Validation of Sentinel-5P TROPOMI tropospheric NO_2 with airborne imaging, ground-based stationary, and mobile DOAS measurements from the S5P-VAL-DE-Ruhr campaign

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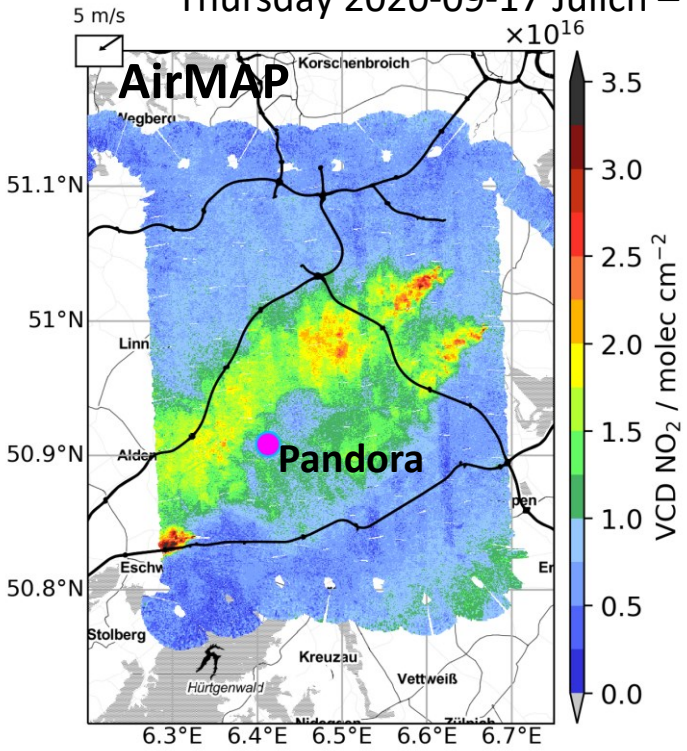
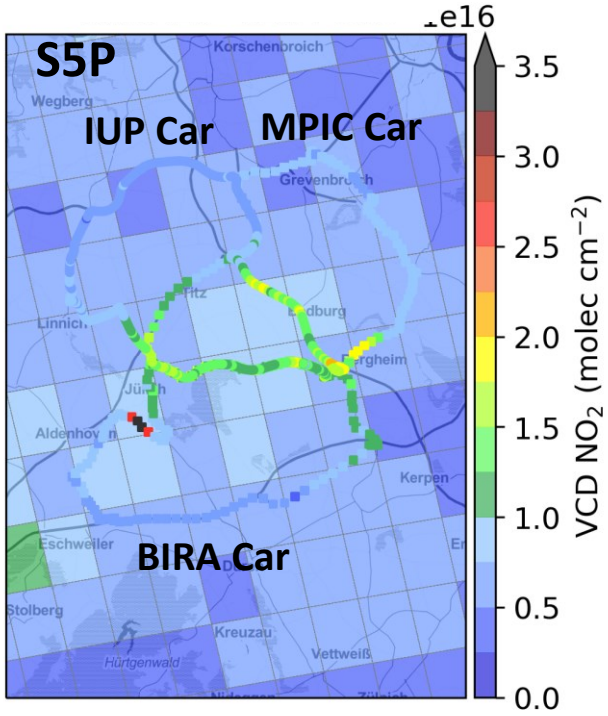
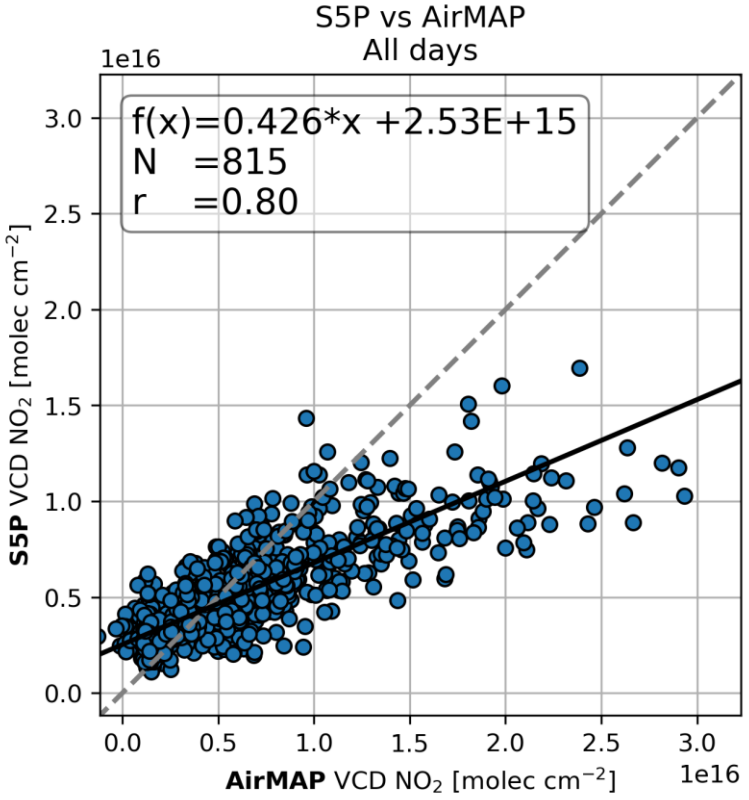
Thursday 2020-09-17 Jülich – S5P overpass 12:37 UTC



