Supporting Information for "EMM EMUS Observations of Hot Oxygen Corona at Mars: Radial Distribution and Temporal Variability"

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Data coverage

Figure S1 shows the sky coverage of the foreground (Figure S1a) and background (Figure S1b) observations in celestial coordinates; that is, in Right Ascension (RA) and Declination (Dec). Both foreground and background observations are made by pointing the instrument at the same part of the sky.

Figure S2 shows the data coverage during the period of study (2021-04-26 to 2023-08-31). Figure S2a shows the tangent altitude coverage, Figure S2b shows the solar zenith angle coverage, Figure S2c shows the variation in Sun–Mars distance, and Figure S2d and Figure S2e show the variation in right ascension and declination, respectively, in equatorial sky coordinates.

Figure S3 shows the geographic data coverage of OS4a observations. The colorbar shows the number of pixels in each geographic bin of size 5° by 5°.

Hydrogen Lyman alpha wing subtraction from OI 130.4 nm

Figure S4 shows an example to demonstrate the baseline fitting method used for subtracting the hydrogen Lyman alpha wing under OI 130.4 nm emission. A first–degree polynomial is used to fit the H Lyman alpha line shape under the oxygen emission. This linear fit is then subtracted from the original spectra to obtain the background subtracted spectra. This is done for each spatial bin (or pixel) and for all integrations of the foreground and interplanetary background spectra observations.

Comparison between EMM/EMUS and MAVEN/IUVS coronal observations

Figure S5 shows the comparison between an averaged oxygen corona profile from MAVEN/IUVS (Figure 3c of Deighan et al. (2015)) and an EMUS OS4 profile for a comparable season and solar activity period in 2022 (McClintock et al., 2015; Holsclaw et al., 2021). As we can see, they are matching pretty well.

Column density estimation from coronal oxygen brightness

We have used a nominal g–factor (fluorescence efficiency factor) value of 4.0e-6 s^{-1} for an average Sun–Mars distance of 1.52 AU and for a given solar flux. This value is then scaled for Sun–Mars distance (Equation 1) for the calculation of column density from hot oxygen brightness (Equation 2). This nominal g–factor value is obtained from the EMUS Level 3 corona data product.

$$\text{g–factor} = 4 \times 10^{-6} \left(\frac{227939134}{\mathrm{r}}\right)^2 \tag{1}$$

$$\text{Column Density} = \frac{\text{Brightness}}{\text{g–factor}} \tag{2}$$

Here the Brightness is in Rayleighs ($1\,\text{Rayleigh} = \frac{10^6}{4\pi}\,\text{photons}\,\text{cm}^{-2}\,\text{s}^{-1}\,\text{sr}^{-1}$) and the Column Density has a unit of cm^{-2}. Figure S6 shows the hot oxygen column density profiles estimated for the average brightness profiles shown in Figure 4a.

Normalization of coronal oxygen brightness with solar irradiances

Figure S7 shows the ratio of coronal brightness (for an altitude range of 2000 – 2500 km) and solar irradiances. Figure S7a is the ratio of coronal 130.4 nm brightness and solar EUV 0–91 nm photoionizing irradiance, Figure S7b is the ratio of coronal 130.4 nm brightness and solar illuminating 130.4 nm irradiance, and Figure S7c is the ratio of coronal 130.4 nm brightness and the product of the solar 130.4 nm and EUV photoionizing irradiance. As we can see from Figure S7c, the ratio of coronal 130.4 nm brightness and the product of the solar 130.4 nm and EUV photoionizing irradiance is nearly a constant for the period of analysis. This further supports that the product of solar photoionizing and illuminating irradiances shows the highest correlation with coronal oxygen brightness.

Figure S8 shows the correlation between solar EUV 0–91 nm ionizing irradiance and the product of coronal oxygen 130.4 nm brightness and solar 130.4 nm irradiance (Figure S8a), as well as the correlation between solar 130.4 nm and the product of coronal oxygen 130.4 nm brightness and solar EUV 0–91 nm ionizing irradiance (Figure S8b). These correlation graphs are similar to Figures 8a and 8b respectively, and are shown for comparison.

