Main use of biomass burning emissions in CAMS

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@m_parrington

Atmosphere Monitoring

SEEDS General Assembly and Stakeholder Engagement Meeting

30 March 2023

Acknowledgements:
Sebastien Garrigues, Vincent-Henri Peuch, Melanie Ades, Anna Agusti-Panareda, Richard Engelen, Johannes Flemming, Antje Innes, Zak Kipling, Nicolas Bousserez, Ernest Koffe, Panagiotis Kountouris (ECMWF)
Johannes Kaiser (DWD)
Martin Wooster (KCL)
CAMS development teams

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Earth Observation satellites in CAMS

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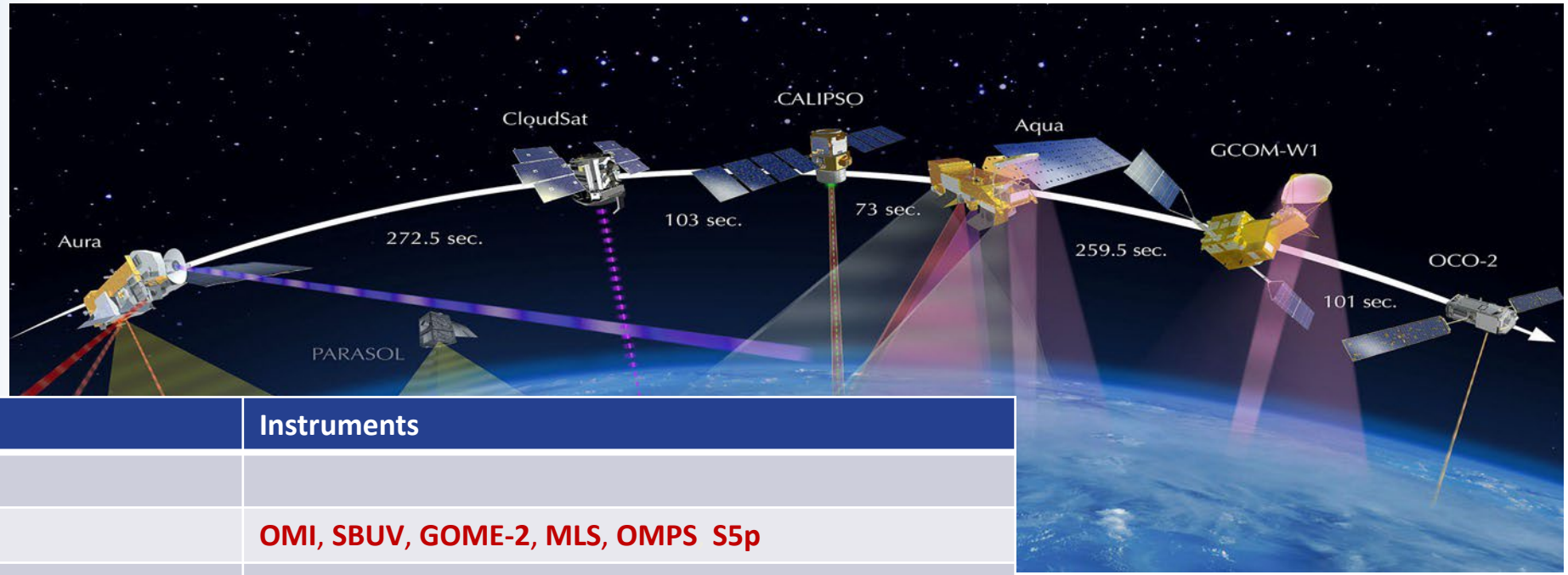

Species	Instruments
Global system	
O_3	**OMI, SBUV, GOME-2, MLS, OMPS S5p**
CO	**IASI, MOPITT, S5p**
NO_2	**OMI, GOME-2, S5p**
SO_2	**OMI, GOME-2, S5p**
Aerosol	**MODIS, PMAp,** VIIRS, S3
CO_2	**GOSAT, OCO-2**
CH_4	**GOSAT, IASI,** S5p
GFAS fire emissions	**MODIS, SEVIRI*, VIIRS,** Sentinel-3, GOES-E/W*, HIMAWARI-8*

Assimilated **Monitored** Under development

*Geostationary platform

CAMS uses Earth Observation data from many satellites for atmospheric composition and weather.

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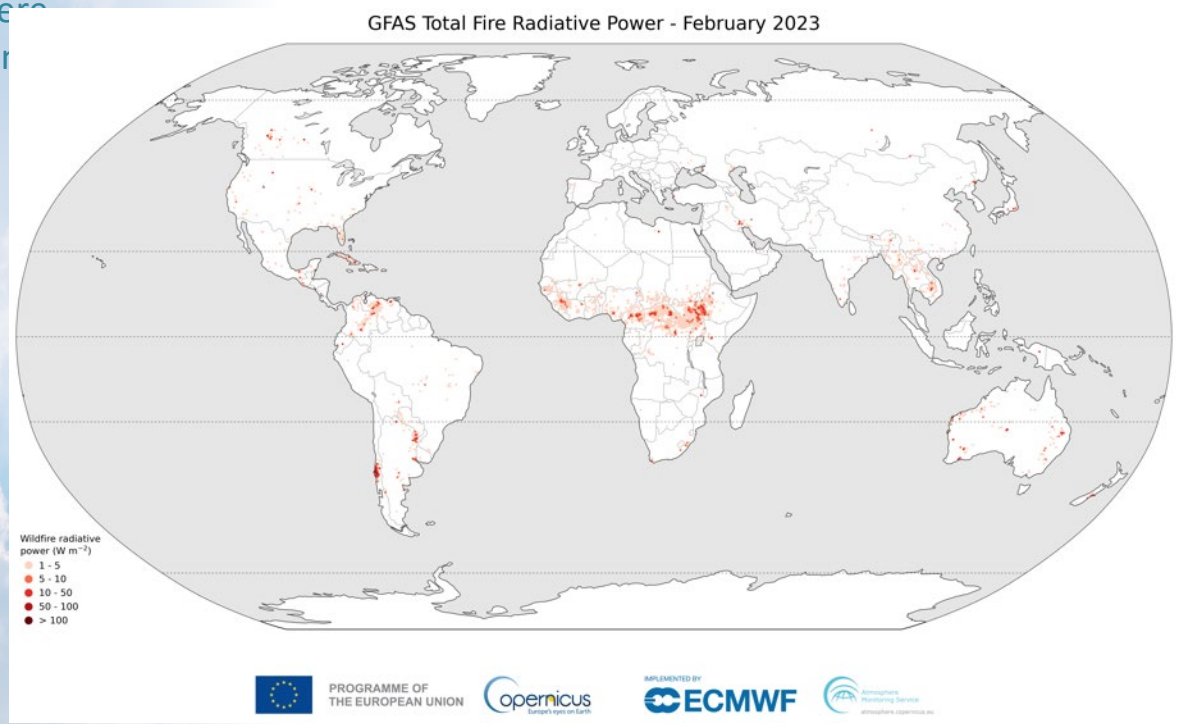
Estimating Global Wildfire Emissions



- Main uses:
  - Input for CAMS global and regional operational systems
  - Applied to many other models across the atmospheric chemistry modelling community
  - Communication activities (e.g., CAMS communication & press; BAMS & C3S state of the climate reports; presented at workshops for various wildfire-related activities)

- Global Fire Assimilation System (**GFAS**); see https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-global-fire-emissions-gfas?tab=overview
- Uses satellite observations of Fire Radiative Power (FRP)
  - Currently Aqua and Terra MODIS FRP observations
  - FRP from VIIRS, Sentinel-3, and geostationary satellites are being tested for future implementation
- Global Coverage at ~10km Resolution
  - *Daily Output: 1-day behind NRT*
  - Hourly Output (+24-h means): 7-hours behind NRT
- Emissions of aerosols and gases are estimated using factors dependent on vegetation type.
- Injection heights calculated with Plume Rise Model and IS4FIRES

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Estimating wildfire emissions

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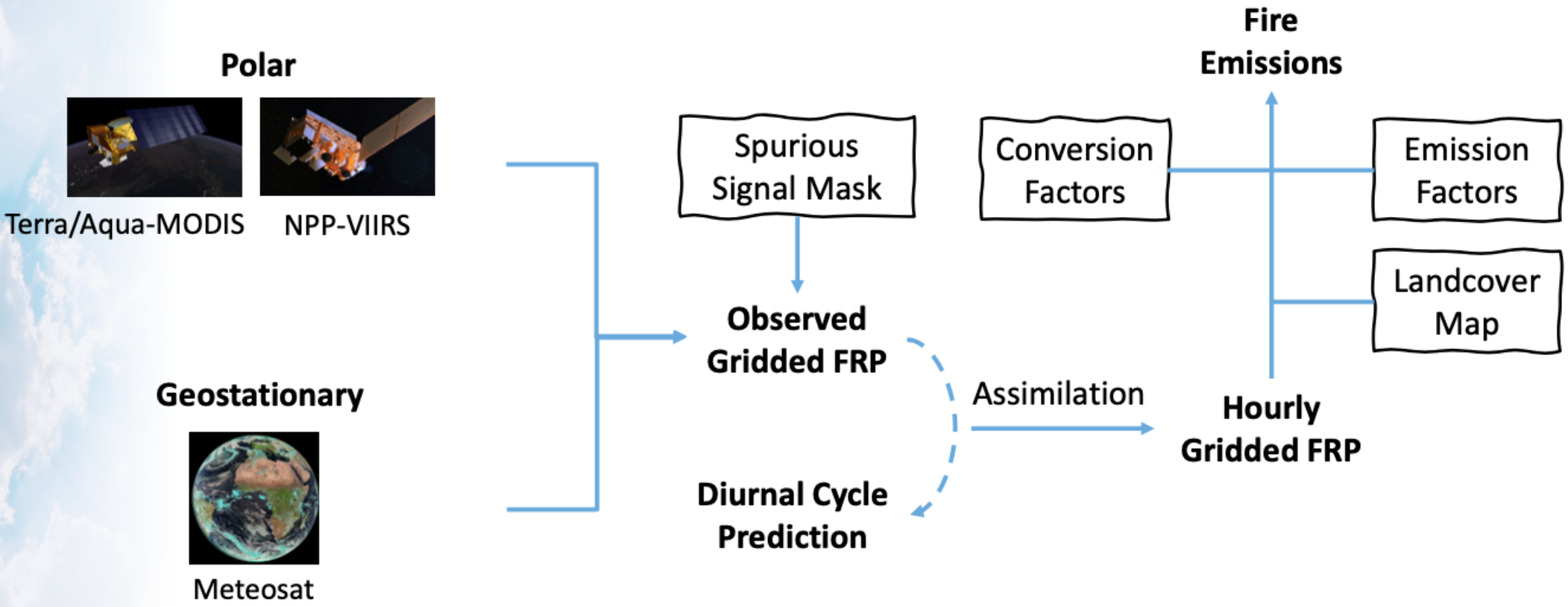


