



PROGRAMME OF
THE EUROPEAN UNION



IMPLEMENTED BY



#EUSpace

#CopernicusAtmosphere

Routine monitoring of aerosol events in CAMS operational products

Mark Parrington (mark.parrington@ecmwf.int)

European Centre for Medium-Range Weather Forecasts

Enza Di Tomaso, Cathy Li, Johannes Flemming, Antje Inness, Melanie Ades, Samuel Remy, Vincent Huijnen, Johannes Kaiser, Richard Engelen, Laurence Rouil + many other CAMS Developers



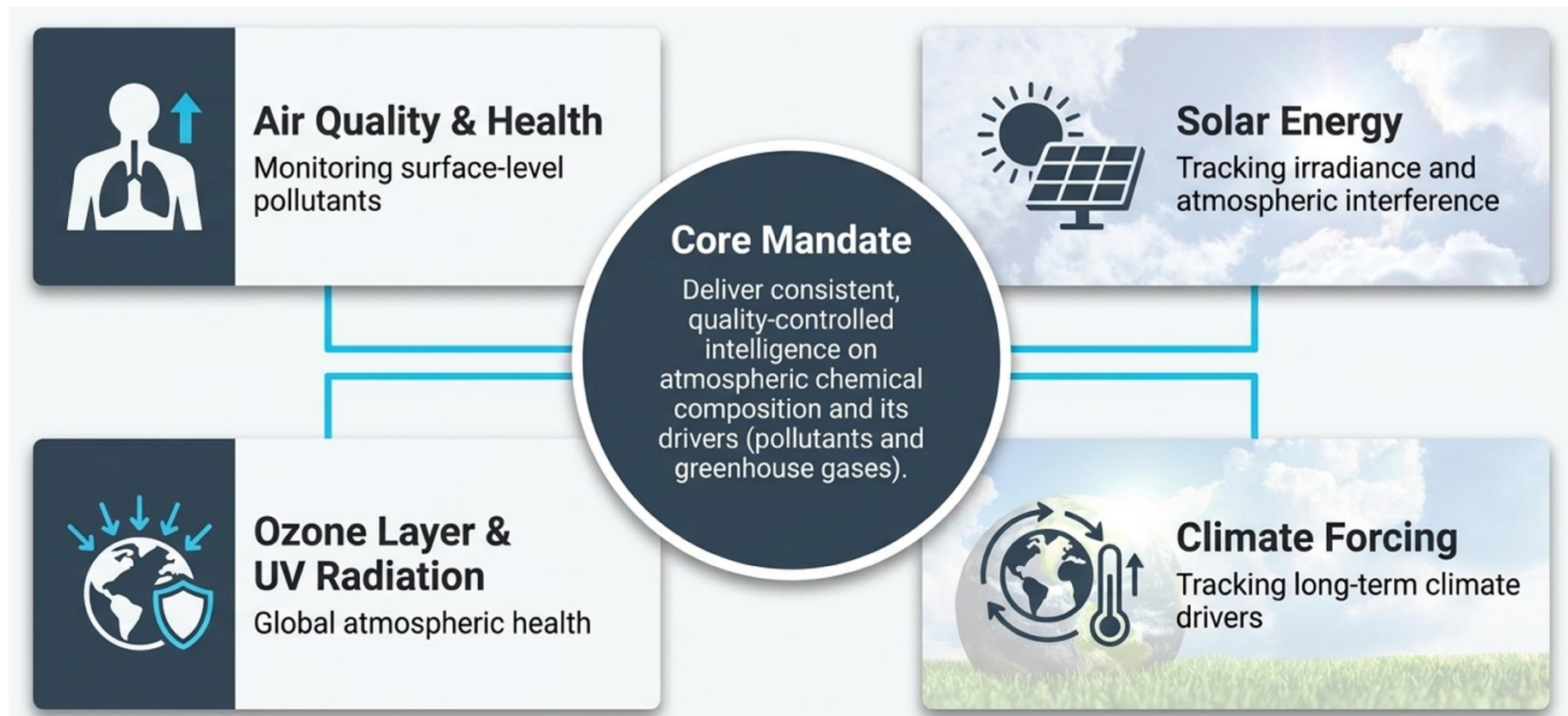
[@mparrington.bsky.social](https://bsky.app/profile/mparrington.bsky.social)

[@CopernicusECMWF.bsky.social](https://bsky.app/profile/CopernicusECMWF.bsky.social)



The CAMS mandate:

<https://atmosphere.copernicus.eu>



Monitoring and
Forecasting

Informing

Policy support : decision
making and assessment

Monitoring and forecasting activities

Air pollution episodes

Forecasting air pollution episodes to inform citizens about their exposure

Ozone layer and UV

Monitoring stratospheric ozone and solar radiation for climate and energy applications

Tracking Acute Atmospheric Crises

Wildfire Impacts

Powered by GFAS (Global Fire Assimilation System), Tracking real-time global wildfire emissions and their immediate injection of carbon and particulates into the atmosphere.

Dust Storm Impacts

Monitoring massive particulate displacement and severe localized air quality degradation across urban centers.

Tracking hot spot emissions

First steps in the implementation of observation-based emissions systems to track emissions sources

Monitoring emissions and fluxes

Bottom-up emission inventories and inverse modelled fluxes constrained by EO



The CAMS 'Weather' Room



Routine monitoring of CAMS NRT products (fire emissions, global/regional forecasts):

Collaboration –
ICAP?

- Identify and resolve potential issues
- Investigate significant issues reported by users/contractors
- Identify notable episodes for communication via social media, website, press, training, user engagement, CAMS validation and policy reports



CAMS Weather Room

Overview

Welcome to the pages of the CAMS Weather Room. These pages are intended to provide regular reports on the routine monitoring of CAMS NRT products, and case studies.

Reporting on current/recent notable events

June	- Global atmospheric composition anomalies and wildfires: May 2026 - Saharan dust transport across the Atlantic: June 2026
May	- Global atmospheric composition anomalies and wildfires: April 2026 - NW Europe wildfires: May 2026 - Saharan dust transport to Europe: May 2026 - Boreal wildfires: May 2026 - Europe ozone pollution: May 2026
April	- Global atmospheric composition anomalies and wildfires: March 2026 - Saharan dust transport to Europe: April 2026 - SE Asia fires and air quality: April 2026

Monthly archive of previous notable events

2026	January	February	March									
2025	January	February	March	April	May	June	July	August	September	October	November	December
2024	January	February	March	April	May	June	July	August	September	October	November	December
2023	January	February	March	April	May	June	July	August	September	October	November	December
2022	January	February	March	April	May	June	July	August	September	October	November	December
2021	January	February	March	April	May	June	July	August	September	October	November	December
2020	January	February	March	April	May	June	July	August	September	October	November	December
2019											November	December

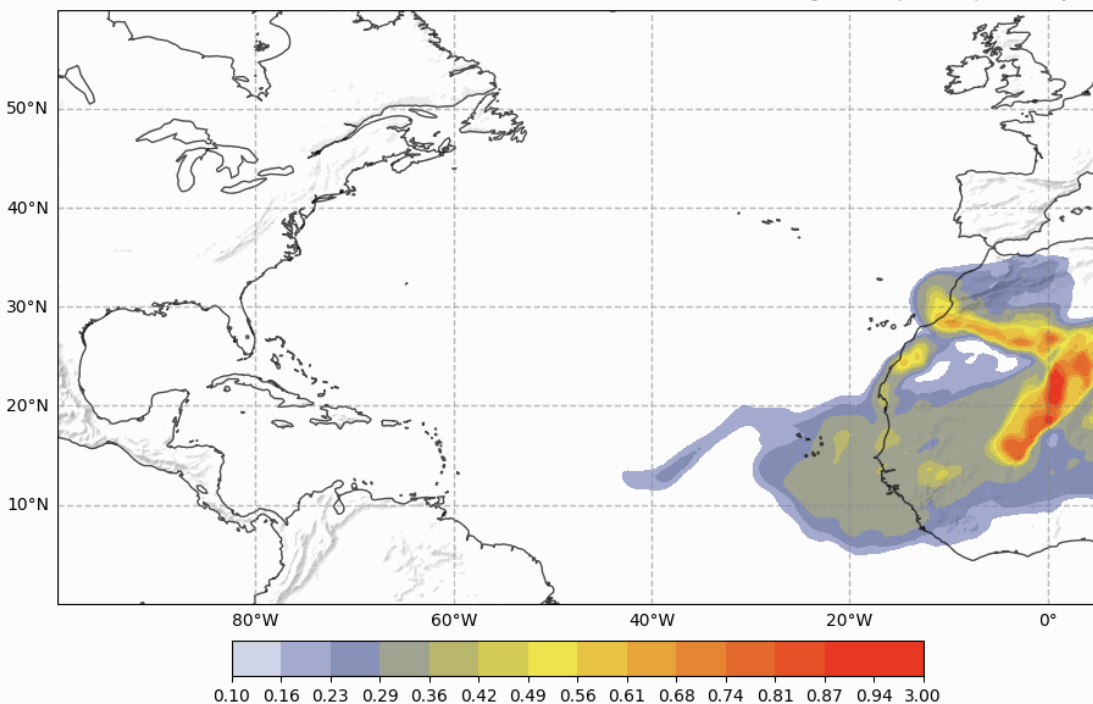
- Emulate daily weather reporting at ECMWF for atmospheric composition.
- Internal space for compiling case studies and evaluation.
- Covers wildfires, mineral dust, volcanic eruptions, surface ozone, transboundary pollution, Antarctic ozone hole, data issues...
- Routine reporting since November 2019.

Saharan dust transport: June 2026

Dust Aerosol Optical Depth at 550nm

2026-05-20 T00

Data: CAMS global atmospheric composition analysis

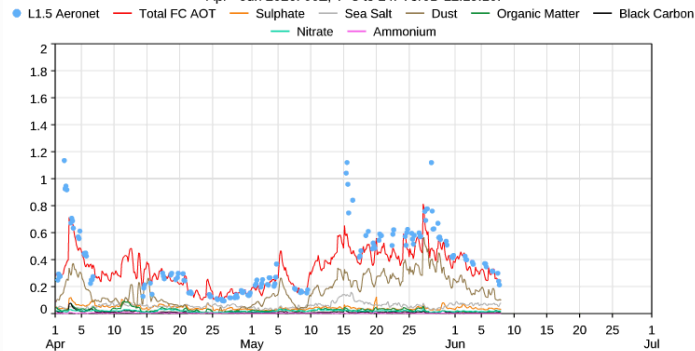


Latest case on Saharan dust across the North Atlantic in June 2026.

