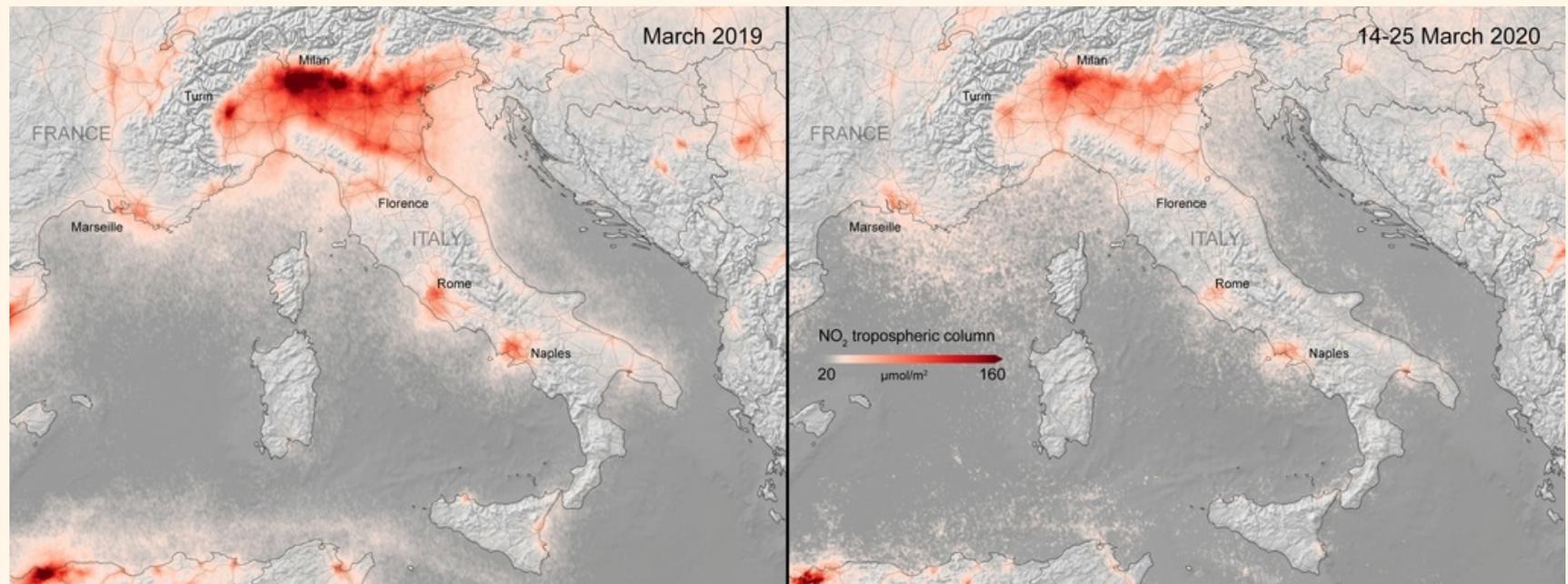


Five years of TROPOMI NO₂: A unique and detailed view on global air pollution

Jos van Geffen

Henk Eskes

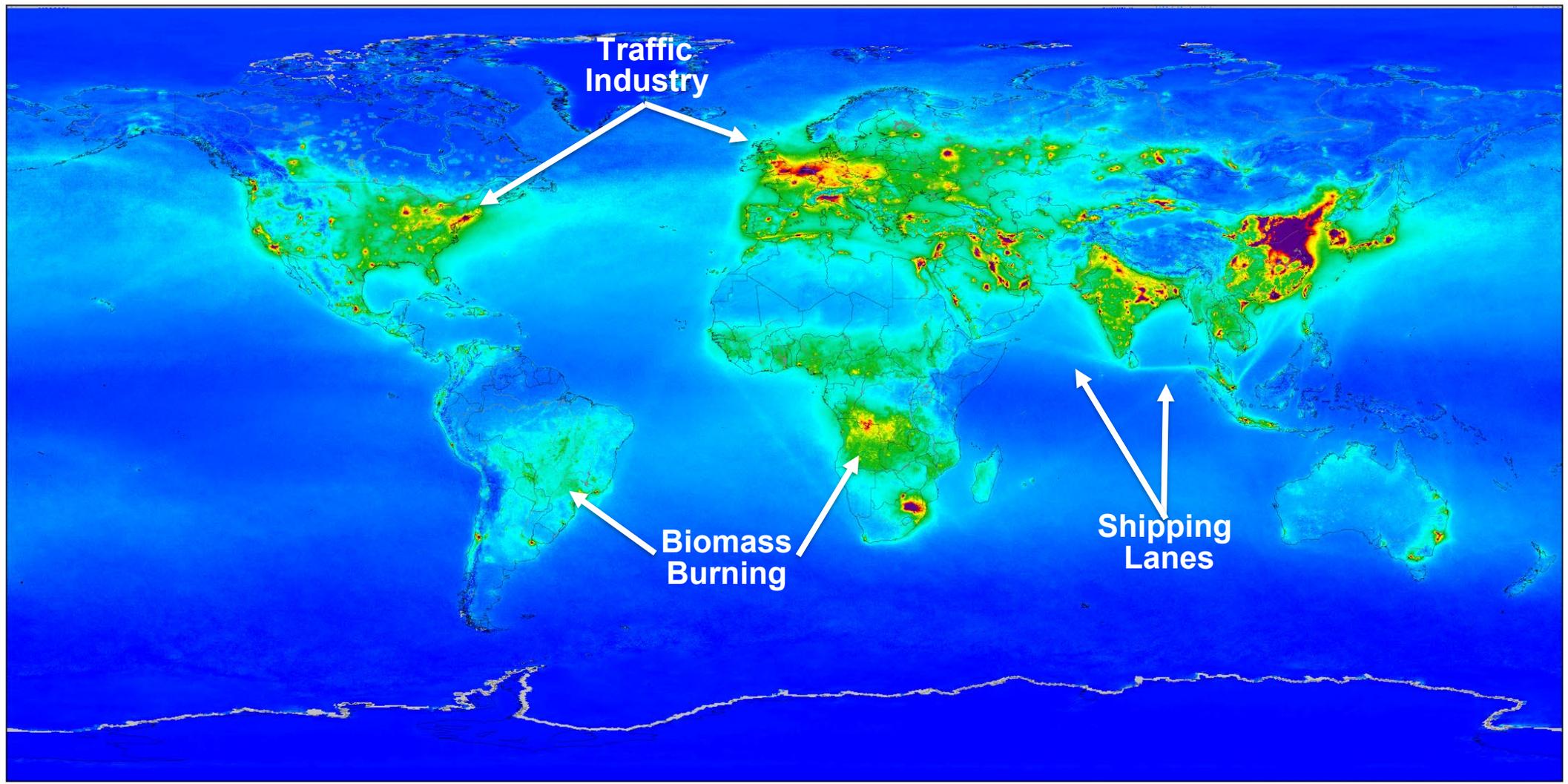
Folkert Boersma
Maarten Sneep
Mark ter Linden
Antje Ludewig
Pepijn Veefkind



