# TROPOMI : a 'game changer' for atmospheric composition from space

## *Early results*

**Ilse Aben** (SRON), Pepijn Veefkind (KNMI)  on behalf of the TROPOMI team

Kleipool, Antje Ludewig,   Henk Eskes, KNMI

Landgraf, Hoogeveen, Hu, Borsdorff, Hasekamp, Tol, van Hees, Houweling et al.  SRON

Angelika Dehn, Diego Loyola, Herbert Nett, Andreas Richter, Michel van Roozendael,

Richard Siddans, Thomas Wagner, Pieternel Levelt   - **and many more**

# TROPOMI: a European co-operation

- TROPOMI is the single instrument on S5-Precursor and developed by The Netherlands and ESA;

- Part of the EU Copernicus programme; and the 1$^{st}$ atmospheric Sentinel

- National contributions from Belgium, Germany, the UK and Finland;

- For all European citizens, policy makers, researchers, commercial companies.
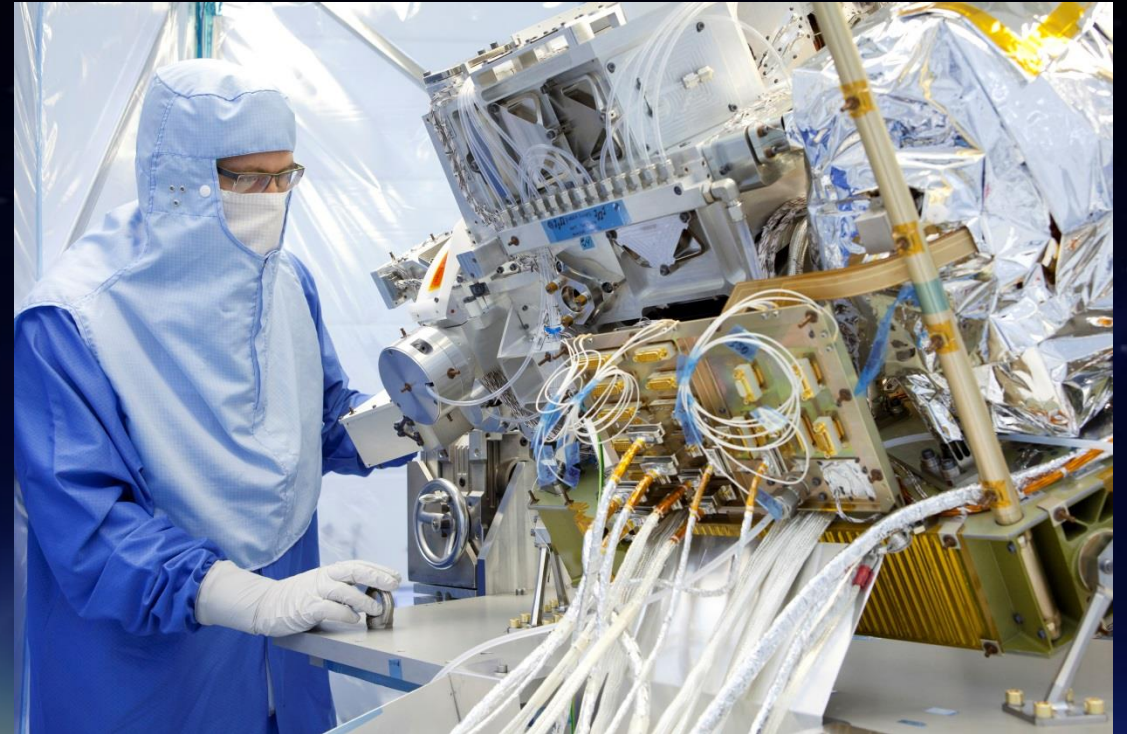
# TROPOMI applications

- Air quality forecast and assessment
- Emission monitoring
- Climate data records
- UV-index
- Volcanic ash detection for aviation safety

# Data Products – fact sheet

| Product Total columns |
|---|
| Ozone |
| NO$_2$ |
| CO |
| CH$_2$O |
| CH$_4$ |
| SO$_2$ |
| Aerosol |
| Clouds |
| UV-Index |

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

**Spatial resolution** : 3.5 x 7 km$^2$ (city scale)
**Global coverage in one (1) day**

**Wrt previous intruments :**

- Higher spatial resolution (> 12x)
- higher sensitivity
- More measurements (20 M/day)



across track (swath)
wavelengths
Flight direction
~7 km (1 s flight)
~2600 km

**Launch** : 13 Oct 2017
**Commissioning phase** 6 months
**Operational** phase since end April

**Public release of data** : starting end June (L1B, O$_3$, NO$_2$, CO, clouds, AAI)

**Near-Real-Time** data : 3 hours after sensing
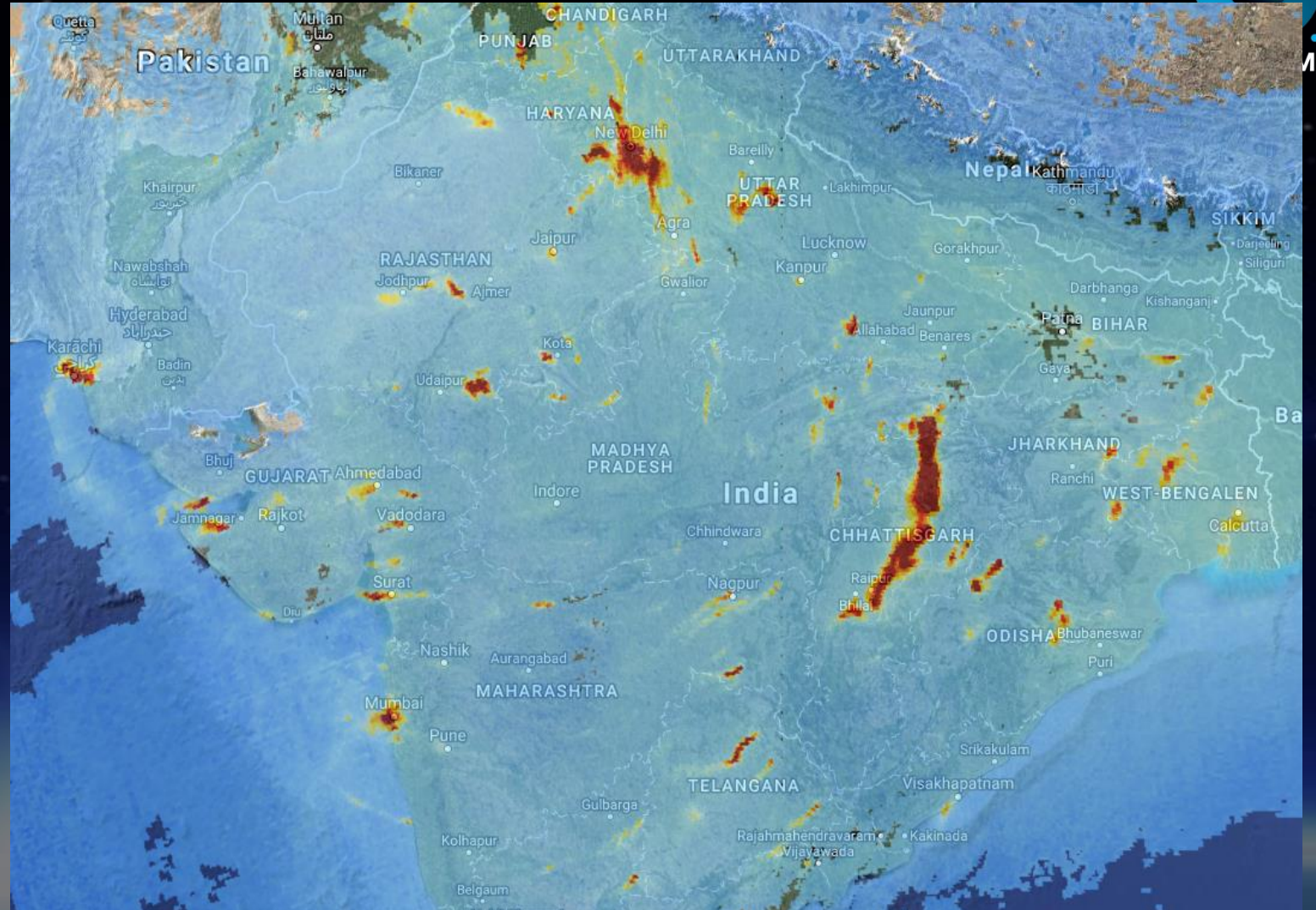**OffLine** products : < 2 weeks after sensing

