Catalog of NO_x point sources derived from the divergence of the NO_2 flux

S. Beirle, C. Borger, S. Dörner, V. Kumar, T. Wagner, MPI für Chemie, Mainz, Germany

Contact: steffen.beirle@mpic.de

- Sentinel-5P/**TROPOMI** provides NO_2 tropospheric columns *V* on high spatial resolution with high S/N
- NO_2 plumes from power plants are clearly visible on **single days**
- Plumes are **smeared out** in temporal means due to changing wind fields

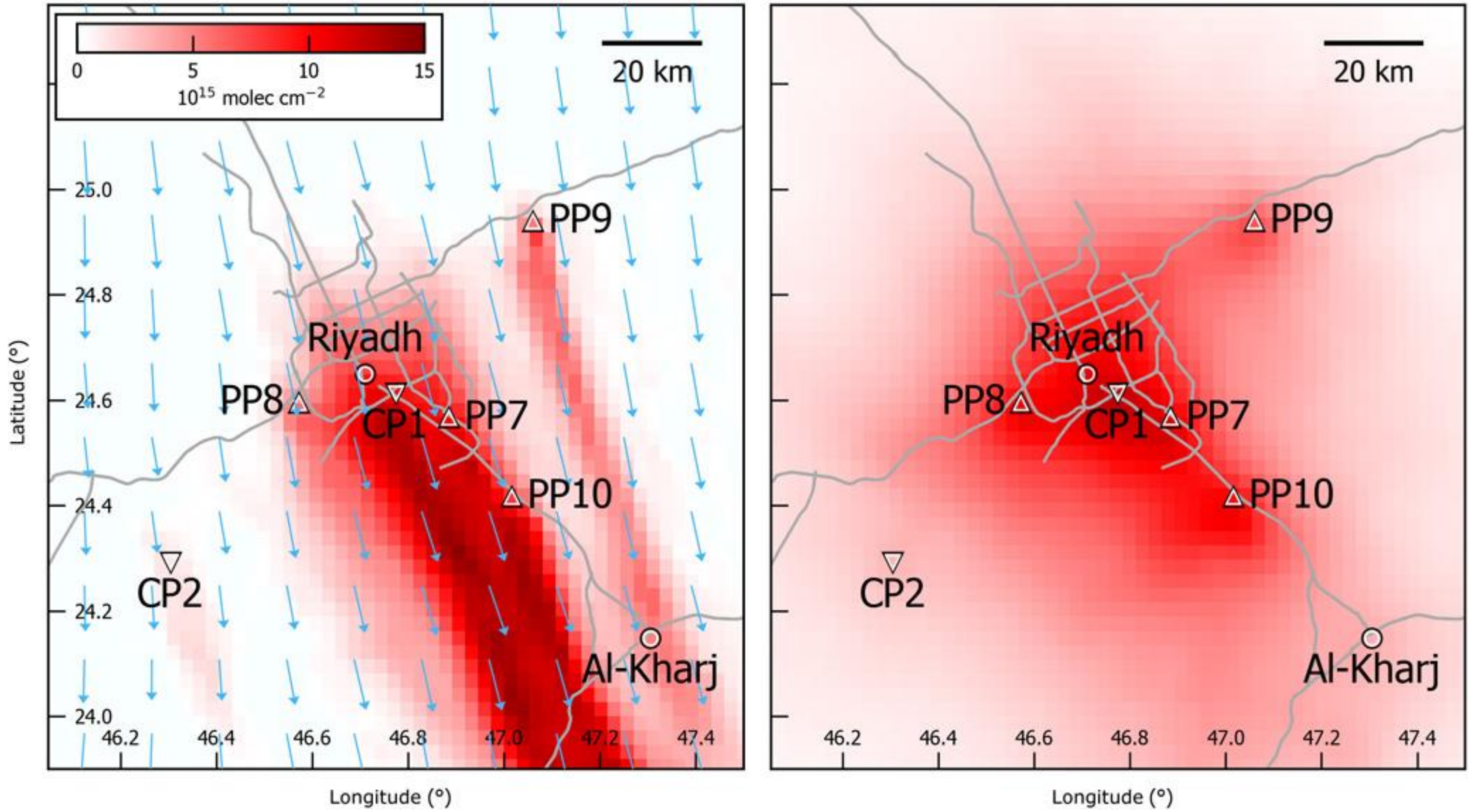
➢ **One day tells you more about point source locations than one year!**

- How to conserve strong daily gradients in TROPOMI NO_2 maps in the temporal means?

