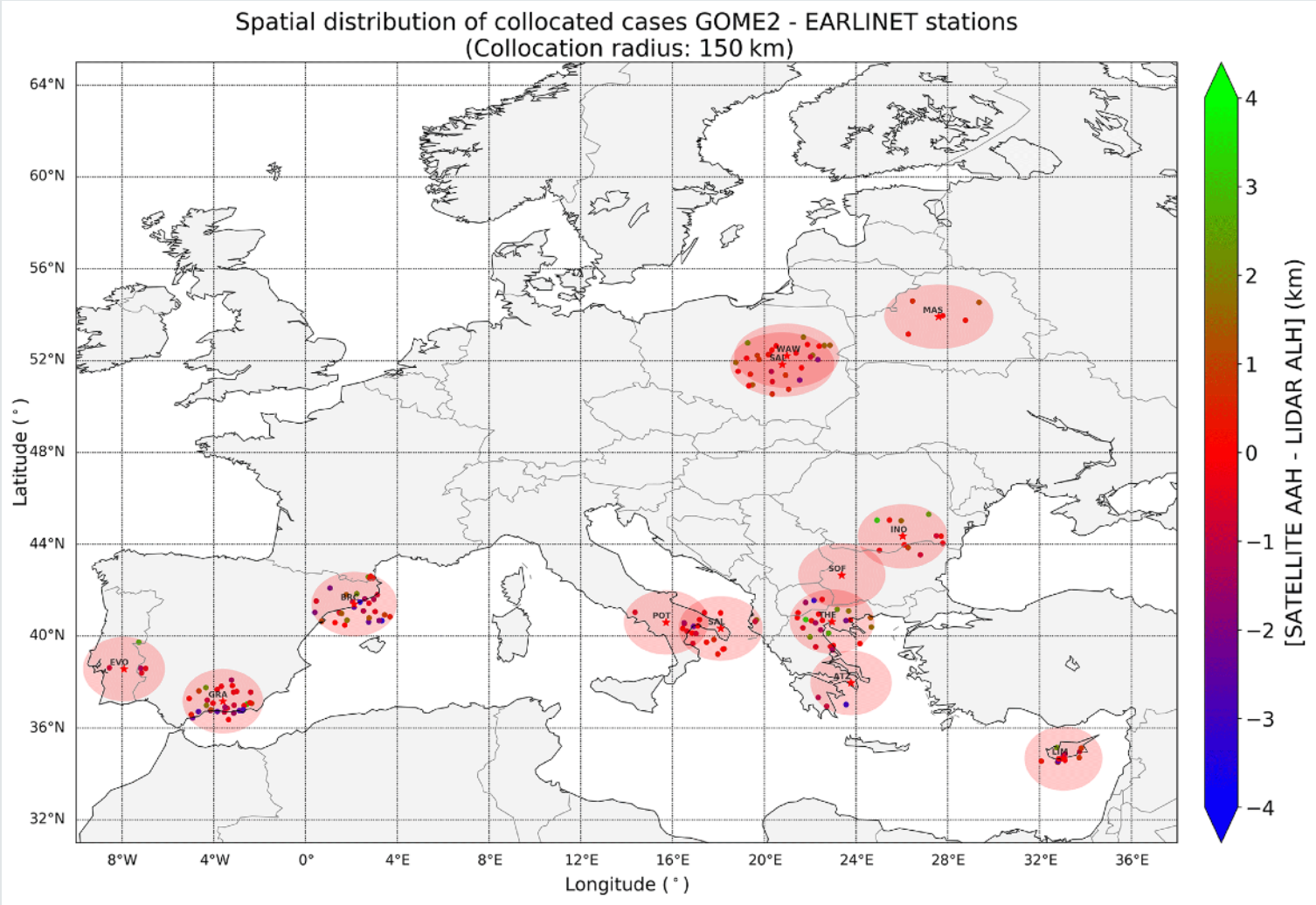


Operational validation services for ESA and EUMETSAT

