



Comparing Sentinel-5P TROPOMI NO₂ column observations with the CAMS-regional air quality ensemble

European TROPOMI NO₂ product

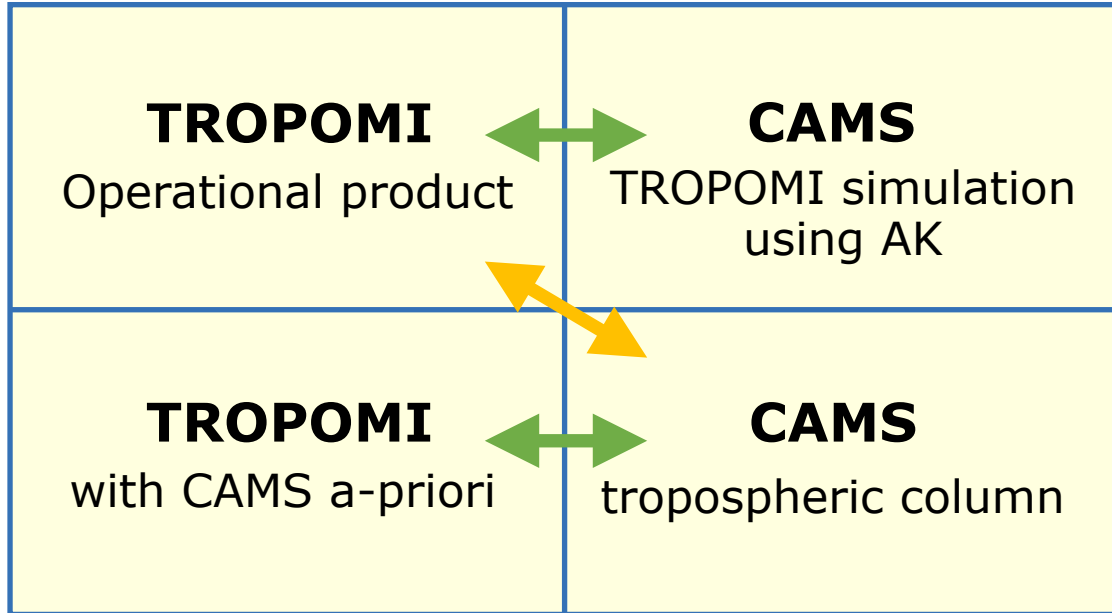
John Douros, Henk Eskes,
Jos van Geffen, K. Folkert Boersma, Steven
Compernelle, Gaia Pinardi, Anne-Marlene
Blechtschmidt, Vincent-Henri Peuch,
Augustin Colette, and Pepijn Veeffkind



EGU, 26 May 2022
Session "Impact COVID-19 on air quality"
11 January 2021

Comparing the CAMS regional models with TROPOMI NO₂ observations

Douros et al., preprint



Satellite: TROPOMI NO₂ column retrieval

Green: good comparisons

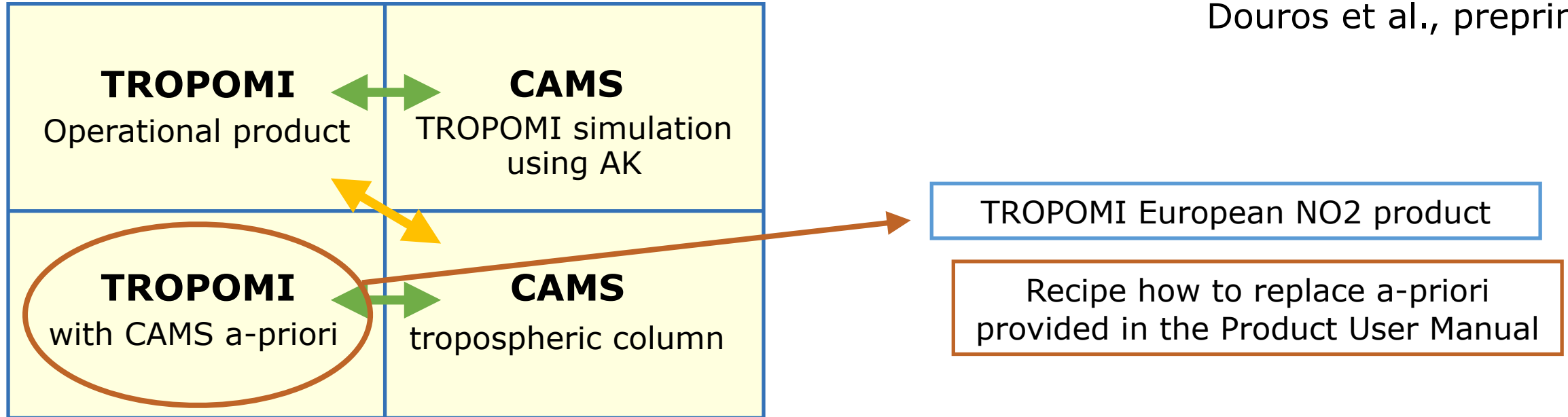
Orange: sub-optimal comparisons (a-priori dependent)

CAMS = Copernicus Atmosphere Monitoring Service

CAMS provides regional AQ forecasts/analysis using ensemble of 11 national AQ models

