CS732/DS732: Data Visualization Assignment 1
2D scalar/vector field visualization Report

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1 Problem Statement

Perform 2D scalar field visualization on cloud moisture mixing ratio, pressure, and temperature using colour mapping (1-colour, 2-colour, 3-colour, and rainbow colour spectrum), contour mapping, and height/elevation mapping techniques; and visualize the vector field of (u,v), i.e. X and Y wind speeds using the quiver/hedgehog plot.

1.1 Data Description

The data set used for this assignment is a simulation of a hurricane from the National Center for Atmospheric Research in the United States. The data is in "Brick-of-Floats" format within binary file provided with the variable name. It consists of a volume of data values at each position in space. The three-dimensional array of data consists of planes of x-y values in ascending z-order; in the data, the x values vary fastest. Assuming the data was stored as a one-dimensional array, the index into that array for the point x, y, z would be:

index=x+dimx*(y+dimy*z)

http://sciviscontest-staging.ieeevis.org/2004/data.html

2 Visualization of scalar field data

Get the data from binary files of following variable names to cloud moisture mixing ratio, pressure, temperature and arrange the data in 500x500x100 sized grids. We are interested in only studying the x-y planes (corresponding to longitude-latitude data). Hence, we aggregate data about the z-axis and analyze it based on the rate of aggregation.

2.1 Color mapping

For a scalar field, cloud moisture mixing ratio, pressure, and temperature. Potentially generate a 2D matrix of RGB colors using a chosen color spectrum, and chosen interpolation method to compute the color value of each grid cell for given scalar value.

2.1.1 Color spectrum to experiment

For a scalar field, generate a 2D matrix of RGB colors using a chosen color spectrum to compute the value at each grid cell. Color spectrum to be experimented include: (a) Blue color spectrum, (b) Blue-green spectrum (2-color), (c) Blue-red diverging spectrum (3-color), (d) Rainbow color spectrum.

- **Blue color spectrum(1 color):**

  In the Blue color spectrum we will be using only the Blue(0,0,1) and White(1,1,1) combination from RGB value. Considering white for the least scalar value of cloud ratio i.e. 0.0 and blue for the maximum scalar value i.e. 1.0000000e+35 treated as "no data"(for the actual ground).

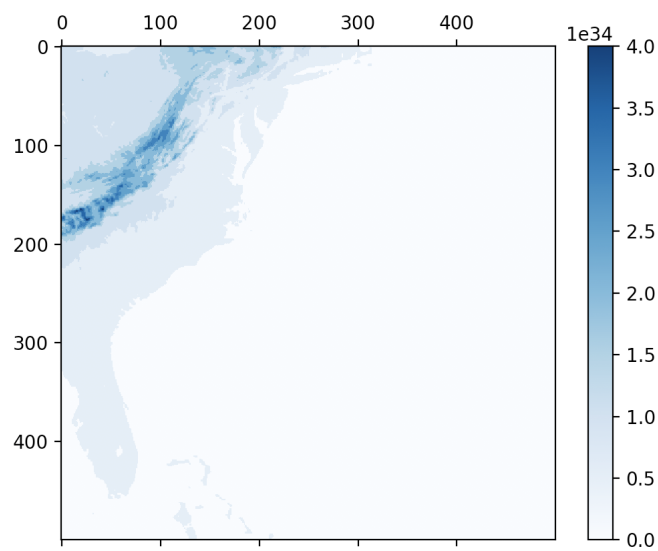


Figure 1: Blue spectrum, Color Mapping of cloud moisture mixing ratio

- **Blue-green spectrum (2-color):**

  In the Blue-green color spectrum we will be using only the Blue(0,0,1) and Green(0,1,0) combination from RGB value. Considering blue for the least scalar value of tempurature i.e. -83.000402 and green for the maximum scalar value i.e. 1.0000000e+35 treated as "no data"(for the actual ground).

