Summer Courses in Ocean Optics and Biogeochemistry: "Monitoring the Oceans with Coastal Observatories" and "Radiative Transfer and Remote Sensing" at the University of Maine Darling Marine Center

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http://www.marine.maine.edu/~eboss/Summer2004_Website/data/data1.html
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LONG-TERM GOALS

The education of a cadre of students who will have a broad perspective of the field and make a difference in oceanography in general and in observatory science in particular. A major goal is to foster integration of optical approaches into oceanographic research in general.

OBJECTIVES

These two courses created an opportunity for graduate students from diverse disciplines to interact with senior researchers in biological and optical oceanography and ocean color remote sensing to learn the fundamentals of optics in a coastal/estuarine environment. The first course of three weeks duration (June 28-July 16, 2004) emphasized instrumentation and observatory science to prepare participants to integrate their knowledge in existing and planned observatories. The second course of two weeks duration (July 19-30, 2004) emphasized radiative transfer theory and ocean color remote sensing. Both courses emphasized the links between optical measurements and the underlying biogeochemistry, with due regard for system integration and errors in data products. The students thus gained a broad perspective of the field, which will enable them to integrate optics, remote sensing, and observatory science into all sub-disciplines of oceanography. Overall course objectives were to provide an environment in which graduate students could learn how to integrate optics, remote sensing, and oceanography and to provide a forum for discourse on new directions in oceanography in general and optics in particular.

APPROACH

The courses were held between 28 June and 30 July 2004, at the University of Maine's Darling Marine Center. The classes used a teaching laboratory and a computer laboratory where 16 wireless computers were available for the required modeling and data analyses. Matlab code for merging and processing data was available to the students during the course, as was Mobley's HydroLight radiative transfer model and his proprietary Monte Carlo radiative transfer model. Instrumentation included a bench-top

spectrophotometer, fluorometer, microscope, Coulter multisizer 3, LISST particle sizer, Barnestead pure water system, and filtration equipment; above-water hand-held spectroradiometer; and in-water radiance/irradiance sensors, absorption and scattering sensors, and fluorometers.

The main components of the courses were (1) formal lectures; (2) laboratory, field, and modeling exercises, with an emphasis on deployment methods and interpretation of measurements via models and theory; (3) demonstrations of new instrumentation; (4) readings from texts and primary journal literature; and (5) student projects, in which the students use data from the field experiments to investigate a specific, focused question. The results of the student research projects were then presented via power point reports, whice were posted on the class web site.

WORK COMPLETED

The courses were held between 28 June and 30 July 2004, at the University of Maine's Darling Marine Center. The first class was comprised of sixteen students and four faculty while the second had eighteen students and three faculty. Each student had their own wireless laptop for the duration of the class.

In the first class the students participated in morning lectures detailing the theory and state of the art of optical measurements, the relation between measurable optical parameters and oceanic biogeochemical properties, the use of optical instrumentation in coastal observatories, and data analysis methods. An optical dock observatory was set up prior to the student arrival that was used to illustrate the concepts associated with long-term high frequency optical measurements. The data from the observatory was displayed on the www in real time at: http://www.marine.maine.edu/~eboss/Summer2004_Website/data/dmc_realtime/ecobb2f_0604.html. In the second class students participated in morning lectures detailing the theory and state of the art of optical measurements, radiative transfer and inversion of remotely sensed reflectance.

In the first class, the afternoon laboratory introduced the students to the biogeochemical measurements such as chlorophyll_a and total suspended mass (TSM) as well as experience with a bench-top spectrophotometer. A time series of these properties was collected through out the course to be used for comparison with the optical data collected by the dock observatory. In the second class, afternoon laboratory sessions introduced the students to Hydrolight, Monte-Carlo modeling, Mie modeling, and inversions of ocean color.

All students went on a scientific cruise with the R/V Ira C, where they deployed optical instrumentation (A package with IOP sensors and CTD, a radiometer buoy, and a wave powered autonomous profiling system equipped with a CTD, a transmissometer, and a fluorometer). In addition surface bucket samples of salinity, temperature and a Secchi disk reading were done by the students.

The first class students used the data collected on the cruise and at the dock to produce a final paper relating to the subject of optics, biogeochemistry and observatories. The second class student used the data collected on the cruise or individual data sets to produce a final presentation which included a forward and an inverse radiative transfer exercise.

