The Status of GEMS Total Ozone and Vertical Ozone Profile Algorithm

- GEMS O3T Algorithm for Total Column Ozone (TCO)
- GEMS O3P Algorithm for Vertical Ozone Profile.

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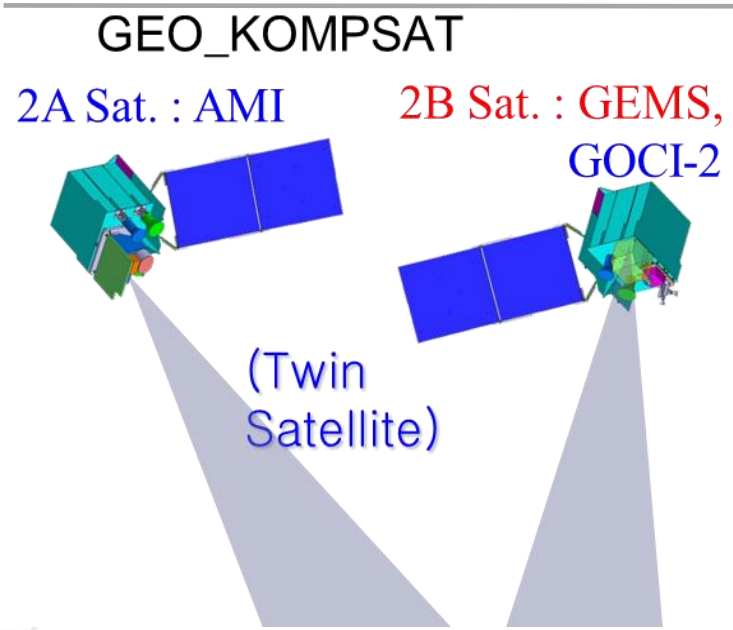
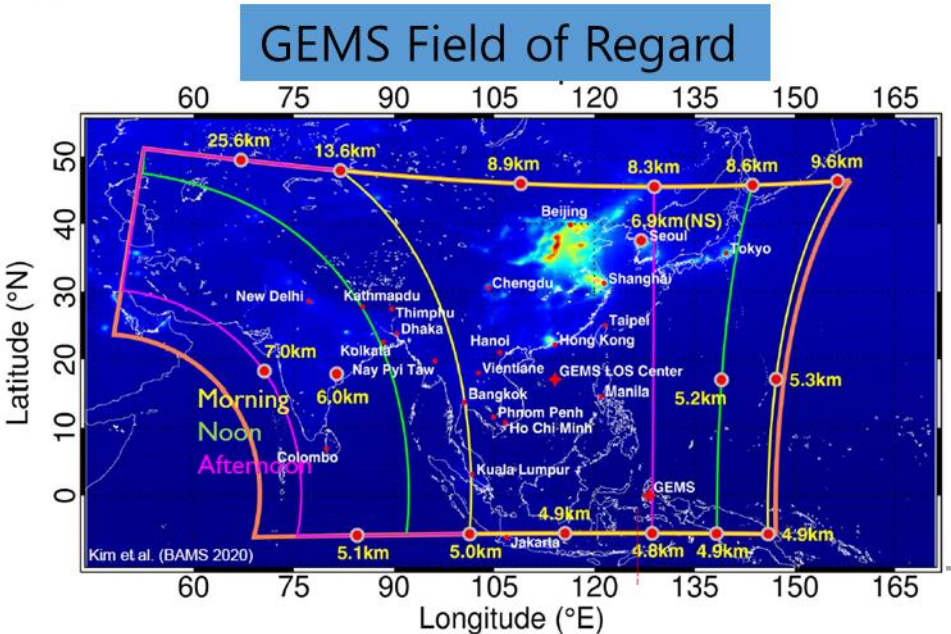
Specifications of GEMS





- Successfully placed in to geosynchronous orbit on 18 February 2020
- Spatial coverage: 5000 x 5000 km (5°S-45°N)
- Spatial resolution: 7km x 8km @ Seoul
- UV/VIS: 300-500 nm @ 0.6 nm
- Duty cycle: 8 times/1-day (9 AM -4 PM)
- Share measurement time with GOCI-2 (~ 30 minute)

