



Atmosphere Monitoring

# Use of TROPOMI data in the near-real-time global CAMS assimilation system

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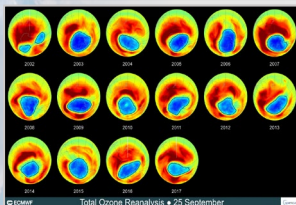
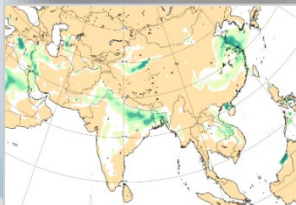
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# Copernicus Atmosphere Monitoring Service



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

This is done by assimilating **satellite retrievals of atmospheric composition** into ECMWF's IFS (in addition to meteorological observations) - **Including TROPOMI data**

<https://atmosphere.copernicus.eu>



# Use of TROPOMI data by CAMS

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Species	Status
<b>TCO3</b>	Active since <b>4 Dec 2018</b>
<b>TCSO2 (volcanic)</b>	Active since <b>5 Oct 2020</b>
<b>TCSO2 (PBL)</b>	Used for tests. Waiting for COBRA algorithm implementation before further tests
<b>TCCO</b>	Passive since 26 November 2018. Biases prevented NRT assimilation. Tests after PDGS upgrade in June 2021 look promising. To be activated in CY48R1 (implementation planned for <b>Q1/2023</b> )
<b>Trop column NO2</b>	Passive since 11 July 2018. Biases in early data versions prevented NRT assimilation. Active since <b>12 Oct 2021</b> .
<b>TCHCHO</b>	Passive 17 December 2018. No immediate assimilation plans, but will be revisited in framework of CAMS inversion prototype (and HE CAMEO project – if funded)
<b>CH4 (offline)</b>	Monitored in CAMS GHG analysis. Used for emission inversion. Assimilation tests due to begin.



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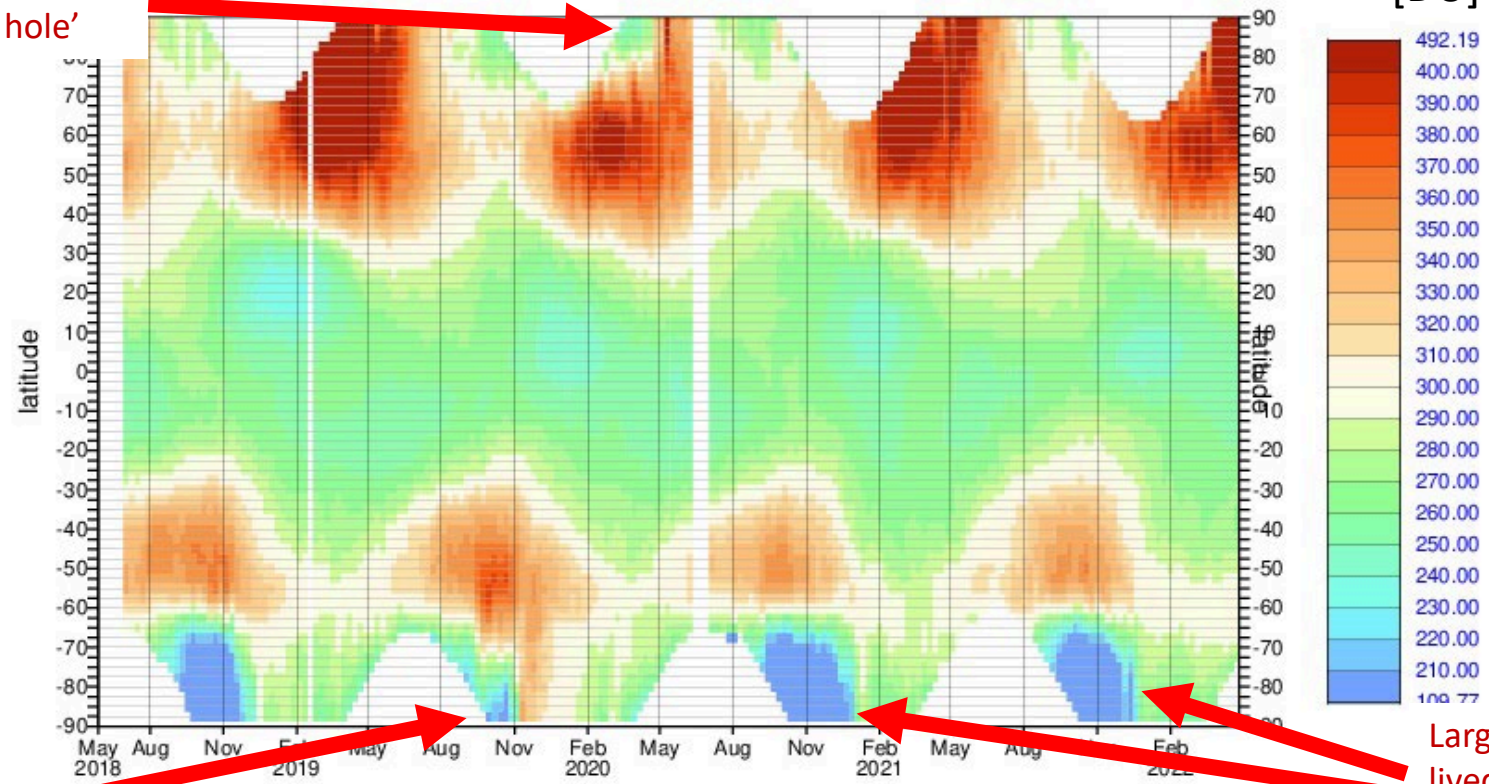
# TROPOMI total column ozone

