Part 1:

1. Extract streamlines using ‘Point Source” seed type.
2. Enhance the rendering by using tubular surfaces.

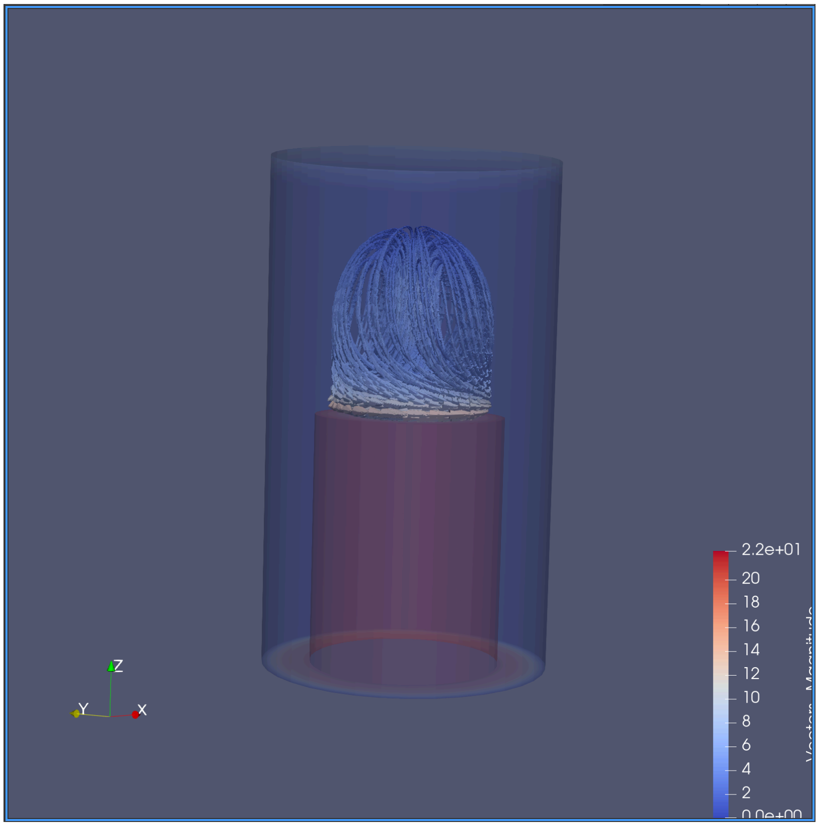


Figure 1: The final rendered version of part 1

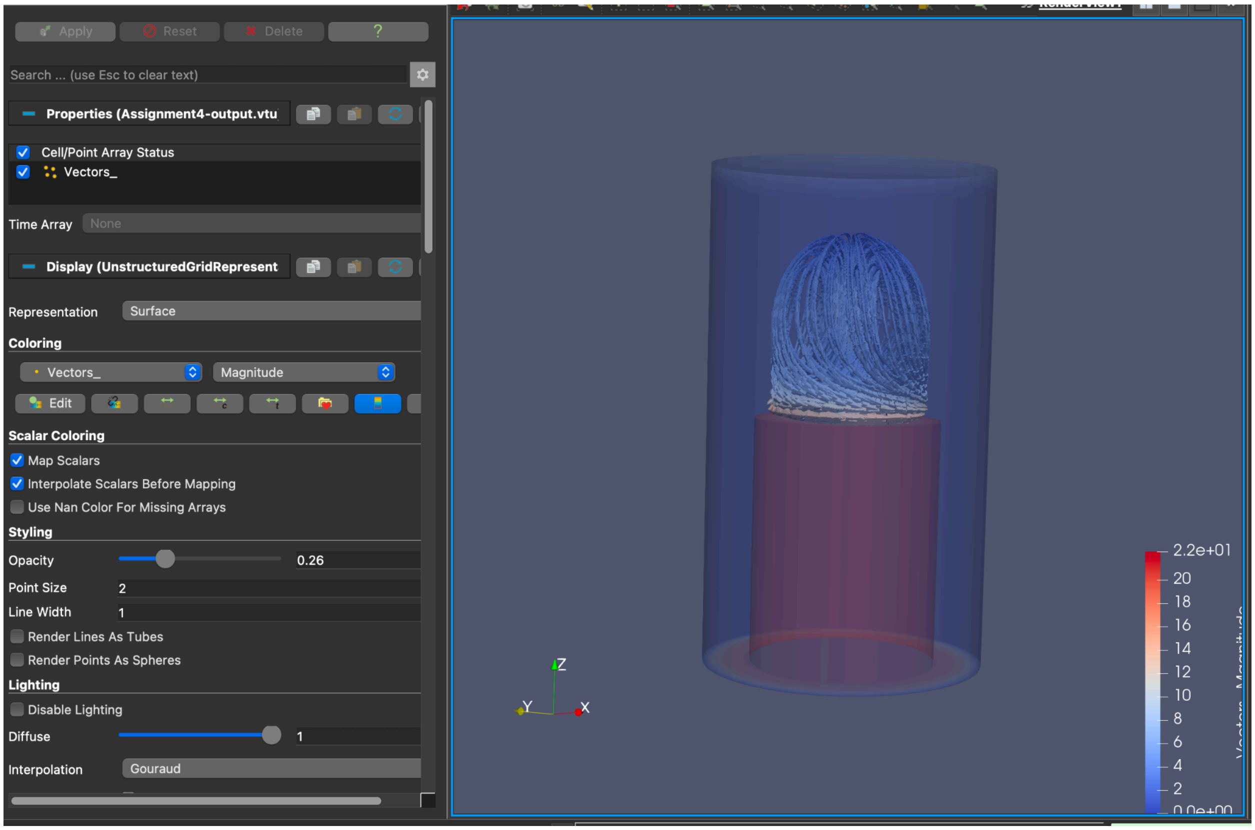


Figure 2: The figure shows the properties set up to render part 1 image

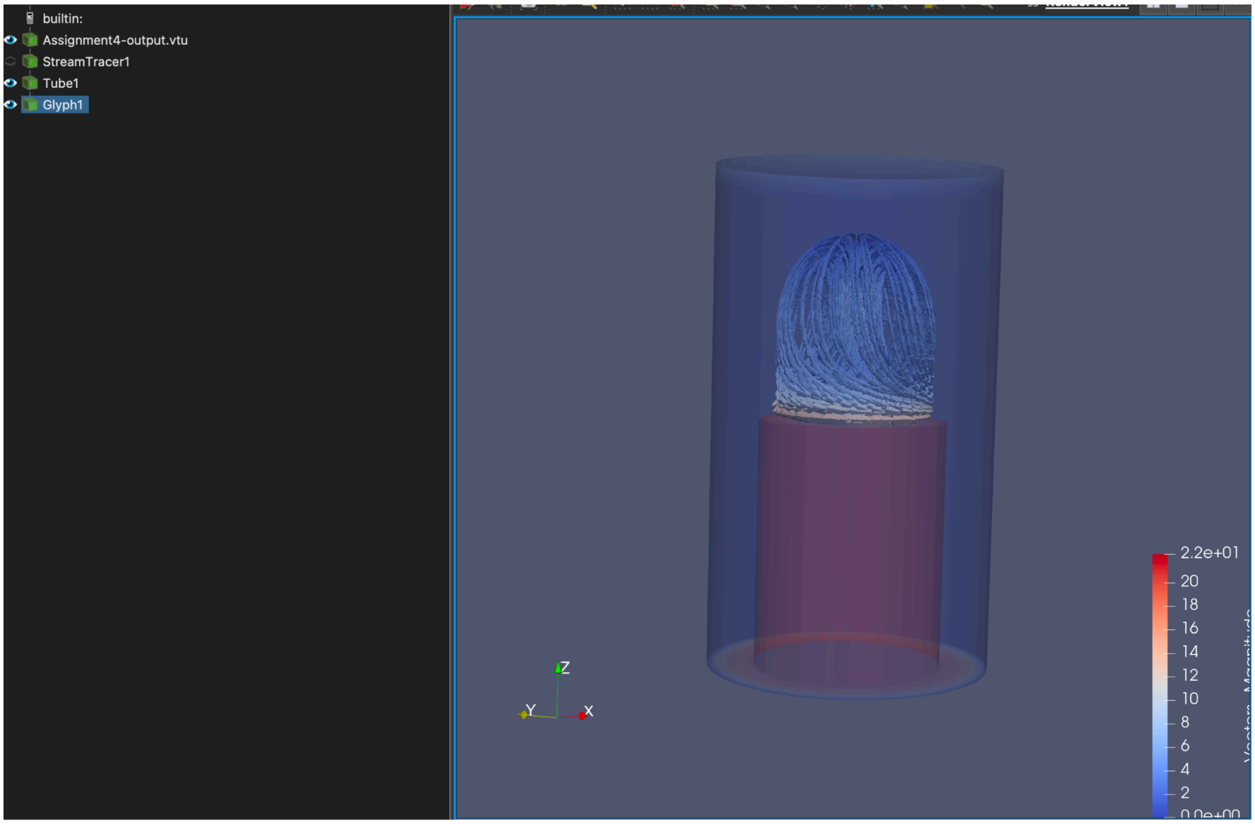


Figure 3: Enhanced rendering using tube filter

With the opacity set to low, I could see the object inside, and with the streamlines set, I could see the strings inside the last; the glyph filter added vector points and lowered the scaler factor the vectors were visibly suitable.

PART 2:

Step 1:

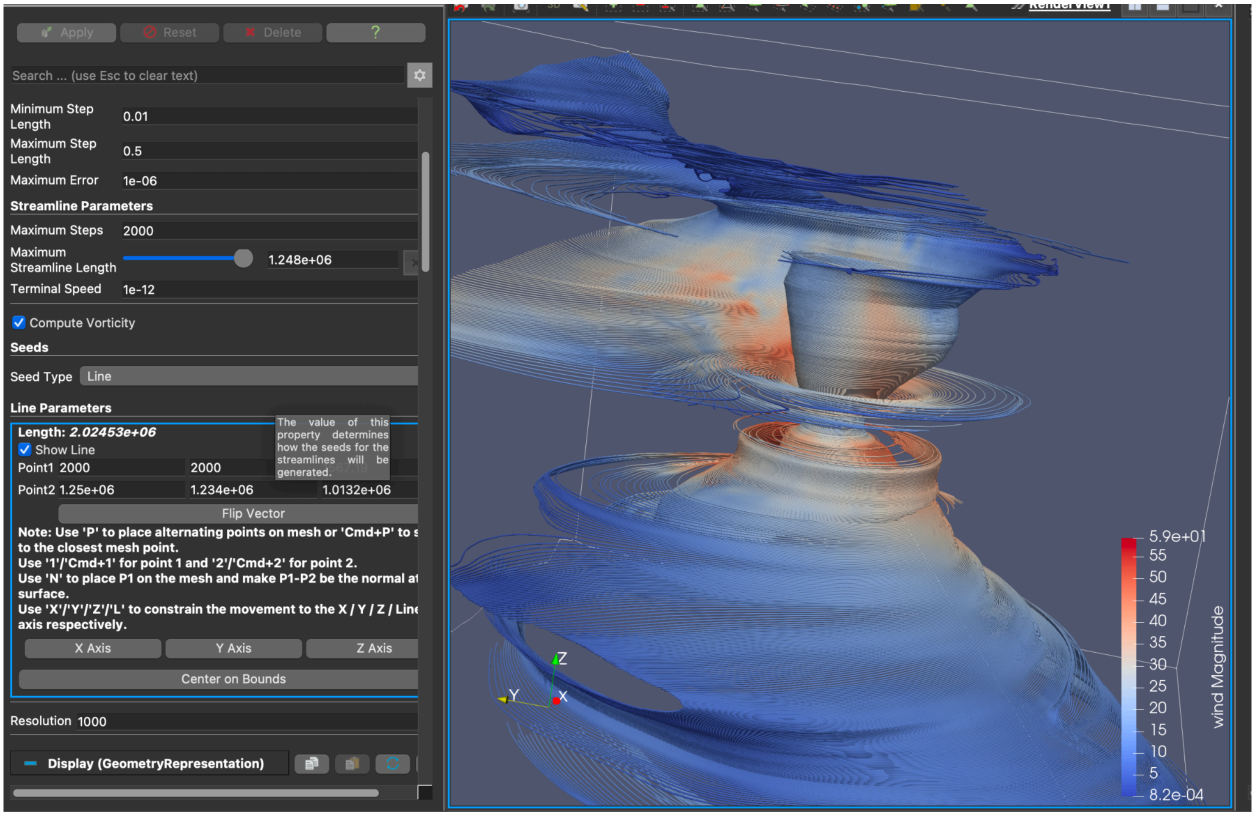


Fig 4: Seed type: Line

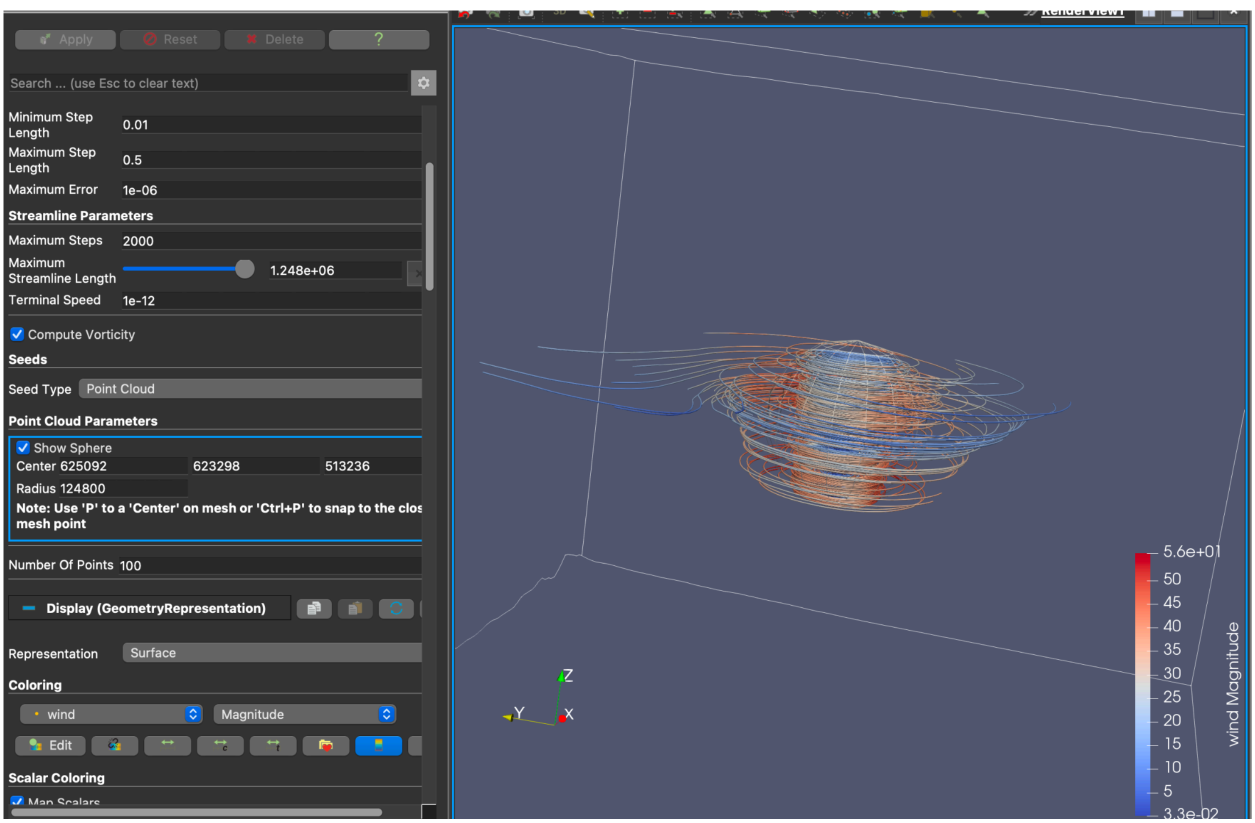