Estimating wildfire emissions

Atmosphere Monitoring

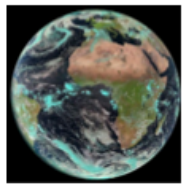
Polar

Terra/Aqua-MODIS

NPP-VIIRS

+ Sentinel3-SLSTR

Geostationary



Meteosat

+ GOES-E/-W + Himawari

Updated based on scientific literature

Spurious Signal Mask

Conversion Factors

Fire Emissions

Emission Factors

Landcover Map

Observed Gridded FRP

Assimilation

Hourly Gridded FRP

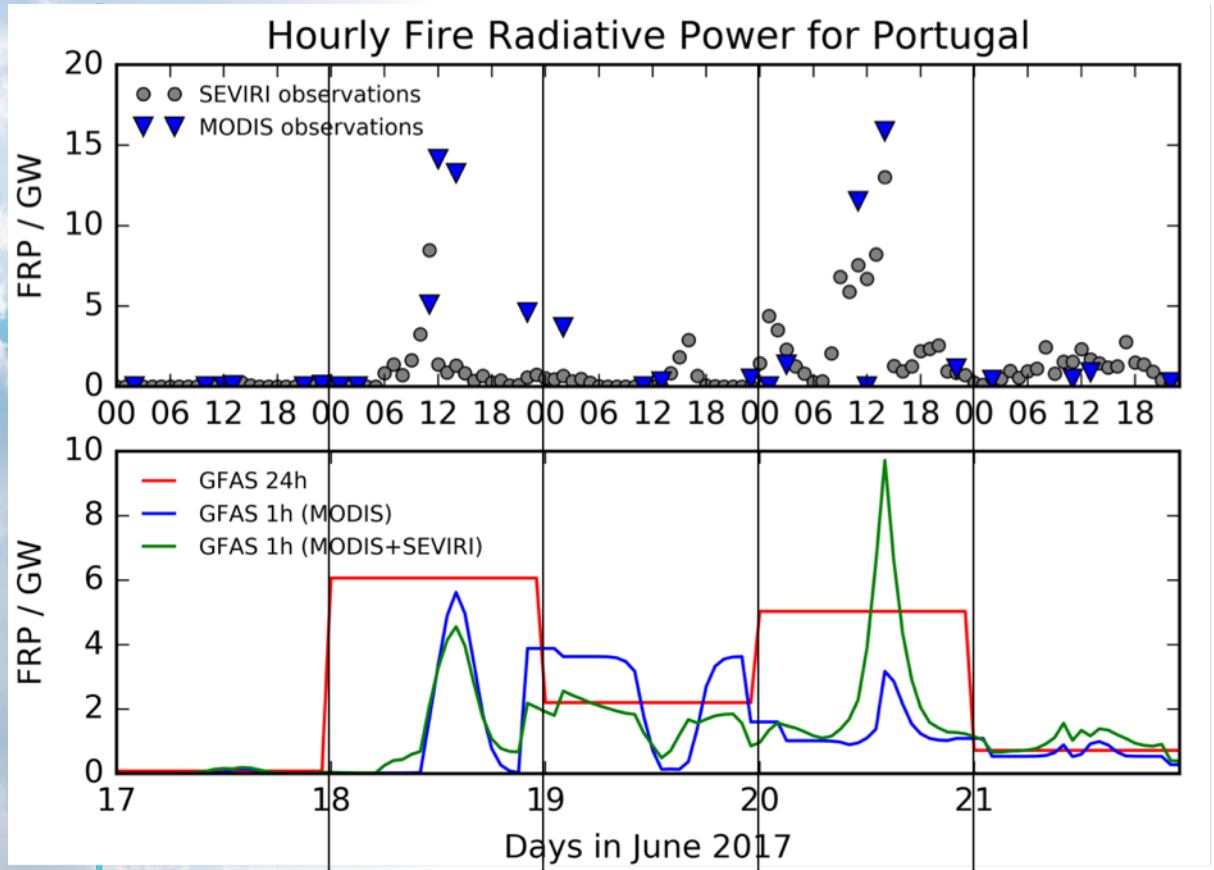
Diurnal Cycle Prediction

Injection Heights

GFAS hourly fire emissions

Atmosphere Monitoring

Portugal fires 17-22 June 2017: diurnal cycle (including LEO+GEO obs) improves temporal profile of fire emissions



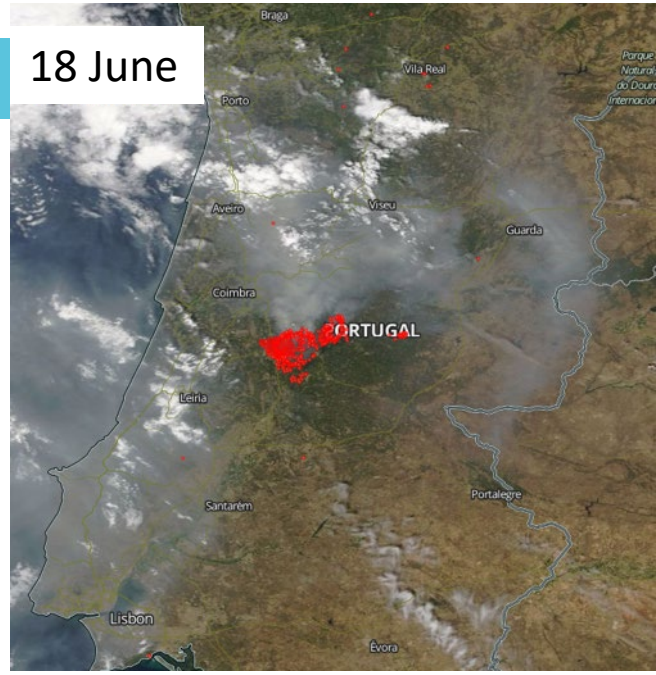
- Fire start reported in afternoon
- but no observations
- Portugal always at the edge of night-time MODIS swaths

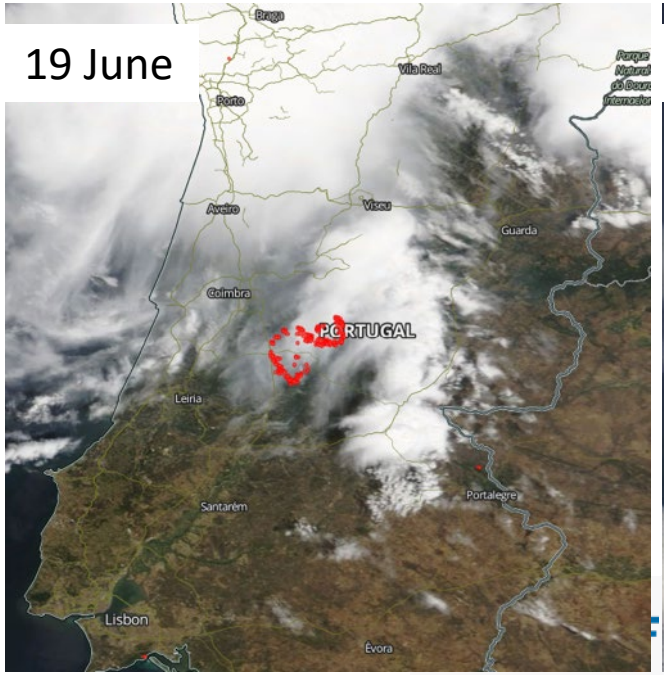
- Fires raging
- First detected at 11 UTC

- Fires burning through the night
- Clouds limit daytime observations

- Fires flare up again

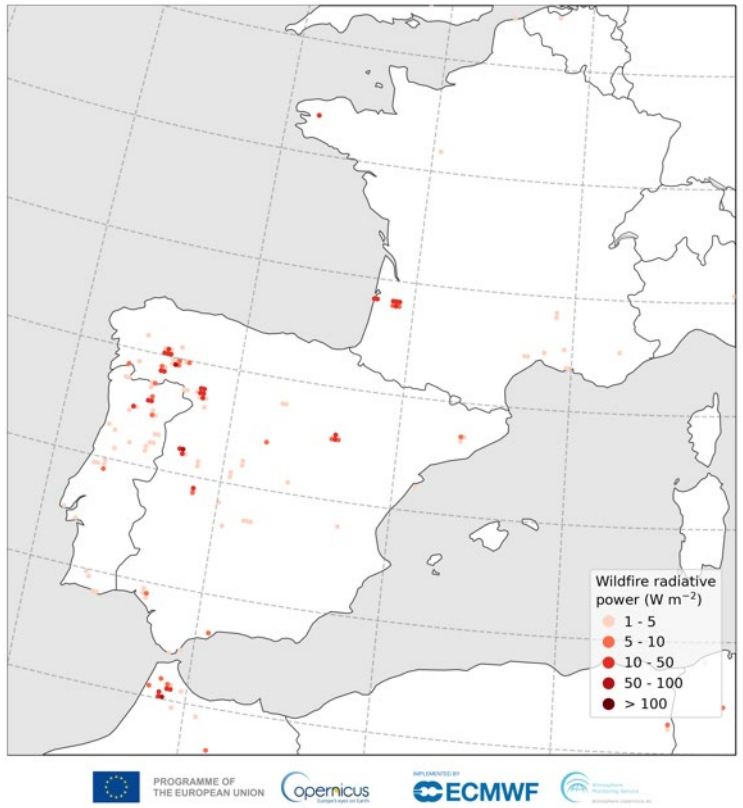
- Distinguishing fires
- extinct at 22/23-06