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Active since 4 Dec 2018

Weekly means: 20180528 - 20220428

2020 Arctic  
'O3 hole'



Small and short-lived 2019 O3 hole

Large and long-lived 2020 & 2021 O3 hole





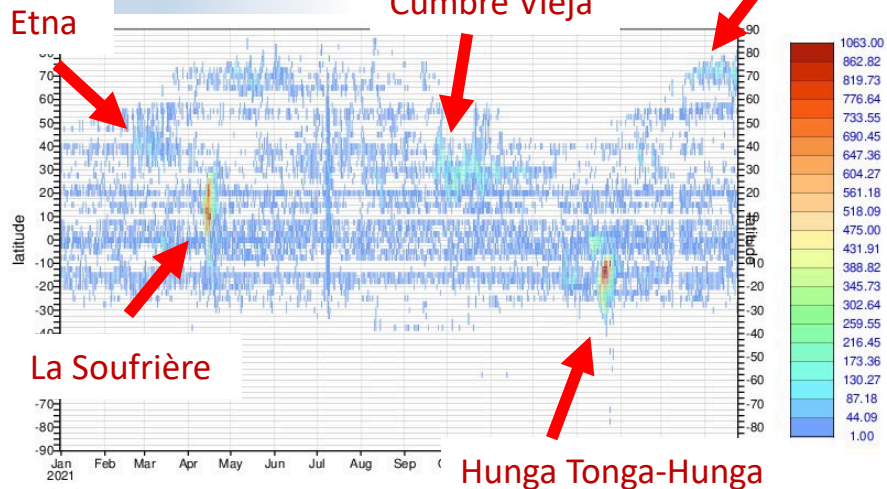
# TROPOMI volcanic SO2

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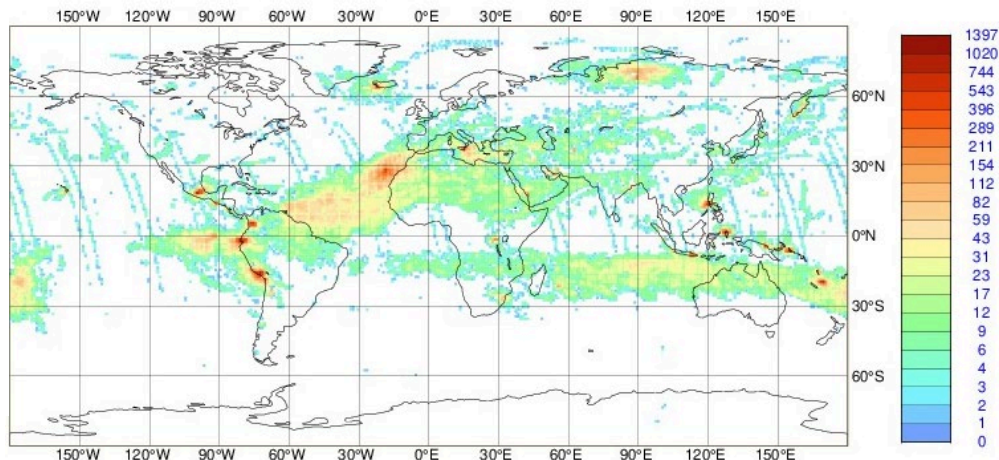
## Zonal mean timeseries

Smelting Siberia

Active since 5 Oct 2020



## Averaged number of obs



Shown are the number of volcanic TROPOMI SO2 observations for the period:  
20210101 - 20220424



