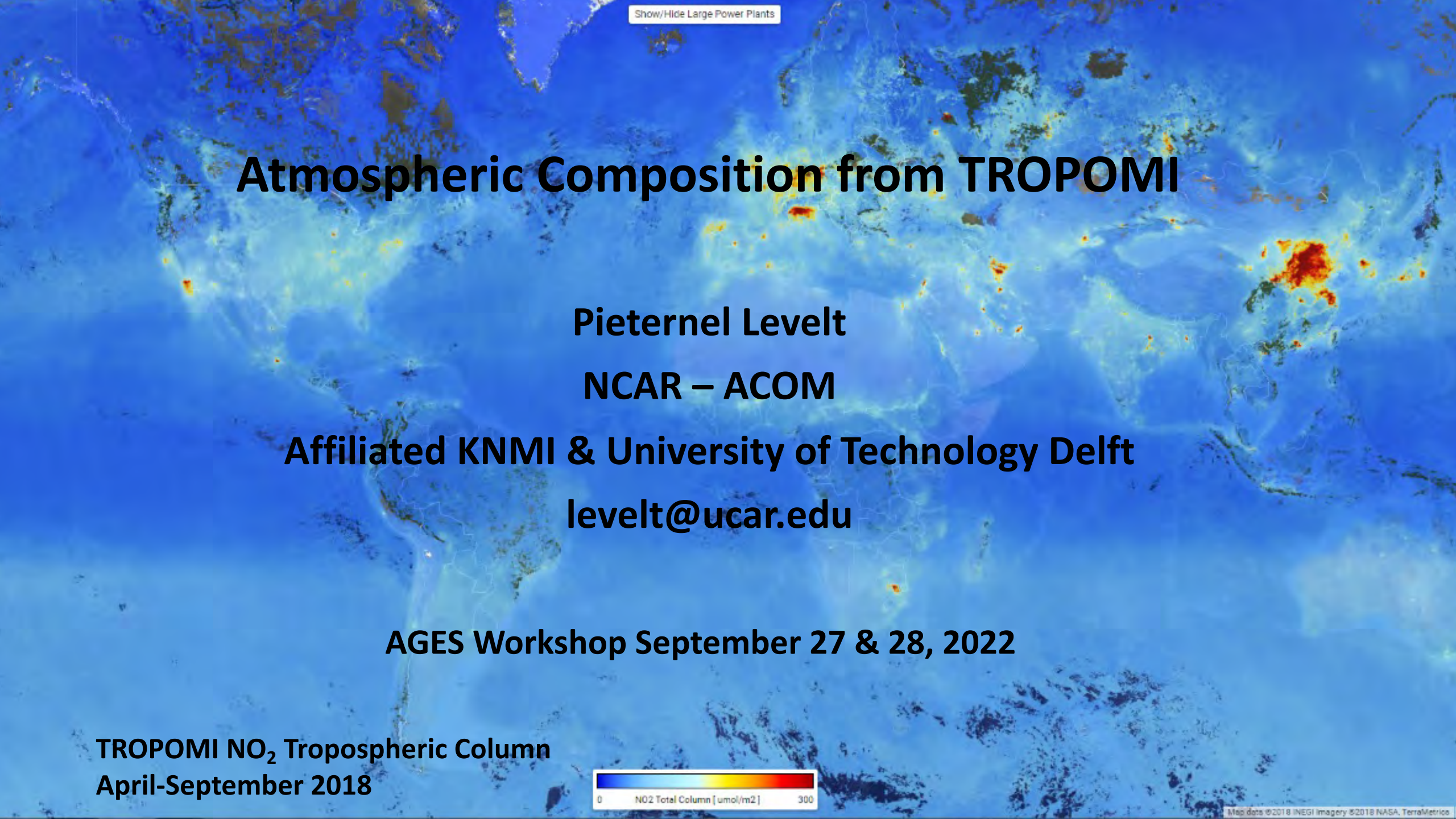


Atmospheric Composition from TROPOMI

Pieternel Levelt

NCAR – ACOM

Affiliated KNMI & University of Technology Delft

