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THE EUROPEAN UNION



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#EUSpace

Uptake of new satellite data in the CAMS system

AC-VC#22 meeting - 2 June 2026

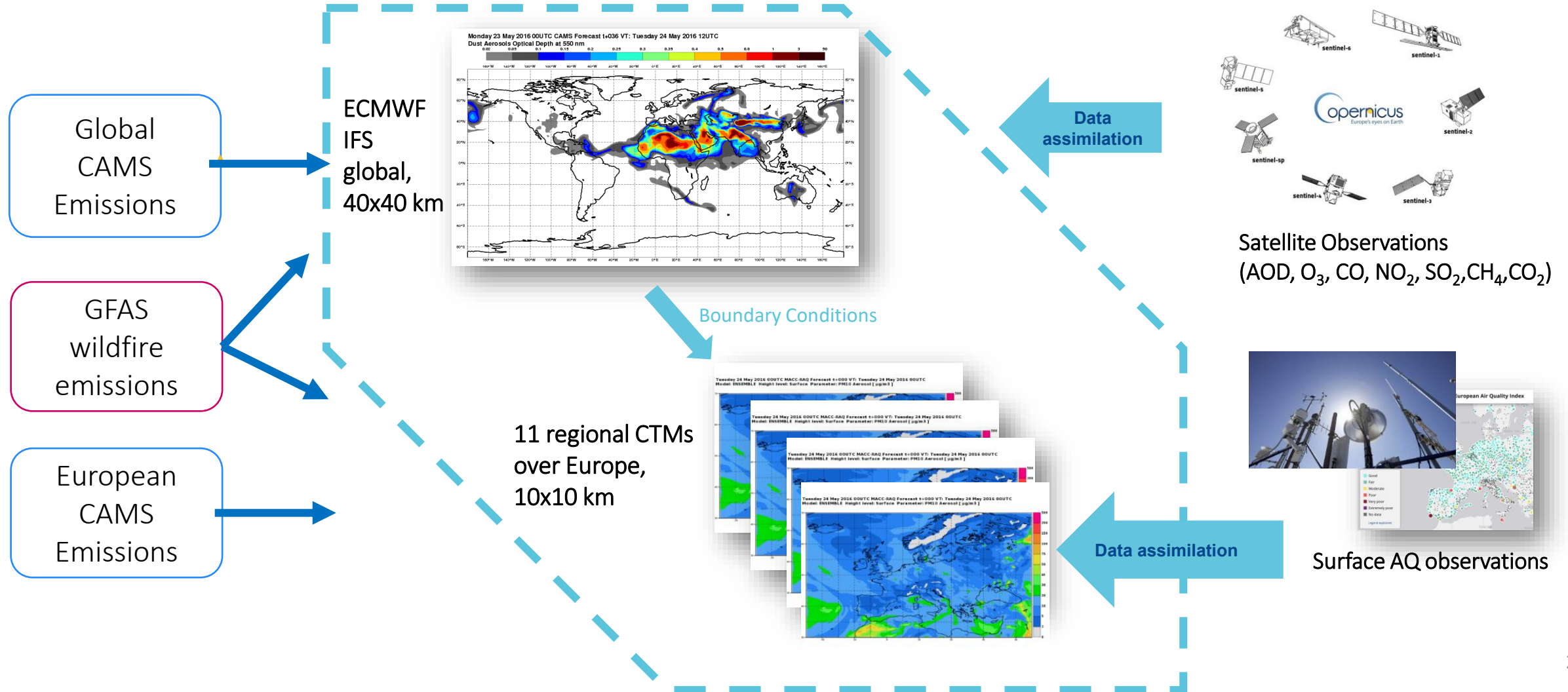
Antje Inness (ECMWF)

With thanks to Melanie Ades¹, Enza Di Tomaso¹, Michael Kahnert¹, Ernest Koffi¹, Panagiotis Kountouris¹, Bavo Langerock²

¹ECMWF

²BIRA

CAMS integrated framework



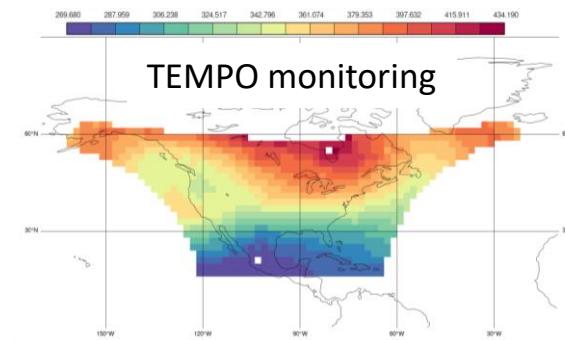
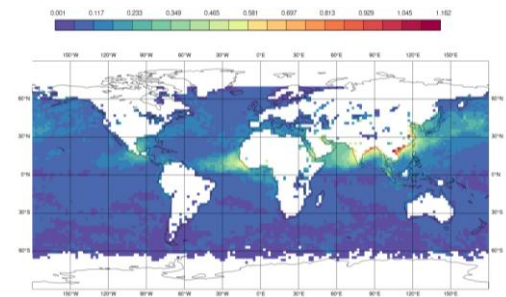
Global CAMS system upgrade to CY50R1 - 12 May 2026

• Major changes

- New anthropogenic emissions CAMS-GLOB-ANT M1 (replacing CAMS-GLOB-ANT 6.2). Activation of weekly cycle in anthropogenic emissions
- Online BVOC to replace CAMS-GLOB-BIO
- New GFAS fire emissions 1.4.2 (MODIS and VIIRS based)
- Higher ozone deposition velocity (lowering ozone concentrations near the surface)
- Several smaller changes in chemistry and aerosol modelling

• Observation changes

- Activation of NOAA-21 OMPS limb-profiler O₃
- Activation of S3 AOD over oceans
- Activation of S5p CH₄ (GHG suite)
- Monitoring of TEMPO NO₂, O₃ & HCHO
- Monitoring of GEMS HCHO



Score cards for CY50R1

Compo suite

Species	Reference	Class	Type	Region	tres	period	Bias	Error	R
CO	CNEMC	Rural & Urban	Surface	China	3-Hourly	2025	7%	4%	0.02
	GAW	Rural	Surface	Global	3-Hourly	2025	-0%	-0%	-0.05
HCHO	TROPOMI	Satellite	T. Column	E. Asia Centre	monthly	2025	13%	6%	0.00
	TROPOMI	Satellite	T. Column	Indonesia	monthly	2025	-19%	-19%	-0.01
	TROPOMI	Satellite	T. Column	S. Africa	monthly	2025	8%	3%	-0.06
NO ₂	CNEMC	Rural & Urban	Surface	China	3-Hourly	2025	-5%	-1%	0.03
	TROPOMI	Satellite	T. Column	Eastern US	monthly	2025	-2%	-5%	-0.01
	TROPOMI	Satellite	T. Column	Europe	monthly	2025	6%	4%	0.00
	TROPOMI	Satellite	T. Column	S. Africa	monthly	2025	5%	5%	-0.01
O ₃	IAGOS	In-situ	FTP	Global	daily	2025	6%	4%	0.05
	REF	limb	SPR	TTL	obs	2025	7%	-0%	0.01
	EEA Airbase	Rural	Surface	Europe	3-Hourly	2025	5%	3%	-0.00
	AirNow	Rural	Surface	N. America	3-Hourly	2025	8%	4%	-0.01
PM10	EVDC	Balloon	T. Column	Global	obs	2025	6%	2%	0.01
	SINCA	In-situ	Surface	S. America	daily	2025	12%	11%	0.03
	TWMOE	In-situ	Surface	Taiwan	daily	2025	1%	3%	0.05
PM2.5	SINCA	In-situ	Surface	S. America	daily	2025	11%	2%	0.00
SO ₂	CNEMC	Rural & Urban	Surface	China	3-Hourly	2025	58%	26%	0.03

GHG suite

Species	Reference	Class	Type	Region	tres	period	Bias	Error	R
CH ₄	NDACC	Remote	Column	Global	obs	2025	0.5%	0.2%	0.00
	TCCON	Remote	Column	Global	-	2025	0.6%	0.5%	0.03
	IAGOS	In-situ	FTP	Taipei	daily	Jan-Jul 2025	0.7%	0.5%	0.06
	IAGOS	In-situ	FTP	Global	daily	Jan-Jul 2025	0.8%	0.4%	0.02
	IAGOS	In-situ	LTP	Taipei	daily	Jan-Jul 2025	0.5%	0.4%	0.06
	IAGOS	In-situ	LTP	Global	daily	Jan-Jul 2025	0.6%	0.1%	-0.02
	ICOS	In-situ	Surface	Europe	monthly	2025	0.6%	0.0%	0.03
	TCCON	Remote	Column	Global	-	2025	0.0%	0.0%	0.01
CO ₂	IAGOS	In-situ	FTP	Taipei	daily	Jan-Jul 2025	0.0%	0.0%	-0.00
	IAGOS	In-situ	FTP	Global	daily	Jan-Jul 2025	-0.1%	0.0%	-0.00
	IAGOS	In-situ	LTP	Taipei	daily	Jan-Jul 2025	0.3%	-0.0%	0.01
	IAGOS	In-situ	LTP	Global	daily	Jan-Jul 2025	0.2%	-0.1%	-0.00
	ICOS	In-situ	Surface	Europe	monthly	2025	0.3%	0.0%	-0.01