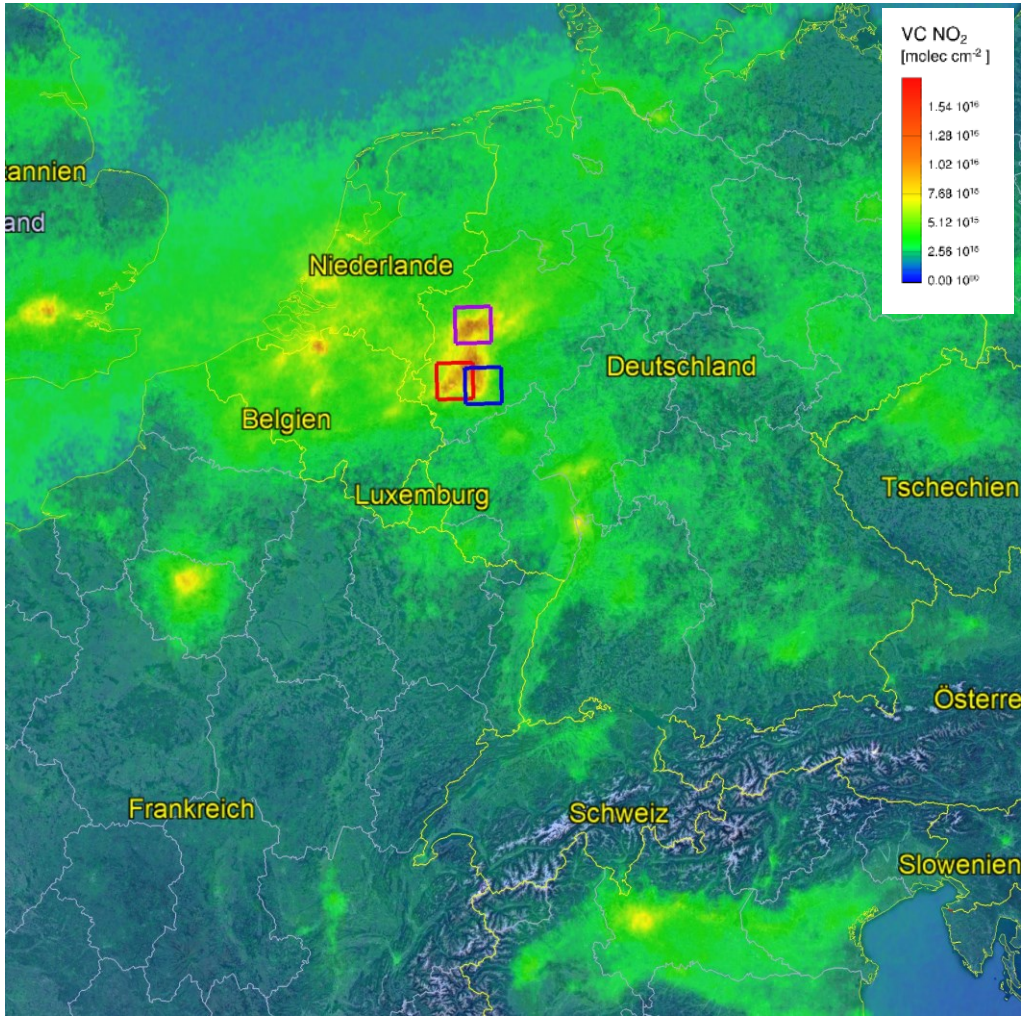




Sentinel-5P-VAL-DE-Ruhr Campaign

- Validation of Sentinel-5P products (**NO_2**, HCHO and SO_2) using different instruments and observation geometries
- Campaign activities took place in North Rhine-Westphalia, a pollution hotspot in Europe
  - Urban character & large industrial emitters
- Seven flight days from 12 - 18 September 2020
  - One flight per day
    - Two flights during the weekend
    - Five flights during the week
  - Three flights in the Duisburg flight sector
  - Two flights each in the Jülich and Cologne sector

Sentinel-5P VC NO_2 1 September 2020 - 30 September 2020



AirMAP vs stationary and mobile measurements

- Airborne DOAS measurements with AirMAP & AvaAir onboard of the Cessna on 7 days

