

First results from the Sentinel-5P-VAL-DE-Ruhr campaign in 2020

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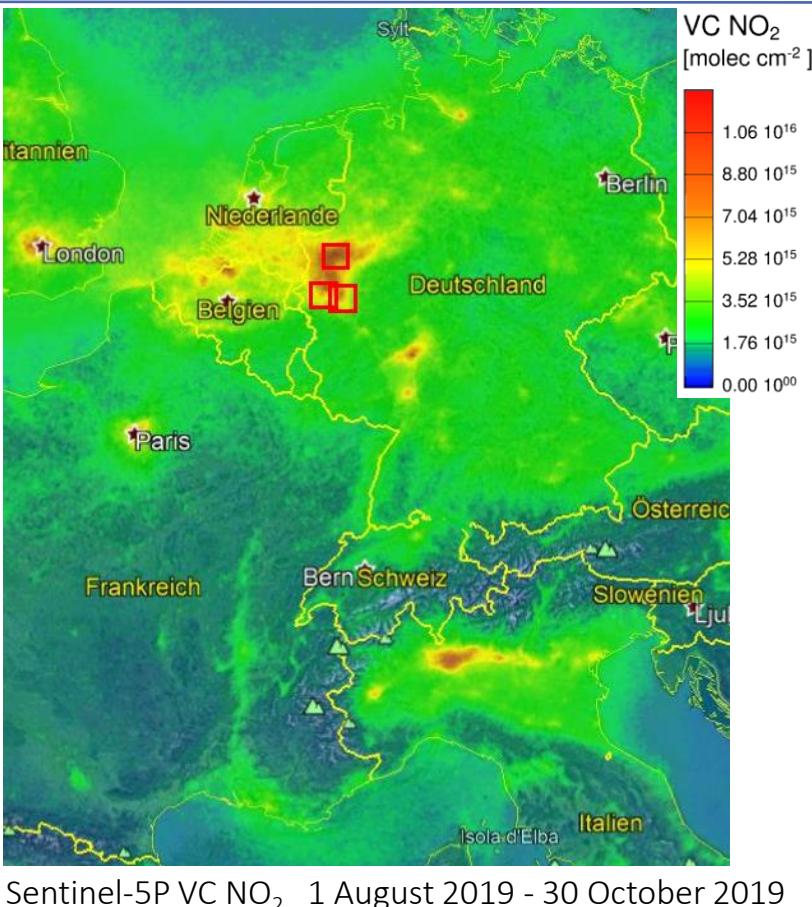
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(5) European Space Agency, ESA-ESTEC, The Netherlands

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
- Campaign was planned for September/October 2019
 - No flights due to bad weather conditions
- Second phase was planned for August/September 2020
 - Unclear situation due to Covid19
 - successful conduction of campaign activities with 7 golden days in September 2020



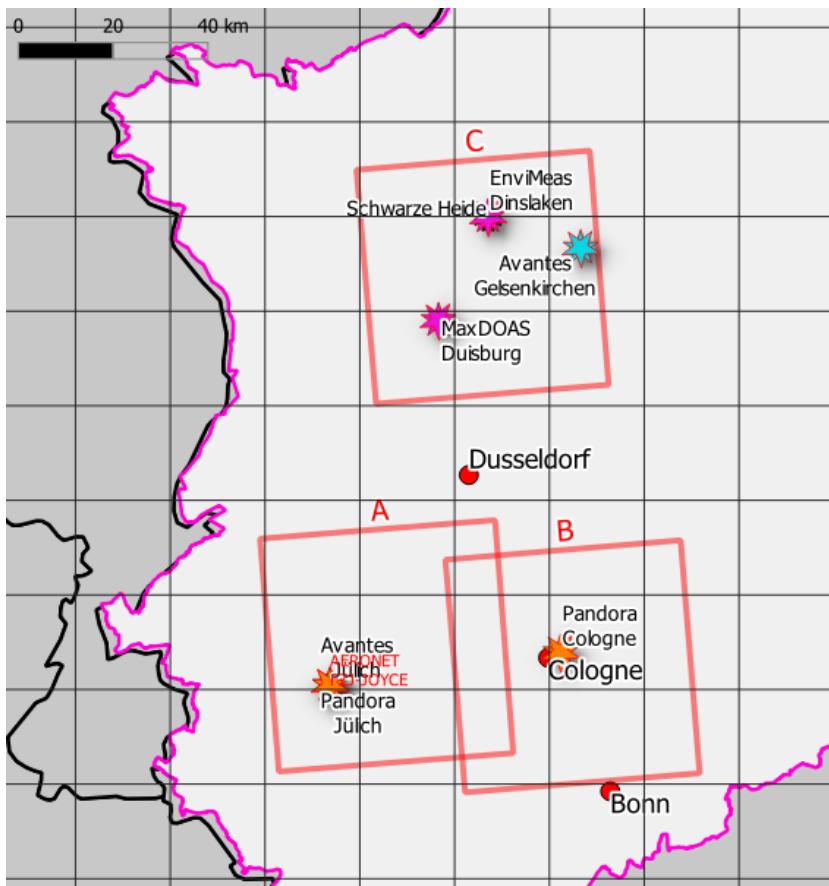
Instruments

Stationary ground-based instruments:

