CS732/DS732: Data Visualization Assignment 2 3D scalar field/2D vector field visualization Report

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September 2019

1 Problem Statement

Demonstrate streamlines of 2D wind speed field (in u,v directions) in sea surface changing over five different time instances. Demonstrate 3D-slicing and isosurface extraction in the volumetric data. For three different scalar fields, and show their changes over time using the same five different time instances.

Choice of time-instances: Generate a box-plot of pressure variable across time instances using pre-computed statistical descriptors2 for each time instance (or uniformly sub-sampled time instances – should have at least 12-time instances). Use this box plot to determine time instances for which you would generate visualizations.

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 the "Brick-of-Floats" format within the 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 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

1.2 Choosing time-instances of pressure variable:

Q1. Other than using the box-plot, which other ways will you identify the time instances for further exploration? What other scalar fields could you have used for a similar study?

To choose 5-time instances of pressure variable to visualize hurricane among 48 given time instances, we used box plot and the standard deviation values for all 48-time instances.

As box plots over 3D volumetric data visually similar. We took only part of 3D data and plotted line graphs between lower quartile, median, upper quartile, and standard deviation, as shown in Figure 1.

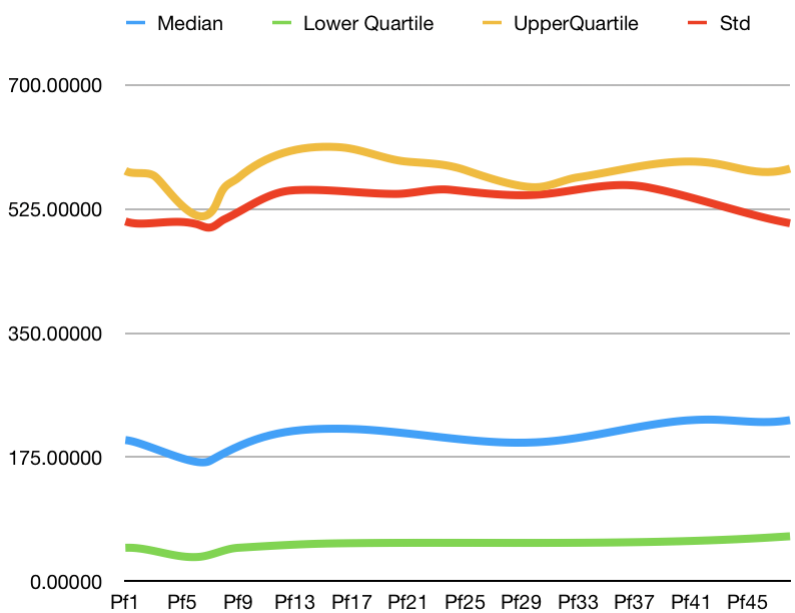


Figure 1: Line graph of the lower quartile, median, upper quartile and standard deviation values of all 48-time instances

Figure 1 depicts the following information :

- There is a global minimum for all curves at instance P6 representing a sharp drop in pressure values
- Followed by a slow increase and Decrease of values there is a local maximum at instance P16 in the median, standard deviation, and upper quartile plots
- Then after 24 instances of the global minimum we again encounter a local minimum at P30, we can tell that at one part in day pressure values are very less
- At P42 we encountered local maximum for median and upper quartile parts
- Altogether, the maps are in increasing fashion with pitfall

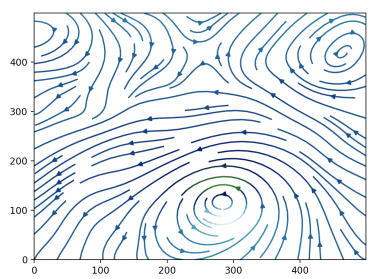
From all the above interpretation, we can see P6, P16, P30, and P42 are critical points and behaves differently apart from other instances. So we choose P1, P6, P16, P30, and P42 for our analysis.

2 Visualization of scalar field data

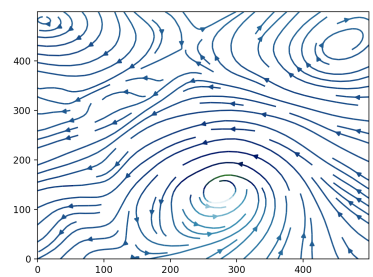
Get the data from binary files of U variable and V variable in 5 chosen time instances from the box plot, where U and V represent the direction of wind speeds. Arrange the data in 500x500x100 sized grids. We are interested in only studying the x-y plane (corresponding to longitude-latitude data). Hence, we take surface data about the z-axis.