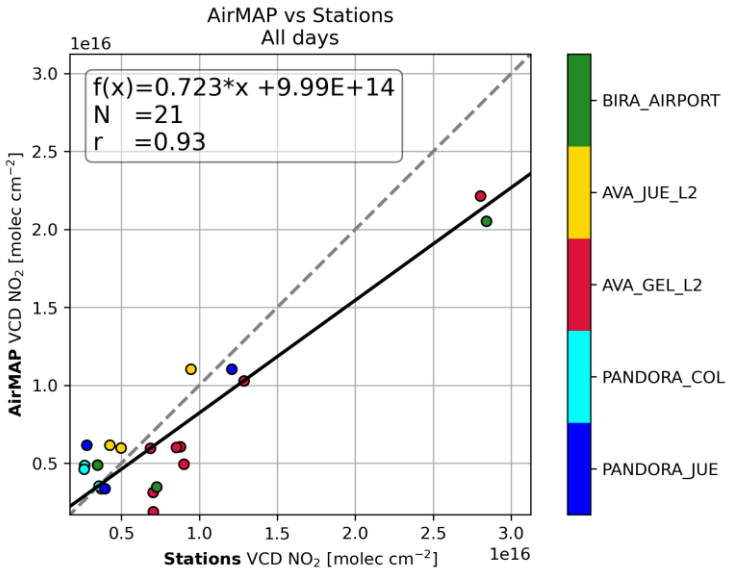
Location	Instrument type
Cessna FU Berlin	AirMAP airborne imaging DOAS instrument
Cessna FU Berlin	AvaAir nadir looking Avantes spectrometer

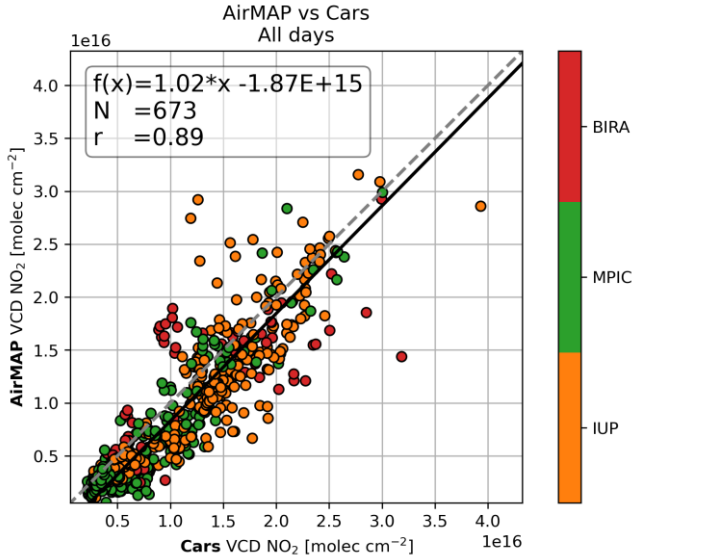
- Stationary measurements were operational on all flight days and before/after campaign period

Location	Instrument type
Gelsenkirchen	IUP Zenith-sky Avantes
Jülich	IUP Zenith-sky Avantes
Airport Dinslaken	BIRA SkySpec MAX-DOAS
Duisburg	IUP measurement truck (MAX-DOAS, in-situ)
Jülich	Pandora
Cologne	Pandora

