

국립환경과학원

Evaluation of GEMS NO, and HCHO products during the GMAP/SIJAQ campaign Kangho Bae¹, Chang-Keun Song¹, Michel van Roozendael², Alexis Merlaud², Gaia Pinardi², Martina M. Friedrich² Andreas Richter³, Kezia Lange³, Thomas Wagner⁴, Steffen Ziegler⁴, Hyunkee Hong⁵ ¹Ulsan National Institute of Science and Technology (UNIST), Korea; ²Royal Belgian Institute for Space Aeronomy, Belgium; ³Institute of Environmental Physics, University of Bremen, Germany; ⁴Max-Planck-Institute for Chemistry, Germany; ⁵National Institute of Environmental Research, Korea (NIER);

Geostationary Environmental Monitoring Spectroscopy (GEMS) provides hourly observations over. To evaluate the GEMS Map of Air Pollutants 2021 (GMAP2021) and the Satellite Integrated Joint monitoring of Air Quality 2022 (SIJAQ2022) campaigns during October 2021 to November 2021 and from June 2022 to July 2022, respectively. In this research, a comparison study between Pandora and Multi-AXis Differential Optical Absorption of GEMS operational v2.0 total column NO₂ and HCHO products is conducted. A comparative analysis between Pandora (P189) and IUP Bremen MAX-DOAS instruments at the Incheon NIER-ESC site was performed to figure out the discrepancy between the retrieval processor, MAX-DOAS: MMF in FRM₄DOAS framework). Aligning the viewing directions of both Pandora and MAX-DOAS leads to a significant increase. The GEMS NO₂ total column product, evaluated over 6 official PGN sites in South Korea, shows good agreement and similar seasonal and diurnal NO₂ cycles. However, GEMS tends to report higher values than Pandora. The magnitude of the GEMS overestimation is amplified in highly polluted conditions (i.e. during winter and at noontime). Compared to 6 MAX-DOAS stations and 6 Pandora. However GEMS tend to be underestimated in large column conditions.

Introduction

- GEMS is successfully producing hourly observation of air pollutants since it launched in 2020.



Table 1. Location of Ground-based remote sensing instruments.					
Instrument	Station	Affiliation	Processor	Location	Period
MAX-DOAS	BIRA_Seoul	BIRA-IASB	MMF	Seoul (127.026° E, 37.585° N)	2021.12.19-2022.06.02
MAX-DOAS	BIRA_Suwon	BIRA-IASB	MMF	Suwon (127.010° E, 37.284° N)	2021.10.21-2021.12.16
MAX-DOAS	UB_Incheon	IUP-Bremen	MMF	Incheon (126.638° E, 37.569° N)	2021.10.09-2022.11.14
MAX-DOAS	UB_Ulsan	IUP-Bremen	MMF	Ulsan (129.306° E, 35.493° N)	2022.06.30-2022.11.13
MAX-DOAS	Olympic	MPIC	MMF	Seoul (127.093° E, 37.503° N)	2021.10.19-2022.08.05
MAX-DOAS	PKNU	MPIC	MMF	Busan (129.107° E, 35.135° N)	2022.06.17-2022.08.10
Pandora 1S	P149	SNU	PGN Blick v1.8	Seoul (126.951° E, 37.458° N)	2021.10.01-2022.11.30
Pandora 1S	P150	UNIST	PGN Blick v1.8	Ulsan (129.190° E, 35.575° N)	2021.10.01-2022.11.03
Pandora 1S	P164	NIER	PGN Blick v1.8	Seosan (126.494° E, 36.777° N)	2021.10.30-2022.11.30
Pandora 1S	P189	NIER	PGN Blick v1.8	Incheon (126.638° E, 37.569° N)	2022.02.03-2022.11.30
Pandora 1S	P20	PNU	PGN Blick v1.8	Busan (129.083° E, 35.235° N)	2021.10.01-2022.11.30
Pandora 1S	P54	YSU	PGN Blick v1.8	Seoul (126.934° E, 37.564° N)	2021.10.01-2022.11.30

♦ Satellite

			• Temporal collocation	
Instrument	version	resolution	ichiporal conocation	
GEMS	V2.0	3.5 km x 8 km	 – GB-RS comparison: av 	
TROPOMI	V02.04	3.5 km x 5.5 km	 Validation: averaged 	
Spatial collocation	n		 Quality filtering 	

• Spatial collocation - NO₂: Only satellite pixels that contain the ground-based

remote sensing station - HCHO: average value of satellite pixels within a 10 km

radius from ground-based remote sensing station



- GEMS: final algorithm flag of 0

– TROPOMI: qa_value > 0.75



GB-RS comparison: averaged within a 3-minute time window Validation: averaged within a 30-minute time window

- Pandora: L2 quality flag of good (0, 10) and normal (1, 11) MAX-DOAS: Overall quality flag of 0 and 1

The agreement is significantly

- Both instruments show similar
- lower than MAX-DOAS

Similar to Tropospheric NO₂

- result, agreement is
- Both instruments show

- Both instruments show similar diurnal pattern but the magnitude of the overestimation is significantly higher around noon.
- Diurnal patterns of weekdays and weekends are similar but much higher during weekdays



- 10¹⁵ molec. cm⁻² cases
- GEMS and Pandora show a different diurnal pattern - GEMS: Inverted U shape with a peak at noontime
- Pandora: Fairly constant NO_2 VCDs until 14 LST and an increase afterwards



- an increase during the morning and a decrease in the afternoon.

Both Pandora and GEMS observe similar diurnal patterns on weekends, but differ on weekdays



- noontime
- winter and higher in summer.



- GEMS underestimate in large columns
- parabolic increase.
- slight decrease after 13 LST and then a second peak at 16 LST.



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Both instruments show similar diurnal pattern but GEMS shows lower values than MAX-DOAS before

• no significant seasonal difference in its diurnal pattern, only exhibiting HCHO TCDs that are lower in

Both instruments capture a similar diurnal pattern of decreasing HCHO concentrations in the morning followed by an increase. However, during 11 to 15 LST, while Pandora increase gradually GEMS shows

• Winter and autumn: P150 shows flat during the day, but GEMS shows an early afternoon peak • Summer: both GEMS and Pandora exhibit a much steeper increase in concentration until 13 LST compared to other seasons. While Pandora maintains its peak concentration until 16 LST, GEMS shows a

- In monthly comparison, both GEMS show good agreement with both Pandora and MAX-DOAS. However, GEMS tends to be underestimated in large column cases
- BIRA and MPIC instruments (red box) show comparatively higher than GEMS. However, according to the Hendrick et al. (2024, in preparation) report these instruments show higher HCHO VCDs compared with the Bremen instrument.