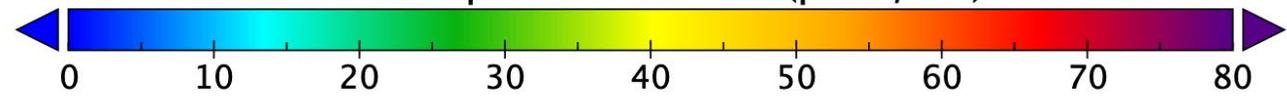
Comparison of tropospheric NO₂ before and during the COVID-19 lockdown.



S5P NO2, 2019 yearly mean



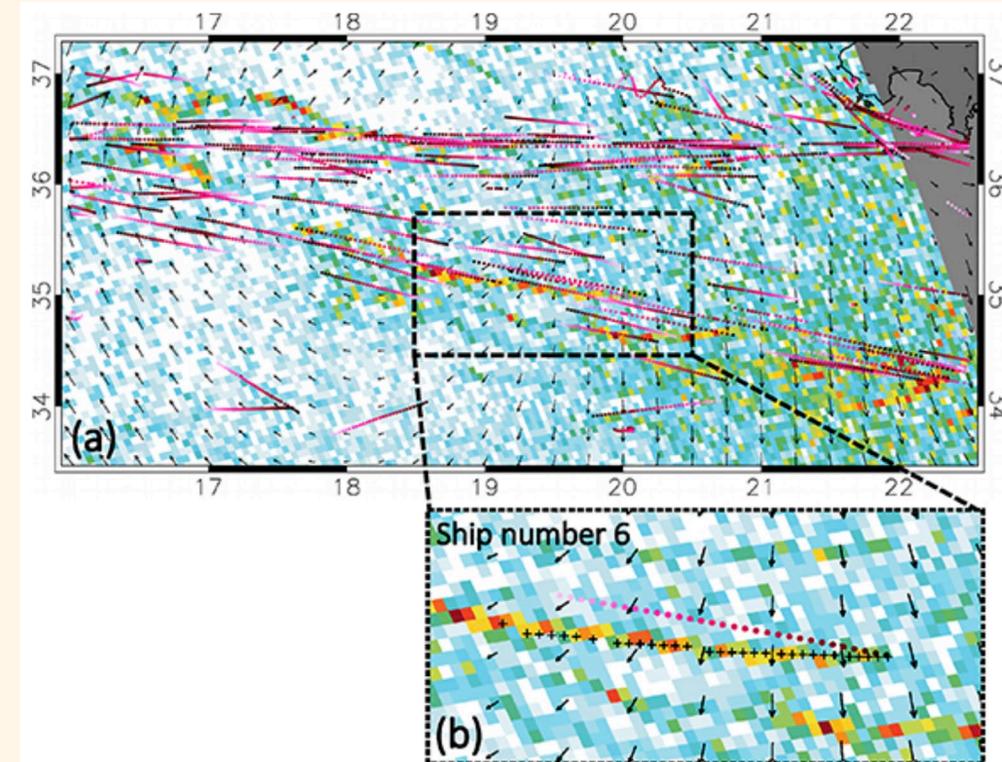
NO2 tropospheric column ($\mu\text{mol}/\text{m}^2$)



Applications of TROPOMI NO₂ vertical column data

Many applications of the NO₂ VCD_{trop}, some of which are discussed in earlier and following presentations, in arbitrary order:

- Monitoring of air pollution over time
- Forecasts of air pollution
- Impact on air pollution of covid lockdowns
- Emission estimates in relation to emission inventories
- Ship tracks & individual ships → *example plot*
- Lightning NO_x
- Comparisons with ground-based
- Comparisons with airborne measurements
- Comparisons with models
- Long-term time series
-



Georgoulias et al., ERL, 2020

>> Thanks to the NO₂ data users for their feedback <<

NO₂ processing scheme – essential steps in short

Retrieval of the (total) Slant Column Density (SCD):

radiance / irradiance → DOAS → SCD

Separation of total in tropospheric and stratospheric contribution:

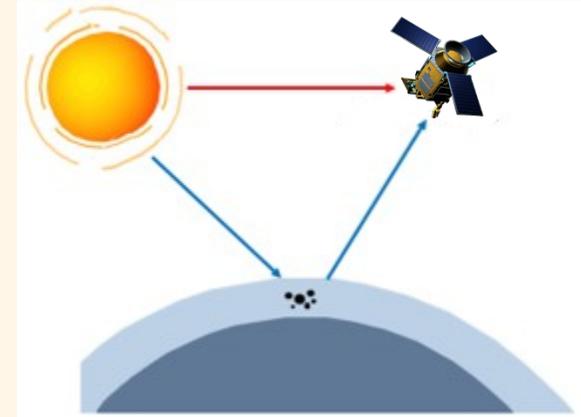
SCD → TM5 → SCD_{trop} + SCD_{strat}

Conversion to Vertical Column Density (VCD) with air-mass factor (AMF):

