Thaw Stage and Incoming Solar Radiation Influence Ebullitive Methane Fluxes from Peatland Ponds

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Introduction

- Methane (CH_4): 28 times higher GWP than CO_2 (Pachauri et al. 2014) and is emitted via three transport pathways : (1) diffusion (2) plant mediated transport (3) **ebullition** (bubbling)
- Thaw ponds, result of permafrost thaw → release a lot of CH_4
- Recent study found small ponds to contribute ~40% of the global CH_4 diffusive flux from lakes and ponds (Holgerson and Raymond, 2016)
- Lacking in CH_4 thaw pond studies (especially long term) (Wik et al. 2016)

Methods

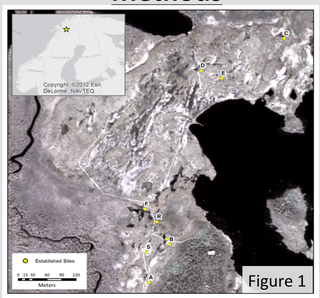


Figure 1. WorldView 2 image of study site, Stordalen Mire, located 11km east of Abisko, Sweden. Yellow dots mark established thaw pond sites where ebullitive emissions were measured.

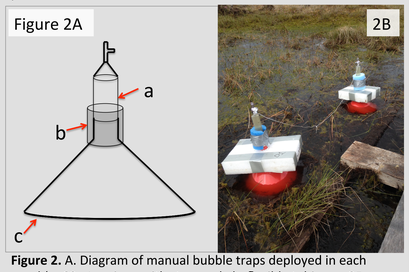


Figure 2. A. Diagram of manual bubble traps deployed in each pond (a: 60mL syringe with stop-cock. b: flexible tubing, c: 25cm plastic funnel). 18 bubble traps deployed in 6 ponds each summer since 2012. B. Two bubble traps deployed in a **Stage 1** pond.

- High sampling frequency over field season (~every 24hrs, June-August)
- Samples analyzed for CH_4 concentration using a Gas Chromatograph – Flame Ionization Detector
- HOBO temperature loggers installed in each pond in July 2013 - continuously recording water temperature throughout the study period

Figure 3. Daily CH_4 emissions from four ponds over four years that represent each stage in the hypothesized thaw sequence.

The hypothesized thaw sequence takes into account changes in dominant vegetation and hydrology where **Stage 1** ponds tend to be early formation, hydrologically isolated and contain mostly *Sphagnum spp.*; **Stage 2** ponds are deeper with *Sphagnum spp.* still present and some sedges at the pond edge; **Stage 3** exhibiting greater sedge infiltration and less *Sphagnum spp.* coverage; **Stage 4** involves the introduction of a hydrological connection to surrounding fen areas.

Spatial Variability

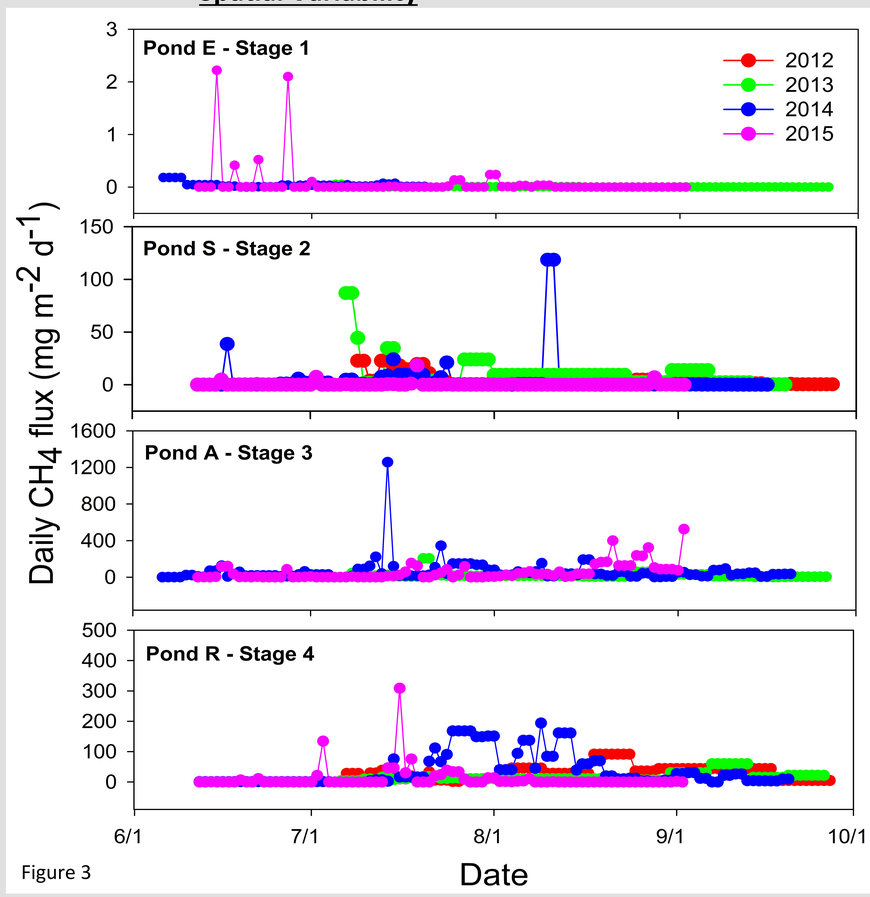
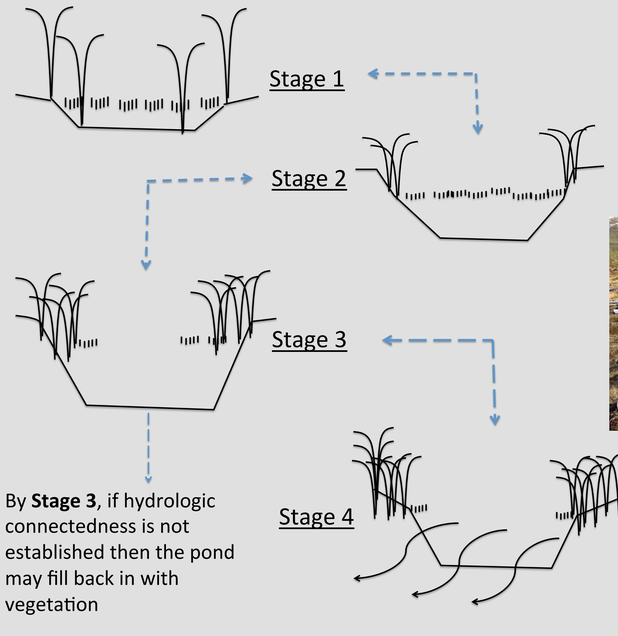


