

1-Core (sig)

FORMAT 6

Submit originals and one copy and electronic copy to **Governance/Faculty Senate Office**
(email electronic copy to fysenat@uaf.edu)

REQUEST FOR CORE ORAL INTENSIVE DESIGNATOR

✓ 10-day
#12 on
name

SUBMITTED BY:

Department	Geology and Geophysics	College/School	CNSM
Prepared by	Erin Pettit	Phone	5389
Email Contact	pettit@gi.alaska.edu	Faculty Contact	Erin Pettit

See <http://www.uaf.edu/uafgov/faculty/cd> for a complete description of the rules governing curriculum & course changes.

1. COURSE IDENTIFICATION:

Dept Course # No. of Credits

COURSE TITLE

Existing Course New Course Pending Approval* XX

*Must be approved by appropriate Curriculum Council.)

2. EMPHASIS DESIRED: (See Guidelines for Oral Intensive Designator)

Group (medium or large class)	<input type="checkbox"/>
Public (medium or large class)	<input checked="" type="checkbox"/> XX
Public (small class)	<input type="checkbox"/>
Public (large class) "O/2"	<input type="checkbox"/>

RECEIVED
OCT - 3 2011
Dean's Office
College of Natural Science & Mathematics

3. CURRENT CATALOG DESCRIPTION AS IT APPEARS IN THE CATALOG: including dept., number, title and credits

Catalog Description pending approval of New Course:

GEOS F377 O Ice in the Climate System

3 Credits
Offered Spring Odd-numbered Years

Earth's cryosphere includes seasonal snow, permafrost, sea ice, mountain glaciers, and ice sheets. This course will cover the formation of each of these forms of snow and ice and their response to changing environmental conditions. Interdisciplinary perspectives allow study the role snow and ice plays within the Arctic system (including atmosphere, ocean, and ecosystems), with an emphasis on Alaska. The cryosphere will also be placed in context of the global climate system. Oral intensive will include instructor and peer feedback. Special fees apply. Prerequisites: PHYS F103X and MATH F200X or instructor permission. (2+3)

JUSTIFICATION FOR ACTION REQUESTED

The purpose of the department and campus-wide curriculum committees is to scrutinize course designator applications to make sure that the quality of UAF education is not lowered as a result of the proposed change. Please address this in your response. This section needs to be self-explanatory. Use as much space as needed to fully justify the proposed change and explain what has been done to ensure that the quality of the course is not compromised as a result.

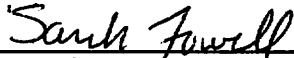

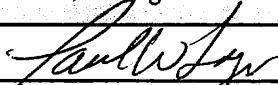
Geology majors current have only two choices for Oral Intensive courses within the department, and one of those is only taught every other year. Adding Oral Designation to Ice in the Climate System will expand these offerings.

Furthermore, as a new course, *the course design integrates the oral component completely* – rather than the oral component being an add-on to a course that has been taught previously.

The attached syllabus must clearly reflect the following basic elements for the **ORAL COMMUNICATION** emphasis requested. Please note them directly on the syllabus, using the corresponding letter. (See Guidelines in this manual.)

GROUP (medium or large class)	(Regularly enrolling at least 12 students)
A	15% of the final grade based on oral communication
B	1 ongoing, integrated group project with 5-8 students
C	2 presentations (minimum of 5 minutes per member)
D	Question & Answer period for both presentations
E	Group and Individual grading
F	Instructor Evaluation/Feedback on all presentations
PUBLIC (medium or large class)	(Regularly enrolling at least 12 students)
A	15% of the final grade based on oral communication
B	3 presentations (minimum of 5 minutes each)
C	Question & Answer period for both presentations
D	Instructor Evaluation/Feedback on all presentations
PUBLIC (small class)	(Regularly enrolling less than 12 students)
A	15% of the final grade based on oral communication
B	2 presentations of 20 minutes with Question & Answer <u>or</u>
C	3 presentations of 10 minutes with Question & Answer
D	Instructor Evaluation/Feedback on all presentations
PUBLIC (large class) "O/2"	(Regularly enrolling 20 or more students)
A	7.5% of the final grade based on oral communication
B	1 presentation (minimum of 5 minutes), <u>and</u>
C	1 presentation of 8-10 minutes with Question & Answer
D	Instructor Evaluation/Feedback on all presentations

APPROVALS:

	Date	10/4/11
Signature, Chair, Program/Department of: <u>Geology + Geophysics</u>		
	Date	9/30/11
Signature, Chair, College/School Curriculum Council for: <u>CNSM</u>		
	Date	Oct 5, 2011
Signature, Dean, College/School of: <u>CNSA</u>		

ALL SIGNATURES MUST BE OBTAINED PRIOR TO SUBMISSION TO THE GOVERNANCE OFFICE


<input type="text"/>	Date	<input type="text"/>
Signature, Chair, Senate Core Review Committee		

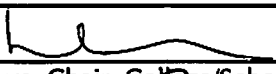
- This course will be *required* for Geology students concentrating in Geophysics.
- This course will be *required* for students completing a minor in Geophysics.
- This course will be an upperlevel science elective for students in Biology, Chemistry, Physics, Math, Fisheries, Engineering, Geography, Natural Resource Management, and others.
- This course will be an Oral Intensive course, expanding the currently limited options within Geology and Geophysics.


This course will not lower education quality at UAF, rather this course will be taught in way that challenges the students in multiple ways:

- This course will draw heavily on the foundation Math and Physics taught in the prerequisites and offer the students useful and interesting applications of those concepts to strengthen their ability to apply math and physics to their future studies
- This course will take advantage of students varying background and challenge for example, the biology students to explain related biologic concepts to the other students and the geophysics students to explain geophysical concepts to the other students. This will help these students solidify their understanding of their field of expertise
- The Oral Intensive nature of the course uses many small presentations (rehearsed and unrehearsed) to give the students a lot of practice in speaking in different formats to help develop confidence and comfort in speaking and answering questions in front of an audience
- Several of the hands-on activities and experiments in the course are structure to provide the students with practice in formulating questions and applying the scientific method to answer those questions. This will help them develop confidence in their abilities as a scientist
- GEOS 377 will be taught as partially field-based (on-campus), this will provide local, safe experience for the students to understand the challenges (particularly in winter) of any type of field work in Alaska, a useful skill for many students at UAF.

APPROVALS: Add additional signature lines as needed.

	Date	9/26/11
Signature, Chair, Program/Department of: <u>Geology + Geophysics</u>		

	Date	9/30/11
Signature, Chair, College/School Curriculum Council for: <u>CNSM</u>		

	Date	Oct 3, 2011
Signature, Dean, College/School of: <u>CNSM</u>		

	Date	
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Signature of Provost (if applicable)

Offerings above the level of approved programs must be approved in advance by the Provost.

