Syllabus for OC-3140 (3-2)

Professor Peter C. Chu
Department of Oceanography
Naval Postgraduate school, Code OC/Cu
Spanagel Hall 237
831-656-3688, pcchu@nps.edu, http://web.oc.nps.navymil/~chu

Course Description

This course is designed for educating students with the basic statistical theories and methods and data analysis techniques currently used in the METOC operations.

The course covers the following subjects: Air-Ocean Data Description, Probability Distribution, Fitting and Testing Probabilities, Sampling and Sampling Distributions, Parameter Estimation, Hypothesis Testing, Analysis of Data Variability, and Regression Analysis.

Office Hours:

Educating students is my highest priority. You may come any time from 7 am to 6 pm.

Course Grade

Lab 30%
Mid-Term 25%
Final Exam 45%

Course Outline

Chapter 1 Introduction
• 1.1. Why do we need statistics?
• 1.2. What is Data Analysis?
• 1.3. Population and Sample
• 1.4. Variables and Data
• 1.5. What is Statistics?
• 1.6. Statistical Models
• 1.7. Measurement
• 1.8. Steps in Analysis

Chapter 2 Data Description
• 2.1. Descriptive Statistics
• 2.2. Ordered Data and Percentiles
• 2.3. Frequency Distribution
• 2.4. Measures of Central Tendency
• 2.5. Measure of Dispersion
• 2.6. Measures of Distribution Shape
• 2.7. Graphical Presentation Techniques
• 2.8. Descriptive Statistics for Two or More Variables

Chapter 3 Probability Distributions
• 3.1. What Is Probability?
• 3.2. Probability and Statistics
• 3.3. Probability Distribution of Random Variables
• 3.4. Descriptive Measures of Probability Distribution Functions
• 3.5. Discrete Probability Distribution Models
• 3.6. Continuous Probability Distributions

Chapter 4 Fitting and Testing Probabilities
• 4.1. Determining Probability Models from Data
• 4.2. Fitting Probability Models
• 4.3.Chi-Square Test
• 4.4. Kolmogorov-Smirnov (K-S) Test

Chapter 5 Sampling and Sampling Distributions
• 5.1. Sampling and Random Sampling
• 5.2. Sampling Distribution
• 5.3. Sampling Distribution of Means
• 5.4. Central Limit Theorem (CLT)
• 5.5. Sampling Distribution of the Difference between Two Means
• 5.6. Probability Distributions for Statistics
• 5.7. Monte Carlo Simulation
• 5.8. Re-Sampling

Chapter 6 Estimation
• 6.1. Point Estimation
• 6.2. Interval Estimation
• 6.3. Confidence Interval of the Mean
• 6.4. Confidence Interval of the Variance
• 6.5. Confidence Interval on the Proportion
• 6.6. Confidence Interval on the Difference of Means
• 6.7. Confidence Interval on the Difference between Two Proportions
• 6.8. Confidence Intervals Using Resampling

Chapter 7 Hypothesis Testing
• 7.1. Hypothesis
• 7.2. Significance Level
• 7.3. Types of Errors
• 7.4. One-sided and Two-sided Testing
• 7.5. Parametric Testing
• 7.6. Hypothesis Testing on the Mean
• 7.7. Hypothesis Testing on the Variance
• 7.8. Hypothesis Testing on the Proportion
• 7.9. Hypothesis Testing on the Difference of Two Means
• 7.10. Relationship between Hypothesis Testing and Interval Estimation
• 7.11. Goodness-of-fit Test

Chapter 8 Analysis of Variance (ANOVA)
• 8.1. One-factor (or One-way) ANOVA
• 8.2. Partitioning of Variability
• 8.3. Mathematical Model of One-way ANOVA
• 8.4. Multiple Comparisons
• 8.5. Two-Factor (or Two-Way) ANOVA

Chapter 9 Regression Analysis
• 9.1. Regression Equation and Coefficients
• 9.2. Residual Analysis
• 9.3 Outliers
• 9.4. ANOVA
• 9.5. Goodness-of-fit Measures
• 9.7 Hypothesis Testing on Regression Coefficients
DEPARTMENT OF OCEANOGRAPHY
NAVAL POSTGRADUATE SCHOOL

ANALYSIS OF AIR-OCEAN TIME SERIES (3-2)

Instructor:  Prof. Jamie MacMahan (Spanagel 327c, ext.2379, jhmacmah@nps.edu)

Recommended Reading:
Class handouts

Course Objectives:

We will learn the basic tools for Fourier analysis and spectral analysis for the interpretation of geophysical processes. Emphasis is placed on understanding the concepts and mathematical methods and applying these to meteorological and oceanographic problems. Because the atmosphere and the ocean must be considered stochastic (randomly varying in time and space) in all but the largest scales, much of the course is concerned with describing stationary random process using spectral analysis techniques. The labs are designed to put into practice the statistical and mathematical concepts presented in the lectures.

A student who successfully completes this course should be able to:

- calculate Fourier series of periodic signals;
- determine theoretically and numerically the auto correlation function and energy density (power) spectrum of a stationary random process;
- understand the concepts associated with processing discretely sampled random data of finite record length and how to apply these concepts to the design of measurement strategy;
- understand the concept of windowing and filtering and be able to apply these techniques to real data.
- determine the cross-correlation function and cross spectrum between two signals;
- determine the transfer function in the frequency domain of simple linear stochastic systems as applied to physical processes and systems placed in the atmosphere and the ocean;

Course Structure:
Midterm (35%), labs and homework (25%), final (40%).
Course Syllabus:

Introduction to data and time series analysis 5
Fourier series and integrals 7
  sine wave representation and harmonic series 8
  Fourier series: the complex form 27
  Fourier integral: extension to aperiodic functions 35

Spectra analysis of stationary random processes 39
  stationary and ergodic random processes 41
  autocorrelation and its properties 45
  Parseval’s Theorem and energy density spectrum 59
  Frequently used Fourier transform pairs 62

Aliasing 73

Leakage 84

Discrete Fourier transform 8
  Fourier representation of discrete data and FFT 96
  confidence interval on spectral estimates 97

Convolution 105

Filtering- Constant parameter linear system 113

Windowing and spectral leakage 115

Cross-spectral analysis 125

Input-output relationships for physical systems 135

Special topics
  2-dimension spectra 159
  rotary spectra 161
  bi-spectra 167
  directional wave spectra 171
  empirical orthogonal function (EOF) analysis

Appendices
  • Laboratory Exercises http://intra.nps.navy.mil/~orzech/oc3150.html 189
  • Problems 195
OC3150

Time Series Analysis Laboratories

Lab 1  Central Limit Theorem, Chi-square goodness-of-fit test, and introduction to your data sets.

Lab 2  Fourier Series amplitude coefficients of simple periodic waves.

Lab 3  Problems

Lab 4  The discrete Fourier transform, sampling techniques, and the phenomena of aliasing and leakage

Lab 5  Problems

Lab 6  Matlab FFT routine to perform spectrum on white noise signal

Lab 7  Energy Density spectra of your two data sets and trade-off between spectral resolution and confidence in the spectral estimate

Lab 8  Problems

Lab 9  Cross-spectra, coherence, and phase between you two data sets

Lab 10  Problems

Lab 11  Review
From: Maslowski, Wieslaw (CIV)
Sent: Friday, August 21, 2009 6:27 AM
To: Stone, Rebecca (CDR)
Cc: Maslowski, Wieslaw (CIV)
Subject: RE: Syllabi collection for AY2009

Hi Jeff,

The included below is the OC3212 Ocean Section syllabus for the summer quarter of AY09.