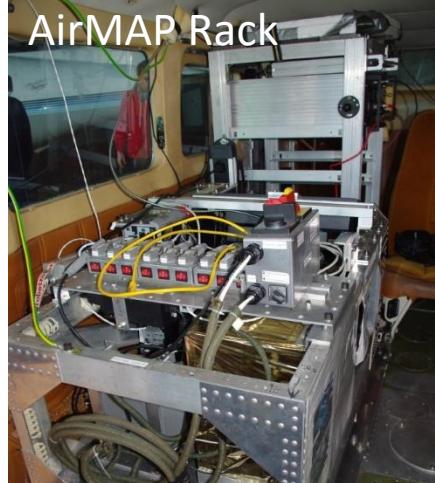
Location (Box)	Instrument type
Jülich (A)	IUP Zenith-sky Avantes
Gelsenkirchen (C)	IUP Zenith-sky Avantes
Airport Dinslaken (C)	BIRA SkySpec
Duisburg (C)	IUP measurement truck (MAX-DOAS, in-situ)
Jülich (A)	Pandora
Cologne (B)	Pandora

Mobile instruments:

Location (Box)	Instrument type
Cessna FU Berlin	AirMAP airborne imaging DOAS instrument
Cessna FU Berlin	Nadir looking Avantes
Car IUP	Zenith-sky Avantes
Car MPIC	Zenith-sky Avantes
Car BIRA	Zenith-sky Avantes



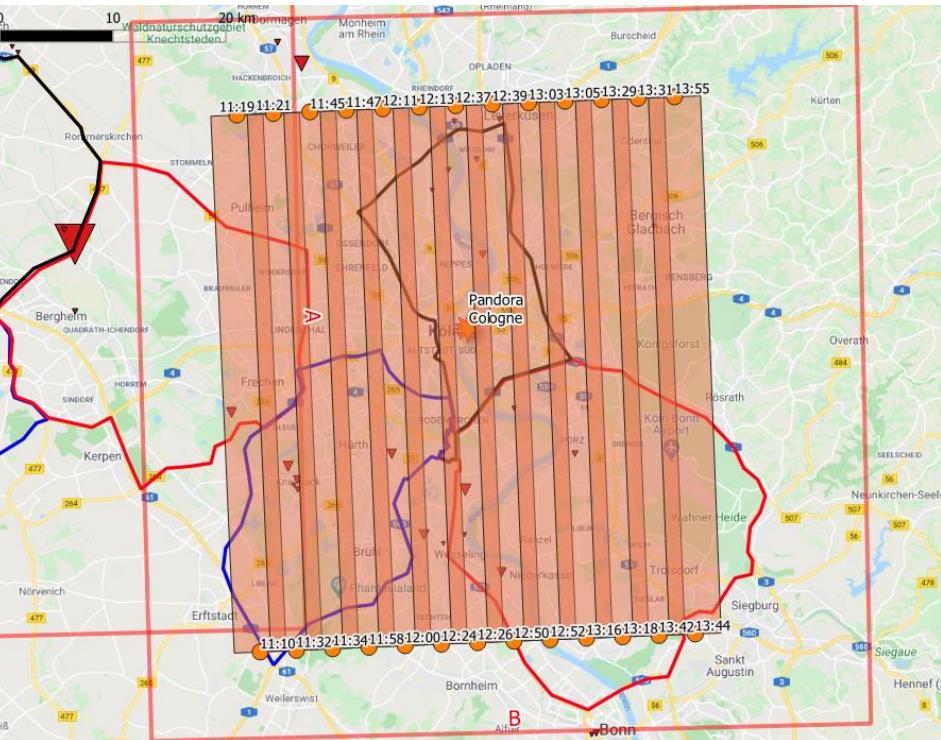
Instruments



- AirMAP airborne imaging DOAS instrument
 - Column of trace gas below the aircraft
 - As aircraft moves forward one across-track line after another (pushbroom) -> full image
- Stationary measurements useful for time series longer than actual campaign period - show the variability in time
- Three car-DOAS systems all in zenith measurement mode

