



*Supplement of*

## **First evaluation of the GEMS formaldehyde product against TROPOMI and ground-based column measurements during the in-orbit test period**

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**Table S1. Summary of the data field variables archived in the GEMS Level 2 HCHO product. Layer, spatial, and image represent the number of vertical layers of the a priori profile, cross-track, and along-track of the GEMS observation, respectively.**

Variable name	Description	Unit	Dimensions
AirMassFactor	AMF	unitless	spatial × image
ClearAirMassFactor	AMF (cloud-free condition)	unitless	spatial × image
AMFCloudFraction	Cloud radiance fraction	unitless	spatial × image
AMFCloudPressure	Cloud top pressure	hPa	spatial × image
AMFDiagnostic	Diagnostic flags in AMF calculation	unitless	spatial × image
AMFSurfaceLER	Surface Lambertian-equivalent reflectivity	unitless	spatial × image
ColumnAmount	HCHO VCD	molecules cm <sup>-2</sup>	spatial × image
ColumnUncertainty	Random uncertainty of the HCHO VCD	molecules cm <sup>-2</sup>	spatial × image
dSCD	Retrieved SCD before background correction	molecules cm <sup>-2</sup>	spatial × image
FitConvergenceFlag	Degree of convergence of the spectral fitting determined by the fitting score of the HCHO dSCD	unitless	spatial × image
FittingRMS	Fitting root mean square error	unitless	spatial × image
GasProfile	HCHO a priori profile	molecules cm <sup>-3</sup>	layer × spatial × image
Layer	Pressure profile	hPa	layer × spatial × image
ScatteringWeight	Scattering weight	unitless	spatial × image
ClearScatteringWeight	Scattering weight (cloud-free condition)	unitless	spatial × image
FinalAlgorithmFlags	Final algorithm flags	unitless	spatial × image

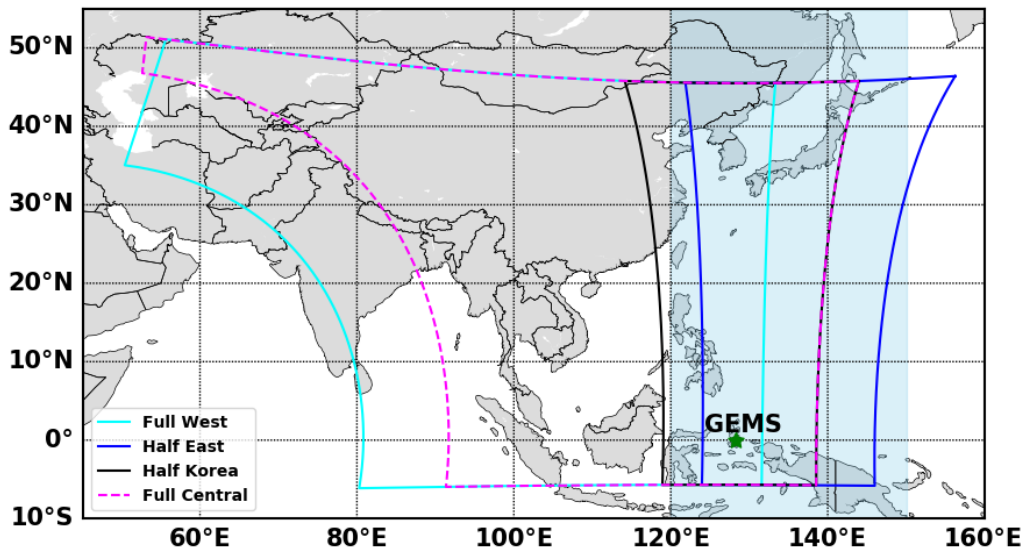


Fig. S1. Operational scan domain of GEMS (adapted from Kwon et al., 2019): half eastern scan (blue), half Korea scan (black), full central scan (dashed magenta), full western scan (cyan), and the GEMS location (green star). Shaded areas (120–150° E) represent regions for radiance references and the common mode.