-Wieslaw

**Section 2 – Polar Oceanography Schedule – Prof. Wieslaw Maslowski**

**Lecture Topics**

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1. State of Arctic Climate – introduction and current status
2. Pan-Arctic geography, general circulation, heat/salt/freshwater budgets
3. Sub-Arctic Pacific/Atlantic water masses and ocean circulation
4. Invited lecture on remote sensing of cryosphere – Dr. W. Abdalati (in SP316, counts toward Sea Ice Section)
5. Central Arctic water masses and ocean circulation
6. Polynyas, effects of ice production on shelf, deep water formation
7. Mesoscale features and their role in large scale circulation
8. Water mass and property exchanges through Bering Strait and Canadian Archipelago
9. Water mass / property exchanges through Fram Strait and Barents Sea
10. Modeling and prediction of climate variability in the Arctic
11. Oceanic consequences of large scale climate variability in the Arctic
12. Arctic Ecosystems
13. Antarctic Oceanography – part I
14. Antarctic Oceanography – part II
15. Section Quiz
<table>
<thead>
<tr>
<th>Wk</th>
<th>Date</th>
<th>Lecture Topic</th>
<th>Lab Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7/6</td>
<td>Course Intro, Physical character of the ocean basins</td>
<td>Computer &amp; Matlab intro</td>
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<tr>
<td></td>
<td>7/7</td>
<td>Fresh and sea water properties</td>
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<tr>
<td></td>
<td>7/8</td>
<td>Equations of state, sound, light</td>
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<tr>
<td>2</td>
<td>7/13</td>
<td>History of oceanography</td>
<td>Seawater properties</td>
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<td></td>
<td>7/14</td>
<td>Heat &amp; freshwater budget, global wind patterns</td>
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<td></td>
<td>7/15</td>
<td>Dynamic height &amp; geostrophic currents</td>
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<tr>
<td>3</td>
<td>7/20</td>
<td>Geostrophy con't.; incl. barotropic, baroclinic</td>
<td>Geostrophic velocity</td>
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<tr>
<td></td>
<td>7/21</td>
<td>Ocean observing techniques today</td>
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<tr>
<td></td>
<td>7/22</td>
<td>Wind-driven circulation; inertial currents, Ekman spiral</td>
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<tr>
<td>4</td>
<td>7/27</td>
<td>Sverdrup transport &amp; Western boundary currents; vorticity</td>
<td>Finish up last week's</td>
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<td></td>
<td>7/28</td>
<td>Review for test</td>
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<td></td>
<td>7/29</td>
<td><strong>TEST</strong></td>
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<tr>
<td>5</td>
<td>8/3</td>
<td>Go over test</td>
<td>Heat flux</td>
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<td></td>
<td>8/4</td>
<td>Eastern boundary currents, incl. coastal upwelling; Equatorial circulation</td>
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<td></td>
<td>8/5</td>
<td>Thermocline incl. subduction</td>
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<tr>
<td>6</td>
<td>8/10</td>
<td>Thermohaline circulation topics incl. T/S diagrams, water masses, sea ice formation</td>
<td>Sverdrup transport and Ekman pumping</td>
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<tr>
<td></td>
<td>8/11</td>
<td>Ocean observing techniques (con't.)</td>
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<td></td>
<td>8/12</td>
<td>Ocean observing systems</td>
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<tr>
<td>7</td>
<td>8/17</td>
<td>Meridional overturning circulation (conveyor belt), incl. deep convection</td>
<td>Review for test</td>
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<tr>
<td></td>
<td>8/18</td>
<td>Southern Ocean</td>
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<td></td>
<td>8/19</td>
<td>Atlantic Ocean circulation</td>
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<td>8</td>
<td>8/24</td>
<td>Atlantic Ocean water masses</td>
<td>Calibration lab and glider</td>
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<td></td>
<td>8/25</td>
<td>Atlantic Ocean adjacent seas</td>
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<td></td>
<td>8/26</td>
<td><strong>TEST</strong></td>
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<tr>
<td>9</td>
<td>8/31</td>
<td>Indian Ocean circulation and water masses</td>
<td>Go over test</td>
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<td></td>
<td>9/1</td>
<td>Arctic Ocean circulation and water masses</td>
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<td>9/2</td>
<td>Pacific Ocean circulation</td>
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<td>10</td>
<td>9/8</td>
<td>Tides</td>
<td>Tides</td>
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<td>9/9</td>
<td>Tides</td>
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<tr>
<td>11</td>
<td>9/14</td>
<td>Pacific Ocean water masses and adjacent seas</td>
<td>No lab</td>
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<td>9/15</td>
<td>Interannual variability; climate change</td>
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<td>9/16</td>
<td><strong>REVIEW for final exam</strong></td>
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OC3240 Dynamical Oceanography-I

OC3260 – Fundamentals of Ocean Acoustics  
Spring AY2009, Tentative Syllabus  
Instructor: C.-S. Chiu, SP-313, X3239, chiu@nps.edu

**Week 1 (Mar 30-Apr 1)**
Course overview  
Speed of sound - empirical formulae and variability  
The acoustic wave equation

**Week 2 (No lectures, only lab on Apr 10)**
Lab 1: Complex numbers and variables

**Week 3 (Apr 13-16)**
Acoustics in homogeneous media  
Boundary conditions and plane wave solutions

**Week 4 (Apr 20-24)**
Plane wave reflection and transmission  
Snell's law  
Sound intensity and pressure levels, and Decibel  
Lab II: Frequency-domain representation of signal

**Week 5 (Apr 27-May 1)**
Point source, near field, and radiation of power  
Transmission loss - an overview  
**Mid-term exam (30%)**

**Week 6 (May 4-8)**
Ray theory - Eikonal and Transport Equations  
Validity of ray theory and Snell's Law  
Lab III: Power spectral density/Spectrogram

**Week 7 (May 11-15)**
Raytracing  
Caustics, shadow zones and convergence zones  
Lab IV: Ambient noise analysis lab project description  
**Lab project report due on Week 12 – 30%**

**Week 8 (No lectures and labs)**

**Week 9 (May 26-28)**
Sound absorption  
Bottom loss

**Week 10 (Jun 1-4)**
Transmitting and receiving directivities of arrays  
Directivity index

**Week 11 (Jun 8-11)**
Passive and active sonar equations

**Week 12 (Jun 15) - Final exam (40%)**

**Homework** will be assigned from time to time but will not be collected and graded. Solution sets will be given.

**Office hours:** Call/email to make appointments as needed.

Instructor: Professor Mary L. Batteen

Office: Spanagel Hall, Room 343

Phone: 656-3265 (leave message on answering machine)

Class Time: Monday through Thursday, 1100-1150
Classroom: SP-332

Grade primarily determined by the following:

3-4 quizzes

Course description:

A foundation course for studies of atmospheric and oceanographic motions. The governing dynamical equations for a rotating stratified fluid are derived from fundamental physical laws. Topics include the continuum hypothesis, real and apparent forces, derivations and applications of the governing equations, coordinate systems, scale analysis, simple balanced flows, boundary conditions, thermal wind, barotropic and baroclinic conditions, circulation, and vorticity.

