HS20 Data Visualization and Analysis

Exercise Session 4
Vector Field Visualization in Python

Outline

- Vector Field Features
- Exercise 4 Instruction
- Demo

Vector Field Features

Vector Field Features

Divergence

- Think of vector field as encoding a fluid flow
- Is a local measure of its "outgoingness", at a point in D
- Given a field $\mathbf{v} : \mathbf{R}^3 \to \mathbf{R}^3$, $\operatorname{div} \mathbf{v} : \mathbf{R}^3 \to \mathbf{R}$ is

$$\operatorname{div} \mathbf{v} = \frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y} + \frac{\partial v_z}{\partial z}$$

- For 2D case, the divergence degenerates to:

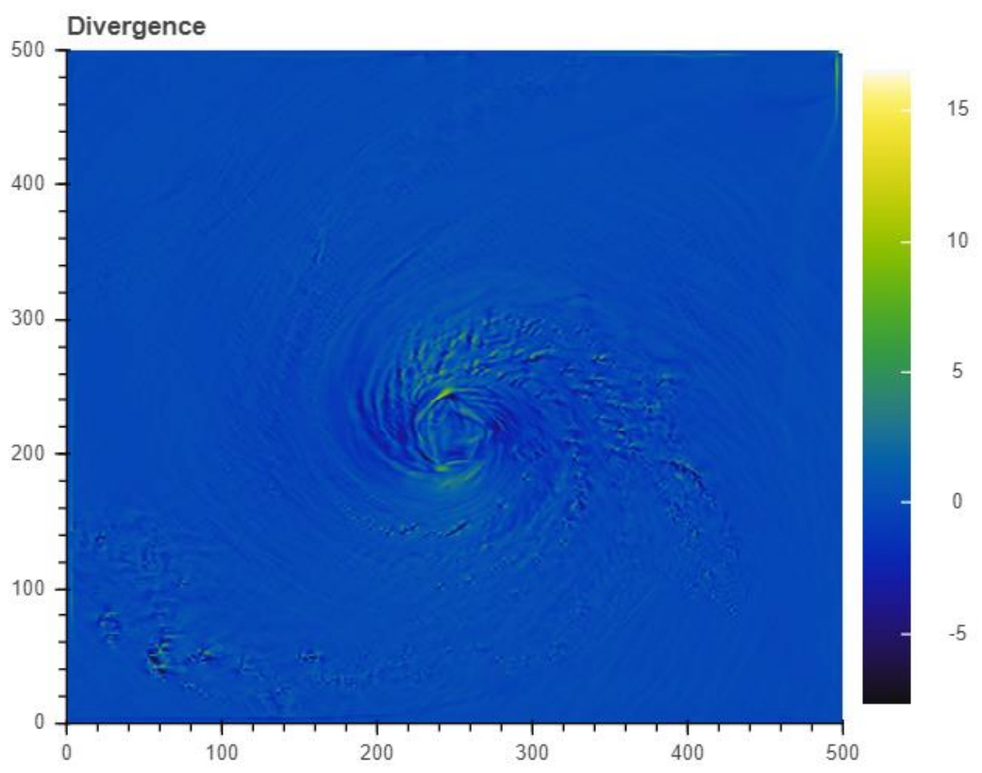
$$\operatorname{div} \mathbf{v} = \frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y}$$

Vector Field Features
Divergence

- Compute using numpy.gradient() function. Calculates the gradient of a vector field w.r.t. all directions. Carefully choose which part of the result you actually need for the divergence calculation.