References

Deighan, J., Chaffin, M. S., Chaufray, J.-Y., Stewart, A. I. F., Schneider, N. M., Jain, S. K., ... Jakosky, B. M. (2015). MAVEN IUVS observation of the hot oxygen corona at Mars. *Geophysical Research Letters*, *42*(21), 9009-9014. Retrieved from https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1002/2015GL065487 doi: https://doi.org/10.1002/2015GL065487

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McClintock, W. E., Schneider, N. M., Holsclaw, G. M., Clarke, J. T., Hoskins, A. C., Stewart, I., ... Deighan, J. (2015, December). The Imaging Ultraviolet Spectrograph (IUVS) for the MAVEN Mission. *Space Science Reviews*, *195*(1-4), 75-124. doi:

10.1007/s11214-014-0098-7

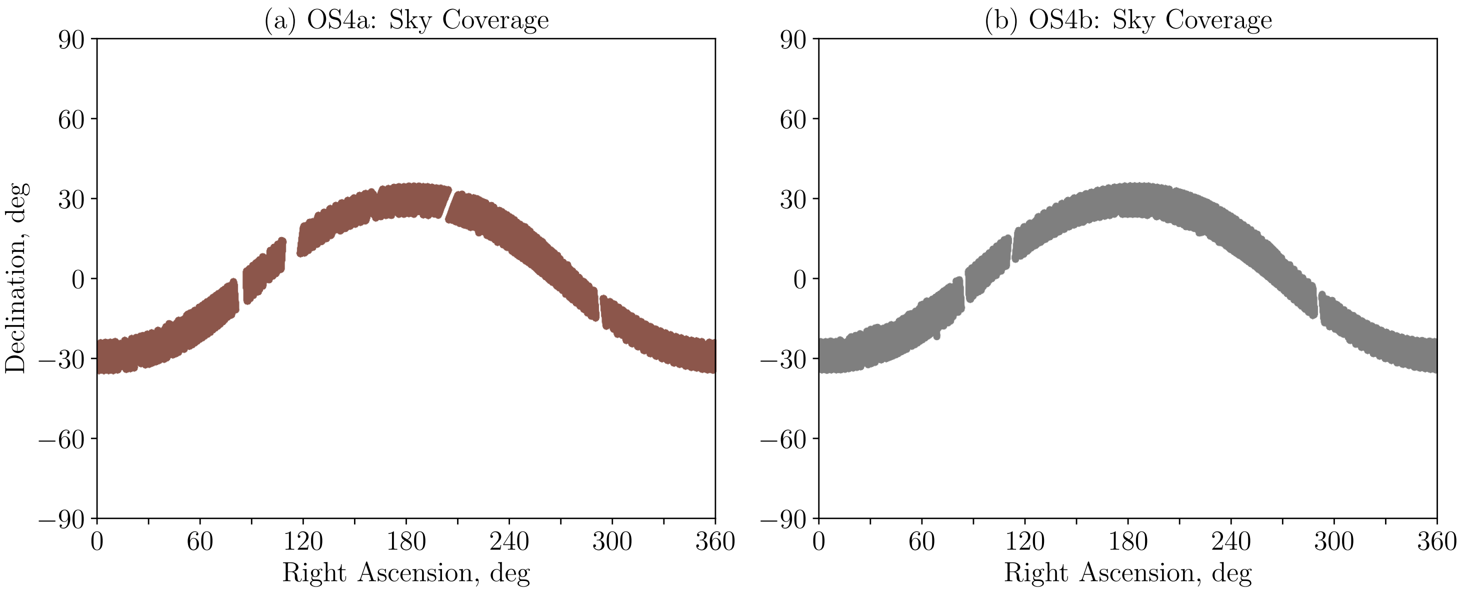

Figure S1. a) OS4a (foreground) sky coverage, and b) OS4b (background) sky coverage. The right ascension and declination are in equatorial sky coordinates.