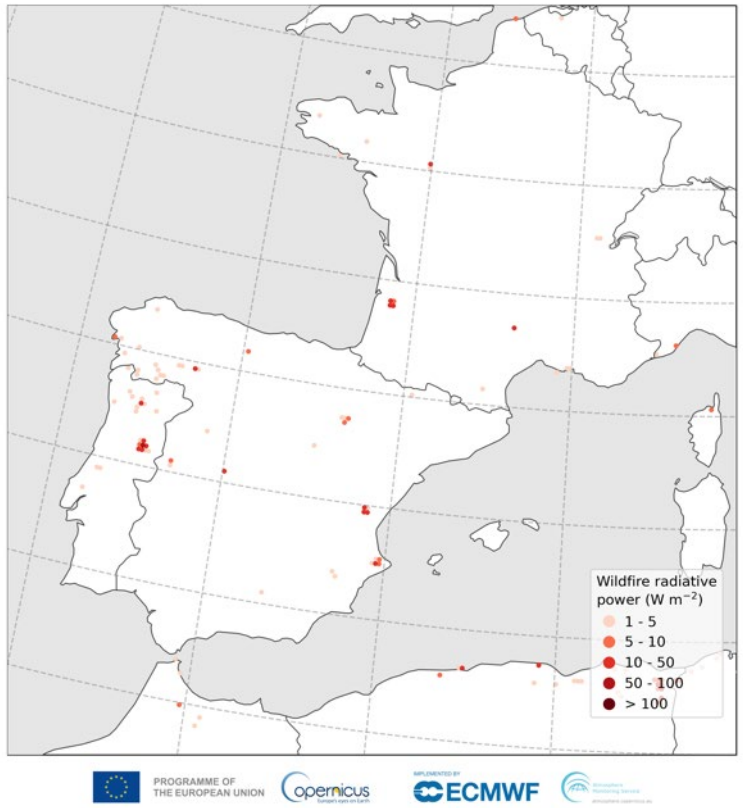


SW Europe wildfires summer 2022: emissions

GFASv1.2 Total Fire Radiative Power: 2022-07-01 - 2022-07-31



GFASv1.2 Total Fire Radiative Power: August 2022



- Numerous large-scale wildfires across SW Europe in July and August 2022.
  - Also several significant fires across central parts of Europe (e.g., Germany, Czechia, Slovenia, Greece) but focus here on SW Europe.
- CAMS GFAS data provide near-real-time (within 7 hours) information on intensity and estimated emissions of wildfires (and open burning).
  - 20-year dataset provides context.

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SW Europe wildfires summer 2022: emissions

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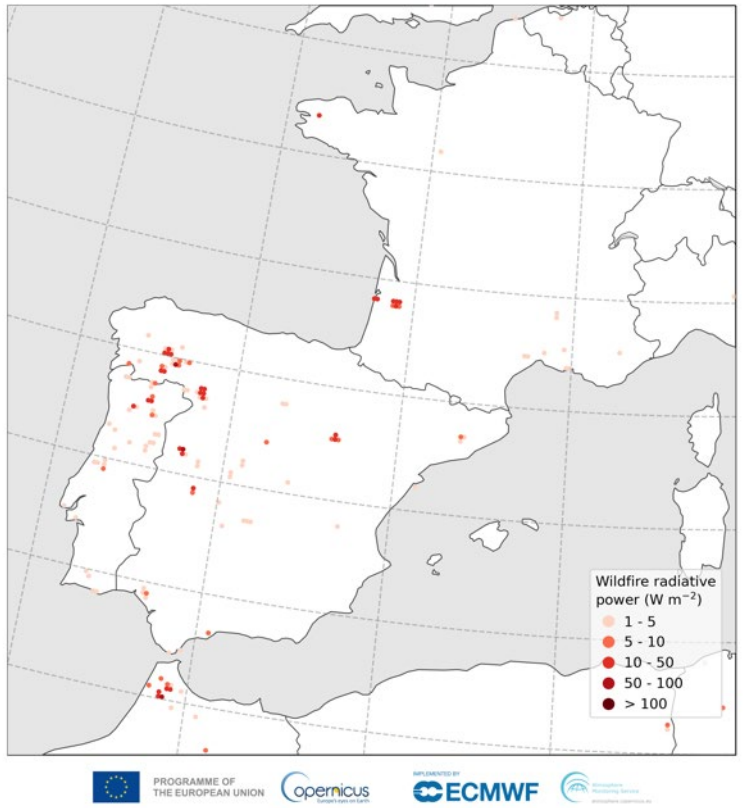
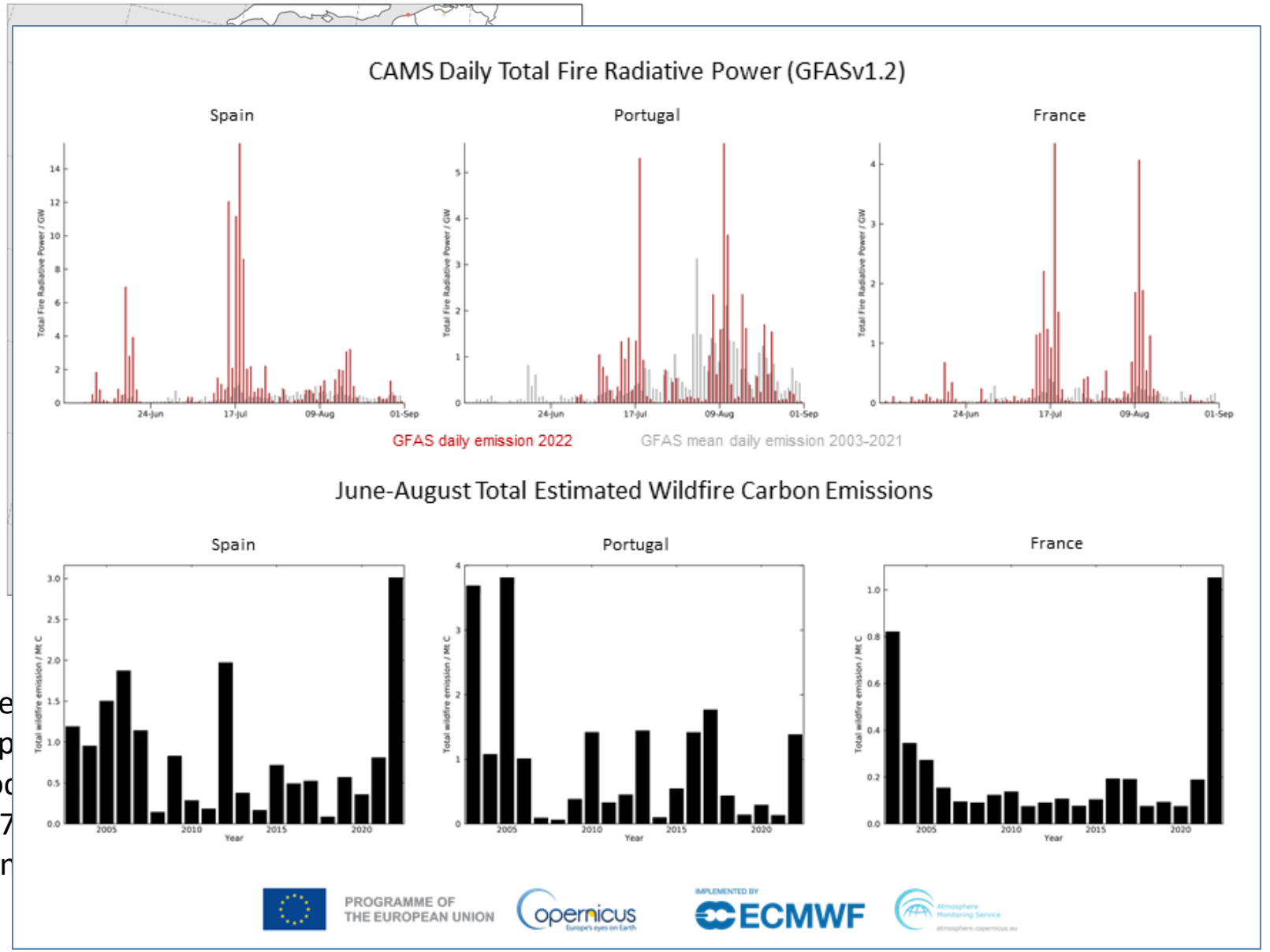


