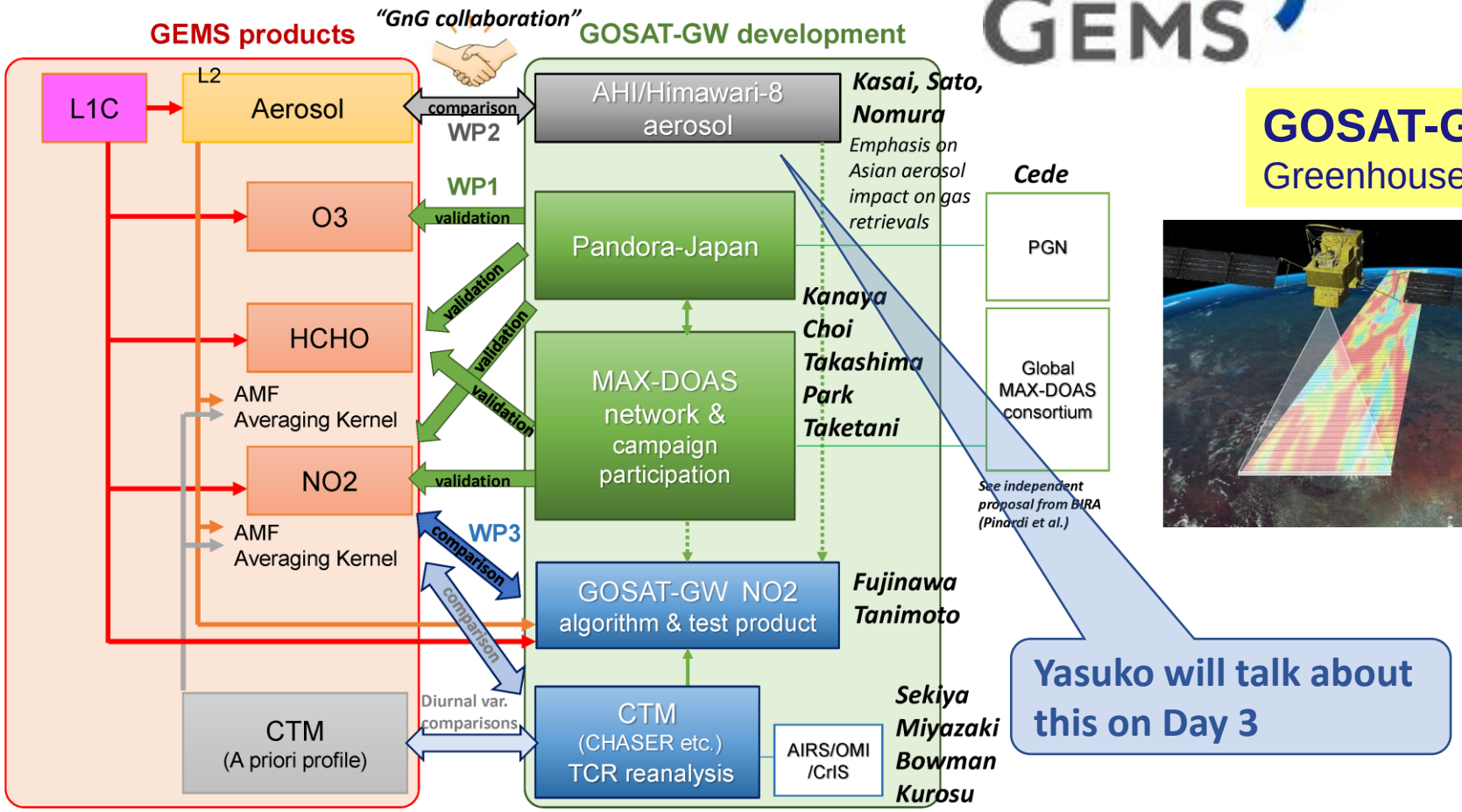
GEMS v1.0 (NO_2, HCHO and O_3) validation results from GnGval team

Yugo Kanaya, Yongjoo Choi (JAMSTEC and HUFS)
Tamaki Fujinawa and colleagues



Yasuko will talk about this on Day 3

GOSAT-GW (Global Observing SATellite for Greenhouse gases and Water cycle)

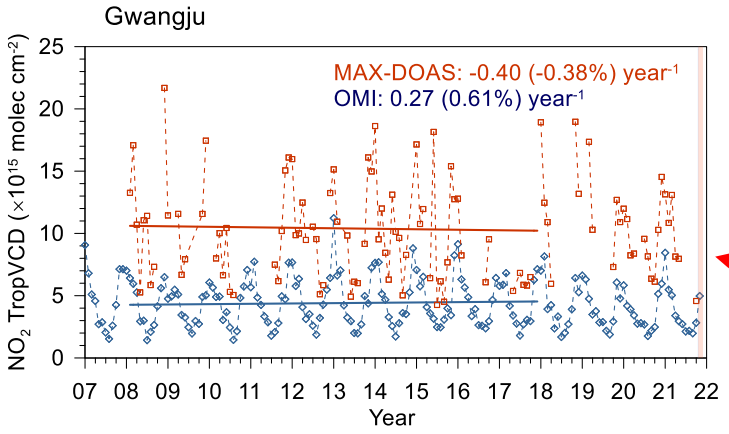
TANSO-3 (Total Anthropogenic and Natural emissions mapping SpectrOmeter-3)

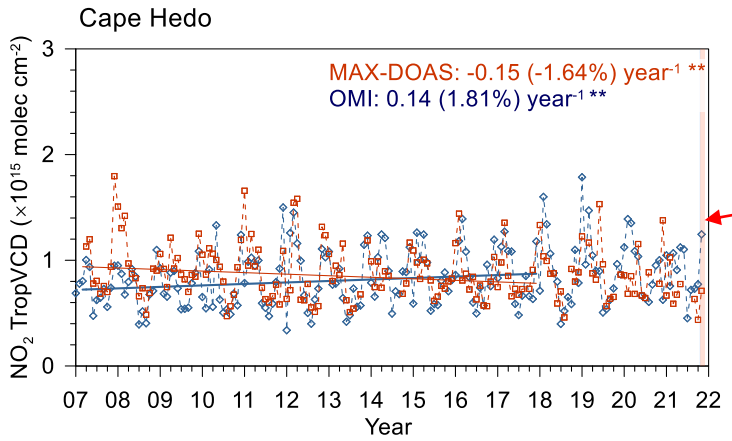
Project: NIES, funded by MoE-Japan
PIs: T. Matsunaga, **H. Tanimoto**
Development: JAXA, Mitsubishi

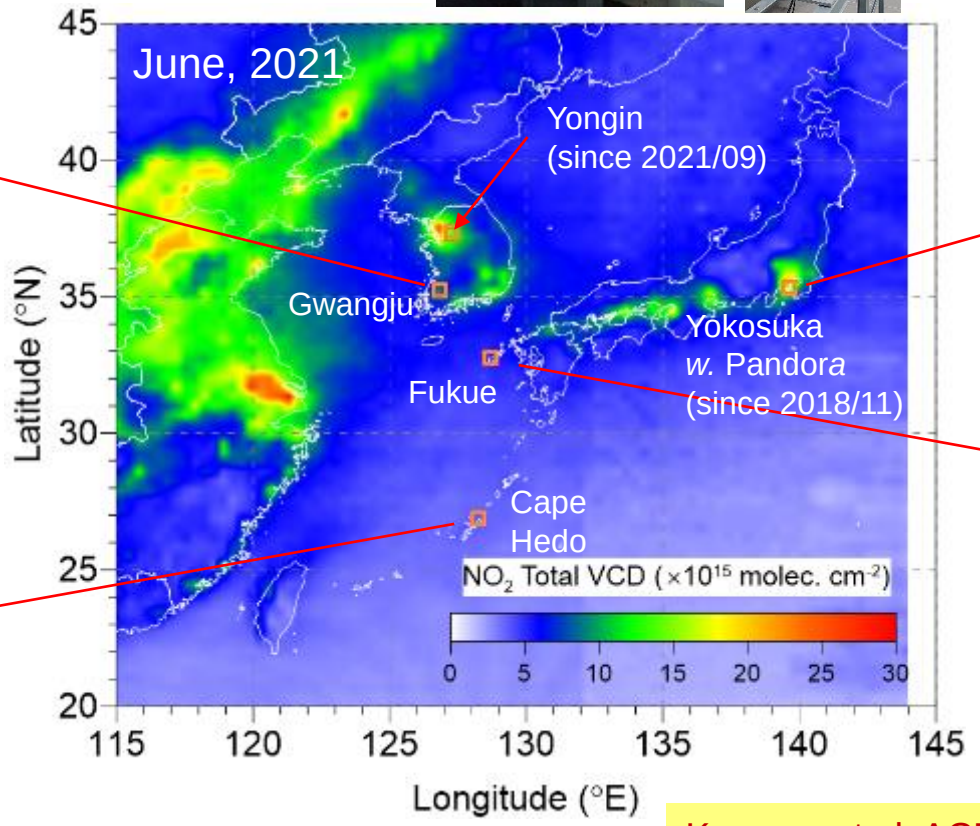
Expected Launch: FY2023

Lifetime: 7 yrs
Orbital altitude: 666 km
Sensor: grating imaging spectrometer
Band: VIS, NIR 0.7, SWIR 1.6 um
Species: CO_2, CH_4, NO_2
Swath: 911 km/90 km
Spatial resolution: 10 km/1-3 km
Global coverage: 3 days
Local time: 13:30