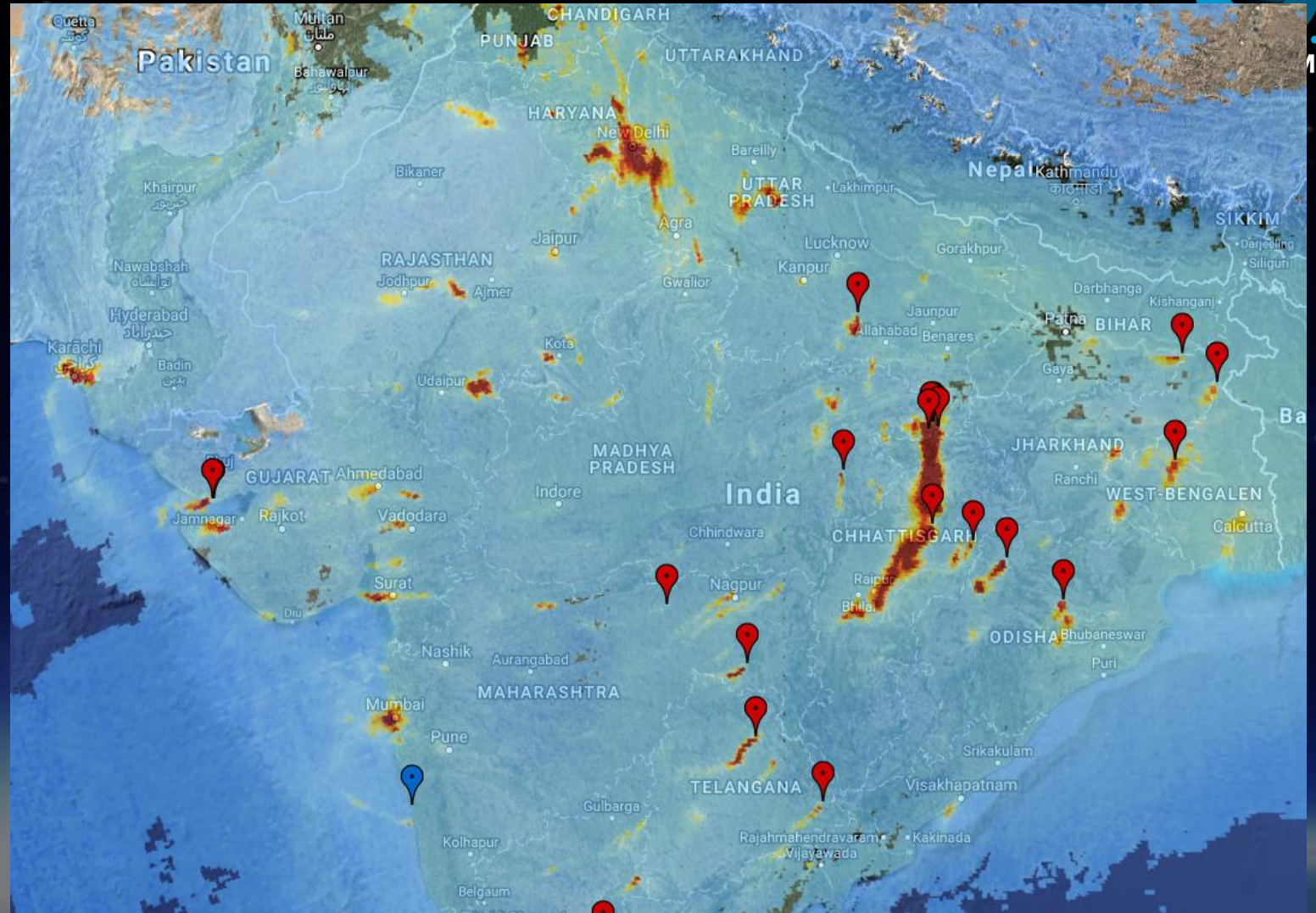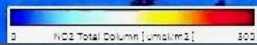NO$_2$ pollution **plumes** visible From space

KNMI/NSO/ESA

NO$_2$ 07-11-2017

TROPOMI

wind
