Satellite-based monitoring air pollution:
Geostationary Environment Monitoring Spectrometer (GEMS)

Jhoon Kim*, GEMS Science Team, & Dong Won Lee, NIER Team
*P.I. GEMS; Dept. of Atmos. Sci., Yonsei University, Seoul, Korea
Outline

• Introduction
• GEMS Instrument & Operation
• GEMS Science Algorithm and Data Products
• Data Application
• Summary
Development of Satellite Remote Sensing for Air Quality

(*) : Revisit time in days

(T): target area observations
(L): Lagrangian point (L1)
*Italic & dashed line: to be launched*

Kim et al. (BAMS 2020)
GEMS E-W SCAN SCENARIO

**GEMS scan profiles**

- Morning
- Noon
- Afternoon

**Kim et al. (BAMS 2020)**

- $N_3$(Total, Trop, Strat), $NO_2$, $SO_2$ (PBL, Volcano), $HCHO$, $CHOCHO$,
- $AOD$, $AI$, $SSA$, $UVI$, $ECF$, $CCP$,
- $SFC_{ref}$ (LER, BRDF), $BrO$, $IO$, $HONO$

**Equations:**

$$y(t)$$

**Data:**

- $2000$ N-S $\times$ $697$ E-W
- $\times$ $8$ times/day $\times$ $20$ products
- $=223,040,000$ data/day
# In Orbit Test (IOT)

## Instrument Activation and Commissioning Timeline

<table>
<thead>
<tr>
<th>Activity</th>
<th>Duration (months)</th>
<th>L0</th>
<th>L0+1m</th>
<th>L0+2m</th>
<th>L0+3m</th>
<th>L0+4m</th>
<th>L0+5m</th>
<th>L0+6m</th>
<th>L0+7m</th>
<th>L0+8m</th>
<th>-L0+12m</th>
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<tbody>
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<td>LEOP (GTO to GEO)</td>
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<td>✔</td>
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<tr>
<td>BUS IOT (start from drift orbit)</td>
<td>0.5</td>
<td>☐</td>
<td></td>
<td>✔</td>
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<tr>
<td>GOCI-II Activation</td>
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<tr>
<td>GEMS Activation</td>
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<tr>
<td>GOCI-II/GEMS INR Test</td>
<td>4</td>
<td>☐</td>
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<tr>
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<tr>
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<td>✔</td>
</tr>
</tbody>
</table>

2/19  3/6  3/23

* BUS: GK-2B spacecraft (GEMS and GOCI-II )
* INR: Image Navigation and Registration
City Coverage of GEMS in Asia

(a) Seoul
(b) Pyeongyang
(c) Beijing
(d) Shanghai
(e) Hebei
(f) Tokyo
(g) Bangkok
(h) Singapore
(i) Taipei

 매 시간!
每時!
毎隔一小时!
時間ごとに
Every hour!
Setiap jam!
NO$_2$ in Seoul Metropolitan Area

GeoTASO Airborne Measurements

GEOTASO
Jay Al-Saadi,
Scott Janz
Matt Kowalewski

Version of L1B data: V2y
SO$_2$ – Point Sources Capture

May 11th
Morning

GeoTASO
Airborne Measurements

George

Chong et al.
(revised, RSE)

GEOTASO
Jay Al-Saadi,
Scott Janz
Matt Kowalewski

Power plant

Steel mill and Power plant

Industrial complex
Columnar AOPs to surface PM$_{2.5}$ using Machine Learning

Satellite AOD + MET. data + GIS information

China

South Korea

Japan

North Korea

Mongolia

Estimated PM$_{2.5}$ • Measured PM$_{2.5}$

Estimated PM$_{2.5}$ • Measured PM$_{2.5}$

Estimated PM$_{2.5}$ • Measured PM$_{2.5}$

Estimated PM$_{2.5}$ • Measured PM$_{2.5}$

PM$_{2.5}$ [μg/m$^3$]
Data Processing and Distribution

Choi et al. (JARS, 2018)
GEMS Validation and Pandora Asia Network (PAN)

PAN site map (project + China, Japan, Korea, Singapore)

(Courtesy, L. Chang, NIER)

Kim et al. (BAMS, 2020)
GEO AQ Sat Data Application & Service
• GEMS was launched on Feb. 19th, 2020, to form an Asian part for the GEO AQ Constellation with TEMPO and Sentinel-4 by early 2020s.

• Application of GEMS data include air quality monitoring, forecast, top-down emission inventory, long-range transport, air pollution studies, public health and much more.

• Validation is a very important part of GEMS to evaluate data quality during the IOT and the lifetime of GEMS. Active participation by participating countries are required for the success of the mission.

• NEACAP can utilize the GEMS dataset for short- and long-term assessment of air quality within the region. GEMS dataset can also be used for top-down emission estimates which can be processed in shorter time scale than bottom-up. These all will contribute to improve the accuracy of air quality forecasting.

• NEACAP can play an essential role in data distribution, joint analysis, and capacity building in above mentioned activities.