DATATHON II : INDIAN OCEAN

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***Abstract*—Data visualizations for various ocean specific variables namely, sea salinity, sea temperature, and zonal and meridional currents.**
Through these visualizations we keep forward few changes observed in the above mentioned variables over the time frame of December 2003 to December 2005.

I. Introduction

The Indian Ocean is the third-largest of the world's oceanic divisions, covering 70,560,000 km2 (27,240,000 sq mi) or 19.8% of the water on Earth's surface.[5] It is bounded by Asia to the north, Africa to the west and Australia to the east. To the south it is bounded by the Southern Ocean or Antarctica, depending on the definition in use.[6] Along its core, the Indian Ocean has some large marginal or regional seas such as the Arabian Sea, the Laccadive Sea, the Somali Sea, Bay of Bengal, and the Andaman Sea.
At times the ocean shows very different unexpected results and events. At times it results in loss of a life and property like in the 2004 Indian Ocean Tsunami or the frequent cyclones along the coast of India.
Through visualizations we try to see if we can predict any of such events or if we can see the impact these events left behind.

II. Problem Statement

Given the two scalar field variables (salinity and temperature) generate visualizations using contour mapping, color mapping and elevation mapping.

For the given vector variables (zonal and meridional currents) generate visualizations for using quiver plots.

III. Data

The data has been computed of Indian Ocean from the ocean model MOM, run by the Indian Ocean National Center for Ocean Information Services, INCOIS, Hyderabad.

The data consists of 4 variables:

- Sea Temperature
- Sea Salinity
- Zonal currents
- Meridional currents

The data is a five-day moving average of values, starting from December, 2003 to December, 2005, with a total of 147 timestamps. For each time stamp the data consists of 3 dimentions, namely the latitude, longitude and depth from the sea surface.
The scalar values have longitude values ranging from [29.8892W, 119.8237W] and latitude values ranging from [29.7511S, 29.7511N].
For vector variables (zonal and meriodionial currents) the longitudes range in [30W,120W] and latitudes ranges in [30.0005S, 30.0005N].
For all variables the third dimension, depth from sea surface, ranges in [-5m, -225m] at intervals of 10m.

IV. Methodology

The scalar variables consists of 188 latitudes [29.7511S, 29.7511N] and 180 longitudes [29.8892W, 119.8237W] and 23 different depth values [-5m, -225m] contributing to 782,460 data points for each scalar variable.
For vector variables, the data consisted of 189 latitudes [30.0005S, 30.0005N] and 181 longitudes[30W, 120W] and 23 different depth values [-5m, -225m] contributing the 786,807 data points each for zonal currents and meriodionial currents.
For the purpose of visualization the data was normalized with the local maxima and local minima of each corresponding variable. The preference for local maxima and minima over global maxima and minima was the aim visualization was to be conducted for the trend in the Indian ocean and not to be compared with other oceans and water boadies.

For the assignment we have reduced the dataset to 85m depth from the sea surface, to adjust with the lower computational power of the system.

V. Visualizations

SCALAR VARIABLES: For scalar variables we plot isosurfaces as it provides the observer with continuous values varying in space. The visulisations were chosen to be translucent to observe the whole volume of data and not just the surface.
For better understanding of the data at each depth we plot slices of the space at each depth. [1-4]

A. Sea Salinity

Fig 1. and Fig 2.below gives us one the visualizations of sea salinity (date: 29th Decemeber 2004). The actual range of values are [18.6981,40.5171].

Fig.1 is an isosurface visualization where as Fig. 2 is a slice of the whole data at the depth of 5 meters from the sea surface.
The salinity is observed to be comparatively higher in the Arabian Sea compared to the other parts of the data. A large part of Bay of Bengal and the whole sea itself shows to have low salinity. The reason behind the the observation could be rivers of the Indian sub-continent as majority of them fall into Bay of Bengal.

As we move long the axis representing, we observe that the salinity of the sea minutely varies. So it can be said that the salinity of sea varies only with it's latitudes and longitudes.

