Copernicus Atmosphere Monitoring Service: Operational global air quality information

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CAMS global and regional production teams

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Atmosphere Monitoring

Overview

- Copernicus program and services
- Copernicus Atmosphere Monitoring Service (CAMS)
  - The role of observations and operational products
- Case studies of CAMS in action during 2020:
  - ‘Godzilla’ dust event over North Atlantic
  - California wildfires
  - European air quality, AQ policy tools and COVID-19
- Data access
- Summary/open questions

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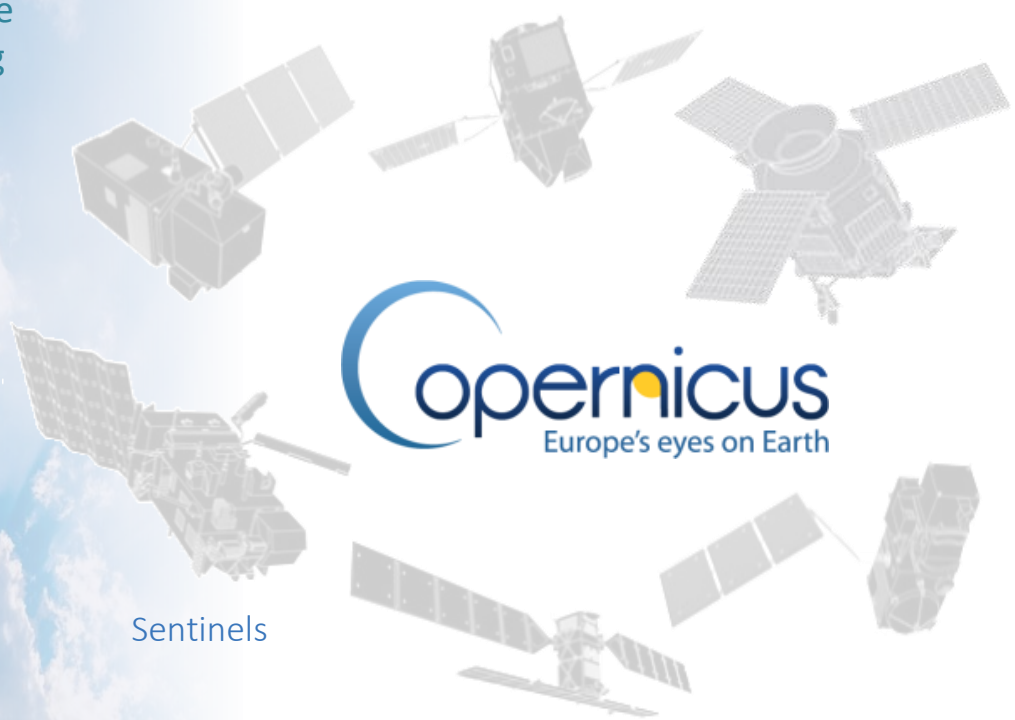
COPERNICUS AND ECMWF

Atmosphere Monitoring



Sentinels

Observations feeding into value-added Services

- Atmosphere
- Climate
- Land
- Marine
- Emergency
- Security

Copernicus is the European Union's operational Earth Observation and Monitoring programme, looking at our planet and its environment for the ultimate benefit of all citizens.

User-driven with free and unrestricted data access

Service is implemented by ECMWF

ECWMF is contributing to the Service

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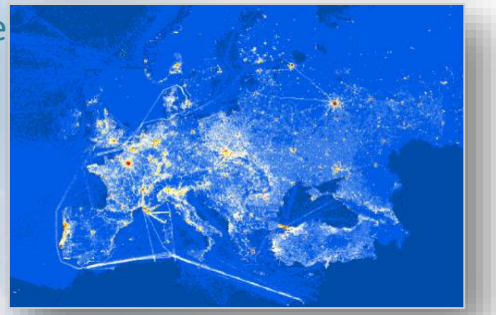
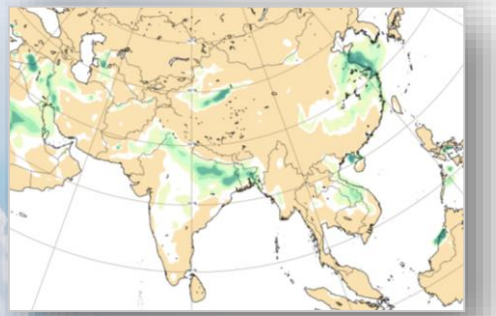
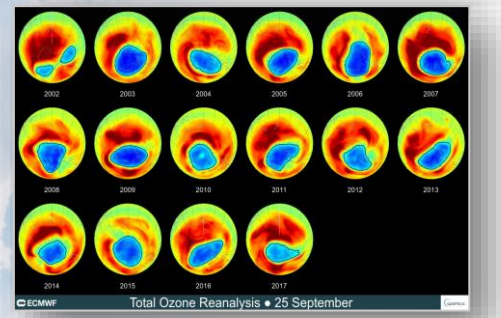
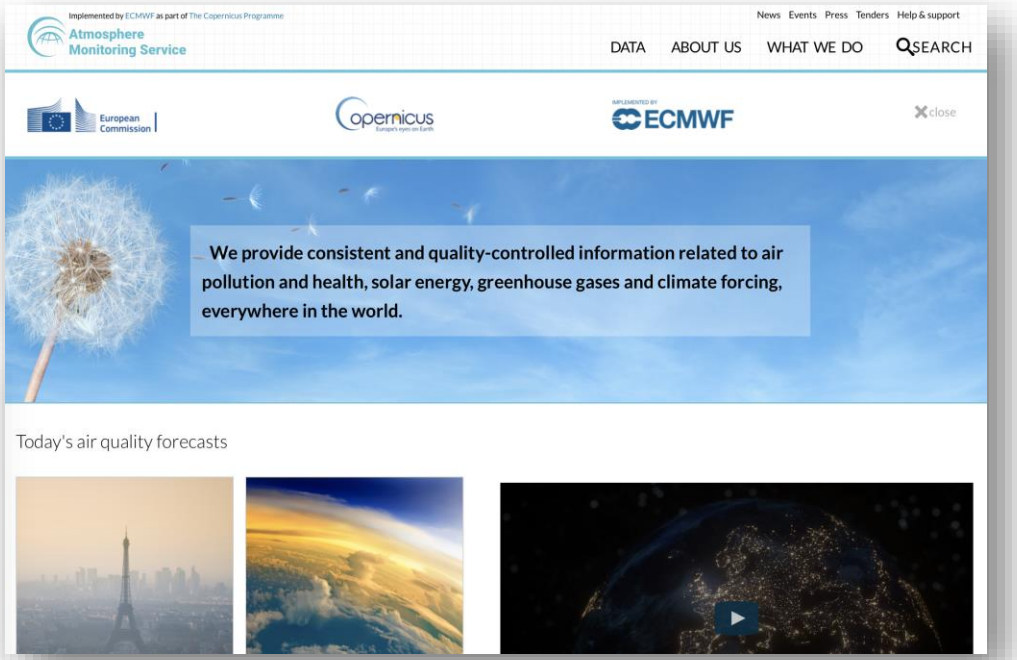
What the Copernicus Atmosphere Monitoring Service has to offer

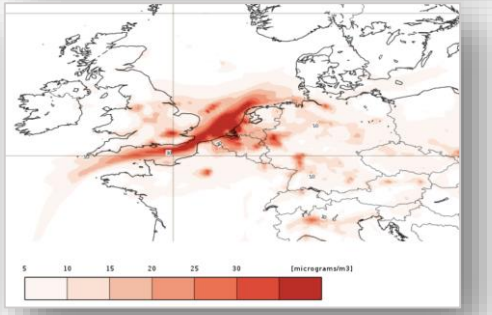
Atmosphere Monitoring

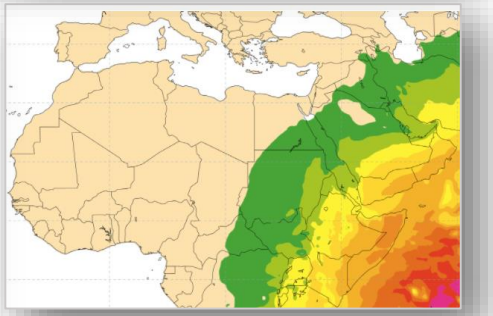












The CAMS portfolio includes Earth Observation based information products about:

- past, current and near-future (forecasts) global atmospheric composition;
- the ozone layer;
- air quality in Europe;
- emissions and surface fluxes of key pollutants and greenhouse gases;
- solar radiation;
- climate radiative forcing.