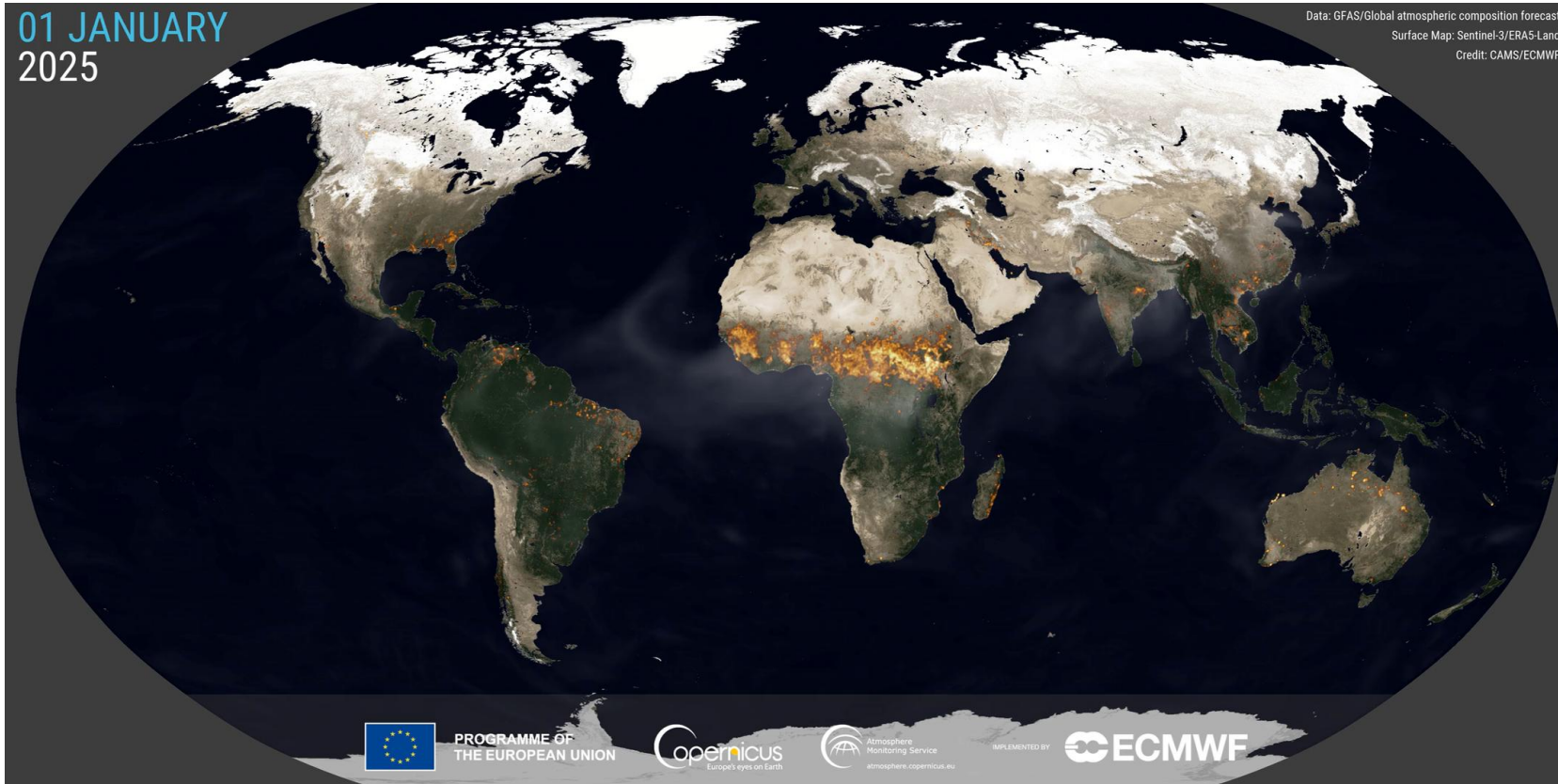
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Fire emissions monitoring in CAMS: Global Fire Assimilation System (GFAS)



Operationally assimilated in CY49R1

Terra/MODIS

Aqua/MODIS



Active in GFAS 1.4.2 (used by cy50r1) and based on CAMS2_64_bis (NILU/KCL/IPMA) dev.:

S-NPP/VIIRS

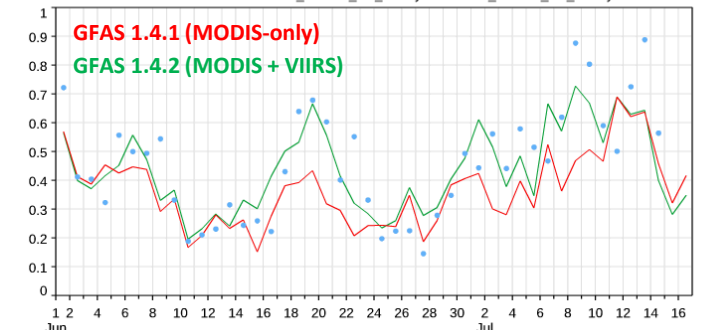
+ together with new spurious signal mask

IFS-COMPO forecast compared to AERONET retrievals

Comparison of iow1_aeronet_1.5_fc1day & iovu_aeronet_1.5_fc1day and L1.5 Aeronet AOT at 500nm over Sakeji_School (11.23°S, 24.31°E).