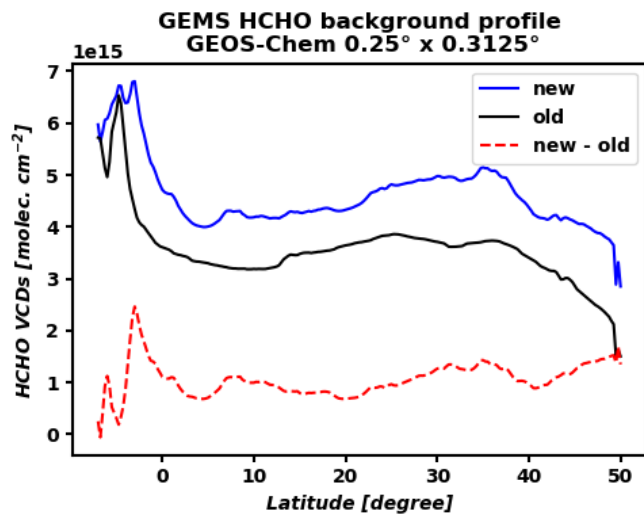


Fig. S2. Simulated annual mean HCHO background VCDs according to the reference sector (new: 120–150° E, old: 143–150° E).

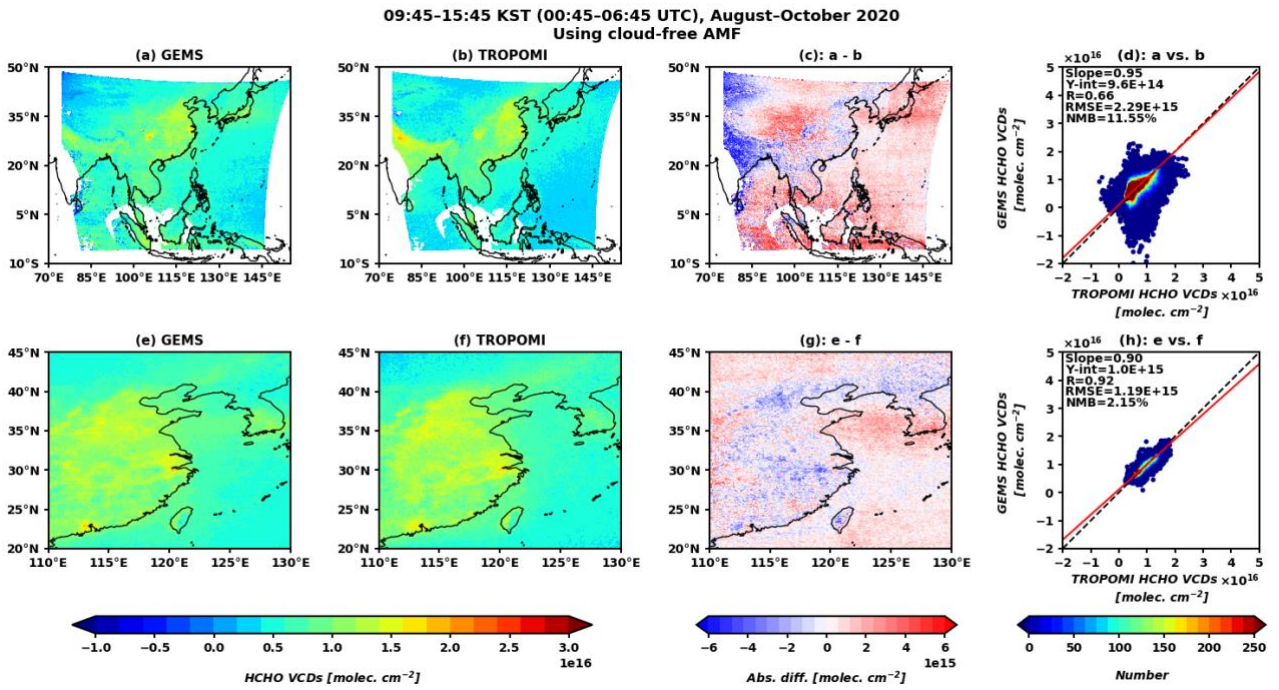


Fig. S3. Same as for Fig. 9 except for the AMF computation under the cloud-free assumption.