Quarterly validation reports of global and regional outputs.

https://atmosphere.copernicus.eu

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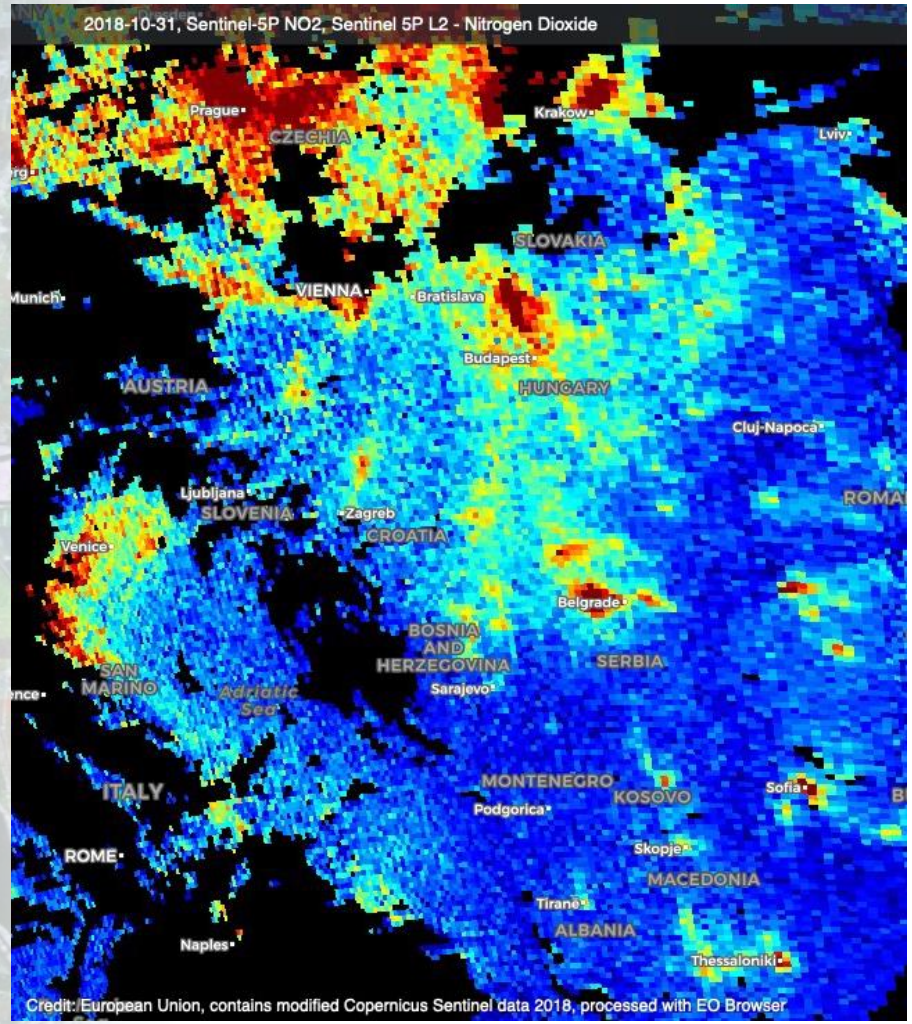
Why is CAMS needed?



Example: NO_2 tropospheric column from Copernicus Sentinel-5P (31/10/2018)

Observations are essential, but **direct use** is generally **limited**:

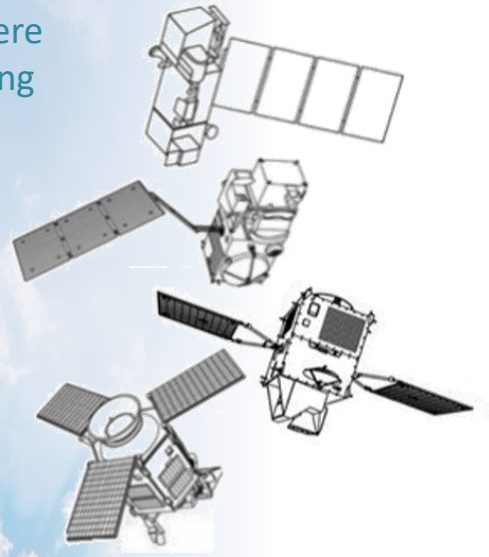
- gaps in space and time
- observed quantities may not be directly relevant (vertical column vs surface concentration)
- can be complex and numerous

What CAMS does:

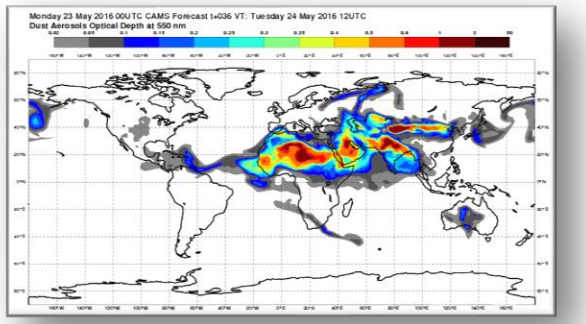
- blend observations (satellite and non satellite) with model to provide a consistent 3D state
- forecasts, a few days ahead
- reanalyses over past years or decades

CAMS Information Flow

Atmosphere Monitoring

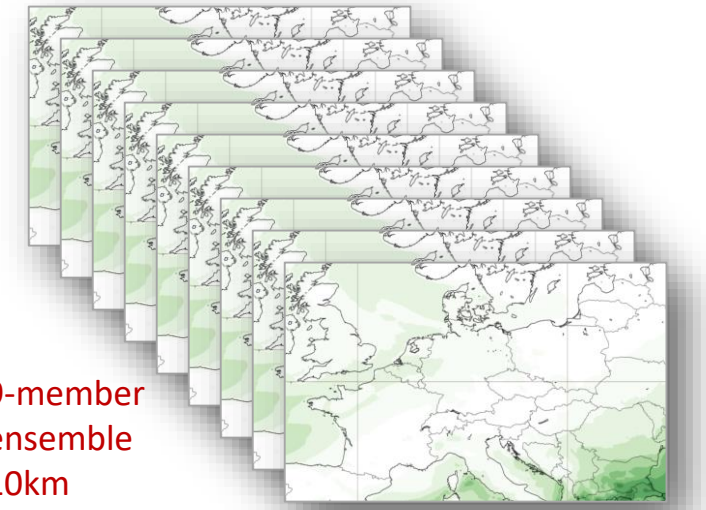


Earth Observation from satellite (>75 instruments) and in-situ (regulatory and research)

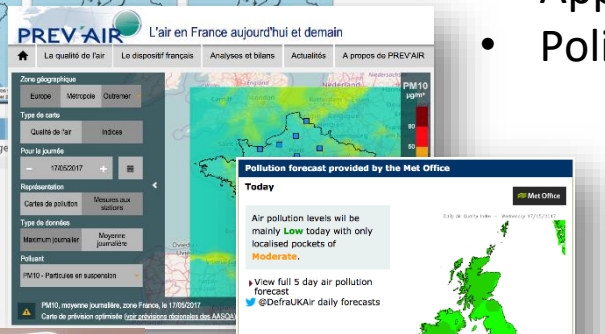


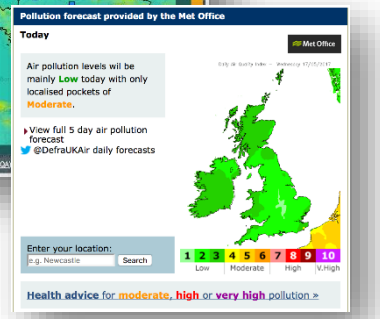
IFS 40km (oper) / 80km (rean) Globe

CAMS main operational data assimilation and modelling systems



9-member ensemble 10km Europe





CAMS users
- Applications
- Policy products

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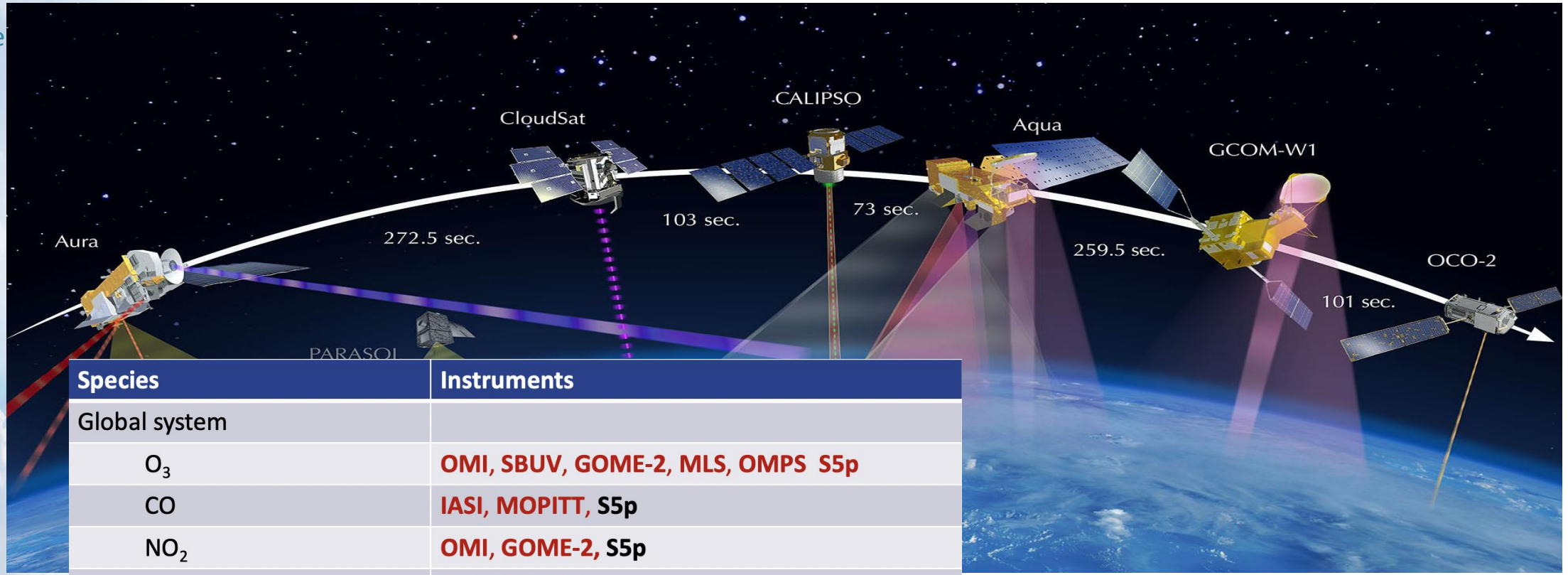
Earth Observation satellites



