Supplement Information of

POMINO-GEMS：A Research Product for Tropospheric NO_2 Columns from Geostationary Environment Monitoring Spectrometer

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1. MAX-DOAS instruments

There are four instruments installed in various areas of Shanghai. The instrument located in the campus of Fudan University is in the urban center of Shanghai (31.34°N, 121.52°E). The telescope's azimuth angle is 0°, and the scattered sunlight is measured at ten elevation angles of 2°, 3°, 5°, 7°, 10°, 15°, 20°, 30°, 45° and 90° within 15 minutes. The Nanhui site is in the suburban area (31.06°N, 121.80°E) and about 10 km southeast to the center of Shanghai. The azimuth angle is set to 2° and it takes about 15 minutes for a full cycle with elevation angles of 2°, 3°, 5°, 7°, 9°, 12°, 15°, 20°, 30°, 45° and 90°. The Dianshan Lake site is located near the Dianshan Lake Scenic Area (31.10°N, 120.98°E), which is at the junction of Suzhou and Shanhai. The Chongming site is on the Chongming Island (31.50°N, 121.82°E) of Shanghai, which is China's third largest island and located in Yangtze River estuary. The instruments in these two suburban sites (Dianshan Lake and Chongming) are operated in the same way as that in the Nanhui site, except with a fixed azimuth angle at 5° (Zhang et al., 2021; Zhang et al., 2022a; Zhang et al., 2022b; Zhu et al., 2022).

The instrument operated in Xianghe is designed by BIRA-IASB and run by both BIRA-IASB and CAS-IAP. It is located in the suburban area (39.75°N, 116.96°E) of Xianghe county to the southwest of Beijing. The telescope's azimuth direction is fixed to the north, and a full scan requiring about 15 minutes comprises nine elevation angles: 2°, 4°, 6°, 8°, 10°, 12°, 15°, 30° and 90°(Clémer et al., 2010; Hendrick et al., 2014).

The instrument in Xuzhou is set on the roof of the School of Environmental Science and Spatial Informatics, China University of Mining and Technology (34.22°N, 117.14°E). It is located 6.5 km away from the urban center of Xuzhou, and about 1 km south to the Yunlong Lake Scenic Area, which is a 5A natural scenic area. It measures scattered sunlight every 5 minutes for five zenith angles: 5°, 10°, 20°, 30° and 90°. This instrument is normally operated from 9:00 to 17:00 local solar time (LST) each day (Liu et al., 2020).

The instrument in Hefei site was deployed in March 2008 and is run by Anhui Institute of Optics and Fine Mechanics (AIOFM), Chinese Academy of Science (CAS). It is located outdoors in the campus of AIOFM and about 10 km northwest to the center of Hefei city (31.91°N, 117.16°E). It takes 30 minutes for a cycle to measure introduced scattered sunlight with sequential elevation angles of 3°, 5°, 10°, 20°, 30° and 90° (Kanaya et al., 2014).

The Fukue and Cape Hedo sites are both remote sites located far away from the major cities (32.75°N, 128.68°E and 26.87°N, 128.25°E, respectively). They are suitable for monitoring tropospheric NO_2 in the background regions and outflow from Korea and China. Similar to the instrument at Hefei, the scattered sunlight is measured by rotating a prism at six elevation angles 3°, 5°, 10°, 20°, 30° and 90°, with 5 minutes for each angle and 30 minutes for a total (Kanaya et al., 2014; Choi et al., 2021).

