

Climate forcings in the Copernicus Atmosphere Monitoring Service (CAMS)



Johannes Flemming (ECMWF)



Atmosphere
Monitoring

WHAT ARE COPERNICUS AND CAMS?

CAMS is one of **six** thematic information services provided by the Copernicus Earth Observation Programme of the European Union.

Copernicus converts cutting-edge EO and the latest science into user-driven **free and open data and information products**.

It is not a project, but a **long-term** activity of the EU (5.4 B€ for 2021-2027 ; recently turned **25y**).



EUROPE'S EYES ON EARTH



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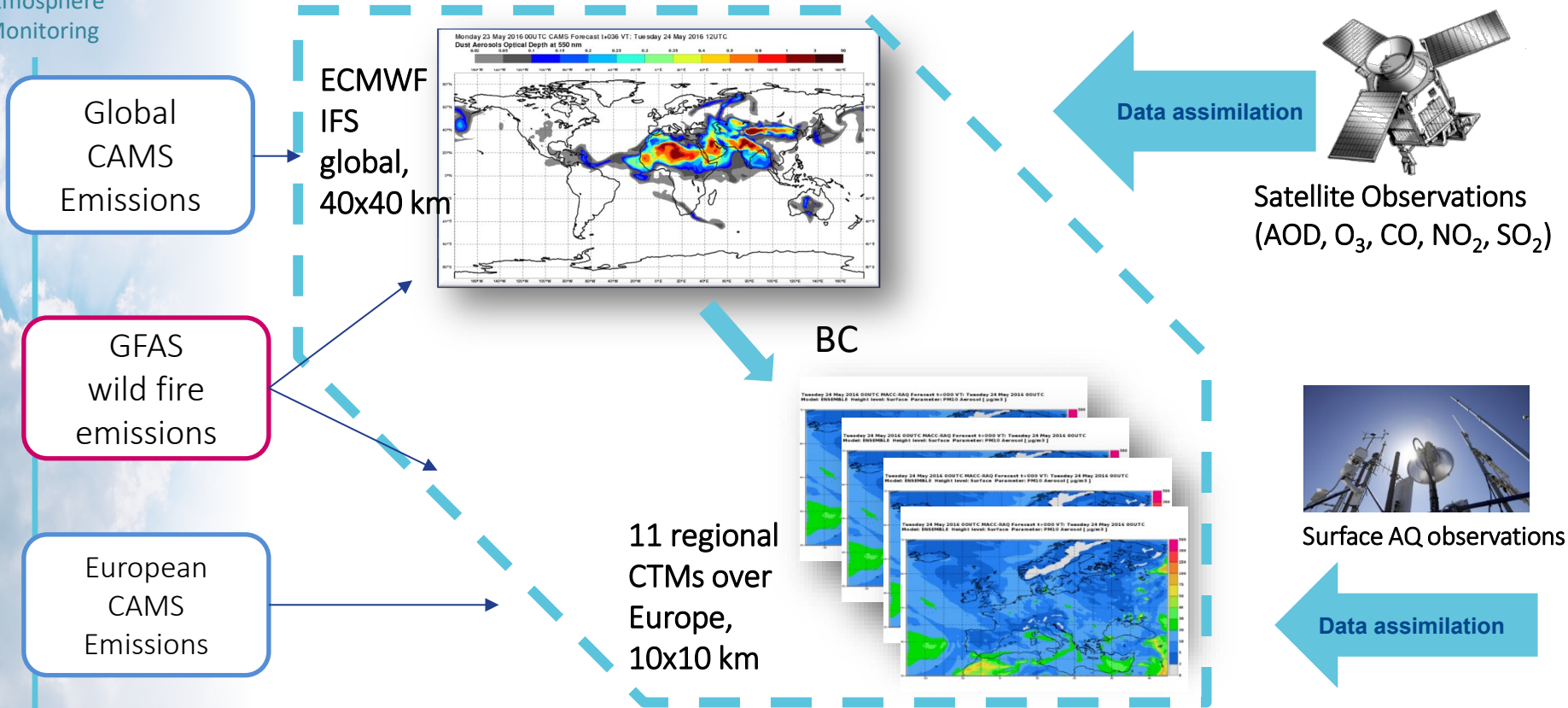
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Global and Regional CAMS systems



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CAMS products (global)