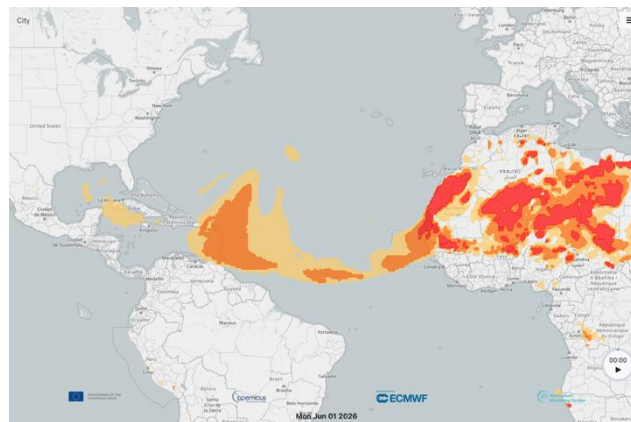
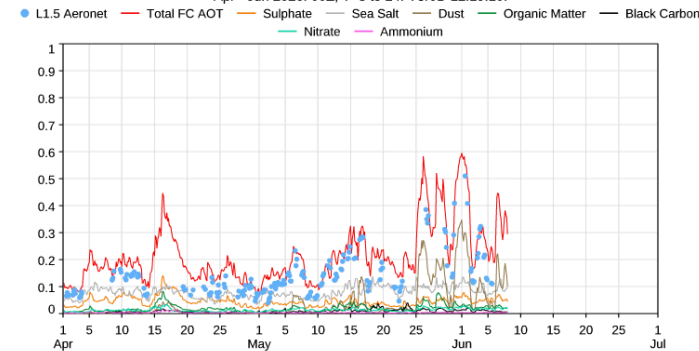
Communication on social media + short media
communique

Comparison of model (oper) and L1.5 Aeronet AOT at 500nm over
Capo_Verde (16.73°N, 22.94°W).

Apr - Jun 2026, 00Z, T+3 to 24, Ver0D 12.19.10.

Comparison of model (oper) and L1.5 Aeronet AOT at 500nm over
Ragged_Point (13.17°N, 59.43°W).

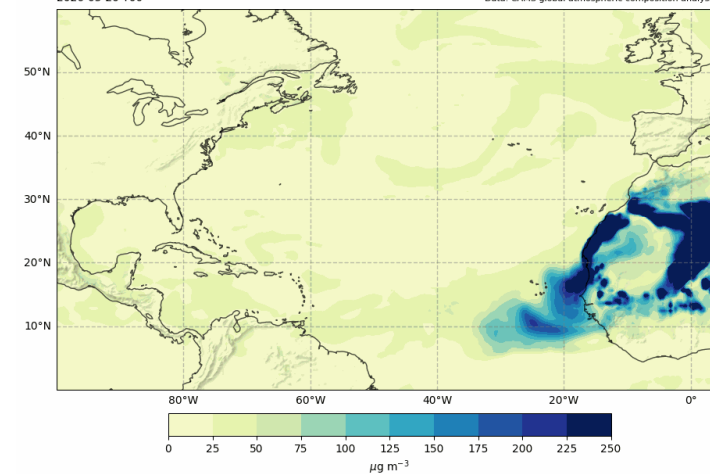
Apr - Jun 2026, 00Z, T+3 to 24, Ver0D 12.19.10.



PM10 Concentration at Surface

2026-05-20 T00

Data: CAMS global atmospheric composition analysis

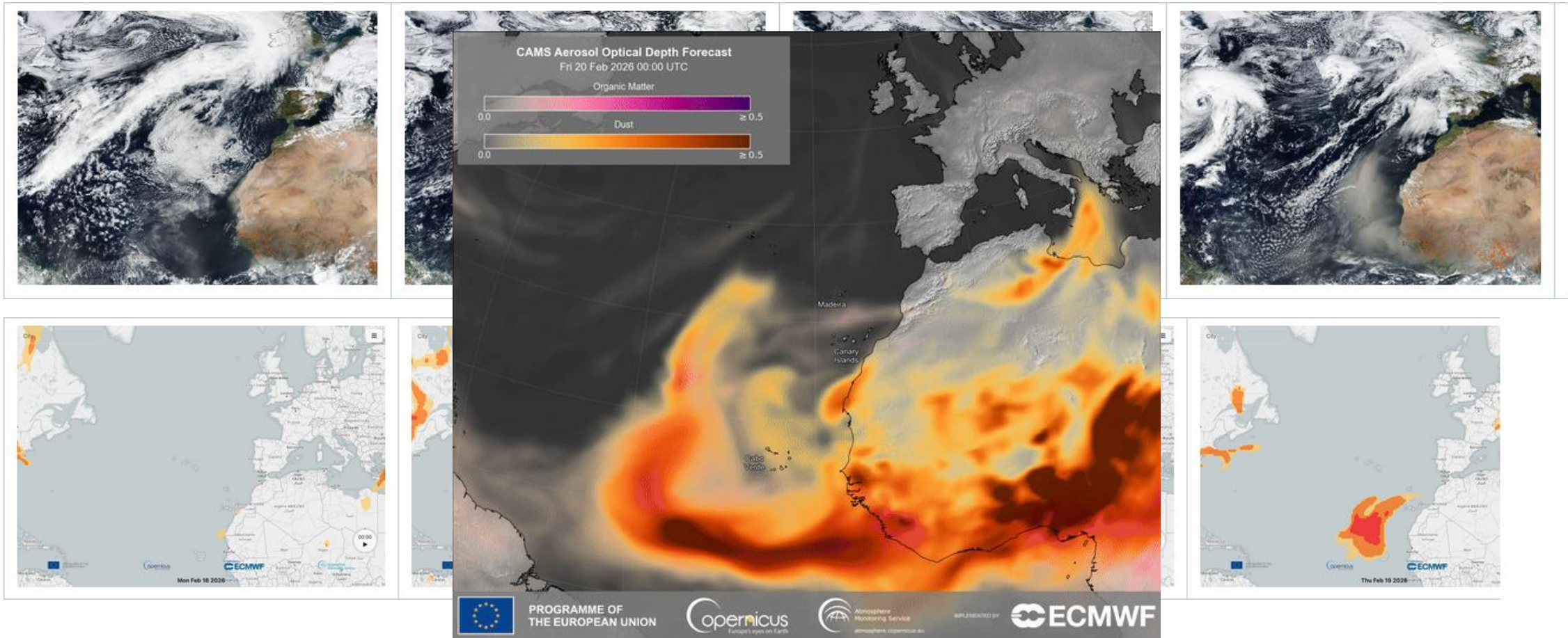


7



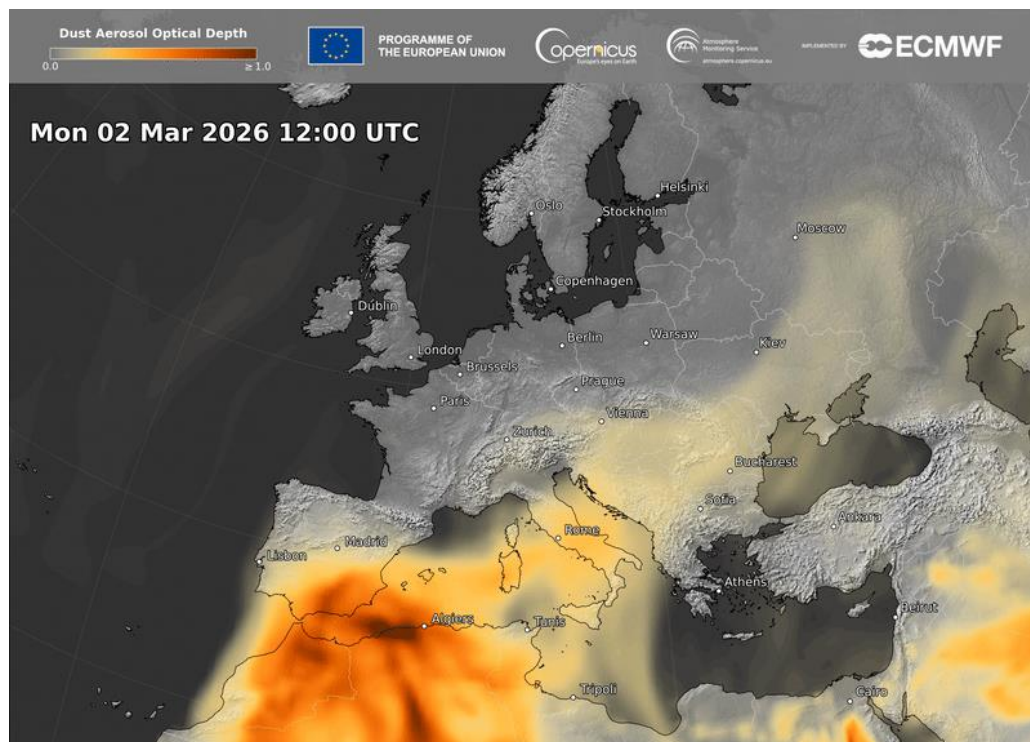
Calima Dust episodes in February

- Significant large-scale aerosol transport to the North Atlantic during February.
- Harmattan winds contributing smoke aerosol from west African (esp. Senegal) fires + Calima winds bringing Saharan dust.
- Part of the plume crossed the Atlantic with another part reaching NW Europe.
- Communicated with press, resulting in media coverage (e.g., "blood rain" in the UK).



Borrasca Regina dust episode in March

- Extra-tropical cyclone (named Regina by IPMA) resulted in large-scale Saharan dust transport to much of Europe in early March.
- Press communique sent on 2 March resulted in excellent European media coverage (including print and radio).

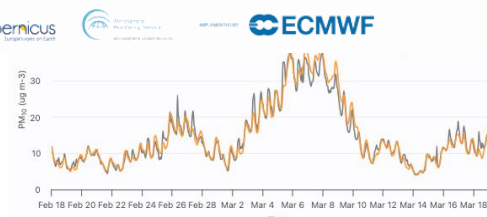
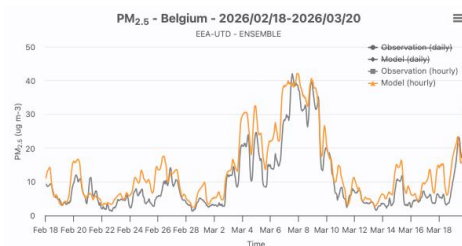
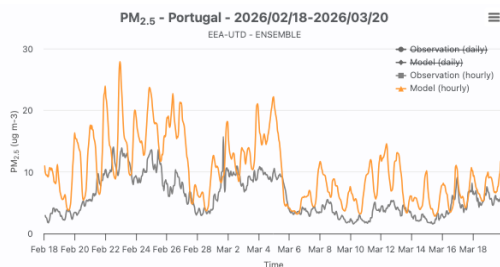
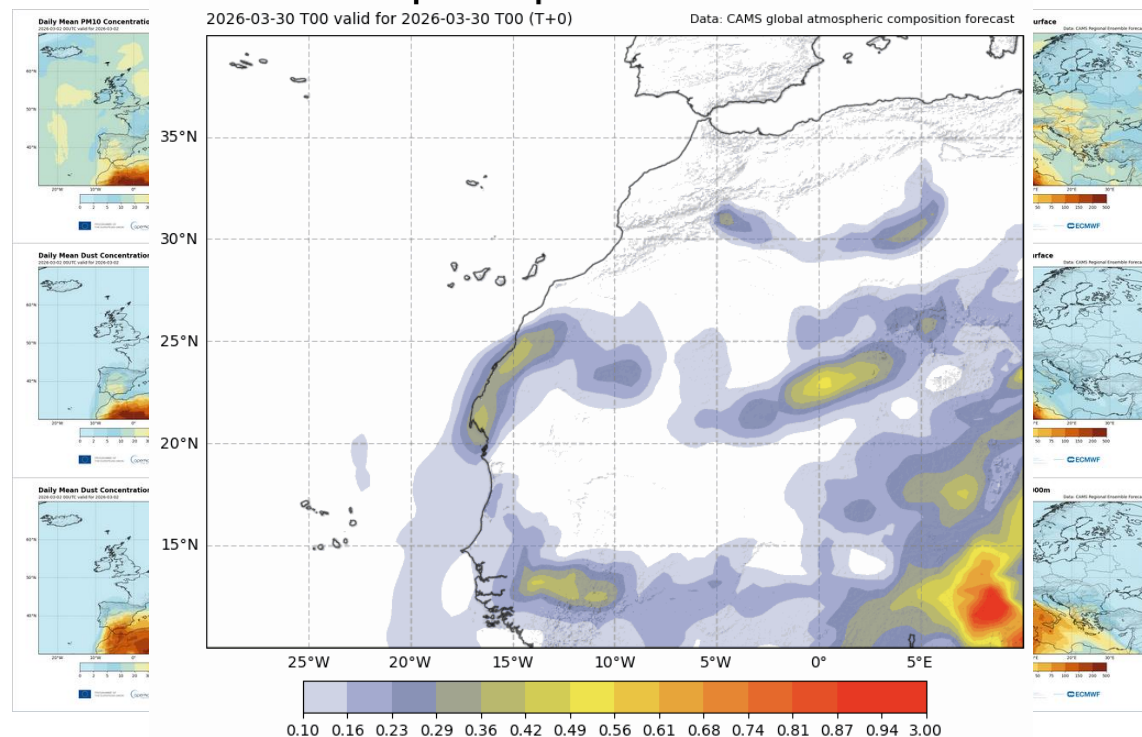


