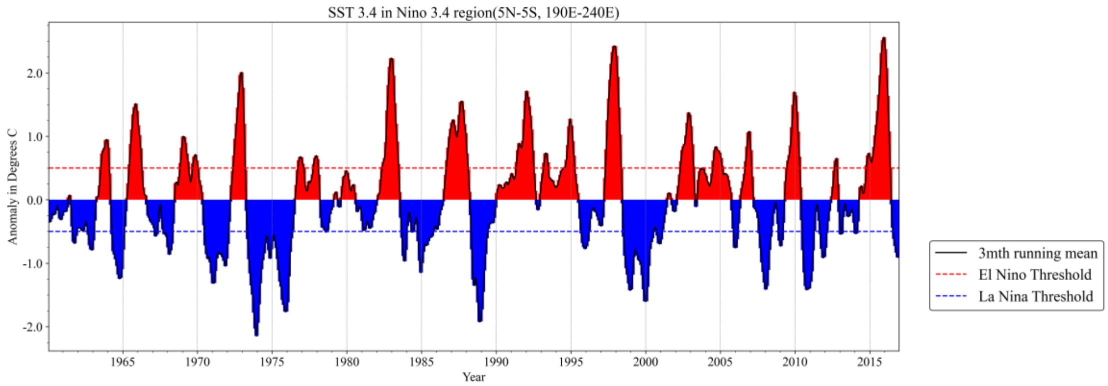
1.Niño 3.4 index

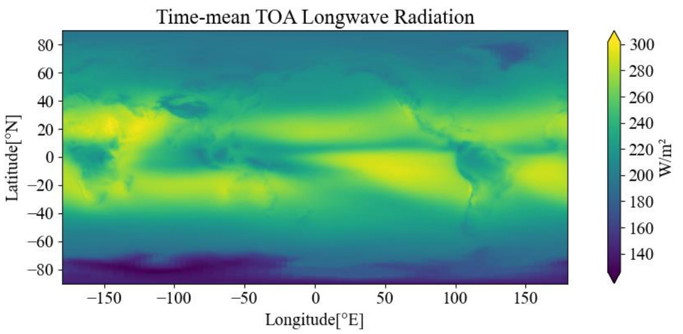
1.1 First, import the netCDF file, which contains global sea surface temperature data. Then use the 'sel' function to select the sea surface temperature data for the Niño 3.4 region, and use the 'mean' function to calculate the average sea surface temperature for the Niño 3.4 region. Use the 'groupby' function and 'mean' function to calculate the average sea surface temperature for each month. Finally, calculate the anomaly of the sea surface temperature.

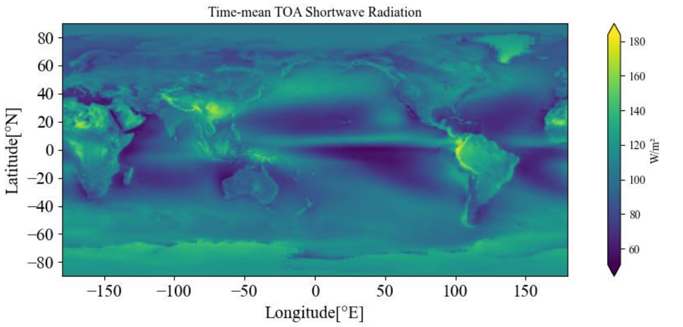
1.2 First, calculate the 3-month rolling average of sea surface temperature anomalies using the ‘rolling’and ‘mean’ functions. Convert the time coordinates to a pandas datetime index using the ‘to_index’ function. Determine the color of the bar chart based on the size of the values. Use the matplotlib library to draw the bar chart. At the same time, a line chart of the 3-month rolling average is also drawn. Add threshold lines for El Niño and La Niña using the ‘axhline’ function. Finally, add labels, titles, and legends, etc.