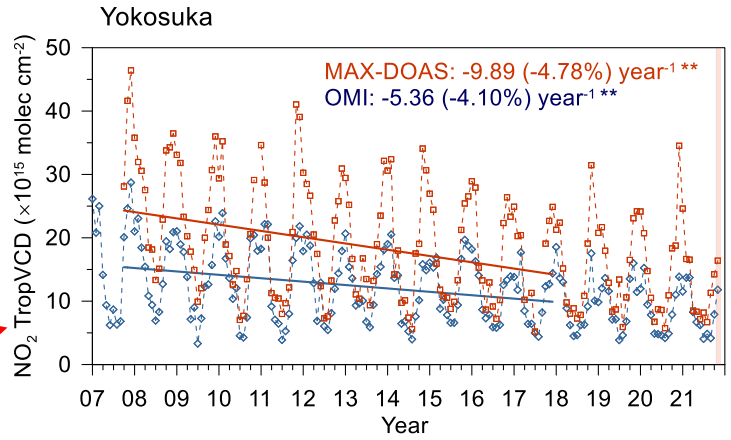
Locations of our validation observations

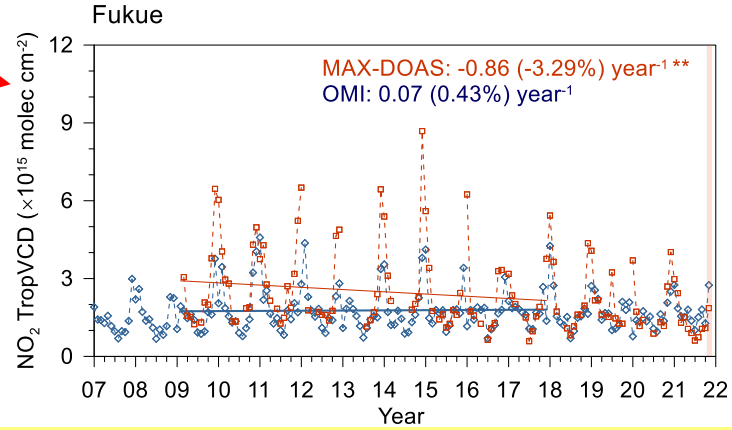






GEMS (grid size 0.5° × 0.5°; SZA<85°; CF<30%)