GEMS Total O3 Algorithm

- Will use new TOMS Version 9 algorithm, while OMI uses TOMS V8.5
  - The main difference between TOMS V9 and V 8.5 is that V9 retrieves total ozone by optimizing three wavelengths (312.5, 317.5, 331 nm). ➔ This procedure provides the characteristics of retrieval error and reduces retrieval error associated with a-priori ozone profile shape.
  - R-λ (Reflectivity and Wavelength) correction based on Dave (1978) ➔ derives reflectivity between 340 and 380 nm wavelengths, and then extrapolates to obtain reflectivity shorter than 340 nm range ➔ corrects aerosols, sun glint effect, and so on at the same time.
- Radiative transfer model : VLIODRT 2.6
  - BDM O3 cross-section
  - Standard O3 profile.
- A priori ozone profile for optimization
  - ML climatology (Mcpeters et al. 2011) (varying with lat & month)

GEMS Ozone Profile algorithm (Optimal Estimation Method: OEM)

Liu et al., (2010a)

Cost Function

$$\chi^2 = \left\| \mathbf{S}_y^{-\frac{1}{2}} \{ \mathbf{K}_i (\mathbf{X}_{i+1} - \mathbf{X}_i) - [\mathbf{Y} - \mathbf{R}(\mathbf{X}_i)] \} \right\|_2^2 + \left\| \mathbf{S}_a^{-\frac{1}{2}} (\mathbf{X}_{i+1} - \mathbf{X}_a) \right\|_2^2$$

Measurement radiance

Simulated Measurement radiance

State vector

A Priori vector

$$\nabla_x J(x) = 0$$

A posterior solution

$$\mathbf{X}_{i+1} = \mathbf{X}_i + (\mathbf{K}_i^T \mathbf{S}_y^{-1} \mathbf{K}_i + \mathbf{S}_a^{-1})^{-1} \{ \mathbf{K}_i^T \mathbf{S}_y^{-1} [\mathbf{Y} - \mathbf{R}(\mathbf{X}_i)] - \mathbf{S}_a^{-1} (\mathbf{X}_i - \mathbf{X}_a) \}$$

Measurement Error Covariance Matrix

A Priori Error Covariance Matrix

- The ozone profile algorithm based on OEM developed by X. Liu at SAO is adopted.
- Running OEM takes a lot of time for ozone profile retrieval, but computation time allowed for the real time ozone retrieval is only 15-20 minutes. So we plan to do 2x2 pixel binning ➔ results in 14 x 16 km spatial resolution.

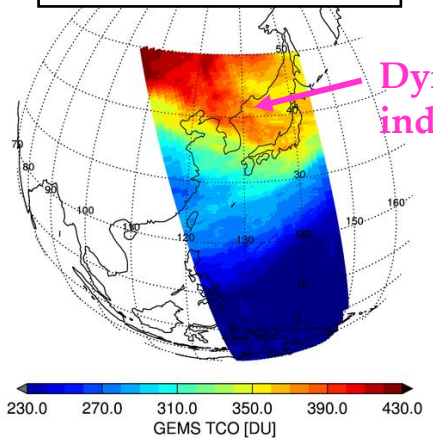
Application of GEMS O_3 Algorithm to OMI L1B

- To evaluate the performance of GEMS O3 algorithm.
- Compare GEMS O3 products with OMI L2 products as well as ground-based ozone measurements.

