Course Information

Course Name: **FVCOM: Algorithms and Training**
Course ID: MAR599
Semester: Spring, summer, and fall semesters
Mode: Online

Instructor Information

Name: Changsheng Chen
Email: Course Messages in MyCourses **OR** c1chen@umassd.edu
Phone: 508-542-6388
Office Hours: 4:00-5:00 PM for students in the US, 8:00-9:00 PM for international students, Monday, Wednesday

Course Description

Prerequisite: No prerequisite courses are required. However, students should have backgrounds in Partial Differential Equations and fluid mechanics.

Course Credits: 3

Required Text: Chen et al. (2013). An Unstructured-grid, Finite-Volume Community Ocean Model FVCOM User Manual (4th edition), SMAST/UMASSD Technical Report-13-0701, University of Massachusetts-Dartmouth, pp 404**.** The pdf format of this report will be available on the course site.

Required Materials:
Mac Pro or Linux workstations with Intel Fortran compiler.

Course Objectives

Objective 1: Learn dynamical principles to develop the advanced unstructured grid finite-volume ocean models focusing on FVCOM.
Objective 2: Learn how to configure FVCOM for different ocean application cases.

Lectures will be focused on FVCOM by comparing it with other popular ocean models. The course consists of 13 lectures and 14 project assignments. Project assignments will be arranged for students on a weekly base. Students will be expected to give a presentation summarizing their findings after completing each project. The instructor will set up a virtual oral examination with individual students to measure student achievement in this course.

Communication Plan

Expectations for Electronic Communication

The instructor or his assistant will check emails daily, Monday through Friday, during normal business hours only. Students can expect a reply from the instructor or his assistant via email within 24 hours during the workweek. You may get an email reply during the weekend, but that would be an exception not the rule.

The instructor will also check and participate in the discussion forums daily during the workweek and reply to any discussion comments directed specifically at the instructor.

Time Considerations

Students should be prepared to spend at least 3 hours a week on reading and course assignments. Please remember that in a traditional "live" course you would be coming to class for 3 hours and then spending an additional 3-6 hours (at least) outside of class on assignments and reading. In our online course environment, the instructor expects that you will spend those 3 "class hours" on your own, working on the concepts you usually get in a live lecture. Please be sure to budget your time accordingly!

Substantive participation in online discussions should:

- Add value to the discussion and avoid simply repeating, agreeing with, or answering yes or no to peer's comments
- Challenge comments in class, including those of the facilitator
- Ask insightful questions
- Answer other people's questions
- Exemplify the point with real-life events when possible
- Make comments that are relevant to the course content and objectives

Things to keep in mind as you write discussion posts and communicate with other students:

- Share an experience related to the discussion. Comment on other participants' experiences that relate to the course.
- Ask others questions about their ideas and experiences that are related to the course
- Challenge a point that another participant made in a respectful manner. Offer a different perspective on an idea that is being discussed
- Give insights gained from assigned readings for the week. If you need more information, ask the participants a question about the week's reading
- Discuss a work issue that is related to the course or discussion and ask for feedback
- Relate how you have applied what you have read, learned or discussed regarding the course to your personal and professional life.
- Share another resource, such as Web links, books, etc., that you have used to answer other participants' questions or as you explore the topics of the course (as it is a violation of copyright law to copy the actual page)

Methods of Instruction

Final Grade Breakdown:

- 20% - **Class Participation**
- 40% -**Training case assignments**
- 20% - **Final Written Project**
- 20% - **Final Presentation**

Explanation of Final Grade Components:

Class Participation: Each lecture will issue a quiz. The quiz is to measure if students gather dynamic principles from the course;
Training case assignments: The primary objective of this course is to train students on how to apply FVCOM to solve different oceanic problems. We expect students to demonstrate their ability to use FVCOM in their research. Training case assignments are designed to help the student achieve this goal.
Final Written Project: This will test to judge the student's ability to integrate their learning from training case assignments
Final Presentation: This will test the student's achievement in defending their research by addressing questions raised by the instructor.

Late Assignments:

Students must inform the instructor with convincible reasons for late assignment submission. It will not affect grading with an instructor's approval.

Center for Access and Success

In accordance with University policy, if you have a documented disability and require accommodations to obtain equal access in this course, please meet with the instructor at the beginning of the semester and provide the appropriate paperwork from the Center for Access and Success. The necessary paperwork is obtained when you bring proper documentation to the Center.

University Academic Policies

These policies are also available in the student handbook on the University website - umassd.edu

- Information on Incompletes
- Student Behavior
- Student Academic Integrity
- Definition of Credit Hour
- Course Withdrawal
- Grade Appeal
- Attendance Policy
- Academic Calendar
- Title IX and Sexual Assault/Harassment

Academic and Technical Support

Tutoring

- If you have difficulty with the coursework, please contact the instructor or the Academic Resource Center.
- The Multiliteracy & Communication Center offers online writing tutoring.

