My Experience as an Engineer, trying to do Biogeochemical Modeling Within an Interdisciplinary, International Team of Modelers and Experimentalists

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TOWARD THE PREDICTION OF GLOBAL CHANGE
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1. Abstract

I discuss several challenging facets of my postdoctoral experience working in a team of marine biogeochemical/ecosystem modelers at an institute dedicated to Earth System Modeling. I seek to provoke discussion of how graduate and postdoctoral programs could better address these challenges.

Although my graduate study as an environmental engineer provided relevant knowledge and useful skills, I have struggled to adapt to doing scientific research with complex models. Reviewers have often criticized my papers as focusing too much on technical details and merely describing "modeling exercises", rather than scientific findings. Institutes like ours expect us to develop new models, conduct simulations, and publish the results in scientific journals. Reviewers and editors at scientific journals, on the other hand, generally expect more focus on new science, with a sufficient (but not too long and boring!) description of the models and methods. Yet reviewers for interdisciplinary studies may come from various backgrounds, and they are of many opinions; some expect a complete description and proof that the results are correct, whereas others expect a minimal description and more discussion of the scientific results.

Collaboration between modelers and experimentalists is critical. Experimental scientists are often reluctant to share their data with modelers who they think may undercut the value of their experimental work by publishing papers exploiting their data. We modelers must communicate to the experimentalist that we can contribute to their efforts. Although I tend to think that we modelers need this collaboration more than the experimentalists, several leading experimental scientists have told me that they need more and more to collaborate with modelers to interpret their results, develop scenarios (especially for funding proposals) and plan experiments. Over the last few years I have developed a very good collaboration with an interdisciplinary team of experimental scientists. One key to this has been making the relationship mutually beneficial.

2. From Engineering to Science

Just as I was finishing my PhD in Environmental Engineering, I spotted a advertisement for a position studying marine biogeochemical modeling at FRCGC. I had recently attended several seminars about global change and its relation to the cycles of carbon and nutrients. This sounded like an interesting and environmentally relevant field for research.

When I interviewed for this position, my current supervisor and I had something in common. For my PhD project, which involved modeling the speciation and transport of metals in sediments, I had studied models of diagenesis in marine sediments. He had also studied such models, from the standpoint of global biogeochemical modeling. I reasoned that the basic principles of and tools for developing coupled models of reaction and transport were the same, and that I should be well prepared for the job.

Don't Underestimate the Difference

At first, it was interesting and work seemed to go well. My first submission to a scientific journal, however, did not go over so well. The reviewers derided it for lacking new, interesting scientific findings and said that it was technically sound. but not scientifically relevant.

Several reviewers have referred to my manuscripts as describing "modeling exercises" that may be of interest to "people in the modeling business" but not to readers of whatever distinguished journal. After a few years, I have a better feel for framing scientific problems and writing scientific papers.

In engineering it was fine to develop a better (more accurate, more efficient, more complete, etc) model of an environmentally relevant process. In science, however, this is just not sufficient.

Similar Challenge for Many Modelers

Institutes like ours (devoted to Earth System Modeling) generally expect researchers to develop complex models, apply them in simulations, AND publish scientific papers.

Suggestion

Educational programs in interdisciplinary fields should help young scientists (or engineers) clearly understand the expectations from prospective employers and from their peers (who review publications).

3. Challenges of Publishing Complex, Interdisciplinary Modeling Studies

I contend that there are interesting and worthy scientific studies that require complex models and approaches. I have found that publishing such studies poses its own challenges because of:

Expectations of reviewers from different backgrounds
e.g., experimentalists vs. modelers, biologists vs. geophysicists

The need to describe the model and methods completely, without boring the reader (and annoying the reviewer)
especially challenging when combined with the previous point

Remaining focused on the scientific problems amid the technical details both in writing and in the course of research

How can educational programs prepare young researchers for these challenges ?

4. Collaborations Between Modelers and Experimentalists

FRCGC was initially devoted solely to modeling global change and related Earth systems, and did not include an experimental or observational division. Furthermore, our research group lacked strong connections to experimental scientists based at universities or other institutes. It was a challenge to develop such relationships having just started work in a foreign country. The degree of this problem was particular to our institute, but it is in general important for modelers and experimentalists to collaborate.

After a few years, I did develop good working relationships with a few experimental scientists.

These collaborations have been most valuable.

The exchange of knowledge and ideas has helped me:
- Understand experimental/observational setups
- Formulate more accurate models
- Think of new ideas for research

Mutually Beneficial Relationships

One key to successful collaborations is making them mutually beneficial. Trust is very important. I have contributed to the efforts of my experimentalist colleagues:
- Interpreting experimental results
- Designing (and conducting) Experiments
- Writing proposals for funding

5. Conclusions

To prepare students and young scientists for interdisciplinary research, educational programs and research institutions should address the following challenges:

Understanding expectations of employers and peers

Focusing on scientific research amid technical complexity

Publishing complex, interdisciplinary studies
- **learning the culture of relevant disciplines**
- **presenting complex research completely yet concisely**

Working with researchers from various disciplines
- **building mutually beneficial relationships**

Funding agencies and research institutes that promote and conduct interdisciplinary research should also address these points.

Although I have detailed several challenging aspects of my fledgling career as a research scientist, **I do not intend to discourage young people from pursuing interdisciplinary research in biogeosciences.**

It has been exciting and interesting to work with an international team, including some leading scientists from modeling and experimental backgrounds.