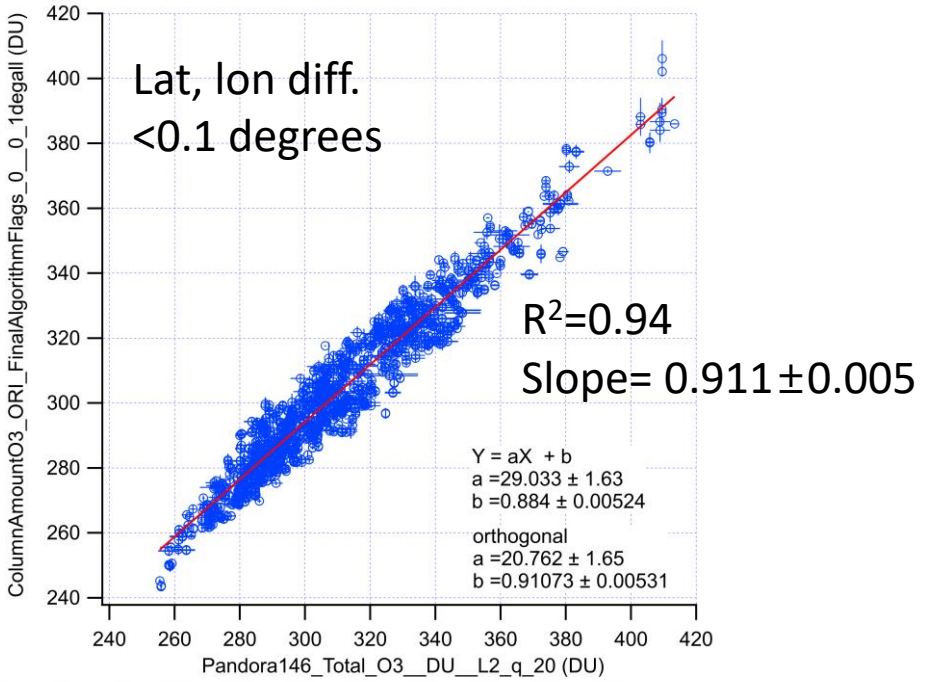


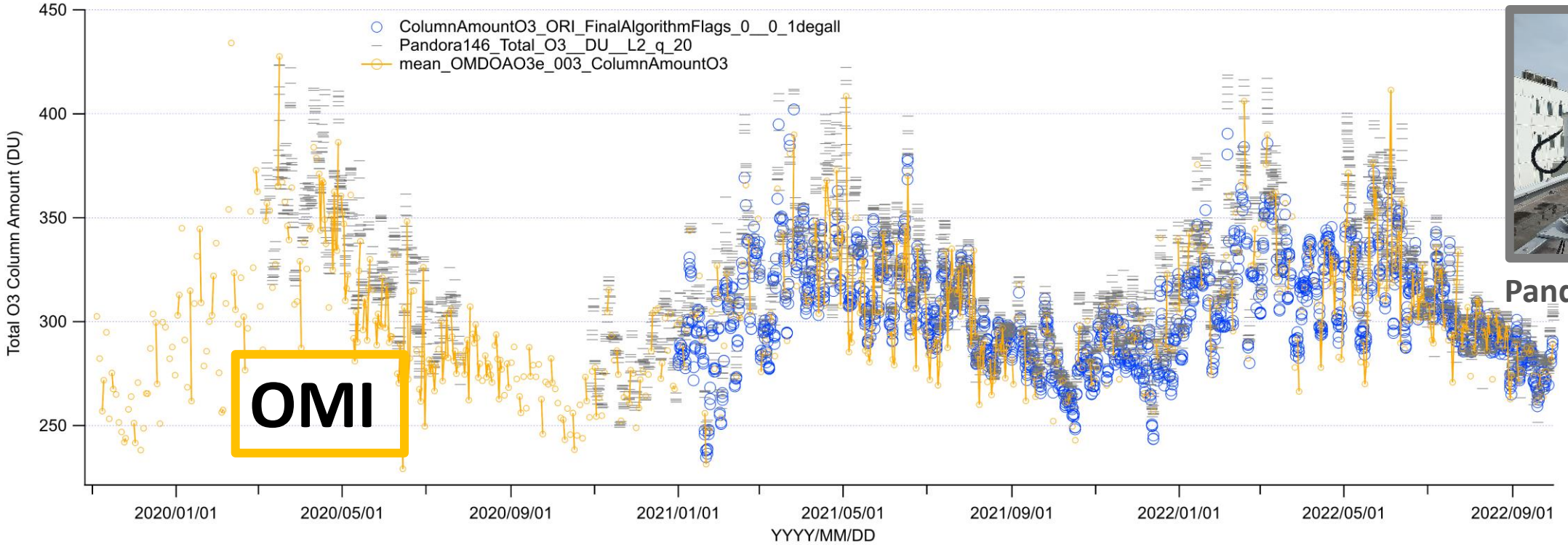


Kanaya et al. ACP 2014, Choi et al. (*RS*, 2021) + extended works

GEMS v1.0 O3T (Total O3) at Yokosuka

from Jan 2021 to Sep 2022

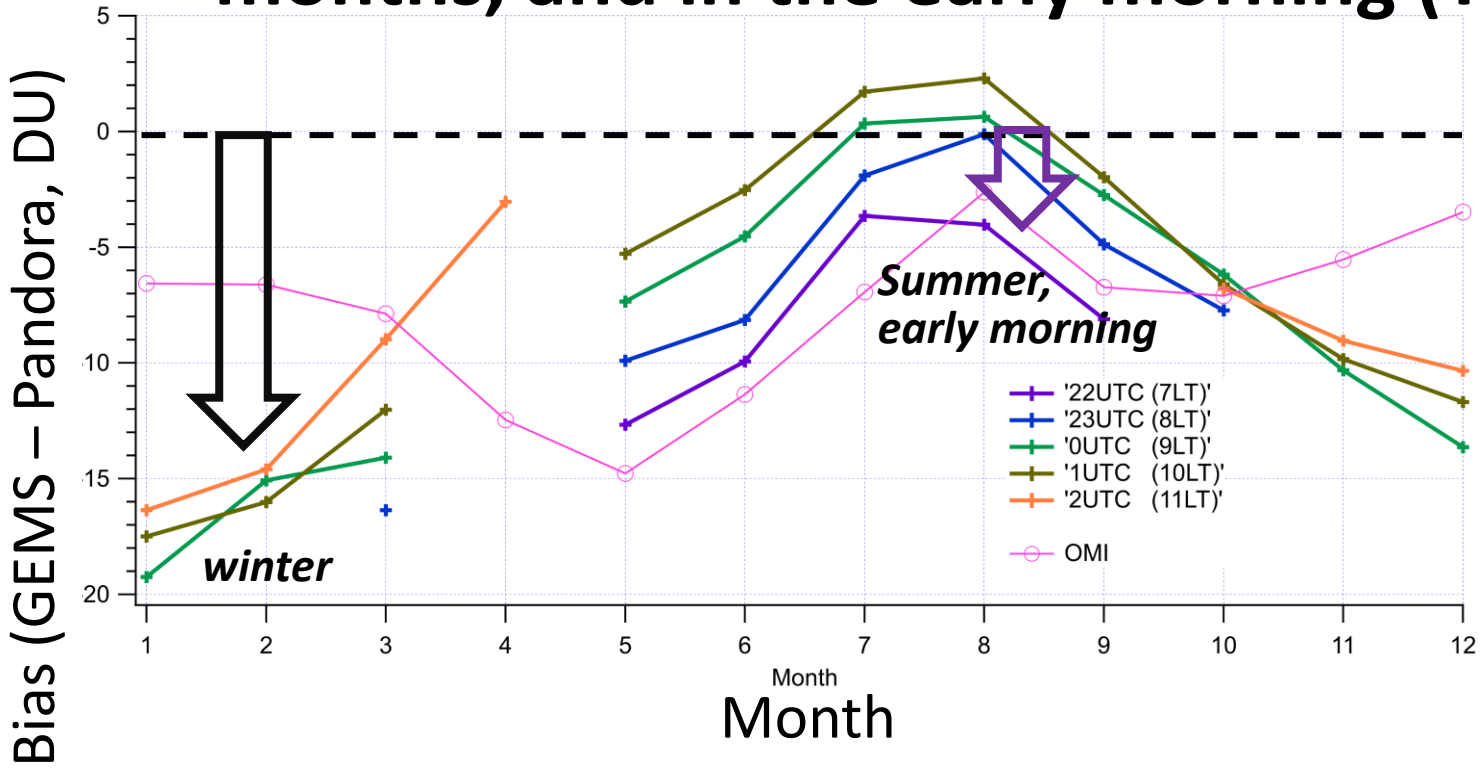


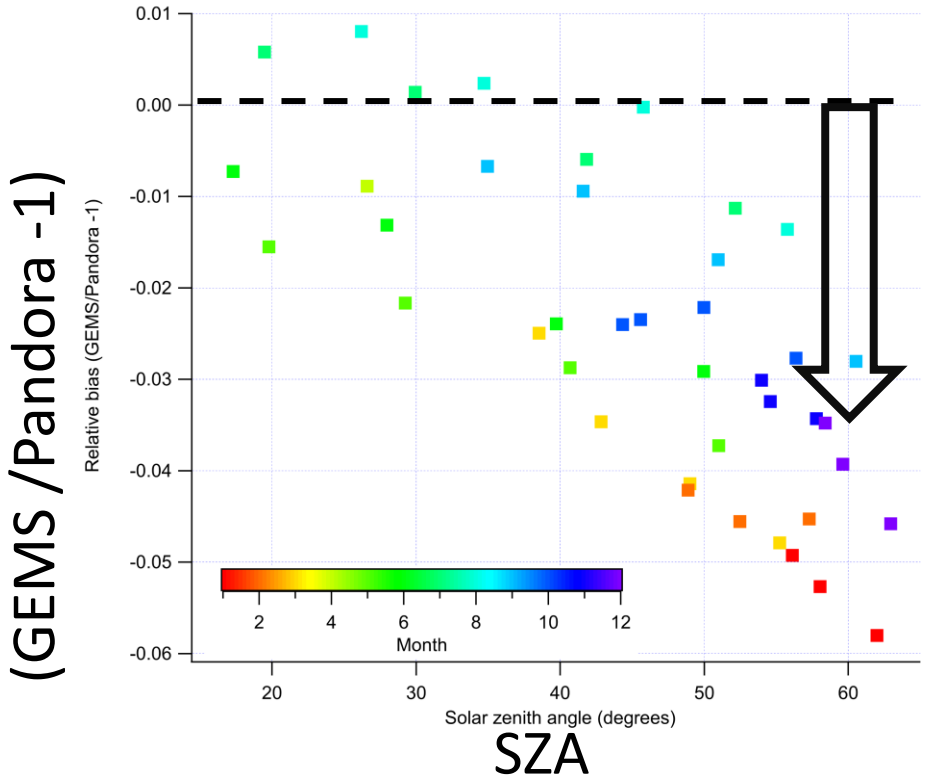


Pandora#146

Pandora146s1_Yokosuka_L2_rout2p1-8.txt

GEMS O3T had slight negative bias, particularly in winter months, and in the early morning (Yokosuka)





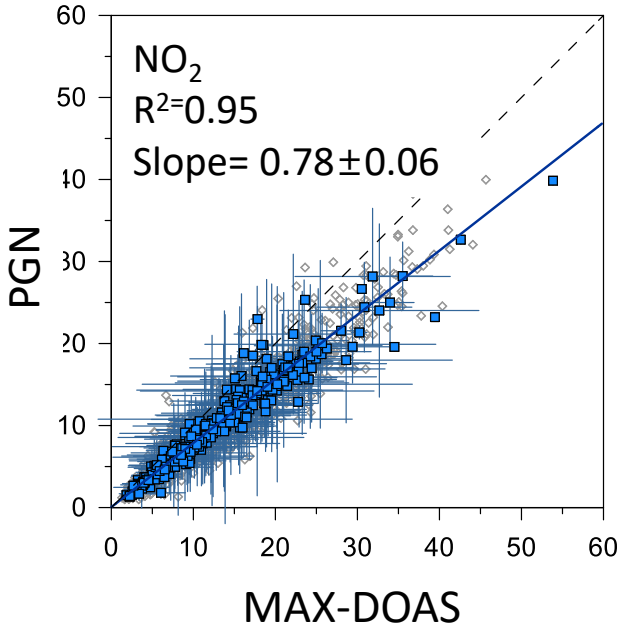
SZA dependencies to season and time of day are similar (relative bias)

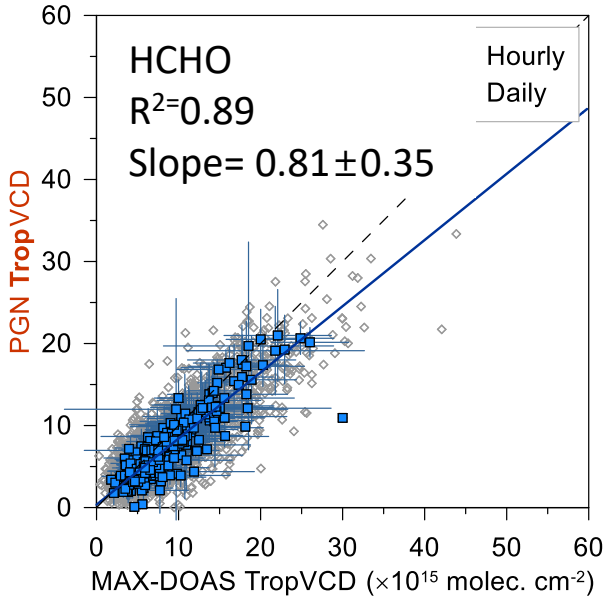
NO_2 and HCHO Tropospheric VCD (TropVCD) from MAX-DOAS and PGN @ Yokosuka, Japan (after June 2021)