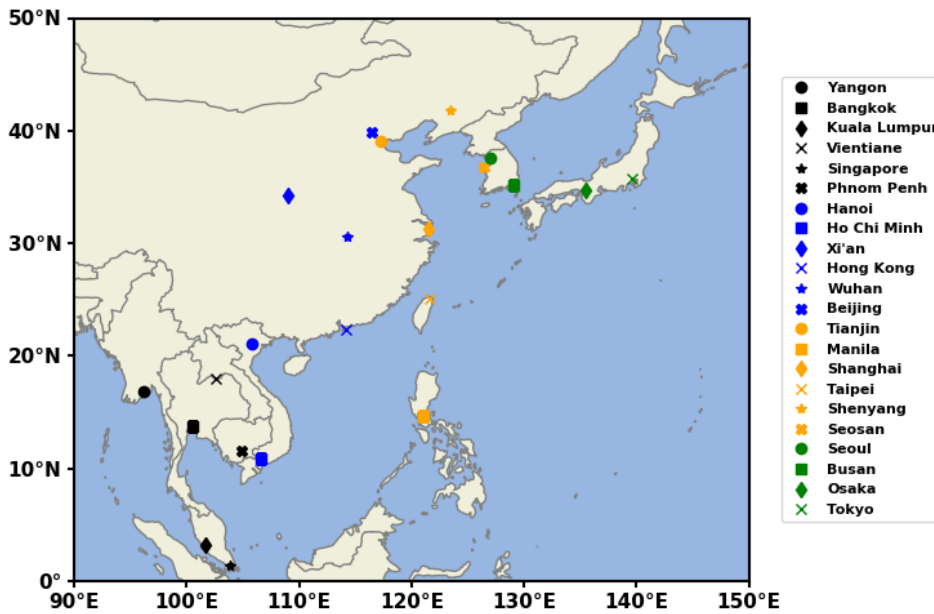


Fig. S4. Regions selected for the comparison between GEMS and TROPOMI.

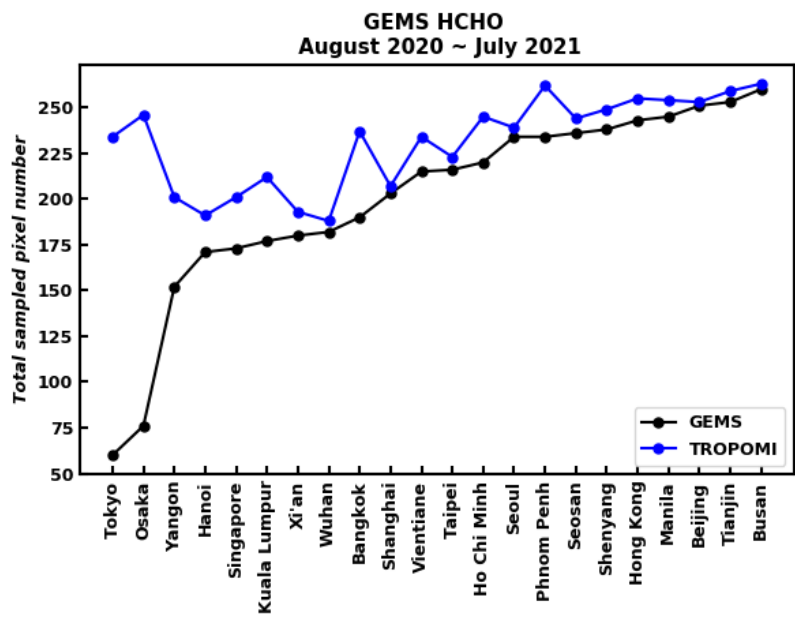


Fig. S5. Total sampled pixels of GEMS and TROPOMI HCHO VCDs by the regions presented in Fig. 10 during the TROPOMI overpass time from August 2020 to July 2021.