GFASv1.2 Total Fire Radiative Power: August 2022



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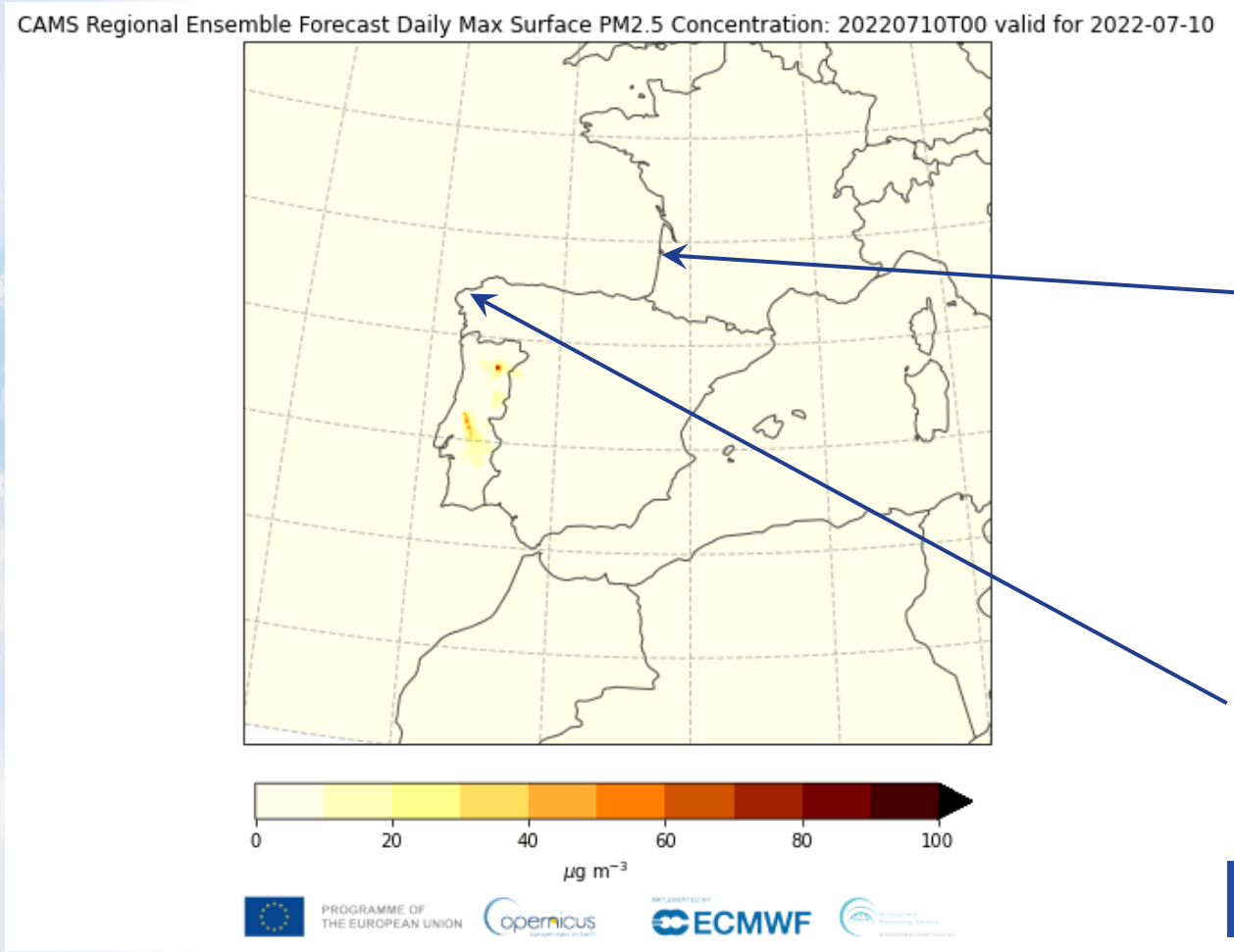
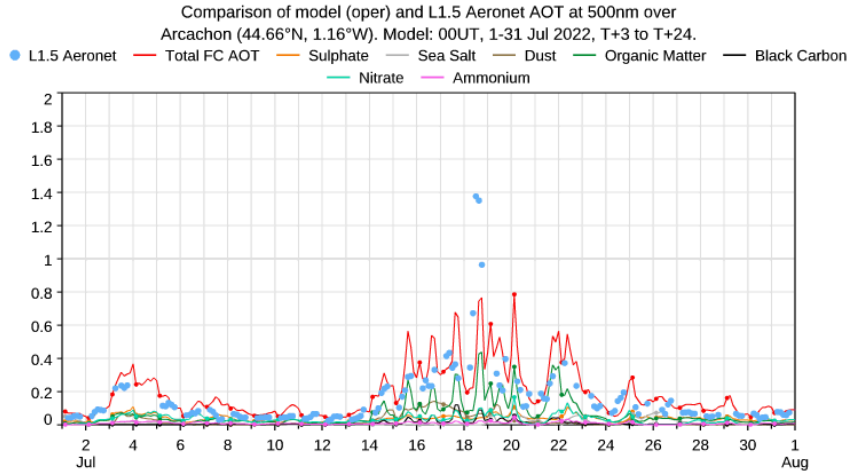
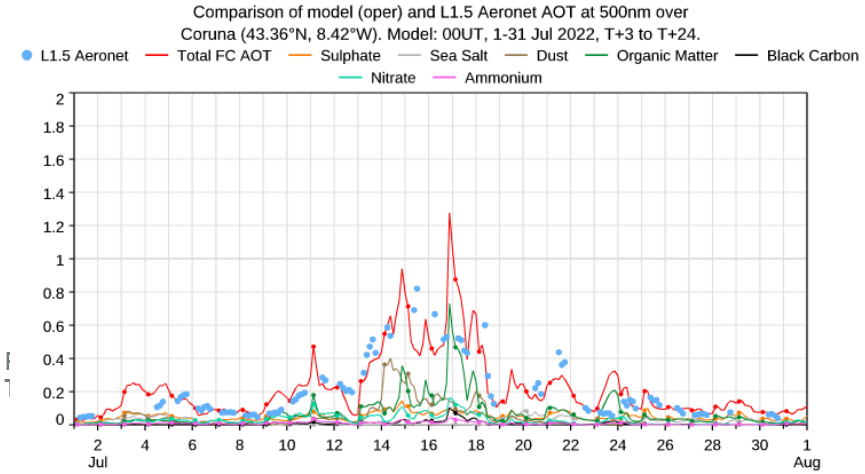
SW Europe wildfires summer 2022: smoke monitoring

Atmosphere Monitoring

- Smoke from fires had regional impacts on air quality (animation shows CAMS regional ensemble daily max surface PM2.5) and longer-range atmospheric composition.
- Good agreement of CAMS global aerosol optical depth against Aeronet (Arcachon & Coruna shown but also as far as Paris and NW Europe).
- Not many surface AQ measurements immediately downwind of transport makes regional evaluation challenging.