levelt@ucar.edu

AGES Workshop September 27 & 28, 2022

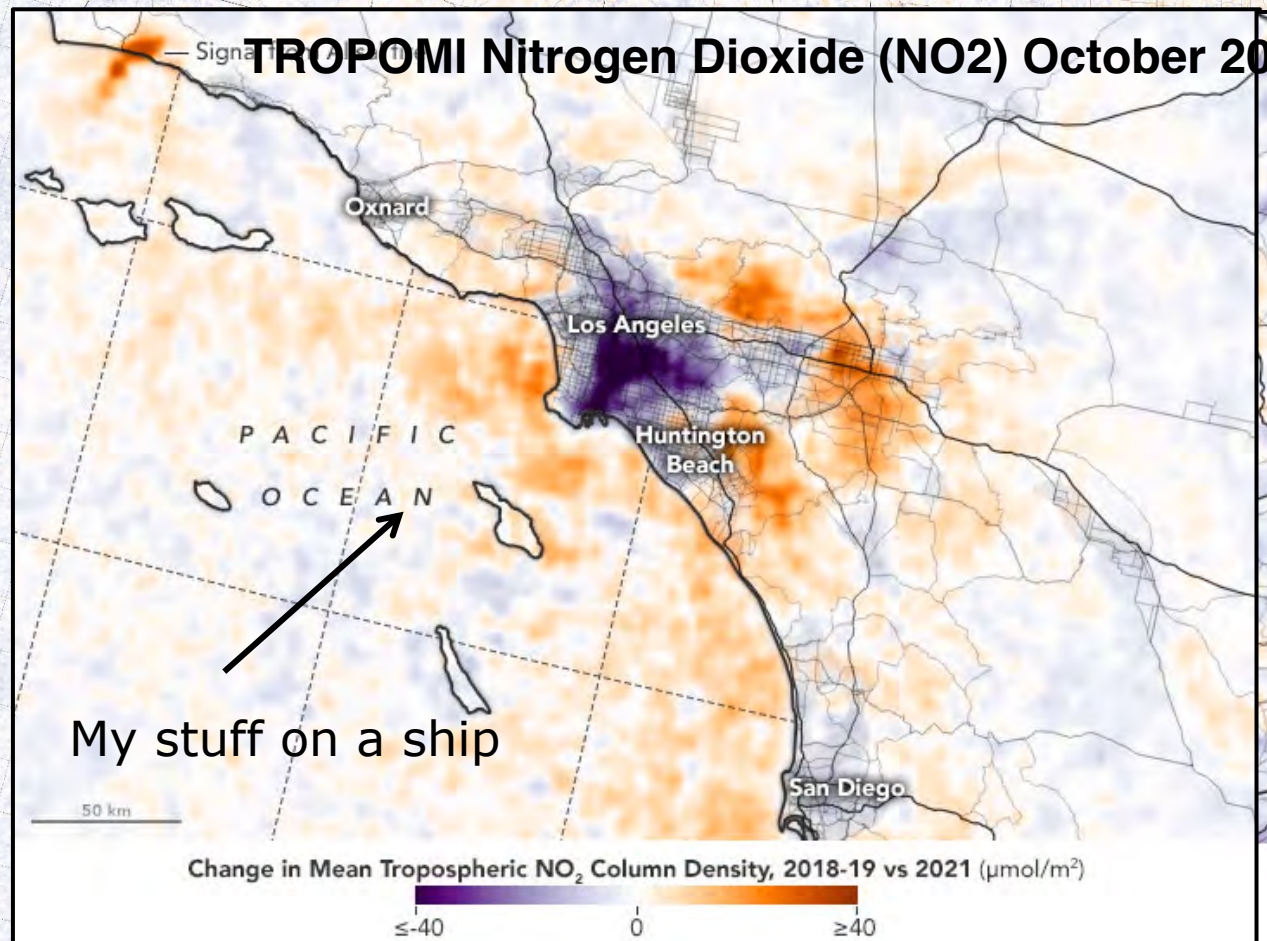
TROPOMI NO_2 Tropospheric Column
April-September 2018