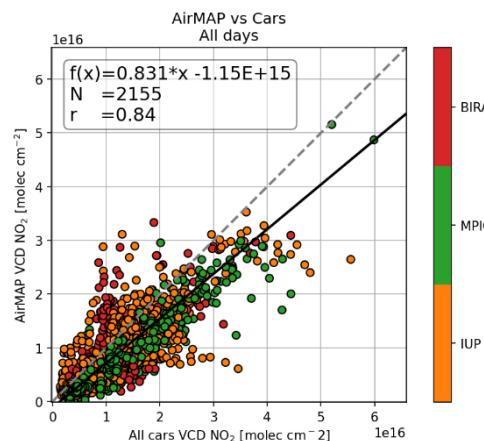
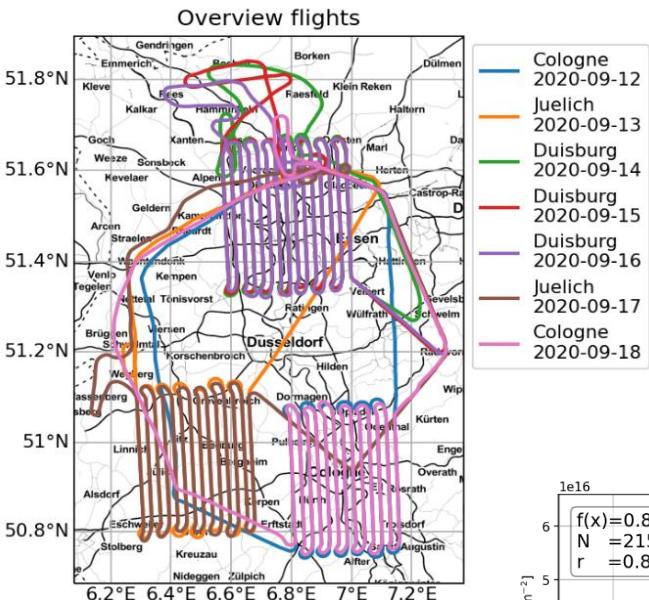
Measurement plans

- Three flight boxes of $40 \times 40 \text{ km}^2$ registered for flight permits
- Shifting of flight pattern within box according to wind direction and sources
- Flight times optimized for Sentinel-5P overpass
- Mobile car-DOAS measurements within area mapped by aircraft
- Co-locations between different car-DOAS instruments as well as stationary instruments

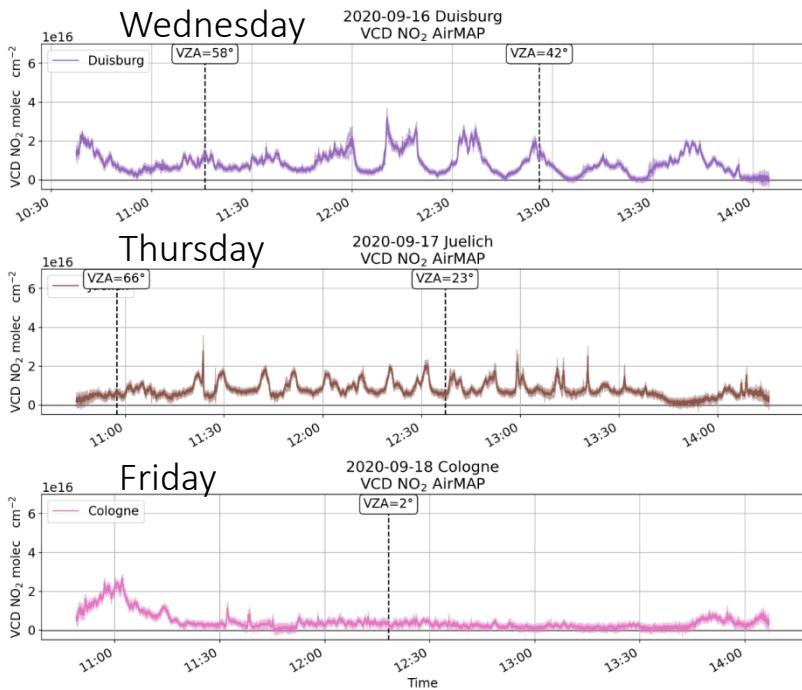
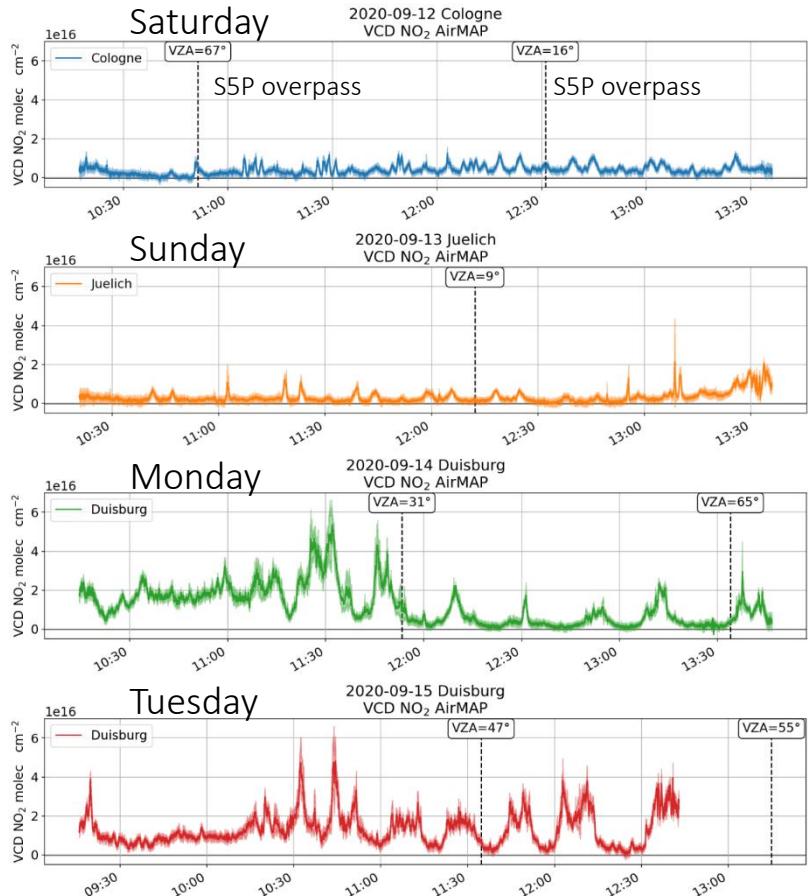


