



Atmosphere Monitoring

Update on CCI data usage in CAMS

Antje Inness (ECMWF)

CCI meeting, Harwell (18 October 2024)



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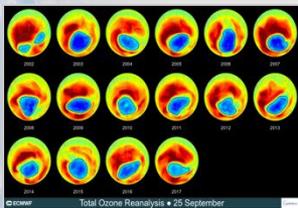
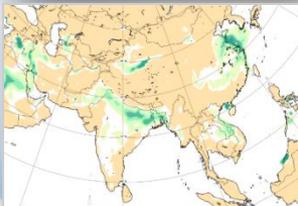
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Copernicus Atmosphere Monitoring Service

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The CAMS portfolio includes Earth Observation based information products about:

- 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.
- reanalysis of atmospheric composition

Quarterly validation reports of global and regional outputs.

This is **CCI data were assimilated in CAMS reanalyses EAC4 & EGG4** on into ECMWF's reanalysis (in addition to meteorological observations,

<https://atmosphere.copernicus.eu>



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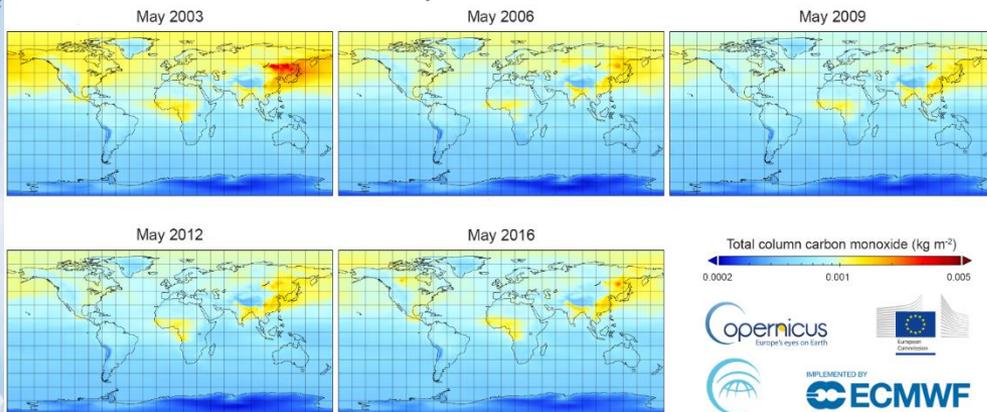
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CAMS global reanalysis 2003 – 2023 (updated every 6 months)

CAMS Global Reanalysis - Carbon monoxide 2003 - 2016



Reanalysis

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

DATA DESCRIPTION

Data type	Gridded
Horizontal coverage	Global
Horizontal resolution	0.75°x0.75°
Vertical coverage	Surface, total column, model levels and pressure levels.
Vertical resolution	60 model levels. Pressure levels: 1000, 950, 925, 900, 850.
Temporal coverage	2003 to 2020
Temporal resolution	3-hourly
File format	GRIB (optional conversion to netCDF)
Versions	Only one version
Update frequency	Twice a year with 4-6 month delay

CAMS global reanalysis (CAMSR4)

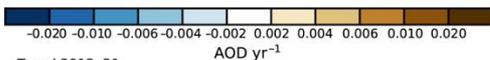
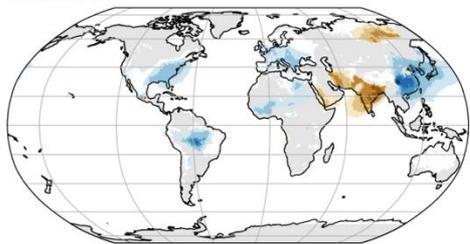
- 2003 –2023, with new years being added
- 80 km horizontal resolution, 60L vertical
- Aerosols, chemical pollutants (**EAC4**)
 - Inness et al. (2019): <https://doi.org/10.5194/acp-19-3515-2019>
 - Wagner et al. (2021): <https://doi.org/10.1525/elementa.2020.00171>
- CO₂ & CH₄ in separate reanalysis (**EGG4**)
 - Agusti-Panareda (2023): <https://acp.copernicus.org/articles/23/3829/2023/>
- atmosphere.copernicus.eu/eqa-reports-global-services
- Data available from ADS <https://atmosphere.copernicus.eu/data>

- Model cycle 42R1
- CB05 tropospheric chemistry
- Cariolle-Déqué scheme for stratospheric ozone
- Interactive prognostic O3 and AER

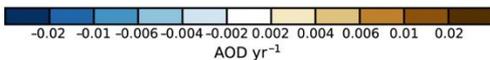
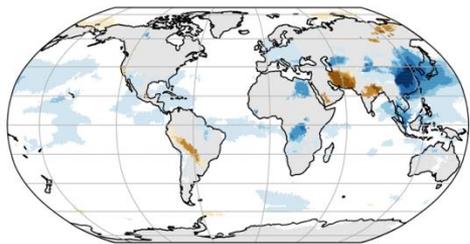


Contributions to BAMS state of the climate

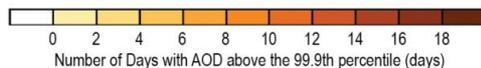
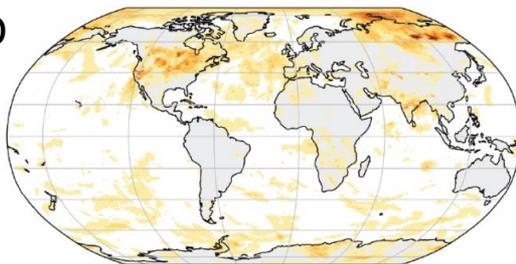
Trend 2003–21



Trend 2012–21



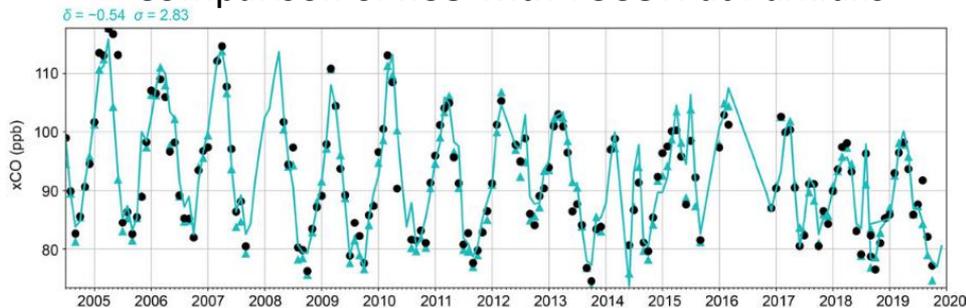
AOD



Remy et al. (2022),
STOC 2021

CAMS reanalysis data have been used for almost a decade to contribute to BAMS State of the Climate reports

Comparison of xCO with TCCON at Parkfalls



18 Nov 2020

Fig. 2.62. Column-averaged CO (xCO, in ppb) at the Park Falls TCCON station. Monthly mean observations are shown by the black dots, and corresponding monthly mean xCO columns calculated using the TCCON-averaging kernels are shown by the blue triangles. The continuous blue line is the monthly xCO from the CAMS reanalysis.