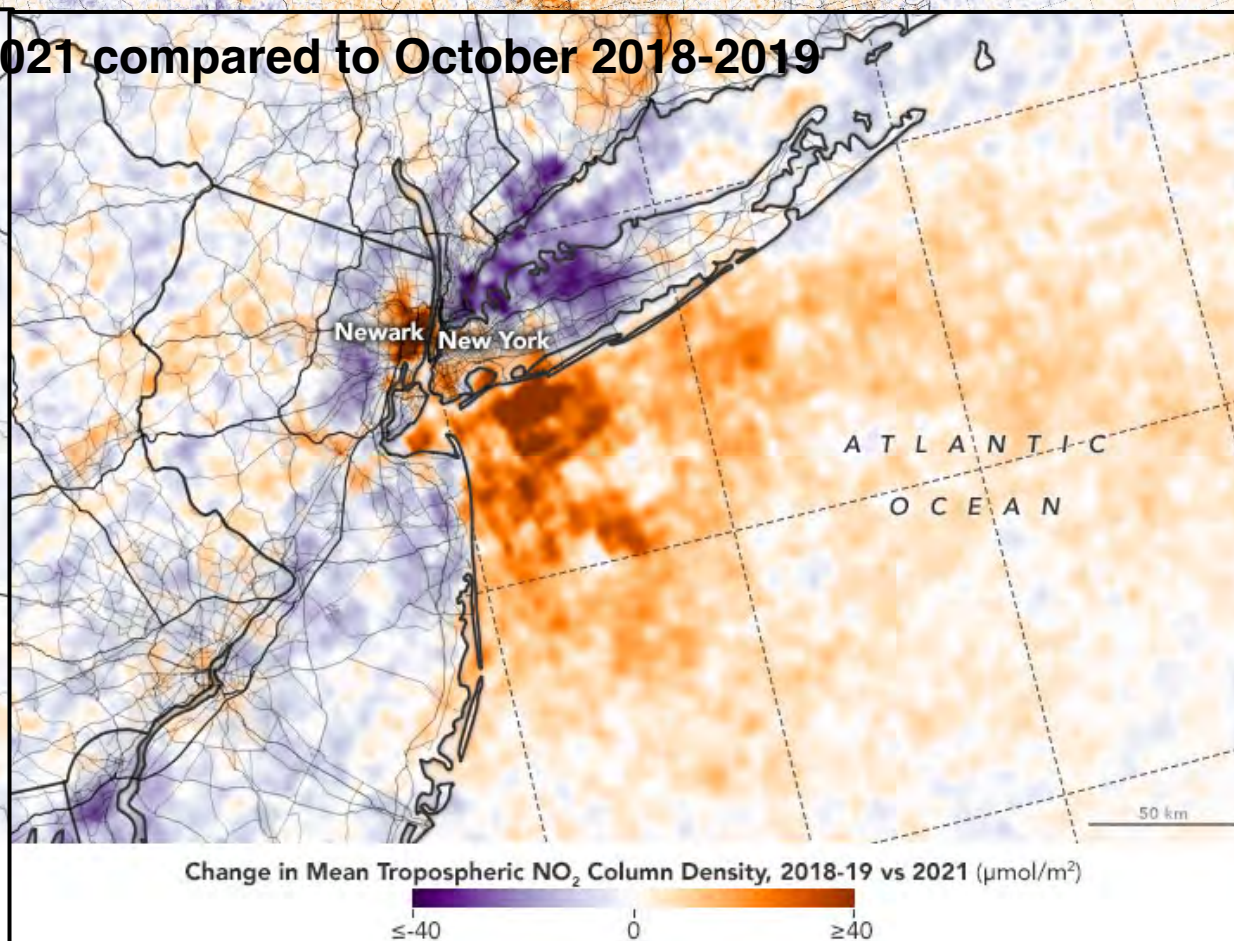
Satellite observations of nitrogen dioxide near key U.S. ports suggest that increased shipping activity and backlogs may be affecting air quality.

NASA Image of the Day for October 28, 2021 (Dan Goldberg, GWU)

Blue = decrease in NO2; red = increase in NO2 (2021 compared to 2018/19)

