Understanding Hurricane Intensity Using Sea Surface Height and Temperature Information

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Abstract

Warmer sea surface temperatures provide more energy for storm intensification, but the surface is only a piece of the ocean-hurricane relationship. Hurricanes extract more energy from deeper waters and sea surface altimetry data provides a way of estimating it. Using sea surface height anomaly data, can yield a better way of understanding the sea/air interactions present in hurricanes. We will compare SST and SSHA to observations of hurricane intensity of three storms in the 2005 season to gain better understanding of the impact of OHC to convective intensity within a hurricane.

Introduction

Hurricanes act as giant heat engines, taking energy from the ocean to intensify. One way to monitor the status of this energy is though monitoring sea surface temperatures. However, this only describes the top layer of the ocean and does not cover all the entire depth of ocean that affects hurricane intensity. Conventional understanding suggests SST above 80°F and a well mixed warm water layer at least 150ft deep are needed to support storm intensification. This warm water layer can be estimated using satellite observations of Sea Surface Height Anomaly (SSHA). SSHA is the physical elevation of the sea surface. It can be used as a general indicator of Ocean Heat Content because warm water expands to lift the elevation of the sea surface while cold dense water contracts to lower the elevation of the sea surface. To a lesser degree, the heights are also affected by net convergence or divergence in a column of water. With this understanding, higher height anomalies suggest that there is a greater depth of warm water in a region which can contribute to the intensification of a storm passing over this region. This research explores that relationship.

Methods of Analysis

This research contributes to a larger research effort conducted by MSFC Earth Science Office personnel who are examining intensity change characteristics of three tropical cyclones during a 2005 field experiment. The tropical cyclones are hurricanes Dennis, Emily and tropical storm Gert. Hurricane Dennis reached a pressure of 938hPa and maximum winds of 130kts, making it a category four. It caused $4 billion in damage and is responsible for 89 deaths. Dennis was the earliest category 4 since 1957. Emily reached a pressure 929hPa and maximum winds of 140kts. The storm caused 15 deaths and $550 million in damage and is the strongest hurricane to ever form in July. Tropical storm Gert was the weakest and only reached a pressure of 1005hPa with maximum winds of 40kts. Even so, it was responsible for 1 death and $6 million in damage. For completeness of the study, hurricanes Katrina, Wilma and Rita were also investigated.

In order to do this research, sea surface height anomaly data were taken from the Topex/Posiedon and Jason satellites. The payload of each satellite includes an altimeter device that uses an accurate global positioning device in combination with laser ranging to determine its position. Each satellite payload also includes a radar with two different frequencies to record sea surface height. The satellites have a swath illustrated in figure 1.

The sea surface temperature information was collected by the MODIS (Moderate Resolution Imaging Spectroradiometer) on the Terra and Aqua satellites. MODIS samples in the visible and infrared frequency ranges and collects information in a 2300km-wide swath beneath the satellite. The data are obscured by clouds which can reduce the information available for the sea surface temperature analysis. Three day composites can be used to mostly eliminate this problem but temporal resolution is lost by this method. The use of the daily data has been emphasized in this study (Fig.2).

Discussion of Results

Preliminary results show a number of things. The most obvious result is the intensity change for hurricanes. The storms generally exhibit noticeable intensification when moving over the high height anomalies. Analysis of satellite imagery suggests that SSHA can be a very good indication of hurricane intensity changes and can many times be better than SST information (Fig. 3). This is useful since SSHA does not change much on a day to day basis. There are too many factors and no significant evidence to assume that weakening hurricanes are primarily caused by low height anomalies due to the other hurricane weakening effects like wind shear that were not investigated by this research.

There are additional data suggesting that sea surface temperature and SSHA are not very well correlated. This implies to a different reason for the high anomalies beyond the sea surface. The large warm anomaly in the center of the gulf is most likely due to an eddy off of the loop current. This constant inflow of warm water and convergence maintains the high height anomaly, creating a seasonal intensification zone for hurricanes regardless of daily weather.

Summary

Understanding hurricane intensification is important so that coastal populations are given the best forecast of landfalling hurricane impacts. Sea surface temperature alone is not the best indicator of possible hurricane intensification and should be consider with. sea surface height anomaly data. The anomalies themselves are the result of currents and are not dependant on weather, shown by the slow changes that take place in the data. SSHA is an important variable and should be used in any hurricane research.

