Periglacial Hydrogeochemistry
GLY4930: Sections 9851; 9852
GLY6932: Sections 9853; 9854
Spring 2021

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Office Hours:	2-3 pm Mon./Thur. or by appointment (call or email first)
Meeting Place:	Synchronous WEB; if anyone signs up for in person or if the pandemic ends in time: 218 Williamson Hall
Meeting Time:	3:00 – 4:55 Wednesday; depending on schedules

Objectives:

In this course we will read, discuss and critically evaluate papers that deal with processes in glacial and periglacial environments, specifically on and under glaciers, foreglacial landscapes, and areas where glaciers were present in the past and have since retreated. The primary focus will be on hydrology, geology, and chemistry of the landscapes, but biological and physical characteristics may be included to a lesser extent. I'll try to choose most papers that are linked to Greenlandic glacial processes, but they may be supplemented by papers from elsewhere. Papers will consist of classic or review papers, as well as papers that have been published within the last few years. I will likely choose most of the papers we will read, but am open to suggestions from anybody taking the class. We will likely read one or two papers per week depending on their length and density.

The course has several objectives that include:

(1) Becoming familiar with glacial processes and how they change as glaciers retreat following glacial maxima;
(2) Learning how to read and critically evaluate scientific literature;
(3) Gaining skills in how to participate in and contribute to group discussions;
(4) Developing an ability to compile information from the primary literature and synthesize it into a short written document.

Readings:

The attached bibliography includes papers we could read, although we will certainly not get through all of them. Further, this bibliography is not an exhaustive listing of the pertinent literature. The bibliography is broken into sections that are organized from glacial environments to exposed landscape, to the coast. This order is the rough organization of the class. The rate we get through the different topics will depend on the student's interest and there will be considerable flexibility as to which papers we will read and their sequence. We may read papers not on the list, particularly if new ones appear during the semester. I welcome your suggestions for papers and especially encourage your suggestions for papers that deal with your thesis topic if appropriate. Typically papers will be assigned at least one week in advance of the class discussion. Papers and selected information will be posted on the class e-learning site.

Expectations and evaluations:

Because this course has a different format from a standard class of lectures followed by exams, the expectations for your work and behavior in class may be a bit different from your previous experiences. Class expectations are:

(1) Come to all classes. Absences must be excused by a note from a doctor or a mortician and unexcused absences will significantly impact your grade (see below).

(2) Read all of the assigned papers.

(3) Participate in the discussions. At the end of class I will assign you a value of 1, 2, or 3 where 1 = never said a word, 2 = briefly spoke one or two times, 3 = actively participated and contributed to the discussion. These points will contribute to your final grade according to the grading rubric below.

(4) Complete Readiness Assurance Tests (RAT) at the start of each class. These tests will consist of 10 (more or less) multiple choice questions that are related to that week's readings. At the start of each class, you will take the RAT as individuals (iRAT) and once everyone is done, you will take the same RAT within a group. Members of each group will be determined during or soon after the first class and remain fixed throughout the semester. The questions on the RATs will lead to discussion in the class, which I will lead.

(5) Write and present to the class an extended abstract/project summary to a proposal or paper on a topic of your choice related to periglacial hydrogeochemistry. The topic may be your dissertation/thesis if appropriate to the course. The document will be 2 pages text, single spaced, 1 inch margins, 12 point font. Figures and references are not included in the text length and to save space in the text, references should follow Nature format (superscript numbers). The abstract/project summary should contain all the material that a paper or proposal would have and will be evaluate the document according the rubric below. At some point during the semester, I may offer a lecture on writing skills, if desired. Various parts of the document will be due throughout the semester according to the following schedule. These due dates assume class will be on Wednesday.

Rubric for proposal

Section	Topics that should be covered	Value (%)
Introduction	Hypothesis introduced early	20
	Background information provided to explain unknowns	
Background	Detailed and thorough review of literature. Only information included that supports hypothesis and why important to test	20
Work plan	Description of how hypothesis will be tested – what will be done, what will be found, how results provide a test	20
Conclusion	Overall importance of paper/project	10
Writing	Grammar, punctuation, spelling	15
	Clarity of thought	15

Schedule for abstract/project summary

This schedule assumes class meeting time remains on Wednesdays. These parts should be submitted by email

February. 3: short (2-3 sentences) description of proposal topic

March 17: Annotated bibliography for proposal

March 24: Campus wide "recharge day"

Martin 31: First draft

April 15: Proposal due

April 21: Proposal presentations.

