Supplementary materials for
"Technical Note: Latitude-time variations of atmospheric column-average dry air mole fractions of CO2, CH4 and N2O"

Ryu Saito¹, Prabir K. Patra¹, Nicholas Deutscher²,³, Debra Wunch³, Kentaro Ishijima¹, Vanessa Sherlock⁴, Thomas Blumenstock⁵, Susanne Dohe⁵, David Griffith⁶, Frank Hase⁵, Pauli Heikkinen⁷, Esko Kyrö⁷, Ronald Macatangay⁶, Joseph Mendonca⁸, Janina Messerschmidt⁹, Isamu Morino⁹, Justus Notholt², Markus Rettinger¹⁰, Kimberly Strong⁸, Ralf Sussmann¹⁰, and Thorsten Warneke²

**Figure S1:** Comparisons of TCCON measurement (black dots) and ACTM-simulation smoothed by averaging kernels and a priori profiles (red dots) for $X_{\text{CO2}}$ at all the sites considered in this study. Only a sub-set of sites are presented in Fig. 4.
Figure S2: Same as Fig. S1, but for time series of $X_{\text{CH}_4}$.
Figure S3: Same as Fig. S1, but for time series of $X_{\text{N}_2\text{O}}$. 
Figure S4: Variations in bias $b$ between seasons: January-March (JFM; black), April-June (AMJ; red), July-September (JAS; blue) and October-December (OND; green).
Figure S5: Seasonal cycles of $X_{CO2}$ are compared for ACTM and TCCON time series (smoothed lines for [fitted curve – long-term trends], and dots are for [original time series – long-term trends]). The seasonal cycles for EUR, SOD and KAR are not depicted because the time series are too short for fitting (ref. main text).
Figure S6: Same as Fig. S5, but the seasonal cycles of $X_{CH4}$ are shown.
**Figure S7:** Same as Fig. S5, but the seasonal cycles of $X_{\text{N}_2\text{O}}$ are shown. No $X_{\text{N}_2\text{O}}$ data are retrieved for KAR, TKB and IZO.
Figure S8: Time series of $X_{CO2}$ residuals (original time series – fitted curve)
Figure S9: Time series of $X_{\text{CH}_4}$ residuals.
Figure S10: Time series of $X_{\text{N}_2\text{O}}$ residuals.

We have also calculated the partial columns, normalized by the surface pressure, as opposed to normalization by the partial pressures of the troposphere and stratosphere (Eqn. 2 and 3). The tropopause height over the FTS sites are chosen to vary with month as well as kept constant at the annual mean tropopause height.

$$X_{y,\text{tropo}} = P_{C_y,\text{tropo}} / P_s \quad (\text{Eqn. S2})$$

$$X_{y,\text{strato}} = P_{C_y,\text{strato}} / P_s \quad (\text{Eqn. S3})$$

In this calculation the tropospheric and stratospheric partial columns add to the total column.
**Figure S11:** Time series of $X_{\text{CO}_2,\text{strat}}$, $X_{\text{CH}_4,\text{strat}}$ and $X_{\text{N}_2\text{O,}\text{strat}}$ at three selected sites (black for annual mean tropopause, blue for tropopause varying monthly). Similar to Fig. 6, but using a different methodology for calculating stratospheric partial column (see above).

**Figure S12:** Time series of $X_{\text{CO}_2,\text{trop}}$, $X_{\text{CH}_4,\text{trop}}$ and $X_{\text{N}_2\text{O,}\text{trop}}$ at three selected sites (black for annual mean tropopause, red for tropopause varying monthly.)