Supplementary Materials:

Diurnal carbon monoxide observed from a geostationary infrared hyperspectral sounder: First result from GIIRS onboard FengYun-4B

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Text S1: Comparing the smoothing effects on the retrieved CO columns by GIIRS and IASI AK matrix

To compare the smoothing effects of the averaging kernel (AK) matrix from GIIRS and IASI retrievals, we applied the AK smoothing to the IASI retrieved CO partial column profile retrievals which are assumed to be close to the truth. Following **Luo et al. (2007)**, we smooth the partial column profiles using the GIIRS or IASI AK matrix, given by:

$$x^*_{smoothed} = A^* x^{IASI}_{ret} + (I - A^*) x^{IASI}_a \quad \text{(S1)}$$

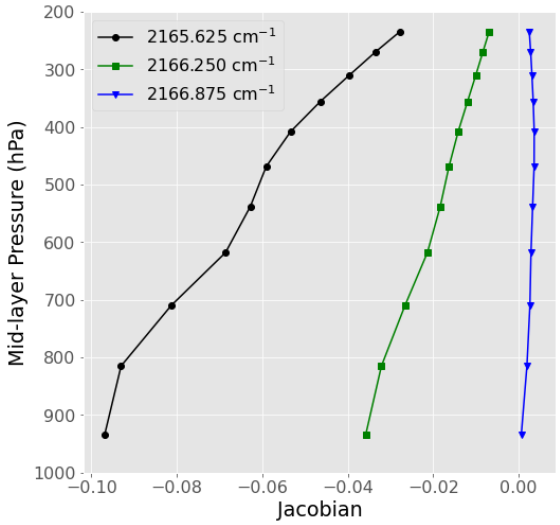
where A^* is either the GIIRS or the IASI AK matrix, and $x^*_{smoothed}$ is the corresponding smoothed result. Since GIIRS and IASI have different footprint sizes and spatial resolutions, for every IASI data, the closest GIIRS AK matrix is used. The comparison results are shown in **Figure S9**.

Table S1. Statistics from the comparison of daily CO total column, as shown in Fig. 13, between GIIRS and IASI averaged over North China Plain, Mongolia, East China Sea, and North India. The adjusted data are generated by adjusting the GIIRS CO retrievals based on the IASI a priori CO profile.

		North China Plain	Mongolia	East China Sea	North India
Nighttime Original	**Corr. Coef.**	0.86	0.66	0.94	0.67
	RMSE (mole/m^2)	0.0028	0.0018	0.0036	0.0040
	Mean (mole/m^2)	0.0024	0.0012	0.0032	0.0033
	Std. Dev. (mole/m^2)	0.0015	0.0013	0.0017	0.0022
Nighttime Adjusted	**Corr. Coef.**	0.88	0.68	0.95	0.67
	RMSE (mole/m^2)	0.0029	0.0035	0.0017	0.0024
	Mean (mole/m^2)	0.0026	0.0033	0.0008	0.0009
	Std. Dev. (mole/m^2)	0.0013	0.0012	0.0014	0.0022
Daytime Original	**Corr. Coef.**	0.88	0.94	0.92	0.84
	RMSE (mole/m^2)	0.0034	0.0009	0.0024	0.0017
	Mean (mole/m^2)	0.0026	0.0008	0.0016	0.0006
	Std. Dev. (mole/m^2)	0.0020	0.0005	0.0018	0.0015
Daytime Adjusted	**Corr. Coef.**	0.87	0.90	0.92	0.82
	RMSE (mole/m^2)	0.0042	0.0013	0.0021	0.0027
	Mean (mole/m^2)	0.0036	0.0011	0.0013	0.0016
	Std. Dev. (mole/m^2)	0.0022	0.0006	0.0017	0.0016

Figure S1. Example of Jacobian as a function of pressure for three channels: strong CO absorption channel at 2165.625 cm^{-1}, median absorption channel at 2166.250 cm^{-1}, and weak absorption channel at 2166.875 cm^{-1}. The Jacobian is the change of radiance ($mW/(m^2 \times sr \times cm^{-1})$) relative to CO partial column ($molecules/cm^2$).