Extreme AOD days in 2021 correspond to extreme boreal fire events, including transport to the Arctic

Flemming et al. (2020), STOC 2019



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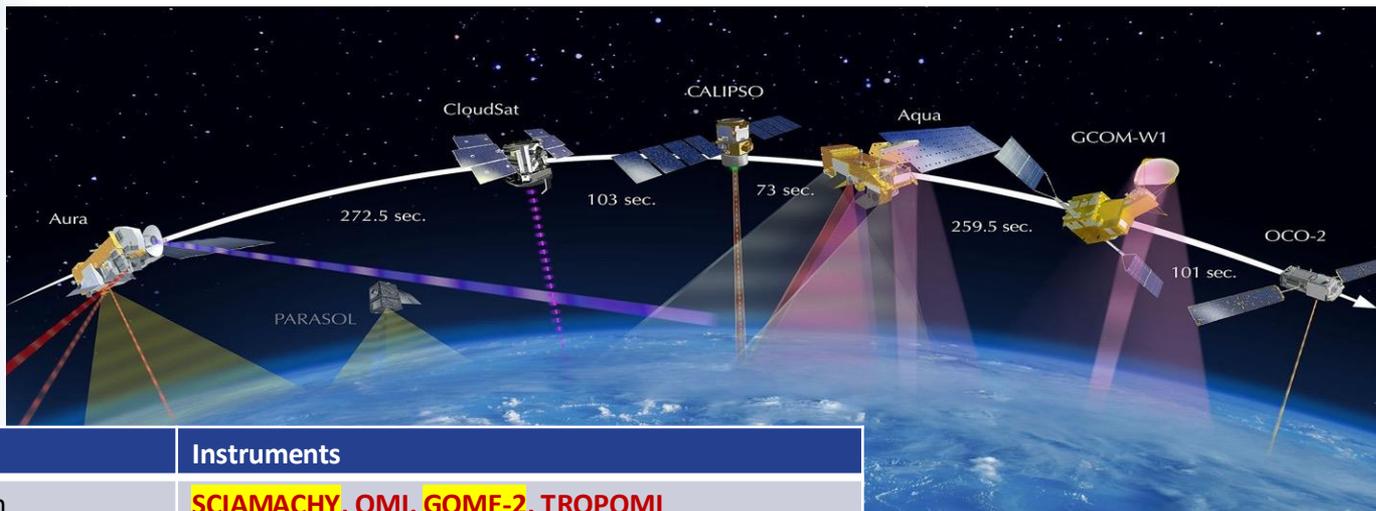
TCCON data from:
<https://tccondata.org/>





AC Observations used in EAC4

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Species	Instruments
O ₃ total column	SCIAMACHY, OMI, GOME-2, TROPOMI
O ₃ profiles	MIPAS, MLS
O ₃ layers	SBUV/2, OMPS-NP
CO	MOPITT
NO ₂	SCIAMACHY, OMI, GOME-2
Aerosol	MODIS, AATSR
GFAS fire emissions	MODIS

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

CCI data used in EAC4

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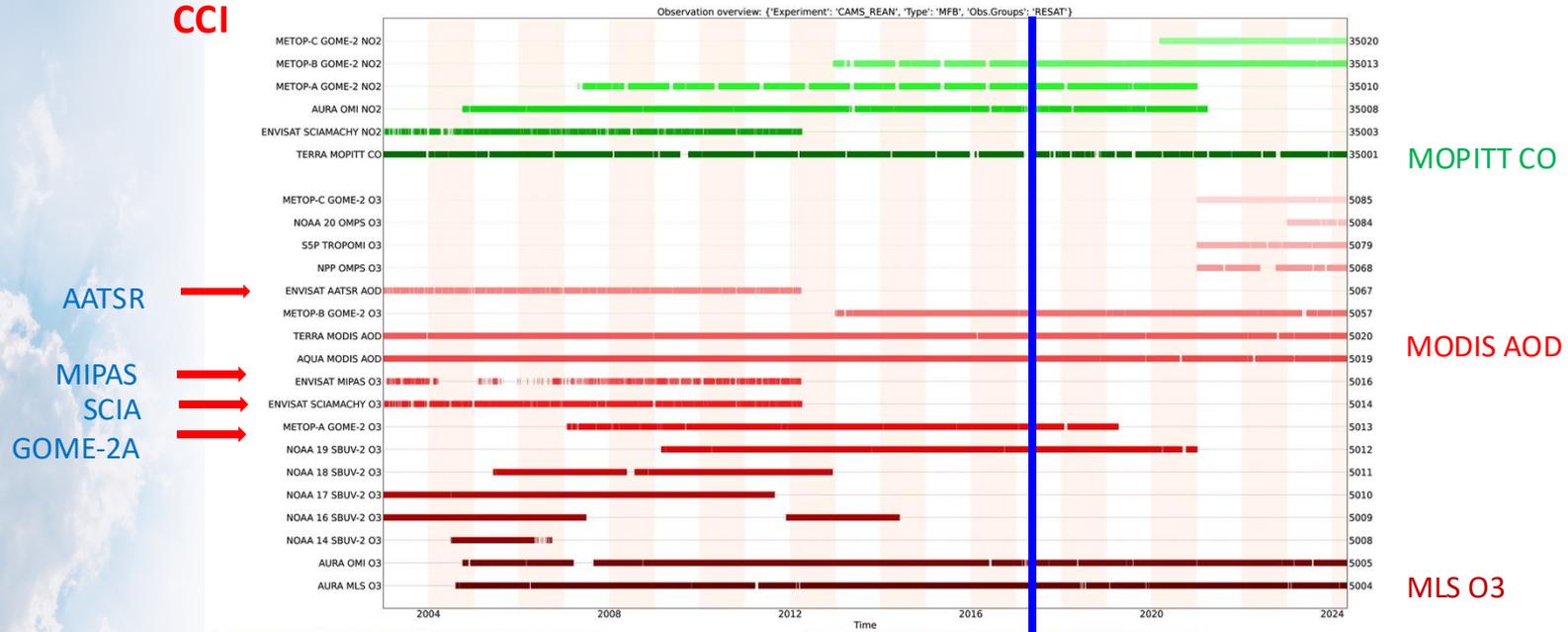
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Atmospheric composition data used in EAC4