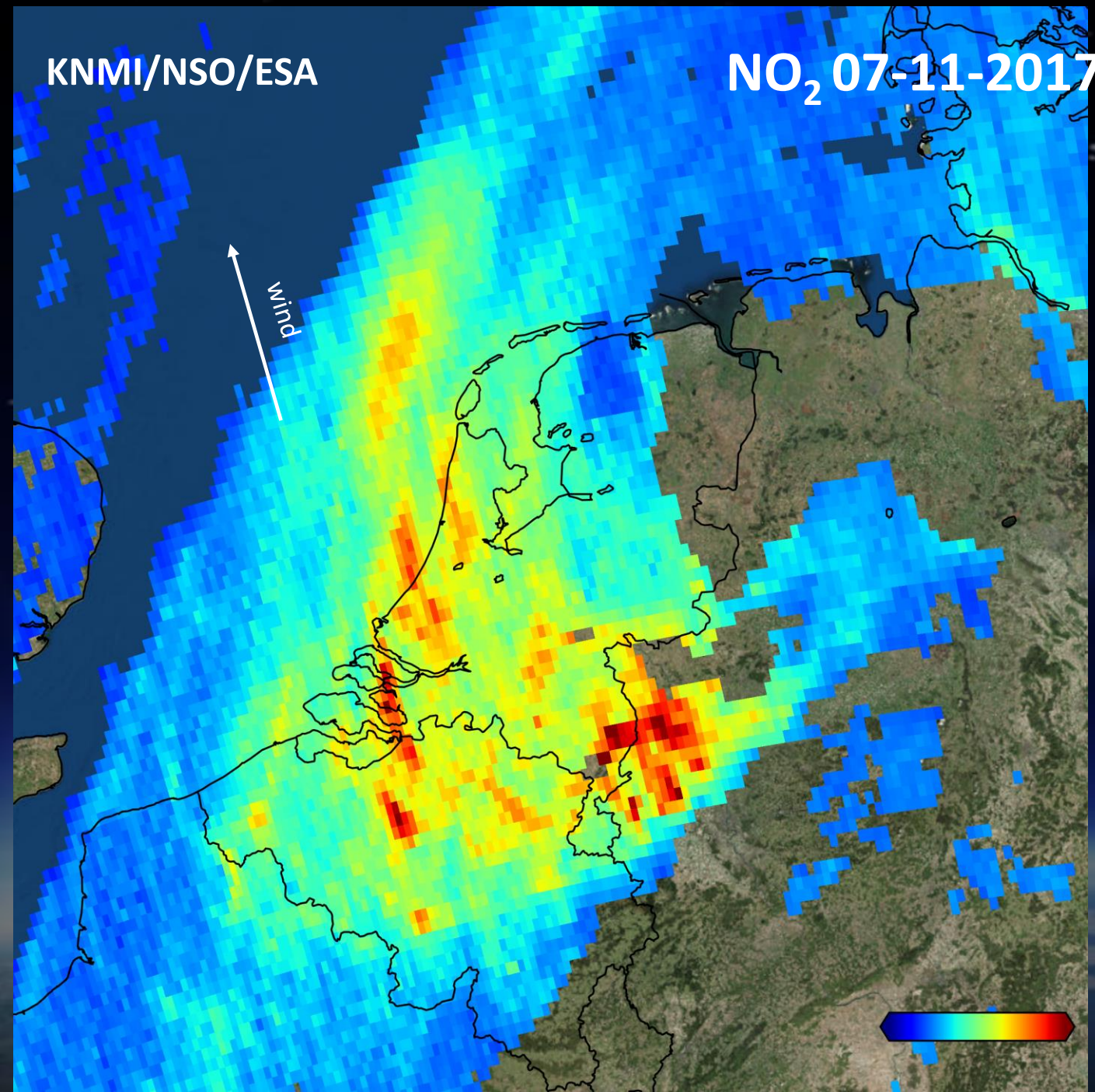
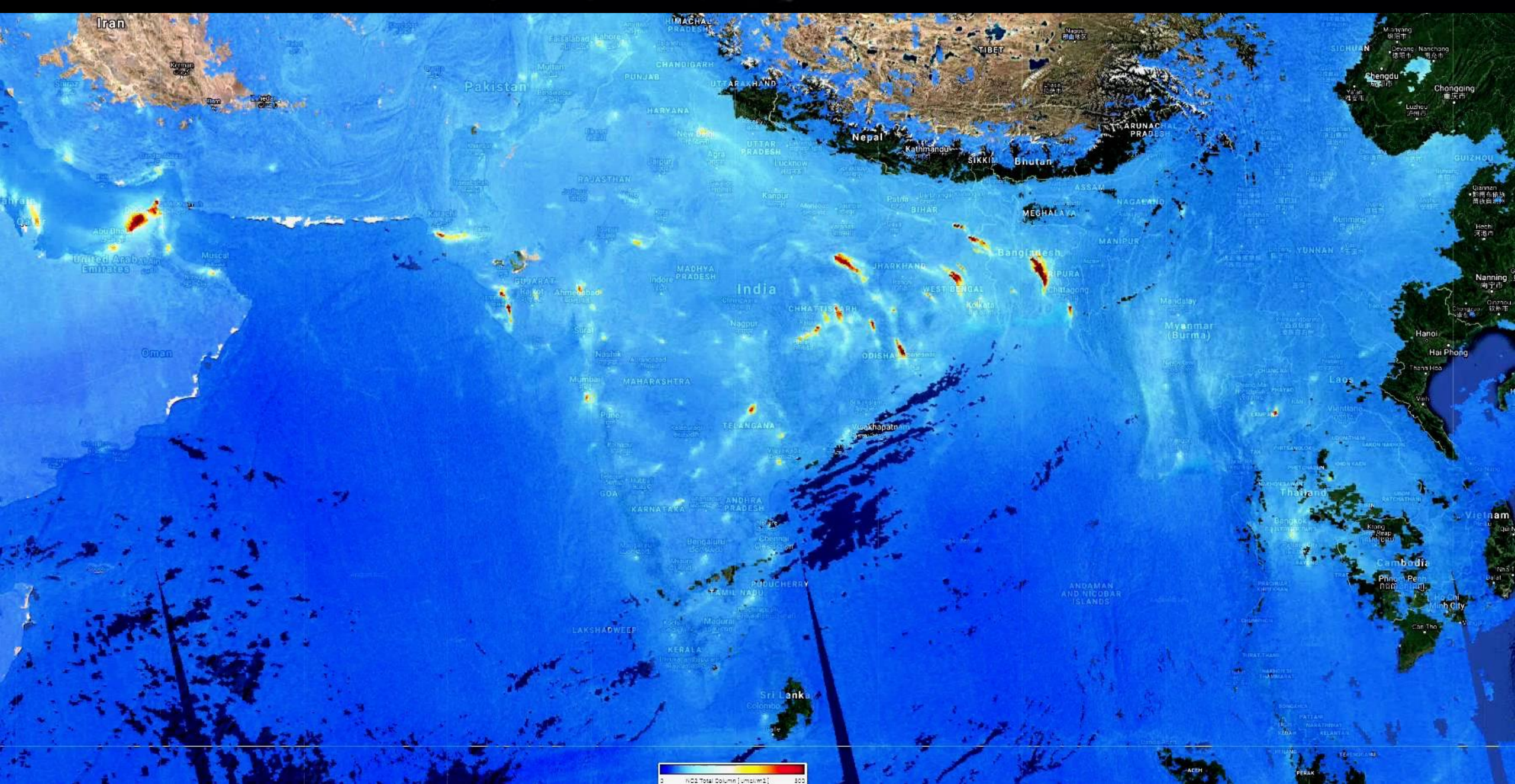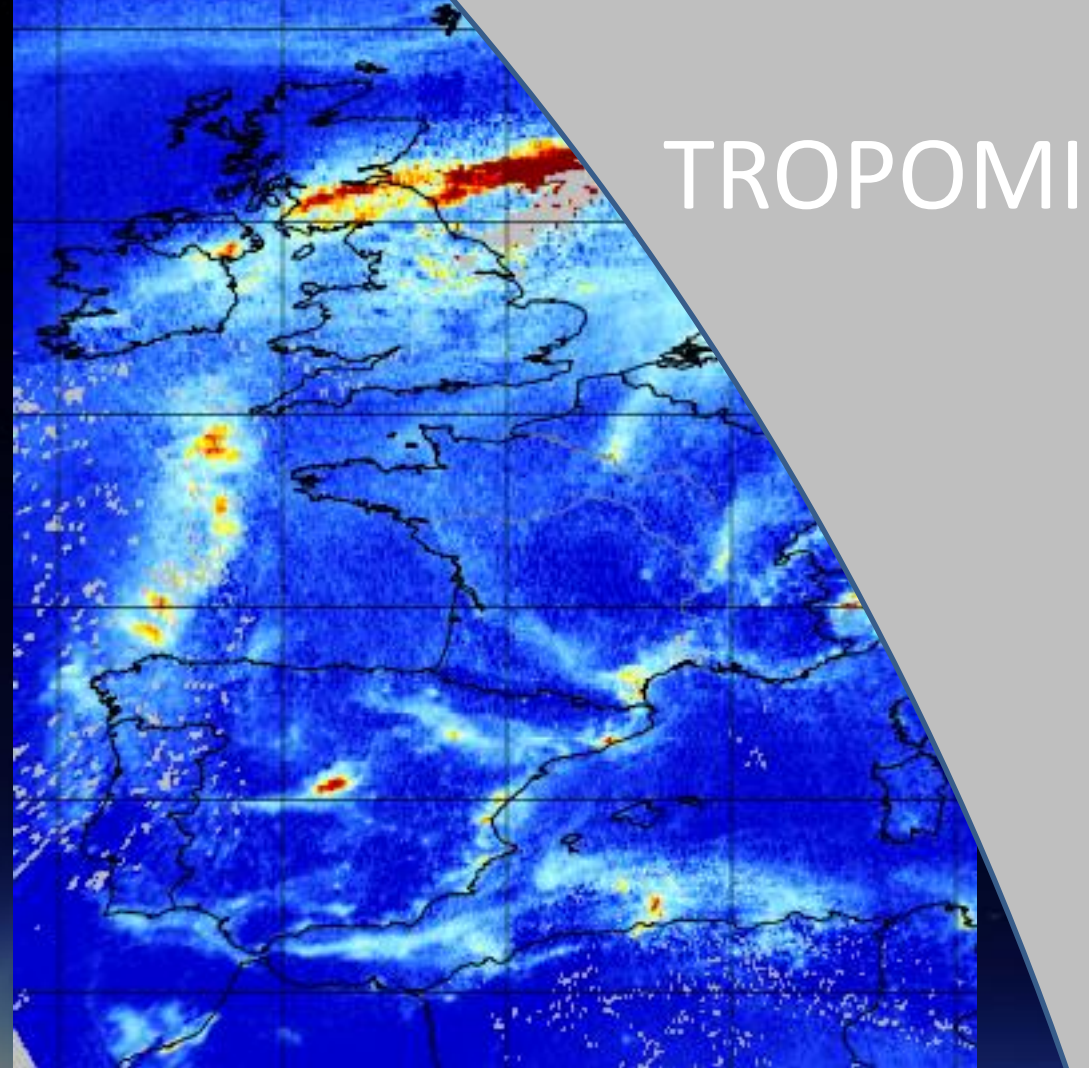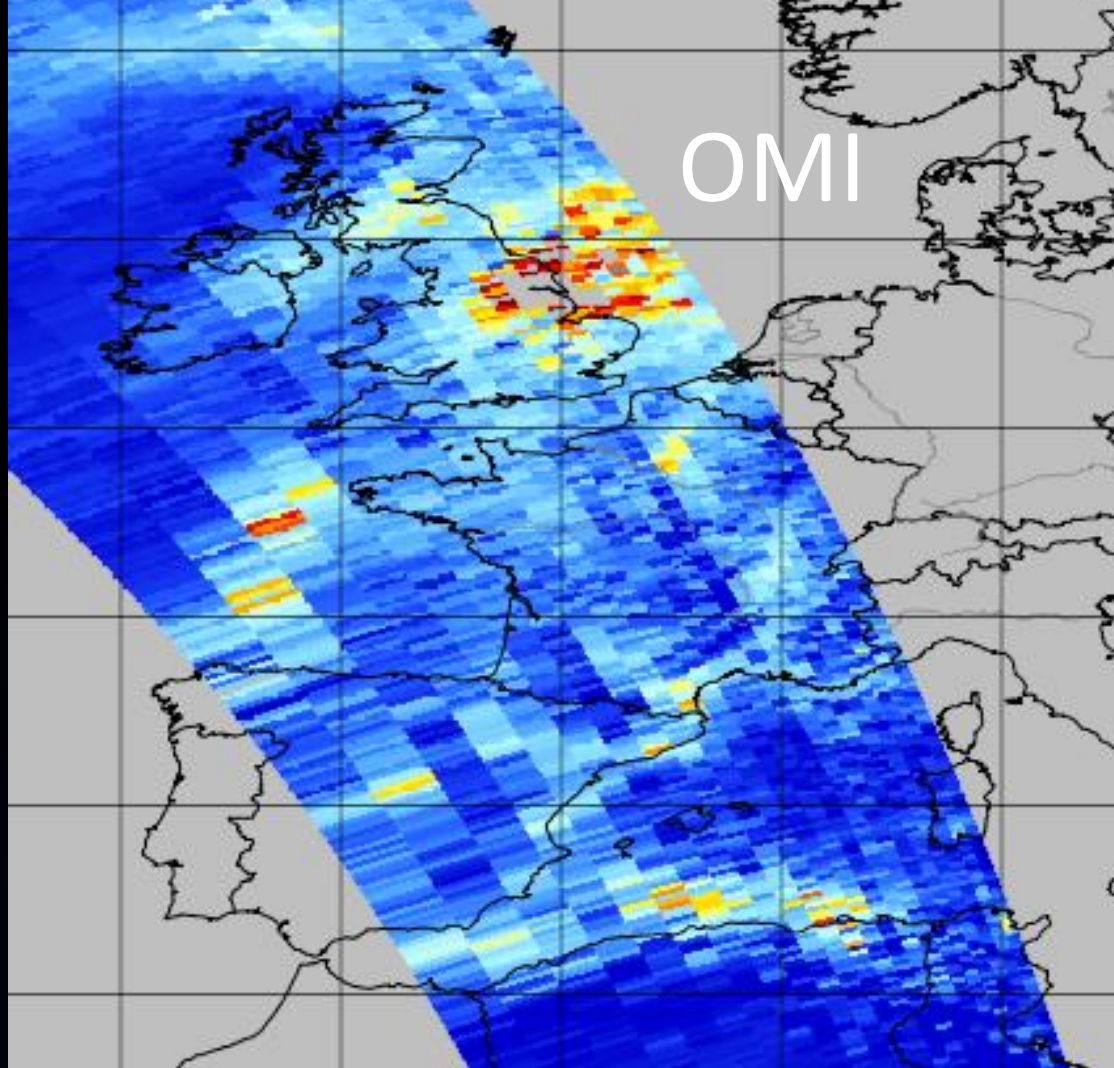# India