- CAMS operational products:
 - Reanalyses of global atmospheric composition (aerosol, reactive gases, GHG, deposition fluxes)
 - NRT forecast and analysis of global atmospheric composition
 - Emissions: anthropogenic, biogenic, natural and fire emissions (GFAS)
- CAMS science and policy support products:
 - Radiative Forcing products
 - Solar radiation industry products
 - Policy support tools
 - Contributions to International intercomparison efforts (HTAP, AEROCOM, ...)
- CAMS service commitment
 - Quality Control and Quality Assurance (Evaluation, documentation, versioning, R2O)
 - All data freely available on Atmosphere/Climate Data Store
 - Period: 2003- Present day (but user requests for backward extension)
 - Long-term funding commitment

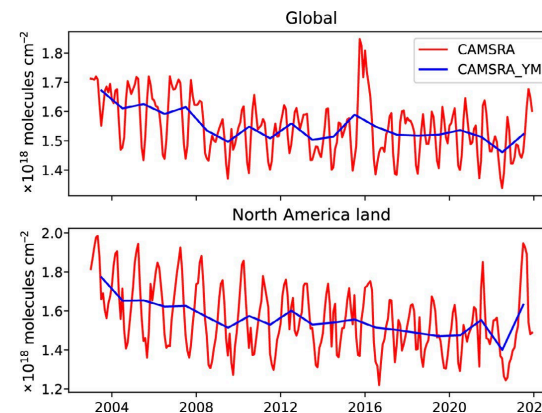




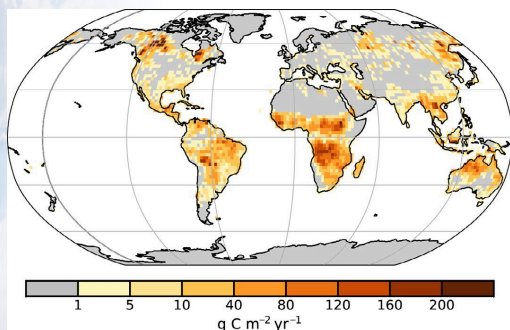
Routine production of reanalysis (EAC4)

The atmosphere datastore now contains a full 20-year global re-analysis dataset for reactive gases and aerosol (EAC4).

The re-analysis takes stock of all available observation datasets using a fixed version of the CAMS forecast model. It is the BEST ESTIMATE of atmospheric composition patterns and evolution over the last two decades.

