Supplementary materials to

Revisiting factors controlling methane emissions from high-arctic tundra

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1. Diurnal patterns in CH4 flux

1.1. Methods

For diurnal dynamic analysis within a specified time interval (Supp. Fig.1) the individual fluxes from each chamber were normalized to average flux for this chamber and this period, then detrended (dividing each normalized value by its linear trend approximation).

1.2 Results

The diurnal dynamics of CH_4 emission was strongly pronounced in some periods, but absent in others (Supp. Fig.1). At the start of the season all the chambers showed more or less pronounced diurnal dynamics with relatively lower fluxes during day time and higher during the night (note that Supp. Fig.1 shows detrended data). These dynamics correlate well with the soil temperatures. During the peak of the growing season, the fluxes had almost no diurnal dynamics, while the temperature cycle was still well expressed. At the end of the season (Supp. Fig.1C) very sharp and consistent diurnal dynamics appeared again and was consistent for more than two weeks. At this time the emission peaked during the morning hours (8-9 AM), which is out of phase with soil temperatures at 5-15 cm depth. Diurnal variation in CH_4 fluxes is site specific as it both have been documented present (Hargreaves and Fowler, 1998; Shannon et al., 1996; Kim et al., 1999) and not present (Rinne et al., 2007; Kormann et al., 2001; Jackovitz-Korchynski et al., 2010) in data from growing season measurements at other sites. We can hypothesize that in our case the prevailing mechanisms in control of CH_4 emission may vary through the season, and those different mechanisms may be differently affected by soil temperature and other factors (Kim et al., 1999).

1.3 Discussion

The hypothesis of multisource character of CH_4 emission (see Fig. 12 and corresponding discussion in the main paper) at our site can to some extent explain its different diurnal patterns throughout the season. In the beginning of the season (Fig. 6A) the main source of CH_4 fluxes is slow methane, produced in the peat matrix. This flux should be relatively higher when diurnal temperature is high and entrapped bubbles are expanded, than when the temperature is low and the bubbles are condensed. During mid-season (Fig. 6B) the fluxes are mainly controlled by plants, and in conditions of polar day do not vary as much as at lower latitudes (Kim et al., 1999). During freezing season (Fig. 6C) the fluxes are mainly caused by water crystallization, so should be higher when the temperature goes down. The described mechanism corresponds with our data (Fig. 6), however, further studies are necessary to confirm or disprove its role.

2. Comparison of net CO2 fluxes with a previous study.

2.1. Methods

Because of the high latitude of our site, the real darkness did not occur until the end of July, so no dark respiration measurements were available during the initial and central part of the growing season. For this reason we did not try to estimate respiration and GPP separately. Instead we compared our net CO_2 fluxes throughout the season with the fluxes from tower measurements of 1997, obtained in the same valley within 1 km distance from our site (Nordstrøm et al., 2001). For the comparison we chosen the data from the growing season 2008. The reason for comparing these particular seasons is that they are quite comparable in the snow melt date: DOY 168-171 for the tower footprint in 1997 (Nordstrøm et al., 2001), and DOY 173 for our site in 2008.

2.2 Results

Supp. Fig. 2 shows a direct comparison of CO_2 fluxes from tower measurements of 1997 (Nordstrøm et al., 2001) and our chamber data of 2008. The CO_2 fluxes show similarity both in seasonal dynamics and magnitudes. The different features are the positive flux peak in the beginning of the season 1997, which was not found in our measurements 2008, and earlier CO_2 fixation in 2008. Both differences caused more negative NEE in our study.

3.3 Discussion

The difference in fluxes between tower measurements 1997 (Nordstrøm et al., 2001) and chamber measurements 2008 can be explained by temporal variability (4 years difference), spatial variability (1 km distance, very different footprints of the tower and the chambers) and a difference in the methods used (eddy covariance vs. chamber). However, the fluxes were quite similar since DOY 205, which let us assume that the differences caused by methodic are not very pronounced.

Nordstrøm et al. (2001) assumed the early-season fluxes 1997 were influenced both by respiration and the physical release of stored CO_2 during the thawing of the soil. In our case the previous (autumn 2007) discharge of subsurface gas pools, both CH_4 and CO_2, could be a reason for the lack of such peak. The CO_2, stored since the previous growing season, was already released during autumn 2007; the CO_2, caused by soil respiration was to large extend refilling the subsurface pool instead of emitting to the atmosphere. On the contrary, CO_2 fixation by aboveground vegetation was instantly reflected in the net CO_2 flux. This explanation is quite speculative without further more detailed studies, however, it shows that autumn burst events can be potentially important for the interannual variability of CO_2 exchange as well as they are for CH_4 fluxes.