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AATSR →

MIPAS →

SCIA →

GOME-2A →

MOPITT CO

MODIS AOD

MLS O3

- Observing system changes with time
- Change from reprocessed to NRT data once EAC4 had caught up with NRT
- MLS important for vertical ozone distribution
- Reliance on MOPITT CO/ MODIS AOD

} End of EAC4 when these die

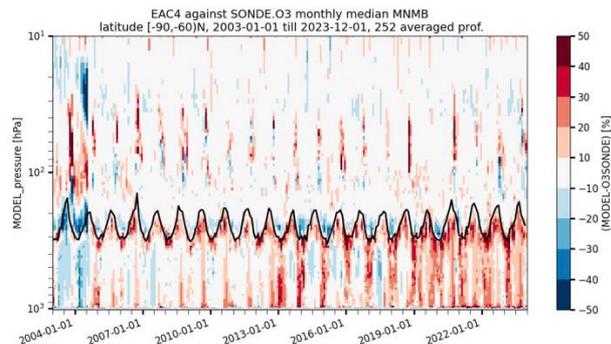
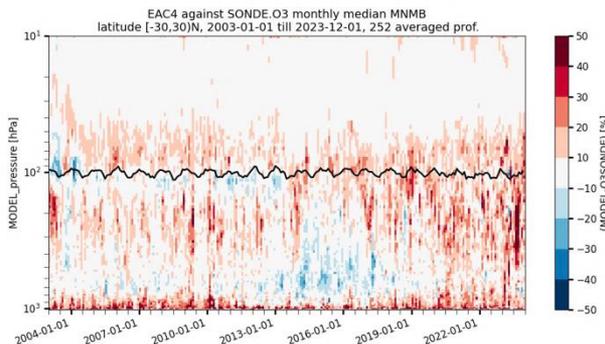
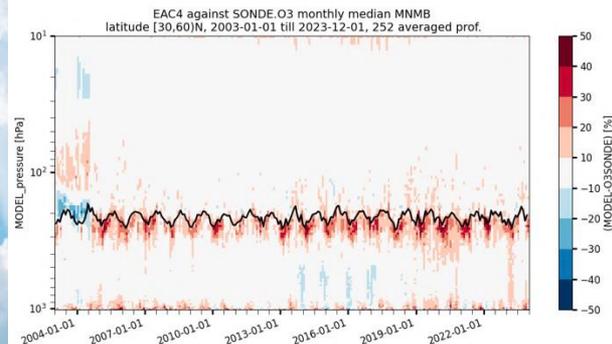


Ozone biases due to changing observing system

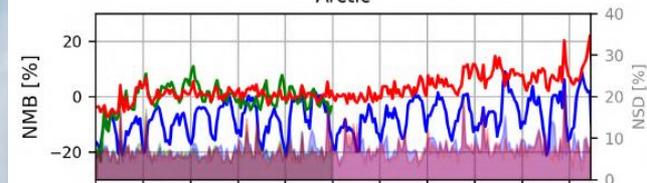
Atmosphere 60-30N

30N-30S

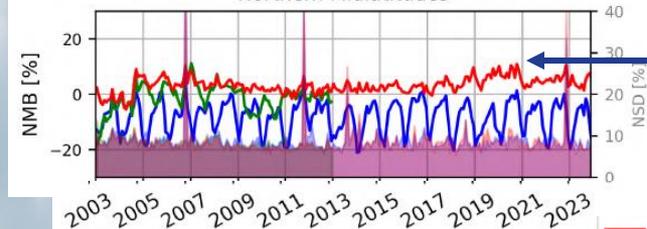
60-90S



NMB and NSD of 100 hPa-surface O3 column above Arctic



Northern Midlatitudes



- Pre-MLS period has different biases
- Stratospheric ozone biases quite stable after Aug 2004
- Tropospheric ozone is affected more by instrument changes than total column or stratospheric ozone
- Increasing ozone bias in Arctic after 2018 (drifting NOAA-19?)
- Stable performance for tropospheric ozone from 2005-2018

Change to TROPOMI,
GOME-2C, OMPS_NP
SNPP O3

— CAMSRA-o3sondes — MACCRA-o3sondes
— Control-o3sondes

<https://atmosphere.copernicus.eu/eqa-reports-global-services>



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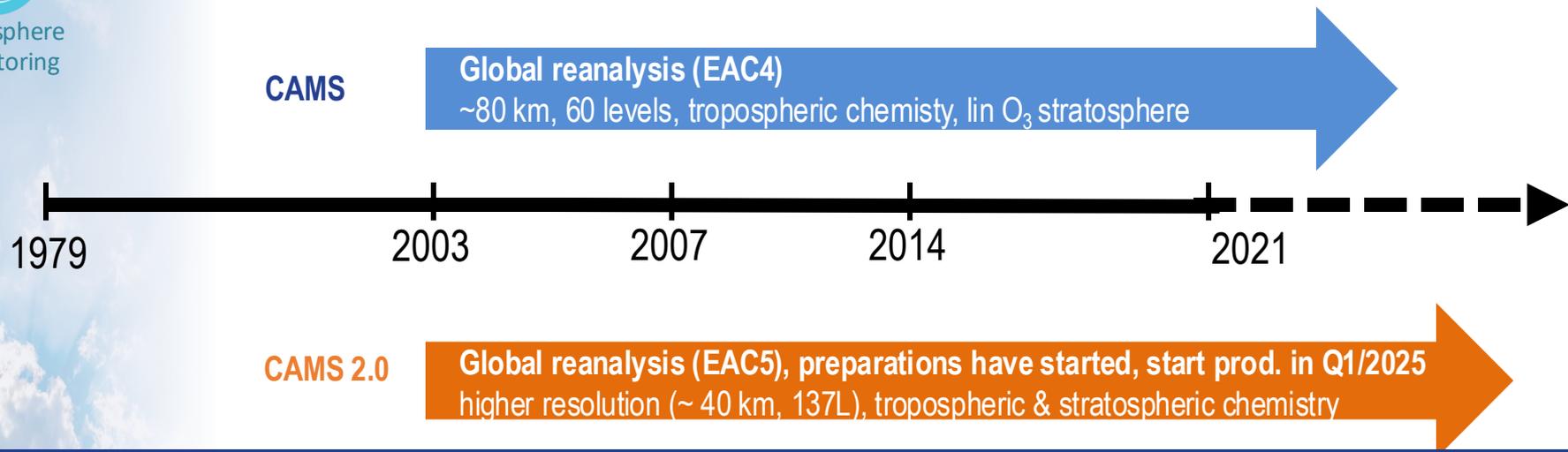
- Problems in the reanalysis due to
 - Changes in observing system (satellites come and go)
 - Inconsistent retrievals from different instruments (varBC can remove/reduce some of these differences for contemporary instruments)
 - Change from reprocessed/offline data to NRT data & version changes
- We need consistent data
- We need offline/reprocessed data close to NRT
- It is useful if data versions are continued (not just replaced by newer/better versions)
- Emission datasets also very important & should be continued