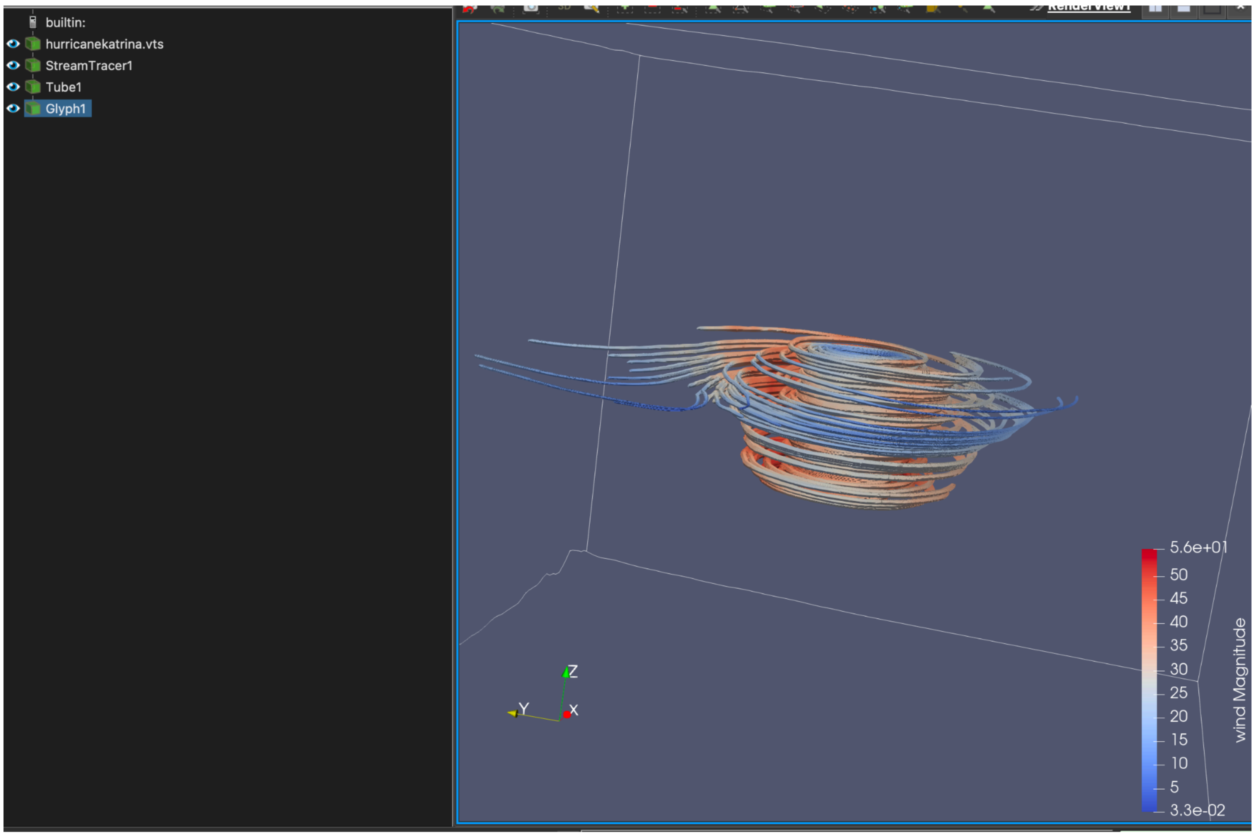
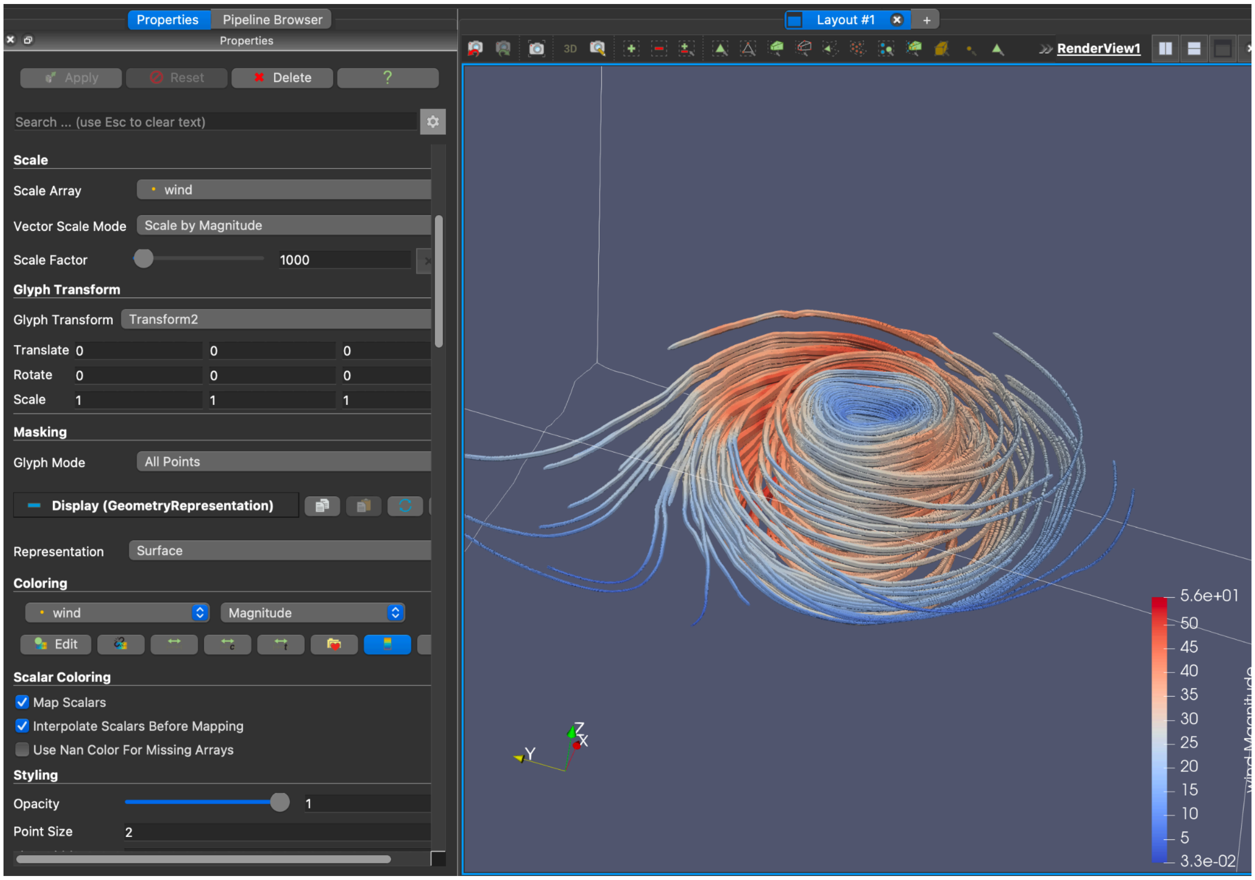