ALL SIGNATURES MUST BE OBTAINED PRIOR TO SUBMISSION TO THE GOVERNANCE OFFICE

	Date	
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Signature, Chair

Faculty Senate Review Committee: Curriculum Review GAAC

Core Review SADAC

ADDITIONAL SIGNATURES: (As needed for cross-listing and/or stacking)

	Date	
Signature, Chair, Program/Department of:		

	Date	
Signature, Chair, College/School Curriculum Council for:		

	Date	
Signature, Dean, College/School of:		

CATALOG DESCRIPTION

GEOS F377 O Ice in the Climate System

3 Credits

Offered Spring Odd-numbered Years

Earth's cryosphere includes seasonal snow, permafrost, sea ice, mountain glaciers, and ice sheets. This course will cover the formation of each of these forms of snow and ice and their response to changing environmental conditions. Interdisciplinary perspectives allow study the role snow and ice plays within the Arctic system (including atmosphere, ocean, and ecosystems), with an emphasis on Alaska. The cryosphere will also be placed in context of the global climate system. Oral intensive will include instructor and peer feedback. Special fees apply. Prerequisites: PHYS F103X and MATH F200X or instructor permission. (2+3)

Ice in the Climate System
GEOS F377 O Syllabus

INSTRUCTOR: Erin Pettit
Tel: 474-5389
email: pettit@gi.alaska.edu (email is best way to contact me)
Offices: 338 Reichardt and 410 B Elvey (GI)
Office hours: by appointment
you are welcome to drop by my office anytime after noon, I am glad to help if I have time.

COURSE LOGISTICS:

Time: We will meet Wednesday and Friday from 1 to 2pm and Thursdays from 2 to 5 pm.
Place: Reichardt 229

PREREQUISITES:

PHYS F103X AND MATH F200X; permission of instructor

COURSE MATERIALS:

Book: There will be one required textbook:

The Global Cryosphere: Past, Present and Future by Barry and Gan, 2011, Cambridge University Press.

Course Packet There will be a course reading packet that contains selected required readings and worksheets for activities. This will be available on Blackboard at the beginning of the semester. A list of required readings included in the course packet is at the end of the schedule.

Field Notebook You will need one *Rite in the Rain* notebook for notes during our outdoor explorations. A variety of online sellers have these. I recommend: Level, Spiral Notebook, 4 5/8" x 7" which has 32 pages. If you write large you may go to a larger size or a version with more pages. You may get any page line pattern you prefer (lines, grids, or plain). *Do not get anything smaller than 4 5/8" x 7"*. You may purchase one from the instructor if you bring cash (\$8) to the second meeting.

Field Clothing You must have boots and clothing capable of keeping yourself warm for several hours at temperatures as low as -30F. It is possible to rent plastic mountaineering boots for the afternoon from Outdoor Adventures for a small cost. I also recommend toe warmers and hand warmers for the coldest days. We will discuss types of clothing on the first day and options for borrowing items you don't own.

Recommended additional books (we will read selections from some of these, they also provide additional background information for activities and projects). These books will be on reserve at the library.

1. *Life in the Cold* by Marchand
2. *The Climate Crisis* by Archer and Rahmstorf
3. *The Cryosphere and Global Environmental Change* by Slaymaker and Kelly

4. *On Sea Ice* by Weeks
5. *Dynamics of Snow and Ice Masses* by Colbeck
6. *Glaciers* by Hambrey and Alean
7. *The Little Ice Age* by
8. *Physics of Glaciers* by Cuffey and Paterson
9. *Earth's Climate: Past and Future* by Ruddiman
10. *Glaciers of North America* by Ferguson
11. *Avalanche Handbook* by McClung and Schaerer
12. *Glacier Science and Environmental Change* by Knight
13. *Sea Ice* by Thomas and Dieckmann

COURSE DESCRIPTION:

Snow, permafrost, sea ice, glaciers, and ice sheets (the cryosphere) play a major role in both local and global climate and ocean system. In this course we will use an interdisciplinary perspective to study how snow, permafrost, sea ice, glaciers, ice sheets respond to changes in climate and environmental conditions and how the local environment responds to changes in snow and ice. We will emphasize Alaska and the Arctic, but also study the global interactions between ice and the climate system. As a geophysics course, we will emphasize the physical processes involved; however, we will also emphasize the interdisciplinary nature of this subject through course assignments which will allow students from other disciplines (such as oceanography, chemistry, biology, or math) to highlight those connections. The course will combine readings, discussions, in-class activities, hands on data collection and analysis, homework assignments, exams, and weekly oral presentations.

After taking this course, you will be able to:

1. describe the formation processes and evolution of snow, sea ice, permafrost, glaciers, and ice sheets
2. recognize the importance of these forms of ice in the Arctic system, particularly with respect to their interactions with climate, weather, ecosystems, ocean, and landscapes.
3. apply basic concepts in physics to processes in the natural world, such as heat flow and mass conservation
4. confidently express concepts, ideas, and conclusions in an oral format with a varying amount of preparation and visual aids.

In order to succeed in this course you will need to have

1. some background in physics and calculus and be willing to try applying those concepts to natural processes
2. an interest in Arctic landscape (biological and physical)
3. a willingness to explore the snow and ice on our campus (we will spend time outside!)

This course will be taught with an interdisciplinary emphasis. This means that if, for example, you come from a physics background, you will be expected to work closely with students from a biology background, for example, and learn from each other the interactions between

biological and physical processes. During most activities, you will work on interdisciplinary teams.

COURSE GOALS: The goal of this course is to build students foundational knowledge in the cryospheric components of the global climate system, with a particular emphasis on the Arctic. After this course, the students will be able to discuss knowledgeably many aspects of Alaskan landscapes with other scientists or science students. This course will use a student-driven learning environment that builds their confidence in making observations, framing questions, and designing experiments in order to understand physical processes.

STUDENT LEARNING OUTCOMES:

Content

Students will be able to:

1. Classify ice masses (land and sea ice) based on their formation, morphology, temperature,
2. Understand the basics of global energy balance,
3. Explain what a positive and negative feedback is and provide examples of feedbacks between the cryosphere and the global climate system,
4. Describe what the mass balance of a glacier, ice sheet, or sea ice is and how climate affects the mass balance for each,
5. Summarize the movement and dynamics on seasonal, decadal, and longer timescales of various forms of ice (glaciers, ice sheets, permafrost, sea ice) and the role dynamics plays in terms of its response to climate change.
6. Discuss the Milankovitch cycle and the theory of the ice ages.
7. List linkages between the physical, chemical, biological processes active in Arctic Landscapes
8. Identify methods for determining past climates and explain in more detail how ice cores record past climate.
9. Discuss the possible future changes in Alaskan icy landscapes under various climate scenarios

Skills

The students will be able to:

Numerical:

1. convert units,
2. make an order of magnitude calculation in one's head,
3. go from a verbal or visual description of an earth process to an equation (in algebra or trigonometry, not calculus)

Spatial Relationships:

1. internalize a map of the earth with continents, oceans, major mountain ranges and major ice bodies in the correct places (be able to sketch from memory),
2. plot positions and measure distances on a map using lat and long,

