Global perspectives on wildfire emissions and air quality with CAMS data

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Atmosphere Monitoring

EO Products for Wildfires Monitoring and Forecast

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Acknowledgements:

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CAMS development teams

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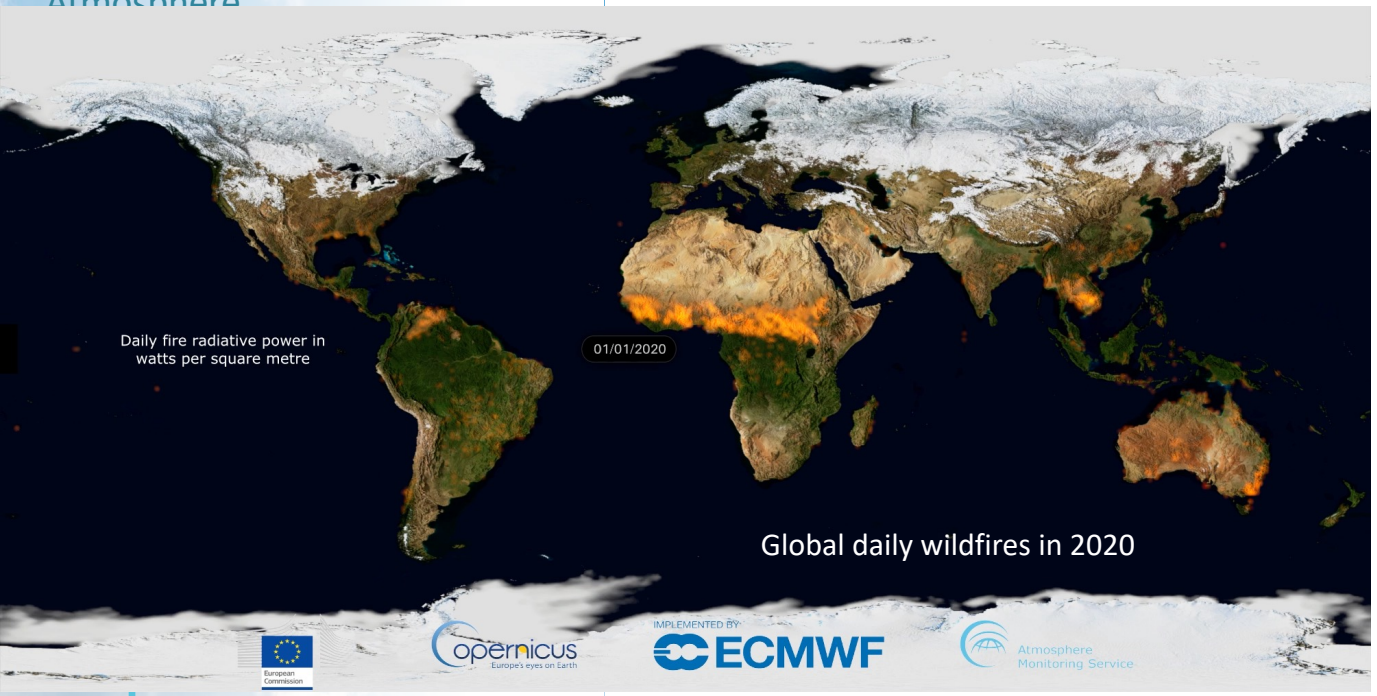
Estimating Global Wildfire Emissions



- Satellite observations of fire locations and estimated emissions available from a number of "inventories" (e.g., GFED, FINN, FLAMBE, FEER, GBBEPx, QFED).
- Based generally on similar observations but can differ in the technique used:
  - Burnt area vs. fire radiative power.

- 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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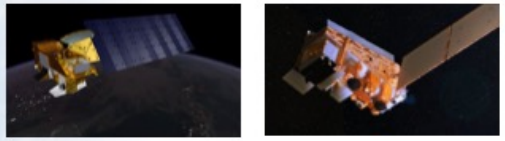
Polar

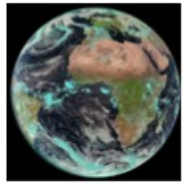


Terra/Aqua-MODIS

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

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Global Wildfire Activity and Emissions in 2021