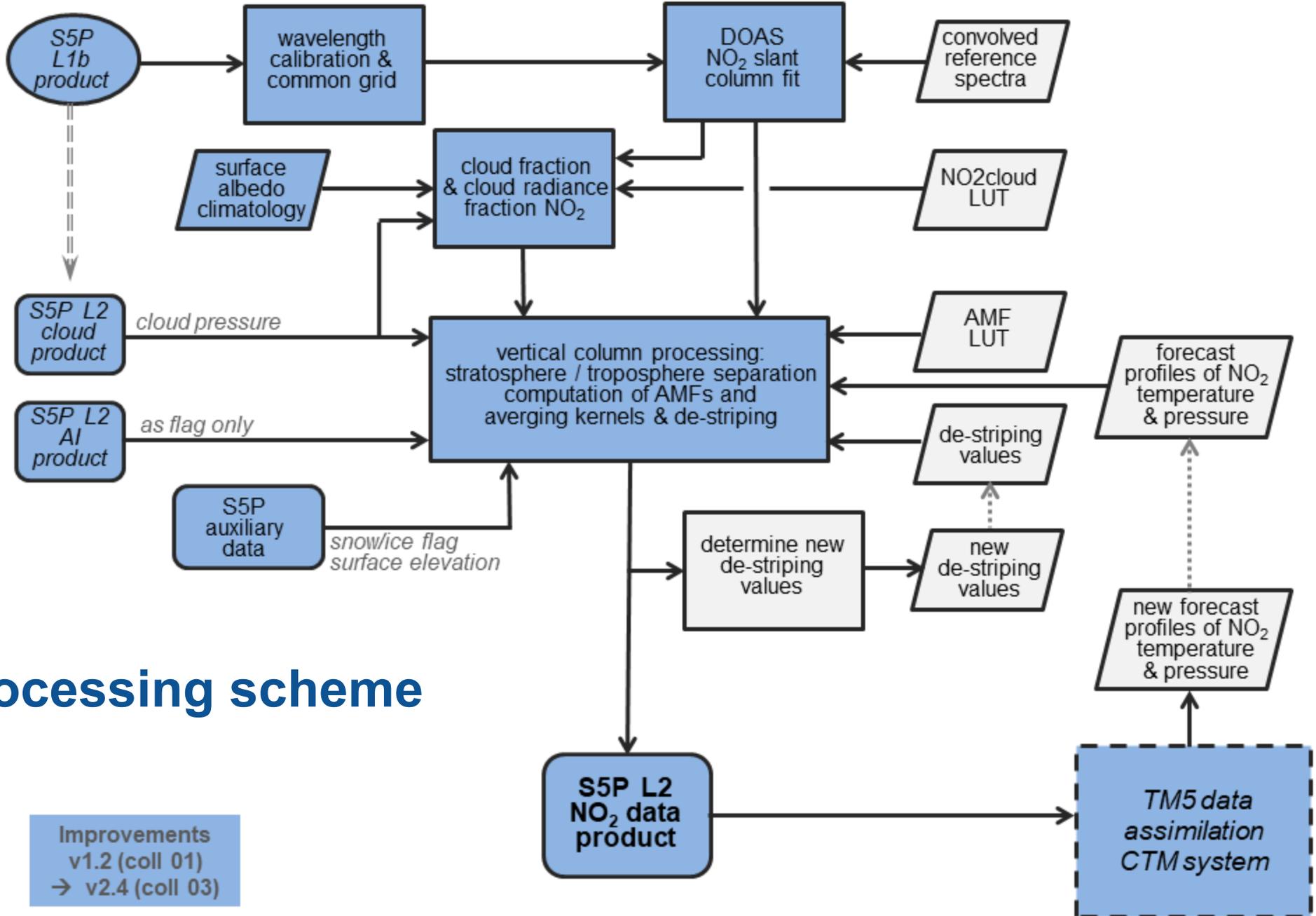
$VCD_{trop} = SCD_{trop} / AMF_{trop}$

taking into account e.g.:

- surface pressure & surface albedo
- cloud height & fraction & albedo *or* scene pressure & albedo *depending on snow/ice flag*
- NO₂ profile shape from TM5
- viewing geometry