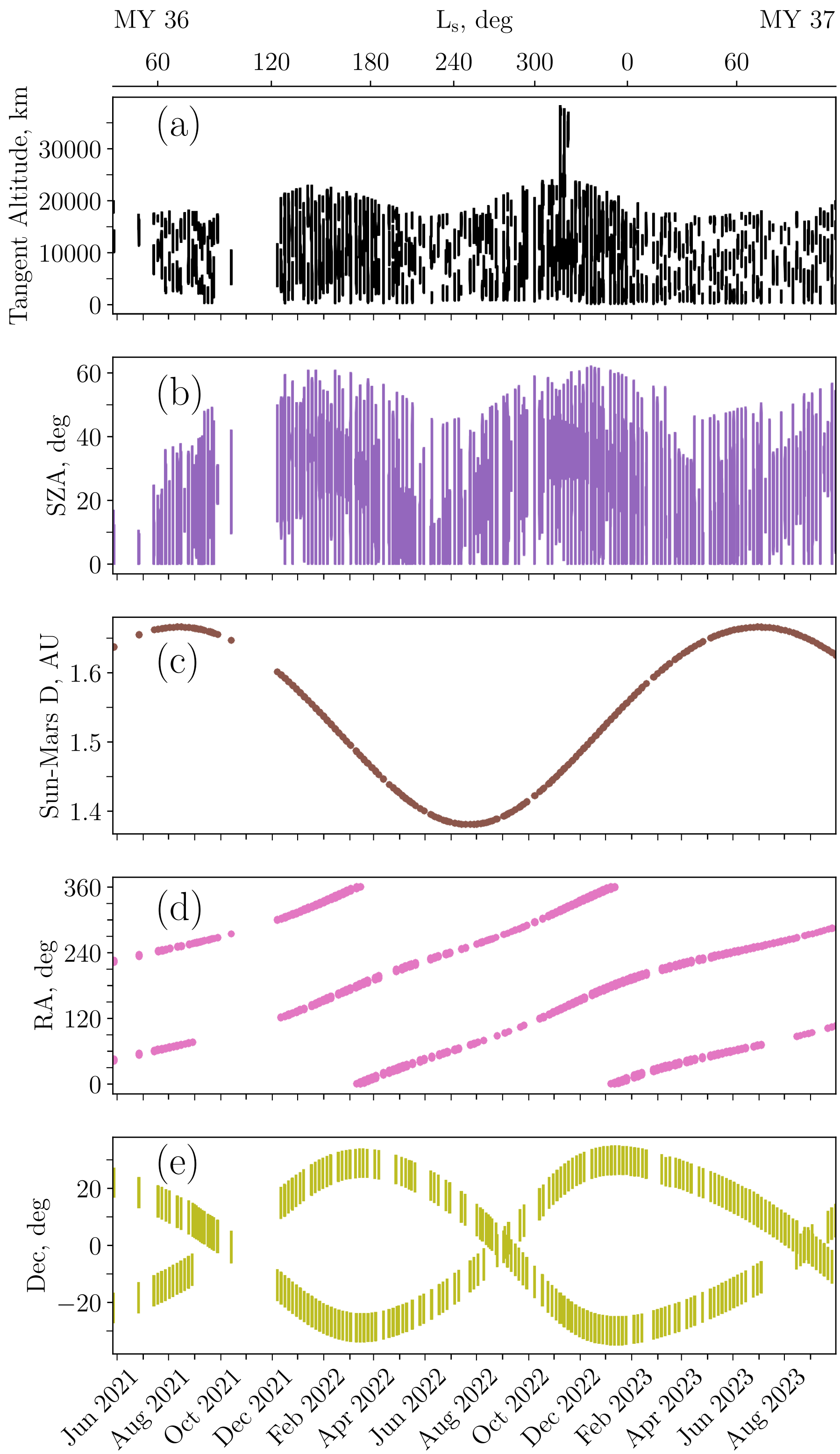

Figure S2. Foreground data coverage during the period of study: a) tangent point altitude, b) solar zenith angle, c) Sun–Mars distance, d) right ascension, and e) declination.