- Car-DOAS measurements on all flight days

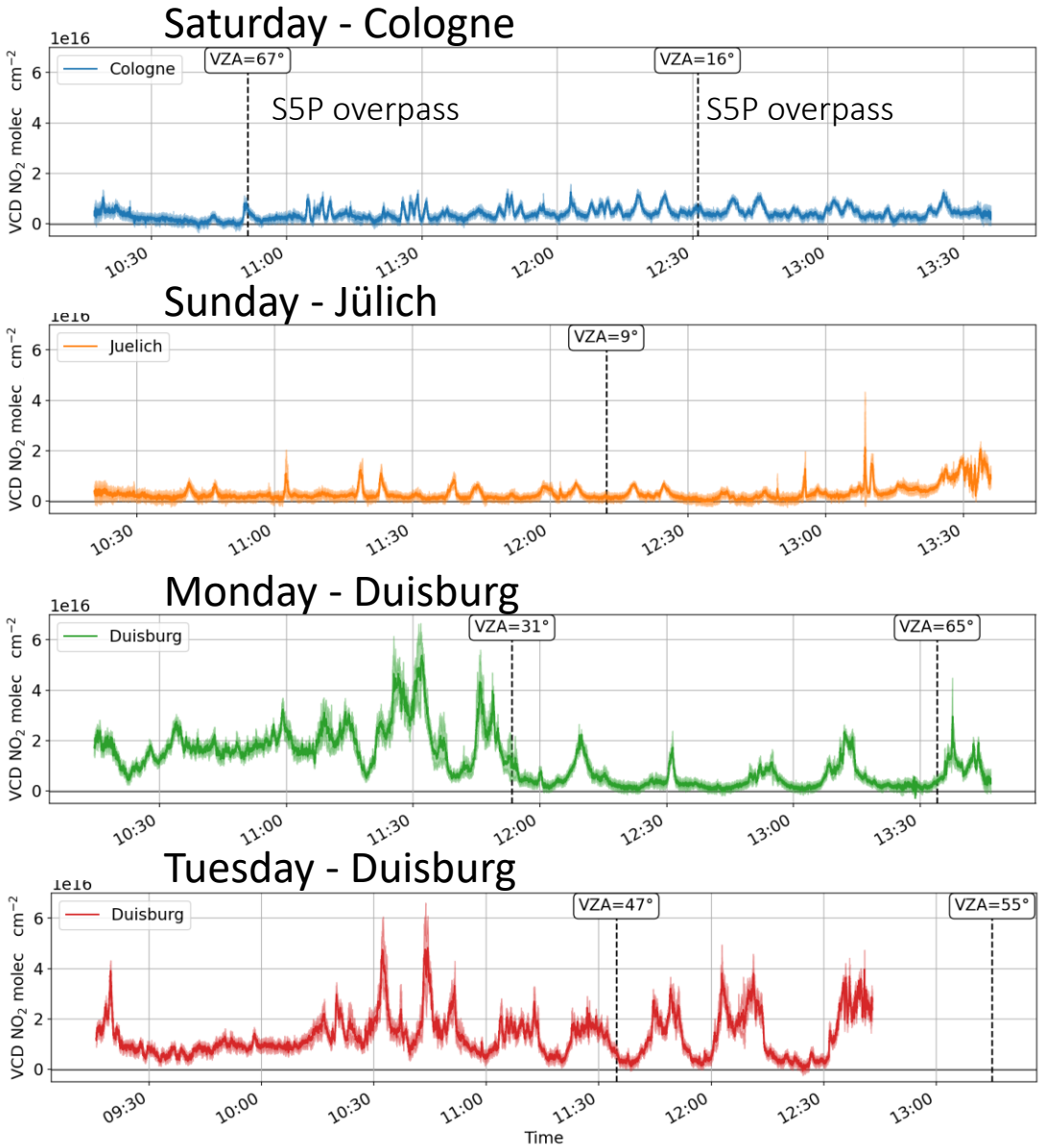
Location	Instrument type
IUP car	Zenith-sky Avantes
MPIC car	Zenith-sky Avantes
BIRA car	Zenith-sky Avantes