Comparing the CAMS regional models with TROPOMI NO₂ observations

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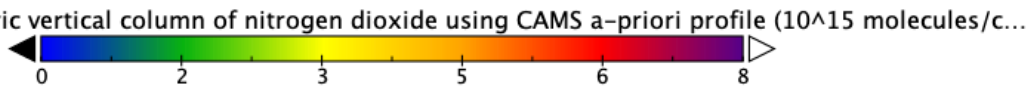
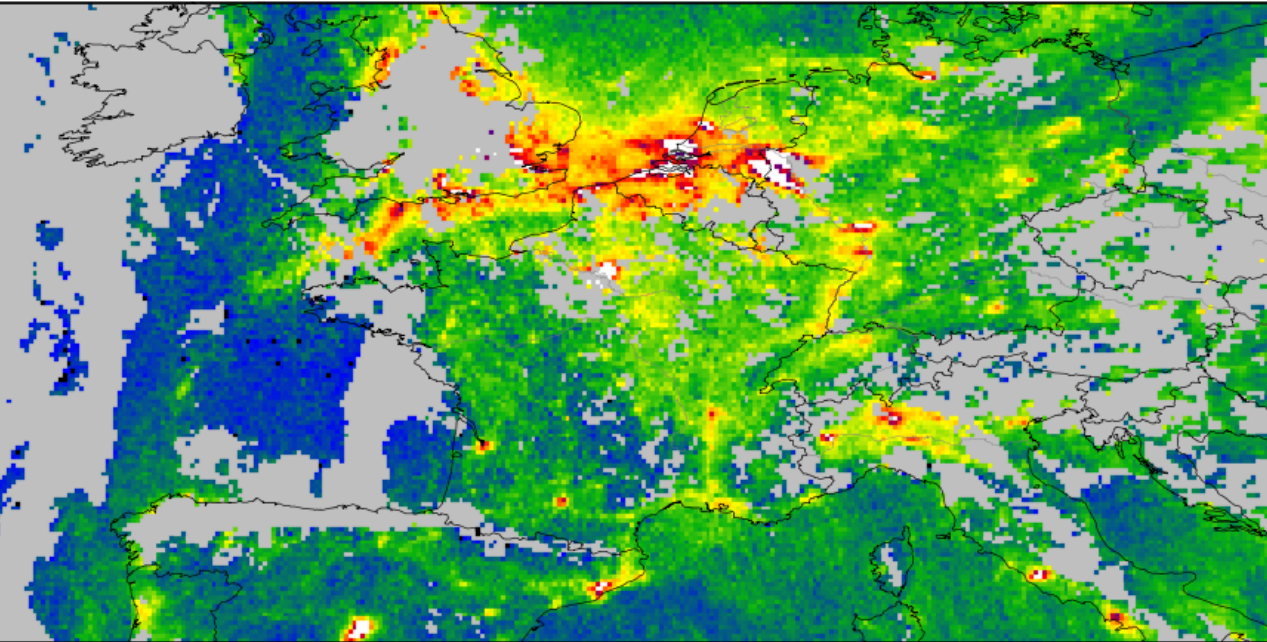
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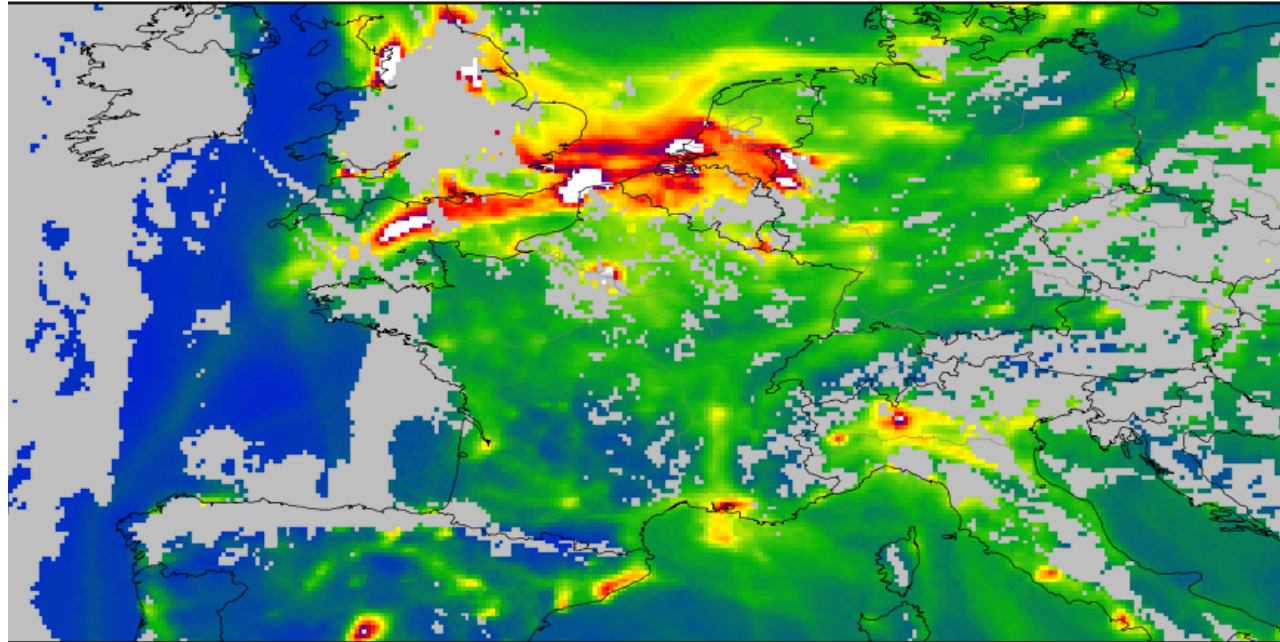
Comparing TROPOMI with models over Europe, on daily basis

