COPERNICUS EARTH OBSERVATION

DATA VISUALISATION WORKSHOP SERIES

PROGRAMME OF THE EUROPEAN UNION

Copernicus — Europe's eyes on Earth

WEkEO

IMPLEMENTED BY

EUMETSAT · MERCATOR OCEAN INTERNATIONAL · ECMWF · European Environment Agency

Air Quality and Wildfires

Bringing wildfire and air quality information to the public
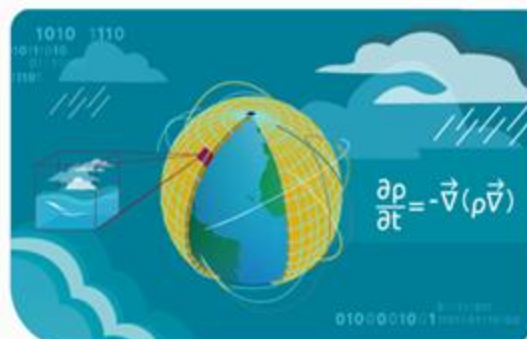
Dr Mark Parrington @m_parrington

European Centre for Medium-Range Weather Forecasts   @ECMWF @CopernicusECMWF

EUMETSAT

#EOData4Storytelling

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CAMS provides consistent and quality-controlled information related to air pollution and health, solar energy, greenhouse gases and climate forcing, everywhere in the world.

atmosphere.copernicus.eu

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2018-10-31, Sentinel-5P NO2, Sentinel 5P L2 - Nitrogen Dioxide

Credit: European Union, contains modified Copernicus Sentinel data 2018, processed with EO Browser
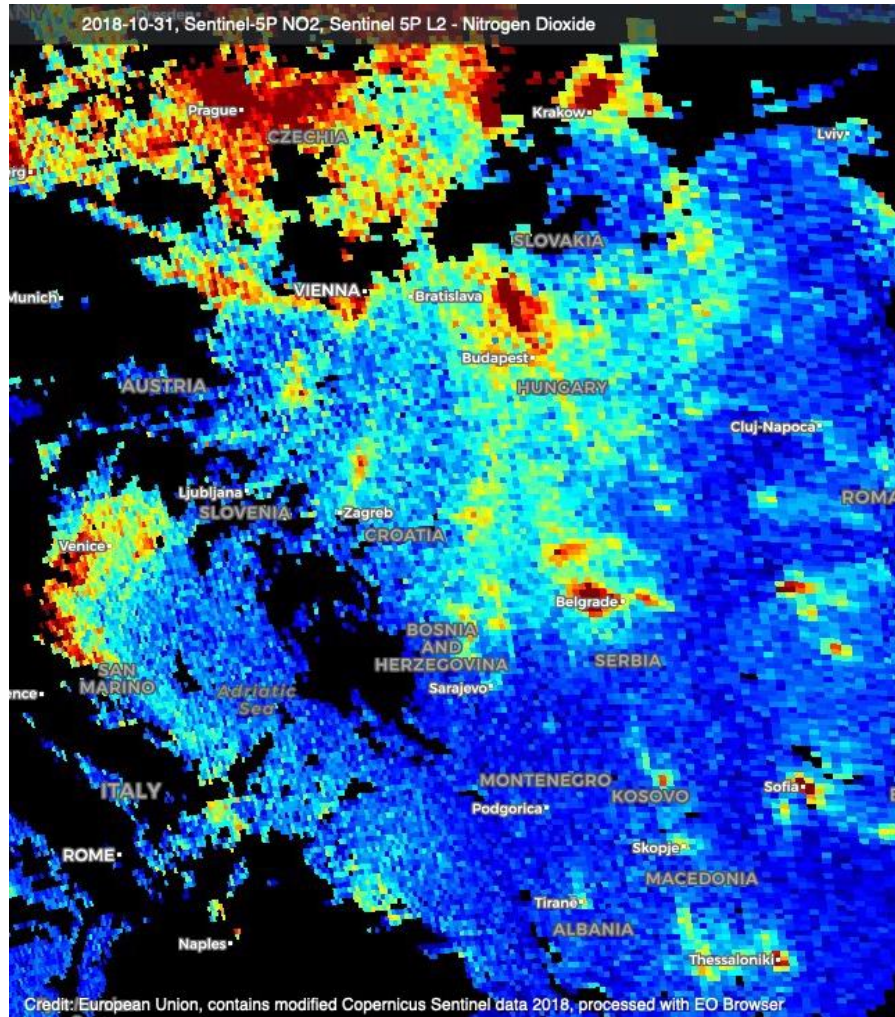
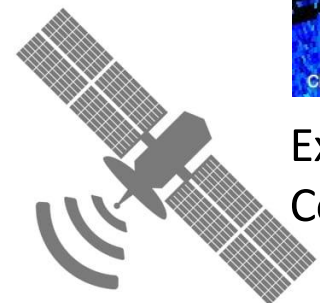Example: NO_2 tropospheric column from Copernicus Sentinel-5P (31/10/2018)

Observations are essential, but **direct use** is generally **limited**:
- gaps in space and time
- observed quantities may not be directly relevant (vertical column vs surface concentration)
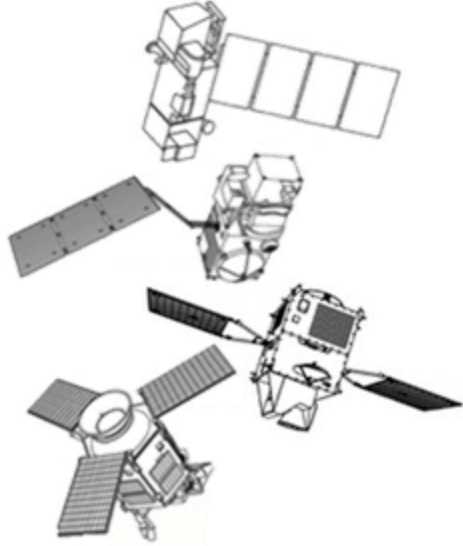- can be complex and numerous