1 Jun - 16 Jul 2024. Daily means using 00Z, T+3 to 24. Ver0D 12.14.5.

● L1.5 Aeronet — iow1_aeronet_1.5_fc1day — iovu_aeronet_1.5_fc1day

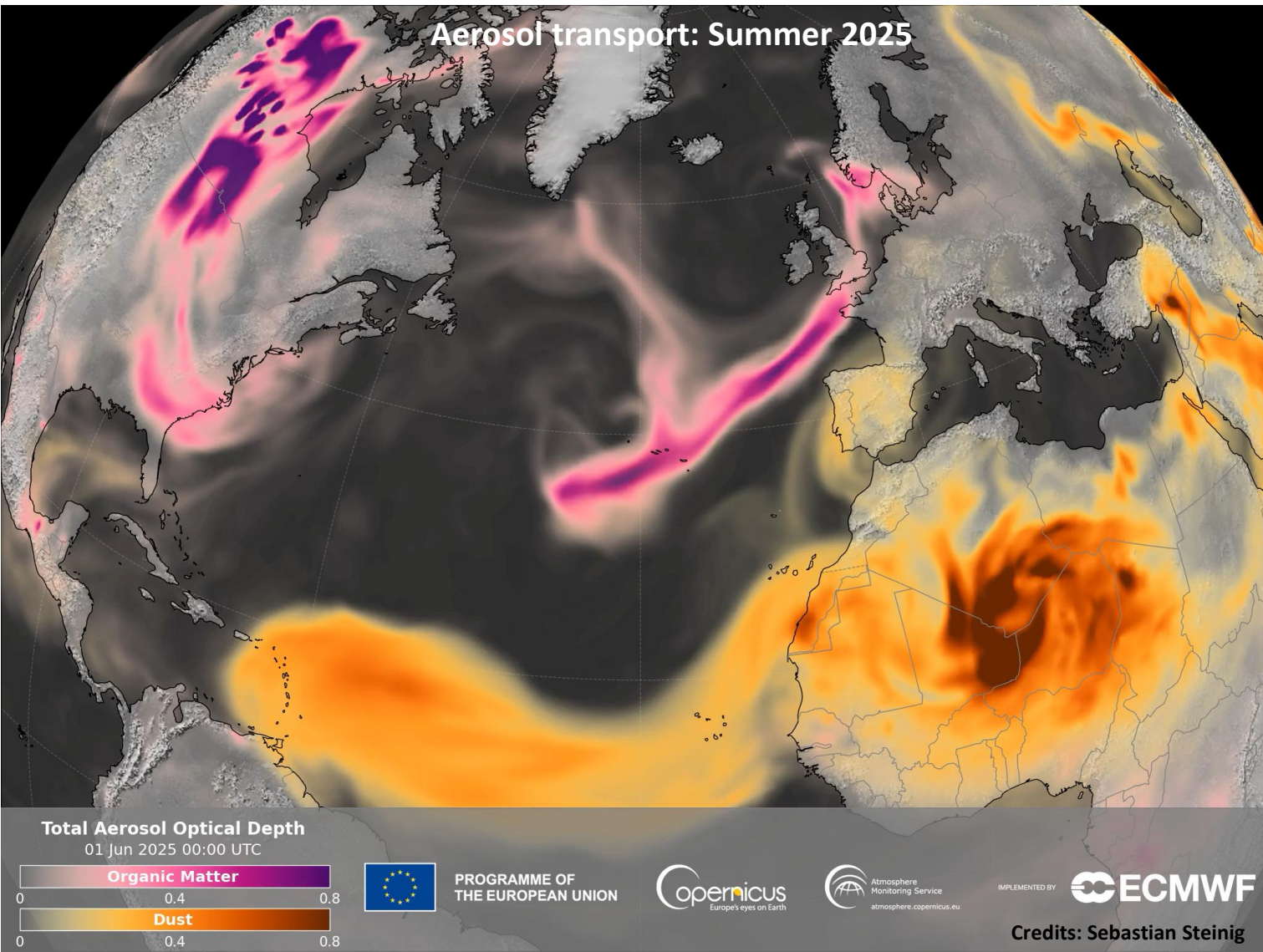


<https://atmosphere.copernicus.eu/2025-sees-intense-wildfire-year-northern-hemisphere>

Credit: Enza Di Tomaso



Current AOD satellite usage in IFS-COMPO



Land & Ocean

EOS-Terra/MODIS

EOS-Aqua/MODIS

S-NPP/VIIRS

NOAA-20/VIIRS

Ocean only

Metop-C/PMAp

Metop-B/PMAp

Sentinel-3A/SLSTR

Sentinel-3B/SLSTR

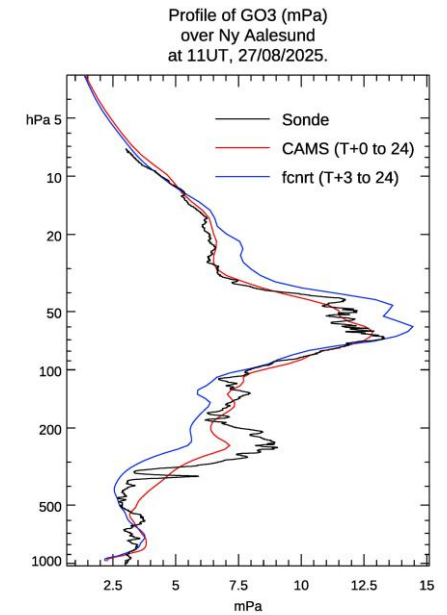


S3 AOD retrievals are assimilated (over ocean) in IFS-COMPO since CY50R1

- retrievals filtered for best quality (QI 2,3);
- product spatially aggregated to better match retrievals (9.5 km) & model (~40 km) resolution;
- assimilated obs bias corrected within a variational assimilation procedure (NOAA-20 VIIRS anchor).

NOAA-21 OMPS limb-profiler O3 data

- MLS O3 is important for the profile shapes of the CAMS O3 analysis, but is nearing the end of its life
- NOAA-21 v2.6 OMPSLP O3 are now assimilated to cushion the future loss of MLS
- OMPSLP is UV/VIS instrument (no night-time data)

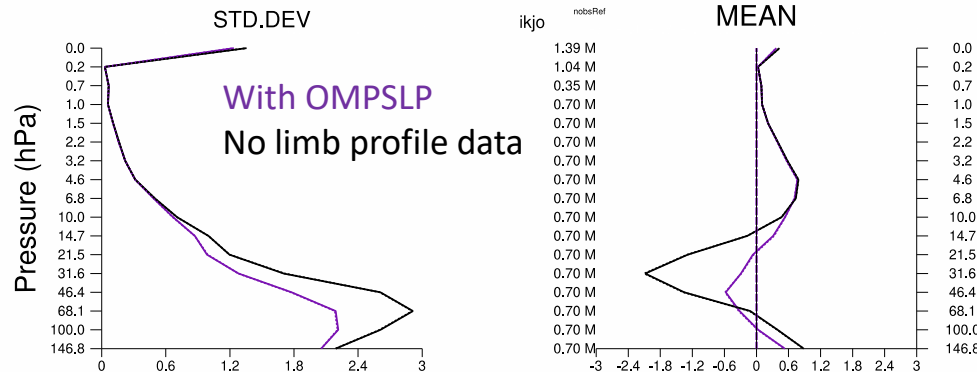


Fit to MLS data

2023060112-2024033112(12)
MLS GO3 N.Hemis
all GO3 AURA MLS

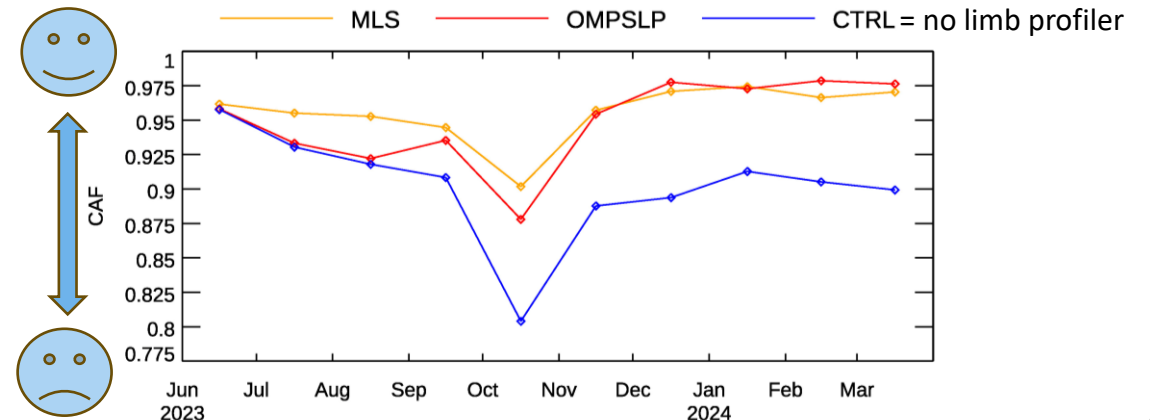
NH

Background departure (o-b) (ikjo) Background departure (o-b) (ikp)
Analysis departure (o-a) (ikjo) Analysis departure (o-a) (ikpv)
Bias correction of obs (ikjo) Bias correction of obs (ikpv)



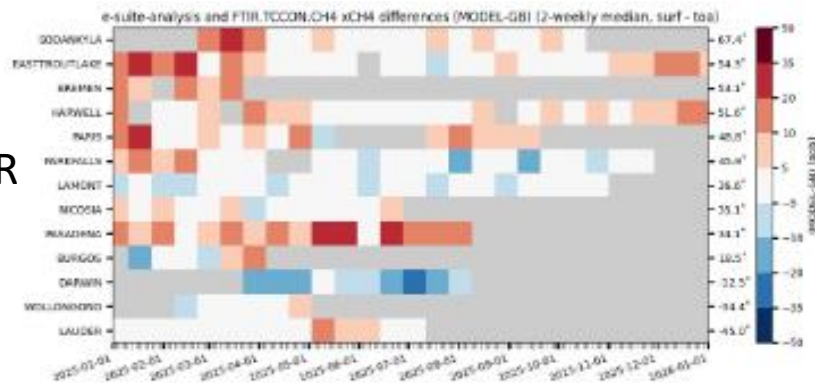
Fit to stratospheric O3 sondes

Common Area Fraction for monthly-mean profiles of
O3 (mPa) over 6 sites in Antarctica
using analyses from Jun 2023 to Mar 2024,
integrated from 100 to 3hPa