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, GOES-E/W*, SEVIRI*,** S3, **VIIRS,** HIMAWARI-8*, GOES-R*

Assimilated **Monitored** Future

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

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ESTIMATING GLOBAL WILDFIRE EMISSIONS IN CAMS

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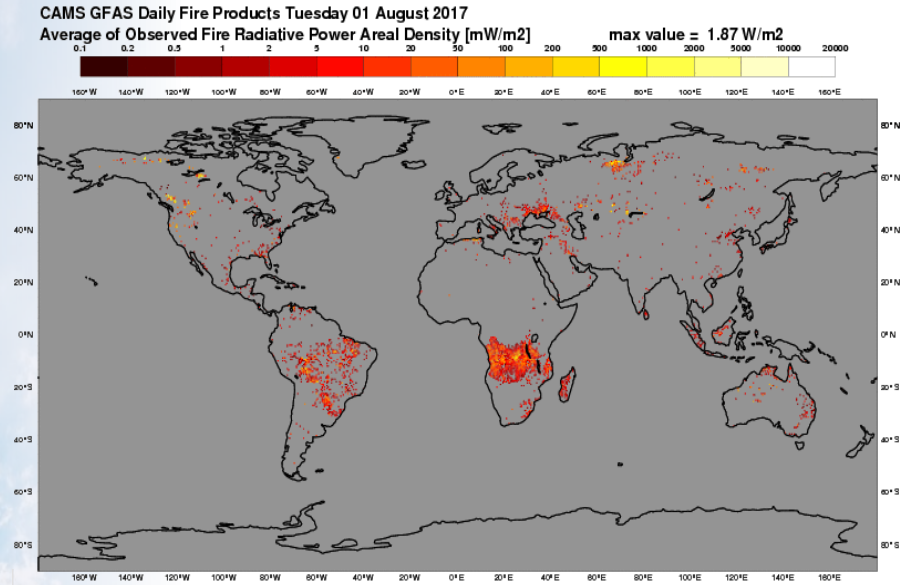
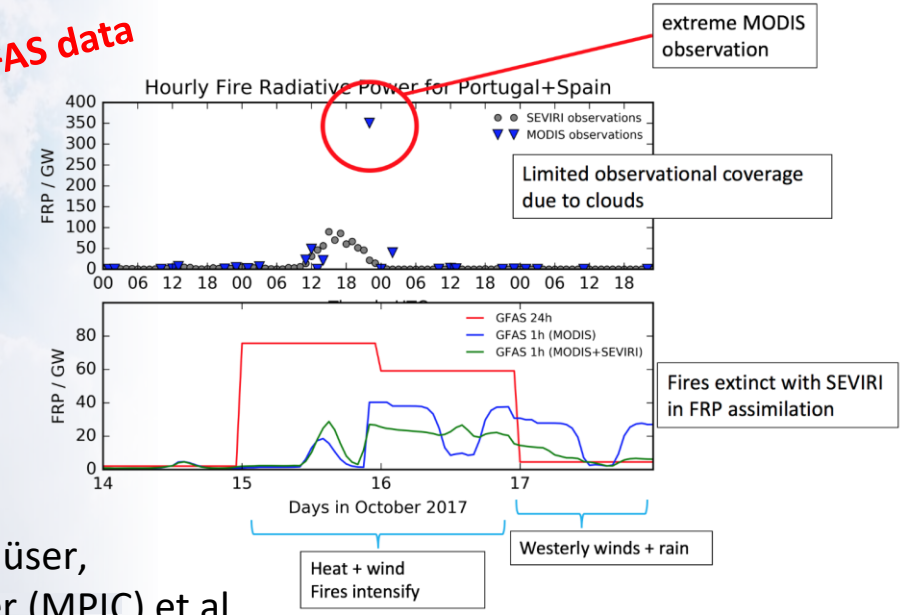


Hourly GFAS data



c/o I. Hüser,
J. Kaiser (MPIC) et al.

- Global Fire Assimilation System (**GFAS**); see http://apps.ecmwf.int/datasets/data/cams-gfas/
- 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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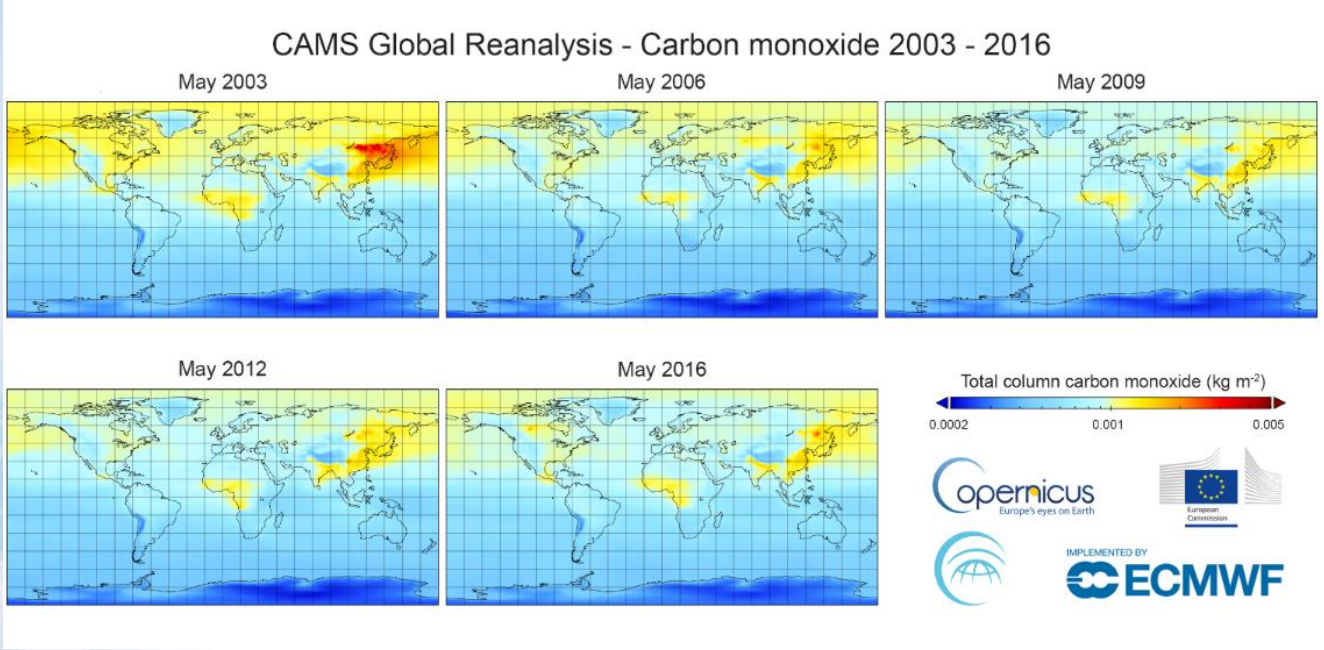
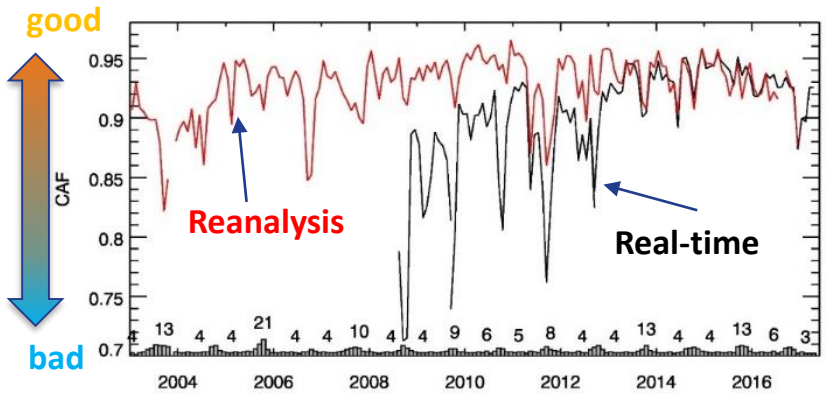
CAMS global reanalysis 2003 – 2019 (updated every 6 months)

https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-global-reanalysis-eac4



Reanalysis
Using a combination of observations and computer models to recreate historical climate conditions.