CAMS European regional ensemble forecast from 2 March 00 UTC

Dust Aerosol Optical Depth at 550nm

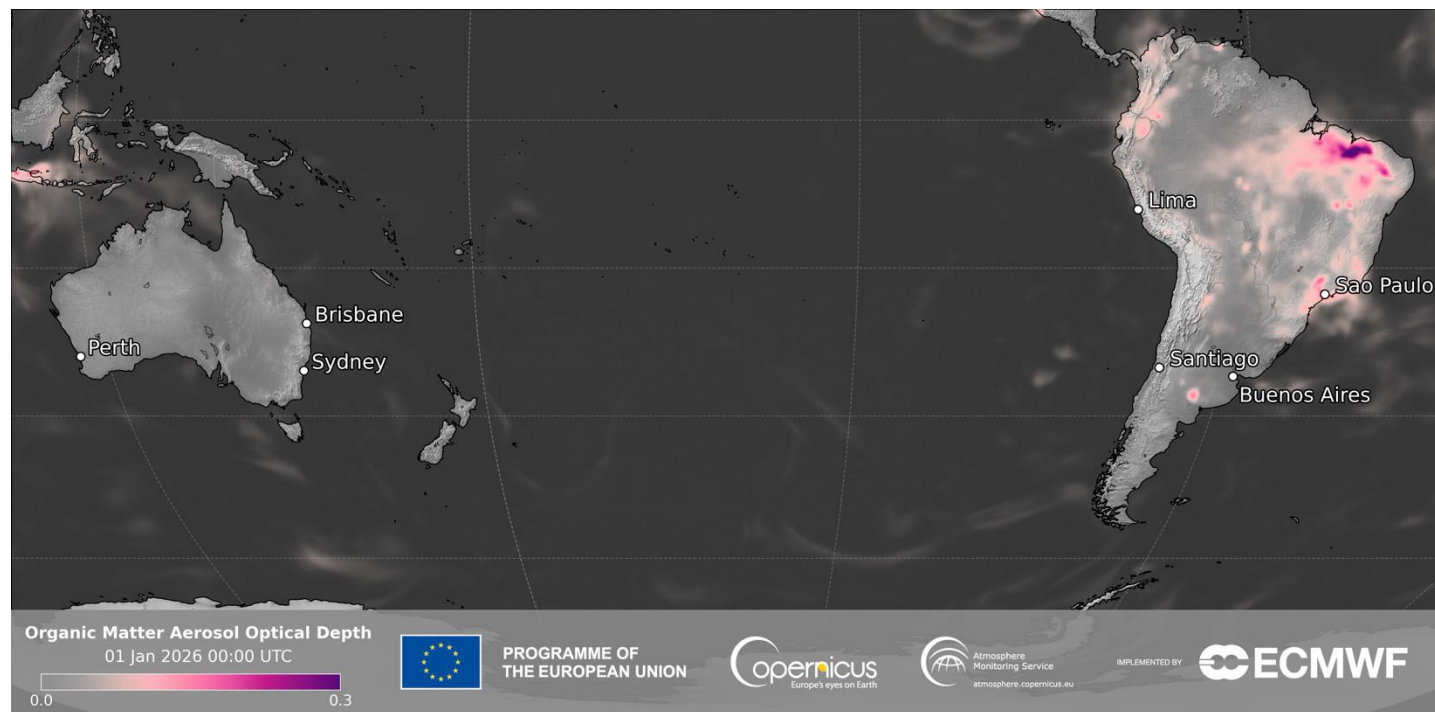
2026-03-30 T00 valid for 2026-03-30 T00 (T+0)

Data: CAMS global atmospheric composition forecast



Wildfire monitoring

- Southern Hemisphere fires monitored at the beginning of the year with significant long range events in 2026
- 2025 was an exceptional wildfire year for the European Union and the UK with the main issues of the emissions being their impacts on air pollution and health



<https://atmosphere.copernicus.eu/southern-hemisphere-hit-intense-wildfires-during-january>

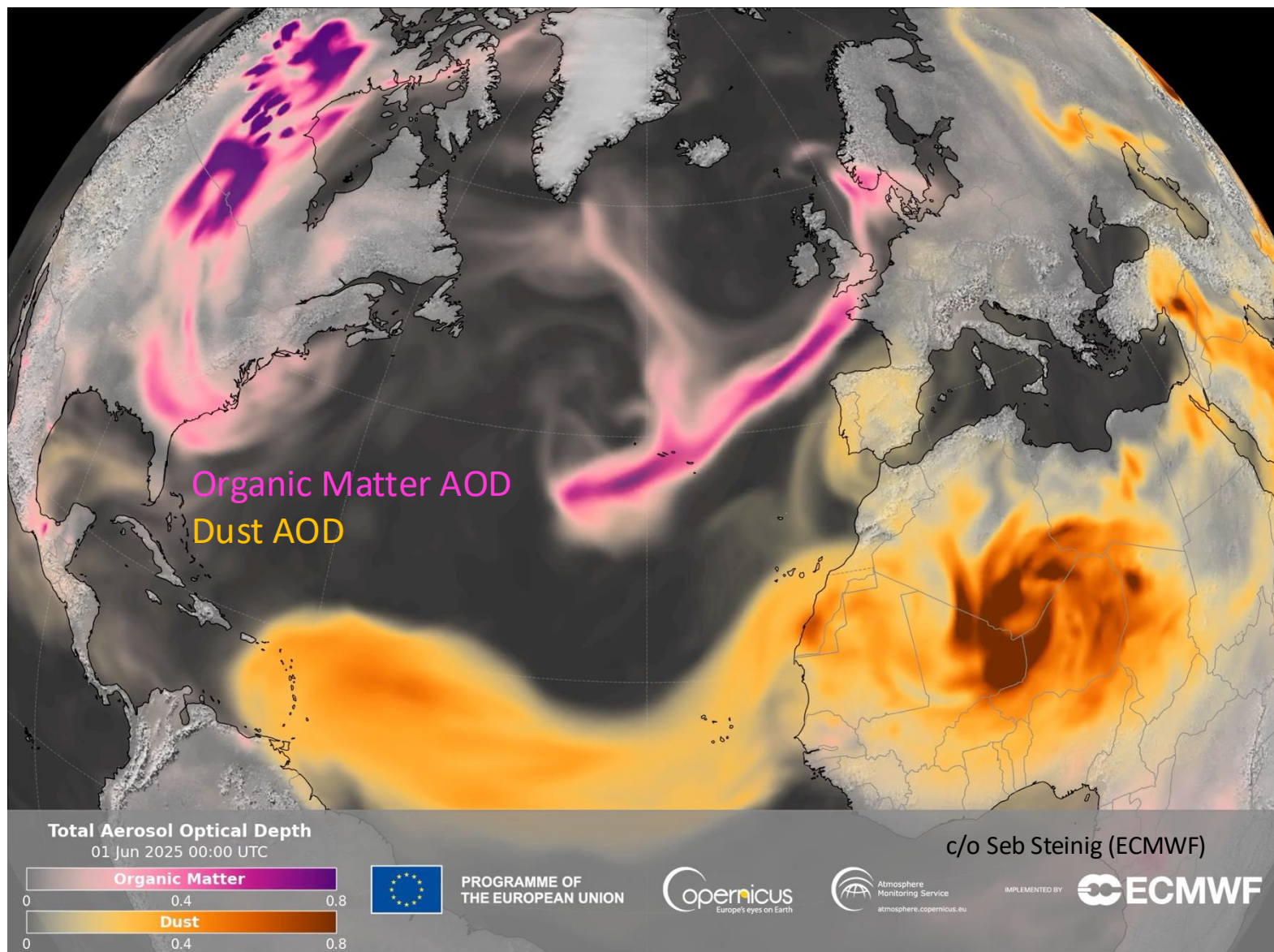
Fire emissions monitoring in CAMS: Global Fire Assimilation System (GFAS)

- Global Fire Assimilation System (**GFAS**): see <https://ads.atmosphere.copernicus.eu/cdsapp#!/datasets/cams-global-fire-emissions-gfas?tab=overview>
- Uses satellite observations of Fire Radiative Power (FRP)
 - Currently Aqua+Terra MODIS and SNPP VIIRS FRP observations
 - Preparing for N20 (+N21) VIIRS FRP in operational implementation
 - FRP from 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 using *Plume Rise Model* and IS4FIRES schemes



<https://atmosphere.copernicus.eu/2025-sees-intense-wildfire-year-northern-hemisphere>

Summer 2025, an active year for Atlantic aerosols

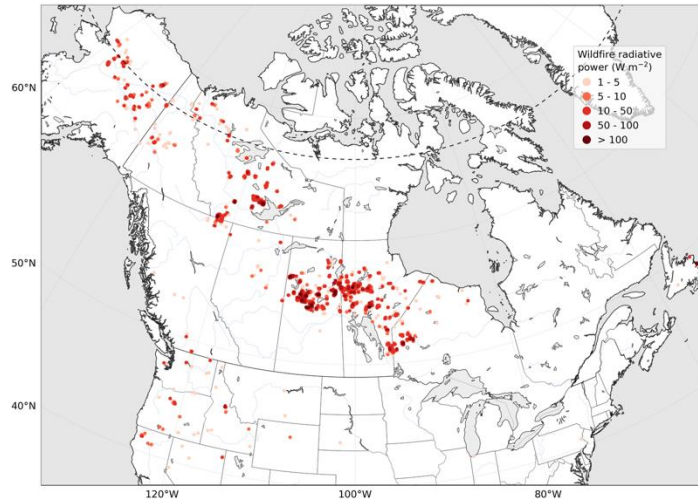


- Very active summer for aerosols, especially across the North Atlantic, in 2025
- 2nd most extreme wildfire year for Canada (3rd consecutive) resulted in large scale smoke transport across North America, also regularly reaching Greenland and Europe
- Almost continuous transport of Saharan dust regularly reached the Antilles, Caribbean and the Americas

