1A.4 MICROWAVE SST CORRELATION WITH CYCLONE INTENSITY

Chelle Gentemann*
Deborah Smith
Frank Wentz
Remote Sensing Systems, Santa Rosa, CA

1. INTRODUCTION

The TRMM Microwave Imager (TMI), operational since November 1997, provides cloud-penetrating sea surface temperature (SST) measurements. At its lowest frequency channel (10.7 GHz) the atmosphere is nearly transparent, making it possible to measure SSTs reliably. This channel has little attenuation from non-raining clouds, giving a clear view of the sea surface under all weather conditions except rain. These attributes make TMI SST especially valuable for measuring SST during severe storms when traditional infrared SST retrievals are often thwarted by cloud cover. Using 2 years of data we analyze the effect of SST on storm intensity. Also, post-storm SST anomalies are examined in order to relate intensity to storm-induced upwelling.

2. OCEANIC RESPONSE TO TRPICAL CYCLONES

Infrared (IR) SST observations have been used to study the oceanic response to tropical cyclones. Directly to the right of their track, strong storms leave a cold wake (Monaldo, 1997; Nelson, 1998). The analysis of the cold wakes has been hampered by lack of IR SST retrievals due to cloud cover or contamination by undetected clouds and atmospheric aerosols (Wentz, *submitted*). Retrieval errors in TMI SST are primarily due to both wind speed and direction (Wentz, 1996). The TMI SST algorithm ingests model winds to minimize this effect. The Reynolds SST maps are used by the National Hurricane Center's (NHC) storm intensity forecast models. SSTs exert significant thermodynamic control on the storm intensity (DeMaria, 1994).

Figure 1 compares the TMI SST field with the weekly Reynolds SST of Hurricane Dennis and Cindy on September 3-5, 1999. Figure 1A shows a three day average of TMI SST directly after the passage of two hurricanes (Dennis and Cindy). The cold wake from Dennis can be seen directly alongside the East Coast of North America. Cindy's cold wake is farther offshore, in the top right of Figure 1A. Reynolds SSTs are used in most coupled weather models and in the NHC intensity forecasts. Figure 1B was the weekly map available by September 5, 1999. The upwelling isn't present because 1) the weekly resolution and 2) the satellite IR SST used in Reynolds analysis is unable to measure SST in the vicinity of the storms due to cloud cover.

***Corresponding author address: Chelle L. Gentemann, Remote Sensing Systems, 438 First Street Suite 200, Santa Rosa, CA 95401; e-mail: gentemann@remss.com**

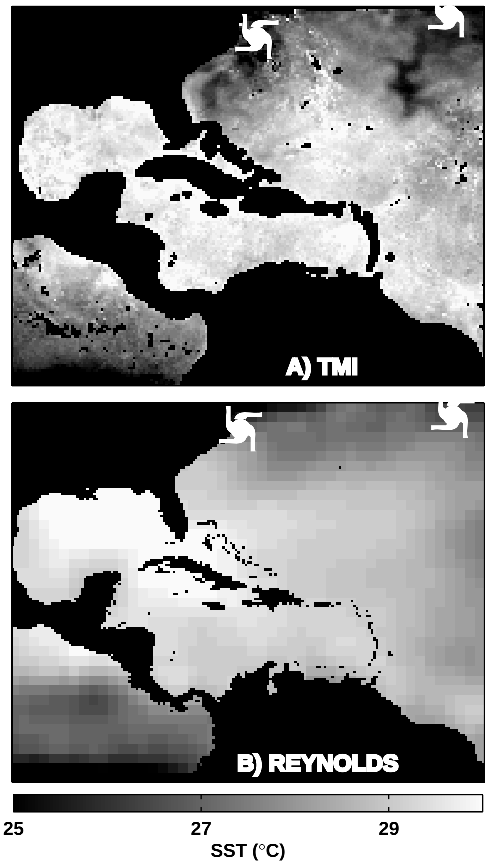

Figure 1. A) TMI SST from September 3-5, 1999. B) Reynolds SST for the week ending August 28, 1999. Positions of Hurricane Dennis and Cindy are indicated by white spiral symbols. Dennis is the leftmost symbol.

3. INTENSITY FORECASTS

Storm track prediction skill has steadily improved along with better numerical models and observations, but intensity prediction skill falls short of expectations (Willoughby, 1999). After initial development, the intensity of severe storms is strongly influenced by the thermodynamic structure of the upper ocean (Emanuel, 1999), and an accurate prediction of the storms future intensity requires measurements of the ocean's thermal structure ahead of the storm. Microwave SST retrievals clearly have the potential to improve skill in these important forecasts (Wentz, *submitted*). Of particular interest, is the spatial/temporal extent to which hurricanes modify SSTs.