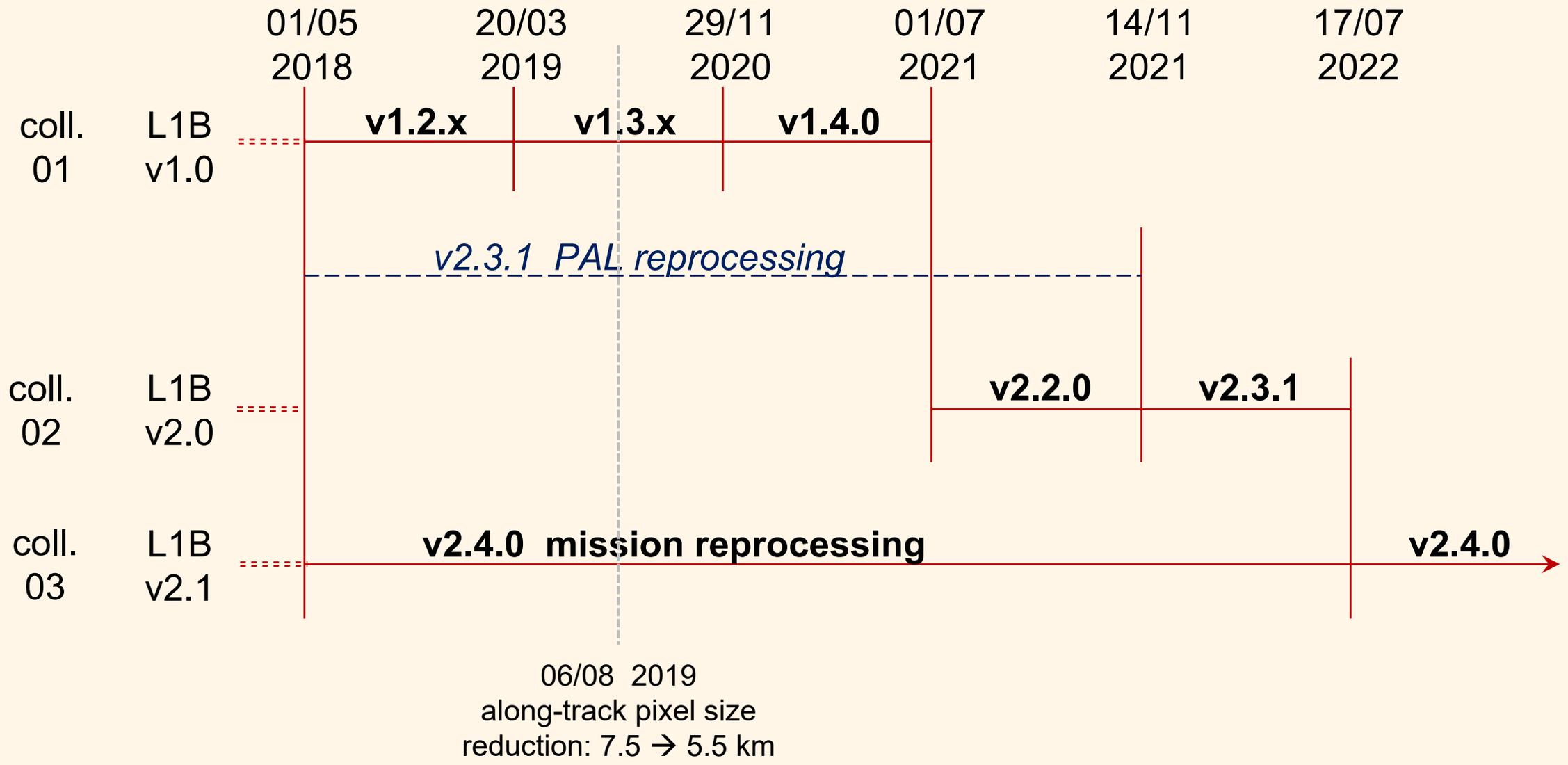
SCD = amount of NO₂ along sun-atmosphere-satellite path