Prerequisite: Vector Analysis (May be concurrent)

Course Objectives:

Know and understand the hydrodynamical equations that govern the motions of the earth’s atmosphere and oceans, including the momentum equations, the continuity equation, the first law of thermodynamics, the equation of state and conservation equations for other constituents in the environment.

Derive and understand the total energy equations.

Do a scale analysis of the hydrodynamical equations in order to isolate specific types of motion and the forces that drive them, including simple flow regimes such as geostrophic and gradient flows.

Distinguish between barotropic and baroclinic thermal structures in fluids and relate the vertical shear of the horizontal velocity to the temperature distribution.

Understand the concepts of vorticity and potential vorticity.
OC 3321 Class Schedule Fall 2008

Week 1 (30 September-2 October):
- Monday: Introduction and organization of class (Lecture 1)
- Tuesday: Pressure gradient force (Lecture 2)
- Wednesday: Gravitational force (Lecture 2)
- Thursday: Friction or viscosity force (Lecture 3)

Week 2 (6-9 October):
- Monday: Properties of a material element (Lecture 7)
- Tuesday: Homework problems on board
- Wednesday: Lagrangian and Eulerian frames of reference (Lecture 7)
- Thursday: Equation of motion in a non-inertial frame of reference (Lecture 10)

Week 3 (13-16 October):
- Monday: Holiday
- Tuesday: Centrifugal and gravity forces (Lecture 4)
- Wednesday: Coriolis force (Lecture 5)
- Thursday: Equations for a fluid at rest: Equation of state and hydrostatic equation (Lecture 6)

Week 4 (20-23 October):
- Monday: Mass conservation equation (Lecture 8)
- Tuesday: Homework problems on board
- Wednesday: Balances for scalar quantities like salinity or humidity (Lecture 9)
- Thursday: Thermodynamic energy equation (Lecture 14)

Week 5 (27-30 October):
- Monday: The complete system of equations in vector form (Lecture 15); Review for Quiz 1
- Tuesday: Quiz 1
- Wednesday: Boundary conditions (Lecture 16)
- Thursday: Spherical coordinates (Lecture 11)

Week 6 (3-6 November):
- Monday: Energetics (Lecture 17)
- Tuesday: Angular momentum background (Lecture 12)
- Wednesday: Shallow approximation (Lecture 12)
- Thursday: Cartesian coordinates, f and beta plane approximation (Lecture 13)

Week 7 (10-13 November):
- Monday: Scale analysis (Lecture 18)
- Tuesday: Holiday
Wednesday: Dynamic similarity (Lecture 19)
Thursday: **Homework problems on board**

**Week 8 (17-20 November):**
- Monday: Review for Quiz 2
- **Tuesday: Quiz 2**
- Wednesday: Simple balanced flows: Geostrophic balance (Lecture 20)
- Thursday: Inertial and Cyclostrophic balance (Lectures 20-21)

**Week 9 (24-27 November):**
- Monday: Gradient balance (Lecture 21)
- Tuesday: The thermal wind and baroclinicity (Lecture 22)
- Wednesday: **NO CLASS**
- Thursday: **Holiday**

**Week 10 (1-4 December):**
- Monday: Thermal “wind” in the ocean and in the atmosphere (Lecture 23)
- Tuesday: Baroclinic and barotropic fluids (Lecture 24)
- Wednesday 1300: Introduction to circulation and vorticity (Lecture 25)
- Thursday: The circulation theorem (Lecture 26)
- Thursday: 1400 Homework problems on board

**Week 11 (8-11 December):**
- **Monday:** Vorticity (Lecture 27)
- Tuesday: The vorticity equation (Lecture 28)
- Wednesday: Potential vorticity (Lecture 29)
- **Thursday: Homework problems on board;** Review for Final Exam

**Week 12 (15-18 December):**
- **FINAL EXAM Tuesday 16 December 0800 to 0950 in Sp-310**
OC3902 Fundamentals of Geographic Information Systems
Arlene Guest, Department of Oceanography
aguest@nps.edu

Course Description and Objectives: In this course we will explore the fundamentals of GIS with an emphasis on practical application of GIS to military-relevant problems. Topics include the basic theory and principles of GIS, data collection and input, data management, and spatial query and analysis. Upon completion of this course, the student will be able to:

- Describe the functions and limitations of geographic information systems.
- Apply scientific and technical methods of inquiry in the analysis of geospatial data for geographic trends, patterns and relationships.
- Acquire and synthesize diverse types of spatial and non-spatial data.
- Understand error and precision in the context of geospatial data and maps.
- Apply a state-of-the-art GIS application, ArcGIS, to decision-making processes and the solution of real-world problems.

Course Format: This course is a mix of concepts, information, and theory, and hands-on "doing". Most people learn best by doing, and I believe that using GIS and being conversant with the application is the best way to learn, and a big motivator for understanding the concepts and theory behind it. We will have a mix of lecture hours and computer lab time each week.

Prerequisites: A basic understanding of algebra, trigonometry and geometry. Basic computer skills.


Software: ArcGIS version 9.3 is available in all the pc labs on campus through a site license. A student version for your laptop can be obtained from ITACS.

Grading:
50% Exams A >92.5%
25% Labs A- 90.0 – 92.5%
25% Final Project B+: 87.5 – 90.0%
B: 82.5 – 87.5%
Course Learning Outcomes

Upon completion of this course students will be able to:

1. Compare and contrast conventional mapping technology to GIS technology.
2. Discuss and demonstrate the concepts and theory behind the use of GIS.
3. Compare and contrast commonly used map projections and change GIS data from one projection to another.
4. Explain the sources and history of various datums. Compare and contrast historical datums with the WGS datum.
5. Define the ellipsoid, geoid and geodesy how they relate to GIS.
6. Use the geographic coordinate system, State Plane Coordinate System and the Universal Transverse Mercator (UTM) system to describe location on Earth.
7. Apply and use basic cartographic principles to produce maps.
8. Define problems associated with acquisition and accuracy of data used in GIS.
9. Compare and contrast which data structure (vector or raster) is best suited to a particular application.
10. Overlay and produce maps combining the two basic GIS data structures.
11. Analyze and manipulate tabular data using ArcGIS.
12. Import text, database files, grids and vector files into ArcGIS, convert them to shapefiles or/and integrate into a geodatabase.
13. Understand what spatial analysis is and how GIS can be used in scientific and resource management applications.
15. Run assigned queries in ArcGIS to display the desired text and graphic output.
16. Construct charts and graphs from analyzed tabular data using ArcGIS.
17. Produce maps in ArcGIS using the correct map coordinate system, datum, projection, and map scales to meet the requirements of a specified project.

