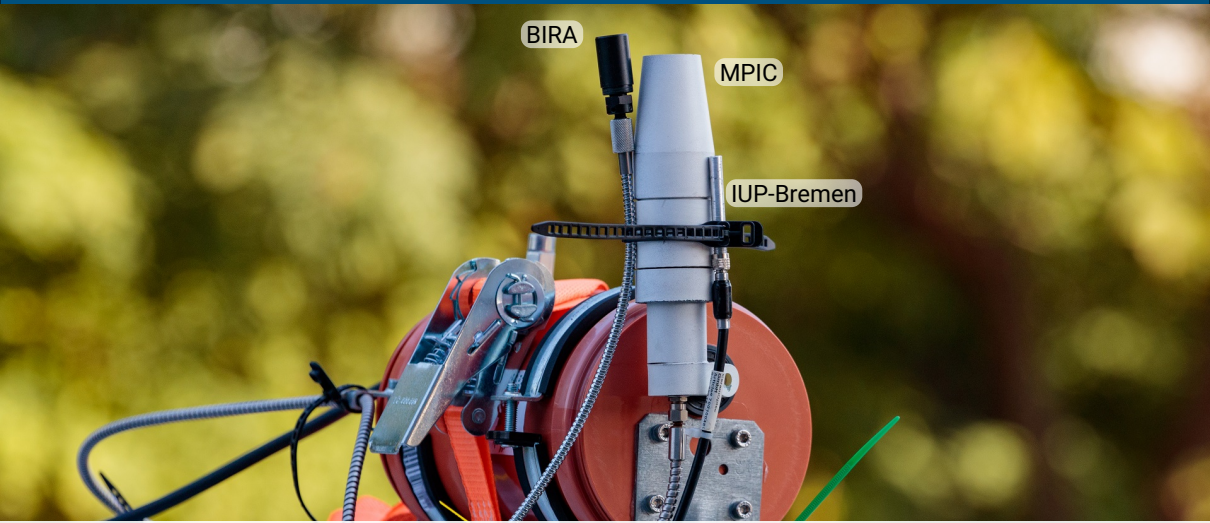
CAR MAX-DOAS MEASUREMENTS DURING GMAP 2021

AS3.22 - EGU22-4586



Steffen Dörner, Kezia Lange, Andreas Richter, Michel van Roozendael, Thomas Wagner and many others…

26th May 2022

Abstract

Satellite Remote Sensing

GMAP 2021 Campaign
DOAS Type Remote Sensing Measurements

- 04.10. to 17.10.2021
  Instrument Validation
- 18.10. to 25.11.2021
  Core Campaign

  Aircraft (GCAS)
  Stationary MAX-DOAS
  Car MAX-DOAS
  Satellite (GEMS)

- Tropospheric VCD comparison
- Intra-Pixel-Variability
- Seoul City emissions
- Characterisation of tropospheric profiles

PKNU/NIER Pandora

BIRA MAX-DOAS

MPIC MAX-DOAS

IUP Bremen MAX-DOAS

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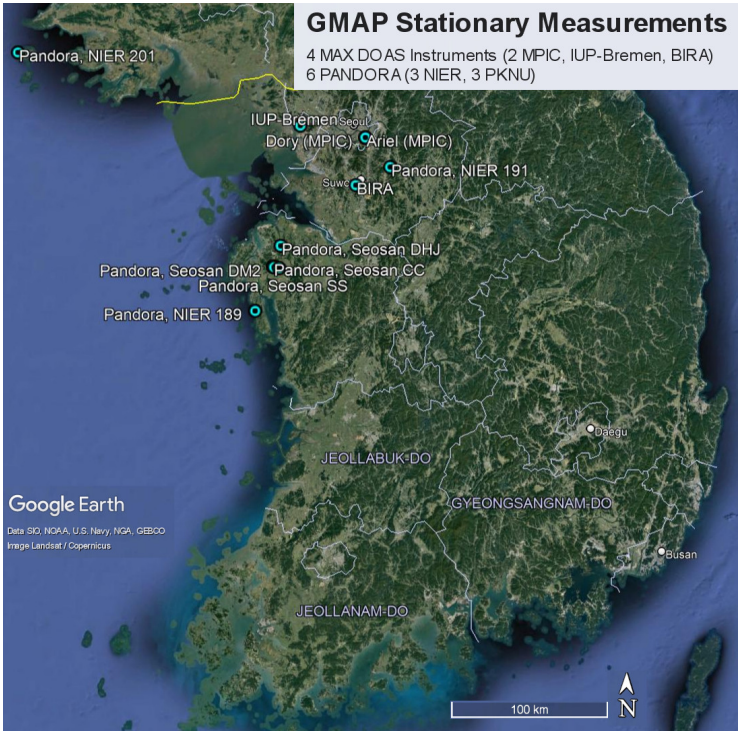

