



### Course Information

**Course Name:** FVCOM: Algorithms and Training

**Course ID:** MAR512-0701

**Semester:** Spring semester

**Mode:** Online

### Instructor Information

**Name:** Changsheng Chen

**Email:** Course Messages in MyCourses **OR** c1chen@umassd.edu

**Phone:** 508-542-6388

**Office Hours:** TBD

**Technical support for assignments:** Dr. Siqi Li

### Course Description

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

Lectures will be given in English, with texts translated into Chinese, Korean, and Japanese languages. The translations were done for Japanese by Professor Jun Sasaki at the University of Tokyo, Japan; for Korean by Professor Seung-Buhm Woo at the Inha University, South Korea, and for Chinese by Dr. Dayan Xu (Lectures 2-3) at the Southern Marine Science and Engineering Guangdong Laboratory (Lectures 2-3), Professor Zhigang Lai (Lectures 4-6) at the Sun Yet-Sen University (SYSU) (Lectures 4-6), Professors Yu Zhang (Lectures 7-9), and Song Hu (Lectures 10-13) at the Shanghai Ocean University (SOU). The Recorded Lectures were created by Drs Lu Wang and Siqi Li at the University of Massachusetts-Dartmouth (UMASS-D).

**Course Credits:** 0

**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: Not applicable.**

**Explanation of Final Grade Components: Not applicable**

### Late Assignments:

Students must inform the instructor with convincing reasons for late assignment submission.

## 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](http://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.

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