SP 21 ME 5013 Big Data Analysis Final Project Report
Salinity Data Relation with Hurricanes
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Introduction

There are widely known relationships between temperature and wind speeds as they relate to hurricanes, however it was not until ocean researchers Karthik Balaguru and Greg Foltz suspected there might be a relationship between these two variables and sea surface salinity and could further be used to analyze their effect on strong storms such as hurricanes. There is sea surface salinity data available to the public that can be used to analyze patterns in changes of sea surface salinity levels and correlated to wind speeds and sea surface temperatures. It is known that the strength of a storm comes from the heat energy available at the surface of the sea, hence a strong correlation is expected between temperature and strength. However, Balaguru states that the higher the wind speed, the more important is the salinity factor; he even asserts that salinity levels cancel the previously accepted effect of temperature on wind speeds.

Experimental Methods

This project uses python packages and libraries to analyze sea surface salinity from the NASA Jet Propulsion Laboratory (JPL) Soil Moisture Active Passive (SMAP) satellite that was launched in 2015. The Level 3 CAP Sea Surface Salinity Standard Mapped Image 8-Day Running Mean V5.0 Validated Dataset was selected for analysis and it ranges from its ranges from May, 5th 2015 until the current time and is in netCDF format. The python packages used are the netCDF4 library to access the data in nc files, the Xarray package to initially extract the data and further convert it into a pandas data frame. Matplotlib was used for plotting. The data set contains global sea salinity data, identified by time, latitude and longitude coordinates. The data was sliced by both geographical coordinates and time so that only the data of the region and time period of interest was loaded at a time. The region selected was in the Atlantic Ocean close to Cuba and the Florida coast because two hurricanes took place in the same region. Hurricane Matthew became a tropical storm in the Atlantic Ocean in September 25, 2016 and made its way to Cuba and landed in Florida on October 8, 2016. Similarly, about a year later, Hurricane Irma became a storm on August 25, 2016 and landed in the Florida coast on September 25, 2016. The variables of interest and used for analysis are the SMAP sea surface salinity, the HYCOM sea surface salinity, sea surface temperature, the SMAP 10 m wind speed and finally, the wind speed using ancillary SSS. Data was extracted for these variables for the time frame with the duration of the storms, as well as for a time frame of a month prior to categorizing them as high strength storms. The data was first plotted to visualize the relationship between the variables at the beginning and ending of the storms. The raw data prior to a month was plotted as well as the averaged data for the region along the time dimension. This region daily average values were also used to retrieve the data correlations.

Results

The following plot allow us to visualize salinity, speed, and temperature at the time when a high strength storm such as Matthew was detected and the day it landed. It is visible that the salinity levels are high before, and as expected, they decrease with the abundance of rain that dilutes the salt. As expected as well, the wind speeds are low at the beginning as compared to the 60 km/hr winds the day that the hurricane landed. The sea surface temperature increased as well.