(a) Daytime



(b) Nighttime

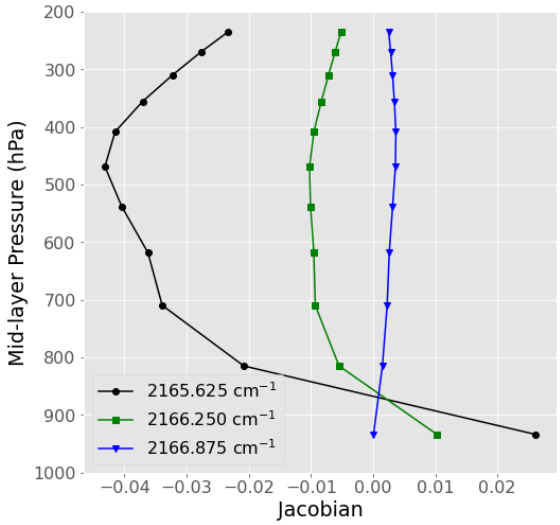


Figure S2. The same as Figure 4, but for Mongolia.

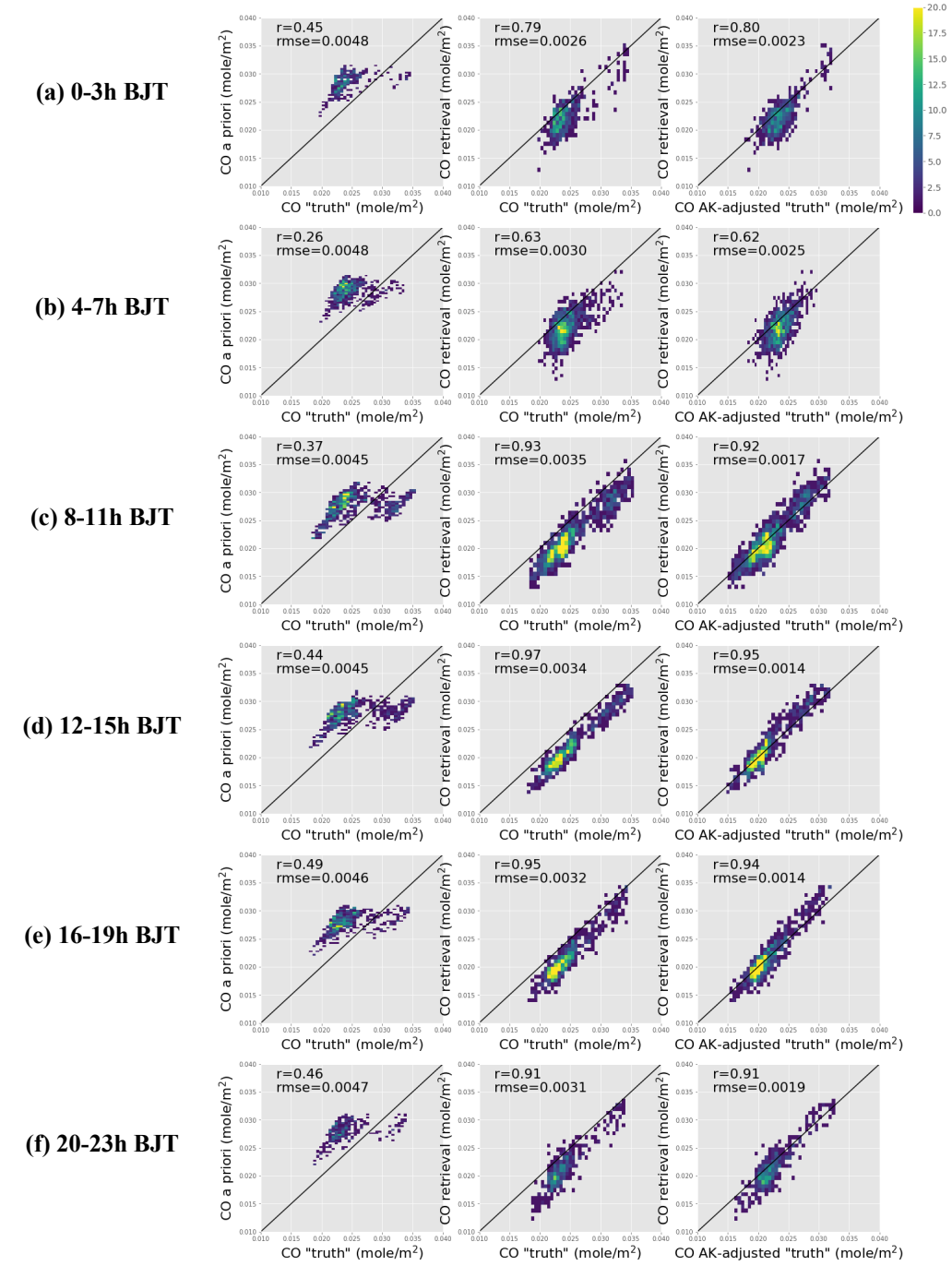


Figure S3. The same as Figure 4, but for East China Sea.