Measurement days

- 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
- Car-DOAS measurements on all flight days
 - Only on 16 September 2020 just one car-DOAS team was available
- Stationary measurements were operational on all flight days and before/after campaign period



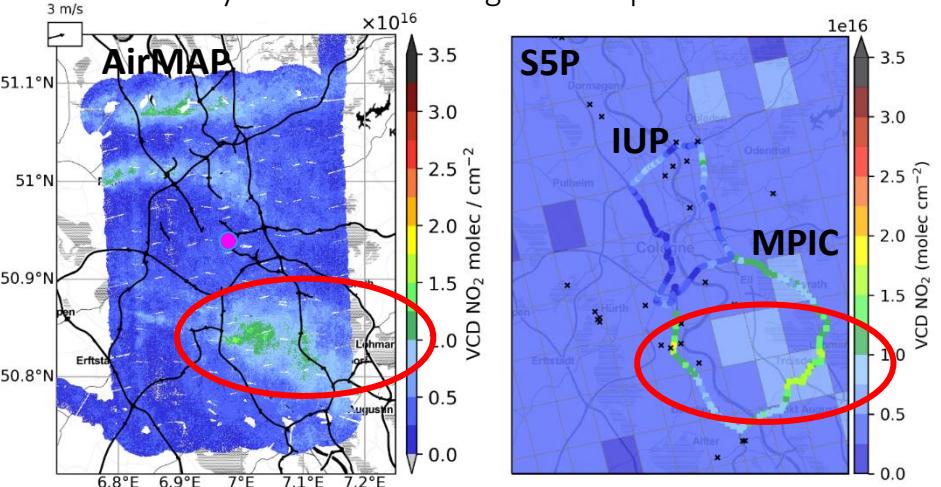
Preliminary results: AirMap timeseries



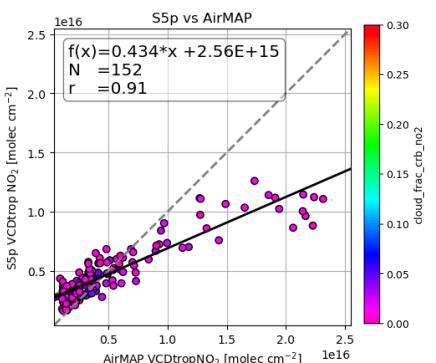
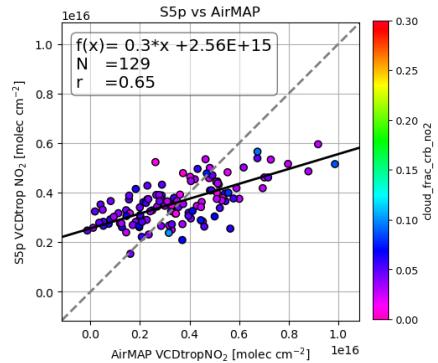
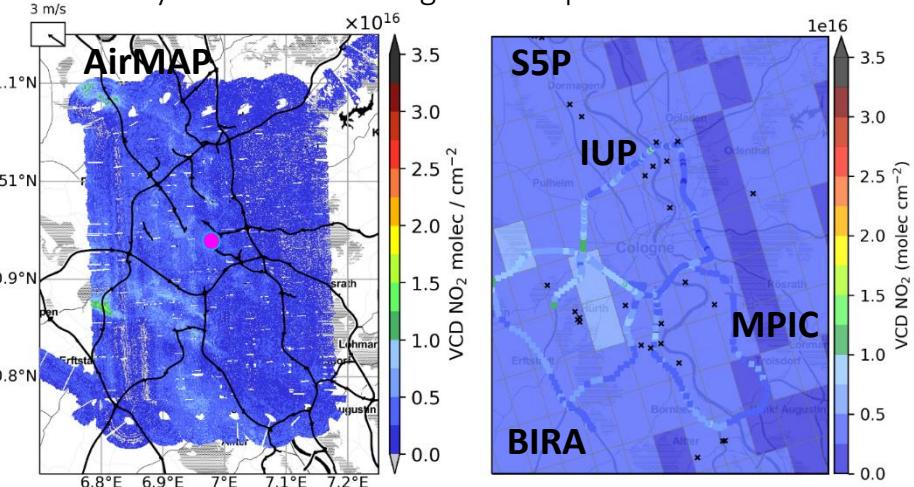
AirMap timeseries of the seven flight days show strong variability from day to day and between the different target areas