Single overpass, 26 July 2018

TROPOMI NO₂ based on CAMS-regional a-priori



CAMS-regional vertical column NO₂

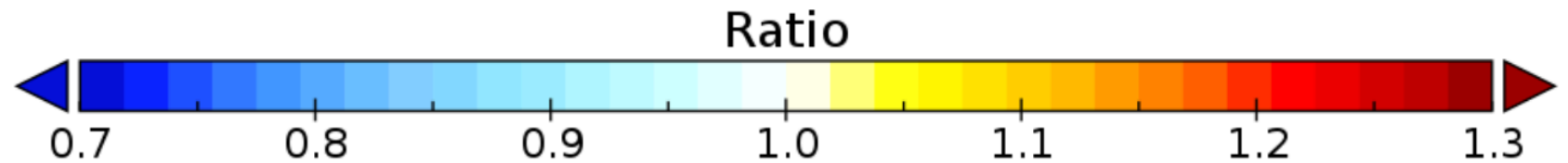
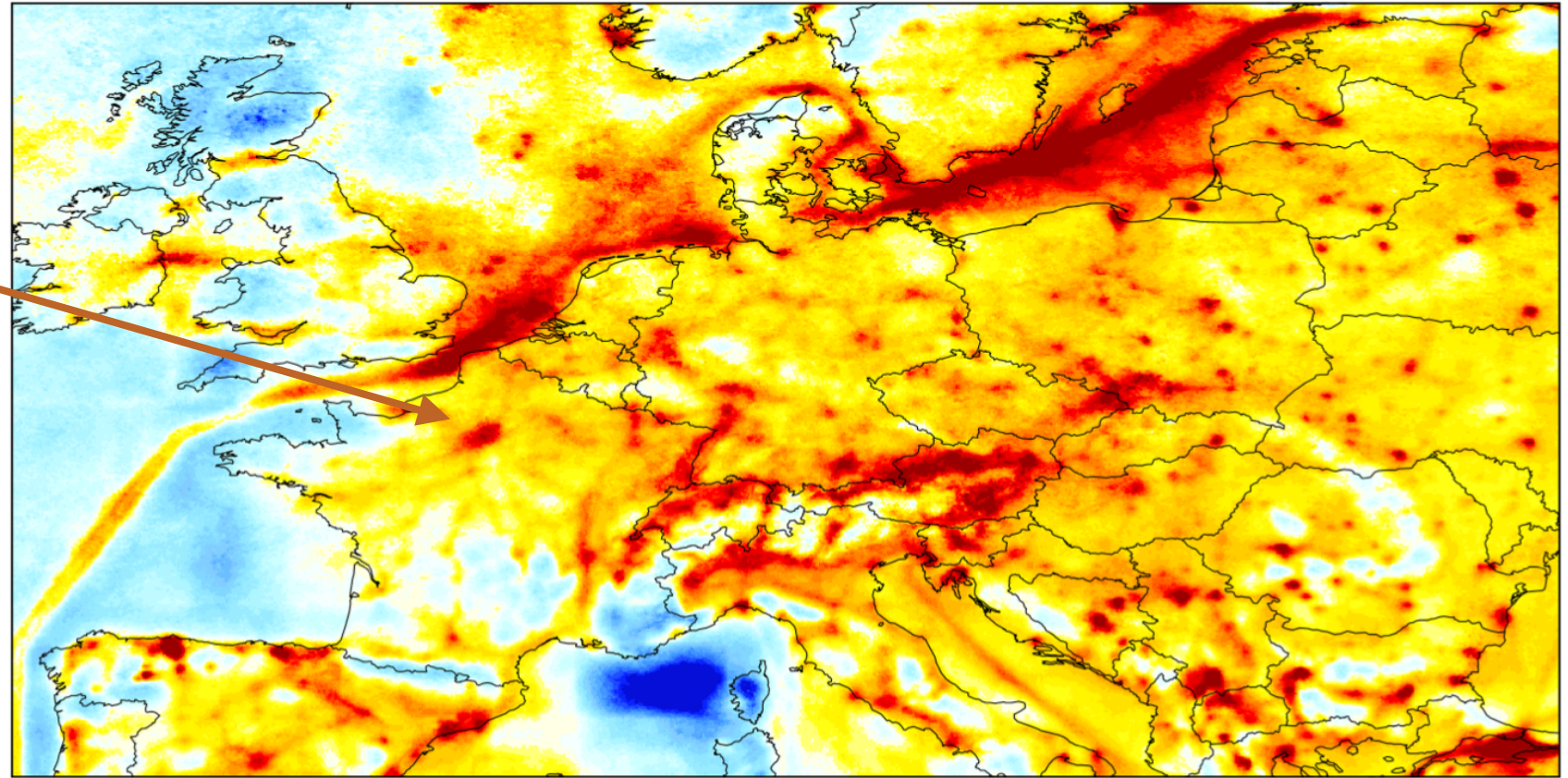


- Detailed comparisons with models are possible on a daily basis (e.g. with the CAMS regional ensemble)
- Make use of averaging kernels! (here kernels are used to replace the a-priori profiles by CAMS)
- Importance free troposphere:
A-priori = CAMS-regional < 3km, plus CAMS-global > 3 km

John Douros, KNMI

Impact of replacing the a-priori by CAMS

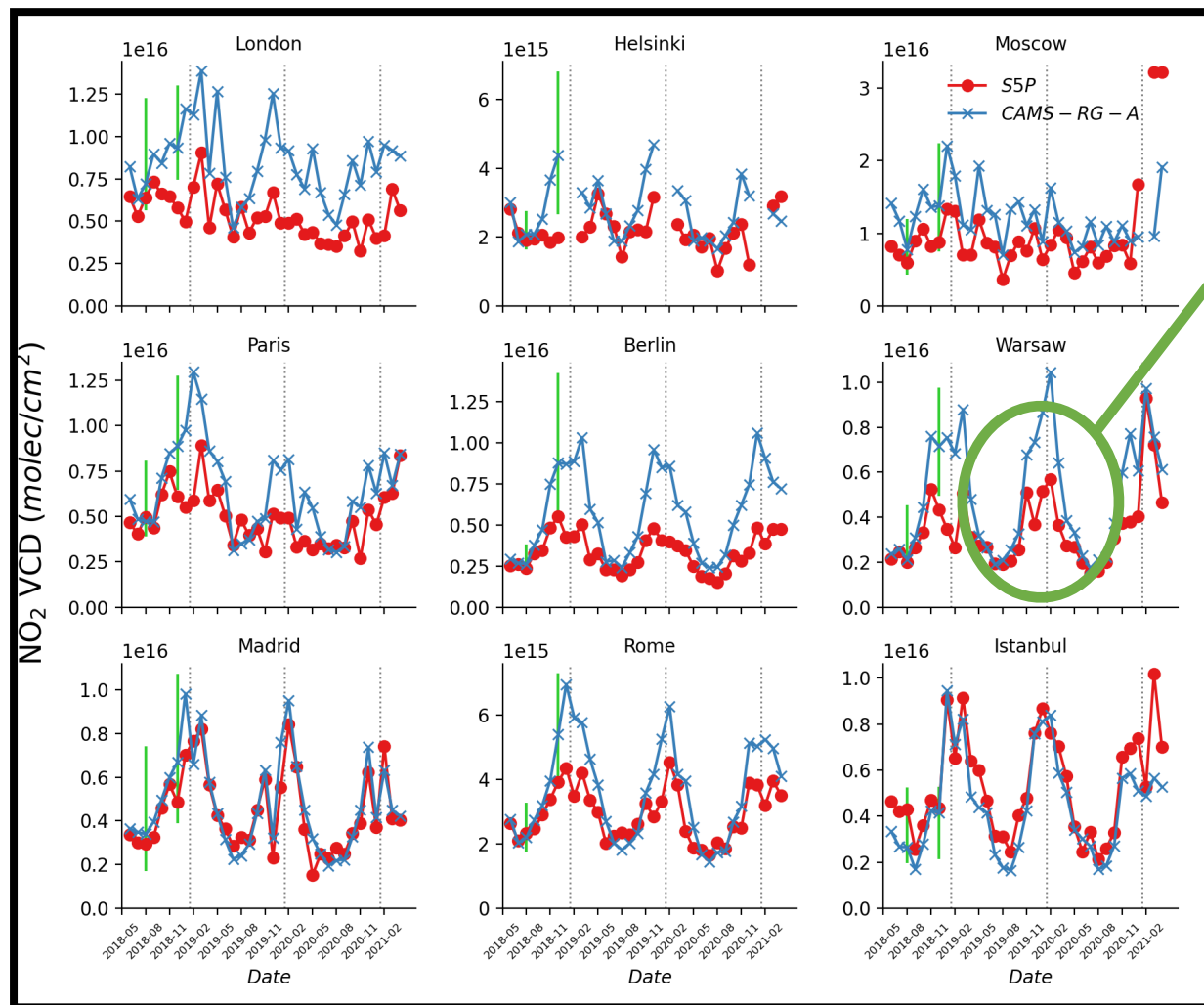
Enhancements largest
over emission hotspots



