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Source characterization and temporal variation of methane seepage from thermokarst lakes on the Alaska North Slope in response to Arctic climate change

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Summary

The goals of this research are to characterize the source, magnitude and temporal variability of methane seepage from two representative thermokarst lake areas within the Alaskan North Slope gas hydrate province, assess the vulnerability of these areas to ongoing and future Arctic climate change and determine if gas hydrate dissociation resulting from permafrost melting is contributing to the current lake emissions. Work during this quarter has focused on continuing the group laboratory analyses on samples and data collected from the Year 1 and 2 fieldwork.

GIS/Geophysics (USGS): The USGS has completed digitizing seismic, DC resistivity, and radar data acquired at Lake Q in 2009 to generate a preliminary bathymetric map (based on over 3000 data points) that can be used to examine methane ebullition during the ice-covered season. The USGS has also begun incorporating the SAR imagery into a GIS framework to develop quantitative constraints on the distribution/thickness of ice with time. The USGS is currently mapping gassy areas within Lake Q from the Chirp data acquired in 2009. USGS researchers have collaborated with MIT colleagues to test methodology related to mapping methane emissions from fine-grained lake-based sediments. The USGS has provided data on the distribution of gassy sediments and active seeps at discrete time intervals. These data can be used to determine whether the MIT model is widely applicable to understanding methane emissions from soft sediments as a function of sediment characteristics and external forcing. The USGS has archived and filed appropriate internal data reports related to research at Lake Teshekpuk in spring (coring) and summer (geophysics) 2010. Tracklines and basic data were incorporated into a new GIS, and preliminary comparisons between the findings of the coring activity and the geophysical imaging (e.g., depth to gas-charged sediments) have been conducted. The geophysical data set will soon be digitized following the workflow used for Lake Q and other lakes, and a new map of bathymetry, seeps, and gas-charged sediments will result.

Task 5.0 and 6.0 - Measuring methane flux on multiple temporal scales. Katey Walter Anthony (UAF): There is no change in the scope of the work concerning measuring the methane emissions from our study sites. Long-term continuous flux measurements of the seeps on the Fairbanks lakes continued through the summer. We were very pleased to receive summer data, as there had been a lack in summer season flux data during previous years due to spring ice movement misplacing the flux traps. This summer data together with the anticipated winter data will complete the long-term seep flux measurements. Data continue to be analyzed. We are determining the extent to which individual seeps behave the same with respect to flux over the long term, or whether there are periodic shifts in seep ebullition regime. We are still waiting for stable isotope and radiocarbon dating results for the seep gases. Our intention is to use isotopes as independent evidence to support the hypothesis of permafrost-derived carbon generating methane at different depths within the sediment package and thaw bulb of the lakes. LiCor data also continue to be collected to monitor atmospheric CH_4 concentrations above Goldstream Lake surface. We recently obtained power via a land line, as opposed to operating only of solar panels and batteries. The new and reliable source of power will enable us to continue measuring atmospheric CH_4 concentrations above the lake throughout the dark winter. We have installed an anemometer to assist in the data analysis and interpretation of atmospheric CH_4 concentration anomalies. We also placed a time-lapse camera on the lake to relate flux data to frequent optical images of the lake surface.

Task 7.0 - Methane oxidation in Alaskan thermokarst lakes. Mary Beth Leigh (UAF) and Ruo He (UAF): All stable isotope probing (SIP) incubations have been performed and samples have been harvested and frozen for analyses of the identity and community structure of methane-oxidizing microorganisms, which is well underway. DNA has been extracted from the sediment SIP samples and subjected to isopycnic centrifugation using cesium trifluoroacetate gradients and fractionated using established methods. DNA distributions in the series of fractions from both ^{13}C-incubated samples and control (^{12}C-incubated) samples were determined using quantitative real time polymerase chain reaction (RTm-PCR) with universal bacterial 16S rRNA primers. ^{13}C-DNA-containing fractions have been subjected to community profiling using terminal restriction fragment length polymorphism (T-RFLP). T-RFLP profiles obtained were compared over incubation time courses and among the study sites using existing software for microbial community statistics analysis and comparisons. High throughput pyrosequencing of 16S rRNA genes of total bacterial communities and bacteria that derived carbon from ^{13}C-methane has been performed. Phylogenetic analyses of the sequences are now in progress.

Task 8.0 - Establishing a long-term record of the variability in methane emissions in relation arctic climate change. Matthew Wooller (UAF): All of the analyses are now complete on the paleo cores (e.g. LQ-West, LQ-CM- Paleo, Terrapin Station and Coffee lake) taken during the year 1 field work. Gaglioti continues to prepare samples from the year 2 field work conducted at Teshekpuk. Samples from the Teshekpuk core have been submitted to NOSAMS for dating and the results are pending. Bulk stable carbon and nitrogen isotope analyses have already been conducted on the core. Further analyses will be conducted in earnest once the preliminary age of the core is known from Teshekpuk.

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