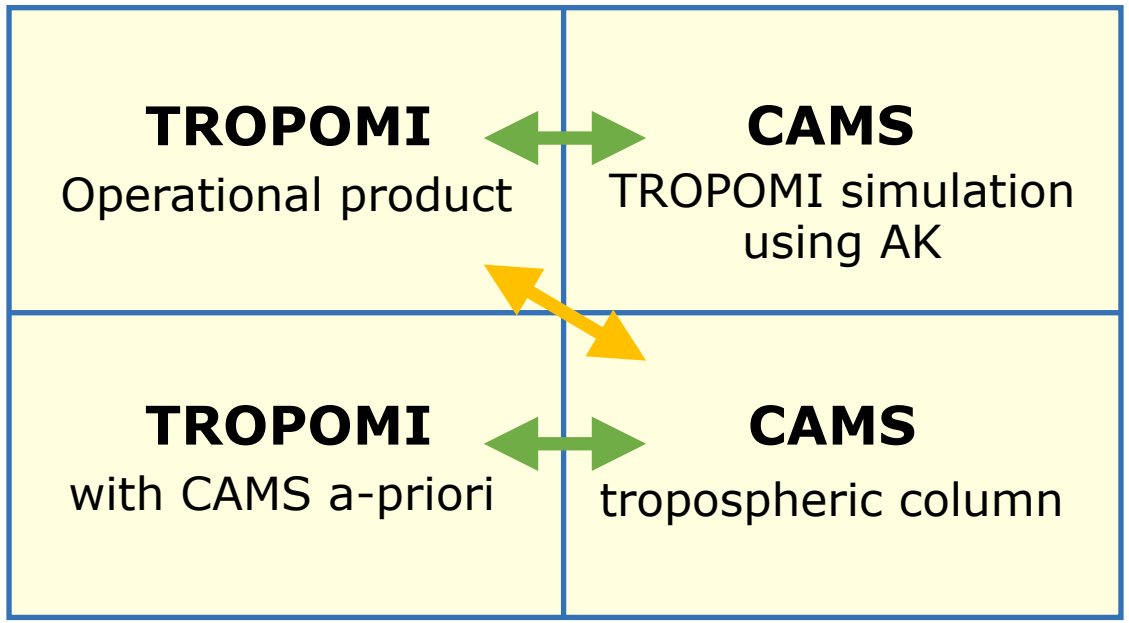
Comparing Sentinel-5P TROPOMI NO2 column observations with the CAMS-regional air quality ensemble