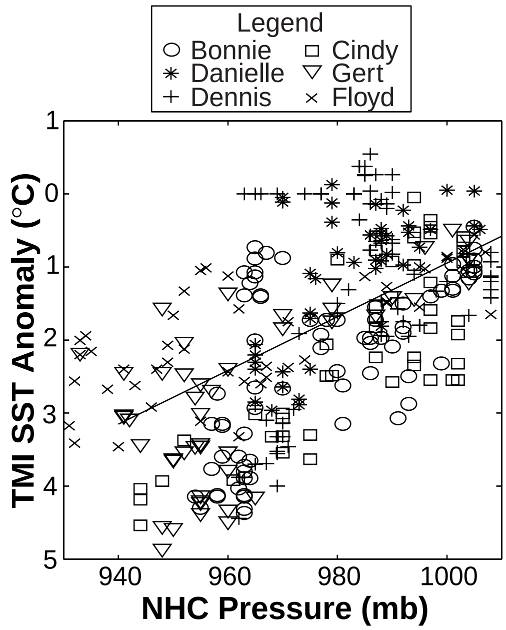

Figure 2. Relationship between hurricane storm induced SST anomalies and storm minimum pressure.

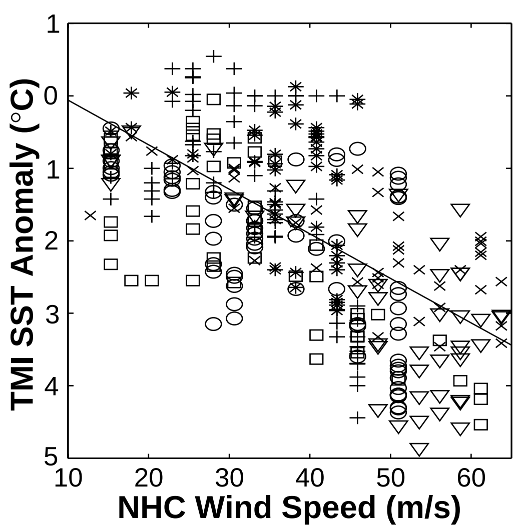

Figure 3. Relationship between hurricane storm induced SST anomalies and maximum sustained wind speed.

3. SST ANOMALY CORRELATION WITH STORM INTENSITY

Six North Atlantic hurricanes were included in this study. Bonnie and Danielle were both in 1998. The rest are 1999 hurricanes. Some storms were excluded because they were in the Gulf of Mexico or spent the majority of the time over land.

For each hurricane, the NHC publishes the best track location, maximum sustained wind speed, and minimum central pressure every three hours. At each NHC best track position, the SST anomaly was calculated daily, for 5 days after the storm, by subtracting the average SST for the three days directly prior to the storm. Since the region of upwelling is generally to the right of the storm track, this 5 day time series of SST anomalies was calculated at several positions to the right of the track location. To find the location of the maximum upwelling at each position, the SST anomalies were temporally averaged. At the position with the largest temporally averaged anomaly, the maximum SST anomaly was identified. This value was then used to examine the relationship between maximum sustained wind speed and SST anomalies (Fig. 2) and minimum central pressure and SST anomalies (Fig. 3).

A weak linear relationship is seen in both Figure 2 and Figure 3. Stronger storms resulted in larger anomalies. The correlation is -0.62 and 0.57, respectively. Some of the scatter and the relatively weak correlation may be attributed to differences in the upper ocean thermodynamic structure between the Equatorial Atlantic and the North Atlantic and varying forward storm velocity, which effects development of vertical mixing. These results are obviously regionally dependent due to variations in the upper ocean structure.

4. REFERENCES

DeMaria, M. and J. Kaplan, 1994: Sea surface temperature and the maximum intensity of Atlantic tropical cyclones. *J. of Climate*, **7**, 1224-1334.

Emanuel, K. A., 1999: Thermodynamic control of hurricane intensity. *Nature*, **401**, 665-669.

Monaldo, F. M and T. D. Sikora, 1997: Satellite imagery of sea surface temperature cooling in the wake of hurricane Edouard (1996). *Mon. Wea. Rev.*, **125**, 2716-2721.

Nelson, N. B., 1998: Spatial and temporal extent of sea surface temperature modifications by hurricanes in the Sargasso Sea during the 1995 season. *Mon. Wea. Rev.*, **126**, 1364-1368.

Reynolds, R. W. and T. M. Smith, 1994: Improved global sea surface temperature analyses using optiumu interpolation. *J. Climate*, **7**, 929-948.

Wentz, F. J., C. L. Gentemann, D. K. Smith, and D. B. Chelton: Satellite measurements of sea-surface temperature through clouds. *Science*, *submitted*.

Wentz, F. J., 1996: AMSR ocean algorithm, RSS Tech. Report 120296.

Willoughby, G. E., 1999: Hurricane heat engines. *Nature*, **401**, 665-669.

This work was supported by NASA TRMM contract NAS5-99191 and NASA's Earth Science Information Partnership through contract SUB1998-101 from the University of Alabama at Huntsville.