2. Supplemental figures

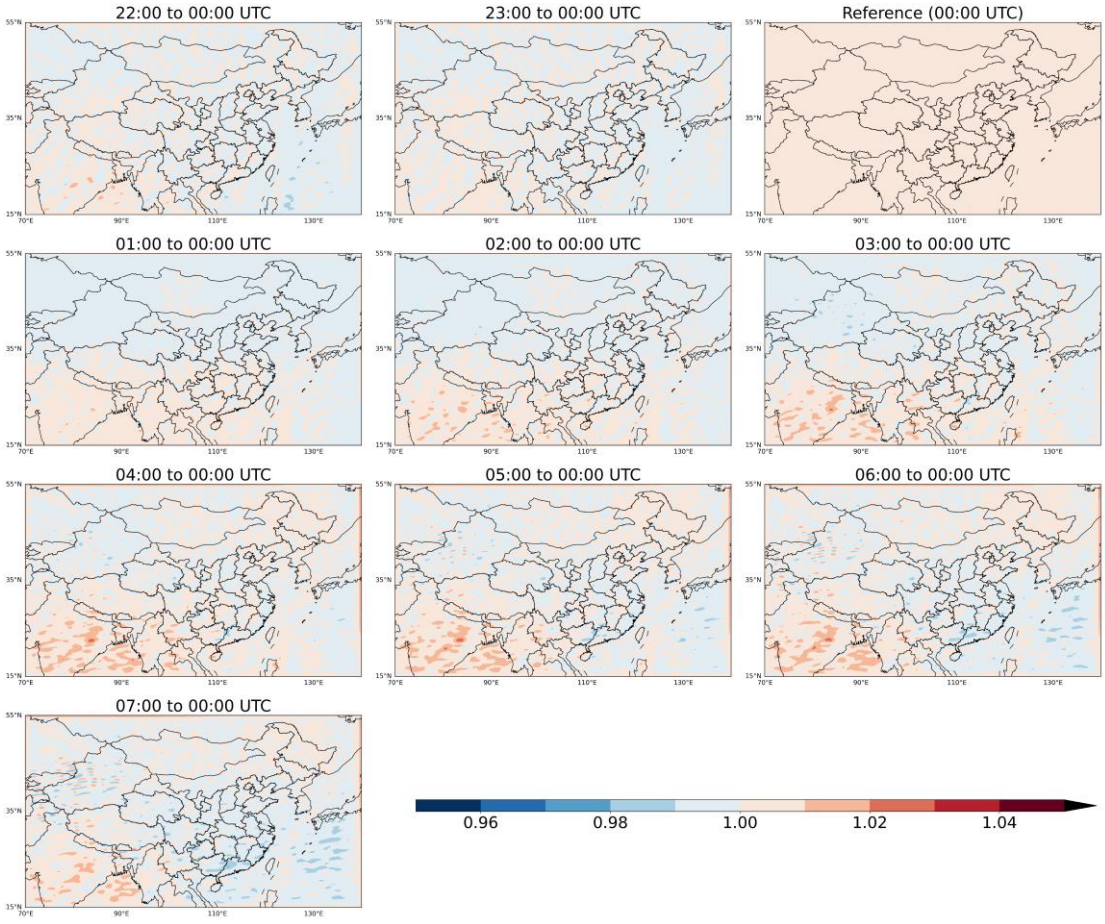

Figure S1. Spatial distribution of GEOS-Chem derived stratospheric NO_2 ratio at each hour to the reference hour (00:00 UTC) on a 0.05° × 0.05 °grid in June 2021.