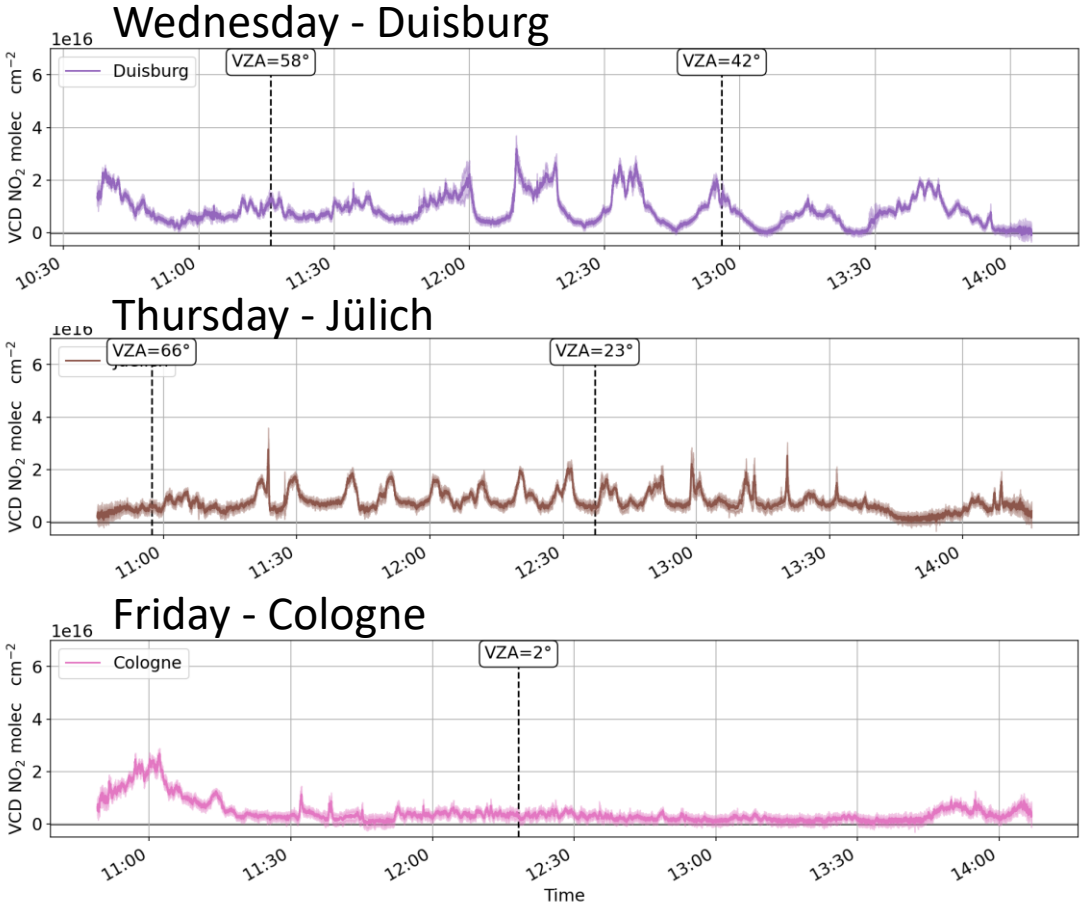




Colocation conditions: ± 15 min and 300 m x 300 m

AirMap timeseries

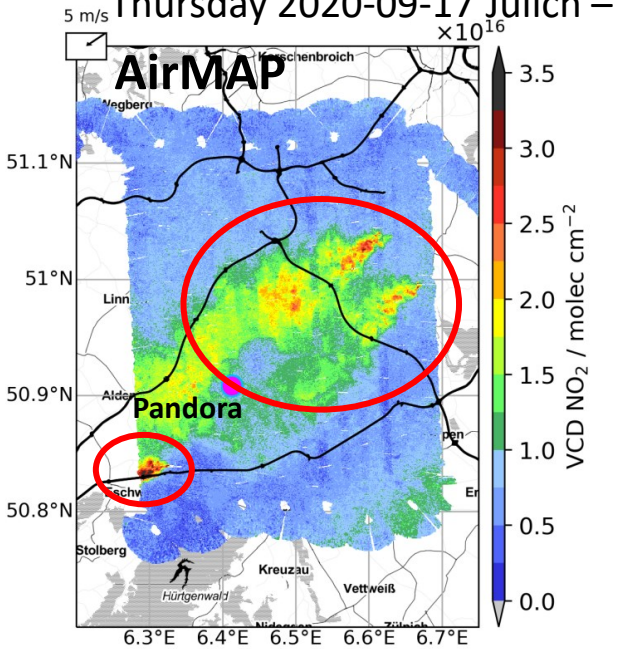


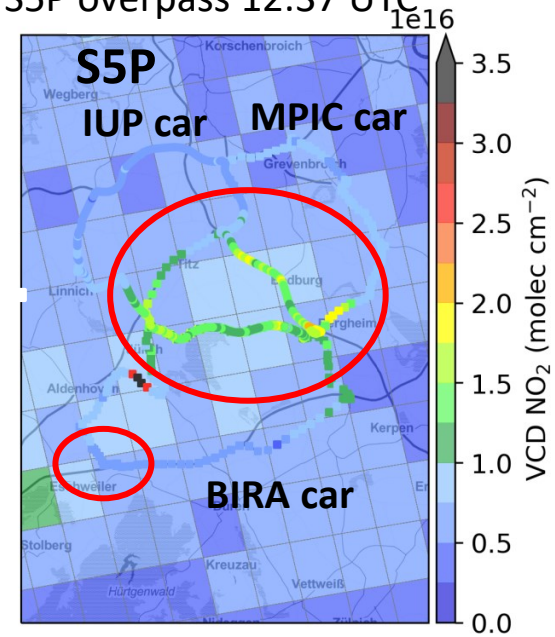


AirMap timeseries (mean over the 35 viewing directions with standard deviation) of the seven flight days show strong variability from day to day (weekday vs weekend) and between the different target areas.

