10-29-2004

CMG Training in Spatio-Temporal Statistical Analysis of Multi-Platform Ocean Optical Observations

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Final Report for Period: 09/2002 - 08/2004 **Submitted on:** 10/29/2004
Principal Investigator: Perry, Mary J. **Award ID:** 0222247
Organization: University of Maine
Title:
CMG Training in Spatio-Temporal Statistical Analysis of Multi-Platform Ocean Optical Observations

Project Participants

Senior Personnel

Name: Perry, Mary
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Beard-Tisdale, Mary-Kate
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Boss, Emmanuel
Worked for more than 160 Hours: No
Contribution to Project:
participated as an instructor in the CMG course

Name: Roelser, Collin
Worked for more than 160 Hours: No
Contribution to Project:
participated as an instructor in the CMG course

Name: Thomas, Andrew
Worked for more than 160 Hours: No
Contribution to Project:
participated as an instructor in the CMG course

Name: Windholz, Thomas
Worked for more than 160 Hours: No
Contribution to Project:
participated as an instructor in the CMG course

Name: Kyriakidis, Phaedon
Worked for more than 160 Hours: No
Contribution to Project:
participated as an instructor in the CMG course

Name: Heuvelink, Gerard
Worked for more than 160 Hours: No
Contribution to Project:
participated as an instructor in the CMG course

Name: Welhan, John
Worked for more than 160 Hours: No
Contribution to Project:
guest instructor in course

Post-doc

Graduate Student

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Findings:

The collaborative course introduced students and faculty to the challenging spatial / temporal data sets that are being collected by the newly emerging ocean observatories AND introduced the students and faculty to the power of geospatial statistical analyses. Both oceanographers and geo-statisticians learned of mutual benefit of maths and geosciences collaborations.

Training and Development:

The major theme of the course was the spatio-temporal analysis and interpretation of optical ocean data. Students received three graduate credits from the University of Maine for SMS 598. The course enabled both students and faculty to gain mutual understanding of the scientific issues, problems, and opportunities in geospatio-temporal analysis.

Students learned how to take, analyze, and interpret ocean optical measurements. Optical measurements serve as proxies for important biogeochemical variables in the ocean including marine phytoplankton, dissolved organic materials, and organic and suspended sediment particles. Optical sensors include passive radiometers as well as active systems with internal light sources and measurements are collected on a variety of spatial and temporal scales by a diverse array of sensors on a number of different platforms including satellites, aircraft, ships, stationary moorings, Lagrangian drifters, underwater gliders, and powered autonomous vehicles.

The data collected are all gappy with respect to space and/or time, and each combination of sensor and platform covers a very different spatial and temporal regime. While data analysis and interpretation arising from any single configuration is demanding, the integration and interpretation of data sets arising from multiple configurations present major challenges to current analytic methodologies. The students were introduced to spatio-temporal statistical modeling, graphical exploratory data analysis, space time point and continuous processes, Baysian analysis of spatioûtemporal data, and experimental sampling design for ocean data.

Outreach Activities:

No specific outreach activities were carried out. The course itself could be considered as an outreach activity.

Journal Publications

Books or Other One-time Publications

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

By training a new generation of scientists in a hybrid field, i.e., optical ocean observations and geo-statistical analysis, we have directly contributed to the advancement of ocean observatory science by providing new analytical tools and to the advancement of geo-statistics by presenting geo-spatial and temporal data sets that present major challenges to current analytic methodologies.

Contributions to Other Disciplines:

The challenges in analysis of environmental data go beyond the ocean domain. The need for new methods of interpreting geo-spatial temporal data have direct societal impacts. The course trained a new generation of students who will be better able to address data in any enviromental observing field.

Contributions to Human Resource Development:

The sole goal of the project was to offer a high-level graduate course to train students in ocean observing methologies and geo-statistical analyses.

Contributions to Resources for Research and Education:

The long-term impact of the course is the creation of a cadre of students who returned to their home institutions with a new perspective of cross disciplinary science. As a result of the course, some students changed dissertation topics. These students, by virtue of their new training should accelerate advances in ocean observations, as well as provide a model system for environmental observations in general. The intense interactions among the ocean and geo-statistical faculty who developed and taught the course resulted in these faculty integrating new data types and methodologies into their own classes.