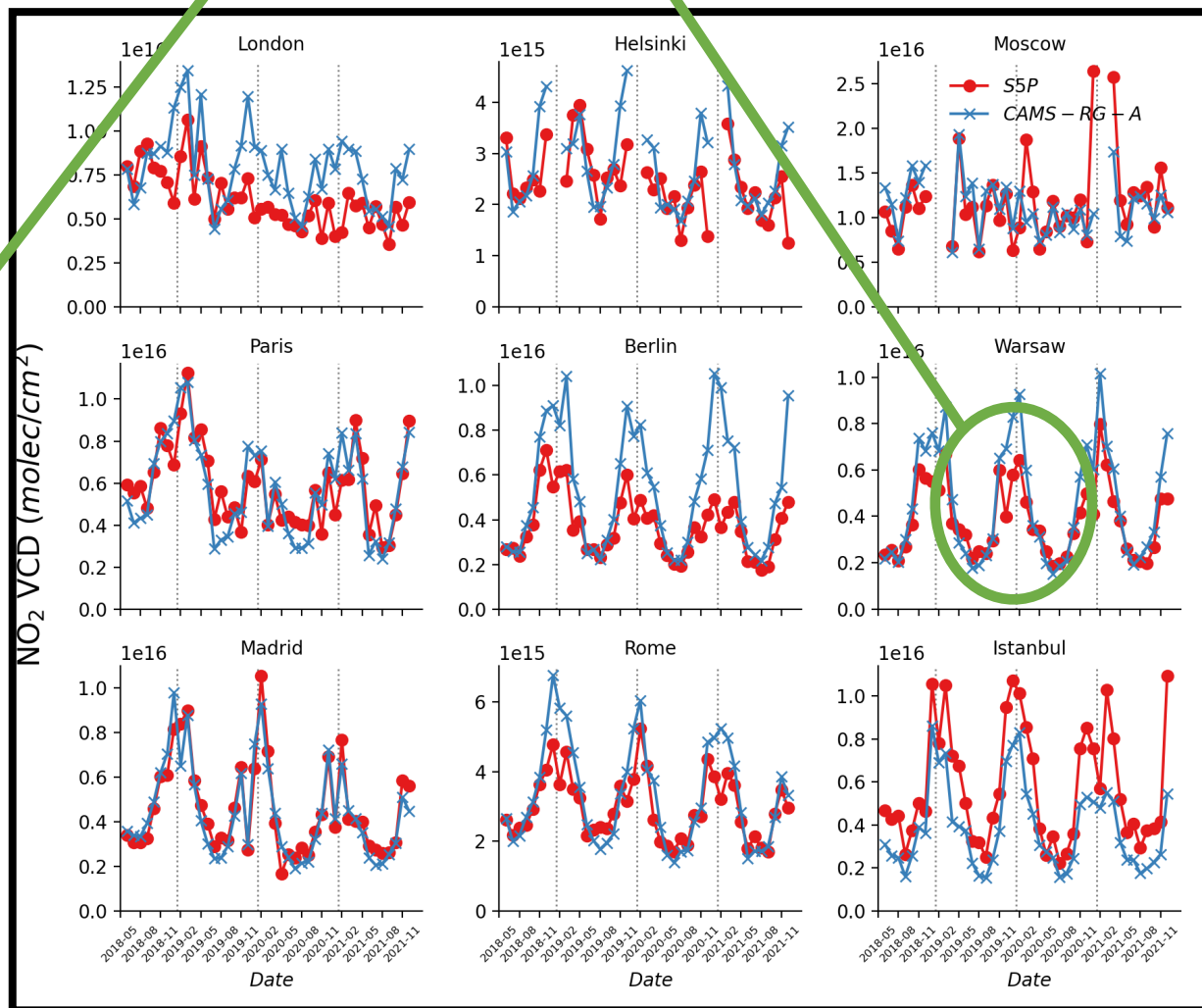
Ratio = TROPOMI NO₂ with CAMS a-priori / TROPOMI NO₂ operational product (TM5-MP a-priori)

CAMS-TROPOMI comparisons over cities

Increase due to use of PAL product



Using TROPOMI OFFL operational product (v1.2.x/1.3.x)