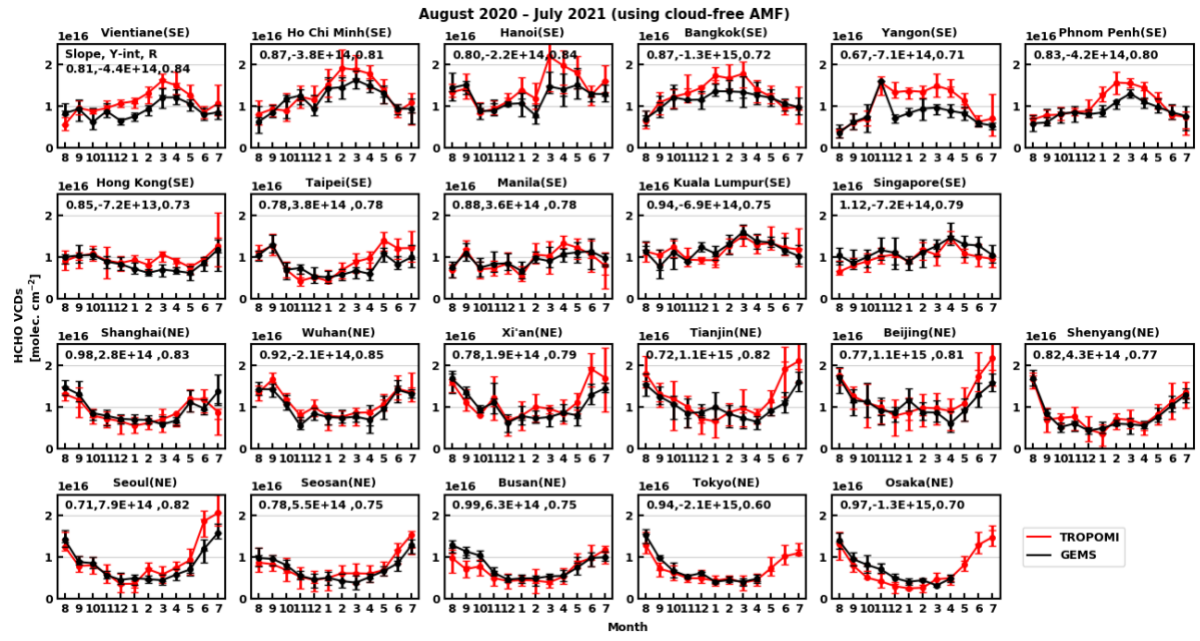


Fig. S6. Same as for Fig. 10 except for the AMF computation under the cloud-free assumption.

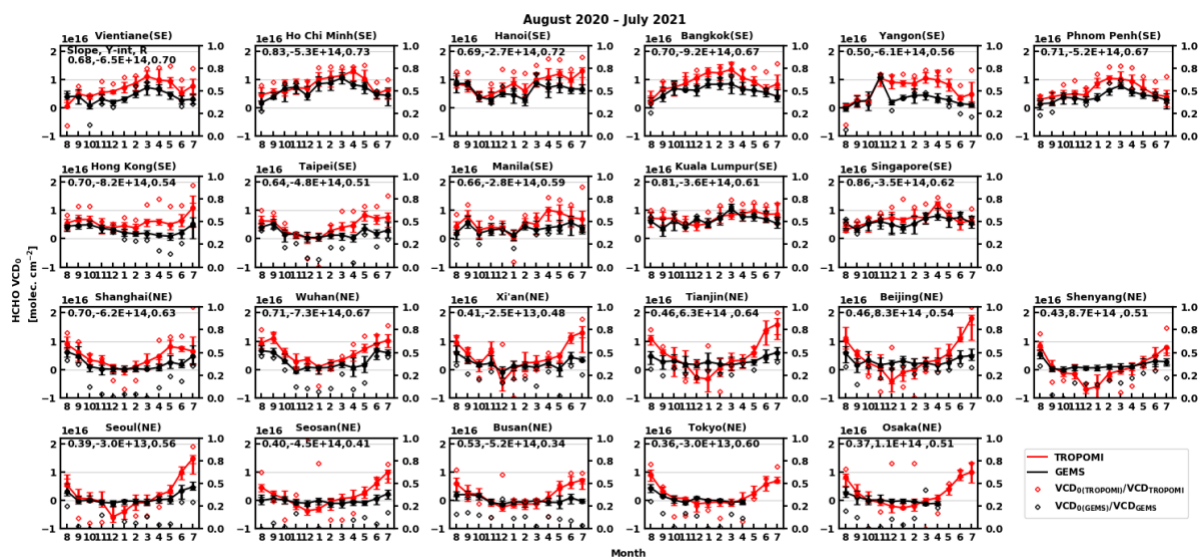


Fig. S7. Same as for Fig. 10 except for  $VCD_0$  (VCDs without background contributions). Diamonds represent an absolute value of  $VCD_0/VCD$ .