Contributions Beyond Science and Engineering:

Categories for which nothing is reported:

Organizational Partners

Any Journal

Any Book

Any Web/Internet Site

Any Product

Contributions: To Any Beyond Science and Engineering

The sole activity of this Collaborations in Mathematical Geosciences grant was the teaching of a five-week, intensive, cross-disciplinary, graduate-level course on ì Spatio-Temporal Statistical Analysis of Multi-platform Optical Ocean Observationsî. The goal of the course, which was successfully achieved, was to expose graduate students and faculty to the fields of Optical Oceanography and SpatioñTemporal Statistics. The course was taught to 18 graduate students by six core faculty, three visiting faculty, and four invited lecturers at the University of Maineís Darling Marine Center in summer 2003.

Curriculum for the Summer 2003 course on ì Spatio-Temporal Statistical Analysis of Multi-platform Optical Ocean Observationsî

WEEK I

Day 1 Monday, June 23
Welcome, general introductions, and course goals, team-building exercise, computer laboratory and file structure, library resources ñ *Mary Jane Perry*

Day 2 Tuesday, June 24
0830 Overview of Oceanography - *Andrew Thomas* -
How does the ocean work? currents; vertical structure; time scales of change: seconds, daily cycles, tides, seasonal cycles, inter-annual variability, climate change.
1030 Overview of Statistics ñ *Thomas Windholz* ñ
Introduction to statistics ñ Measurement theory, data types, random variables, distributions, densities, parametric and non-parametric statistics.
1330 Statistics Laboratory:
One-dimensional Time Series *ñThomas Windholz & Emmanuel Boss*
Exploration of time series data set from BATS - monthly profiles of temperature, chlorophyll concentration, and one nutrient.
Exercise: explore vertical and seasonal structure of the water column.
1900 Playing with Light *ñ Emmanuel Boss*

Day 3 Wednesday, June 25
0830 Introduction to Phytoplankton ñ *Mary Jane Perry* -
Phytoplankton as biological and optical particles; time scales and distributions.
1030 Data Analysis and Assumptions in Statistics - *Thomas Windholz*
Assumptions, stationarity and deviations from stationarity, isotrophy, measures of dependence, covariance functions, variograms for space, trends in space and time
1330 Statistics Laboratory:
Variograms, Covariograms, Trend removal - *Thomas Windholz & Andrew Thomas*

Day 4 Thursday, June 26
0830 Inherent Optical Properties (IOPs) and their measurement *ñ Emmanuel Boss*
1030 Data Analysis - *Thomas Winholz* -

Regression, ordinary least squares, generalized least squares, goodness of fit, robustness

1330 Optical Measurements:
How marine particles and dissolved organics interact with light -
Mary Jane Perry, Collin Roesler, and Emmanuel Boss
Introductory lecture to ac9 - *Collin Roesler*
Laboratory: ac9, backscattering and chlorophyll measurements by 4 teams; uncertainties at each step of measurement; error analys in scattering (b = c - a) and RS reflectance.

Day 5 Friday, June 27

0830 Other Absorbers and Scatters in Marine Waters *ñ Collin Roesler*
Other particles & dissolved organics; processes regulating their time scales and distributions

1030 Data Analysis: - *Thomas Windholz* -
errors, degrees of freedom, confidence tests, significance, residual analysis, bootstrap.

1330 Statistical error analysis using data from optics lab, Day 4 :
scattering correction for ac9; absorption correct for VSF; calculate uncertainty and propagation of error (different operators, machines; etc.), including propagation of error

WEEK II

Day 6 Monday, June 30

0830 Radiative Transfer Theory and basis of ocean color remote sensing
ñ *Collin Roesler*

1030 Data Analysis - *Thomas Windholz ñ*
Scale, resolution, data quality, support, and aggregation.

1330 Satellite Data Laboratory
Satellite data analysis (technical lecture and lab) *ñ Andrew Thomas*
Satellite data, pixel issues, and scales; raw data, digital image analysis, visualization.

Day 7 Tuesday, July 1

0830 Spatial and temporal scales of variability in the ocean *ñ Andrew Thomas*

1030 Data Analysis - *Thomas Windholz* -
Spatial interpolation and prediction; kriging; likelihood

1330 Statistics Laboratory: *Thomas Windholz ñ*-
Interpolation, regression, cross validation, and 2-D kriging
Subsample at different scales; detrend images; how to deal with spatially gappy data within one image.