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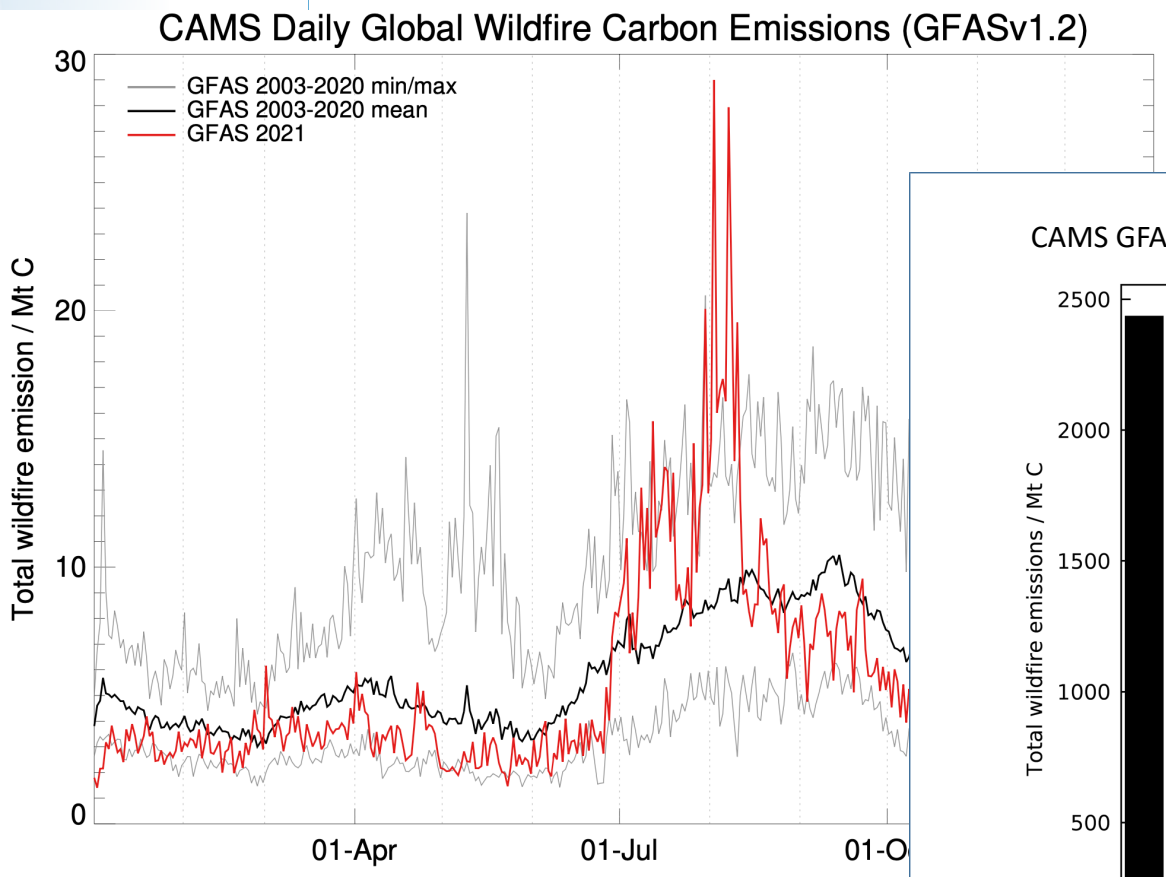
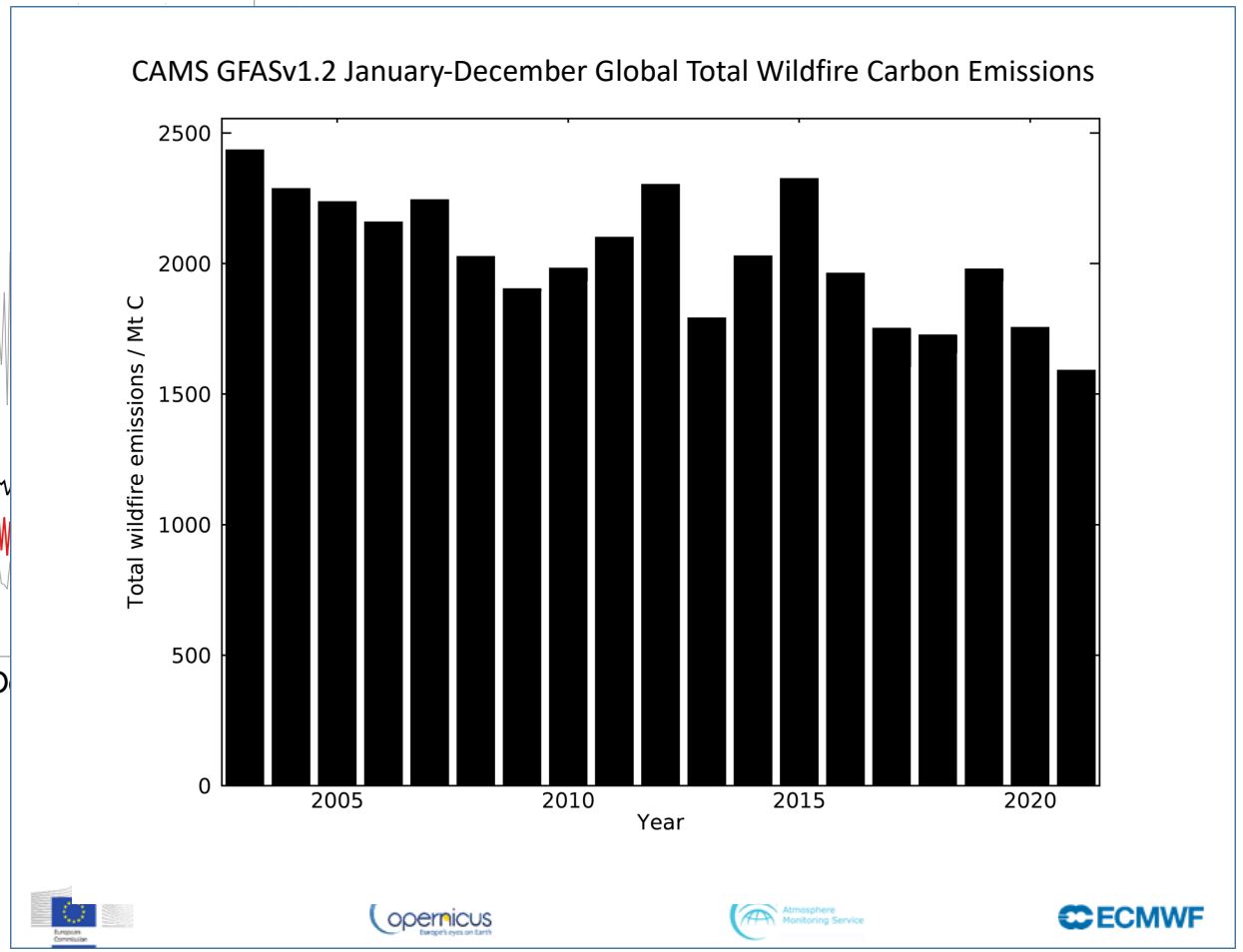


Estimated emissions reflect the scale and intensity of active fires.



- Radiative energy of fires can be observed by satellites and can be used to estimate emissions of pollutants.
- 2021 has generally been below average at the global scale apart from July and August (related to large-scale boreal wildfires in Siberia and N America).
- General downward trend in global annual total emissions due to declining savannah fires in the tropics.

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CAMS GFAS: 19 years of Africa fire activity

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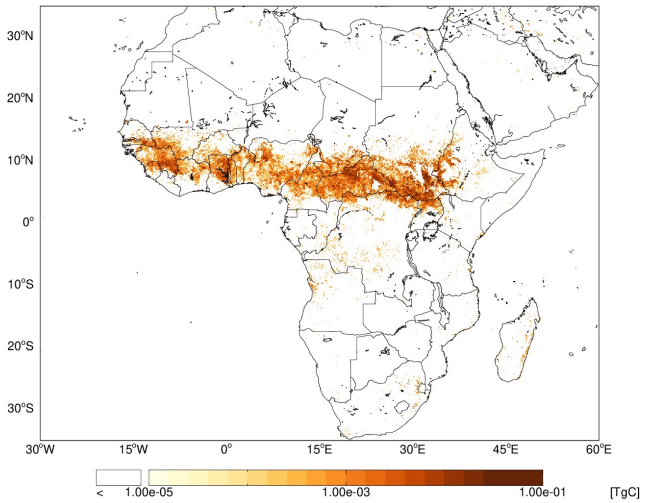
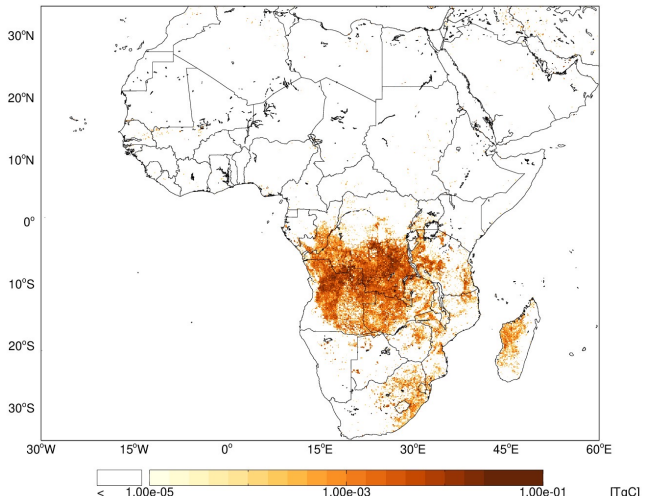
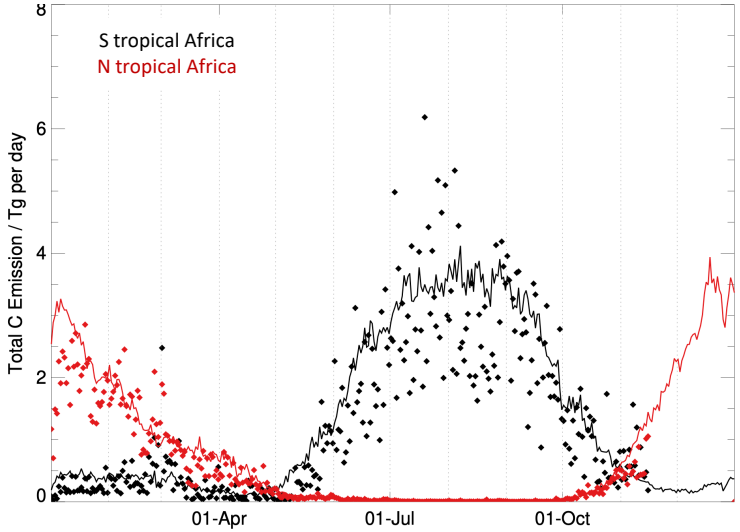
Total estimated carbon emission: January 2021