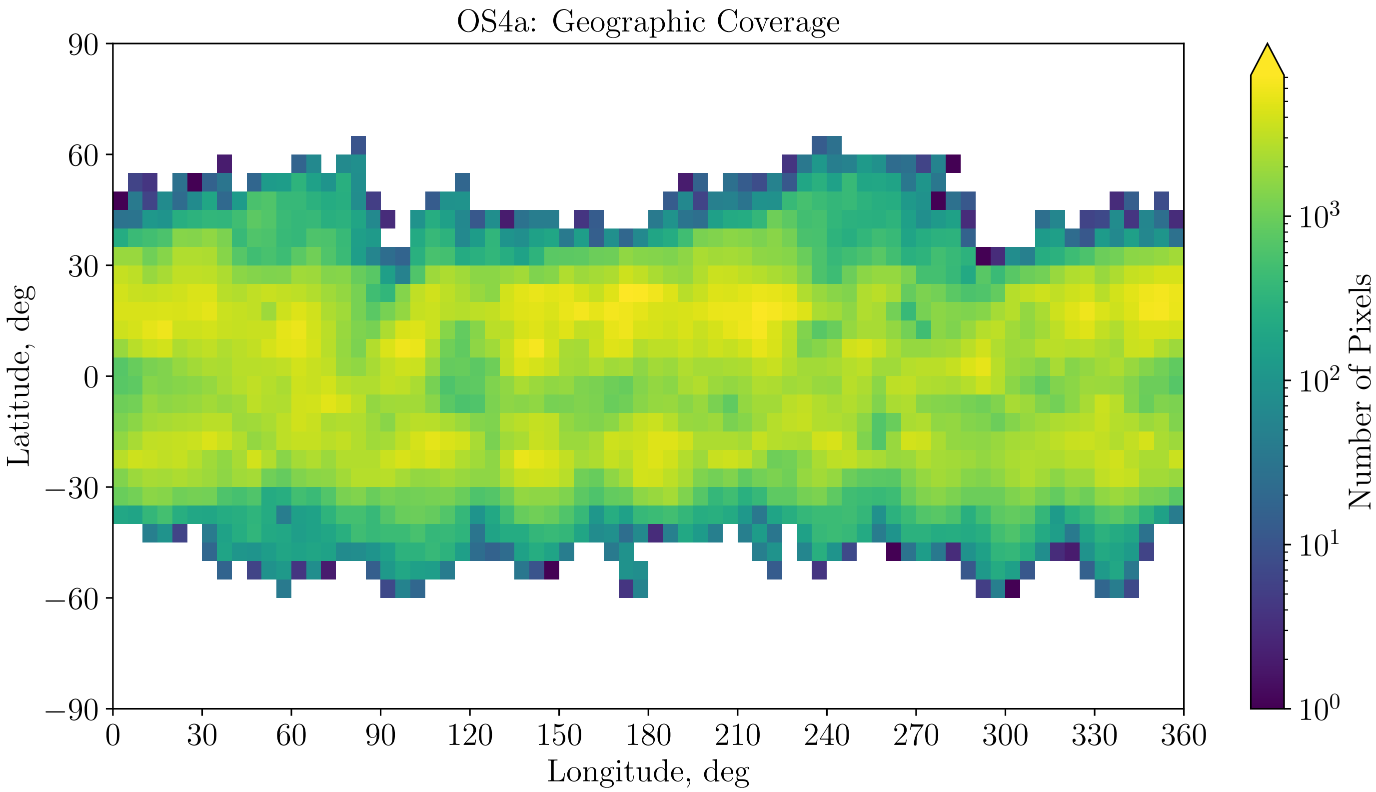

Figure S3. Geographic coverage of EMUS foreground observations in longitude and latitude. Each geographic bin is 5° by 5°, and the colorbar shows the number of pixels in each bin.

