12-4-2008

Collaborative research: Geophysical evaluation of biogenic gasses in peatlands

Andrew S. Reeve
Principal Investigator; University of Maine, Orono, asreeve@maine.edu

Final Report for Period: 09/2007 - 08/2008
Submitted on: 12/04/2008
Principal Investigator: Reeve, Andrew S.
Award ID: 0510004
Organization: University of Maine
Submitted By:

Title:
Collaborative research: Geophysical evaluation of biogenic gasses in peatlands

Project Participants

Senior Personnel

Name: Reeve, Andrew
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Name: Comas, Xavier
Worked for more than 160 Hours: Yes
Contribution to Project:
Geophysical monitoring of Caribou Bog including biweekly (on average) GPR measurements to assess gas content in Caribou Bog (peat), GPR surveys to refine peat basin morphology, and preparation of publications. Supported by the grant as a post-doctoral researcher at UMaine for 8 months.

Graduate Student

Name: Tyczka, Zachary
Worked for more than 160 Hours: No
Contribution to Project:
Completed slug testing and ground-water monitoring for comparison with GPS measurements. Assisted with monitoring well installation. Working on computer simulation of ground-water flow in Caribou Bog. Receives summer support from grant.

Name: Rhoades, Josh
Worked for more than 160 Hours: No
Contribution to Project:
Assists with slug testing and hydrologic monitoring. Completed data entry for project.

Undergraduate Student

Name: Beebe, Calvin
Worked for more than 160 Hours: Yes
Contribution to Project:
Calvin assisted with sample collection and completed grain-size analysis on sediment samples collected from the mineral sediment ridge underlying Caribou Bog.

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Rutgers University Newark

University of Minnesota-Twin Cities

Other Collaborators or Contacts

I have worked with individuals associated with the multiphysics software 'FiPy', developed at the Center for Theoretical and Computational Materials Science at the National Institute of Standards and Technology. This group has provided guidance in the use of their software package.

Activities and Findings

Research and Education Activities:

During 2005/2006, I provided logistical support for Lee Slater, Xavier Comas and associated graduate students from Rutgers University Newark. I was involved in planning for summer activities including recruiting a graduate student to work on this project and planning for our summer field campaign.

During the summer of 2006, Zachary Tyczka and I installed monitoring wells, a rain guage, and moisture probes in Caribou Bog. These monitoring stations were installed near platforms constructed to monitor the peatland for free phase gas. Through the summer and fall 2006, and spring 2007, we have monitored well clusters for hydraulic head and have performed slug tests on all wells. Data has been collected from moisture sensors, pressure/temperature sensors, and a rain gauge (all equipped with data loggers) that continuously collect data.

Through the spring and fall,2008, Reeve and Tyzcka constructed computer models, using the FiPy computer modeling system, in an affort to evaluate the impact of a buried esker on the hydrology of Caribou Bog. Tyzcka reviewed and processed slug testing data collected through the past year.

Findings:

We have measured rapid changes in free-phase gas content in the peat that indicate ebullition events ocurr periodically through the growing season. Free phase gas in the peat builds up over the winter when the peatland is frozen and is rapidly released during spring thaw. Hydraulic conductivity, measured using slug tests, decrease over the summer. No clear relationship between gas content and measure hydrualic conductivity is evident, but additional statistical analysis is needed to further explor this data.

Hydraulic head data collected along a transect across an infered buried esker indicate that pore-water in the peatland converges toward this system, suggesting the esker drains or redistributes water within this peatalnd system.

Conceptualized computer simulations indicate that small isolated and
permeable esker deposits will alter the flow patterns within a peatland, producing isolated recharge and discharge zones on the hydraulically up and down gradient ends of a sediment lens, respectively. Adding a larger scale permeable zone within the mineral sediments below these small lenses of permeable material provides additional connectivity between the high hydraulic head zone at the bog dome and the low hydraulic head zone at the peat lagg. This interconnection strengthens and spreads recharge beneath the bog dome while strengthening and spreading the discharge component in each of the lenses hydraulically down gradient of the peat dome. This latter simulation reproduces the down flow observed near an esker within Caribou Bog and suggests the esker bead imaged by Comas et al. (2005) is likely part of a hydraulically interconnected system that extends beneath Caribou Bog's lagg.