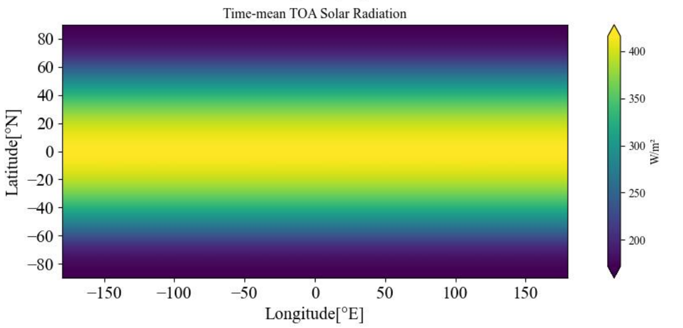


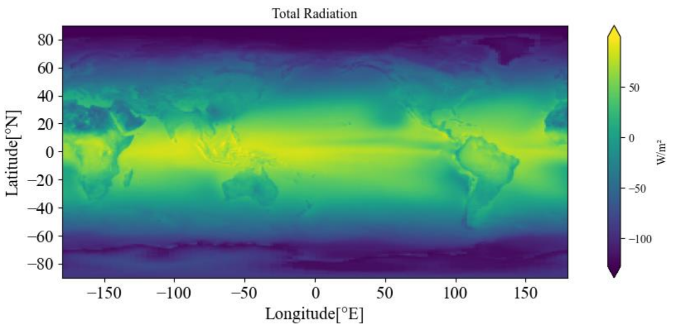
2. Earth’s energy budget

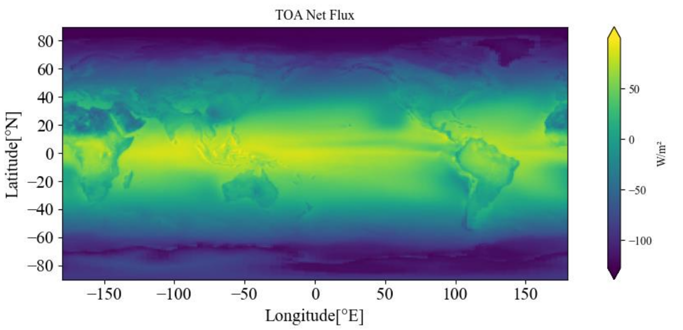
2.1 First, calculate the time average of each type of radiation (longwave radiation, shortwave radiation, and solar radiation). Then create five subplots. Plot the time average of longwave radiation on the first subplot, and the time average of shortwave radiation on the second subplot. Plot the time average of solar radiation on the third subplot. Then subtract longwave radiation and shortwave radiation from solar radiation to get the total radiation, and plot the total radiation on the fourth subplot. Plot the time average of TOA net radiation on the fifth subplot.











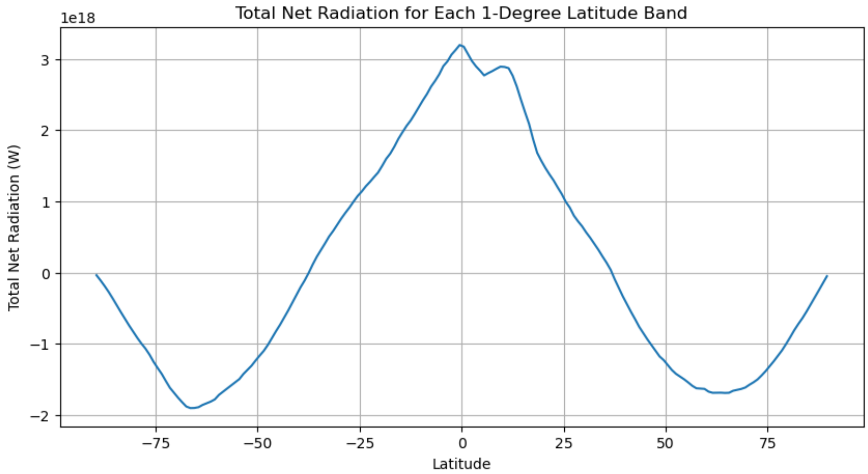
2.2 First create an array of the same shape as the 'solar_mon' variable, with all elements of the array having a value of 1. Then, multiply the result by the cosine of the latitude in radians, then by the difference of the longitude in radians, and finally by the square of the Earth's radius in square meters. The total area of the Earth is then calculated by summing the areas of all grids. The same latitude and longitude ranges are selected and the time-averaged values of solar radiation, long-wave radiation and short-wave radiation are calculated, and then the results are multiplied by the area of each grid.