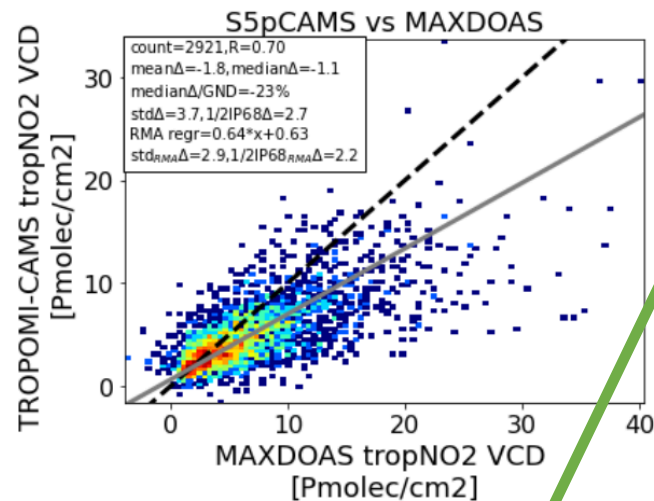
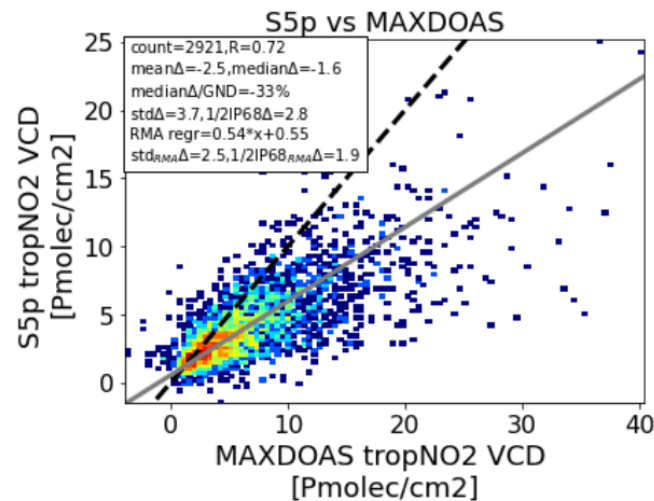


Using TROPOMI PAL reprocessed data (v2.3.1)

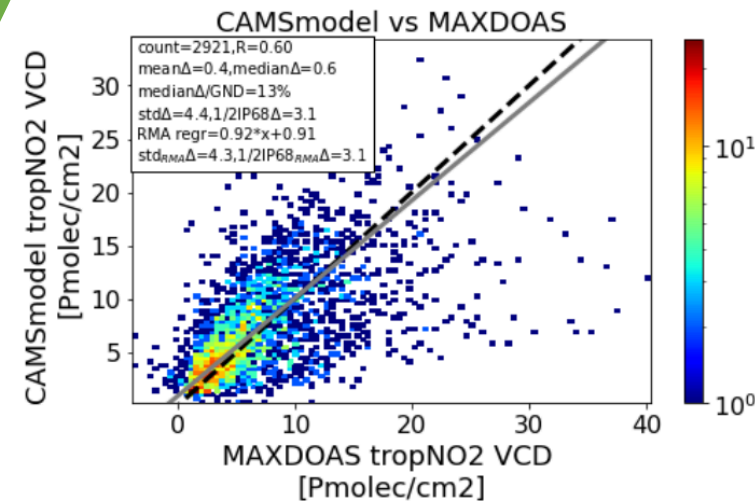
Validation with MAXDOAS and PANDORA

(Note: still based on v1.2 / v1.3 TROPOMI OFFL)

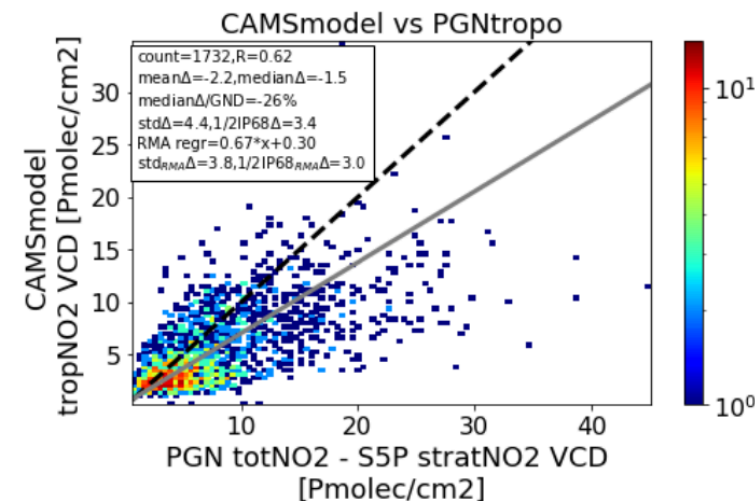
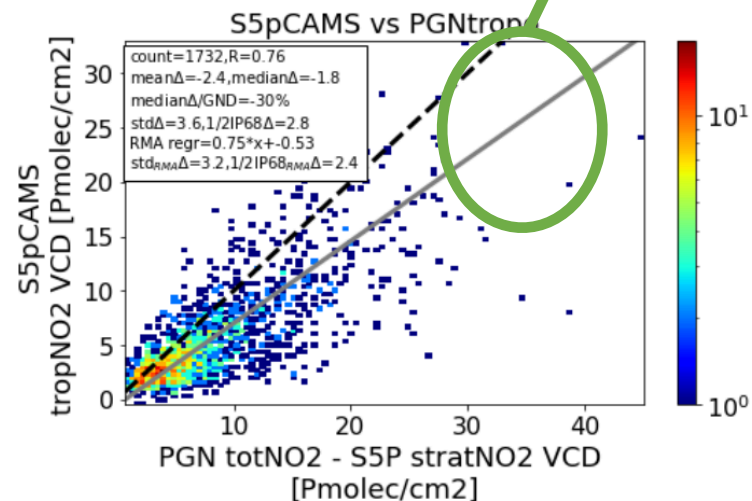
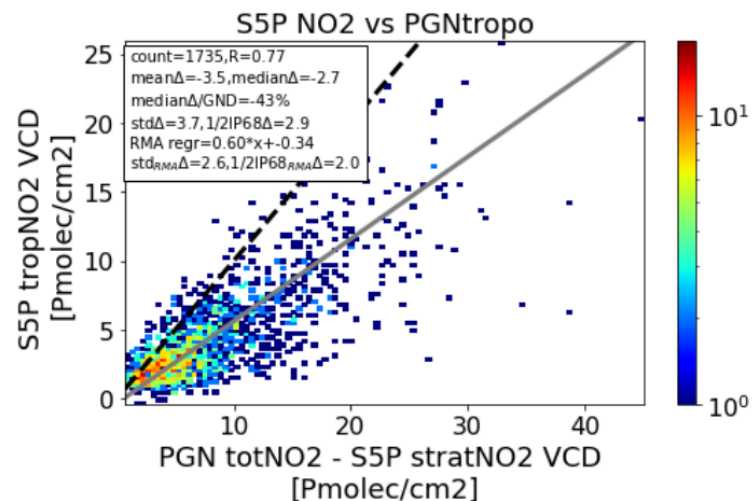
MAXDOAS