O3 score at Neumayer station



CAMS global reanalysis

- 2003 – 2019, with new years being added
- Aerosols, 13 chemical pollutants, CO_2 & CH_4
- 80 km spatial resolution
- Inness et al. 2019, https://doi.org/10.5194/acp-19-3515-2019

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CAMS in action: ‘Godzilla’ dust event

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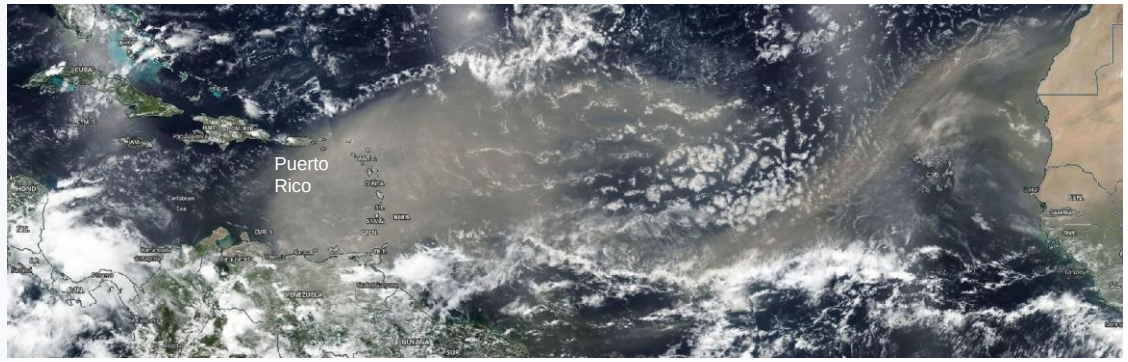
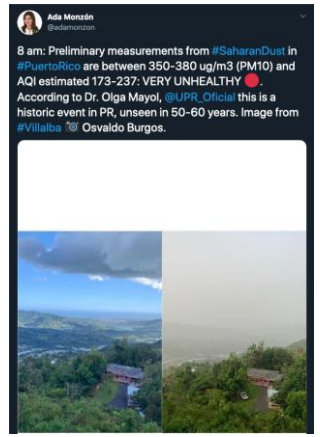
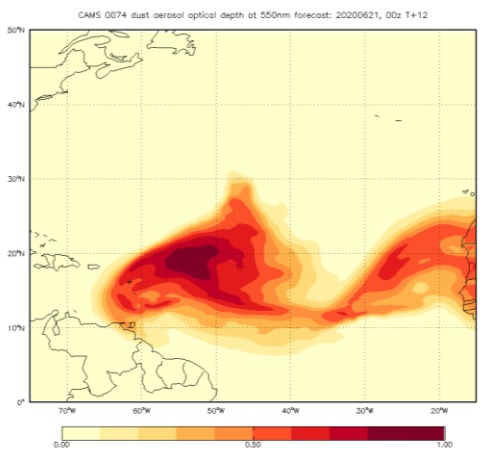


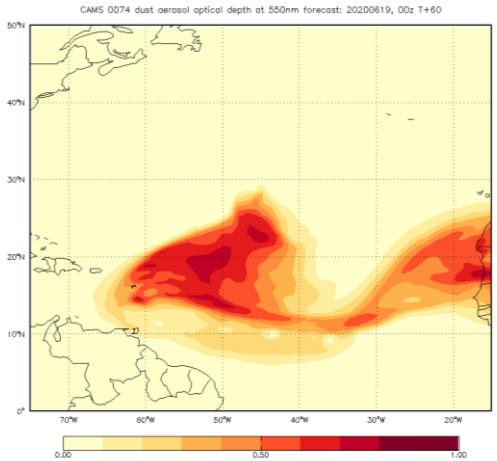
NASA/NOAA Suomi-NPP VIIRS imagery for 21 June 2020



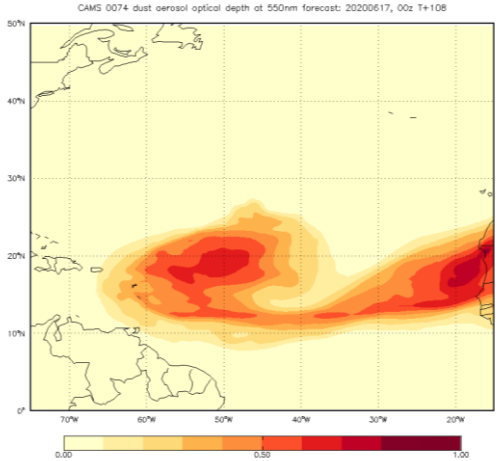
CAMS dust aerosol optical depth forecast initialiazed at 00 UTC on 21 June 2020



+12h forecast



+60h forecast



+108h forecast

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CAMS in action: 'Godzilla' dust event

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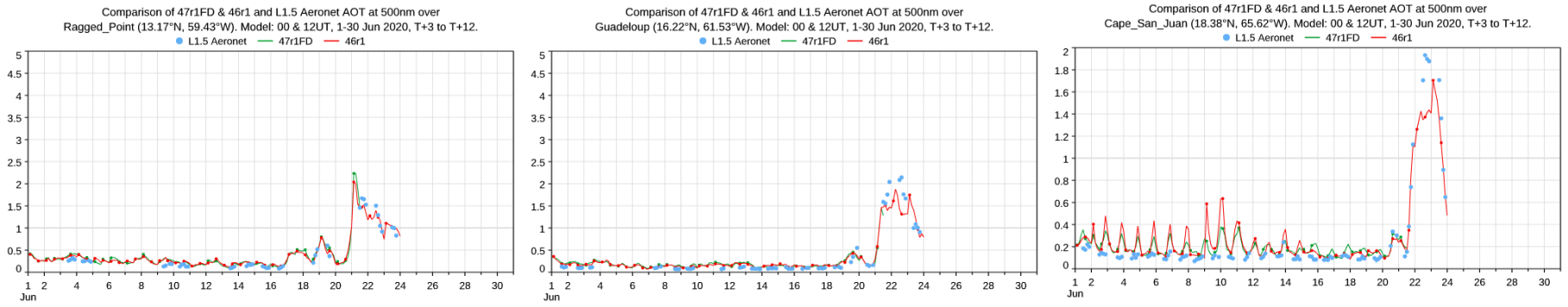
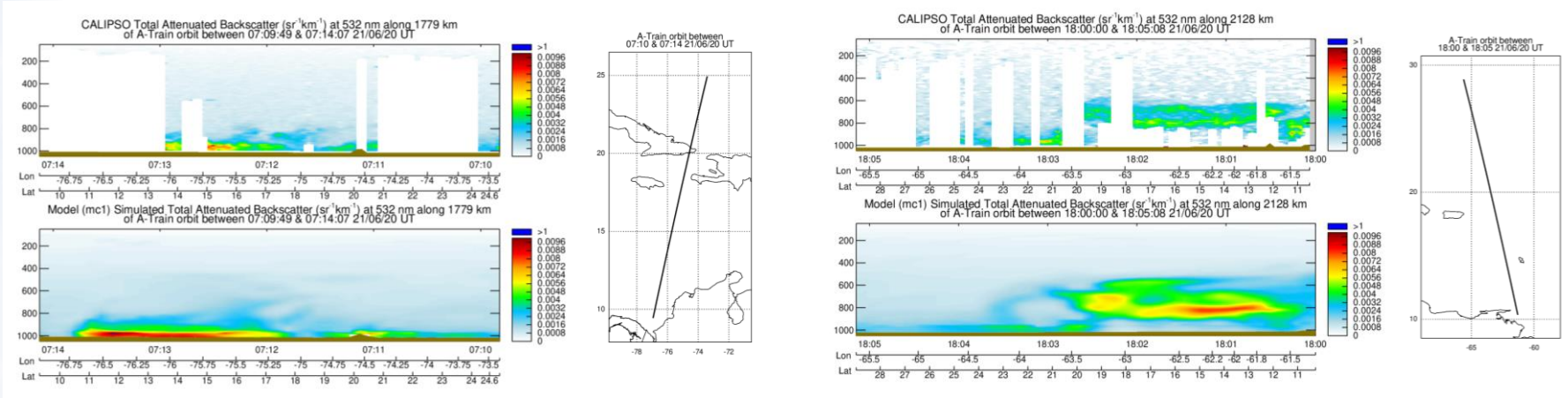
Routine evaluation against independent observations is essential



vs Aeronet in the Caribbean at Ragged Point, Guadeloupe, Cape San Juan



vs two CALIPSO orbits over eastern Caribbean on 21 June 2020

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CAMS in action: California fires in August-September 2020

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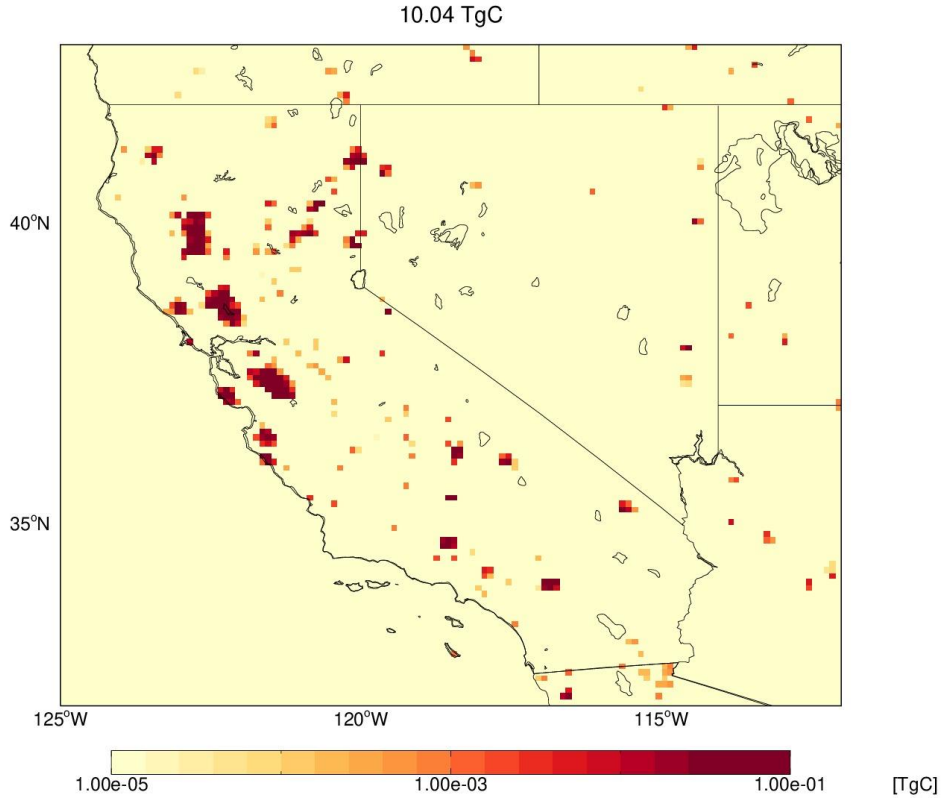