Total incoming solar radiation: 340 W/m^2

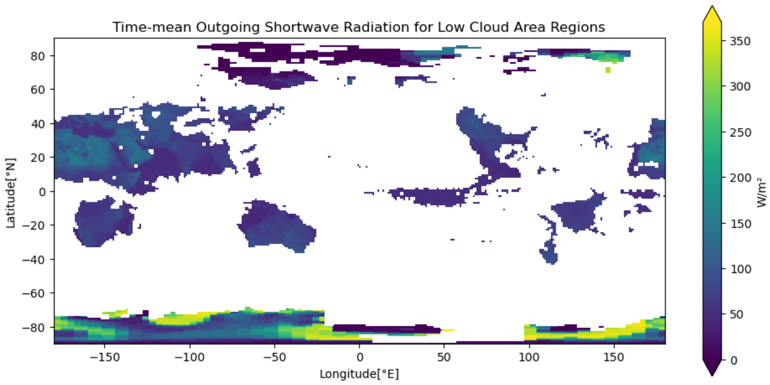
Total outgoing longwave radiation: 240 W/m^2

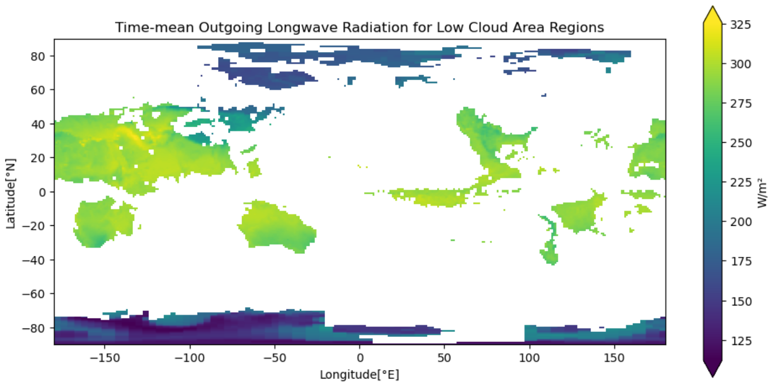
Total outgoing shortwave radiation: 98 W/m^2

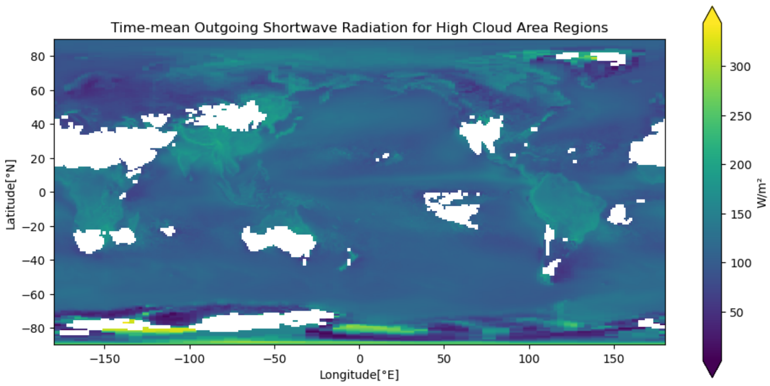
2.3 Firstly, calculate the net radiation of each latitude band. This is achieved by taking the mean of the top-of-atmosphere (TOA) net radiation over time and then multiplying by the area of each grid. Secondly, sum the net radiation over all longitudes to get the total net radiation for each 1-degree latitude band. Finally, create a new figure of the total net radiation for each 1-degree latitude band.

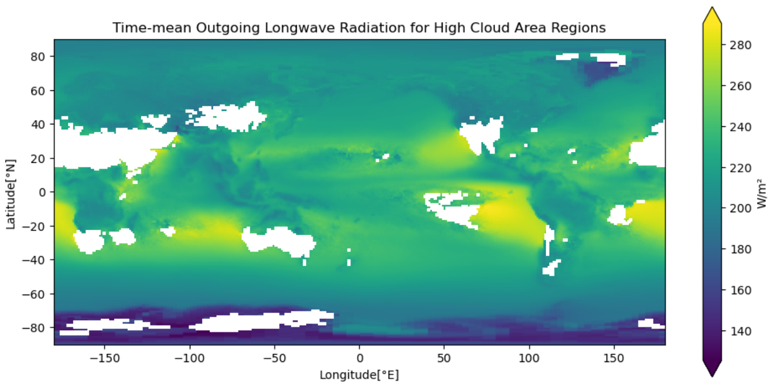


2.4 Firstly, select the shortwave and longwave radiation data where the cloud area is low or high, and then take the mean over time. Next, Create a figure with four subplots.