3. use the concept of scale in describing earth processes (e.g. different properties of ice at microscopic and macroscopic scales)

Time and Changes Through Time (rate):

1. discuss and visualize a specific earth process occurring on a variety of timescales (for example: changes in the mass balance of glaciers over seasonal to multi-millennial time scales)

Critical Thinking:

1. identify and articulate assumptions;
2. assemble a logical chain of reasoning from cause to proximal effect to distal effect;
3. articulate the difference between cause-effect relation and correlated data sets;
4. assemble a logical chain of reasoning from observation to inference;
5. detect flaws in other people's chains of reasoning;
6. recognize a testable hypothesis;
7. given a set of observations, formulate a potentially testable hypothesis to explain those observations

Communication:

1. make a lucid, *unrehearsed*, short oral presentation of a geoscientific observation, process or chain of reasoning using appropriate professional vocabulary;
2. make a lucid *rehearsed* oral presentation describing a geoscientific observation, process or chain of reasoning using appropriate professional vocabulary;
3. provide useful visual aids for an oral presentation
4. use a simple plotting program for figures and diagrams
5. use email (with appropriate level of formality for the content and receiver(s));

INSTRUCTIONAL METHODS and COURSE FORMAT:

This course will consist primarily of hands on activities and group discussions/activities. There will be minimal traditional lecturing. You will be expected to read the materials *before* each class and use the knowledge from the reading during the class discussions.

Wednesday and Friday: We will meet for one hour for discussion of reading material, group and individual problem solving and short answer questions, group discussion, oral presentations, and exams.

Thursday: We will meet for a three hour block that will typically be used for group projects involving making observations of the snow and ice on campus, setting up experiments, discussing the processes we observe, collecting data, and preparing oral presentations. This time will also be used, for example, to visit the CRREL Permafrost Tunnel.

Outdoor activities: *We will spend at least half of the Thursday afternoon block time out of doors.* We will go outside regardless of the weather, we will discuss what you should wear the first day of class. If you do not come prepared to be out of doors, the same policy applies as if you had missed class.

Blackboard: In addition to the course packet, the digitally available readings will be posted on Blackboard, this provides a secured place to put copyrighted material. We will also hold on-line discussions on Blackboard.

Prezi: We will use spatial presentation software Prezi (prezi.org) for concept maps as well as to display visual aids for oral presentations. You will need to use your alaska.edu email account to create a FREE prezi educational account for yourself. Please take time to familiarize yourself with prezi.

Website: The course website is <http://ice.gi.alaska.edu/education/iceandclimate>
I will post the syllabus, additional information, and links to interesting online material here.

COURSE CALENDAR:

Please see attached detailed course schedule.

COURSE POLICIES:

I make the course policies regarding late assignments or missed classes flexible enough to accommodate reasonable amount absence for illness, emergencies, or required university sponsored absence. It is up to you to decide if and how to use the flexibility I have built into the course. Because of this built in flexibility and the hands-on nature of this course, I do not generally make additional accommodations.

1. **Absence:** If you miss a class, you will be required to make up the work with assistance from your group members or you will have to complete an alternative assignment. Please contact me by email as soon as you know you will miss a class (even if it is just one hour before the class).

Wednesday and Friday Classes: You may miss two (2) Wed or Fri classes without significant impact on your grade if you make up the work before the following Wednesday class.

Thursday Block Class: You may miss one (1) Thurs Block class without significant impact on your grade if you work with your group to make up the work promptly. Making up work on Block days will take substantial more effort and will require you working closely with your group. You will still be required to be a contributor to group projects; for example, if you miss a day of data collection, you will be required to take more a of a lead on the analysis of the data. In some cases you may need to complete an alternative assignment.

2. **Late Assignments:**

- (a) You will make approximately one oral presentation per week (thirteen total). Because this is an oral intensive course, these generally cannot be given late. I will drop the lowest oral presentation score (which means you can miss one presentation without penalty). The dates for the graded Oral Presentations are listed in the left column on the schedule as *Oral #1*.
- (b) There are 10 written short answer/problems (due dates on left column of schedule as *Written #1*). These are due in Wednesday classes. You may turn them in by Friday for 5% off of the grade or the following Monday for 10% off of your grade, or the following Wednesday for 15% off your grade. Because these are for immediate feedback for your learning I do not accept them later than one week after their due date. I will drop your lowest homework grade (or you may not turn in one).

ASSESSMENT:	Attendance (5 pts per week)	70
	Written Assignments (40 pts each)	360
	Oral Assignments (40 pts each)	480
	Completion of Outline/Notes from Readings	100
	Written Final	120
	Oral Final	120
	Contributions to Activities and Discussions (5 pts per week)	70
Total Possible	1320	

- 1. Attendance:** You receive one point for each Wed/Fri Class and three points for each Block Class you attend and participate. As written above, you may miss two Wed/Fri Classes and one Thur Block without penalty.
- 2. Written Assignments:** Written assignments include both short answer, short essays (paragraphs), and problems. There will be 10 assignments total, I will drop your lowest score.
- 3. Oral Assignments:** This is an oral intensive course: there are 13 oral assignments, worth 40 pts each. Two of the oral assignments will have two parts (each worth 40 pts). I will drop your lowest score. Most of the oral assignments will be 2-5 minutes. During the semester, you must choose 3 from a list of specific oral assignments to expand your presentation to a full 5 minutes for a more thorough assessment of your speaking skills (these three are not eligible to be the dropped score).
- 4. Completion of Outline/Notes from Readings:** I will check completion of written outline and notes from the readings (using the guided outline I provide) during the first week and then several random checks throughout the semester. If a random check happens on a day you are absent, you will be asked on another day (not necessarily the day following). Each incomplete outline will result in deduction of up to 15 pts.
- 5. Written Final:** The written final will be similar to the written assignments and may include short answer, short essay and problem solving.
- 6. Oral Final:** The oral final will consist of a poster developed by your group and an individual oral component of 3-5 minutes.
- 7. Contributions to Activities and Discussions:** This includes being cooperative in working in your groups, contributing to group discussion (without my having to ask or remind you to contribute), being helpful in preparing for hands on activities, offering thoughtful ideas and asking questions, providing peer feedback as requested, and volunteering to help others in the class. These points will be earned through a combination of my observations and interactions with you and through anonymous peer feedback. I will provide written feedback in the 4th and 10th week of the semester on your progress and offer suggestions for improvement if necessary. You are welcome to request additional feedback.

Your final grade will be calculated as a percentage of the total number of points possible.

