Introduction to earth's water system: processes and modeling

(Cross-listed on two campuses)

Course numbers: VIMS MSCI 531 (Banner CRN: 18522)

Univ. of Wisconsin-Madison: CEE 618

Are you ever wondering the role our ocean plays in the changing climate? Also, are the coasts, estuaries, rivers, and lakes becoming more vulnerable to extreme weather events?

Water is essential to all life on earth. Water surplus or scarcity can have detrimental effects on ecological systems and human societies. Specifically, oceans, coasts/estuaries, lakes, and rivers become more vulnerable to extreme weather events and climate change.

The main goal of this course is for students to:

1. Describe how earth's hydrosphere regulates and interacts with other components (atmosphere, cryosphere …), thus understanding the environmental changes happening at the moment;
2. Identify processes and models of water movements from large scales (e.g., global ocean or large lake circulation), intermediate scales (e.g., coastal/estuarine hazards) to small scales (e.g., stream/river flooding) and their interactions with each other and with other components of the earth system (atmosphere in particular).
3. Practice hands-on modules for a few models and computer tools.
4. Identify key processes as revealed by numerical models so they are prepared for a higher-level course on numerical modeling in the future.

The course will be offered in the fall semester and consists of formal lectures that are team-taught by two faculty across two campuses. The class will meet twice a week with 75-minute lectures each lesson. It is expected for approximately 4 additional hours per week of work outside of class for homework each week. The class will be offered for 3 credits.

Short description (255 characters max): Water system processes and modeling

The course introduces students to processes and models of the earth's water systems (oceans, coasts/estuaries, and rivers/streams) and their interactions. It provides the students with the foundation for a higher-level course on numerical modeling.

Instructors

VIMS: Joseph Zhang (yjzhang@vims.edu; 804 6847466)

UW: Chin H. Wu (chin.wu@wisc.edu; 608 2633078)

Course information

Semesters offered: fall semesters, every other year starting in 2023

Credits: 3

Grading: pass/fail, based on 20% attendance, 50% from homework, and 30% for final project

Participation: means you are actively listening and participating in discussion at classes, not browsing the internet. It also means that you come prepared with pre-class reading finished. Some homework may require teamwork, so you also need to work with a team.

Excused leave policy: you are allowed one unexcused absence without penalty. Each additional unexcused absence will lower your participation score by 30%. Excused absence must be arranged beforehand with the instructor, accompanied by appropriate documentation (e.g., notice from Dean's Office, medical certificate etc).

W&M's Honor Code Pledge: As a member of the William & Mary community, I pledge on my honor not to lie, cheat, or steal, either in my academic or personal life. I understand that such acts violate the Honor Code and undermine the community of trust, of which we are all stewards.

Prerequisites: Calculus

HPC access: W&M's Sciclone (for UW students also) (https://www.wm.edu/offices/it/services/researchcomputing/using/index.php)

For students who need a Sciclone account: if you already have a W&M Banner ID, please go to Step 2 directly. Otherwise, please contact Joseph (yjzhang@vims.edu) and provide the following info:

a) Date of birth
b) Phone
c) Address

Step 2: Once you receive your Banner ID, you can fill out a simple online application form to receive Sciclone account (W&M IT will also send you some basic info on how to access).

Setting up ssh and X to Sciclone

For Windows users: download and install mobaxterm to use ssh and X window. Download the free Installer Edition.

For Mac users: Mac comes with a utility "terminal", a command-line interface. One can directly login HPC with ssh –X <hostname>. Here are instructions from Apple. You'll also need to install XQuartz to get the Xwindow working properly.

Rationale: current PO offerings at VIMS either do not cover some aspects of the water system processes or are not aimed at preparing students for higher-level modeling courses.

Class time: 1.25 hours each lesson including discussion time on remote lectures; Tues & Thursday, 2:00-3:15pm ET (1:00-2:15 CT)

VIMS venue: Classroom C, Waterman's Hall (in-person classes with zoom connection for students from the other campus)

UW venue: Classroom Engineering Hall-1269 (in-person classes with zoom connection for students from the other campus)

Office hours: (1) VIMS: upon request; (2) UW:

Office locations: (1) Joseph Zhang: Room 224, Davies Hall, VIMS; (2) Chin Wu: Room 1261B

Course outline

Five modules in total, with ~25 lecture hours and ~14 lab hours.