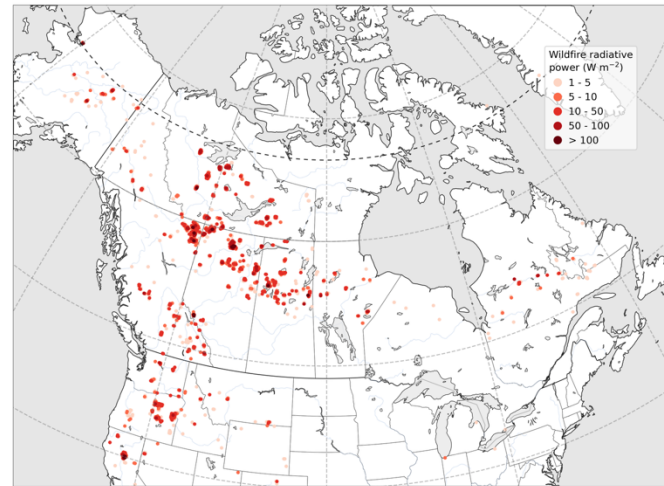
<https://atmosphere.copernicus.eu/highest-wildfire-emissions-least-23-years-europe-after-hectic-summer>

North America wildfires in 2025

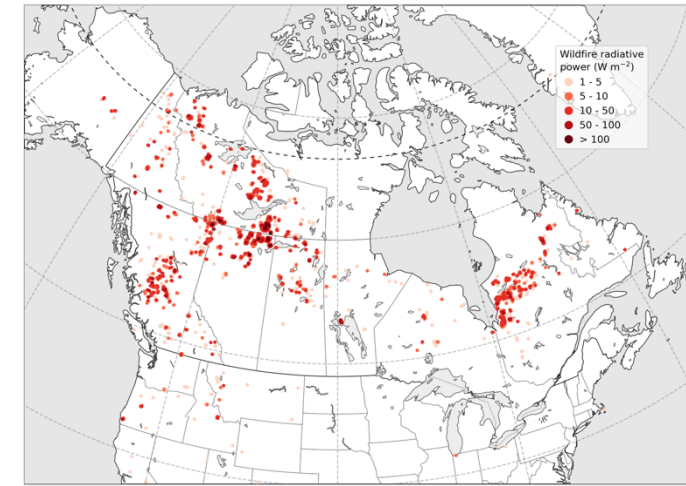
GFASv1.2 Total Fire Radiative Power: 2025-07-01 - 2025-07-31



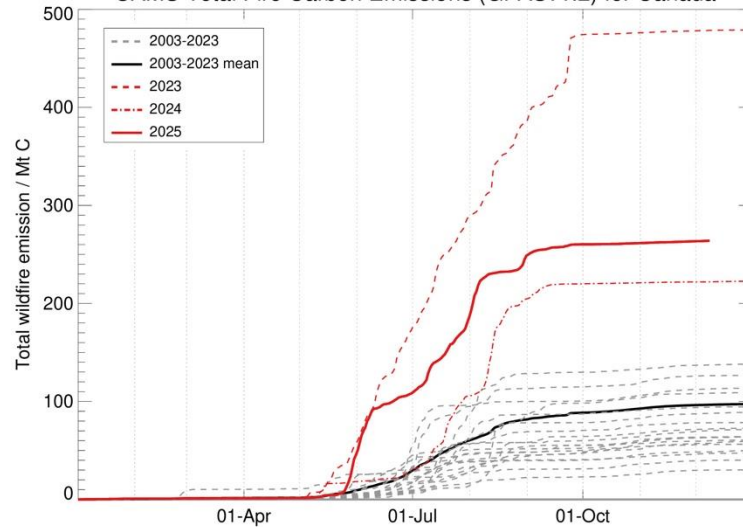
GFASv1.2 Total Fire Radiative Power: 2024-07-01 - 2024-07-31



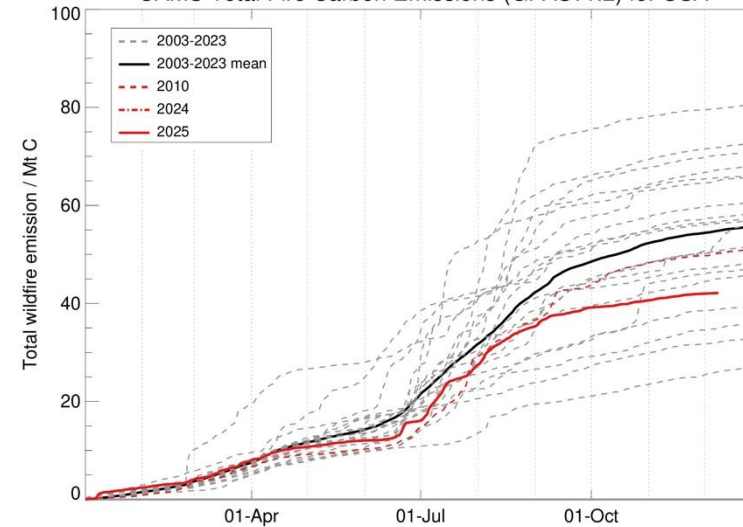
GFASv1.2 Total Fire Radiative Power: 2023-07-01 - 2023-07-31



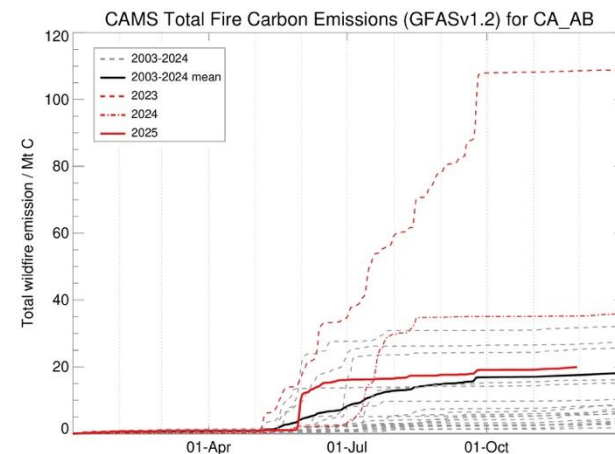
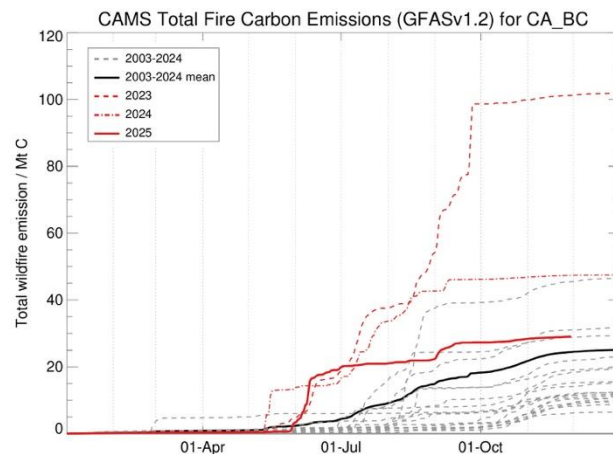
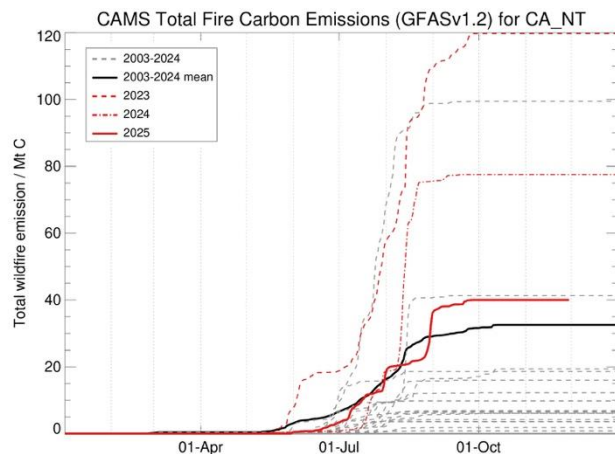
CAMS Total Fire Carbon Emissions (GFASv1.2) for Canada



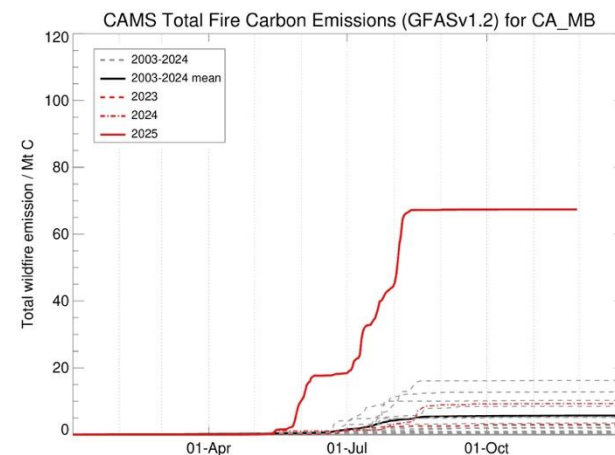
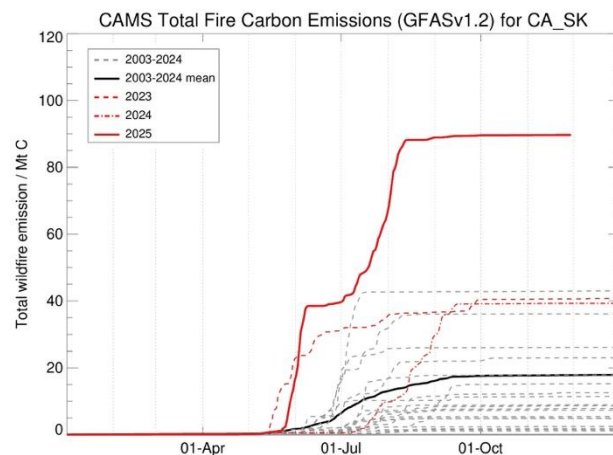
CAMS Total Fire Carbon Emissions (GFASv1.2) for USA



Canada wildfires by province

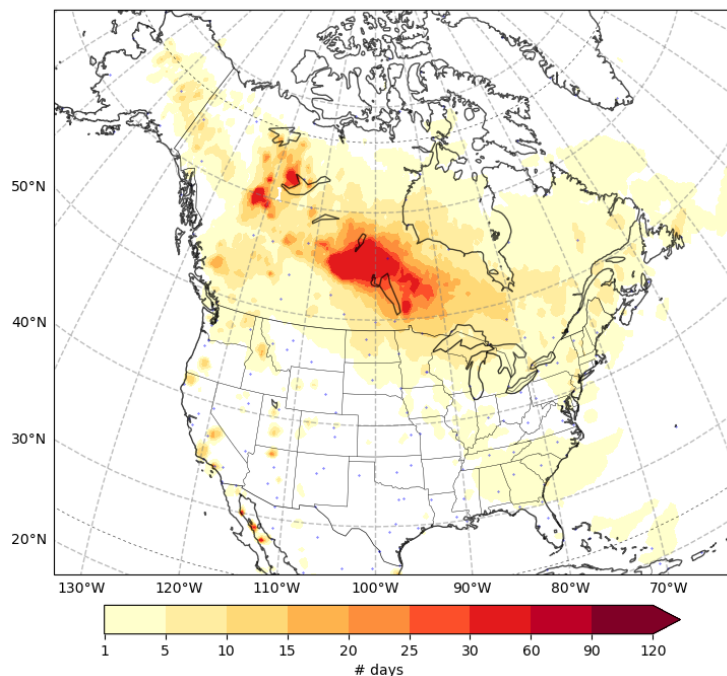


- 2025 fire emissions dominated by prairie provinces, Saskatchewan and Manitoba.
 - cf 2023 & 2024 dominated by western provinces + NWT
- Notable fires also for Ontario, Newfoundland and Nova Scotia.