GOME-2 AAH Validation

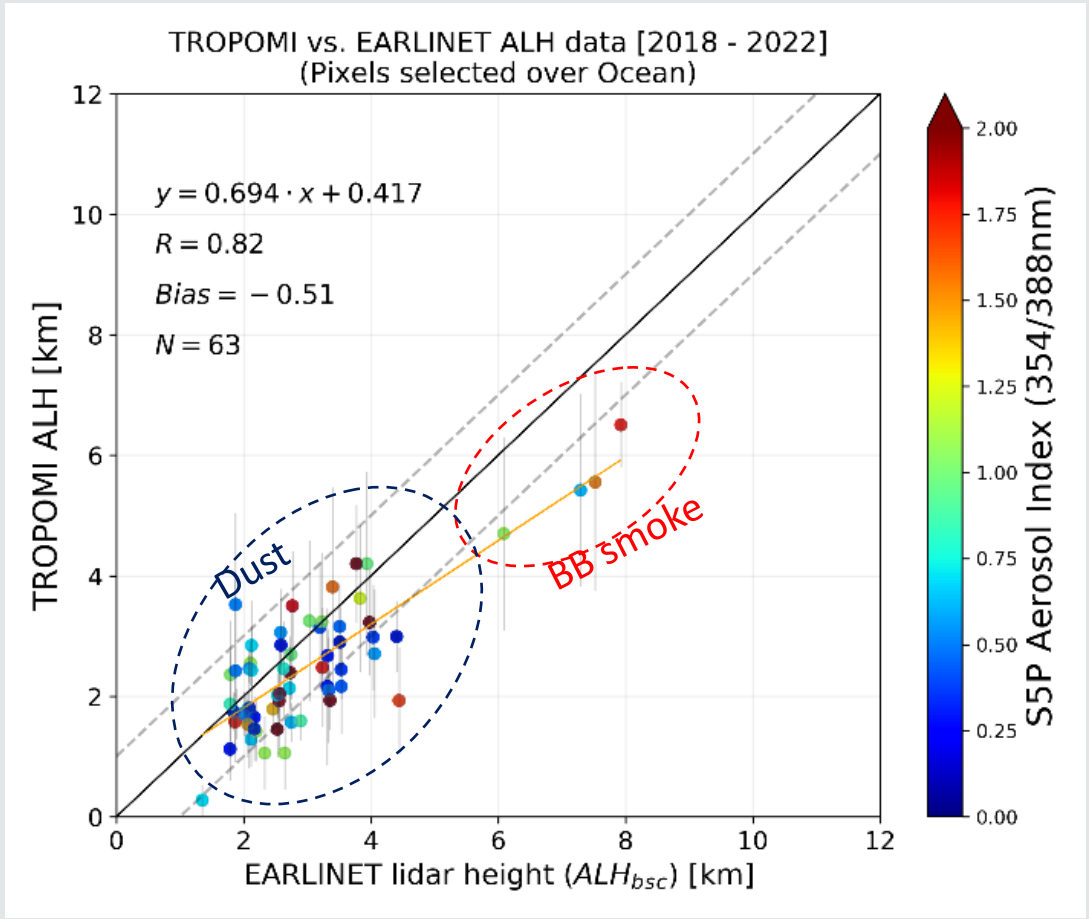


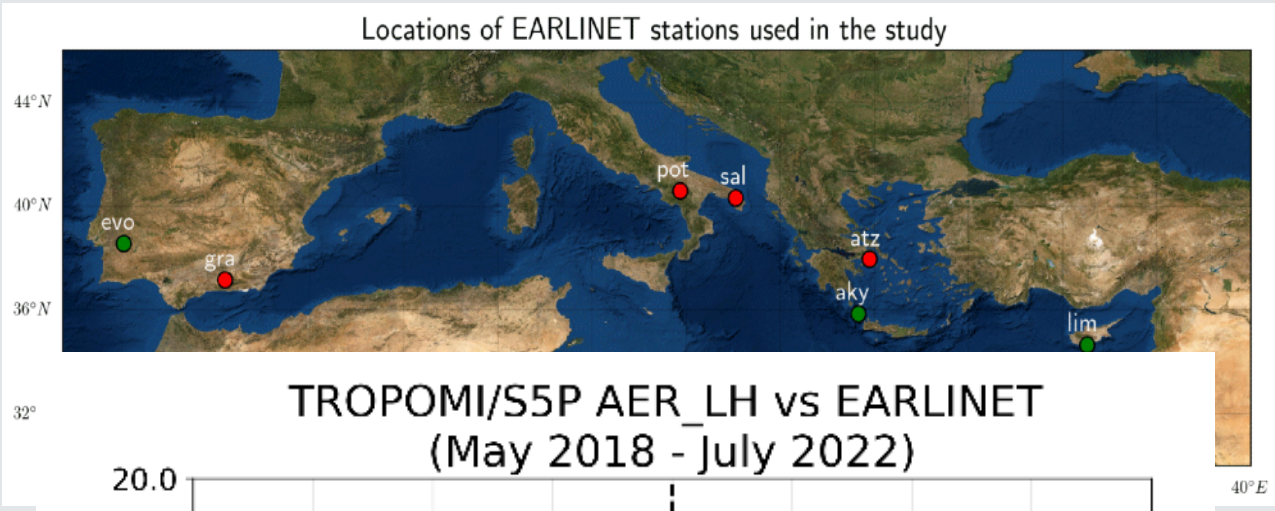