Appendix

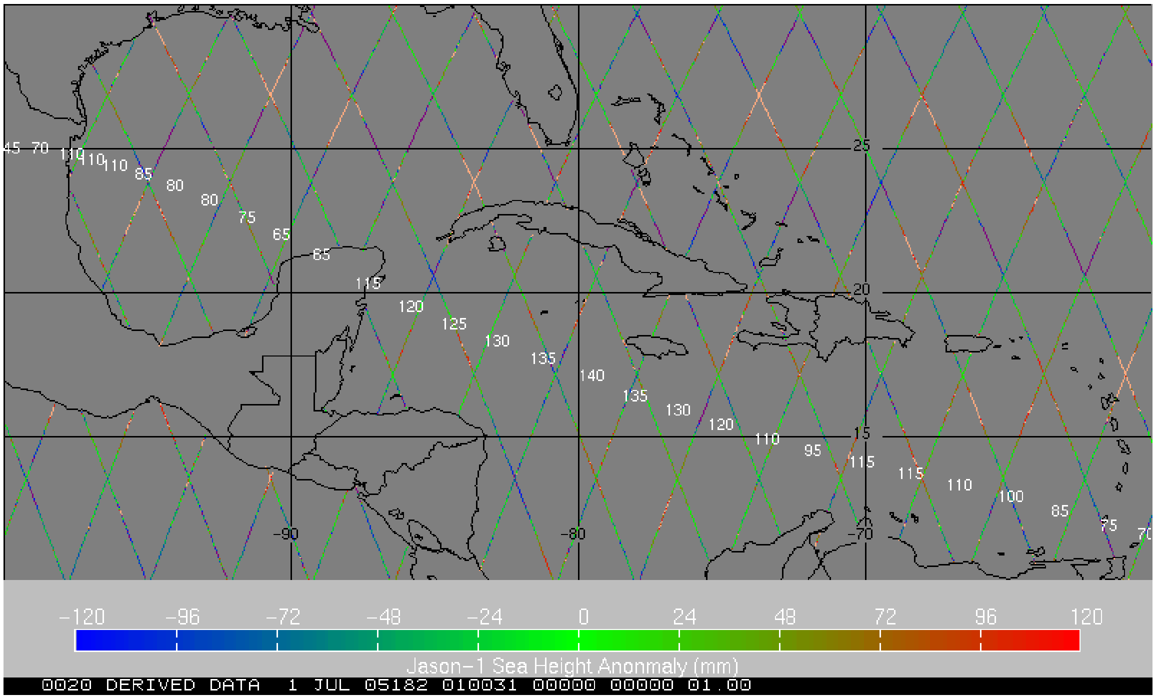

Fig. 1. June along-track SSHA data from the Jason satellite with maximum sea surface winds of hurricane Emily overlaid along the storm track.

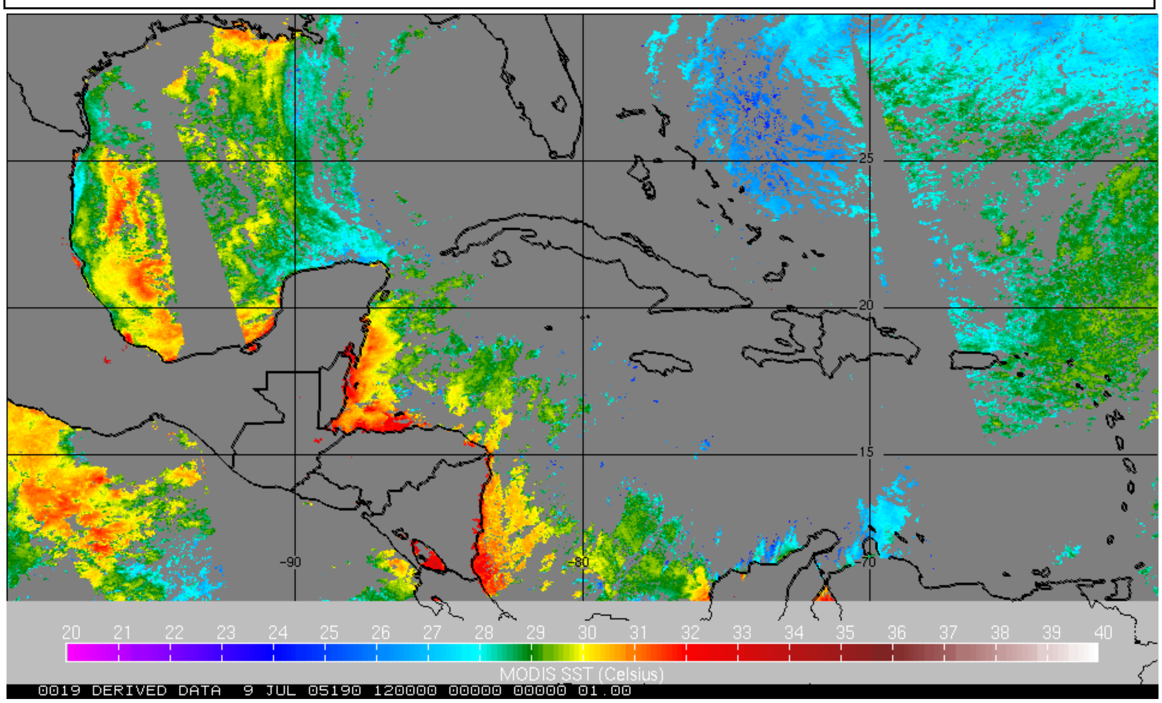

Fig. 2. Daily Sea surface temperature sampled by MODIS on the Aqua satellite during hurricane Dennis 9 July 2005