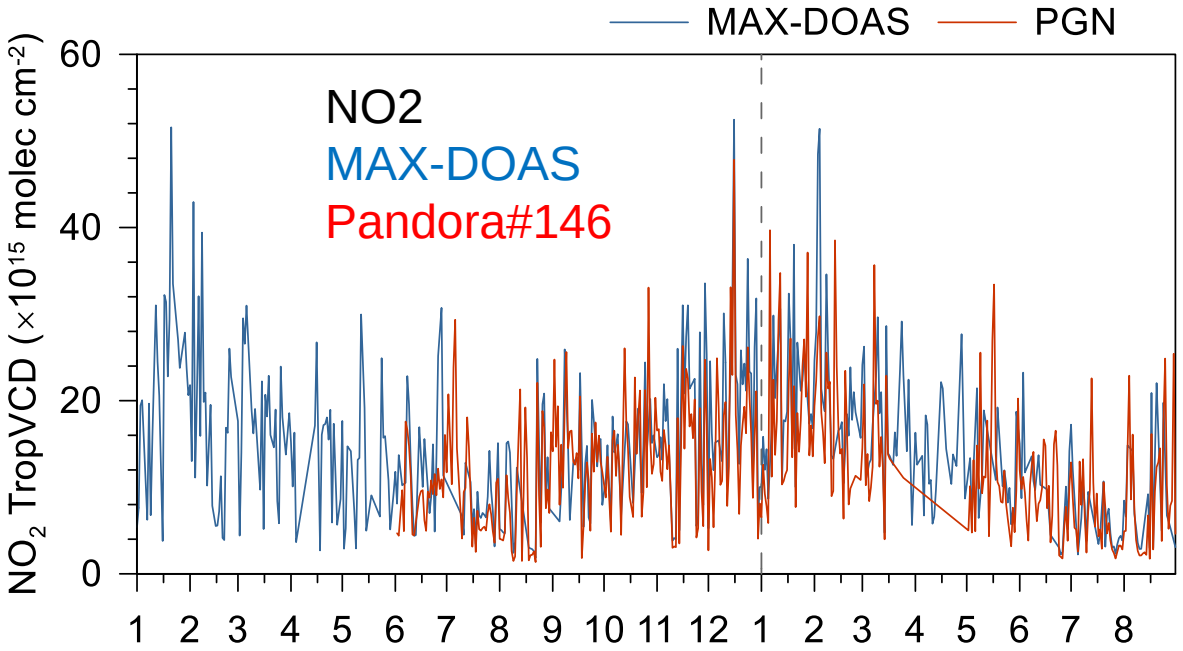
PGN official products

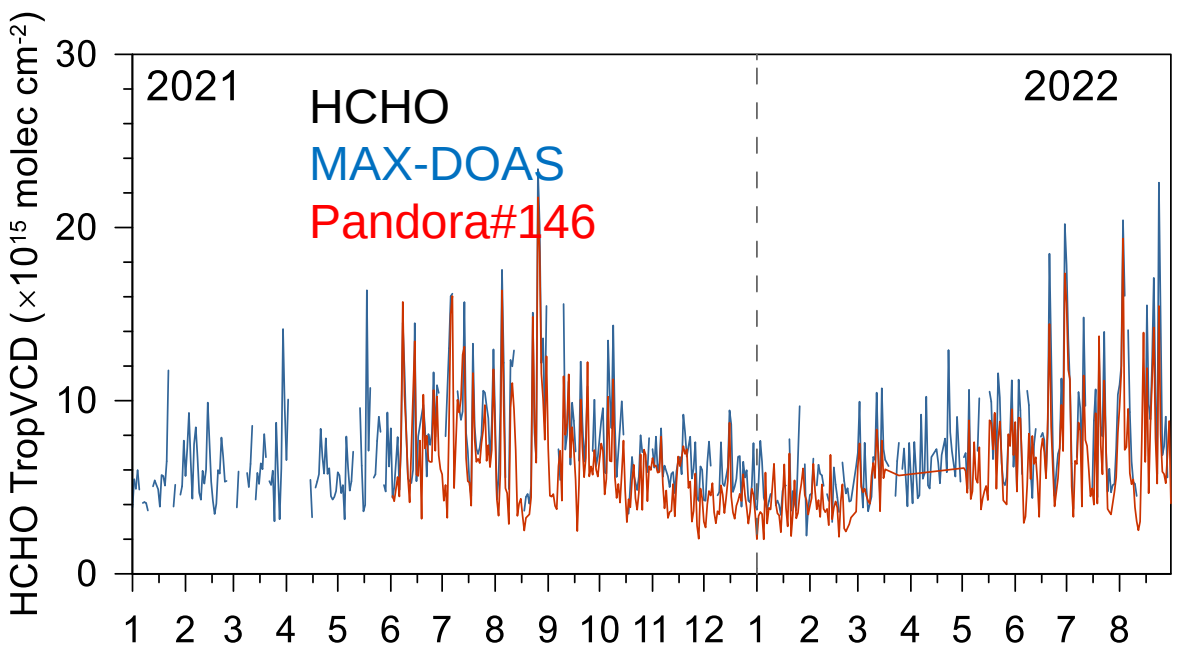
NO_2: Pandora146s1_Yokosuka_L2_rnvh3p1-8.txt

HCHO: Pandora146s1_Yokosuka_L2_rfuh5p1-8.txt







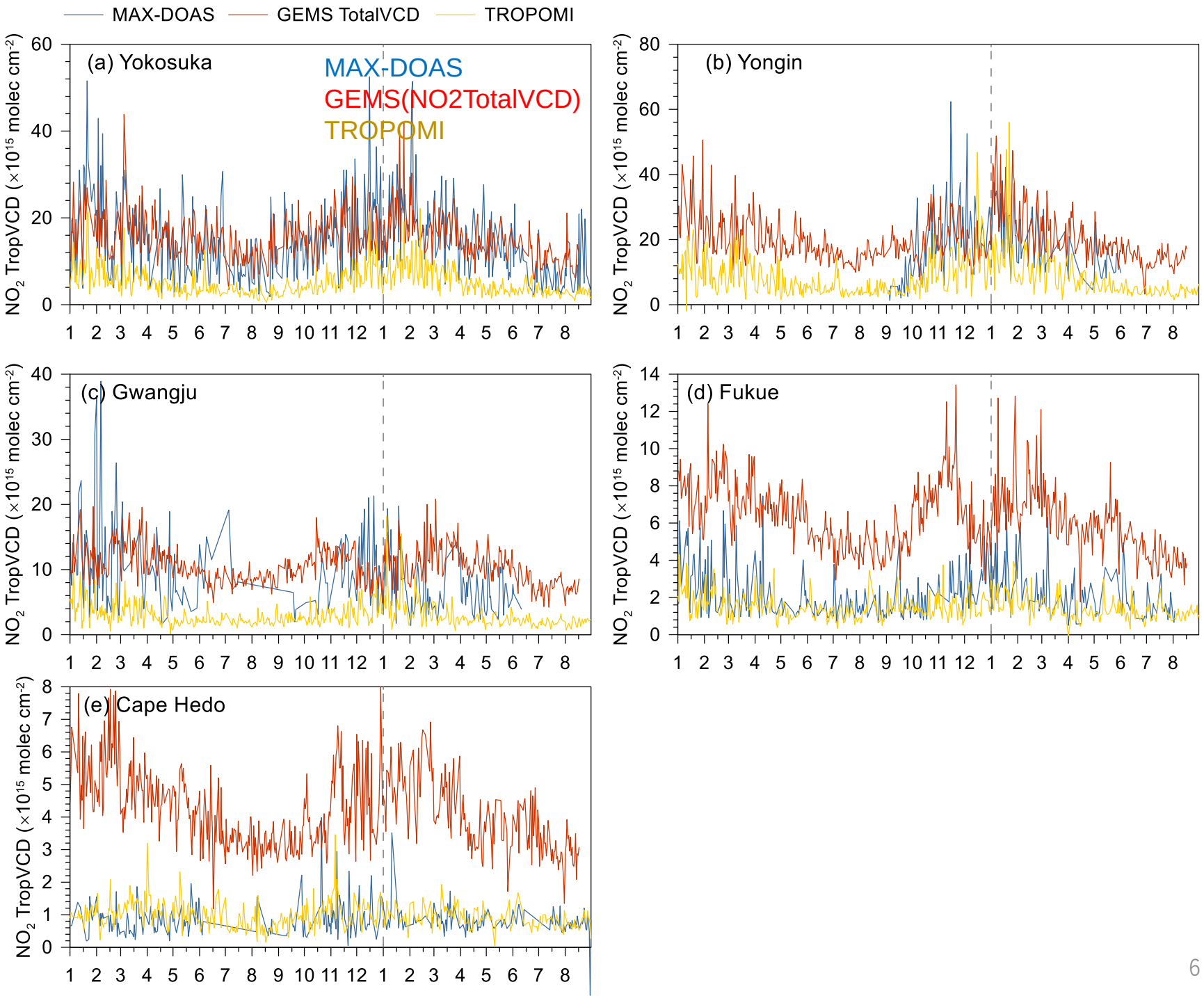


GEMS v1.0 NO_2 (Total VCD), MAX-DOAS, TROPOMI (TropVCD) from Jan 2021 to Aug 2022

CF<0.3, SZA<85°, Quality flag =0, within ±0.05°

TROPOMI: S5P_L2_NO2__HiR

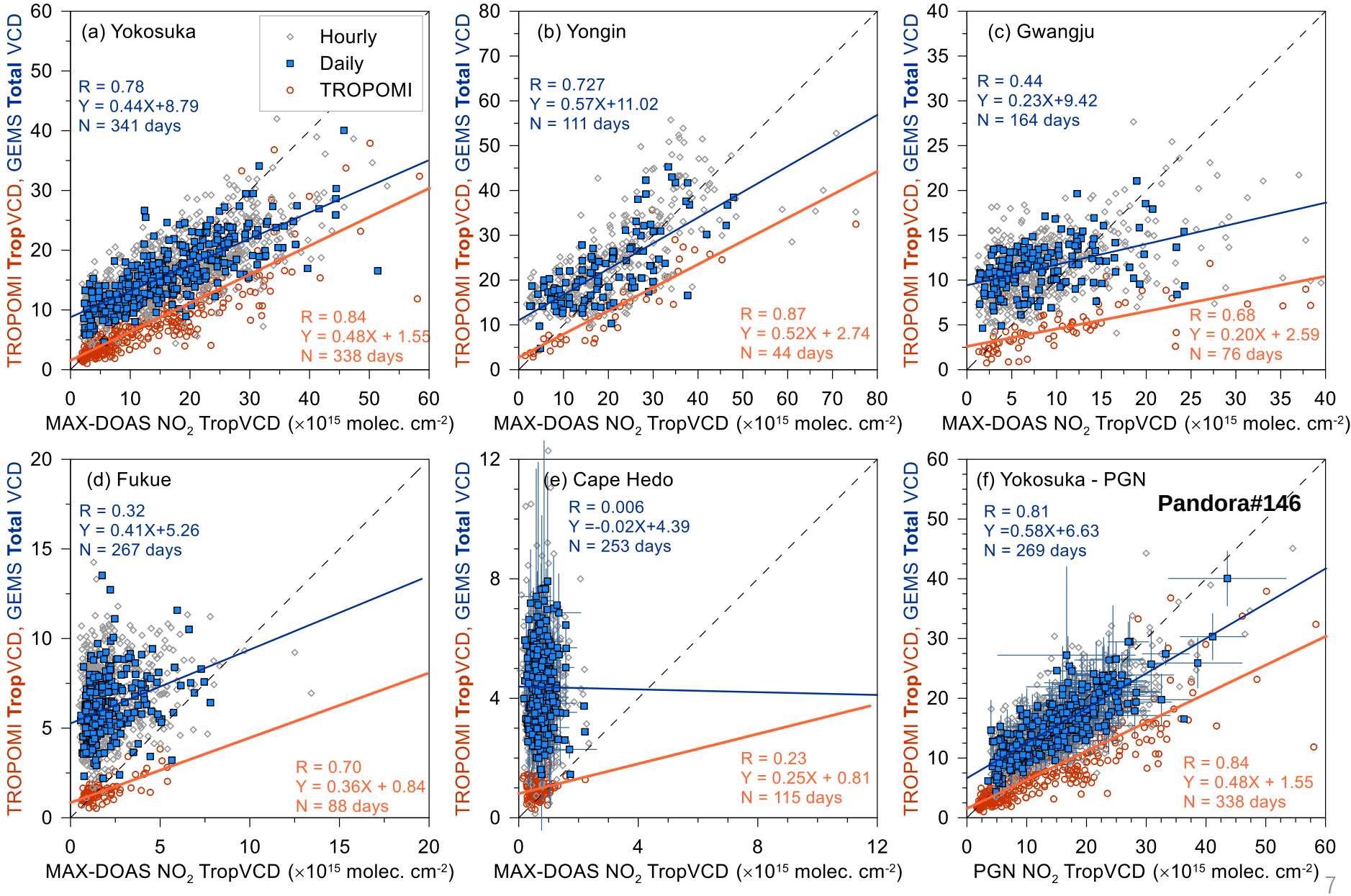
GEMS overestimated NO2 at remote sites (Fukue and Cape Hedo)