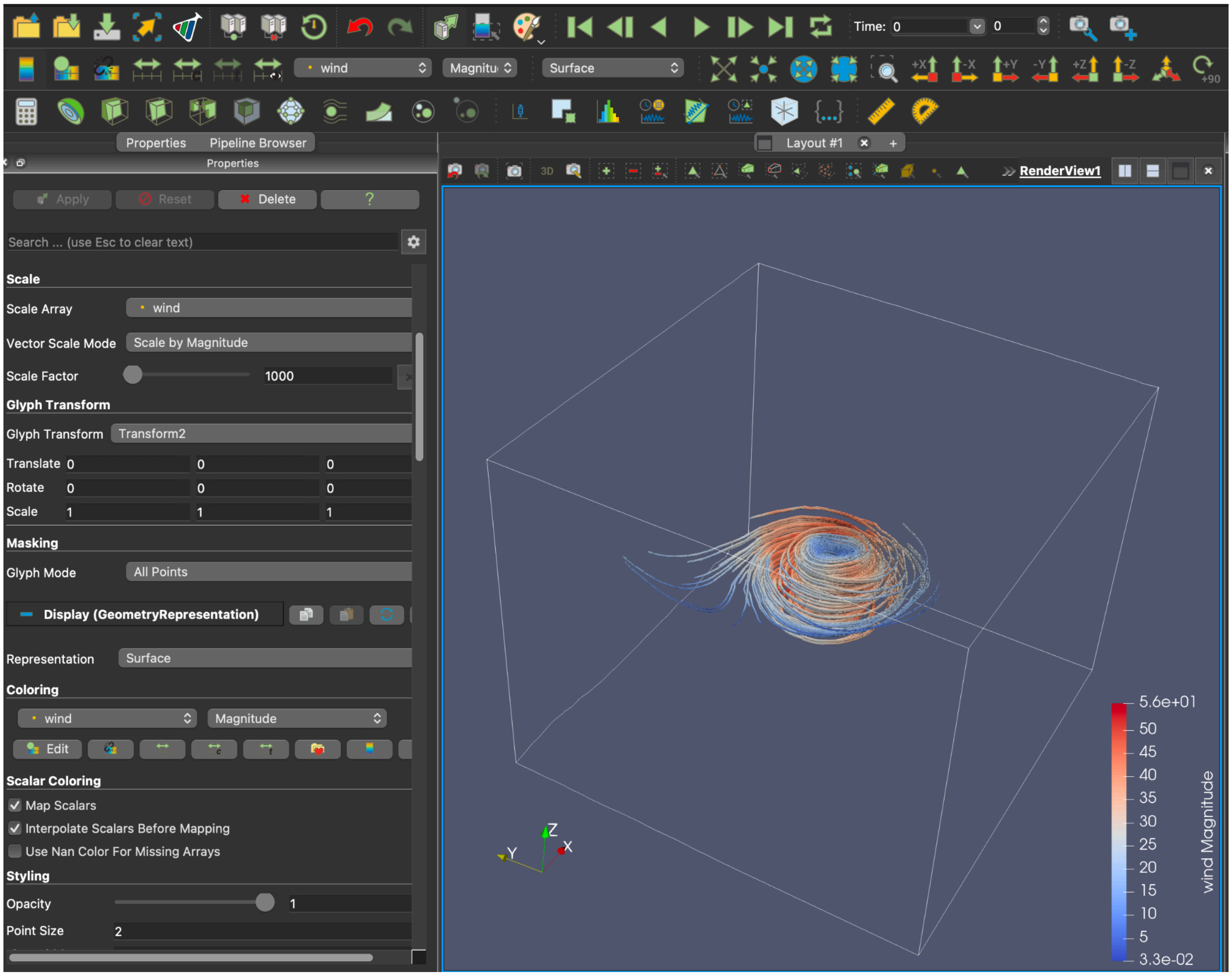
Figure 5: Seed type point cloud

With point cloud, I can easily see the wind whirlings, and with line seed type, the streamlines are not easily separable and look concentrated so much.

Step 2:
The figures below show the filters added to show the visualization with the direction of wind flow with speed with arrow glyphs




Properties
Pipeline Browser
Properties
Apply
Reset
Delete
Search ... (use Esc to clear text)
Scale
Scale Array
wind
Vector Scale Mode
Scale by Magnitude
Scale Factor
1000
Glyph Transform
Glyph Transform
Transform2
Translate 0 0 0
Rotate 0 0 0
Scale 1 1 1
Masking
Glyph Mode
All Points
Display (GeometryRepresentation)
Representation
Surface
Coloring
wind
Magnitude
Edit
Scalar Coloring
Map Scalars
Interpolate Scalars Before Mapping
Use Nan Color For Missing Arrays
Styling
Opacity
1
Point Size
2
Layout #1
RenderView1
5.6e+01
50
45
40
35
30
25
20
15
10
5
3.3e-02



Part 3:

1. Load the dataset: https://my.eng.utah.edu/~cs6635/Assignment4-output.vti.gz
2. Design a transfer function for direct volume rendering of flow velocity magnitudes to create a visualization similar to the following (Red: relatively high magnitudes, Blue: relatively low magnitudes)

Output of this part:

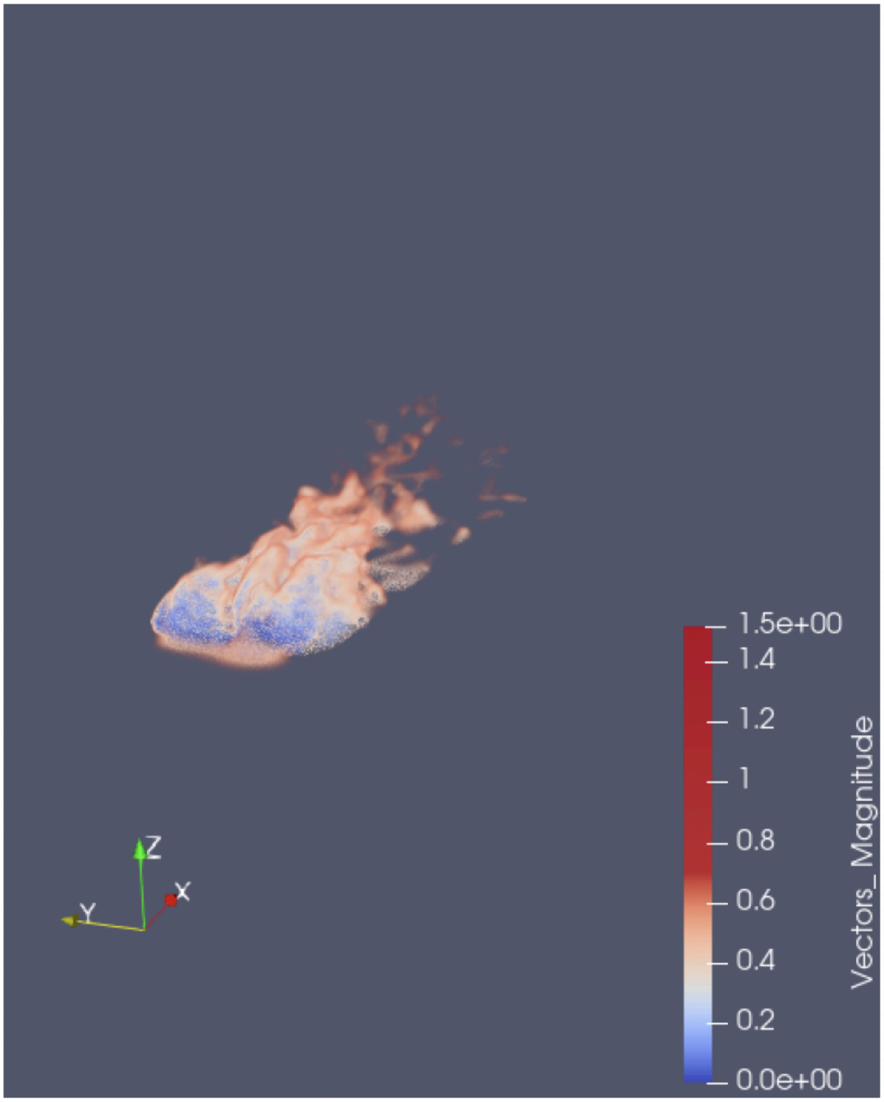


Figure 7: Applying the transfer function

3. Apply the Stream Tracer filter to output.vti. Please orient a seed line orthogonal to the moving direction and keep it horizontal before applying the filter.
4. Apply the ribbon filter to streamline. Set ribbon width parameter such that the resulting visualization has a pleasing appearance. Note the ribbons, in contrast to tubes, enable to better illustrate small-scale helicoidal trajectories (in turbulent areas). The image looks

similar to the following:

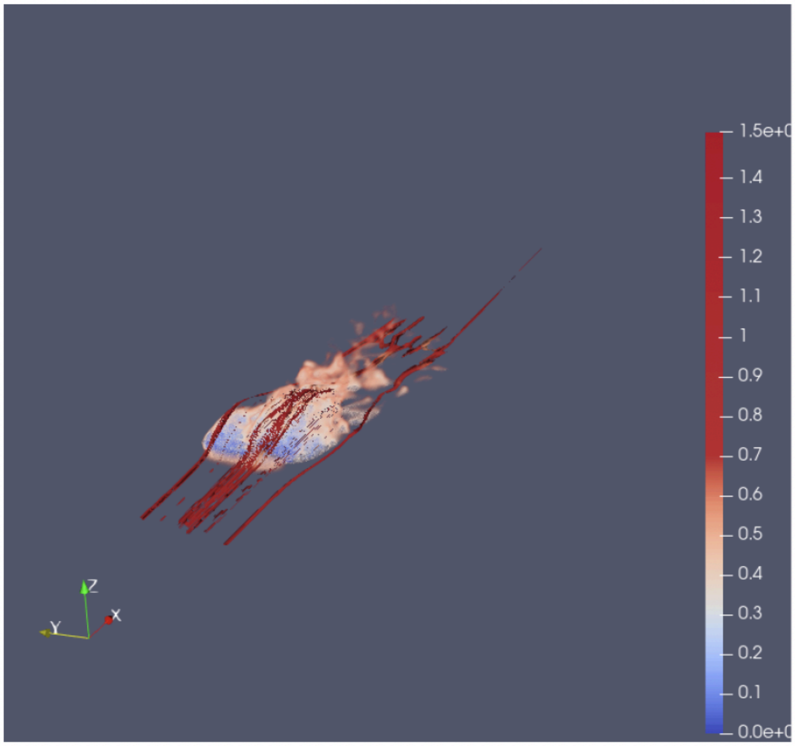


Figure 8: Applying stream tracer and Ribbon filters with seed type Line

5. Create visualizations similar to image in question 4 for two more seed configurations of your choice. My answer:

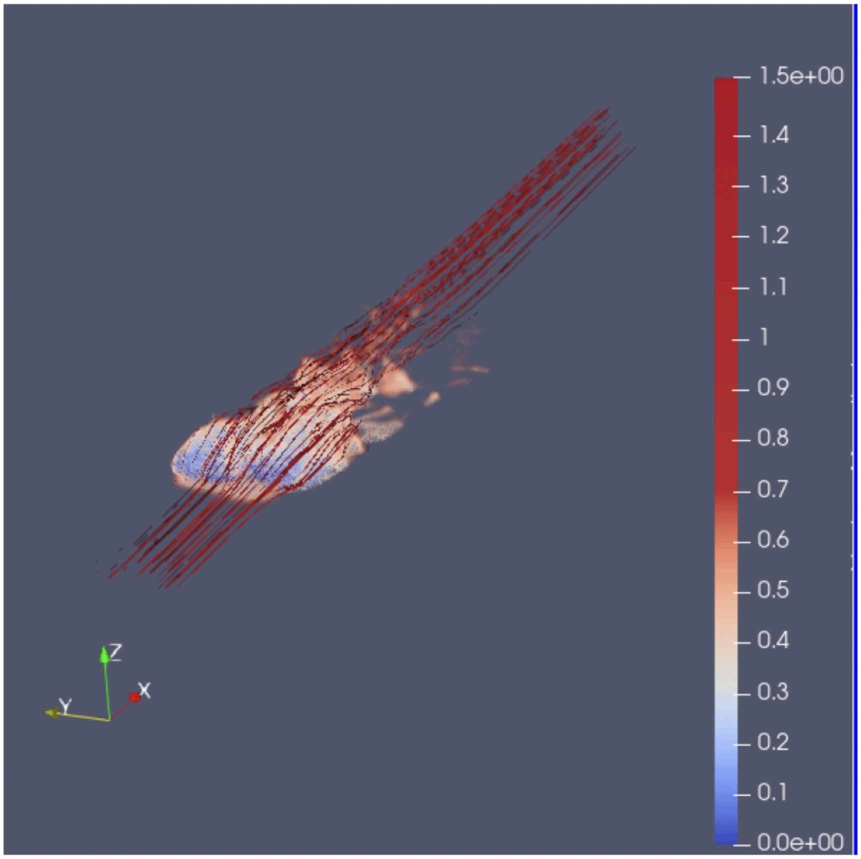


Figure 9: Applying seed type point cloud

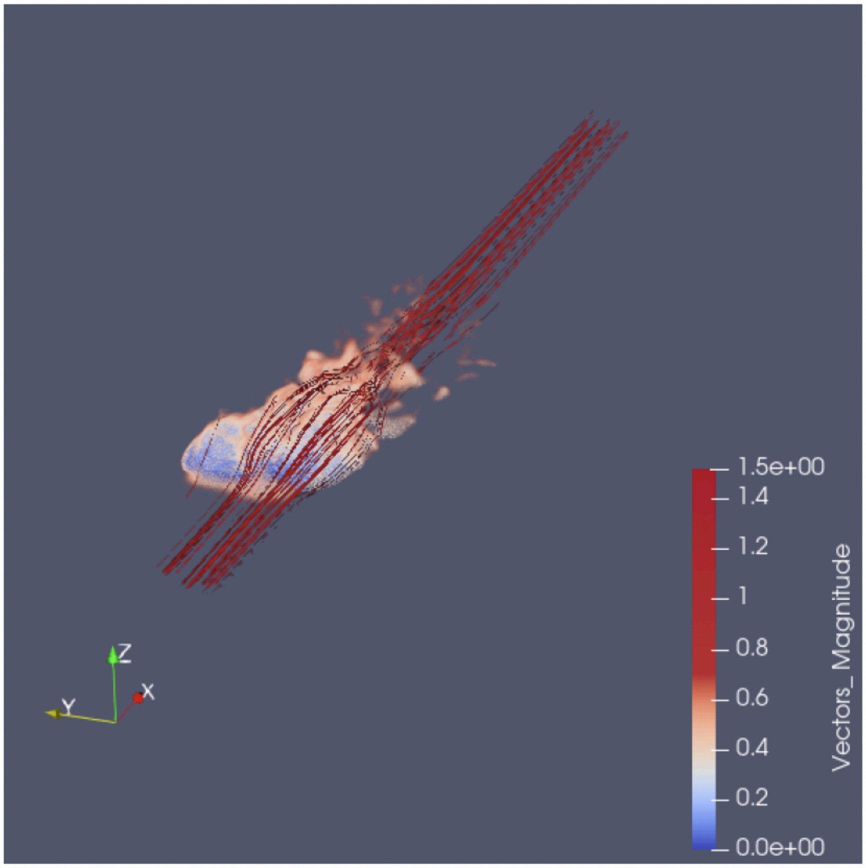


Figure 10: After applying seed type of point cloud with a radius value five.

With the change of seed type to point could, the streamlines are more prominent, visible and distinguishable.

Part 4:

1. Use random sampling to generate 15 seed points within the range [0,19] in both dimensions. Also, manually set the random seed to an arbitrary number. This will give you consistent seed points, which will be helpful for comparison. Show an image of your plot.

Answer:

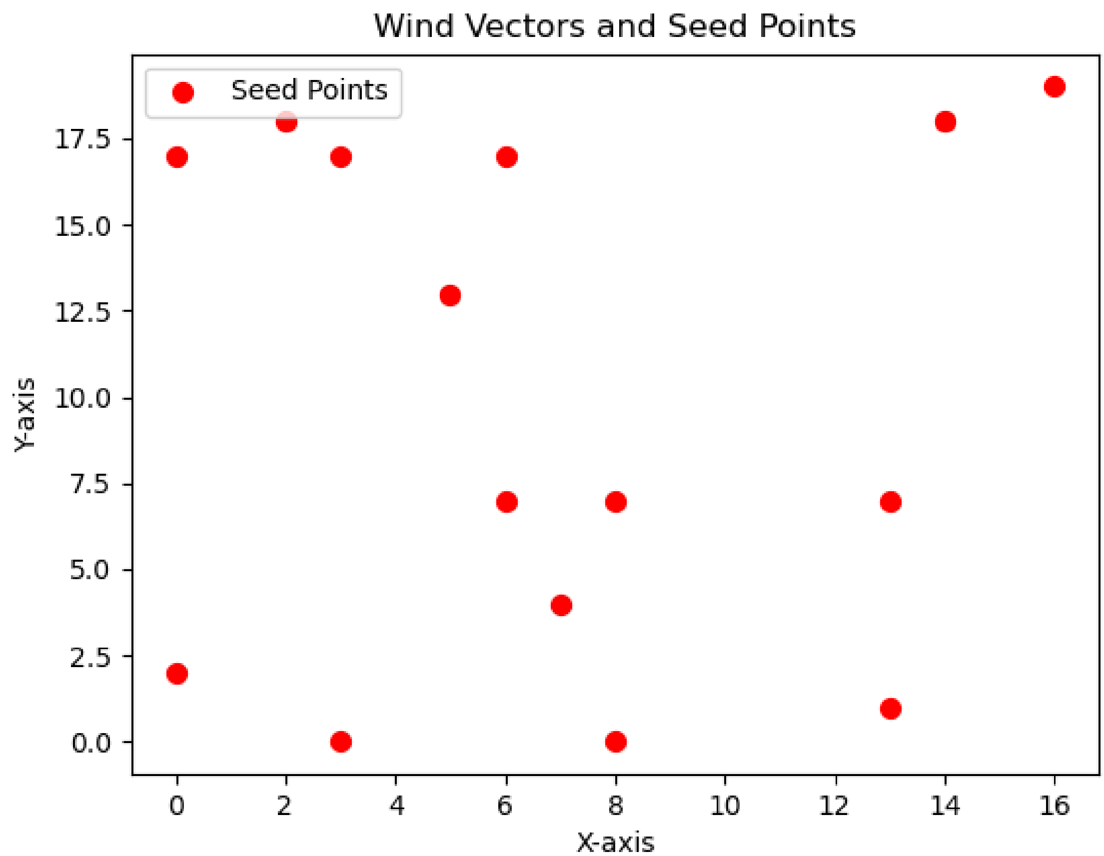


Figure 11: Visualization of seed points

2. Trace a streamline from each point. Use a time step value of 0.3 and perform 8 steps for each streamline. You will need to write a function that will calculate the bilinear interpolation(wikipedia.org/wiki/Bilinear_interpolation) of the four neighboring vectors. Bound your points to the data range [0,20] along both dimensions. You can stop tracing early if you reach the image boundary. Show an image of your plot.

Answer:

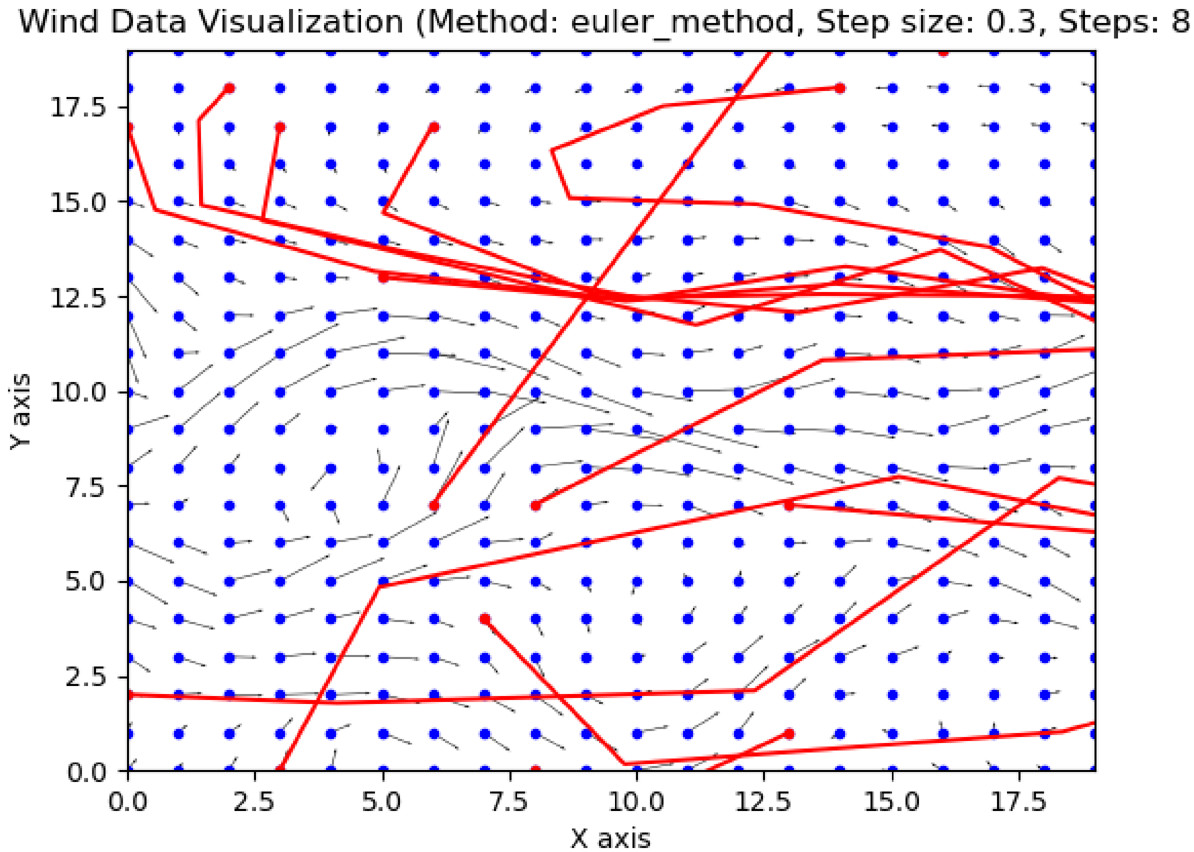


Figure 12: Wind data visualization using Euler method (step size: 0.3, steps: 8)

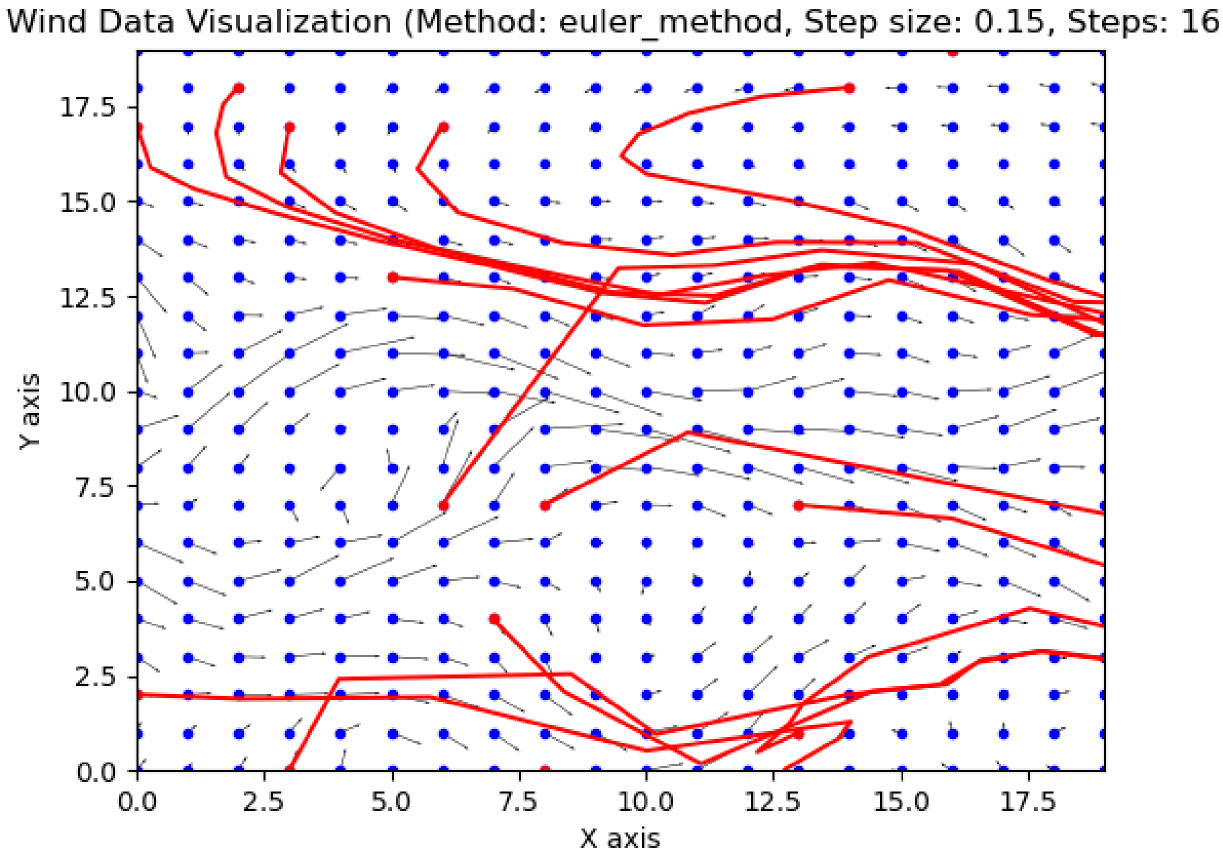


Figure 13: Wind data visualization using Euler method (step size: 0.15, steps: 16)

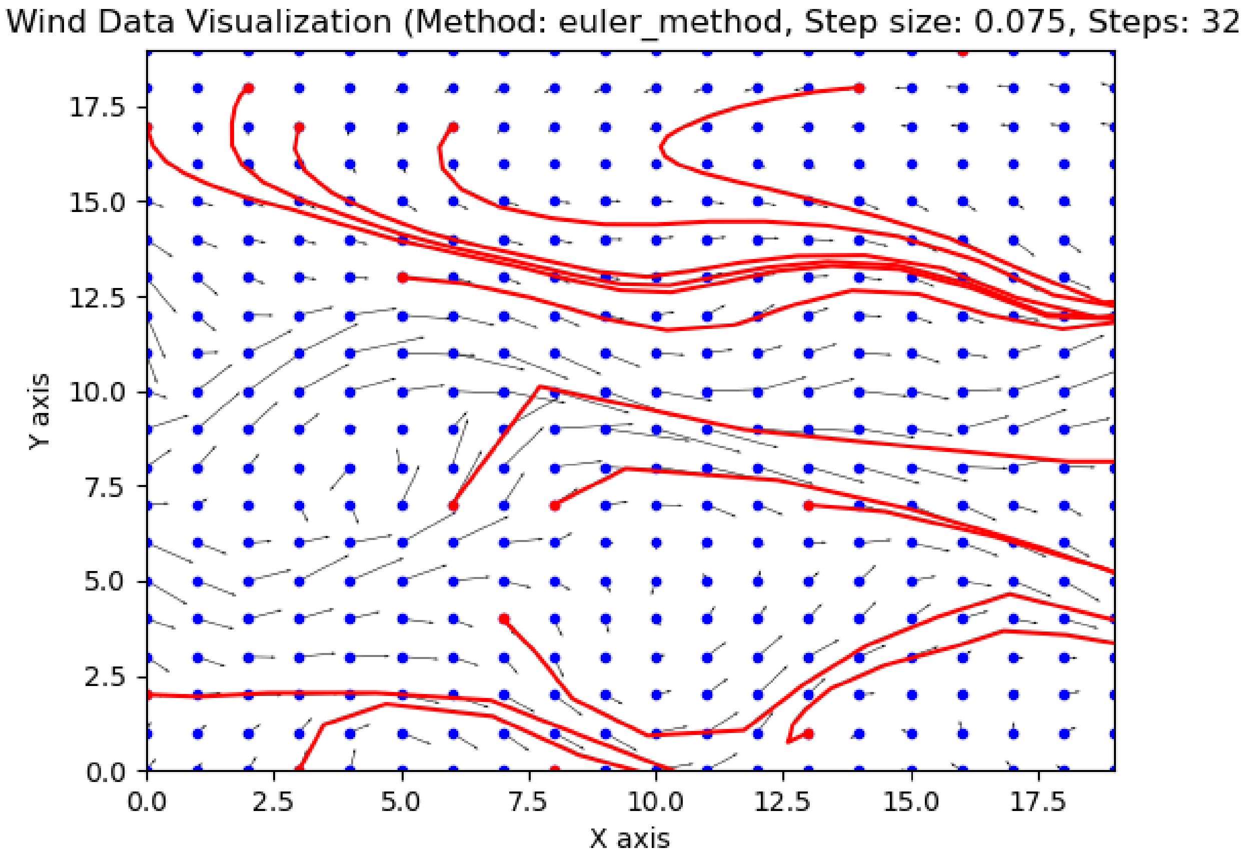


Figure 14: Wind data visualization using Euler method (step size: 0.075, steps: 32)