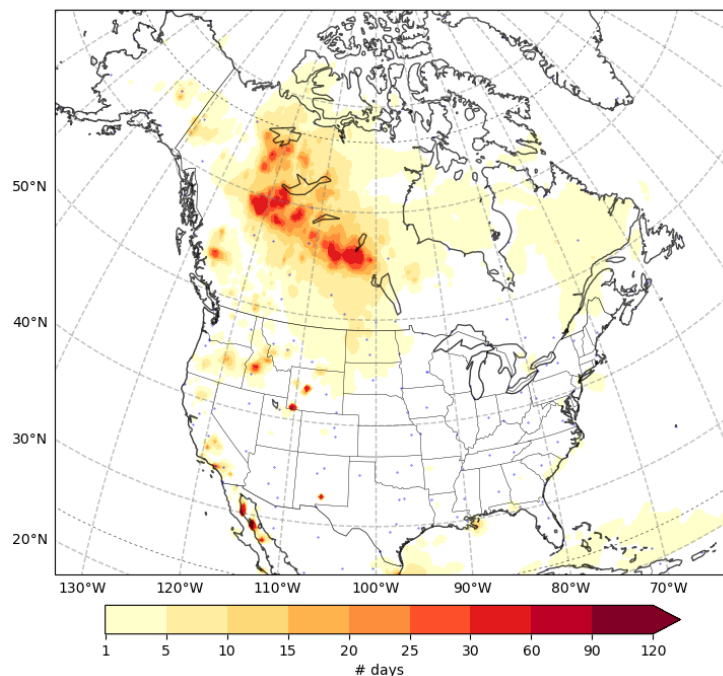


Surface air quality: #days $\text{PM}_{2.5} > 35\mu\text{g}/\text{m}^3$

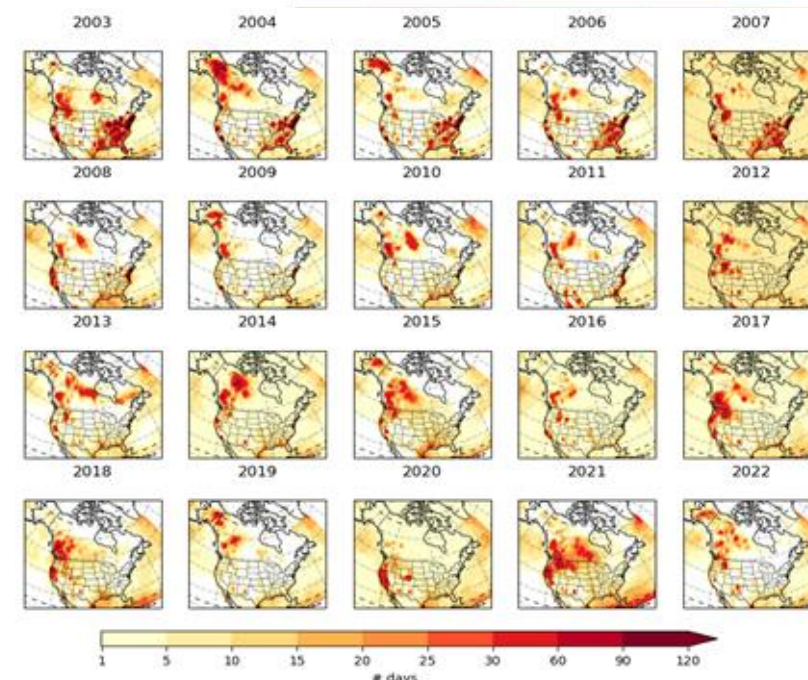
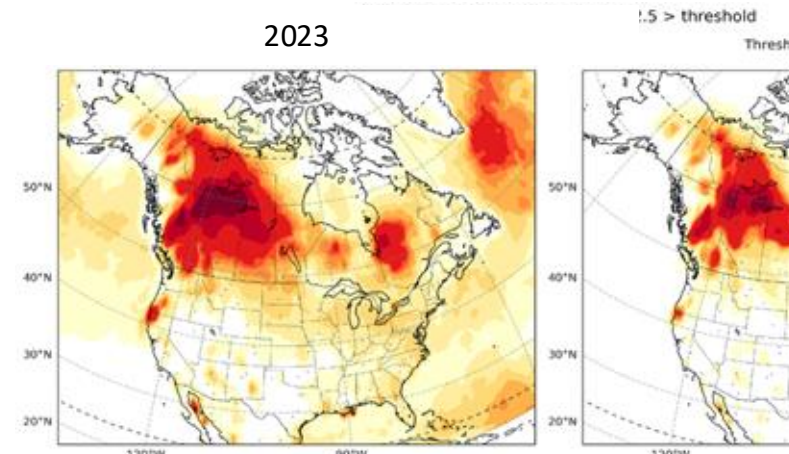
2025 (up to 15 Sept)



2024

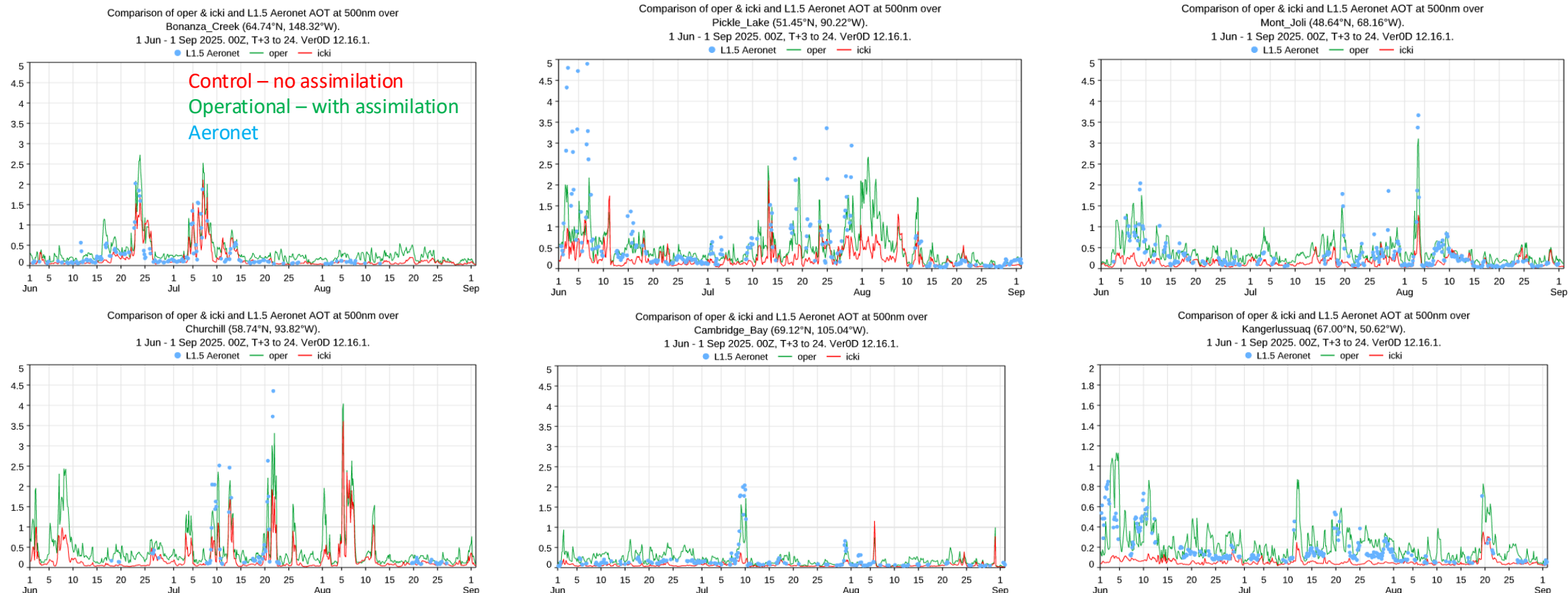


2023



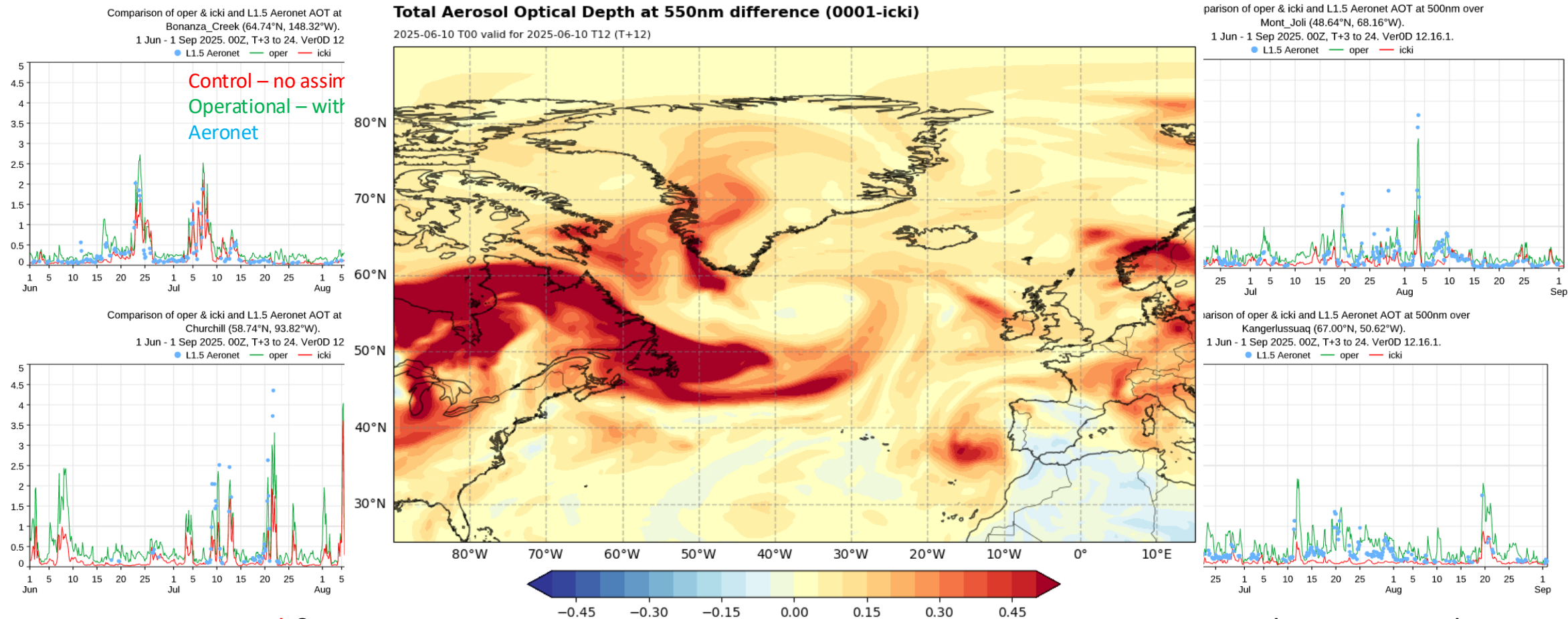
- Smoke from Canadian wildfires resulted in widespread air quality impacts across North America, particularly for the Great Lakes.
 - Maps show outputs based on CAMS operational forecast for 2023-2025 and CAMS global reanalysis for 2003-2022.
- Threshold set at WHO annual average exposure threshold to highlight air quality impacts local to fires.