GEMS NO_2 TotalVCD shows good agreement at urban areas

Statistic parameters (R and slope) are similar to TROPOMI

GEMS overestimated NO2 at remote sites (Fukue and Cape Hedo)

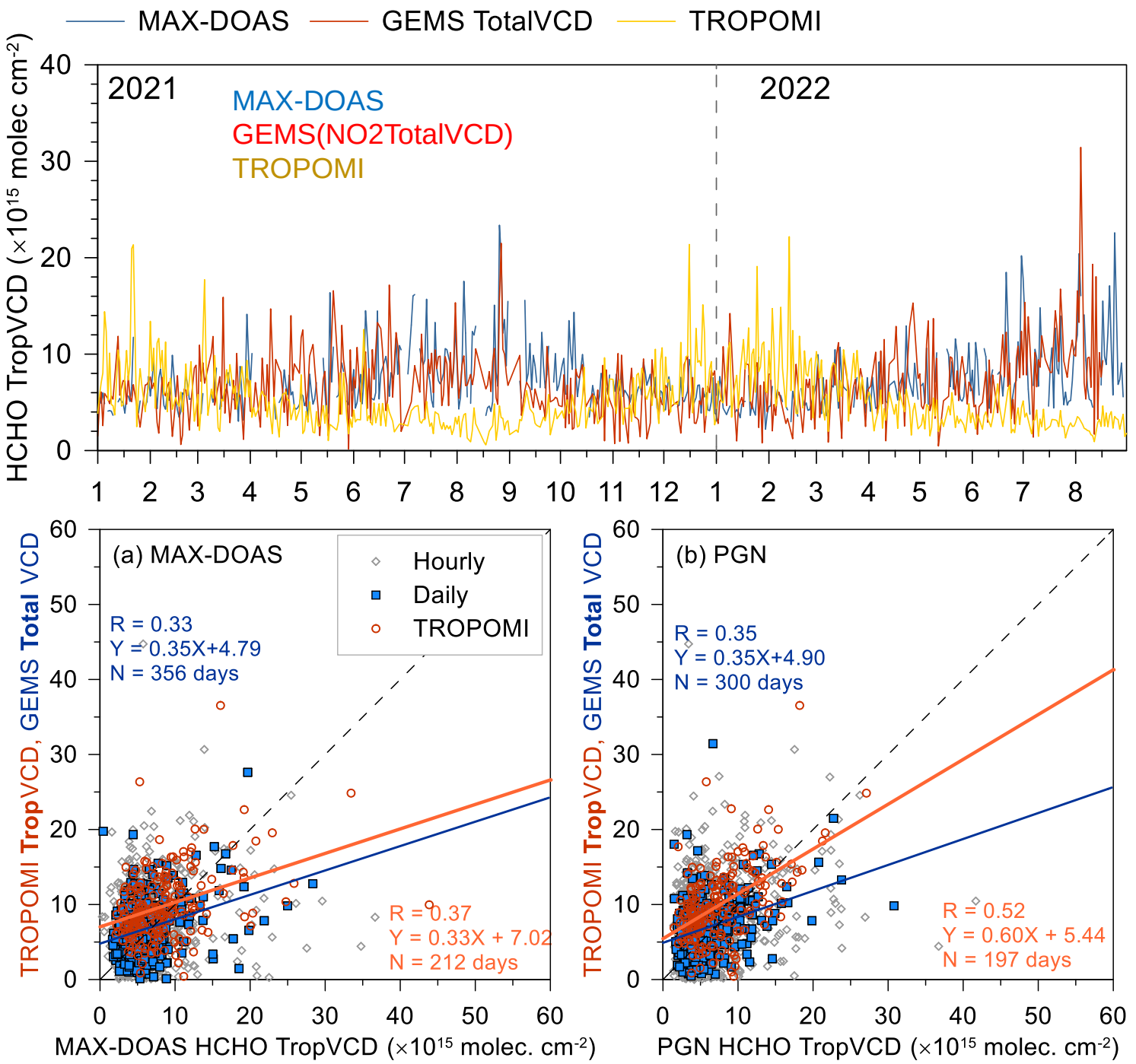


GEMS v1.0 HCHO (Total VCD), MAX-DOAS, TROPOMI (TropVCD) from Jan 2021 to Aug 2022

CF<0.3, SZA<85°, Quality flag =0, within ±0.05°

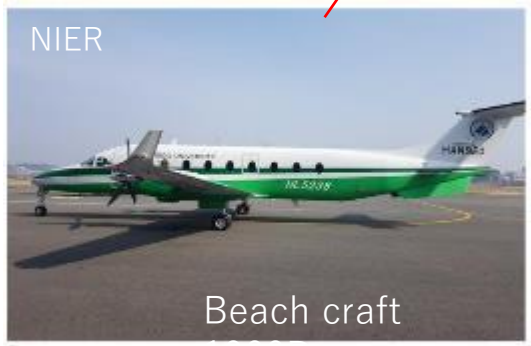
TROPOMI: S5P_L2_HCHO__HiR

Poor correlation between GEMS and MAX-DOAS/PGN compared to TROPOMI



Site information of Yongin (HUFS) during GMAP 2021/2022

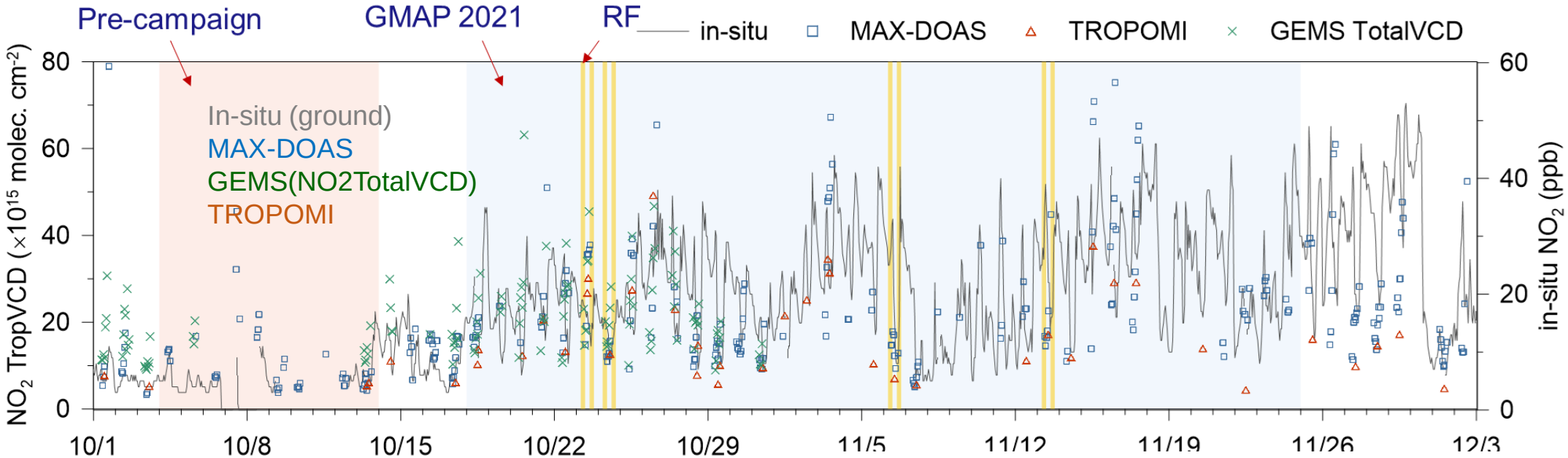
- **JAMSTEC:** NO_2 and HCHO (MAX-DOAS)
- **HUFS**: NOx, CO, SO_2, CO_2, O_3, NMHC, CH_4, NH_3, black carbon (MAAP), scattering coefficients (Nephelometer), SKYNET, AERONET
- **KNMI, KNU**: NO_2 sonde
- **KNU**: O_3 sonde
- **PKNU**: NO_2 profile (sky scanner), 355nm Aerosol profile, CO_2 profile(night) (CO_2 Raman Lidar)
- **SU**: Ceilometer, Wind Lidar Microwave Radiometer, Radiometer
- **Air quality monitoring station (~ 2 km)**: $PM_{2.5}$, PM_{10}, CO, **NO_2**, SO_2, O_3

