ATS 743 Interactions of the Ocean and Atmosphere

3 credits (3-0-0)

Spring 2009

Instructor: Eric Maloney
Short title: Ocean-Atmosphere Interaction
Long Title: Interactions of the Ocean and Atmosphere

Prerequisites: ATS 601 and ATS 602, or permission of instructor.

Short Description:
Ocean-atmosphere interaction in observations, theory, and models. Time mean atmosphere-ocean circulations through climate variability and change.

Long Description: This course concentrates on the observations, theory, and modeling of ocean-atmosphere interactions. It begins with a description of the atmospheric and oceanic general circulation, including the zonally symmetric atmospheric circulation, the atmospheric energy transport, the wind-driven ocean circulation, and the partitioning of energy transport between ocean and atmosphere. The course then moves to the problem of tropical climate variability, exploring the issues of the Madden-Julian Oscillation (MJO), the El Nino-Southern Oscillation (ENSO), and atmospheric teleconnections between the tropics and midlatitudes. Topics from midlatitude ocean-atmosphere interactions include decadal variability in both the Atlantic and Pacific. The course concludes with a discussion of the role of atmosphere-ocean interactions in climate change.

Student Learning Objectives: (1) To develop an understanding of the atmospheric and oceanic general circulation, including the poleward energy transports in both the atmosphere and ocean; (2) To familiarize the student with the key concepts involved in tropical climate variability, including the Madden-Julian Oscillation, El Nino-Southern Oscillation (ENSO), and atmospheric teleconnections; (3) To acquaint the student with current research on midlatitude ocean-atmosphere interactions and the role of such interactions in climate change.

Instructional Methods: The method of instruction is based primarily on traditional lectures (3 hours per week). Although there are no exams, students will be assigned homework problems and will present their solutions in both written form and orally in class. Students will be assigned a specific modeling project involving an existing atmospheric or oceanic computer model. A written report summarizing the results and implications of these computer simulations will be submitted near the end of the semester. Students will also be assigned a specific research topic, based on papers in the atmospheric and oceanographic journal literature. Each student will prepare a written paper evaluating the key scientific results from these papers and will present a summary oral presentation to the class near the end of the semester.

Grading:	Homework	30%
	Modeling Project	20%
	Oral Presentation on Research Topic	20%
	Written Paper on Research Topic	20%
	Class Participation	10%

Suggested Texts:
"Atmospheric and Oceanic Fluid Dynamics: Fundamentals and Large-Scale Circulation", by G.K. Vallis, Cambridge University Press, 2006
"Circulation of the Atmosphere and Ocean", J. Marshall and A. Plumb, Academic Press, 2007

Outline

I. General circulation (review/overview):

A. Atmospheric general circulation (week 1)
1) Class overview
2) Description of the atmosphere general circulation. Why such a circulation must exist. Zonally symmetric atmospheric general circulation, potential energy, eddies and stationary waves
3) Atmospheric energy transport

B. Ocean general circulation and coupled circulations in the time mean (weeks 2 and 3)
1) The wind-driven ocean circulation, Ekman transport. Sverdrup balance. Ocean energy transport
2) Partitioning of energy transport between ocean and atmosphere
3) Tropical air-sea interactions in the time-mean and annual cycles (e.g. Bjerknes feedback, maintenance of the east Pacific cold tongue, thermocline, etc.)
4) Maintenance of the Pacific warm pool

II. Tropical Climate Variability:

A. Madden-Julian Oscillation (Tropical Intraseasonal Oscillation) (weeks 4 and 5)
1) MJO observations
2) MJO Theory
3) 1-D mixed layer heat budget

B. El Nino-Southern Oscillation (ENSO) (weeks 6,7,8, and 9)
1) 3-D ocean response to tropical wind stress variations
2) Equatorial waves
3) Atmosphere response to tropical SST variations
4) ENSO observations
5) The Cane-Zebiak model
5) ENSO theory: delayed oscillator
6) ENSO theory: discharge/recharge

7) ENSO stability. Stochastic forcing, ENSO irregularity
8) Optimal atmospheric structures for forcing ENSO

C. ENSO Teleconnections/Atmospheric Bridges (weeks 10,11,and 12)
1) Stationary Rossby waves
2) ENSO teleconnections to midlatitudes
3) Atmospheric bridges and the influence on the ocean
4) Tropical ENSO teleconnections
5) ENSO teleconnections to the Indian monsoon and Atlantic hurricane region

III. Mid-Latitude Ocean-Atmosphere Interactions (weeks 13 and 14)
1) The impact of internal atmospheric variability on the ocean
2) The impact of midlatitude SST anomalies on the atmosphere
3) Re-emergence mechanism, atmospheric response to midlatitude SST anomalies
4) Pacific decadal variability: mechanisms
5) Atlantic interannual/decadal variability
6) North Atlantic Oscillation, Arctic Oscillation
7) Different paradigms for North Atlantic/Arctic variability

IV. Ocean-atmospheric interactions and climate change (week 15)

Final Exam Period: Since there is no final exam, the scheduled final exam period will be used for oral presentations (by enrolled students) of the assigned research topics.