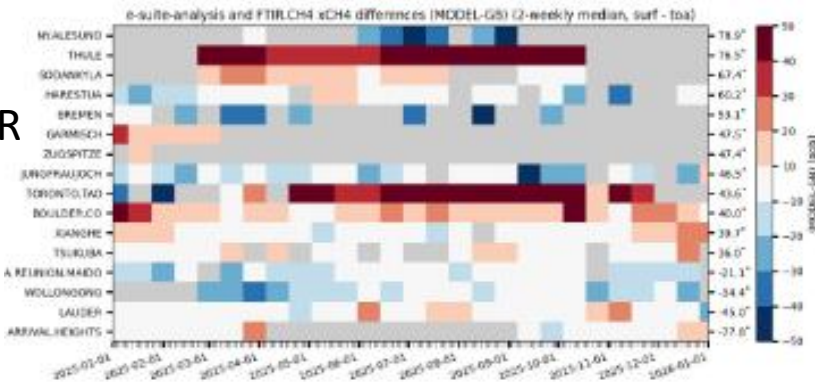


Activation of S5p CH₄ in CY50R1

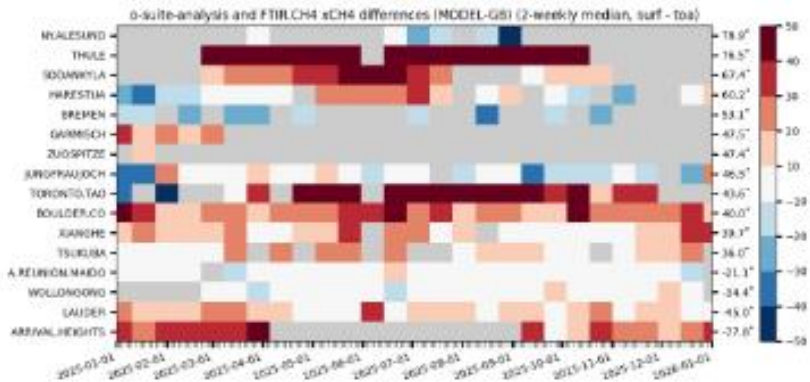
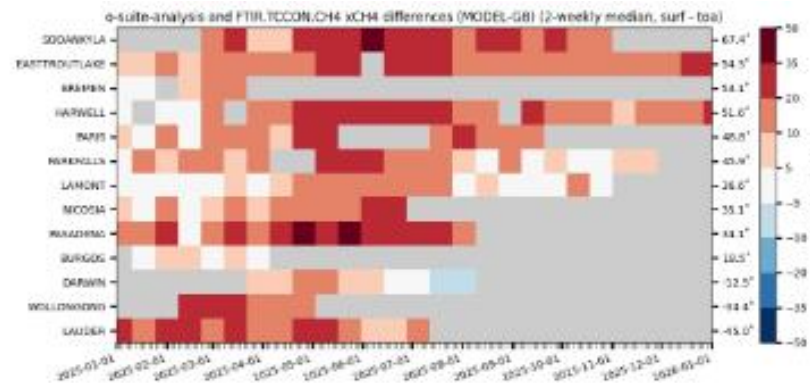
New CY50R1: with S5p CH₄



NDACC FTIR
TCCH₄



Old CY49R1: no S5p CH₄



Improved fit to
TCCON and NDACC
CH₄ data if S5p CH₄
is assimilated



AC observations used in global NRT CAMS system



Species	Instruments
CAMS NRT	
O ₃	S5P, GOME-2, OMI, OMPS-NP, MLS, OMPS-LP, GEMS, TEMPO
CO	S5P, IASI, MOPITT
NO ₂	S5P, GOME-2, GEMS, TEMPO
Aerosol	MODIS, VIIRS, PMAp, S3
CO ₂	GOSAT, IASI, OCO-2
CH ₄	GOSAT, IASI, S5P
SO ₂ (volcanic)	S5P, GOME-2, IASI
SO ₂ (anthropogenic)	S5P
HCHO	S5P, GEMS, TEMPO
GFAS fire emissions	MODIS, VIIRS, GOES, S3

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

---- Used

---- Undergoing testing

---- Retired since Feb 2025

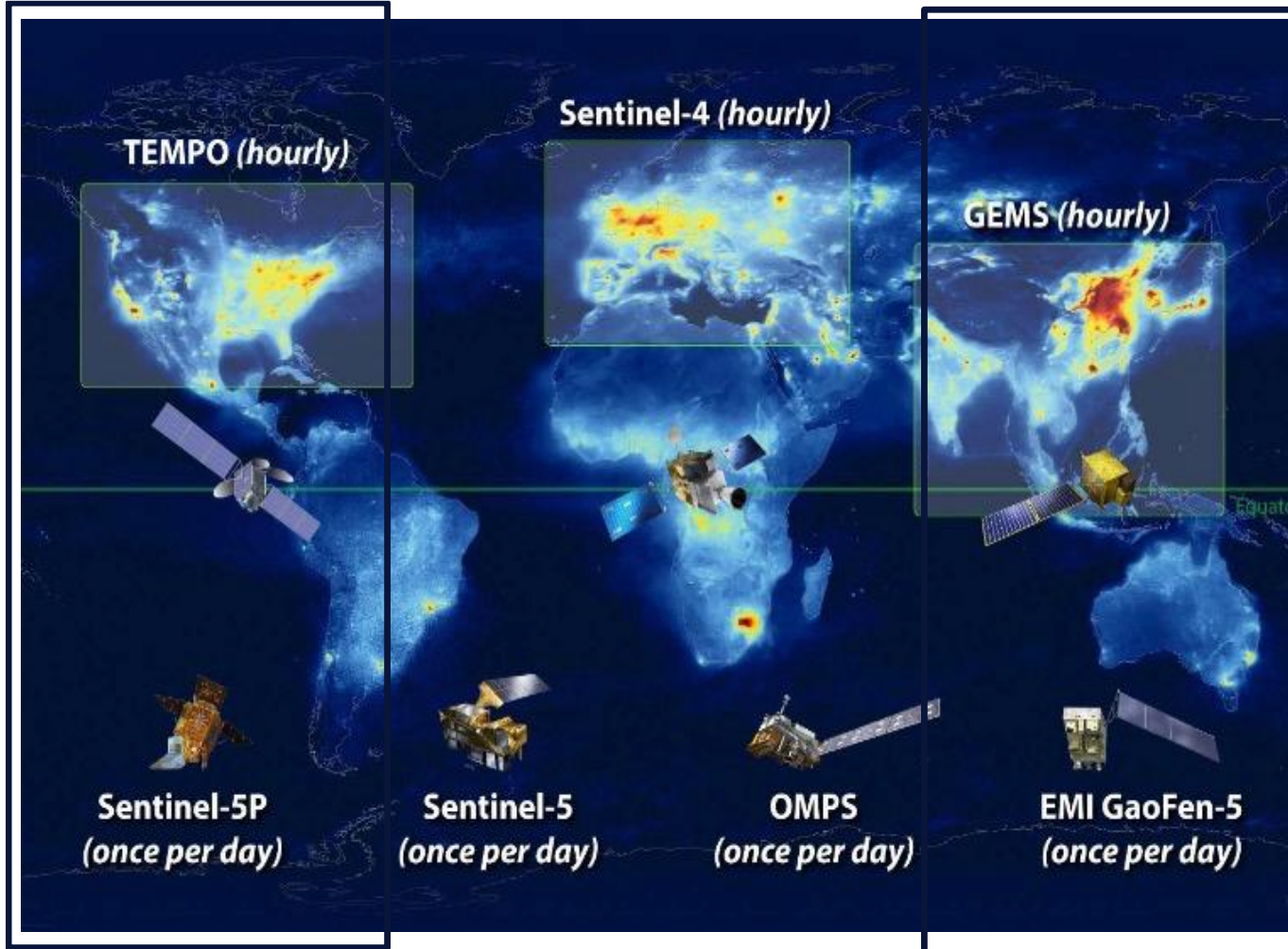
---- New in CY50R1, 12 May 2026



Examples of CAMS ‘work in progress’

- Geostationary air quality data
- Improving the aerosol analysis:
 - Assimilation of IASI coarse dust
 - Assimilation of ceilometer ground stations from E-profile network
- Assimilation of GHG data:
 - Assimilation of OCO2 CO2
- New CAMS reanalysis EAC5

Geostationary AC data



- Using TEMPO and GEMS data to prepare for Sentinel-4
- Some of this work was carried out as part of the HE CAMEO project



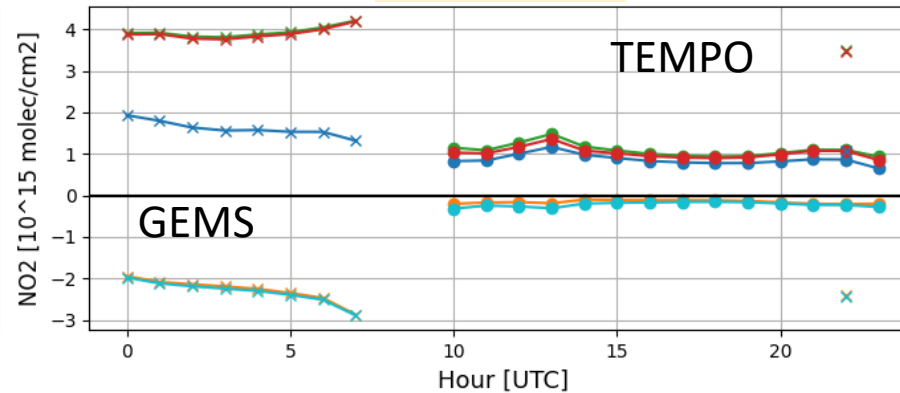
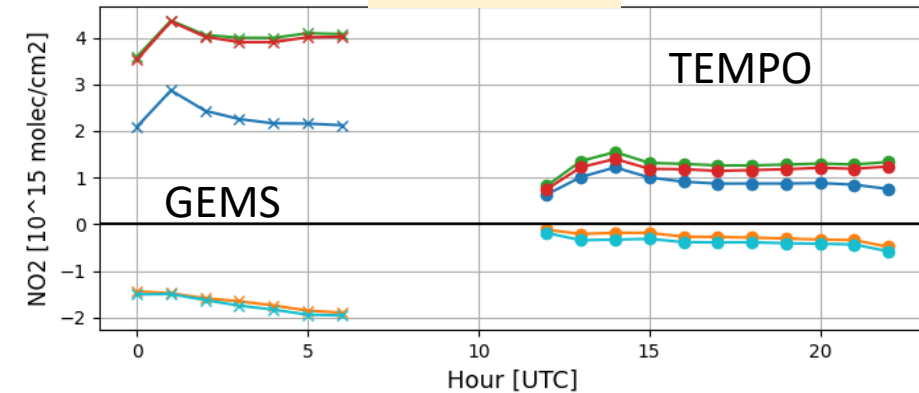
Averaged hourly TEMPO & GEMS NO₂ fields and departures