European TROPOMI NO2 product

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

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 NO_2 column retrieval

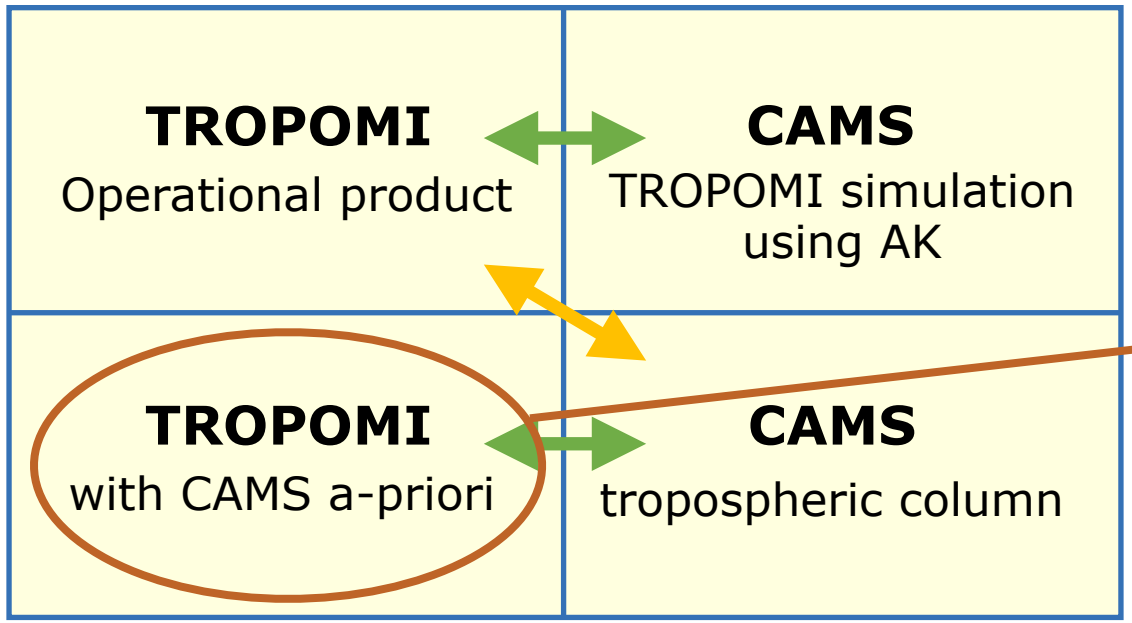
Green: good comparisons

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



Douros et al., preprint

TROPOMI European NO2 product

Recipe how to replace a-priori provided in the Product User Manual

Satellite: TROPOMI NO_2 column retrieval

Green: good comparisons

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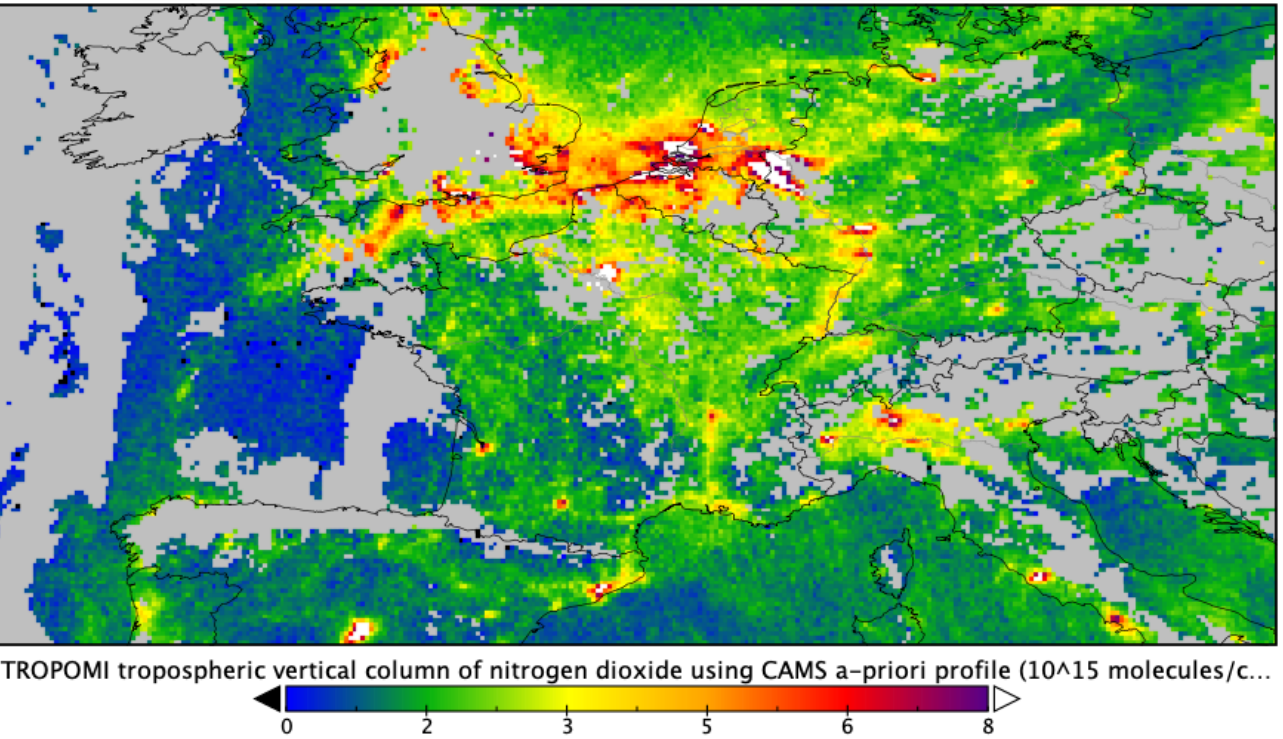
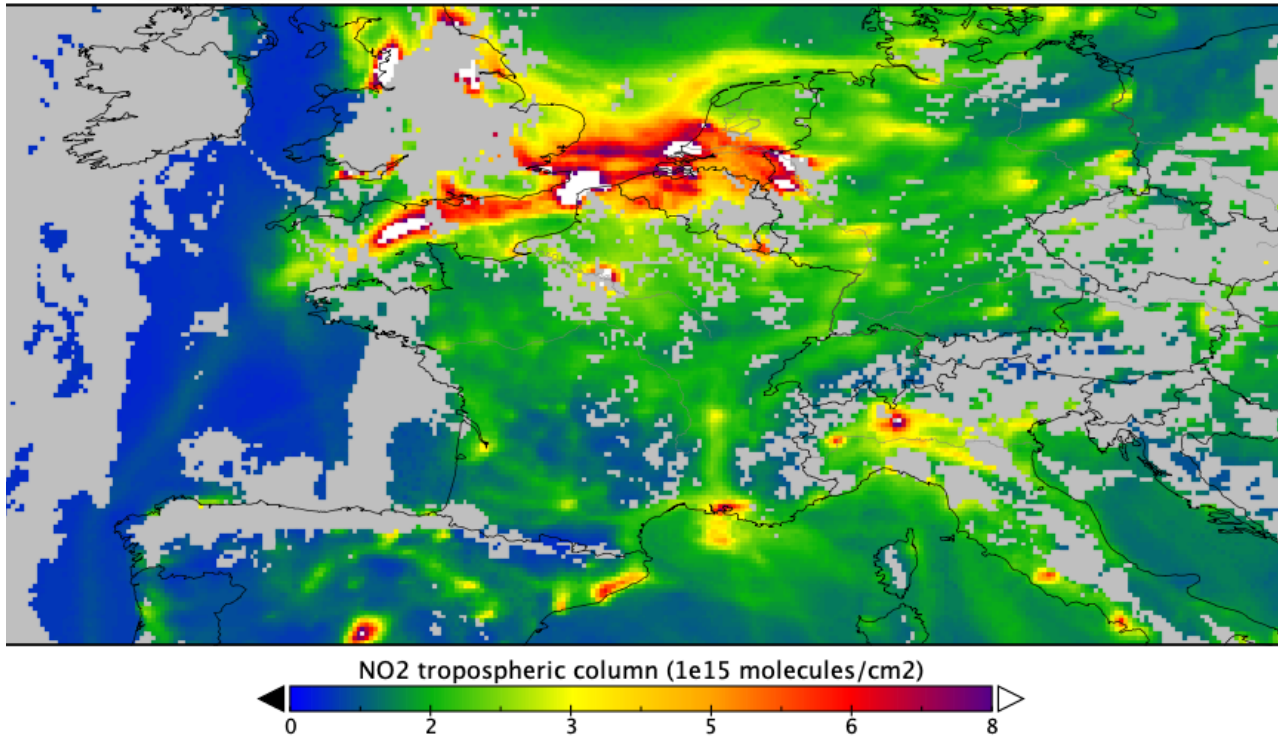
Comparing TROPOMI with models over Europe, on daily basis