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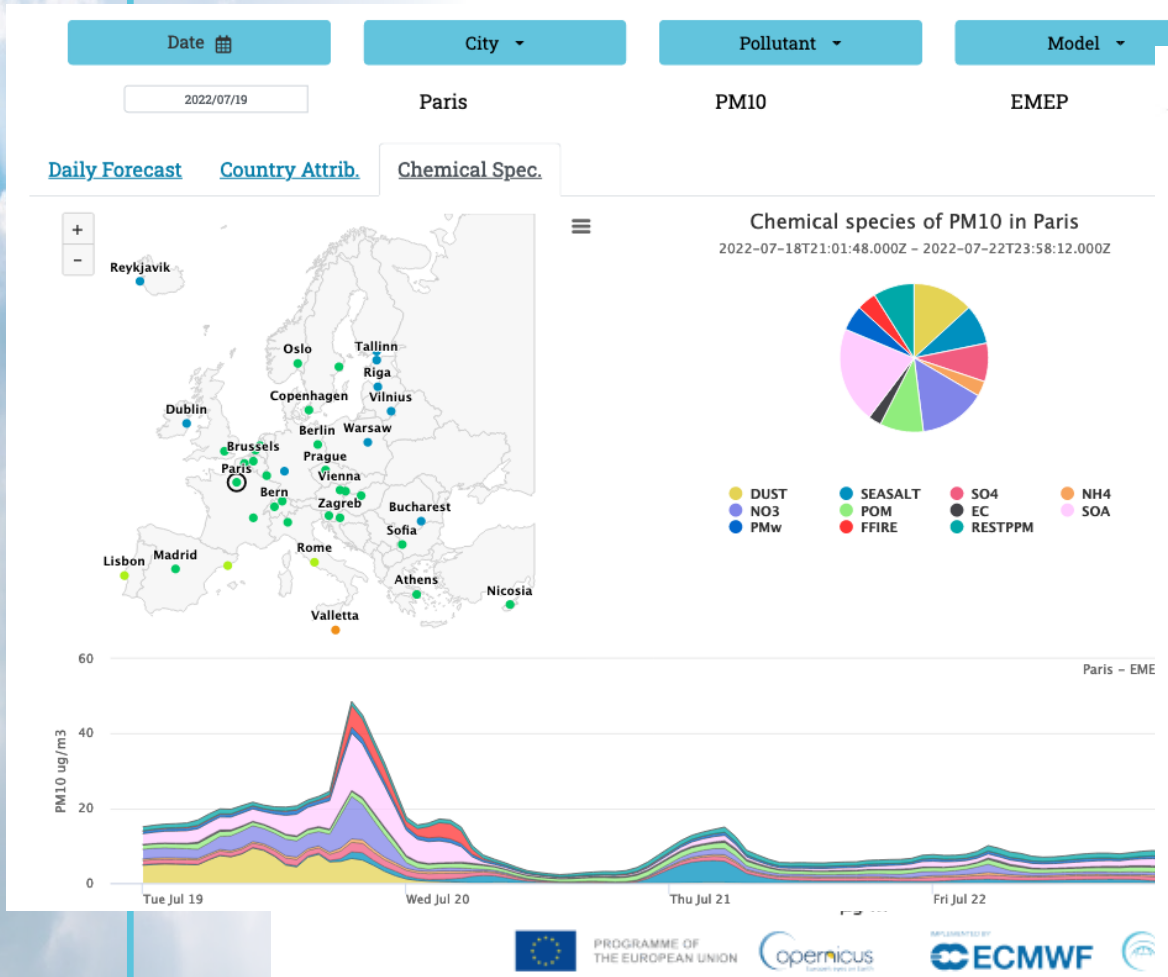
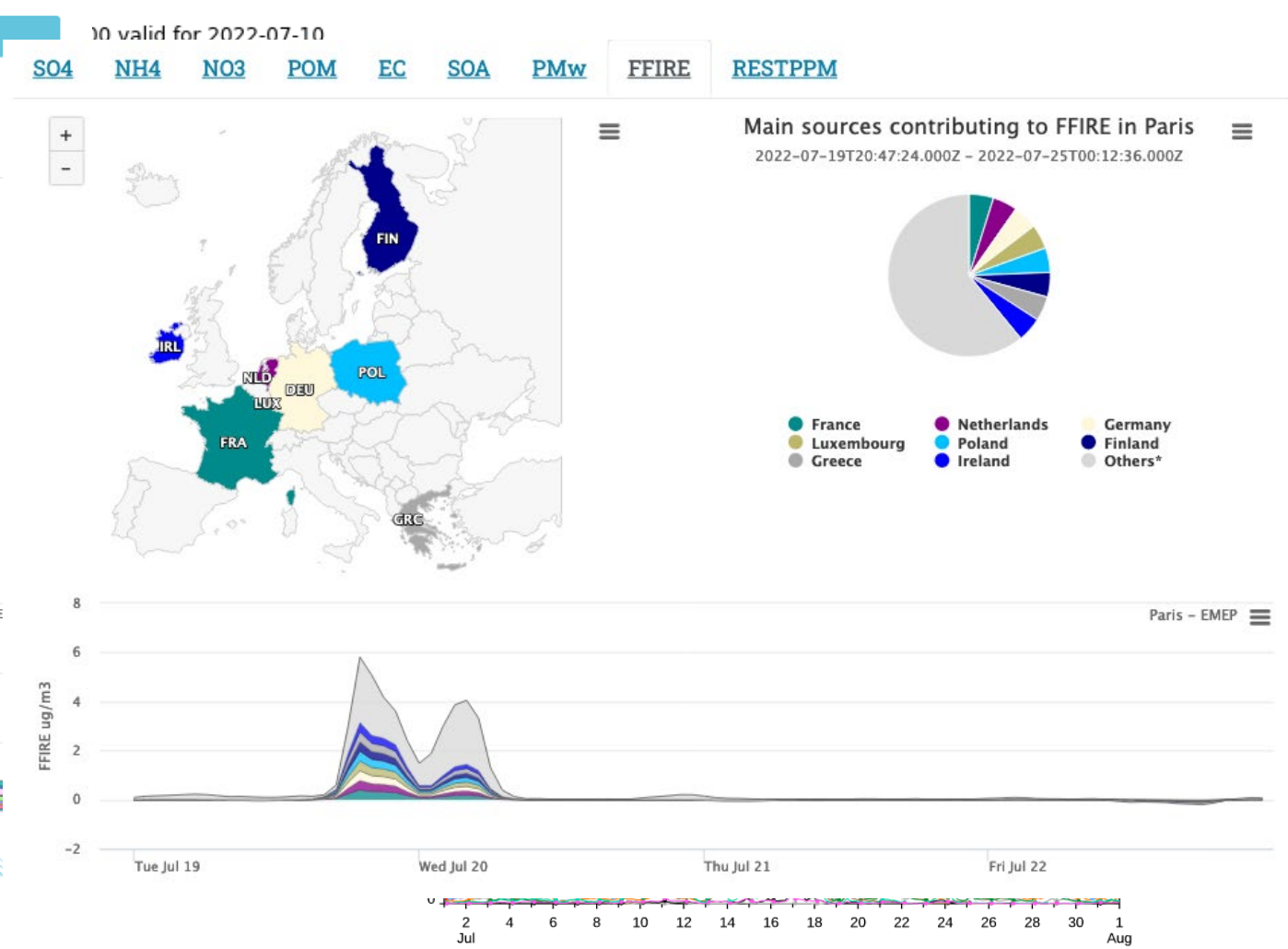
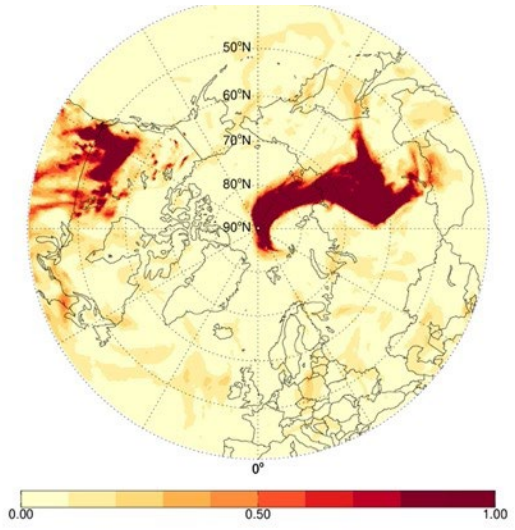




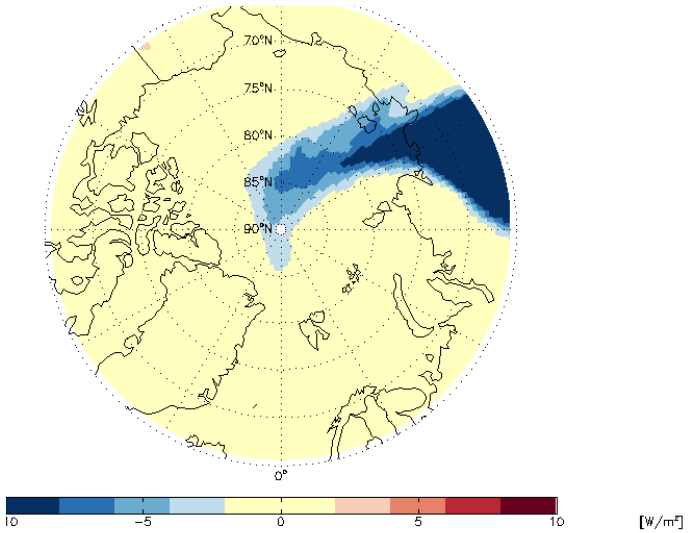
Atmosphere Monitoring

Siberian wildfires 2021: Atmospheric impacts

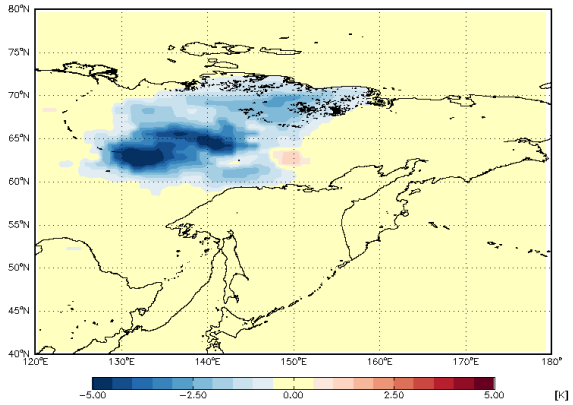
Organic Matter AOD analysis: 2 August, 00 UTC



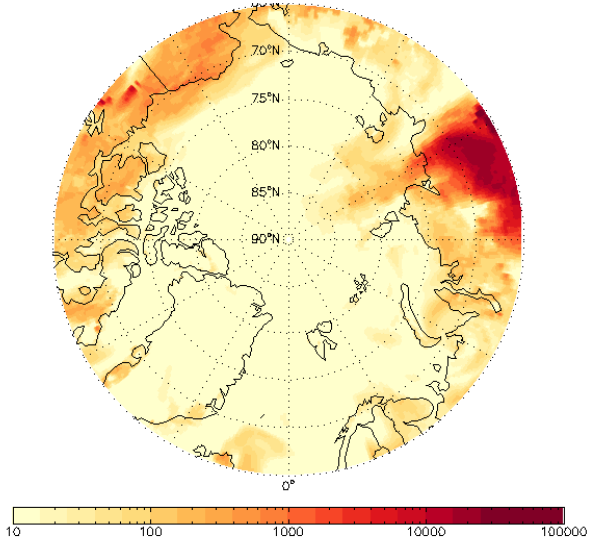
Surface SW radiation (24-h mean), 2 August