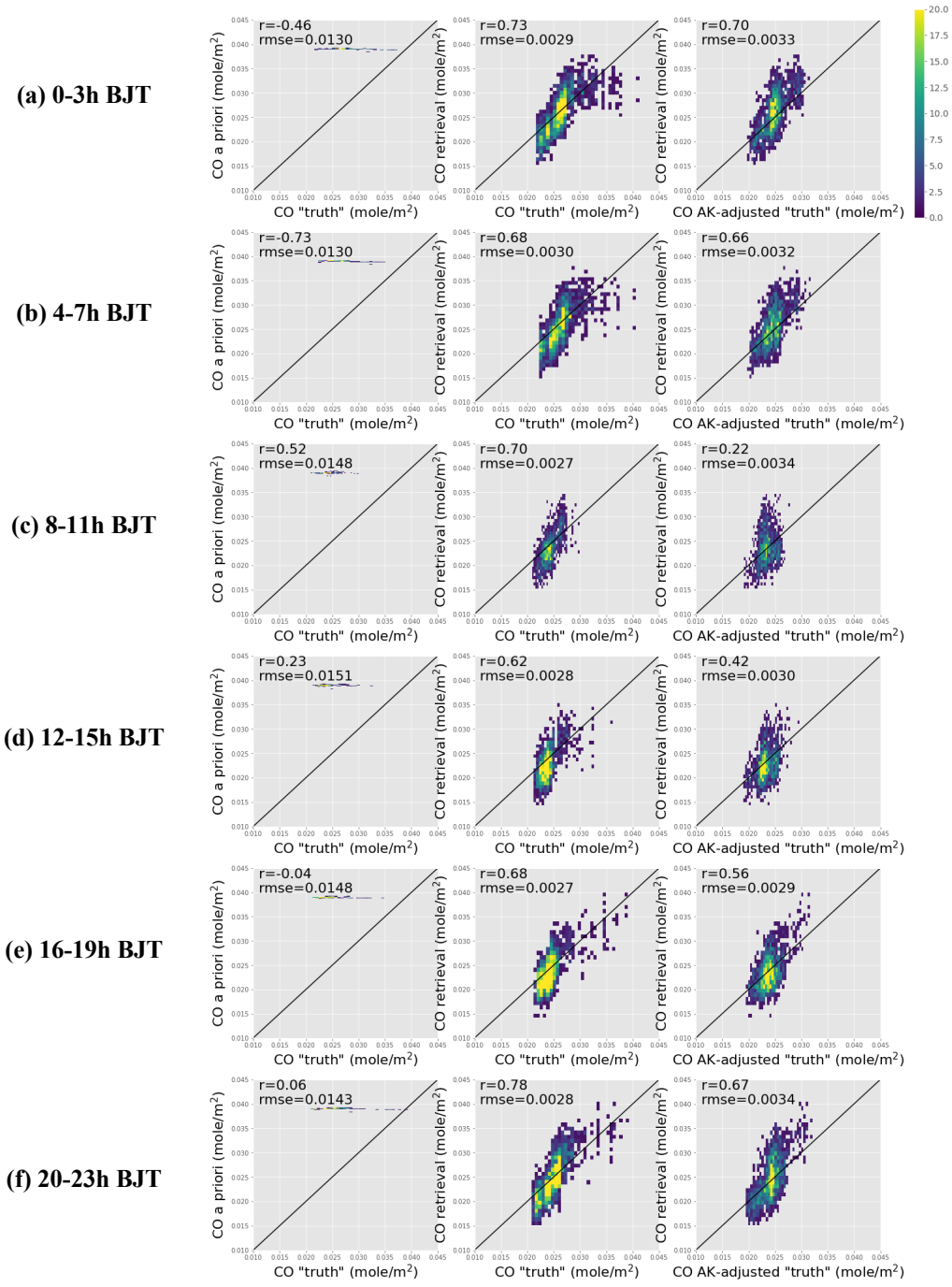


Figure S4. The same as Figure 4, but for North India.