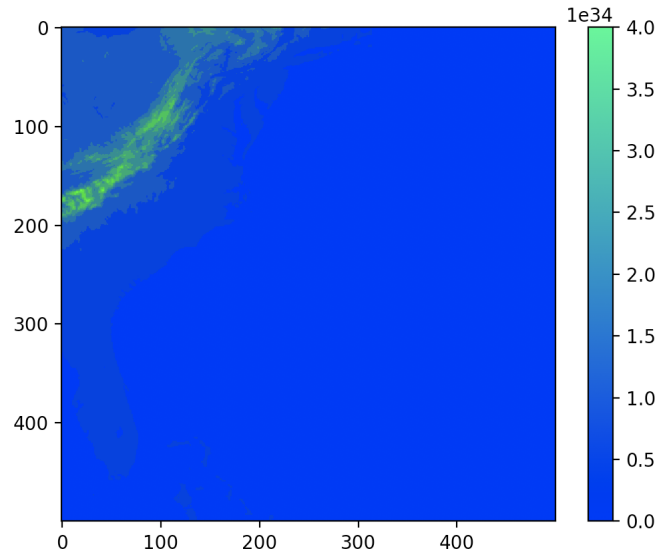


Figure 2: Blue-green spectrum, Color Mapping of Temperature

- **Blue-red diverging spectrum (3-color):**

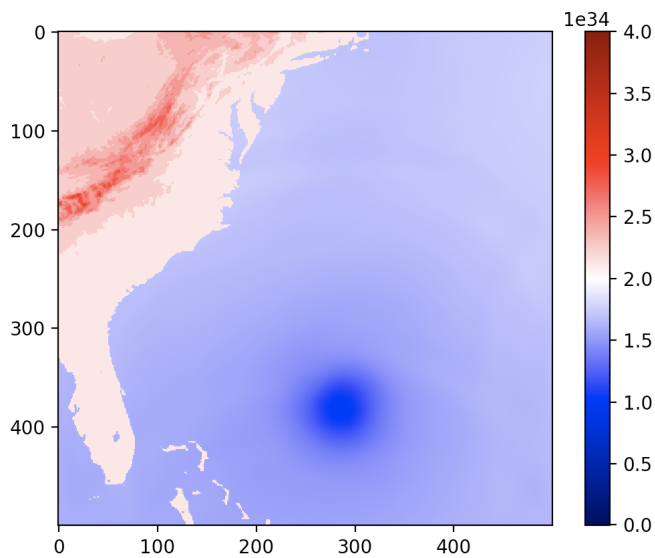


Figure 3: Blue-red diverging spectrum, Color Mapping of pressure

In the Blue-red color diverging spectrum we will be using only the Red color spectrum for land data values in range 1.0000000e+35 to 3225.42578 and Blue color spectrum for pressure data values on the ocean surface in

range 3225.42578 to -5471.85791 where 3225.42578 holds white color in between

- **Rainbow color spectrum:** In the Rainbow color spectrum, we will be using seven colors i.e VIBGYOR where violet indicates the minimum value and red indicates the maximum value and will divide the range of values into six equal parts and each part will start with one color and ends with the preceding color of next part.

  We use bi-linear interpolation method to plot color maps

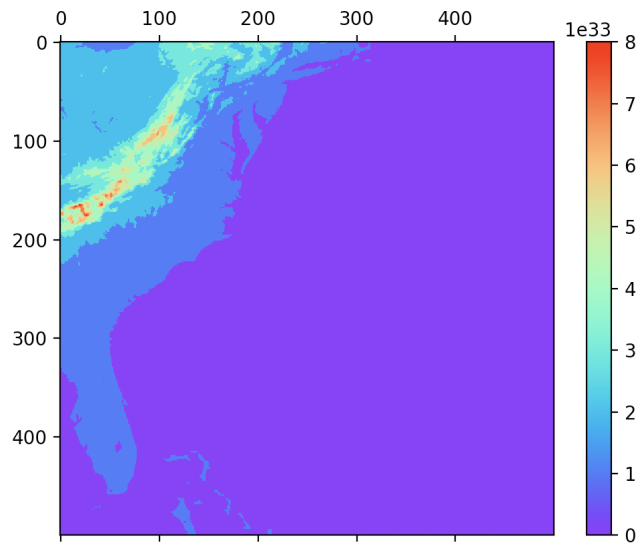


Figure 4: Rainbow color spectrum, Color Mapping of pressure

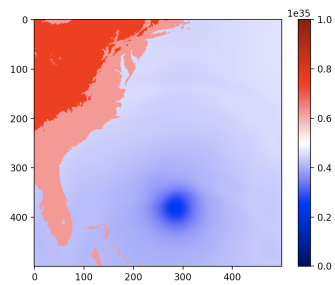
2.1.2 Different insights on the Color spectrum and rate of aggregation

Among all the color maps used the rainbow color map and diverging color maps can visualize the geographical part of Florida coast. But the diverging map used in mentioned limits where red is for land data and blue is for pressure in the ocean can visualize the hurricane in the ocean perfectly.

