Electronic Supplement to: First ground-based FTIR observations of methane in the inner tropics over several years (Petersen et al.)

1 Methane from biomass burning emissions

Using typical emission factors of CO and CH_4 from biomass burning of tropical forest (see Table 1 in main document), we can estimate the enhancement of CH_4 relative to background levels emitted from biomass burning.

$$
\begin{aligned}
(\mathrm{CH_4})_{BB} &= \frac{EF(\mathrm{CH_4})}{EF(\mathrm{CO})} \cdot (\mathrm{CO})_{BB} \\
&= \frac{6.8}{104}\left(\frac{[\mathrm{g\ CH_4}]}{[\mathrm{g\ CO}]}\right)^{-1} \cdot (\mathrm{CO})_{BB} \\
&= \frac{6.8}{104}\left(\frac{16.04\mathrm{g\ mol^{-1}}}{28.01\mathrm{g\ mol^{-1}}}\right)^{-1} \cdot (\mathrm{CO})_{BB} \\
&= 0.114 \cdot (\mathrm{CO})_{BB}
\end{aligned}
$$

For example, during the events of biomass burning pollution in LDS2005 CO enhancements of up to 1.5×10^{18} molec cm^{-2} above background are observed (see Petersen et al. (2008)). From these observed CO levels, we estimate 1.7×10^{17} molec/cm^2 of additional methane from tropical fire biomass burning:

$$
\begin{aligned}
(\mathrm{CH_4})_{BB} &= 0.114 \cdot (\mathrm{CO})_{BB} \\
&= 0.114 \cdot (1.5 \times 10^{18}\ \mathrm{molec\ cm^{-2}}) \\
&= 1.7 \times 10^{17}\ \mathrm{molec\ cm^{-2}}
\end{aligned}
$$

From the observed CO levels during the LDS 2005, we expect 0.3 to 1.7×10^{17} molec/cm^2 of additional methane from biomass burning assuming tropical forest emission factors. This is equivalent of around 0.1 to 0.5 % (2 to 9 ppb).

2 Biomass burning signatures in the ratio CH_4/CO_2

In this section, we investigate the influence of biomass burning on the CH_4/CO_2 ratio. Using typical emission factors of CO and CO_2 from biomass burning of tropical forest (see Table 1), we can estimate the enhancement of CO_2 relative to background levels emitted from biomass burning.

$$
\begin{aligned}
(\mathrm{CO_2})_{BB} &= \frac{EF(\mathrm{CO_2})}{EF(\mathrm{CO})} \cdot (\mathrm{CO})_{BB} \\
&= \frac{1580}{104} \frac{[\mathrm{g\ CO_2}]}{[\mathrm{g\ CO}]} \cdot (\mathrm{CO})_{BB} \\
&= \frac{1580}{104} \left(\frac{16.04\mathrm{g\ mol^{-1}}}{44.01\mathrm{g\ mol^{-1}}} \right)^{-1} \cdot (\mathrm{CO})_{BB} \\
&= 9.67 \cdot (\mathrm{CO})_{BB}
\end{aligned}
$$

For the high CO enhancement of 1.5×10^{18} molec cm^{-2} during the LDS 2005, this yields

$$
\begin{aligned}
(\mathrm{CO_2})_{BB} &= 9.67 \cdot (\mathrm{CO})_{BB} \\
&= 9.67 \cdot (1.5 \times 10^{18} \mathrm{\ molec\ cm^{-2}}) \\
&= 14.5 \times 10^{18} \mathrm{\ molec\ cm^{-2}}
\end{aligned}
$$

The ratio CH_4/CO_2 for background level of 1720 ppb for methane and 360 ppm for carbon dioxide is

$$
\begin{aligned}
\frac{\mathrm{CH_4}}{\mathrm{CO_2}} &= \frac{1720 \mathrm{\ ppb}}{360 \mathrm{\ ppm}} \\
&= \frac{3.7 \times 10^{19} \mathrm{\ molec\ cm^{-2}}}{7.7 \times 10^{21} \mathrm{\ molec\ cm^{-2}}} \\
&= 0.00481 \frac{\mathrm{molec\ cm^{-2}}}{\mathrm{molec\ cm^{-2}}}
\end{aligned}
$$

For the CO enhancement of 1.5×10^{18} molec cm^{-2} during the LDS 2005, the ratio is

$$
\begin{aligned}
\frac{\mathrm{CH_4} + (\mathrm{CH_4})_{BB}}{\mathrm{CO_2} + (\mathrm{CO_2})_{BB}} &= \frac{(3.7 \times 10^{19} + 1.7 \times 10^{17}) \mathrm{\ molec\ cm^{-2}}}{(7.7 \times 10^{21} + 14.5 \times 10^{18}) \mathrm{\ molec\ cm^{-2}}} \\
&= 0.00482 \frac{\mathrm{molec\ cm^{-2}}}{\mathrm{molec\ cm^{-2}}}
\end{aligned}
$$

The methane emissions due to biomass burning are hidden in the CH4/CO2 ratio as both species are enhanced in a similar way, as shown above. The good agreement of the CH_4/CO_2 ratio of FTIR and satellite and the differences between the FTIR and satellite XCH4 indicate that the influence of biomass burning for methane can hardly be detected by the satellite (with this retrieval method). The consistency of the FTIR and satellite observations of CH_4/CO_2 suggests that biomass burning might be the cause for the observed differences between the FTIR observations and the satellite observations of XCH_4 and the TM5 model.

References

Andreae, M. O. and Merlet, P.: Emission of trace gases and aerosols from biomass burning, Global Biogeochem. Cycles, 15, 955–966, 2001.

Petersen, A. K., Warneke, T., Lawrence, M. G., Notholt, J., and Schrems, O.: First ground-based FTIR observations of the seasonal variation of carbon monoxide in the tropics, Geophys. Res. Lett., 35, doi: 10.1029/2007GL031393, 2008.