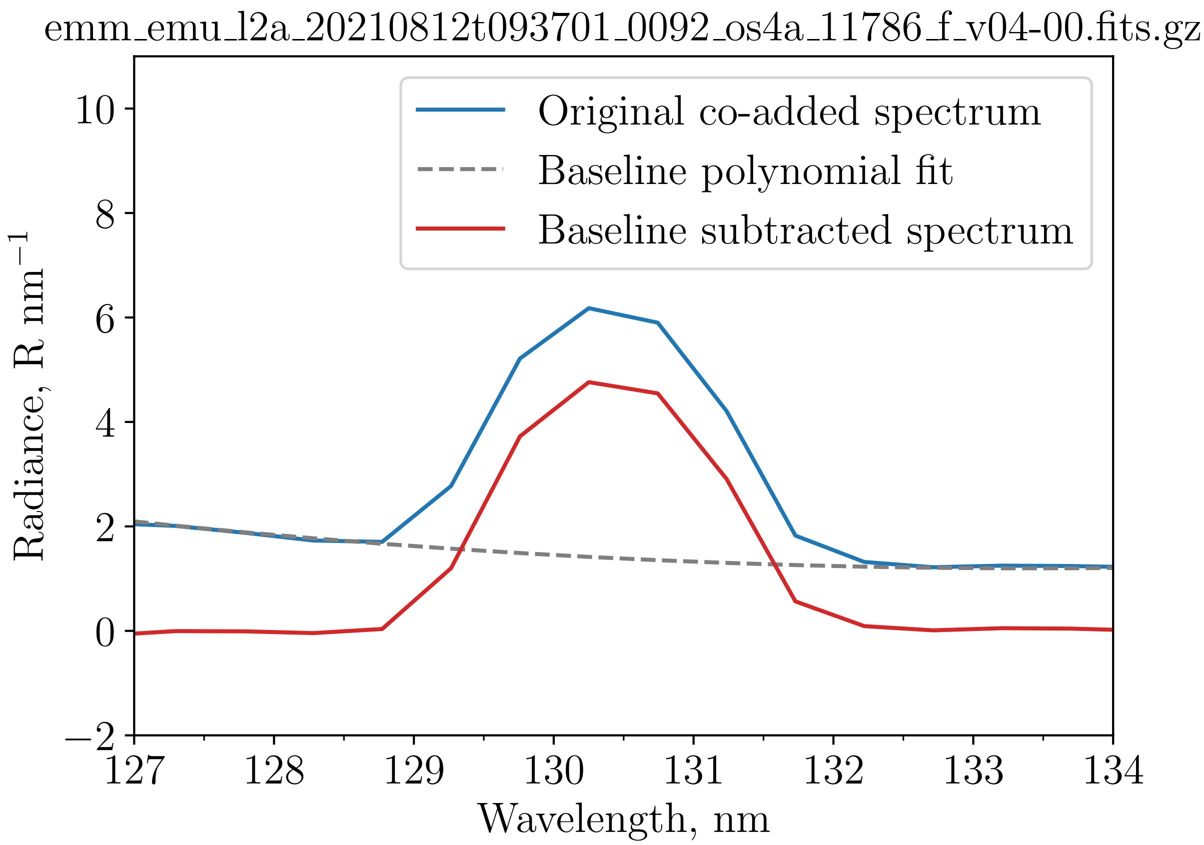

Figure S4. Example illustrating the hydrogen Lyman alpha wing background subtraction method.

