Atmosphere–Ocean Interactions

INSTRUCTORS AND CONTACT INFORMATION

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DESIGN AND OBJECTIVES

This course examines the physics and climatic effects of atmosphere–ocean interactions at a variety of scales, and covers the following topics over 15 weeks:

1. an introduction to the atmosphere–ocean system, including relevant thermodynamics and dynamics;
2. an overview of boundary layers on both sides of the ocean surface;
3. descriptions of the general circulations of the atmosphere and ocean and the interactions between them;
4. discussion of major modes of coupled atmosphere–ocean variability in the tropics, including the El Niño–Southern Oscillation (ENSO), the Madden–Julian Oscillation (MJO), and coupled monsoon systems;
5. extension to coupled atmosphere–ocean variability in mid-latitudes, with particular focus on interannual and decadal variability in the northern Pacific Ocean;
6. an examination of coupled atmosphere–ocean–sea ice variability in the Arctic;
7. a review of air–sea interactions of long-lived greenhouse gases;
8. a brief discussion of the role of atmosphere–ocean coupling in climate change.

Special attention is paid to the mechanisms responsible for modes of coupled atmosphere–ocean variability, the interactions among these modes of variability, and the influences that they exert on global climate. The coursework is application-oriented and intended to help students develop skills in scientific thinking and practical programming for climate research. To support these objectives, lectures will also periodically include introductions to concepts and tools in python programming for atmospheric and oceanic sciences, including real-world examples from published papers when possible.

MATERIALS

Lecture slides and notes covering core concepts will be distributed to students electronically when available. The lecture notes include suggestions for further reading, but no textbook is required. Lecture slides and notes will also be provided along with example code to support the programming aspect of the course. Homework assignments will be assigned weekly for the first nine weeks of the course.

EVALUATION

Students are evaluated based on lecture attendance and participation (15%), weekly assignments (45%), and the completion of a course research project summarized in a written paper (40%). Course projects will be self-directed, with clear milestones to meet during the semester. Students will be required to identify a scientific question or problem they intend to address, formulate a hypothesis, and propose possible approaches for testing this hypothesis (week 5), and then complete a series of progressively more detailed drafts of the final paper (weeks 11 through 15).

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COURSE SCHEDULE

Week 1 21 February	• Introduction to the coupled atmosphere–ocean system: an energy balance perspective • Introduction to the python programming language: data types, functions, modules
Week 2 28 February	• Structure and composition of the atmosphere and ocean • Basic file I/O, modeling systems of differential equations with application to the Lorenz model
Week 3 7 March	• Thermodynamics, part 1 • A brief introduction to pandas (python data analysis library)
Week 4 14 March	• Thermodynamics, part 2 • CliMT, with application to deriving moist thermodynamic variables
Week 5 21 March	• A brief review of geophysical fluid dynamics **(project proposals due)** • Linear regression, with application to cyclogenesis in the western North Pacific
Week 6 28 March	• Boundary layers • Mapping using iris and cartopy, with application to the Asian tropopause aerosol layer
Week 7 11 April	• Atmospheric general circulation • Windspharm, with application to moisture convergence in East Asia
Week 8 18 April	• Ocean general circulation • Time series filtering, with application to intraseasonal variability in monsoon precipitation
Week 9 25 April	• The El Niño–Southern Oscillation • EOFs, with application to the Indian Ocean dipole and basin modes
Week 10 7 May	• The Madden–Julian Oscillation
Week 11 9 May	• Monsoon systems **(paper outlines due)**
Week 12 16 May	• Extratropical air–sea interactions **(first draft of introduction and methodology due)**
Week 13 23 May	• Atmosphere–ocean–sea ice interactions in the Arctic **(first draft of results due)**
Week 14 27 May	• Air–sea interactions of long-lived greenhouse gases **(full first draft due)**
Week 15 6 June	• Atmosphere–ocean coupling and climate change **(final paper due)**