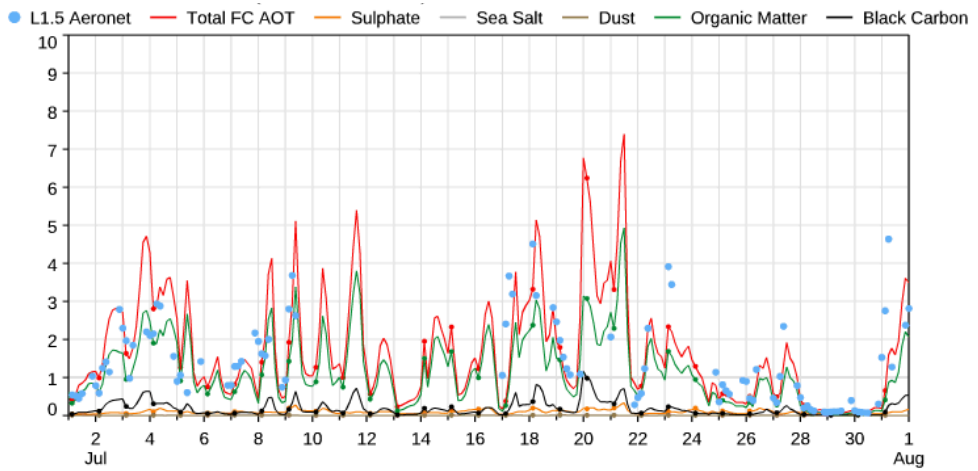
2m temperature (24-h mean), 4 July



Daily total estimated BC dry deposition: 2 August



Aerosol Optical Depth comparison vs Aeronet at Yakutsk



ECMWF

Arctic fire monitoring: June 2022

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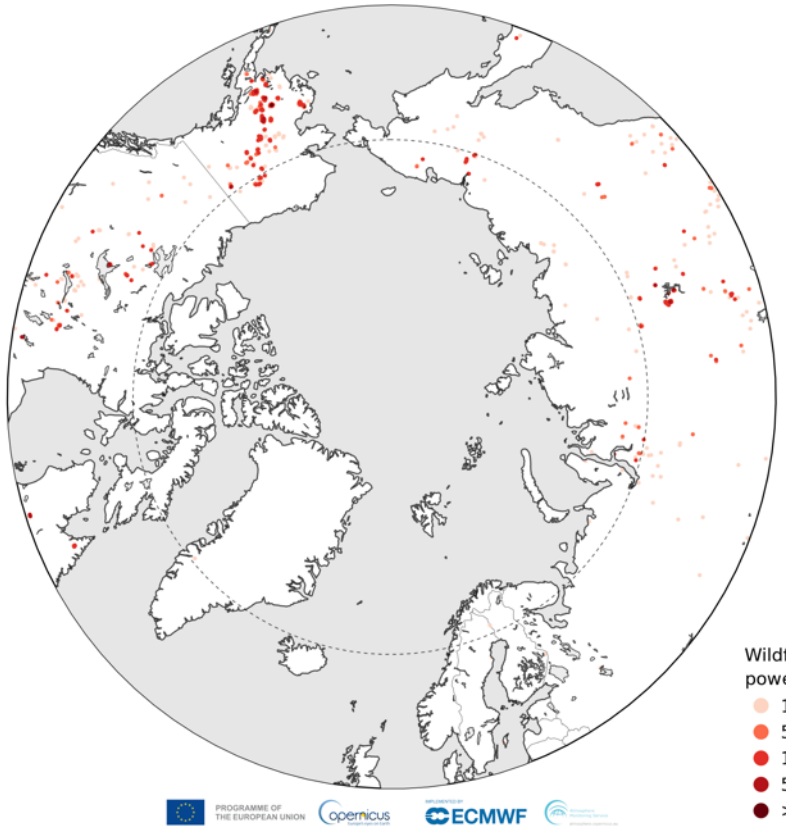
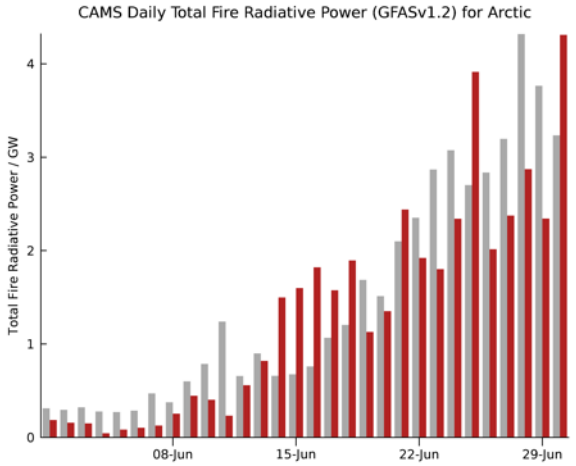
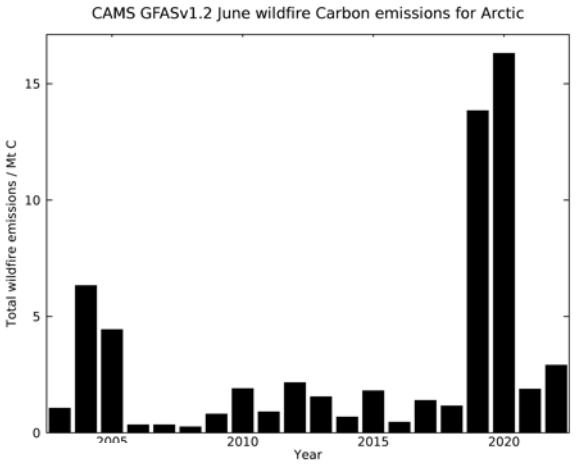
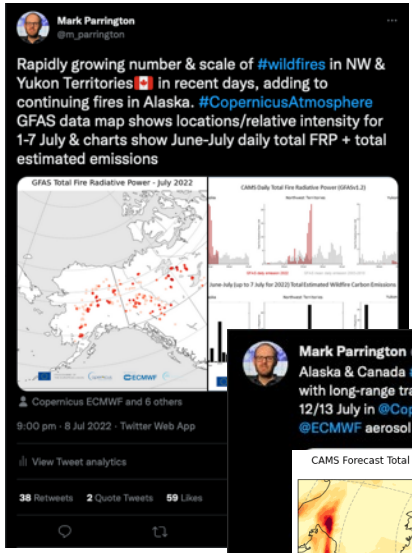
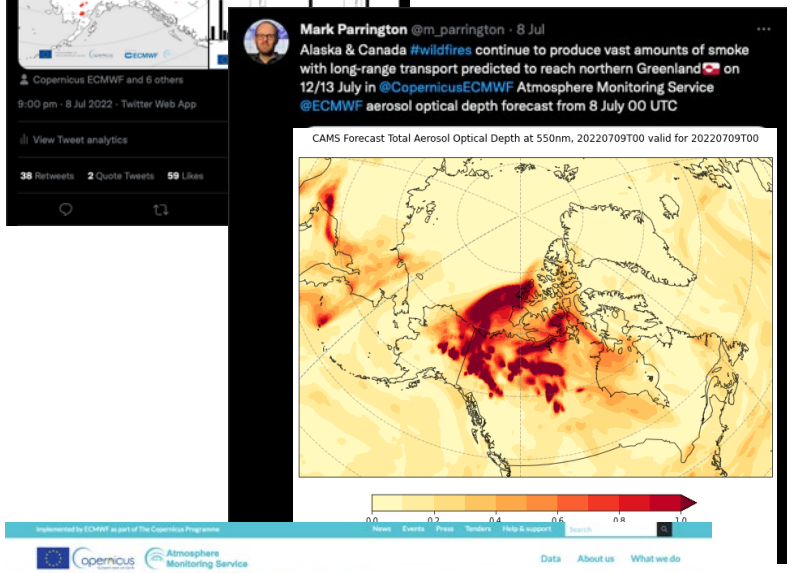
GFAS Total Fire Radiative Power: 1-30 June 2022



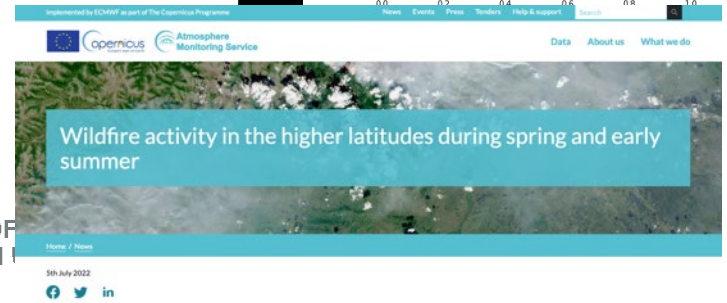








CAMS near-real-time monitoring used widely via social media to engage with general public, users and media.



- Arctic Circle wildfires in June 2022 were fairly typical for the month.
- Persistent wildfires in (Arctic & sub-Arctic) Alaska since the beginning of June.
- Several instances of smoke transport across Beaufort Sea, Arctic Ocean as far as northern Greenland.
- Use of data via social media facilitates two-way exchange of information and engages with local expertise

https://atmosphere.copernicus.eu/wildfire-activity-higher-latitudes-during-spring-and-early-summer

Atmosphere Monitoring

Summary of strengths and limitations

- CAMS/GFAS provides a 20-year consistent dataset based on MODIS observations with morning and afternoon coverage
  - One of (very) few operational fire emissions datasets available in NRT*
  - NRT monitoring/evaluation of emissions and global/regional atmospheric impacts via CAMS Weather Room during wildfire season(s)/events
  - Wide usage: CAMS communications/press activities; scientific community

- Several developments to address limitations in recent years are currently being implemented and tested in GFAS
  - Additional LEO (VIIRS, Sentinel-3) and GEO (SEVIRI, GOES, Himawari) FRP observations
  - Spurious signal mask based on information provided with FRP datasets
  - FRP to dry matter conversion factors to remove dependence on (very old) burned area observations
  - Vegetation maps updates based on ESA-CCI data to provide more detailed specification of biomes (including peat)
  - Emission factors updates based on updated scientific literature to improve estimated emissions under different conditions

- Discussion points
  - Spatial resolution – current 0.1 degree by 0.1 degree may be too coarse for some regions but optimises observable fires
  - Best implementation of emissions data for operational applications (GFAS availability 7 hours behind NRT to optimise availability of FRP observations)