LRT June 2025 – impact of data assimilation



- CAMS **operational** & **control** AOD (T+03 to T+24 forecasts) vs. **Aeronet** sites across boreal North America and SW Greenland.
- Assimilation of satellite total AOD obs increases forecast AOD and better matches Aeronet in absolute terms.
 - Reflecting underestimation of GFASv1.4 emissions (plus injection heights?)

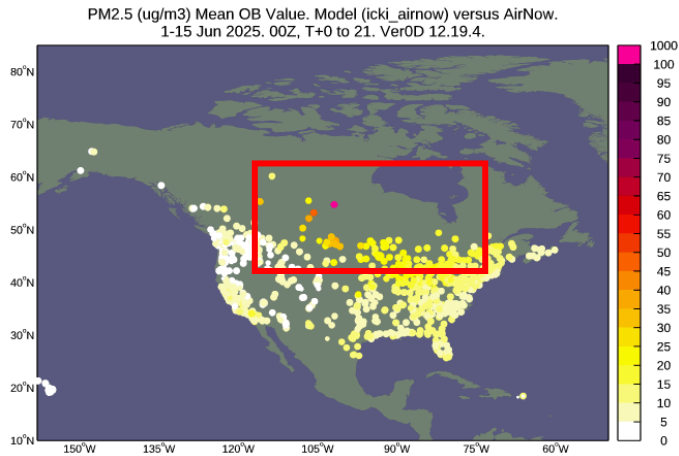
LRT June 2025 – impact of data assimilation



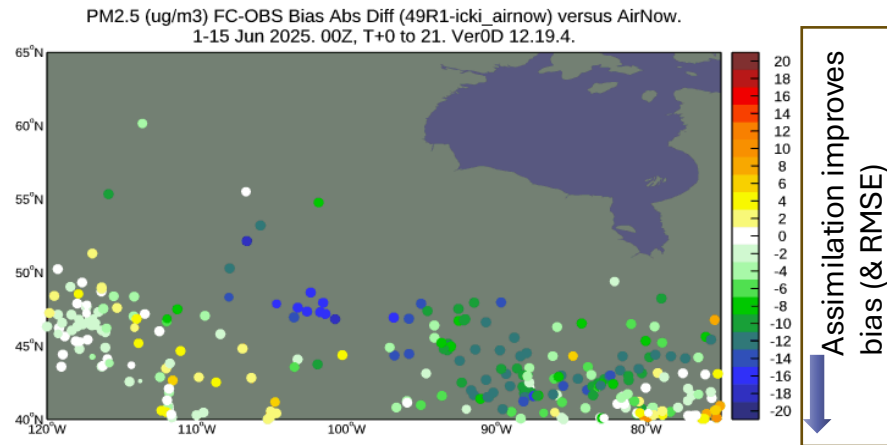
- CAMS **operational** & **control** AOD (T00 to T+24 forecasts) vs. **Aeronet** sites across boreal North America and SW Greenland.
- Assimilation of satellite total AOD obs increases forecast AOD and better matches Aeronet in absolute terms.
 - Reflecting underestimation of GFASv1.4 emissions (plus injection heights?)

Evaluating the assimilation impact on PM2.5

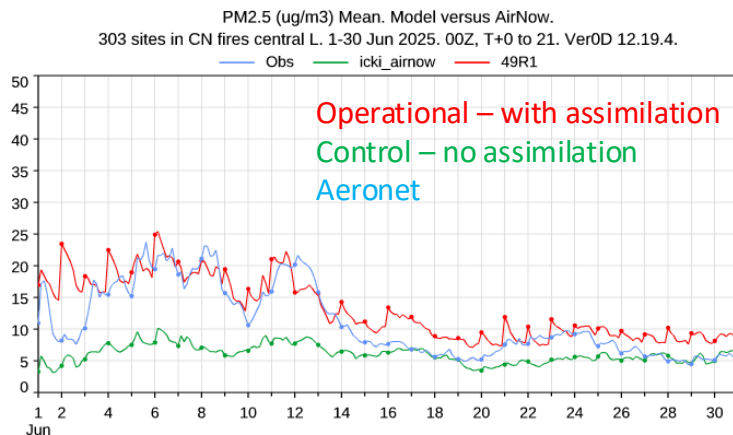
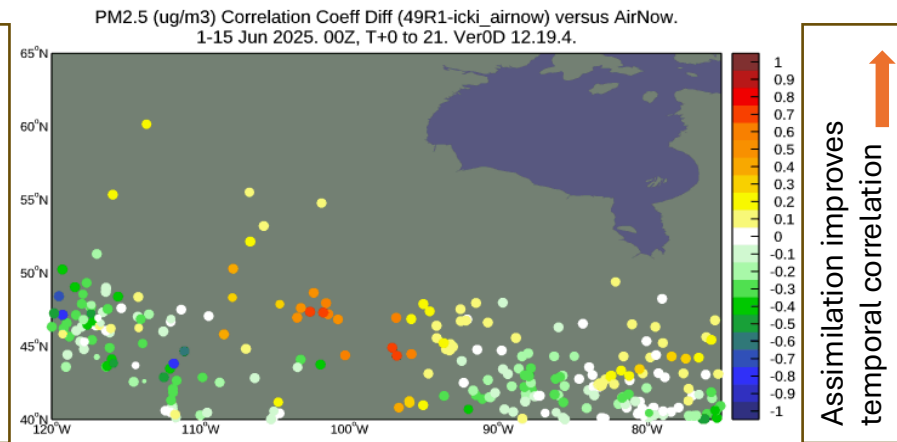
Observed PM2.5



Absolute mean bias



Temporal correlation



- Comparing the model outputs with/without assimilation of AOD with independent measurements allows more complete evaluation of forecast performance.
- Assimilating AOD leads to clear reduction in absolute mean bias, RMSE (not shown) and improvement in temporal correlation of **PM2.5 surface concentrations** at **near-field downwind measurement sites**.

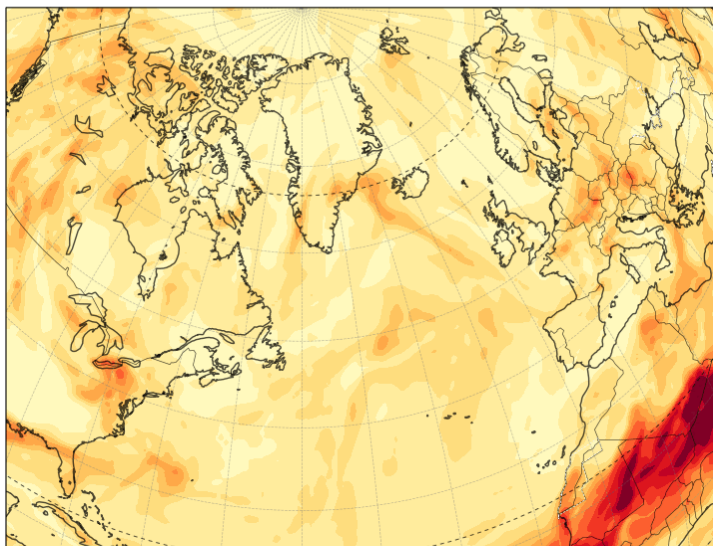
LRT June 2025 – AOD over Europe

Control – no assimilation
Operational – with assimilation
Aeronet

CAMS Analysis Total Aerosol Optical Depth at 550nm

2025-05-22 T00

Data: CAMS global atmospheric composition forecast • Credit: CAMS/ECMWF

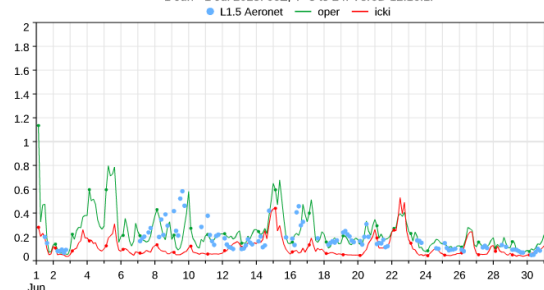


- Increased total AOD from assimilation improves forecast relative to Aeronet.
- Data assimilation impact is greatly reduced after 12 June due to Saharan dust plume.

Comparison of oper & icki and L1.5 Aeronet AOT at 500nm over

Birkenes (58.39°N, 8.25°E).

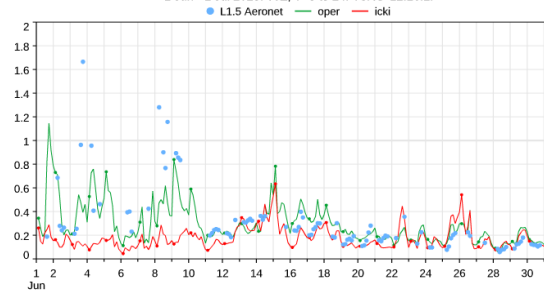
1 Jun - 1 Jul 2025, 00Z, T+3 to 24. VerOD 12.16.1.



Comparison of oper & icki and L1.5 Aeronet AOT at 500nm over

FZJ-JOYCE (50.91°N, 6.41°E).

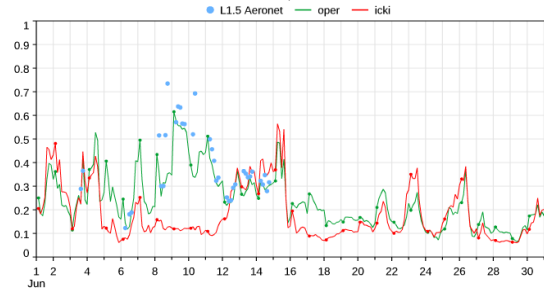
1 Jun - 1 Jul 2025, 00Z, T+3 to 24. VerOD 12.16.1.



Comparison of oper & icki and L1.5 Aeronet AOT at 500nm over

Payerne (46.81°N, 6.94°E).