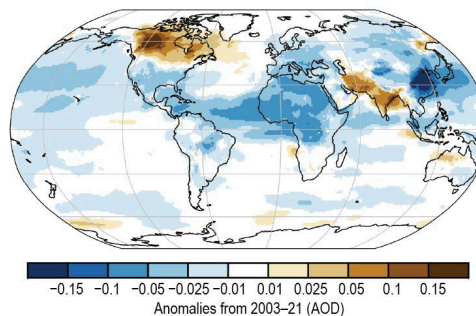


Carbon monoxide



Fire emissions

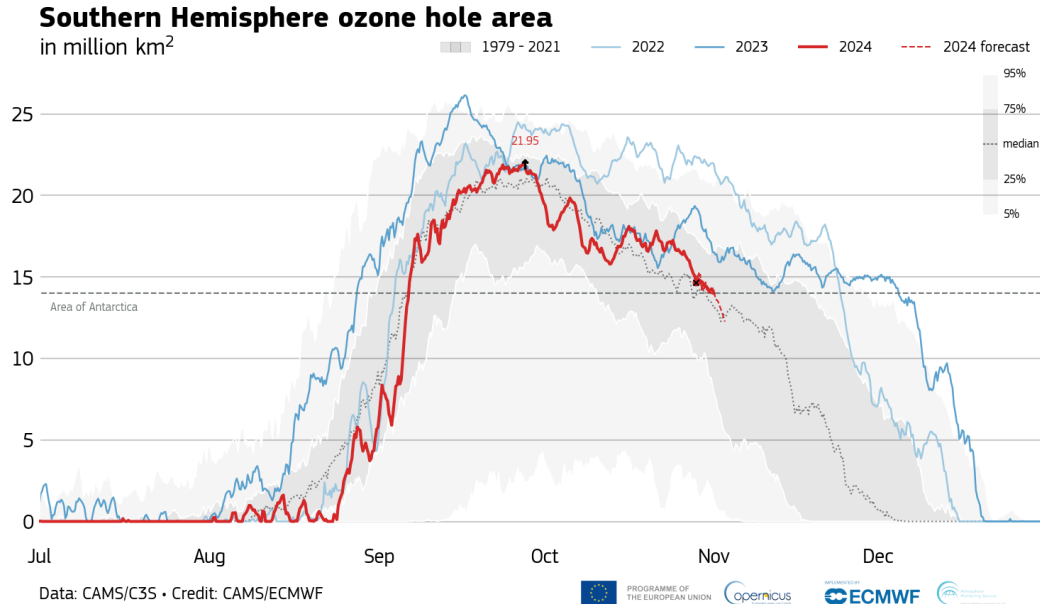
(x) Total Aerosol Total aerosol



CAMS contributed to the BAMS State of the Climate with detailed information.



Ozone Hole Monitoring



Comprehensive stratospheric chemistry was introduced in June 2023 to more accurately monitor the ozone layer, improve the forecasts (including UV), and improve our understanding of the formation of the ozone hole each year.



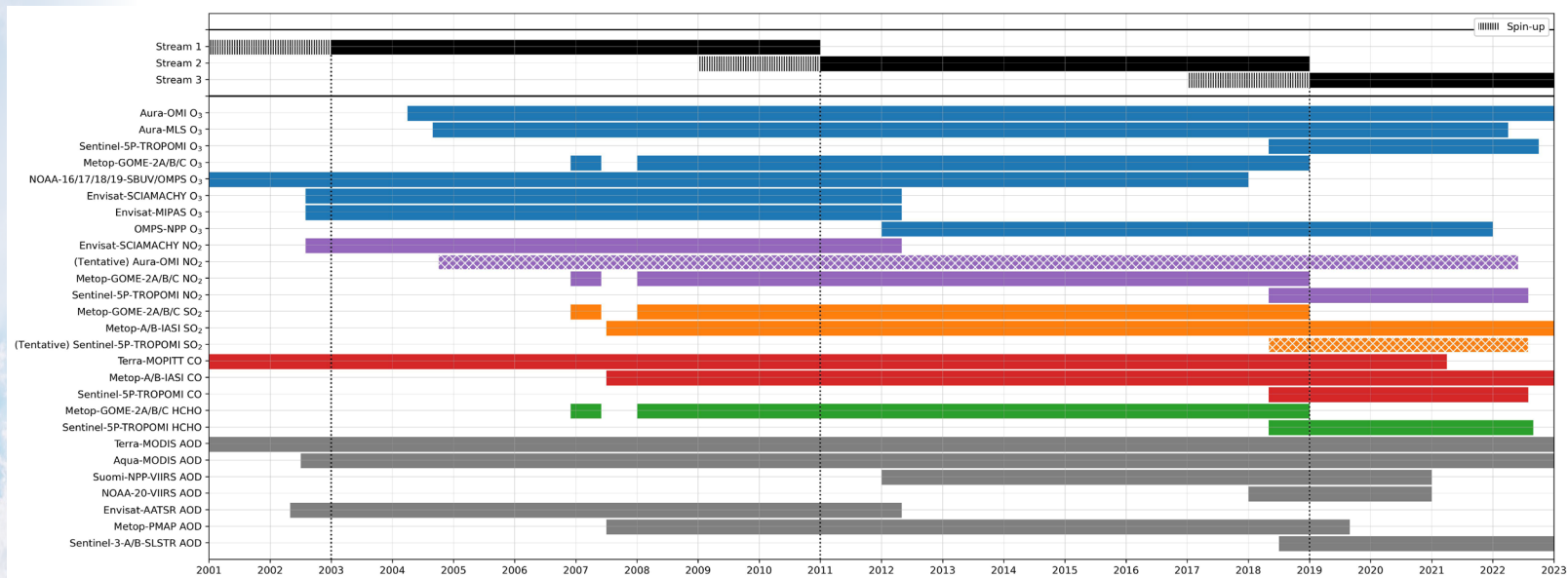


- Modelling updates:
 - Resolution upgrade to 40 km (was 80 km)
 - Stratospheric chemistry coupled to aerosol scheme (stratospheric sulphate)
 - secondary aerosols: nitrates, ammonium, secondary organic aerosols
- New assimilated AC retrievals:
 - Sentinel 5P (CO, NO₂, O₃), VIIRS (AOD), Sentinel 3 (AOD), METOP (SO₂)
- Emissions updates:
 - CAMS-GLOB-ANT 6.2/EDGAR6
 - online biogenic VOC
 - Honga Tonga stratospheric water vapour injection (2022)
- Data sets: (user input still welcome)
 - 3D concentrations and total columns
 - Aerosol optical diagnostics (AOD, SSA, backscatter coefficients, absorption AOD, extinction)
 - Dry and wet deposition fluxes
 - Emissions and surface fluxes
- Production start in Q1/2025 (will reach NRT in 2027/28)