Total estimated carbon emission: July 2020

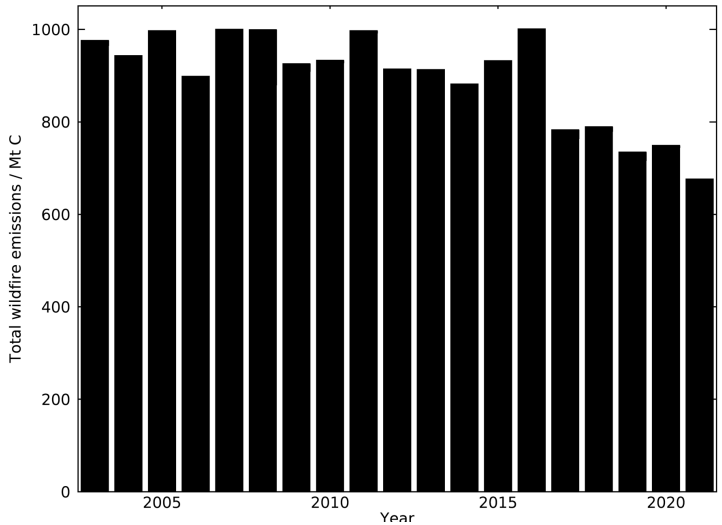


Daily total estimated carbon emissions



Mean daily total Fire Radiative Power for northern and southern tropical Africa

Total estimated annual carbon emission for Africa



Annual total estimated wildfire carbon emissions for Africa (up to 15 Nov for 2021)

- NRT estimates of emissions from fires are an essential component of CAMS atmospheric composition forecasts.
- The 19-year dataset also provides valuable context and information on fire activity at daily, monthly and yearly scales.
- These examples show how fire emissions change seasonally across across Africa, and how the annual total emissions have changed between 2003 and 2021.

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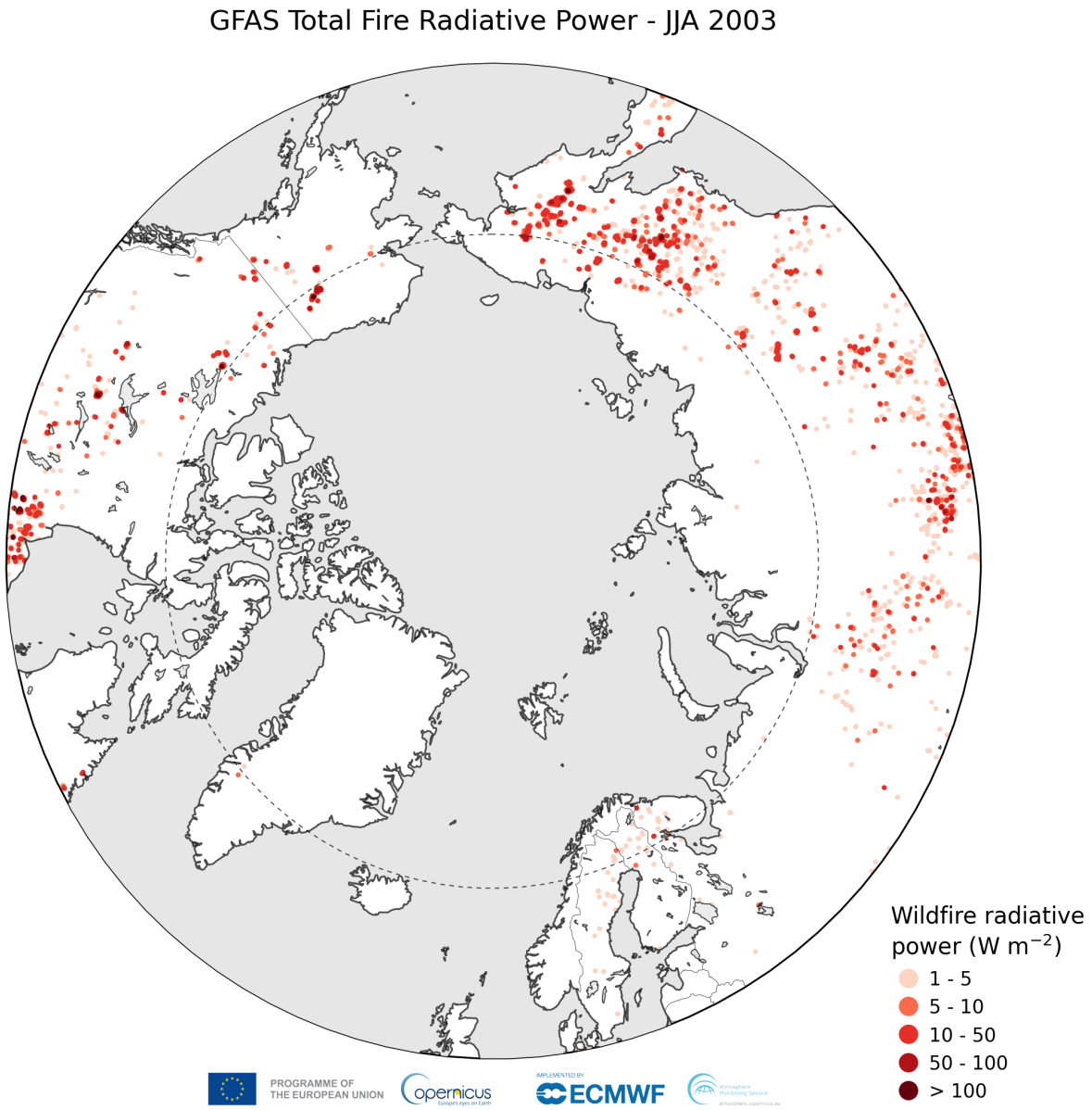
Interannual variability of Arctic wildfires



Animation of June-August total MODIS active fire observations from 2003 to 2022.