	A+ (97-100%)	=1280
	A (93-96.9%)	=1228
	A- (90-92.9%)	=1188
	B+ (87-89.9%)	=1148
	B (83-86.9%)	=1096
Minimum Points Required:	B- (80-82.9%)	=1056
	C+ (77-79.9%)	=1016
	C (73-76.9%)	=964
	C- (70-72.9%)	=924
	D+ (67-69.9%)	=884
	D (63-66.9%)	=831
	D- (60-62.9%)	=792
	F (0-59.9%)	=0

DISABILITY ACCOMMODATION: The Office of Disability Services implements the Americans with Disabilities Act (ADA), and insures that UAF students have equal access to the campus and course materials. UAF is committed to equal opportunity for all students. If you have a documented disability, please let us know **AS SOON AS POSSIBLE**, and we will work with the Office of Disabilities Services to make the appropriate accommodation(s). If you have a specific undocumented physical, psychiatric or learning disability, you will benefit greatly by providing documentation of your disability to Disability Services in the Center for Health and Counseling, 474-7043, TTY 474-7045. (For example: procrastination issues, dyslexia, ADHD...)

If you are the first in your family to attempt a four-year college degree, and/or eligible for Pell grants, you have opportunities for tutorial and other forms of support from the office of Student Support Services. We will collaborate with the Office of Disabilities and/or the Office of Student Support Services to make your educational experience in our class as positive as possible. Check the following website for further information:
<http://www.uaf.edu/advising/learningresources/>

Ice in the Climate System GEOS F377 O Schedule

General Weekly Schedule:

Wednesday: 1-2pm ("W Class")

Thursday 2-5pm ("Block")

Friday 1-2pm ("F Class")

Typical weekly content:

Wednesday (W Class): one hour of introduction to concepts for the week.

- Students arrive having read the material and taken notes or answered questions based on an outline I provide (with incentives such as random checking of outline/notes or initial activity that requires using some basic concepts from reading).
- Question Time: Discussion regarding questions emailed to me the night before or asked at this point to clear up questions from reading.
- 1-2 activities such as small group discussions, gallery walks, think/pair/shar, jigsaws that require them to work alone and together to solve problems/answer questions/practice using material from the reading.

Thursday (Block): three hour block of time for deeper hands-on problem solving, experiential learning activities. These activities vary including setting up experiments, collecting data, working with Google Earth on computers, solving problems, and working in teams to prepare a group presentation.

Friday (F Class): one hour of instruction that will include several activities intended to review/solidify the concepts of the week and will typically involve students giving a short 1-5 min oral presentations.

Selected Readings the following Books:

Barry and Gan *The Global Cryosphere, Past Present and Future* : Your Textbook

Marchand *Life in the Cold*

Archer and Rahmstorf *The Climate Crisis*

Colbeck *Dynamics of Snow and Ice Masses*

Cuffey and Paterson *Physics of Glaciers*

Ruddiman *Earth's Climate: Past and Future*

Ferguson *Glaciers of North America*

McClung and Schaerer *Avalanche Handbook*

Knight *Glacier Science and Environmental Change*

Thomas and Dieckmann *Sea Ice*

And the following articles:

Chapman and Davis. 2010. *Climate Change Past Present and Future* EOS 91(37)

Yde and Paasche. 2010. *Reconstructing Climate Change: Not all Glaciers Suitable* EOS 91(21)

Falkner and others. 2011. *Context for the Recent Massive Peterman Glacier Calving Event* EOS 92(14)

Grosse and others. 2011. *Vulnerability and Feedbacks of Permafrost to Climate Change* EOS 92(9)

Post and others. 2011. *Tidewater Glaciers* EOS 92(25)

Kwok and Untersteiner. 2011. *The Thinning of Arctic Sea Ice* *Physics Today*. April 2011.

Summary of Oral Assignment Topics:

Oral #1: Week 1, Discovering Snow

Oral #2: Week 2, Exploring Snow

Oral #3: Week 3, Climate and Cryosphere

Oral #4: Week 4, Permafrost Tunnel

Oral #5: Week 5, Making Ice Predictions

Oral #6: Week 7, Making Ice Results

Oral #7 and #8: Week 8, Smith Lake Radar Experiment

Oral #8 and #10: Week 10, Flubber Teaching

Oral #11: Week 11, GPS on Campus

Oral #12: Week 12, Glaciers Move

Oral #13: Week 13, Going Back in Time

Oral Final: Week 15, Snow, Sea Ice, Glaciers, or Ice Sheets (topic determined by the interdisciplinary learning groups topic from day one)

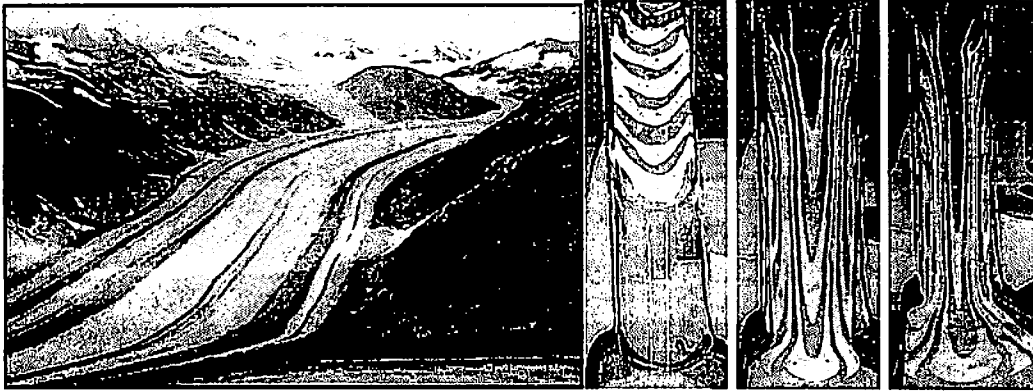
	Reading/Assignments	Topics	In-Class Activities
Week 1	<p>W Class: No reading</p> <p>Block: No reading</p> <p><i>Oral #1 due</i></p> <p>F Class:</p> <p>Barry and Gan Ch 1.1-1.2, 2.1-2.3</p> <p>Archer Ch 4</p>	<p>Intro to Course</p> <p>Overview of Cryosphere</p> <p>Snow</p> <ul style="list-style-type: none"> • formation in atmos • sun penetration • wind redistribution • interaction with vegetation • interaction with organisms <p>How to make observations and formulate questions</p> <p>Oral: The basic components of an oral presentation.</p>	<p>W Class: Introductory Group Puzzle</p> <p>F Class:</p> <p>Check outlines/notes from reading.</p> <p>Short answer worksheet for <i>Written #1</i></p> <p>Block: <i>Discovering Snow Activity</i> (see attached activity). Learning Outcomes:</p> <p>Oral: Discovering Snow includes oral synthesis presentations as a group</p>
Week 2	<p>W Class:</p> <p>Barry and Gaw Ch 2.4-2.7</p> <p><i>Written #1 due</i></p> <p>Block: Supplemental Readings</p> <ul style="list-style-type: none"> • Bio: Marchand Ch 1,3,4 • Phys: McClung Ch 2 • Chem: McClung Ch 3 • Geo: Barry and Gaw Ch 2.8-2.11 <p>F Class:</p> <p><i>Oral #2 due</i></p>	<p>Snow</p> <ul style="list-style-type: none"> • metamorphism • depth hoar formation • water percolation • ecology of snow • small scale (microscopic snow) • large scale (landscape patterns) • avalanching <p>Going from observations and questions to designing an experiment</p> <p>Oral: Using oral format to teach a concept</p>	<p>W Class:</p> <p>Check outline/notes from reading</p> <p>discussion of snow photographs</p> <p>Prepare for Snow Exploration</p> <p>F Class: Oral component (teaching) of Snow Exploration</p> <p>Block: <i>In Depth Snow Exploration:</i></p> <p>Oral: Each-one-teach-one synthesis</p>

