Problem Set 1 ATM 622: General Circulation of the Atmosphere August 28, 2019 DUE: September 11, 2019

The Clouds and the Earth's Radiant Energy System (CERES) has been taking measurements of the shortwave and longwave radiation at the top of the atmosphere for over two decades. You will use data from the CERES experiment to investigate aspects of the implied meridional energy flux.

Zonal and time averaged CERES data may be downloaded at:

http://www.atmos.albany.edu/facstaff/tang/classes/atm622/CERES.nc

There are three variables in the netCDF file:

zsolar_clim: Incoming shortwave radiation *ztoa_sw_all_clim*: Outgoing shortwave radiation *ztoa_lw_all_clim*: Outgoing longwave radiation

The latitudinal resolution is 1 degree from -89.5° S to 89.5° N. The data for each month is averaged from 2005 to 2015.

1) Using whatever scripting language (Python, NCL, Matlab, etc.) you are most comfortable with, read in the data. Calculate and plot the annual mean net radiative flux as a function of latitude, keeping in mind that incoming radiative fluxes should be positive and outgoing radiative fluxes should be negative. (Note: You may assume that each month has an equal number of days to make this calculation easier.)

2) Calculate and plot the implied zonally integrated meridional energy flux as a function of latitude using the annual mean net radiative flux.

What is the meridional energy flux at the Equator? Is this flux consistent with the hemispheric asymmetry in the OLR?

What is the meridional energy flux at 89.5°N? Recall that the meridional energy flux is required to vanish at each pole. Contradiction? Explain why.

3) Calculate and plot the zonally integrated meridional energy flux at the Equator as a function of month. Compare this flux to the observations of the DJF and JJA meridional flow at 1000 hPa and 200 hPa at the Equator from the lecture slides. Based on your calculations and observations, determine whether the low-level flow or the upper-level flow dominates the zonally integrated meridional energy flux at the Equator.