High degree of interannual spatial variability of boreal forest fires, and fires in the Arctic Circle, driven by surface hydrology (e.g. soil moisture) and meteorology.

More on recent trends in Siberian & high latitude fires:

- *Ponomarev et al. (2021), MDPI Atmosphere*
- *Conard & Ponomarev (2021), IAWF* *https://www.iawfonline.org/article/fire-in-the-north-the-2020-siberian-fire-season/*
- *McCarty et al. (2021), BGS* *https://bg.copernicus.org/articles/18/5053/2021/*

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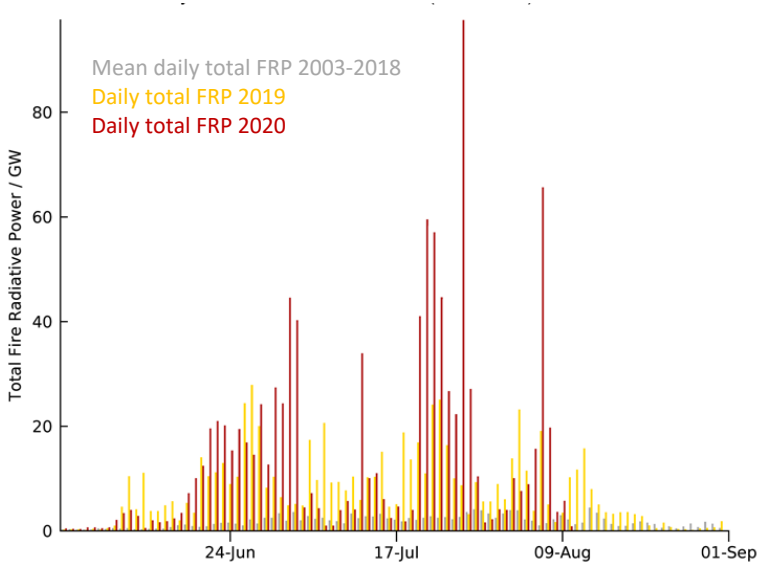
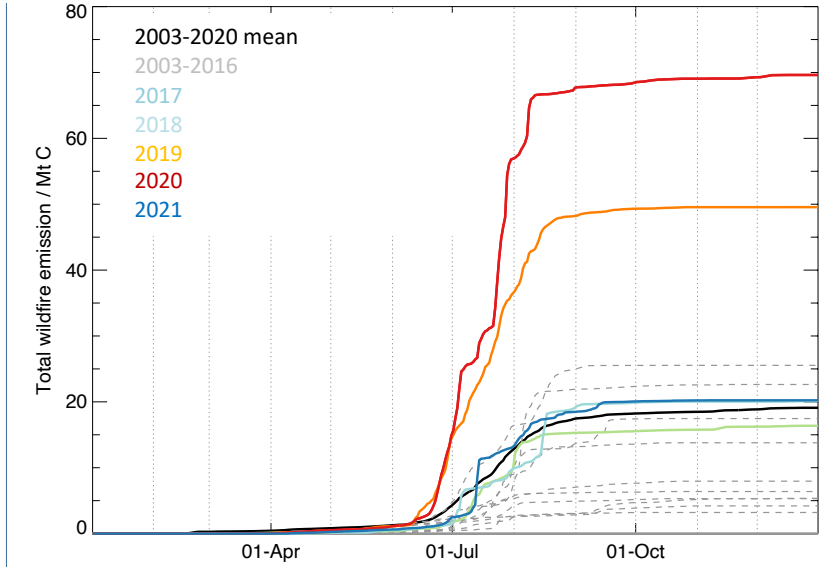
Monitoring daily and seasonal Arctic wildfires

Daily total Fire Radiative Power



Cumulative daily total carbon emissions

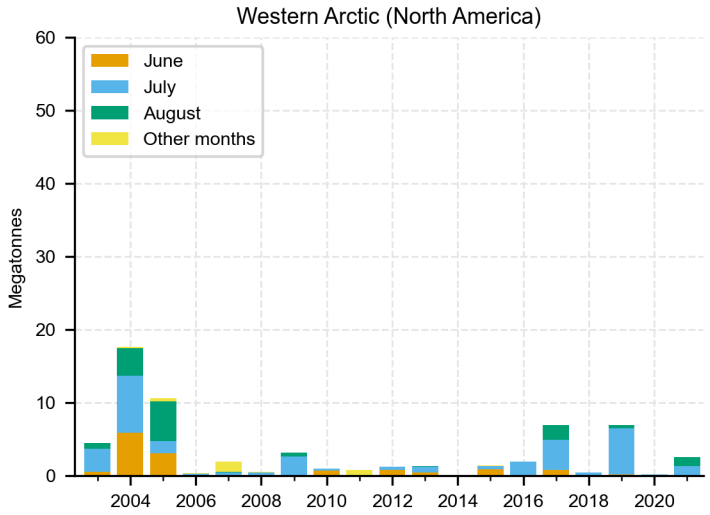


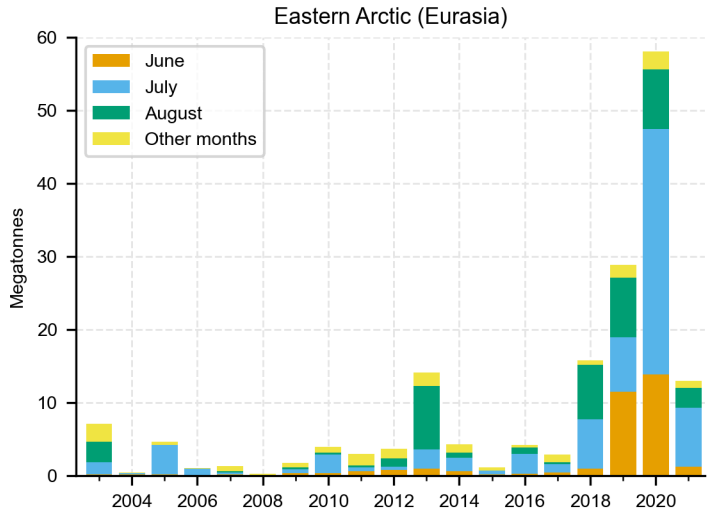
Data: Copernicus Atmosphere Monitoring Service/ European Centre for Medium-Range Weather Forecasts

Daily totals of Fire Radiative Power and estimated carbon emissions monitored in near-real-time.

Comparison against mean of previous years provides context on how 'normal' the fire activity is.

