CLIM712: Physical and Dynamical Oceanography

Fall 2019 - Syllabus

Instructor: Bohua Huang
Office: 269 Research Hall
Phone: 703-993-6084
Email: **bhuang@gmu.edu**

Class Schedule: Time: 3:00 – 4:15 pm, Tuesday, Thursday
Room: Research Hall 121

Office Hours: on appointment

Course Description:
CLIM712 gives an introduction to the climatology of the world ocean circulation and its associated physical and dynamical processes. It starts from a discussion of the physical properties of seawater and a description of the three-dimensional structures of the observed oceanic temperature and salinity distribution as well as its major seasonal and interannual variability. Then, the heat and salt budgets of the world oceans are examined, with emphasis on the physical processes that are responsible for the heat and freshwater exchanges with the atmosphere. Some general principles and basic concepts of ocean dynamics are introduced. These principles are applied to understand the patterns of the large-scale circulation of the ocean, including the wind-driven circulation and overturning circulation. The special topics include the formation of western boundary currents (such as the Gulf Stream), ocean wave dynamics, and the role of turbulent mixing within the ocean. Overall, this course provides background knowledge of the world oceans that are useful to students in physical oceanography, meteorology, and climate studies.

Course References:

Textbooks:
- Talley, L. D., G. L. Pickard, W. J. Emery, and J. H. Swift, 2011: Descriptive Physical Oceanography, An Introduction. 6th edition, 555pp, ELSEVIER. (Des)
- Pond, S., and G. L. Pickard, 1983: Introductory Dynamical Oceanography. 2nd edition, 329pp, Butterworth-Heinemann. (Dyn)

Other titles of interest:
- Mellor, G.L., 1996: Introduction to Physical Oceanography, 260pp, AIP Press.
- Knauss, J.A., and N. Garfield 2017: Introduction to Physical Oceanography, 310pp, 3rd edition, Waveland Press, Inc.

Useful Websites for Physical Oceanography Courses
- M. Tomczak: Introduction to Physical Oceanography
- R. H. Stewart: Introduction to Physical Oceanography

Course Requirement

- Attending class (advance notice of absence)
- Homework assignments: five sets, 50%
- Mid-term exam (Thursday, 3:00-4:15pm, October 18, close book): 20%
- Final exam (Thursday, 1:30-4:15pm, December 15, close book): 20%
- Project: monthly discussion of currently observed ocean state and term paper and presentation 10%

Major Topics

- Properties of seawater
- T-S forcing and conservation laws
- Global T-S distribution
- Fluid dynamics on rotating sphere
- Description of large-scale gyres
- Barotropic dynamics of large-scale gyres
- Rossby waves, instability and mesoscale eddies
- Mixing, turbulence, surface layer
- Large-scale overturning and thermohaline circulation
- Surface gravity waves (nonrotating and rotating)
- El Nino
- Internal gravity waves
- Coastal processes: currents, fronts, estuaries
- Tides

Course Outline

Properties of seawater [Des 2, 3, 6]

1. Composition
2. Equation of state
3. Measurement: T, S, pressure

Global T-S distribution [Des 4]

1. Surface profiles
2. Vertical profiles
3. Static stability
4. Annual cycle and interannual variability

T-S Forcing and conservation laws [Des 5]

1. heat flux components
2. heat flux distribution
3. evaporation, precipitation, runoff
4. box models

Fluid dynamics on rotating sphere [Dyn 6, 8, 9.1-9.4]

1. Coriolis force

2. equations of motion
3. geostrophy
4. Ekman layers

Description of large-scale gyres [Des 7]

1. wind patterns and gyres
2. western and eastern boundary currents
3. polar currents
4. equatorial currents

Barotropic dynamics of large-scale gyres [Dyn 9.5-9.14]

1. vorticity dynamics
2. gyres and western boundary currents
3. Sverdrup, Stommel, and Munk

Rossby waves, instability and mesoscale eddies [supplied reading]

1. Rossby wave dynamics
2. observations of eddies

Mixing, turbulence, surface layer [supplied reading]