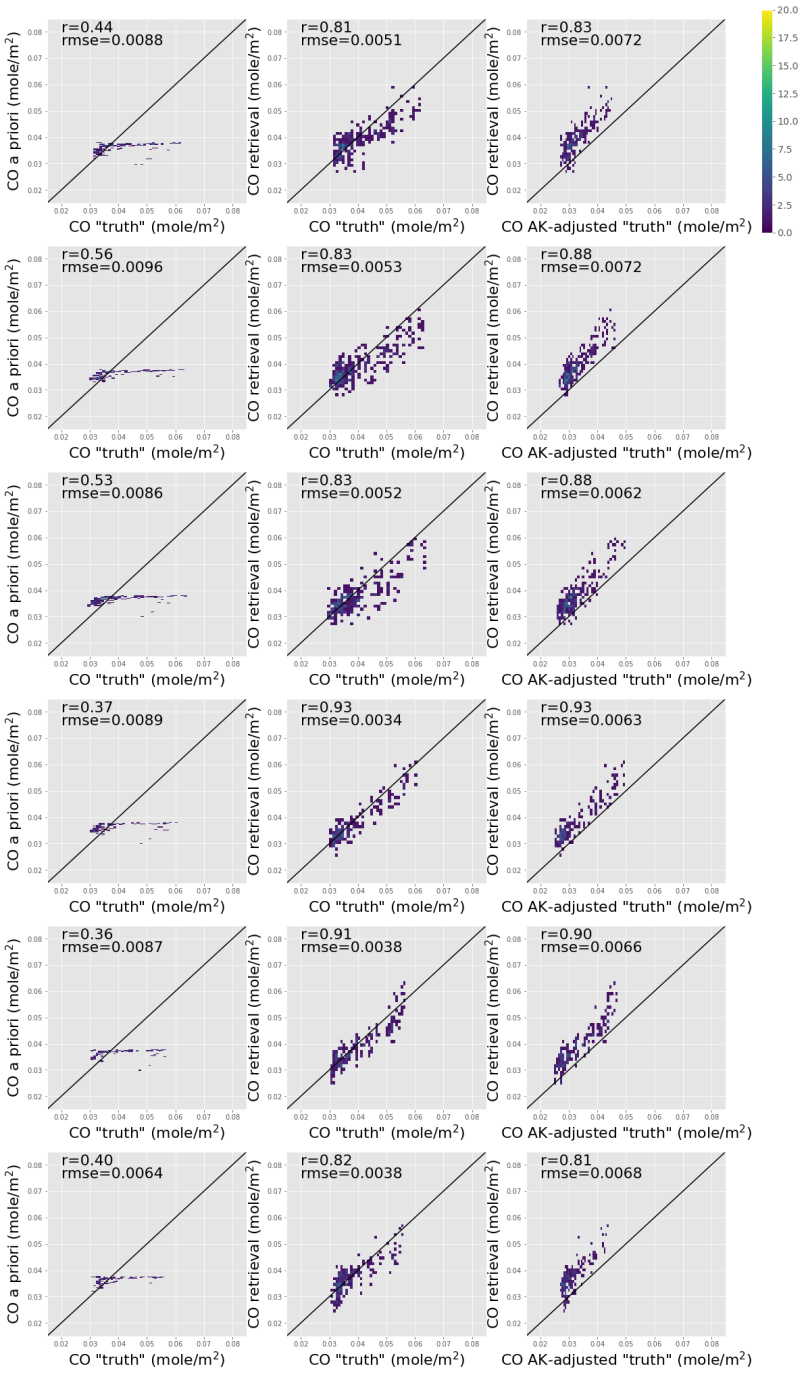


Figure S5. Examples of spectral fits and the residual in brightness temperature. These two examples are selected from observations on July 07, 2022. The reduced χ^2 for the daytime example is 1.11, and for nighttime example it is 0.90.