2.1 Stream lines

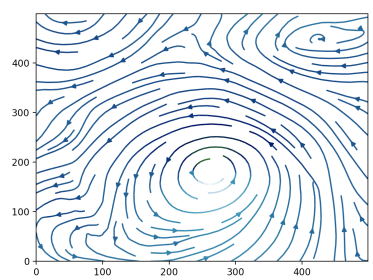
Streamline gives you information about a particular particle in space and describes how it moves through the vector field.



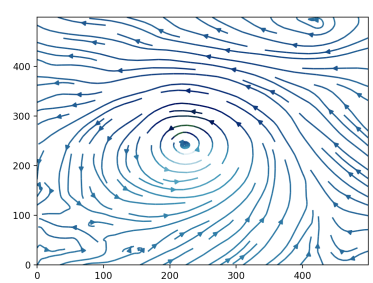
(a) At 1st time instance



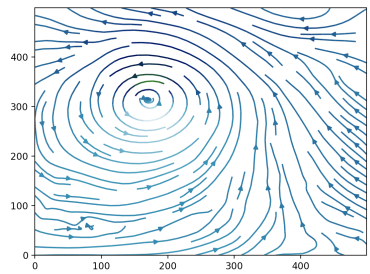
(b) At 6th time instance



(c) At 16th time instance



(d) At 30th time instance



(e) At 42nd time instance

Figure 2: Streamlines of pressure for various instances at tenth slice across z-axis

To generate streamlines, we will first choose some seed locations. And calculate a vector field value there and move ahead in that vector direction with the help of step length value to locate the next continuity point. Then we should specify the stopping point (i.e., the no. of steps it goes ahead in that direction, larger the number for maximum steps will generate longer streamlines).

Here are the streamlines at tenth slice across z axis for all the chosen time instances we can visualize the hurricane eye motion across time instances.

3 3D Visualization of scalar field data

Get the data from binary files of pressure variable in 5 chosen time instances from the box plot and arrange the data in 500x500x100 sized grids. We are interested in only studying the x-y plane (corresponding to longitude-latitude data). Hence, we take surface data about the z-axis.

3.1 Isosurface extraction

An isosurface is a three-dimensional analog of a Contour line. It is a surface that represents points of a constant pressure value within a volume. We extract the isosurfaces implementing marching cubes, which gives us a set of triangular surfaces.

It gets 3D cubes in the volume where each corner of the cube is a grid point. We have 256 such cube configurations. These cubes intersect with triangles that draw a boundary between iso-valued grid points and non iso-valued grid points. The triangle choosing part can be done by relating it to one of the cases in the lookup table. As shown in Figure 3., we should find out the vertices of triangles i.e., interpolation points of cubes. We plot all these triangles together using trisurf function in matplotlib where a set of vertices are passed as arguments to it.