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Plans for CAMS2.0 reanalysis (EAC5)



Preparations for EAC5 have started

- Improvements to chemistry (IFScompo-BASCOE, including stratospheric chemistry)
- Newer/ improved IFS version (better meteorology): CY49R2 – same as ERA6
- Increased resolution (137 vertical levels; TL511 horizontal, ~ 40 km)
- New reprocessed observation, new emissions including online biogenic emissions

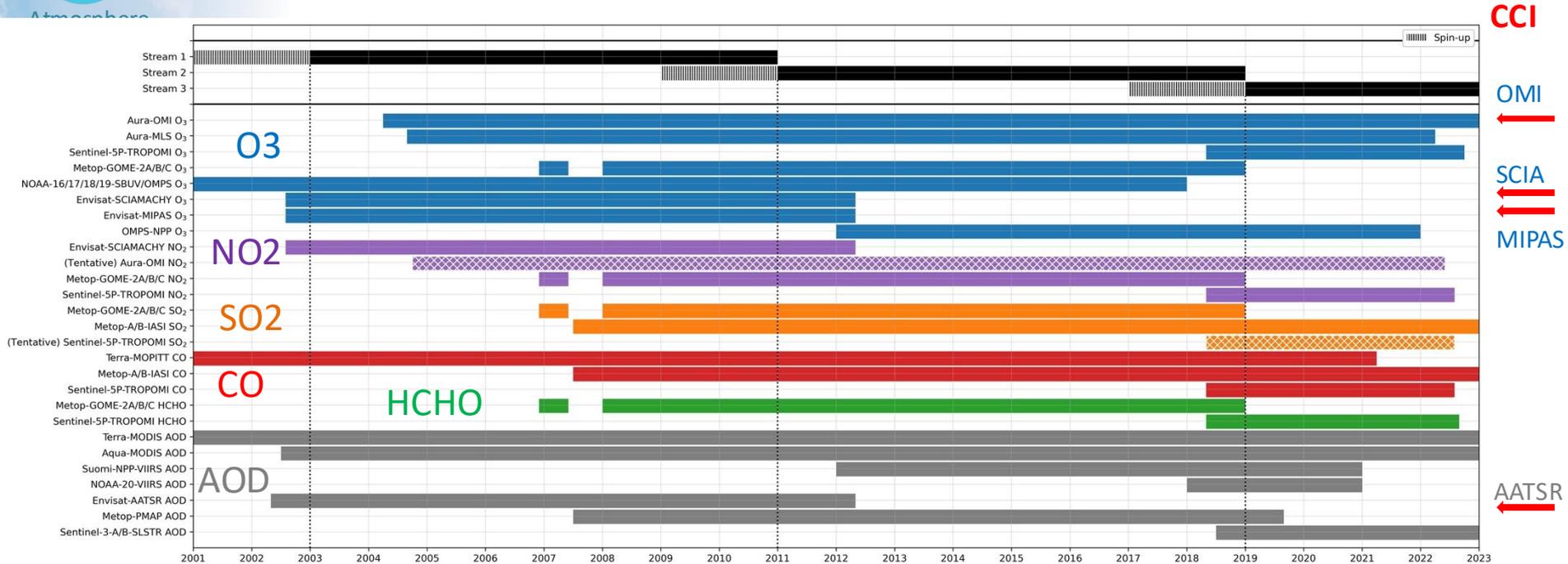
Status

- Acquisition and processing of observations almost finished
- Testing of model and DA configuration in progress, final code updates
- Improved QC for assimilated data before starting production
- No emission inversion yet in EAC5

Production to
start in
Q1-Q2/2025



Data acquisition and preparation



Credit: Chris Kelly

- Data acquisition almost complete
- This was a big task taking several years
- 150 TB of data (more than 2 million compressed files) in different formats ranging from pure binary to netCDF/HDF/BUFR and coming from different providers

