SYLLABUS

Attention: this is NOT the final version of the syllabus. Minor changes may be made until the first class (January 12, 2026).

ATMO708 —General Circulation of the Atmosphere

- Term: Spring 2026
- Time: Monday and Wednesday 1:30PM - 2:45PM
- Location: HIG 311
- Office hours: After class or by appointment
- Office: HIG340
- Instructor: Professor Hongwei Sun. hongwei8@hawaii.edu
- Prerequisites: MET 402 or MET 600 (Dynamics I)

REQUIRED TEXTBOOK:

• Ian N. James, 1994: Introduction to Circulating Atmosphere. Cambridge University Press. 422 pp.

REFERENCE MATERIAL:

1. E. N. Lorenz, 1967: The Nature and Theory of the General Circulation of the Atmosphere. World Meteorological Organization, 161 pp.
2. D. Randall, 2001: Introduction to General Circulation. http://kiwi.atmos.colostate.edu/group/dave/at605
3. K. E. Trenberth, 1992: Climate System Modeling. Cambridge University Press.

COURSE OBJECTIVE:

This course covers selected materials in theory, observations, large-scale analyses, and global model simulations that describe characteristic large-scale circulation of the atmosphere. The theoretical part aims at providing students with an understanding of the physical and dynamical processes responsible for the observed, analyzed, and simulated large-scale circulation of the earth's atmosphere. The diagnostic part describes main features of the general circulation of the atmosphere, illustrates how the global atmospheric wind systems organize themselves to satisfy the conservation laws of physics, and highlights how primary processes can be distinguished from secondary processes in the complex atmospheric system. Main features of the general circulation of the atmosphere to be described and understood include the zonally averaged climatology (e.g., the global energy balance, the easterly trade winds, the storm tracks, the westerly jets in the midlatitudes, the Hadley cell in the tropics, the Ferrell cell in the midlatitudes) and the asymmetric features of the general circulation (such as stationary waves in the midlatitudes, Atlantic and Pacific storm zones, tropical monsoon systems, blocking of the midlatitude flow, teleconnection patterns, and interactions between transient and steady eddies). The course allows students to have a hands-on experience to create their own climate statistics using readily available software and data sets, and enhances students' ability to use theoretical tools to gain insight into various aspects of the general circulation of the atmosphere.

CONTENTS

Ch. 1. An introduction and an overview of the Governing Physical Laws

We introduce the general circulation problem and review the fundamental governing equations of atmospheric motion, including the primitive equations, hydrostatic and geostrophic balances, thermal wind balance, etc. The goal is to establish the physical and mathematical framework used throughout the course.

Ch. 2. An overview of observed Circulation

This week focuses on the observed large-scale structure of Earth's atmosphere, examining the circulation from different perspectives (e.g., zonal-mean, annual-mean, and seasonal-mean). We also discuss how reanalysis data are used to diagnose circulation features in modern climate studies.

Ch. 3. The Atmospheric Heating

In this chapter, we discuss the basic physical principles describing the thermal forcing of the general circulation: the concept of radiative equilibrium, the global mean energy balance etc.

Ch. 4. The Zonal Mean Meridional Circulation

In this chapter, the traditional zonal mean view of the global circulation is provided. This is a compact way of studying the general circulations. It serves as a starting point to understand the general circulations (e.g., Hadley cell).

Ch. 5. Transient disturbances in the midlatitudes

In this chapter, we describe the mean scales, shapes, energy and distribution of transients, discuss the mechanisms (baroclinic instability) which generate these transients, and illustrate how these transients (a collection of individual weather systems) transport heat and other quantities across the globe and contribute to the general circulation of the atmosphere. Emphasis will be given to high frequency transients with periods between one and ten days.

Ch. 6. Stationary waves

This week examines wave propagation and steady waves (eddies). We will first analyze steady waves from observations, and then use the barotropic potential vorticity model to study how Rossby wave propagate. We will also discuss the application to observed stationary waves (e.g., Zonal jet generated by momentum fluxes of mountain-induced stationary Rossby waves) and EP (Eliassen-Palm) flux.

Ch. 7. Low frequency variability

We investigate variability on weekly to seasonal timescales, including the annular modes, NAO/PNA teleconnections, blocking events, and regime transitions. Discussion centers on how stochastic forcing and wave-mean flow interactions produce persistent anomalies in the circulation.

Ch. 8. ENSO dynamics

Dr. Fei-Fei Jin will give two guest lectures about ENSO on January 26 and January 28, 2026.

Ch. 9. Stratospheric circulation

We analyze the structure and dynamics of the stratosphere, focusing on Brewer-Dobson circulation (BDC), quasi-biennial oscillation (QBO), polar vortex (including sudden stratospheric warmings), and stratosphere and trosphere exchange (STE). If time allows, we may discuss how stratosphere-troposphere coupling influences surface weather.

GRADING

Homework 50%
Midterm presentation (plan for the final project) 20%
Final individual project 30% (8-page double-line final paper)

I hope students can connect the material from this course to their own research. The midterm presentation and the final project are designed to help build this connection. For the midterm, each student will select a research topic covered in the course that aligns with their own research interests or thesis, do a literature review, and outline a plan for the final project. The final project will take the form of a journal-style paper and must include at least two original figures created by the student.

Schedule for ATMO708 (Spring 2026)

	Mon	Wed	
Week 1	Jan 12 Syllabus & Intro	Jan 14	
Week 2	~~Jan 19~~ (HOLIDAY: Martin Luther King, Jr. Day)	Jan 21	
Week 3	Jan 26 (trip: AMS)	Jan 28 (trip: AMS)	**ENSO (by Prof. Fei-Fei Jin)**
Week 4	Feb 2	Feb4	
Week 5	Feb 9	Feb 11	
Week 6	~~Feb 16~~ (HOLIDAY: President's Day)	Feb 18	
Week 7	Feb 23	Feb 25	
Week 8	March 2	March 4	**Midterm presentation**
Week 9	March 9	March 11	
Week 10	~~March 16~~ (SPRING RECESS)	~~March 18~~ (SPRING RECESS)	
Week 11	March 23	March 25	
Week 12	March 30	April 1	
Week 13	April 6	April 8 (trip: Simons)	**Guest lecture on April 8**
Week 14	April 13	April 15	
Week 15	April 27	April 29	
Week 16	May 4	May 6 (Last day of instruction)	
Week 17	Study Period		
Week 18	Final Examination Period		**Final project paper (Due by May 15)**