Application of GEMS Total O3 Algorithm to OMI L1B

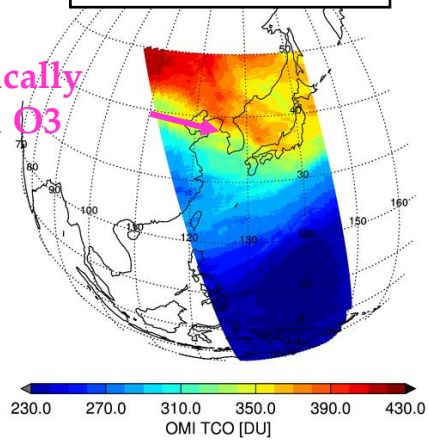
15th March, 2005 (OMI orbits#7614, 7615)

TCO GEMS O3T

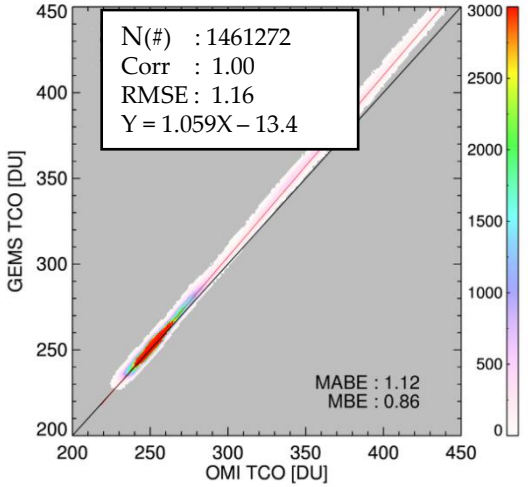


Dynamically induced O3

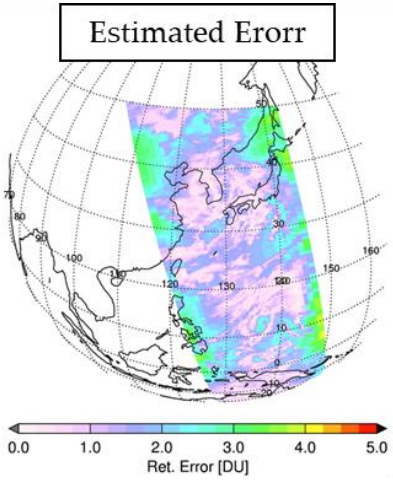
TCO OMI V85



2005-2006



Estimated Erorr

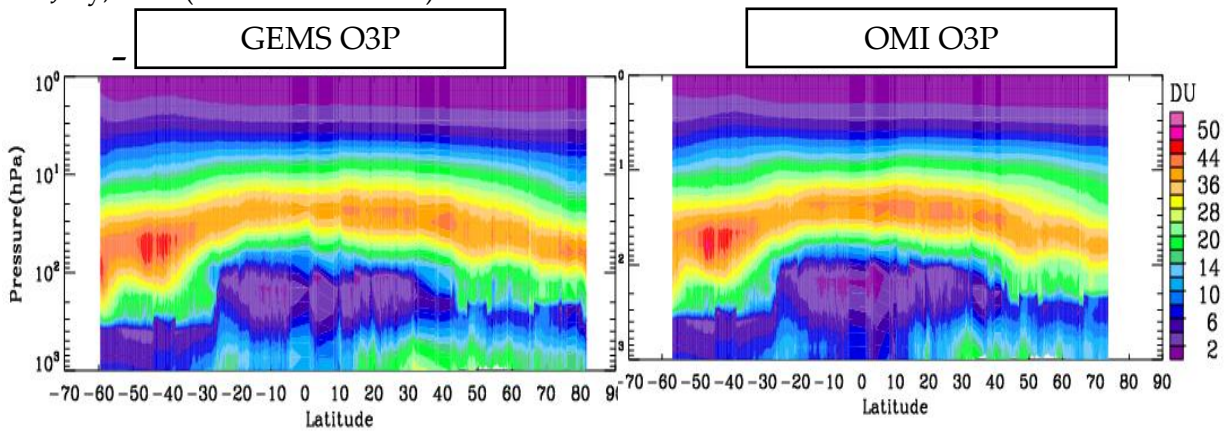


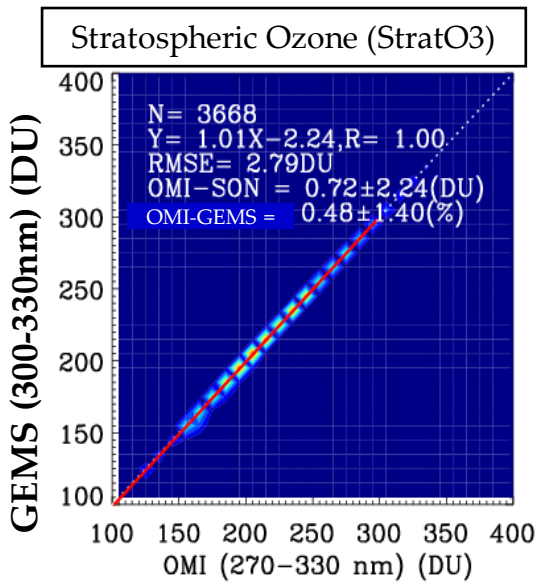
- Two O3 products have a good agreement in distribution.
- A good Correlation coefficient of 1, RMSE of 1.16 and MB of ~ 1 %.
- GEMS slightly overestimates to OMI. It could b due to the difference in used O3-xsection for each algorithm.