Improved slope



PGN-tropo



S5P operational

S5P, CAMS a-priori

CAMS analysis

TROPOMI NO2 European product (with CAMS regional a-priori profiles)

Regional Tropospheric NO2 columns from TROPOMI with CAMS apriori



[Tropospheric NO2](#)

NO2 observation for:

Region:

Year:

Month:

Day:

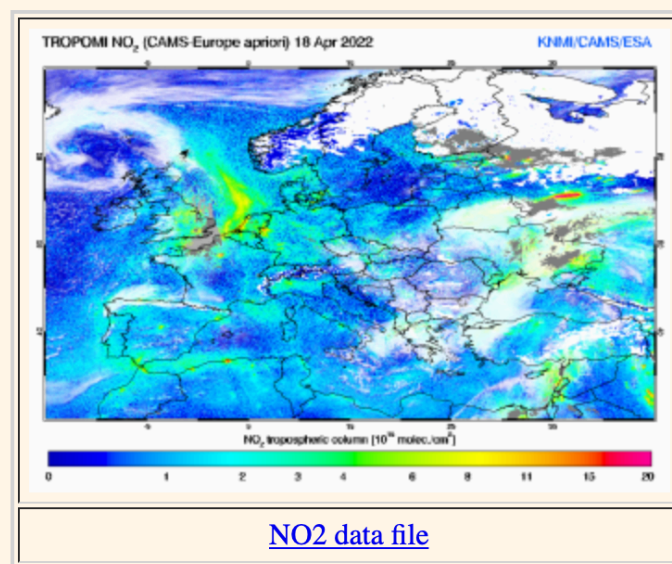
[<-- previous day](#)

[<-- previous month](#)

[next day -->](#)

[next month -->](#)

Tropospheric NO2 on 18 April 2022



https://www.temis.nl/airpollution/no2_cams.php

Summary

- * The CAMS regional ensemble AQ analyses are compared to TROPOMI NO₂: Models and satellite correlate well in both space and time.
- * Impact of replacing the a-priori profile is most pronounced in emission hotspots (cities), 20-30% increases. Small impact in rural areas.
- * CAMS a-priori improves slope in comparison to MAXDOAS and PANDORA.
- * Free troposphere is important factor in comparisons.
- * The European TROPOMI NO₂ product (based on PAL reprocessing) is made available on TEMIS.

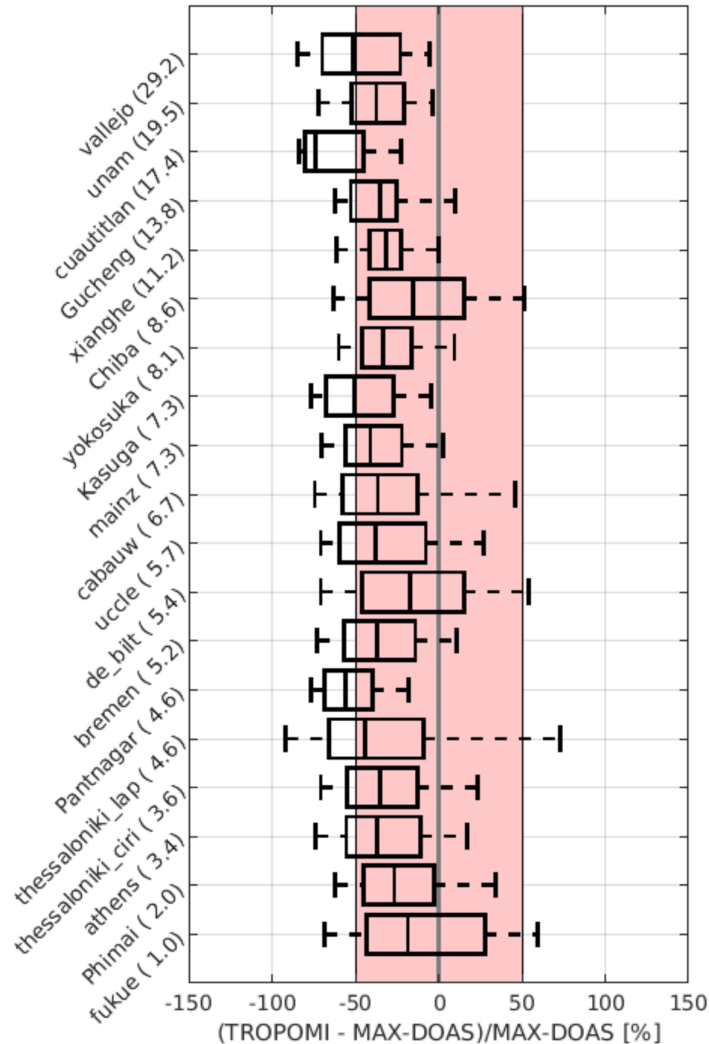
Comparing Sentinel-5P TROPOMI NO₂ column observations with the CAMS-regional air quality ensemble

(submitted to GMD, May 2022)

John Douros¹, Henk Eskes¹, Jos van Geffen¹, K. Folkert Boersma^{1,2}, Steven Compernelle³, Gaia Pinardi³, Anne-Marlene Blechschmidt⁴, Vincent-Henri Peuch⁵, Augustin Colette⁶, and Pepijn Veefkind¹