KNMI/NSO/ESA

Locations of power plants

KNMI/NSO/ESA

NO2 Total Column [ µmol/m2 ]

# Shipping Lanes : now visible in a single satellite overpass !!



Sentinel 2, Strait of Gibraltar, 22 February 2018

# Shipping Lanes : now visible in a single satellite overpass !!



**KNMI**    Sentinel 2, Strait of Gibraltar, 20 February 2018
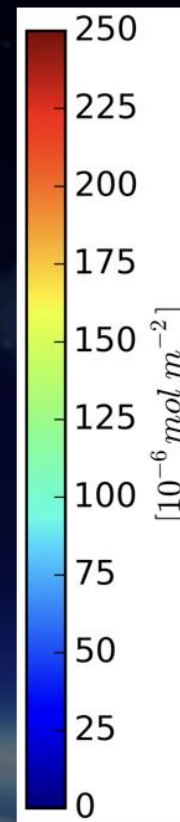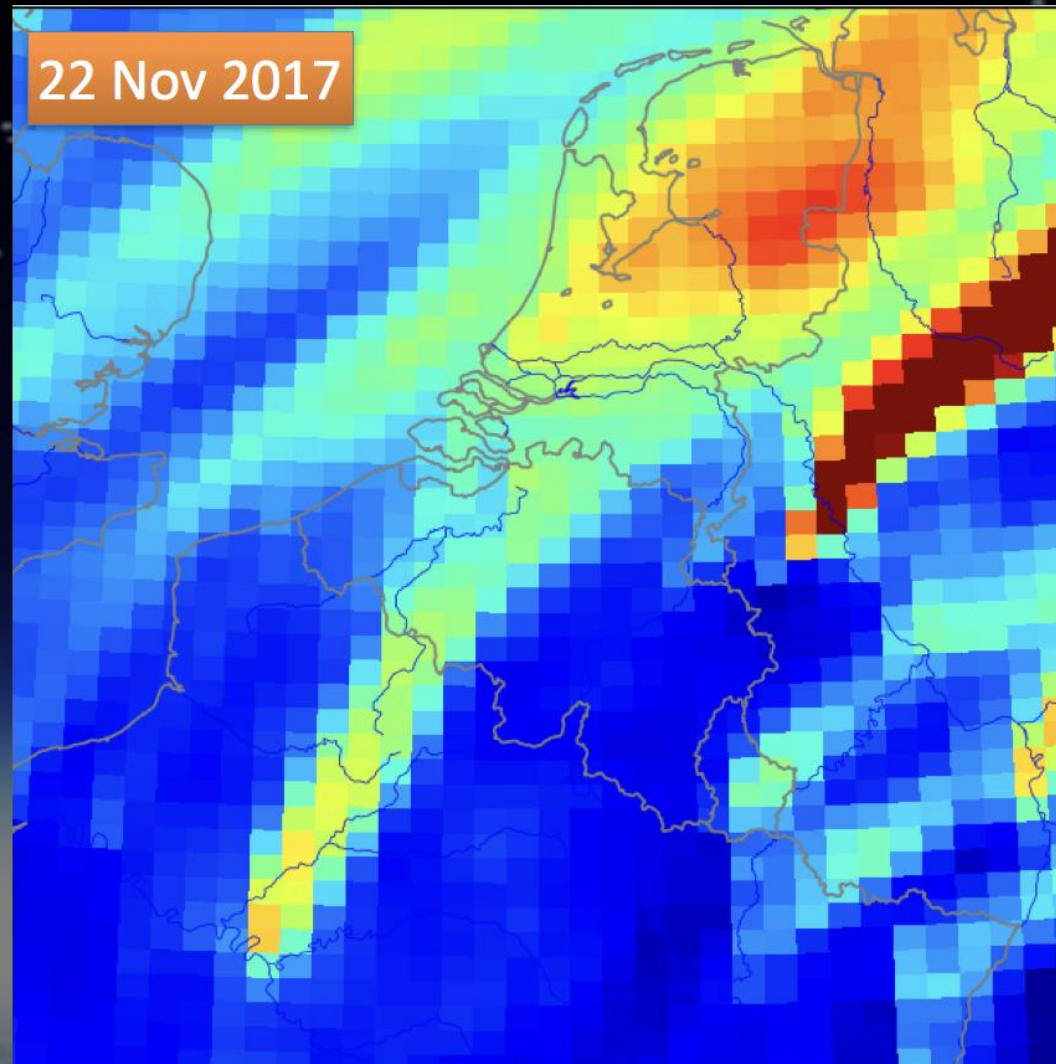
OMI
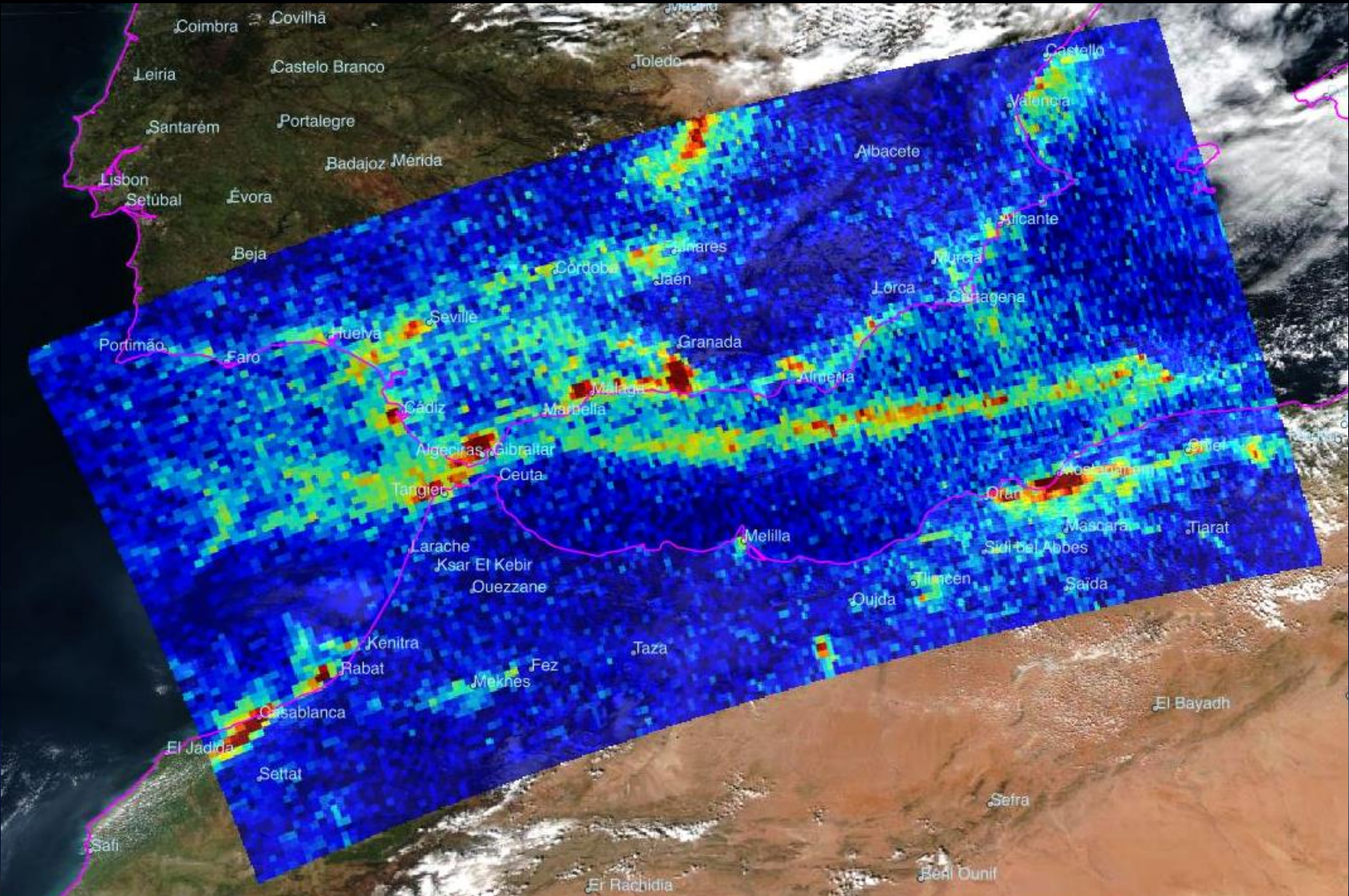
TROPOMI

22 nov 2017

Eskes, KNMI

New instrument TROPOMI :

- Higher spatial resolution (>12x)
- Higher sensitivity per measurement
- More measurements