TROPOMI Nitrogen Dioxide (NO2) October 2021 compared to October 2018-2019



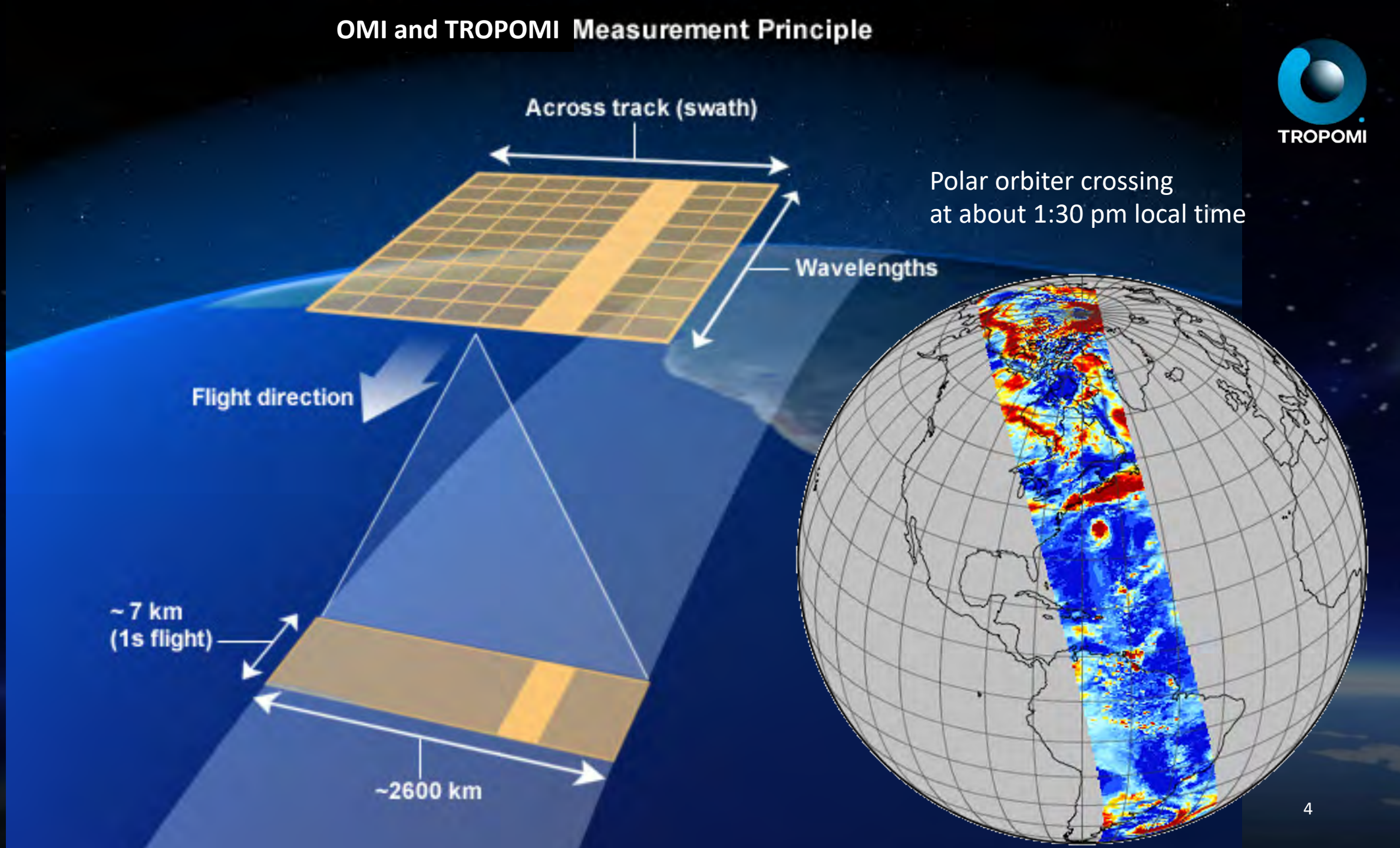


Applications TROPOMI

- The objective of TROPOMI is to provide accurate and timely observations of key atmospheric species, for services on **air quality, climate, and the ozone layer.**
- The TROPOMI daily global observations are used for improving **air quality forecasts as well as for monitoring** the concentrations of atmospheric constituents **(EU-CAMS : https://atmosphere.copernicus.eu/).**
- **Trend monitoring** is very important to verify the efficacy of policies implemented to reduce atmospheric emissions.
- In addition, TROPOMI contributes to **operational services** on volcanic ash for aviation safety, warnings for high levels of UV radiation that can cause skin damage, and to numerical weather prediction.

