

# Spatial variability of methane ebullition from permafrost thaw ponds in a subarctic mire

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## Introduction



Methane (CH<sub>4</sub>) has an important role in the energy budget of the atmosphere. Warming due to radiative forcing by this and other greenhouse gases is amplified at high latitudes, where rising soil and air temperatures lead to permafrost thaw and the potential release of large amounts of CH<sub>4</sub> and carbon dioxide (CO<sub>2</sub>) to the atmosphere.

Small ponds are key features of these warming high-latitude landscapes. Forming in depressions of previously frozen ground, thaw ponds may release large quantities of CH<sub>4</sub> through ebullition (bubbling), yet little has been done to assess their potential contribution to carbon emissions from ecosystems with thawing permafrost. Since the factors influencing ebullition from these ponds are poorly understood, it is important to monitor CH<sub>4</sub> ebullition in these ponds to facilitate predictions about future carbon feedbacks.

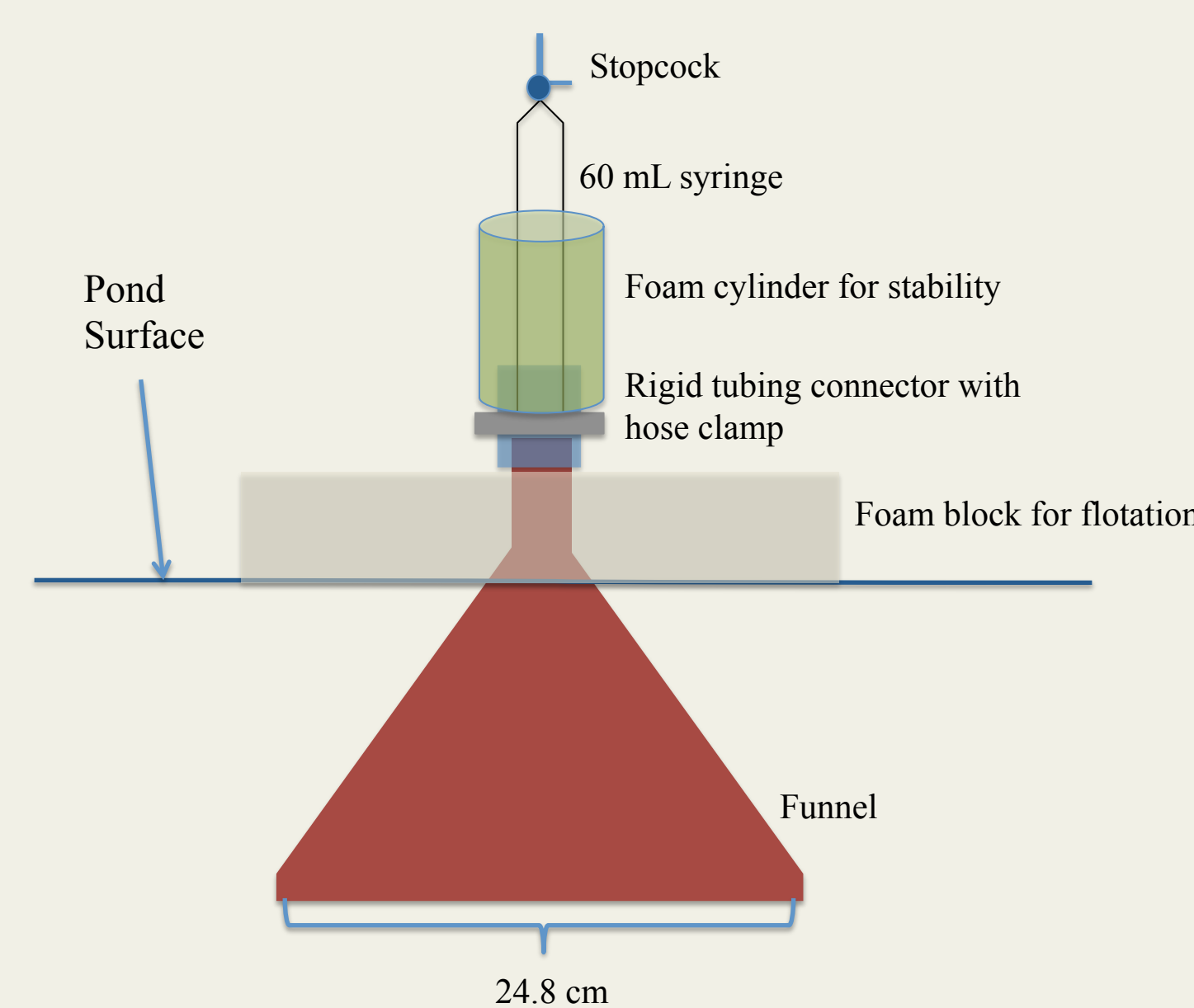
## Research Questions

*How does CH<sub>4</sub> ebullition vary across Stordalen mire in thaw ponds and peat, and what factors have the greatest influence on ebullitive flux?*