TROPOMI

LOTOS-EUROS MODEL

22 Nov 2017
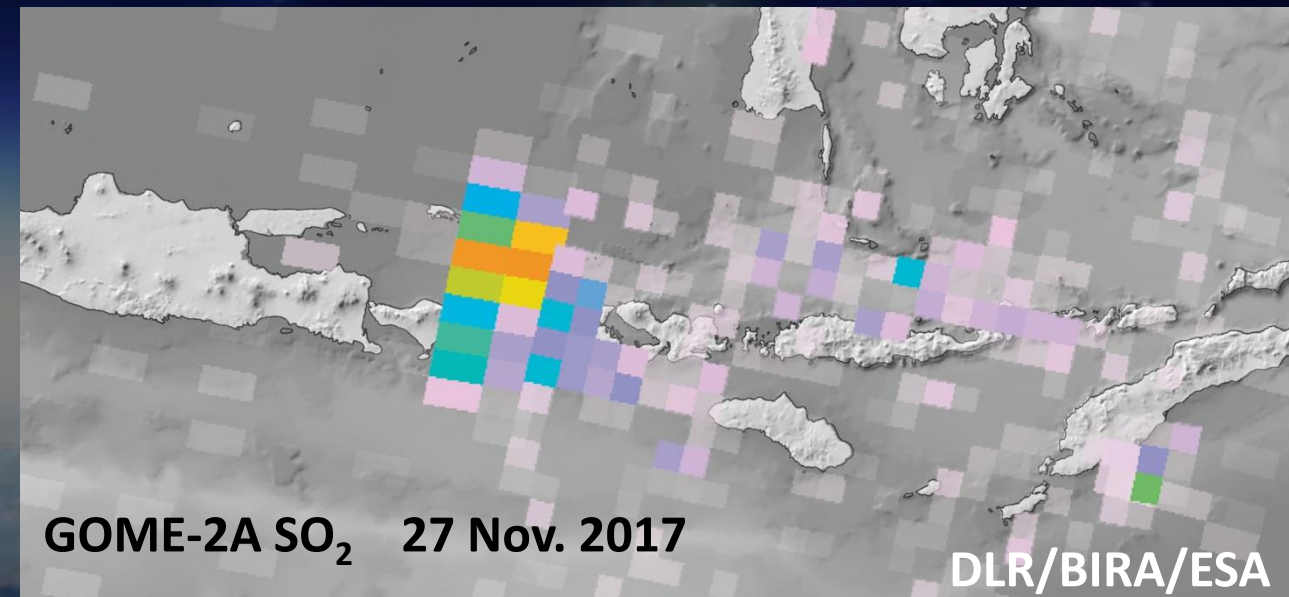
22 Nov 2017

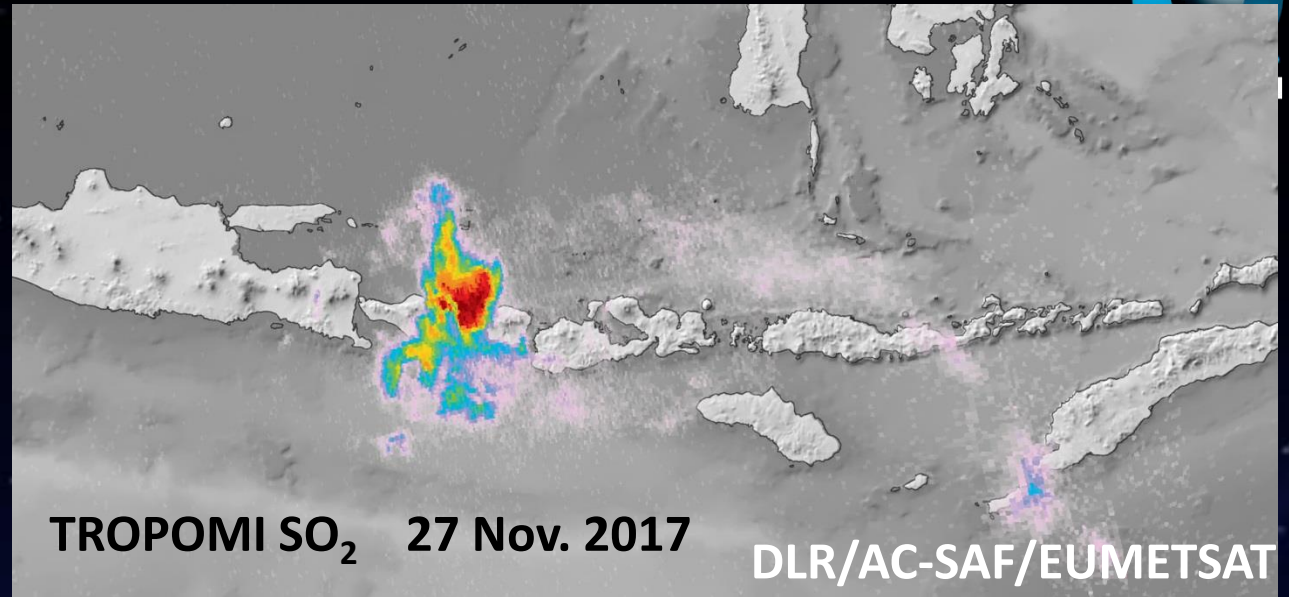$[10^{-6}\,mol\,m^{-2}]$

Henk Eskes, KNMI
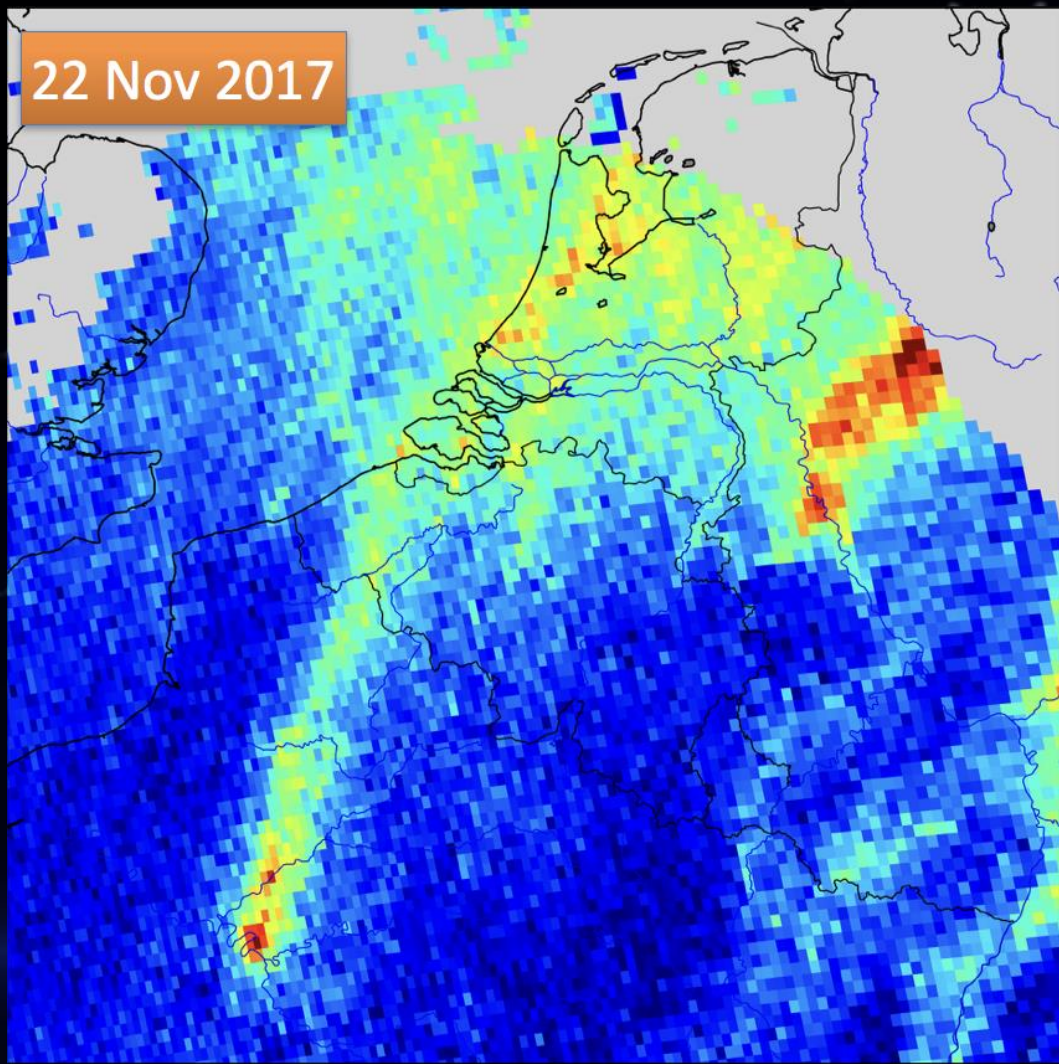
# Volcanic eruptions : SO$_2$ emissions



MOUNT AGUNG        © REUTERS



TROPOMI SO$_2$    27 Nov. 2017        DLR/AC-SAF/EUMETSAT
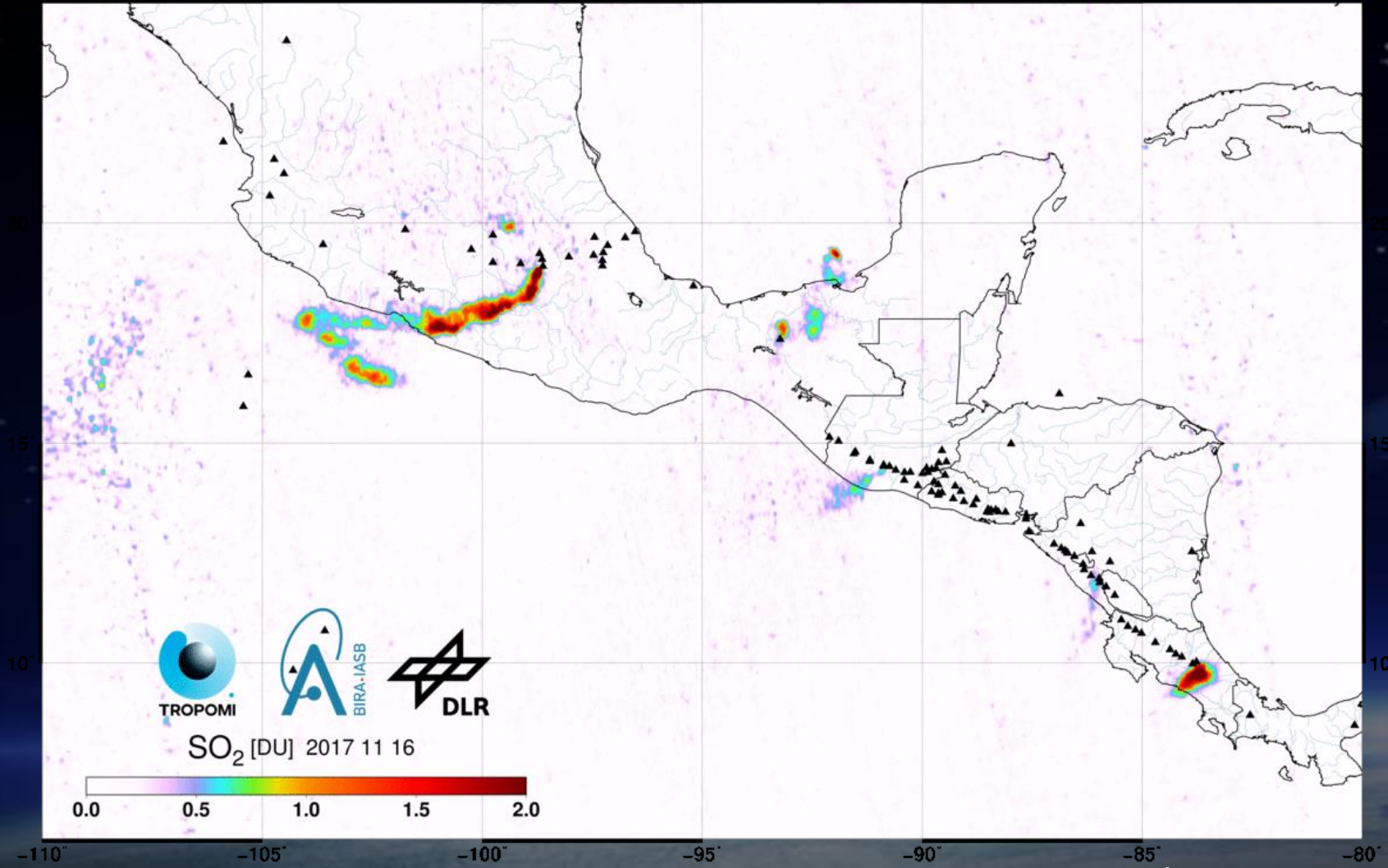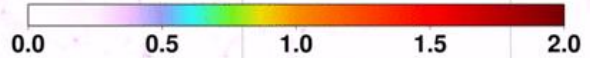