Grading:

Item	Total Value (%)
Attendance	Variable*
Class participation	50
iRAT (TBL stuff)	3
tRAT (TBL stuff)	12
Proposal	25
Proposal presentation	10
Total	**100**

* Each unexcused absence will lower your class score by 5 percentage points.

Some additional information

(1) Attendance is mandatory. Do not be late; the iRAT will start on time.
(2) No make-up work will be allowed.
(3) No textbook is required.
(4) Letter grades will include minus grades. The grading scale is ≥93 = A; 90-92 = A-; 87-89 = B+; 83-86 = B; 80-82 = B-, etc. Values will be rounded to nearest whole numbers
(5) Class demeanor:
    a) Class will start on time. Please be punctual. Turn off cell phones.
    b) I expect lively discussions in this class, but demand respect for each other's views and backgrounds. Personal slights, either overt or covert, will not be tolerated. Everyone should talk and everyone should respect what others have to say.
    c) Because work expectations and the pedagogical approach of this course depend heavily on student engagement and interaction, you are required, at a minimum, to participate in class activities through the audio function of Zoom. Your video presence is invited as well.
(6) All students are expected to follow the University honor code: neither give nor receive unauthorized aid in doing any assignment. Not adhering to this policy will result in a failing grade for the class.
(7) Students requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the Instructor when requesting accommodation.
(8) Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

Possible Readings

Ice sheet and outlet glacier dynamics: past and projections

Alley, R. B., J. T. Andrews, J. Brigham-Grette, G. Clarke, K. M. Cuffey, J. Fitzpatrick, S. Funder, S. Marshall, G. Miller, and J. Mitrovica (2010), History of the Greenland Ice Sheet: paleoclimatic insights, *Quaternary Science Reviews*, *29*(15-16), 1728-1756.

Archer, D., A. Winguth, D. Lea, and N. Mahowald (2000), What caused the glacial/interglacial atmospheric pCO2 cycles?, *Reviews of Geophysics*, *38*(2), 159-189.

Bergmann, I., G. Ramillien, and F. Frappart Climate-driven interannual ice mass evolution in Greenland, *Global and Planetary Change*, *82â€“83*(0), 1-11.

Bierman, P. R., L. B. Corbett, J. A. Graly, T. A. Neumann, A. Lini, B. T. Crosby, and D. H. Rood (2014), Preservation of a preglacial landscape under the center of the Greenland Ice Sheet, *Science*, 1249047.

Bjørk, A. A., K. H. Kjær, N. J. Korsgaard, S. A. Khan, K. K. Kjeldsen, C. S. Andresen, J. E. Box, N. K. Larsen, and S. Funder (2012), An aerial view of 80 years of climate-related glacier fluctuations in southeast Greenland, *Nature Geoscience*, *5*(6), 427-432.

Bogard, M. J., C. D. Kuhn, S. E. Johnston, R. G. Striegl, G. W. Holtgrieve, M. M. Dornblaser, R. G. Spencer, K. P. Wickland, and D. E. Butman (2019), Negligible cycling of terrestrial carbon in many lakes of the arid circumpolar landscape, *Nature Geoscience*, *12*(3), 180-185.

Briner, J., H. Stewart, N. Young, W. Philipps, and S. Losee (2010), Using proglacial-threshold lakes to constrain fluctuations of the Jakobshavn Isbræ ice margin, western Greenland, during the Holocene, *Quaternary Science Reviews*, *29*(27-28), 3861-3874.

Briner, J., N. Young, E. Thomas, H. Stewart, S. Losee, and S. Truex (2011), Varve and radiocarbon dating support the rapid advance of Jakobshavn Isbræ during the Little Ice Age, *Quaternary Science Reviews*, *30*(19-20), 2476-2486.