Future directions for fire monitoring in Copernicus and ECMWF

Atmosphere Monitoring

- Extra slides

Atmosphere Monitoring

Linking Copernicus Services: From fire monitoring to fire forecasts

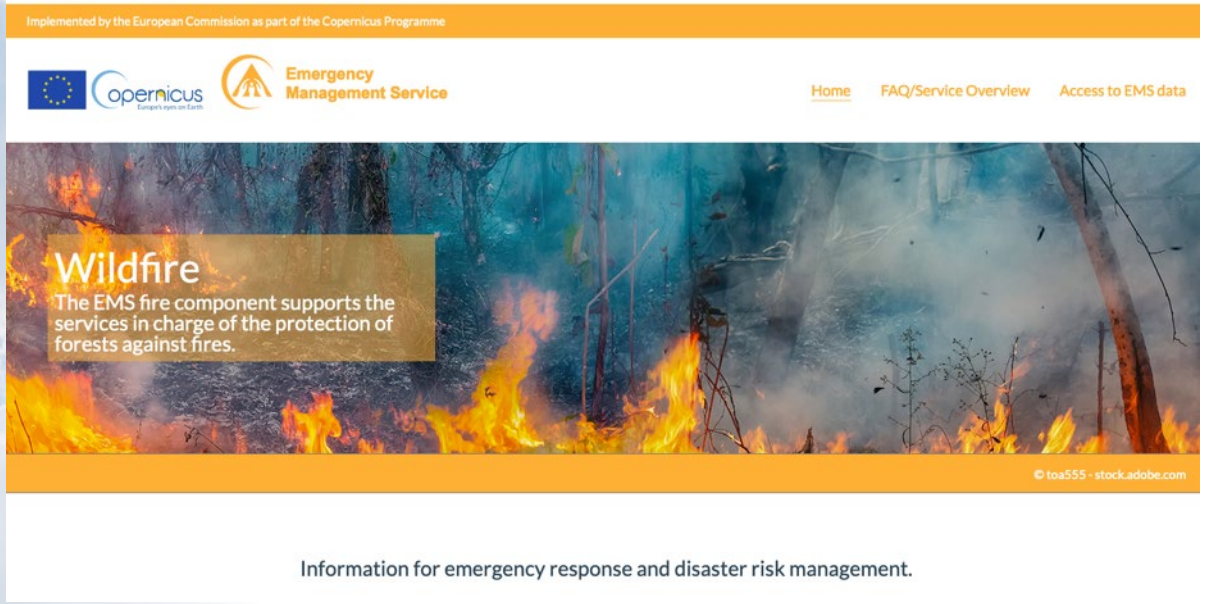
CAMS

Copernicus Emergency Management Service

Global Fire monitoring

Global fire evolution forecasting (d+5)

Global fire danger forecasting (d+10)



https://emergency.copernicus.eu/

The European Forest Fire Service (EFFIS) is implemented by the EU Joint Research Centre

Flood and fire danger forecasts are provided by ECMWF.

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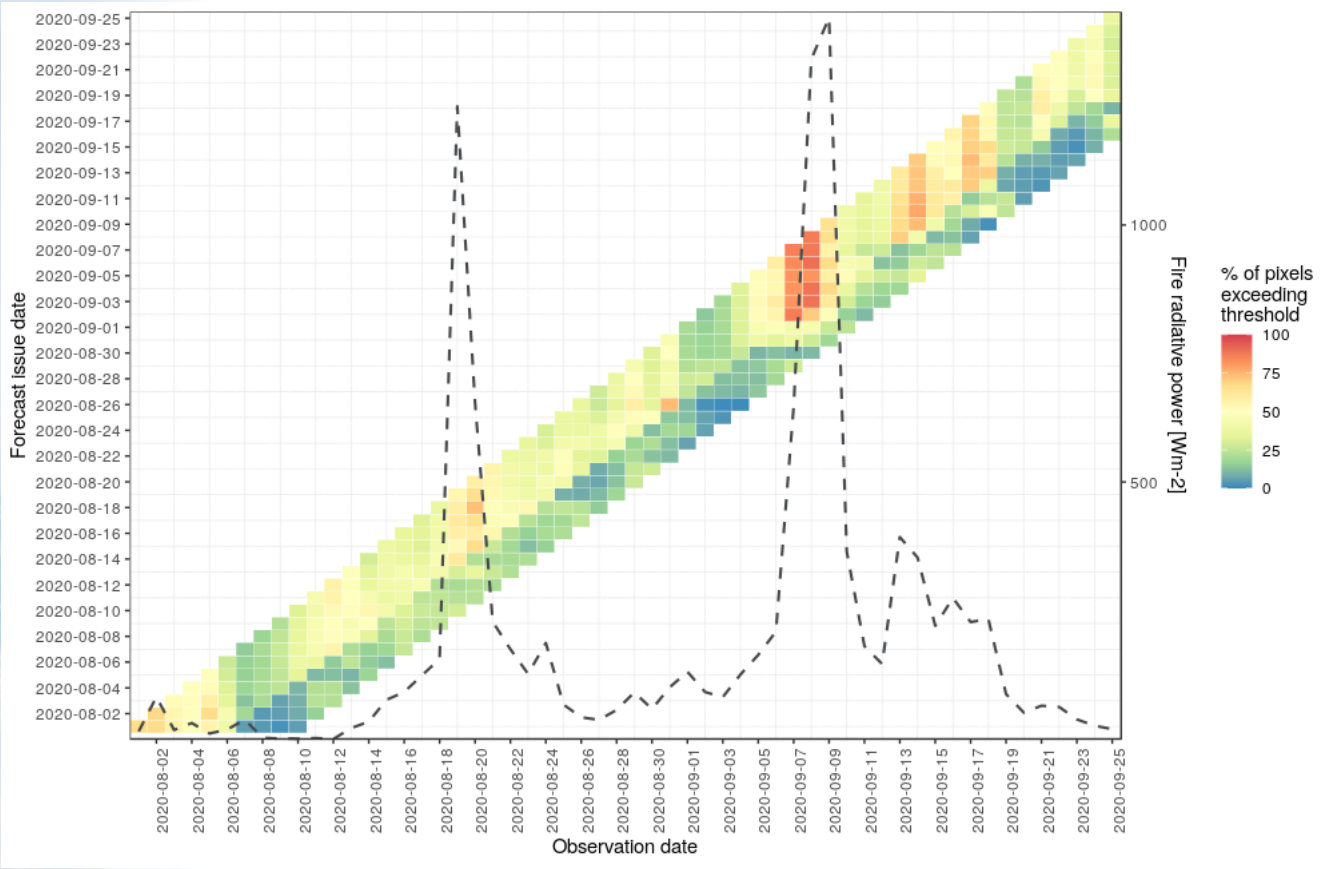
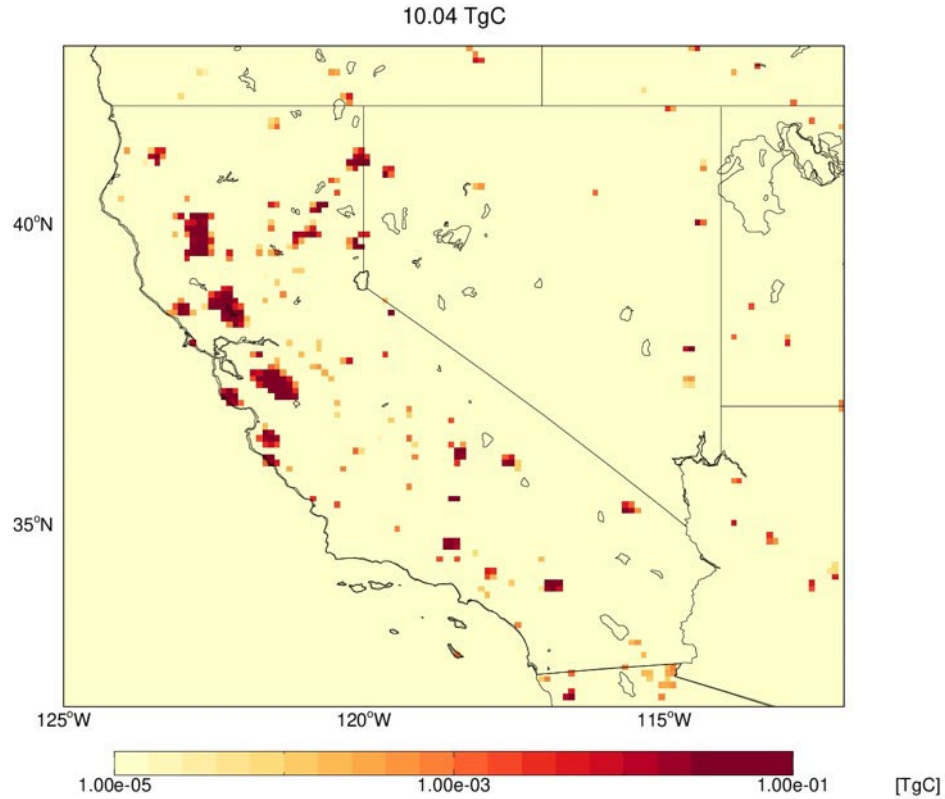
California fires in August-September 2020





- As in previous cases, highest % of pixels exceeding very high fire danger rating in California forecast 6-8 days ahead of fire activity between 18-22 August and 5-10 September.
- Strong correspondence with highest % and observed active fire emissions.
- Air quality impacts of smoke persisted across California (and the western states) for many days and eventual long-range transport to the North Atlantic and as far as Europe.