GOME-2A SO$_2$    27 Nov. 2017        DLR/BIRA/ESA

- 40.000 people evacuated, 22 villages
- Airports closed

Central America

SO$_2$ [DU]  2017 11 16

0.0   0.5   1.0   1.5   2.0

Theys, BIRA

# Extreme pollution episode over India
## Carbon Monoxide CO

10 – 20 Nov 2017

TROPOMI
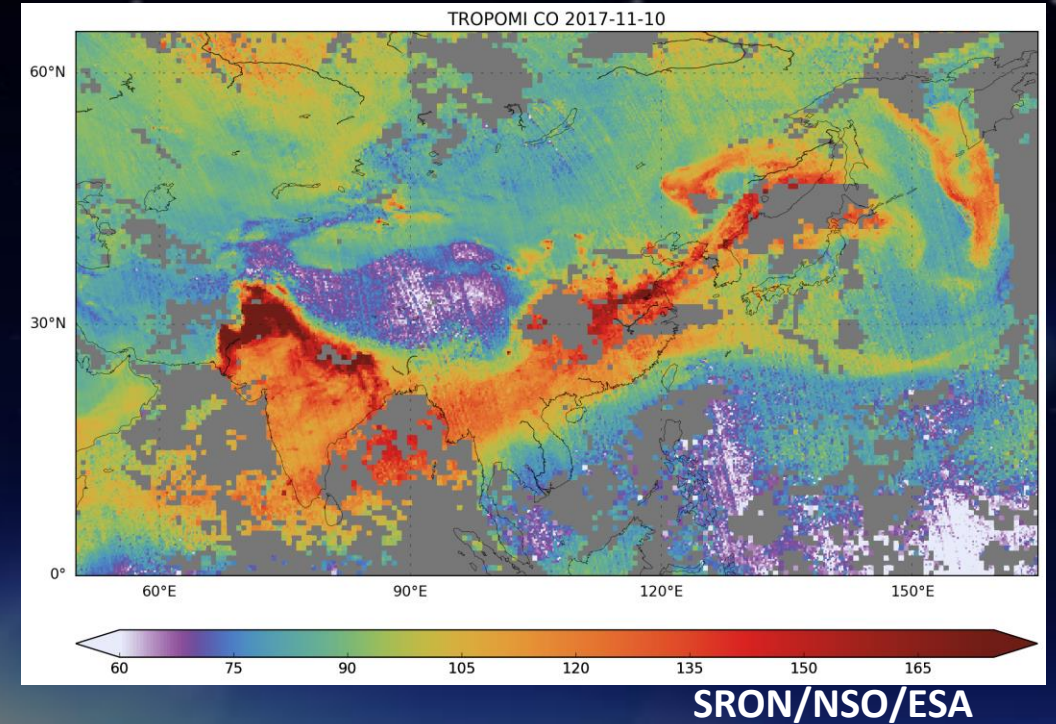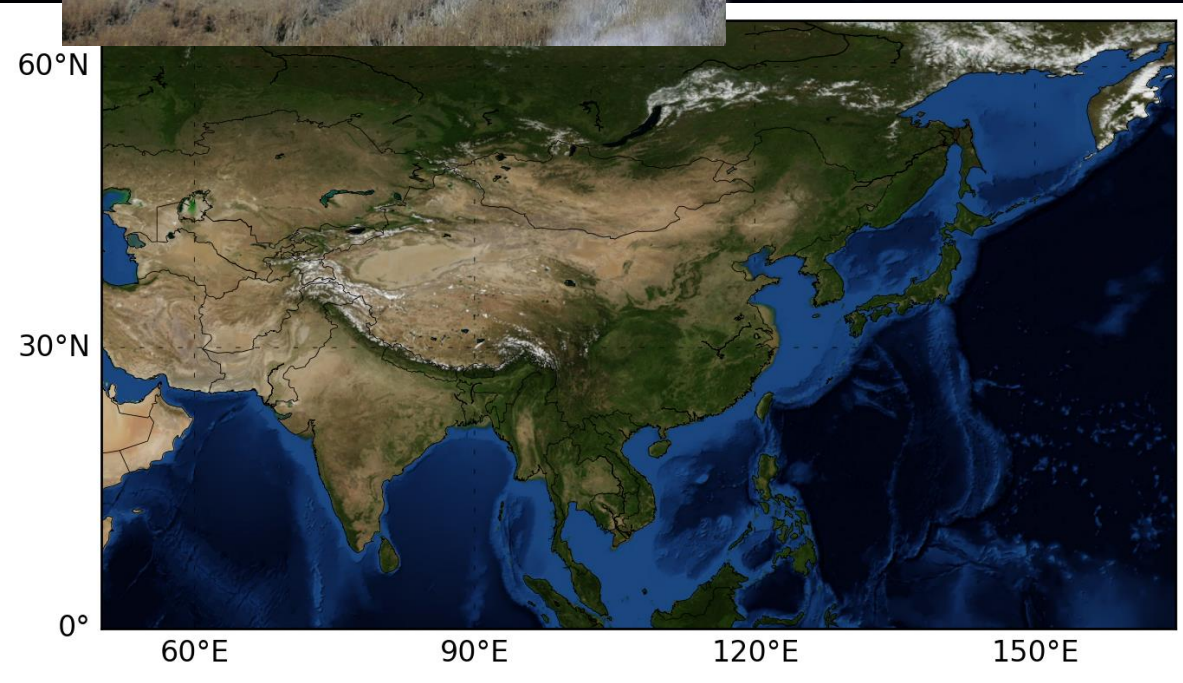
SRON/NSO/ESA

Inside Asia, Commentary cur... Opinions expressed b...

Delhi's Deadly Air: How India Is Falling Short On Fighting Pollution
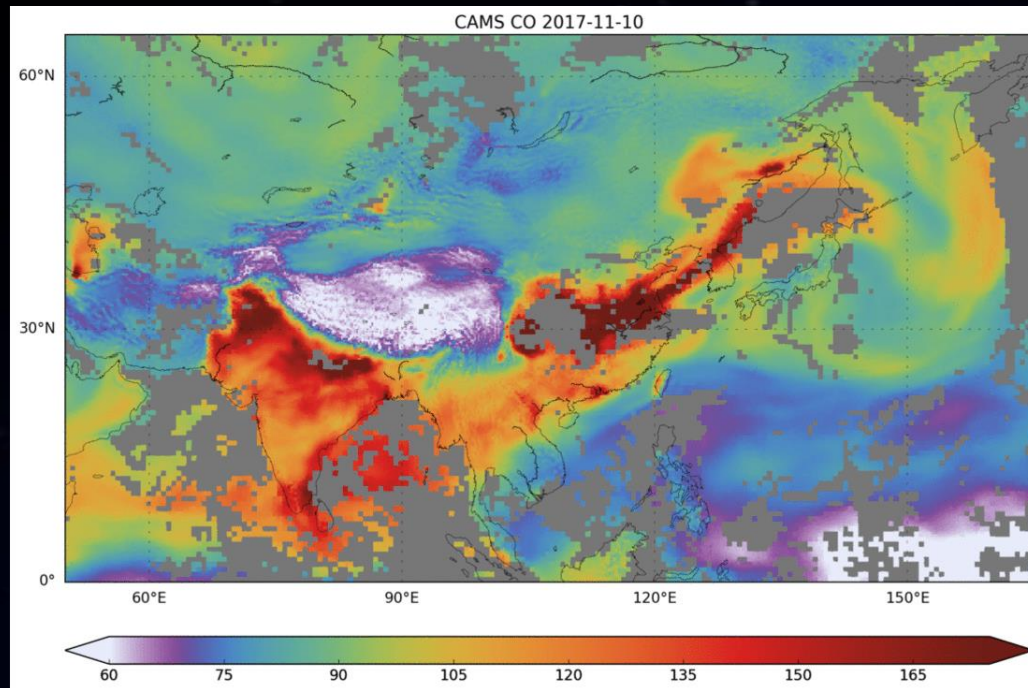
*Borsdorff et al, GRL, 2018*
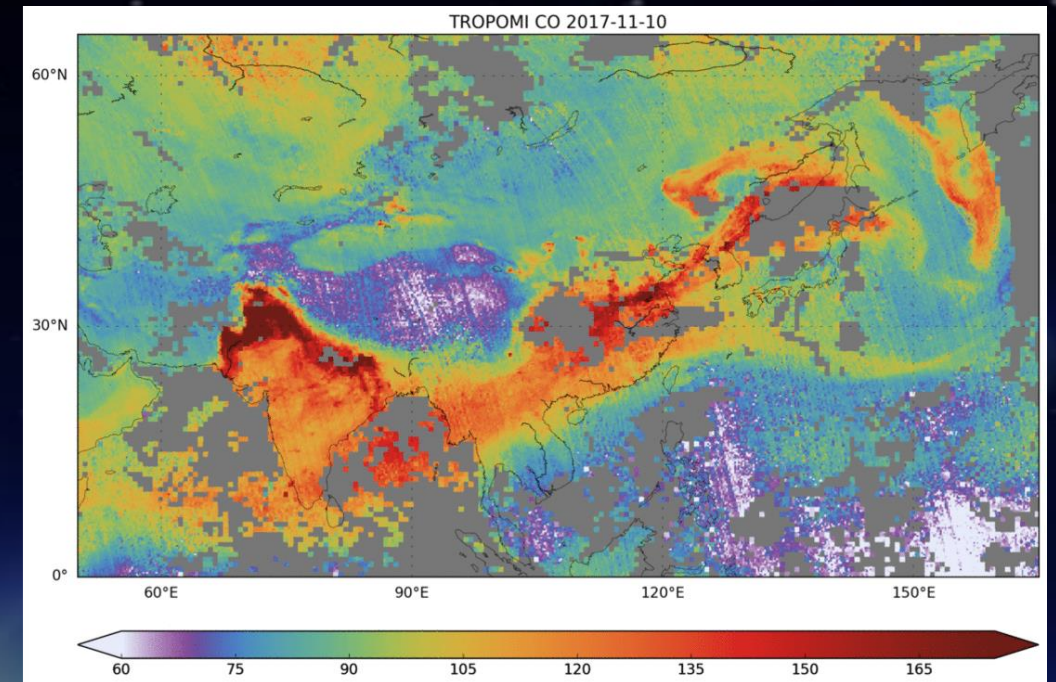
# Extreme pollution episode over India
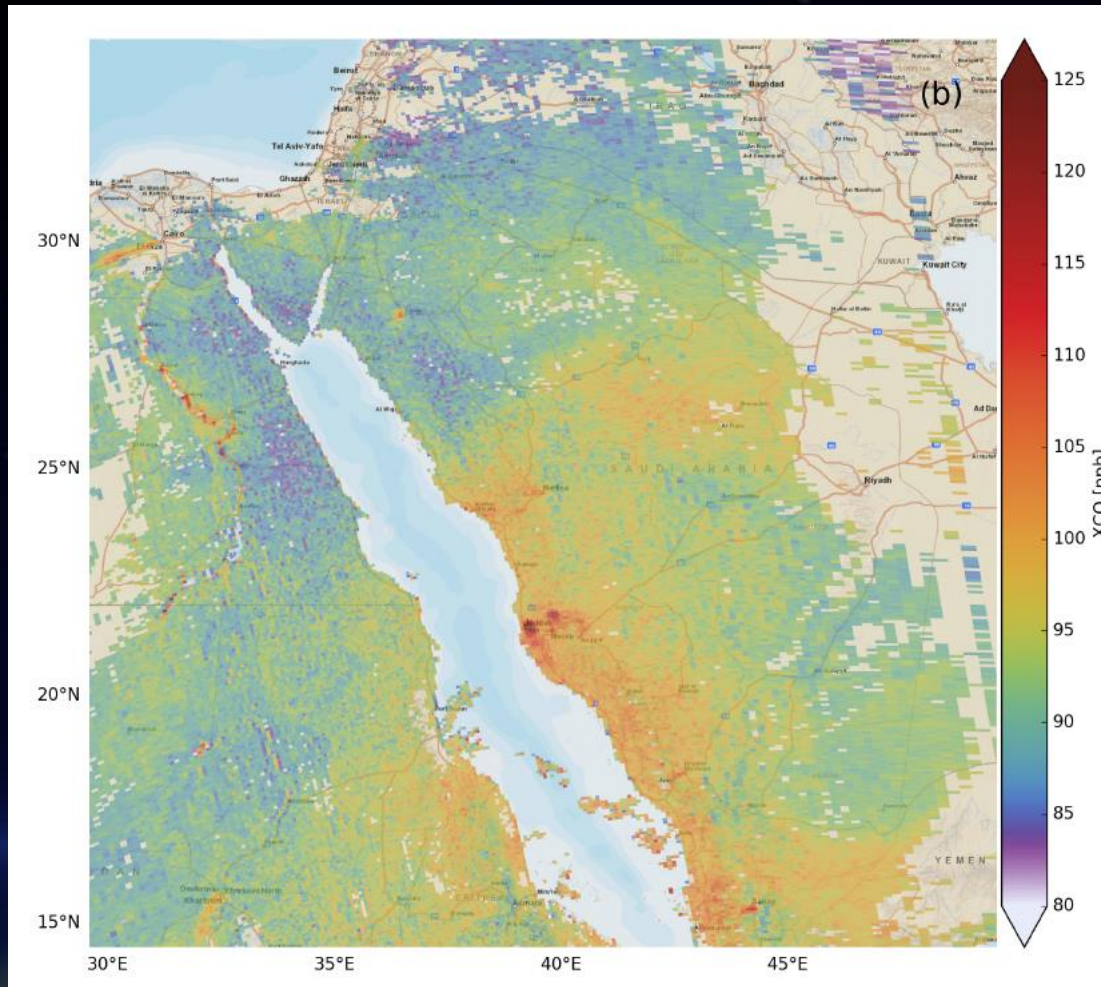## Carbon Monoxide CO