(a) Daytime **(b) Nighttime**

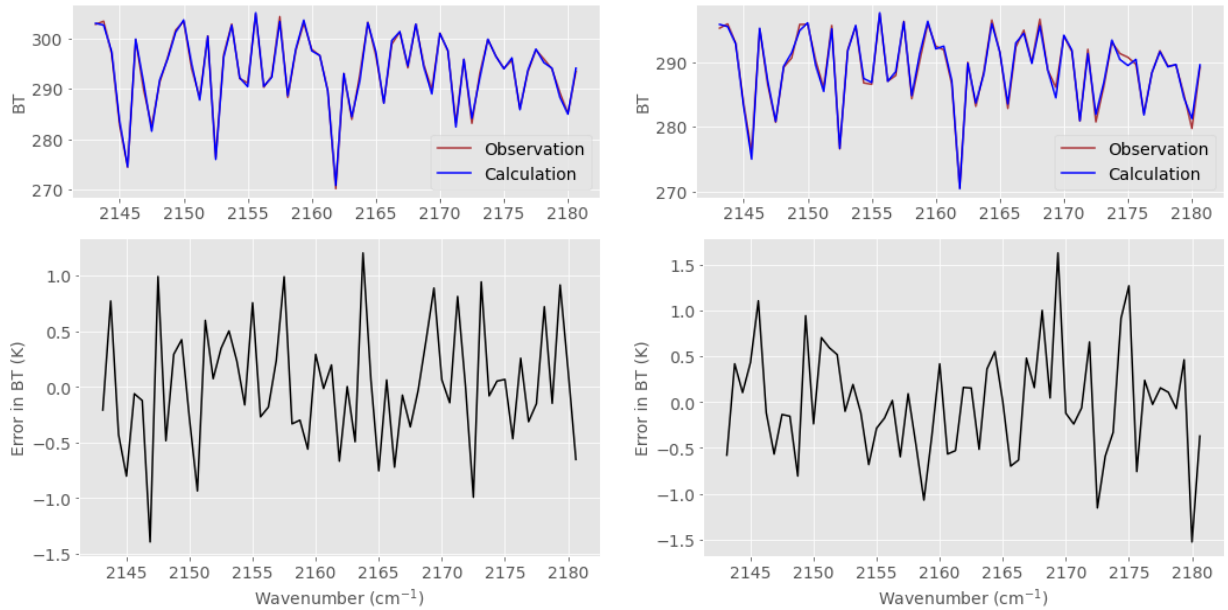


Figure S6. The diurnal changes (every 3-hour) of simulated ground-level CO volume mixing ratio (VMR) in July 2022 averaged over the selected regions. The simulation data are adopted from ECMWF Atmospheric Composition Reanalysis 4 (EAC4) reanalysis dataset.

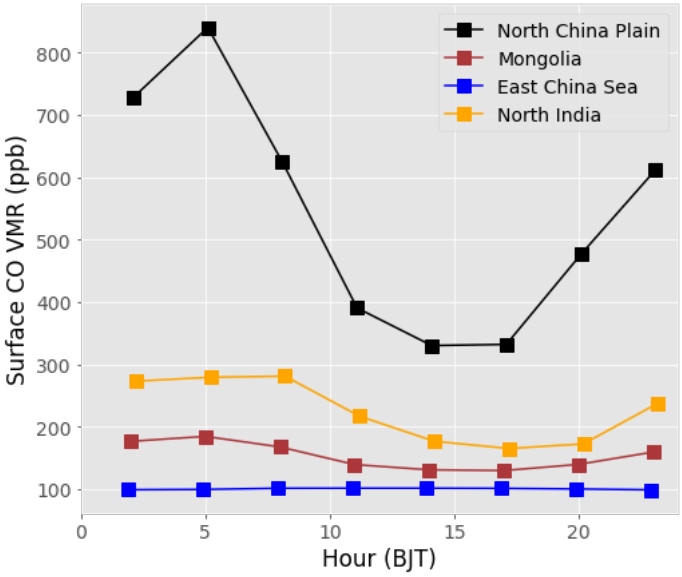


Figure S7. Observation hours (in Beijing Time) of IASI CO retrievals on July 07, 2022 for (left) daytime and (right) nighttime.