Cumulative daily total carbon emissions





Data: GFAS • Credit: CAMS/C3S/ECMWF

Routine evaluation of monthly and seasonal total estimated emissions provides larger-scale context for interannual variability over last two decades of active fire observations.

Climatological background 2019-2021

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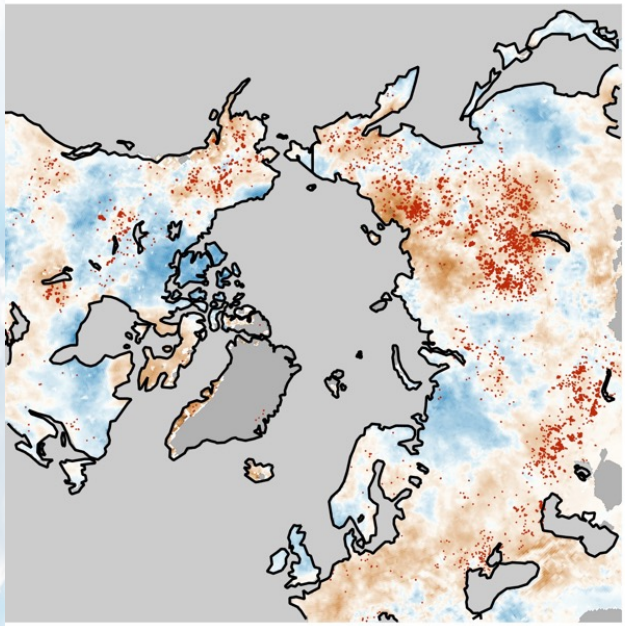
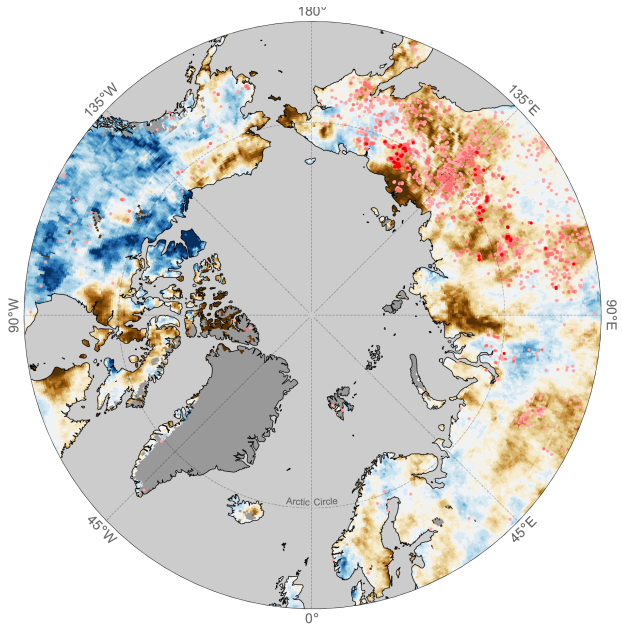
June-August soil moisture anomaly & fire locations

Active fire observations throughout the summer of 2019, 2020 and 2021 corresponded with areas of negative (drier) soil moisture anomalies (relative to 1981-2010 climatology) from the Copernicus Climate Change Service (C3S).

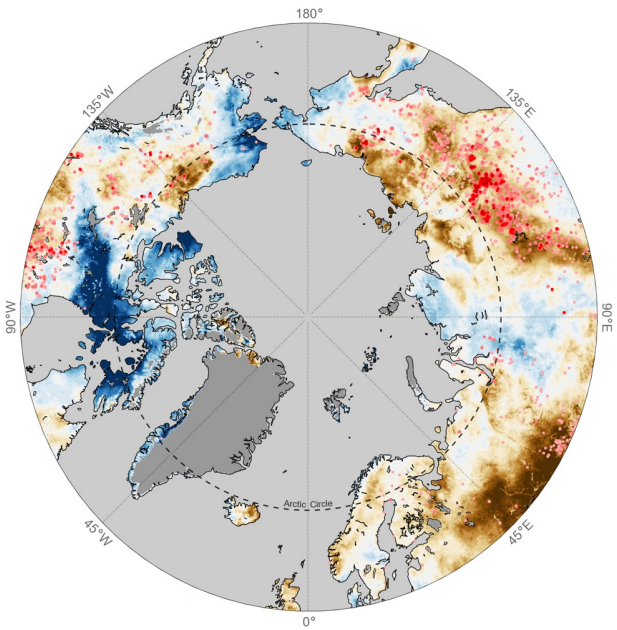
JJA 2019

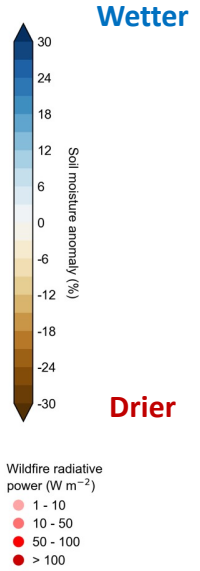


JJA 2020



JJA 2021





https://www.copernicus.eu/en/news/news/observer-copernicus-services-enable-civil-authorities-anticipate-spread-wildfires-and
https://climate.copernicus.eu/esotc/2020/heat-siberia
https://climate.copernicus.eu/esotc/2021/arctic-wildfires

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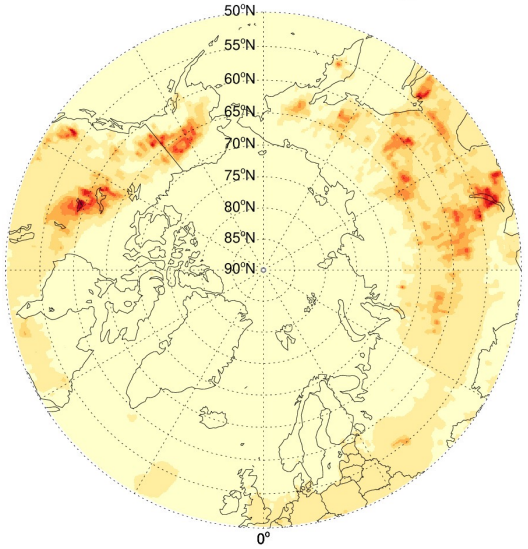
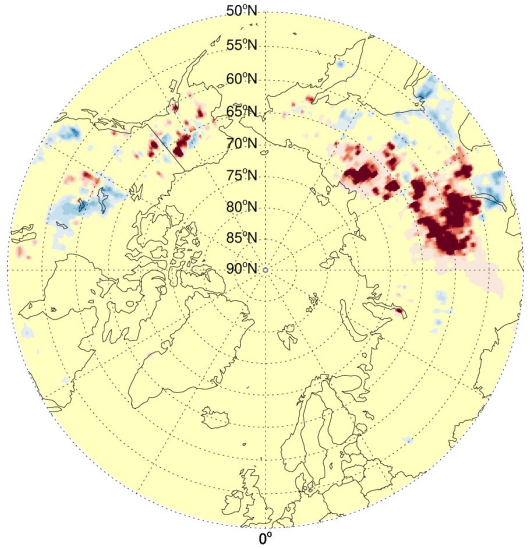
Air quality impacts of high latitude wildfires