What CAMS does:
- blend observations (satellite and non satellite) with model to provide a consistent 3D state
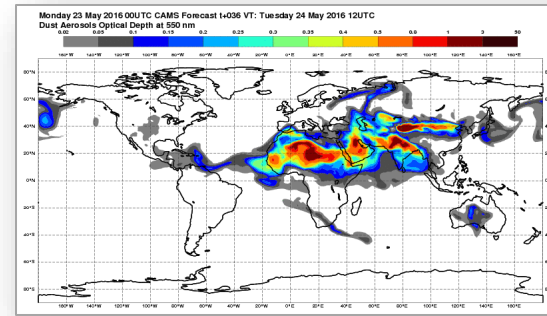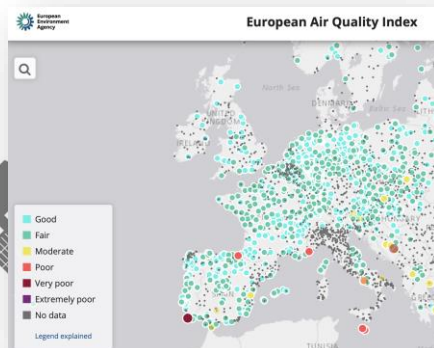- forecasts, a few days ahead
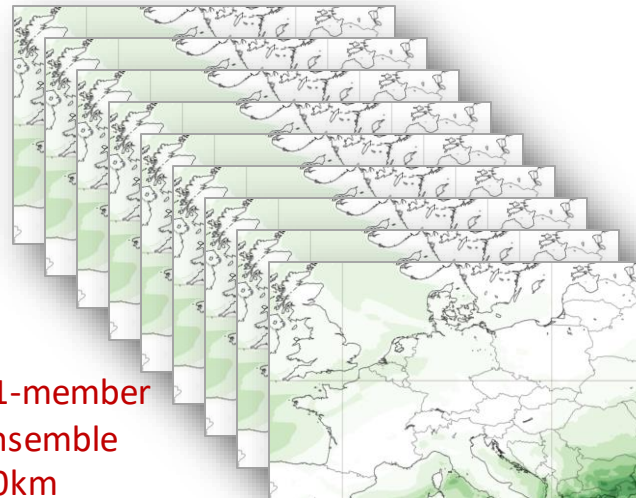- reanalyses over past years or decades

→ Maps without gaps

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IFS 40km (oper) / 80km (rean) Globe

CAMS main operational data assimilation and modelling systems

11-member ensemble 10km Europe

Earth Observation from satellite (>75 instruments) and in-situ (regulatory and research)

CAMS users
- Applications
- Policy products

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- Visualisation of assimilated atmospheric composition to show global transport of atmospheric pollution.
  - Combination of model with multiple satellite observations measuring at different wavelengths

- Carbon monoxide (CO) is a product of incomplete combustion with a photochemical lifetime of ~1 month.

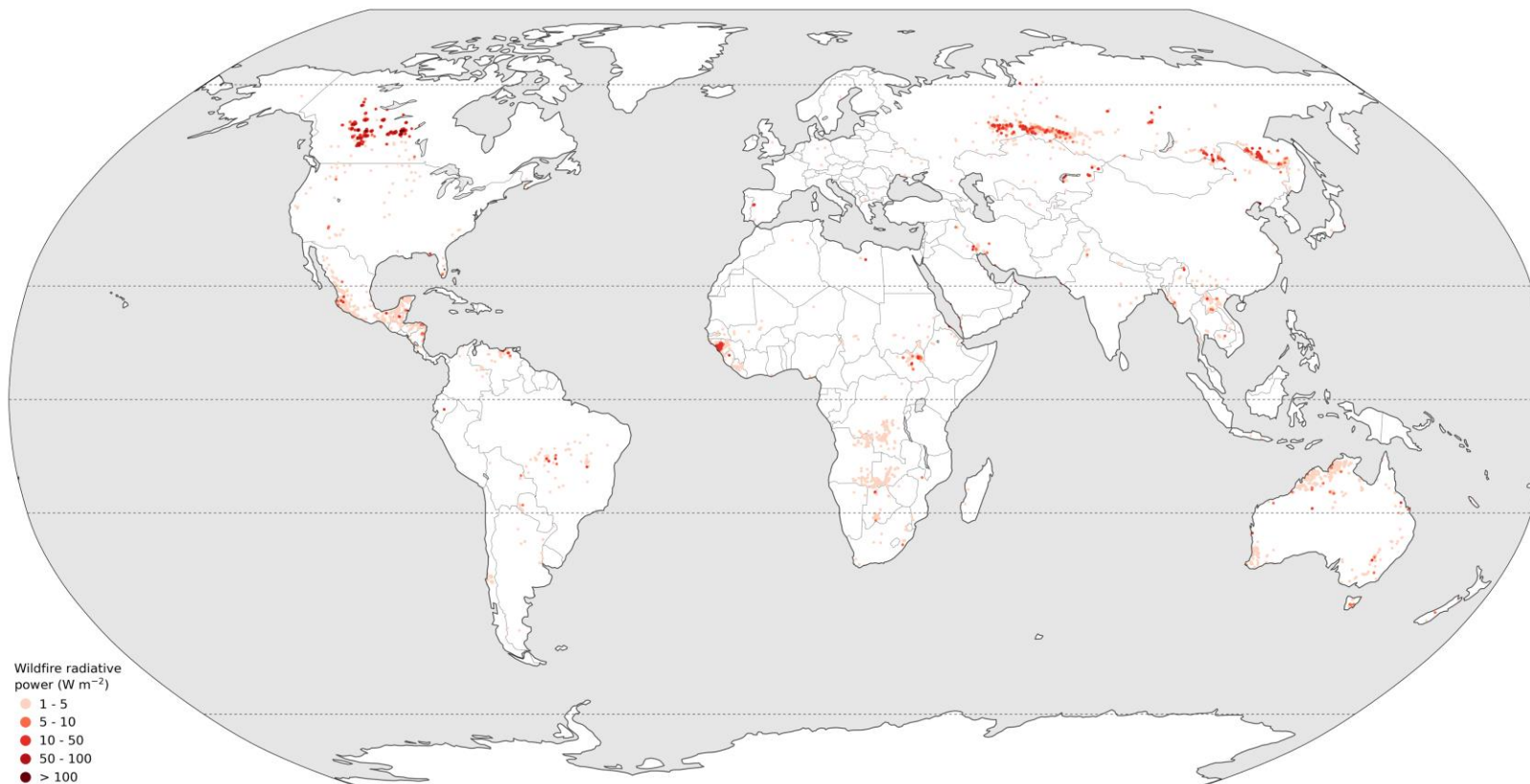- Animation shows CO concentration at 850 hPa (~1.5 km) analyses between 1-22 May 2023.