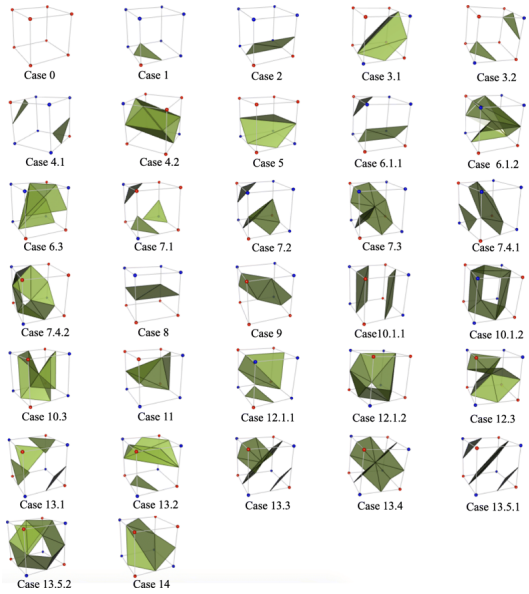


Figure 3: Look Up table for marching cubes

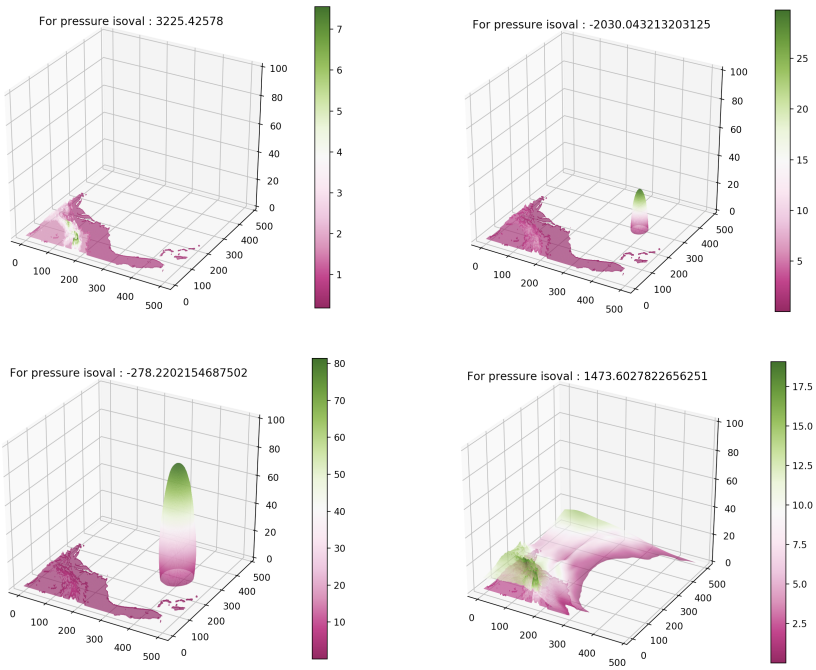
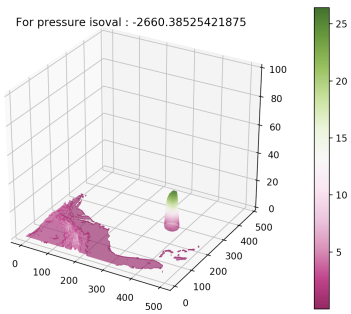
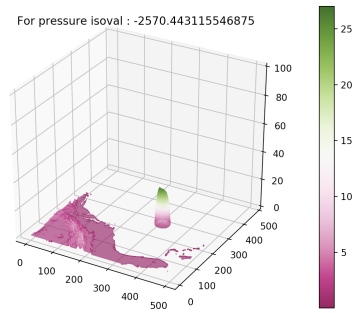


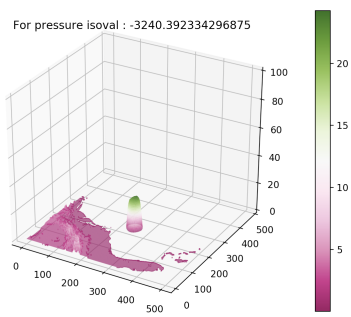
Figure 4: Isosurfaces of pressure variable at P01 time instance for different isovalue



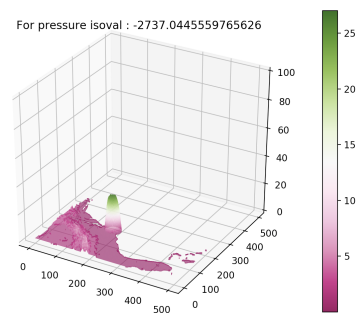
(a) At 6th time instance



(b) At 16th time instance



(a) At 30th time instance



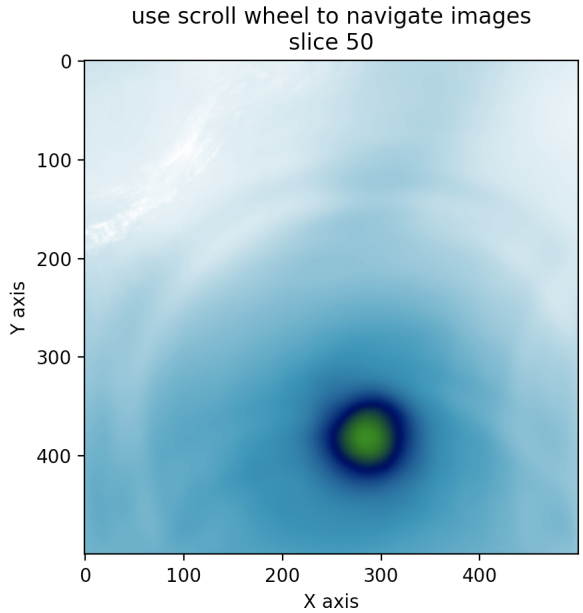
(b) At 42nd time instance

Figure 5: Isosurfaces for pressure iso-value at different time instances

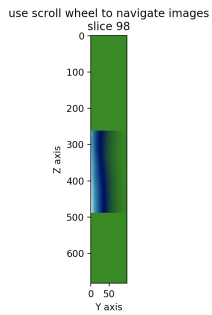
We can also see the pressure iso-value of hurricane eye moving towards land segment in each time instance and finally touched the surface line at the 42nd-time instance.