Averaged hourly NO₂ data, exp=is6s
Period=20250101-20251231

Data actively used

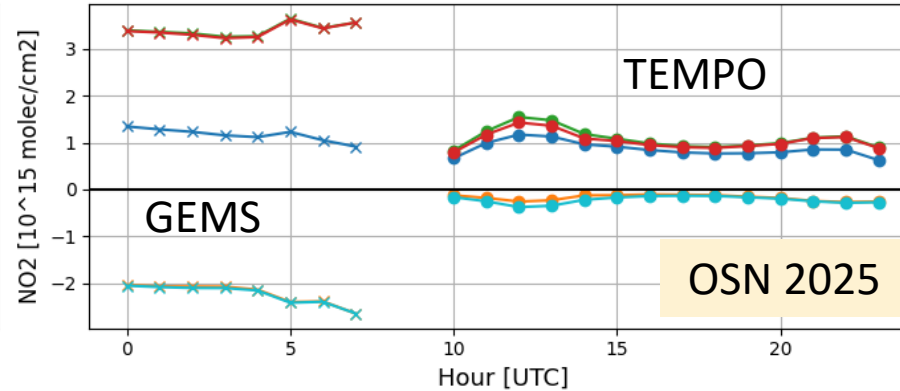
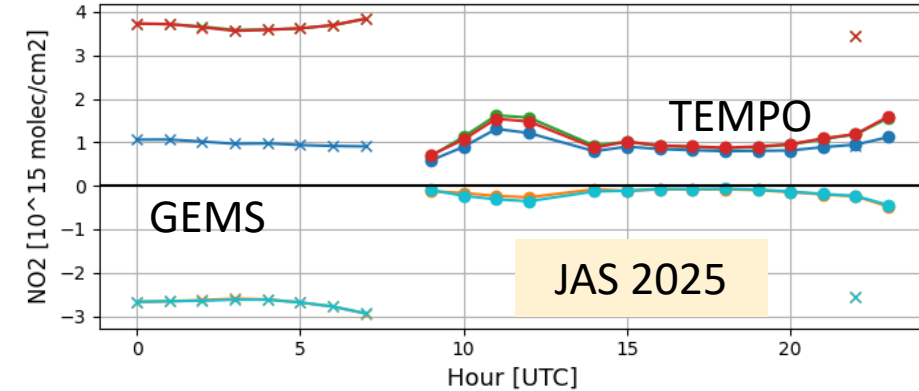
JFM 2025

AMJ 2025



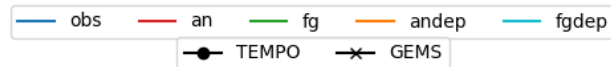
July-September 2025

October-December 2025



JAS 2025

OSN 2025



- Large negative bias for GEMS
- Small bias for TEMPO
- GEMS bias increases during the day
- Only very small impact of NO₂ assimilation

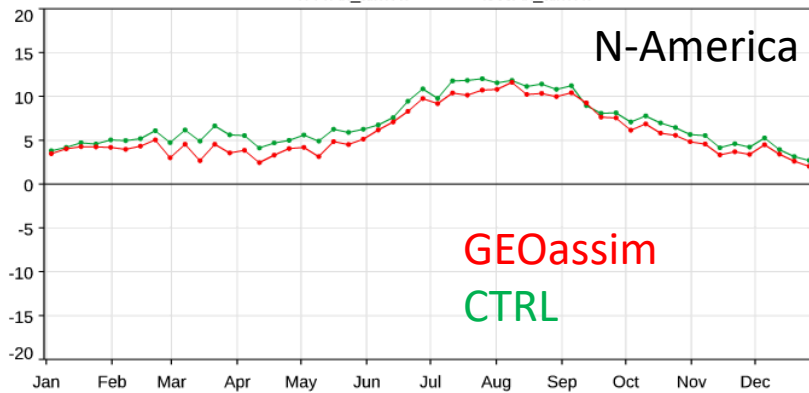
Impact of NO₂ assimilation on surface O₃

Timeseries of surface O₃ bias

O₃ (ppb) FC-OBS bias. Model versus AirNow.

1207 sites in N-America. 31 Dec 2024 - 29 Dec 2025. 00,06,12,18Z, T+0 to 0. Ver0D 12.17.5.

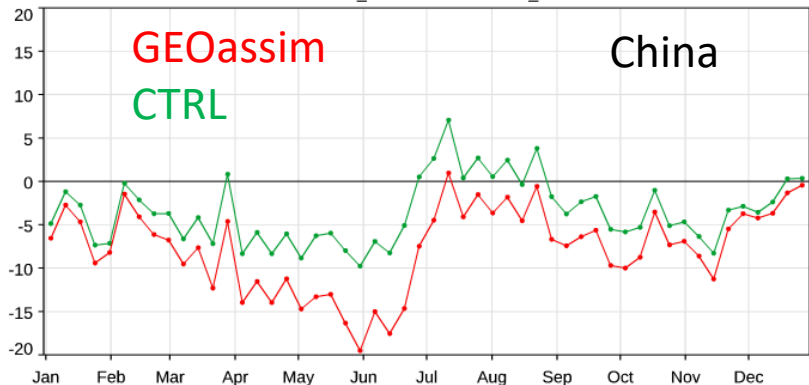
— io0An_ainow — is6sAn_ainow



O₃ (ug/m3) FC-OBS bias. Model versus China AQ.

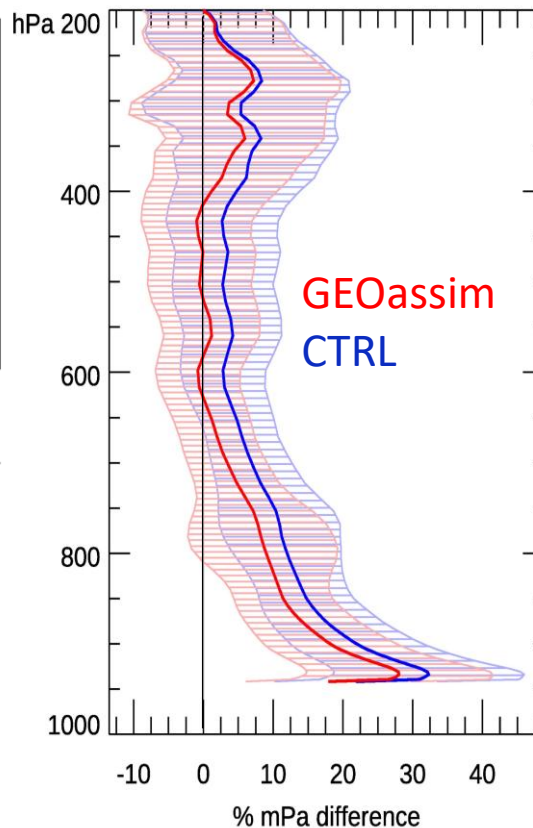
1686 sites in China_whole. 31 Dec 2024 - 29 Dec 2025. 00,06,12,18Z, T+0 to 0. Ver0D 12.17.5.