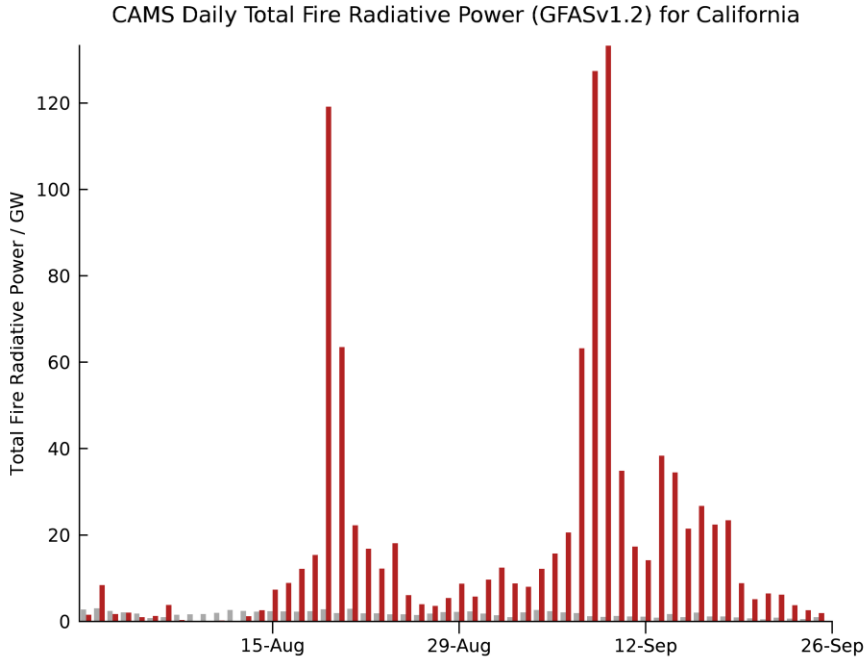

- Widespread wildfires across California and western states through August and September 2020.
- GFAS data used to monitor state-level active fires location and intensity.
- CAMS global analyses and forecasts of aerosol optical depth and total column carbon monoxide used to monitor local and long-range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

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CAMS in action: California fires in August-September 2020

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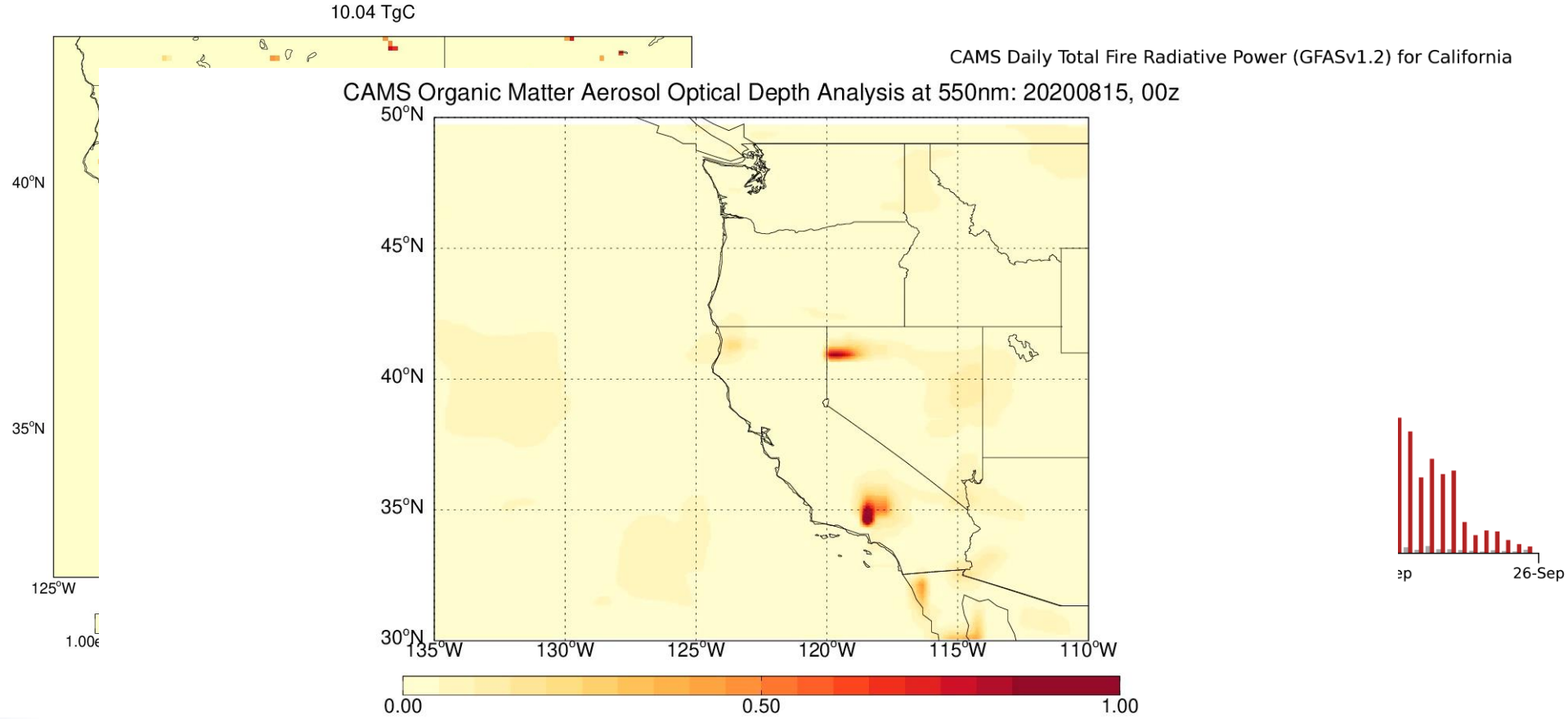

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CAMS in action: California fires in August-September 2020

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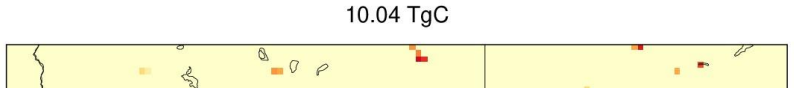
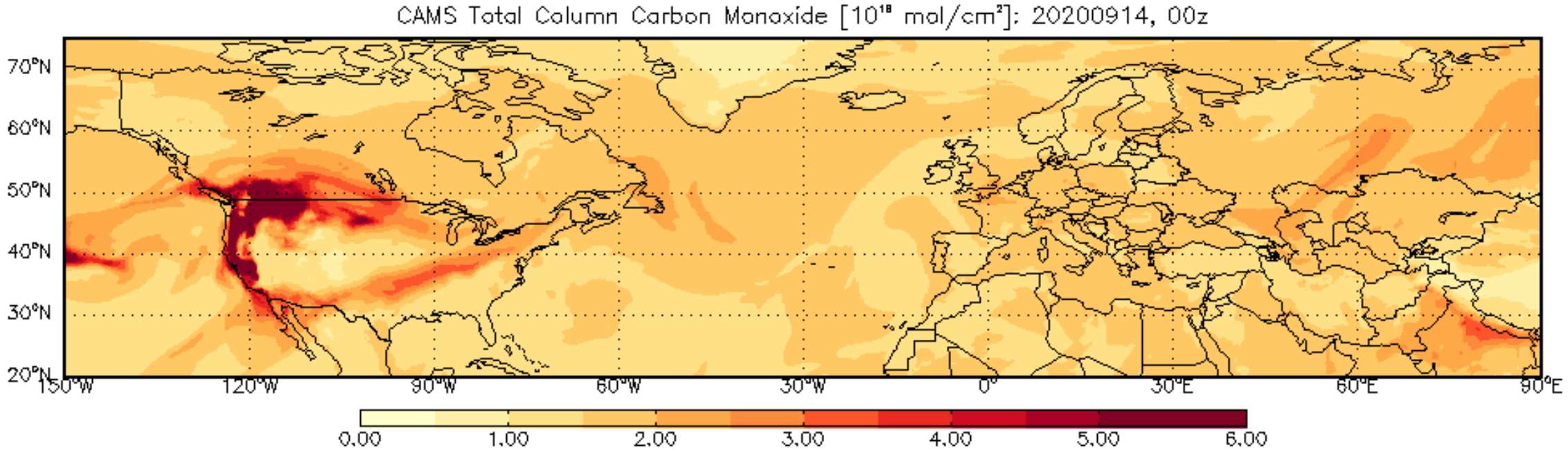


CAMS Daily Total Fire Radiative Power (GFASv1.2) for California



- CAMS global analyses and forecasts of aerosol optical depth and total column carbon monoxide used to monitor local and long-range smoke transport.