➢ Take **wind fields *w*** into account

➢ Average NO_2 **fluxes *F* = *wV***

One day ***One year***



17 December 2017

Δ Power Plant (PP)

∇ Cement Plant (CP)

Dec 2017-Oct 2018

Continuity equation (steady state):

- The **divergence** (spatial derivative) of the ***flux*** yields **balance of sources** *E* **and sinks** *S*:
- $D := \nabla \cdot \mathbf{F} = E - S$
- Linear equation: can be applied on ***mean*** flux
- Allows direct **mapping of NO_x emissions**: $E = D + S$
- *D* is very **sensitive to point sources** where changes of flux are always high
- Close to point sources: $D \gg S \Rightarrow E \approx D$

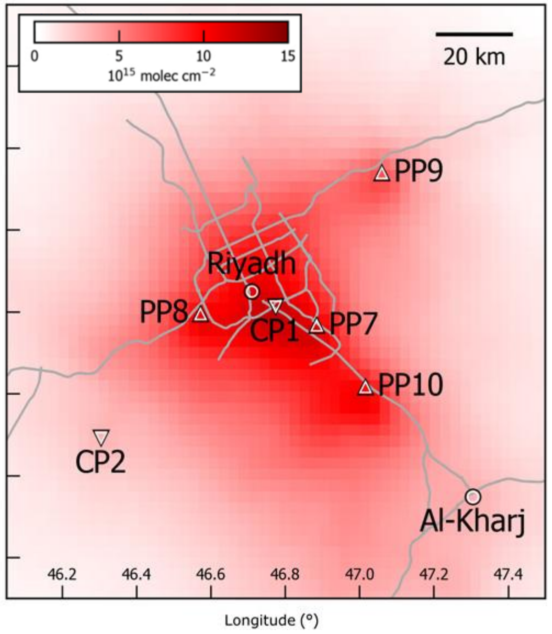
SCIENCE ADVANCES | RESEARCH ARTICLE

ATMOSPHERIC SCIENCE

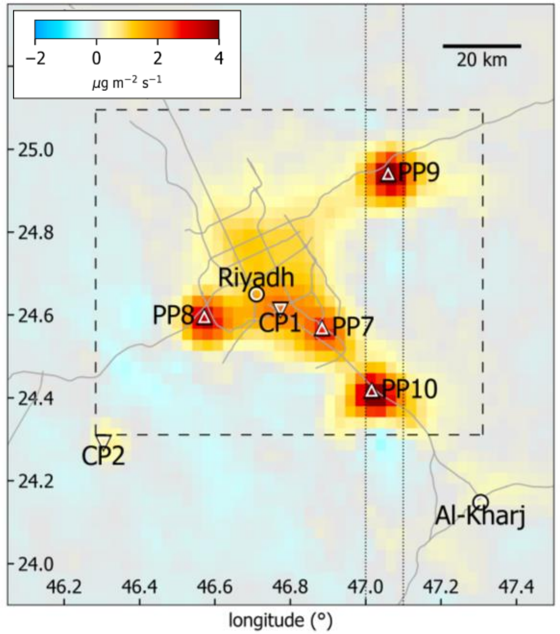
Pinpointing nitrogen oxide emissions from space