NO₂ processing scheme

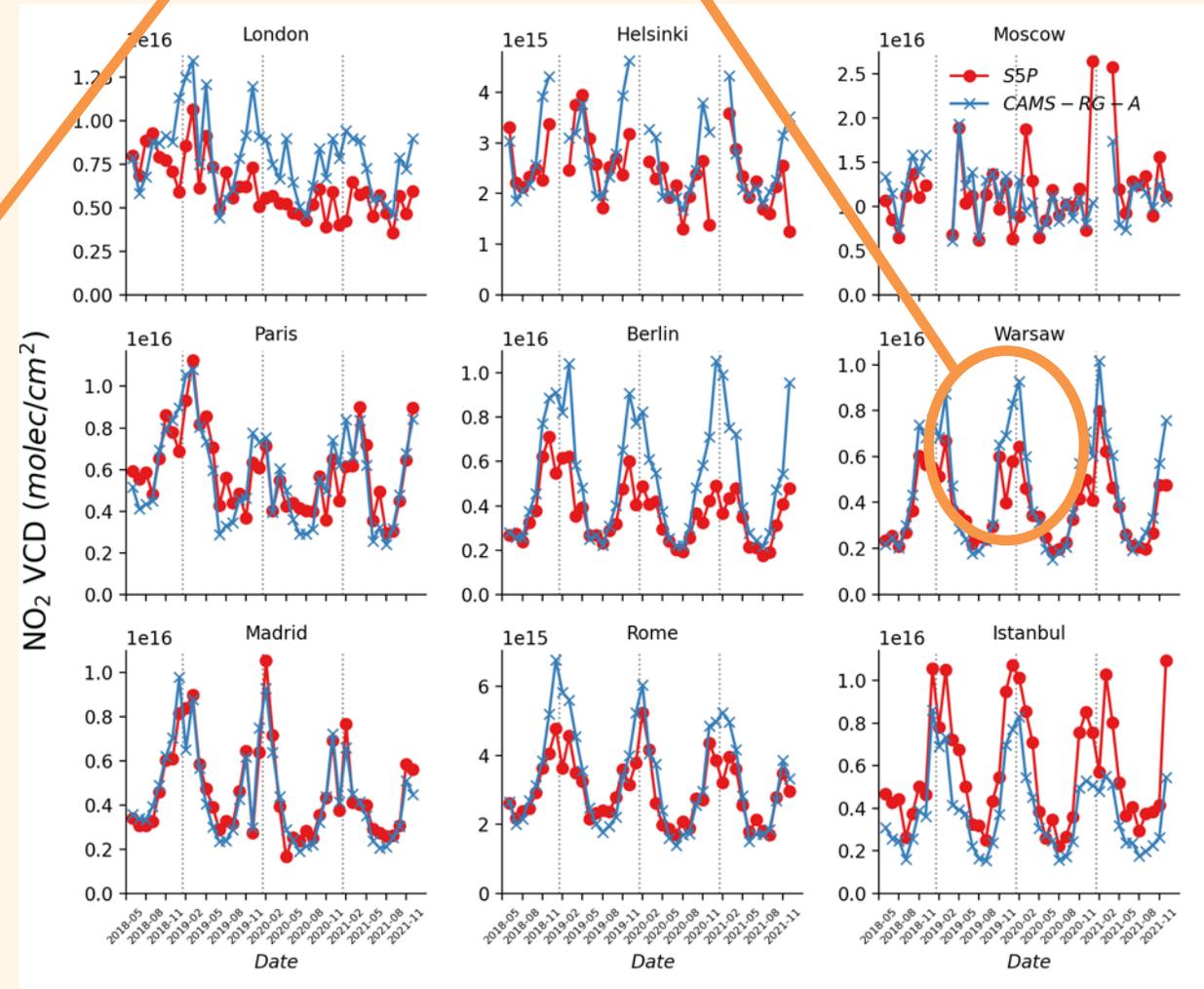
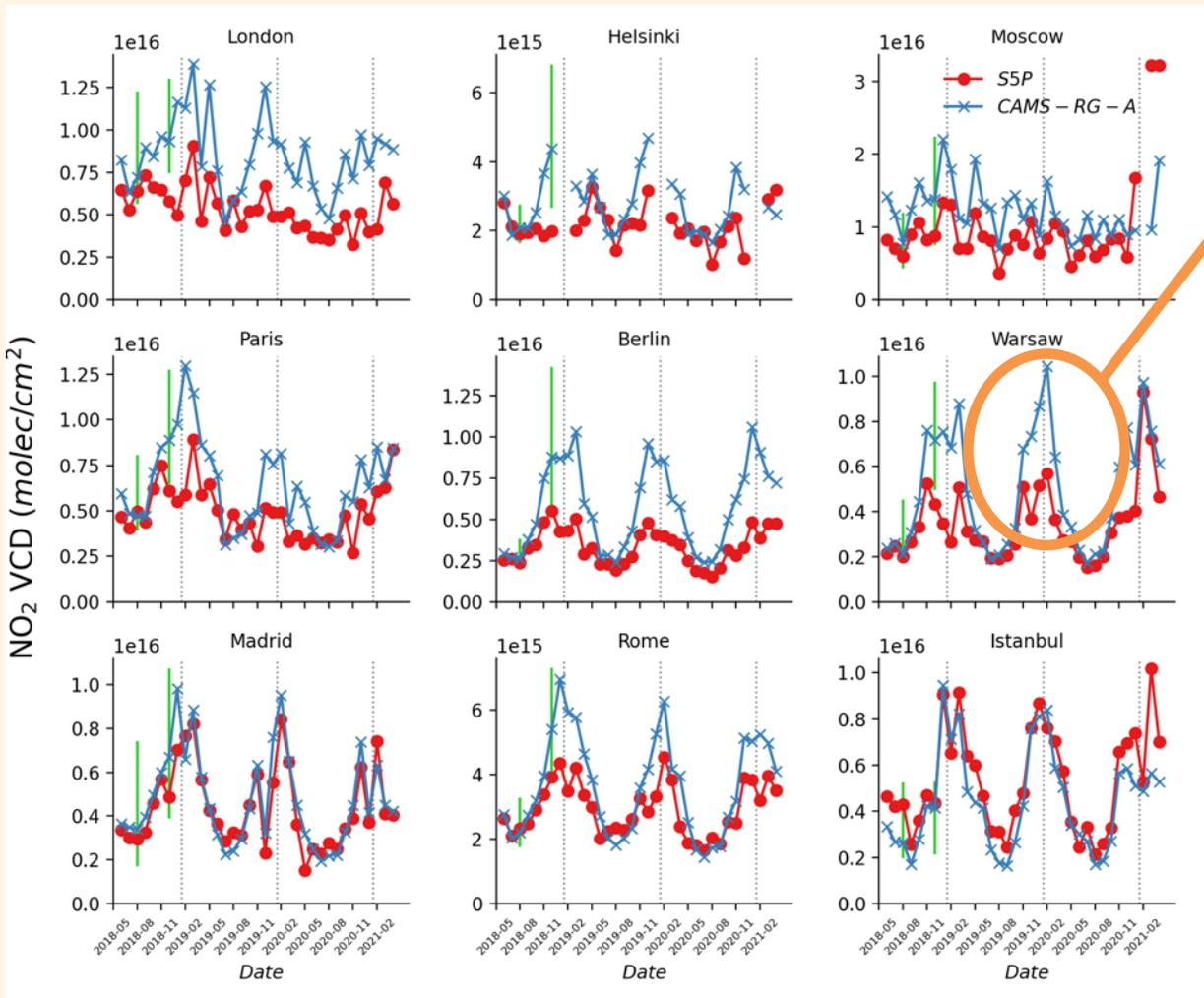
Improvements
v1.2 (coll 01)
→ v2.4 (coll 03)

Version confusion



Comparison over cities with CAMS

Increase due to use of PAL product



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

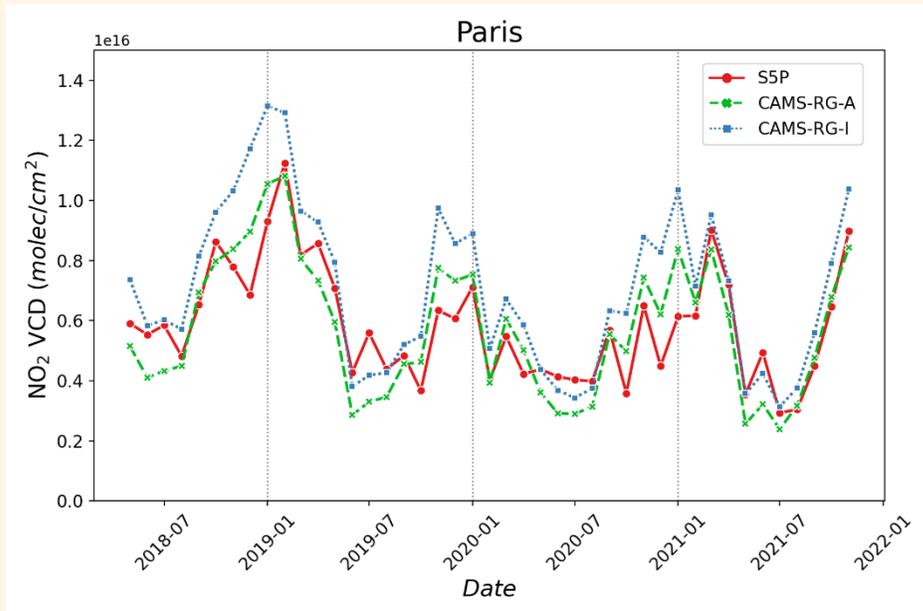
Using PAL reprocessed data (v2.3.1)