- GEMS O3T provides additional error analysis information.

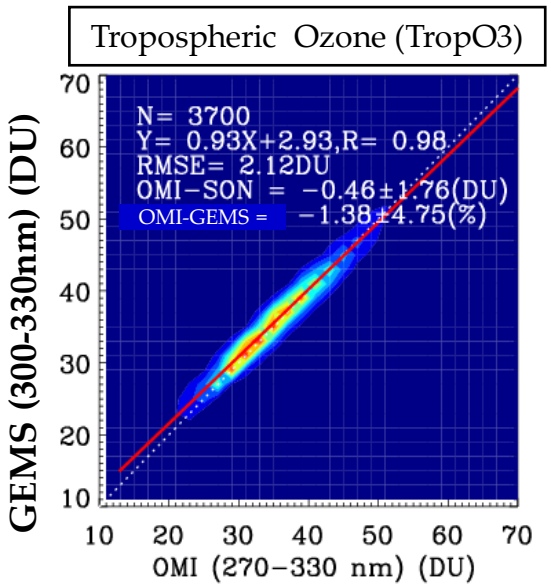
Application of GEMS Ozone Profile Algorithm to OMI L1B

Fitting windows of 270-330 nm for OMI
300-330 nm for GEMS

1th July, 2007 (OMI orbits#15241)





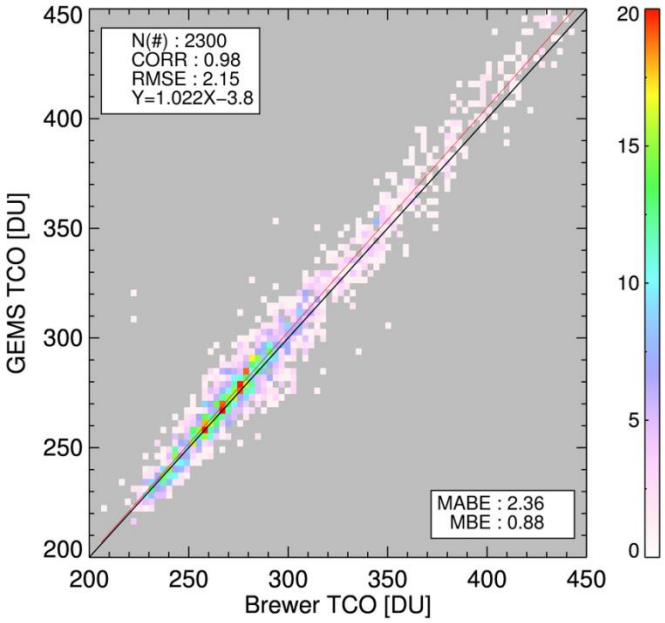


- GEMS O3P might provide insufficient information on stratosphere compared to OMI due to the absence of UV at less than 300nm
- Vertical O3 distributions from GEMS and OMI show a similar agreements except for troposphere.