Smoke pollution impact on NWP

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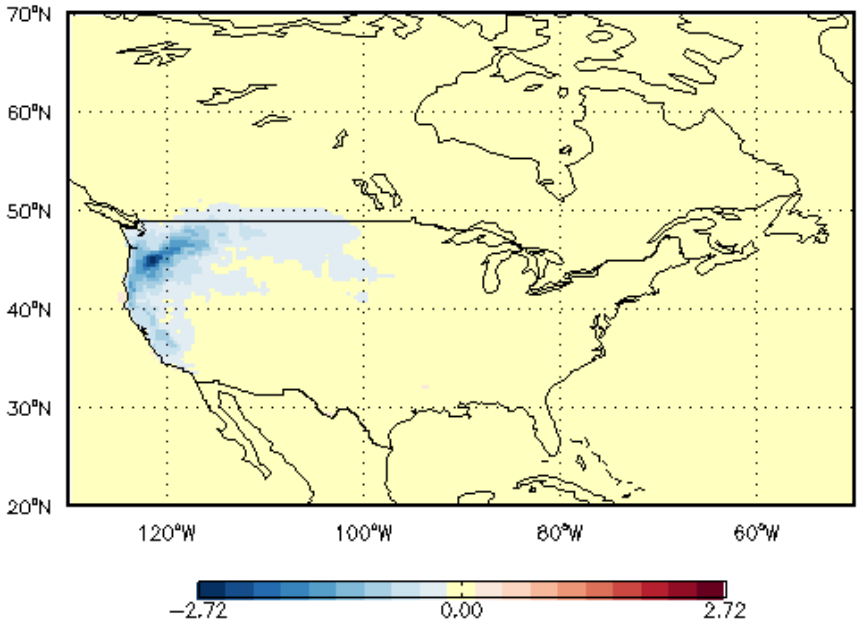
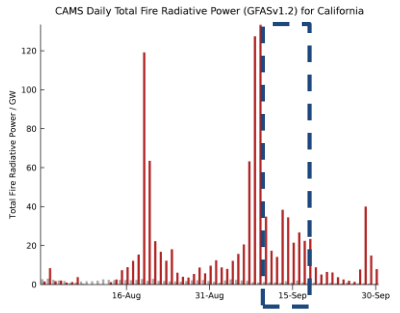
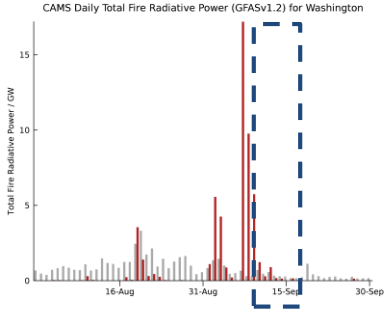
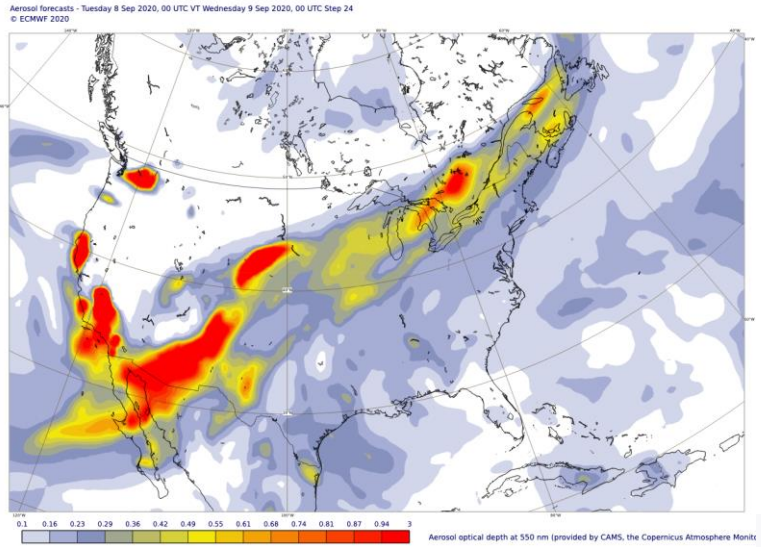
2m temperature difference (K) between a run with climatological aerosol and a run with interactive aerosol: average for 9-17 September 2020









- Gaining confidence on aerosol-radiation interactions
- Aerosol-cloud interactions still very much uncertain

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CAMS in action: European Air Quality

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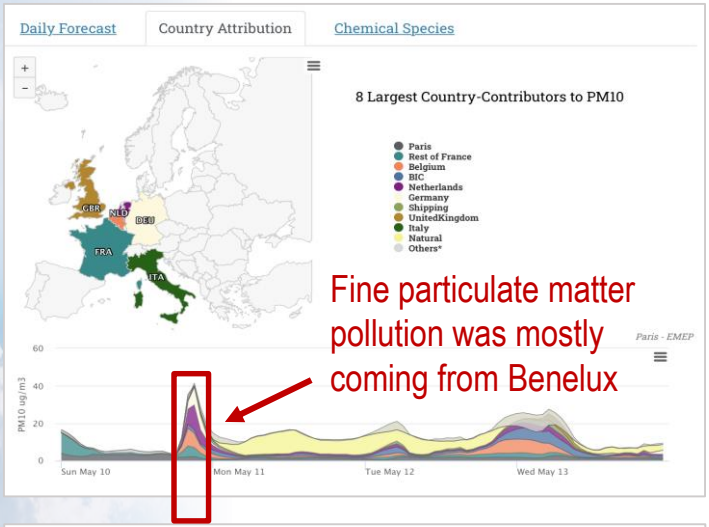
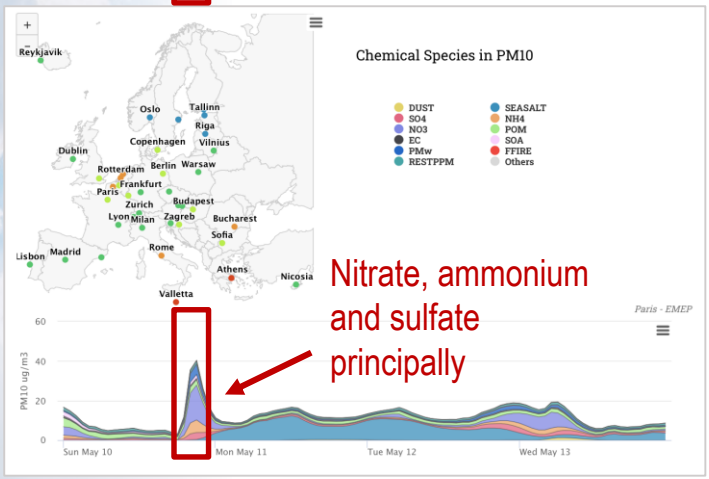
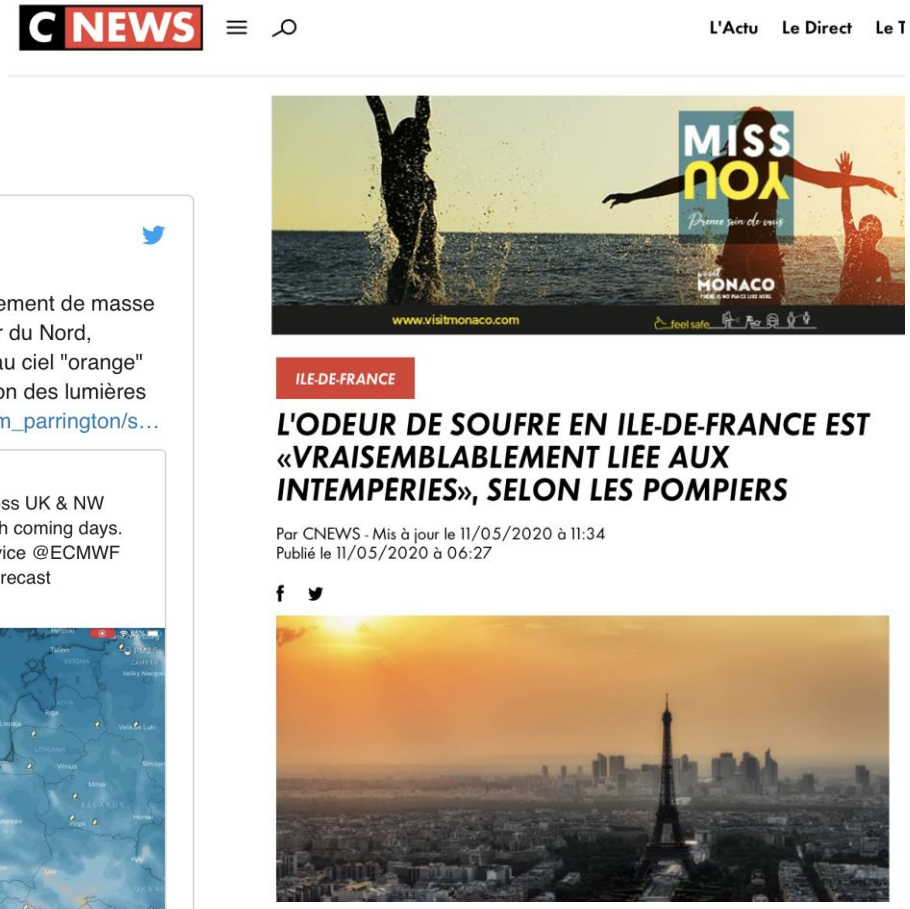
On Sunday 10 May evening, strong sulphurous smell are experienced in Paris area. CAMS was used to bring first insights about the situation.