18. Discuss and demonstrate the concepts and theory behind the use of GPS.

19. Collect GPS data and integrate it into ArcGIS.

20. Demonstrate the ability to define a problem and develop a methodology to study, analyze, and develop solutions towards solving it.
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<thead>
<tr>
<th>Week</th>
<th>Mon</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mar 30 – Apr 3</td>
<td>Introduction to course and to GIS</td>
<td>Introduction to GIS</td>
<td>Lab #1: Exploring ArcCatalog and ArcMap</td>
<td>Lab #2: Creating a map from scratch;</td>
<td>Finish Lab #2</td>
</tr>
<tr>
<td>2</td>
<td>Apr 6 - 10</td>
<td>Geodesy; Coordinate systems</td>
<td>Coordinate Systems; Projections</td>
<td>Lab #3: Projection Distortion</td>
<td>UTM, MGRS, State Plane Coordinate systems</td>
<td>Lab 4: Coordinate systems &amp; Reprojecting in ArcGIS</td>
</tr>
<tr>
<td>3</td>
<td>Apr 13 - 17</td>
<td>Finish Lab 4</td>
<td>Cartographic concepts – map types, classification of data;</td>
<td>Lab 5: Classification and Symbology</td>
<td>Vector Data model; Tables</td>
<td>Start: Earthquake Project – getting data into ArcMap</td>
</tr>
<tr>
<td>4</td>
<td>Apr 20 - 24</td>
<td>Queries</td>
<td>Lab 7: Queries</td>
<td>Work on Earthquake project</td>
<td>Joining Tables ; Lab 8:</td>
<td>Finish lab 8 &amp; earthquakes</td>
</tr>
<tr>
<td>5</td>
<td>Apr 27 – May 1</td>
<td>Exam #1</td>
<td>Raster Data Model; Imagery</td>
<td>Georeferencing Lecture and Lab 9</td>
<td>Lab 10: Symbolizing rasters</td>
<td>Continue Labs 9 and 10</td>
</tr>
<tr>
<td>6</td>
<td>May 4 - 8</td>
<td>Satellite Remote Sensing: Dr. Chris Olsen</td>
<td>Data Types and Sources; Project data search</td>
<td>The Global Positioning System</td>
<td>Project data search / discussions</td>
<td>GPS Data Collection</td>
</tr>
<tr>
<td>7</td>
<td>May 11 - 15</td>
<td>Creating and editing features; Finish GPS lab</td>
<td>Project work</td>
<td>5-minute Project proposal presentations</td>
<td>Project work</td>
<td>Lab: Digital Nautical Charts</td>
</tr>
<tr>
<td>8</td>
<td>May 18 - 22</td>
<td>Animation using Tracking Analyst</td>
<td>Project work</td>
<td>Spatial analysis</td>
<td>Project work</td>
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<td>9</td>
<td>May 25 - 29</td>
<td>Holiday</td>
<td>Project work</td>
<td>Spatial accuracy and error; Metadata</td>
<td>Lab: Create metadata;</td>
<td>Project work</td>
</tr>
<tr>
<td>10</td>
<td>Jun 1-5</td>
<td>Exam #2</td>
<td>Project work</td>
<td>3D GIS</td>
<td>Project work</td>
<td>Project work</td>
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<td>11</td>
<td>Jun 8 - 12</td>
<td>Project presentations</td>
<td>Project presentations</td>
<td>Project Presentations</td>
<td>Project Presentations</td>
<td>Project Report Due</td>
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Naval Postgraduate School

**OC4211 OCEAN WAVES (4-0).**
Linear theory of surface, internal, inertial-internal and Rossby waves, barotropic and baroclinic instabilities. Coastal and equatorial trapped waves.

**PREREQUISITES:** MA3132 and OC3240

Quarter: Spring 2009

Instructor: Thomas H. C. Herbers

Office: Spanagel Hall, Room 331B

Phone: 656-2917

Lectures: Mon, Tue, Wed, Thu 14:00-14:50 Sp-332

Final Exam: Wednesday 08:00-09:50 Sp-332

Grading Policy: Mid-Term Exam: 40 %
               Final Exam: 60 %
<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
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</thead>
</table>
| 1    | **I  INTRODUCTION**  
|      | Overview of ocean wave phenomena.  
|      | **II  SURFACE WAVES**  
|      | Governing equations and boundary conditions.  
| 2    | Surface gravity waves.  
|      | The details of the motion; phase and group speeds.  
| 3    | Observations of ocean surface waves.  
|      | Dispersive deep water waves (wind waves).  
|      | Non-dispersive shallow water waves (tsunamis).  
| 4    | Capillary waves.  
|      | **III INTERNAL WAVES**  
|      | Interfacial waves in a two-layer fluid.  
| 5    | Equations for a continuously stratified fluid.  
|      | Internal waves  
| 6    | The oceanic wave guide.  
|      | **IV INERTIAL AND**  
|      | **ROSSBY WAVES**  
|      | Effects of rotation.  
| 7    | *MID-TERM EXAM*  
|      | Poincare waves, inertial oscillations, and inertial-internal waves.  
| 8    | Beta-plane approximation.  
|      | Equatorially trapped waves.  
| 9    | Quasi-geostrophic motion.  
|      | Planetary Rossby waves.  
| 10   | **V COASTALLY TRAPPED**  
|      | **WAVES AND SEICHES**  
|      | Edge waves, Kelvin waves, and continental shelf waves.  
| 11   | Seiches and tides in gulfs and channels.  
| 12   | **FINAL EXAM**  
|      | **REVIEW**  
|
Naval Postgraduate School
OC4213 NEARSHORE AND WAVE PROCESSES (3-1).
Shoal-water wave processes, breakers and surf; nearshore water circulation; beach characteristics;
littoral drift; coastal hydraulics; storm surge.

PREREQUISITE: OC4211 or consent of instructor.

Quarter: Winter 2009

Instructor: Prof. Thomas H. C. Herbers

Office: Spanagel Hall, Room 331B

Phone: 656-2917

Lectures: Mon, Tue, Wed
1000-1050
Spanagel Hall, Rm 310

Computer Lab: Thu
1000-1050
Spanagel Hall, Rm 263
POC: Paul Jessen
Sp-331C
x 2974