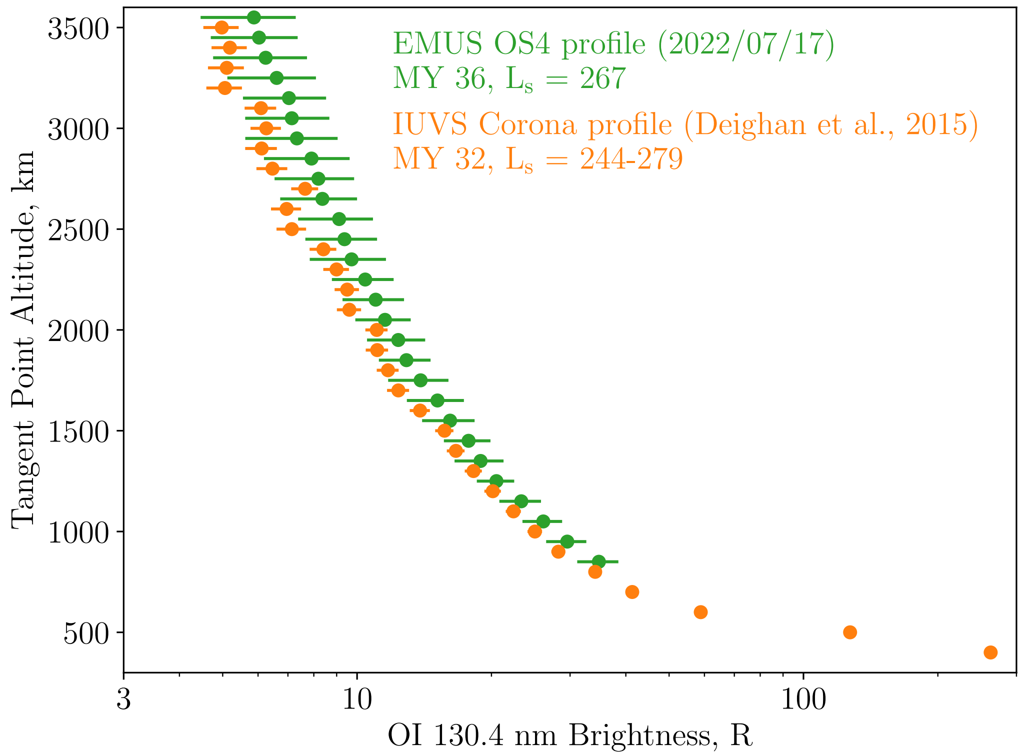

Figure S5. Comparison between an averaged oxygen corona profile from MAVEN/IUVS (Figure 3c of Deighan et al. (2015)) and an EMUS OS4 profile for a comparable season and solar activity period obtained on 2022/07/17. Both profiles are binned at 100 km resolution and the errorbars show 1-σ uncertainty.