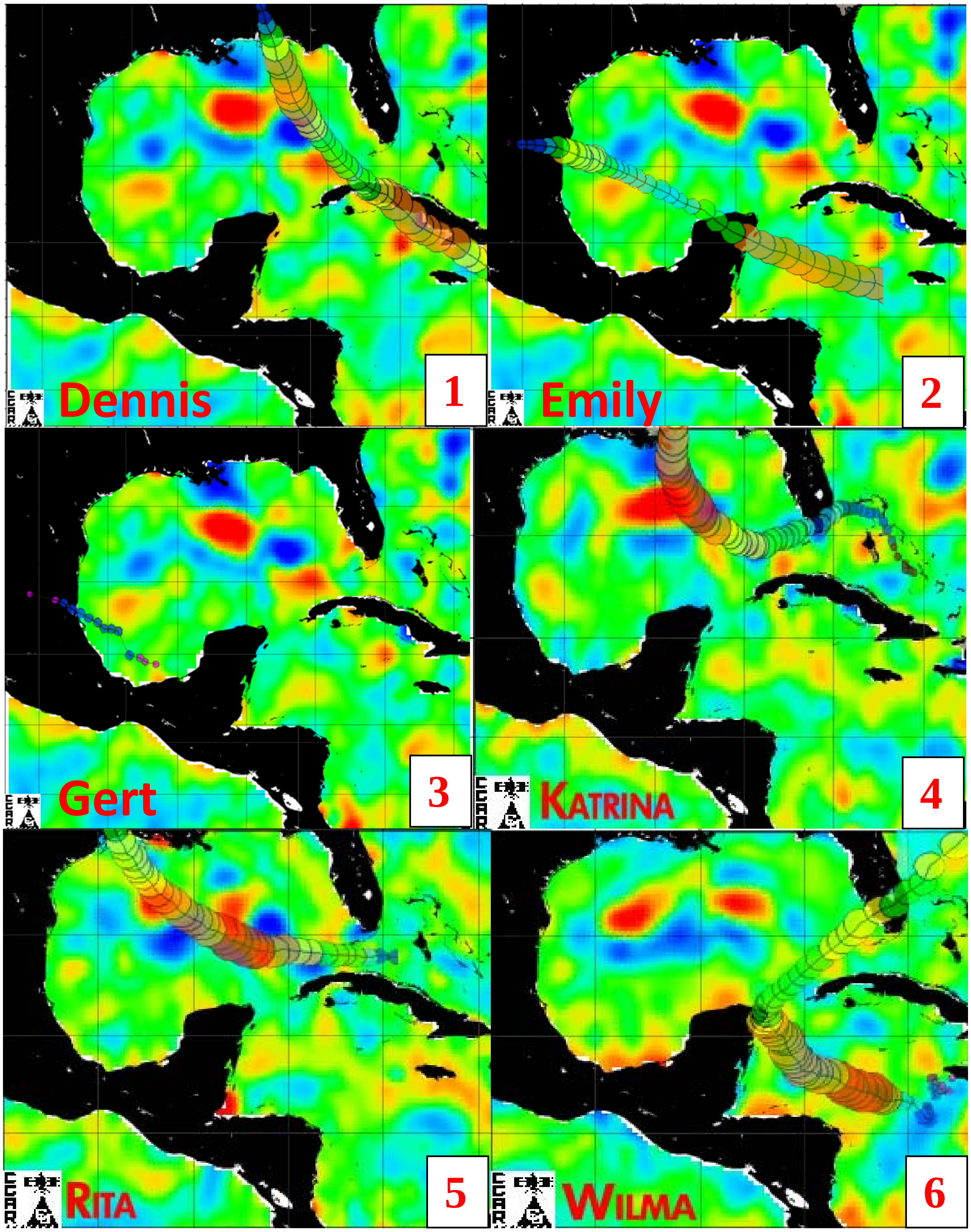

Fig. 1.1 SSHA with track for hurricane Dennis overlaid. **Fig. 1.2** SSHA with track for hurricane Emily overlaid. **Fig. 1.3** SSHA with track for hurricane Gert overlaid. Fig. **1.4** SSHA with track for hurricane Katrina overlaid. **Fig. 1.5** SSHA with track for hurricane Rita overlaid. **Fig. 1.6** SSHA with track for hurricane Wilma overlaid.

Products

GridSSH1.pl – Takes Jason and Topex/Posiedon satellite along-track SSHA data and returns it in a gridded form for imaging. The spatial resolution of the data is at .05 degrees and .01 degrees. The data are also separated by separate passes within the day. Different passes within the days range from two to four, starting at different hours throughout the day. See Fig. 2.

SSTReader.pl – Takes Modis SST data over the whole globe and returns only the data in the proper range 100-60W latitude and 30-10N longitude. Data is .0416666 degree resolution and is in 12 hour segments from 0z and 12z. Data is also provided from both Aqua and Terra satellites. See Fig. 3.