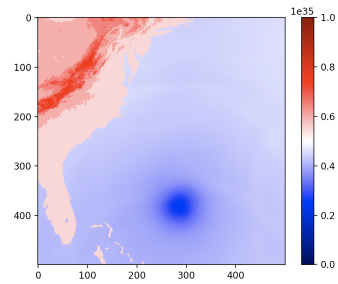
As the color mapping can be done only on 2D data we aggregate the 3d matrix along Z-axis and obtain 2D matrices. Aggregating the data may result in information loss. So we need to choose a proper aggregation rate which gives a correct approximation. In Figure 5 we can see the color map of the pressure variable at different aggregation rates. As aggregation rate increases we can pressure on the water surface is close to its min value given more blue color and if aggregation rate is low, the pressure value are

closer to maximum value on the land part. At the rate of five visualizations is better and information is mostly maintained with minimal loss

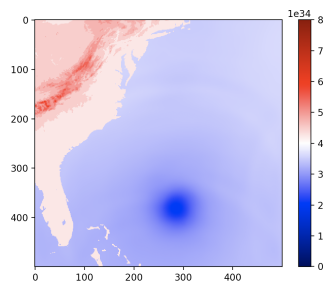
Hence diverging color map at aggregation rate of 5 gives better visualization for this hurricane data set



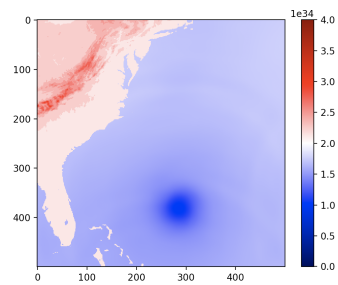
(a) aggregation rate = 2



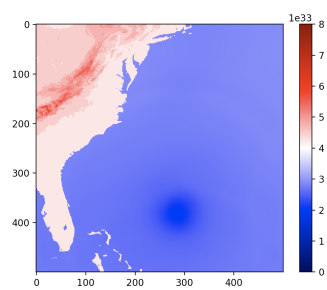
(b) aggregation rate = 5



(c) aggregation rate = 10



(d) aggregation rate = 20



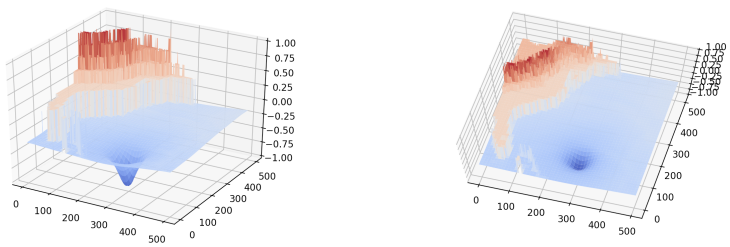
(e) aggregation rate = 100

Figure 5: Color Mapping of pressure for various rates of aggregation along z-axis

2.2 Elevation mapping

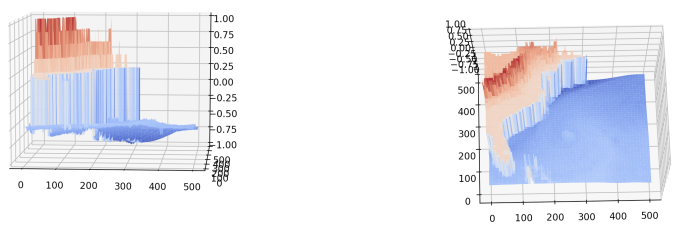
Elevation Mapping gives us the visualization in 3D plot which shows the variation in the scalar field across the longitude and latitude. For rendering

the data on a 3D plot, Matplotlib's plotsurface function enabled us to do the same. We pass longitude, latitude and the scalar value to the function i.e. 500*500 mesh with chosen scalar field value at each point is plotted in z dimension and color is also given based on elevation. Figure 6 shows the Elevation Map for pressure values at different view points and Figure 7 shows the Elevation Map for pressure values at different view points.



(a) (b)

Figure 6: Elevation Mapping of pressure from different viewpoints



(a) (b)

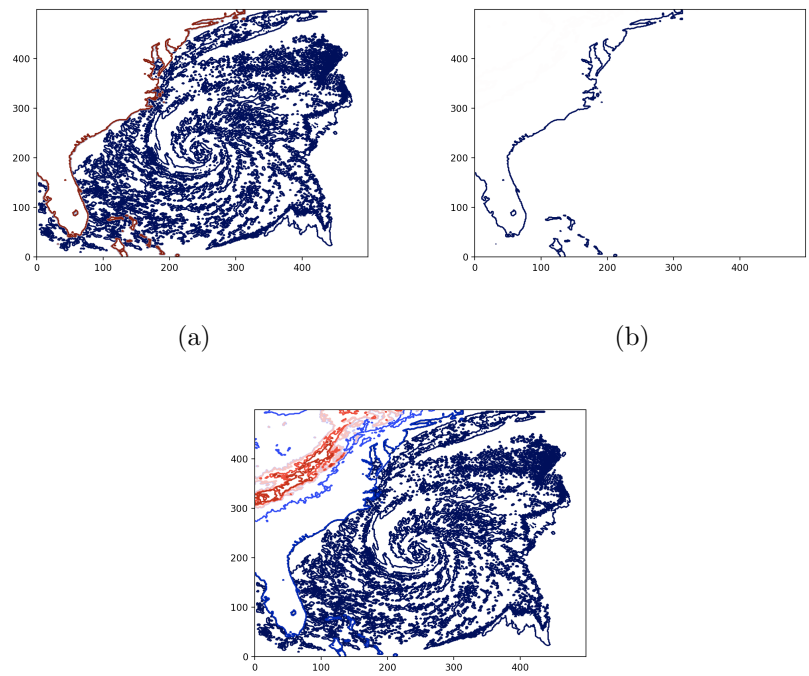
Figure 7: Elevation Mapping of Temperature from different viewpoints