3.2 Slicing

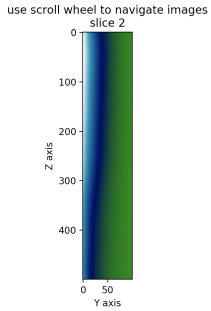
Slicing is obtaining a plane in 3D volume. In slicing, we need to specify the axis to traverse across, and for oblique slicing, we should also specify the angle the plane makes across the axis. For oblique slicing, we will rotate the cube across that axis with a specified angle and visualize the plane transformed the cube



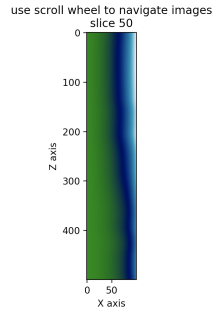
(a) slice across z axis



(b) slice making 30 deg across X axis



(c) slice making 90 deg across X axis



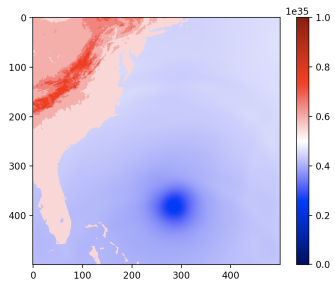
(d) slice making 180 deg across Y axis

Figure 6: Slices of 3D volumertic pressure data at 1st time instance

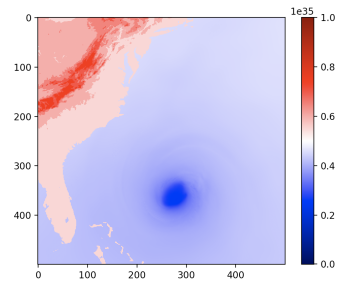
Q2. What is your conclusion on the evolution or timeline of Isabel Hurricane based on your visualization results? Is tracking the eye of the hurricane sufficient to manage disasters owing to the hurricanes?

Tracking the eye of hurricane across is simply not enough but we must also track the change in pressure, temperature values and change in intensity of wind speeds along the coast line to manage diasters. We can track the eye of hurricane on the evolution of time line for pressure data using color map in

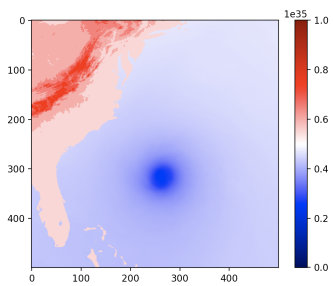
Figure 7. But this visulaiztion is hardly giving information about how intense the hurricane is



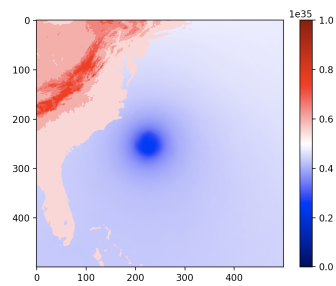
(a) At 1st time instance



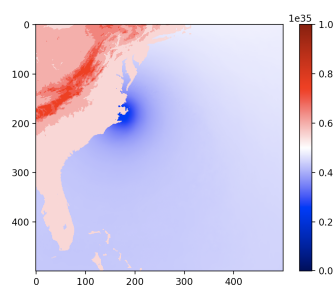
(b) At 6th time instance



(c) At 16th time instance



(d) At 30th time instance

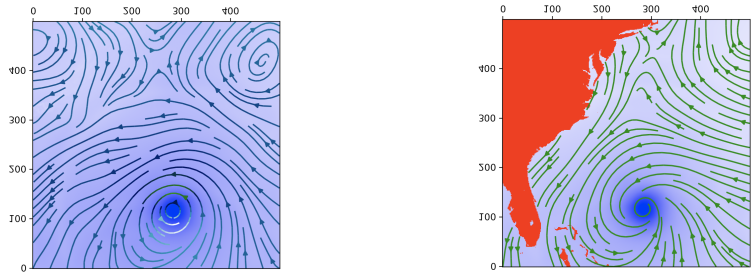


(e) At 42nd time instance

Figure 7: Tracking hurricane eye across time instances for pressure

Q3. How would you build a real-time hurricane tracking visualization application? What visualizations will you include, and why?

The real time hurricane tracking system should contain geographical structure of ocean and land which is given by color map and it must also have direction of wind speeds so we also must have stream line plot(as quiver plot is to small we don't consider it)



(a) (b)

Figure 8: Stream plot on color map for pressure data variable