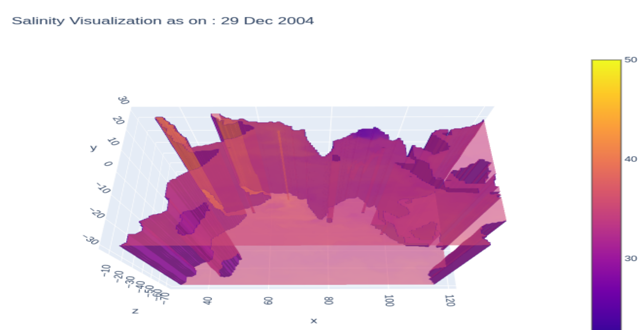

Fig. 1: Sea Surface Isosurface Visualization (29th Decemeber 2004)

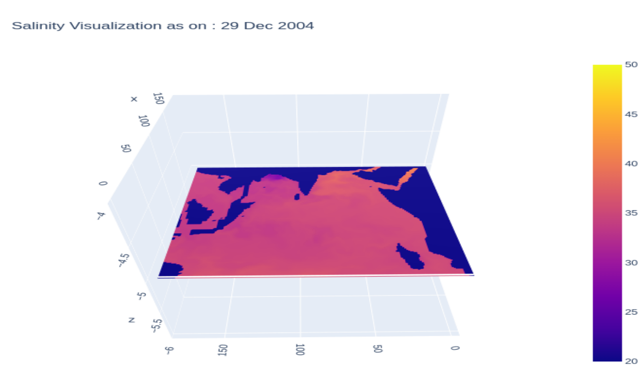

Fig. 2: Sea Surface Slice Visualization (5m depth) (29th Decemeber 2004)

Moving along the temporal axis we observe that the salinity increases for the given two year time frame.

B. Sea Temperature

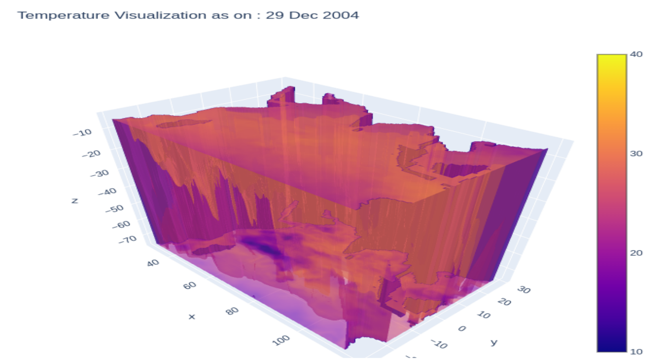

Fig. 3: Sea Temperature Isosurface Visualization (13th May, 2004)

Fig 3. and Fig 4. are a visualization of the temperature of the surface of the sea. The range of values varies between [15.1564,35.1531].

Fig 3. represents the isosurface visualization of the data in space where as Fig 4. represents a slice of volume at a depth of 5 meters from the sea surface.

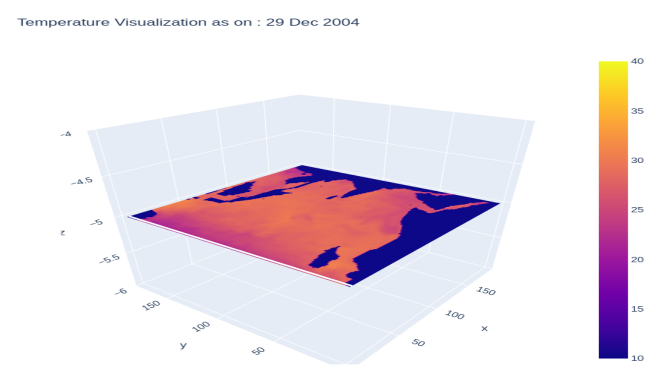

Fig. 4: Sea Temperature Slice Visualization (5m depth) (13th May, 2004)

Moving along the depth axis we observe that the isosurfaces become narrower and temperature decreases. This is also expected from other scientific results.[5]

The trend viewed for the two year time frame was close to expectation. The value along the equator remained close to constant as it receives direct sun rays throughout the year.
During the period of February to July the temperature in the northern hemisphere starts to increase, which is expected as the northern hemisphere experiences summer during this period. The contrast is observed for the southern hemisphere which shows temperature drop during the this period as. Fig 2. helps in the the above observation.