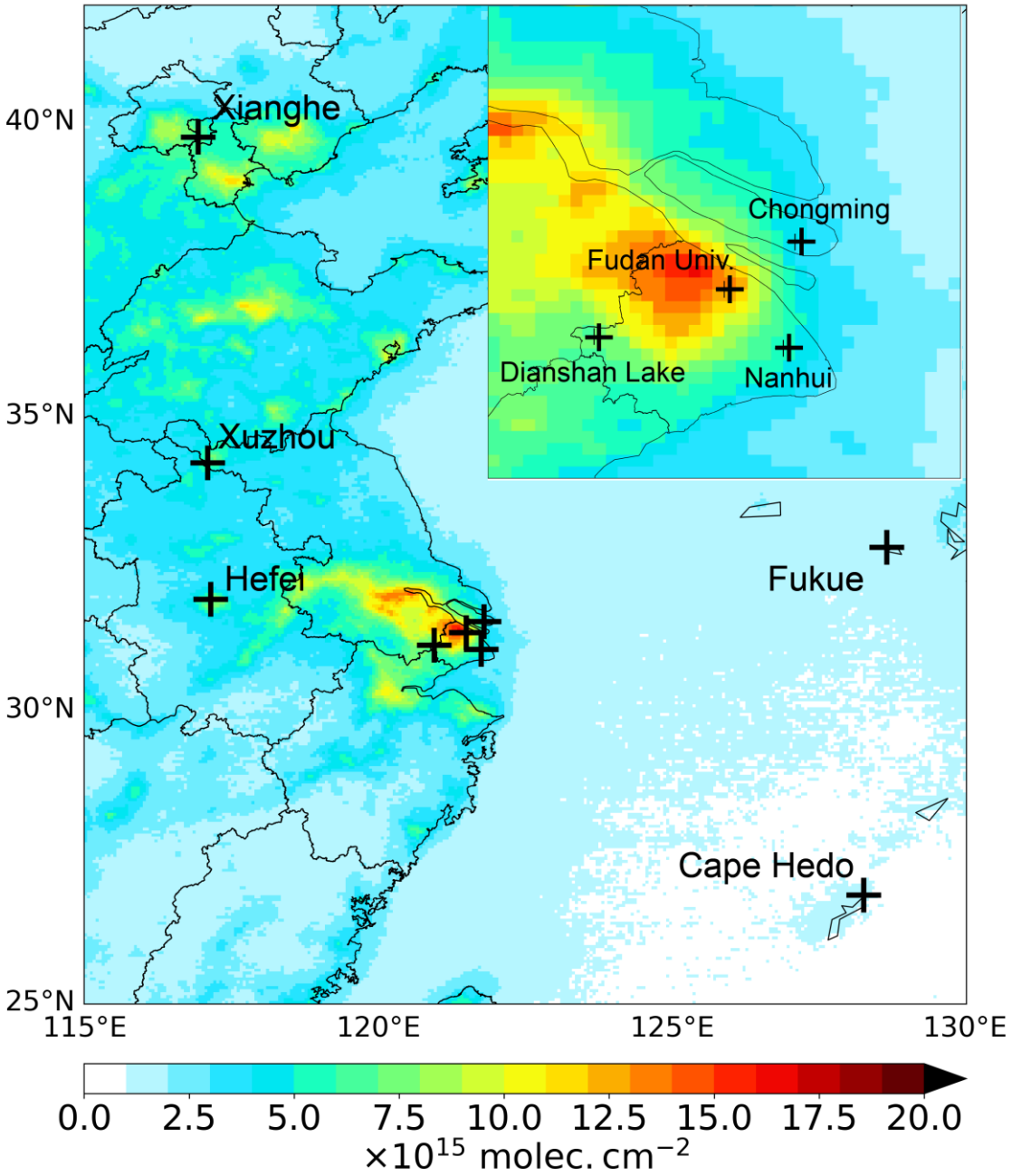

Figure S2. Spatial distribution of MAX-DOAS sites used in this study. Overlaid in the background is the spatial distribution of POMINO-GEMS tropospheric NO_2 VCDs in JJA 2021 on a 0.05° × 0.05 °grid.