Carlson, A. E., and P. U. Clark (2012), Ice sheet sources of sea level rise and freshwater discharge during the last deglaciation, *Reviews of geophysics*, *50*(4).

Charbit, S., D. Paillard, and G. Ramstein (2008), Amount of CO2 emissions irreversibly leading to the total melting of Greenland, *Geophysical Research Letters*, *35*(12).

Clark, P. U., A. S. Dyke, J. D. Shakun, A. E. Carlson, J. Clark, B. Wohlfarth, J. X. Mitrovica, S. W. Hostetler, and A. M. McCabe (2009), The Last Glacial Maximum, *Science*, *325*(5941), 710-714, doi:10.1126/science.1172873.

Deschamps, P., N. Durand, E. Bard, B. Hamelin, G. Camoin, A. L. Thomas, G. M. Henderson, J. i. Okuno, and Y. Yokoyama (2012), Ice-sheet collapse and sea-level rise at the Bølling warming 14,600 years ago, *Nature*, *483*(7391), 559-564.

Forman, S. L., L. Marin, C. van der Veen, C. Tremper, and B. Csatho (2007), Little Ice Age and neoglacial landforms at the Inland Ice margin, isunguata Sermia, Kangerlussuaq, west Greenland, *Boreas*, *36*, 341-351.

Golledge, N. R., E. D. Keller, N. Gomez, K. A. Naughten, J. Bernales, L. D. Trusel, and T. L. Edwards (2019), Global environmental consequences of twenty-first-century ice-sheet melt, *Nature*, *566*(7742), 65-72.

Gregory, J. M., P. Huybrechts, and S. C. Raper (2004), Climatology: Threatened loss of the Greenland ice-sheet, *Nature*, *428*(6983), 616.

Hatfield, R. G., A. V. Reyes, J. S. Stoner, A. E. Carlson, B. L. Beard, K. Winsor, and B. Welke (2016), Interglacial responses of the southern Greenland ice sheet over the last 430,000

years determined using particle-size specific magnetic and isotopic tracers, *Earth and Planetary Science Letters*, *454*, 225-236.
Jacob, T., J. Wahr, W. T. Pfeffer, and S. Swenson (2012), Recent contributions of glaciers and ice caps to sea level rise, *Nature*, *482*(7386), 514-518.
Kelley, S. E., J. P. Briner, and N. E. Young (2013), Rapid ice retreat in Disko Bugt supported by 10Be dating of the last recession of the western Greenland Ice Sheet, *Quaternary Science Reviews*, *82*, 13-22.
Kelley, S. E., J. P. Briner, N. E. Young, G. S. Babonis, and B. Csatho (2012), Maximum late Holocene extent of the western Greenland Ice Sheet during the late 20th century, *Quaternary Science Reviews*, *56*, 89-98.
Kelly, M. A., and T. V. Lowell (2009), Fluctuations of local glaciers in Greenland during latest Pleistocene and Holocene time, *Quaternary Science Reviews*, *28*(21-22), 2088-2106.
Leeson, A., A. Shepherd, K. Briggs, I. Howat, X. Fettweis, M. Morlighem, and E. Rignot (2015), Supraglacial lakes on the Greenland ice sheet advance inland under warming climate, *Nature Climate Change*, *5*(1), 51-55.
Levy, L. B., M. A. Kelly, J. A. Howley, and R. A. Virginia (2012), Age of the Ørkendalen moraines, Kangerlussuaq, Greenland: constraints on the extent of the southwestern margin of the Greenland Ice Sheet during the Holocene, *Quaternary Science Reviews*, *52*, 1-5.
Long, A. J., S. A. Woodroffe, G. A. Milne, C. L. Bryant, M. J. Simpson, and L. M. Wake (2012), Relative sea-level change in Greenland during the last 700 yrs and ice sheet response to the Little Ice Age, *Earth and Planetary Science Letters*, *315*, 76-85.
Palmer, S., A. Shepherd, P. Nienow, and I. Joughin (2011), Seasonal speedup of the Greenland Ice Sheet linked to routing of surface water, *Earth and Planetary Science Letters*, *302*(3-4), 423-428.
Reyes, A. V., A. E. Carlson, B. L. Beard, R. G. Hatfield, J. S. Stoner, K. Winsor, B. Welke, and D. J. Ullman (2014), South Greenland ice-sheet collapse during marine isotope stage [thinsp] 11, *Nature*, *510*(7506), 525-528.
Ridley, J., J. M. Gregory, P. Huybrechts, and J. Lowe (2010), Thresholds for irreversible decline of the Greenland ice sheet, *Climate Dynamics*, *35*(6), 1049-1057.
Rignot, E., and P. Kanagaratnam (2006), Changes in the velocity structure of the Greenland Ice Sheet, *Science*, *311*(5763), 986-990.
Rignot, E., J. Mouginot, M. Morlighem, H. Seroussi, and B. Scheuchl (2014), Widespread, rapid grounding line retreat of Pine Island, Thwaites, Smith, and Kohler glaciers, West Antarctica, from 1992 to 2011, *Geophysical Research Letters*, *41*(10), 3502-3509.
Rignot, E., I. Velicogna, M. R. van den Broeke, A. Monaghan, and J. T. Lenaerts (2011), Acceleration of the contribution of the Greenland and Antarctic ice sheets to sea level rise, *Geophysical Research Letters*, *38*(5).
Rinterknecht, V., Y. Gorokhovich, J. Schaefer, and M. Caffee (2009), Preliminary 10Be chronology for the last deglaciation of the western margin of the Greenland Ice Sheet, *Journal of Quaternary Science*, *24*(3), 270-278, doi:https://doi.org/10.1002/jqs.1226.
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Glacial hydrology: surface and basal