Reanalysis (EAC5)

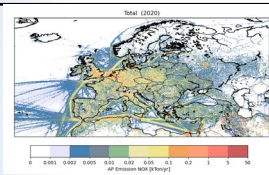


The next global reanalysis is being prepared with a strong focus on acquiring the most recent reprocessed satellite data. Much credit goes to EUMETSAT, ESA, and other space agencies. The reanalysis production will commence in Q1 2025 using the latest version of the global CAMS forecasting system.

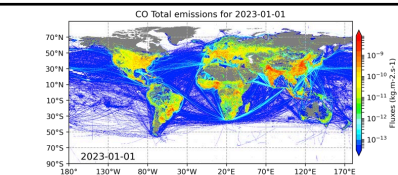


CAMS emissions products

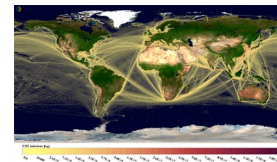
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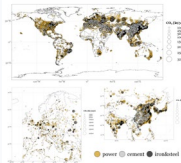
Regional emission inventories for Europe, consistent with national reported emissions to EMEP/CEIP and UNFCCC



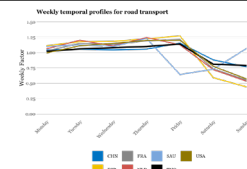
Global emission inventories based on EDGAR and CEDS with projection to current year



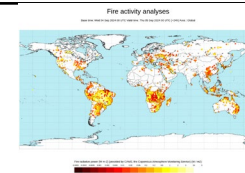
Shipping emissions based on STEAM model with inputs from EMSA



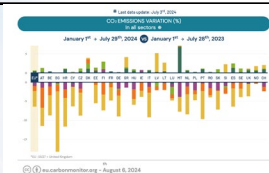
Point source data base



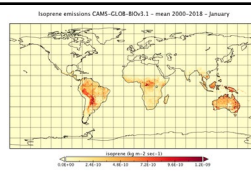
Temporal profiles (seasonal, diurnal, weekly)



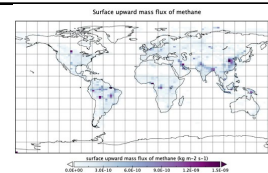
Daily and hourly fire emissions based on satellite observations (GFAS)



Activity-based CO2 emissions (to be extended to other species)



Model-based vegetation fluxes (e.g., CO2 and Volatile Organic Compounds)

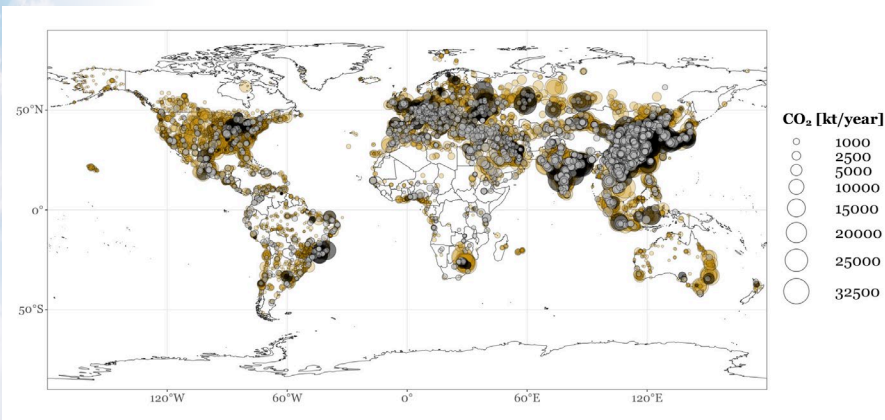
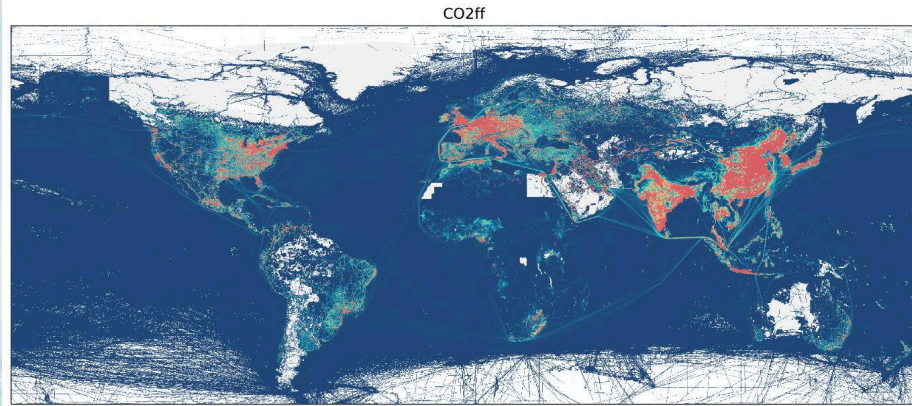