Comparison with CAMS-regional

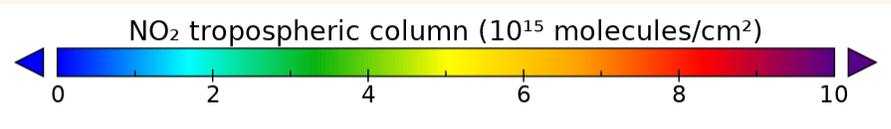
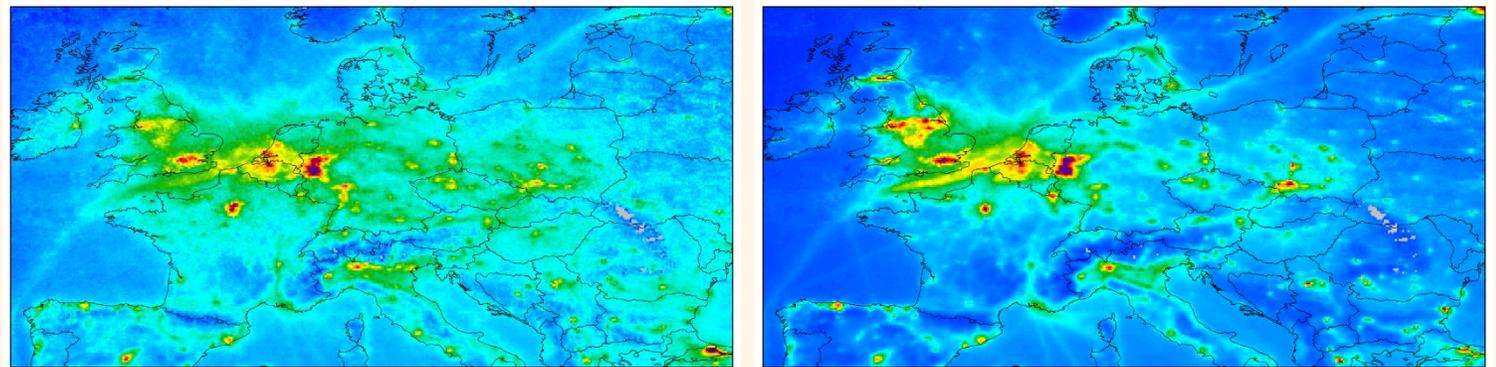
← From: John Douros et al., “Comparing Sentinel-5P TROPOMI NO₂ column observations with the CAMS-regional air quality ensemble,” *Geosci. Model Dev.*, in review.

It is important to account for differences in the NO₂ profile shapes when comparing with model or measurement data !

European tropospheric NO₂ data with CAMS a priori
 where the 1.0° x 1.0° TM5 profiles are replaced
 by the 0.1° x 0.1° CAMS profiles
https://www.temis.nl/airpollution/no2_cams.php



Monthly averaged S5P with CAMS-regional a priori (left) and CAMS-regional (right) columns for July 2018



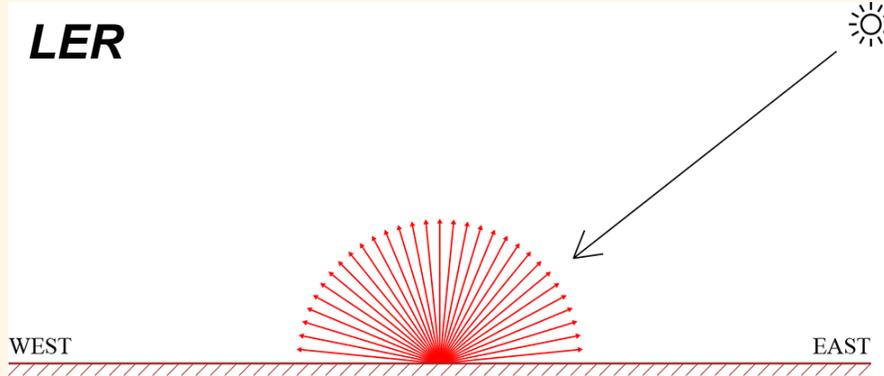
Surface albedo database: from LER to DLER

Versions v1.2.x – v2.3.1

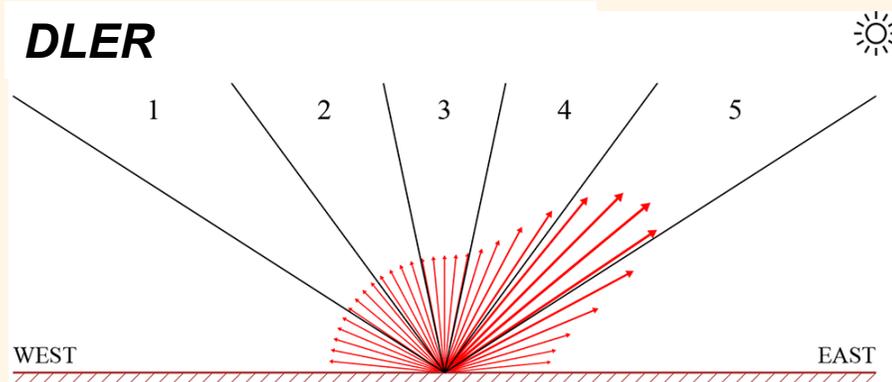
- For NO₂ window: OMI LER, 5-year version [Kleipool et al., 2008]
- For cloud retrieval: GOME-2 LER, v3.1 [Tilstra et al., 2017, 2021]

Version 2.4.0 & mission reprocessing

- For NO₂ & cloud retrieval: TROPOMI DLER (=directional-LER) v1.0 [Tilstra et al., in prep.]