https://policy.atmosphere.copernicus.eu/DailySourceAllocation.php

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Source apportionment/ attribution of PM exceedences

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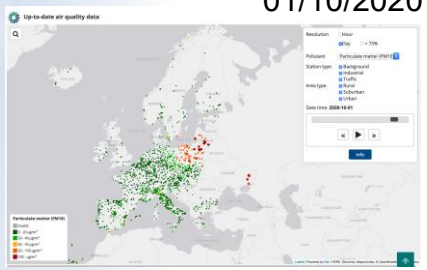
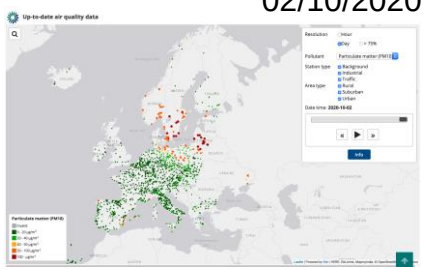
01/10/2020



02/10/2020



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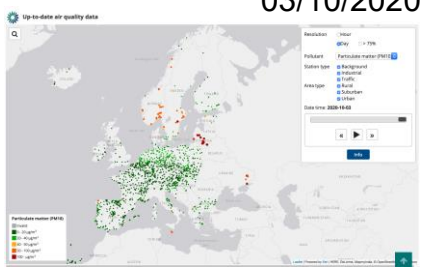
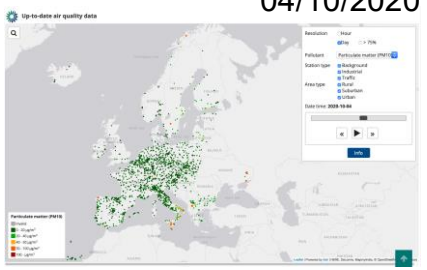
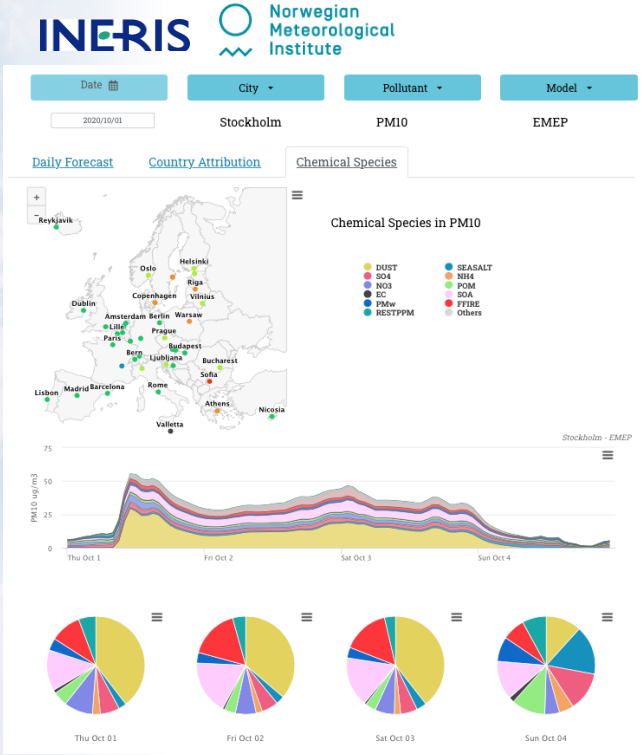
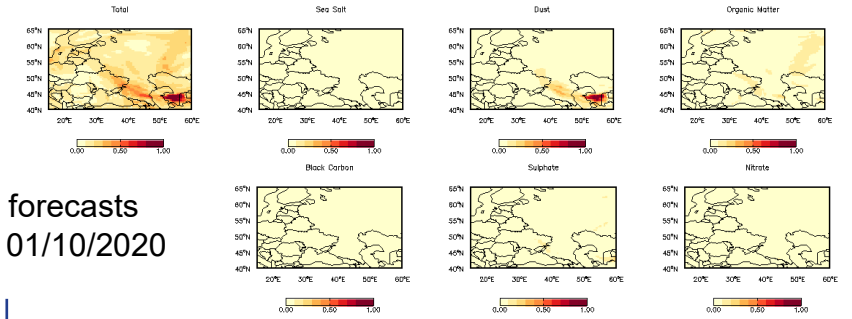


04/10/2020



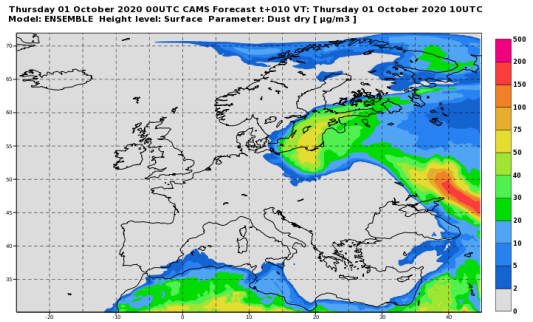
Long-range dust transport from Caspian Sea to Scandinavia





CAMS global forecasts
IFS Forecast 01/10/2020
+12h

CAMS regional forecasts (dust)
9-member ensemble 01/10/2020
+10h



CAMS policy products
https://policy.atmosphere.copernicus.eu/DailySourceAllocation.php?date=2020-10-01&city=Stockholm

High surface PM10 measurements from European Environment Agency

CAMS products provide context from global to regional scale and policy-relevant products

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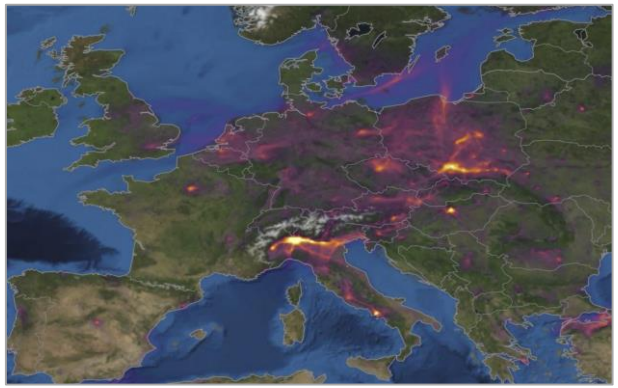
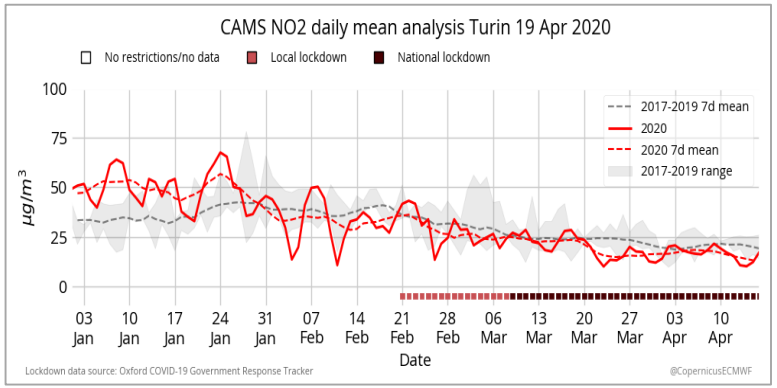
CAMS in action: CAMS COVID-19 Minisite

Atmosphere Monitoring

https://atmosphere.copernicus.eu/european-air-quality-information-support-covid-19-crisis

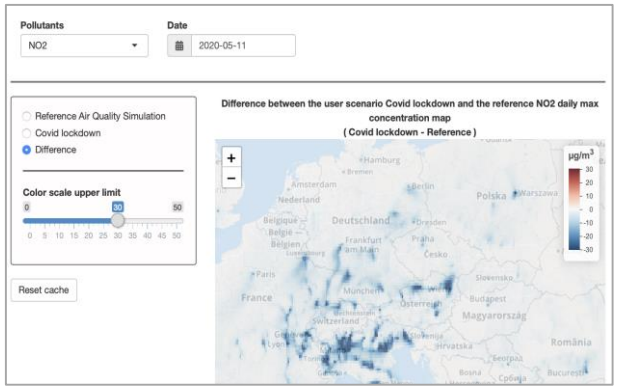
Maps and animations of the latest situation in Europe.

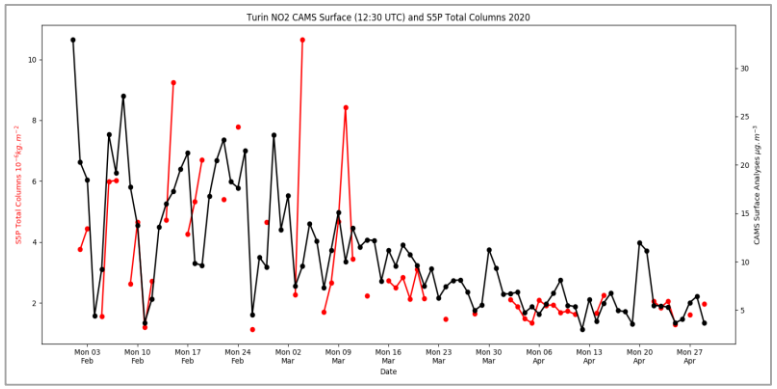




Air pollution across Europe compared to 2017-2019 and as a function of lockdown measures.