CAMS global reanalysis of atmospheric composition:
https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-global-reanalysis-eac4?tab=overview

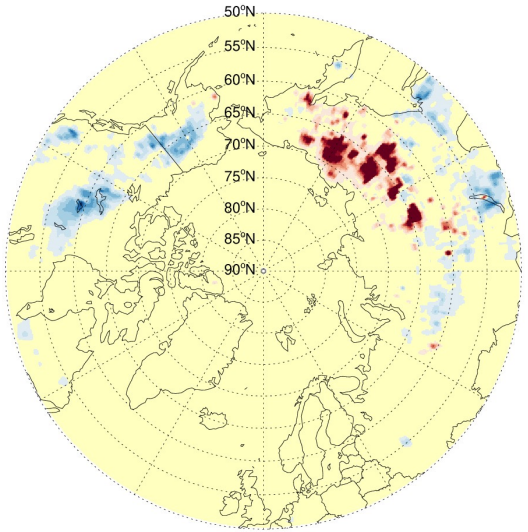
2003-2018 climatology



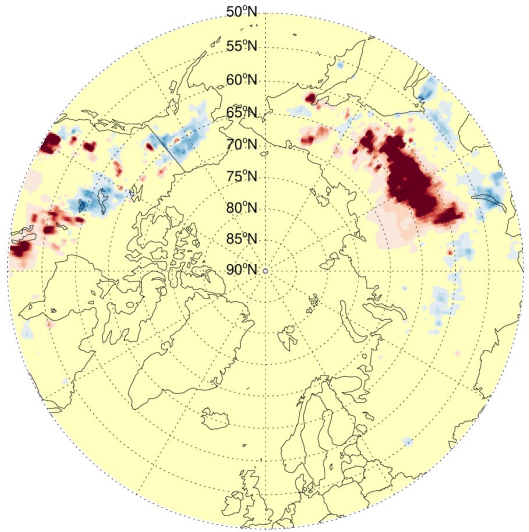
2019 anomaly



2020 anomaly



2021 anomaly



- Climatology of surface PM2.5 concentration shows limited impact of wildfires on air quality in Siberian Arctic.
- Anomalies for 2019 and 2020 show direct impact of high latitude wildfires on surface air quality as activity increases and expands poleward.
- 2021 anomaly shows air quality impacts in Siberia and North America localised to fires.

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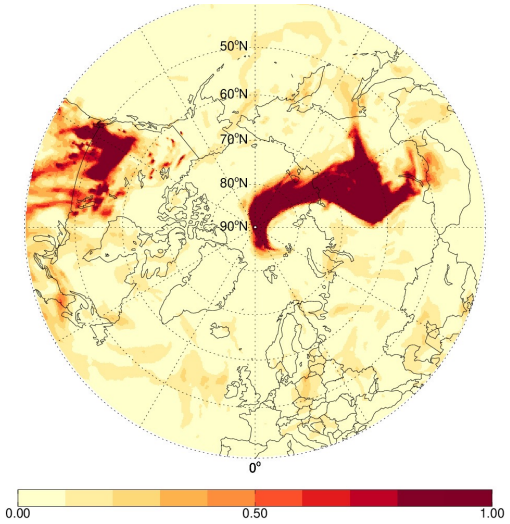
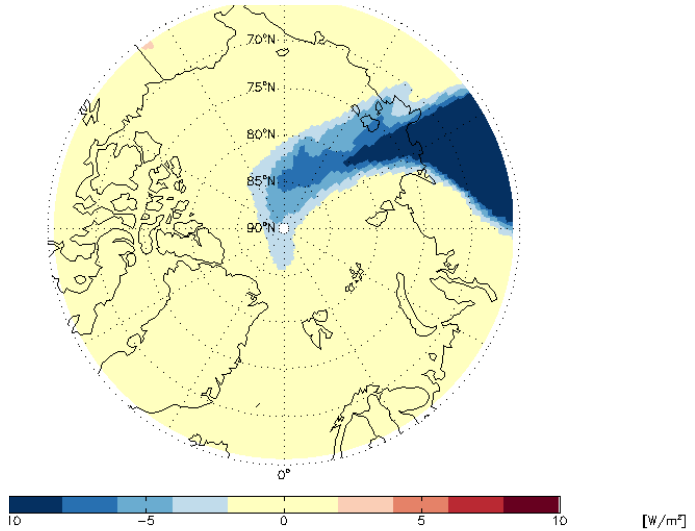
Siberian wildfires 2021: Atmospheric impacts

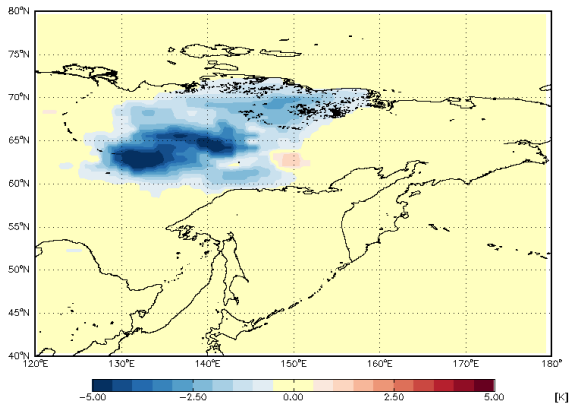
Organic Matter AOD analysis: 2 August, 00 UTC



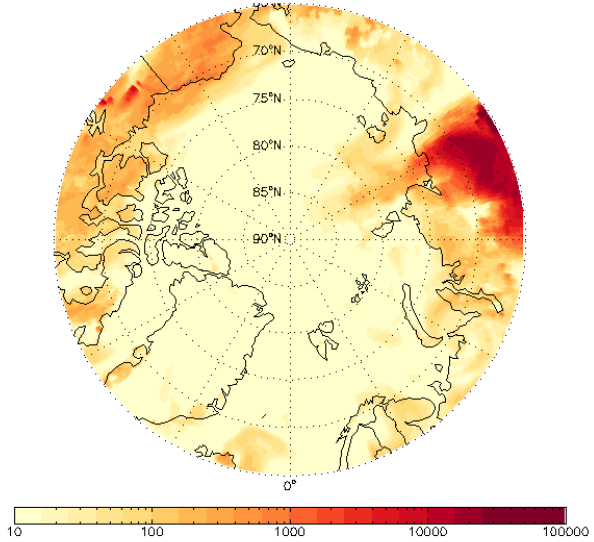
Surface SW radiation (24-h mean), 2 August



