Middle Atmosphere Dynamics, Homework 4

1) Observational analyses: One place to get a sense of the observations is the NASA Atmospheric Chemistry and Dynamics Branch climatological plots:
http://code916.gsfc.nasa.gov/Data_services/met/nmc_climatology.html
Please examine the following pairs of plot and answer the following:
a. Climatological time-height plots of zonal mean winds at 60N, 60S:
Explain the seasonal evolution and the differences between the two fields.
ftp://hyperion.gsfc.nasa.gov/pub/ftpmet/nmcdata/multi/UBALY00XX00_GLAT60N.gif
ftp://hyperion.gsfc.nasa.gov/pub/ftpmet/nmcdata/multi/UBALY00XX00_GLAT60S.gif
b. Time-height plots of meridional heat flux at 60N and 60S.
What do these fields represent? Explain the time evolution of each of the fields. Explain the difference in sign and magnitude between the heat fluxes in the plots.
ftp://hyperion.gsfc.nasa.gov/pub/ftpmet/nmcdata/multi/EHFBY00XX00_GLAT60N.gif
ftp://hyperion.gsfc.nasa.gov/pub/ftpmet/nmcdata/multi/EHFBY00XX00_GLAT60S.gif
c. Do the same for the momentum fluxes: what do these represent? What does it mean the momentum fluxes change sign in the lower stratosphere?
ftp://hyperion.gsfc.nasa.gov/pub/ftpmet/nmcdata/multi/EMFBY00XX00_GLAT60N.gif
ftp://hyperion.gsfc.nasa.gov/pub/ftpmet/nmcdata/multi/EMFBY00XX00_GLAT60S.gif

2) Hemispheric differences: Use the web pages above, as well as the power point presentations from class: http://www.tau.ac.il/~harnik/MAD/MAD-course.htm (all 4 presentations), to compare various fields in the two hemispheres:
a. Describe the differences between the zonal mean zonal flow, and the zonal mean temperature between the hemispheres. How are the differences in these two fields related?
b. Describe the main differences in planetary wave structure, and in wave induced EP flux divergence. Where do these differences come from. Are the differences in planetary wave structure due to the differences in the mean flow, or vice-verse? Explain. Note your answer to question 4 below.

3) Use the index of refraction to estimate the critical wind values for stationary planetary waves 1,2 and 3 (the number of wavelengths around a latitude circle).
a. Assume a beta plane channel centered at 50N, a constant Brunt Vaisala frequency of $4x10^{-4}$ sec^{-2}, a scale height of 7 km, and a meridional wavenumber l=0.
b. Repeat for a case where half a meridional wavelength fits into the channel which has a width equivalent to 45 degrees latitude.
c. Repeat the calculations assuming the meridional wind curvature increases the meridional gradient of PV to a value of 4β.

4) Redo question 3 of homework 1.

5) The attached figure shows the zonal mean wind for September, 1996, in the southern hemisphere, the stationary wave 1 index of refraction squared, and the corresponding vertical and meridional wavenumbers, as described in class. Also shown are the September mean wave 1 geopotential height and temperature wave amplitude and phase: $\varphi= |\varphi|e^{i\theta}$, with the amplitude shown in solid lines, and the phase, in units of π, shown in dashed lines.

Explain the wave amplitude and phase structure given the basic state shown. How are the wave temperature and geopotential height related.