10 – 20 Nov 2017

SRON/NSO/ESA

**CAMS**

**TROPOMI**

CAMS used as very quick first check on TROPOMI data

*Borsdorff et al, GRL, 2018*

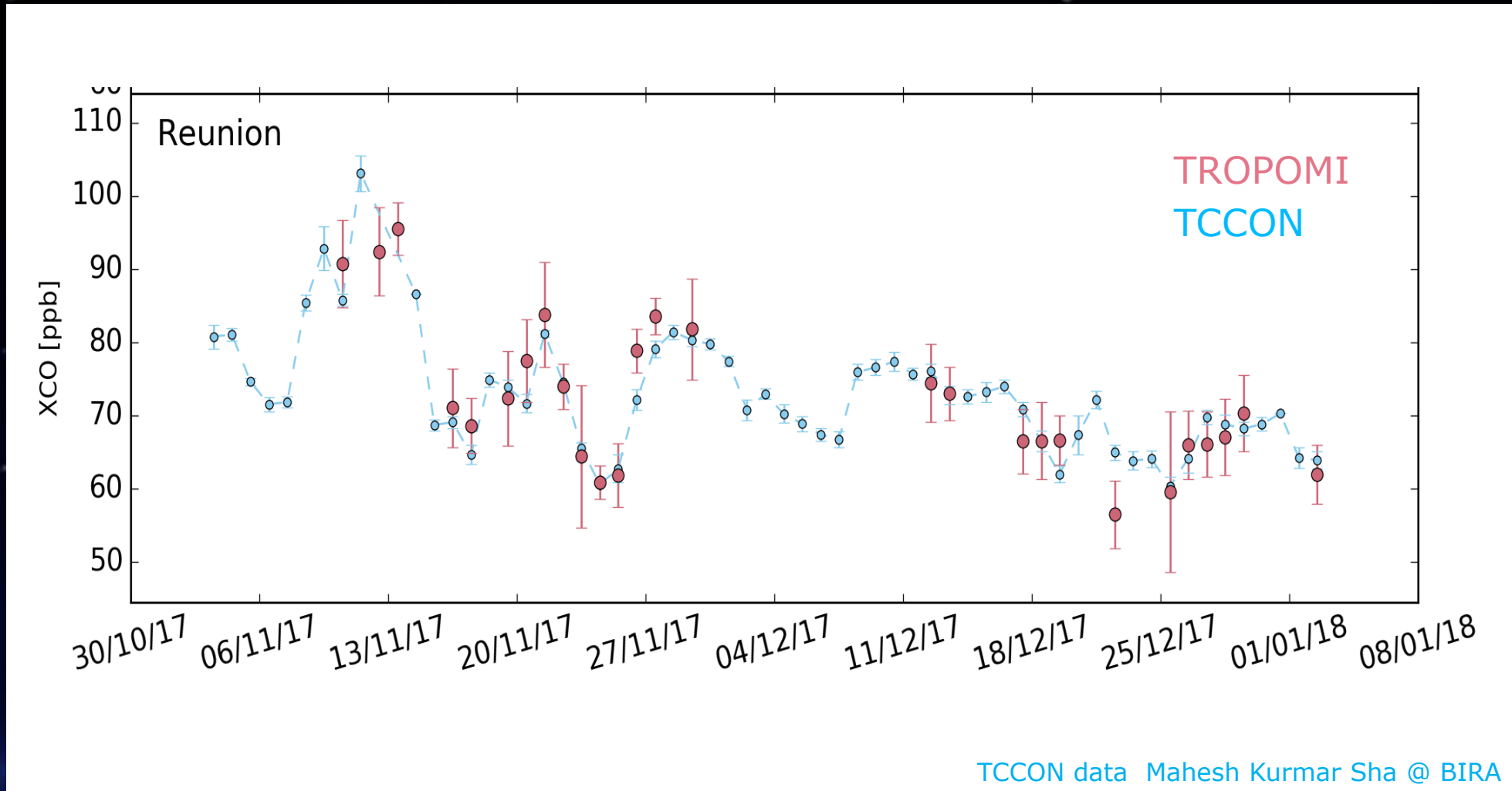# City scale CO pollution



Borsdorff, Landgraf et al, 2018
SRON

Single overpass

Emission from individual cities visible !!

Note : lifetime CO ~2 months

# Carbon monoxide: validation with TCCON



Reunion
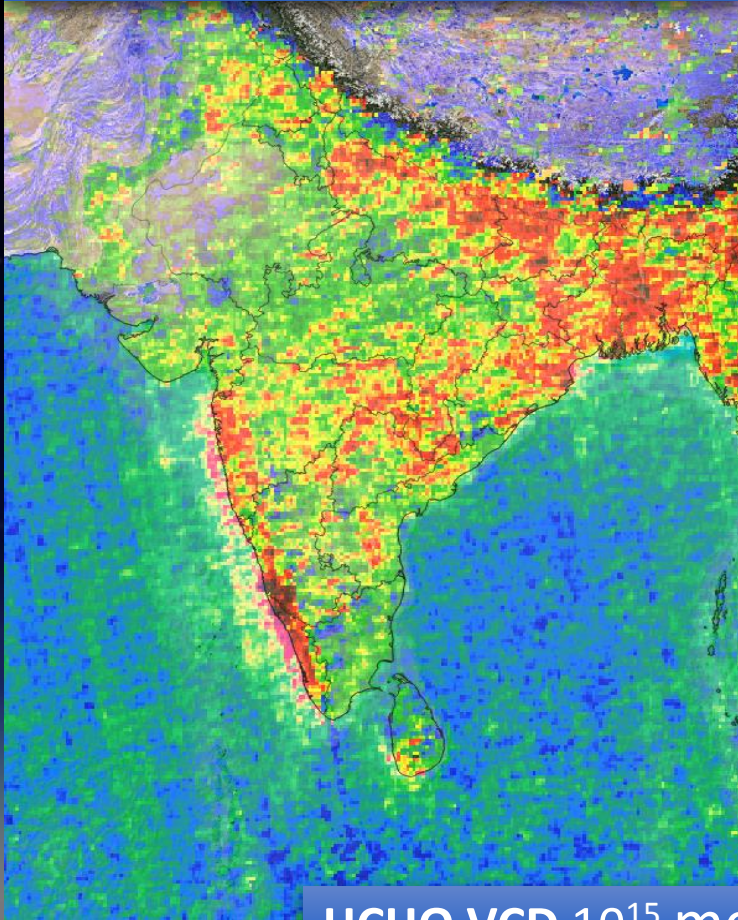
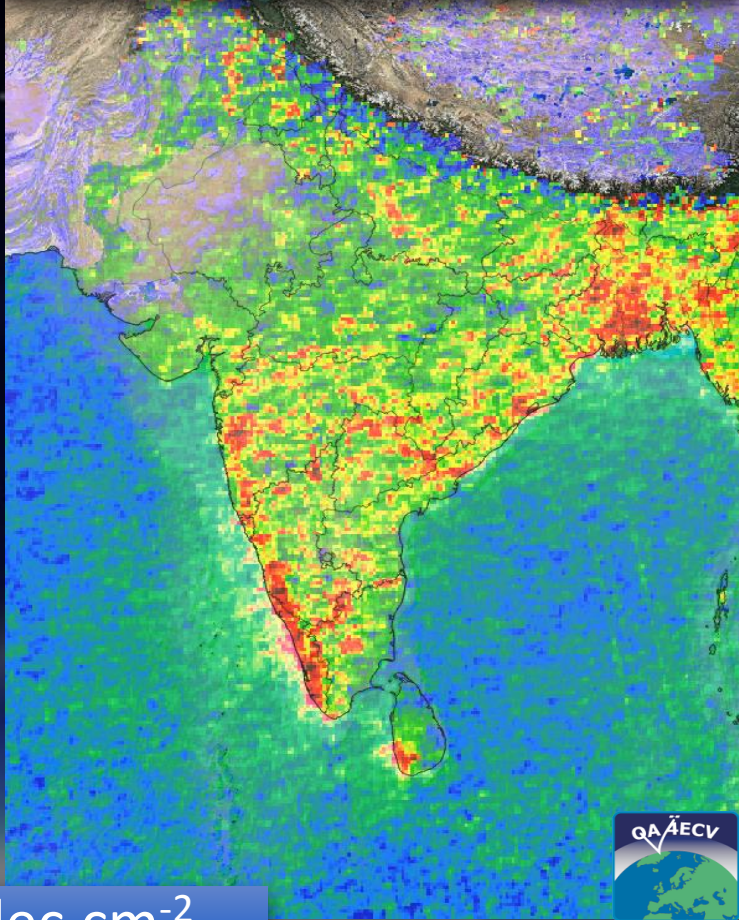XCO [ppb]