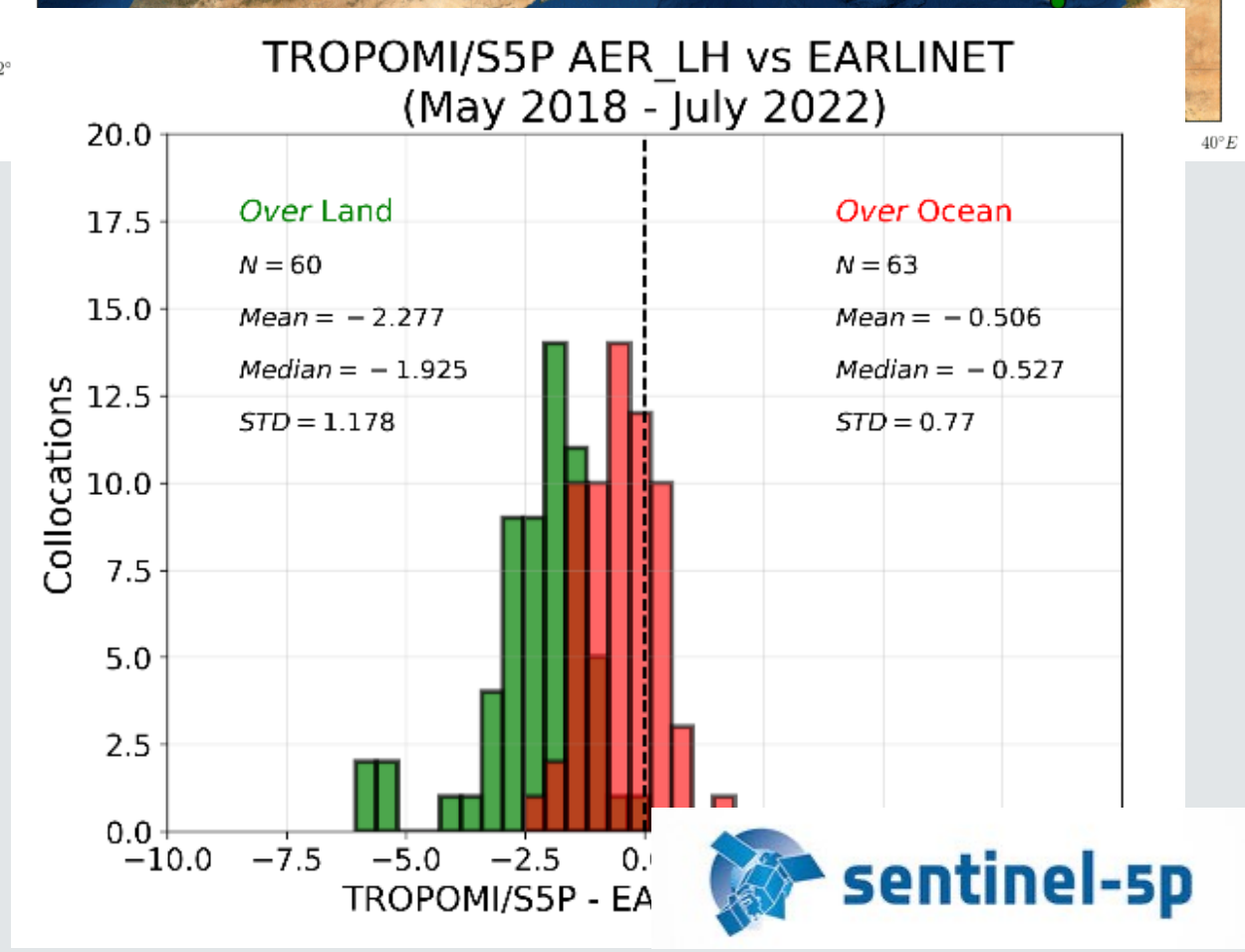


Michailidis, K., et al., ACP, 2021.

