AOSC 617: Atmospheric and Oceanic Climate

Web Description: *The general circulation of the atmosphere and oceans, historical perspective, observations, and conceptual models; wind-driven and thermohaline circulation of the oceans. Seasonal cycle and monsoon circulations; interannual to interdecadal climate variability; climate change.*

Background: Atmospheric and oceanic climate refers to the monthly/seasonal averaged distributions of circulation, temperature, moisture, and related eddy transports. The course will provide a dynamically oriented description of the observed distributions, with the intent of elucidating the *dynamics* of terrestrial climate. Both circulation structure and the underlying dynamical/thermodynamical constraints and mechanisms will thus be of interest.

The availability of atmospheric and oceanic reanalysis data sets within the last decade has lead to improved 3D descriptions and new insights into atmospheric and oceanic general circulation. Historical perspectives will be supplemented by modern views of the general circulation, supported by theory and simple models of the involved dynamical processes.

The course seeks to build expertise in dynamical diagnosis by presenting students both observations and simulations of the general circulation; with the express goal of developing hypotheses for the observation-simulation differences. The hypotheses must recognize interactions and feedbacks operating at various levels in the climate system.

Books:

Introduction to Circulating Atmospheres — Ian N. James (Chaps 4-9)
Cambridge University Press, 1995; Paperback; ISBN 0521429358
Recommend buying

An Introduction to Dynamic Meteorology — James R. Holton (Chaps 10-12)
4th Edition, Academic Press, 2004; ISBN 0123540151

The General Circulation of the Atmosphere — David A. Randall
http://kiwi.atmos.colostate.edu/group/dave/at605.html

Introduction to Geophysical Fluid Dynamics — Benoit Cushman-Roisin
Prentice Hall, 1994; ISBN 0133533018 Chapter 8

Physics of Climate — Jose P. Peixoto and Abraham H. Oort
American Institute of Physics, 1992; ISBN 0883187124

Theory of the General Circulation of the Atmosphere — Edward N. Lorenz, WMO Monograph, 1967

Outline:

- *Zonal-mean circulation:* Description; Angular momentum in sigma coordinates; Historical interpretation (Halley, Hadley, Thomson, Ferrel, Jeffreys, Starr, ...); Held-Hou model of the Hadley circulation; Zonal-mean easterlies in the Tropics.

- *Zonal-mean circulation in midlatitudes:* Kuo-Eliassen equation for Eulerian mean-meridional circulation; Thermally direct and indirect circulations; Transformed Eulerian mean and quasi-Lagrangian views of the mean meridional circulation; Zonal-mean potential vorticity equation and the Eliassen-Palm flux; Lorenz energy cycle.

- *Zonally-varying circulation in midlatitudes:*

  Stationary eddies: Observed 3D structure; Barotropic model of orographic forcing and horizontal propagation of Rossby waves; Critical and turning latitudes; Charney-Devore model ("form drag" and multiple equilibria); Response of heating in a QG baroclinic model; Zonal-eddy interaction

  Transient eddies: Midlatitude storm tracks; Eddy tilts and momentum and heat fluxes; Atmospheric energetics revisited.

  Interaction between Stationary and Transient Eddies: 2D and 3D E-vectors

- *Tropical circulations:* Large-scale tropical motions; Condensation heating; Kuo convection scheme; Monsoons (and deserts); Easterly waves; Madden-Julian oscillation; Walker circulation; Seasonal variability in the eastern tropical ocean basins.

- *Low-frequency variability:* El Niño Southern Oscillation; Pacific/North American variability pattern; North Atlantic Oscillation; North Pacific Oscillation/Western Pacific pattern. Pacific Decadal Variability.

- *Oceanic general circulation (topics to be fine tuned a bit):* Surface currents; Sverdrup transport; Western boundary currents; Thermocline ventilation; Heat exchange with atmosphere; Poleward heat transport; Abyssal (deep) circulation.

- *Stratospheric circulation (time permitting):* Seasonal cycle; Vertical wave propagation; Rossby critical velocity; Sudden stratospheric warming; Quasi-biennial oscillation.

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- **Instructor**: Sumant Nigam
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  with project help from Renu Joseph
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- **Time & Room**: AOSC Conference Room (CSS 3425); 9:30-10:45am (M,W)
Class make-up days will be Fridays: same time/place; several make-ups are anticipated because of instructor travel and project presentations.

- **Your info & interests**: Please send me an email with your contact information; include "AOSC 617" in the title line. Mention your current research interests, name of your advisor, degree sought, topics that you would like to see covered, and list other courses you are taking this semester. Also let us know if you are auditing the course.

- **Course format**:

Home work assignments	15%
Mid-term exam (2 hours, April)	40%
Project	45%

Logistics: Individual projects, Fortran/Grads, data access
Assigned on/by February 20
Mid-term report (10 minutes, oral, peer assessment): 10%
(On Friday, March 15)
Final written report + 20 minute oral presentation: 35%
(Both due week of May 15th)

Mid-term report: Problem statement, motivation, literature search and contextual discussion of why you believe your analysis of observations and/or climate model simulations will clarify our understanding or provide new insights into aspects of atmospheric/oceanic general circulation. I will be expecting a nice, brief synthesis of what is done and not done, and the unique aspects of your proposed study.

Final report: Will additionally include discussion of data sets, analysis methods, description <u>and discussion</u> of obtained findings. An abstract at the beginning and a conclusion section at the end are also required.