Single overpass, 26 July 2018

TROPOMI NO2 based on CAMS-regional a-priori



CAMS-regional vertical column NO2

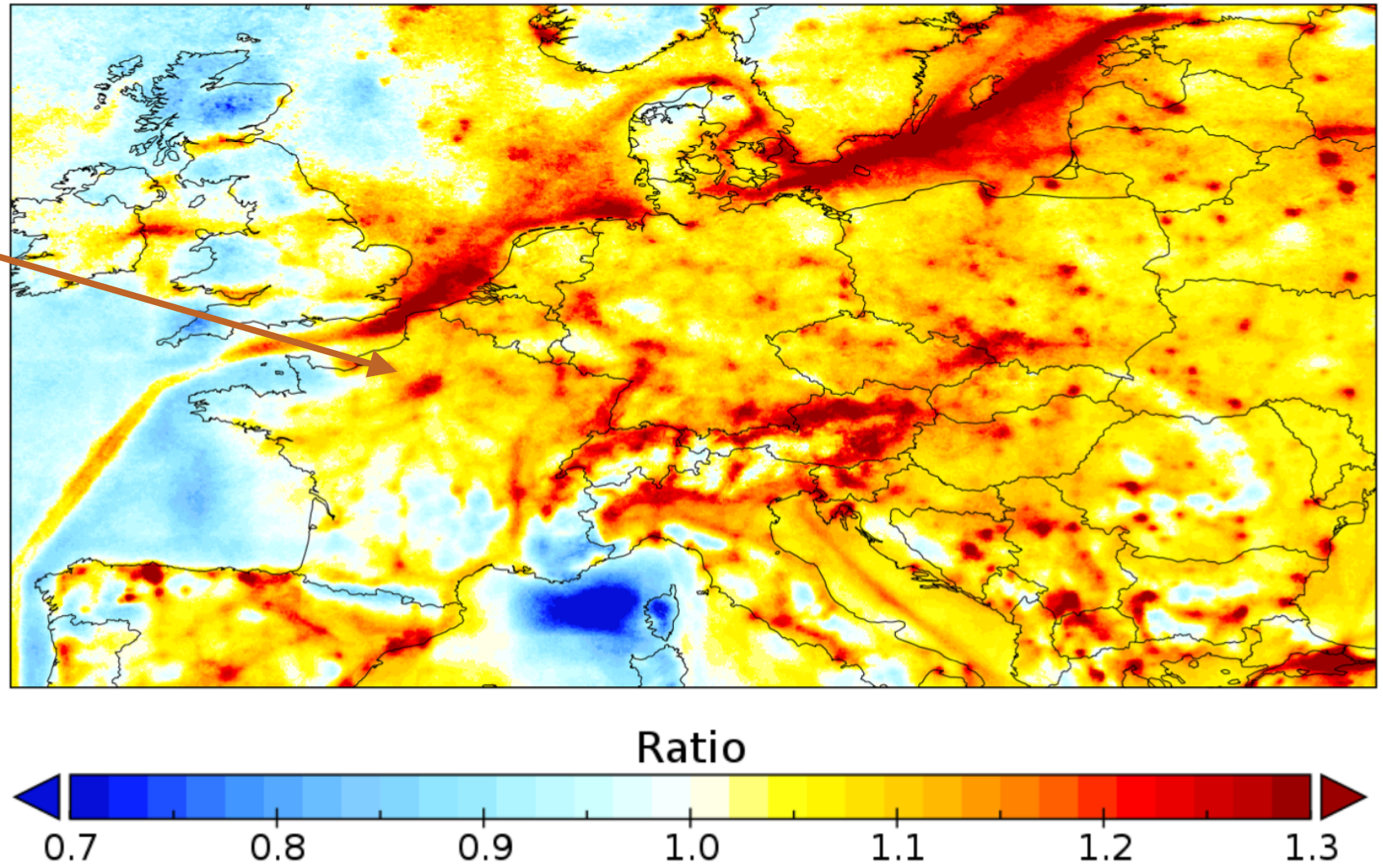


- Detailed comparisons with models are possible on a daily basis (e.g. with the CAMS regional ensemble)
- Make use of averaging kernels! (here kernels are used to replace the a-priori profiles by CAMS)
- Importance free troposphere:
  A-priori = CAMS-regional < 3km, plus CAMS-global > 3 km

John Douros, KNMI

Impact of replacing the a-priori by CAMS

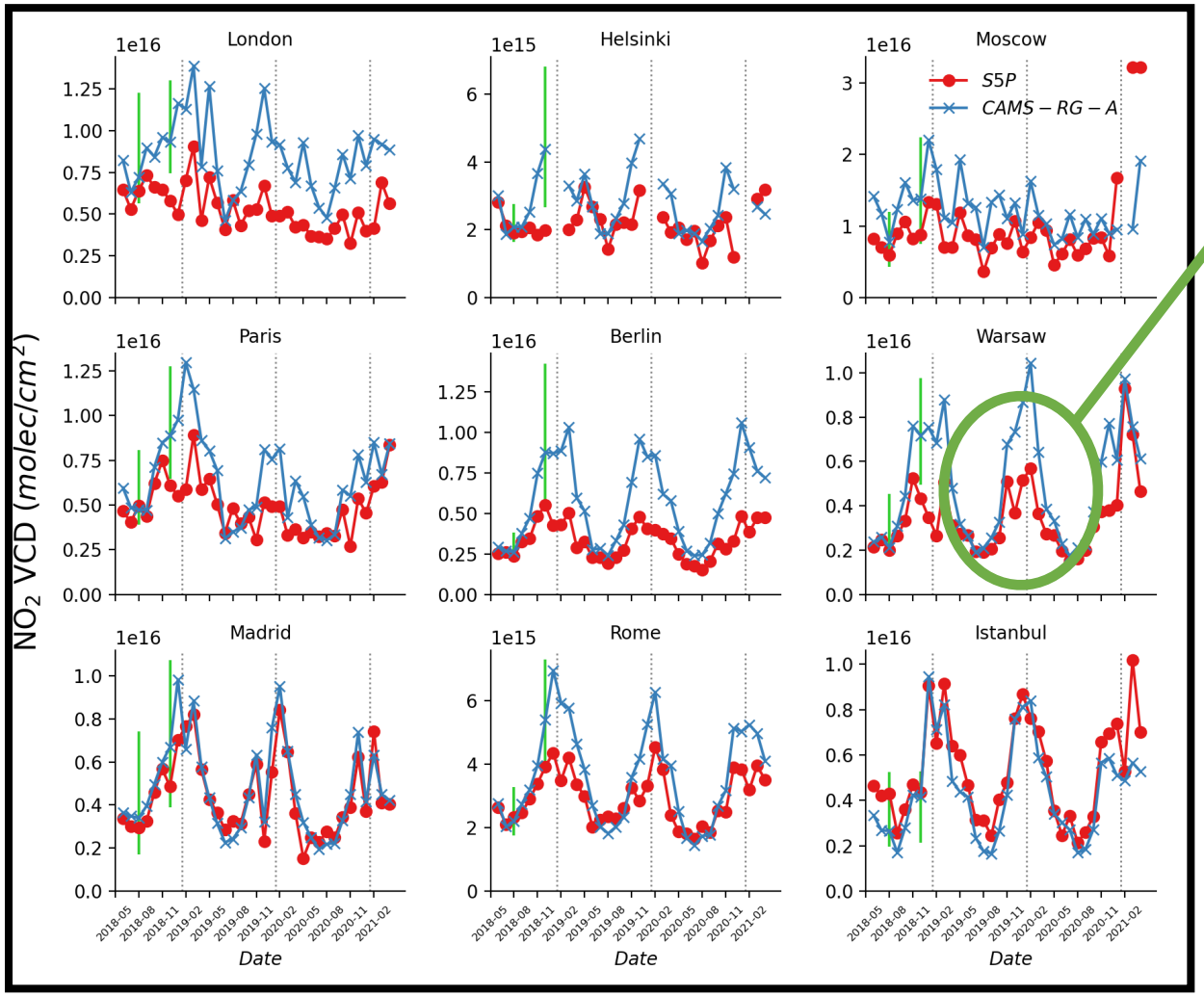
Enhancements largest over emission hotspots