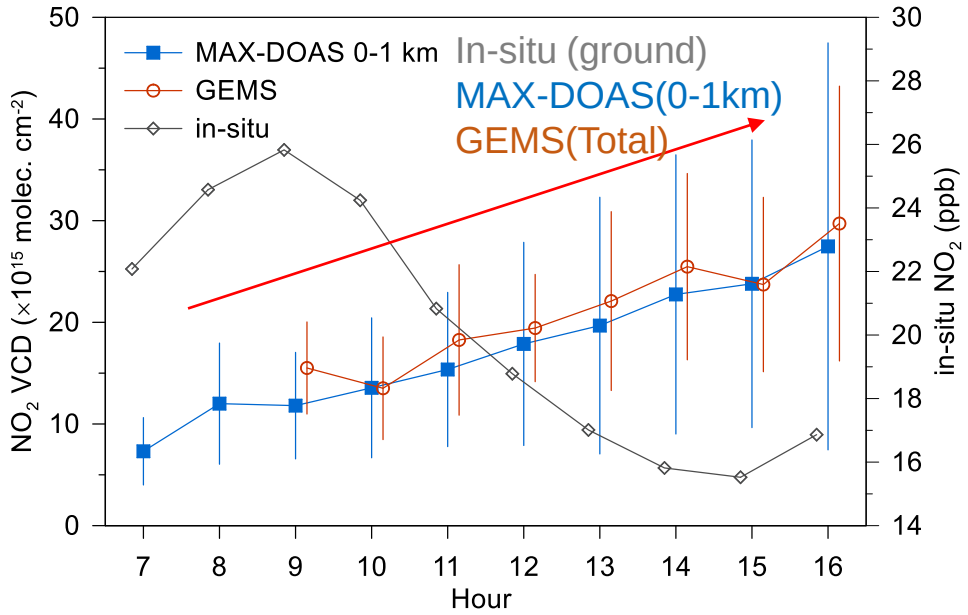


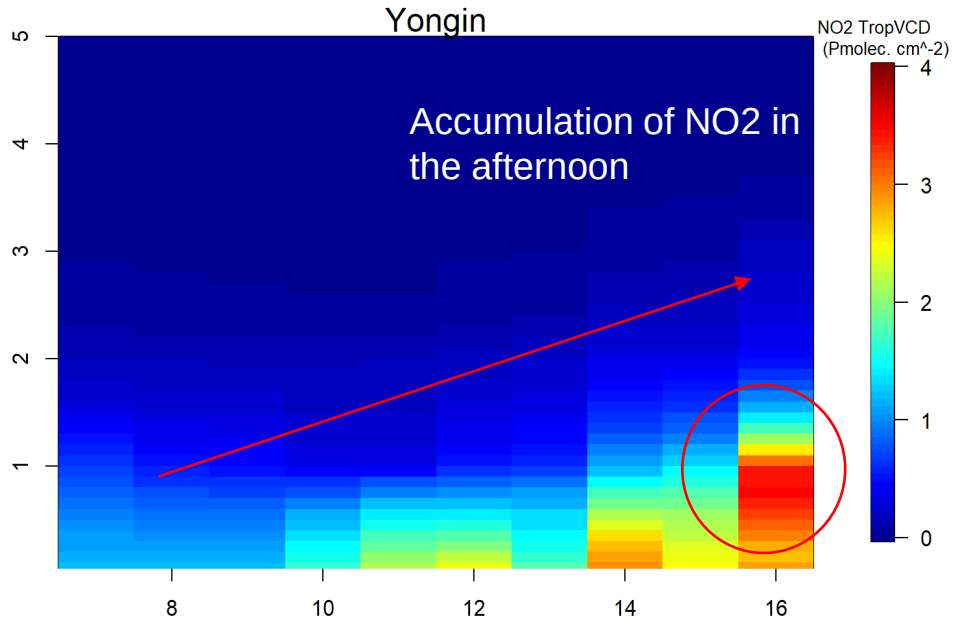
- **HUFS**: CO, CO_2, CH_4, **NO_2**, O_3, NH_3 (CRDS), VOCs (PTR-ToF-MS), PM_1 (organics, sulfate, nitrate, ammonium; HR-ToF-AMS), Particle size distribution (POPs)
- **UC Irvine**: HNO_3 or SO_2 (CIMS)
- **NASA & UNIST**: NO_2, HCHO (GCAS)

Courtesy to Taehyoung Lee @ HUFS

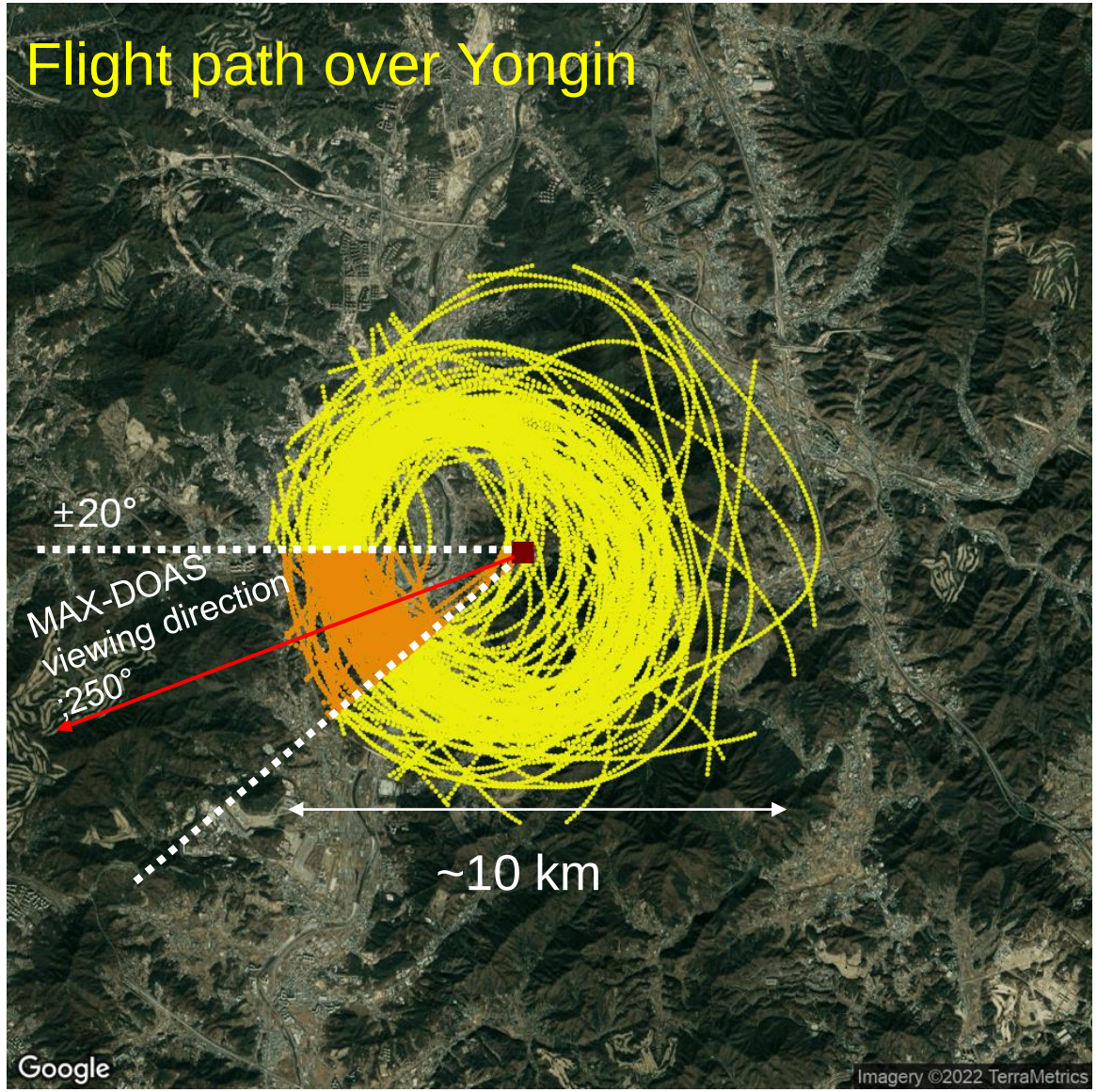
Temporal variation of NO_2 from various platforms during GMAP 2021