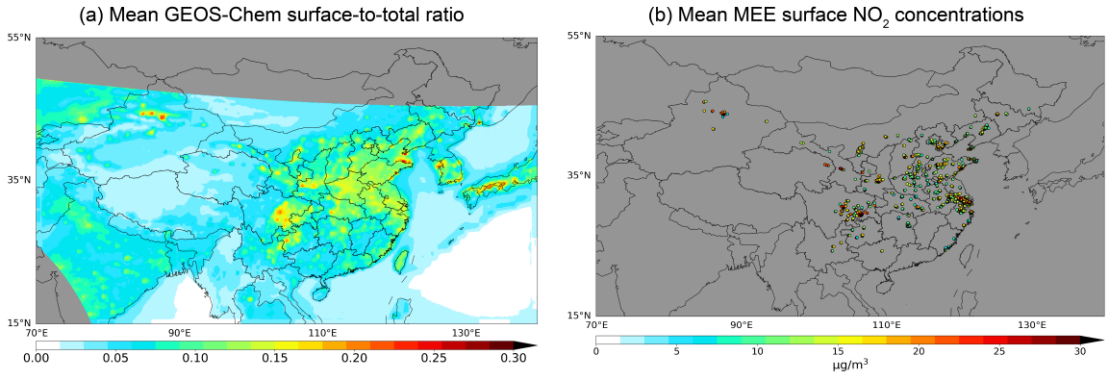

Figure S3. (a) Mean surface-to-total ratio of GEOS-Chem simulated NO_2 in the GEMS FOV on a 0.05° × 0.05 ° grid, and (b) mean MEE surface NO_2 concentrations at filtered MEE stations in JJA 2021.