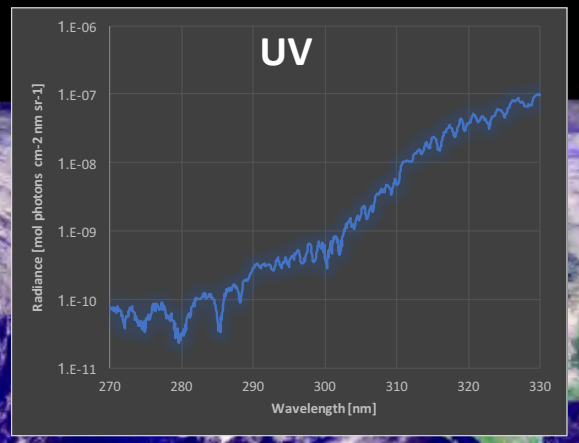
- New arising application field is **emission calculations- especially for methane.**

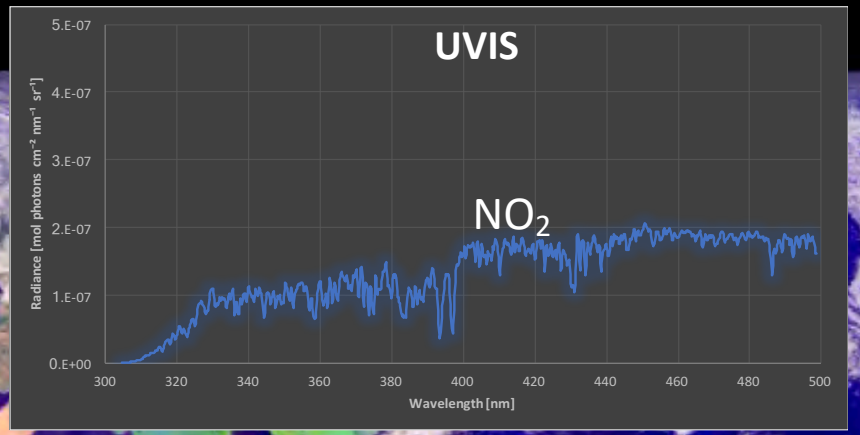
OMI and TROPOMI Measurement Principle



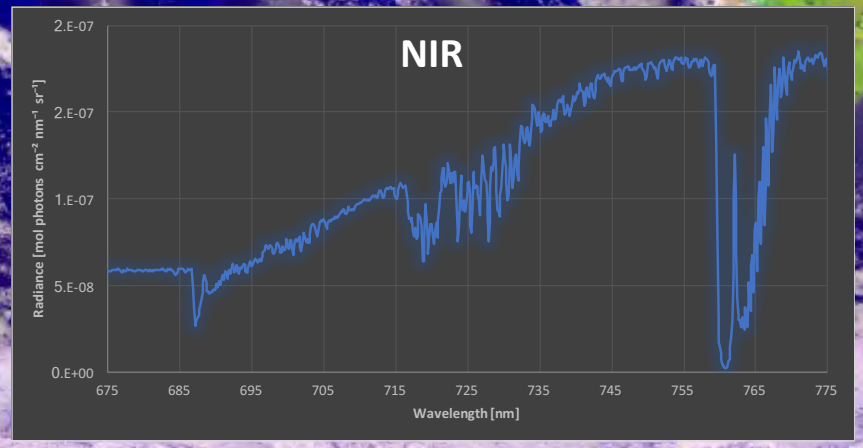
Polar orbiter crossing
at about 1:30 pm local time

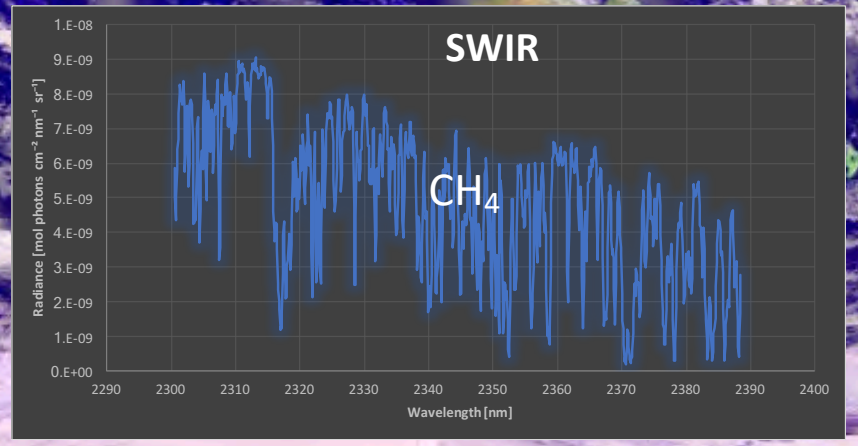
TROPOMI first measurement November 7, 2017





