ATMS 545 2010   Study guide for the second midterm

(1) Give (or be prepared to interpret) an example an example showing how the zonally symmetric circulation responds to a prescribed forcing. Start by showing how the imbalance of forces in the meridional plane gives rise to a mean meridional circulation. Show how the mean meridional circulation opposes the forcing yet at the same time causes the unforced field to change in a manner so as to maintain thermal wind balance.

(2) Describe the changes in the zonally averaged zonal wind and temperature fields that occur in response to prescribed forcing such as the radiative fluxes in the upper atmosphere as they vary in response to the changing seasons, a sudden doubling of the momentum flux, etc.

(3) Under what conditions will a forcing of the zonally symmetric flow yield a thermally direct or indirect mean meridional circulation? Give specific examples.

(4) Relate the answers to (1), (2) and (3) above to the four box version of Lorenz's kinetic energy cycle.

(5) Describe and interpret the relationship between the zonally symmetric zonal wind and potential vorticity fields in the meridional plane. For example, what does the potential vorticity field look like in the vicinity of an easterly or westerly jet?

(6) Be prepared to relate polarities (algebraic signs) of various diagnostics in questions such as, *"When the flux of westerly momentum is poleward, the flux of geopotential is (poleward, equatorward)"*.
   Among the kinds of quantities that might appear in such questions are
$$[q*v*], \; d[u]/\partial t, \; \overline{E}, \; \nabla \cdot \vec{E}, \; -\partial/\partial y[u*v*], \partial/\partial y[v*T*], \; \overline{v*\Phi*}, \; -\partial/\partial p[P/\sigma]$$
the flux of wave activity, the Stokes drift, the direction of a mean meridional circulation cell, the direction of the various energy conversions in the Lorenz cycle, whether the flux of zonal momentum or heat is up the gradient or countergradient, the rate or increase or decrease if the energy in one of the reservoirs of the Lorenz cycle.

(7) Basic observational knowledge. Be able to locate the tropical and extratropical tropopause, tropospheric and polar night jet streams, the strongest poleward momentum fluxes, the latitude of the strongest baroclinic waves, the latitude and level of the strongest poleward eddy heat fluxes in baroclinic waves, the positions and relative strengths of the Hadley and Ferrell cells, Lagrangian versus Eulerian MMC, Stokes drift, extrema in some of the quantities listed in the previous paragraph.

(8) Describe the life cycle of baroclinic waves and interpret it in terms of the Lorenz kinetic energy cycle, relying on numerical experiments.

(9) Be able to describe the basic differences between the wintertime stratospheric polar night jet under relatively undisturbed conditions versus sudden warmings.

ATMS 545 2010   Study guide for the second midterm

(10) Discuss the role of latent heat release in the atmospheric general circulation, with reference to the Lorenz kinetic energy cycle. Discuss the more limited role of Newtonian cooling.

(11) Be able to write down and interpret the terms in the equation for the conservation of wave activity *A*, and various simplified forms of it that result from neglecting transience and/or dissipation.

(12) Describe the basis of our knowledge of the Eulerian and Lagrangian (i.e., "Brewer-Dobson") MMC, referring to observations and results of simple general circulation models.

(13) Be able to contrast the Eulerian and Lagrangian-mean MMCs and reconcile the differences between them.

(14) The transformed Eulerian mean (TEM) formalism is widely used in stratospheric dynamics but much less so for interpreting wave-mean flow interactions in the troposphere. Explain.

(15) Explain why, in the Earth's atmosphere, surface westerlies prevail in the extratropics and surface easterlies prevail in the tropics, with specific reference to baroclinic instability and the Eliassen-Palm flux.