1. Background Module

Week	Date	Lecturer	Lecture/lab	Reading materials	Learning goal
1: Introduction to the course	Sept 7	CW, JZ	• Cross-campus logistics; syllabus; self-intro; setup instructions/video recording; HPC access; etc. • 2-person cohorts for final project; examples of potential project topics (storm surge/compound flooding, Champlain, etc.) • Pre & post reading assignment		Inform the cross-campus learning-teaching logistics Introduce Earth Water System and syllabus
2: Review of geophysical fluid dynamics	Sept 12	CW	Conservation laws (mass, energy, momentum)	Cushman (part I. Fundamentals)	Understand conservation laws for fluid flow
	Sept 14	JZ	UNIX basics; Sciclone and schismView (slides) (recording; reading 2)	a. Unix Tutorial for Beginners b. matlab basics	Familiarize with basic UNIX commands and HPC tools required by this course

2. Ocean Module

Week	Date	Lecturer	Lecture/lab	Reading materials	Learning goal
3. Global oceanic processes	Sept 19	JZ	Large-scale oceanic processes	Cushman	-Simplest possible large-scale ocean circulation theory under trade wind -Concept of vorticity -Sverdrup relation -Munk's solution for western boundary currents -Main concept of wave mechanics -Dimension checks -Planetary (Rossby) waves and their roles in ocean climate -Deep circulation
	Sept 21	JZ	Large-scale oceanic processes, part II (homework for large-scale processes (due in 2 weeks)	Cushman (Chapter 9)	
4. Oceanic processes	Sept 26	JZ	Lab: large-scale processes		Students will calculate the Gulf Stream transport using theory
	Sept 28	JZ	Tides and internal waves	a. Arbic	-Origin of tides

				b. Cushman	-Tidal species: diurnal, semi-diurnal, compound tides -Nodal variation -Differences between surface and internal waves -Buoyancy frequency (of internal motion) -Internal radius of deformation

3. Coastal & Estuarine Module

Week	Date	Lecturer	Lecture/lab	Reading material	Learning goal
5. Hurricane and flooding	Oct 3	JZ	Hurricanes & compound surges	a. Holland b. Santiago-Collazo	-Conservation of potential vorticity -Holland wind model for hurricanes -Major forcings for storm surge -Mechanisms of air-sea exchange -Major forcings for compound surge -Geostrophic balance
	Oct 5	JZ	Lab: Compound flood model (pre-built SCHISM)	Homework for tides, hurricanes (due in 2 weeks?)	Students will play with a simple model to study the compound effects from interaction between tides and river flow
6. Coastal & estuarine processes	Oct 10	JZ	Introduction to estuarine dynamics	Geyer&MacCready	-Gravitational circulation -Classes of estuaries based on estuarine Richardson number, mixing number & Froude number -Lateral circulation
	Oct 12	JZ	Estuarine models: a review		-Major classes of models

7.	Oct 17	JZ	Lab: 3D estuarine model (pre-built SCHISM)		Visualize key estuarine processes
7. Coastal processes	Oct 19	CW	Tsunamis, meteotsunamis, edge waves, shelf waves		
Mid-term: take-home exam (due in 1 week); mid-term survey					
8. Wind waves	Oct 24	CW	Surface wind waves, wave-current interactions		
	Oct 26	CW	Wind wave modeling		

4. River module

Week	Date	Lecturer	Lecture/lab	Reading material	Learning goal
9. River/Stream	Oct 31	CW	Introduction to river		
	Nov. 2	CW			
10. River modeling	Nov. 7	No class (lection day)			
	Nov. 9	CW	Lab: HECRAS Modeling		

5. Lake Module

Week	Date	Lecturer	Lecture/lab	Reading material	Learning goal
11.	Nov. 14	CW	Lake processes		coastal upwelling & Ekman transport; edge waves and resonance
	Nov. 16	CW, JA	Lab: Models for lakes (pre-built SCHISM etc)		

CERF week Nov. 12 (JZ away; back Nov 25. Either Bob Polley or Dan Yu will start the Zoom session and record the classes)

Week 12: Thanksgiving Week (no classes)

Week 13: Final project work [JZ, CW]
Lab Q&A (Nov 28):

Lab Q&A (Nov 30):

Week 14	Final project presentations and wrap-up
(Dec 5):	students A-M
(Dec 7):	students N-Z

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