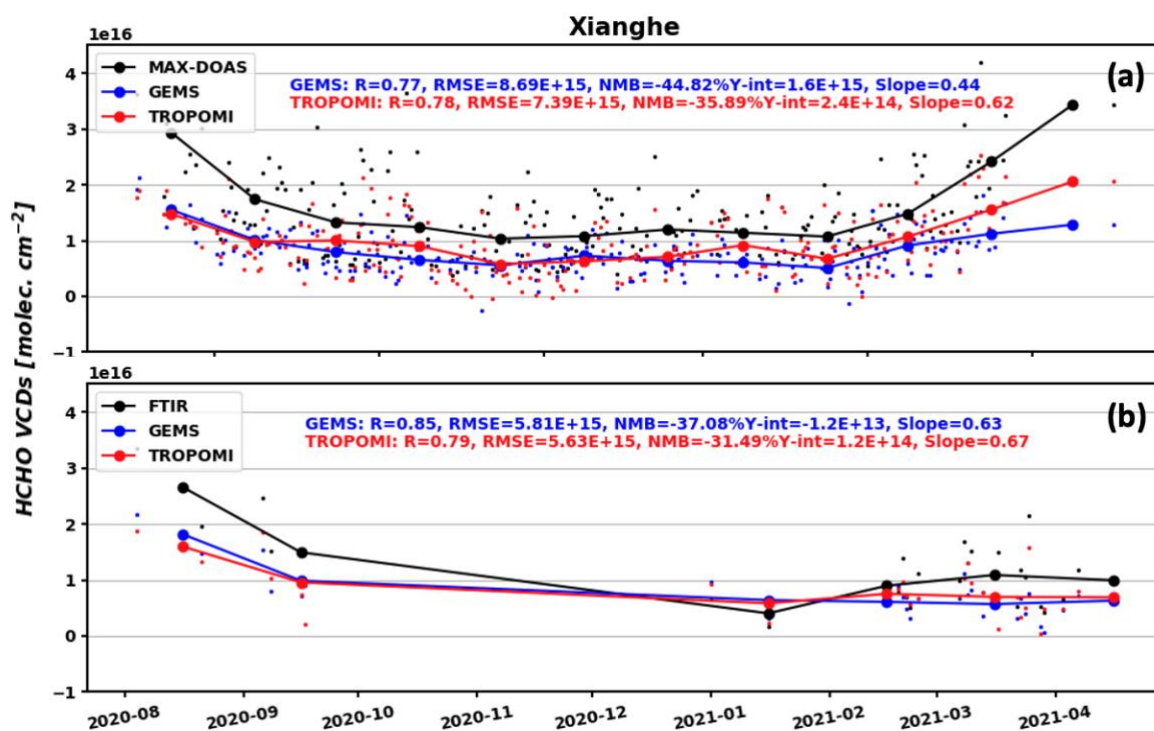


Fig. S8. Time series of daily (small marker) and monthly (large marker with solid line) mean vertical columns for GEMS (blue) and TROPOMI (red) against (a) MAX-DOAS (black) and (b) FTIR (black) for the TROPOMI overpass time (13:30, local time). GEMS and TROPOMI HCHO VCDs were directly compared with MAX-DOAS and FTIR without averaging kernel smoothing and a priori substitution.

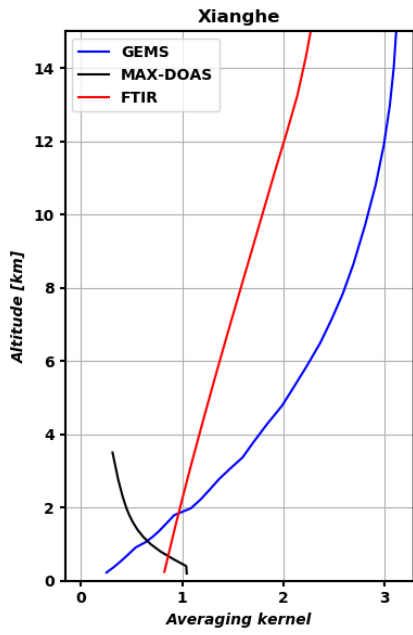


Fig. S9. Daily mean averaging kernels of GEMS (blue), MAX-DOAS (black), and FTIR (red) on 3 August 2020.

