Visualization of Cyclone and Aurora based on NOAA data

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ABSTRACT

The project is designed to visualize some geospatial data under the framework of cartopy. Cartopy is a python package designed for producing maps and other geospatial data analyses. Data used in this project are from the National Oceanic and Atmospheric Administration (NOAA). The main result is for two different applications, one that for visualizing the path for a given cyclone or all the paths on the Atlantic ocean for a given year. Sample output figures are attached to this report.

Index Terms: Geospatial data processing; Meteorological data visualization

1 INTRODUCTION

Geospatial data often refers to the objects or phenomena with a specific location in space. In such cases, it will have a spatial address and it will be possible to visualize them in specified format, which are often called maps [4].

2 DATA FORMAT

All data is from the National Oceanic and Atmospheric Administration (NOAA). A real time web crawler is deployed to fetch the real time data for it. It is important especially for the aurora application since the real time estimation changes rapidly. In this section, I will introduce the data source and its format.

2.1 Aurora Forecast

NOAA uses the so called OVATION model to predict the aurora. It is a empirical model that uses the solar wind velocity and interplanetary magnetic field measured from multiply locations to estimate the probability of aurora occurs. It is derived by assuming a linear relationship to the intensity of the aurora. [1] [3]

It is a short-term forecast and NOAA update the prediction very frequently. On its official website, it offers the current forecast of probabilities all over the world in a JSON file. In the JSON file, it include features as the observed time, the forecast time, and also the coordinates. The coordinates is a 2-dimensional array, with each row in it is a pair of longitude and latitude in integer values and the associated probability of aurora. There are total 65160 data points as 360 longitudes multiply by 181 latitudes.

2.2 Tropical Cyclones

NOAA keeps a dataset known as Atlantic HURDAT2, it is the imporved version of the original HURDAT database. It has a comma-delimited, text format with six-hourly information on the location, maximum winds, central pressure, and (beginning in 2004) size of all known tropical cyclones and subtropical cyclones. The current version contains all the hurricane data from 1851 to 2020. NOAA is updating the database yearly to include the best track for the previous year.

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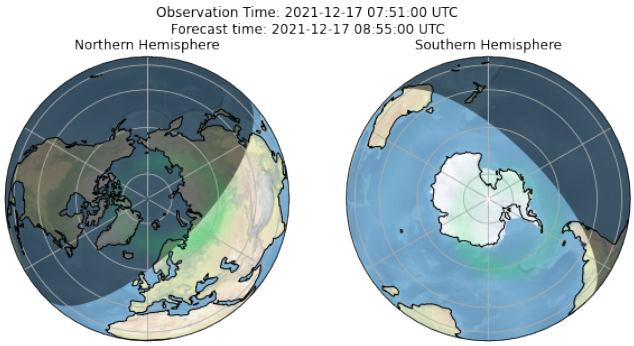

Figure 1: A visualization of the aurora estimation.

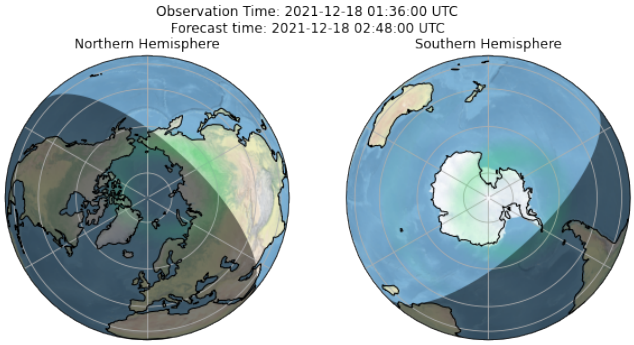

Figure 2: Another visualization of the aurora estimation.

3 TOOLS

The project is based on python. Multiple packages are included to achieve the final result. Packages like urllib is used to handle the web crawler, while the visualization is mainly based on matplotlib.pyplot and cartopy. Matplotlib is used to output the figures, while cartopy [2] is a python package originally developed by UK Met office to visualize data on maps. It includes a programmatic interface built on top of Matplotlib, which is easy to learn and can make the use of powerful PROJ, Numpy and Shapely libraries.

4 AURORA VISUALIZATION

The Aurora Visualization sample results can be seen in figure 1 2. The forecasted probability is a scalar field that covers all around the world. Since in the main land it is hard to see the aurora, the visualization only aim to project the whole dataset to the northern and southern hemisphere. More precisely, the north Antarctica area and the south Antarctica area. The colour map is adjusted to mimic the aurora. Night shading is added since it will benefit the user in choosing locations. The final results are generated so that more geospatial data analysis can be conducted.

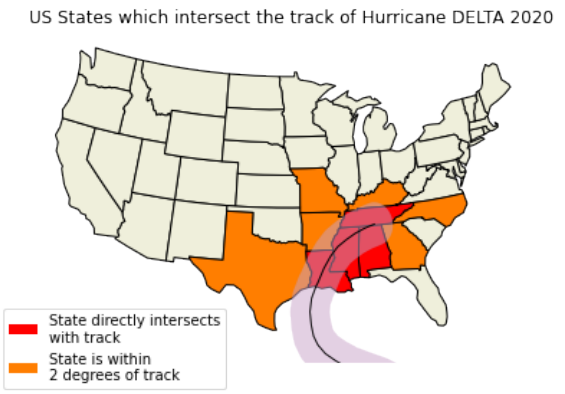

Figure 3: A visualization of cyclone DELTA in 2020.

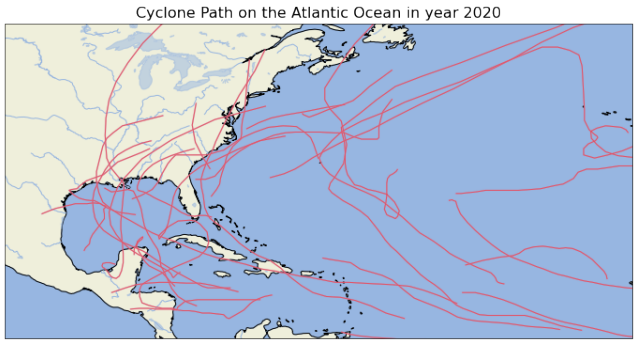

Figure 4: A visualization of all the cyclone path on the Atlantic ocean in 2020.

5 Cyclones Visualization

5.1 Path of specific cyclones

The specific cyclone path visualization sample results can be seen in figure 3. The center of the cyclone is marked as a black line. The pink region along with the line is the possible effected region. But one thing need to be noted is that this is a non-physical distance. Stronger cyclone may have much larger influencing areas. The directly intersected states are marked red on the graph, the states that are connected with the directly intersected states (possibly also influenced by the hurricane) are marked in orange.

5.2 Path of all cyclones in a year

The path of all cyclones in a year can be seen in figure 4. Since Atlantic hurricane database (HURDAT2) is mainly based on the Atlantic ocean area, the result is also projected to that area. The cyclone paths are in red, each line indicate the moving path of a different cyclone.

6 Future Improvement

There are places that the project can be further improved. In the path of all cyclones visualization, it may be possible to derive the relative strength of the cyclones using the data like maximum sustained wind or minimum pressure. With that data, it is possible to set the stronger cyclones with wider lines. Different glyth may also be tried to reach a better result.

7 Conclusions

In this project, I tried different method in geospatial visualization and finally selected the cartopy library to achieve the two different applications. A lot of methods are given a try including scalar field visualization and vector field visualization.

Acknowledgments

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References

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