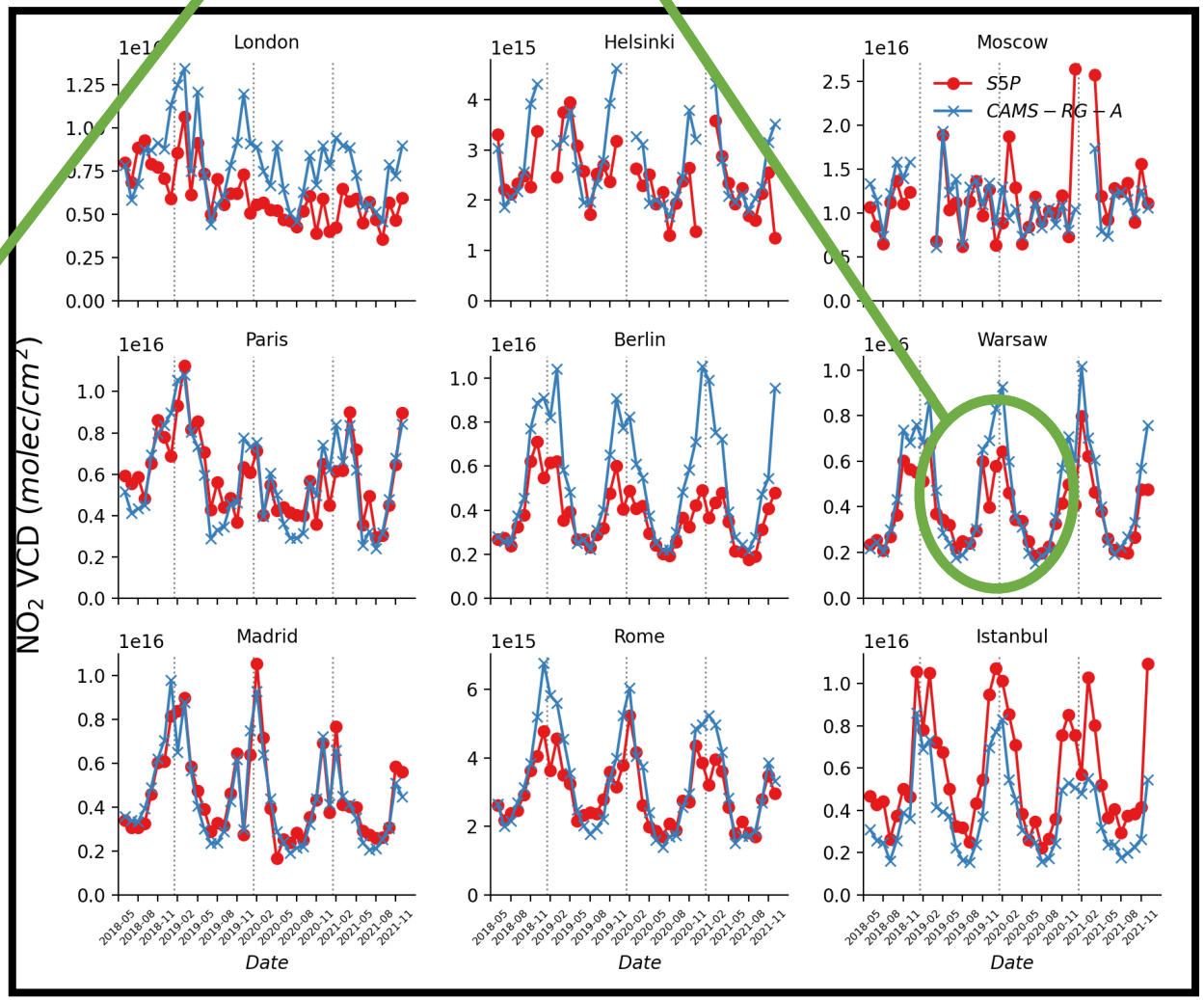


Ratio = TROPOMI NO2 with CAMS a-priori / TROPOMI NO2 operational product (TM5-MP a-priori)

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)