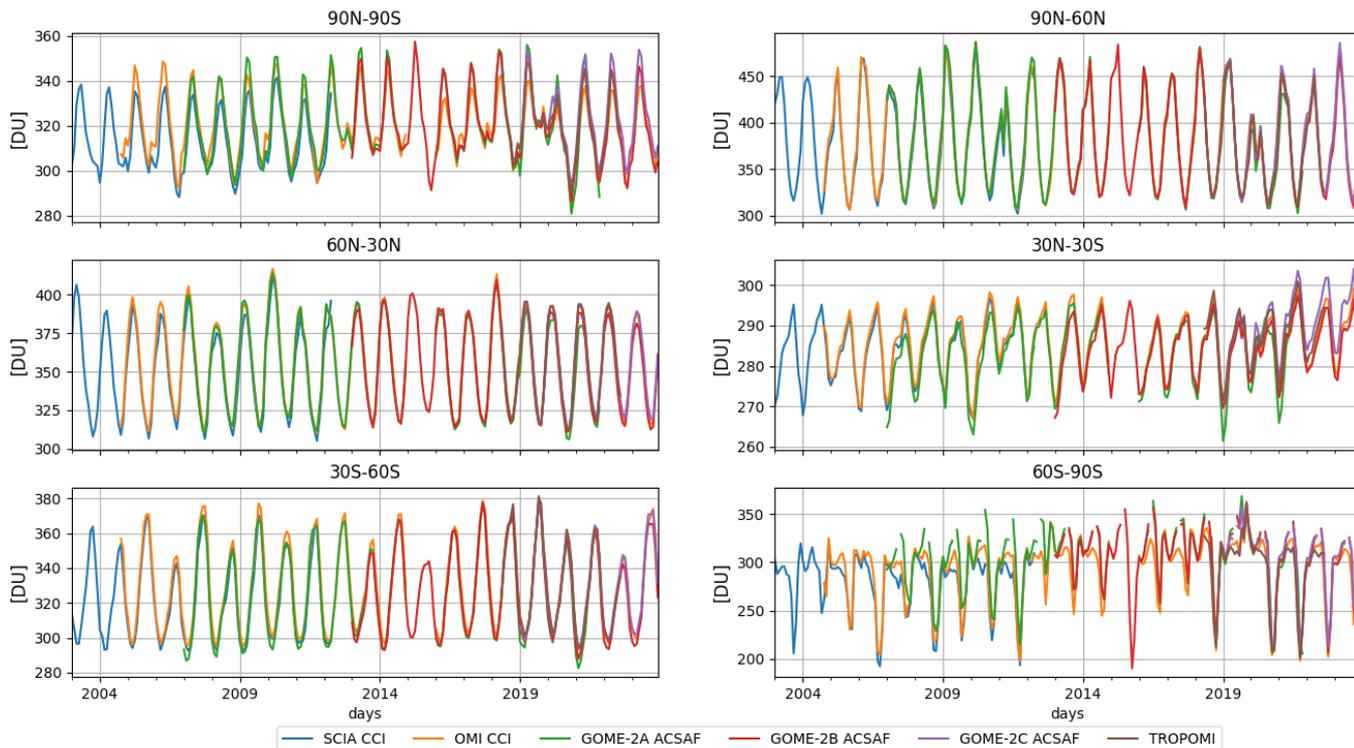


Quality check of TCO₃ retrievals

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- Assess quality of observations before production of EAC5
- Assess biases between the retrievals from different instruments

Total column ozone data for use in EAC5



SCIA CCI
OMI CCI

GOME-2A AC-SAF
GOME-2B AC-SAF
GOME-2C AC-SAF
TROPOMI ESA

- Good agreement between the TCO₃ datasets
- varBC will handle remaining differences

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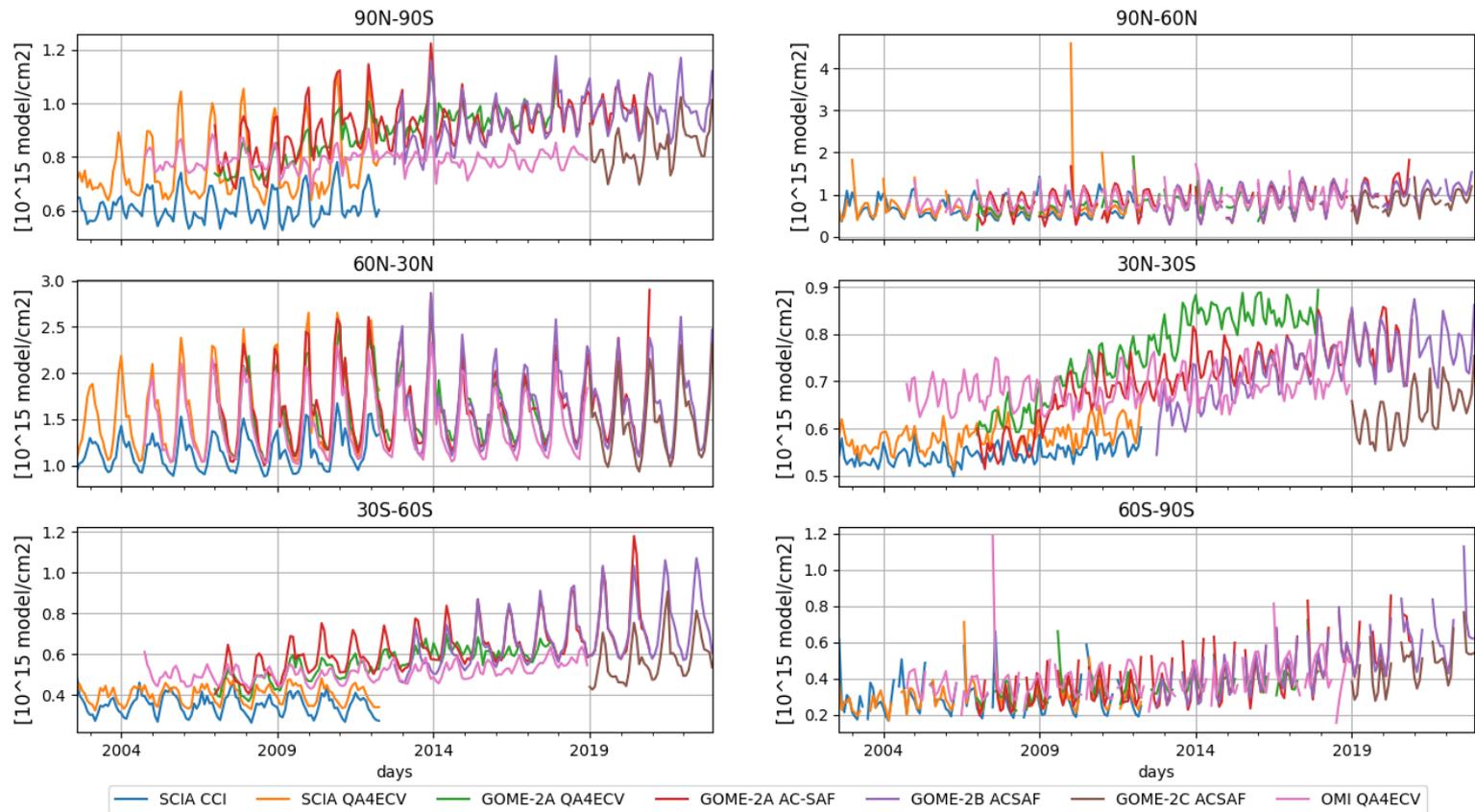
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Quality check of NO₂ retrievals