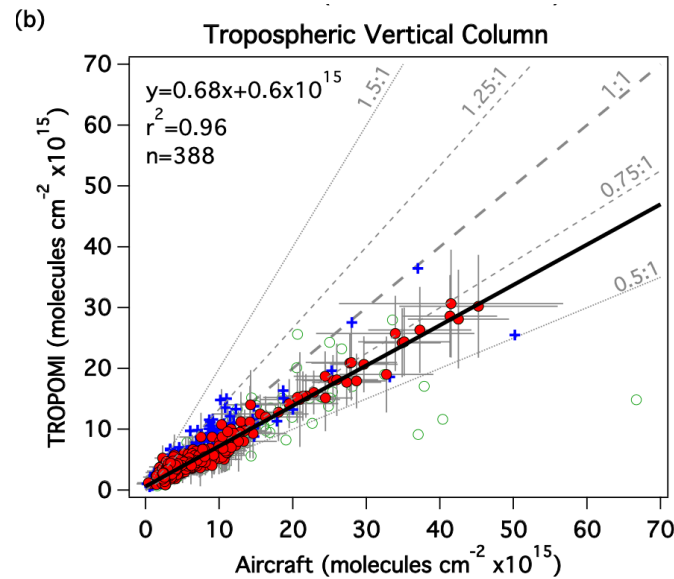
TROPOMI NO₂ v1.2.x / v1.3.x (2019-2020): Validation summary

TROPOMI tropospheric NO₂ (RPRO+OFFL)

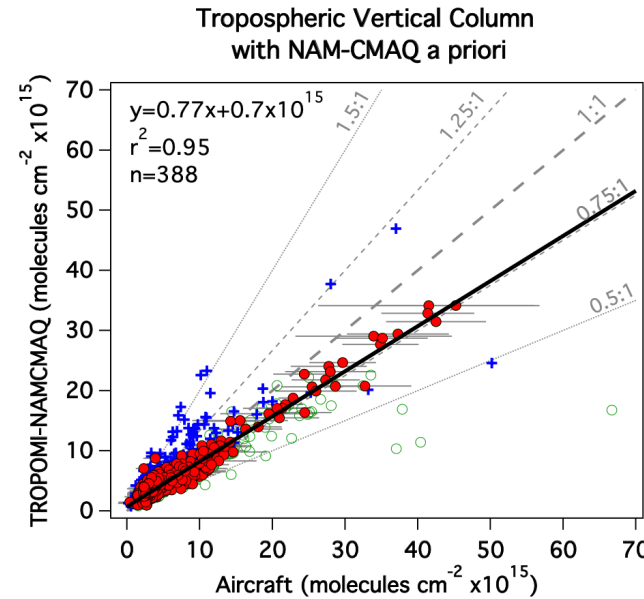


TROPOMI
20-50%
lower than
MAX-DOAS

Verhoelst et al.,
2020



TROPOMI vs
aircraft
Slope 0.68
 $R^2 = 0.96$



With high-res
a-priori
Slope 0.77
 $R^2 = 0.95$

Conclusions:

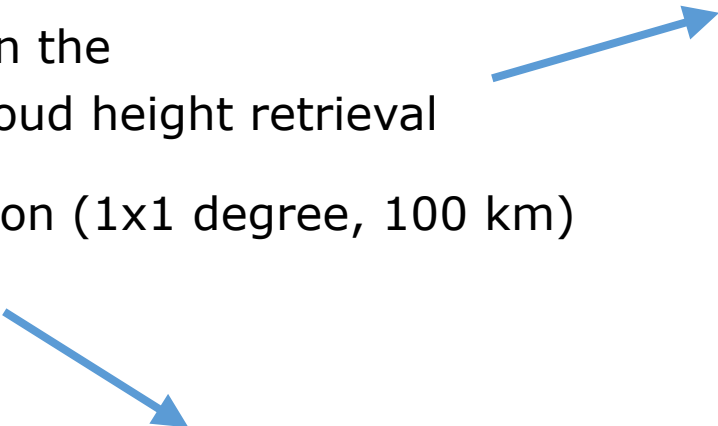
- TROPOMI has low bias
- Partly due to (resolution of) the a-priori NO₂ profile.
- High correlation vs aircraft

Judd et al., 2020
Tack et al., 2020

Reasons for the low bias in the v1.x.y TROPOMI NO₂ products

We identified **two main contributions** to explain the low bias:

1. A systematic low bias in the FRESCO (O2A band) cloud height retrieval
2. The low spatial resolution (1x1 degree, 100 km) of the a-priori profiles



Update of FRESCO (FRESCO-WIDE) introduced in processor version 1.4.0
Version 2.3.1 reprocessing:
The S5P-PAL dataset

This talk



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(submitted to GMD, May 2022)

PAL reprocessed TROPOMI NO2 product, May 2018 - present

S5P-PAL Data Portal



NO2

The NO2 dataset provided by S5P-PAL is a reprocessing of the official NO2 data product using the official NO2 L2 processor. This dataset is dedicated to support research on the impact of the COVID lockdown on air quality from space.

This dataset has been generated due to a switch in the processor version of the NO2 processor during early December 2020 introducing a discontinuity in the time series of the Sentinel-5P NO2 data. To harmonize this data record the latest operational processor (version 02.03.01) was used to reprocess the data from the beginning of the mission until mid November 2021 (aligning with the operational deployment of the V02.03.01 processor). The reprocessing consisted of a regeneration of the FRESCO and AAI input products, followed by a reprocessing of the NO2 product itself using these new inputs. Only the final NO2 products are made available via the S5P-PAL data portal.

In order to distinguish the reprocessed products from the operational products, all products generated with PAL use **PAL_** for the file class, as can be found in the filename of each product.

Note that this reprocessing activity is independent of the full mission reprocessing that is planned for 2022, which will use a new radiance calibrated L1b dataset and will be performed by the Sentinel-5P PDGS.

The dataset does not provide a full timeline and products for several orbits are known to be missing. Information about known acquisition gaps in the data can be found on the [Mission Status](#) webpage of Sentinel-5P. In addition to those cases there are gaps due to missing L1b data (as can be found at the [Sentinel-5P Pre-Operations Data Hub](#)) for the following orbits: 6623, 6714, 6890, 7232, 7234, 7236, 8561, 14426. For orbits 11266-11268 no data was available due to a processor issue.

Information about NO2

The NL-L2 NO2 processor is developed and maintained by [KNMI](#).

All users are encouraged to first look at the [README](#) file before downloading the data.

Further documentation about the NO2 processor and product quality can be found at the official [PAL Algorithms](#) documentation website of Sentinel-5P.

Maps are available on the [Sentinel-5P Mapping Portal](#) which has been updated to include the reprocessed dataset.

Interactive product browsing and download

Available product files can be selected and downloaded using the [SpatioTemporal Asset Catalog \(STAC\) interface](#).