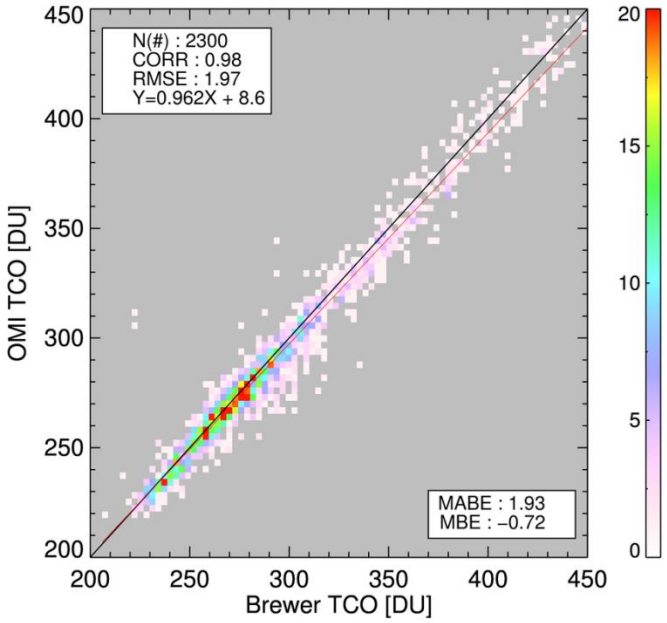
- In order to quantitatively evaluate GEMS O3P products, we compare the difference b.t.n GEMS and OMI StratO3 as well as b.t.n GEMS and OMI StratO3.
- The StratO3 differences due to not using spectrum below 300 nm shows 0.5 % mean biases with 1.5 % variability.
- However, the effect on TropO3 retrievals is 3 times larger than Strato3
- The little changes of the retrieval characteristics need to be carefully considered in developing the GEMS algorithm for tropospheric O3

Evaluation of GEMS retrievals (total O3) against ground based measurements

GEMS



OMI

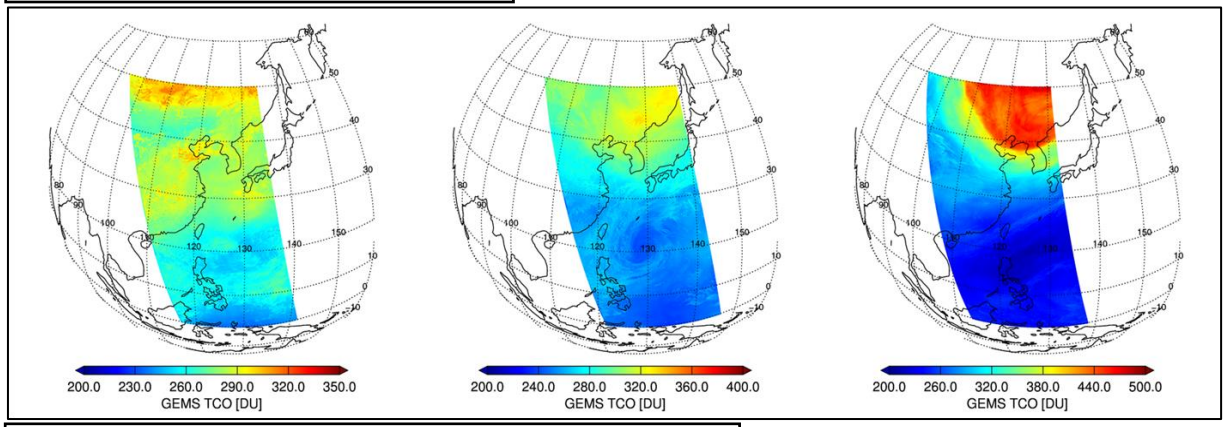


- A good correlation coefficient of 0.98 with Brewer measurements.
- GEMS total O3 overestimate by ~ 1 % rand OMI total O3 underestimate by ~ 1 % and relative to Brewer measurements
- These results agree with those of Balias et al., (2007), who reported that the uncertainty of OMI relative to ground-based measurement was about 2%