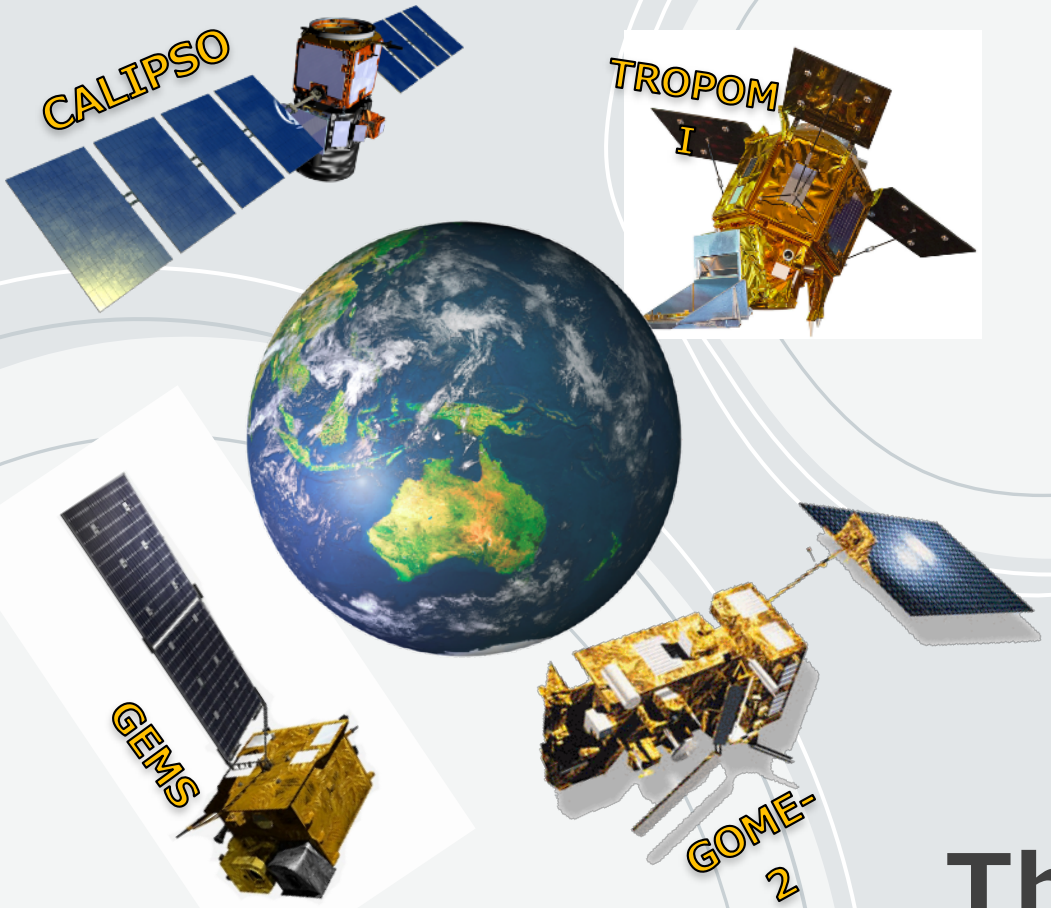
S5P/TROPOMI ALH Validation







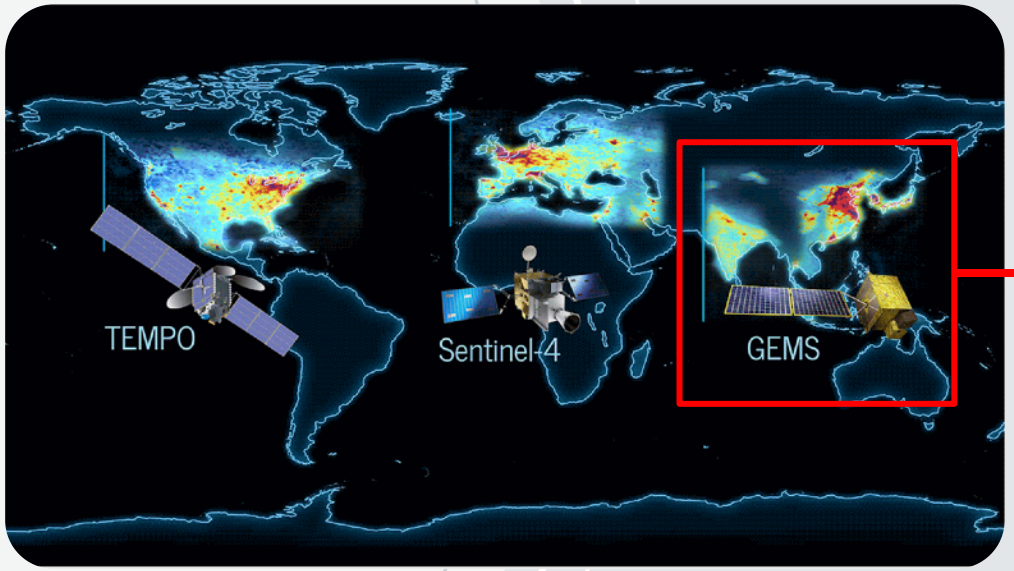