Beirle *et al.*, *Sci. Adv.* 2019; **5**:eaax9800   13 November 2019

Mean column V



Mean divergence D



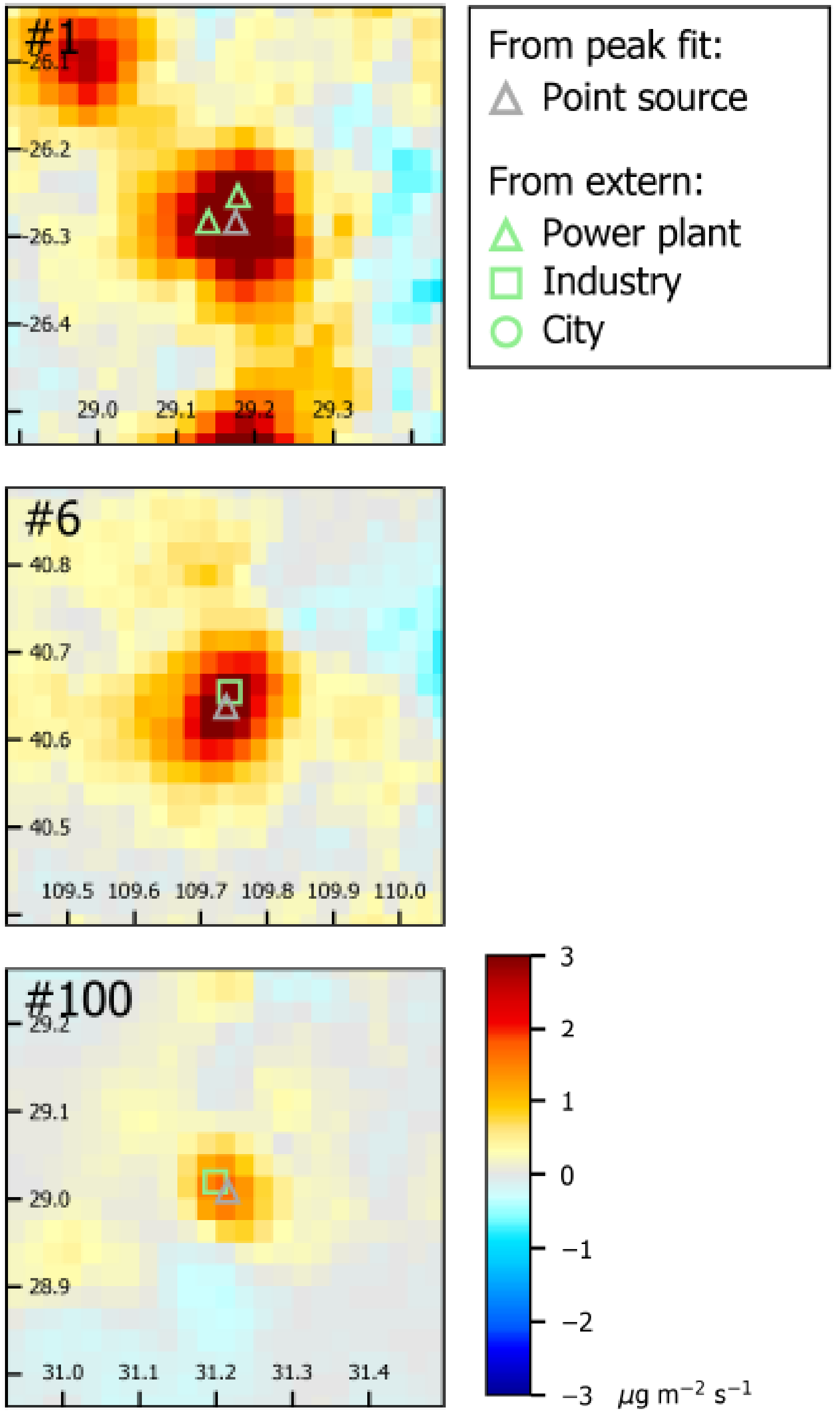
Beirle et al., 2019: Method applied for **selected regions** (Riyadh, South Africa, Germany)