Emission Inversions – CO2MVS (CO2, N2O, CH4, Nox) in development

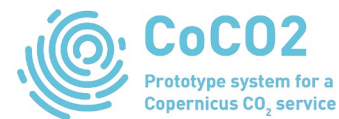




Emission inventory developments



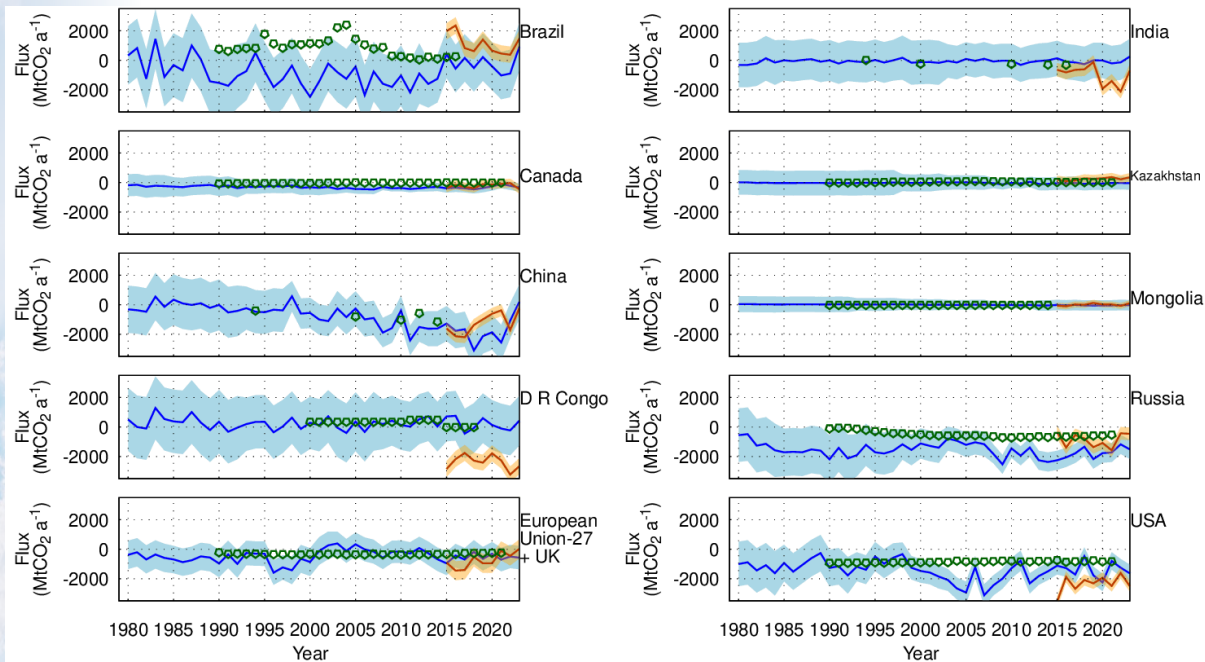
Recent improvements through Horizon Europe CoCO₂ and CORSO projects include the creation of a global mosaic of regional emission inventories as well as creating an up-to-date point source database.





A FOLU estimates

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Nationally reported
In situ
Satellite

Atmospheric inversion flux estimates for CO₂ are now used to provide annual AFOLU sector estimates for large countries and regions. In situ observations provide long data record that is mostly consistent with satellite-based estimates and nationally reported emissions.