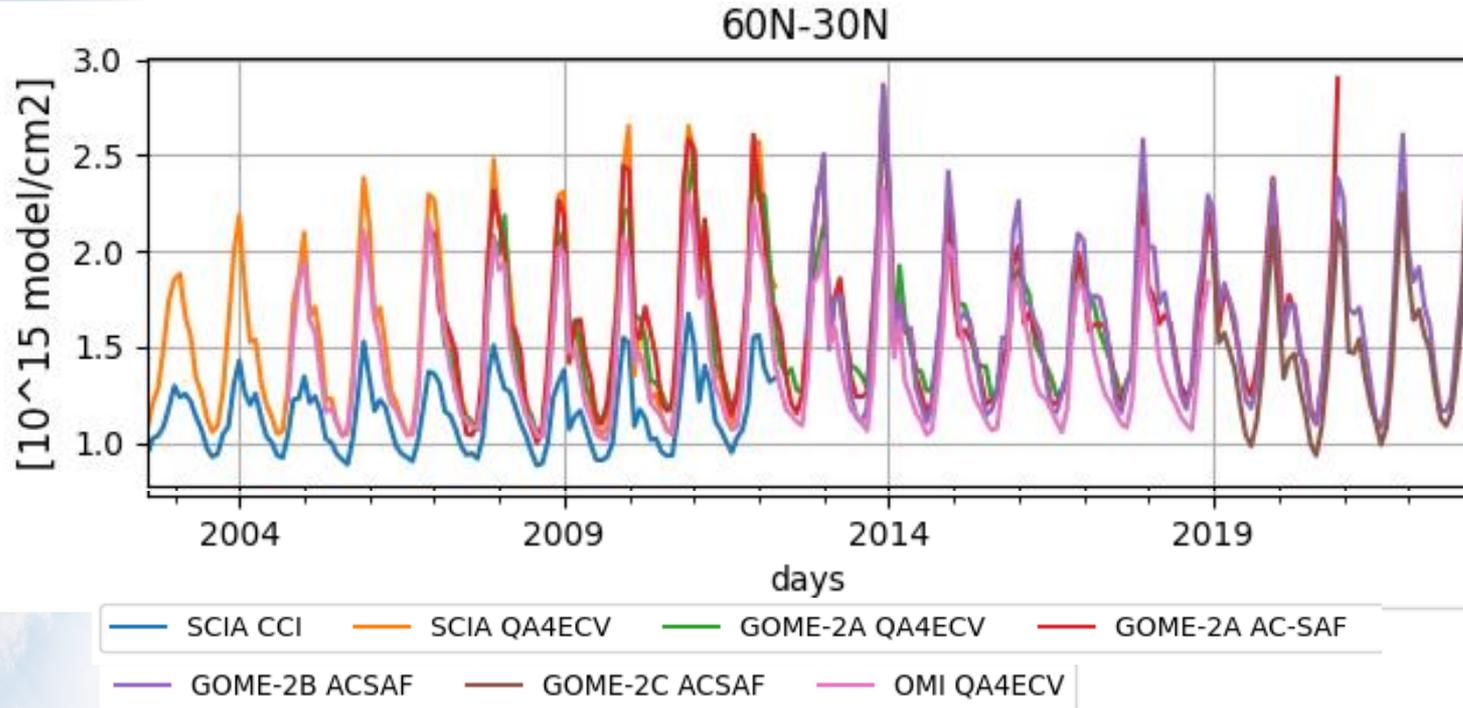
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Tropospheric NO₂ columns for use in EAC5





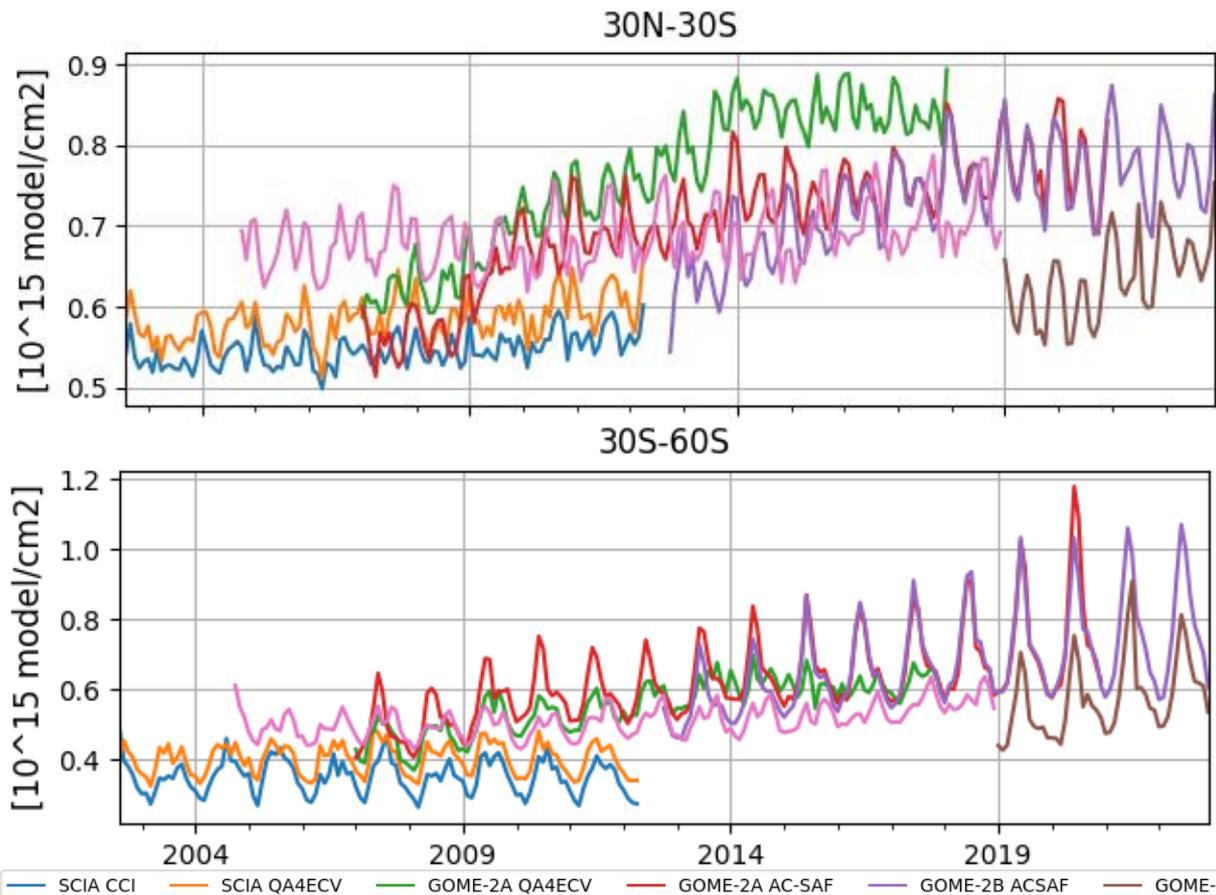
Quality check of NO₂ retrievals



Data are consistent where it matters most: 60-30N; apart from [SCIAMACHY CCI](#)