Grading Policy: Labs: 30 %
Presentations (2): 70 %
<table>
<thead>
<tr>
<th>Week</th>
<th>Topics</th>
<th>Lecture Schedule</th>
<th>Labs (Thursday)</th>
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<tbody>
<tr>
<td>1</td>
<td><strong>I Introduction</strong>&lt;br&gt;• course outline and objectives&lt;br&gt;• general description of nearshore processes</td>
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<td>2</td>
<td><strong>II Waves and surf</strong>&lt;br&gt;• linear waves review&lt;br&gt;• wave shoaling and refraction on a beach</td>
<td>Mon Tue Wed</td>
<td>I Tide/Surge/Swell Observations</td>
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<td>3</td>
<td>• wave transformation over irregular bathymetry&lt;br&gt;• diffraction around breakwaters and harbor entrances</td>
<td>Tue Wed</td>
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<td>4</td>
<td>• nonlinear waves (Stokes, Cnoidal, Solitary waves)&lt;br&gt;• nonlinear wave transformation over shoals and beaches</td>
<td>Mon Tue Wed</td>
<td>II Wave Refraction Computations</td>
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<td>5</td>
<td>• wave reflection and “surf beat”&lt;br&gt;• spilling, plunging, and surging breakers</td>
<td>Mon Tue Wed</td>
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<td>6</td>
<td><strong>Selected Topics</strong></td>
<td>Class Presentations</td>
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<td>7</td>
<td><strong>III Currents and sea level</strong>&lt;br&gt;• wave set-up and undertow</td>
<td>Tue Wed</td>
<td>III Wave Shoaling Observations</td>
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<td>8</td>
<td>• longshore and rip currents&lt;br&gt;• wind-driven currents and storm surge</td>
<td>Mon Tue Wed</td>
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<td>9</td>
<td>• tides and seiches&lt;br&gt;• numerical models</td>
<td>Mon Tue Wed</td>
<td>IV Surf-Zone Current Observations</td>
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<td>10</td>
<td><strong>IV Sediment transport</strong>&lt;br&gt;• sediment mechanics&lt;br&gt;• sediment transport and the evolution of beaches&lt;br&gt;• beach morphology (ripples, bars, and cusps)</td>
<td>Mon Tue Wed</td>
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<td>11</td>
<td><strong>Selected Topics</strong></td>
<td>Class Presentations</td>
<td>Mon Tue Wed</td>
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</table>
OC 4220 COASTAL CIRCULATION (4 lecture hours and 1 lab hour per week)

Lecture portion description:

Coastal ocean physical processes; dynamics and models of coastal circulation driven by wind, boundary current and ocean eddy forces; coastal trapped waves; submarine canyons, the shelf break, shallow shelves, shoreline variations and other topographic perturbations; barotropic and baroclinic tides; thermohaline-driven coastal circulation; current Navy and DoD research emphases.

Lab portion description:

Littoral ocean regions and strategic seas and straits of the world:
  a) Eastern boundary currents (California, Canary, Peru-Chile, Benguela, West Australia (Leeuwin), Gulf of Alaska)
  b) Western boundary currents (Gulf Stream, Brazil, Kuroshio, East Australia, Agulhas, Somali)
  c) Marginal seas (Mediterranean and Black Seas; Sea of Okhotsk and Sea of Japan; E. China, Yellow and S. China Sea; Irish, North and Baltic Seas; Indonesian Throughflow; Arabian Sea, Arabian Gulf, Bay of Bengal, and Red Sea; Gulf of California to the Galapagos; Gulf of Alaska; Bering Sea; Caribbean Sea; Gulf of Mexico; S. Atlantic Bight; Great Australian Bight)
  d) Polar ocean boundaries (Antarctica; Arctic coastal regions)

Naval Relevance:

Measurements, analysis and forecasting of littoral ocean variables that occur in association with synoptic/mesoscale processes over limited regional and temporal domains.
Areas of emphasis include littoral ocean physical processes (driven by wind, thermohaline, tidal, boundary current, and ocean eddy forces) and littoral ocean regions and strategic seas and straits of the world.

OC 4220 Sample of Class Schedule Fall 2008

Week 1 (29 September-2 October):
  Tuesday: Introduction and organization of class
  Wednesday: Shelf dynamics and how it is different from the open ocean
  Thursday: Shelf dynamics and how it is different from the open ocean

Week 2 (6-9 October):
  Monday: Basic physical concepts
  Tuesday: Basic physical concepts
  Wednesday: Basic physical concepts
Thursday: Seasonal or steady flow of currents over the shelf
Review of semi-permanent currents via MOVIE of global simulation of ocean currents

Week 3 (14-16 October):
Monday: HOLIDAY
Tuesday: A survey of eastern boundary currents
Wednesday: A survey of western boundary currents
Thursday: Movie: The Gulf Stream

Week 4 (20-23 October): Presentations on EBCs and WBCs
Monday: Nicky Wheatley: The California Current
And Francisco Almeida: The Benguela Current
Tuesday: Guillermo Coll: The Canary Current
And Bill Swick: The Leeuwin Current
Wednesday: Dimitrios Alevras: The Agulhas Current
And Rip Coke: The Somali Current
Thursday: Lincoln Trainor: The East Australia Current
And Tim McGeehan: The Kuroshio Current

Week 5 (27-30 October):
Monday: Wind-driven coastal upwelling
Tuesday: Models on the shelf
Wednesday: Models on the shelf
Thursday: Basic concepts to address for theoretical studies

Week 6 (3-6 November):
Monday: A hierarchy of models of wind-driven eastern boundary currents
Tuesday: Models of eddies and filaments in littoral regions
Wednesday: Models of currents and eddies over topography
Thursday: Models of currents and eddies over topography

Week 7 (10-13 November):
Monday: NO CLASS!
Tuesday: HOLIDAY
Wednesday: Coastal trapped waves
Thursday: Topographical influences on coastal circulation

Week 8 (17-20 November): Presentations on Marginal Seas
Monday: Nicky Wheatley: The Irish, North and Baltic Seas
And Lincoln Trainor: Australian N. Shelf and Indonesian Throughflow
Tuesday: Guillermo Coll: Antarctica
And Tim McGeehan: The Bering Sea
Wednesday: Dimitrios Alevras: The Mediterranean Sea
And Rip Coke: The Black Sea
Thursday: Francisco Almeida: The Arabian Sea, the Bay of Bengal, the Red Sea, 
And the Persian Gulf 
And Bill Swick: The Yellow and E. China Seas

Week 9 (24-27 November):
Monday: Tides 
Tuesday: Tides 
Wednesday: NO CLASS 
Thursday: HOLIDAY

Week 10 (1-4 December):
Monday: Tidal influences on coastal circulation 
Tuesday: Wind forcing, topography and thermohaline effects on eddies and 
currents: Northern Canary and Southwest Australia Current Systems 
Wednesday: Acoustic effects in eastern boundary currents 
Thursday: ASW analogous areas

Week 11 (8-11 December): Presentation of Final Projects
Monday: Nicky Wheatley: Oceanography for Mine Warfare 
And Lincoln Trainor: Observations of ocean surface wave damping on a muddy 
continental shelf 
Tuesday: Francisco Almeida: The influence of wind on HF radar surface 
current forecasts 
And Guillermo Coll: The Strait of Gibraltor and the Mediterranean 
Outflow 
Wednesday: Rip Coke: The mouth of the Chesapeake Bay 
And Dimitrios Alevras: On the response of the Aegean Sea to climatic 
variability 
Thursday: Studies of drifting mines and spills within the Persian Gulf

Week 12 (15-18 December): NO CLASS, NO FINAL EXAM
OC4240: Littoral Field Studies

Course Description: Employs the scientific method for studying nearshore and wave processes using field observations in littoral battlespace environments. Students will design a small nearshore field experiment(s), deploy state-of-the-art instrumentation, and analyze data to test relevant nearshore hypotheses. Introductions and limitations of instrumentation will be discussed and integrated into the field design, which include deployment schemes and subsequent analysis. Data quality control and analysis techniques will be described and implemented. In particular, tidal harmonic analysis will be introduced and performed. Monterey Bay, CA is a natural laboratory for studying a plethora of littoral related topics. The course is divided into 1) in-class discussions (instrumentation, deployment schemes, and data analysis techniques), and 2) field exercises that require student participation in performing the proposed small experiments.