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CAMS in action: California fires in August-September 2020

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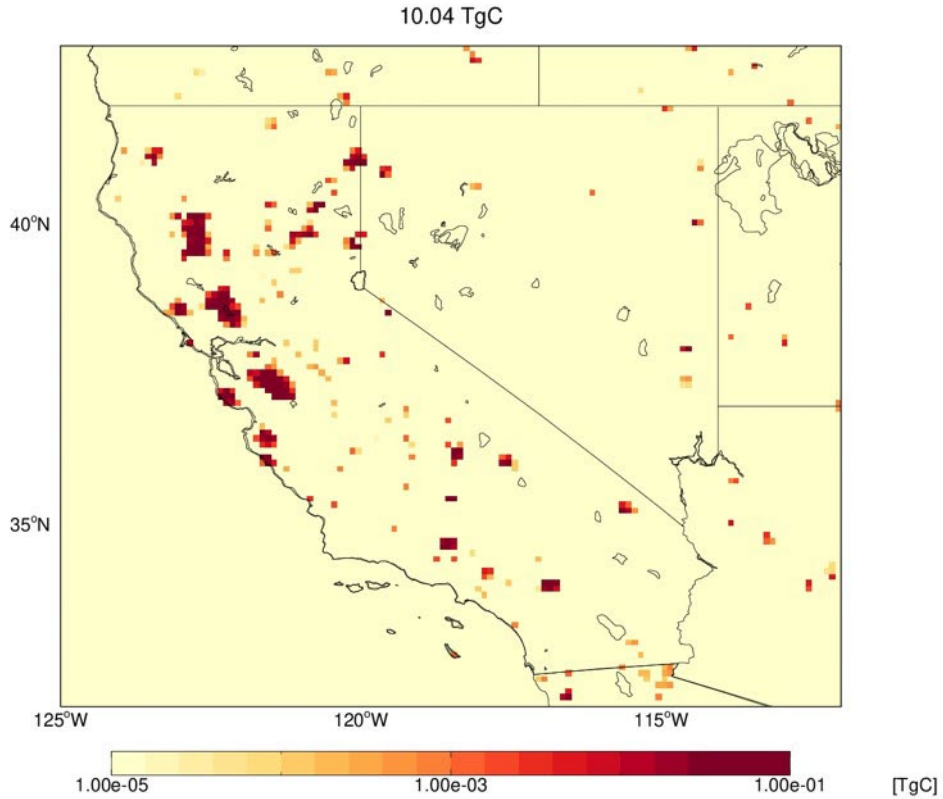

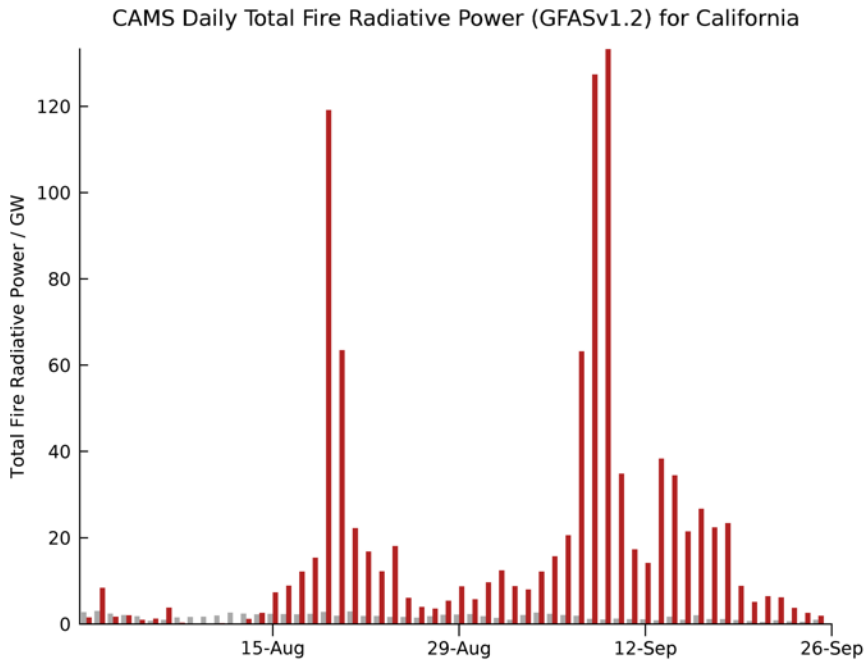

- Widespread wildfires across California and western states through August and September 2020.
- GFAS data used to monitor state-level active fires location and intensity.
- CAMS global analyses and forecasts of aerosol optical depth and total column carbon monoxide used to monitor local and long-range smoke transport.

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CAMS in action: California fires in August-September 2020

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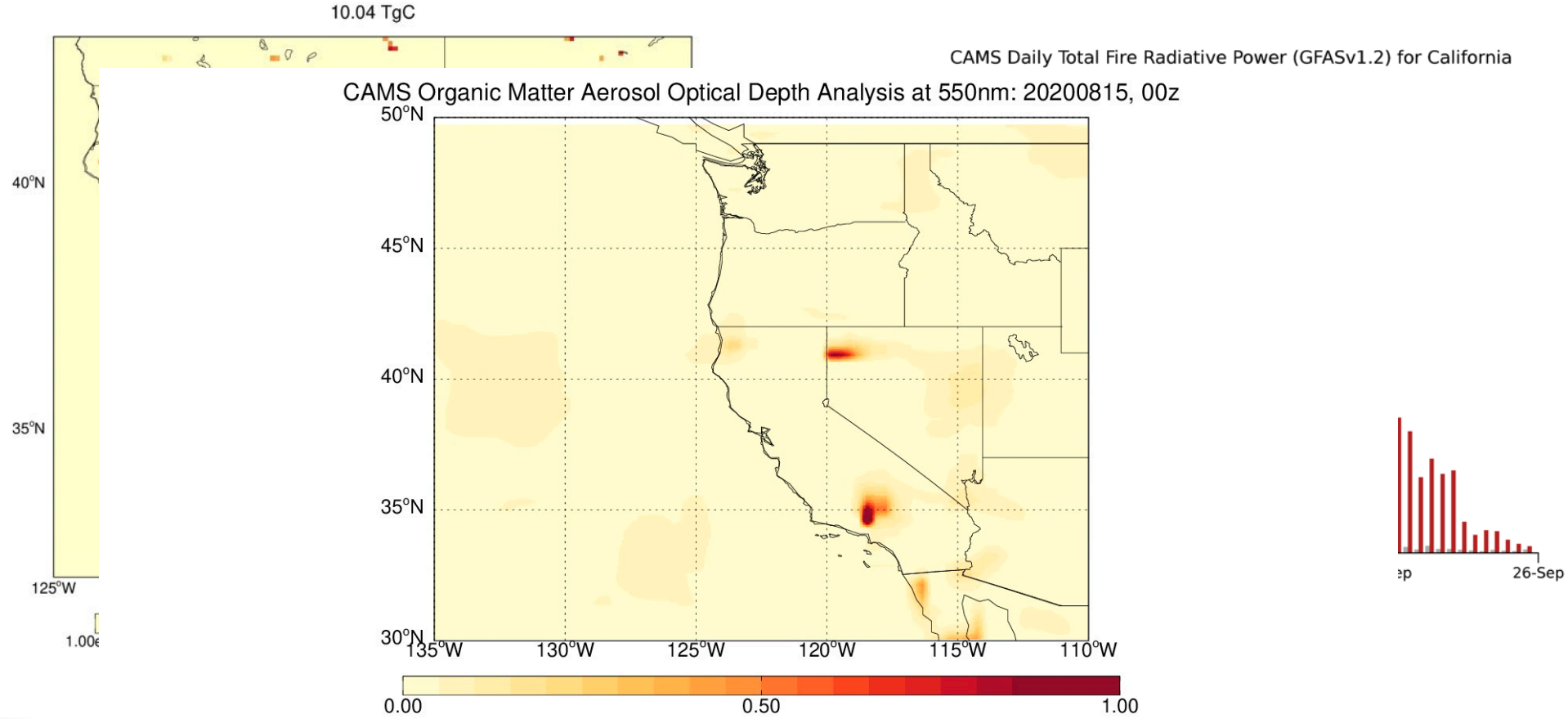

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CAMS in action: California fires in August-September 2020

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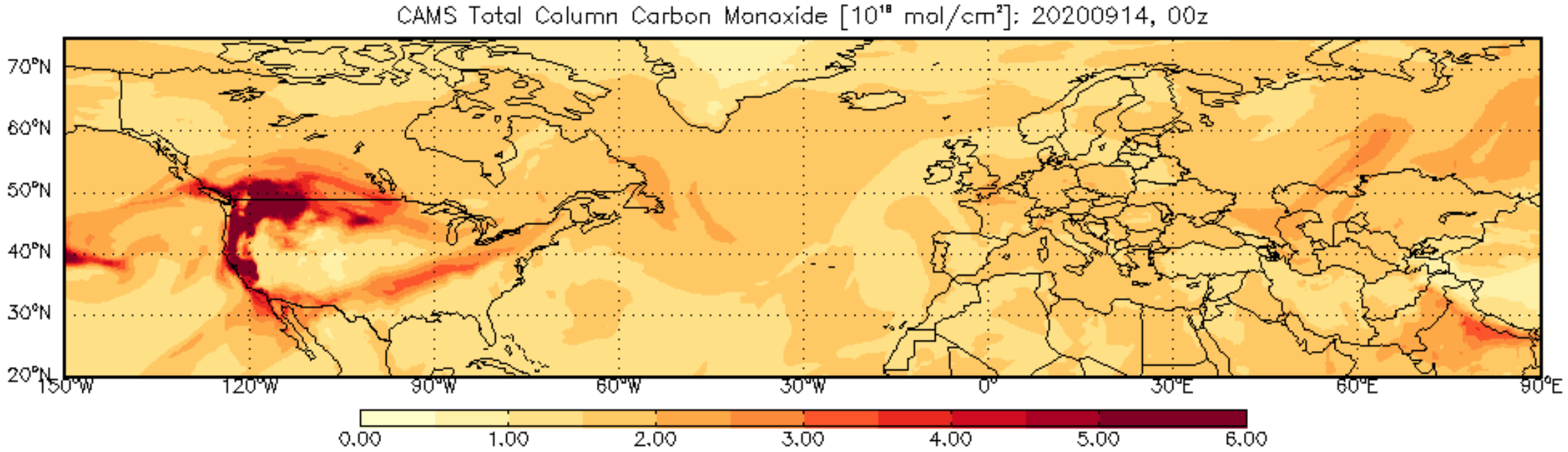
CAMS Daily Total Fire Radiative Power (GFASv1.2) for California



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