Quality check of NO₂ retrievals



Comments from F. Boersma and H. Eskes:

- Differences in tropics are within uncertainty range. Different methods to estimate stratospheric columns in the retrievals (assimilation in QA4ECV, reference sector in AC-SAF)
 - GOME-2A suffers from degradation in L1 data. This might contribute to the increase in the tropics between 2009-2013
- Use QA4ECV SCIA and OMI
• Use AC-SAF GOME-2ABC
• TROPOMI NO₂

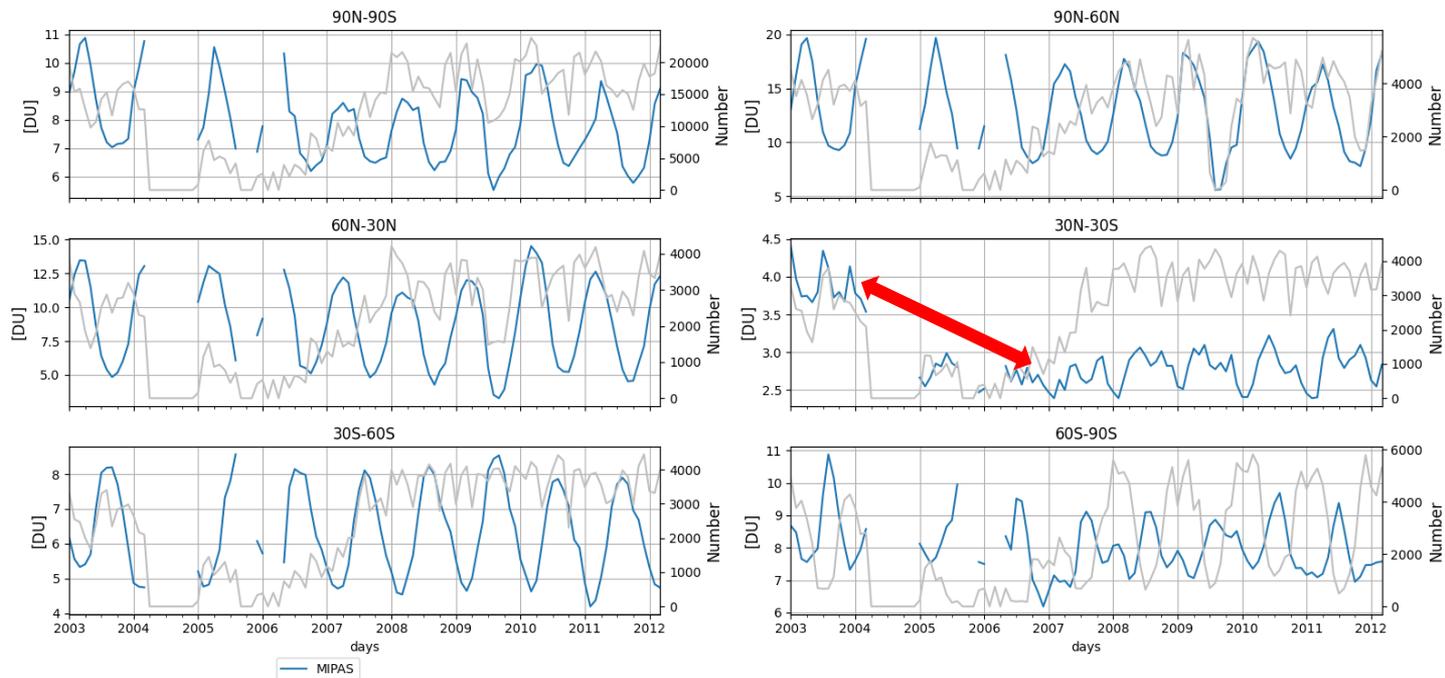




MIPAS O₃ data

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MIPAS ozone data for use in EAC5, layer=17000-20000 Pa



- MIPAS dataset not consistent in time because of change of observation mode after instrument failure in March 2024, e.g. visible in tropics.
- Later data might be better, but we need data in the pre-MLS period.
- **MIPAS ends in 201204. Use MIPAS only until MLS becomes available (-> 20040731).**
- Use as anchor for VarBC



EAC4/ EGG4

- O3 SCIAMACHY BIRA
- O3 MIPAS KIT
- O3 GOME-2 BIRA (for part of the reanalysis)
- AOD AATSR Swansea
- CO2 SCIAMACHY Bremen
- CO2 TANSO SRON
- CH4 SCIAMACHY SRON
- CH4 TANSO SRON