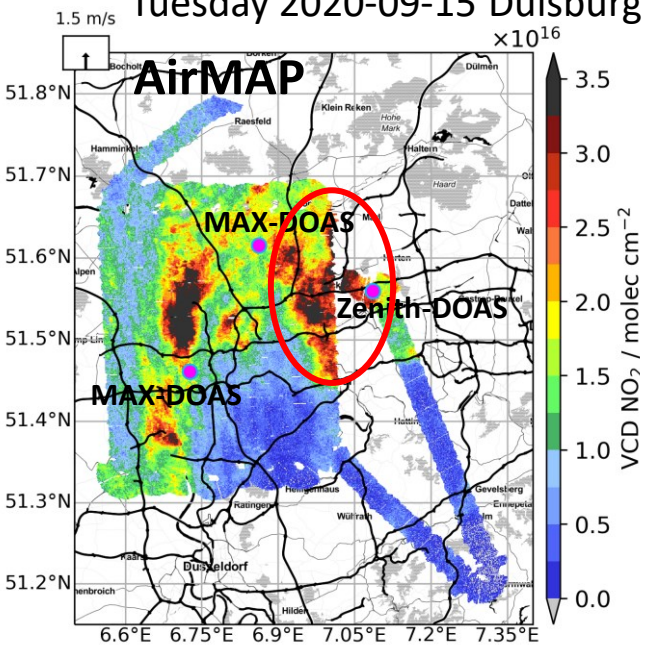
S5P vs AirMAP

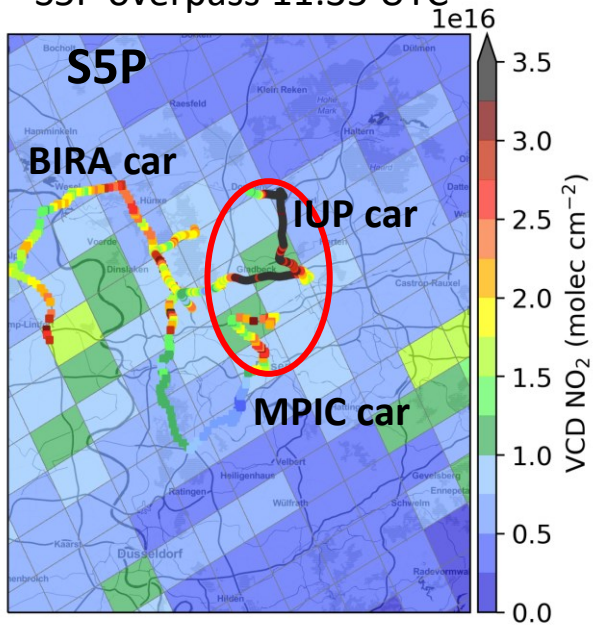
Thursday 2020-09-17 Jülich – S5P overpass 12:37 UTC

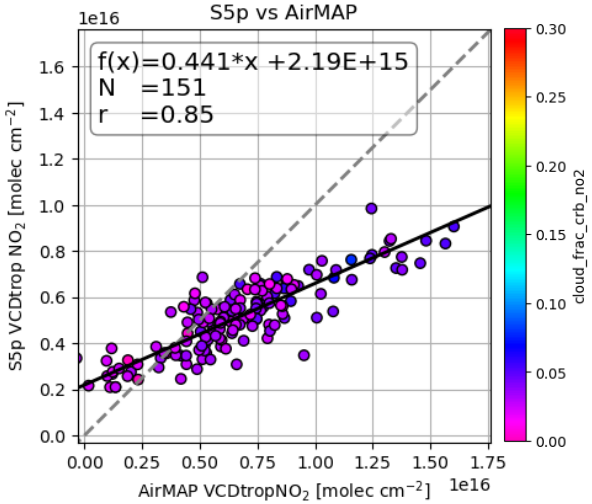




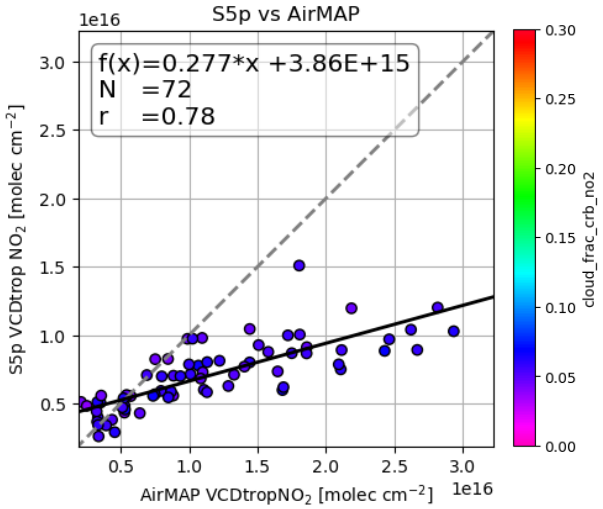
Tuesday 2020-09-15 Duisburg – S5P overpass 11:35 UTC