There is a high probability that students will get wet, but it is not a requirement.

Prerequisites: OC3140; OC3150; OC4213; Matlab familiarity; or consent of instructor.

Course Timeline
Week 1 – Introduction, Scientific Method, Projects, Pressure Sensor (Tides)
Week 2 – Available Instrumentation, Communication Ports, Battery, Memory,
   Time Syncing, Surf Zone Field Deployment, Moorings
Week 3 – Discuss Relevant Papers for Selected Hypothesis
Week 4 – Design Experiment
Week 5 – T-Tides – Tidal Harmonic Analysis
Week 6 – Mini Experiment (tentatively 2 days)
Week 7 – Nearshore Data Quality Control – e.g. reading input and output, filtering, data outliers, data gaps, interpolation, extrapolation, and time synchronization
Week 8 – Data Analyses – e.g. when to use confidence intervals, linear regression, auto-(cross) correlation, spectral analysis, and higher order data techniques
Week 9 – Data Presentation – e.g. contour plotting, colorline, and timestacks
Week 10 – Hypothesis Testing
Week 11 – Presentation(s)/Summary

Preliminary Proposed Projects
Topic 1) Evaluate void fraction as function of wave height, evaluate optical relationship with void fraction
Topic 2) Surf zone dispersion
Topic 2) Circulation and Wave patterns in Monterey Harbor
Topic 3) Circulation patterns in Elkhorn Slough small tidal flat channels
Topic 4) Elkhorn Slough Dispersion
Topic 5) Elkhorn Slough Tidal Currents
Topic 6) Wave Dissipation due to kelp forest
Topic 7) Build a kayak environmental monitoring platform for bathymetry and water quality.
Topic 8) Sea Breeze Influence
Topic 9) Sediment Suspension
Topic 10) cross-shore transport (dissipative and reflective beaches)
Topic 11) Stokes Drift  
Topic 12) Storm water tracking  

Available Instrumentation  
1) Pressure sensor  
2) Survey-grade GPS  
3) 4 acoustic Doppler current meters  
4) Chl-A and turbidity optical sensor  
5) Conductivity, Temperature, Depth sensor  
6) Optical dye tracking sensor  
7) GPS self-tracking loggers  
8) Jet-pump for jetting instruments poles in  
9) Acoustic Backscatter Sensor  
10) Echosounder  
11) Serial Data logger  
12) 2 kayaks, 1 zodiac, 1 PWC, (can rent an additional whaler)  
13) AUV (may be by the time of the course)
Weeks 1 & 2
Course overview
An overview of detection theory:
  sonar equations and initial detection ranges (review)
  probabilities of detection and false alarm
  threshold concept: detection index and ROC curves
  effects of environmental fluctuations and uncertainties

Weeks 7, 8 & 9
Normal mode theory:
  modes in an idealized, layered ocean
  cutoff frequency and mode number
  phase and group velocities
  modes in a refractive ocean
  low frequency cutoffs in ducts and channels
SW Nonlinear Internal waves and their acoustic impacts

Week 3 & 4
Mixed layer:
  mixed-layer depth (MLD) variability
  Urick's surface-duct TL model
  AMOS surface scattering loss model
  diffraction leakage model
  optimal frequency for transmission

Weeks 10 & 11
Ambient noise and its prediction
Sound scattering by rough boundaries:
  grating due to periodic surfaces
  effect of randomly rough surface
  Scattering loss and the coherent reflection coefficient
  Eckart scattering loss model and its variance.
  Helmholtz-Kirchhoff integral
  surface and surface-layer reverberation:
    surface scattering strength
    Eckart-Chapman-Scott theoretical model
    Chapman-Harris empirical model
    Ogden-Erskine empirical model
  bottom reverberation:
    Lambert's rule
    Mackenzie's modification

Week 5 & 6
Parabolic Equation methods
DW Ocean fronts and eddies and their acoustic impacts
1st mid-term

2nd mid-term

Grading breakdown: 2 mid-term exams (1/2 of the total score each). Reading assignments and homework will be assigned from time to time.
If an equal sonar design capability is accorded to each side in the encounter, then he who best understands and exploits the ocean environment and the acoustic operational factors...will be expected to prevail."

Albert W. Cox
Raytheon – Submarine Signal Division

I. Course Credits and Prerequisites
OC4270 Tactical Oceanography (3-4)
OC3260 required, OC4267 preferred

II. Text*
Text: Principles of Underwater Sound, 3rd Edition
Author: Robert J. Urick
Publisher: Peninsula Publishing, 1983
*Purchasing the text is optional. Reading material will be provided.

III. The Big Picture

What do you need to know to understand, anticipate and tactically exploit the variability in ocean acoustic propagation due to changes in the ocean environment?
1. Acoustics (underwater acoustic propagation and sonar system design)
2. Equipment (platforms, systems, sensors and weapons)
3. Environment (knowledge of oceanography)
4. Tactics (to exploit the environment)
5. Tools for characterization and prediction
   a. models and databases
   b. references and resources
   c. PC-IMAT, ASPECT, PC-TIDES and others
6. Experience
   a. cruise (collecting real data)
   b. project (answering tactical questions)
   c. labs, reading, class discussions (leading you through the process of critical analysis)

IV. Method of Instruction and Evaluation

This course consists of lectures on variability, modeling, and tactics; guest speakers presenting real-world examples of tactical oceanography; a student cruise during which you will collect acoustic data for further analysis; a tactical project; labs and required reading. It is structured, but exploratory in nature.

Cruise project 30%
Tactical project 30%
Required reading 20%
Labs and class participation 20%

Each portion of the course counts for part of your grade, but all must be completed to pass the class.

Notes:
1. **Feedback:** Your feedback is important. Steve and I will modify the course after each time we teach it, based on your constructive feedback. Offer any ideas or suggestions you may have regarding the course anytime; you don’t have to wait until the SOFs at the end of the quarter!

2. **Course schedule:** Due to the complexity of scheduling guest lecturers, the course may not flow smoothly from one topic to the next. Think “parallel,” not “series,” as we go through the course. Each part of the course attempts to address one part of the Big Picture, however discontinuously. Steve and I will update the schedule as we move through the quarter, so be sure you’ve got the latest version.

3. **Student cruise:** The student cruise is scheduled for Aug 14. This will be a one-day cruise to collect data to learn about multipath propagation, detection range/probability/uncertainty, and ambient noise characteristics in the real ocean. The purpose of the cruise project is to apply your experience and education to extract information from the data and explain some aspect of acoustic propagation.

4. **Labs:** The primary purpose of the labs is to learn about the modeling and analysis tools that will assist you in completing the projects.

5. **STBL access:** We will hold some classes in the STBL (basement of Glasgow). Please get access to the STBL and a SIPRNet account by filling out the form at the STBL. There is a short brief you are required to receive prior to the account being approved.

6. **Required reading:** Reading assignments will be given from time to time. Each assignment is due the Monday following the assigned period to complete the reading. For each reading assignment, email to Prof. Chiu a one-page (no longer than two!) write-up that begins with a statement that you have read the assigned materials, followed by a succinct summary of what you have learned (or relearned).