- Visualize the divergence using bokeh image() function

Height=20



Vector Field Features
Vorticity

- Consider again a vector field as encoding a fluid flow
- Measures how quickly the flow ‘rotates’ around each point
- Given a field $\mathbf{v} : \mathbf{R}^3 \rightarrow \mathbf{R}^3$

$$\text{rot } \mathbf{v} = \left(\frac{\partial v_z}{\partial y} - \frac{\partial v_y}{\partial z}, \frac{\partial v_x}{\partial z} - \frac{\partial v_z}{\partial x}, \frac{\partial v_y}{\partial x} - \frac{\partial v_x}{\partial y} \right)$$

- For 2D cases, the derivations of the z-component and the derivation of the x- and y-component w.r.t. the z-direction become 0. Therefore, the magnitude of the vorticity can be computed using the following equation:

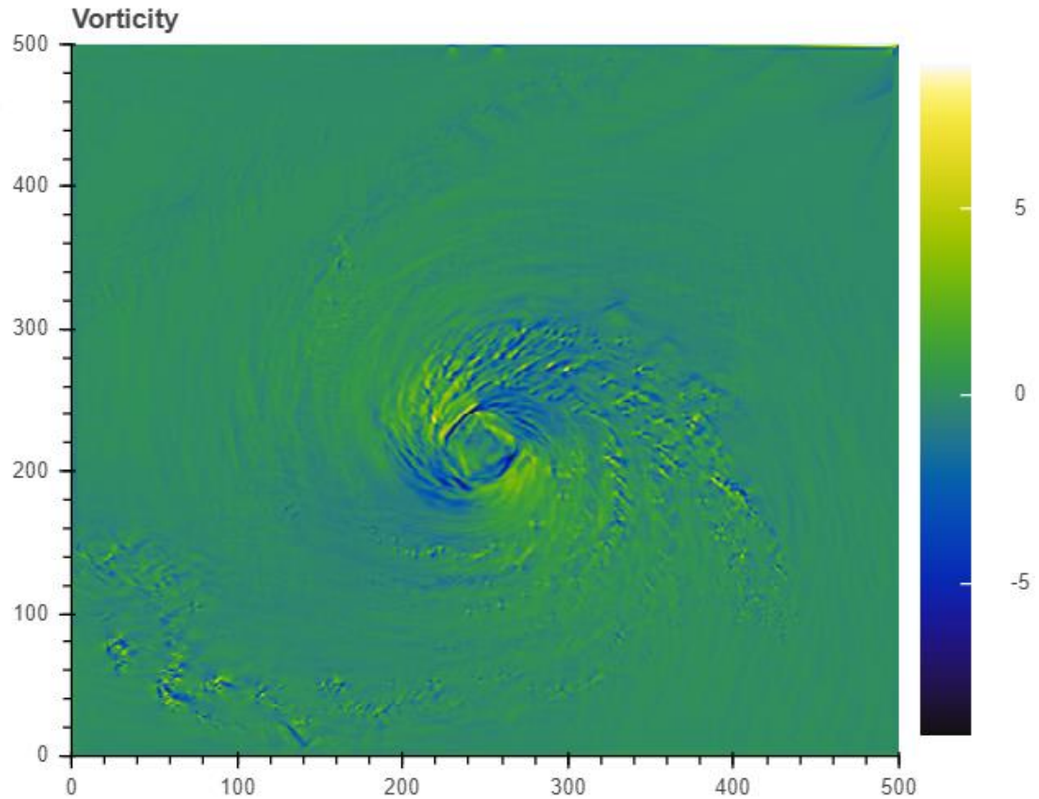
$$\text{rot } \mathbf{v} = \frac{\partial v_y}{\partial x} - \frac{\partial v_x}{\partial y}$$

Vector Field Features

Vorticity

- Compute using definition with partial derivatives. Find out how you can use the numpy.gradient() results to achieve this.
- Visualize angular velocity using bokeh image() function