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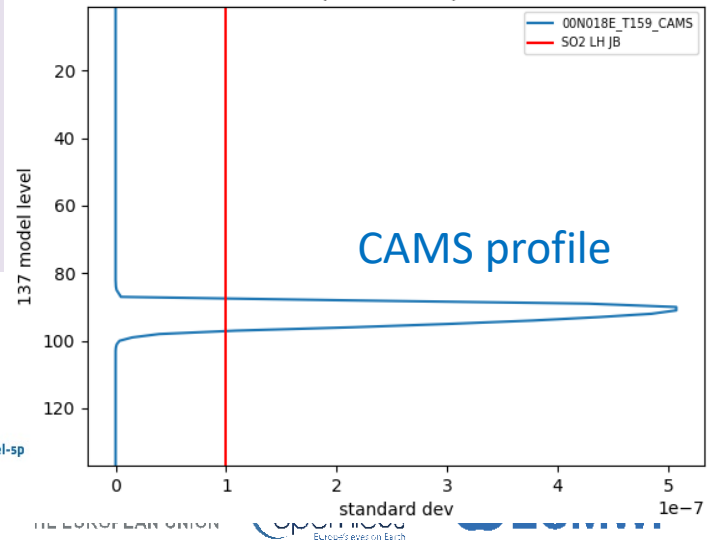
- CAMS assimilates **GOME-2BC** and **TROPOMI** TCSO<sub>2</sub> retrievals making use of the volcanic flags provided by data providers (AC-SAF, ESA; algorithm from DLR)

- We need to make assumptions about the plume height if this is not known in NRT
- Default: SO<sub>2</sub> is placed in troposphere at model level 98 (~ 550 hPa, 5 km) by using a prescribed bg-error stdv profile
- This can be modified if injection height is known
- Currently: Globally constant injection height
- 'Baseline configuration: BLexp'

- DLR have developed algorithm to provide information about the plume height in NRT from TROPOMI (Hedelt et al., 2019, doi.org/10.5194/amt-12-5503-2019)
- SO<sub>2</sub> LH project - one of ESA's S5P Innovation projects
- Data useful for SO<sub>2</sub> > 20 DU
- CAMS is testing the use of these data: 'LHexp'



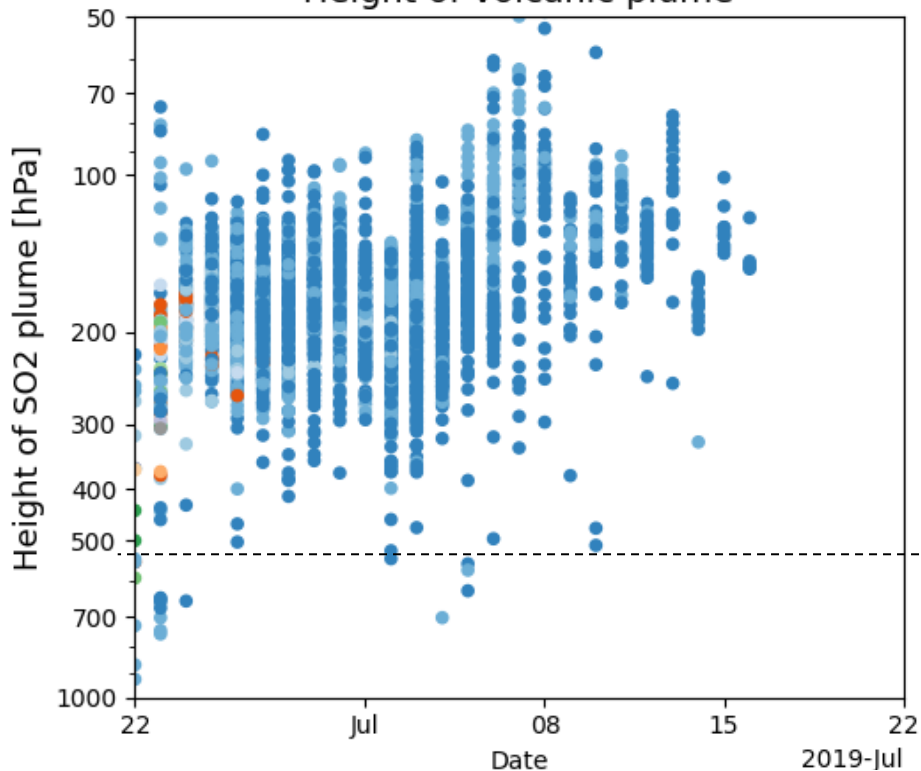
## SO<sub>2</sub> background error standard deviation



