ICTP DIPLOMA PROGRAMME IN EARTH SYSTEM PHYSICS 2014-15

SYLLABUS

PHYSICS OF THE OCEANS - [12 lectures: 18 hours] - M. Gacic, P. Poulain, A. Crise

Physics of the Oceans: overview

Miroslav GACIC

Lecture 1

Introduction

- Physical Oceanography – definition and aims;
- world ocean geography;
- temporal and spatial variability of motion in the ocean.

Temperature, salinity and density

- Temperature and salinity, definitions;
- geographic distribution (spatial and temporal characteristics);
- density;
- measurements and calculations;
- potential temperature;

The oceanic heat budget

- Heat budget terms;
- direct and indirect calculations of heat fluxes;
- geographic distribution of terms;
- meridional heat transport;
- global warming.

Lecture 2

The freshwater budget

- Freshwater sources and sinks for the world ocean;
- geographic distribution of terms;
- global warming and freshwater budget;
- estuarine and anti-estuarine circulation.

Geostrophic currents

- Geostrophic aproximation;
- hydrostatic equilibrium;
- thermal wind relation;

- barotropic and baroclinic flow;
- interior flow and boundary layers;
- limitations of the geostrophic aproximation.

Wind influence and bottom friction

- Ekman layer and Ekman balance;
- Ekman mass transport;
- inertial oscillations;
- bottom boundary layer.

Lecture 3

Vorticity in the ocean

- Definition of vorticity;
- conservation of vorticity;
- vorticity and friction;
- Ekman pumping.

World ocean circulation and global processes

- Global conveyor belt;
- western intensification;
- coastal and open ocean upwelling.

Lecture 4

Waves in the ocean

- Rossby waves;
- Kelvin waves (equatorial and coastal);
- baroclinic and barotropic wave solutions.

Equatorial dynamics and climate variability

- El Nino and teleconnections;
- Observing and predicting El Nino.

Suggested reading:

- Benoit Cushman Roisin, 1994: Introduction to Geophysical fluid Dynamics, 320 pp., Prentice Hall, Englewood Cliffs, New Jersey 07632.

- Robert H. Stewart, 2000: Introduction to Physical Oceanography, Dept. Of Oceanography, Texas A&M University, 343 pp. (http://oceanworld.tamu.edu/resources/ocng_textbook/contents.html)

- Matthias Tomczak, 2002: An Introduction to Physical Oceanography, Flinders University of South Australia in Adelaide, 13 lectures. (http://www.es.flinders.edu.au/~mattom/IntroOc/)

Physics of the Oceans: instrumentation

Pierre-Marie POULAIN

Lecture 1

Introduction. Classical methods (Research vessels, XBT, CTD, Rosette, current meters, tide gauges, etc.)

Lecture 2

Autonomous systems (moored buoys, surface drifters, sub-surface floats and profilers, gliders, AUVs, etc.)

Lecture 3

Remote sensing: ADCP, acoustic tomography, HF coastal radars

Lecture 4

Remote sensing from satellites (Sea surface temperature & ocean color , altimetry,scatterometry, SAR)

Suggested reading:

- Chaper 1. Data Acquisition and Recording
  Data Analysis Methods in Physical Oceanography
  W. J. Emery & R. E. Thomson
  Elsevier

- Oceanographic Instrumentation
  An Introduction to Physical Oceanography
  M. Tomczak
  http://www.es.flinders.edu.au/~mattom/IntroOc/lecture13.html

- Instrumentation for Physical Oceanography: the last two decades and beyond
  C. C. Eriksen

- Autonomous Underwater Gliders
  C. Eriksen
  www.geo-prose.com/ALPS/white_papers/eriksen.pdf

Physics of the Oceans: numerical models

Alessandro Crise

Lecture 1: Geophysical Fluid Dynamic - the Oceans case 1

- Geophysical Fluid Dynamics basic eqs:
- Navier Stokes (NS) equations derivation
- Conservation of mass, momentum and energy
- Spherical coordinates
- NS Properties

Lecture 2: Geophysical Fluid Dynamic - the Oceans case 2

- Scale analysis
- Adimensional numbers in GFD
- Popular approximation in NS ocean applications
- Primitive equations
- Consequences of non-linearity
- Taylor curtains

Lecture 3: Numerical modelling 1

- Continuous equation approximation
- Consistence, Stability, Convergence
- Timestepping schemes
- Finite differences
- Stability
- CFL criterion

Lecture 4: Numerical modelling 2

- Horizontal coordinates
- Spatial discretization and waves
- Staggered grids
- Finite difference and finite volumes
- Vertical coordinates systems

Main suggested reading:

B. Cushman-Roisin& J- M.Beckers**: Introduction to Geophysical Fluid Dynamics: Physical and Numerical Aspects**, *to be published by Academic Press*
http://engineering.dartmouth.edu/~cushman/books/GFD.html

Additional references:

Haidvogel&Beckman **'Numerical Ocean Circulation Modelling**' Imperial College Press,1999

Kanta&Clayson '**Numerical Models of Oceans and Oceanic Processes',** Academic Press,2000

MITOPENCOURSEWARE-12.003 Physics of Atmosphere andOceans
http://ocw.mit.edu/OcwWeb/Earth--Atmospheric--and-Planetary-Sciences/12-003Fall-2007/CourseHome/index.htm