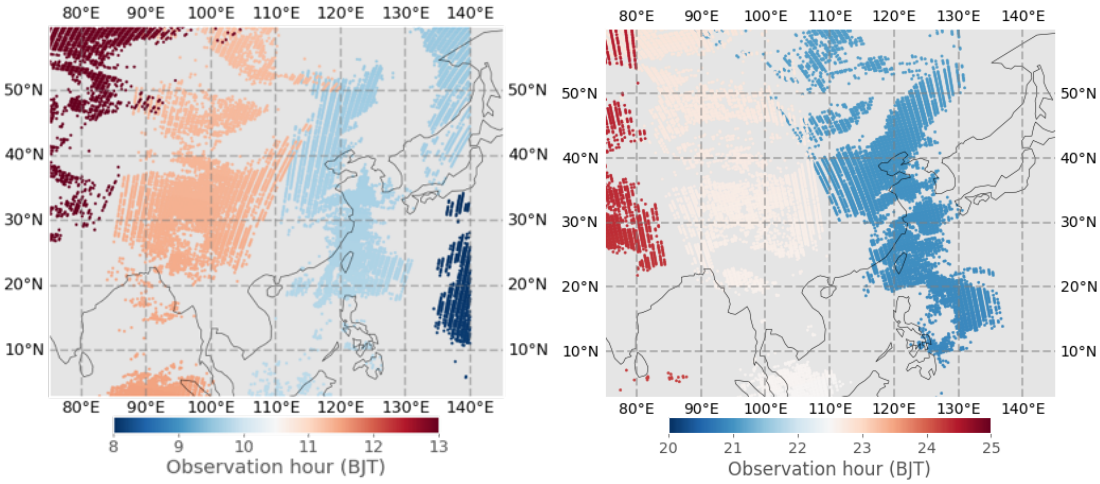


Figure S8. Comparing DOFS from CO column retrievals by GIIRS and IASI on July 07, 2022, using daytime and nighttime observation. The observation times are also indicated.

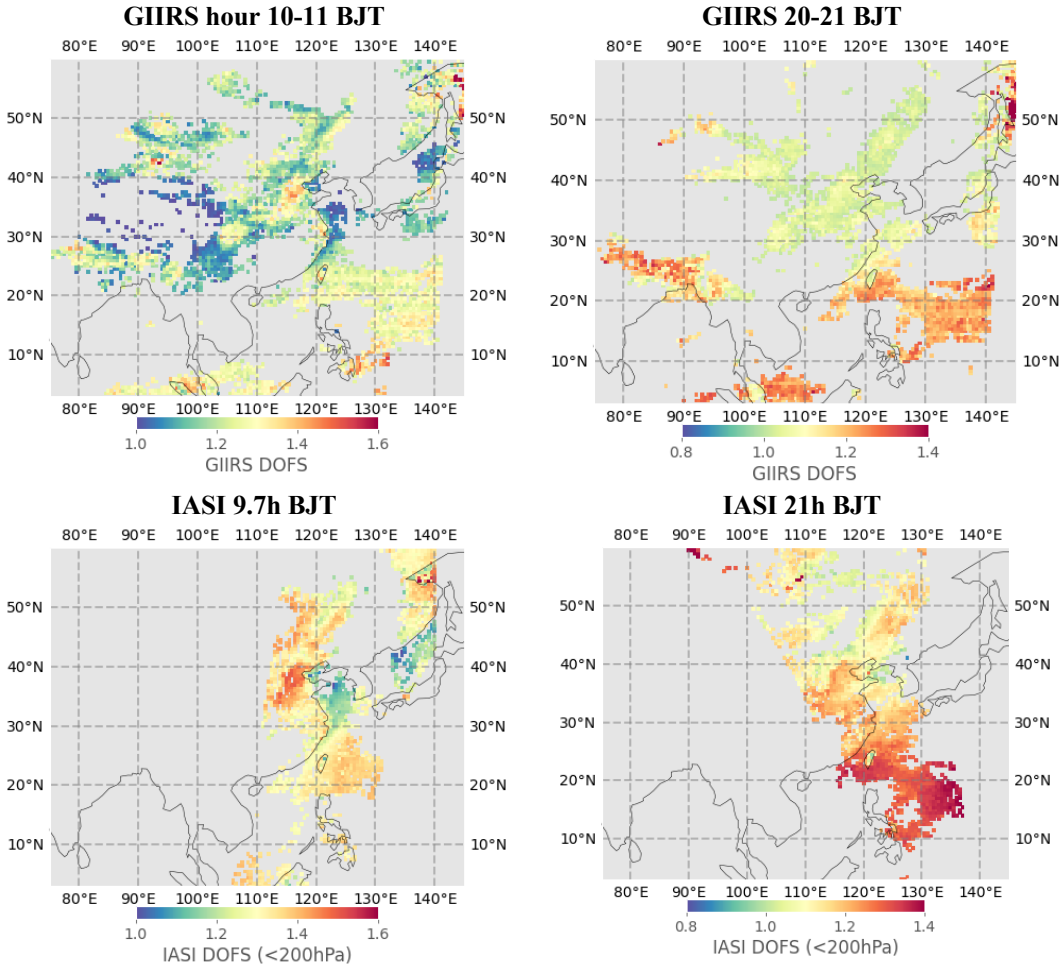


Figure S9. Comparison of AK-smoothed CO columns between GIIRS and IASI for (a) daytime and (b) nighttime data corresponding to Fig. 13. The linear fit slopes, correlation coefficients (r), and root-mean-square-error (rmse) are also indicated.