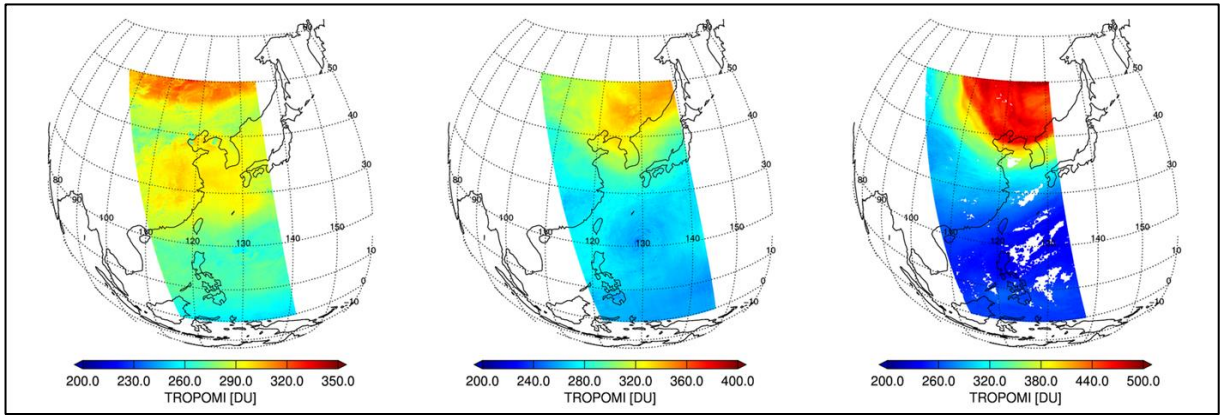
Application of GEMS Ozone Algorithm to TROPOMI L1B data

Application of GEMS Ozone (total O3) Algorithm to TROPOMI L1B data

GEMS O3T total O3



TROPOMI total O3



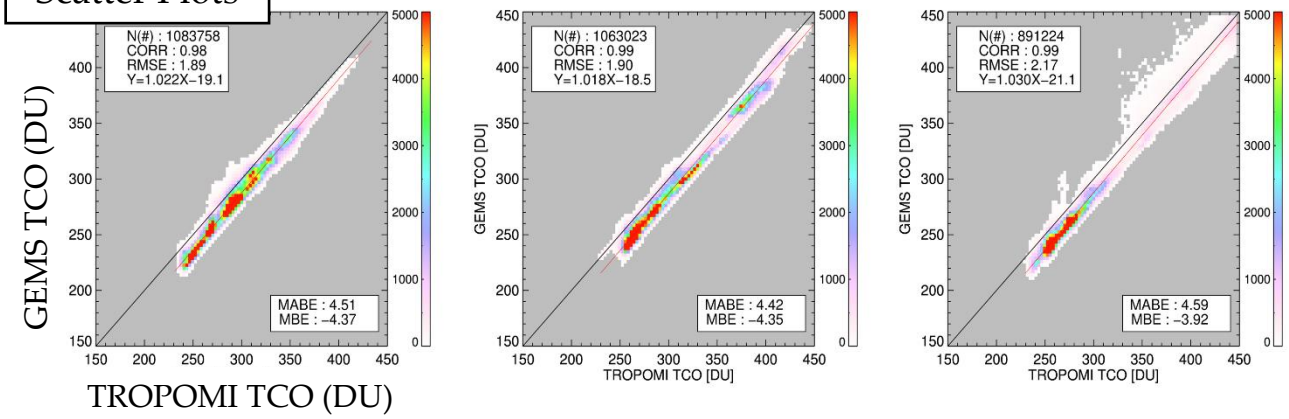
- Similar spatial distribution
- Capture the significant event well (i.e. High ozone appear at Eastern China in summer and at North Korea in spring).
- The absolute values between two O3 products showed slight differences possibly due to the algorithm differences
- GEMS O3T have lower TCO compared to TROPOMI over cloud region.