— io0An_china — is6sAn_china

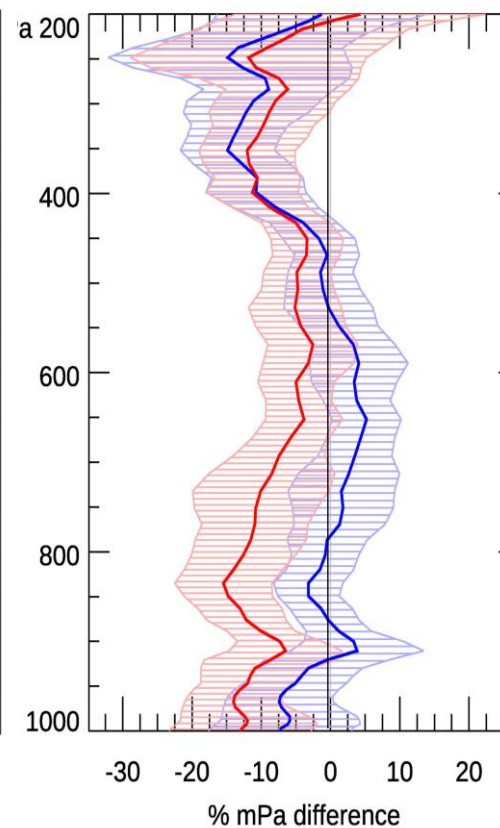


Average relative bias 2025 against ozone sondes

North America



South East Asia

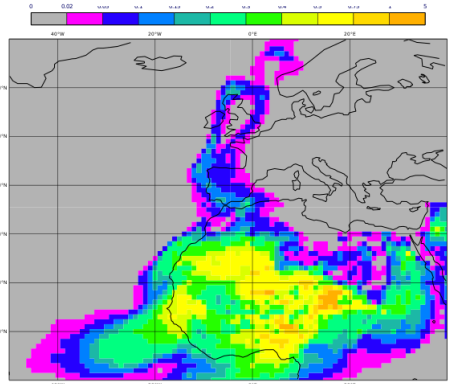


- Reduced positive O₃ bias over N-America
- Increased negative O₃ bias over China
- TEMPO NO₂ data will potentially be activated in next model cycle CY51R1

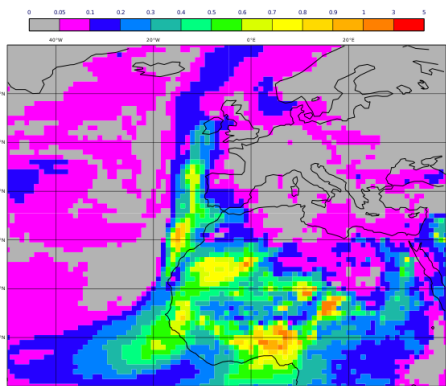
IASI 10um AOD obs (ULB retrieval)

A test case in February 2023 - a plume of desert dust from the Sahara is advected over Europe and then Scandinavia but is not solely represented as dust

Dust AOD 550nm
15th Feb

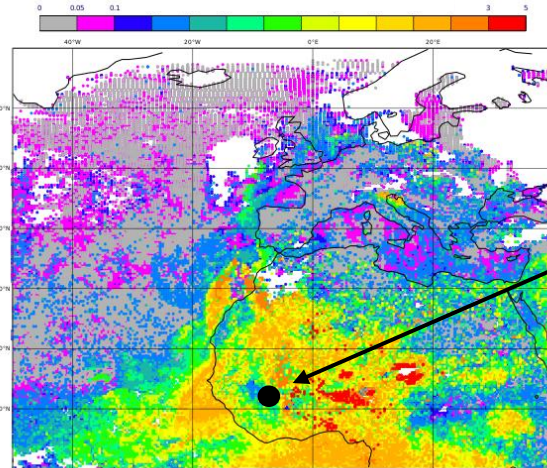


Sulphate AOD 550nm
15th Feb

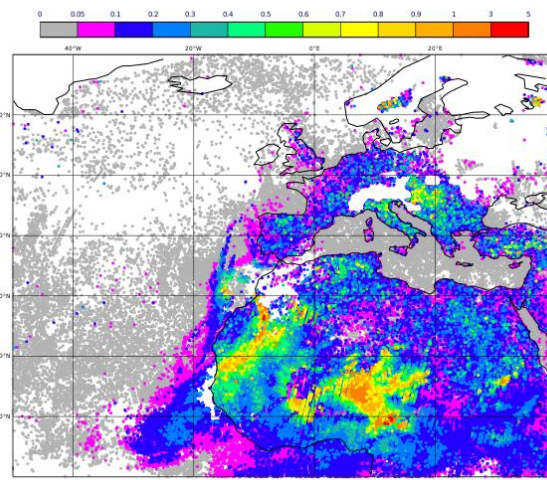


Credit: Melanie Ades

VIIRS – all obs
14-17th Feb



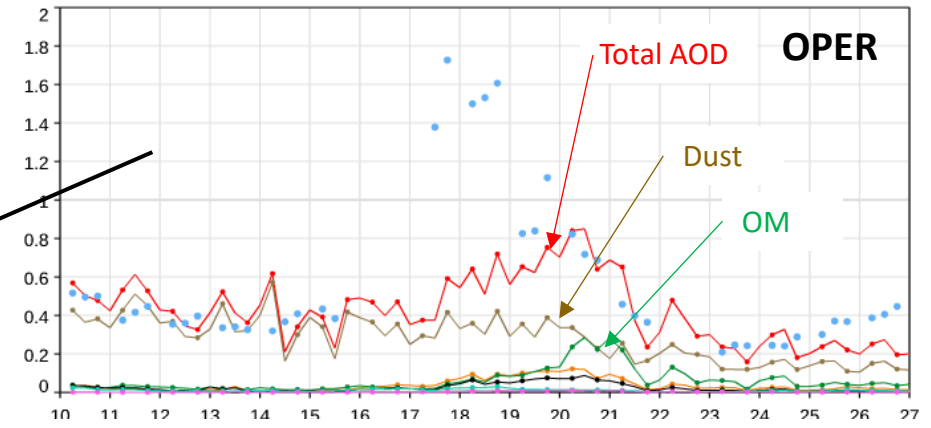
IASI 10um – all obs, 14-17th Feb



Comparison of model (ihhf) and L1.5 Aeronet AOT at 500nm over
IER_Cinzana (13.28°N, 5.93°W).

10-26 Feb 2023. 00,12Z, T+6 to 12. Ver0D 12.17.5.

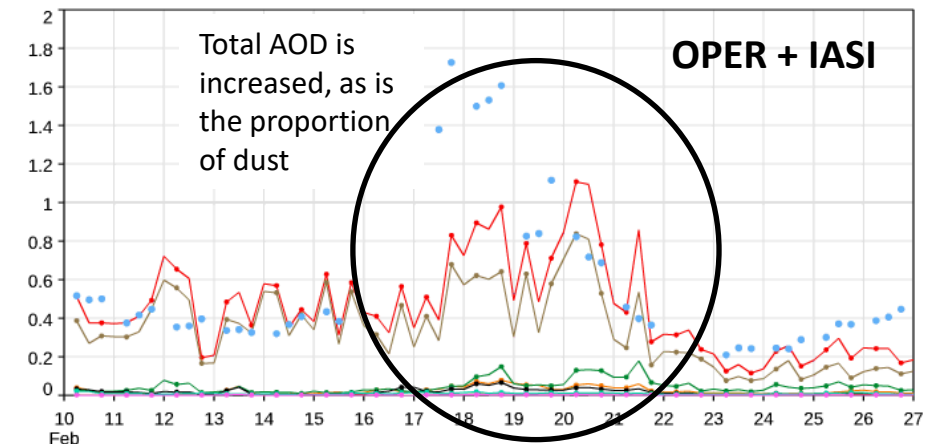
● L1.5 Aeronet — Total — SO4 — SS — DU — OM — BC
— NO3 — NH4



Comparison of model (ihhf) and L1.5 Aeronet AOT at 500nm over
IER_Cinzana (13.28°N, 5.93°W).

10-26 Feb 2023. 00,12Z, T+6 to 12. Ver0D 12.17.5.