2.2.1 Different insights on elevation map:

The scalar value when plotted on an elevation map will display the peak and the valley corresponding to the scalar data. The highest point is much more prominently visible in the visualization. To make the lowest point equally prominent we performed normalization as in the color map giving positive values to pressure data and negative values as the pressure in ocean showing peak drop in pressure and sheer drop in temperature at hurricane eye in terms of elevation

2.3 Contour Mapping

A contour map, reveals the relief of an area through contour lines where each such line passes through points of the same scalar values from available data points. Generally, contour values are plotted for the significant scalar values which make a graph in regions. By default, we compute contours for minimum, first-quartile, average, median, third-quartile, and maximum values of the field and give different colors for the contours to indicate the statistical property of the value, consistently across any chosen scalar fields. The code must output each contour as a set of line-segments with corresponding color value. To calculate the contours Marching squares algorithm is used. the draws contours on a 2-Dimensional plane for a scalar data. we implement it using contour function of matplotlib.



(a) (b)

(c)

Figure 8 : contour plots of cloud moisture mixing ratio for different range of values

The scalar values used to plot contour lines on the map can be provided using list values to draw as a parameter to function. At first, the land data values form 0.00000 to 1.0000000e+35 is normalized on between 0 to 1 and cloud moisture mixing ratio values from 0.00000 to 0.00332 in the ocean is normalized form 0 to -1. Then Figure 8a is plotted by providing

a list of values [-1,-0.5,0], Figure 8b is plotted by providing a list of values [1,0.5,0] and Figure cc is plotted by taking default values.

The lower the rate of aggregation plot gives more no.of contour lines. Here are the contour plots of pressure and temperature variables at rate of 5

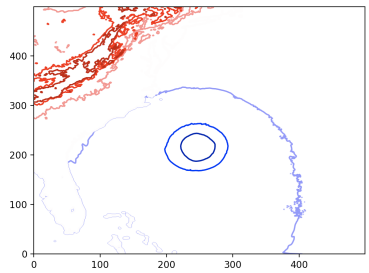


Figure 9(a): contour plot of pressure

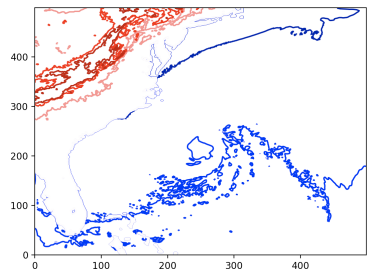
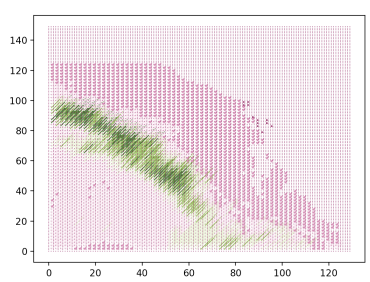


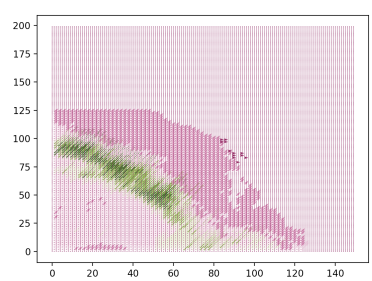
Figure 9(b): contour plot of temperature

2.4 Hedgehog Plots

A quiver plot is a type of 2D plot that shows vector lines as arrows defined by the components u and v at points described by the coordinates defined by x and y of dimension 500*500. The component u describes X wind speed (positive means winds from west to east) in the range -79.47297 to 85.17703 and component v describes Y wind speed (positive means winds from south to north) in the range -76.03391 to 82.95293. Figure 10 shows the quiver plot for pressure values for different sample size



(a)



(b)

Figure 10 shows the quiver plot for pressure value