GEMS O3T : TOMS method
TROPOMI : DOAS method

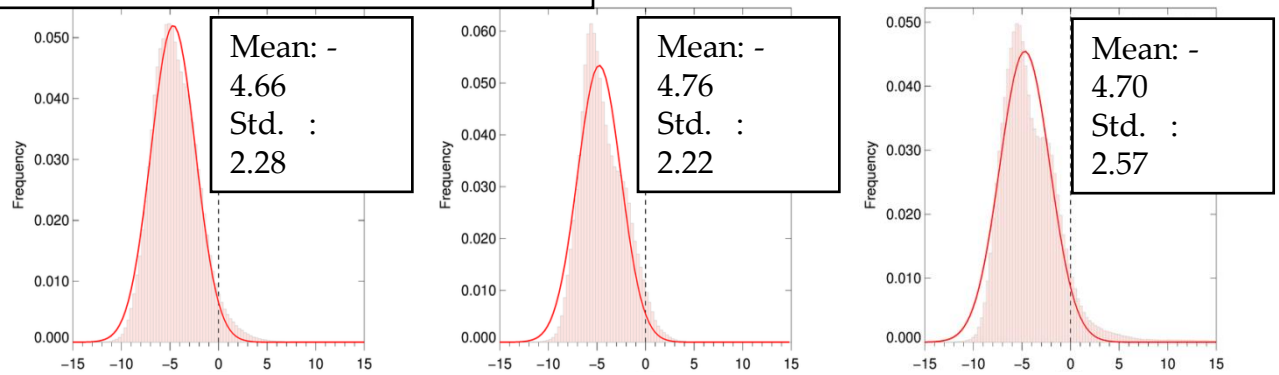
Application of GEMS Ozone (total O3) Algorithm to TROPOMI L1B data

2018.08.08 2019.08.26 2019.03.30

Scatter Plots



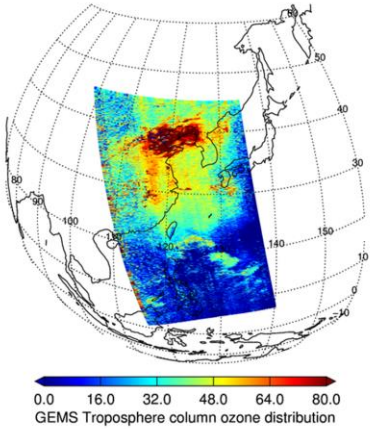
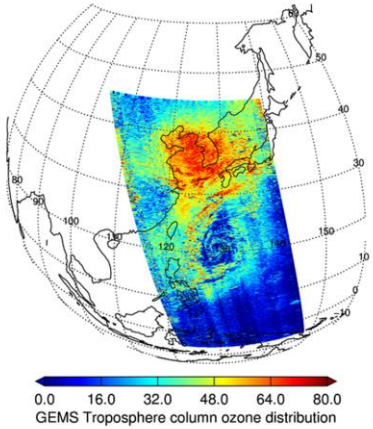
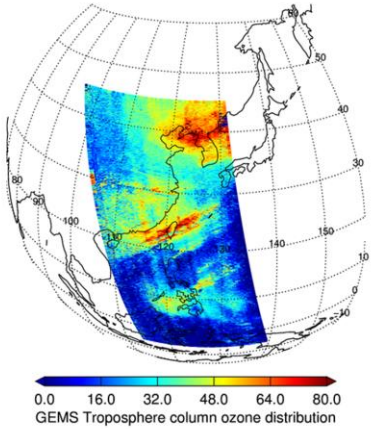
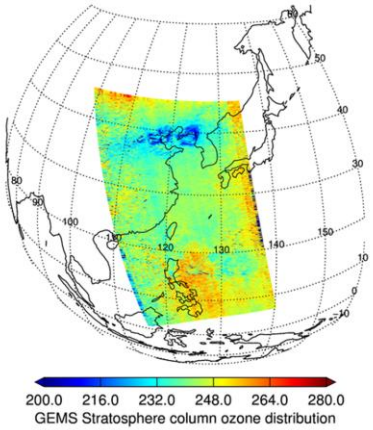
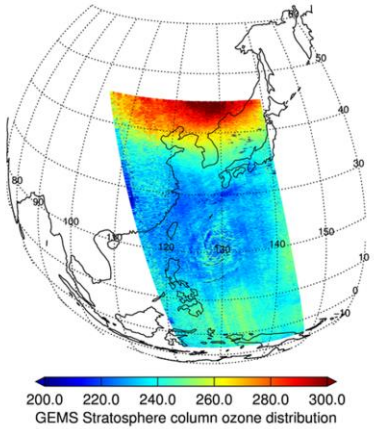
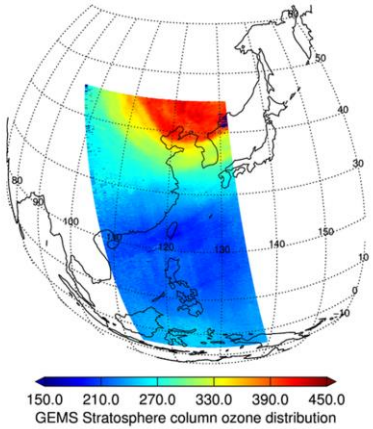
Histogram distribution of Bias