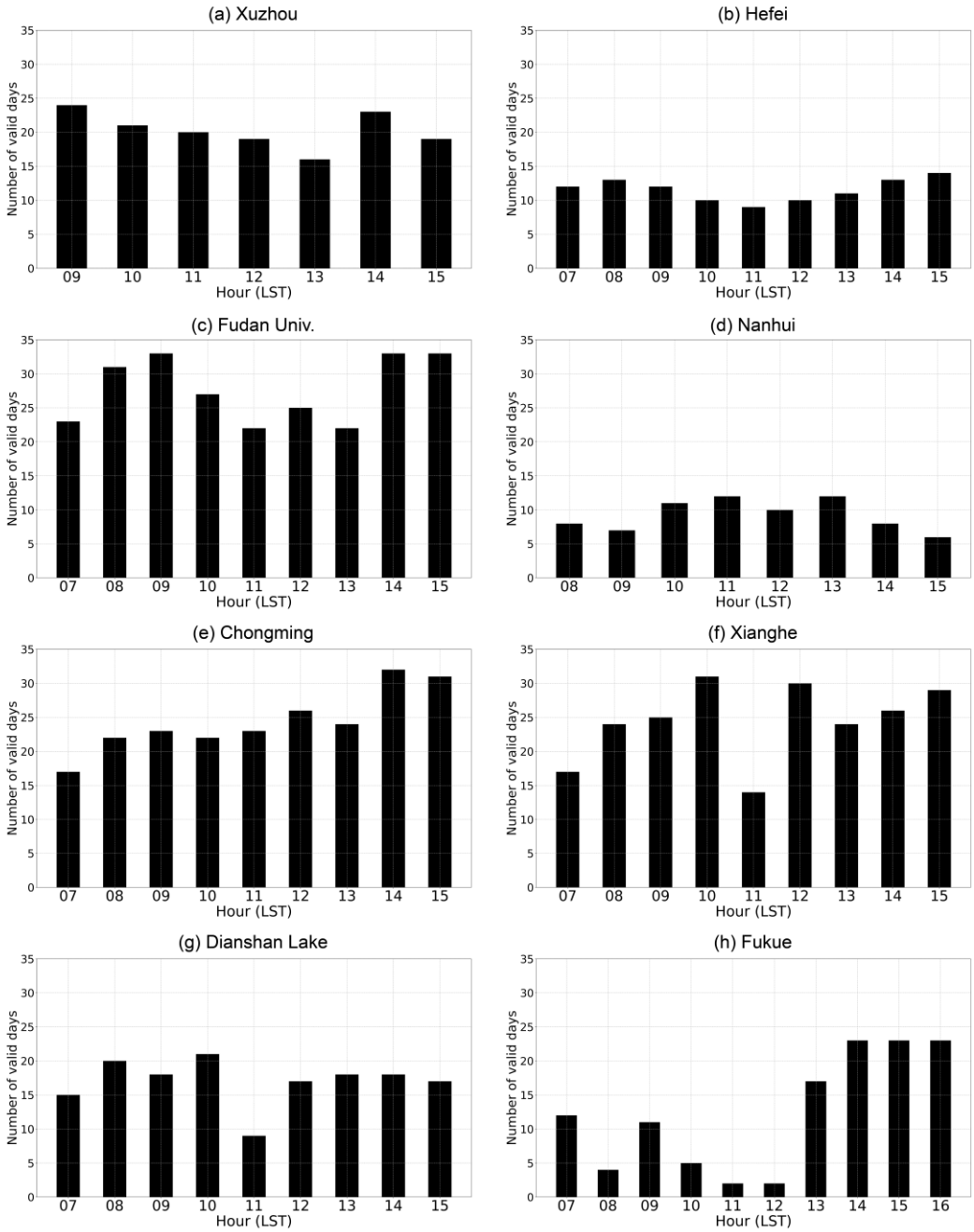

Figure S4. Number of valid days for each hour at eight sites in JJA 2021.

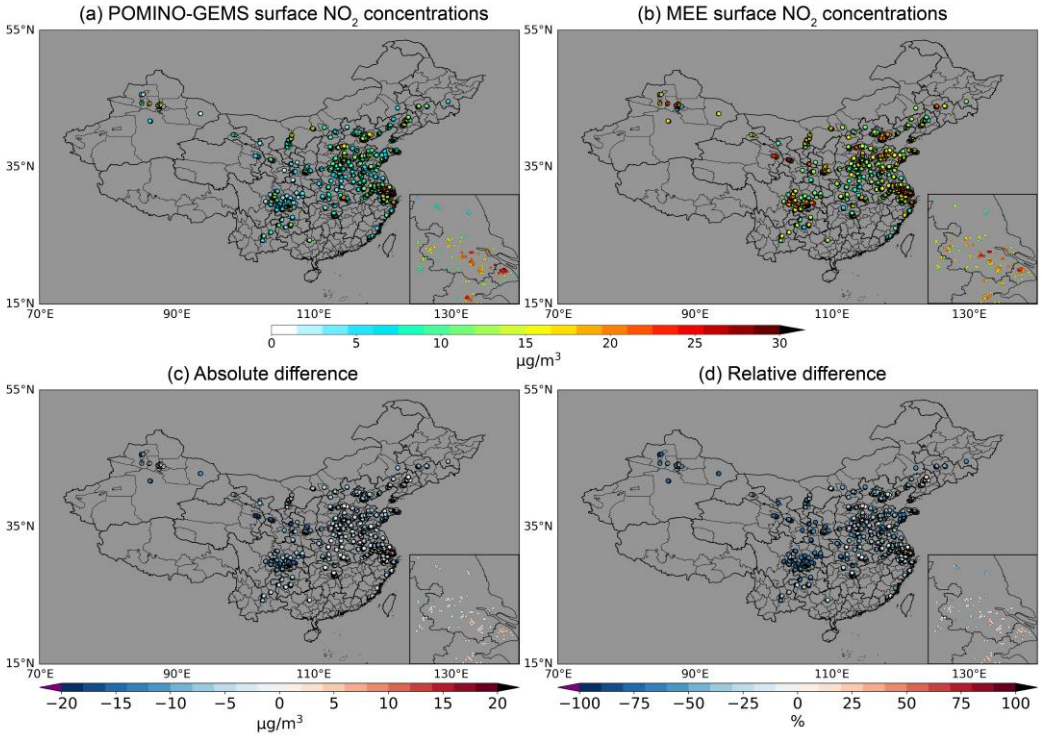

Figure S5. Evaluation of POMINO-GEMS derived surface NO_2 concentrations. Mean surface NO_2 concentrations (a) derived from POMINO-GEMS VCDs and (b) taken from MEE measurements at 855 stations in JJA 2021. Panels (c) and (d) are the absolute and relative differences of POMINO-GEMS relative to MEE. The sub-figures show a zoomed-in map around the Yangtze River Delta (YRD) region (118-122°E, 30-34°N).

