Quantitative Earth Sciences at UBC: challenges and opportunities

Prof. C. Schoof, April 2021.

Background

The Department of Earth, Ocean and Atmospheric Sciences at UBC (EOAS) has been hosting three degree programs in quantitative Earth Sciences (QES), excluding geological engineering: geophysics, atmospheric sciences and a combined major in oceanography and physics. (Roughly speaking, by QES we mean Earth Science content requiring fluency on graduation in advanced math - linear algebra, differential equations - modern data analysis, coding, and parts of second- to third-year physics.) These programs continue teaching activities that predate the foundation of the department. They can be traced to the former Department of Astronomy and Geophysics (geophysics), the Department of Geography (atmospheric sciences) and the former School of Oceanography (oceanography and physics). Enrollments have shrunk significantly in geophysics (32 students across all years in 2015 to 20 students now) and atmospheric sciences (29 students in 2011 to 10 students now) while oceanography & physics has always had small student numbers (~ 2). As a result, enrollment in many core courses has shrunk to critical levels (5-10). Atmospheric sciences underwent a significant curriculum reorganization in 2015 that led to the cancellation of low-enrollment courses. This has not led to a rebound in program enrollment, but the remaining program courses have sustainable student numbers due to cross-over with the Environmental Sciences program. The same curriculum change has also represented a move away from traditional QES, with core material such as Geophysical Fluid Dynamics and Dynamical Meteorology no longer offered regularly to undergraduates.

An informal survey of colleagues in peer programs elsewhere (University of Alberta, University of Calgary, University of Toronto, McGill university, Memorial University, Georgia Tech, Colorado School of Mines, Stanford University) has revealed a similar picture, with the programs most closely identified with resource extraction and fossil fuels most heavily affected. It is unclear whether this is due to a lack of desire to work in these industries, or due reduced employment opportunities due to the depressed price of oil. A common refrain has been the impression that quantitatively-inclined students have heavily drawn into computer science, limiting recruitment.

This situation represents a challenge as well as an opportunity. Faculty in EOAS have significant strengths in quantitative disciplines that would be under-or unutilized were these programs, and a complete refocusing on non-quantitative programs represents a challenge to retention and complicates aligning the expertise and research directions of future hires with core teaching activities. At the same time, quantitative Earth sciences provide a rich environment for context-driven teaching of material drawn from mathematics, statistics and physics, with unique opportunities in areas such as data and image analysis, inverse modelling and topical issue-driven content such as climate physics. Career opportunities for quantitatively-trained students are many; already we have numerous geophysics alumni who are employed in tech companies, and they report a well-trodden path from numerate science degrees other than computer science into tech sector, primarily in data science.

The remainder of this document sketches some of the strategies we are initiating in order to capitalize on these opportunities.

A way forward

The challenge in maintaining a viable QES program is two-fold: i) to create an attractive set of course choices that is not closely tied to cyclical or sunset industries with an image problem, and ii) to effectively advertise the training and career opportunities beyond these industries that come with a QES degree.

To create an attractive program, we have begun to reconfigure the geophysics curriculum to focus less on solid Earth material while maintaining a path to accreditation as a professional (exploration) geophysicist. This has led to a core of 'methods' courses in mathematical techniques, continuum mechanics and data analysis, and a choice of application courses spanning traditional solid Earth geophysics as well as environmental material in hydrology and a revived dynamical meteorology / geophysical fluid dynamics, with an upper-level climate physics course in preparation, and a course on image analysis anticipated. While enrollment is low, some of these application courses will be taught in alternate years, and we hope to attract a small number engineering or physics students who would be qualified to take these as technical electives. This new curriculum was recently approved by the Faculty of Science at UBC.

In terms of applications, our vision behind our curriculum reform is to integrate a broader range of `hard science' courses aligned with attractive and relevant environmental and climate topics, aimed at a more quantitative demographic than the Environmental Sciences program in EOAS, and to reflect the breadth of `geophysics' as represented by e.g. the American Geophysical Union. In terms of preparation for future careers, we intend to focus on transferable quantitative skills, with greater emphasis on data analysis and computing, including practical skills in demand by potential employers (e.g. multi-generational, collaborative open-source code package development). While the separate programs in atmospheric sciences and oceanography are likely to remain, we intend to recreate a quantitative path through the existing Atmospheric Science program that shares a common core with geophysics and thereby consolidate our student cohorts.

A greater challenge is advertising this program to the intended audience of quantitatively-inclined students. Campus events (`Meet your Major') have proven ineffective, and there is poor awareness of QES material among Faculty of Science Students. We have identified several issues:

1) High school courses in Earth Sciences in BC, where available, stress qualitative aspects of the subject.

2) First year EOAS courses focus on descriptive material and leave the impression that EOAS is not home to `hard' sciences.

We have two projects aimed at alleviating this: i) the new Data Science 100 course at UBC will have an Earth-Sciences-focused section to be taught by EOAS faculty in collaboration with Statistics and ii) we are in the early stages of developing a 100 level Physics of Climate course that would integrate first year material from Mathematics and Physics into an attractive topic, to capitalize on a new Faculty of Science breadth requirement that obliges students to take courses from 6 out of 7 different areas of science.

3) Low visibility of QES offerings to students in Math, Computer Science, Physics.

Visibility of our programs and courses to students in these traditionally quantitative science departments is likely to be key to our success since we expect these departments to continue attracting the majority of students in the target demographic for QES courses. In our informal survey of peer programs, the only program not reporting a significant drop in student numbers was the Geophysics Specialist program at the University of Toronto, which is housed in the Department of Physics and run in collaboration with Earth Sciences. Guest lecturing in 1st and 2nd year classes in other departments is a pathway to increased visibility that has reportedly worked well for the geophysics program at Stanford University, and the Math and Physics Departments at UBC have indicated a willingness to facilitate guest lectures. In the long run, closer and more formal links may be necessary as even students who are aware of our programs and courses may choose to stay in a traditional quantitative science program due to better perceived employment prospects: a physics degree may be seen as more valuable in the job market than an EOAS-based degree, regardless of actual content. As a first step, we have implemented a defined geophysics minor program in order to create an easy path through QES for students majoring in another discipline.

4) Numerous websites still hosted by EOAS, the Faculty of Science and beyond continue to give a limited, overly disciplinary perspective of `geophysics' focused on the resource sectors.

We have begun to identify online advertising material related to QES content at UBC, whether controlled by EOAS or not, and are developing a strategy to reorient that material, including participation in a redevelopment of the public-facing EOAS website.

This set of strategies is not guaranteed to succeed; if it does not and UBC decides strategically to maintain a presence in areas such as geophysics, then alternative solutions such as more cross-appointments of faculty in these areas in other departments, where their expertise aligns more closely with teaching opportunities, may need to be explored in future.