OE 995: Dynamics of Air-Sea Interaction

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Fall 2025 — 3.0 credits
Monday & Wednesday
2:10 PM - 3:30 PM
Chase 175

Course Description

Interaction between the earth's oceans and atmosphere fuels the generation of extreme storms, drives the transport of buoyant surface pollutants, and is a central component of the earth's climate system. A better understanding of this interaction is crucial for advancements in ocean engineering.

In this course, we will cover the dynamics of the ocean surface wave field and its role in mediating air-sea coupling. Topics range from the scaling of surface layer turbulence to the mechanics of energy and momentum exchange across the air-sea interface. Techniques for measuring air-sea fluxes will be reviewed through both classroom lectures and laboratory/field data analysis projects. We will connect small-scale physical phenomena with the larger-scale boundary layer processes covered in traditional physical oceanography and atmospheric dynamics courses.

Where You Fit In

The objective of the course is to provide a thorough understanding of the interaction between the lower atmospheric and upper oceanic boundary layers. There is an emphasis on describing individual physical phenomena through observations and theory. The lectures and collaborative literature reviews are designed for those specializing in ocean engineering, physical oceanography, chemical oceanography, or atmospheric science.

By the semester's end, you will be able to enumerate the core processes of air-sea interaction. You will know the best observational tools for measuring them—and be able to use both simple dimensional analysis and primitive equations to describe them. In short: you'll be the life of the party.

Prerequisites

The concepts in this course rest heavily on a basis of differential equations, fluid dynamics, thermodynamics, and the principles of physical oceanography/atmospheric physics. As students come to study air-sea interaction from a wide variety of backgrounds, no formal prerequisites are listed, but the instructor's (my) permission will be required for registration.

Assignments & Grading

Homeworks & Mini-Projects (x4)	60% (20% per assignment; lowest score dropped)
Final Project	40%

Helpful Textbooks

- *Air-Sea Interaction: Laws and Mechanisms*. Csanady, G. T. (2001). Cambridge University Press.
- *The Dynamics of the Upper Ocean*, Phillips, O. M. (1977). Cambridge University Press.
- *Atmosphere-Ocean Interaction*, Krauss, E. B. & Businger, J. A. (1994). Oxford University Press.
- *Boundary Layer Meterology*, Stull, R. B. (1991). Kluwer Academic Publishers.
- *Wind Generated Ocean Waves*, Young, I. R. (1999). Elsevier
- *A First Course in Turbulence*, Tennekes, H. and Lumley, J. L. (1977). MIT Press.

Breakdown of Lectures

1. Introduction & Basic Concepts (Week 1)
    - Overview of the Course
    - Regarding Scales, Boundary Layers, and Fluxes
    - State of Matter Near the Air-Sea Interface
2. Turbulent Transfer Across the Air-Sea Interface (Weeks 2-5)
    - Governing Equations
    - Statistical Descriptions of Fluctuating Quantities
    - Wind Velocity Spectra and Co-Spectra
    - Structure of the Interface and Adjacent Layers
    - Monin-Obukhov Similarity Theory
    - Methods for Determining Air-Sea Fluxes Observationally
3. Whence Water Waves? (Weeks 6-9)
    - Small-Amplitude Linear Wave Theory
    - Development of Surface Waves Under Wind Forcing
    - Gravity and Capillarity as Restoring Forces
    - Wave Measurement Techniques
    - Wave Spectra, Spectral Ranges, and Wind Input
4. The Near-Surface Ocean Response (Weeks 10-13)
    - Surface Wave Breaking
    - Wind-Induced Currents
    - Stokes Drift
    - Near-Surface Ocean Turbulence (Including Langmuir Turbulence)
    - Hurricanes and Other Very Bad Weather™
    - Sea Spray and Marine Aerosols
5. Air-Sea Gas Exchange (Weeks 14-15)
    - Mechanisms, Models, and Theories
    - Field Measurements
    - Remote Sensing of Gas Exchange
    - Bubble-Mediated Exchange
    - Surface Films