● L1.5 Aeronet — Total — SO4 — SS — DU — OM — BC
— NO3 — NH4





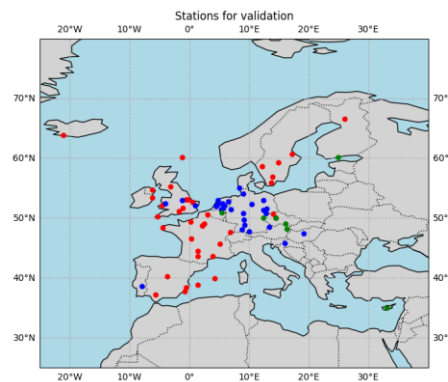
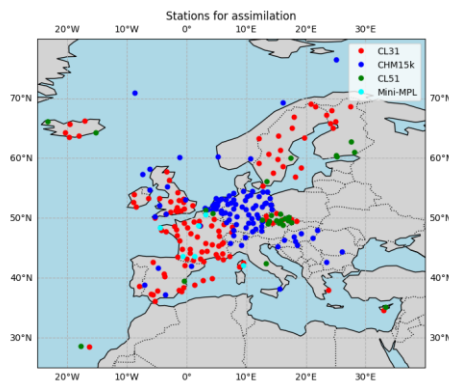
Assimilation of ceilometer ground stations from E-profile network



Canadian wildfire episode Aug 2024

assimilated

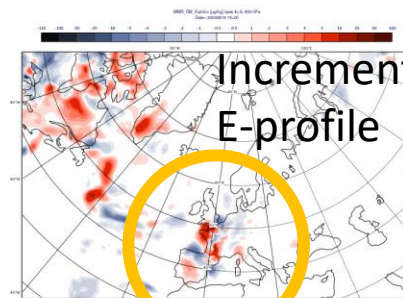
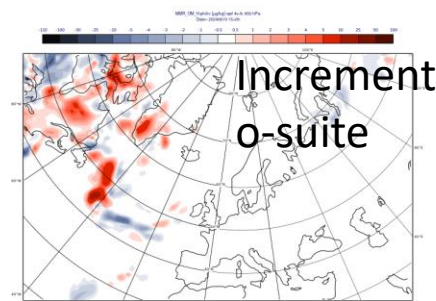
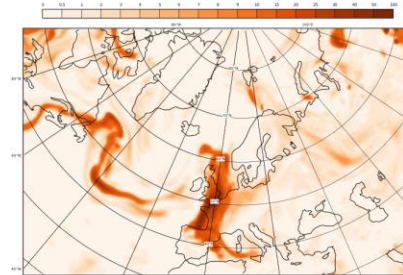
withheld



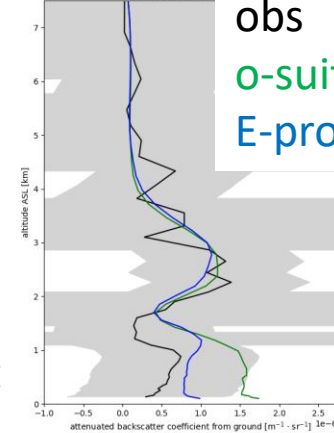
- Assimilation of ceilometer data leads to improved fit to vertical profile at four non-assimilated stations that lie in the path of the smoke plume
- Shown is the attenuated backscatter coefficient

Credit: Michael Kahnert

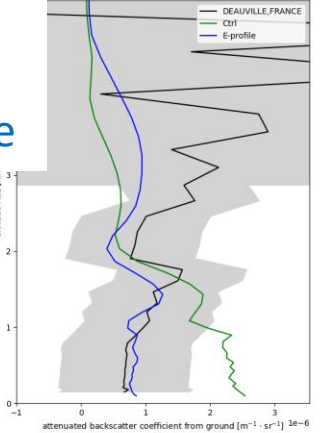
AOD forecast



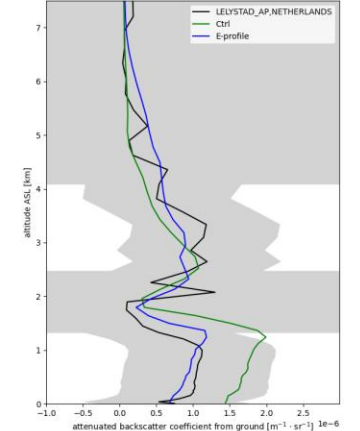
StationID: 0-20000-0-03354 Instrument: CL31 $\lambda = 910.0$ nm
date: 20240819



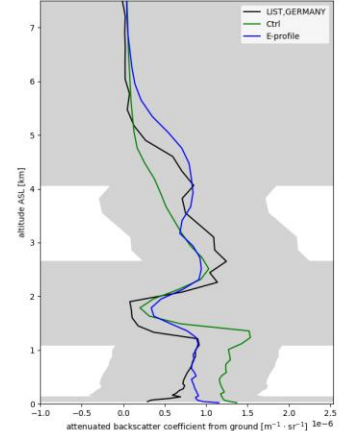
StationID: 0-20000-0-07031 Instrument: CL31 $\lambda = 910.0$ nm
date: 20240819 time: 12



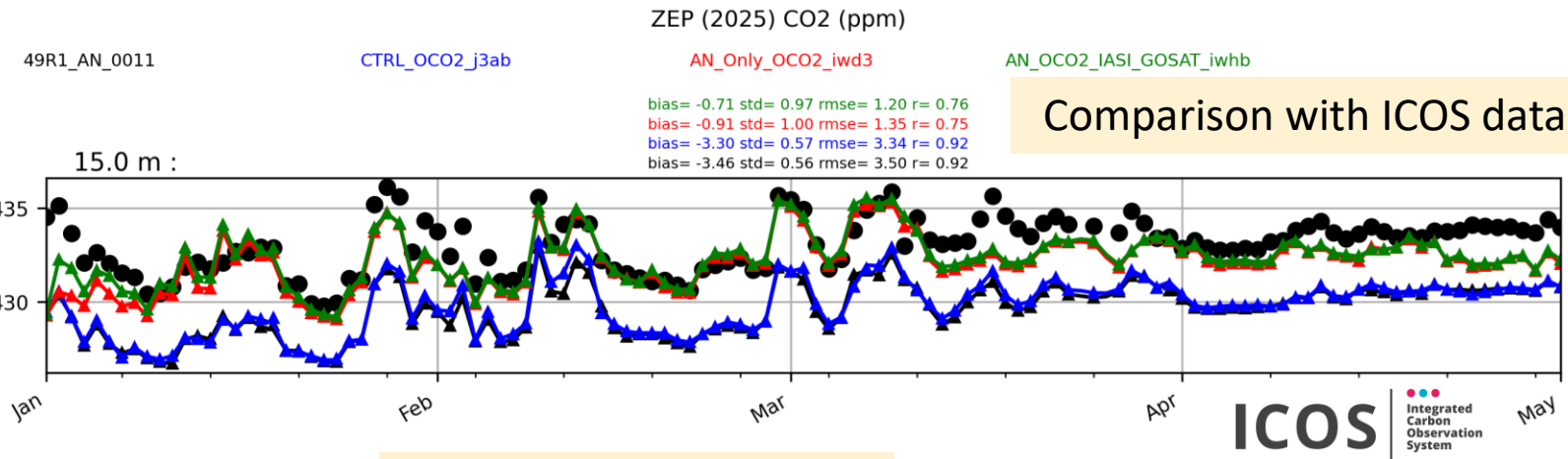
StationID: 0-20000-0-06269 Instrument: CHM15k $\lambda = 1064.0$ nm
date: 20240819 time: 150000



StationID: 0-20000-0-10020 Instrument: CHM15k $\lambda = 1064.0$ nm
date: 20240819 time: 210000



Exploring the use of OCO2 CO2 retrievals



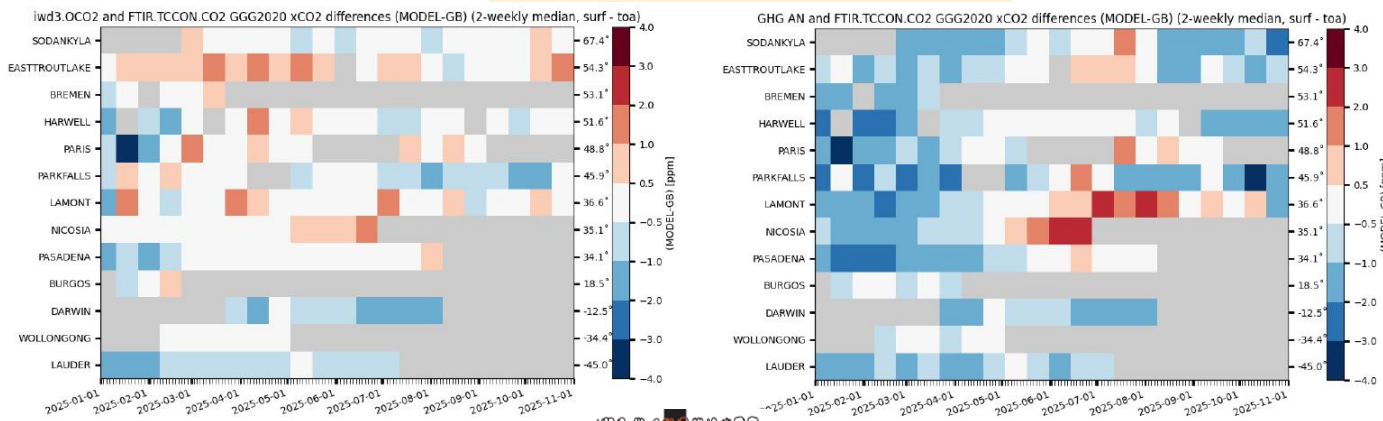
j3ab: CTRL for OCO-2 analysis

iwd3: OCO-2 retrievals only

iwhb: OCO-2/IASI/GOSAT

- Improvement for several stations in terms of bias and RMSE
- OCO-2 retrievals dominate
- Mean bias reduced by about 35% when comparing with current configuration