7. **Tactical Projects:**

   **Purpose:** The purpose of the tactical project is to apply your knowledge of oceanography and acoustics to a particular tactical senario.

   **Method:** Usually, students are divided into groups. Due to the small number of students this quarter, you will work as one group on a single tactical scenario.

   **Form:** You will (i) choose a tactical scenario, including the geographical location, (ii) present the environmental conditions, including potentially exploitable factors and variability, and (iii) present final analysis results on tactics (detection, evasion, etc.).
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<th>Week 1: No class</th>
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<th>Week 2: Variability</th>
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<th>Week 3: Tactics</th>
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<th>Week 4: PCIMAT</th>
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<th>Week 5: Monterey Bay</th>
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Syllabus for OC4323 Numerical Air and Ocean Modeling (4-2)

Professor Peter C. Chu  
Department of Oceanography  
Naval Postgraduate school, Code OC/Cu  
Spanagel Hall 237  
831-656-3688, chu@nps.navy.mil, http://oc.nps.navy.mil/~chu

Course Description

This course provides most advanced theories and techniques for numerical models of atmospheric and oceanic phenomena. Topics include finite difference, finite volume, and finite element techniques for solving partial differential equations, atmospheric forcing functions, linear and nonlinear computational instability, hydrostatic and nonhydrostatic models, and multi-layer and multi-level primitive equation models, treatment of irregular geometry, sigma coordinate system, global /basin scale modeling, regional/coastal modeling, air-ocean coupling, data assimilation, and structured and unstructured grids.

Course Structure

• Chapter 1 Air-Ocean Modeling – the Navy/DOD’s Needs
  – 1.1. Modeling – a Major Component of DoD’s Operational Oceanography
  – 1.2. Numerical Ocean Modeling CONOPS
  – 1.3. Ocean Modeling for Homeland Security

• Chapter 2 Basic Concepts in Air-Ocean Numerical Modeling
  – 2.1. Basic Processes in Air-Ocean Modeling
  – 2.2. Ocean Component in Atmospheric GCM
  – 2.3. Difference Between Atmospheric and Oceanic Models
  – 2.4. Model Initialization
  – 2.5. Air-Ocean Coupled Model
  – 2.6. Classification of Partial Differential Equations
  – 2.7. Numerical Methods

• Chapter 3 Numerical Differentiation
  – 3.1. Taylor Series Expansion
  – 3.2. Forward Differentiation
  – 3.3. Backward Differentiation
  – 3.4. Central Differentiation
  – 3.5. Differentiation Errors
  – 3.6. Lagrange Differentiation
  – 3.7. Partial Derivatives
  – 3.8. Bi-harmonic Operator
• Chapter 4 Numerical Integration
  – 4.1. Basic Numerical Integration
  – 4.2. Trapezoidal Rule
  – 4.3. Simpson’s 1/3 Rule
  – 4.4. Simpson’s 3/8 Rule
  – 4.5. Midpoint Rule
  – 4.6. Better Numerical Integration
  – 4.7. Composite Simpson’s Rule
  – 4.8. Richardson Extrapolation
  – 4.9. Romberg Integration
  – 4.10. Gaussian Quadratures
• Chapter 5 Numerical Methods for Solving Partial Differential Equations
  – 5.1. Poisson Equation
  – 5.2. Laplace Equation
  – 5.3. Numerical Solutions
  – 5.4. Numerical Solution of Laplace Equation
  – 5.5. Convergence Criteria
  – 5.6. Gauss-Seidel Method
  – 5.7. Successive Over-Relaxation - SOR
• Chapter 6 Atmospheric Forcing in Ocean Models
  – 6.1. Wind and Wind-stress
  – 6.2. Surface Fluxes
  – 6.3. Forcing Data Generated Using Atmospheric Models
• Chapter 7 Computational Instability
  – 7.1. Linear Advection Equations
  – 7.2. Spatial Discretization
  – 7.3. Temporal Discretization
  – 7.4. CFL (Stability) Condition
  – 7.5. Stability of Various Schemes
  – 7.6. “Intuitive” look at stability
  – 7.7. Two-dimensional advection equation
  – 7.8. Nonlinear Instability
• Chapter 8 Hydrostatic and Nonhydrostatic Ocean Models
  – 8.1. Basic Equation
  – 8.2. Boundary Conditions
  – 8.3. Time Stepping
8.4. Horizontally Staggered Grids
8.5. Ocean Modeling History
8.6. Contemporary Ocean Models
8.7. Model Testing

• Chapter 9 Global/Basin Scale Ocean Models

9.1. Ocean Modeling History
9.2. Transformations of the Vertical Coordinate
9.3. Classification of Global/Basin Scale Ocean Models
9.4. Modular Ocean Model (MOM)
9.5. Layered Models (NLOM, MICOM)
9.6. Finite Volume Model
9.7. Hybrid Coordinate Ocean Model (HYCOM)
9.8. Model Testing

• Chapter 10 Regional/Coastal Ocean Modeling

10.2. Variability in coastal systems
10.3. Equilibrium and Three Kinds of Variability
10.4. Shelf dynamics overview
10.5. Coastal Model Inventory
10.6. Hydrodynamics of Coastal Regions
10.7. Parameterization of Surface and Bottom Boundary Layers
10.8. Numerical Discretization
10.9. NCOM Ocean Model
10.10. Barotropic Dynamics
10.11. Vertical Diffusion
10.12. Pressure Gradient Force in Sigma Coordinate System
10.13. Wetting and Drying Schemes

• Chapter 11 Air-Ocean Coupling

11.1. Is There a Better Set of Boundary Conditions at the air-ocean interface?
11.2. Atmosphere-Swamp Ocean
11.3. Atmosphere-Mixed Layer Ocean
11.4. Atmosphere-Ocean GCM
11.5. Coupling Methods
11.6. Climate Drift
11.7. Flux Corrections/Adjustments
11.8. Three methods for Air-Ocean Coupling
11.9. Design of Coupled Model Experiments

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11.4. Atmosphere-Ocean GCM
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11.6. Climate Drift
11.7. Flux Corrections/Adjustments
11.8. Three methods for Air-Ocean Coupling
11.9. Design of Coupled Model Experiments

• Chapter 12 Data Assimilation

  12.1. Why do we need data assimilation?
  12.2. Basic Concepts of Data Assimilation
  12.3. Statistical Approach to Data Assimilation
  12.4. Univariate (scalar) data assimilation
  12.5. Optimal Interpolation
  12.6. Kalman Filter
  12.7. 3d-Variational (3D VAR) Method
  12.8. 4d-Variational (4D VAR) Method

• Chapter 13 Structured and Unstructured Grids

  13.1. What are structured and unstructured grids?
  13.2. Finite Difference (Grid Point) Method
  13.3. Properties of Horizontal Grids
  13.4. Vertical Staggered Grid
  13.5. Round-off Errors
  13.6. Time Stepping
  13.7. Barotropic Dynamics and Time Splitting

**Prerequisites:**

MR4322, OC4211, MA3132, MA3232 desirable.