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Andrews, L. C., G. A. Catania, M. J. Hoffman, J. D. Gulley, M. P. Lüthi, C. Ryser, R. L. Hawley, and T. A. Neumann (2014), Direct observations of evolving subglacial drainage beneath the Greenland Ice Sheet, *Nature*, *514*(7520), 80-83.
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Bamber, J., M. van den Broeke, J. Ettema, J. Lenaerts, and E. Rignot (2012), Recent large increases in freshwater fluxes from Greenland into the North Atlantic, *Geophysical Research Letters*, *39*(19).
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Banwell, A. F., N. S. Arnold, I. C. Willis, M. Tedesco, and A. P. Ahlstrøm (2012), Modeling supraglacial water routing and lake filling on the Greenland Ice Sheet, *Journal of Geophysical Research: Earth Surface*, *117*(F4).
Bartholomew, I., P. Nienow, D. Mair, A. Hubbard, M. A. King, and A. Sole (2010), Seasonal evolution of subglacial drainage and acceleration in a Greenland outlet glacier, *Nature Geoscience*, *3*(6), 408-411.
Bartholomew, I. D., P. Nienow, A. Sole, D. Mair, T. Cowton, M. A. King, and S. Palmer (2011), Seasonal variations in Greenland Ice Sheet motion: Inland extent and behaviour at higher elevations, *Earth and Planetary Science Letters*, *307*(3-4), 271-278.

Bring, A., I. Fedorova, Y. Dibike, L. Hinzman, J. Mård, S. Mernild, T. Prowse, O. Semenova, S. L. Stuefer, and M. K. Woo (2016), Arctic terrestrial hydrology: A synthesis of processes, regional effects, and research challenges, *Journal of Geophysical Research: Biogeosciences*, *121*(3), 621-649.

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Chandler, D., J. Wadham, G. Lis, T. Cowton, A. Sole, I. Bartholomew, J. Telling, P. Nienow, E. Bagshaw, and D. Mair (2013), Evolution of the subglacial drainage system beneath the Greenland Ice Sheet revealed by tracers, *Nature Geoscience*, *6*(3), 195-198.

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Ignéczi, Á., A. J. Sole, S. J. Livingstone, A. A. Leeson, X. Fettweis, N. Selmes, N. Gourmelen, and K. Briggs (2016), Northeast sector of the Greenland Ice Sheet to undergo the greatest inland expansion of supraglacial lakes during the 21st century, *Geophysical Research Letters*, *43*(18), 9729-9738.

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Glacial water chemistry: weathering and microbiology

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