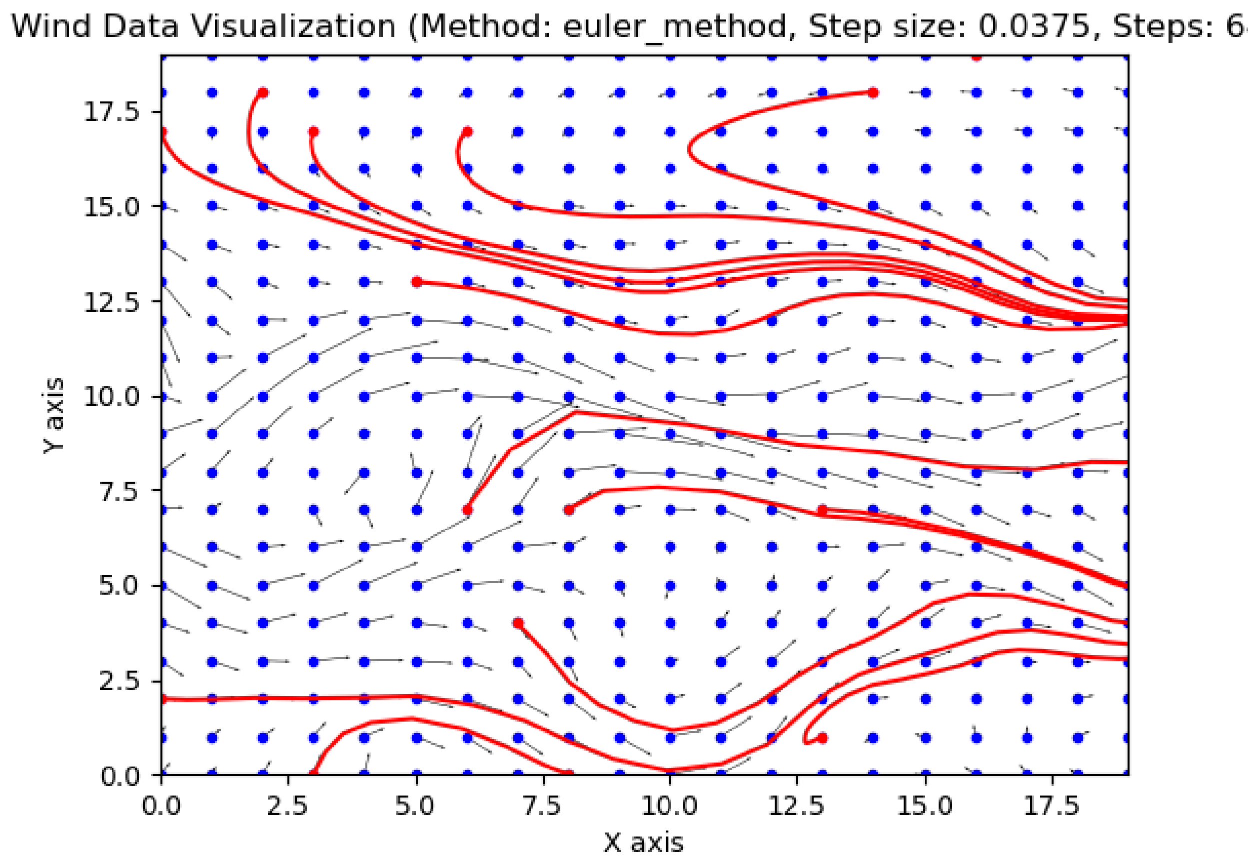


Figure 15: Wind data visualization using Euler method (step size: 0.0375, steps: 64)

4. Describe the differences you see between the figures. Explain what divergence is. How does this relates to your results?

Answer:
The difference in the figures is when the step size and the steps increase then the plotting gives more accurate wind data visualization than the smaller step size and steps visualization. Divergence means lines going in different directions. Here we want to see a visualization where wind streamlines diverge. So, From the figure, we can say that FIgure-16 gives better visualization than other previous figures as for step size 0.0375 and 64 steps, the streamlines converge into better visualization where wind flow diverges and where streamline doesn't intersect with each other.

Part 5:

1. What are steady and unsteady state flows? What are pathlines and streamlines?

Answer:
Steady and unsteady state flows, pathlines, and streamlines represent and examine fluid flow behavior. Researchers and engineers can better comprehend the underlying physics and spot patterns, and make predictions about fluid motion by visualizing these flows.
Steady and unsteady state flows:

1. Steady State Flows: If the fluid's characteristics at any particular point remain consistent over time, the flow is said to be steady. When visualizing steady-state flow, the focus is on portraying the steady flow patterns throughout the research. Methods commonly include streamlines, streaklines, and vector plots to display the direction and strength of the flow.
2. Unsteady State Flows: If the fluid characteristics at any one point in a flow alter over time, the flow is said to be unsteady. The dynamic nature of the flow and its alterations over time is captured when visualizing unsteady flows. Time-dependent streamlines, pathlines, streaklines, and animations that display the development of the flow field are common methods for displaying unstable flows.

Pathlines and streamlines:

1. Pathlines: Pathlines indicate the course that individual fluid particles follow over time. They help visualize fluid particle mobility and history in the flow field. Since fluid motion might fluctuate over time in unsteady state flows, pathline visualization is especially helpful.
2. Streamlines: Understanding the flow patterns in a fluid is made possible by visualizing streamlines. Streamlines are curves perpendicular to the fluid's velocity vector at any given position and show the flow direction. Pathlines and streamlines can differ for unsteady flows, but they are the same for steady flows.

2. Briefly describe any three classifications of vector-field visualization techniques.
Answer:
Three classifications of vector field visualization techniques are arrow plot, line integral convolution, and streamlines.

1. Arrow Plot: A well-known example of direct flow visualization based on glyphs is the conventional method of arrow plots where tiny arrows are drawn at specific grid places to indicate the flow direction and act as local velocity field probes.
2. Line Integral Convolution: To take advantage of spatial correlation in the flow direction, line integral convolution convolves white noise using a low-pass filter along pixel-centered symmetrically bi-directional streamlines. Like the pattern formed by wind-blown sand, LIC creates an image that offers a dense global representation of the flow.
3. Streamlines: A class of curves known as streamlines includes curves whose tangent vectors constitute the flow's velocity vector field. They display the path a massless fluid element will take at any given time.

Conclusion:
Learned streamlines and differences between different seed types. Also learned the Euler method and its importance in visualization. Other figure comparisons are described above.