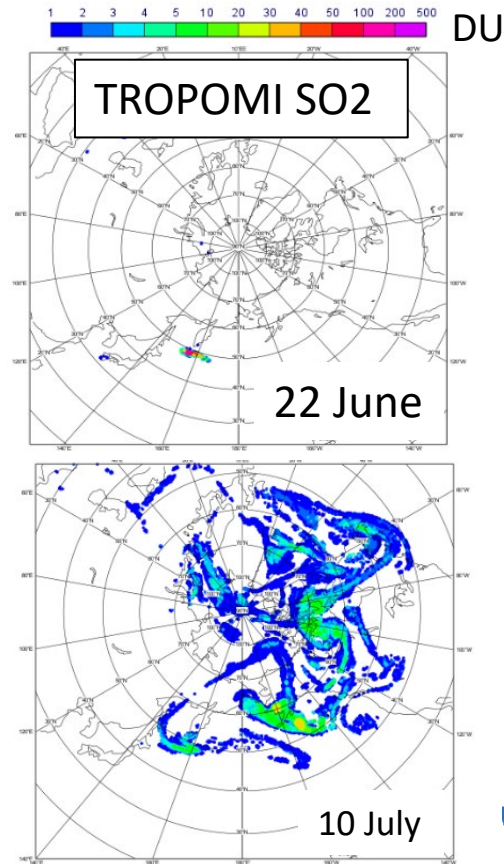
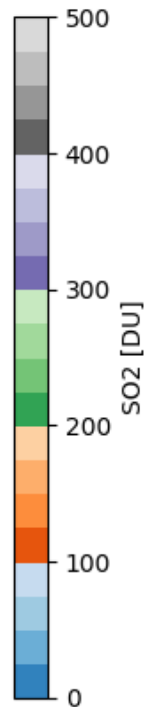


# Raikoe eruption 22 June - 21 July 2019

### Height of volcanic plume



Default of placing the SO2 signal around 550 hPa is clearly wrong in this case



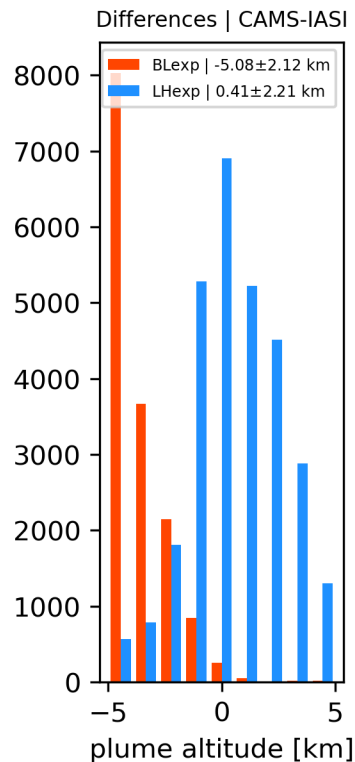
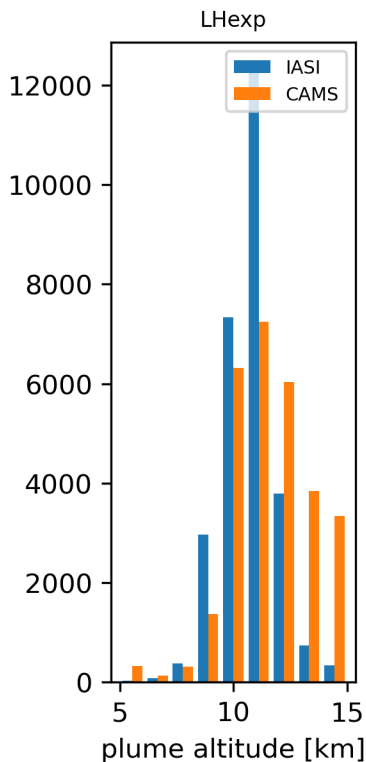
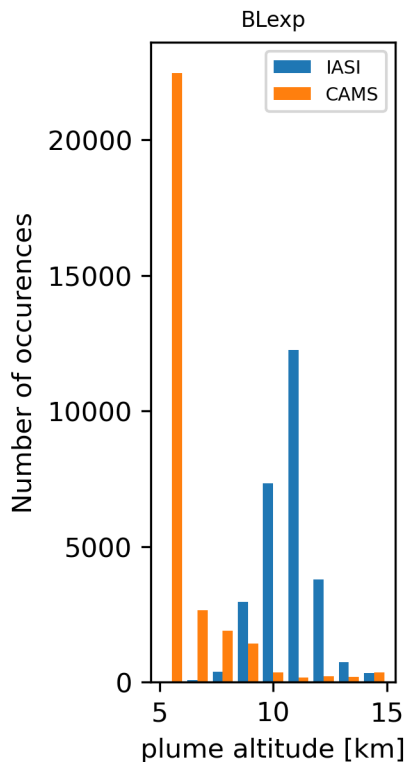
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# Comparison of CAMS plume height with IASI