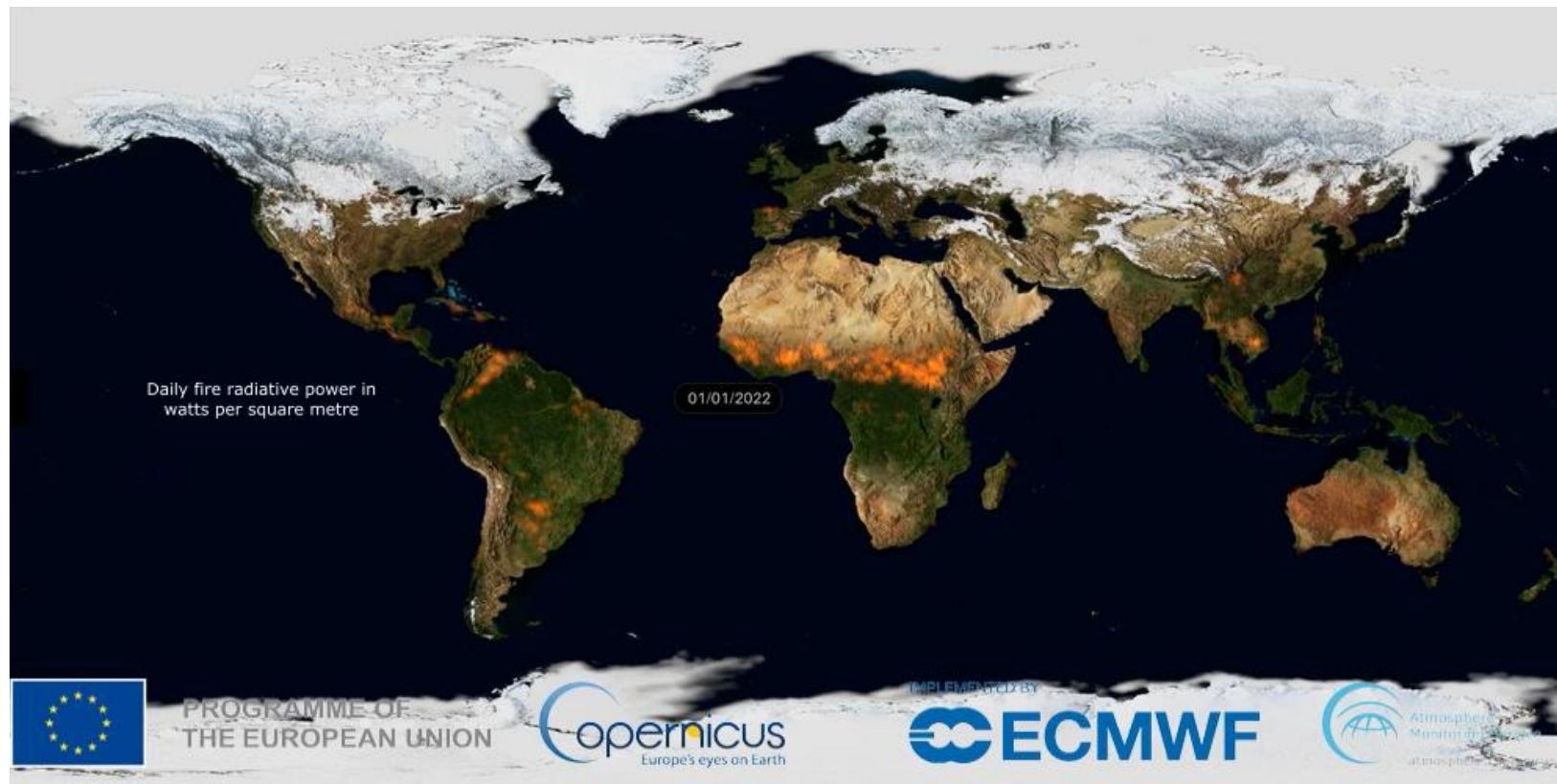CAMS Analysis carbon monoxide volume mixing ratio at 850 hPa: 20230501T00
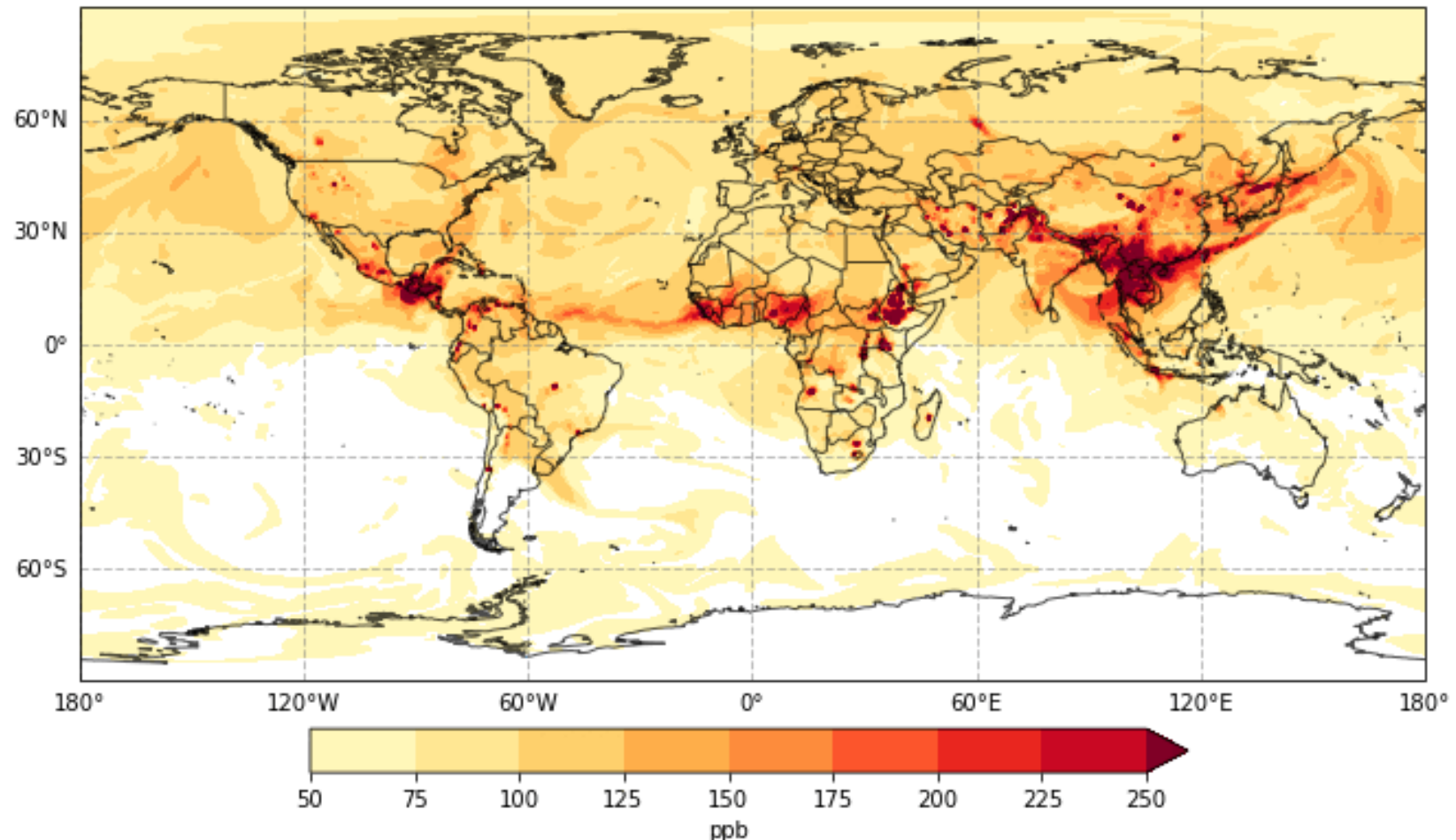
Global Wildfire Emissions