<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Week 3</p>	<p>W Class: Barry and Gaw Ch 2.11 Barry and Gaw Ch 9.1-9.2, 10.1-10.3 Archer Ch 2 Block: No reading <i>Oral #3 due</i> F Class: No reading</p>	<p>Climate overview</p> <ul style="list-style-type: none"> • Global Energy Budget • Atmospheric circulation • Greenhouse effect <p>Albedo feedback</p> <ul style="list-style-type: none"> • Snowball Earth • Modern Albedo effect 	<p>W Class: Create Climate concept Map Group activity: simple climate data sets F Class: Group problem solving and short answer (<i>Written #2</i>) Block: <i>Climate Activity</i> Requires use of Geology Computer Lab Oral: 2 minute presentation</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Week 4</p>	<p>W Class: Barry and Gan Ch 5 <i>Written #2 due</i> Block: No reading <i>Oral #4 due</i> F Class: Grosse and others (2011)</p>	<p>Permafrost</p> <ul style="list-style-type: none"> • types of permafrost • formation of permafrost • Active layer • thermal structure • role of permafrost in arctic 	<p>W Class: Intro to Permafrost processes Activity F Class: Group problem solving activity (turned in as <i>Written #3</i>) Block: <i>Permafrost Tunnel</i> visit Oral: Individual 2 min presentation</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Week 5</p>	<p>W Class: <i>Written #3 due</i> Block: No reading <i>Oral #5 due</i> F Class: Life under Ice Marchand Ch 5</p>	<p>Evolution and Change of Permafrost</p> <ul style="list-style-type: none"> • formation of patterned ground • thermokarst • spatial variability across the arctic <p>Freshwater ice</p> <ul style="list-style-type: none"> • formation • Lake Ice • River Ice • Role in the Arctic 	<p>W Class: Permafrost Jigsaw activity F Class: Lake/River Ice group question/problem solving activity as <i>Written #4</i> Block: Begin <i>Making Ice Experiment</i> Oral: Each group makes presentation on their predictions</p>

<p style="text-align: center;">Week 6</p>	<p>W Class: <i>Written #4 due</i> Barry and Gan Ch 7</p> <p>Thomas and Dieckmann 5</p> <p>Block: No reading</p> <p><i>Oral #6 due</i></p> <p>F Class:</p> <p>Thomas and Dieckmann Ch 2</p>	<p>Sea Ice</p> <ul style="list-style-type: none"> • formation • growth • movement • thickness • formation of keels and pressure ridges • temperature 	<p>W Class: Sea Ice Growth Activity</p> <p>F Class: Sea Ice group question/problem solving activity as <i>Written #5</i></p> <p>Block: Continuation of <i>Making Ice Experiment</i> (just monitoring the ice development)</p> <p>Begin <i>Smith Lake Radar Experiment</i></p> <p>Oral: Oral component of <i>Smith Lake</i> activity happens in second week.</p>
<p style="text-align: center;">Week 7</p>	<p>W Class:</p> <p>Thomas and Dieckmann Ch 8, 11</p> <p>Kwok and Untersteiner (2011)</p> <p>Block: No reading</p> <p><i>Oral #6 due</i></p> <p>F Class:</p> <p><i>Written #5 due</i></p>	<p>Sea Ice</p> <ul style="list-style-type: none"> • microbiology of Sea Ice • sea ice as habitat • response to climate change 	<p>W Class: Gallery Walk of sea ice biology</p> <p>F Class: Role Playing discussion/debate of retreating Arctic Sea Ice</p> <p>Block: Completion of <i>Making Ice Experiment</i></p> <p>Oral: Making Ice Experiment concludes with structured 5-8min oral presentation by each group</p>
<p style="text-align: center;">Week 8</p>	<p>W Class:</p> <p>Barry and Gan Ch 3</p> <p>Selections from Cuffey and Paterson Ch 4, 5</p> <p>Block: No reading</p> <p><i>Oral #7 and 8 due</i></p> <p>F Class: No Reading</p>	<p>Mountain Glaciers</p> <ul style="list-style-type: none"> • Formation • mass balance • surface energy balance • response to climate <p>Oral: How to focus an oral presentation for a specific audience.</p>	<p>W Class: Mountain Glaciers Challenge activity</p> <p>F Class: Exploring temperature gradients activity - Computer Lab</p> <p>Block: Completion of <i>Smith Lake Radar Experiment</i></p>

Week 9	<p>W Class: Selections from Cuffey and Paterson Ch 8 Post and Others (2011) Yde and Paasche (2010) F Class: No reading</p>	<p>Mountain Glaciers</p> <ul style="list-style-type: none"> • movement and flow • erosion • tidewater glaciers • surging glaciers 	<p>W Class: Designing Experiments using Scientific Method Activity and Discussion F Class: Special types of Mountain Glaciers Block: <i>Flubber Ice Experiment</i></p>
Week 10	<p>W Class: Barry and Gan Ch 4,8 Block: No reading <i>Oral #9 and 10 due</i> F Class: No Reading</p>	<p>Ice Sheets</p> <ul style="list-style-type: none"> • formation • mass balance • feedbacks with climate • movement 	<p>W Class: Comparing Ice Sheets Discussion/Activity (may need computer lab) F Class: Glaciers group question/problem solving activity as <i>Written #6</i> Block: Continuation and Completion of <i>Flubber Experiment</i> Oral: 15 minute presentations to teach elementary students about glaciers.</p>
Week 11	<p>W Class: Barry and Gan Ch 8 Falkner and others (2011) <i>Written #6 due</i> Block: No reading <i>Oral #11 due</i> F Class:</p>	<p>Ice Sheets</p> <ul style="list-style-type: none"> • ice streams • ice shelves • instability of ice shelves and ice sheets 	<p>W Class: Ice Shelf Disintegration Discussion/Questions F Class: Group problem solving/questions turned in as <i>Written #7</i> Block: <i>Exploring campus using GPS</i></p>
Week 12	<p>W Class: Archer Ch 6 Chapman and Davis (2010) Cuffey and Paterson Ch. 15 (Selections) <i>Written #7 due</i> Block: No reading <i>Oral #12 due</i> F Class: No reading</p>	<p>Ice Sheets: paleoclimate and ice cores</p> <ul style="list-style-type: none"> • Chemistry of ice cores • physics of ice cores • interpreting ice cores • relating ice cores to past climate 	<p>W Class: Ice Cores Jigsaw (Chem/Phys/Bio/Geo) F Class: Group Problem Solving/Questions turned in as <i>Written # 8</i> Block: Glacier movement using GPS.</p>