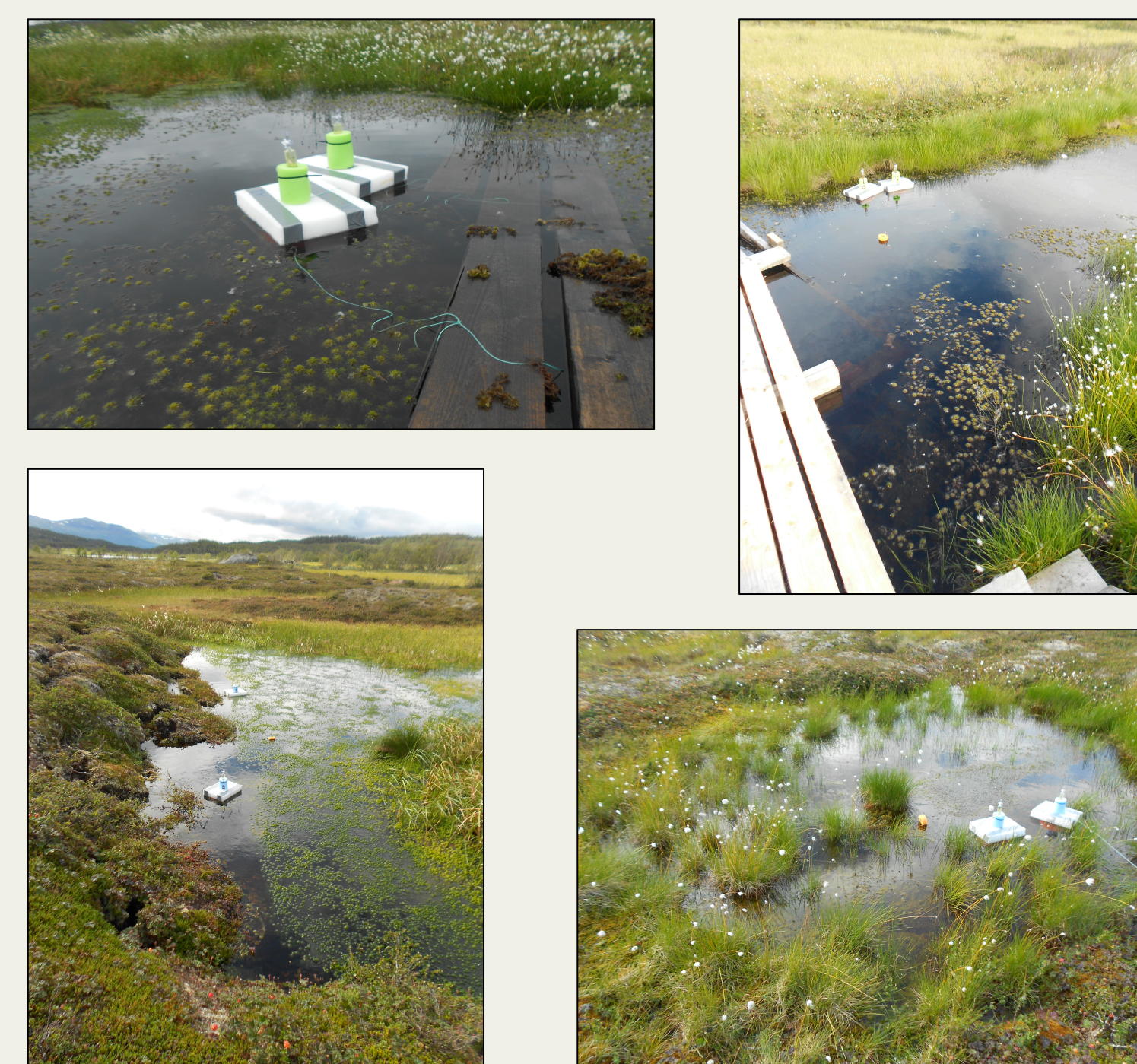
## Methods

Ebullition traps were deployed in 3 peat types and 5 thaw ponds on Stordalen Mire near Abisko, Sweden and collected ebullition from July 3-25, 2013. Gas was sampled 3-4 times per week from the twelve pond ebullition traps and analyzed for CH<sub>4</sub> concentration using GC-FID. Temperature readings were recorded at the surface and bottom of the ponds every 15 minutes for the duration of the sampling period. Water depth, active layer depth, and surface area were determined for each pond in order to understand the characteristics of the pond substrate and its effect on ebullitive flux.