This browser interface does not currently support the more advanced search queries made possible that you will need to [programmatically query the S5P-PAL STAC endpoint](#).

Support




This service is provided as part of the Sentinel-5P Product Algorithm Laboratory (S5P-PAL) and covers Copernicus Sentinel data processed by S&T.

Questions regarding this service can be sent to the [ESA EO Support Helpdesk](#).

[Browse S5P-PAL products](#)

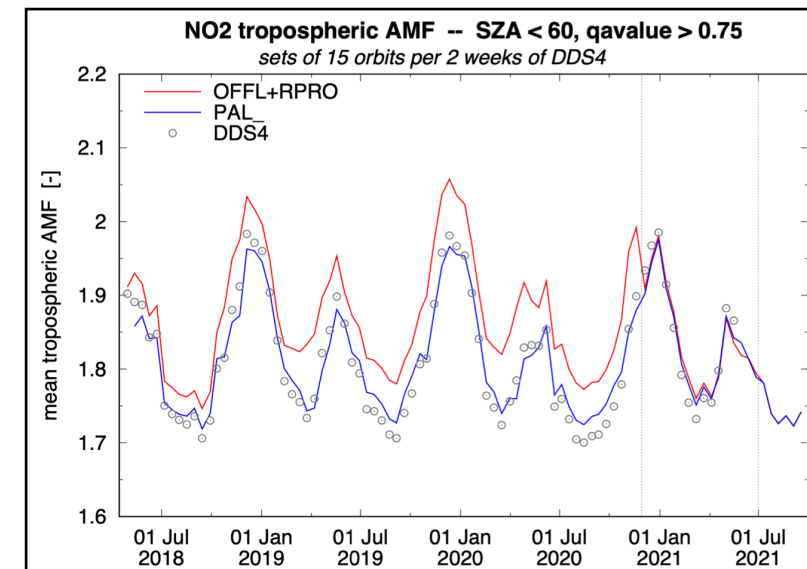
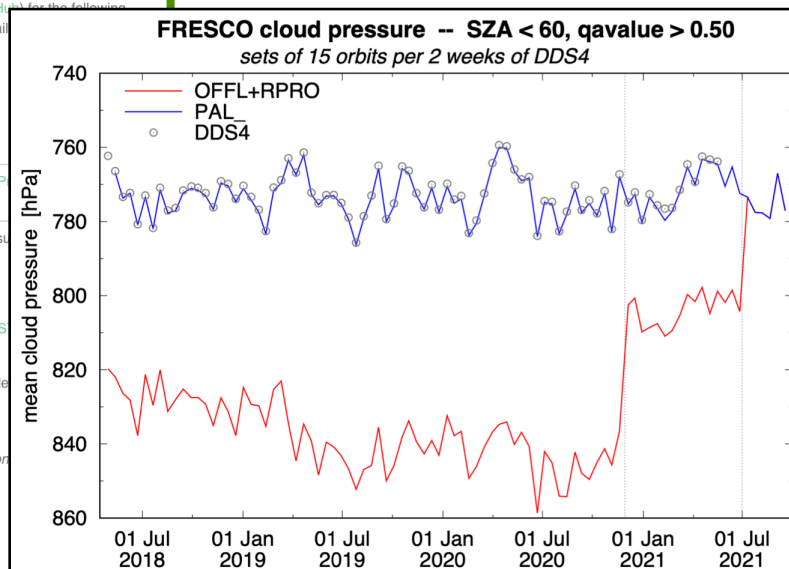
[API info](#)

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<https://data-portal.s5p-pal.com>

- Based on processor version 2.3.1
- File class "PAL_"
- May 2018 - November 2021
- Became available December 2021
- Connects seamlessly to OFFL



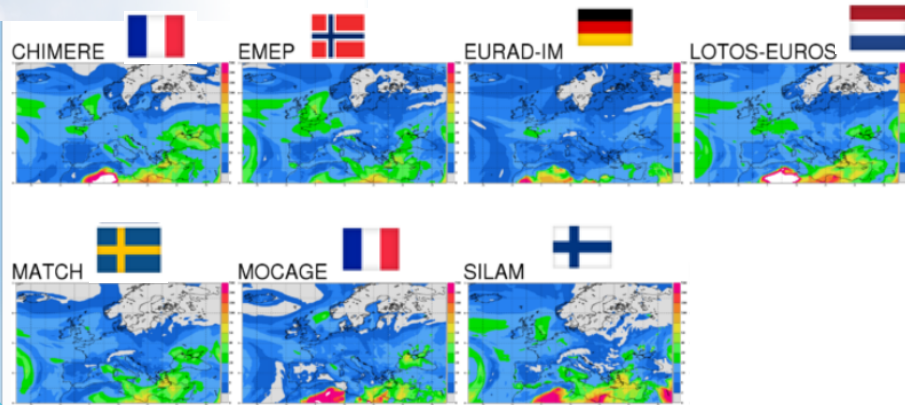


Atmosphere
Monitoring

CAMS EUROPEAN AIR QUALITY PORTFOLIO

Based on a multi-model approach (same boundary conditions, same emissions, same meteo, assimilation of 1000+ surface observations for key species)

Individual operational AQ models



DEHM (AARHUS University)



GEM-AQ (IEP)



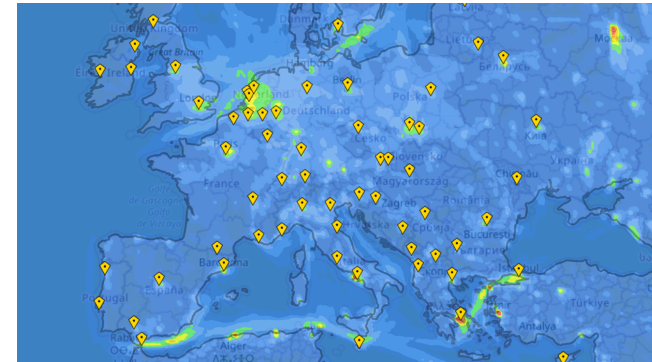
MINNI (ENEA)



MONARCH (BSC)



Operational AQ ensemble (incl. spread/uncertainty)



- Once daily D+4 forecasts
- Regulatory pollutants and pollens
- Annual reanalyses
- ~ 10km resolution

<http://regional.atmosphere.copernicus.eu>