Preliminary results: Cologne

Saturday 2020-09-12 Cologne - overpass 12:31 UTC

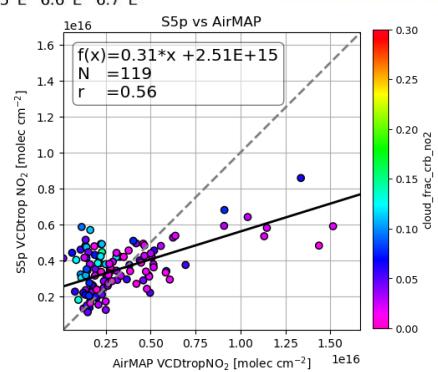
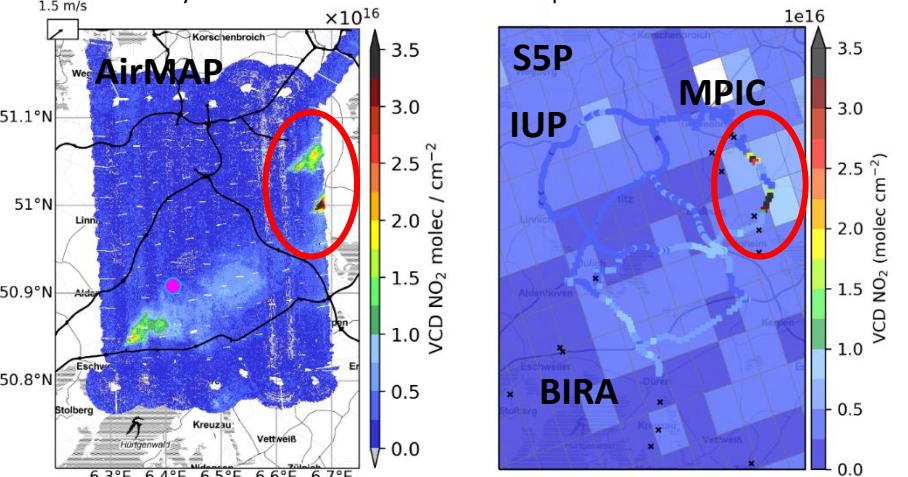


Friday 2020-09-18 Cologne - overpass 12:18 UTC

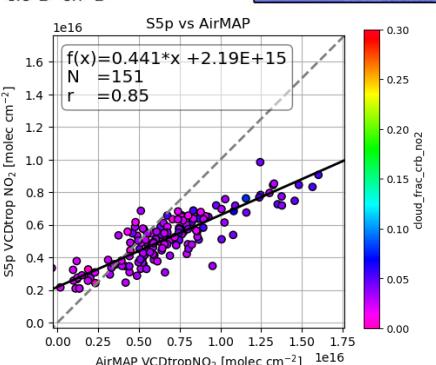
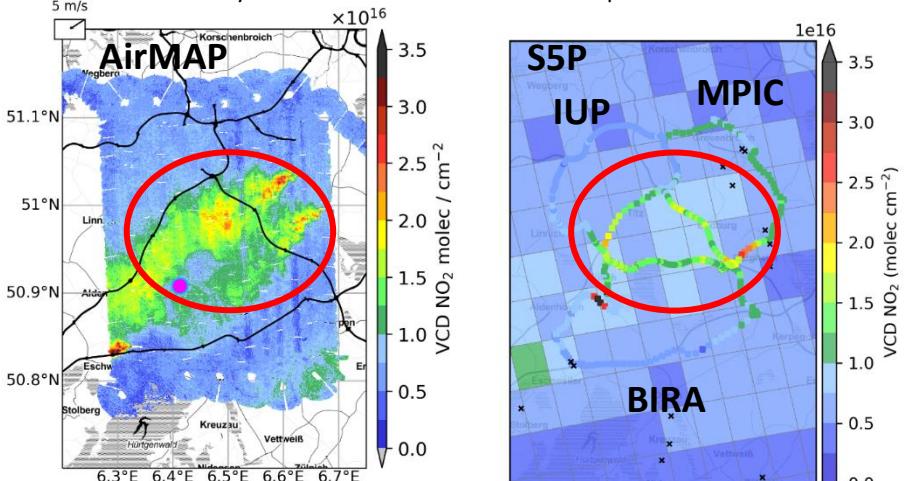