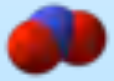
- 1 scanline per second
- 440 spectra per scanline
- 3000 scanlines per orbit
- 15 orbits per day
- 20 million groundpixels per day
- 225 Gbyte raw data per day
- 1 Tbyte L1b data per day





Veefkind, J. P., Aben, I., McMullan, K., Förster, H., de Vries, J., Otter, G., Claas, J., Eskes, H. J., de Haan, J. F., Kleipool, Q., van Weele, M., Hasekamp O., Hoogeveen R., Landgraf J., Snel R., Tol P., Ingmann P., Voors R., Kruizinga B., Vink R., Visser H., and Levelt P.F., .: TROPOMI on the ESA Sentinel-5 Precursor: A GMES mission for global observations of the atmospheric composition for climate, air quality and ozone layer applications, Remote Sensing of Environment, 120, 70–83, doi:10.1016/j.rse.2011.09.027, 2012.

TROPOMI Operational Data Products

Parameter	Data Product	Vertical Resolution	Bias	Random
Ozone 	Ozone Profile	6 km	10-30%	10%
	Total Ozone	total column	3.5-5%	1.6-2.5%
	Tropospheric Ozone	trop column	25%	10%
NO_2 	Stratospheric NO_2	strat column	<10%	0.5e15
	Tropospheric NO_2	trop column	25-50%	0.7e15
SO_2 	SO_2 enhanced	total column	30%	0.15-0.3 (0.06-0.12) DU
	Total SO_2	total column	30-50%	1-3 (0.4-1.2) DU
Formaldehyde 	Total HCHO	total column	40-80%	1.2e16 (4e15)
CO 	Total CO	total column	15%	<10%
Methane 	Total CH_4	total column	1.5%	1%
Cloud 	Cloud Fraction	total column	<20%	0.05
	Albedo (Optical Thickness)	total column	<20%	0.05 (10)
	Cloud Height (Pressure)	total column	<20%	<0.5 km (<30hPa)
Aerosol 	Aerosol Layer Height	total column	<100hPa	<50hPa
	Aerosol Type	total column	~1 AAI	<0.1 AAI
Surface UV	Provided by FMI in frame of the Finnish Sentinel Collaborative Ground Segment			

KNMI | DLR | BIRA-IASB | SRON | RAL |IUP-Bremen | MPIC | FMI

TROPOMI and AGES

- All TROPOMI level 2 products are available in NRT, with the exception of CH4. They can therefore be used for flight campaign planning, as was already done for e.g. FIREX-AQ, WE-CAN and LISTOS.
- In the past the OMI/TROPOMI team has used flight campaigns for the validation of the data products and the assumptions on for example the trace gas profile. For that we need column and profile measurements. An in-situ measurement at a certain altitude only is less useful.
- Any flight campaign data and satellite measurements can also be used in concert together with modelling capabilities to study specific phenomena in the atmosphere.

Challenges in current TROPOMI retrievals and emission calculations.

- Due to the high spatial resolution TROPOMIs retrievals are more challenging than for example OMI. Detailed information on **aerosols, clouds and albedo** together with the specific trace gas measured is therefore important for improving the retrieval and get an improved assessment of the errors made in the retrieval.
- Confirmation of **emission calculations** based on TROPOMI data: Requires amongst others in-situ flight campaign data around a clearly defined emission field and also vertical profiles and/or column measurements from aircraft (for example NO2, SO2 and methane).

Conclusions

- TROPOMI NRT data can be used for flight planning
- The satellite data and flight campaign data can be used in concert for scientific research
- TROPOMI can benefit from the aircraft campaign data – depending on the exact plans for these aircraft campaigns

- Contact institutes are KNMI and ESA

Information for Scientists

- www.tropomi.eu
  - Information on data L1/L2 products and documentation (ATBD, PUM, README).
  - Publication list (please inform us about your latest one!)
- mps.tropomi.eu
  - Orbit calendar, lots of calibration data. SWIR specific results: https://www.sron.nl/tropomi-swir-monitoring
- mpc-vdaf.tropomi.eu
  - Validation reports and access to automated validation results.
- https://sentinels.copernicus.eu
  - Mission descriptions and documentation.
- s5phub.copernicus.eu
  - Access to the data
  - Support please send an e-mail to eosupport@copernicus.esa.int
- disc.gsfc.nasa.gov
  - NASA data mirror
- maps.s5p-pal.com
  - Gridded images of NO_2 and CO.