Training and Development:

Both my graduate students have been exposed to a new field setting (peatlands) and automated monitoring techniques. Both have been trained to use a scripting language (Python) and spreadsheet software to analyze data sets and both are currently using a new (to hydrogeologists) modeling platform, FiPy, to simulate ground-water processes.

One undergraduate completed grain-size analysis (with assistance from Dr. Daniel Belknap, University of Maine) on samples recovered from the infered esker.

Outreach Activities:

I have remained active with the Orono Bog Boardwalk project and serve as a guide to schools and other groups that visit this site. During tours I discuss the hydrology of peatland systems and geologic background to the study area. The Orono Bog Boardwalk serves about 100,000 visitors each year and attracts a large number of school classes in the spring and fall. I provide an annual 'nature walk' delivered to a group of about 14 people each year, discussing peatland morphology, hydrology and their role in carbon cycling.

Journal Publications

Comas X., L. Slater, A. Reeve, "In situ monitoring of free-phase gas accumulation and release in peatlands using ground penetrating radar (GPR)", Geophys. Res. Lett., p. L06402, vol. 34, (2007). Published,

Comas X., L. Slater, A. Reeve, "Seasonal geophysical monitoring of biogenic gases in a northern peatland: Implications for temporal and spatial variability in free phase gas production rates", Journal of Geophysical Research, p. , vol. 113:G01, (2008). Published,

Books or Other One-time Publications

Comas, X., L.Slater, L., A.Reeve, J. Nolan., "Evolution of biogenic gasses in peat soils using ground penetrating radar (GPR).", (2006). abstract, Published
Bibliography: Geological Society of America Annual Meeting

Comas X., L. Slater, A. Reeve, "Long term monitoring of biogenic gasses in peat soils using electromagnetic (EM) measurements", (2007). Abstract, Published
Bibliography: Eos Trans. AGU, 88(23)

A.S. Reeve, X. Comas, and L.D. Slater
, "Stratigraphic controls on the hydrogeology of Caribou Bog, Maine
", ( ). Book, Submitted
Editor(s): A. Baird, L. Belyea, X. Comas, A. Reeve, and L. Slater
Collection: Northern Peatlands and
Carbon Cycling
Bibliography: AGU

A. Reeve, Z. Tyczka and X. Comas, "Utilizing computer simulations to evaluate ground-water flow patterns within a peatland system", (2008). Abstract, Published
Bibliography: Geological Society of America Abstracts with Programs. Vol. 40

Z.D.Tyczka, A.S. Reeve, X. Comas, "Temporal changes in hydraulic conductivity in a large Maine
peatland and its impact on 3-D groundwater flow simulations", (2008). Abstract, Published
Bibliography: Society of Wetland Scientists Annual Meeting. Washington D.C.

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

Free-phase gas (FPG) from peatlands builds up withing peatlands during the winter months when the surface is frozen and this gas is rapidly released during the spring thaw. This release of gas is difficult to capture using chamber measurements and represents a potentially large flux of greenhouse gases from peatland systems, if applicable to all peatland systems. FPG content in peatlands varies over short time periods and

indicates that carbon gases build up and are released episodically.

We are exploring the relationship between gas content, hydraulic head, and the measured hydraulic conductivity of peatland systems. Peat pore-water flow is strongly influenced by heterogeneity within the peat and underlying mineral sediments. Our data and subsequent numerical experiments indicate the esker will create local recharge and discharge zones and we suggest these shifts in fluxes modify vegetation communities present at the peat surface, as well as influence biogenic gas production.

Contributions to Other Disciplines:

The flux of greenhouse gases from peatlands is linked to global carbon cycling and is an important component in global warming scenarios. Our research will provide important data to those evaluate larger scale global warming issues.

Understanding the current hydrology within peatland systems is also crucial for the management and preservation of peatland ecosystems for rare or endangered plant species. Five rare plant species have been identified an Caribou Bog (Davis and Anderson, 1999).

Contributions to Human Resource Development:

This project has provided support for one post doctoral researcher, one graduate student, and one undergraduate student. The postdoctoral researcher has secured an academic position at Florida Atlantic University where he will continue to educate students and apply near surface geophysics to environmental research.

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Categories for which nothing is reported:

Any Web/Internet Site

Any Product

Contributions: To Any Resources for Research and Education

Contributions: To Any Beyond Science and Engineering