Figure 3



By **Stage 3**, if hydrologic connectedness is not established then the pond may fill back in with vegetation

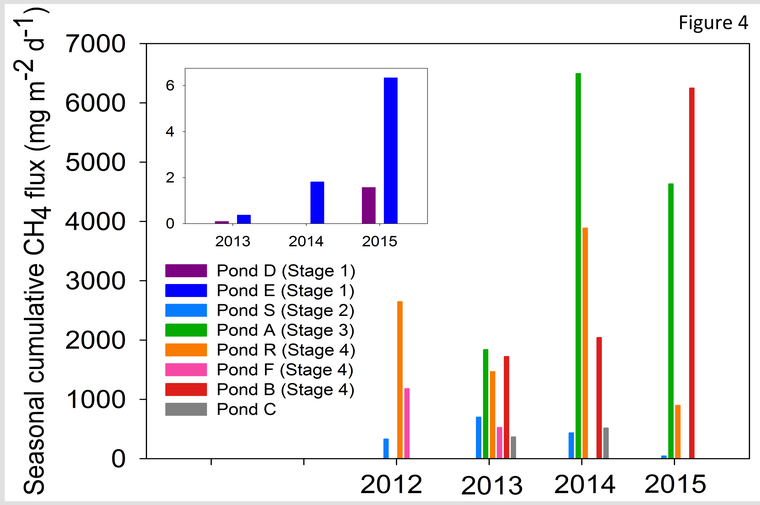
Interannual Variability

Table 1. Meteorological summary for Stordalen Mire for 2012-2015. Measurements were collected from a meteorological station at the Abisko Scientific Research Station.

Environmental variable	2012	2013	2014	2015
Average Air Temperature (°C)	8.3	10.6	10.6	9.4
Total Precipitation (mm)	153.9	197.9	160.9	171.3
Ice-Out Date	5/13	5/6	5/12	5/14
Average Shortwave Radiation (W m^{-2})	154.5	163	184.4	170.5

Figure 4. Seasonal cumulative CH_4 flux from each pond measured since 2012. Consistently on an annual basis, ponds classified as **Stage 1** have the lowest emissions while **Stage 3** have the highest.

Figure 4



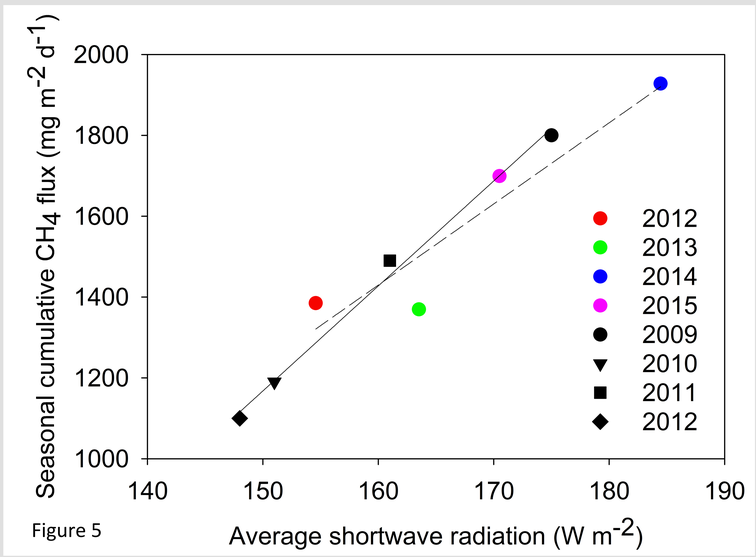


Figure 5

Figure 5. Cumulative CH_4 flux (from ice out to Sept. 30) versus average shortwave radiation measured. Colored circles are emissions from thaw ponds with the dashed black line denoting the linear fit (r^2 =.82, p=.0588). Black shapes represent measurements from three lakes at Stordalen Mire, with the solid black line denoting the linear fit (r^2 of .99, Wik et al. 2014).

Conclusions/Future Work

- Strong correlation was observed between cumulative seasonal pond CH_4 flux and average incoming solar radiation.
- Spatial differences in CH_4 emission appears dependent on thaw stage and will change with landscape transition.
- UAV will be used to monitor seasonal and interannual changes in thaw pond size.

Figure 7. UAV used to collect areal images of thaw ponds. Photo Credit: Katharine Rocci.

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