Preliminary results: Jülich

Sunday 2020-09-13 Jülich - overpass 12:12 UTC

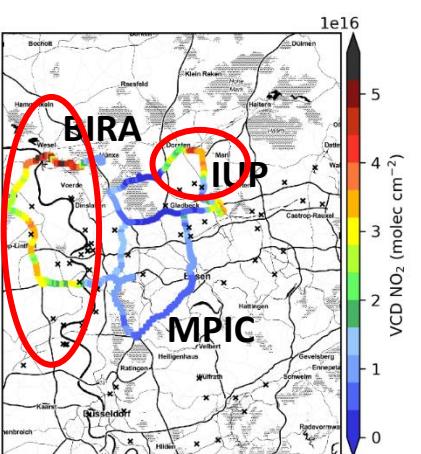
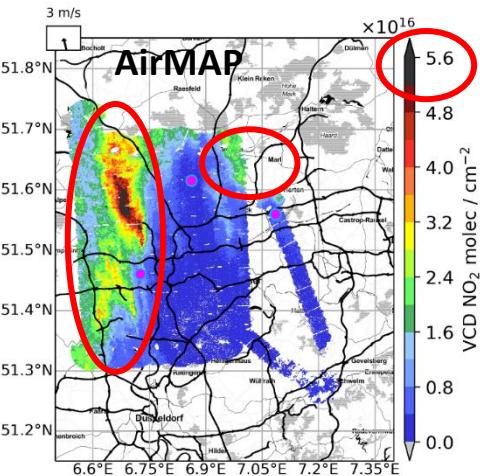


Thursday 2020-09-17 Jülich - overpass 12:37 UTC

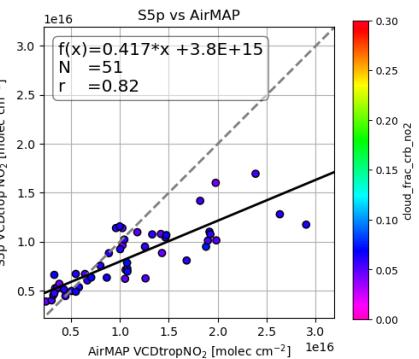
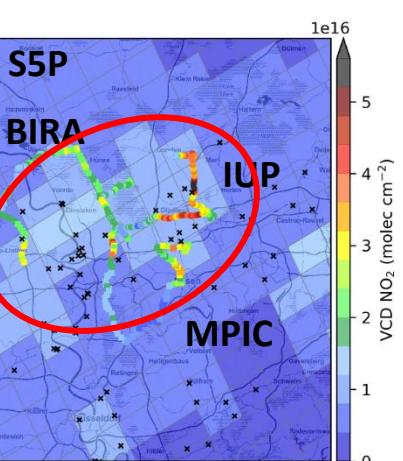
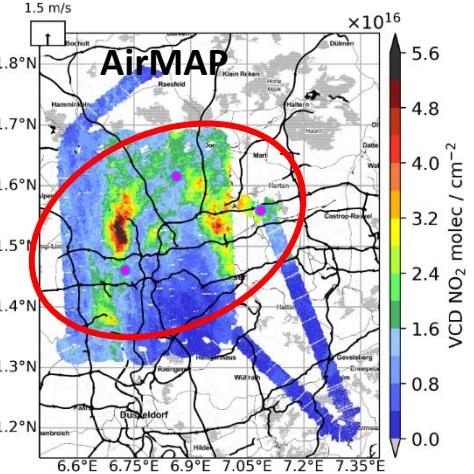