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Period:  
22 -29 June 2019

CAMS SO2 analysis shows improved agreement with IASI LATMOS/ULB SO2 altitude data if TROPOMI SO2 LH data are used

**Biases against IASI:**  
BL exp:  $-5.1 \pm 2.1$  km  
LH exp:  $0.4 \pm 2.2$  km

Using the LH data leads to improved SO2 analyses

Plot provided by MariLiza Koukoulis

IASI SO2 altitude retrieval from LATMOS/ULB



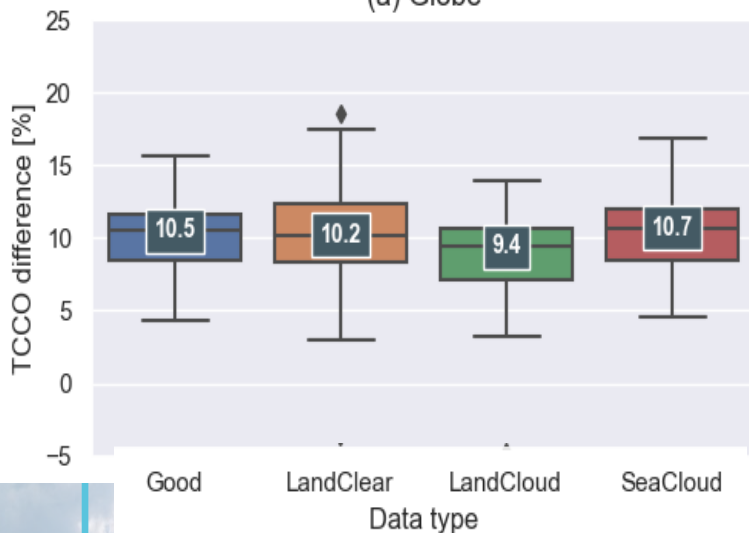


# Differences TROPOMI – CAMS TCCO

Atmosphere Monitoring S5P CO has been monitored since Nov 2018

Relative difference TROPOMI – CAMS CO  
20181119-20211231

(a) Globe



- TROPOMI TCCO is about 10% higher than CAMS in global mean
- CAMS CO also has a negative bias wrt other data

- Positive S5P bias for all data types (or **negative CAMS bias**)
- Differences between clear and cloudy data over land
- Impact of boreal and austral fires
- Impact of CAMS model upgrades and TROPOMI algo updates



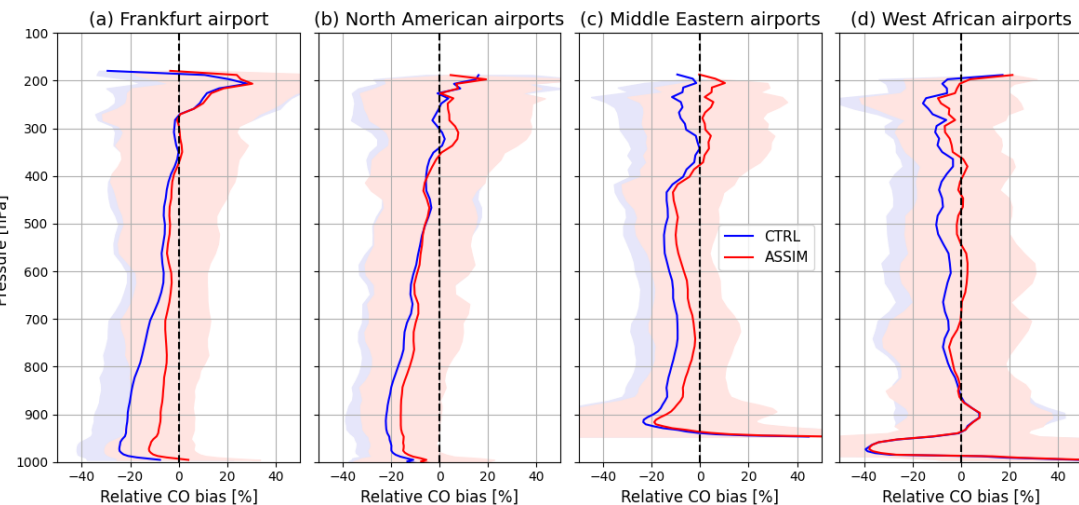
# Results from S5P CO assimilation tests

