The Clouds and the Earth’s Radiant Energy System (CERES) is a follow-on to the Earth Radiation Budget Experiment (ERBE). Since the end of 1997, CERES has been taking radiometric measurements of the shortwave and longwave radiation at the top of the atmosphere. You will use data from the CERES experiment to investigate aspects of the implied meridional energy flux.

Zonal and time averaged data over the CERES period can 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 $-89.5^\circ$ S to $89.5^\circ$ N. The data for each month is averaged over the time range of the CERES experiment.

1) Using whatever data analysis tool (Python, NCL, Matlab, etc.) you are knowledgeable 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 are positive and outgoing radiative fluxes are negative. Compare this with the ERBE top of atmosphere net radiative flux data from lecture. (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 consistent with the hemispheric asymmetry in the OLR?

   What is the meridional energy flux at $89.5^\circ$ 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 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, conclude whether the low-level flow or the upper-level flow is predominately responsible for the zonally integrated meridional energy flux at the Equator.