2.5 Calculate the global mean outgoing shortwave and longwave radiation for low cloud area regions and high cloud area regions. This is done by selecting the shortwave and longwave radiation data where the cloud area is low and high, and then taking the mean.

Results：

Global mean shortwave radiation in low cloud regions: 97 W/m^2
Global mean longwave radiation in low cloud regions: 247 W/m^2
Global mean shortwave radiation in high cloud regions: 111 W/m^2
Global mean longwave radiation in high cloud regions: 215 W/m^2

Short-wave radiation is primarily an energy transfer from the Sun to the Earth. The lower value (97 W/m^2) in regions of low clouds suggests that these clouds may be thicker or reflect solar radiation more efficiently.

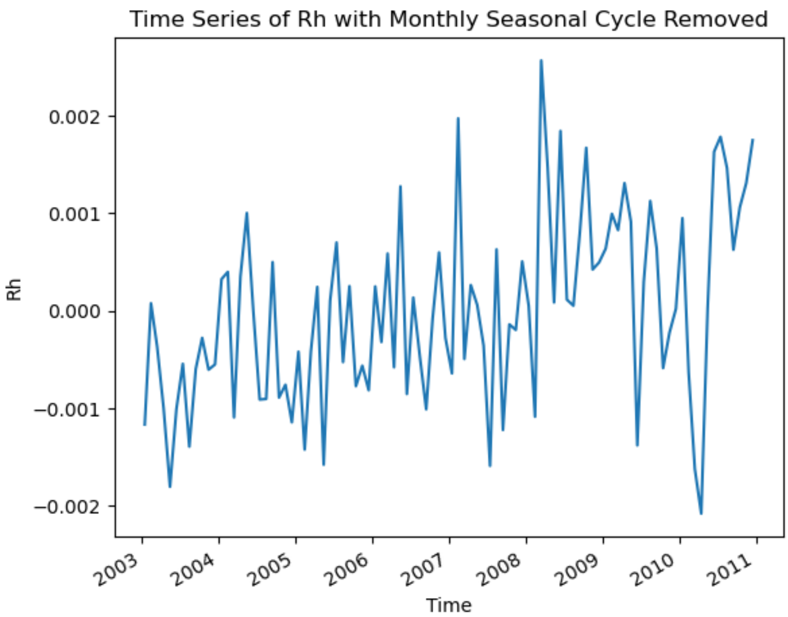
Long-wave radiation is thermal energy emitted by the Earth into cosmic space. The higher value (247 W/m^2) in the low cloud region means that these clouds may be warmer and therefore radiate more heat energy.

The higher value of shortwave radiation (111 W/m^2) in the region of high clouds may be due to the fact that these clouds are thinner and do not reflect solar radiation as effectively as low clouds.

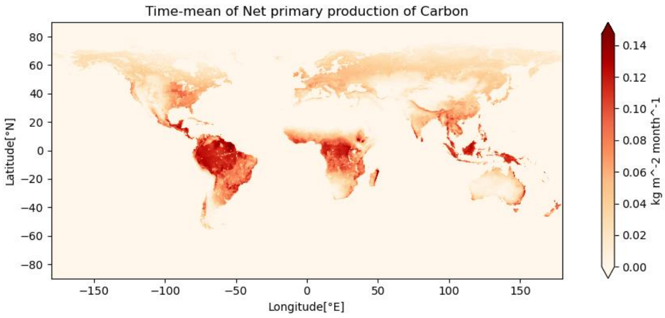
High cloud regions have lower values of longwave radiation (215 W/m^2), probably because high clouds are in a colder atmosphere and therefore radiate less heat.