Week 13	<p>W Class: Barry and Gan Ch 9.5-9.6, Ch 10 Cuffey and Paterson Ch 13 (Se- lections) <i>Written #8 due</i></p> <p>Block: No reading</p> <p>F Class: <i>Oral #13 due</i></p>	<p>Cryosphere-Climate</p> <ul style="list-style-type: none"> • Feedbacks • changes in each cryosphere component 	<p>W Class: Questions/Problem solving turned in as <i>Written #9</i></p> <p>F Class: Oral Component of Going Back in Time Give assignment for <i>Written #10</i></p> <p>Block: Going Back in Time Activity</p>
Week 14	<p>W Class: Cuffey and Paterson Ch 14 (Se- lections) <i>Written #9 due</i></p> <p>Block: No reading</p> <p>F Class: <i>Written #10 due</i></p>	<p>Cryosphere and Climate Bringing it all together</p>	<p>W Class: Expand on Climate Concept Map Challenge Review questions as Groups</p> <p>F Class: Review Discussion for fi- nal</p> <p>Block: Preparation for Final Oral Presen- tation</p>
Week 15			<p>Final Exam and Final Oral</p>



(a)

(b)

GEOS 377 O Ice and Climate
Flubber Glacier Flow Experiments
Erin Pettit
University of Alaska Fairbanks

1 Brief Description

This activity has two overarching objectives. First to give you an opportunity to go through a science experiment from beginning to end. Second, for you to discover and explore some of the key factors that affect glacier flow.

**Note this is an advanced version of an activity currently done in GEOS F120.*

2 Context

- This activity is intended for a semester long course called Ice in the Climate System. This is a 3rd year undergraduate course required for geophysics students, but taught in an interdisciplinary way to engage biology, physics, chemistry and geology students.
- Students need basic skills in data collection and analysis for this activity.
- This activity is conducted over two 3-hour block periods. The first 3 hour block is intended for development of the ideas, design of the experiments, and collection of data. The second block one week later, is intended to conduct additional experiments, process the data, and present the results to other students in the class.

3 Goals

1. Content and Concepts of Glacier Flow

- how temperature affects flow
- spatial patterns of flow,
- how slope and bed conditions affect flow,
- how the shape of the terminus reflects internal flow dynamics,
- techniques for making field observations

2. Higher Order Concepts

- recognizing the difference between observations and inference,
- framing a scientific question,
- formulating a hypothesis,
- designing a method for measuring flow.

3. Other Skills Goals

- working in groups
- synthesizing results toward making an oral presentation

4 Description

The students will come into this activity with some background in glacier flow from the reading and some background for designing experiments from past science classes. In their groups, they will formulate specific testable questions based on the reading, design experiments, conduct experiments, consider modifications necessary to improve their results, process their data, present their results to others.

5 Evaluation

- Formative assessment is provided by the instructor through reviewing the development of their questions and their experimental design. The instructor will do this both verbally and through reviewing written notes.
- Summative assessment is through the 5-10 minute presentation the group gives at the end. Their presentation will be judged on designing an experiment that isolates variables of interest, clarity of describing methods used, usefulness of diagrams and figures, connecting

conclusions with data directly supporting those conclusion. A rubric will be provided to the students describing the assessment in detail. Individual students will additionally be assessed on their contributions to the group effort.

6 Materials

1. Flubber Ice (make multiple colors)

Mix 1 = 3/4 cup warm water, 1 cup Elmer's glue, food coloring

Mix 2 = 1/2 cup warm water, 2 teaspoons Borax

Mix each separately, then slowly add Mix 2 to Mix 1 while mixing with your hands.

2. Toothpicks or other marking tools

3. Tray for base

4. Sandpaper

5. Vegetable or similar oil

6. Stopwatch

7. Camera (point and shoot)

8. Graph paper

9. Sharpie markers

7 Assignment: What is given to students

Background: The Scientific Method:

Science never goes as planned. Scientists do not know the conclusions of their experiments until they actually get there, along the way they may go down several dead end roads, they may have to choose one direction or another not knowing which is better. Science is like being dropped off in a mountainous landscape with no map and not being told what your goal is suppose to be. This is incredibly difficult to teach in a classroom situation because attempting it require the desire to explore without necessarily a known end point. This lab is more about the exploration than the endpoint. So enjoy the exploration.

Many (but probably not all) of you have learned and tried to conduct experiments using the scientific method in past classes (or at home on your own), this is your chance to bring together what you have learned in the past about the scientific method and apply it here to

learn about glacier flow. This activity is designed to help you learn both concepts regarding glacier flow as well as concepts in how the scientific method works.

This is based on Dr. Pettit's version of the scientific method (which has some slight variations from the "standard" scientific method).

Step 1: Explore.

The goal of this step is to get your creative mind working. Brainstorm with your group ideas on how you can use flubber ice to simulate glacier flow. A brainstorm idea can be a question or an idea on how to use materials.

Here are some examples of brainstorming ideas to get you started:

1. What materials are you working with?
2. Take the flubber ice in your hand and explore its properties. Does this seem like it might work to simulate glacier flow?
3. Consider the aspects of glacier flow that you have learned in class. Set it on the table and watch it change. Does it maintain its shape or does the shape change? If it breaks do the sharp edges persist or do they round off?
4. What other material do you have available that might help simulate aspects of glacier flow?
5. Does the temperature of the flubber ice matter?
6. Does it matter if it is flowing across a smooth surface versus a rough surface?
7. Does it flow differently if it is on the flat tabletop or flowing down an inclined plane?
8. Does the top of the flubber blob flow faster than the bottom (where it touches the table or ramp)?
9. Is there a spatial pattern to the flow – faster in some places and slower in others?
10. Can you create "valley" shapes that would cause it to stretch in some places and compress in others?
11. What if it flows over another object?
12. Or flows down a slope through a constriction?
13. What are different variables that might affect the way the flubber ice flows?

Take at least 15 minutes to just brainstorm and write at least 10 of your group's brainstorm ideas here:

Step 2: Questions.

Now that you have some ideas you need to narrow down your ideas to focus on a few questions that you want to pursue in an experiment. Please focus on three questions that are realistic and testable in terms of making actual observations. Clear, specific questions are better than general questions. For example:

Bad: What affects flubber ice flow speed? *This question is too general.*

Good: How is flubber ice flow speed affected by the temperature of the flubber ice? *This question is specific enough to test*

You can go back to the Explore step if necessary. And you can work back and forth between Question, Experimental Design, and Hypothesis steps (see below). You will find that the more specific the question and hypothesis are the easier it is to design the experiment. When you have decided among your group, write your three questions here:

Step 3: Hypothesis and Predictions.

A hypothesis is a type of prediction that is testable. For each of your questions listed in Step 2 you need to have a hypothesis for what you think might happen. For the example question above, one possible hypothesis is:

Ok, but not great: Flubber Ice increases its flow speed as temperature increases.