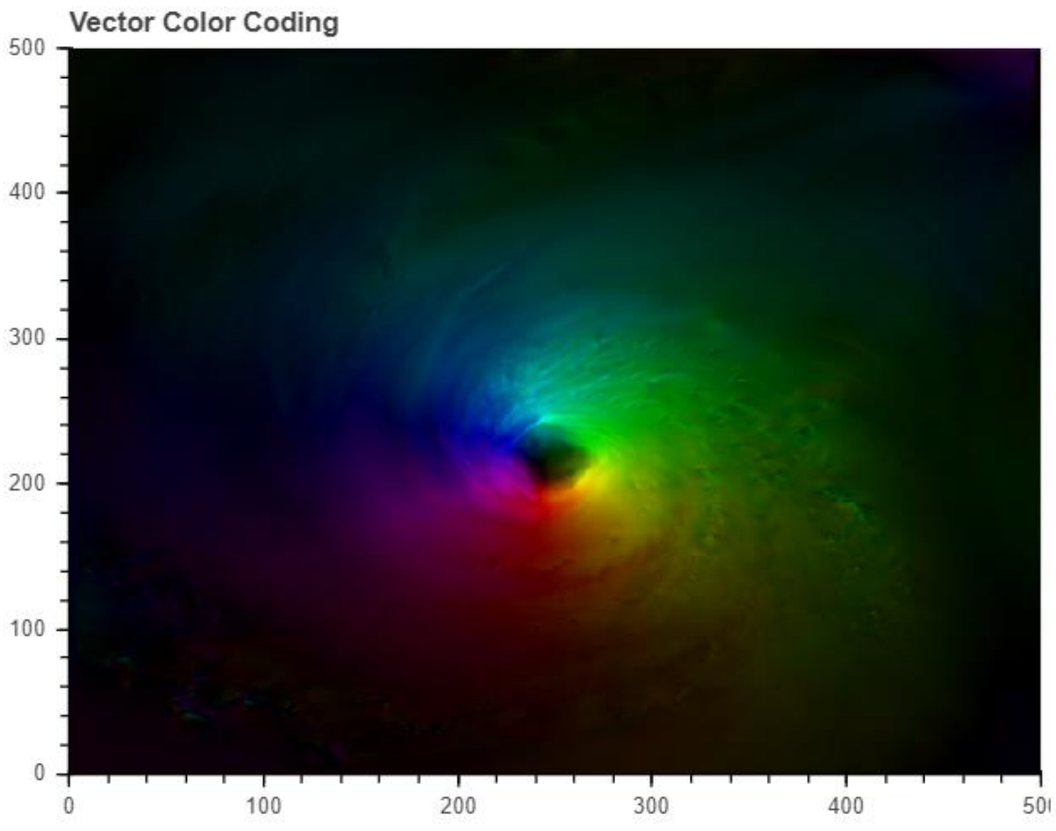
Height=20

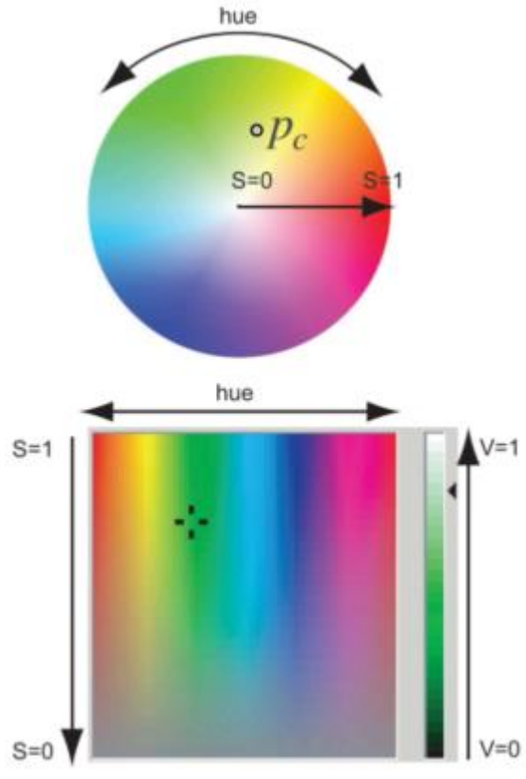


Vector Field Features

Vector Color Coding

- Associates the orientation and magnitude of a vector with a color.
- Find angle between x-axis and a given vector. Perform an HSV to RGB color conversion. Formula: https://www.rapidtables.com/convert/color/hsv-to-rgb.html