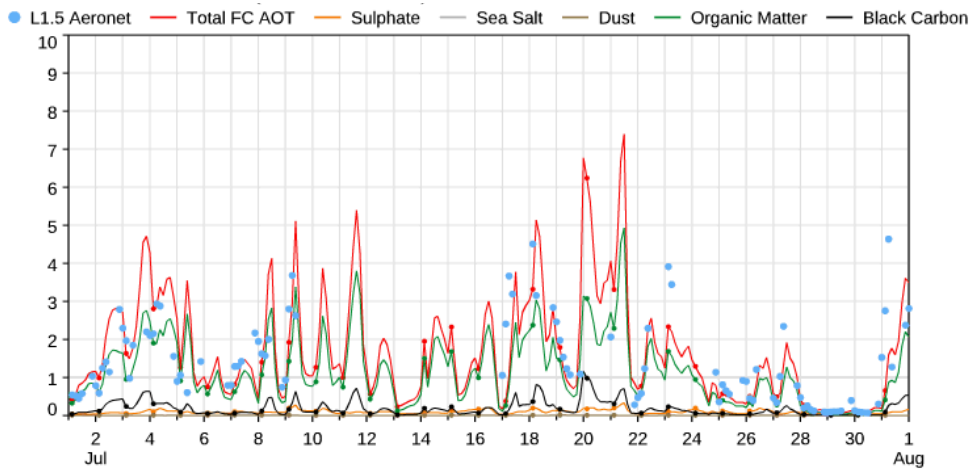
2m temperature (24-h mean), 4 July



Daily total estimated BC dry deposition: 2 August



Aerosol Optical Depth comparison vs Aeronet at Yakutsk



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Arctic fire monitoring: June 2022

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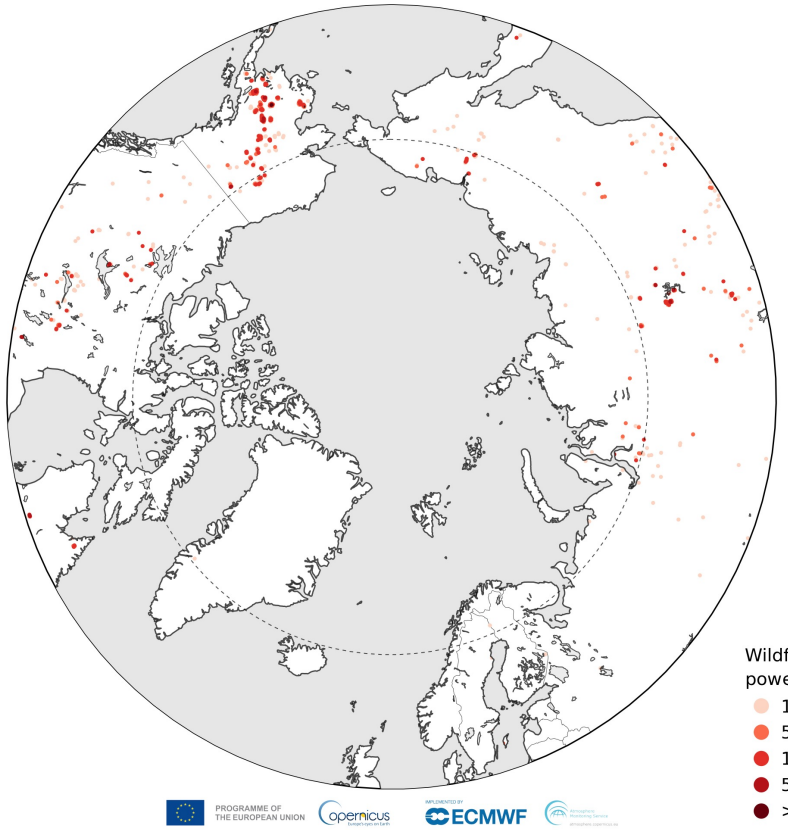
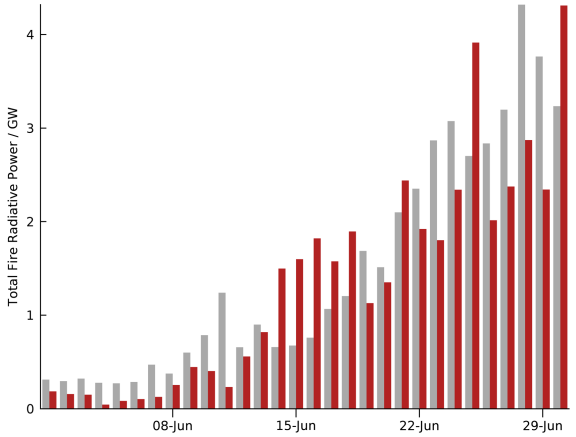
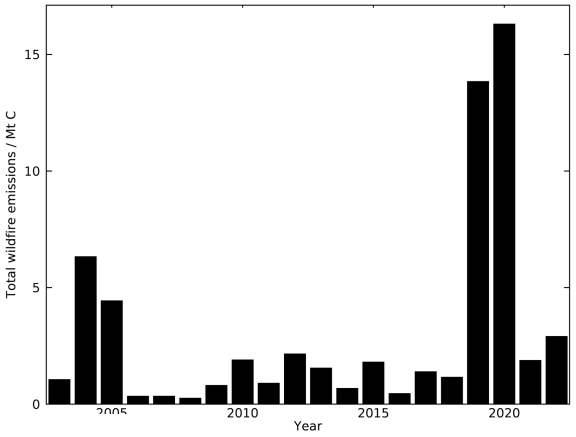
GFAS Total Fire Radiative Power: 1-30 June 2022