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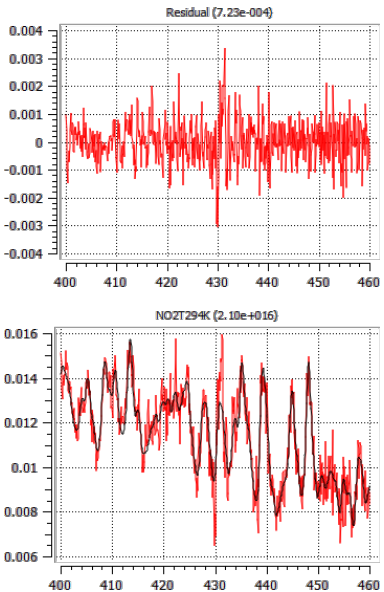
Oct 2021 Group Picture

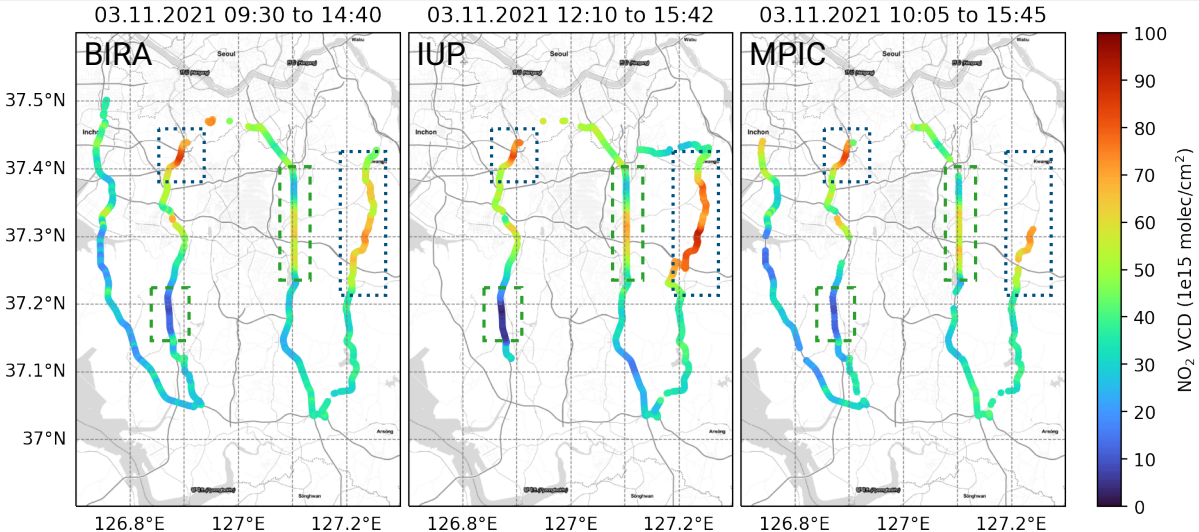
Nov 2021 Group Picture

Nitrogen Dioxide Fit

- Integration Time
  BIRA: 10 s IUP Bremen: 10 s MPIC: 15 s
- Constant reference on 22.10.2021
  approx. 09:38 to 09:42 UTC
- Trop. VCD calculation according to
  Wagner et al., 2010
- Stratospheric VCD taken from climatology
  (B3dCTM for 22.10.2021)
- Fit Settings (MPIC)
  - 400 to 460 nm
  - NO2T294K - Vandaele et al., 1998
  - H2OT293K - Lampel et al., 2015
  - O3T223K - Serdyuchenko et al., 2014
  - O4T293K - Thaman and Volkamer, 2013
  - Polynomial 5th degree
  - Offset constant + first order
  - Shift against constant reference