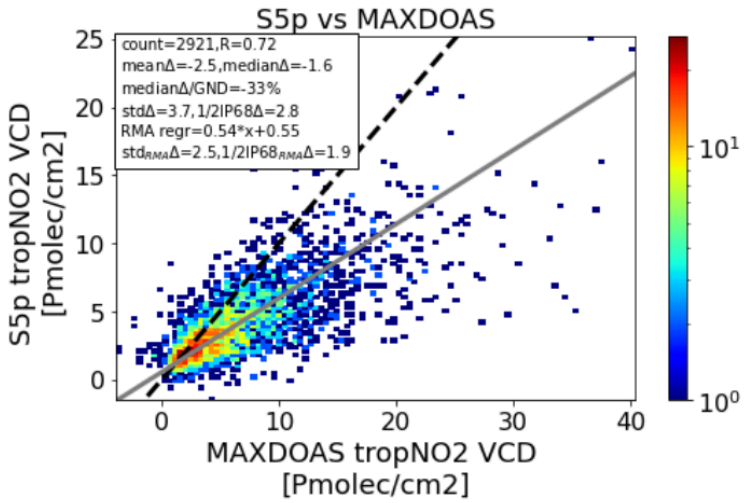
Validation with MAXDOAS and PANDORA

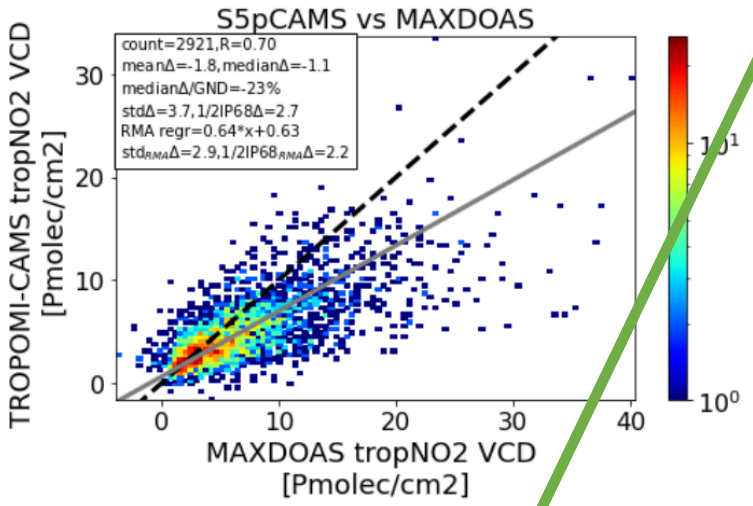
(Note: still based on v1.2 / v1.3 TROPOMI OFFL)