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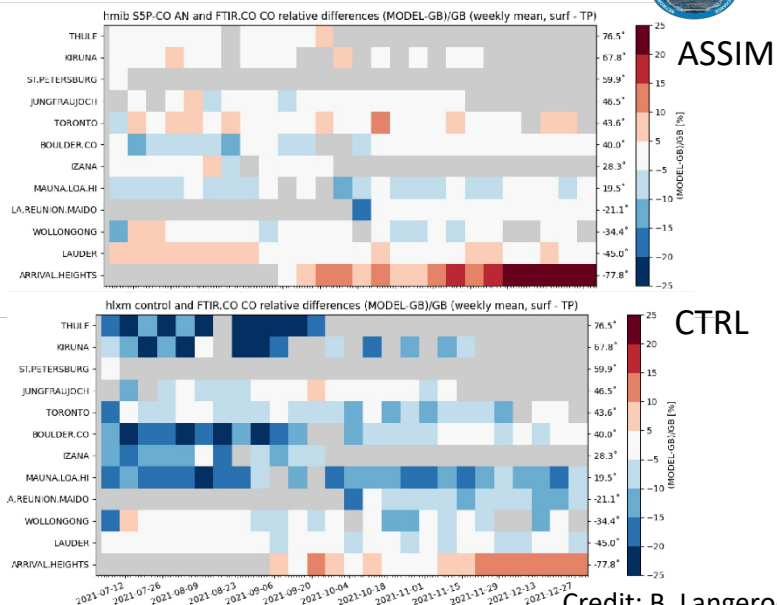
## Comparison with IAGOS aircraft data



Period: July - December 2021



## Comparison with NDACC FTIR data



Credit: B. Langerock

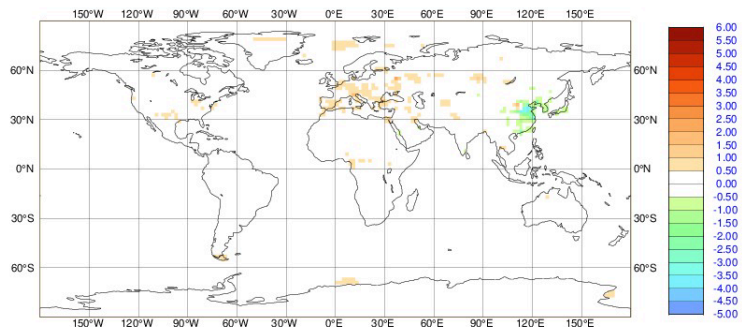
- Assimilation of TROPOMI CO leads to improved fit to independent data, especially in the lower troposphere.
- To be activated in next CAMS model upgrade (CY48R1, Q1/2023)
- **Assimilation of TROPOMI CO** can give additional information in lower troposphere in DA system that already assimilates MOPITT TIR and IASI CO retrievals



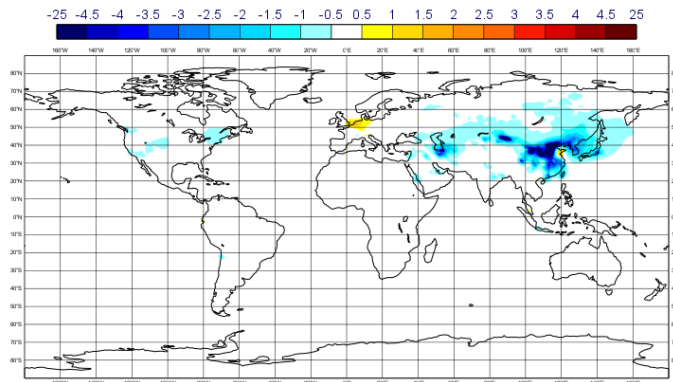
Period: 20211101-20220430

Active since 12 Oct 2021

## S5P NO<sub>2</sub> first-guess departures

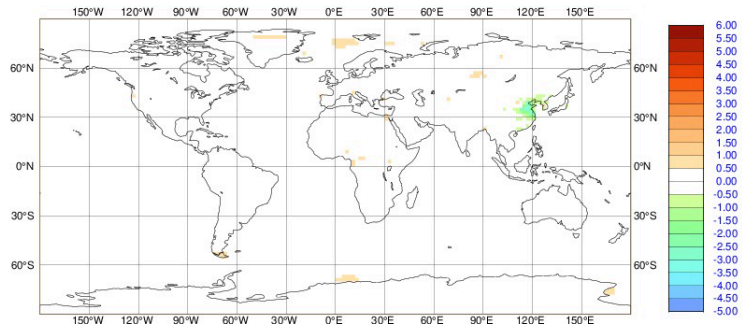


## ASSIM minus CONTROL



ASSIM also assimilates GOME-2BC NO<sub>2</sub>

## S5P NO<sub>2</sub> analysis departures



Assimilation of TROPOMI NO<sub>2</sub> (and GOME-2BC) data reduces the CAMS NO<sub>2</sub> analysis over Asia where it is known to have a positive bias



