Using Hydrologic Measurements to Investigate Free Phase Gas Ebullition in a Maine Peatland, USA

Bon, Reeve, Slater, Comas

Figure 1: Two competing models for ebullition of CH_4 from northern peatlands. *Left:* "Deep Peat" ebullition model modified from Glaser et al. (2004). *Right:* "Shallow Peat" ebullition model modified from Coulthard et al. (2009). Notice the unknown upward flux of CH_4 from deeper peat that was a "call for further research." This study is a direct response to this call for research.

Figure 2: Map of central and southern portion of Caribou Bog (outlined by dashed line), a multi-unit peatland, with study area in the central unit highlighted by the black box. The study area is shown enlarged in Figure 10.

Figure 3: Gas trap installed at one location to conclude if wells were conduits for gas release and change pressure regimes below the surface.

Figure 4: *Top:* CH_4 concentrations versus depth. A weak correlation was found between depth and CH_4 concentrations ($R^2 = 0.134$, $p = 0.005$). *Bottom:* CH_4 concentrations increase with increasing CO_2 concentrations for September 13 ($R^2=0.667$, $p = 0.0008$) and November 26, 2012 ($R^2=0.956$, $p = 4.51493E-09$).

Figure 5: CH_4 concentrations at the pools and esker site [ii]. Data showed the highest average concentrations of CH_4 from all 4 sites. Data from September 13 and November 26, 2012, shows higher concentrations at the approximate depth of the esker crest (~3 m) indicating increased CH_4 production at depth and possible hotspot production due to esker influence. The quadratic regression line shown is significant ($R^2 = 0.47$, $p = 0.002$).

Figure 6: Plot highlighting fluctuations in hydraulic head from the 6.9 m well at the shrub site [i]. Fluctuations believed to be an ebullition event are outlined by the red box. Daily fluctuations in hydraulic head are believed to be caused by evapotranspiration. Low reading of 40.36 m was recorded when the logger was pulled to download data.

Figure 7: Fluctuations in hydraulic head at the shrub site [i] on October 20, 2011, believed to be ebullition events occurring during a strong drop in atmospheric pressure and a low precipitation event. The pressure release lasts for different lengths of time at different depths of peat. The pressure fluctuations move upward in the peat column at 7:00.

Figure 8: Pressure transducer data during the initial atmospheric pressure drop during Tropical Storm Irene on August 28, 2011. Fluctuations in pressure data believed to be gas release occur in all loggers. A downward gradient in hydraulic head towards the esker is also evident.

Figure 9: Temperature data from 0.9 and 6.1 m monitoring wells equipped with pressure transducers. Temperatures were constant in deep peat allowing for constant CH_4 production.

Figure 10: Central Unit enlarged showing the positions of 9 well clusters and the relative position of the esker and esker crest (Comas et al. 2011). Groundwater flow in the central unit is based off water level readings from 3 m wells on Nov 5, 2011. White line, A-A', refers to cross sections in Figure 11. There is an area of lower hydraulic head above the esker driving convergent flow.

Figure 11: Cross Section A-A' from Figure 9 on Nov 5, 2011. The esker crest is driving down flow that may drive a downward transport of labile carbon to deeper peat and increase FPG production.

Figure 12: Conceptual model showing gas production during stable atmospheric pressure and ebullition of FPG during a decrease in atmospheric pressure.