First year course

Some time in 2020

Rationale

One major item on this year's agenda for the quantitative earth sciences committee is to design a first year course that reflects the nature of the quantitative program(s) in the department - ultimately, whatever collection of courses we will end up bundling under the QUEST umbrella as the "revamped geophysics".

To set the background here - as a working assumption, revamped geophysics will mean anything that is under the umbrella of what e.g. the American Geophysical Union does that involves advanced physics, mathematics, data analysis.

The target of this program would be to output students well grounded in Earth Science, with a certain degree of choice in specialization (solid earth, fluid earth, hydrology/hydrogeology, climate/earth systems science) who are also (age-appropriately) fluent in math up to pdes and linear algebra, in scientific computing, in data analysis, and in the physical foundations behind this (mechanics/continuum mechanics, thermodynamics, electromagnetism where required).

Our challenge is perhaps less to construct a 2nd year+ program than it is to attract students into it (even if partially through whatever joint programs). The first year course idea is one strand of this. Our current EOSC1xx / ATSC1xx offerings do not signal the content I've described above, which most likely means that the students we want would not even consider taking our programs. The point of a first year course is to change that perception and create visibility.

Key is the new breadth requirement - everyone in science has to take something from 6 out of 7 pre-defined categories, so physics / math / compsci students have to take courses from some traditionally descriptive fields, see http://www.calendar.ubc.ca/vancouver/index.cfm?tree=12,215,410,1663

Our hope is to fill that part of that niche with quantitative content, which should appeal to students not keen on taking life sciences or descriptive earth & planetary sciences. Our challenge is that astronomy is part of the same category as EOAS, ENVR and ATSC, which may attract many physics students. Therefore, we must be creative and proactive in marketing the course to appropriate students.

Action items

We have a pretty blank canvas here. A few ideas - climate physics and earth systems science first and foremost - have been suggested. I'd like to turn this around - in order to attract the audience we want, let's start with what they are likely to be attracted to:

1) What abstract tools, methods, concepts should we illustrate using Earth Science examples? How do those fit in with first year material concurrently taught? For instance, I can see lots of ways of making first year math come alive (especially calculus). What is likely to be attractive? What can we build on later. *Note: data science aspects of earth science are taken care of separately through a new DSC 100-level course in which EOAS gets to teach a section.*

2) Which Earth science subfields should we touch on? More? Fewer, to keep it focused? What does past experience tell us?

3) Is there an overarching theme that lends itself to points 1,2. Catchy title? As above, climate physics and Earth systems science have been suggested.

4) Single versus multiple instructors - again, keeping students engaged by having continuity versus student getting exposed to a wider set of approaches and not having a course moulded to a single individual as instructor.

5) Lab versus lecture. I bring this up because of an abortive attempt 20 years ago to create something similar as a lab-based 1st year course, which died again because 1st year requirements were changed, although this time in a way that didn't favour us. Current circumstances do not favour lab-based courses.

Here's where you put your stuff under each of the bullets above. Leave a name or initials if you are happy to so I can follow up. Also, if you correct someone else's stuff, please use the "suggesting" mode rather than default "editing".

CGS = Christian Schoof

RHW = Rachel White

FJ = Francis Jones

FJ: These five points do provide a useful starting point. Also, well-established course development tactics should ideally be followed. It is useful to concentrate first on the course's intentions by focusing on what we want students to come away with. **Then** the "tactics" can be addressed. Let's not mix these up. For example, instructing models (eg one or few or many instructors) can be debated independently from defining the course. Also, specific tactics such as use of Jupyter notebooks, other creative learning activities, the balance of scripted vs unscripted lessons, etc.; all these details can be discussed and developed, AFTER agreeing on what knowledge, attitudes, skills, and habits students will learn and how they will demonstrate that they've learned them. This boils down to defining "Course Learning Objectives" or CLOs that will inform the design of learning, assessment and instruction. CLOs do invariably evolve as course development proceeds, but establishing a first draft of 5 – 8 CLOs is a useful and commonly accepted first step.