GFAS Total Fire Radiative Power - May 2023

Wildfire radiative power (W m^{-2})
- 1 - 5
- 5 - 10
- 10 - 50
- 50 - 100
- > 100

- 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.

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IMPLEMENTED BY   ECMWF   Atmosphere Monitoring Service atmosphere.copernicus.eu

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Global Wildfire Emissions

Daily fire radiative power in watts per square metre

01/01/2022

Animation created by Sylvie Lamy-Thepaut (ECMWF)

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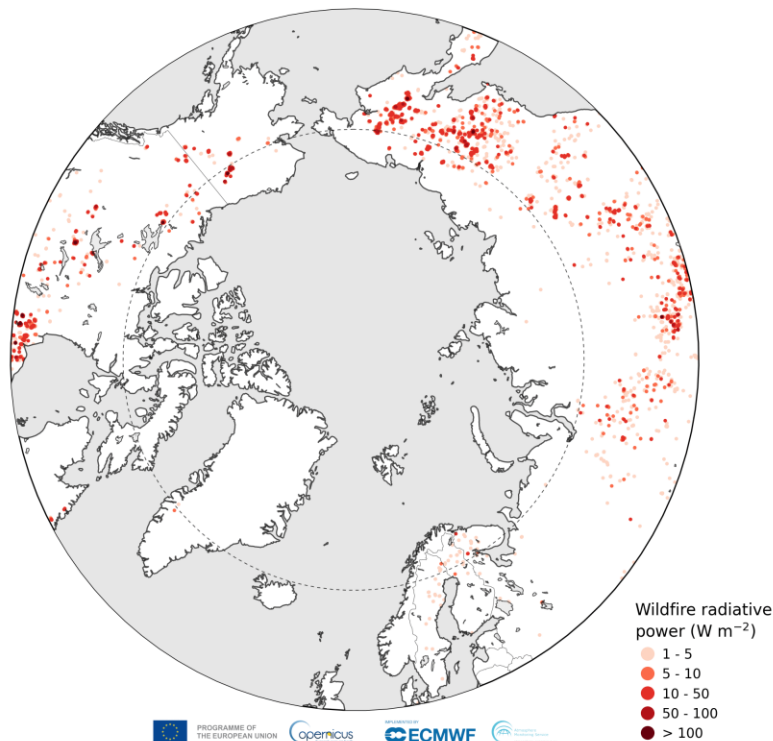- Emissions of aerosols and gases are estimated using factors dependent on vegetation type.

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Arctic wildfires

GFAS Total Fire Radiative Power - JJA 2003

Wildfire radiative power (W m⁻²)
- 1 - 5
- 5 - 10
- 10 - 50
- 50 - 100
- > 100

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Daily total Fire Radiative Power

GFAS mean daily total FRP 2003-2018
GFAS daily total FRP 2020
GFAS daily total FRP 2019

Total Fire Radiative Power / GW

24-Jun   17-Jul   09-Aug   01-Sep
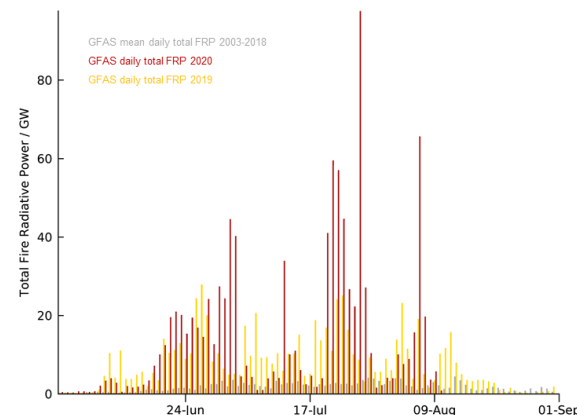
Cumulative daily total carbon emissions

- 2003-2019 mean
- 2021
- 2020
- 2019
- 2018
- 2017
- 2003-2016

Total wildfire emission / Mt C

01-Apr   01-Jul   01-Oct
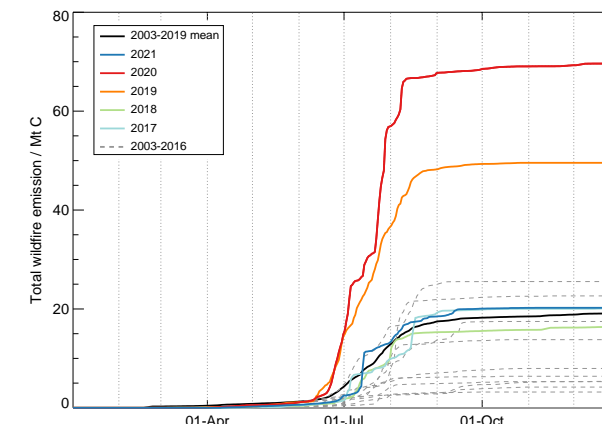
Cumulative JJA total carbon emissions