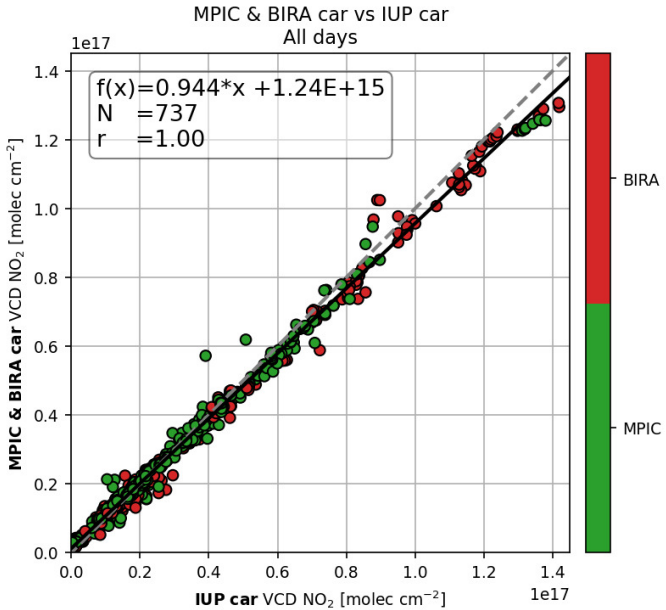


CAR MAX-DOAS
03.11.2021 BLUE BOX (GCAS COMPARISON)



- Generally good agreement between all instruments
- Some high signals appear quite stationary (**blue dotted**)
- Others vary in time (**green dashed**)

CAR MAX-DOAS – VALIDATION

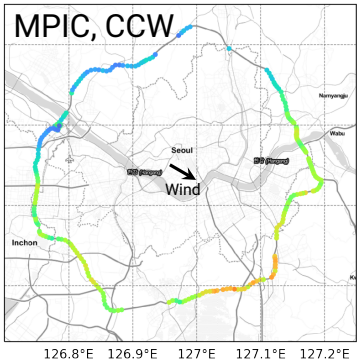


- Collocation of all three instruments if they are at the same location at the same time ($\Delta t \leq 2$ min, $\Delta s \leq 50$ m)
- Shown are all data points from all measurement days which fulfill the collocation criteria
- Good agreement between all data sets, remaining difference could be attributed to different fit settings (IUP Bremen, MPIC, BIRA)
- Variations seen in maps originating from temporal evolution of NO_2 concentration

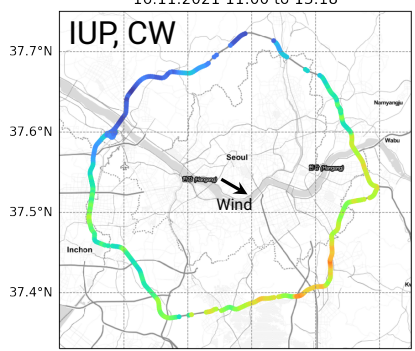
CAR MAX-DOAS
16.11.2021 SEOUL CITY EMISSION