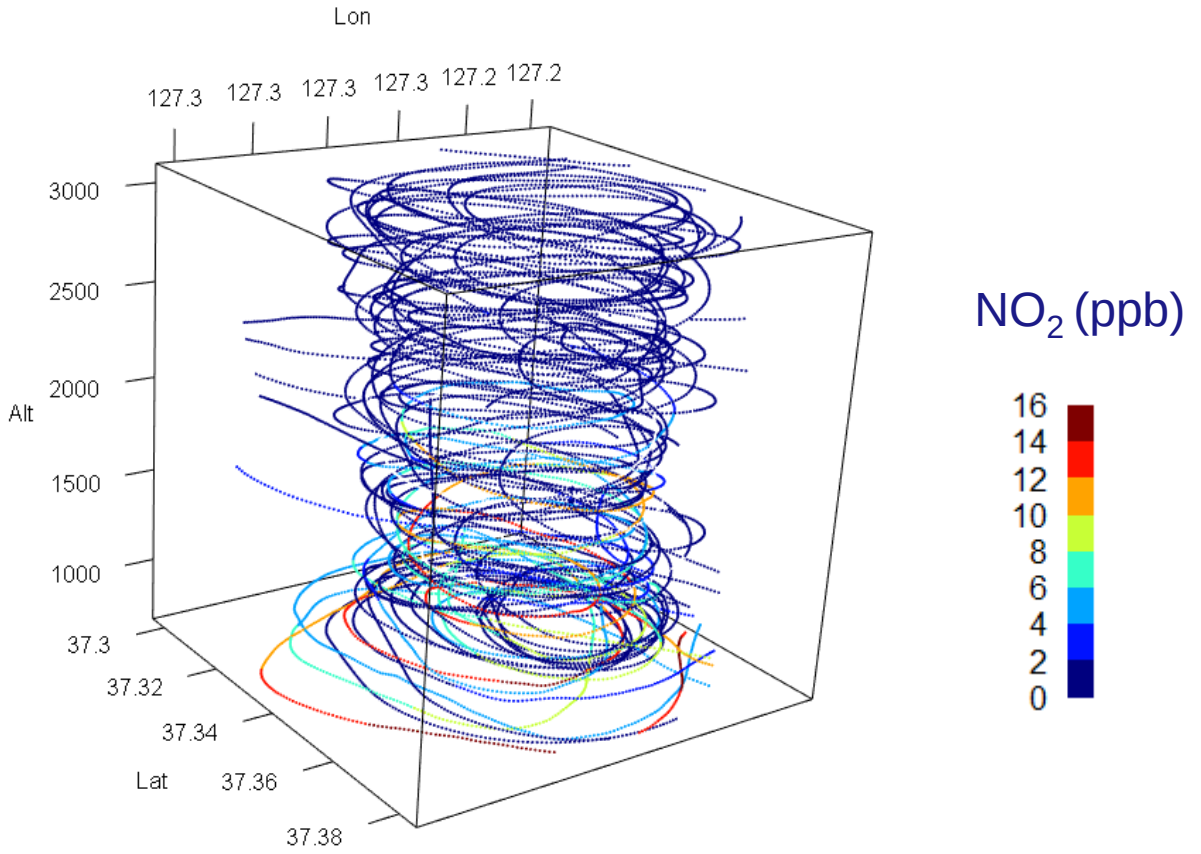






Spiral flight over Yongin site (HUFS) on the weekend

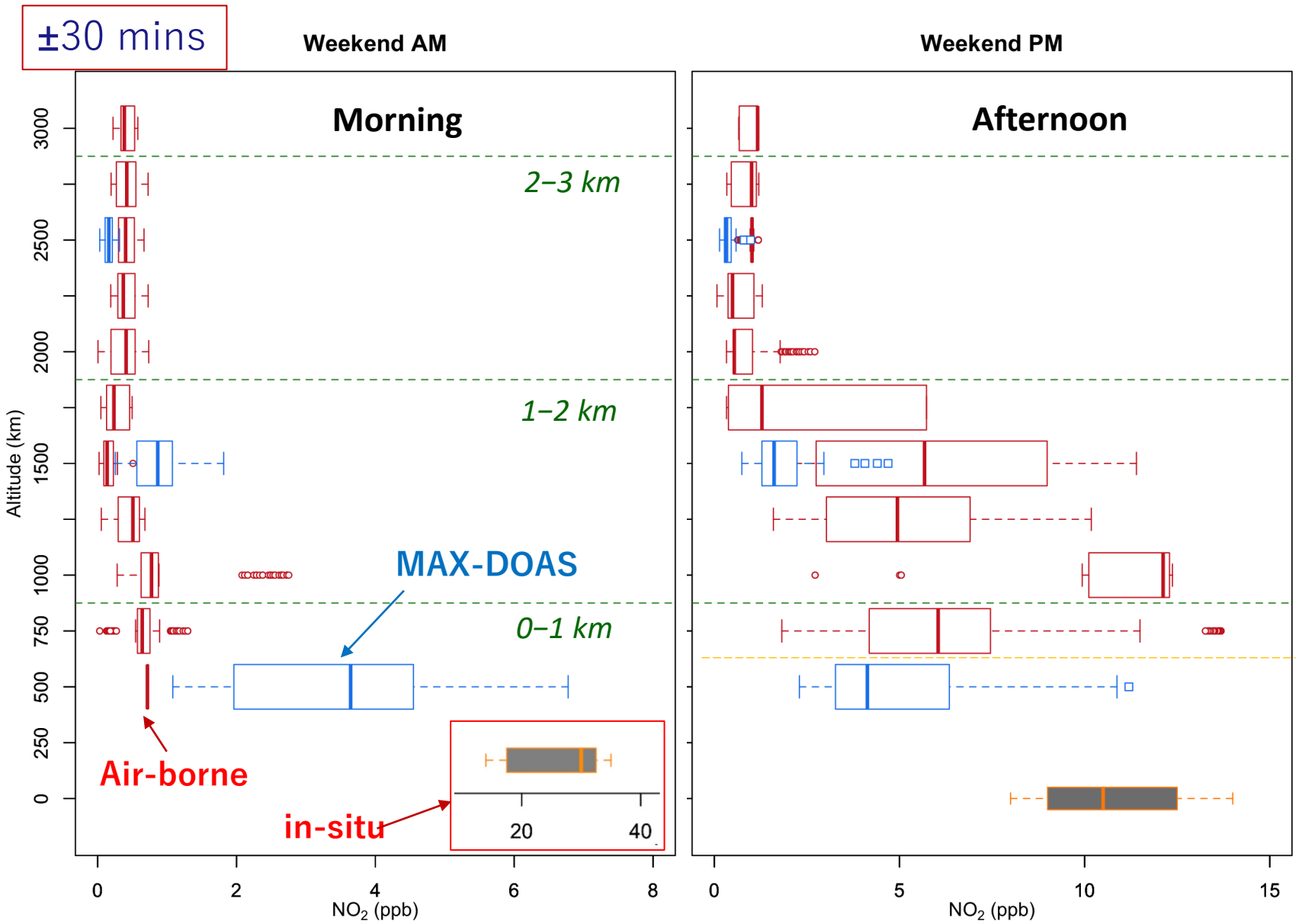




Beach craft 1900D flew over Yongin (0.7 – 3 km altitude)

- Oct.: **23 AM/PM**, 24 AM/PM
- Nov.: 6 AM/PM, 13 AM, 14PM

Overall NO_2 vertical profile in weekend (AM/PM)



- Overestimation of NO_2 from MAX-DOAS at *0 – 1 km* in the morning, but underestimation at *1 – 2 km* in the afternoon.

(ppb)

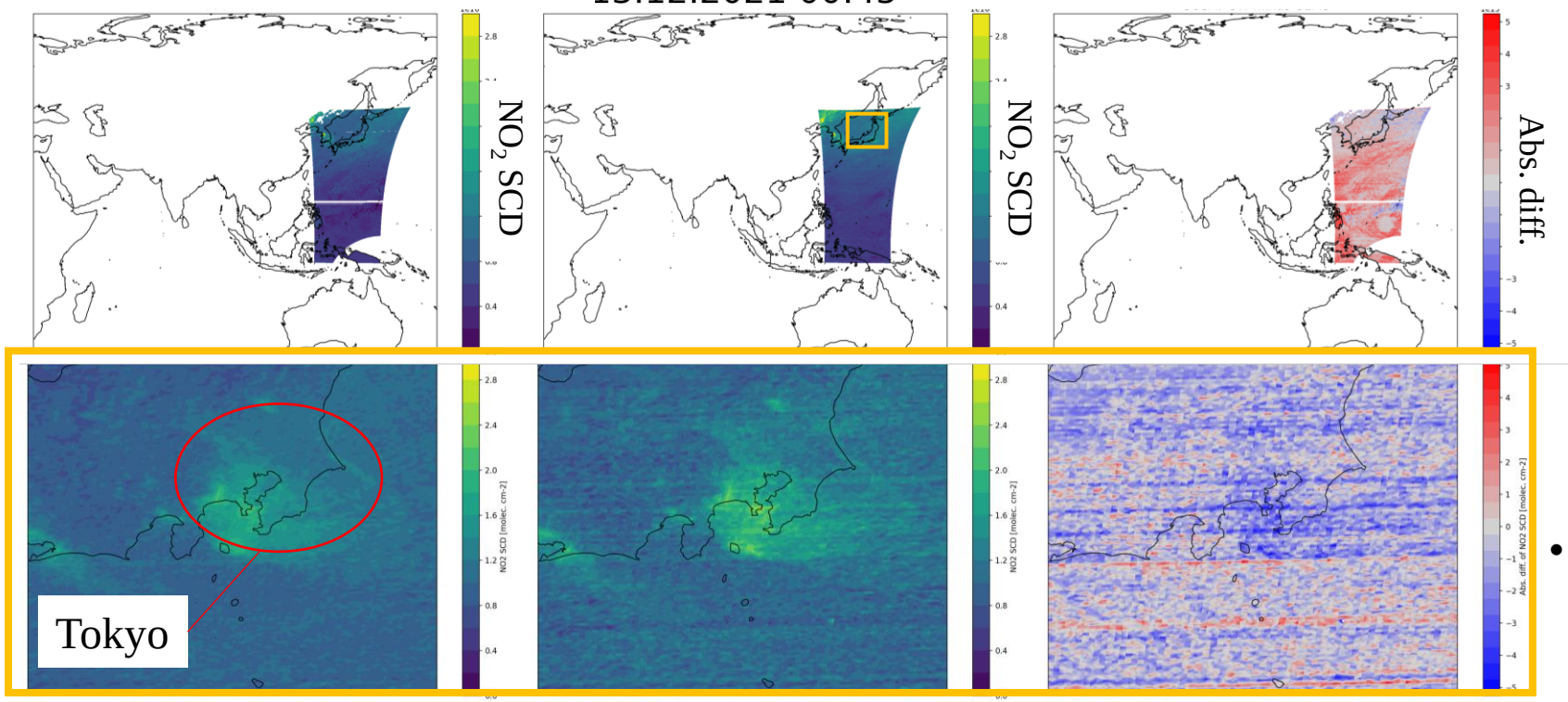
AM	air-borne	MAX-DOAS
0-1 km	0.64±0.24	3.50±1.56
1-2 km	0.48±0.51	0.87±0.38
2-3 km	0.40±0.18	0.16±0.07