Michailidis, K., et al., ACP, 2023.



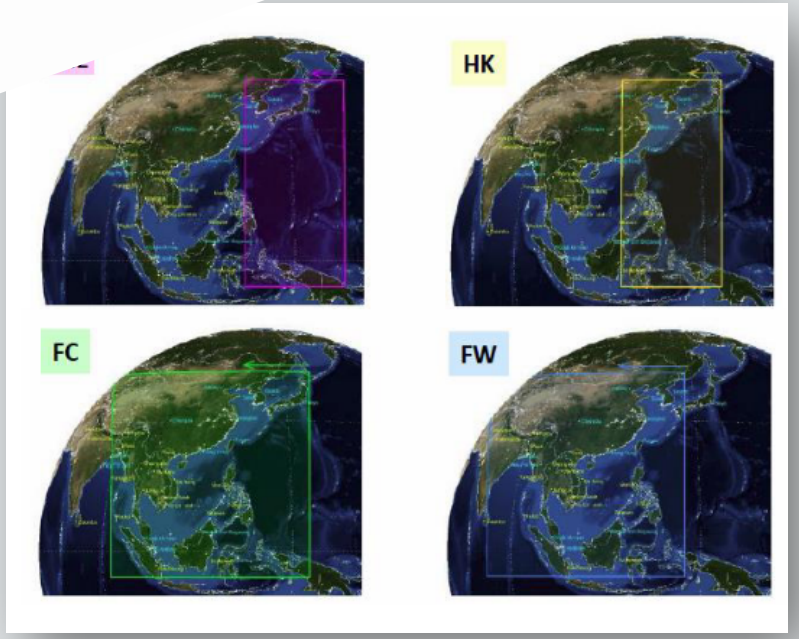
The future of space-born aerosol observations