Total wildfire emissions / Mt C

2005   2010   2015   2020
Year

PROGRAMME OF THE EUROPEAN UNION — Copernicus — IMPLEMENTED BY ECMWF
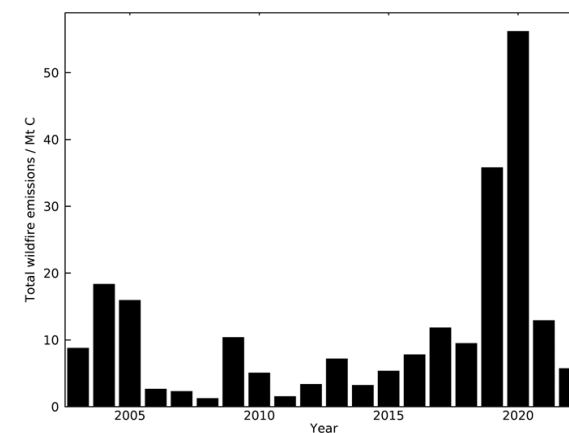
20 years of of June-August MODIS active fire observations.

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.
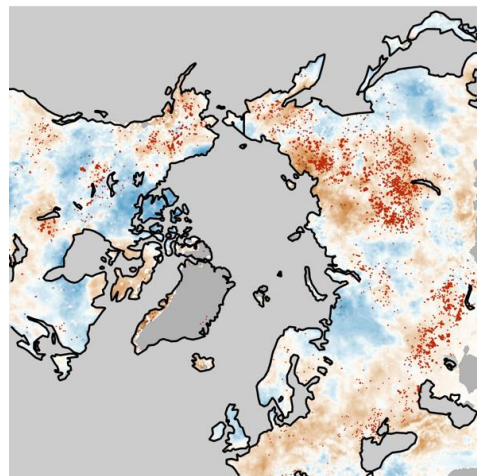
rth Observation
Data Visualisation Workshop Series
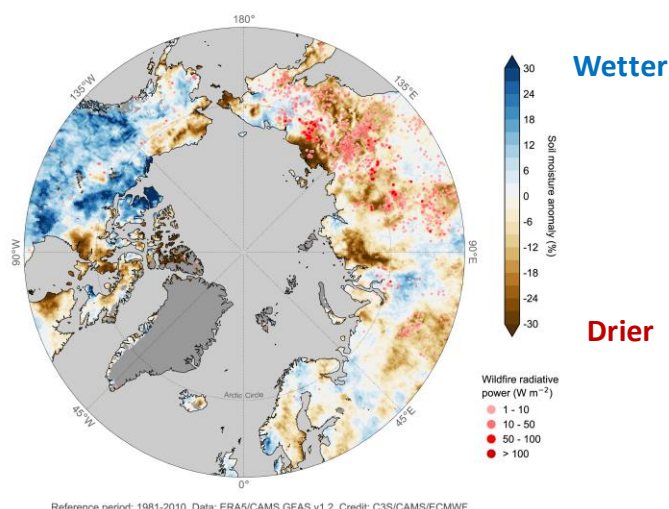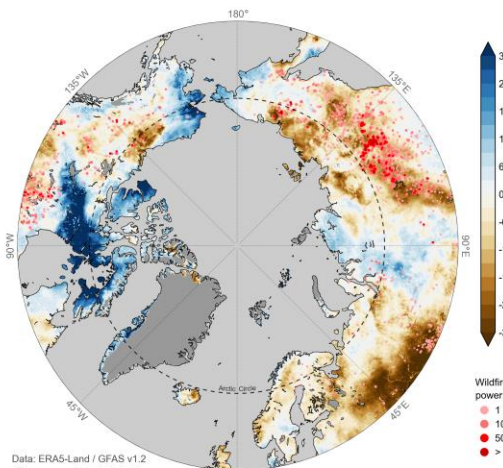Air Quality & Wildfires

Arctic wildfires

JJA 2019

JJA 2020

Wetter

Drier

Reference period: 1981-2010. Data: ERA5/CAMS GFAS v1.2. Credit: C3S/CAMS/ECMWF

JJA 2021

JJA 2022

Data: ERA5-Land / GFAS v1.2
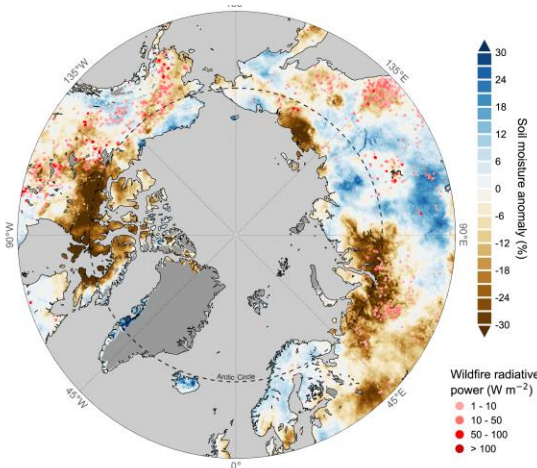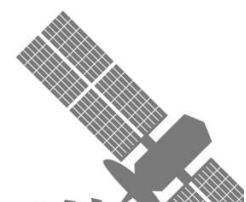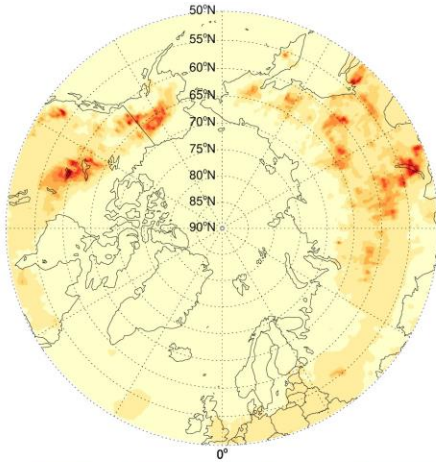
- June-August soil moisture anomaly & fire locations.

- Merging independent datasets from CAMS and the Copernicus Climate Change Service (C3S).

- Active fire observations throughout the summer of 2019, 2020, 2021 and 2022 corresponded with areas of negative (drier) soil moisture anomalies (relative to 1981-2010 climatology) from C3S.