PM	air-borne	MAX-DOAS
0-1 km	6.58±3.10	5.05±2.55
1-2 km	5.12±3.43	1.92±1.00
2-3 km	0.84±0.48	0.39±0.21

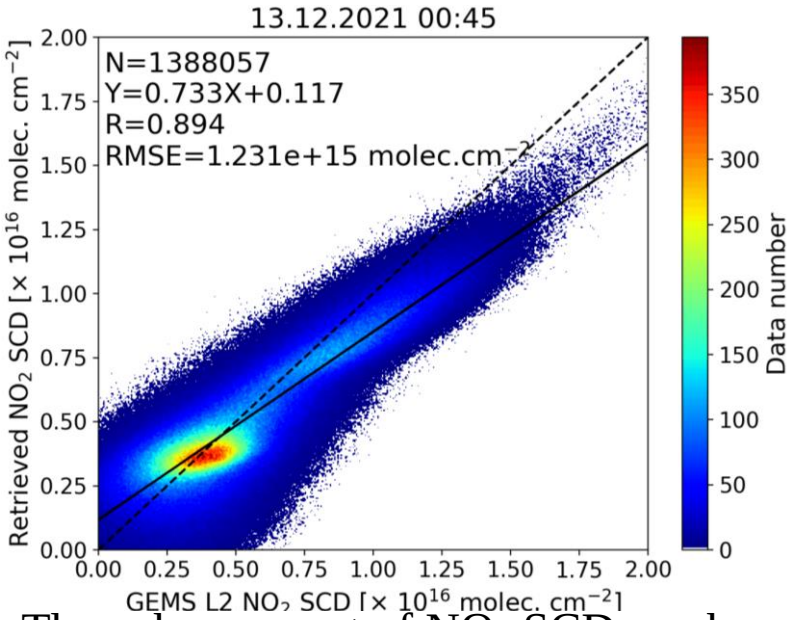
Testing GOSAT-GW algorithm with GEMS L1C

Tamaki Fujinawa (NIES)

Retrieved NO_2 SCD (GOSAT-GW algo) | **GEMS NO_2 SCD** | **GOSAT-GW minus GEMS**



	GEMS	GOSAT-GW
Fitting window	432-450 nm	420-490 nm
Abs. cross section	NO_2 (220K):VanDaele(1998) O_3(243, 293K): Bogumil(2000) O_4:Thalman and Volkamer(2013) H_2O: HITRAN 2012 Ring: Chance and Spurr(1997)	NO_2 (220K):VanDaele(1998) O_3(243K): Bogumil(2003) O_4:Hermans(2011) H_2O: HITRAN 2012 Ring: Chance and Spurr(1997)

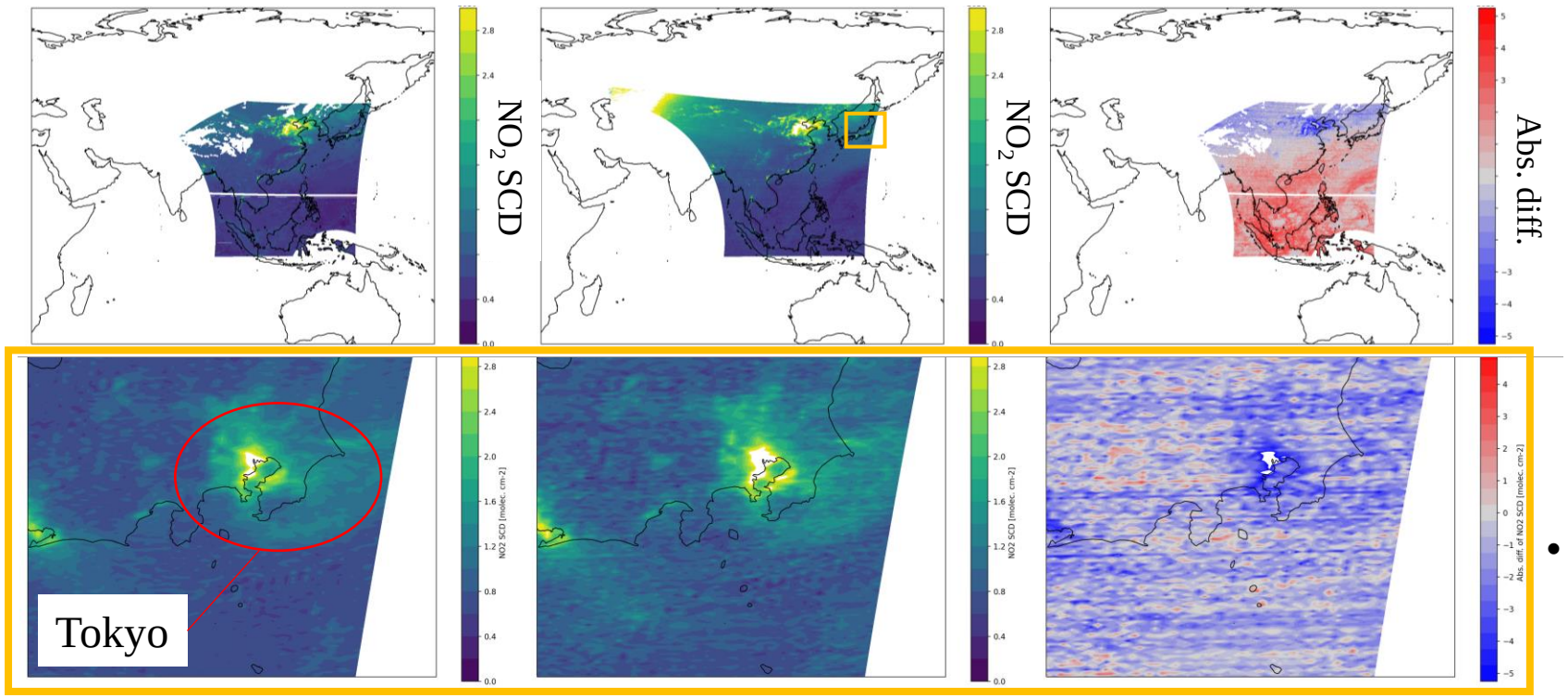


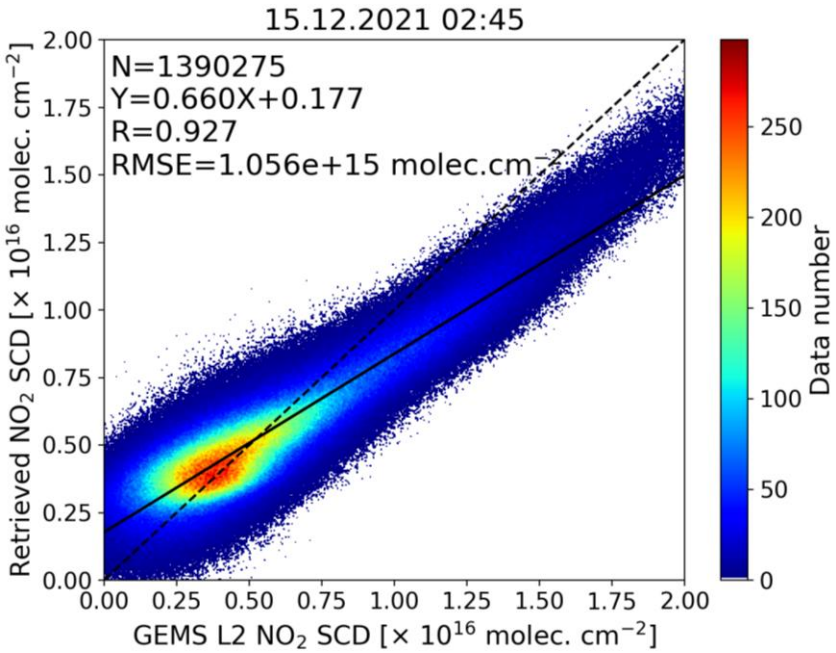
- The enhancement of NO_2 SCD can be seen in both cases, e.g., in East of China and Japan.
- The retrieved NO_2 using a part of the GOSAT-GW retrieval algorithm tends to **underestimate** by up to 5.0 x 10^{15} molec. cm^{-2} in heavy polluted plumes, e.g., especially in central Tokyo (lower panels) although it tends to **overestimate** near coastlines including the South-East Asia (upper panels).

Testing GOSAT-GW algorithm with GEMS L1C

Tamaki Fujinawa (NIES)

Retrieved NO_2 SCD (GOSAT-GW algo) | **GEMS NO_2 SCD** | **GOSAT-GW minus GEMS**





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Summary

- The GEMS version 1.0 **O3T** algorithm performs well but we recommend checking the possibility of negative bias under the conditions of high solar zenith angle.
- Tests of GOSAT-GW **NO2** algorithm were enabled by GEMS L1C.
- The GEMS version 1.0 **NO2** algorithm performs well at urban area but we recommend checking algorithms (AMF) at remote areas.
- The GEMS version 1.0 **HCHO** algorithm is recommended to improve the correlation with ground-based instruments.
- During GMAP 2021, MAX-DOAS and GEMS showed high NO_2 VCD in late afternoon due to local advection (from Seoul) at ~1 km altitude.
- NO_2 from airborne measurement also supported the increase at ~1 km altitude in the late afternoon
- However, our MAX-DOAS algorithm should be tuned up to minimize the discrepancy of NO_2 vertical profile from airborne measurements.