Exercise 4 Instructions

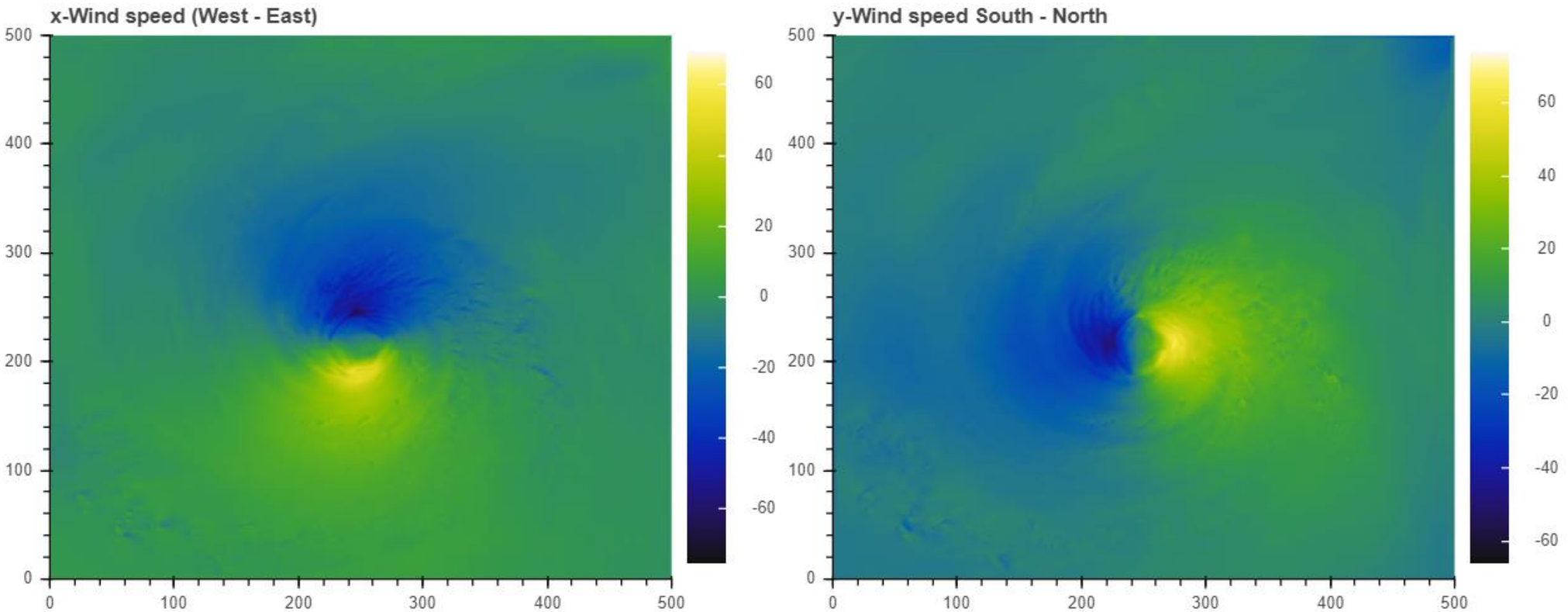
Exercise 4 Instructions
Hurricane Dataset

- Dataset was used in IEEE Visualization 2004 contest
  - http://vis.computer.org/vis2004contest/data.html
- Summary of the data information
  - Hurricane Isabel (2003)
  - **13** Variables, **48** timesteps, data size **500 x 500 x 100**
  - Each height point is 0.2km, max 19.8km
  - Format: Brick-of-Floats

Exercise 4 Instructions

Hurricane Dataset

- Visualization of X, Y wind speed at time step 24
  - shows the wind speed as images at a certain height (at index 20)
  - Positive x-direction is West to East and positiv y-direction is South to North



Exercise 4 Instructions

Tasks

- Three tasks
  - **Task 1:** Calculate the divergence of the wind vector field and visualize it in a plot.
  - **Task 2:** Calculate the vorticity of the wind vector field and visualize it in a plot. Use the signed value of the magnitude
    for the visualization, since this allows the expression of the rotation direction.
  - **Task 3:** Calculate the Vector Color Coding of the wind vector field.

Exercise 4 Instructions
Do It Yourself

- Use **forum** to ask and/or answer questions
- Make ‘**google**’ your best friend
- Make sure to produce desired results with **Bug-Free** code
- Add necessary notes in the “readme.txt” file