Forecast model estimate of reduction in air pollution is expected on a daily basis accounting for weather effects.





How consistent are surface and satellite measurements?

CAMS currently contributes to a number of epidemiological studies trying to evaluate the links between air pollution and COVID-19 (effects of long- and short-term exposure; fine particulate matter as a potential vector in air for the virus?...)

CAMS regional air quality forecasts: Météo-France, Ineris (FR)
CAMS COVID-19 scenario forecasts: Ineris (FR)
CAMS website: ECMWF

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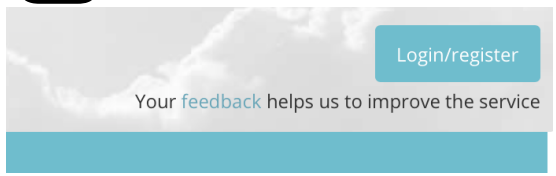
OPENING OF THE ATMOSPHERE DATA STORE

Atmosphere Monitoring

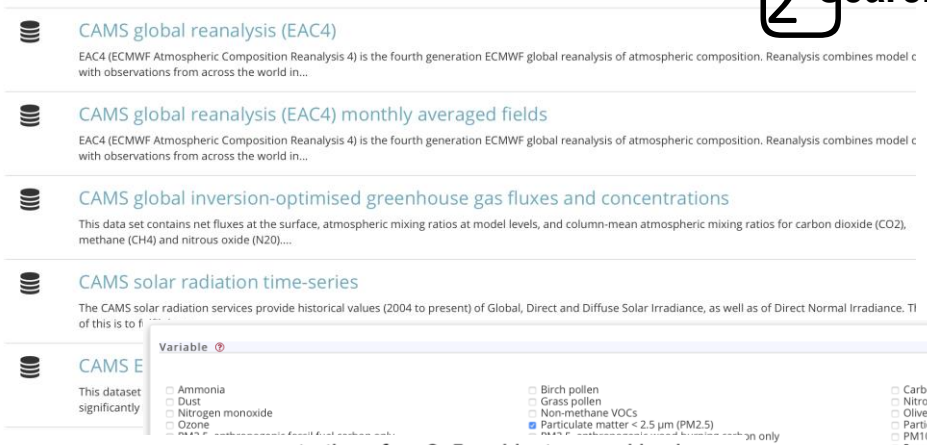
Based on CDS

Climate Change Service

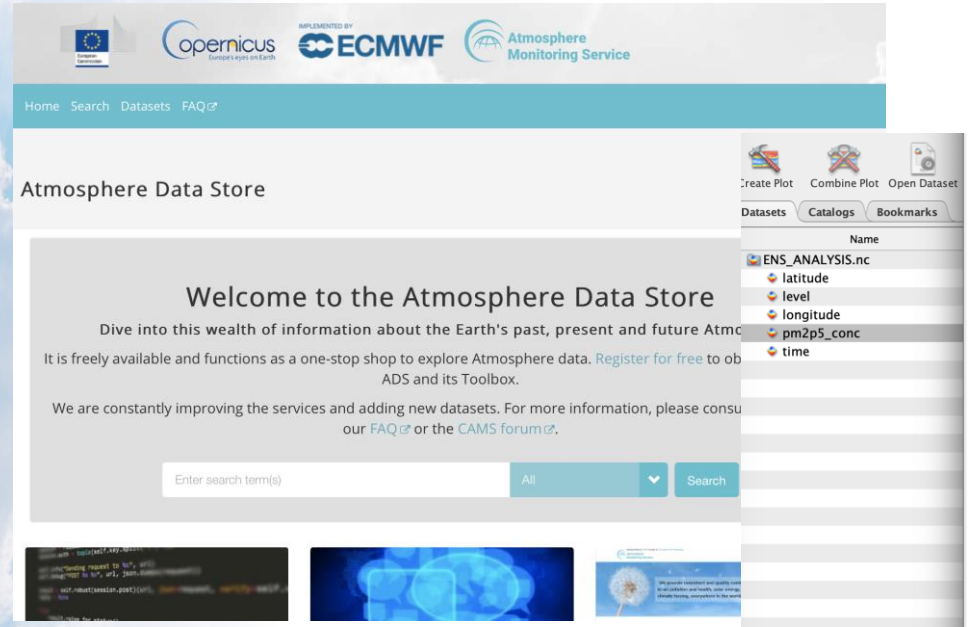
1 Register (once)

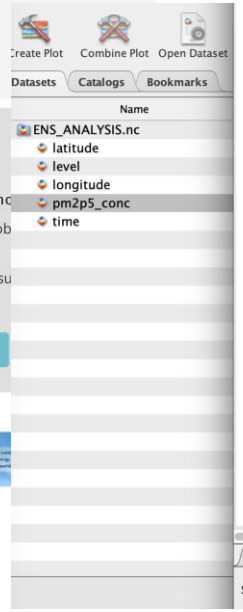


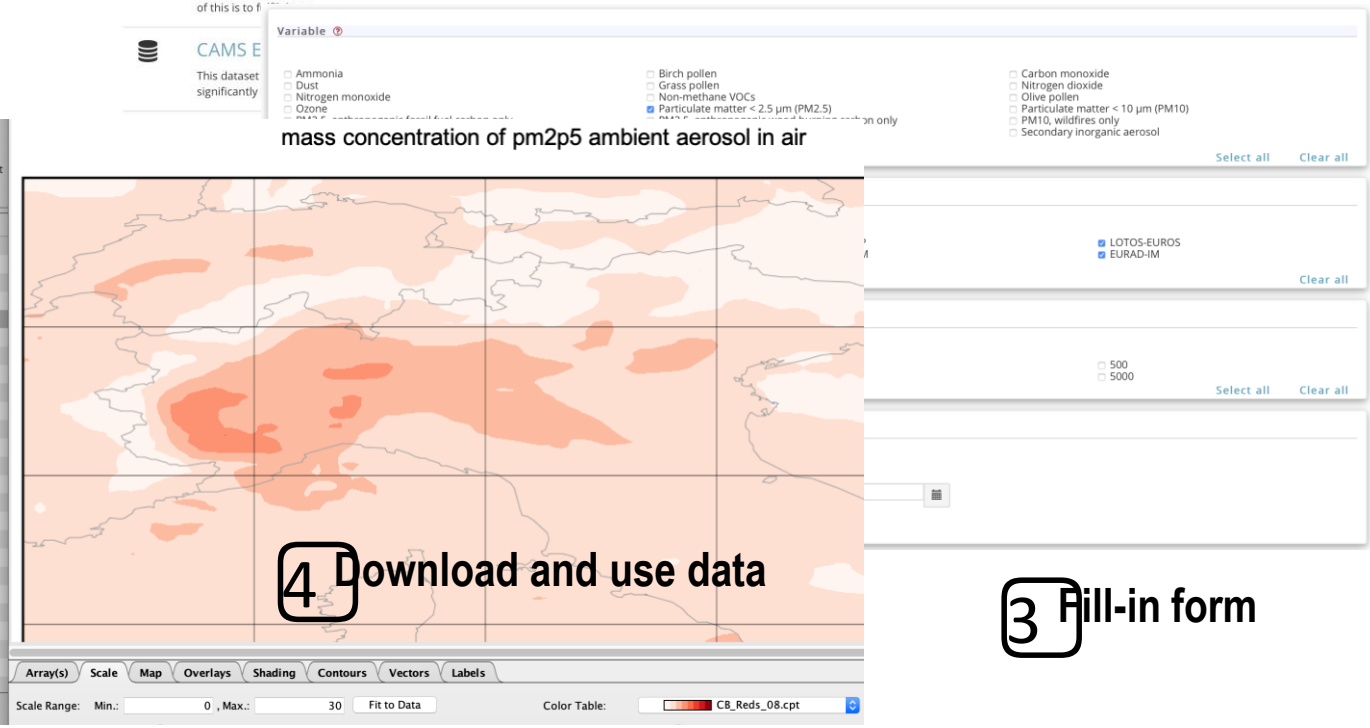
2 Search catalogue



http://ads.atmosphere.copernicus.eu







4 Download and use data

3 Fill-in form

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Atmosphere Monitoring

Summary and open questions

- Copernicus Atmosphere Monitoring Service provides comprehensive detailed information on global atmospheric composition and air quality.
- Earth Observation and in situ data play a key role in CAMS.
- Wide range of applications for global and regional air quality.
- All Copernicus data are free and open for everyone to access.

http://atmosphere.copernicus.eu | @CopernicusECMWF | @CopernicusEU

- Open Questions:
  - How best to relate global model output for regional air quality in different regions (CAMS currently only covers Europe)?
  - How can global models be improved using local air quality information (e.g., sources/sinks, background conditions, local meteorology)?
  - What additional information and links can be made between CAMS and MARAMA/EPA related to operational air quality monitoring?

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