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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
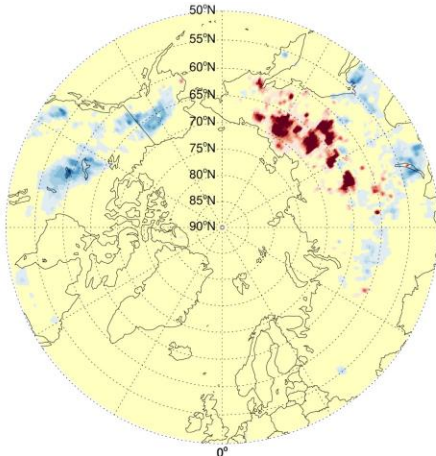https://climate.copernicus.eu/esotc/2022/arctic-wildfires

Arctic wildfires

2003-2018 climatology

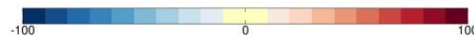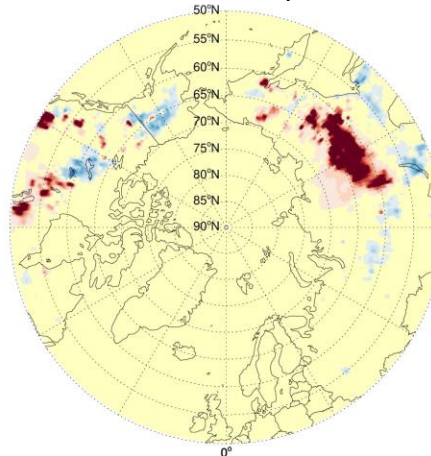2019 anomaly
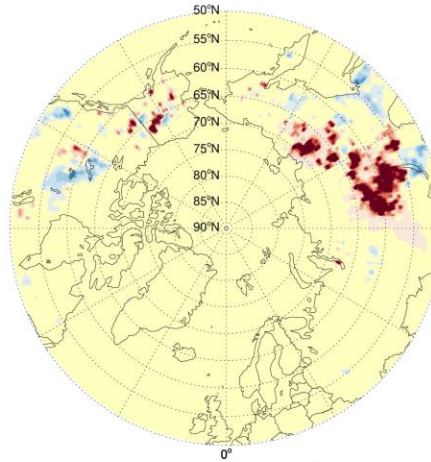
2020 anomaly

2021 anomaly

- Air quality impacts of Arctic wildfires between 2019-2021.
- Climatology of surface PM2.5 concentration shows limited impact of wildfires on air quality in Siberian Arctic between 2003-2018.
- 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.

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

Copernicus Earth Observation
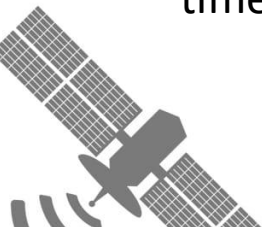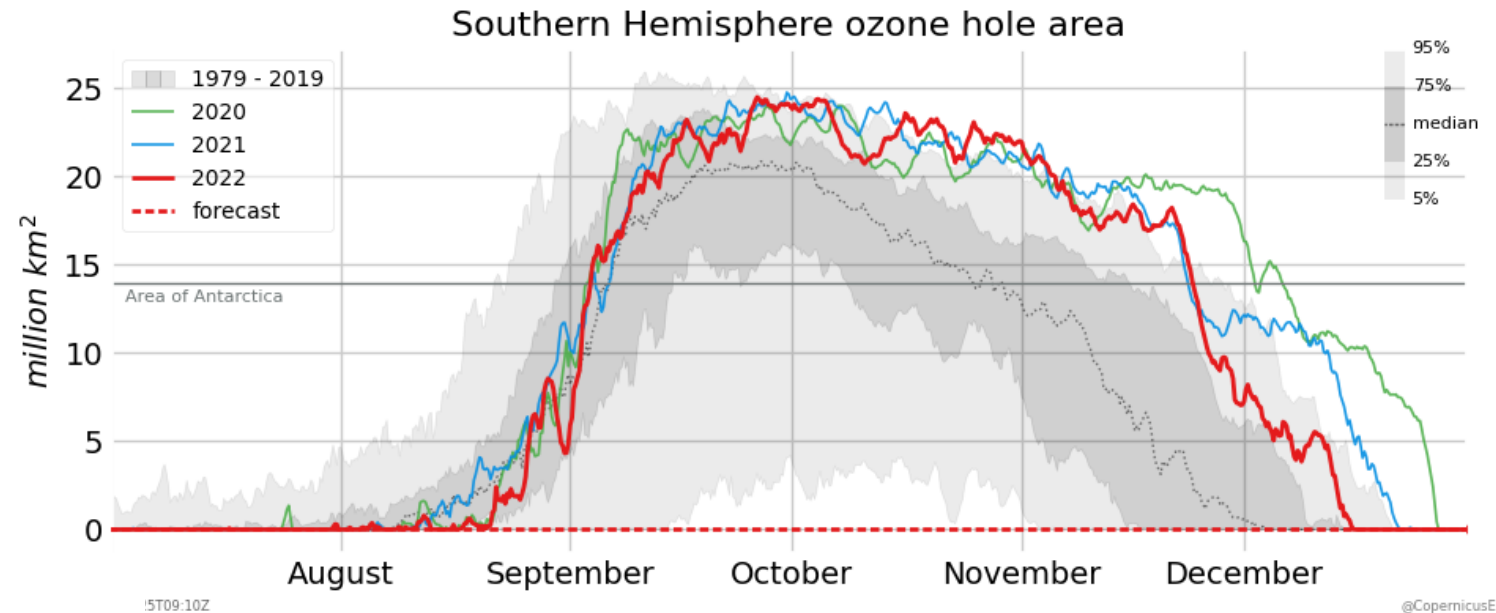Data Visualisation Workshop Series
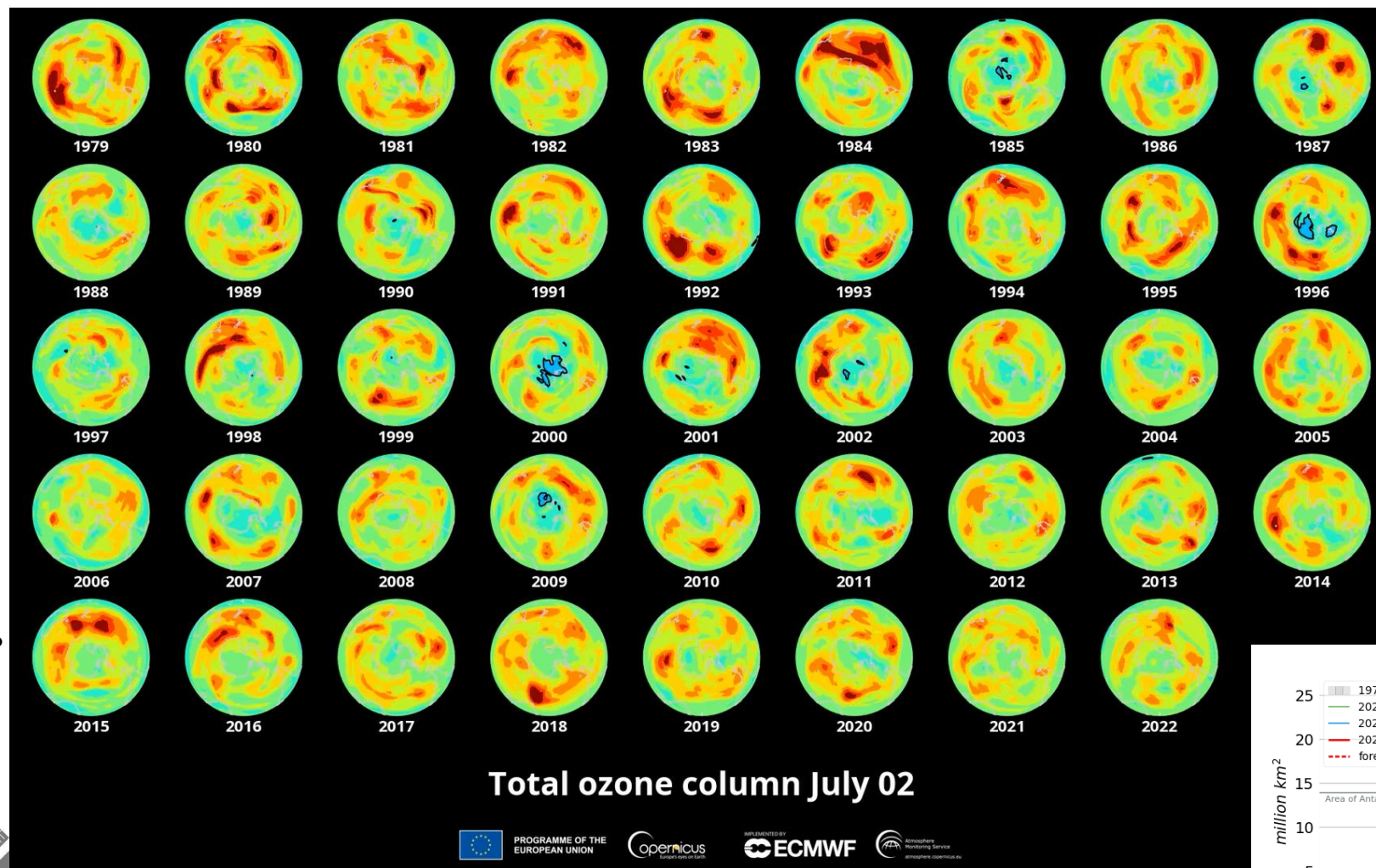Air Quality & Wildfires