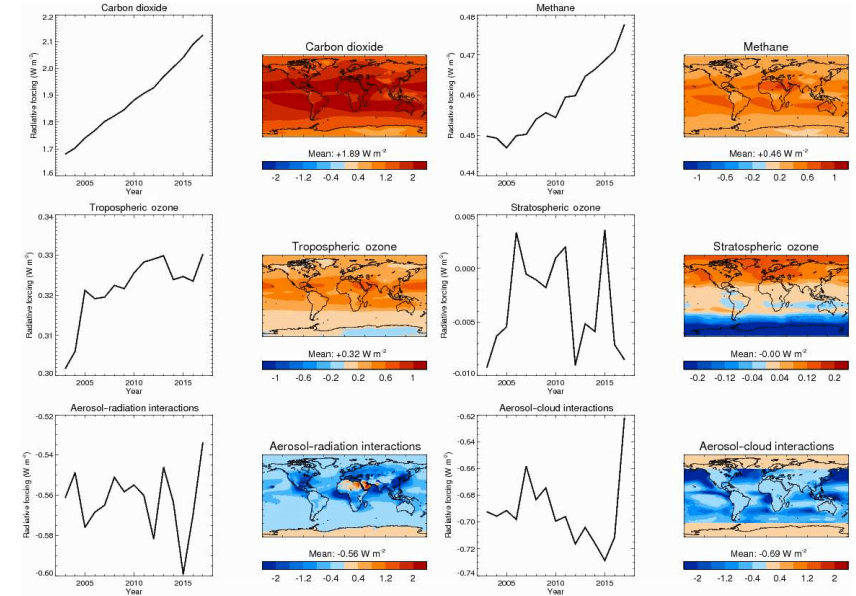
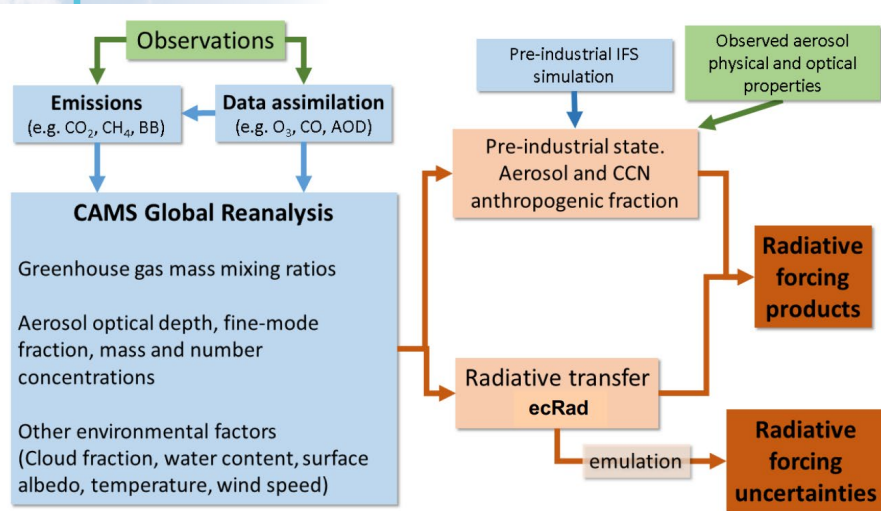




CAMS radiative Forcing Products (CAMS 74)

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Production Chain



Bellouin et al. ESSD 2020

Project to be repeated for EAC5



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Impact on Arctic Wildfires in 2mT forecasts

(JJA 2021) RMSE CAMS -osuite (Prog AER) - RRMS CR (Clim Aero)

JJA 2021

2t 00utc T+24 rmsef[K] (mc_0001 - rd_hj88)

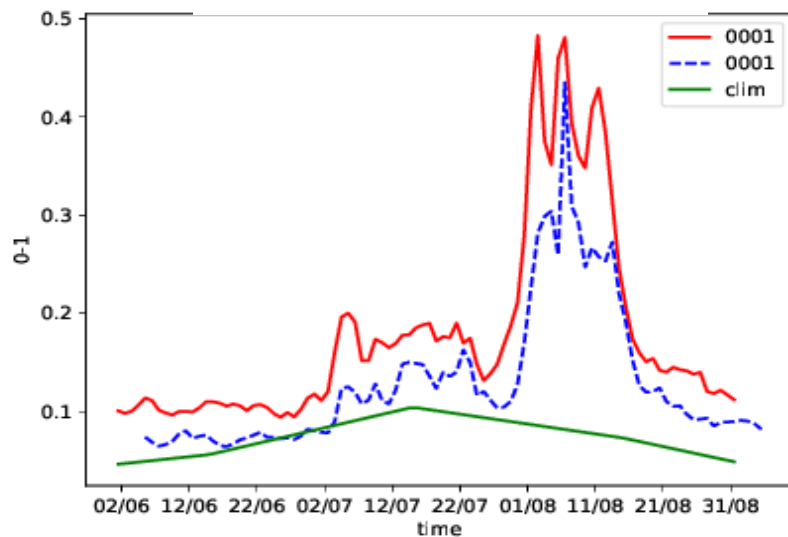
Legend: -10-5, -5-2, -2-1, -1-1, 1-2, 2-5, 5-10