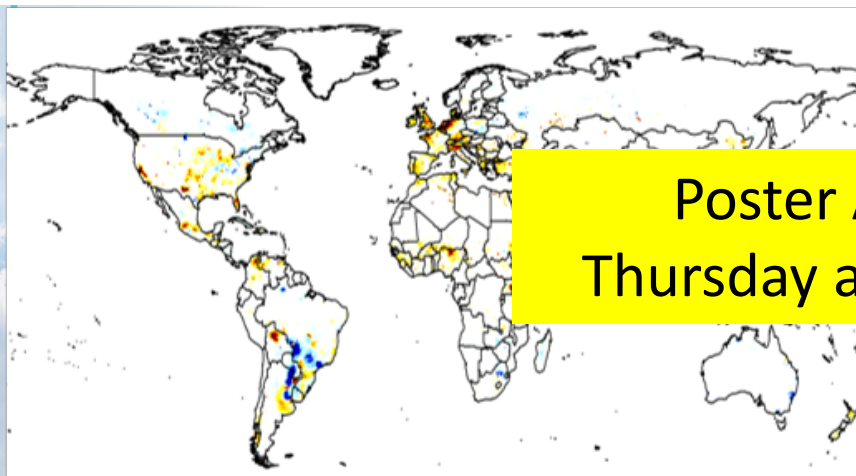


# TROPOMI CH<sub>4</sub> in IFS emission inversions

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Credit: Joe McNorton

TROPOMI, alongside GOSAT and IASI, has been used to perform short-window (24 hour) 80 km global inversions using an extension of the current 4D-Var system.

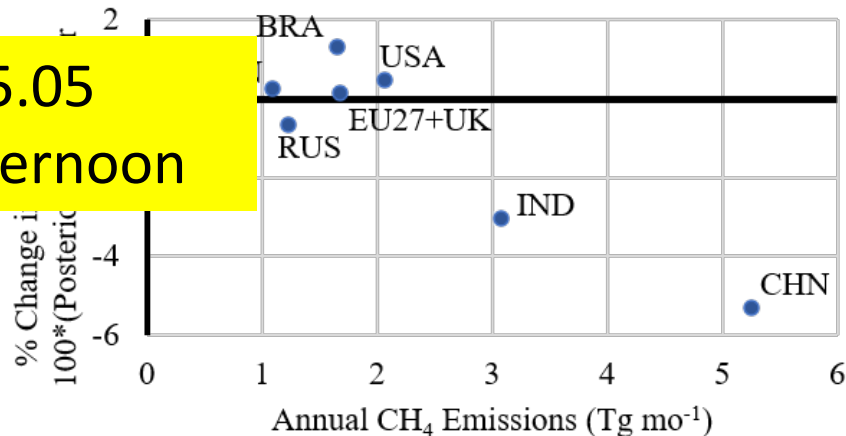


$\Delta$  CH<sub>4</sub> Flux (kg m<sup>-2</sup> s<sup>-1</sup>)

-1x10<sup>-11</sup>   -5x10<sup>-12</sup>   0   5x10<sup>-12</sup>   1x10<sup>-11</sup>

Average difference between posterior and prior CH<sub>4</sub> emissions for Jan-Jun 2019

Poster A5.05  
Thursday afternoon



Posterior adjustment of anthropogenic CH<sub>4</sub> emissions per country.