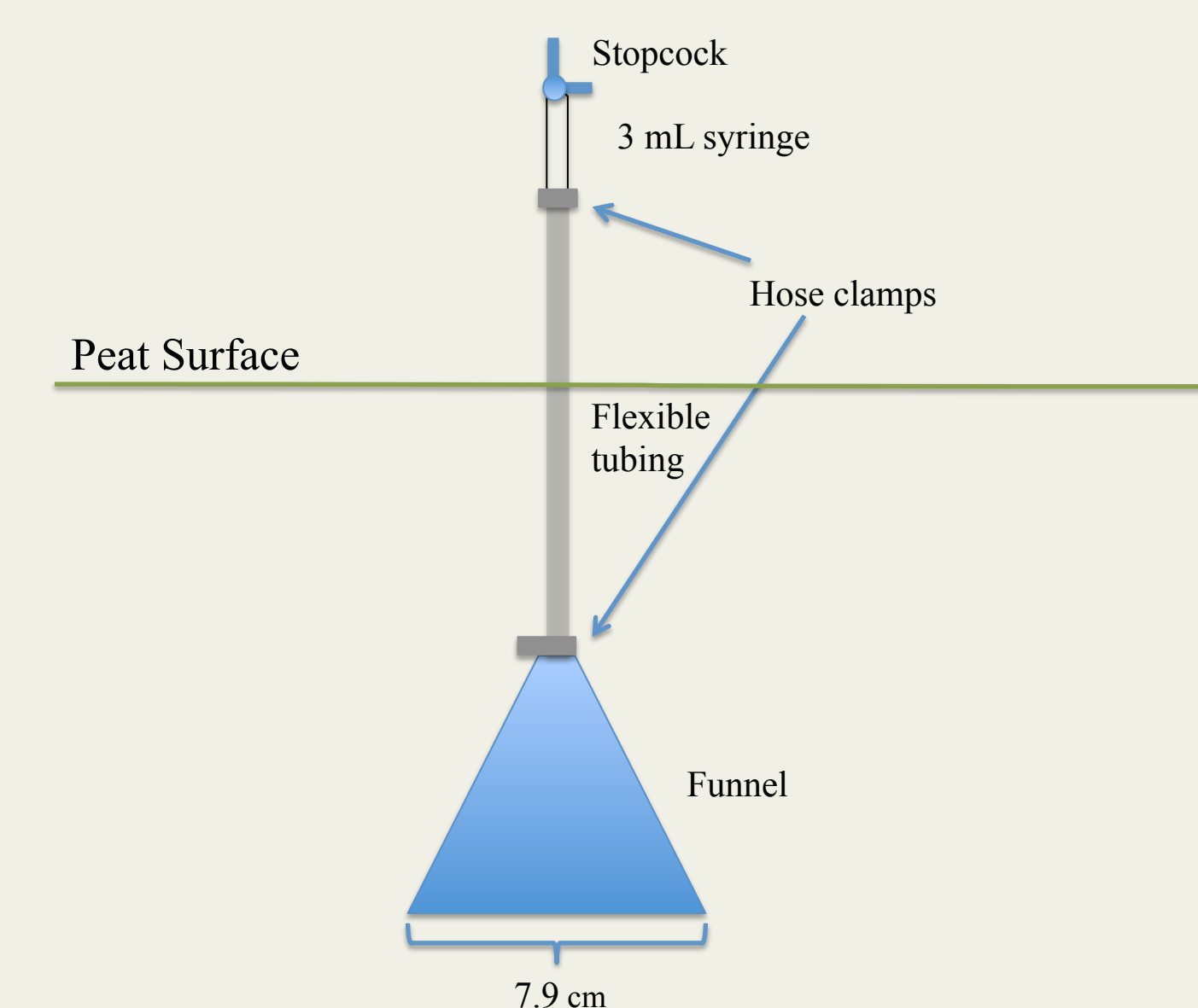
### Thaw Pond Ebullition Trap Design