1) Abstract tools, methods, concepts

CGS: A few math concepts I'd like to introduce in a first year appropriate way:

- differentiation - derivative as a "local" constant of proportionality linking change in one property to change in another (e.g. displacement is expected to be proportional to time elapsed, so long as you're looking at short times elapsed; velocity is the constant of proportionality)
- ii) integration as a Riemann sum independently of anti-derivatives: e.g. summing over local density*small volume to get mass
- iii) integration as anti-derivative: summing changes in one quantity dx gives sum in v dt etc
- iv) simple differential equations from first principles, plus solution by separation of variables (and why that is necessary)
- v) the concept of stability of equilibrium solutions
- vi) even some simple bifurcation stuff involving hysteresis (though I would not let the word "bifurcation" pass my lips! Hysteresis - yes). I can map these onto most science subjects; they are pretty universal and would give context to the context-free math they are likely doing in MATH101/102. I can also explain these without the full math machinery being in place.

FJ: Are these desirable because they are "fundamental" or because the are necessary to address the course content that is being prepared? Is this a "methods course" with Earth or climate for context, or an "Earth and climate" course that introduces abstract methods on an as-needed basis? Ideally the focus of the course needs defining first, then the necessary abstract tools, methods and concepts can be identified, along with the appropriate level of "master" expected for a rigorous 1st year course. I think it would be more productive for discussions to focus on the inspiring Earth & climate concepts we want students to become conversant with, then the necessary abstract methods will become evident.

RHW: These sounds good to me. Without much experience yet of what students learn where, I don't have many strong views on concept - I'll keep thinking though.

RHW: I think Jupyter notebooks could be a good tool to use to demonstrate quite a lot of these points in a tangible way, while also giving students some python coding experience (without needing any prior experience coding). But, I can also see disadvantages of this in terms of (a) work to set things up initially, and (b) continuity throughout the course if we have different instructors. That being said, if we have funding to pay undergrads to create the notebooks at the beginning, as Phil has been doing, even instructors who don't use jupyter could relatively easily create some interactive notebooks. Indeed, this could potentially lend a sense of continuity through the course. I like the idea of students learning something analytically, and then seeing this applied in a notebook to solve some Earth science problem. FJ – sure, BUT – start with the earth science problem (motivation) and offer analytical approaches as means of addressing it.

CGS: nice idea; how much does it force an incoming instructor to stick with a pre-set script? We do want the course to "flow" and be internally well aligned, so lots of structure is good, but I've never been able to lecture using someone else's notes. Perhaps notebooks are a bit different.

RHW: In my head the general idea is from the flipped classroom perspective, the notebooks are what the students work through on their own, with the lectures then focusing on aspects of this. I guess if we went down the one main lecturer + guest lecturer thing, then guest lecturers could use jupyter notebooks if they wanted to, or not? If we create a series of notebooks at the beginning of this course design then incoming lecturers would either have to stick to the notebooks (aka using someone else notes - though the actual lecture content could be a little different?), OR be able to program in python to change up the notebooks.

CGS sounds good

FJ: The course needs to be engaging, yet efficient. Jupyter notebooks are certainly an effective tool. This and many other tactical ideas can be developed, then the most efficient, sustainable and "transferable" (from one instructor to the next) teaching model can be chosen. Course developers will benefit from exploring the large global community of educators who teach geoscience "first-exposure" courses, especially NAGT and the SERC repository of geoscience teaching wisdom. The best ideas will serve as inspiration for adaptation to the EOAS context and the particular needs of this new course.

2) Earth science subfields

CGS: Following this morning's conversation with Philippe (he backs the "physics of climate" theme, in fact, seems to think that's what it should be, there is a plausible "spheres" split (atmsophere, ocean, cryosphere, surface processes / longer-term geochemical stuff - the latter Mark J also reiterates in both of his 2xx and 4xx courses so perhaps it's ok to stick with nearer-term climate, up to perhaps glacial cycles.