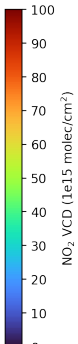
Different Target Area for BIRA Car

16.11.2021 11:04 to 13:06



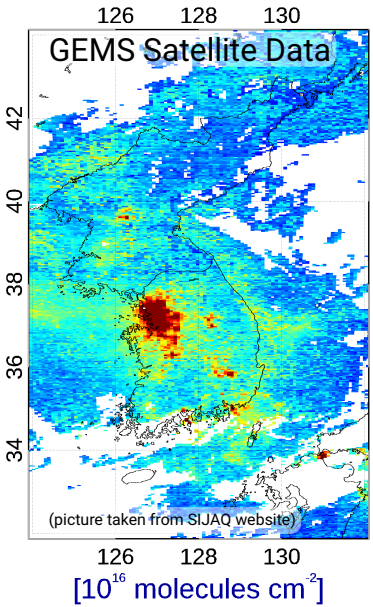
16.11.2021 11:00 to 13:18





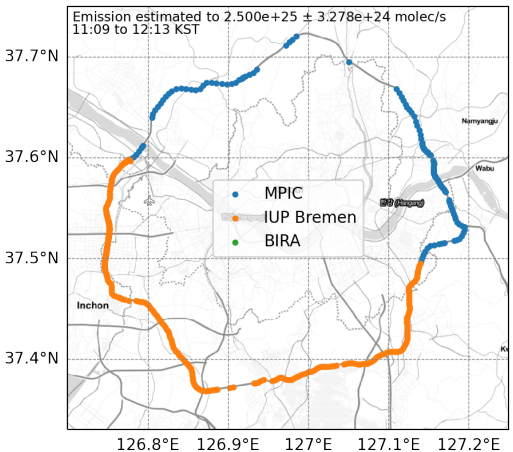
- Wind Speed: 3.0 m s^{-1}
- Wind Direction: NW (313°) to W (292°)
- 0/8 clouds
- Consistent outflow direction
- Temporal variation of local maxima

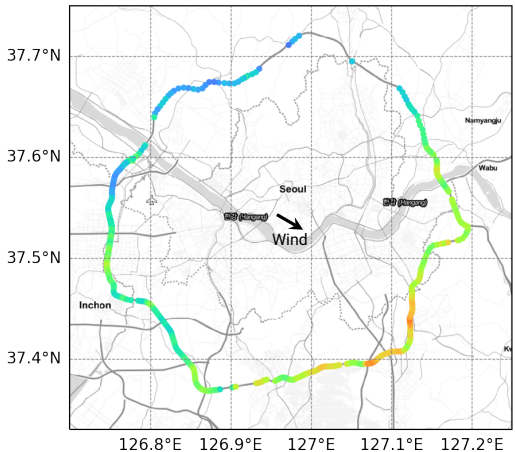
Total NO_2 VCD
2021/11/16 11:45 KST



Car MAX-DOAS – New Approach

16.11.2021 Seoul City Emission

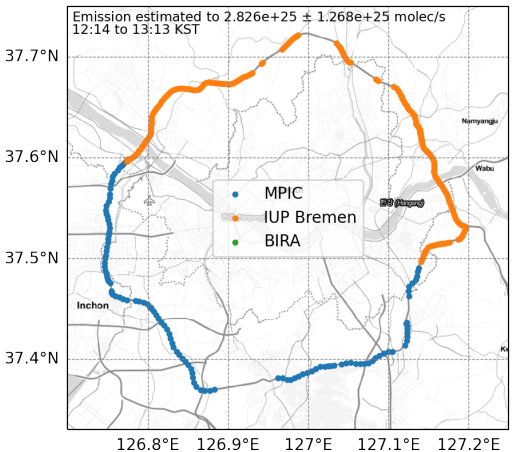


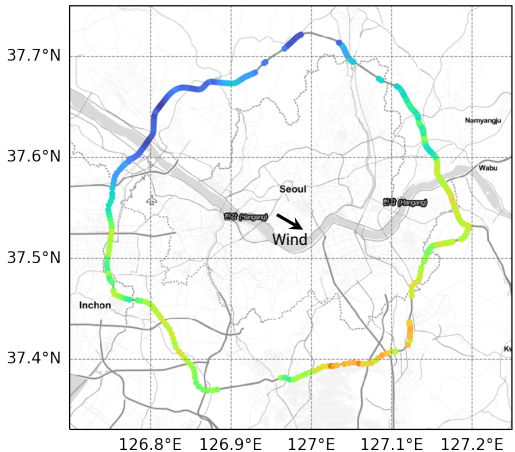


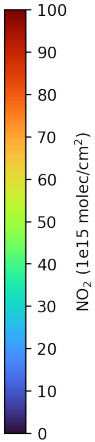
- Good agreement between instruments enable a direct combination of all three data sets
- Combining different instruments yields more emission estimates per day
- Shorter time per "circle" improves method
- Could be improved further if cars don't start at the same point