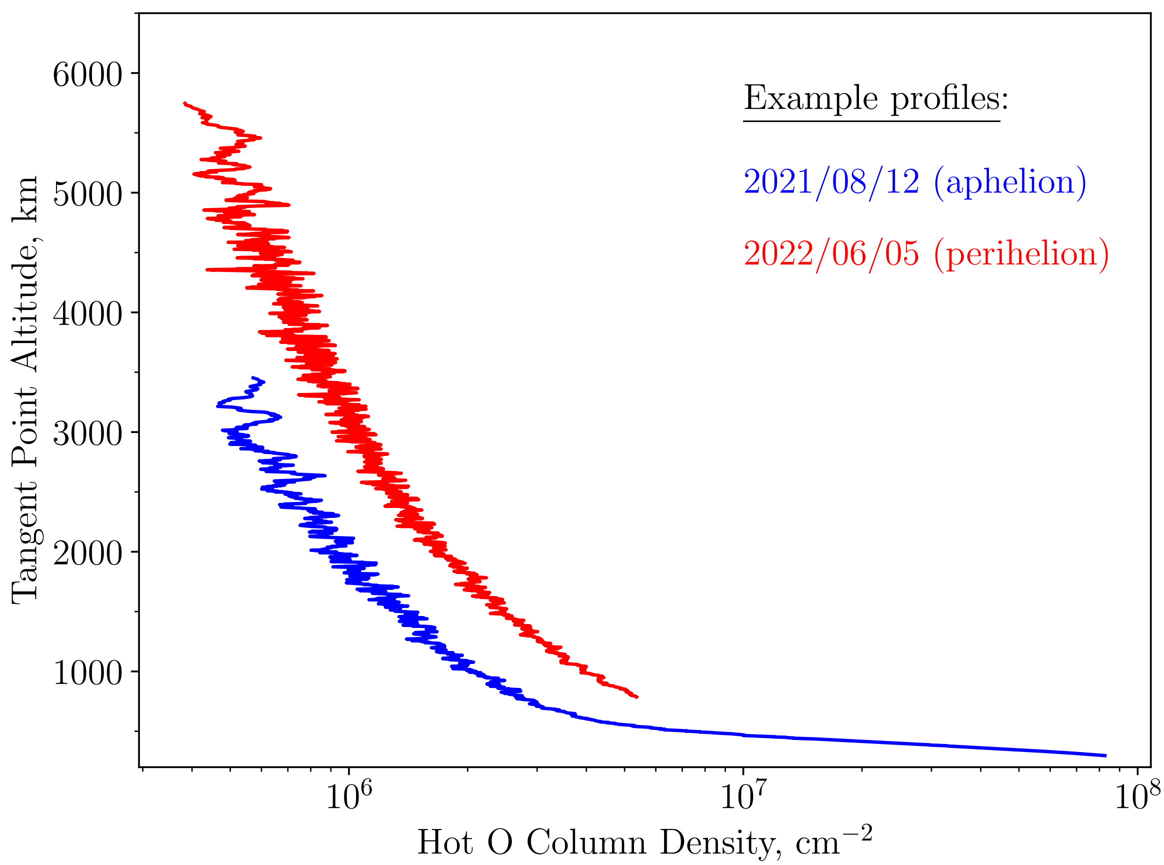

Figure S6. The hot oxygen column density profiles estimated, using a Sun–Mars distance scaled g–factor (see Equations 1 and 2), for the average EMUS brightness profiles shown in Figure 4a.