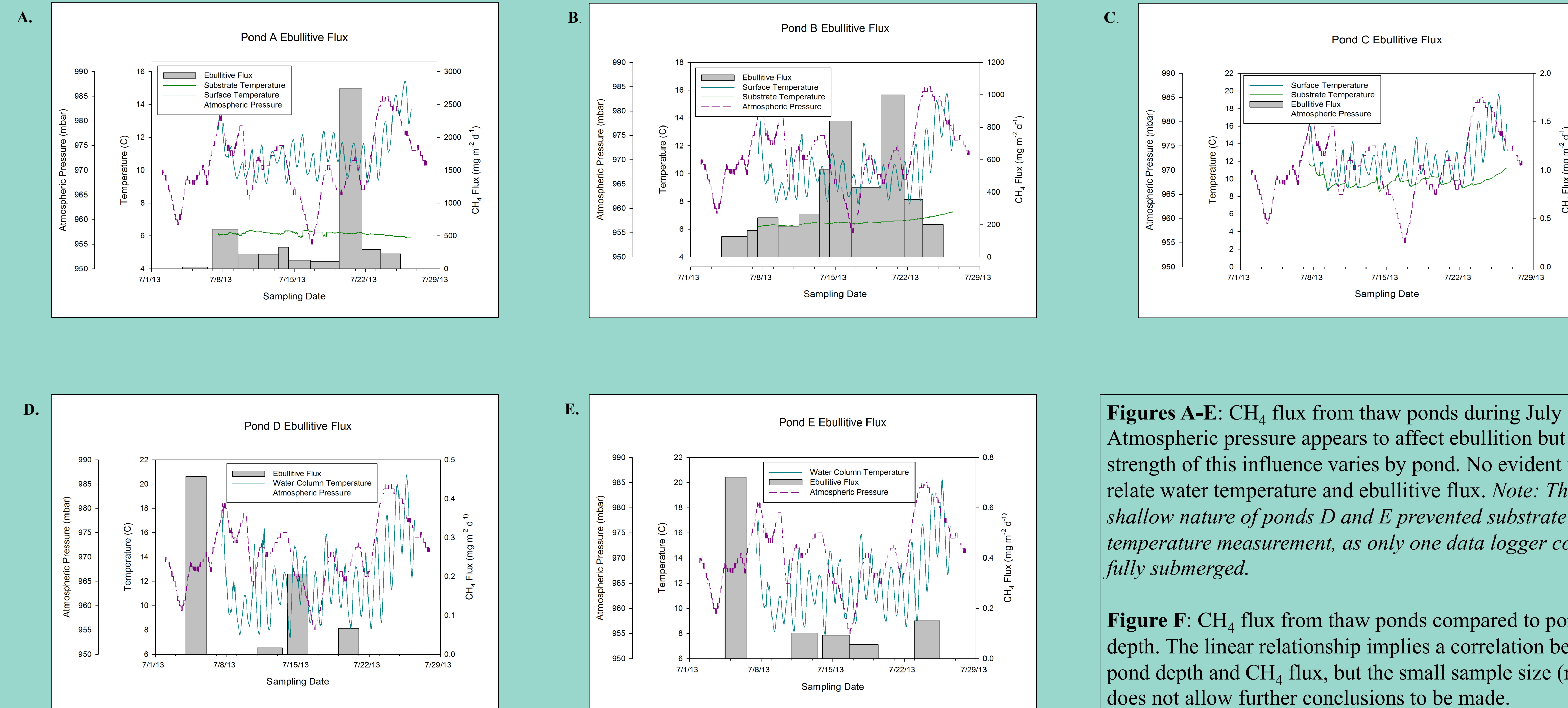
### Ebullition traps in Ponds A, B, E, and C (clockwise from left)