**Course Grade**

Lab 30%
Mid-Term 25%
Final Exam 45%
**General Topic** | **Subtopics** | **Week**
--- | --- | ---
Introduction | General Circ. versus "eddies" | 1/2
 | Eddy Paradox (Gill/Ped) | 
 | 1 1/2 Layer Model | 
 | Drifters; Eddy Kinetic Energy (EKE) | 
MODE | Eddy time/length scales | 2/3
 | Sampling Methods/Problems | 
Objective Analysis | Techniques/Pitfalls | 3
 | Computer Lab Assign | 
Isolated Vorticies | Self and topo. interactions | 4
 | Propagation on beta-plane | 
Gulf Stream Rings | Cold/Warm Core Rings | 5
 | Navy Ops. Mapping (OTIS, MVOI) | 
Exam-1 | All of the above | 5
Instability Theory | Hydrodynamic Instability | 7
 | Barotropic Instability | 
Instability Theory (continued) | Baroclinic Instability | 7/8/9
Eastern Boundary Currents | California Current Examples | 9
 | Squirts and Jets vs. Eddies | 
 | Wind Stress Curl Effects | 9/10
Other Fronts | Shelf Break Fronts | 10
 | River Plumes and Sediments | 10
 |  |  
Eddy Effects | Modeling and Diffusivity | 10/11
Exam-2 | Material Since Exam-1 | 11
Student Presentations | 2/day on above topics | 11
Syllabus for OC-4413, Air-Sea Interaction (4-0)

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Course Description

Fundamental concepts in turbulence; oceanic planetary boundary layer including the dynamics of the well mixed surface layer; atmospheric planetary boundary layer, including surface layer, and the bulk formulas for estimating air-sea fluxes.

Course Structure

Chapter 1 Introduction

1.1. Importance of Air-Sea Interaction  
1.2. Atmospheric Effects on the Ocean  
1.3. Oceanic Effects on the Atmosphere  
1.4. Examples of Air-Sea Interaction  
1.5. Importance to the Naval Operations

Chapter 2 Basic Concepts of Instability

2.1. Buoyancy Driven Instability  
2.2. Kelvin-Helmholtz Instability

Chapter 3 Planetary Boundary Layers of Atmosphere and Oceans

3.1. Atmospheric Planetary Boundary Layer  
3.2. Oceanic Planetary Boundary Layer

Chapter 4 Basic Concepts of Turbulence

4.1. Boussinesq Approximation  
4.2. Viscous Stress and Force  
4.3. Nature of Turbulence  
4.4. Analysis Methods for Turbulent Flows
4.5. Spectral Gap
4.6. Averaging Operator
4.7. Reynolds Equations
4.8. Turbulent Kinetic Energy
4.9. TKE Equation
4.10. KE and PE Equations for the Mean Flow
4.11. Boundary Layer Assumptions
4.12. Dissipation Method
4.13. Scales of Turbulent Flows
4.14. Flux Richardson Number

Chapter 5 Ocean Mixed Layer Dynamics

5.1. Well Mixed Surface Layer
5.2. Ocean Mixed Layer Dynamics
5.3. TKE Closure
5.4. Obokhov Length Scale of the Ocean Mixed Layer
5.5. Analytical Solutions with $w_h = 0$
5.6. Thermodynamic Features of the Detrainment Regime

Chapter 6 Atmospheric Surface Layer

6.1. Mixing Length Theory (First-Order Closure)
6.2. Dynamics of the Neutral Surface Layer
6.3. Determination of $l$
6.4. Simplification of the Basic Equation
6.5. General Solution for Neutral Surface Layer – Log Profile
6.6. Non-Neutral (Stratification) Surface Layer
6.7. Fluxes in the Atmospheric Surface Layer
6.8. Obukhov Length Scale for the Stratified Surface Layer
6.9. Similarity Theory
6.10. Determination of Similarity Functions
6.11. Log-Linear Profiles in near Neutral Surface Layer

Chapter 7 Calculation of Air-Sea Fluxes

7.1. Drag Coefficient
7.2. Heat and Moisture Exchange Coefficients
7.3. Bulk Formulae for the Air-Sea Fluxes

Chapter 8 Recent Advances in Air-Sea Interaction Research
Suggested Reference Books


Course Grade
Mid-Term 40%
Final Exam 60%

Office Hours:

Educating students is my highest priority. You may come any time from 7 am to 6 pm.
Naval Postgraduate School
OC4610 WAVE AND SURF PREDICTION (2-2).
Theory and prediction of wind-generated ocean waves.
Spectral transformation of waves from deep to shallow water.
Global and regional models for forecasting wave and surf conditions. Wave measurements and model validation.

PREREQUISITES: OC3150 and OC4211 or consent of instructor.

Quarter: Spring 2009

Instructor: Prof. Thomas H. C. Herbers
Office: Spanagel Hall, Room 331B
Phone: 656-2917

Lectures: Monday, Wednesday
1100-1150
Spanagel Hall, Rm 310

Computer Lab: Thursday
0900-0950
POC: Paul Jessen
Office: Spanagel Hall, Room 331C
Phone: 656-2974
Location TBD

Cruise: 28 April (group A) and 29 April (group B)
all afternoon (tentative schedule, to be firmed up!)
R/V John Martin

Grading Policy: Labs: 40 %
Presentations (2): 60 %
<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture Topics</th>
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<th>Lab Topics</th>
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<tr>
<td>1</td>
<td>I Introduction</td>
<td>Mon Wed</td>
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<td>General description of waves and surf</td>
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<td>2</td>
<td>II Deep Water Theory and Prediction</td>
<td>Mon Wed</td>
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<td></td>
<td>Review linear wave theory</td>
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<td>3</td>
<td>Wave generation by wind (Phillip’s &amp; Miles’ theories)</td>
<td>Mon Wed</td>
<td>Lab I Analysis Hurricane Wave Measurements</td>
<td>Thu</td>
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<td>Wave breaking (‘Whitecaps’)</td>
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<td>Equilibrium spectra (Pierson-Moskowitch, JONSWAP)</td>
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<td>4</td>
<td>Nonlinear wave-wave interactions</td>
<td>Mon Wed</td>
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<td>Radiative transfer equation</td>
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<td>5</td>
<td>III Operational Global Models</td>
<td>Mon Wed</td>
<td>Lab IIa Monterey Bay Field Data Collection</td>
<td>All afternoon Tue or Wed (tentative)</td>
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<td>WAM and WaveWatchIII</td>
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<td>Source term parameterizations</td>
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<td>6</td>
<td>Numerical implementation and validation</td>
<td>Mon Wed</td>
<td>Lab IIb Monterey Bay Data Analysis</td>
<td>Thu</td>
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<td>CLASS PRESENTATIONS (deep water topics)</td>
<td>Mon Wed</td>
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<td>8</td>
<td>IV Shallow Water Theory and Prediction</td>
<td>Mon Wed</td>
<td>Lab IIIa WaveWatchIII Model Introduction</td>
<td>Thu</td>
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<td>Shoaling, refraction and diffraction</td>
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<td>Wave breaking (‘Surf-Zone’)</td>
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<td>V Operational Regional Models</td>
<td>Wed</td>
<td>Lab IIIb Hindcast Fetch-Limited Sea</td>
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<td>11</td>
<td>CLASS PRESENTATIONS (shallow water topics)</td>
<td>Mon Wed</td>
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