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## S u m m a r y

- CAMS makes use of NRT TROPOMI O<sub>3</sub>, SO<sub>2</sub>, NO<sub>2</sub>, CO, CH<sub>4</sub> and HCHO data
- NRT TROPOMI O<sub>3</sub>, volcanic SO<sub>2</sub>, NO<sub>2</sub> are actively assimilated by CAMS
- Assimilation of TROPOMI CO assimilation improves fit of CAMS analysis to independent data and is planned for next CAMS model upgrade (Q1/2023)
- TROPOMI CH<sub>4</sub> used in emission inversion. Routine assimilation tests about to begin.
- TROPOMI SO<sub>2</sub> layer height data can improve CAMS SO<sub>2</sub> analysis and forecasts (for strong volcanic eruptions)
- TROPOMI HCHO will be used to develop biogenic emission inversion framework in HE CAMEO project (if proposal is funded)
- CAMS data freely available from ADS: <https://atmosphere.copernicus.eu/data>

<http://atmosphere.copernicus.eu>

| @CopernicusECMWF

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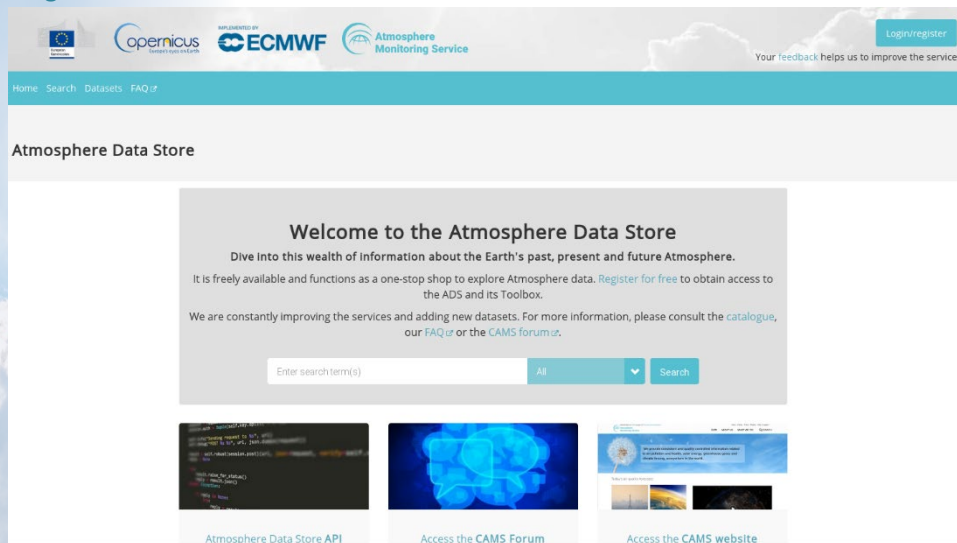




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# The Atmosphere Data Store (ADS)

## All CAMS data are freely available



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### Atmosphere Data Store

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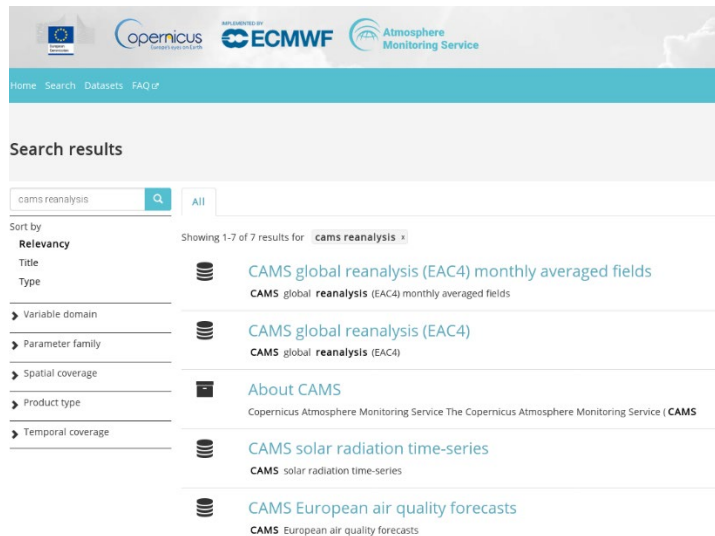
Dive into this wealth of information about the Earth's past, present and future Atmosphere.

It is freely available and functions as a one-stop shop to explore Atmosphere data. Register for free to obtain access to the ADS and its Toolbox.

We are constantly improving the services and adding new datasets. For more information, please consult the [catalogue](#), our [FAQ](#) or the [CAMS forum](#).

Enter search term(s)  All

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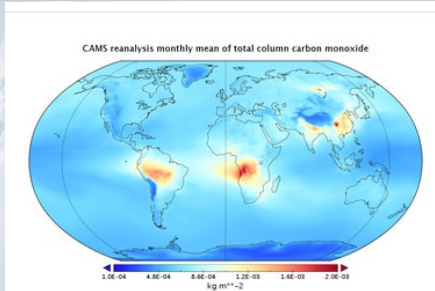
Title

Type

Showing 1-7 of 7 results for **cams reanalysis**

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