Technical Help

- 24/7 email, live chat, and phone support for myCourses is available at the myCourses support portal.
- Do you need help with other UMass Dartmouth technologies? Please contact CITS.

Course Schedule

Lecture 1: The course introduction: introduction of FVCOM (1.0 hour)

Topic 1: What is FVCOM?
Topic 2: A brief review of FVCOM
Topic 3: What types of applications could you apply FVCOM to?
Topic 4: The course syllabus/grading
Topic 5: Project assignments
Topic 6: Course interaction plan-expectation for electronic communications
Topic 7: Reading materials

Reading(s):

- FVCOM User Manual: Chapters 1 and 2
- Lecture pptx

Assignment(s):

- Quizzes (online): one quiz for each topic. Questions will be created by random selections from a question pool.

Lecture 2: FVCOM installation, compilation, execution (1.0 hour)

Topic 1: Where and how to obtain the FVCOM source code?
Topic 2: What libraries are required to install for FVCOM?
Topic 3: Which Fortran Compiler works for FVCOM?
Topic 4: How to compiler FVCOM? Which files do users need to modify?
Topic 5: How to run FVCOM?

Reading(s):

- FVCOM User Manual: Chapter 17
- Lecture pptx.

Assignment(s):

- Quizzes. One quiz for each topic. Questions will be created by random selection from a question pool.
- Practice: Install FVCOM source codes and libraries on your computers.

Lecture 3: **FVCOM formulations and finite-volume discrete methods (3 hours)**

Topic 1: Primitive governing equations for oceans in the generalized coordinate system
Topic 2: FVCOM grid designs and finite-volume discrete methods
Topic 3: FVCOM validations
Topic 4: Reading materials

Reading(s):

- FVCOM User Manual: Chapter 3

Assignment(s):

- Training case project 2: Set up and run FVCOM for an idealized river case.
- Quizzes (online). One quiz for each topic. Questions will be created by random selection from a question pool.

Lecture 4: Non-hydrostatic FVCOM (2 hours)

Topic 1: Comparisons between hydrostatic and nonhydrostatic dynamics
Topic 2: FVCOM non-hydrostatic solvers: projection and pressure-correction methods
Topic 3: Non-hydrostatic FVCOM validations
Topic 4: Reading materials

Reading(s):

- FVCOM User Manual: Chapter 4

Assignment(s):

- Quizzes (online): one quiz for each topic. Questions will be created by random selection from a question pool.
- Training assignment 1: Non-hydrostatic Look-exchange in a 2-D channel.

Lecture 5: External Forcing and Open Boundary Treatments

Topic 1: External forcing at the sea surface, lateral solid or open boundaries, and at the bottom
Topic 2: Options of parameterization methods for wind stress and heat flux calculations
Topic 3: Boundary tidal forcing and global equilibrium tidal potential gradients.
Topic 4: Node- and edge-based river discharge methods
Topic 5: One-way and two-way nesting methods
Topic 6: Groundwater discharges from the bottom

Reading(s):

- FVCOM User Manual: Chapters 5-6

Assignment(s):

- Quizzes (online). One quiz for each topic. Questions will be created by random selection from a question pool.
- Training assignment 2: Freshwater discharge over an idealized continental shelf

- Training assignment 3: Two-way nesting in an idealized channel.

Lecture 6: Wet/Dry Treatments for Flooding/Drying Processes and a Dyke Module (2 hours)

Topic 1: FVCOM wet/dry treatment methods
Topic 2: Dyke treatment algorithms
Topic 3: Examples of FVCOM flooding/drying applications
Topic 4: Examples of FVCOM dyke module applications

Reading(s):
- FVCOM User Manual: Chapters 3 and 7

Assignment(s):
- Quizzes (online). One quiz for each lecture. Questions will be created by random selection from a question pool.
- Training assignment 4: Tidally driven flooding/drying process in a semi-enclosed channel
- Training assignment 5: Tidally driven estuarine with dikes and groynes

---

Lecture 7: FVCOM Sediment Modules (3 hours)

Topic 1: Governing equations for the community model for coastal sediment transport
a. Sediment classes
b. Sediment bed
c. Erosion
d. Deposition
e. Suspended sediment
f. Bottom stress
g. Bedload transport
h. Morphology
i. Effects of sediment on density

Topic 2: Cohesive sediment processes in the FVCOM sediment model
a. Floc-FLOCMOD: Aggregation gain and loss, Collision efficiency, Shear breakup, Collision-induced breakup gain and loss.
b. Fluid Mud Model
c. Vegetation