RHW: I like the spheres theme. Don't know whether hydrosphere would be split into ocean and surface water, quite possibly it should be actually.

FJ: A framework for the whole course, like spheres, will be very useful. Perhaps the interconnectedness of spheres is a theme? Further debate about what to include and what to leave out (or simply hint at) will be needed - and interesting! It will be OK to start with a long list of possibilities, but the final result should be a "brutal" cull to find the minimum that results in a cohesive course. The goal after all is to inspire students and leave them wanting more, not to somehow cram the whole discipline into a short time.

FJ: Consider thinking in terms of modules. If carefully designed, these may be swapped in and out according to the preferences of each instructor. Varying the modules from year to year will also result in a course that is a little different each term (always a good thing). If modules are ~3 weeks each (9hrs of lessons + ~15hrs homework), then there is room for four. This model is used successfully in DSCI-100. They have four statistical concepts that students are to learn and practice. A relevant problem is identified for each concept, the challenges and possible solutions are considered, then details associated with the statistical thinking, necessary mathematics, and corresponding programming or visualization skills are developed (in "R" or Python, depending on course section). For an EOAS1xx course, modules could be independent (like in DSCI-100) or they could be coupled using the framework of "spheres", or along some other form of climate or Earth science relationships.

During course design, it might be useful to specify the first four modules to be taught, but design five or six so the course is ready for the first few seasons. The department should then commit to supporting development of one module perhaps every 3-4 years. Adapting or developing new modules (under supervision) make good jobs for worklearn or graduate student employees.

3) Overarching Theme

CGS: I think climate science is a great objective here; we need to draw on the unique strength in EOAS in having faculty from multiple disciplines, so "climate" is not the purview of atmospheric science, or even seen predominantly through that lens - Rachel White, Anais Orsi, Mitch Darcy, Ali Ameli, Stephanie Waterman, Valentina Radic, Mark Johnson, Christian Schoof, Mark Jellinek, Phil Austin, Susan Allen and probably others make a good QES climate core

RHW: I like the idea of a climate focus, and I agree that it isn't just atmospheric sciences. I also wonder if we could make it even more broad, some sort of 'critical problems in Earth and Climate Sciences'? Some student feedback from questionnaires for the Climate Change credential/certificate working group questioned the possible "left-ist agenda" of a climate change specified.

CGS: I see where the leftist agenda thing is going but if we start changing the title (rather than demonstrating that climate *science* is apolitical), are we simply playing into this preconception? "The physics of climate" should be ok. We're not calling it "Global Warming" or even "Climate Change", presumably

RHW: "Physics of the Earth and Climate"?

CGS: Plausible, need to think about the other EOS1xx courses. "Earth" may have a preconceived (solid earth?) meaning

RHW: good point. I like The Physics of (the Earth's?) Climate, that's hopefully pretty broad in the minds of students (I don't have a good sense of what the average first year thinks when they hear 'climate' - do they just think climate change?)

Maybe Climate Sciences (to emphasize the different sub-fields/sciences within the broader scope of the climate system)?

FJ: All good thoughts. It does seem as if "Climate Sciences" or "Climate Physics" or something similar is timely, inspiring, appropriate given the Dep't goal for this course (introducing quantitative Earth sciences), and feasible given EOAS faculty expertise. With a little creativity, any EOAS faculty member should be able to lead this course.

4) Single versus multiple instructors

RHW: I like the idea of multiple instructors, for giving a sense of how these fundamental maths tools are applicable across a wide range of Earth Science problems, as well as promoting the diversity in research and researchers across the department. Perhaps one way of doing this could be to have one instructor throughout the term for the more abstract maths concepts, e.g. giving one or two lectures a week, and then one lecture each week is given by “guest” lecturers, each of whom is there for maybe two lectures (i.e. two weeks) a term to give more applied, topic-based instruction and examples for the concepts introduced that week. I realize this could end up with about 6 instructors in one term, but 5 of them would only be teaching two lectures - I don’t know if this is really a thing that people would buy into or not, but it would be a bit different, and could be appealing to students? Sounds like (from discussion in breakout rooms today in the faculty meeting) that this could potentially work well, if all instructors felt they had enough of a role in deciding what concepts their material was focused on, not just being told: here, teach hydrology using ODEs, for example.