Car MAX-DOAS – New Approach

16.11.2021 Seoul City Emission







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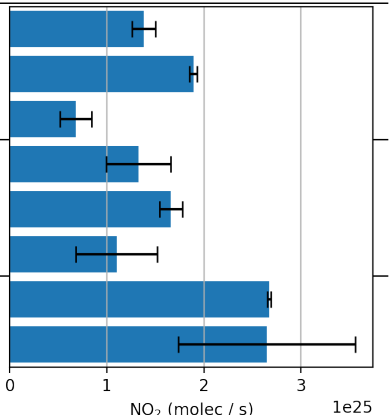
CAR MAX-DOAS
EMISSION SUMMARY, PRELIMIARY RESULTS (!)

Date	Time Range (KST)	Emission (10^{25} molec/s)
22.10.2021 (1)	11:02 to 12:21	1.38 ± 0.12
22.10.2021 (2)	12:22 to 13:26	1.89 ± 0.04
22.10.2021 (3)	15:00 to 16:48	0.68 ± 0.16
27.10.2021 (1)	10:02 to 11:37	1.33 ± 0.33
27.10.2021 (2)	11:44 to 13:31	1.66 ± 0.12
27.10.2021 (3)	14:50 to 16:12	1.10 ± 0.42
16.11.2021 (1)	11:09 to 12:13	2.67 ± 0.02
16.11.2021 (2)	12:14 to 13:13	2.65 ± 0.91



- Error estimation only includes emission calculation uncertainty
- For optimal measurement conditions clear days with stable wind conditions (not calm) are chosen
- DOAS measurements are easier to interpret (simpler light path)
- Background NO_2 levels are reduced (clean influx)

SUMMARY

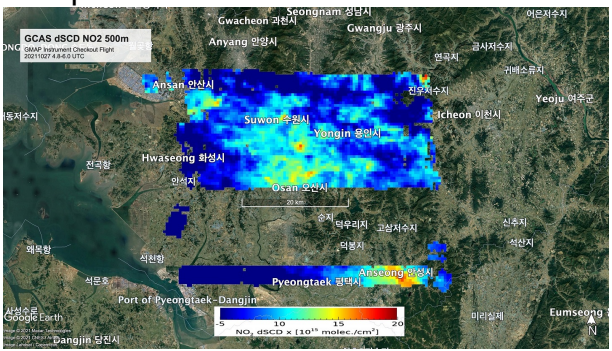
- Mobile measurements by BIRA/MPIC/IUP Bremen
  12 measurement days with ≈ 100 h with each instrument

20.10.2021 ≈ 8 h (Seoul Inner City)	03.11.2021 ≈ 9 h (GCAS, blue box)
22.10.2021 ≈ 8 h (Seoul City Emission)	05.11.2021 ≈ 10 h (GCAS, red box)
27.10.2021 ≈ 9 h (Seoul City Emission)	12.11.2021 ≈ 9 h (GCAS, red box)
28.10.2021 ≈ 8 h (Pyeongtaek)	14.11.2021 ≈ 8 h (GCAS, blue box)
01.11.2021 ≈ 8 h (Seoul Inner City)	16.11.2021 ≈ 6 h (Seoul City Emission)
02.11.2021 ≈ 8 h (Seoul Inner City)	17.11.2021 ≈ 9 h (GCAS, red box)