Better: The flow speed at the surface a Flubber Ice glacier increases linearly with temperature. The flow speed is more sensitive to temperature than to other common factors such as slope and width of the glacier.

Having this hypothesis gives you something to test. Most likely you have been thinking about each hypothesis as you wrote the questions and you will continue to think about this as you design the experiment, but you need to write it down explicitly. At this point, write a "first draft" of your hypotheses for your three questions. You may have a different hypothesis than the other members of your group. Be as specific as you can! Write down your hypotheses here:

Step 4: Experimental Design.

1. What variable are you testing? How can you "control" other variables - keep them constant while you vary the variable you are interested in.
2. What do you need to measure (all measurements)? How often do you need to make each measurement in order to answer your questions? For example, if you want to measure the speed of the flow, how will you measure the distance the flubber ice moves? How will you measure the time? Would you get better results if you make the measurement several times and average the results in the end?

3. Be aware that some experiments may go quickly, some slowly. If your experiment goes slowly in the beginning, it is ok to alter your design to make the experiment run faster.
4. List the materials that are necessary. For example, are toothpicks useful? If so, how will you use them? What measuring device will you use?
5. Write the detailed steps you need to take to make each measurement.
6. Remember that when you compare results from different runs, you need to make sure everything is the same except the variable your question focuses on.
7. Write down everything you do that would be necessary if someone else wanted to take your method and repeat your experiment as closely as possible. For example, does the size and shape of the initial "blob" you start with matter for your repeated experiments?
8. It might be appropriate for you to draw a diagram or take a photo of your experimental setup.
9. In order to keep track of your measurements, you will need to make at least three tables (one for each experiment) that show how your variables are changing and what you will measure for each experimental run.
10. It is also good to think about possible errors in your measurements at this point (see Step 7)

Step 5: Run your Experiment.

Take the data tables that you drew for the experimental design and use it as a guide to run your experiments. But, we know that science never happens as we plan it to, if you realize part way through that your table is not quite right for the experiments you are running. Stop and fix it! That is ok, that is part of the learning process! In addition to keeping track of the data in the data table, it will probably be useful to draw how the "glacier" (and any markers you put on the "glacier") changes through each run. You can also use the digital cameras in the lab to take before, during, and after photos or even videos. Collect as much data and take as many notes as you can at this stage. If you notice something interesting, write it down! It might be useful at the end when you look at all the data together.

(drawings, photos, diagrams, extra notes on experimental runs here)

Step 6: Conclusions.

Steps 6, 7, and 8 all go together. After finishing the experiments, discuss with your group what conclusions you feel confident in. For each question and hypothesis you should have a corresponding conclusion. For example, were your measurements different enough to be able to say definitively that warm flubber ice flows more quickly than cold flubber ice? You may find you need to plot your data to see the conclusion more clearly. Write down your

conclusions as they relate directly to your questions and hypotheses. These conclusions will be the same for everyone in your group because you are working as a team. Once again, be as specific as possible. If the flubber ice at -5°C flows 10 times faster than flubber ice at -10°C , then write this down as your conclusion (not just that warm flubber ice flows faster).

Step 7: Uncertainty and Error Analysis.

As you write out your conclusions and compare them with other groups running similar experiments it is critical for you to think through what factors might have led to small differences in your measurements. Did you do multiple runs with the same exact conditions? This will help you understand the uncertainties caused by your experimental design. How well were you able to make each measurement with the tools that you have? For example, is your ruler for measuring distances ticked off in mm or cm? Make a list of possible sources of errors here, we will discuss this as a class as well.

Step 8: Present Your Results

This step is very important for real scientists. You have written your conclusions as a team in Step 6, but what would it take to convince someone who wasn't in the room that your conclusions are true? If you were to try to convince a friend of yours, would you show them pictures? A graph of the data? Your group will present this to the class, but to help develop the presentation, do the following:

- Write a couple of introductory ideas for the presentation. What were the questions you were trying to answer? Why is this interesting?
- For each question, provide the conclusion and explain your evidence (the data and results from your experiments) that made you reach the conclusion you did.
- Include any drawings, diagrams, or graphs that provide supporting evidence for your conclusion.
- If your conclusion differed from your hypothesis, offer a reason why.

8 Assessment

How will this lab be graded?

Because of the experimental nature of this lab, you will not be graded on whether you get a specific answer in making your measurements. Instead you will be graded on these concepts or activities for each step as presented in your final presentation and through handed in evaluation of your group efforts:

- Explore. How well did your team work together? Did all people in a group contribute to the brainstorming and identifying the questions.

- **Question.** Are your questions clearly written, specific, and feasible?
- **Experimental Design.** Did you think carefully about which are your variables and which are things that need to be kept constant? Did you come up with good methods for making the measurements? Did you draw data tables? Did all members of your team contribute to the experimental design?
- **Hypothesis.** Do you have a hypothesis for each of your questions? Is each hypothesis specific enough to be able to test it?
- **Conduct Experiment.** Were the experimental runs completed in an orderly fashion with good note taking? Were you careful with your measurements? Did you work together as a team?
- **Conclusions.** Are your conclusions based on evidence from your experiment (even if it doesn't match your hypothesis)? Did you state all of your conclusions clearly?
- **Uncertainty and Errors.** Did you discuss your possible sources of slight variations in measurements with the other lab groups?
- **Overall presentation of your results** (see guidelines on good presentation techniques).

GEOS 377 O Ice and Climate
Snow Exploration
Erin Pettit
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1 Brief Description

This activity is intended to get students engaged and thinking about the role that snow plays in our climate system. It is a hands-on inquiry-based activity that students with no background knowledge can do. The students dig shallow snow pits on campus make observations of texture and color, sketch any layered or other patterned structure, measure the density, and view and sketch crystals in a microscope.

2 Context

1. This activity is intended for the first day of a semester long course called Ice in the Climate System. This is a 3rd year undergraduate course required for geophysics students, but the activity would work for any upper level undergraduate science major (or lower level undergraduate with slight modifications).
2. As an introductory activity, they do not need any skills or concepts before the activity, just an initial curiosity.
3. It is intended for the first day of the lab class (3 hours maximum), but could be used at the beginning of a short unit on snow or climate also. The main part of the activity should take 2.5 hours (30 minutes each for 4 parts, plus another 30 minutes for oral syntheses from each group)

3 Goals

1. Content and Concepts
 - (a) snow crystal growth in atmosphere,
 - (b) Snow pack structure,
 - (c) metamorphism (equilibrium and temperature gradient),
 - (d) snow albedo and the snow albedo feedback,
 - (e) techniques for making field observations

2. Higher Order Concepts

- (a) recognizing the difference between observations and inference,
- (b) framing a scientific question,
- (c) formulating a hypothesis,
- (d) designing a method for measuring density.