Preliminary results: Duisburg

Monday 2020-09-14 Duisburg - overpass 11:53 UTC

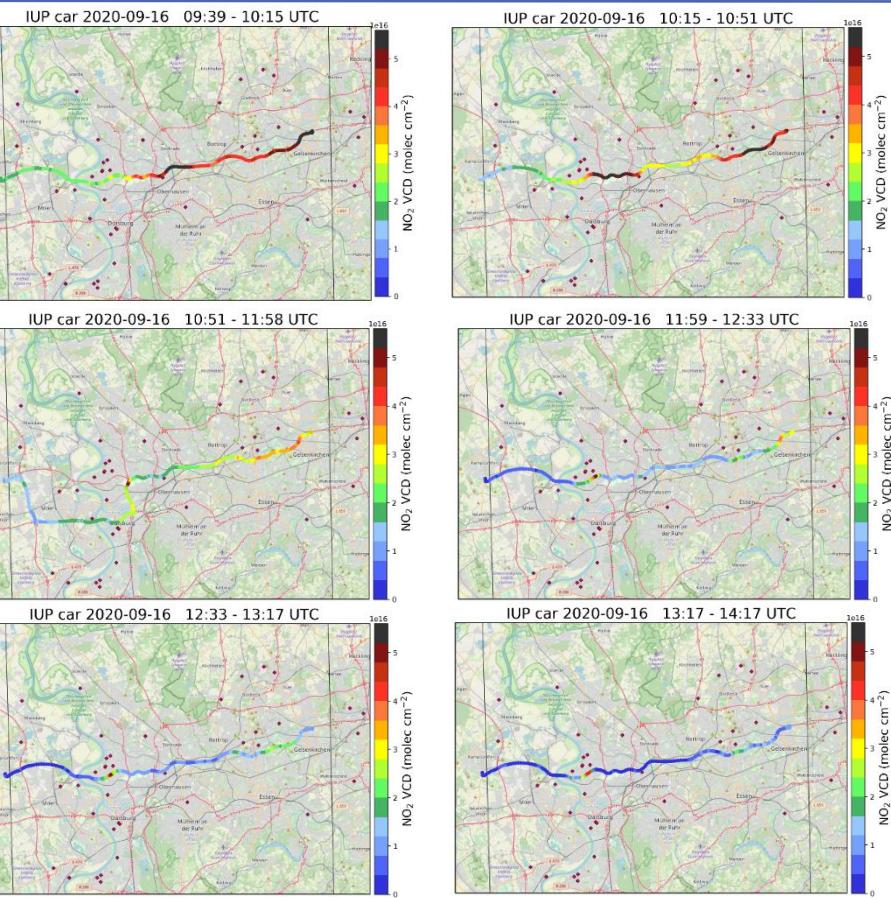
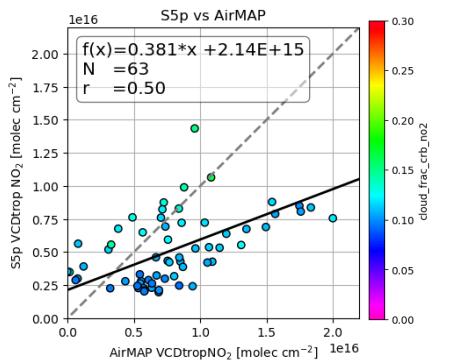
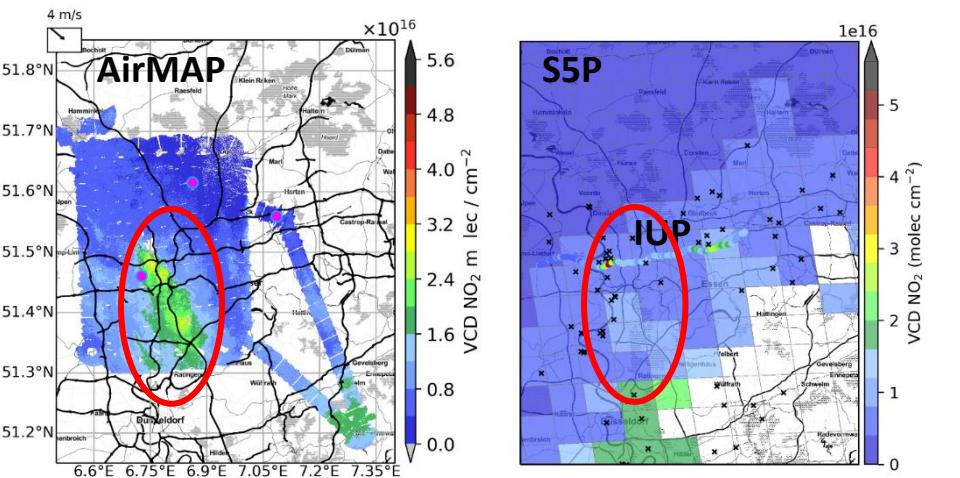