Now: Global catalog of point sources

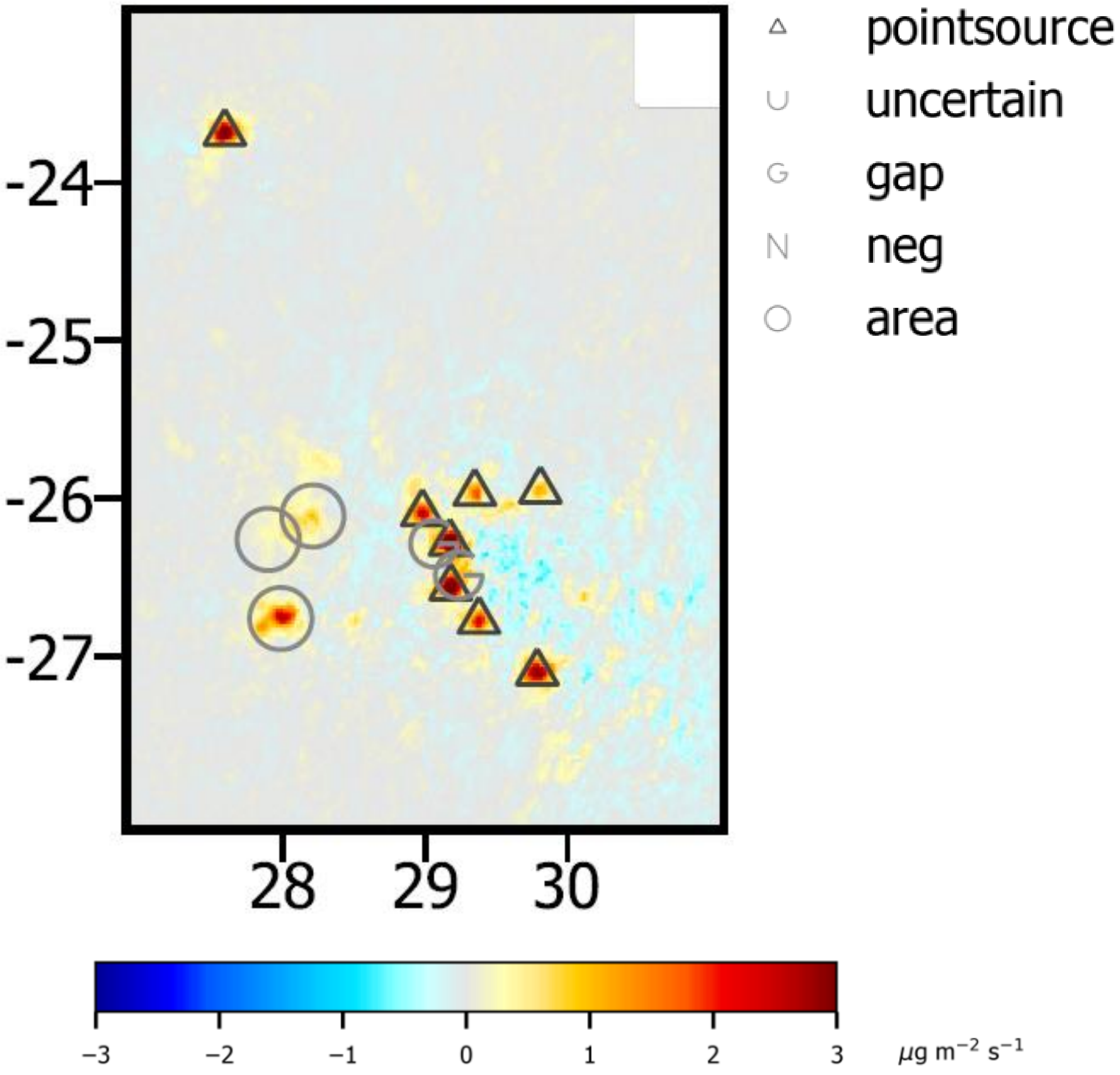
- Input data:
  - TROPOMI NO_2 2019-2020
  - ECMWF reanalysis wind fields 300 m above ground
- Data reduction:
  - Regions of interest defined based on magnitude and temporal variability of *V*
- Calculation of mean fluxes and divergence maps for regions of interest
- Fully automatized peak classification and point source emission fit
- 451 point sources detected

NO_x point source catalog:

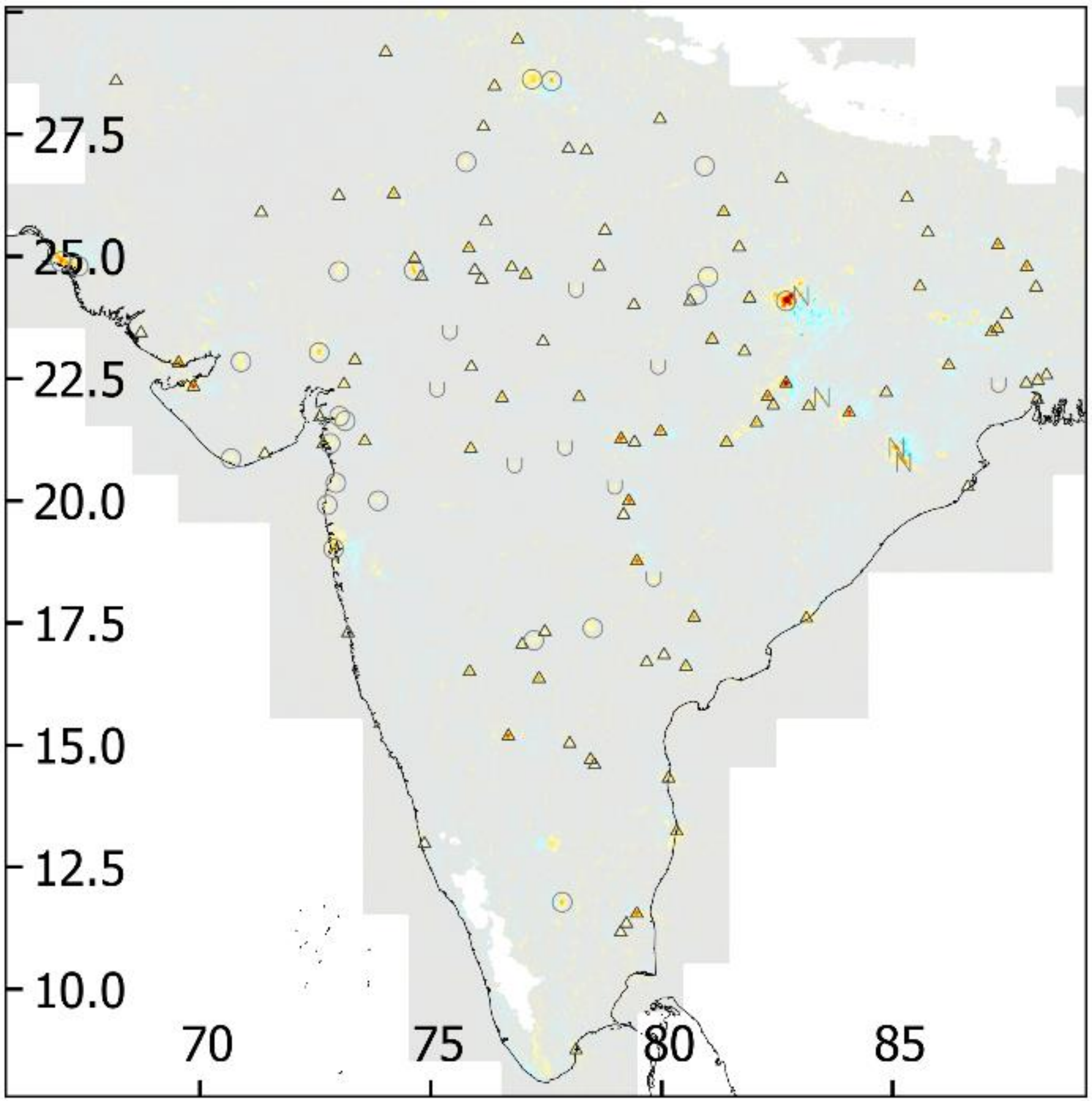
Rank	Lat [° N]	Lon [° E]	Emissions [kg/s]	Source	Country
1	-26.28	29.18	0.886	Matla & Kriel power plants	South Africa
2	-26.57	29.18	0.679	Secunda CTL coal liquifier	South Africa
3	-23.69	27.59	0.669	Matimba & Medupi power plants	South Africa
4	-27.10	29.79	0.668	Majuba power plant	South Africa
5	22.40	82.69	0.588	Korba power plant	India
6	40.64	109.74	0.528	Baotou iron & steel	China
7	35.50	129.30	0.523	Ulsan	South Korea
8	-26.78	29.38	0.474	Tutuka power plant	South Africa
9	28.70	48.33	0.460	Al Zour power plant	Kuwait
10	34.93	127.72	0.460	Gwangyang steel works	South Korea
...					
100	29.01	31.22	0.151	Beni Suef cement plant	Egypt
200	44.67	89.09	0.093	Wucaiwan power plant	China
300	-22.54	-44.12	0.062	Presidente Vargas Power Plant	Brasil
400	29.10	-110.99	0.040	Hermosillo	Mexico



Strongest point sources in **South Africa:**



Most point sources in **India:**



Limitations:

- Catalog is **incomplete**:
  - Persistent **gaps** at desert coasts (e.g. Dubai) due to missing cloud data
  - **Artifacts** in *D* (inaccurate wind fields over mountains, high noise for high background pollution due to sampling effects)
- Catalog emissions are **biased low**:
  - TROPOMI NO_2 is biased low

Potential:

- **Up-to-date** point source emissions
- Location of **NO_x and CO_2 sources** with about **2-3 km accuracy**
- **Spatial patterns** of NO_x emissions on high spatial resolution
  - to be compared to bottom-up inventories

Contact: steffen.beirle@mpic.de

References:

Beirle et al., Pinpointing nitrogen oxide emissions from space, Sci. Adv. 5, doi:10.1126/sciadv.aax9800, 2019.

Beirle et al., Catalog of NO_x point sources derived from the divergence of the NO_2 flux, to be submitted to ACP, 2020.