Geostationary Aerosol Height Validation

Geostationary passive satellites
GEMS, TEMPO, Sentinel-4



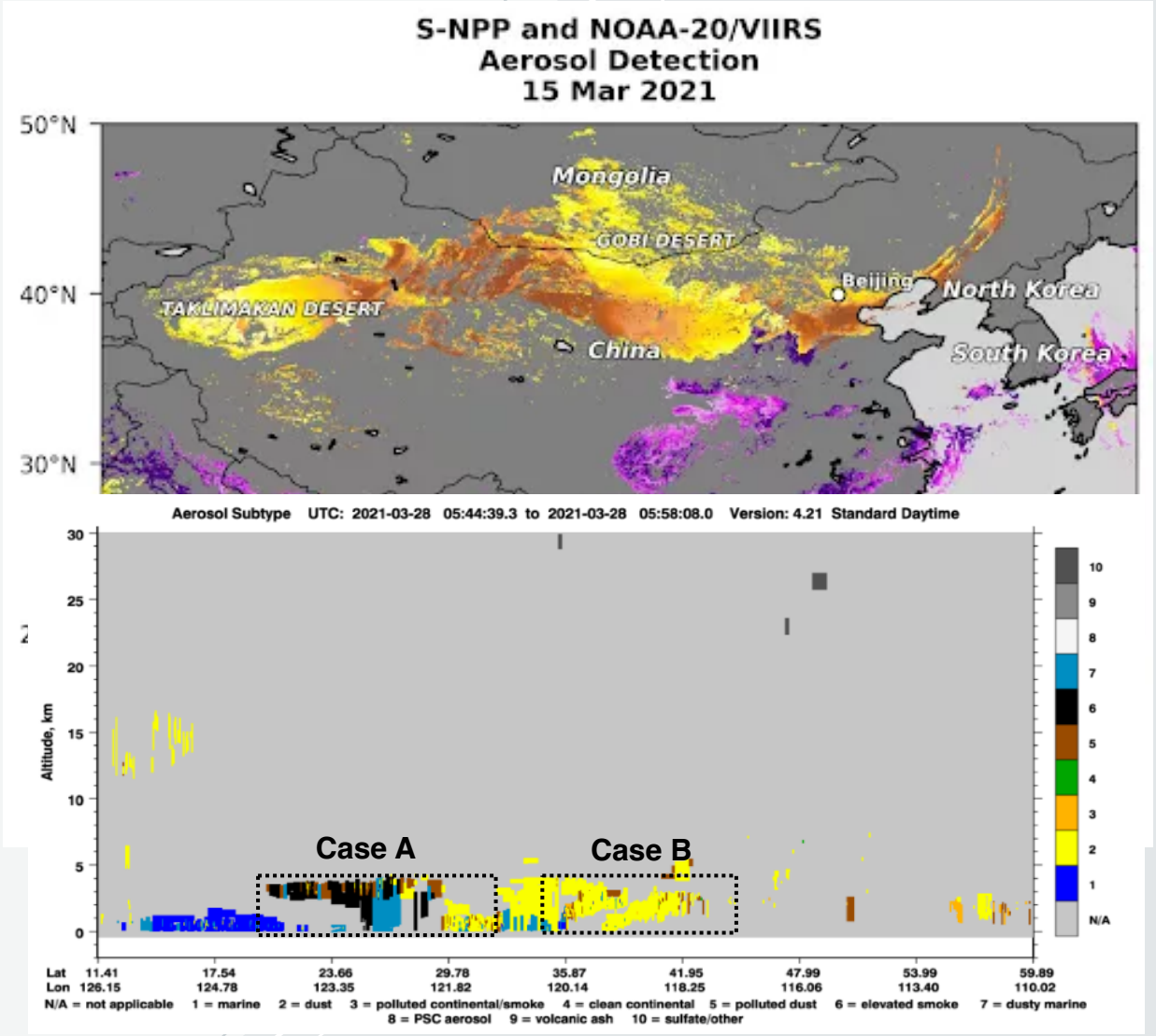
Able to provide Aerosol Layer height products on high resolution.