### Peat Ebullition Trap Design



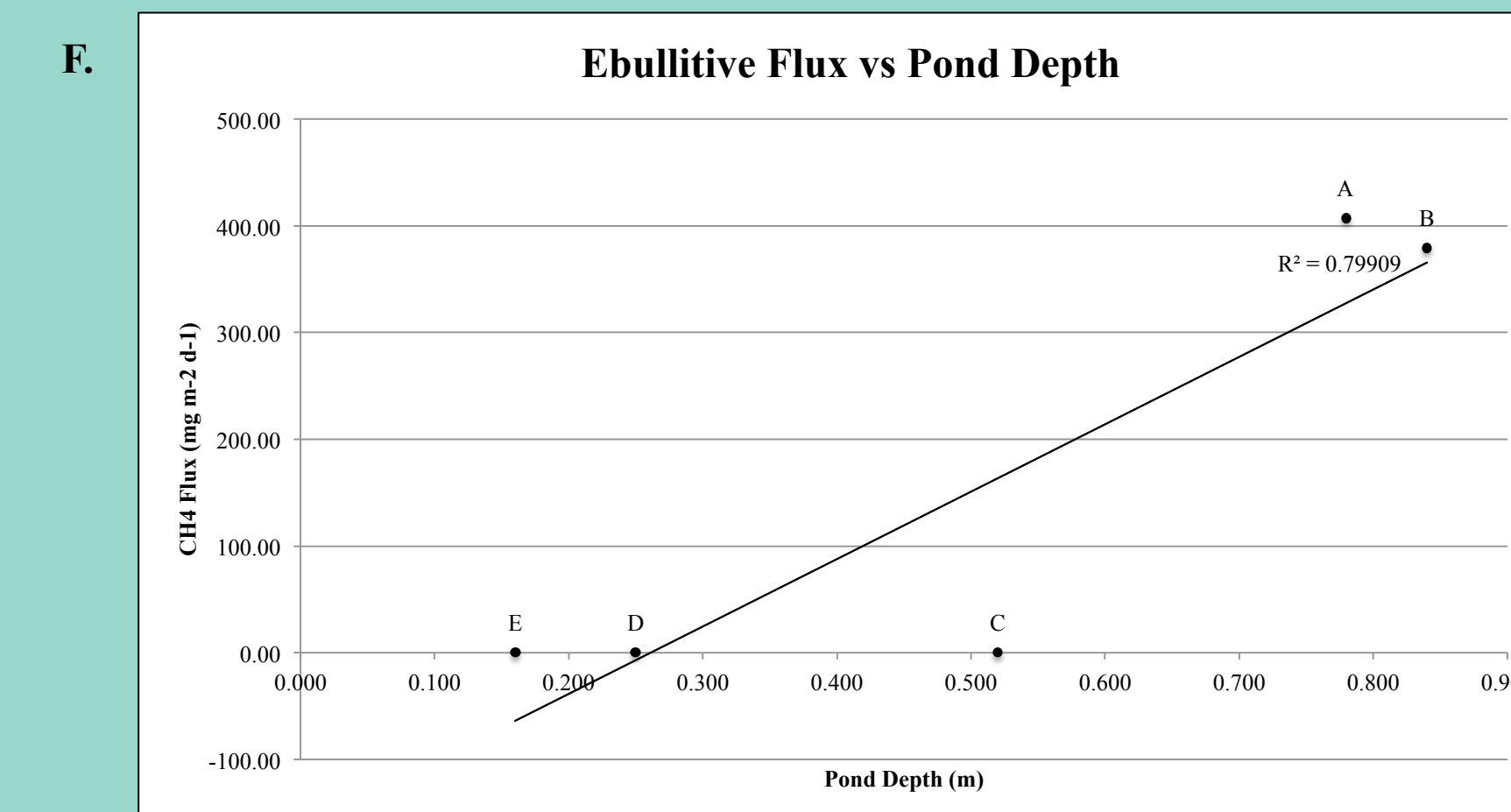
## Results



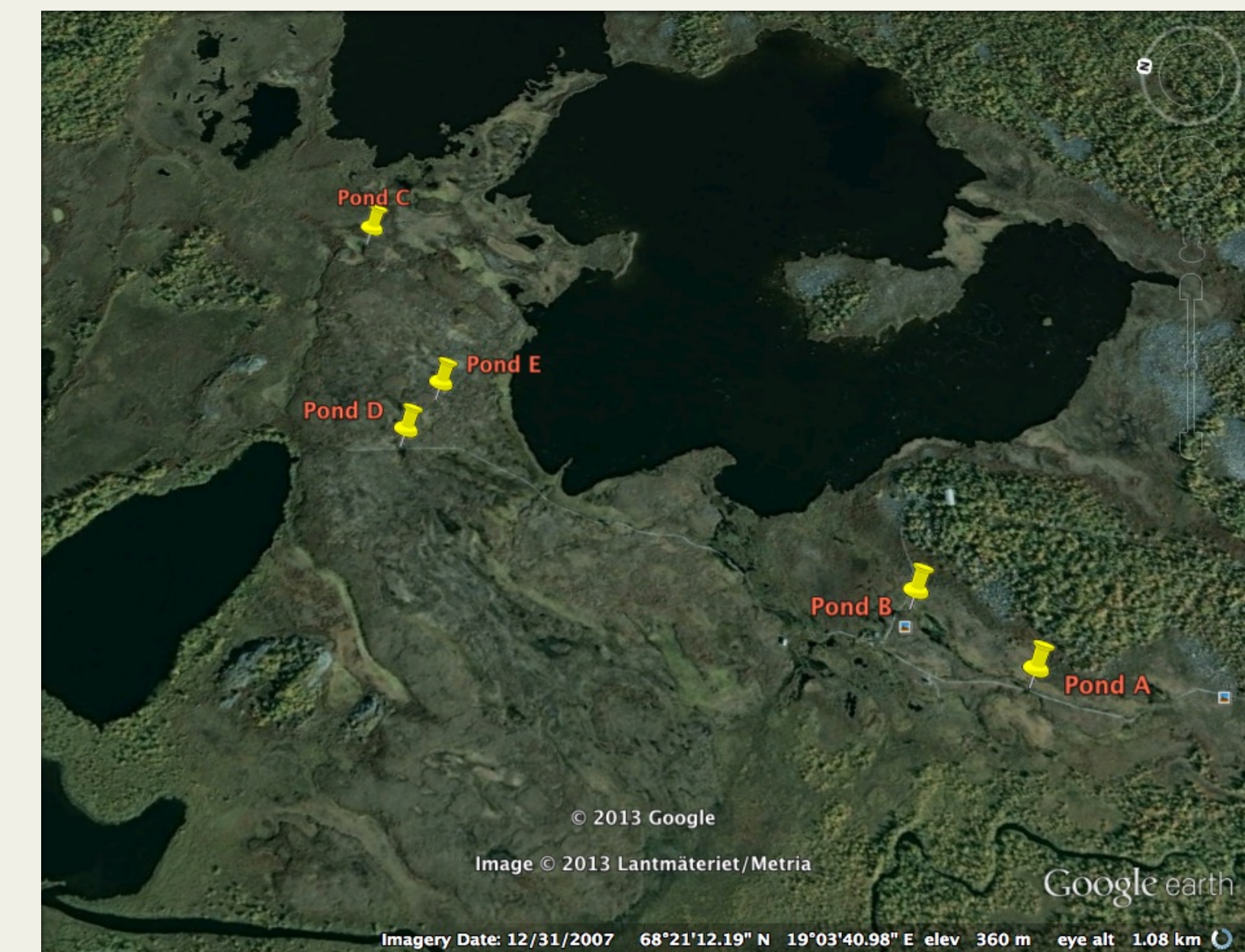
**Figures A-E:** CH<sub>4</sub> flux from thaw ponds during July 2013. Atmospheric pressure appears to affect ebullition but the strength of this influence varies by pond. No evident trends relate water temperature and ebullitive flux. *Note: The shallow nature of ponds D and E prevented substrate temperature measurement, as only one data logger could be fully submerged.*