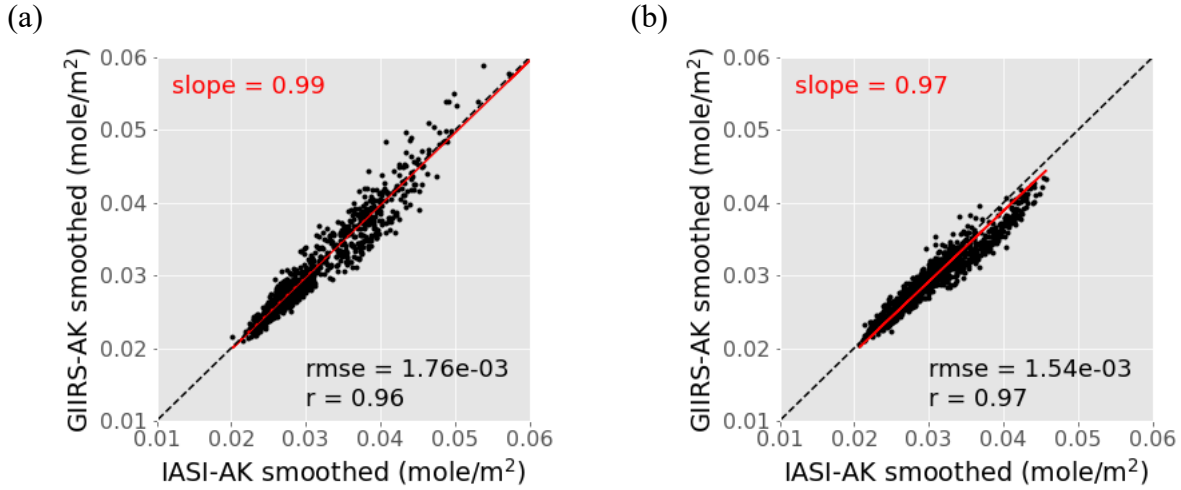


Figure S10. The diurnal change of surface temperature and bottom layer air temperature extracted from ECMWF ERA5 reanalysis data for the four representative regions: North China Plain, Mongolia, the East China Sea, and North India. These temperature values are averaged for every two-hour corresponding to the clear-sky GIIRS observations in December 2022.

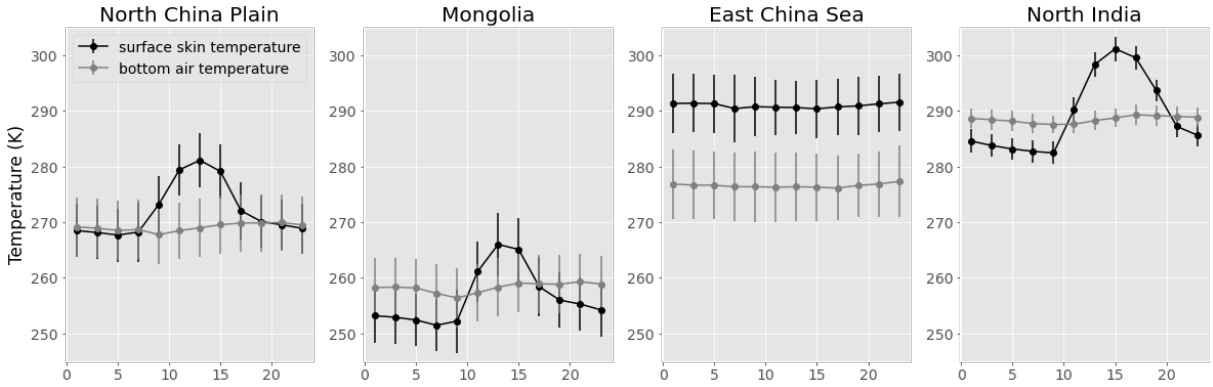
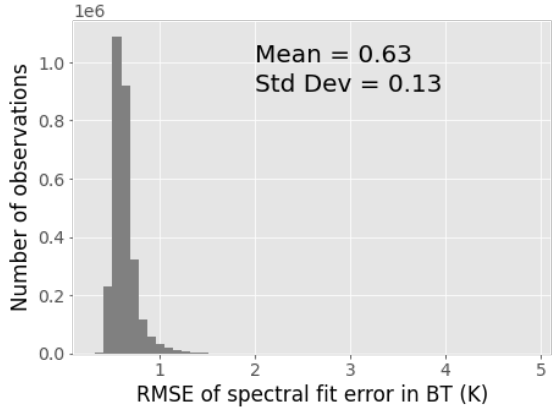