- The statistical values between GEMS and TROPOMI are good but mean bias are somewhat large (~ 4.5 %)
- The histogram distribution of bias follow a gaussian distribution.
- TROPOMI overestimated about ~ 5% compared to GEMS total O3.
- These differences could be caused by the algorithm differences (including cross-section, spectral calibration) but these are somewhat large compared to previous study

- For OMI, Kroon, et al., (2008) showed differences of ozone column between OMI-TOMS and OMI-DOAS vary 0 to 3 %.

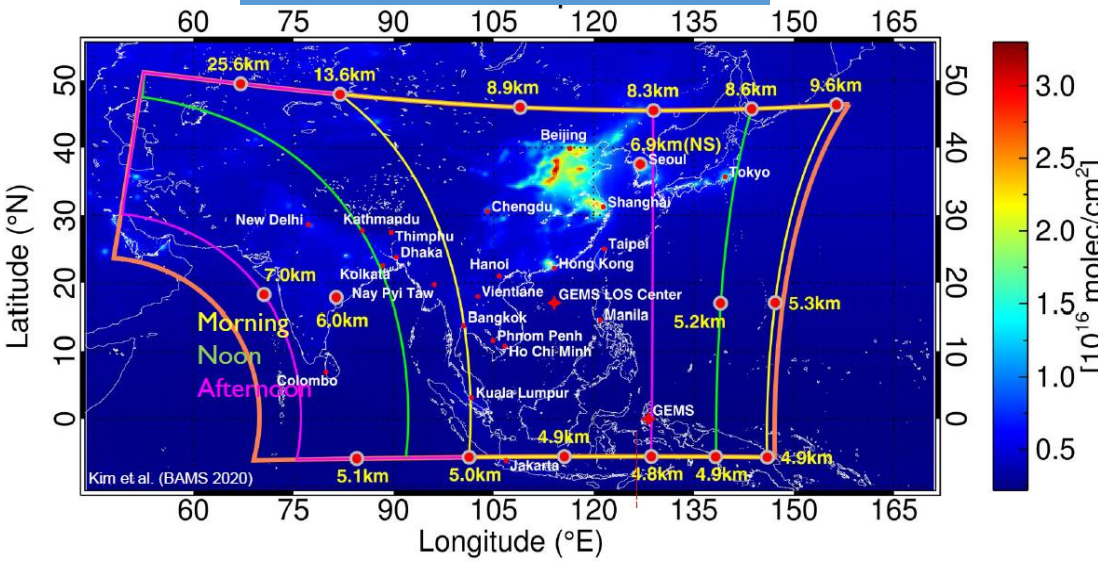
Application of GEMS Ozone (OEM) Algorithm to TROPOMI L1B data

	2018.08.08	2019.08.26	2019.03.30
Troposphere Ozone			
Stratosphere Ozone			

- Operational TROPOMI product does not released for this period.
- Over East Asia, High Tropospheric Ozone are well captured especially in summer.
- Both tropospheric and stratospheric ozone distribution appears striping pattern
- It may be improved in the future after applying soft calibration and using calibrated L1B data.

GEMS ground validation Pandora site

GEMS Field of Regard



Pandora measurement sites