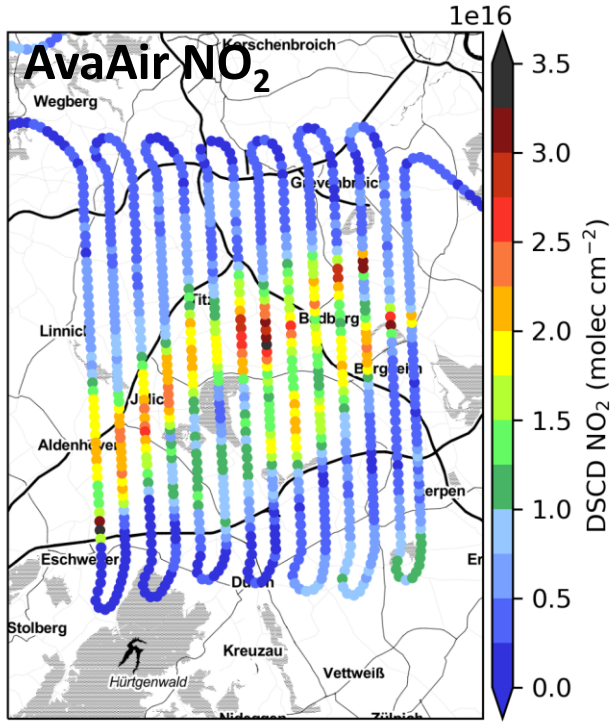
- Consistent measurements of AirMAP and car DOAS
- Good correlation of S5P and AirMAP measurements
- Low biased S5P TROPOMI NO_2 data of around 30% to 45%, with varying magnitude for different days and areas



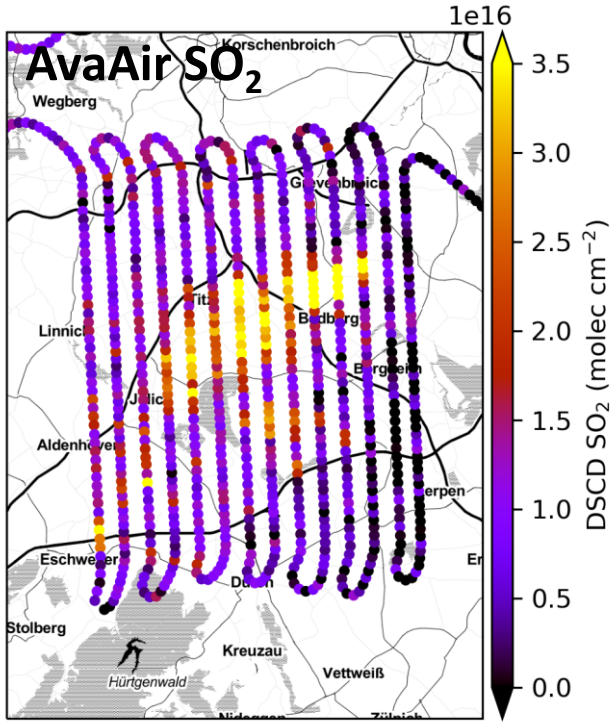
SO_2 signal

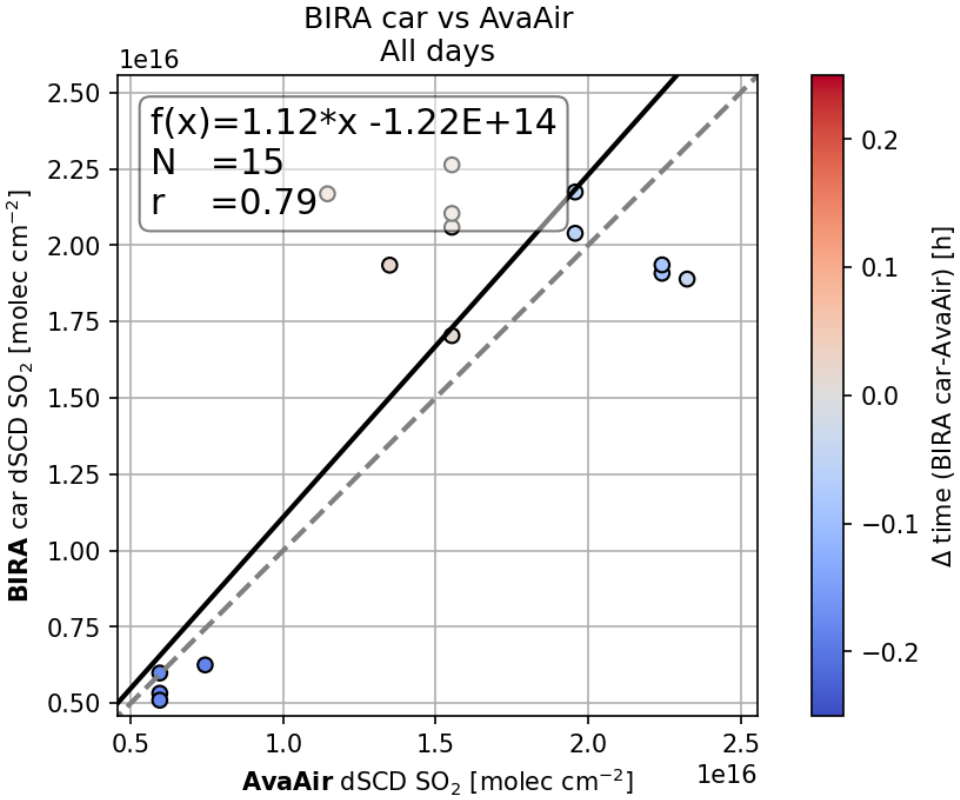
- Nadir viewing zenith Avantes AvaAir next to the AirMAP instrument on board of the Cessna
- In addition to NO_2 also possible to look at HCHO and SO_2
- First quick looks show no signal for HCHO but strong SO_2 signals, for some days
- SO_2 measurements also possible with car DOAS instruments