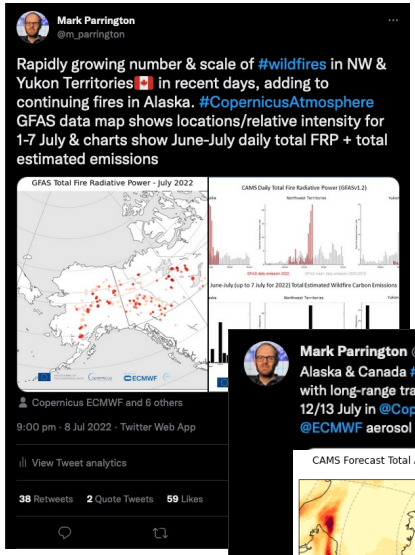


CAMS Daily Total Fire Radiative Power (GFASv1.2) for Arctic

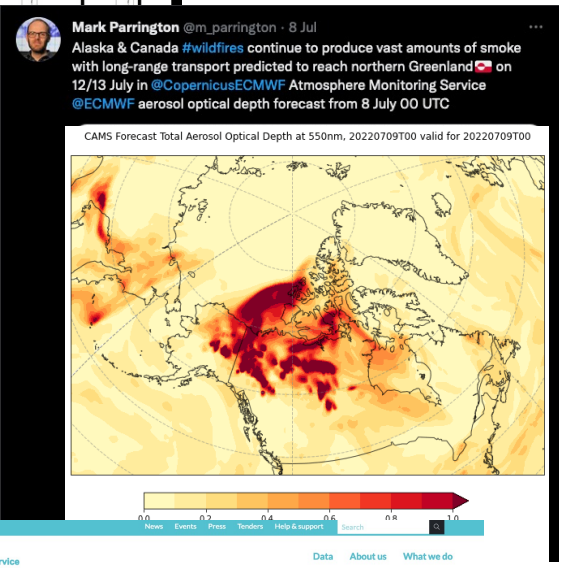


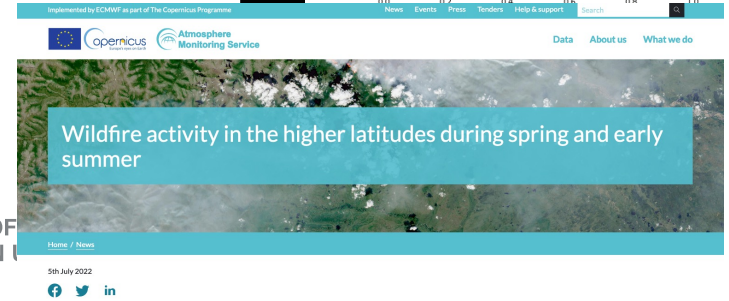
CAMS GFASv1.2 June wildfire Carbon emissions for Arctic





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

International activities

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WMO Vegetation Fire and Smoke Pollution Warning Advisory and Assessment System (VFSP-WAS)

ACTIVITY AREAS (1)

- Global Atmosphere Watch Programme (GAW)

Satellite imagery of smoke from land-clearing fires, spaceborne measurements and ground evidence of atmospheric pollution reveal excessive application of fire in land-use change in the Maritime Continent between 1997 and 2015. Satellite imagery / data: Courtesy NASA

- Working group on wildfires
- Regional centres established for SE Asia and North America
- https://community.wmo.int/activity-areas/gaw/science/modelling-applications/vfsp-was

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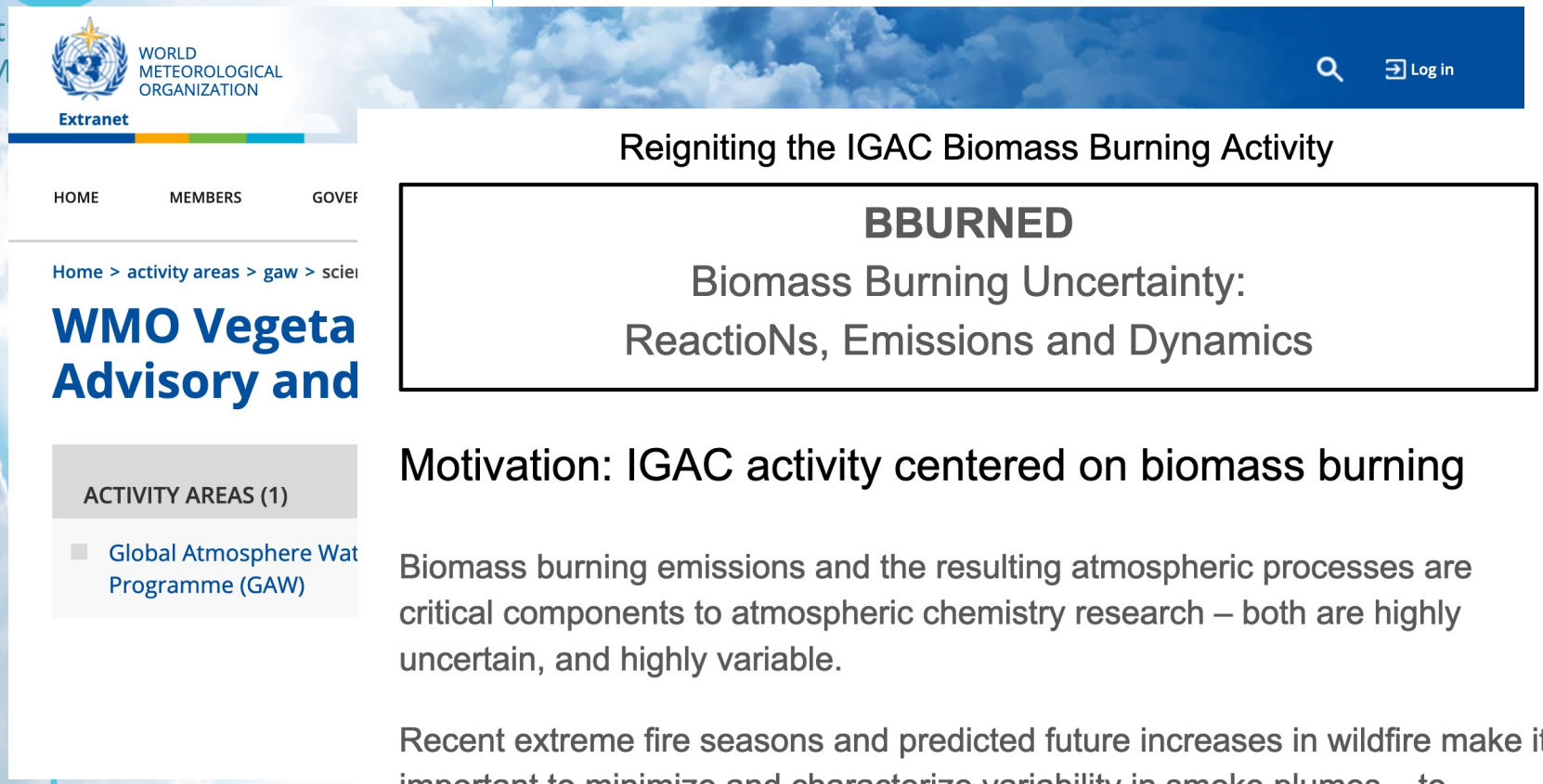
International activities



Reigniting the IGAC Biomass Burning Activity

BBURNED

Biomass Burning Uncertainty:
ReactioNs, Emissions and Dynamics

Motivation: IGAC activity centered on biomass burning

Biomass burning emissions and the resulting atmospheric processes are critical components to atmospheric chemistry research – both are highly uncertain, and highly variable.

Recent extreme fire seasons and predicted future increases in wildfire make it important to minimize and characterize variability in smoke plumes – to correctly quantify the air quality and climate impacts.

BBURNED will connect with other biomass burning initiatives (e.g. WMO, HTAP) to avoid duplicating efforts, and will specifically focus on atmospheric chemistry relevant aspects of the biomass burning problem.

- WMO expert working group on wildfires
- Regional centres established for SE Asia and North America
- https://community.wmo.int/activity-areas/gaw/science/modelling-applications/vfsp-was

- International Global Atmospheric Chemistry network under Future Earth
- Specific focus on understanding uncertainties from fire ecology to EO
- Connecting to other initiatives
- Please contact me if you would like to be added to the mailing list

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