Teaching Snow Hydrology to Science and Non-Science Majors

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ABSTRACT

The Watershed Sciences Program at Colorado State University offers a number of snow courses. The undergraduate Snow Hydrology (WR474) course is directed at the watershed sciences majors. To complement this course, a semester long snow field course (WR 406 Seasonal Snow Environments) is offered for both science majors and non-science majors. During the spring 2003 semster, one-half of the students were Natural Resource Recreation and Tourism or Natural Resources Management majors. Few of these students have taken a hydrology, advanced mathematics, or physics course. The other students in the course were watershed or engineering majors. A survey at the beginning of the course showed that NRRT and NRM majors hoped to learn more about snow in the context of avalanches, while the science and engineering majors hoped to learn measurement techniques for estimating snow and snowpack properties. The challenge in the course was to bridge the gap between the needs of the two groups.

Keywords: field methods, snow hydrology, teaching

INTRODUCTION

Snow Hydrology has been a staple of the Watershed Sciences Program in the College of Natural Resources at Colorado State University since its inception. The College is currently comprised of the Departments of Geosciences (GS), Fishery and Wildlife Biology (FWB), Forest, Rangeland, and Watershed Stewardship (FRWS), and Natural Resource Recreation and Tourism (NRRT). The College's snow hydrologist teaches a *Snow Hydrology* course each fall (now *WR474*) that caters to the course curriculum for the watershed sciences program, as well as a spring semester course (*WR 406 Seasonal Snow Environments*), and two graduate courses (*WR 574 Advanced Snow Hydrology* in the spring and *WR674 Modeling in Snow Hydrology*).

In the past the Seasonal Snow Environments (*WR406*) course was taught as in part as an avalanche course. To supplement the undergraduate snow hydrology course (*WR474*), the snow hydrologist decided to teach a semester long snow field course that would cater to both science and non-science majors. This semester, one-half of the students are NRRT or Natural Resources Management (NRM) majors. Few of these students have taken a hydrology, advanced mathematics, or physics course. The other students are watershed or engineering majors. A survey at the beginning of the course showed that NRRT and NRM majors hoped to learn more about snow in the context of avalanches, while the science and engineering majors hoped to learn measurement techniques for estimating snow and snowpack properties. The challenge in the course was to bridge the gap between the needs of the two groups. This paper describes the course, the students, their interests and how they were assessed, and suggestions for the future.

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THE COURSE

The course topics and field activities are summarized in Table 1. The 14 topics and field exercises focused on components of the hydrological cycle, with the first nine building the background for later exercises, especially the last three fun topics, i.e., snow stability, the physics of skiis, and snow structures. The single most important exercise was likely the digging of snow pits for density, temperature, layer identification and crystal characterisation. Field exercises were undertaken in and around Fort Collins, depending in part upon the laboratory and the weather conditions. On average Fort Collins receives six significant winter storms. The NCAR Marshall Field and the University of Colorado NIWOT Ridge Long Term Ecological Research sites were visited, as well the spatial snow surveys were undertaken as part of the US Forest Service April 1st Fraser Experimental Forest Snow Survey or the NASA Cold Land Process Experiment. Most of the remaining fieldwork was performed 115 km west of Fort Collins along Colorado Highway 14 at Cameron Pass, which is near the US Department of Agriculture Joe Wright SNOTEL site.

Marks for the course came from a quiz, a summary of a field exercise, a paper review, a project, and a final examination. One field laboratory was summarized by each student and these were put online at the course website. The students were responsible for the field material for the final examination. Each student prepared a paper review in the form of a summary and an oral presentation. The summary was circulated to the students prior to each class to help facilitate discussion after each 10 minute presentation. The project provided the largest portion of term's marks. The project was designed to address an issue related to the seasonal snow environment and the students were to use methods learned in class or out in the field. The project consisted of an initial project discussion, a proposal including a data collection methodology, a report and an oral presentation. The final exam was primarily methodology-type short essay questions.

THE STUDENTS

For the spring 2003 semester, the students came from the following majors: Natural Resource Recreation and Tourism (5 seniors), Watershed Sciences (2 juniors, 2 masters, 1 non-degree second bachelors), Natural Resources Management (2 seniors), Civil Engineering (1 PhD), and Fishery and Wildlife Biology (1 junior).

Discussions with potential students yielded interesting comments as to what they expected from the courses. A NRRT major who did not take the course inquired whether it would count as a physical education credit, whereas a bio-systems and agricultural engineering undergraduate who did not take the course inquired whether the course could be considered a technical elective. A line was drawn in the snow to differentiate between the students who were actually interested in the course and those who thought it would be easy credit.

STUDENT COMMENTS

As students had a variety of backgrounds and interests, the instructor had a brief discussion with each student to assess interest, abilities, and inform the student of the format of the course, as well as the expectations of the student.

During the introductory class, the instructor distributed a course syllabus with list of topics, overheads printed with a brief questionnaire, and overhead pens. After the instructor introduction to the class, giving background, etc., each student then stood in front of the class and briefly went through his or her overhead of questionnaire responses. The questionnaire asked the following: students name, major, little known hobby or interest, why the student was taking this course, what the student hoped to learn during the course, topics of interest in this course, and a self-assessment of outdoor abilities (from 1 to 9), including snowshoeing, backcountry skiing, being at altitude and being in the snow.