Antarctic Ozone Hole

Ozone hole development 2022
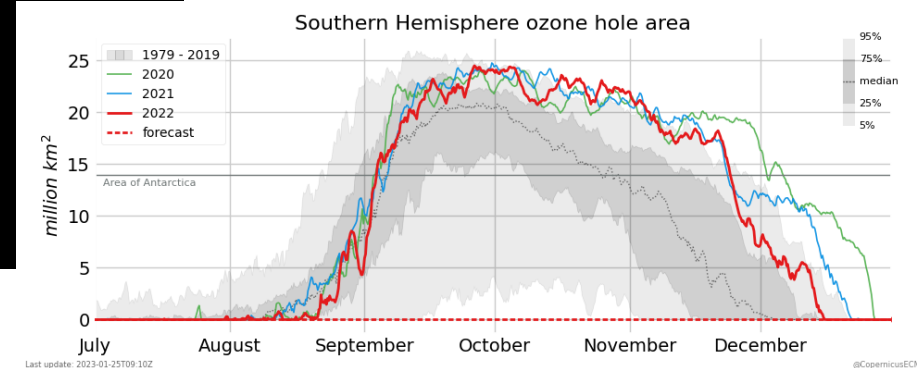12 mPa ozone partial pressure isosurface coloured by total column ozone

- The Antarctic ozone hole forms in the spring of the southern hemisphere as sunlight returns to the polar region and activates chemical loss constrained by the polar vortex.

- CAMS assimilates total column ozone observations and provides a 40-year dataset of the ozone hole in combination with C3S data.

Southern Hemisphere ozone hole area

- Animation shows evolution of 2022 ozone hole, reflecting time series of the area.

Animation created by Miha Razinger (ECMWF)
https://atmosphere.copernicus.eu/monitoring-ozone-layer

Antarctic Ozone Hole

Total ozone column July 02

Animation created by Miha Razinger (ECMWF)

- Evolution of 40+ years of Antarctic ozone hole evolution.