TROPOMI
TCCON

TCCON data  Mahesh Kurmar Sha @ BIRA

Borsdorff, Landgraf et al, 2018
SRON

Formaldehyde   HCHO
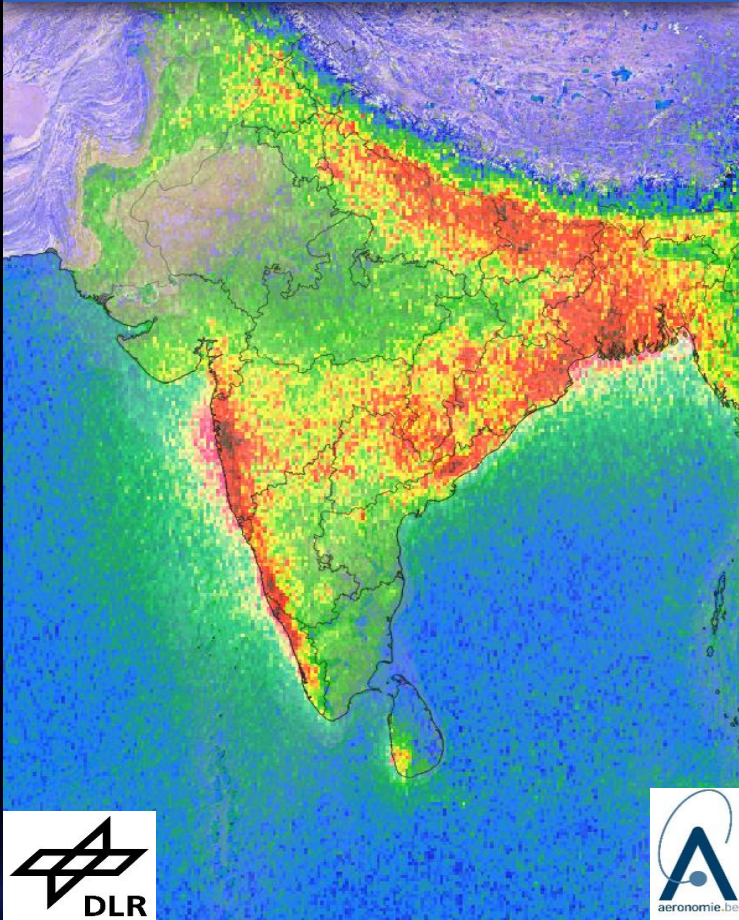
TROPOMI Feb. 2018    OMI Feb. 2018    OMI Feb. 2005

HCHO VCD $10^{15}$ molec.cm$^{-2}$

0    2    4    6    8    10    12    14    16    18    20
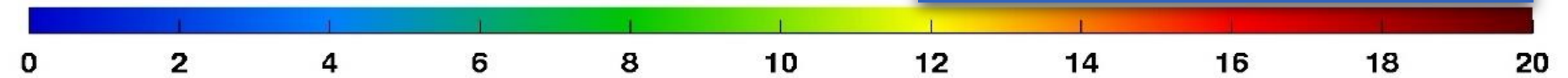
De Smedt, BIRA

# methane



TROPOMI        November 12th to December 30th, 2017        GOSAT

No measurements processed over sea yet
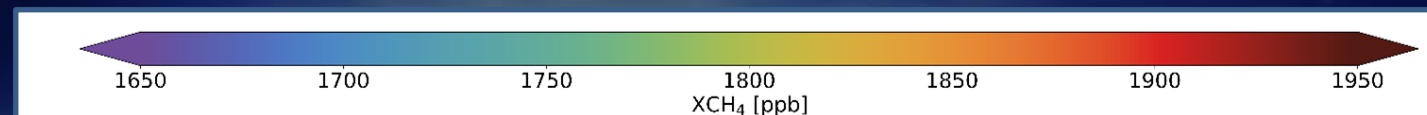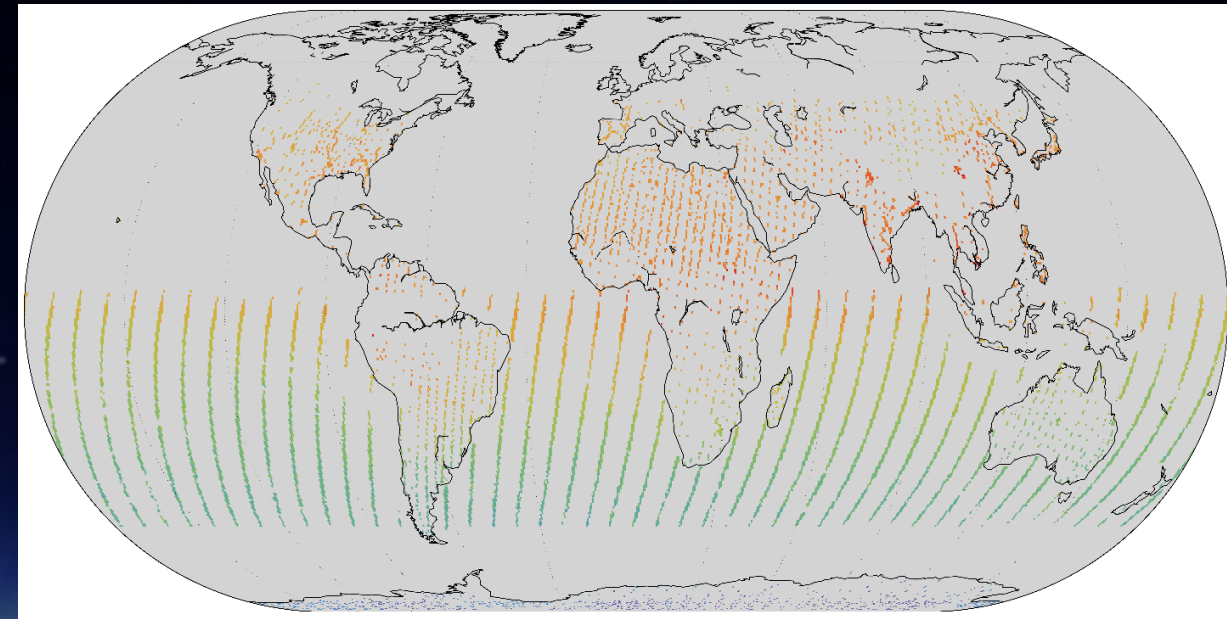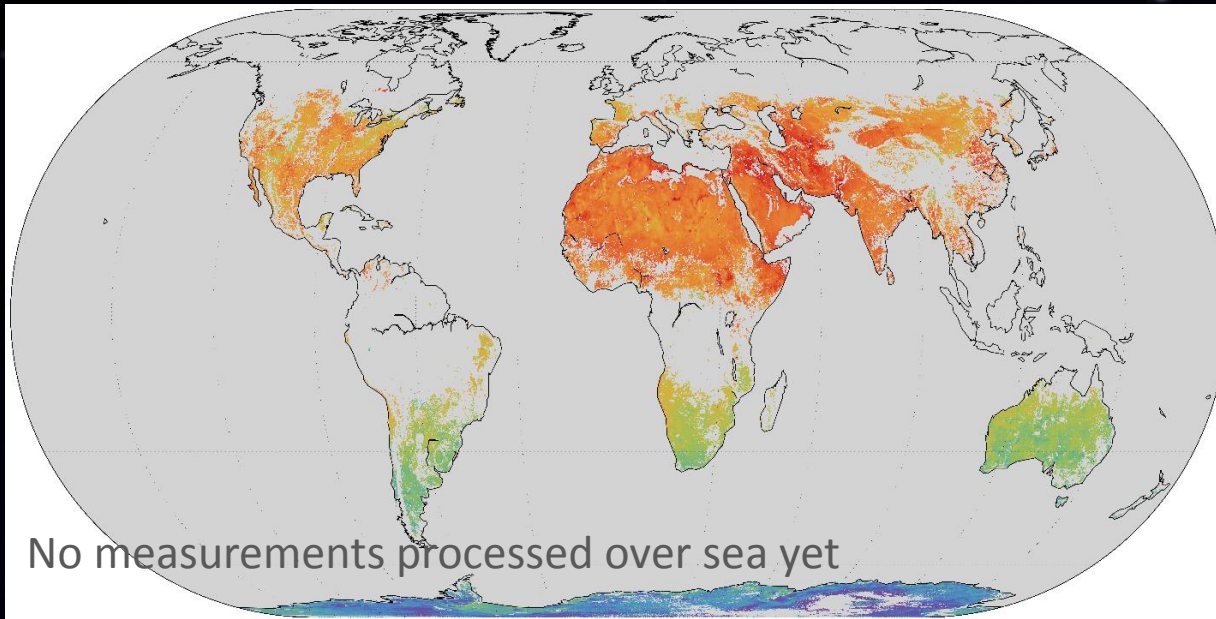
**SRON/NSO/ESA**

*Hu et al, GRL, 2018*

1650    1700    1750    1800    1850    1900    1950

$XCH_4$ [ppb]

TROPOMI 1000 x times more measurements, and we have real maps of methane.

Data needs to be cloud-free → not a lot of observations left

# Summary

- The TROPOMI performance is excellent  ('game changer')

- Operational phase just started

- Public release of data will start in summer 2018

- Data is soon ready to use !!

Info on Tropomi.eu

- BIRA-IASB $SO_2$ retrieval algorithm has been designed for S5P *(Theys et al., AMT, 2017)* and applied to OMI *(Theys et al., JGR, 2015)*.
- OMI captures very weak sources like shipping emissions (first space measurements)
- $SO_2$ from ships will likely be better captured with S5P owing to superior spatial resolution (3.5x7 km²)

**2005-2009**



OMI tropo. $NO_2$ [molec.cm$^{-2}$]

OMI $SO_2$ VCD [DU]

Spatial cross-section (background corrected)



Red Sea

aeronomie.be