Fig 3. shows the data for the time stamp of December 29th 2004, where the northern hemisphere observes the winter season, and we observe that the temperature has dropped as compared to the previous time stamp (Fig 2.). As expected the southern hemisphere shows a slight increase in temperature during its summer season.

The values observed at a particular period of the year in 2004 were observed to repeat for the year 2005 as well.

VECTOR VARIABLES: For vector variables we visualize them using cones as slice them according to the depth. The data along the depth axis was not available in the dataset so the corresponding component was replaced with zero vector.

C. Zonal and Meridional Currents

Fig 5. is a conical quiver visualization for the given time frame. The general trend of the currents observed was that the currents are seen to originate the west coast of the southern eastern Asian countries and move towards west along which they gain a lot of velocity in the middle and hit the eastern coast of Africa. After hitting the eastern coast of Africa the currents lose velocity and constantly change direction in a clockwise pattern.

As we move on the depth axis, initially we observe that directions of the currents remain close to same and very minute change in the magnitude. The change in magnitude is close to negligible as we move more deeper down the depth axis.

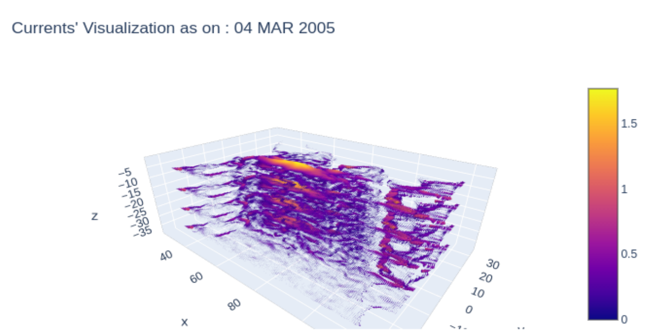

Fig. 5: Zonal and Meridional Currents (9th December, 2004)

Fig 5. depicts the data as in 4th March 2005 where we observe a spike in the current's velocity along the eastern coast of India. This observation is important because the coast is prone to frequent cyclones. The similar trend is observed the previous year as well during the same time of the year.

We observe a similar spike in current velocity along the current southern eastern coast, yet another area prone to cyclones. The event is recorded on 9th Decemeber 2004 and visualized in Fig 6. The similar spike is again observed the subsequent year at the same time of the year.

VI. Implementation

The implementation of the whole task was done using python as the programming language.
The data was present in the form of text file and the was converted to numpy arrays to be used for visualizations. For reading the file and converting the data to usable form the libraries used were: os, numpy.

For the purpose of creating the visualizations the numpy arrays were feeded to matplotlib APIs. For getting the background of the map basemap library of matplotlib was used. For scalar variables a contour fill plot was plotted, whereas for vector variables a quiver plot was plotted. Libraries used for visualization were: matplotlib, basemap, animations, plotly.

VII. Other Inferences

Other than mentioned events there a few of the observations were tried to be observed or predicted.

A. 2004 Tsunami

The data for the particular date, 26th December 2004 was not available and no unexpected or abnormal behaviour in the data of the variables was observed before or after the event.

B. 2005 Mumbai Floods

The heavy rainfall that left not so good memory for Mumbai occurred on 26th July 2005. The exact data for the same date was not included and no unexpected currents pattern was observed.

VIII. Submission

Google Drive Link : here

IX. References

[1] Plotly — Graphics Library — 3D Isosurfaces — Last accessed : September 21, 2020— 3d-isosurface-plots

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[7] [6] Plotly — Graphics Library — Vector Represntation — Last accessed : September 21, 2020— vector-field-visualization