3. Other Skills Goals

- (a) working in groups
- (b) synthesizing results toward making an oral presentation

4 Description

The students will come into this activity with no or very little knowledge of snow. They will divide into groups, each group receiving the first list of questions (on Rite-in-Rain paper). The questions help guide them through their inquiry and are divided into groups: A) initial observations, B) measurement and detailed observations, and C) inferences and hypotheses. They dig a snow pit to the ground (typically < 2ft).

Part A, they study the layered structure, the texture of different layers, the color (presence of sediment?), initially using basic sketching. Then they decide what aspects are worth measuring in further detail (such as thickness of layers, hardness of layer, density of layers, size of crystals) and come up with a plan.

Part B, they are allowed to begin making their measurements and they are given guiding questions, such as what are the errors in these measurements? How many measurements is sufficient to describe the characteristic you are describing?

Part C is primarily brainstorming ideas and hypotheses among their group, and they can return inside if they choose. They are asked consider the role that snow plays on the landscape. How does the snow affect the ground underneath it? Would that role be different at the coldest part of winter than during the spring melt? Does snow affect the air above it? How might snow play a role in the large climate system?

Part D - Oral Synthesis: after completing Part C, each group is given a different overarching question, they must use what they have learned and their ideas to give a 4-5 minute oral synthesis to the class.

This activity is meant to give them new insights into a common geologic material and to recognize the linkages between the atmosphere above the ground and the geology and ecosystem below.

5 Evaluation

The activity involves the students answering 3 series of questions, some of which have more explicit answers than others, which are more open ended. The open ended question are explicit in that they identify the number/type of ideas they should right down. The final task is to synthesize what they learned into a 4-5 minute oral synthesis (given guidelines for the synthesis).

6 Assignment: What is given to students

1. Divide students into teams of 4.
2. Make sure students have proper footwear and clothing for being outside for 1-2 hours in temperatures - many students don't know how to dress for standing in cold weather, take the time to prep them the class before.
3. Give students shovel and Part A question and instructions.
4. When they have completed Part A (they have 30 minutes maximum for Part A), look at their answers and provide guiding questions if the answers are not complete. When their answers are complete, then given them Part B (again for 30 minutes maximum).
5. When their answers to Part B are sufficiently complete, give them Part C (again 30 minute maximum).
6. When Part C is complete, give them Part D (Part D is different for each group). They have 30 minutes to complete Part D. Then each group has 5 minutes to present to the rest of the class.
7. List of suggested equipment for each group:
 - (a) shovel, ideally with flat cutting edge
 - (b) tape measure in cm
 - (c) ruler with mm marks, or laminated card with mm size squares
 - (d) plastic or metal spatula such as for spackling a wall
 - (e) field microscope or hand lens
 - (f) snow density cutter
 - (g) scale (resolution of 1g is best, but depends on size of snow density cutter, could be shared among nearby groups)

Discovering Snow: Part A

1. Find a site that has not been trampled by footsteps, dig a square pit down to the ground *keeping one side of the pit free of footsteps!*
2. Sketch the wall of your pit that is on the non-trampled side (all persons in the group should be on one side of the pit facing the "clean" wall. What colors do you see? What textures? What does the snow feel like to touch? Are there patterns, such as layers? What does the top surface look like? What does the snow look like where it touches the ground? What does the ground underneath look like? Label your sketch with your own labels and arrows for reference ("layer 1" , "hard spot here", don't worry about using any technical wording). Just draw and label what you see, feel, smell, taste, etc.
3. Among your group, make a list of what each of you know about snow from previous classes or from experience. Don't judge any of this knowledge as right or wrong yet, this is to help your group and your instructor get an idea of where each of you is coming from.
4. Now you need to make some measurements. Based on your sketch, what do you think are the most important measurements to add a quantitative component to your sketch. The first couple are easy, I've provided a few as suggestions, then you decide. Consider all the labels and observations you put on your sketch - how would you quantify them? What tools would you need to quantify these concepts?
 - (a) What is the temperature outside today?
 - (b) Is the sun shining or is it cloudy? How would you quantify this?
 - (c) How tall and wide is your snow wall (ground = 0m)?
 - (d) How big are the snow crystals? Are they the same size everywhere?
 - (e) ?
 - (f) ?

Discovering Snow: Part B

Make the measurements you identified in Part A after discussing the list with your instructor. You might need or want to redraw your sketch to be able to relate the quantities measured to your pit wall.

For each type of measurement you make, please describe briefly your technique and what you think the major source of errors are.

Discovering Snow: Part C

Among your group, discuss the following questions, come up with ideas to how your observations relate to these questions. You may do this in the classroom or outside, or both. *This is a brainstorming session, write down all ideas, you can discuss them, but do not judge them critically yet*

1. How does the ground underneath the snow affect the snowpack? What if the snow fell on top of a picnic table? Would it look different?
2. Look around you, how representative is your snow pit compared to snow across the landscape? Is the snow different near the trees (thicker, thinner, darker, harder, softer)?
3. Within the wall of your pit, is the snow homogeneous (does it have the same properties everywhere?) If not, why not? What types of things could alter the properties of the snow?
4. How would the snow in your snow pit change if the weather warmed up or cooled down by 10° C (18°F)?
5. It is common to hear people warn that it is important to wear sunglasses around snow because of its brightness, is all snow bright? what makes it less bright? If this brightness affects us and our eyes, how do you think this brightness affects the air, the trees, or any other component of the biosphere?
6. How easy is it to make a snowball with this snow? What do you think might make it easier or harder to make a snowball (what properties of the snow do you think are important)?
7. What might affect the size and shape of snow crystals?

Discovering Snow: Part D

Guidelines for Oral Synthesis

You have been given an overarching question. Consider the observations and ideas you have made during the activity and synthesize them into ONLY 1-3 sentence answers to these questions.

This is the only part of this activity which you will hand in. Your grade will be based on this one page synthesis. Therefore, use specific wording in your short answers in order to pack in as much information into the fewest words!

Bad: "The snow has lots of colors."

Good: "The snow is darker brown in the top layer, greenish in the middle layer and white in the bottom layer."

1. What observations did you make that relate to this overarching question?
2. What other background knowledge (from coursework, personal experience) does your group have that you feel might contribute to answering the question?
3. What are several ideas (2-4) that might be answers to your overarching question?
4. What would you want to measure or observe next to work towards a better understanding?
5. What additional background information would be useful to look up in order to help understand how your observations relate to the overarching question?

You will rotate through the members of your group to present the answers to these questions in 1-2 sentences (60 seconds each - no longer).

Overarching Questions (one for each group)

1. What does a snow crystal look like under the microscope? Are they all the same? What might cause the differences you see in the crystals?
2. What are the physical characteristics of this snow pack? How might they change when you change atmospheric conditions (make it warmer? cause it to rain?)
3. What happens to snow after it falls on the top of the snowpack during a cold period (below -10°C)?
4. What happens to snow after it falls on the ground during a relatively warm period (near 0°C)?
5. Does the snow affect the atmosphere above it?
6. How does the snow affect the ground underneath? Is the effect of the snow different at different times of the year?

7 Instructor's Notes

8 Solution Set

9 Supporting Materials