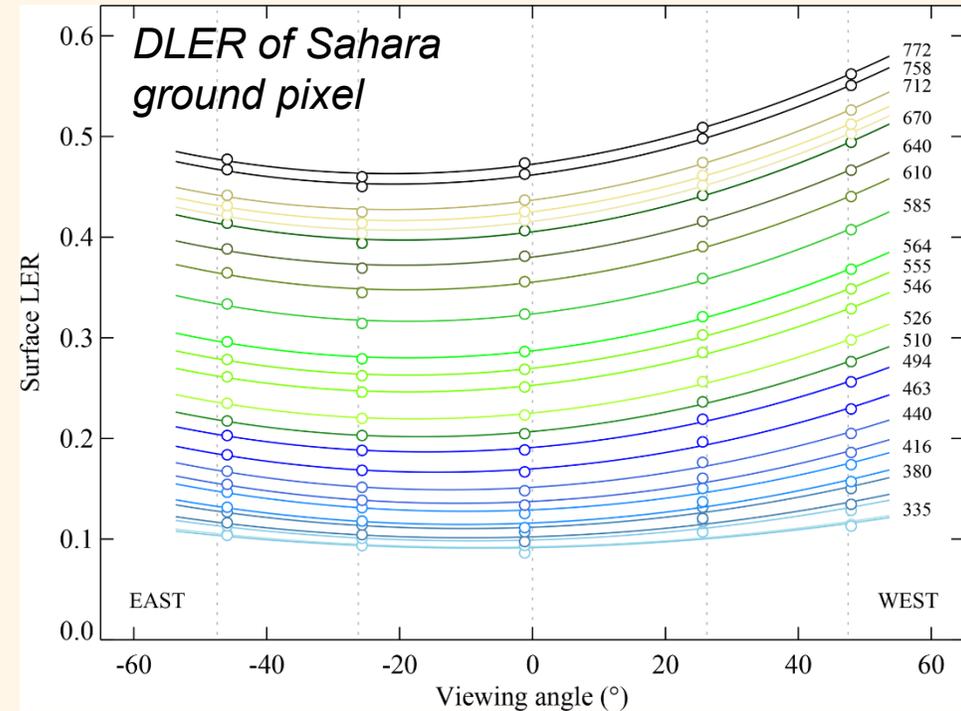


Figures from Tilstra et al. (2021) for GOME-2.



For GOME-2 the west side of the track has a higher albedo than the east side.

For TROPOMI it is the other way around.

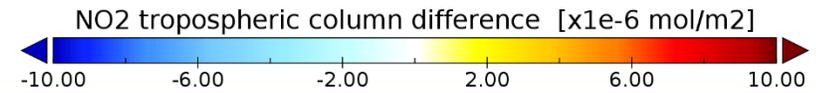
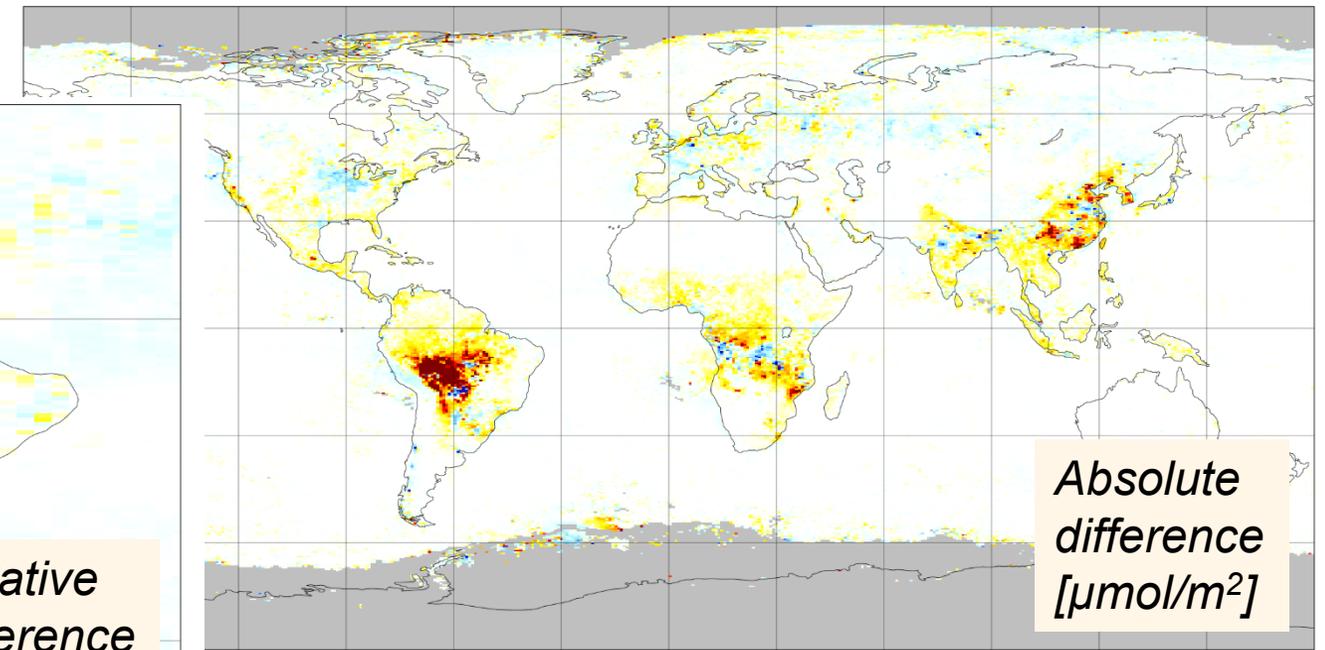
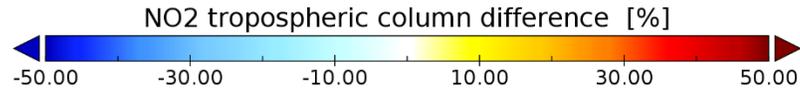
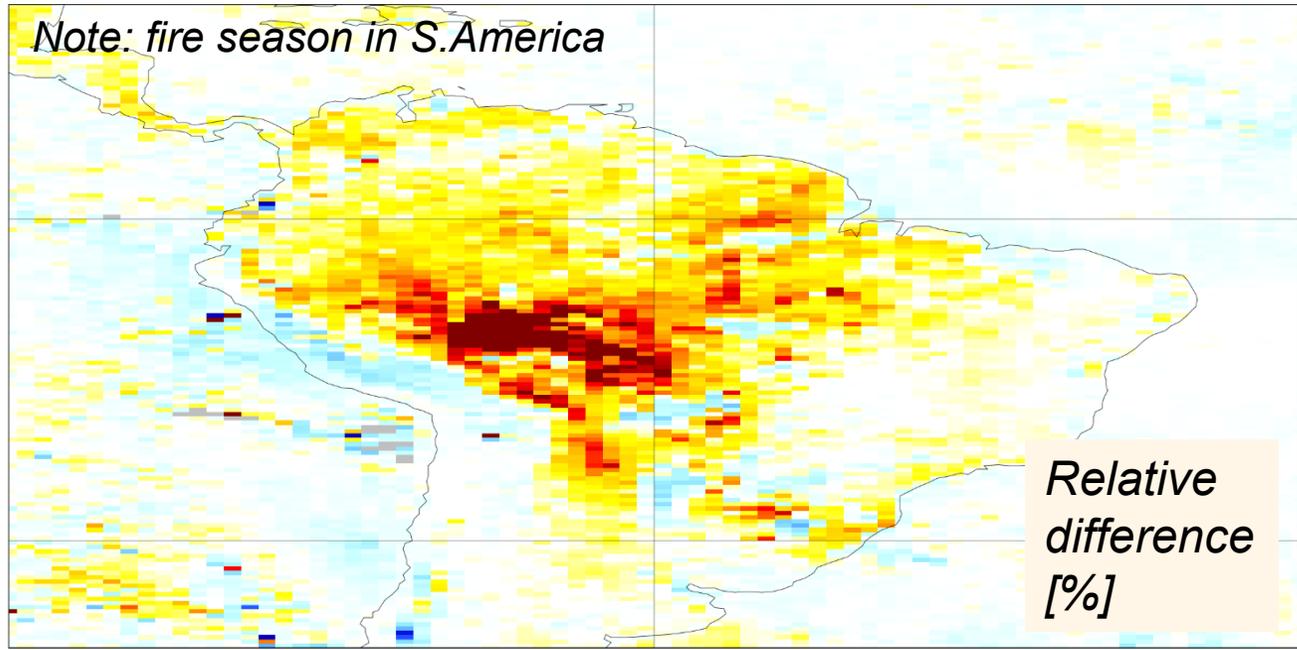