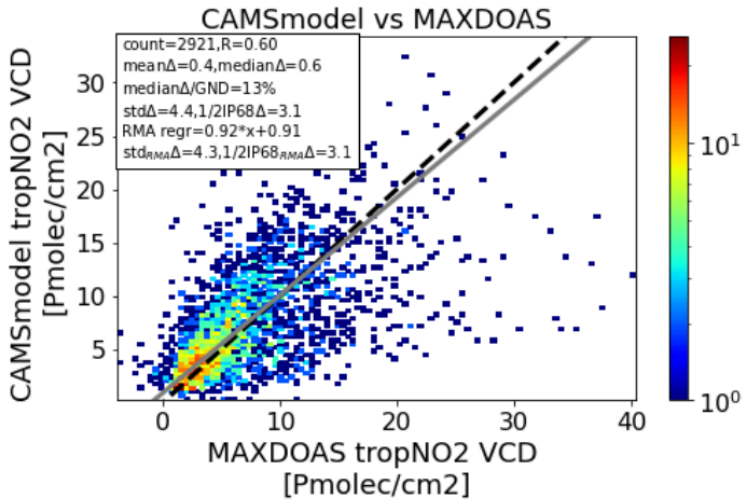
Improved slope

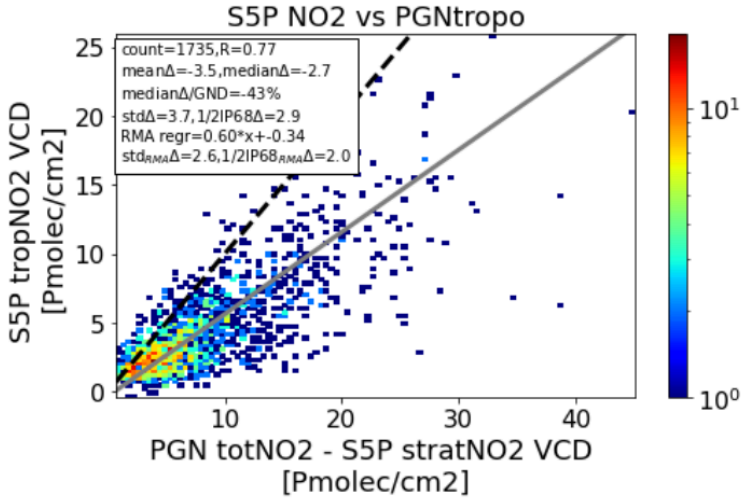
MAXDOAS

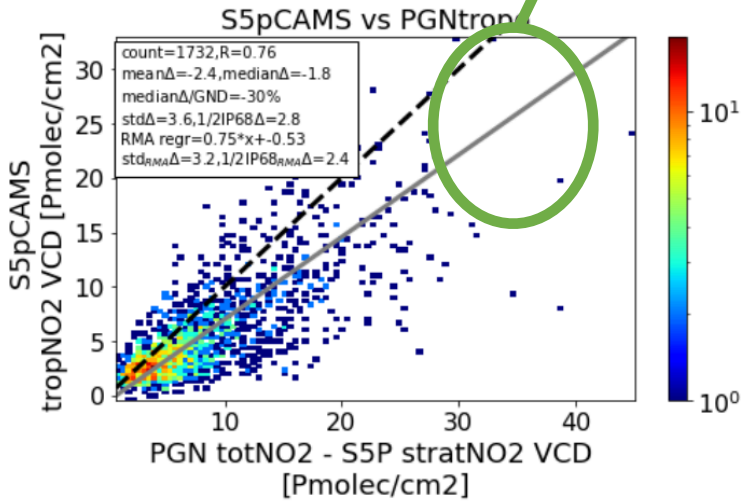
PGN-tropo

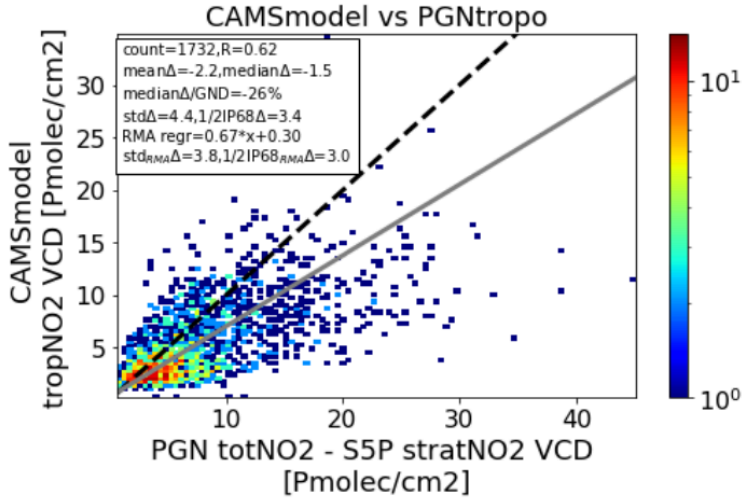












S5P operational

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

TEMIS

Tropospheric NO2

NO2 observation for:

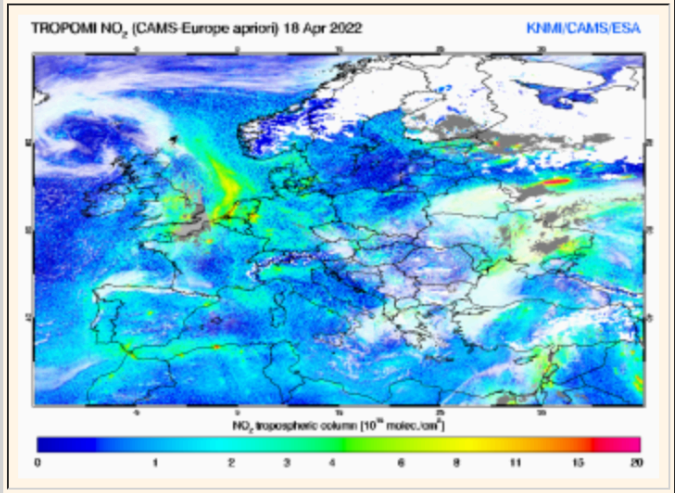
Region: Europe
Year: 2022
Month: April
Day: 18

submit

<-- previous day
<-- previous month

next day -->
next month -->

Tropospheric NO2 on 18 April 2022



NO2 data file

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

Summary

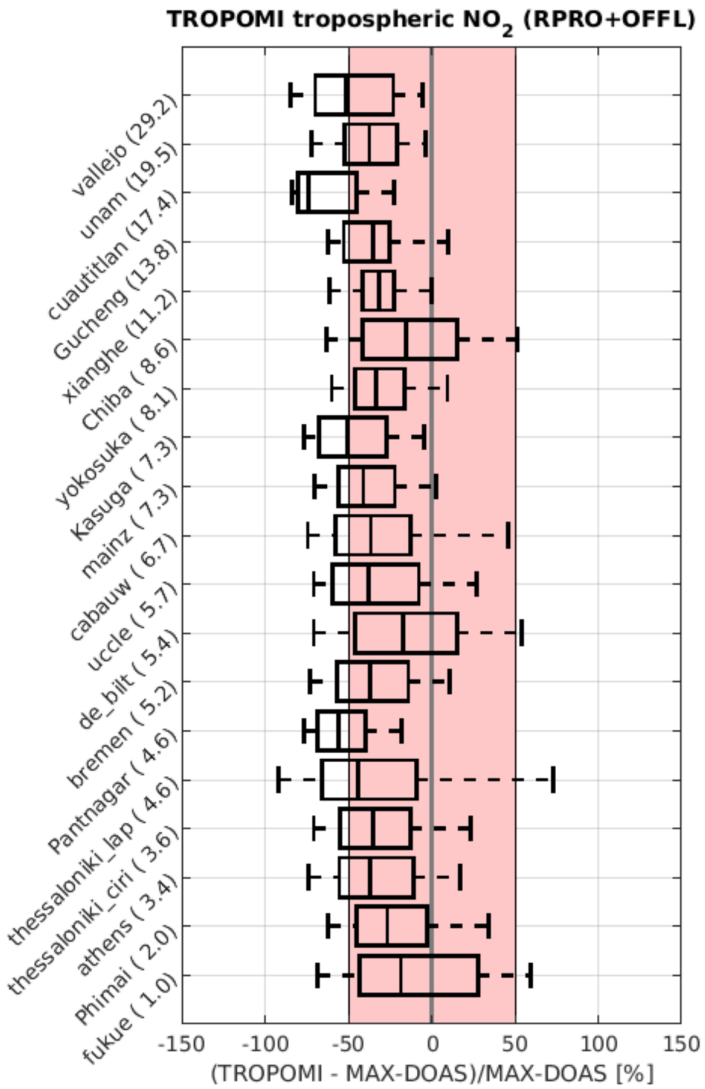
- The CAMS regional ensemble AQ analyses are compared to TROPOMI NO2: Models and satellite correlate well in both space and time.
- Impact of replacing the a-priori profile is most pronounced in emission hotspots (cities), 20-30% increases. Small impact in rural areas.
- CAMS a-priori improves slope 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 NO_2 column observations with the CAMS-regional air quality ensemble

(submitted to GMD, May 2022)