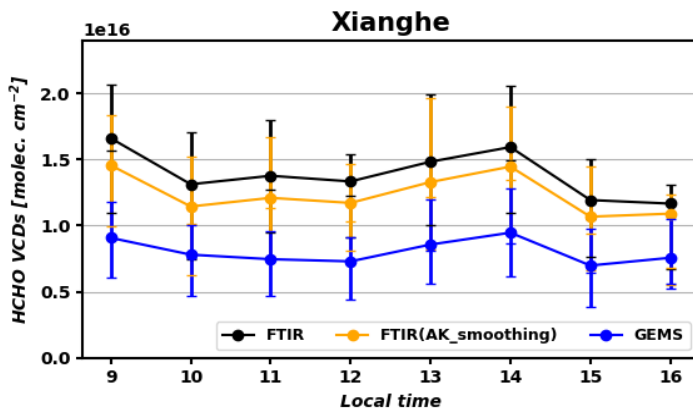


Fig. S10. Same as for Fig. 12 except for the FTIR observation.

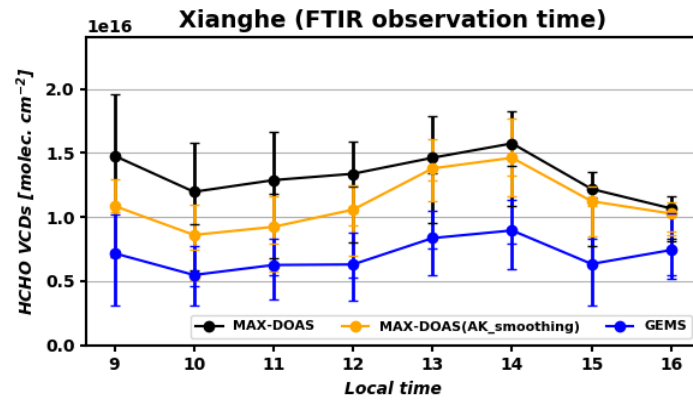


Fig. S11. Same as for Fig. 12 except for the MAX-DOAS HCHO in the FTIR observation time.

## Xianghe

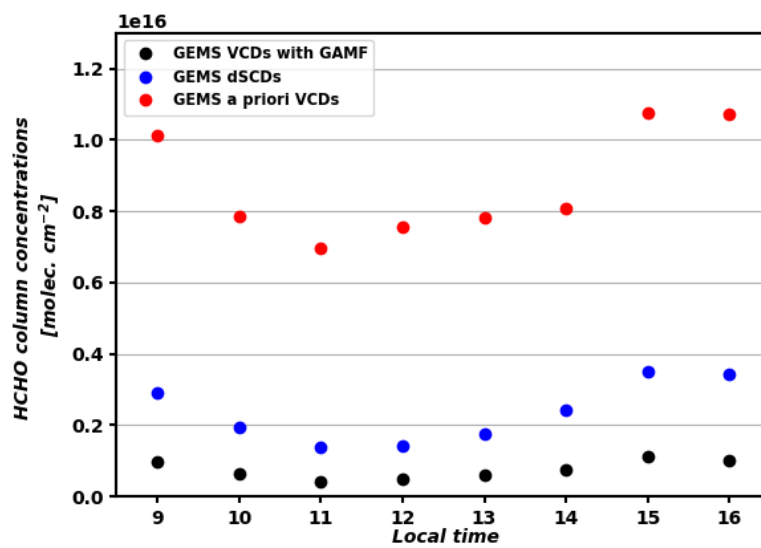


Fig. S12. Diurnal variations of median HCHO column concentrations from August 2020 to July 2021 in Xianghe: GEMS VCDs using geometric AMF (GAMF) without background corrections (black), GEMS dSCDs (blue), and model VCDs from GEMS a priori profiles (red).