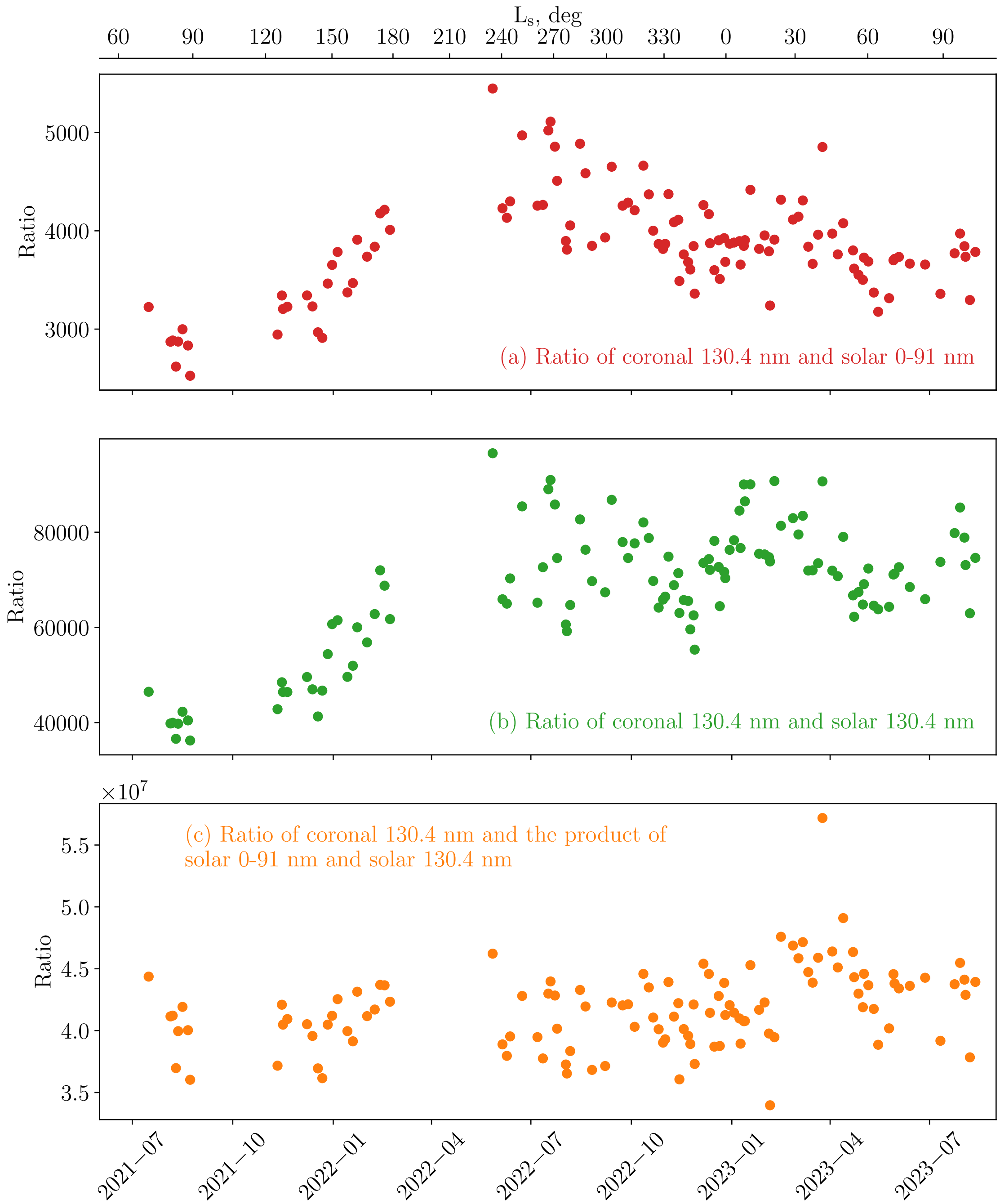

Figure S7. The ratio of coronal brightness (for an altitude range of 2000 – 2500 km) and solar irradiances. a) The ratio of coronal 130.4 nm brightness and solar EUV 0–91 nm photoionizing irradiance, b) the ratio of coronal 130.4 nm brightness and solar illuminating 130.4 nm irradiance, and c) the ratio of coronal 130.4 nm brightness and the product of the solar 130.4 nm and EUV photoionizing irradiance.

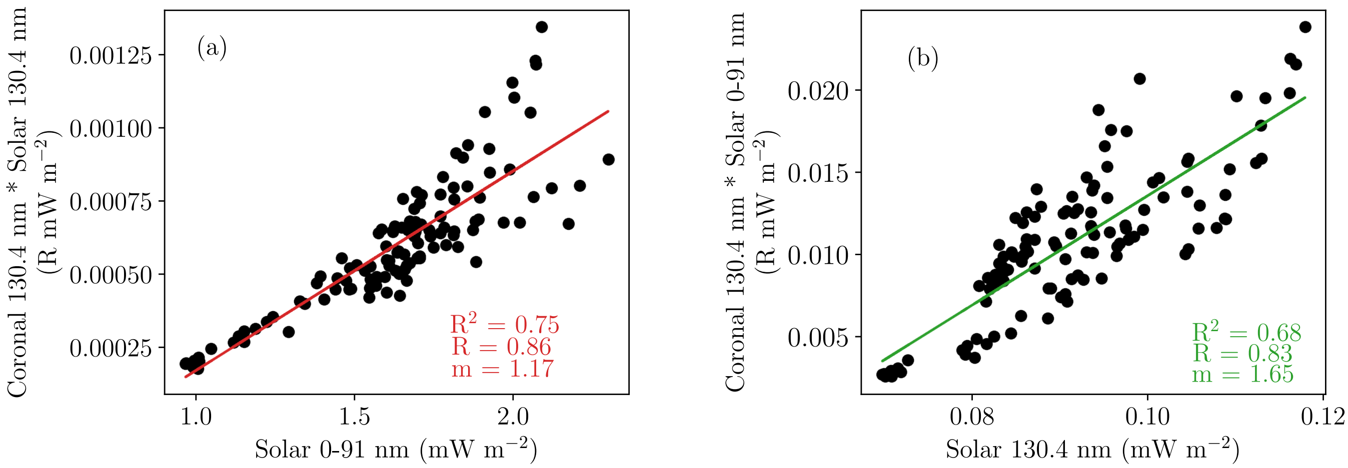

Figure S8. a) Correlation between solar EUV 0–91 nm ionizing irradiance and the product of coronal oxygen 130.4 nm brightness and solar 130.4 nm irradiance, and b) correlation between solar 130.4 nm and the product of coronal oxygen 130.4 nm brightness and solar EUV 0–91 nm ionizing irradiance. The coronal brightness is for an altitude range of 2000 – 2500 km. The symbol m is the normalized slope of the fit, R is the correlation coefficient, and R^2 is the goodness of fit.