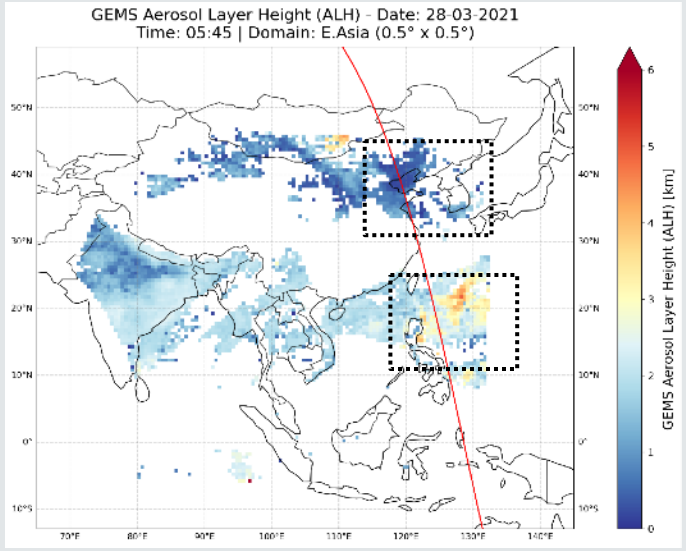
ESA PEGASOS Project

Dust event over Asia – March 2021

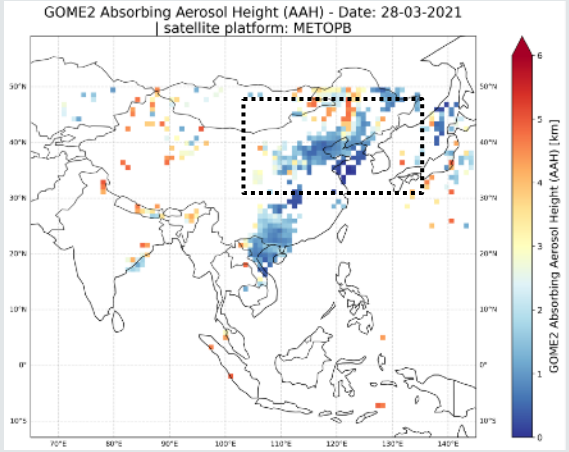
One of the worst sand and dust storms in a decade hit Mongolia, northern China and other parts of Asia



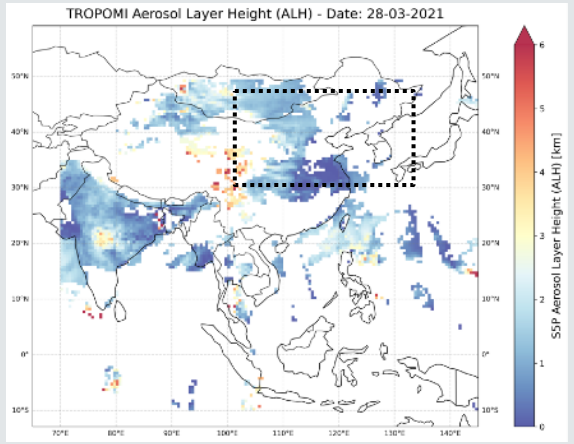
GEMS ALH



GOME-2/MetOpB AAH



TROPOMI/S5P ALH



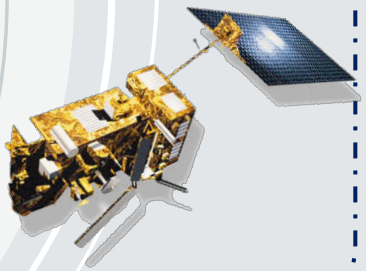
LAP-Auth Validation Tool

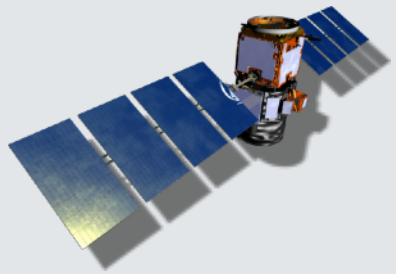
ATLANTIS: Visualization and Analysis Tool for validating satellite aerosol products

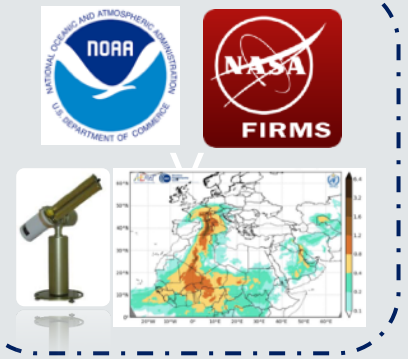
Ground-based Data (EARLINET Database)

Satellite Data (GOME-2, TROPOMI, CALIPSO)

Additional (models, satellites, etc)







The validation tool & methodology have been developed in the framework of the projects:

EUMETSAT AC SAF (a) ACSAF , (b) QA4EO-IDEAS, (c) S5P+I QA4EO