CGS: I’ve just talked with Philippe and he suggested 3-4 instructors max, but the guest lecturer plus main lecturer model is interesting

RHW: potential other benefit of main + guest lecturer model is that this could give clear leadership coming from the main lecturer, to help guide design etc and make sure it feels like one cohesive course, not 4 3-week courses run one after the other - still with input from potential guest lecturers about what they want to teach and where, but with the final say/responsibility from the main lecturer (I say all this with zero experience of what designing a course like this would be like in EOAS, so feel free to tell me I’m way off base here!)

CGS: I think we’re in the same boat. I’ve never taught “my” stuff to undergrads before (as in, cryosphere, not fluid dynamics, plenty of that), don’t know how easy it is to set up for someone else to do the bulk of it but we’re talking first year so the ~~didactic~~ pedagogic aspects are much more important than expert content. There is also the practical question of teaching credit and how that would be split.

RHW: I heard some feedback from others during the last faculty meeting that there is a marine pollution class that is run similarly (i.e. multiple guest lecturers), and is very successful and the students really enjoy it. Though I forgot the course number unfortunately - maybe 474?) In terms of teaching credit, yeh, I have no idea how that would work out logistically I’m afraid!

FJ: Leadership and consistency is very important to students. They generally do not thrive in courses that “change” from week to week. At the same time, they benefit and enjoy opportunities to interact with experts. I think the main+guests model can be made to work very well. The “serial monogamy” model with a sequence of 4-6 instructors rotating into the “main role” results in a fragmented experience that is counterproductive in a course that has a single main theme – such as climate physics in this case. The fragmented model also results in instructors who are not well-motivated to put in suitable effort.

As this is a first-year course, it should be true that any EOAS faculty member could take on the “main” teaching role for the course, even if they initially feel otherwise. Making guest contributions in a first year course ought be considered a privilege rather than a chore. Also, I believe the main+guests model could enhance the Department’s sense of community. We are all eager to promote our science, and making small contributions for eager young first year students is an ideal - and efficient - opportunity to do just that. Course designers can work towards optimizing both the efficiency and efficacy of instructional delivery and student learning & assessment. All it needs is some creativity with support of geoscience education expertise.

5) Lab versus lecture

FJ: Given past experience, and benefits (to instructors and students) of clarity & simplicity, let’s keep it straight forward; no fancy or unusual scheduling or pedagogic needs, and no labs that end up needing resources, personnel, TA training, etc. With creativity we can accomplish the goals without labs. (By the way, ATSC 113 has good examples of creative approaches to engaging learning at this level.)

Next steps

FJ: Suggested next steps:

- Summarize / list key points from this discussion to make it easier for others to grasp the thinking so far.
- Identify a "project PI" to move project forward.
- Generate a first draft (~2pgs) of a proposed course description, with a few tentative course learning objectives, suggested assessment & instructional tactics, and a brief estimate of resources, time & funding needed. Perhaps include a proposed time-line towards first-offering.
- List first thoughts about marketing. What types of students should thrive in this course? What prior capabilities will they need to succeed? How will we convince them that this course is a worth-while first year option? Will we somehow deny others (eg 3rd & 4th year students) from taking it as an elective? And other aspects of making the course visible and attractive to appropriate students.
- Project PI to present the proposal to the Department, then engage one-on-one with faculty who are interested, to address questions, concerns and suggestions.
- A second version of the proposal will emerge, to be used as the basis for a funding request (perhaps a small TLEF, or other UBC / FoS / EOAS funding opportunity).