References

Choi, Y., Kanaya, Y., Takashima, H., Irie, H., Park, K., and Chong, J.: Long-Term Variation in the Tropospheric Nitrogen Dioxide Vertical Column Density over Korea and Japan from the MAX-DOAS Network, 2007–2017, Remote Sensing, 13, 1937, 10.3390/rs13101937, 2021.

Clémer, K., Van Roozendael, M., Fayt, C., Hendrick, F., Hermans, C., Pinardi, G., Spurr, R., Wang, P., and De Mazière, M.: Multiple wavelength retrieval of tropospheric aerosol optical properties from MAXDOAS measurements in Beijing, Atmospheric Measurement Techniques, 3, 863-878, 10.5194/amt-3-863-2010, 2010.

Hendrick, F., Müller, J.-F., Clémer, K., Wang, P., De Mazière, M., Fayt, C., Gielen, C., Hermans, C., Ma, J. Z., Pinardi, G., Stavrakou, T., Vlemmix, T., and Van Roozendael, M.: Four years of ground-based MAX-DOAS observations of HONO and NO₂ in the Beijing area, Atmospheric Chemistry and Physics, 14, 765-781, 10.5194/acp-14-765-2014, 2014.

Kanaya, Y., Irie, H., Takashima, H., Iwabuchi, H., Akimoto, H., Sudo, K., Gu, M., Chong, J., Kim, Y. J., Lee, H., Li, A., Si, F., Xu, J., Xie, P.-H., Liu, W.-Q., Dzhola, A., Postylyakov, O., Ivanov, V., Grechko, E., Terpugova, S., and Panchenko, M.: Long-term MAX-DOAS network observations of NO₂ in Russia and Asia (MADRAS) during the period 2007–2012: instrumentation, elucidation of climatology, and comparisons with OMI satellite observations and global model si, Atmospheric Chemistry and Physics, 14, 7909-7927, 10.5194/acp-14-7909-2014, 2014.

Liu, M., Lin, J., Kong, H., Boersma, K. F., Eskes, H., Kanaya, Y., He, Q., Tian, X., Qin, K., Xie, P., Spurr, R., Ni, R., Yan, Y., Weng, H., and Wang, J.: A new TROPOMI product for tropospheric NO2 columns over East Asia with explicit aerosol corrections, Atmos. Meas. Tech., 13, 4247-4259, 10.5194/amt-13-4247-2020, 2020.

Zhang, R., Wang, S., Zhang, S., Xue, R., Zhu, J., and Zhou, B.: MAX-DOAS observation in the midlatitude marine boundary layer: Influences of typhoon forced air mass, Journal of Environmental Sciences, 120, 63-73, https://doi.org/10.1016/j.jes.2021.12.010, 2022a.

Zhang, S., Wang, S., Xue, R., Zhu, J., Tanvir, A., Li, D., and Zhou, B.: Impact Assessment of COVID-19 Lockdown on Vertical Distributions of NO2 and HCHO From MAX-DOAS Observations and Machine Learning Models, Journal of Geophysical Research: Atmospheres, 127, e2021JD036377, https://doi.org/10.1029/2021JD036377, 2022b.

Zhang, S., Wang, S., Zhang, R., Guo, Y., Yan, Y., Ding, Z., and Zhou, B.: Investigating the Sources of Formaldehyde and Corresponding Photochemical Indications at a Suburb Site in Shanghai From MAX-DOAS Measurements, Journal of Geophysical Research: Atmospheres, 126, e2020JD033351, https://doi.org/10.1029/2020JD033351, 2021.

Zhu, J., Wang, S., Dao, X., Liu, D., Wang, J., Zhang, S., Xue, R., Tang, G., and Zhou, B.: Comparative observation of aerosol vertical profiles in urban and suburban areas: Impacts of local and regional transport, Science of The Total Environment, 805, 150363, https://doi.org/10.1016/j.scitotenv.2021.150363, 2022.