Bias against TCCON data



OCO-2 retrievals only



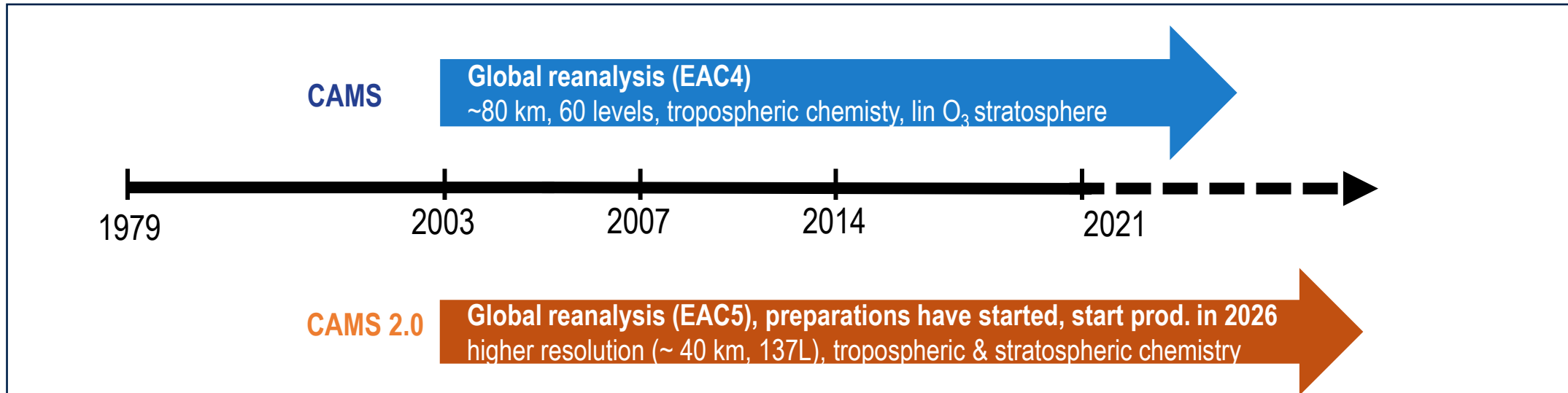
Without OCO-2 retrievals

- Clear improvement for all the stations
- the negative biases are significantly reduced for several stations

Credit: Ernest Koffi (ECMWF), Bavo Langerock (BIRA)



A new CAMS reanalysis (EAC5)



Final preparations for EAC5 ongoing

- 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

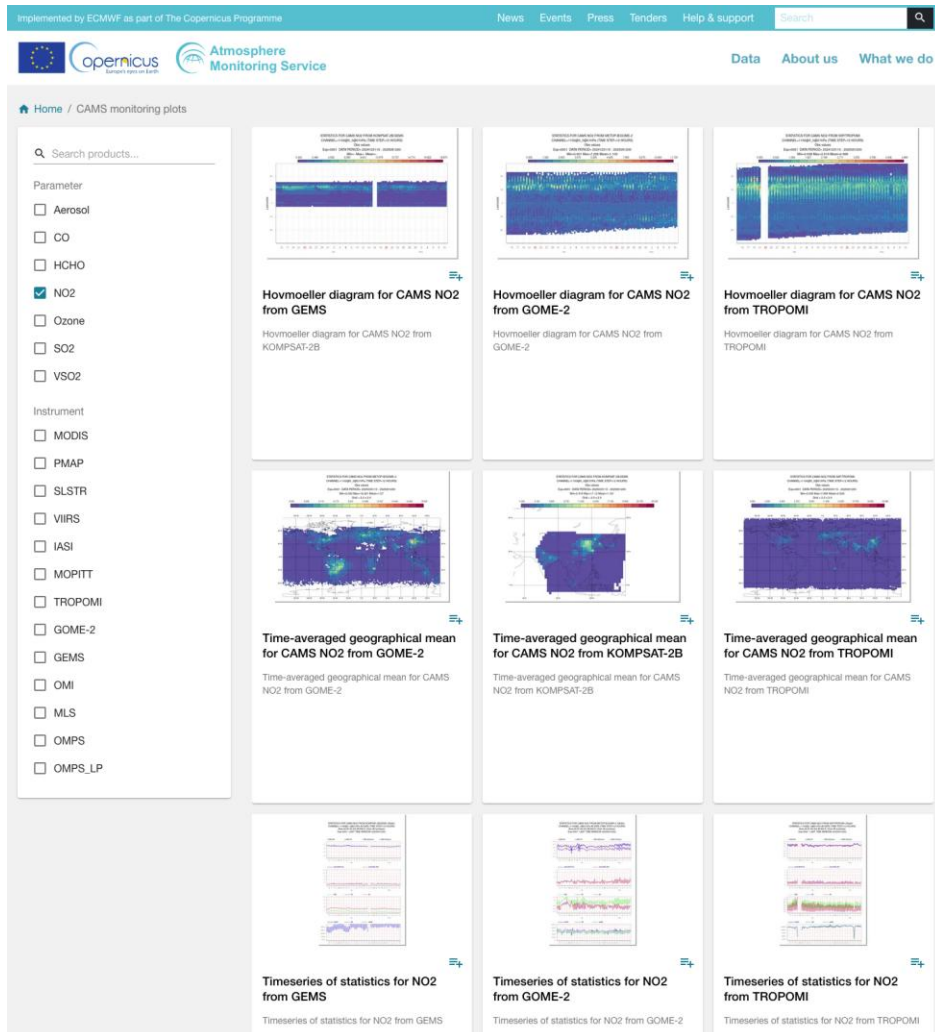
Status

- Acquisition and processing of observations finished
- Testing of model and DA configuration and archiving setup in final stages
- Improved QC for assimilated data before starting production
- No emission inversion yet in EAC5

Production to
start in
2026



CAMS satellite monitoring page



Monitoring plots

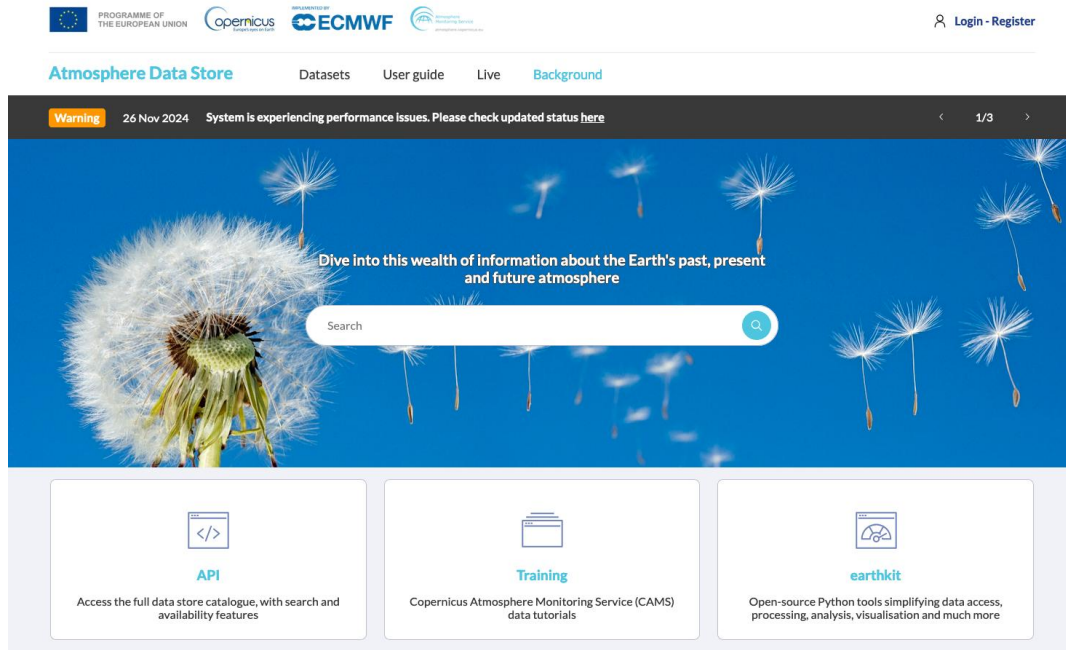
- Are routinely displayed on the CAMS website
- give CAMS and the data producers timely information about any changes in the data

https://atmosphere.copernicus.eu/charts/packages/cams_monitoring/



The Atmosphere Data Store (ADS)

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



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Copernicus ECMWF



www.copernicus.eu
atmosphere.copernicus.eu



@copernicusecmwf.bsky.social

Documentation of atmospheric composition in IFS:

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

Validation reports and validation servers:

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



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