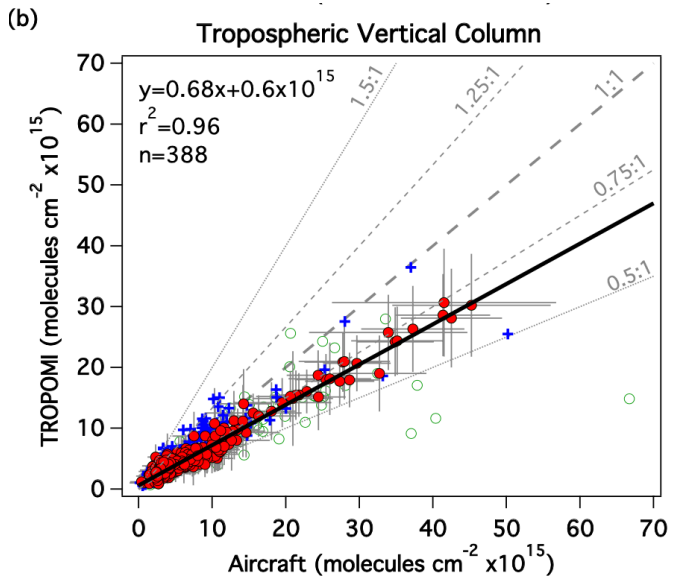
John Douros[1], Henk Eskes[1], Jos van Geffen[1], K. Folkert Boersma[1,2], Steven Compernolle[3], Gaia Pinardi[3], Anne-Marlene Blechschmidt[4], Vincent-Henri Peuch[5], Augustin Colette[6], and Pepijn Veefkind[1]

TROPOMI NO_2 v1.2.x / v1.3.x (2019-2020): Validation summary

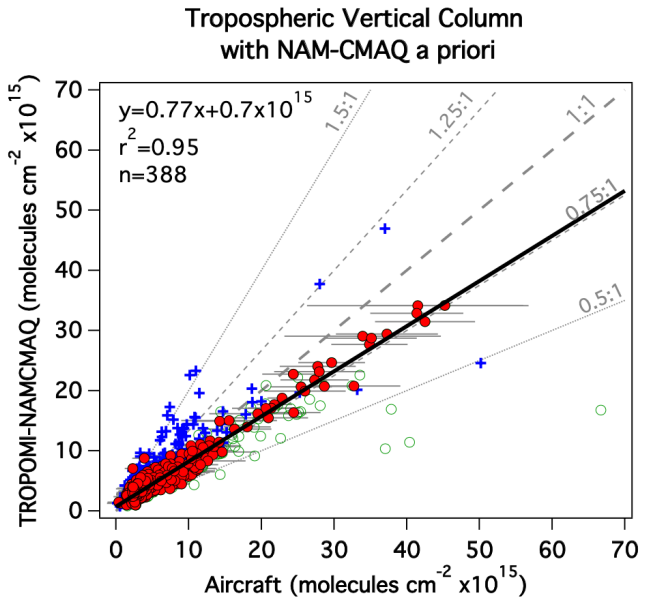


TROPOMI 20-50% lower than MAX-DOAS

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

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

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

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

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

2. The low spatial resolution (1x1 degree, 100 km) of the a-priori profiles

   → This talk

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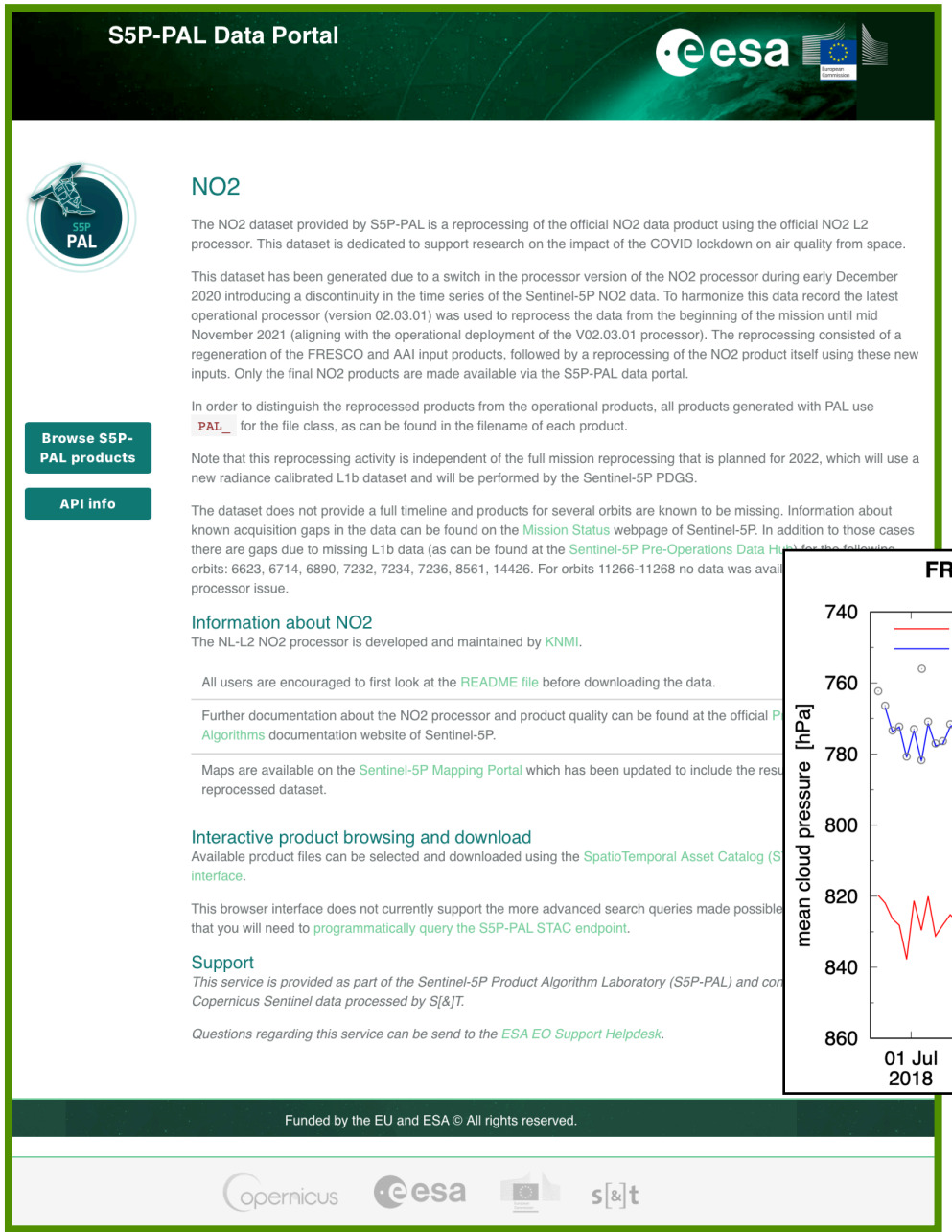
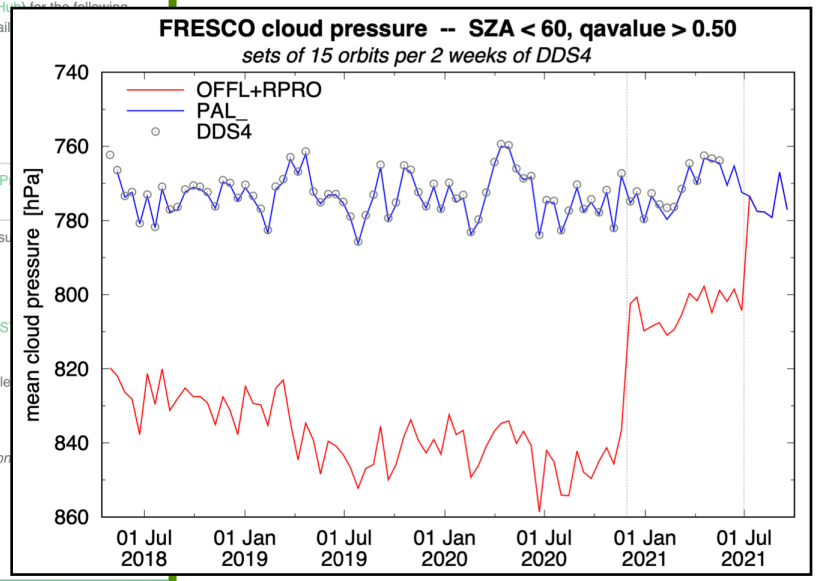
(submitted to GMD, May 2022)