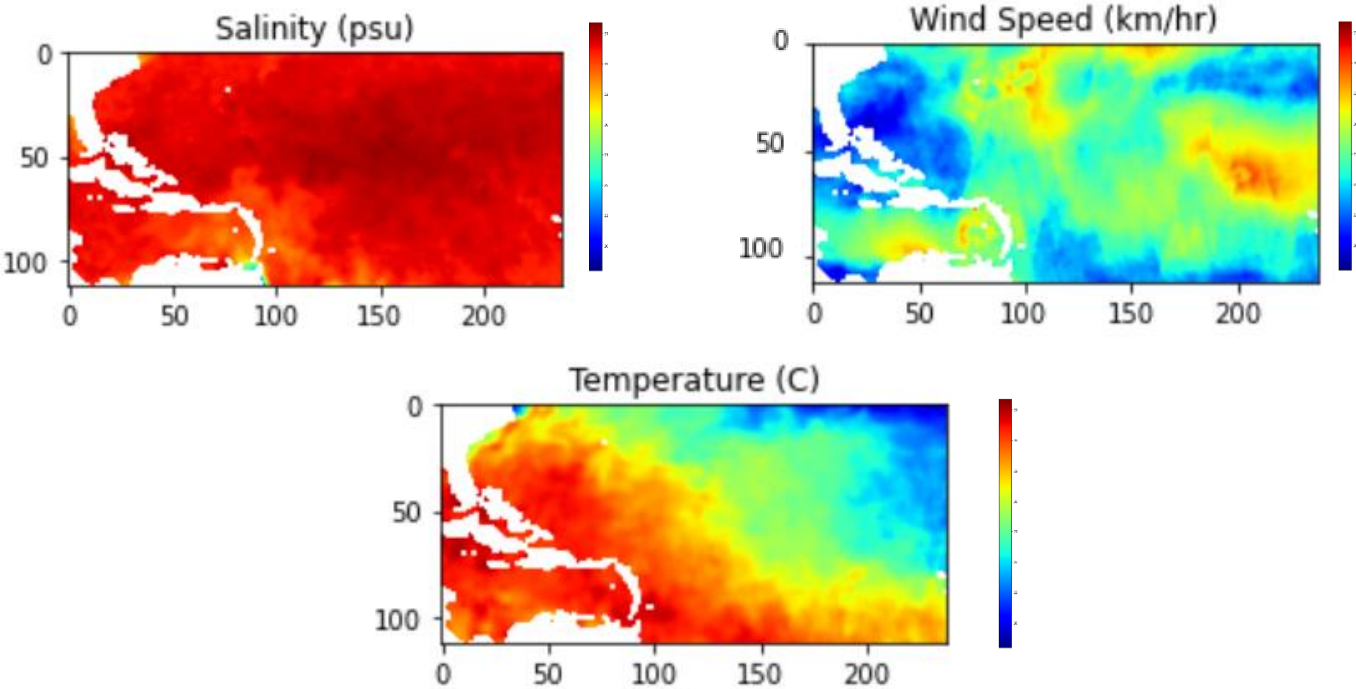


Fig.1 a) b) and c) Atlantic Ocean Area on September 25, 2016, when Hurricane Matthew was detected as a strong storm.

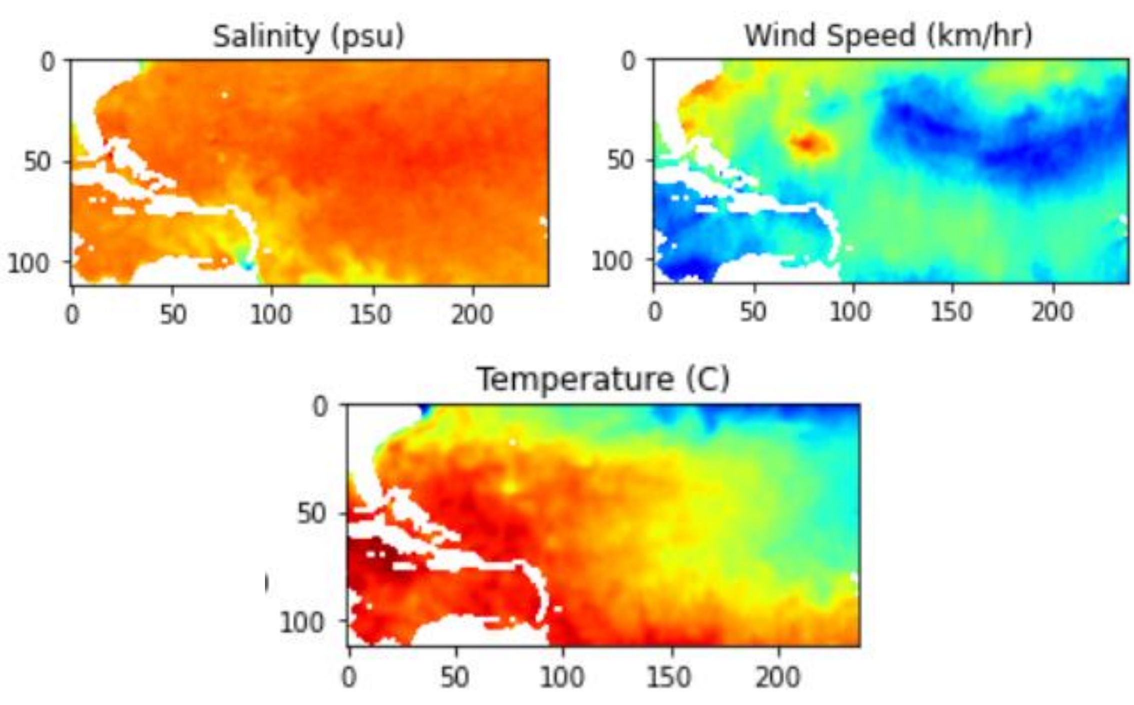
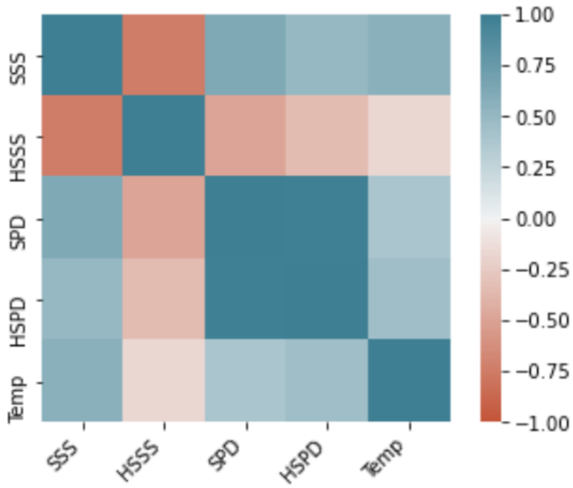