Topic 3: Coupling of FVCOM, FVCOM-SWAVE, FVCOM-SED, and Vegetation

Reading(s):
- FVCOM User Manual: Chapter 8

Assignment(s):
- Quizzes (online). One quiz for each lecture. Questions will be created by random selection from a question pool.
- Training assignment 6: Cohesive sediment simulation in an idealized inlet
- Training assignment 7: Fluid-mud simulation in an idealized inlet

---

Lecture 8: FVCOM surface wave module (SWAVE) (2 hours)

Topic 1: Wave action density spectrum equations and FVCOM discrete methods
Topic 2: Treatment of singularity at the North Pole
Topic 3: Swells and wind sea waves
Topic 4 FVCOM-SWAVE benchmark tests
Topic 5: FVCOM and SWAVE coupling

Reading(s):

- FVCOM User Manual: Chapter 9

Assignment(s):

- Quizzes (online). One quiz for each lecture. Questions will be created by random selection from a question pool.
- Training assignment 8: Current-wave interactions in an idealized inlet

---

Lecture 9: FVCOM ice module (UG-CICE)

Topic 1: Ice dynamics
Topic 2: Ice thermodynamics
Topic 3: FVCOM and UG-CICE coupling
Topic 4: Ice-embedding
Topic 5: FVCOM discrete algorithm for UG-CICE
Topic 6: UG-CICE benchmark tests

Reading(s):

- FVCOM User Manual: Chapter 10

Assignment(s):

- Quizzes (online). One quiz for each lecture. Questions will be created by random selection from a question pool.
- Training assignment 9: Sea ice simulation under a one-dimensional (vertical) condition.

Lecture 10: FVCOM-based Ecosystem Modules (3 hours)

Topic 1: FVCOM-GEM-A generalized ecosystem module
Topic 2: The NPZ model
Topic 3: The NPZD model
Topic 4: UG-RCA-Row-Column Advanced water quality model
Topic 5: UG-ICM-Army Corps Engineers' water quality model
Topic 6: WASP-EPA water quality analysis simulation program
Topic 7: ERSEM-European Regional Ecosystem Model

Reading(s):

- FVCOM User Manual: Chapter 11

Assignment(s):

- Quizzes (online). One quiz for each lecture. Questions will be created by random selection from a question pool.

- Training assignment 10: A 1-D biological model simulation using FVCOM-GEM
- Training assignment 11: A 1-D simulation using ERSEM.

Lecture 11: Tracer-tracking modules and a 3-D Lagrangian particle tracking program (1 hour)

Topic 1: Tracer-tracking modules
Topic 2: Particle-tracking modules
Topic 3: Examples of the FVCOM dye experiments
Topic 4: Examples of the FVCOM particle tracking experiments
Topic 5: Population Dynamics Models

Reading(s):

- FVCOM User Manual: Chapter 12

Assignment(s):

- Quizzes (online). One quiz for each lecture. Questions will be created by random selection from a question pool.
- Training assignment 12: Online and offline particle tracking experiments

---

Lecture 12: Data Assimilation Modules in FVCOM

Topic 1: Nudging assimilation
Topic 2: Optimal Interpolation (OI) assimilation
Topic 3: Kalman filter assimilations (RRKF, EnKF, EnSKF, EnTKF, and SEIK)
Topic 4: Kalman filter benchmark tests
Topic 5: Observing System Simulation Experiments (OSSEs)

Reading(s):

- FVCOM User Manual: Chapter 14

Assignment(s):

- Quizzes (online). One quiz for each lecture. Questions will be created by random selection from a question pool.
- Training assignment 13: Kalman filter simulations in an idealized circular basin

---

Lecture 13: Atmosphere-Ocean Coupling: WRF+FVCOM

Topic 1: Carnot's theorem and air-sea interaction processes
Topic 2: WRF and FVCOM coupling algorithms
Topic 3: Applications of coupled WRF and FVCOM model for hurricane and typhoon simulations
Topic 4: Procedure to prepare and run the coupled WRF and FVCOM model

Reading(s):

- Li and Chen, 2022: Air-sea Interaction Processes during Hurricane Sandy: Coupled WRF-FVCOM Model Simulation. *Progress in Oceanography*, 206, 102855. doi: http://doi.org/10.1016/ j.pocean.2022.102855.

Assignment(s):

- Quizzes (online). One quiz for each lecture. Questions will be created by random selection from a question pool.
- Training assignment 14: WRF-FVCOM coupled experiments in a realistic bathymetry harbor

---

Final Written Project:

Topic: Prepare a written project summarizing the learning from training assignments 1-14.

Reading(s): None

Assignment(s):

- Prepare a written project due within two weeks.

Final Presentation:

- The instructor will set up a time for individual students. The students are required to present their written projects orally. The presentation will be evaluated for 1) objectives, 2) methodology, and 3) results.