Magic 4.3.3 (64 bit) - lyander - m - Tue Sep 21 21:11:48 2021

ECMWF

AOD mean Artic



CAMS forecast and analysis (IFS) includes NWP

Prognostics aerosol and ozone interacts with radiation scheme

Active vegetation fires in Siberia

red: AOD analysis, blue 108 h forecast

green: climatology)





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Thank you



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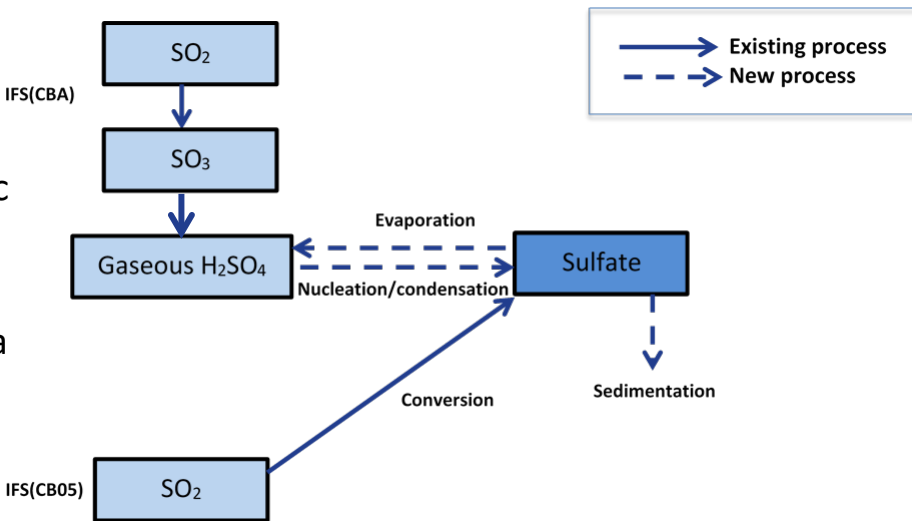
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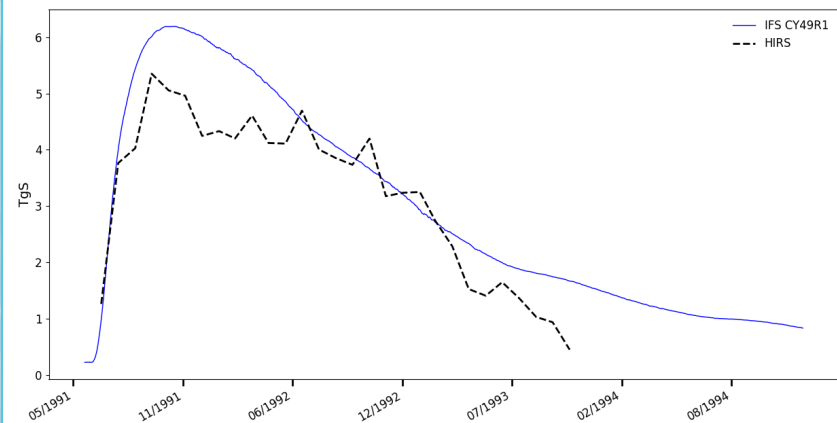


Stratospheric aerosol in CY49R1

- A representation of the stratospheric sulphur cycle has been implemented in cycle 49R1, including coupling between stratospheric chemistry and stratospheric sulfate
- This simple scheme works well in representing the main characteristics of a large volcanic eruption



Architecture of the stratospheric extension of IFS-AER and its coupling with IFS(CBA) and IFS(CB05), with existing and new processes. Sedimentation is indicated as a new process because it has been revisited.



Simulated (49R1 fc only) and retrieved global stratospheric sulfate during and after the June 1991 Pinatubo eruption