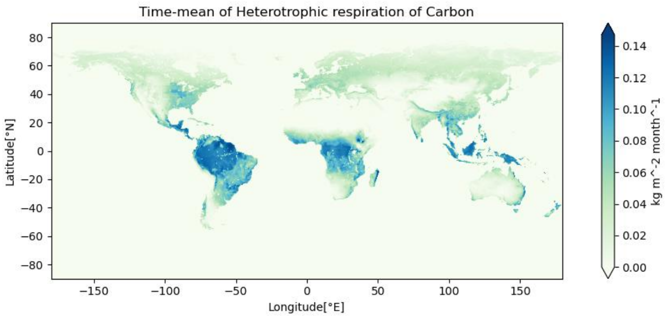
3. Explore a netCDF dataset

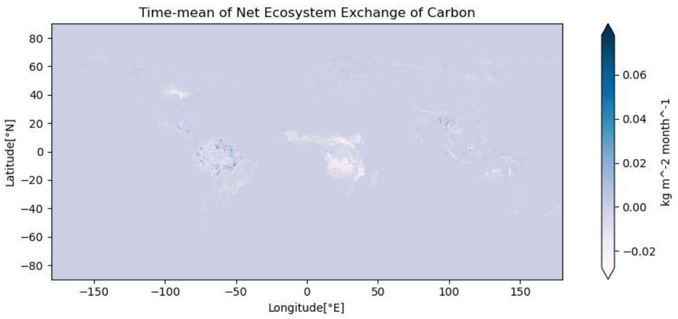
3.1 First, the relevant dataset files on the website are composed of multiple nc files, so the concat function in xarray is used to combine these files according to the time dimension. Then, grouping the Rh values by month, calculating the mean Rh value for each month, and then subtracting these mean values from the original Rh values. The result is a new time series of Rh values with the monthly seasonal cycle removed.Then, Calculate the mean of the deseasonalized Rh values over all latitudes and longitudes. This reduces the 3D time series to a 1D time series.Plot the 1D time series of mean deseasonalized Rh values.

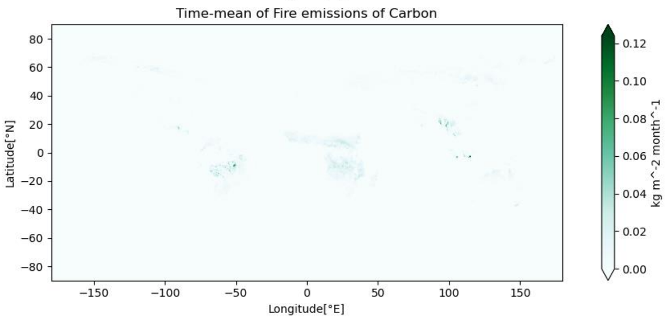


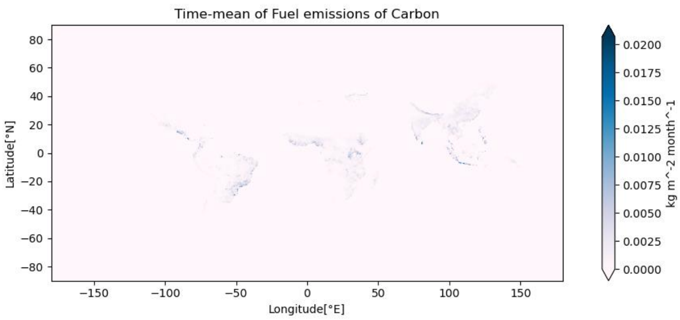
3.2 Variables are selected from the dataset. These variables include NPP, Rh, NEE, FIRE, and FUEL. then, the time-averaged values of each variable are calculated. Next, create five subplots, each plotting the time-averaged values of NPP, Rh, NEE, FIRE, and FUEL in turn. Use the imshow function to display the data as an image.


Time-mean of Net primary production of Carbon
Latitude[°N]
Longitude[°E]
kg m^-2 month^-1
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14


Time-mean of Heterotrophic respiration of Carbon
Latitude[°N]
Longitude[°E]
kg m^-2 month^-1
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14


Time-mean of Net Ecosystem Exchange of Carbon
Latitude[°N]
Longitude[°E]
kg m^-2 month^-1
−0.02
0.00
0.02
0.04
0.06


Time-mean of Fire emissions of Carbon
Latitude[°N]
Longitude[°E]
kg m^-2 month^-1
0.00
0.02
0.04
0.06
0.08
0.10
0.12


Time-mean of Fuel emissions of Carbon
Latitude[°N]
Longitude[°E]
kg m^-2 month^-1
0.0000
0.0025
0.0050
0.0075
0.0100
0.0125
0.0150
0.0175
0.0200