Day 8 Wednesday, July 2

0830 Optical Measurements - *Mary Jane Perry*
sensors, QC, and proxies (including satellites)

1030 Data Analysis - discussion on gappy data with student examples

Day 9 Thursday, July 3
0830 Optical measurements from moorings (Eularian) ñ *Collin Roesler*
1030 Data Analysis: spatial sampling schemes ñ *Thomas Windholz*
sampling schemes (random, stratified, systematic) and asset allocation

1330 Group A:
Satellite Data Analysis - *Andrew Thomas and Thomas Windholz*
Continue with satellite data analysis from Tuesday, July 1.
1200 Group B:
Cruise on the *R/V Ira C*.
Field sampling on the Ira C. for collection of multivariate spatial data [surface temperature, salinity, 2 wavelengths of backscattering, chlorophyll fluorescence, CDOM fluorescence, and in-water remote sensing reflectance] ñ *Collin Roesler, Emmanuel Boss, and Mary Jane Perry*

WEEK III

Day 11 Monday, July 7
0830 Guest Lecture: *Janet Campbell, UNH*:
binning; aggregated data in non-linear models
1030 Data Analysis: Introduction to Multivariate Analysis *ñ Thomas Windholz*
1330 Optical Data Laboratory
Students analyze field data from previous week

Day 12 Tuesday, July 8
0830 Optical Sampling from drifters (true Lagrangian) *ñ Emmanuel Boss*
1030 Data Analysis: Principal Components Analysis - *Thomas Windholz ñ*
1330 Statistics Laboratory
Multivariate exploratory methods (1st of 2 sessions) - *Thomas Windholz*

Day 13 Wednesday, July 9
0830 Hyperspectral Aircraft data - *Marcos Montes, Naval Research Laboratory*
1030 Data Analysis: discussion of kreiging in temporal domain - *Thomas Windholz*
1330 Multivariate exploratory methods (2nd of 2 sessions)
satellite data and high spectral resolution aircraft

Day 14 Thursday, July 10
0830 AOP Models - *Collin Roesler*
Apparent Optical Properties (AOP) inversion models (analytic models)
1030 Geo-statistical modeling of spatial and spatial-temporal data ñ *John Welhan*
Random function model and auto correlation analysis and modeling
1330 Statistics Laboratory
Auto correlation analysis and modeling - *John Welhan*
1600 Darling Marine Center Lecture Series

Directed sampling ships, AUVS, and gliders ñ *Mary Jane Perry*

Day 15 Friday, July 11
0830 Geo-statistical modeling of spatial and spatial-temporal data - *John Welhan*
Part 3: modeling of variability and the analysis of uncertainty
1030 Ocean Observatories Initiative ñ *Larry Clark, National Science Foundation*
1330 Statistics Laboratory Lab - *John Welhan*
modeling of variability and the analysis of uncertainty

WEEK IV

Day 16 Monday, July 14
0830 Data Analysis- spatial variability ñ *lecturer Gerard*
1030 Oceanography - why there are no Case I or Case II waters - *Collin Roesler*
1330 Statistics Laboratory - *Gerard Heuvelink*

Day 17 Tuesday, July 15
0830 Data Analysis- spatial variability ñ *Gerard Heuvelink*
1030 Data Analysis- spatial variability ñ*Gerard Heuvelink*
1330 Statistics Laboratory - *Gerard Heuvelink*

Day 18 Wednesday, July 16
0830 Data Analysis ñ *Gerard Heuvelink*
1030 Data Analysis ñ *Phaedon Kyriakidis*
data integration issues, change of support data integration issues,
change of support
1330 Statistics Laboratory - *Gerard Heuvelink and Phaedon Kyriakidis*

Day 19 Thursday, July 17
0830 Scattering proxies - *Emmanuel Boss*
1030 Sochastic simulation for uncertainty assessment - *Phaedon Kyriakidis*
1330 Statistics Laboratory - *Phaedon Kyriakidis*

Day 20 Friday, July 18
0830 Fluorescence quenching and merging of proxies - *Mary Jane Perry*
1030 Geostatistical space-time model - *Phaedon Kyriakidis*
1330 Statistics Laboratory - *Phaedon Kyriakidis*

WEEK V (student projects during afternoon computer labs)

Day 21 Monday, July 21
0900 Visualization -- *Guest lecture: Larry Mayer, UNH*

Day 22 Tuesday, July 22
0830 Point processes ñ *Kate Beard*

Day 23 Wednesday, July 23
0900 Frontiers in optical measurements *ñ Emmanuel Boss*

Day 24 Thursday, July 24
0830 Inversion models ñ *Collin Roesler*

Day 25 Friday, July 25
0830 Student presentations and synthesis