EAC5

- O3 SCIAMACHY BIRA
- O3 OMI BIRA
- O3 MIPAS KIT
- AOD AATSR Swansea

No GHG analysis in EAC5

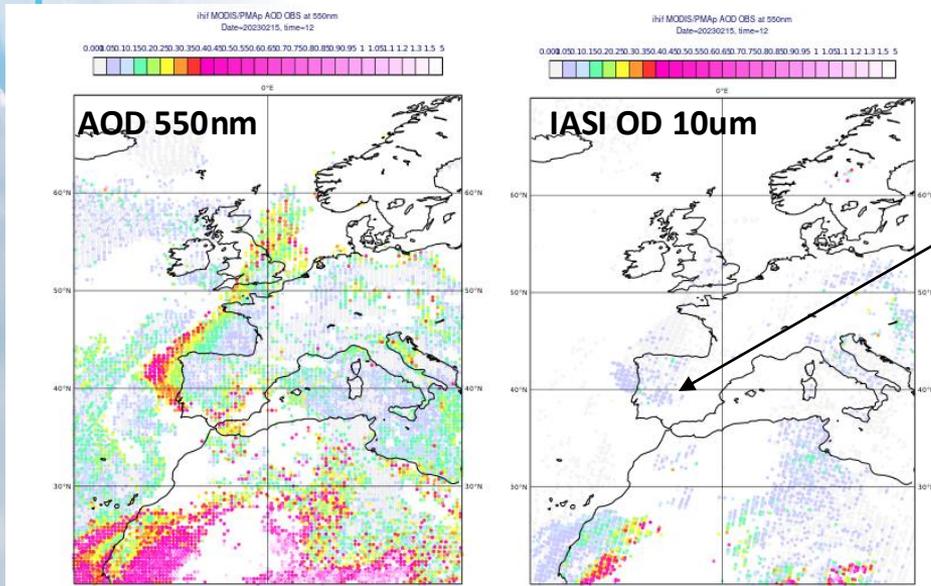




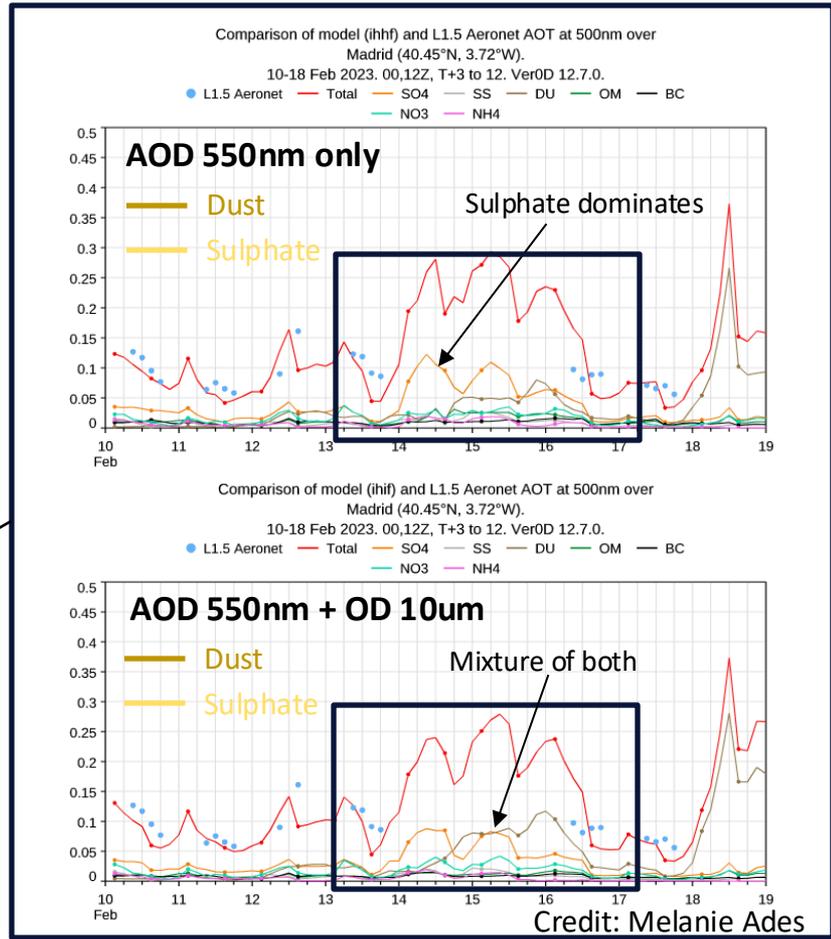
IASI ULB coarse particle CCI retrieval

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- Dust was advected from the Sahara across Europe in Feb 2023
- Distinctive dust plume across the UK on the 15th Feb 2023 captured by AOD but attributed partly to sulphate
- IASI optical depth at 10um CCI retrieval is being explored to see if it can help with the speciation of the aerosols
- Using the OD10 retrievals together with AOD brings improvement



Aerosol observations on 20230215



Credit: Melanie Ades



R e c o m m e n d a t i o n

- Consistency between datasets is important
- If there are differences between datasets there should be advice for users (e.g. why is GOME-2C NO₂ so different and what should we do about this?)
- Explain to users what the differences are between different products (e.g. CCI and AC-SAF data)
- For use in reanalysis it is important that data provision is continued with ‘frozen’ version into the future
- Continuation of offline/reprocessed data should be available no later than 1-2 months behind NRT
- It would be useful if timing of production of future CCI+++... datasets could be coordinated with plans for CAMS EAC6/ EGG6 reanalysis (will be in next phase of Copernicus funding, likely not before 2030)
 - Note that data acquisition and processing for EAC6/EGG6 will begin 2-3 years before start of production





Summary and outlook

- CAMS is testing assimilation of IASI optical depth at 10um CCI (dust) retrieval
- CAMS used some CCI data in its reanalysis of atmospheric composition (EAC4, EGG4)
- CAMS will use some CCI data in its next reanalysis (EAC5)
- Production of new CAMS reanalysis EAC5 will start in Q1-Q2/2025
 - Increased vertical and horizontal resolution
 - New model cycle, observations, emissions
 - Stratospheric chemistry
 - Data acquisition almost finalized
 - Assimilation tests have started
- Timing of future CCI reprocessing activities important. Can they fit with plans for EAC6/EGG6? No date yet for EAC6/EGG6, not likely before 2030

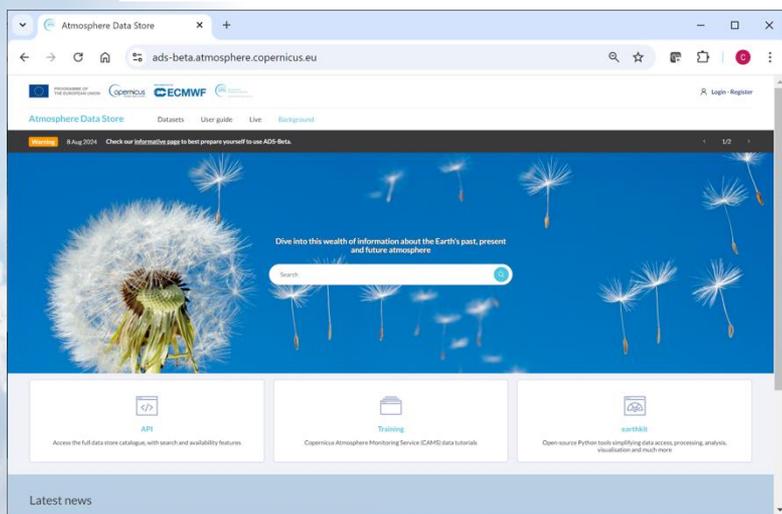




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The Atmosphere Data Store (ADS)

All CAMS data are freely available: <https://ads.atmosphere.copernicus.eu/>



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Documentation of atmospheric composition in IFS:

<https://www.ecmwf.int/en/elibrary/81374-ifs-documentation-cy48r1-part-viii-atmospheric-composition>

Validation reports from:

<https://atmosphere.copernicus.eu/quality-assurance>



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