Table 1. List of the course topics and field exercises with the location of each laboratory

week	topics	field laboratory
1	Introduction	introductory discussion [1]
2	Snow Crystal Characteristics	falling snow crystal examination [1]
3	Snowfall Measurement	precipitation gauges and shields [2]
4	Fresh Snow Characteristics	snowboards and fresh snow crystal identification [1]
5	Snowpack Properties	snow pits: density, layer and crystal identification [3]
6	Radiative Properties of Snow	albedo and depth of penetration [3]
7	Spatial Snowpack Sampling	snow probing, SWE estimation [3,4,5]
8	Snow in the Canopy	interception characteristics in trees [3]
9	Snowpack Metamorphosis	snow pits and crystal characteristics [3]
10	Energetics around a Tree	tree well investigation [3]
11	Sublimation from the Snowpack	short-term changes in snowpack surface properties [1]
12	Blowing Snow	snow fences [6]
13	Biogeochemistry	national atmospheric deposition program (NADP) site [7], sample collection for chemistry measurement [3]
14	Snowmelt	finger flow and runoff [3]
15	Snow in the Urban Environment	de-icing agent application, snow removal [8]
16	Snow Stability	snow stability tests and avalanche identification [3]
17	Physics of Skiis	downhill, telemark and cross-country skiis, snowboards and snowshoes [3]
18	Snow Structures	construction of snow structures [3]
19	Summary	wrap-up and make-up field exercises [3]

[1] Sherwood Forest on CSU campus, Fort Collins
[2] Marshall Field, an NCAR field site near Boulder
[3] Cameron Pass, along Colorado Highway 14, 115 km west of Fort Collins (near the Joe Wright US Department of Agriculture SNOTEL site)
[4] Fraser Experimental Forest, near Fraser (as part of the US Forest Service April 1st Snow Survey)
[5] NASA Cold Land Process Experiment field work near Fraser, Walden and Steamboat
[6] along Pena Boulevard near Denver International Airport
[7] NIWOT Ridge Long Term Ecological Research site operated by the University of Colorado at Boulder located 50 km west of Boulder
[8] around the city of Fort Collins

Overall, the students stated that they were enrolled in the course to learn more about snow and snow properties, snow safety and avalanches. Other comments included that the student was interested in all aspects of water, or that snow is important to the student's major. The students hoped to gain a better understanding of the snowpack properties, the physics of snow, snow chemistry, and field methods in snow hydrology. The specific topics of interest varied, and included avalanche safety, and understanding the snowpack for recreational purposes. All students had moderate to good ability to snowshoe and/or backcountry ski, as well as were at least moderately comfortable at attitude and quite comfortable at being in the snow.

While students were happy with most aspect of the course, a mid-term evaluation illustrated that some students though the course was too technically specific, i.e., too many equations, while other students wanted more depth with the equations. The instructor continued to emphasize the physics underlying processes that are supported by equations, but also stated that the course sought to provide an understanding of the mechanics as well as the methods to measure, i.e., understand what the equations are trying to represent but do not be concerned with memorizing the equations.

To follow up on the introductory questionnaire, an end of semester questionnaire was distributed at the end of the last class in order to assess what the students felt that they learned, especially with respect to what they wanted to learn, what they thought the most interesting and challenging topics were, and who they would recommend the course to. They cited the most interesting topics as snowpack characteristics, snow metamorphosis, snow structures, and avalanches (snow stability). The avalanche lecture was presented by Dr. Kelly Elder of the Rocky Mountain Research Station (US Forest Service) and he provided an excellent introduction to avalanche awareness. Both he and I emphasized that the key to subject is continued training, especially through formal avalanche courses, as well as perpetual awareness before going into the field and while in the field. The most challenging topic was biogeochemistry. Two students did comment that everything scientific or mathematical was challenging, since neither was a science major and had "not done math in a while." They were both glad that they "didn't have to know all the formulas." One of the science majors stated that "every topic can be challenging, depending on how deep [the student] wanted to learn it." Some students did not recall what they initially wanted to learn, but overall the students wanted to learn more about the properties of snow, and get an introduction to field methods. They said that they would recommend the course to students in their major (including other ski/snowboard bums), as well as anyone interested in snow.

Some additional comments from the end of semester survey were that the students especially enjoyed the experience attained during the laboratories, and that the class prompted the students to want to continue to learn more about snow.

SUGGESTIONS FOR THE FUTURE

The biggest problem was scheduling fieldwork. Field laboratories were scheduled to accommodate a majority of the students, but at times less than half were able to participate. Some students had to work afternoon and weekends. No formal laboratory period was established since it was thought that field exercises would require at least 2 hours of travel each way and during the early winter this would restrict time available for activities. In future, a formal 3-hour laboratory period will be scheduled, proceeded by an additional lecture hour for use earlier in the winter. One or two full-day weekend multi-topic exercises will also be officially scheduled as part of the course.

Some of the students initially wanted to take an avalanche course. They were informed that the course was a field methods course and would provide a background to avalanche courses. In future, it will be emphasized at the onset, as occurred this year, that the course is not an avalanche course. Students will again be referred to courses by organizations such as the American Avalanche Association.

As some of the students felt that parts of the course were too technical, the measurement and field components of snow hydrology will be emphasized. As well as ample time will be spent on "fun" snow issues, such as snow structures and the physics of skiis. This semester the physics of skiis lecture included a short history of skiis, a topic that both the instructor and the students found novel and interesting. The equations are necessary for some lectures as they portray the physics behind a specific process. Some topics are difficult to demonstrate with individual field exercises, such as sublimation. These topics either need to be replaced or appropriate exercises need to be developed, that may have a temporal component. Other topics, such as blowing snow or snowmelt, need precisely timed laboratories or exercises that induce the process of interest. Lysimeters will likely be used to illustrate snowmelt, and the mechanics of blowing snow may be presented with wind tunnel experiments.