Fig. 2 d) e) and f) Atlantic Ocean Area on October 8, 2016, when Hurrican Matthew Landed.



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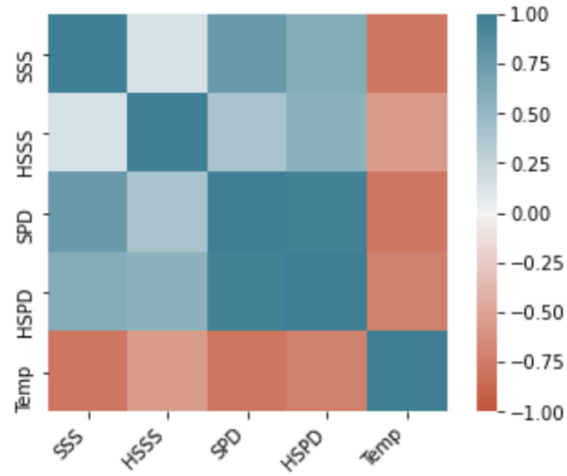
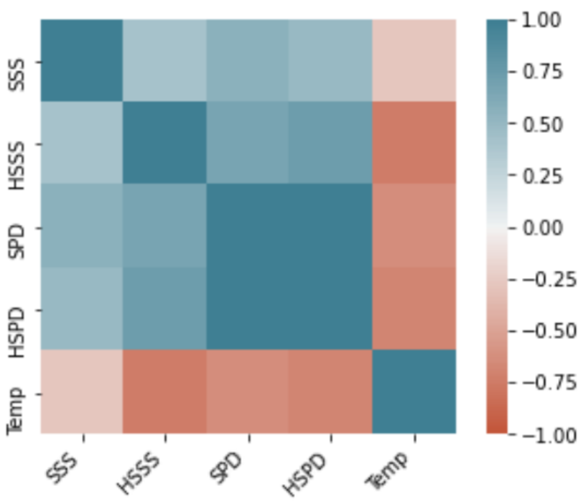


h)

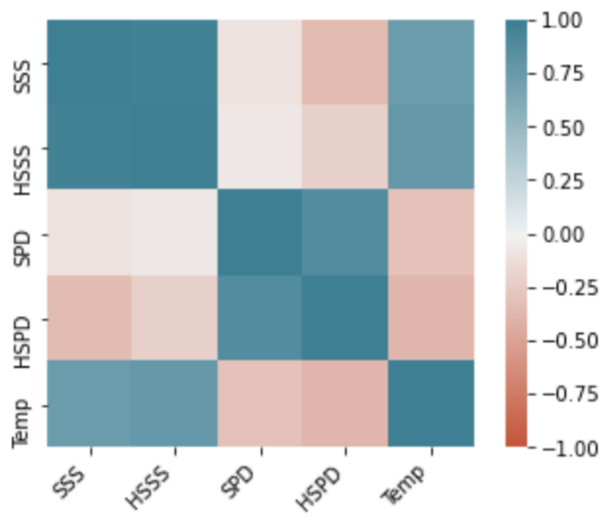
Fig 3. Heat Maps for Hurricane Matthew

g) Variable correlation for the duration of Hurricane Matthew.

h) Variable correlation for the month before Hurricane Matthew was detected.



i)



j)

Fig 3. Heat Maps for Hurricane Matthew

i)Variable correlation for the duration of Hurricane Irma.
j)Variable correlation for the month before Hurricane Irma was detected.

