Machine Learning for Loop Current Detection

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Introduction

The Loop Current (LC) is a warm ocean current located in the Gulf of Mexico. It provides a robust heat source allowing tropical cyclones to rapidly intensify. A recent example of this phenomenon is Category 4 Hurricane Ida in 2021. Development of automated detection methods is valuable in predicting the LC's evolution over time. Also, the LC plays a vital role in meteorology, ecology, and oceanography.

Methods

A Python script was utilized to process geospatial oceanic data across 2018-2020. A common variable in the LC detection literature known as Sea Surface Height (SSH) was derived. The SSH parameter was generated using absolute dynamic topography (ADT), which is defined as the sea surface level above the geoid. Mean ADT was subtracted from the ADT field to create the SSH field.

After SSH was derived, the script identified the LC via the outlined literature methods. Specifically, a 17 cm threshold was utilized for SSH, allowing for some error. Specifically, the margin used was 9.35 cm. After this dataset was generated, the values were plotted onto an image.

Once the LC threshold image was obtained, image processing techniques were utilized to dilate the image. This results in a continuous LC, essential for proper contouring.

After the LC was made continuous, it was isolated from the noise in the dataset. Contour lines were drawn across all objects in the image. The LC contour was isolated by finding the longest contour in the image and removing the other contours from the dataset, thus eliminating the noise.

Finally, the perimeter of the LC was computed by running Python functions on the isolated and continuous LC contour. The resulting perimeter was stored in a list, and the process repeated for each daily timestep in the 2018-2020 dataset. During each timestep, the newly calculated perimeter was appended to the list in order to be saved for analysis of the LC perimeter.

Results

Figure 1: A continuous LC after dilation

Figure 2: LC detection after 17 cm threshold and contouring

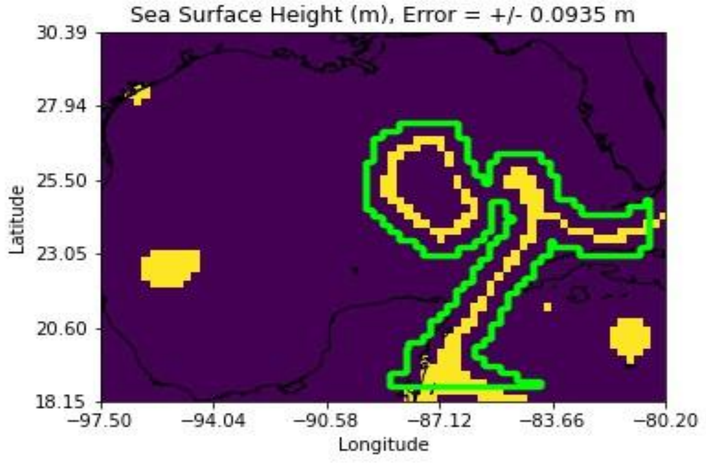

Figure 3: An instance of an unrepresentative contour

Discussion

Preliminary results indicate that the current contouring method is inconsistent and often leads to erroneous contours that do not represent the LC. Thus, current perimeter values are misleading.

Adjustments to the methodology are necessary to improve this method. This may be done by adjusting how SSH is derived, altering dilation levels, and changing margins of error for the LC threshold. After this, a statistical analysis of the LC's perimeter will be performed across historic data (2000-2020).

Conclusion

Automated LC detection can be performed by utilizing computer vision techniques through Python on outputs from satellite-derived datasets. Improvement of automated methods may help in assimilating high-resolution data from satellites into numerical models, improving their accuracy. This has a positive influence on hurricane forecasts, particularly for systems that cross over the LC. The current methodology shows some progress but is currently inconsistent. Once this method is improved, it will be used to train artificial neural networks on the automatic detection of the LC from multi-spectral satellite data.

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