**Figure F:** CH<sub>4</sub> flux from thaw ponds compared to pond depth. The linear relationship implies a correlation between pond depth and CH<sub>4</sub> flux, but the small sample size (n=5) does not allow further conclusions to be made.

Physical Characterization of Ponds						
Pond	Mean Flux (mg CH <sub>4</sub> m <sup>-2</sup> d <sup>-1</sup> )	Mean Surface Temp (°C)	Mean Substrate Temp (°C)	Approx. Pond Area (m <sup>2</sup> )	Depth (m)	Active Layer Depth (below pond) (m)
A	406.85	11.12	6.14	15.0	0.78	>1
B	379.35	10.34	6.55	25.0	0.84	>1
C	0.00	12.06	9.72	20.0	0.52	>1
D	0.03	12.03	n/a	17.0	0.25	>1
E	0.09	12.08	n/a	8.0	0.16	0.49



## Thaw Pond Distribution



## Discussion

- Thaw ponds are capable of emitting high concentrations of CH<sub>4</sub> into the atmosphere, though ebullition is spatially and temporally variable.
- No ebullition was captured from peat during the sampling period, suggesting that CH<sub>4</sub> emission from peat occurs mainly via a different pathway.
- Temperature does not appear to be as important as other physical characteristics such as substrate material and pond depth in influencing ebullitive flux from thaw ponds.
- Pond depth may be a proxy for age, reflecting the tendency of ponds to produce more CH<sub>4</sub> with time and further development as permafrost subsidence continues.

### Future Work

- Ponds will be monitored for ebullition in Summer 2014 and physical characteristics such as depth, surface area, and turbidity will be measured to track yearly changes in the ponds.
- Potential thaw pond sites (permafrost subsidence and depressions) will also be monitored over time to watch for thaw pond development.
- Carbon dating and analysis of isotopic pathways for CH<sub>4</sub> emissions in these ponds will allow us to determine the age and transport mechanism(s) of the carbon being released.
- High-resolution satellite images of the mire will be analyzed to determine total thaw pond cover in the area

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