As far as the variables correlations, for the most part the correlations are weak. The highest values resulted to be positive or negative correlations of around 0.7 and are not very comparable from one hurricane to the other.

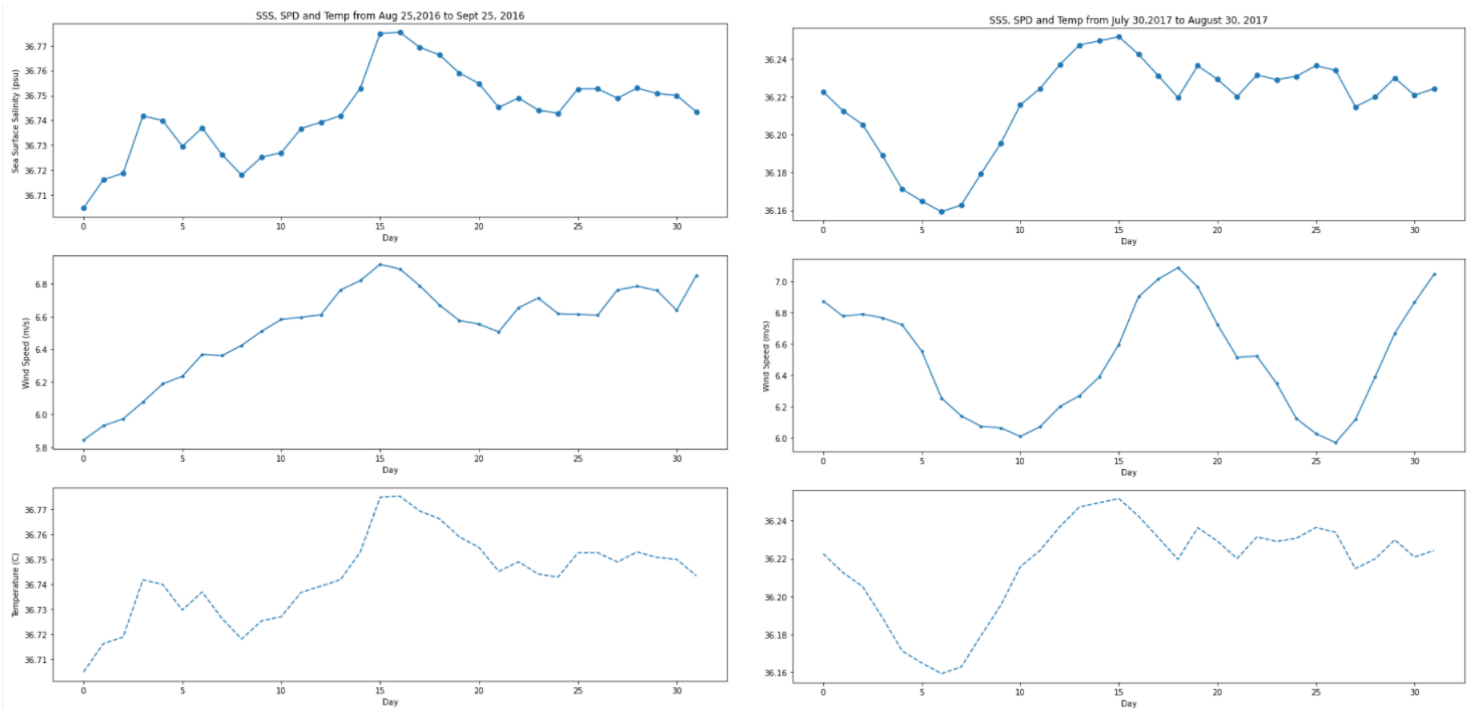


Fig. 4 Sea surface salinity data trends for the months before hurricanes.

For the trends of salinity of the moth leading to the hurricane for both years, again, it is found they are not comparable from one year to the other. For the individual hurricane, the trends for the three variables, salinity, temperature, and wind speed are very similar in shape. It can be concluded that temperature and salinity are positively correlated, while both being negatively correlated to salinity, however, this correlation changes leading up to the hurricane detection day.

Conclusion

From the results, it can be concluded that more analysis needs to be performed to be able to identify patterns that could indicate when a hurricane will form. For the cases presented in this project, some of the trends did not follow the expected behavior. This indicates that more factor that were not taken into account such as the uncertainty and the Gaussian weighing factors need to be considered when performing the analysis. However, the code that was developed can be further built upon and easily used to perform further analysis.