From LER to DLER: effect on NO₂ tropospheric VCD

Albedo → cloud pressure, cloud fraction, AMF → VCDtrop

Example: difference “DLER – LER” for 6 – 14 Sept. 2020 gridded average

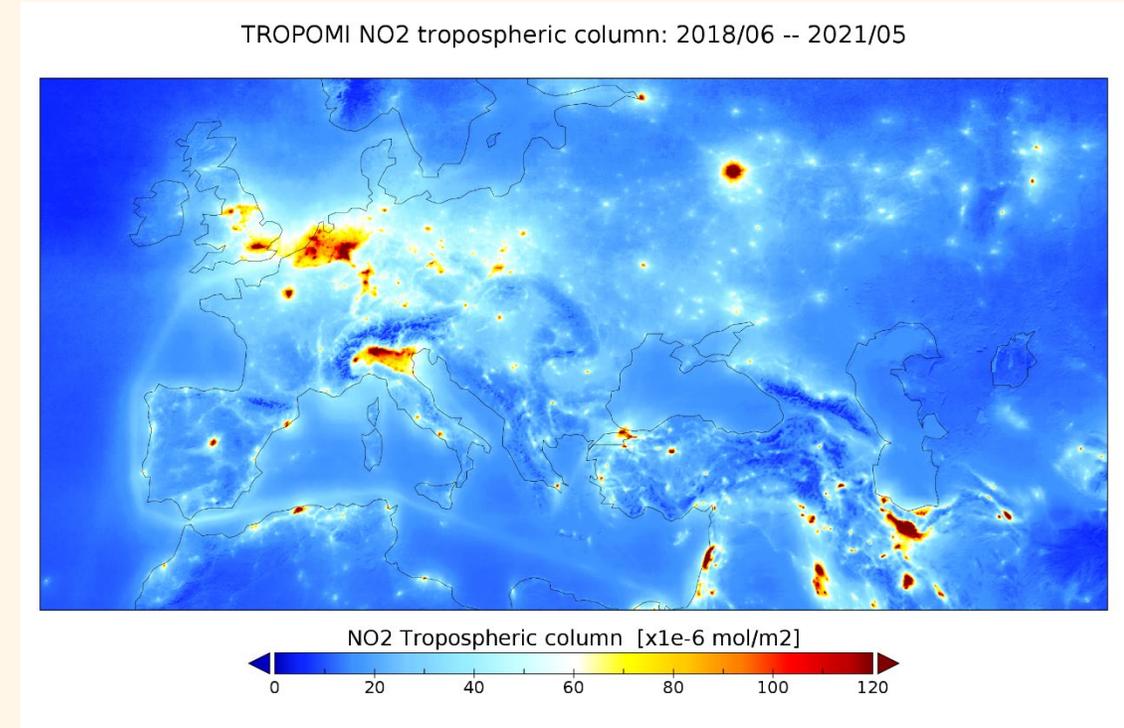
Note: fire season in S.America





Concluding remarks

- The unprecedented spatial resolution & signal-to-noise of TROPOMI allows for detailed monitoring of NO₂ emission sources.
- When comparing NO₂ measurements it is important to account for differences in the NO₂ profile shapes between these measurements.
- NO₂ v1.2 (collection 01) → v2.4 (collection 03):
 - improved L1b spectra → impacting NO₂ directly and via impact on cloud product
 - improved NO₂ retrieval algorithm
 - improved snow/ice flag
 - improved cloud algorithm
 - use of the new TROPOMI DLER v1.0 surface albedo climatology
-



>> Looking forward to the Collection 03 reprocessing data <<