Thursday 2020-09-17 Jülich



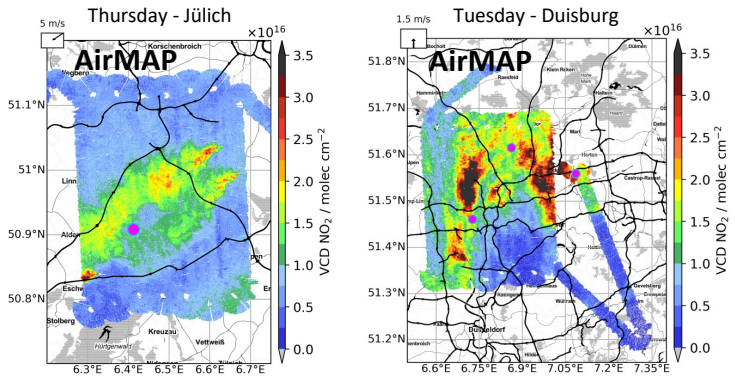
Thursday 2020-09-17 Jülich



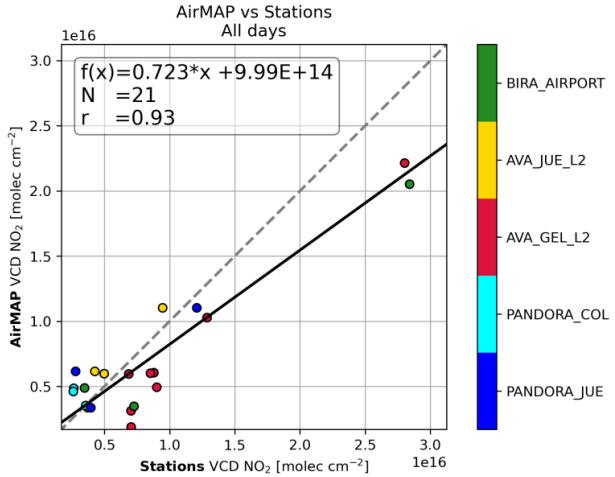


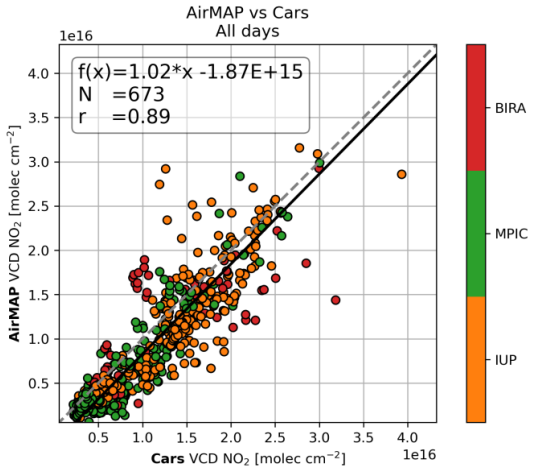
Conclusion and Outlook

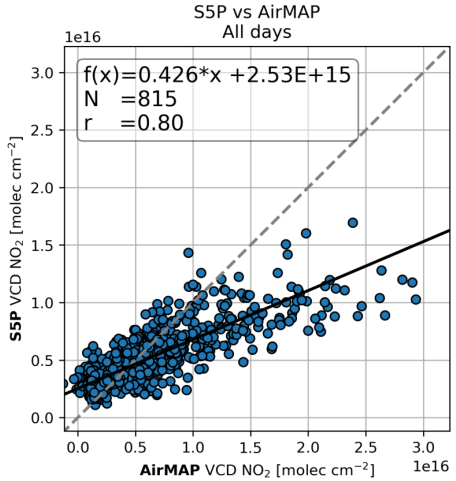
- Seven successful measurement days for validation of Sentinel-5P products
  - three different target areas in the Ruhr area
- High spatial and temporal variability in NO_2



- Consistent measurements of AirMAP and stationary and mobile car DOAS measurements
- Overall low bias of the S5P operational NO_2 data for all target areas but with varying magnitude for different days







- Outlook: Comparison of the campaign data set to custom TROPOMI NO_2 products, using different auxiliary data, such as albedo or a priori vertical profiles to evaluate the influence on the Sentinel-5P TROPOMI data product to investigate the low bias and the high spatial and temporal heterogeneity in NO_2.