Southern Hemisphere ozone hole area

Air Quality & Wildfires

Near-real-time monitoring of Canada wildfires and smoke

CAMS data visualisation, story telling and communication is based on active monitoring of atmospheric composition events as they are occurring (e.g., Canadian wildfires in May 2023).
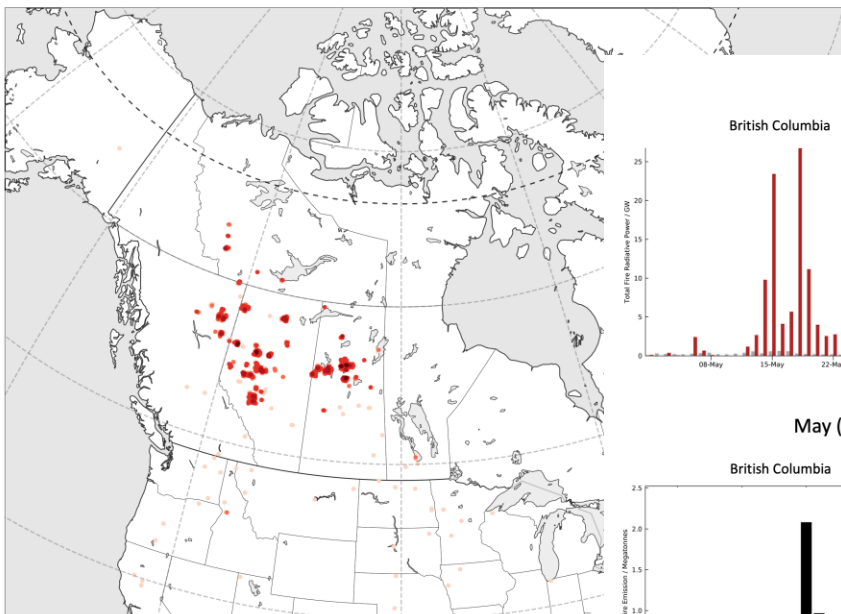
- Information can be provided quickly in response to, e.g., journalists questions.
- Social media allows on-the-fly scientific analysis with experts from different fields as well as local, on the ground, information.
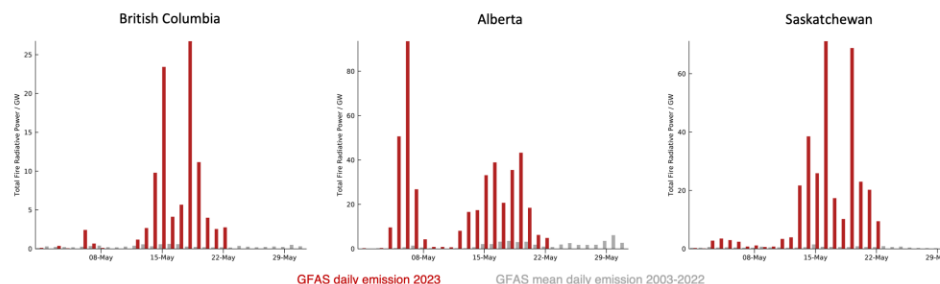
Near-real-time monitoring of Canada wildfires and smoke

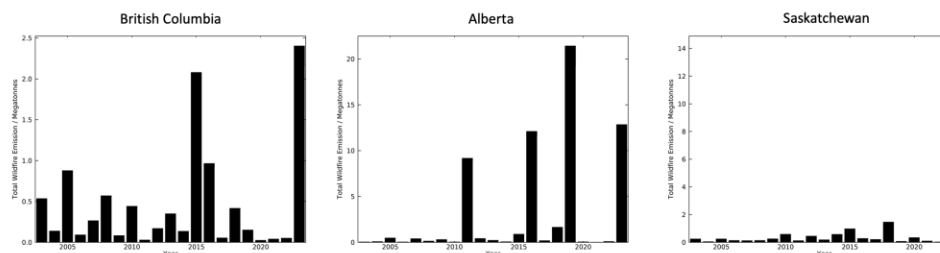GFASv1.2 Total Fire Radiative Power: 2023-05-01 - 2023-05-22
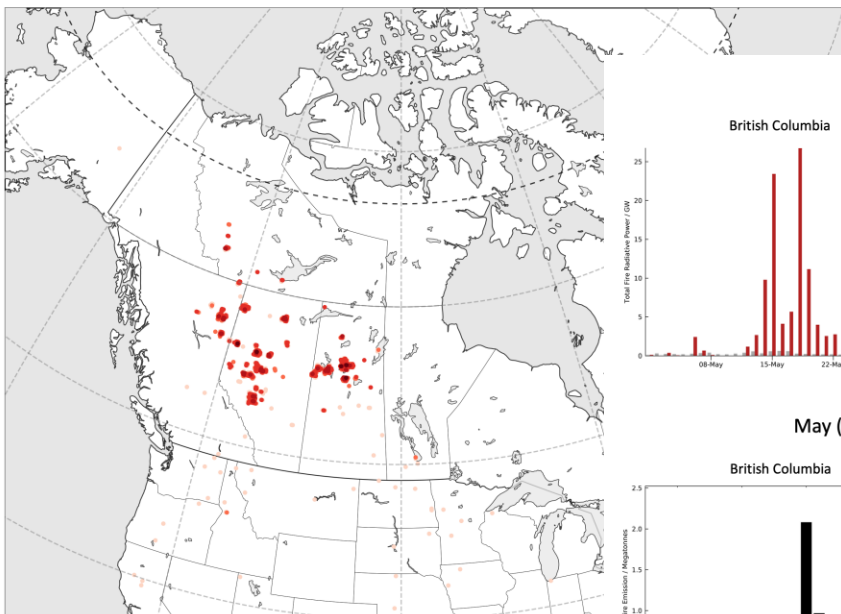
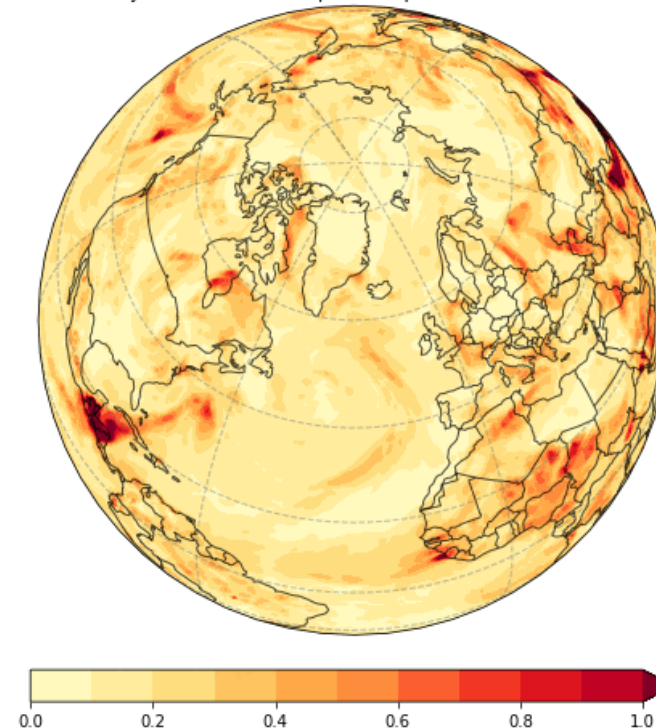CAMS Daily Total Fire Radiative Power (GFASv1.2)

British Columbia — Alberta — Saskatchewan

GFAS daily emission 2023 — GFAS mean daily emission 2003-2022

May (up to 22 May for 2023) Total Estimated Wildfire Carbon Emissions

British Columbia — Alberta — Saskatchewan

Aerosol Optical Depth analyses

CAMS Analysis Total Aerosol Optical Depth at 550nm, 20230501T00

CAMS data visualisation, story telling and communication is based on active monitoring of atmospheric composition events as they are occurring (e.g., Canadian wildfires in May 2023).

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Thank you!
Questions?