References

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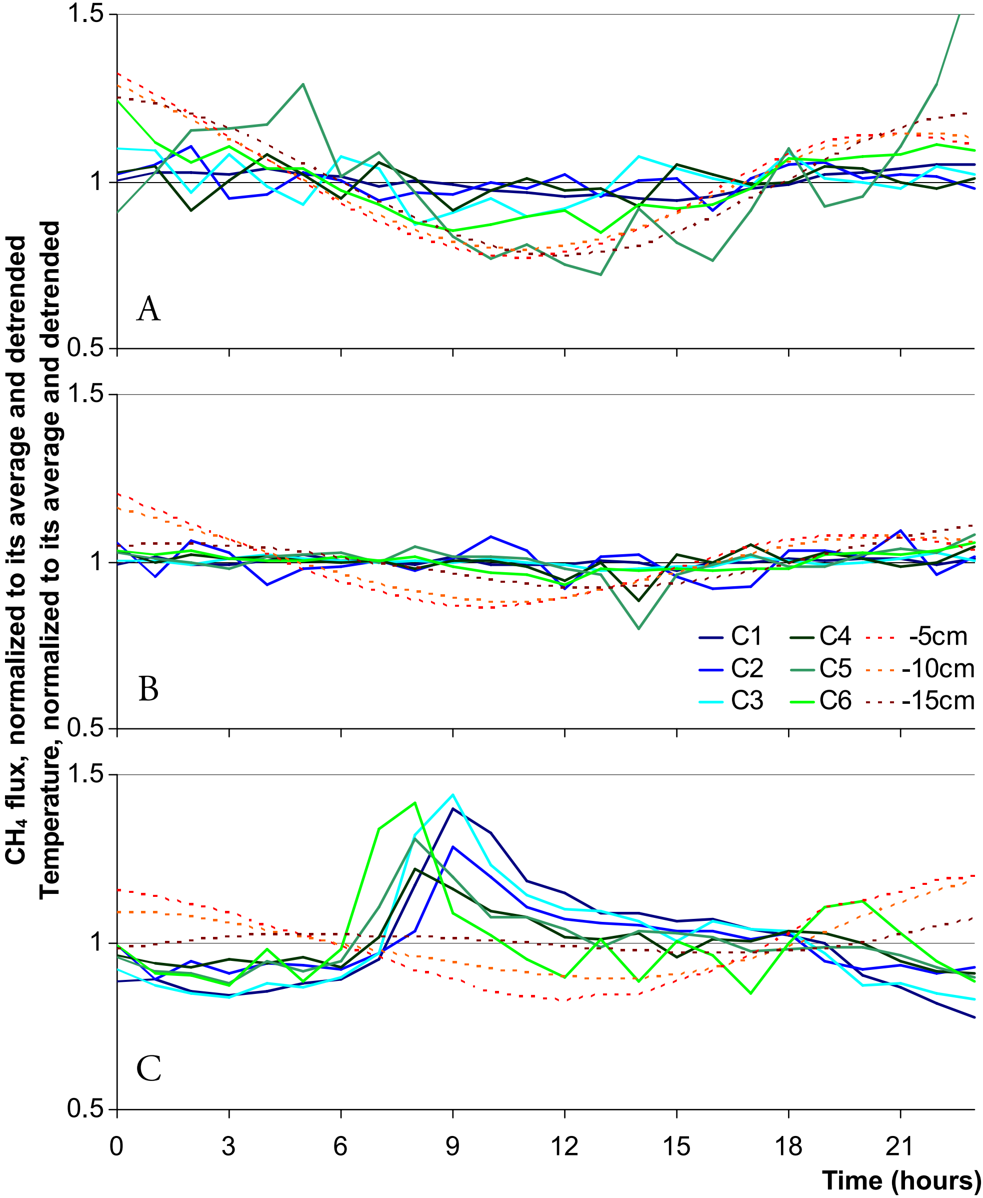
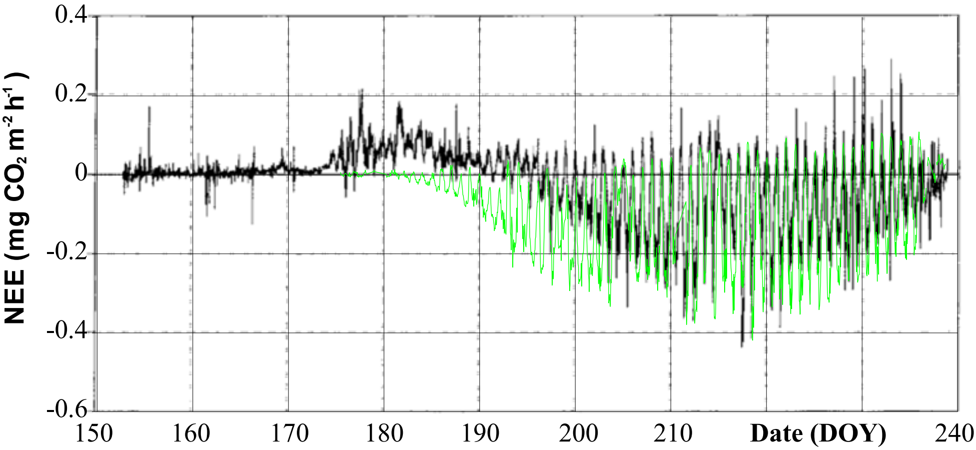
Figure captions.

Supplementary Figure 1. Examples of diurnal dynamics of CH_4 fluxes and soil temperature. Full lines: CH_4 fluxes in individual chambers, normalized to their average and detrended; dotted lines: soil temperatures at 3 depths, normalized to their average and detrended. X scale: daytime, hours. A: one week of data, DOY 165-171 (DASM 15-21), 2009. B: one week of data, DOY 178-184 (DASM 28-34), 2009. C: two weeks of data, DOY 246-259 (DASM 96-109), 2009.

Supplementary Figure 2. A plot of NEE data 2008, green, over tower NEE data 1997 (Nordstrom et al., 2001), black.



Supplementary Figure 1.



Supplementary Figure 2.