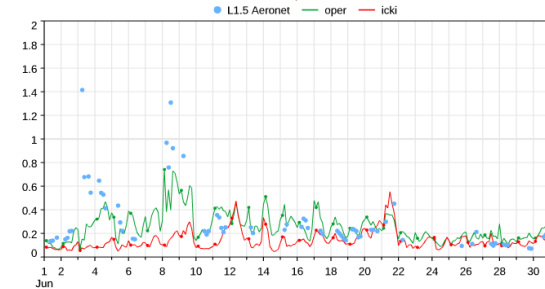
1 Jun - 1 Jul 2025, 00Z, T+3 to 24. VerOD 12.16.1.



Comparison of oper & icki and L1.5 Aeronet AOT at 500nm over

Rhyl_MO (53.26°N, 3.51°W).

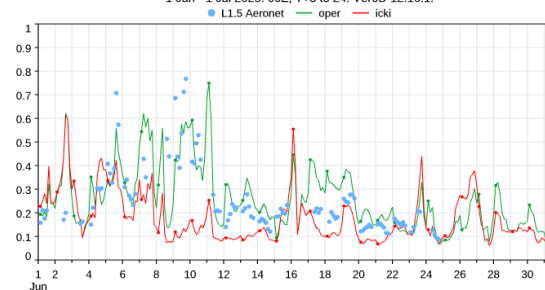
1 Jun - 1 Jul 2025, 00Z, T+3 to 24. VerOD 12.16.1.



Comparison of oper & icki and L1.5 Aeronet AOT at 500nm over

Vienna_BOKU (48.24°N, 16.33°E).

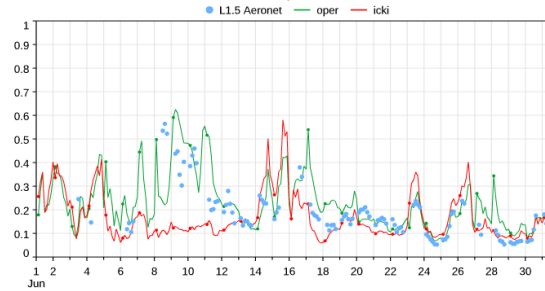
1 Jun - 1 Jul 2025, 00Z, T+3 to 24. VerOD 12.16.1.



Comparison of oper & icki and L1.5 Aeronet AOT at 500nm over

HohenpeissenbergDWD (47.80°N, 11.01°E).

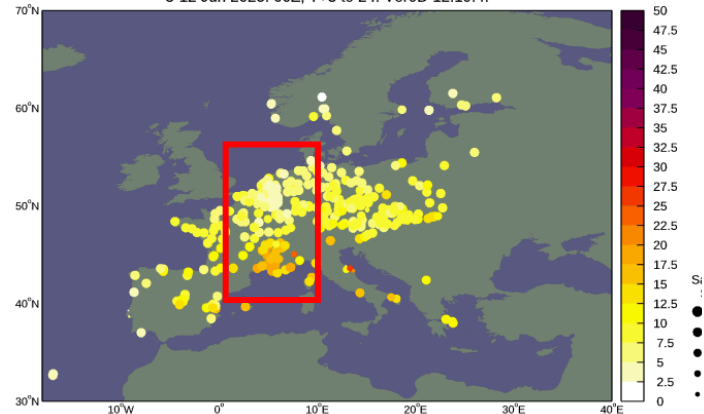
1 Jun - 1 Jul 2025, 00Z, T+3 to 24. VerOD 12.16.1.



Evaluating the assimilation impact on PM2.5

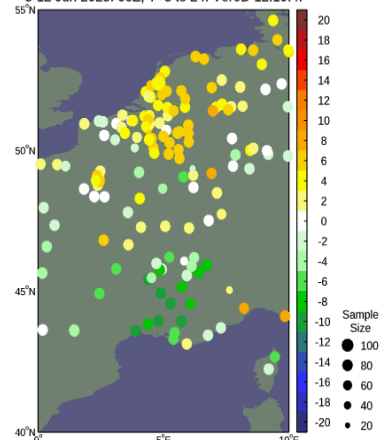
Observed PM2.5

PM2.5 (ug/m3) Mean OB Value. Model (49R1) versus AirBase.
3-12 Jun 2025. 00Z, T+3 to 24. VerOD 12.19.4.



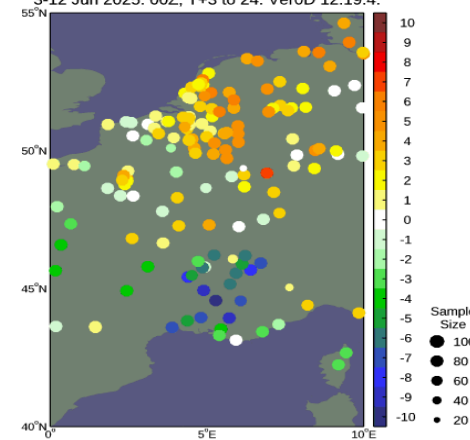
Absolute mean bias

PM2.5 (ug/m3) FC-OBS Bias Abs Diff (49R1-icki_airbase) versus AirBase.
3-12 Jun 2025. 00Z, T+3 to 24. VerOD 12.19.4.



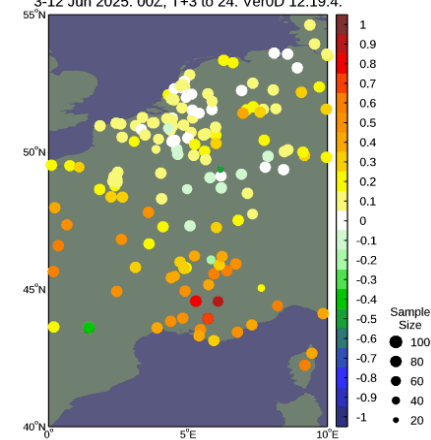
RMSE

PM2.5 (ug/m3) RMS Error Diff (49R1-icki_airbase) versus AirBase.
3-12 Jun 2025. 00Z, T+3 to 24. VerOD 12.19.4.



Temporal correlation

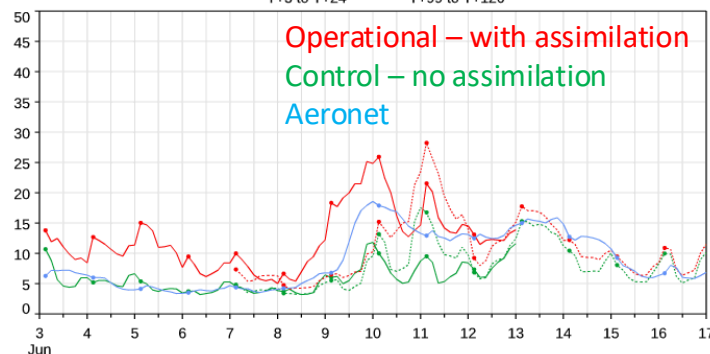
PM2.5 (ug/m3) Correlation Coeff Diff (49R1-icki_airbase) versus AirBase.
3-12 Jun 2025. 00Z, T+3 to 24. VerOD 12.19.4.



PM2.5 (ug/m3) Mean. Model versus AirBase.

167 sites in Alpine. 3-12 Jun 2025. 00Z, T+3 to 120. VerOD 12.19.4.

— Obs — icki_airbase — 49R1
— T+3 to T+24 — T+99 to T+120



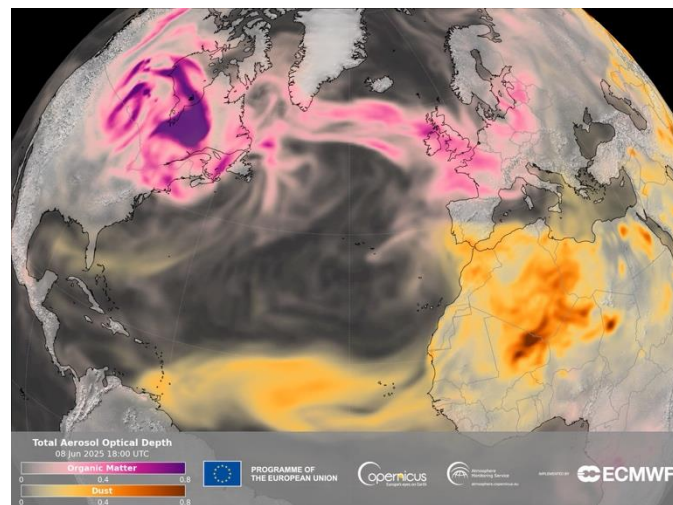
- Comparing the model outputs with/without data assimilation with independent measurements allows more complete evaluation of forecast performance.
- Assimilating AOD leads to clear reduction in absolute mean bias, RMSE (not shown) and improvement in temporal correlation of **PM2.5 surface concentrations** at **European Alpine measurement sites**.
 - Higher elevation sites are relatively isolated from PBL atmospheric pollution & sample smoke plume directly

LRT June 2025 – AOD over Europe

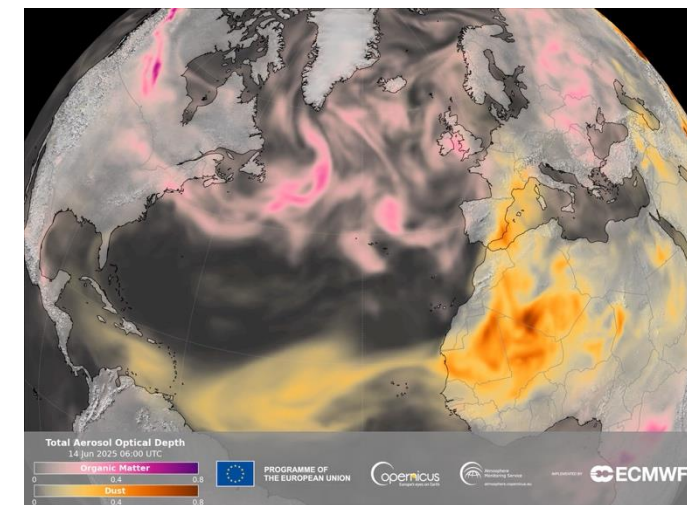
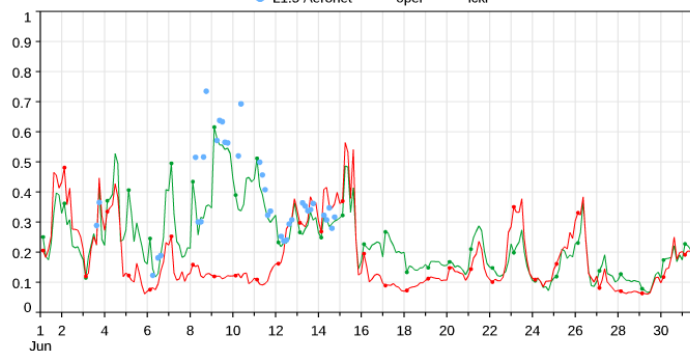
French Alps 9/11 June c/o Sam Remy



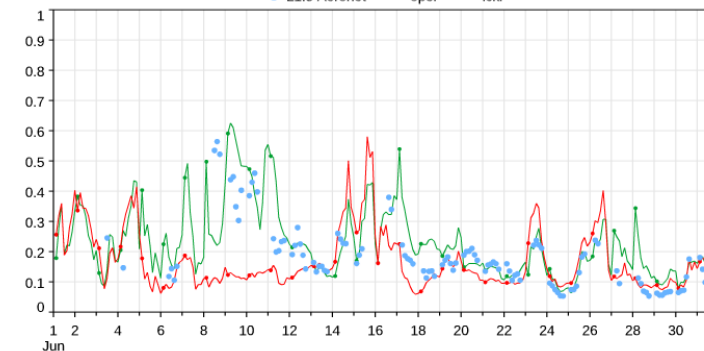
- Notable change in air mass over the Alps in mid-June with Canadian smoke replaced by Saharan dust intrusion.
- CAMS o-suite and control forecast better match Aeronet at Alpine sites for dust (emissions calculated online with model meteorology) compared to smoke in this case.