Figure S11. The root-mean-square-error of spectral fitting residual in brightness temperature in July and December, 2022. The mean and standard deviation are also indicated.

(a) July



(b) December

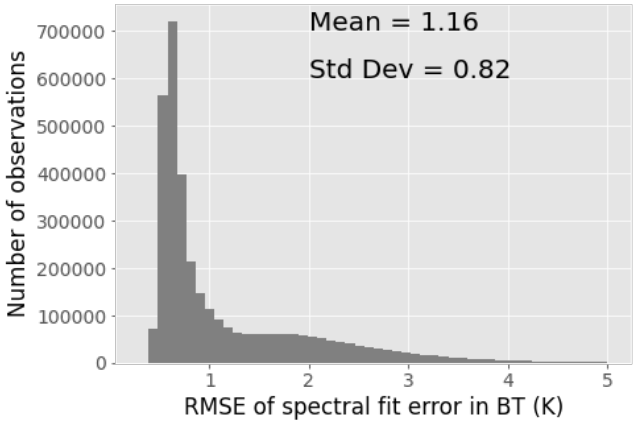
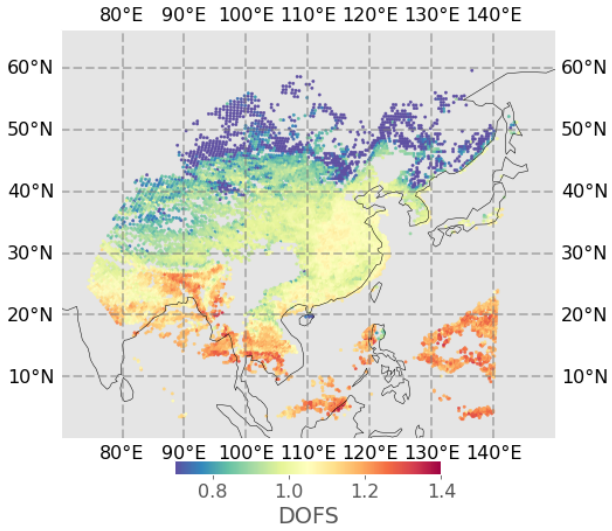
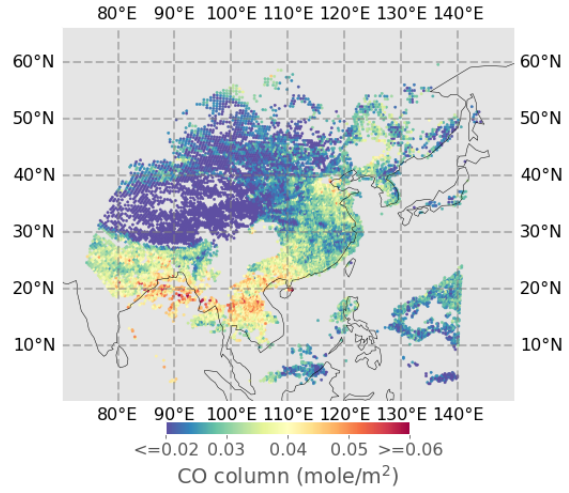


Figure S12. (a) DOFS of CO retrievals on December 18, 2022 (hour 3-4) from FY-4B/GIIRS; (b) The retrieval results after filtering using reduced χ^2<1.5 only; and (c) The retrieval results after filtering using reduced χ^2<1.5 and RMSE of the fitting residual<1K.

(a) DOFS



(b) Filtered based on reduced χ^2 only



(c) Filtered by reduced χ^2 and fitting residual