Tuesday 2020-09-15 Duisburg - overpass 11:35 UTC



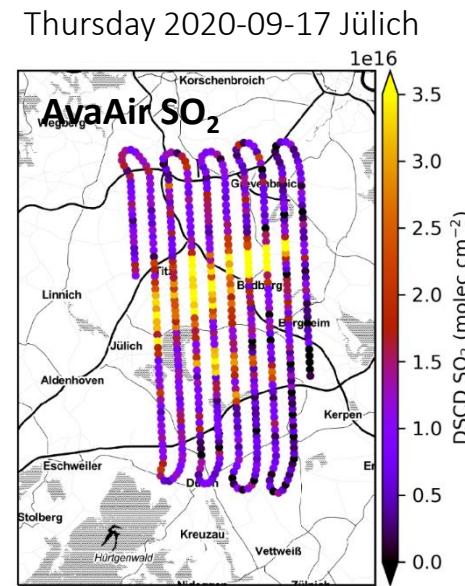
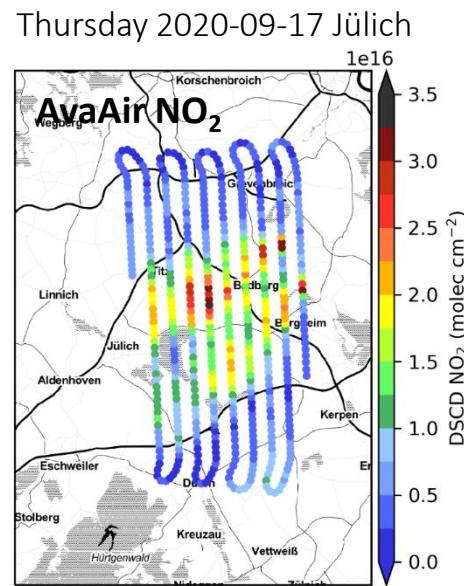
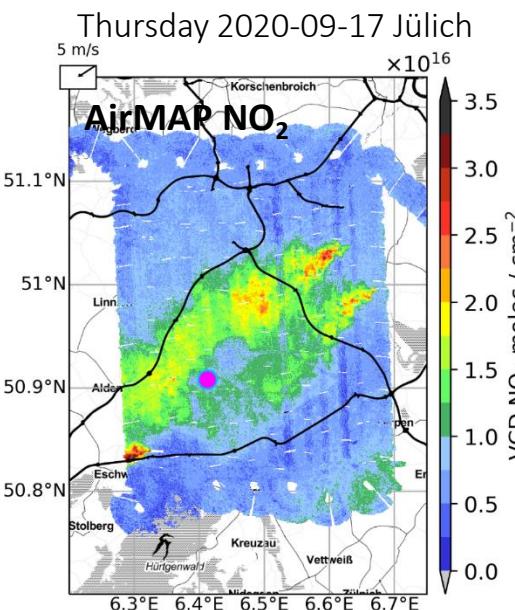
Preliminary results: Duisburg

Wednesday 2020-09-16 Duisburg - overpass 12:56 UTC



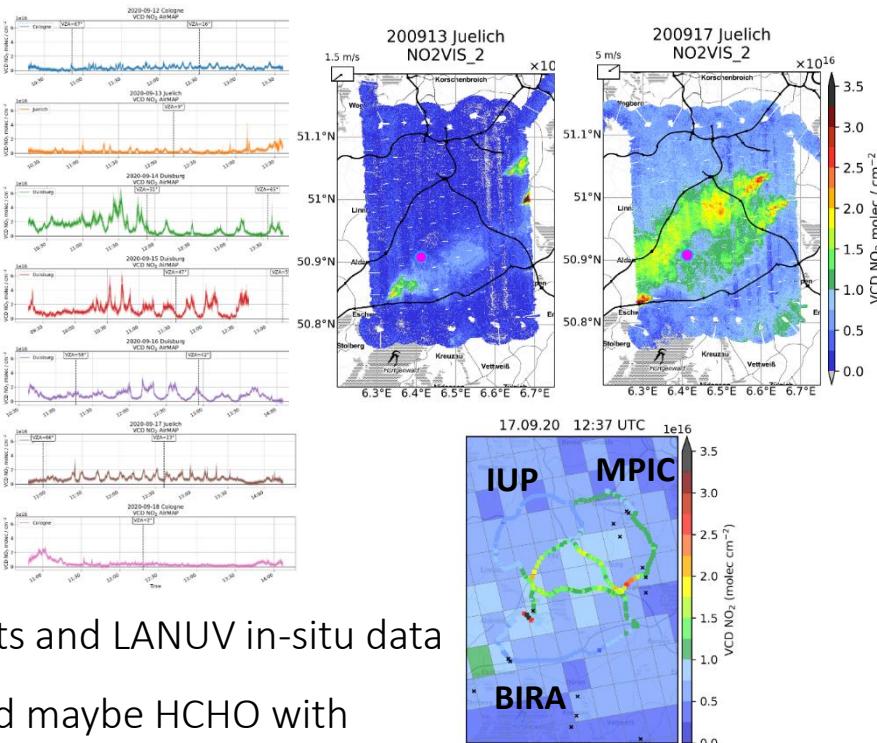
Preliminary results: SO₂ signal

- Nadir viewing zenith Avantes next to the AirMAP instrument on board of the Cessna
- In addition to NO₂ also possible to look at HCHO and SO₂
- First quick looks show no signal for HCHO but for some days strong SO₂ signal



Conclusion and Outlook

- Seven successful measurement days
 - in three different target areas
 - with strong variability from day to day
- High spatial and temporal variability
- Underestimation by Sentinel-5P compared to AirMAP and car-DOAS measurements of
- Next Steps
 - Analysis of stationary ground-based instruments and LANUV in-situ data
 - Validation of Sentinel-5P products NO₂, SO₂ and maybe HCHO with airborne, car-DOAS and stationary ground-based instruments
 - Variation of input data: a priori profile (CMAS regional), albedo, aerosol



Acknowledgments

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References:

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