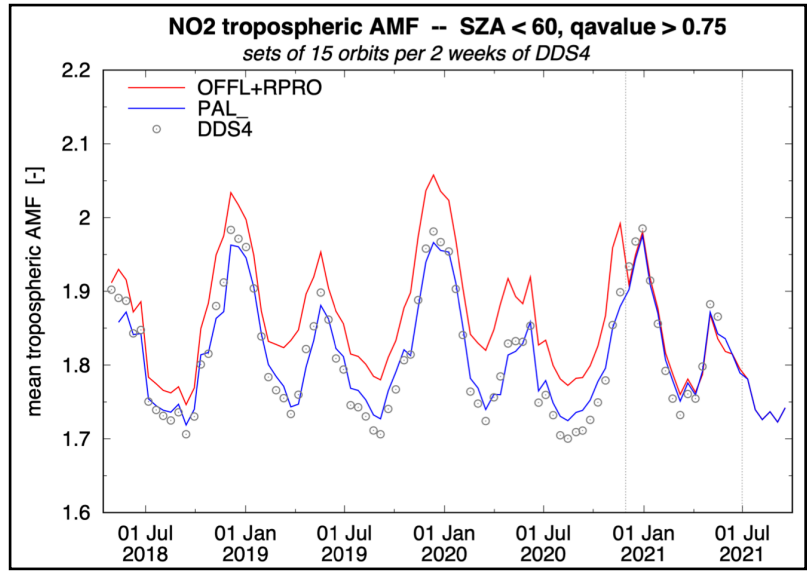
PAL reprocessed TROPOMI NO2 product, May 2018 - present



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



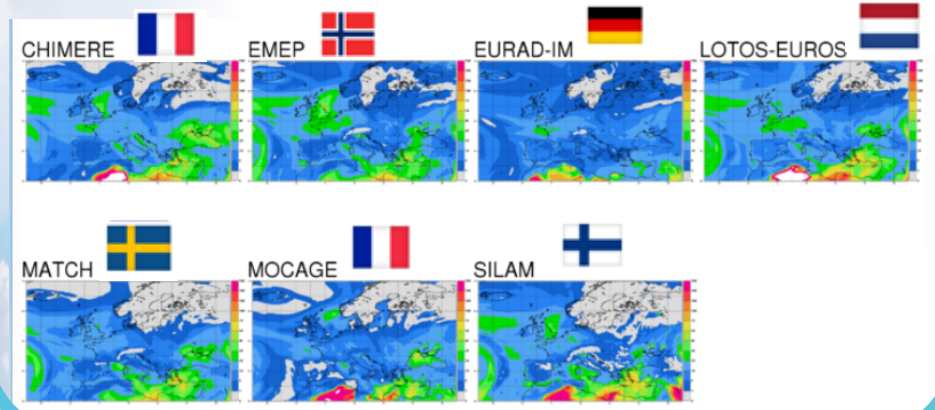


CAMS EUROPEAN AIR QUALITY PORTFOLIO

Atmosphere Monitoring

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)

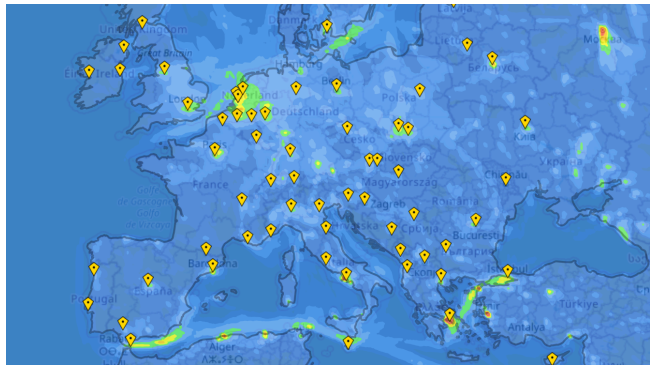
MINNI (ENEA)

MONARCH (BSC)

http://regional.atmosphere.copernicus.eu

Operational AQ ensemble

(incl. spread/uncertainty)



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

ECMWF Copernicus Europe's eyes on Earth European Commission