Comparison of oper & icki and L1.5 Aeronet AOT at 500nm over
Payerne (46.81°N, 6.94°E).
1 Jun - 1 Jul 2025, 00Z, T+3 to 24. Ver0D 12.16.1.
● L1.5 Aeronet — oper — icki



Comparison of oper & icki and L1.5 Aeronet AOT at 500nm over
HohenpeissenbergDWD (47.80°N, 11.01°E).
1 Jun - 1 Jul 2025, 00Z, T+3 to 24. Ver0D 12.16.1.
● L1.5 Aeronet — oper — icki



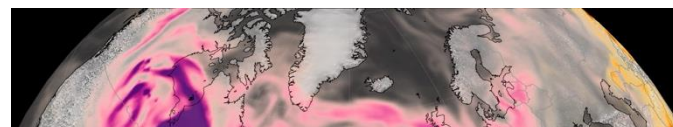


LRT June 2025 – AOD over Europe

French Alps 9/11 June c/o Sam Remy



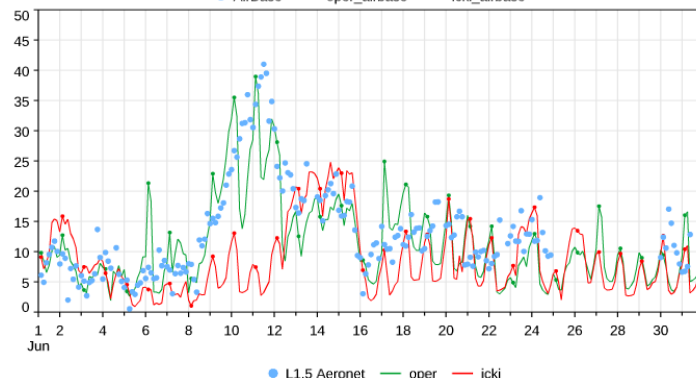
- Notable change in air mass over the Alps in mid-June with Canadian smoke replaced by Saharan dust intrusion.
- CAMS o-suite and control forecast better match Aeronet at Alpine sites for dust (emissions calculated online with model meteorology) compared to in this case.
- Surface PM2.5 concentrations well forecast by CAMS.
 - Two example sites in French Alps
 - DA also improves forecast for smoke at surface



Comparison of oper_airbase & icki_airbase and AirBase PM2.5 (ug/m3) at FR33220 (45.92°N, 6.71°E).

1 Jun - 1 Jul 2025. 00Z, T+3 to 24. VerOD 12.16.1.

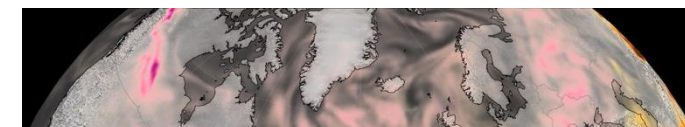
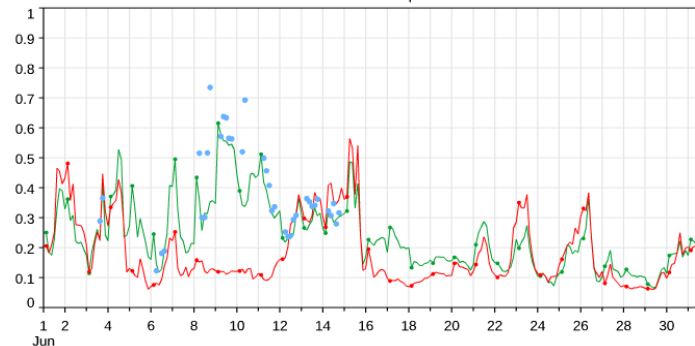
• AirBase • oper_airbase • icki_airbase



Comparison of oper & icki and L1.5 Aeronet AOT at 500nm over Payerne (46.81°N, 6.94°E).

1 Jun - 1 Jul 2025. 00Z, T+3 to 24. VerOD 12.16.1.

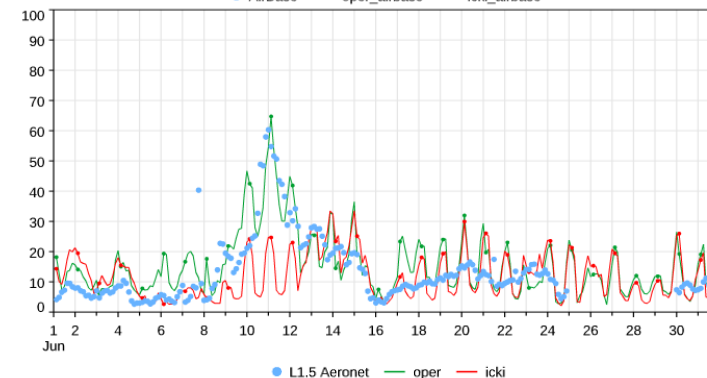
• L1.5 Aeronet • oper • icki



Comparison of oper_airbase & icki_airbase and AirBase PM2.5 (ug/m3) at FR33212 (46.19°N, 6.22°E).

1 Jun - 1 Jul 2025. 00Z, T+3 to 24. VerOD 12.16.1.

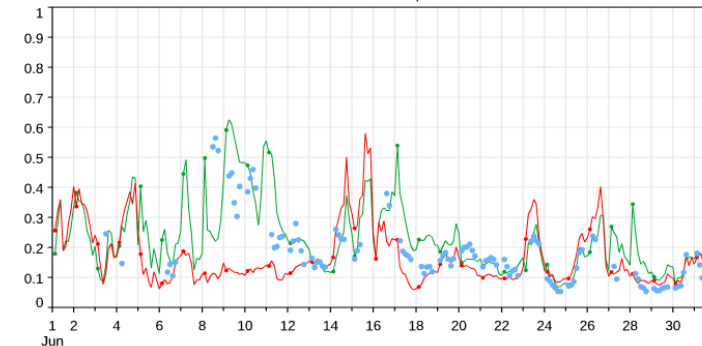
• AirBase • oper_airbase • icki_airbase



Comparison of oper & icki and L1.5 Aeronet AOT at 500nm over HohenpeissenbergDWD (47.80°N, 11.01°E).

1 Jun - 1 Jul 2025. 00Z, T+3 to 24. VerOD 12.16.1.

• L1.5 Aeronet • oper • icki





Summary

- Routine, timely monitoring of CAMS operational products
 - Identify potential technical issues in the forecast
 - Builds on available NRT observation streams for 'on-the-fly' evaluation of operational forecasts.
 - Typically Aeronet for AOD and in situ for surface PM – expanding to more routinely include lidar/ceilometer and satellite observations.
 - Evaluation against other forecast systems on a (very) ad hoc basis.
 - Identify problems with forecasts and have information prepared for communication activities and media requests, and supporting users
- Scope within ICAP for coordinating/communicating NRT operational forecast evaluation around aerosol episodes?
 - Knowledge exchange for datasets and tools for evaluation
 - Share aspects of evaluation for specific cases
 - Build on common tools for comparing ICAP models – i.e., NRL Maproom

IGAC activity on biomass burning uncertainties



<https://www2.aom.ucar.edu/bburned>

IGAC activity started in 2023 to address key uncertainties in biomass burning, from emissions to atmospheric chemistry and dynamics of smoke plumes.

Three Working Groups – **get in touch if you would like to get involved (especially ECRs)!**

- Emissions
- Atmospheric Chemistry
- Atmospheric Modelling

Fire Emissions Workshop (FEW) in November 2023

- Co-organized with HTAP to support upcoming fire model intercomparison
- Manuscript published in Elementa in September 2025 (<https://doi.org/10.1525/elementa.2024.00089>)

Fire Uncertainty in Chemistry Emissions and Modelling (FUNCHEM) workshop in September 2024

- Co-organized with iLEAPS
- **AGU cross-journal special issue open until December 2027**

Workshop: FEW (2023)

A joint BBURNED/HTAP virtual meeting was held on 7, 8, 9 and 14 November, 2023.

FEW: Fire Emission Workshop

Purpose: To bring together major global fire emissions datasets to understand their methods and recent updates, discuss current intercomparison results and inventory disagreements, and determine which combination would be useful for the HTAP fire emission modeling study.

Biomass burning emission estimation in the MODIS era: state-of-the-art and future directions



Mark Parrington^{1,*}, Cynthia H. Whaley², Nancy H. F. French³, Rebecca R. Buchholz⁴, Xiaohua Pan⁵, Christine Wiedinmyer⁶, Edward J. Hyer⁷, Shobha Kondragunta⁸, Johannes W. Kaiser⁹, Guido van der Werf^{10,11}, Mikhail Sofiev¹², Kelley C. Barsanti⁴, Arlindo da Silva⁵, Anton S. Darnenov⁵, Wenfu Tang⁴, Debora Griffin¹³, Maximilien Desservettaz¹⁴, Therese (Tess) Carter¹⁵, Clare Paton-Walsh¹⁴, Tianjia Liu^{16,17}



BBURNED
Fire Emission
Workshop, 2023 -
State of the Science

The joint BBURNED/HTAP Fire Emission Workshop was a successfully interactive virtual meeting that summarised the current state of fire-emission science for atmospheric chemistry. The meeting identified some key challenges moving forward, including the loss of fire detection sensors, MODIS, and the change to VIIRS, as well as discussed our goals as a community.

BBURNED Fire Emission Workshop (FEW2023) brought together major global fire emissions datasets to learn about methods and recent updates, discuss intercomparisons and inventory differences, and inform the upcoming multi-model multi-species HTAP study focused on fires. Over 100 attendees logged into the virtual conference, from locations all around the globe, on November 7 to 9 and 14, 2023. The cohort included emission inventory creators, modelling experts and observationalists, ensuring a well-rounded discussion.

The first two and a half days covered invited presentations on global fire emissions datasets, as well as global and regional intercomparison studies. The third day included a discussion of three questions, summarised below:

Where are you joining from today?



FIGURE 1: Online participants indicated where they were joining the workshop from.

March 2024

Home / Biomass Burning Uncertainty: ReactionNs, Emissions And Dynamics (BBURNED)

Workshop: FUNCHEM (2024)

A joint BBURNED/iLEAPS hybrid workshop was held 14-15 September, 2024, in Kuala Lumpur, Malaysia.

FUNCHEM: Fire UNCertainty in CHEMistry Emissions, and Modelling