RESULTS

The class was a resounding success as can attest the student projects (for the first class: http://www.marine.maine.edu/~eboss/Summer2004_Website/data/data1.html, for the second class see: http://www.marine.maine.edu/~eboss/Summer2004_Website/data/data2.html). Projects subject spanned from 'Sun, Tides, and the BB2F' to 'Inverting Bioluminescent Radiance'.

We have provided the students with a detailed evaluation form at the end of both classes (besides that mandated by the U of Maine. The overall feeling among the students was that:

1. The class exceeded their expectations, and met their goals. As one student wrote: 'I was planning on a nice summer vacation in Maine getting some rest, meeting new people and learning a little optics. The rest thing didn't happen. Way too much work for a vacation!...it was a tremendous opportunity, and probably the most beneficial course I ever took'. 'I received more than expected in terms of science and content'. 'the course was eye opening in terms of being able to create some new long term goals…' wrote another student.
2. The tools provided will accelerate their ability to do research. As one student wrote: 'I did not expect to have the understanding of, and facility with, the state of the art ocean color science'. Another wrote: '..I am much more confident in my ability to understand the literature'.
3. The students felt they worked much harder then they expected; as another student wrote: 'The work was much harder than I envisioned. But it was totally worthwhile and almost fun.'
4. The students felt they learned more than they expected especially given the short duration of the class.
5. All students said they would take the class again if they could turn back the clock (or even with out turning the clock back!) and that they would highly recommend it to their colleagues. They felt there was nowhere else they could get the exposure and access to peoples, resources, and training as they got in the class.
6. The students felt that the cruise experience and the dock observatory added greatly to their experience.
7. The students felt that three weeks was too short, and that in order to do justice to the material and have some time to sleep, and additional week or two was essential.
8. The students felt that their class project contributed a lot to their learning. As one student wrote: 'it is all too easy to follow a lecture, but find that shortly thereafter, the knowledge is lost unless it has been applied to some problem that forces one to reconsider the theory'.
9. The students felt that the facilities were great: 'while we really didn't need to be as pampered as we were, having few obligations other than "lecture-lab-matlab-sleep" meant I could maximize my learning'. Another wrote: '…the campus was awesome. The scenery is second to none'. Close access to labs, lecture room and dock all contributed to their learning.
10. The students felt that the course provided them with a community of colleagues and friends that will enhance their ability to do science in future years.
11. Student appreciate receiving matlab code from the instructors (especially a semi-analytic inversion code developed by Collin Roesler) and felt it provided them with a 'running start'

Students suggested numerous improvements to the classes. In particular they felt that the ultra-structure for data management (formatting, merging and archiving) and website should have been in place prior to their arrival. Student requested a career planning/discussion on one evening. Increase the wireless coverage at the DMC. Include the use of data from other types of radiometers then those

provided in the class as well as satellite imagery. Include the use of optics for biological applications such as optical plankton recorders, imaging flow-cytometry, etc'. Students who took both Ocean Optics classes said they would have preferred a single 5-6week class. That would lower the pace, reduce redundant content and allow for a longer final project cycle.

IMPACT/APPLICATIONS

This course had three important impacts.

1. The course provided a valuable dimension in the education of the next generation of oceanographers, versed in optical oceanography, its relationship to the underlying biogeochemistry and its use in coastal observatories.
2. The knowledge and experience the students gained in this course directly benefits their advisors, most of whom are federally-sponsored investigators.
3. Because some of the students are non-U.S. students, international connections that may prove valuable in the future were established.

A testimony of the impact can be found in a comment by a student in the written evaluations: 'I think this course should be required of anyone going into remote sensing or ocean optics. It had both breadth (covering many techniques and approaches) and depth (going into detail on the theory and fine-tuning), and introduced us to a wealth of literature for future reference.

RELATED PROJECTS

These courses were team taught by, Emmanuel Boss and Mary Jane Perry of the University of Maine, and Collin Roesler of Bigelow Laboratory for Ocean Sciences and Curt Mobley of Sequoia Scientific. Curt was separately funded for his participation.

PUBLICATIONS

There are no research publications from this work. However, the student presentations on their projects can be seen at

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for the first and second classes, respectively.