ATMS 545 Syllabus Spring Quarter 2010

Overview

Part I

The half of the course introduces some diagnostic schemes that can be applied to the atmosphere as a whole or to various parts of the atmosphere or Earth system in order to address fundamental questions related to basic conservation laws. The major topics covered in this section of the course are Lorenz's kinetic energy cycle and the balance requirements for angular momentum, total energy, and mass. Also included is the formalism for decomposing the general circulation into zonally symmetric and eddy components; into time mean and transient components; and into steady zonally symmetric, transient zonally symmetric, steady eddy, and transient eddy components. Part I concludes with an overview of the equations governing the evolution of a geostrophically-balanced, zonally symmetric vortex (i.e., the so-called Eliassen - Kuo formulation). This short section provides some additional insights into the workings of the general circulation and it serves as a concise review of the quasi-geostrophic formalism that leads to the geopotential tendency equation and the omega equation.

Part 2

The second half of the course begins with several lectures showing how the formalisms introduced i Part I can be extended to diagnose the interactions between the eddies and the mean flow in the atmospheric circulation.Then we will consider how the zonally-varying boundary forcing of the general circulation gives rise to zonally asymmetric features in the time-mean flow such as the monsoons and the wintertime stratospheric planetary waves. The boundary forcing also gives rise to pronounced zonal variations in the characteristics of the transient eddies, which are strongly frequency dependent. At the high frequencies it manifests itself as well defined storm tracks over preferred sectors of the Northern and Southern hemispheres, while on the low frequency end of the spectrum it fives rise to preferred spatial patterns sometimes referred to as *teleconnection patterns*. The course concludes with a review of the forced variability associated with the diurnal and annual cycles, ENSO, and the MJO, including a discussion of how it mediates the unforced variability.

Tentative Schedule

1. The kinetic energy cycle Mar. 28, 20-Apr 2
    - Available Potential Energy
    - Energy generation and conversion processes
    - KE cycle in a limited domain; application to the stratosphere
2. Angular Momentum Balance Apr 4, 6, 9, 11
    - the balance requirement
    - role of exchange processes
    - vertical transport; equation for zonally averaged zonal wind
3. Total energy balance Apr 13, 16, 18, 20
    - components of the total energy; the balance requirement

transport mechanisms; role of the oceans
equation for zonally averaged temperature, role of diabatic processes
role of the hydrologic cycle

4. The zonally averaged circulation Apr. 23-30
   - more on eddy heat fluxes
   - dynamics of a zonally symmetric vortex: governing equations
   - First Midterm
5. Wave-mean flow interaction May 2, 4, 7
   - exchanges of APE and KE
   - the Eliassen-Palm flux
   - Lagrangian vs. Eulerian mean, Stokes drift, the non-interaction theorem
6. Effects of zonally-varying boundary conditions May 9, 11, 14, 16, 18
   - stationary waves
   - storm tracks
   - teleconnection patterns
7. ENSO, the MJO May 21, 23, 25
8. Response to time dependent forcing May 30, June 4, 6
   - diurnal cycle
   - annual cycle
   - ENSO
   - MJO
9. Review, discussion June 8

Readings

1. Wallace and Hobbs: Section 7.8 and Section 8.1, especially 8.1.1.
2. Course Notes
3. Supplementary figures for course notes
4. Source papers (bibliography included with course notes
5. Additional postings (graphics files) as needed

Assignments and Grading

Midterm (20%) Monday, April 30
Final (40%)
  both exams are based on broad discussion questions
  only hypothetical quantitative questions... e.g., “How would you estimate...?”
Term paper on a topic of your choice (40%)

Term papers

Students are strongly encouraged to select a term paper topic by the end of the second week of the quarter and get it approved by the instructor. Papers are ordinarily on the order of 4000 words in length. They should contain a roughly 250 word Abstract and a list of references. Figures are optional but encouraged. Most papers are in the nature of review papers involving the synthesis of material from more than one primary source. Topics should be sufficiently specific as to permit some in depth discussion. Here are a few indications of possible topics.

- Phenomena in the Earth’s atmosphere: e.g., the ITCZ, the South Pacific and South Atlantic convergence zones; the winter climate of China, differing expressions of the ENSO cycle, the midwinter suppression of baroclinic wave activity over the Pacific storm track, the pronounced annual cycle in tropical cold point temperature, role of tropical cyclones in the general circulation. Need to be careful about handling of topics for which there are recent published comprehensive review papers.

- The general circulation of the Northern versus Southern Hemisphere; of planetary atmospheres other than the Earth’s; in model simulations with differing rotation rates, stratification, heating rates, frictional dissipation, etc. Illuminating contrasts between the atmospheric and oceanic general circulation or stratospheric versus tropospheric circulation.

- Tracing the development and/or usage of a particular diagnostic technique such as the angular momentum balance or the Eliassen-Palm flux decomposition of atmospheric variability by zonal wavenumber, spherical harmonic, or temporal frequency. Comparative evaluation of competing methodologies.

- An original contribution on a topic of your choice