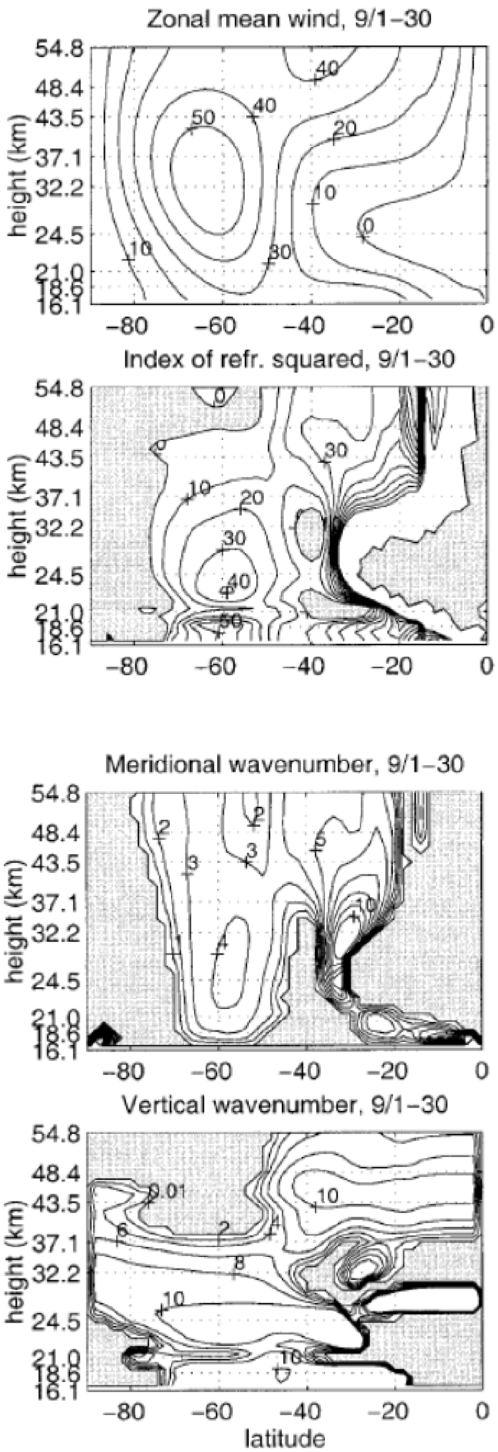

FIG. 5. (top to bottom) Observed time mean of zonal mean wind, the index of refraction squared [normalized by N^2, the term in brackets, Eq. (C2)], and the meridional and vertical wavenumbers calculated from the steady-state model solution, for (left) 18 Jul–19 Aug and (right) 1–30 Sep 1996. Wind in meters per second meridional wavenumber in inverse radians and vertical wavenumber in 10^{-5} m^{-1}. Negative values in the lower three rows are shaded. See text for details.

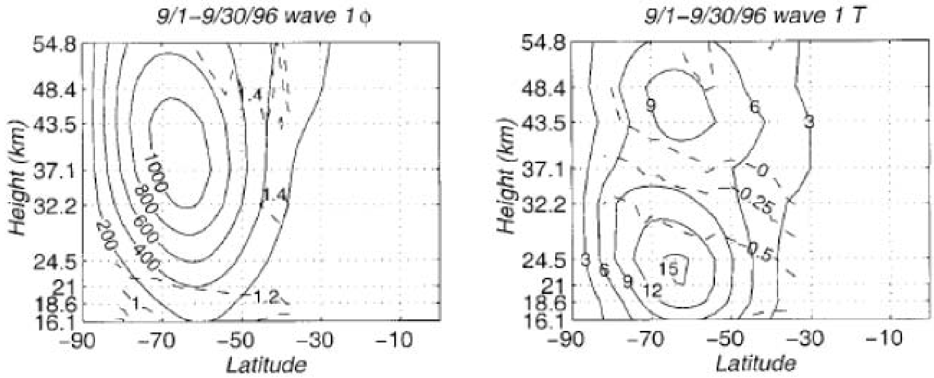

FIG. 4. (left) Time-averaged wave 1 geopotential height and (right) temperature amplitude (solid) and phase (dashed), for (top) 18 Jul–19 Aug 1996 and (bottom) 1–30 Sep 1996. Geopotential height amplitude is in meters, temperature amplitude in degrees kelvin, and phase in units of π. Phase is plotted only in latitudes where the waves are noticeable. The vertical grid is the observation grid in log-pressure height (km), using a scale height of 7 km. Time averaging was done on the amplitude and phase separately.