1. descriptive Kelvin-Helmholtz instability
2. surface mixed layer dynamics
3. sources of subsurface mixing

Large-scale overturning [supplied reading]

1. thermohaline structure and meridional overturning
2. advective-diffusive balance and overturning
3. Stommel-Arons patterns
4. subduction and shallow cells

Surface gravity waves (nonrotating and rotating) [Dyn 12.1-12.8, 12.10.1-12.10.3]

1. short and long nonrotating SGWs
2. Poincare and Kelvin waves
3. nonlinear effects

Internal gravity waves [Dyn 12.9]

1. two-layer fluid
2. rotational effects
3. continuous fluid

El Nino [supplied reading]

1. air-sea feedbacks
2. equatorial waveguide
3. ENSO description

Coastal processes: currents, fronts, estuaries [Des 8]

Tides [Dyn 13.1-13.7]

1. tidal forcing
2. equilibrium theory
3. forced response

Goals and Learning Outcomes:

The course will provide:

1. A general description of the ocean general circulation and structure of the ocean temperature and salinity, as well as their variability.
2. Fundamental principles of physical and dynamical oceanography.
3. Application of these principles to explain large-scale oceanographic processes and phenomena.

Academic Integrity:
Mason is an Honor Code university; please see the University Catalog for a full description of the code and the honor committee process. The principle of academic integrity is taken very seriously and violations are treated gravely. What does academic integrity mean in this course? Essentially this: when you are responsible for a task, *you* will perform that task. When you rely on someone else's work in an aspect of the performance of that task, you will give full credit in the proper, accepted form. Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. When in doubt (of any kind), please ask for guidance and clarification.

Please note: The homework for this course should be your own work, not done in collaboration with other students.

Diversity
George Mason University promotes a living and learning environment for outstanding growth and productivity among its students, faculty and staff. Through its curriculum, programs, policies, procedures, services and resources, Mason strives to maintain a quality environment for work, study and personal growth.

An emphasis upon diversity and inclusion throughout the campus community is essential to achieve these goals. Diversity is broadly defined to include such characteristics as, but not limited to, race, ethnicity, gender, religion, age, disability, and sexual orientation. Diversity also entails different viewpoints, philosophies, and perspectives. Attention to these aspects of diversity will help promote a culture of inclusion and belonging, and an environment where diverse opinions, backgrounds and practices have the opportunity to be voiced, heard and respected.

The reflection of Mason's commitment to diversity and inclusion goes beyond policies and procedures to focus on behavior at the individual, group and organizational level. The implementation of this commitment to diversity and inclusion is found in all settings, including individual work units and groups, student organizations and groups, and classroom settings; it is also found with the delivery of services and activities, including, but not limited to, curriculum, teaching, events, advising, research, service, and community outreach.

Acknowledging that the attainment of diversity and inclusion are dynamic and continuous processes, and that the larger societal setting has an evolving socio-cultural understanding of diversity and inclusion, Mason seeks to continuously improve its environment. To this end, the University promotes continuous monitoring and self-assessment regarding diversity. The aim is to incorporate diversity and inclusion within the philosophies and actions of the individual, group and organization, and to make improvements as needed.

GMU Email Accounts:
Students must use their Mason email accounts to receive important University information, including messages related to this class. See http://masonlive.gmu.edu for more information.

Disability Accommodations:
If you are a student with a disability and you need academic accommodations, please see me and also contact the Office of Disability Services (ODS) at 993-2474. All academic accommodations must be arranged through the ODS.
http://ods.gmu.edu

Other Useful Campus Resources:
Mason has several support services for students. Please go to http://ctfe.gmu.edu/teaching/student-support-resources-on-campus/ for a directory of services.

University Policies:
The University Catalog, http://catalog.gmu.edu, is the central resource for university policies affecting student, faculty, and staff conduct in university academic affairs. Other policies are available at http://universitypolicy.gmu.edu/. All members of the university community are responsible for knowing and following established policies.