- Stationary measurements from 19th Oct until today

OUTLOOK

- Comparison of mobile measurements to GCAS measurements



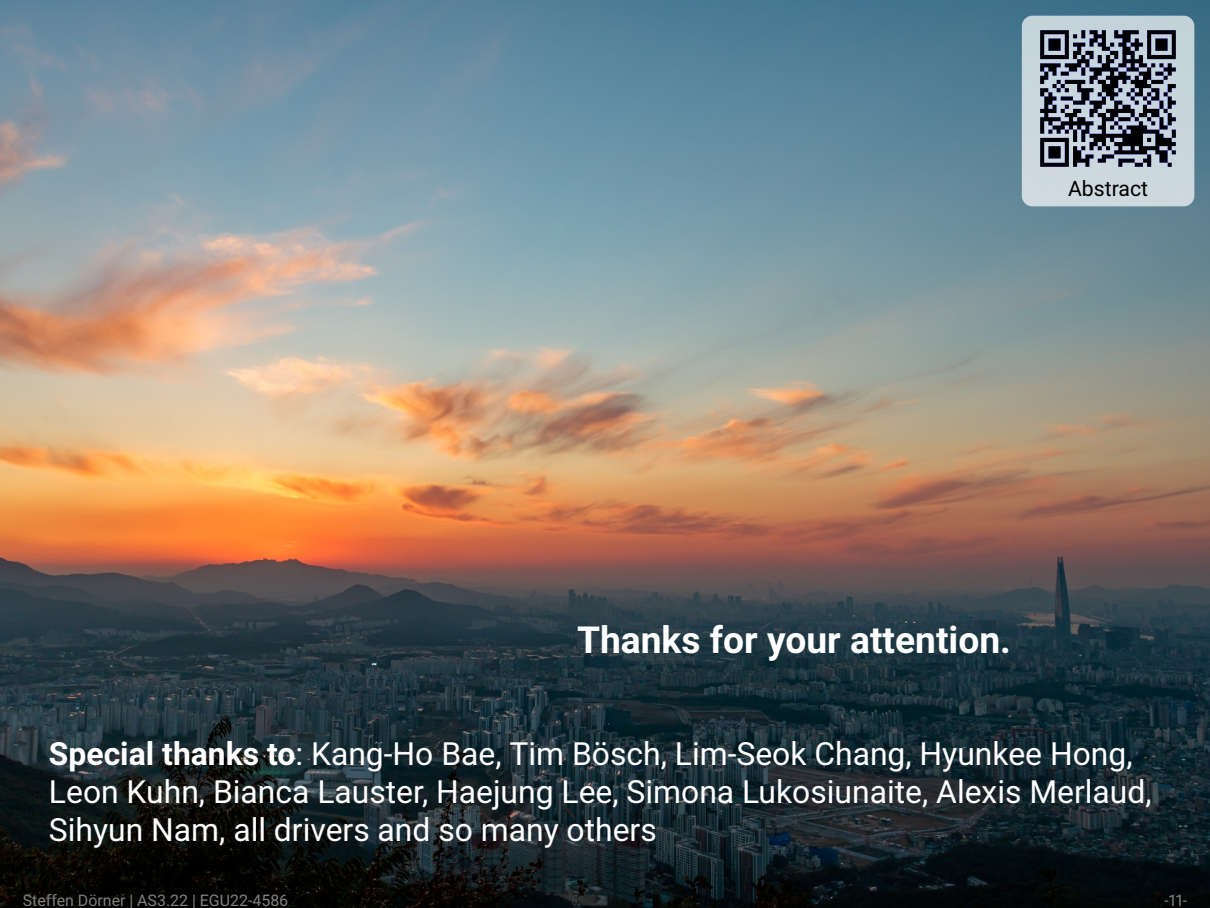
(Jayne Boehmler, SIJAQ website, preliminary, test flight on 27.10.2021)

- Deriving surface concentration/profiles/VCD for stationary measurements

- Comparison of stationary measurements to HUFS aircraft in-situ data
- Analysis of HCHO and SO_2 for stationary and mobile measurements

Conclusion

- Consistent results for stationary and mobile measurements
- Successful campaign provides a solid data set for satellite validation
- Seoul Metropolitan Area appears to be a strong source of NO_2
- **Remark:** Possible selection bias for NO_2 emissions of Seoul city
- As to be expected: Near NO_2 sources significant temporal variation and horizontal gradients were found


Abstract
Thanks for your attention.
Special thanks to: Kang-Ho Bae, Tim Bösch, Lim-Seok Chang, Hyunkee Hong, Leon Kuhn, Bianca Lauster, Haejung Lee, Simona Lukosiunaite, Alexis Merlaud, Sihyun Nam, all drivers and so many others