P1.10 A WEB INTERFACE FOR VIEWING SATELLITE MICROWAVE DATA OF TROPICAL CYCLONES

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1. INTRODUCTION

In July 2003, Remote Sensing Systems (RSS) implemented a new web site that includes a continually updated near-real time interface and a data archive for viewing scatterometer and radiometer microwave data in and around tropical cyclones. The archive includes microwave data from July 1999 through the present in a simple, focused environment specifically designed to aid in user understanding of several microwave data sets, each containing valuable information about tropical cyclone evolution and development. The archive has proven useful to those performing tropical cyclone research and retrospective analysis. We present in this poster details about the archive data, site structure and design.

2. DATA SET DESCRIPTION

The tropical cyclone web interface presented in this poster contains various types of microwave data processed at Remote Sensing Systems (RSS). These data include ocean surface wind vectors derived from scatterometers as well as columnar rain rates and sea surface temperatures from radiometers. Storm-centered images are extracted from the satellite data using information from the Automated Tropical Cyclone Forecast (ATCF) system.

A scatterometer transmits radar pulses to Earth's surface and measures the returned power that is scattered back to the instrument. This "backscattered" power is a measure of surface roughness. Over water surfaces, the surface roughness is highly correlated with the near-surface wind speed and direction. Hence, wind speed and direction at a height of 10 meters over the ocean surface are retrieved from measurements of the backscattered power. The retrieval process is not without ambiguity as the model function used to process the backscattered power into wind vectors produces several solutions from which the most likely is selected. This process is referred to as 'ambiguity selection' and performs poorly in low wind or high rain conditions for parabolic Ku-band (14 GHz) scatterometers such as the SeaWinds scatterometer on the QuikSCAT platform. We refer to this instrument as QuikSCAT in this document. For this reason, a rain flag is used to identify poor quality data. Our tropical cyclone interface contains the QuikSCAT surface wind vector data available from July 1999 onward. We also include a limited amount of 2003 data from the SeaWinds instrument onboard the Midori-II platform.

Radiometers collect microwave signals from the surface of the Earth. The frequency of the microwaves permits their passage through clouds. In this manner, microwaves are said to be able to "see" through clouds to the surface of the earth. This makes radiometer data especially useful in tropical cyclone environments where clouds cover large regions surrounding the storm eye. Several geophysical parameters are derived from the observed microwave radiation including ocean surface wind speed, columnar water vapor, cloud liquid water, columnar rain rate and sea surface temperature. Surface wind speeds, however, cannot be obtained in regions of rain, so only outer region wind speeds are available for tropical cyclones. RSS processes and makes available on our general web site data from currently operating radiometers in orbit; 3 SSM/I instruments on DMSP platforms, AMSR-E on the Aqua platform and the TRMM Microwave Imager (TMI).

The TMI has previously been shown to provide valuable sea surface temperature information in front of tropical cyclones (Wentz, 2000), so we include in the archive an Optimally Interpolated Microwave (MW OI) SST daily product at one quarter degree (~25 kilometer) resolution constructed from TMI and AMSR-E SST retrievals. Using a diurnal model, TMI and AMSR-E data are 'normalized' to a daily minimum SST corresponding to approximately 8 AM, local time. These MW OI SSTs represent a significant improvement over weekly, 1 degree (~100 km) NCEP OI (Reynolds) SSTs. While IR SSTs can

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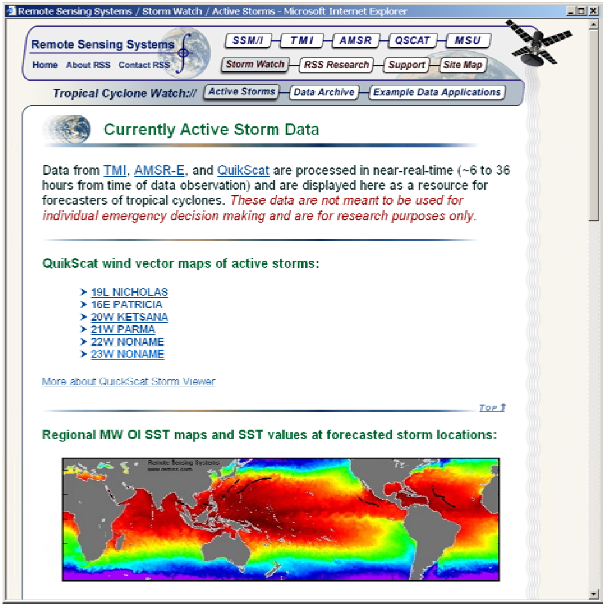

Figure 1. RSS Tropical Storm Watch Web Site.

achieve significantly higher spatial resolution, the infrared wavelengths do not penetrate clouds, significantly contaminating or blocking SST retrievals in and around tropical cyclone systems. Additional instruments will be blended into the RSS microwave OI product in the near future. SST anomaly maps are also available and are created by differencing the MW OI SSTs and the NCEP OI monthly climatology SSTs. These anomaly maps are used in the archive interface to highlight storm cold wake intensities.

In addition to the sea surface temperature data, we also include columnar rain rates from the SSM/I instruments onboard the DMSP platforms. Currently three DMSP SSM/I are functioning, F13, F14 and F15. The F13 SSM/I instrument best collocates with QuikSCAT and these data are most often included in the archive. Knowledge of heavy rain locations can assist users in interpreting the ambiguities within the scatterometer data. The other geophysical parameters available from radiometers are not yet included in the archive but have value to those trying to understand the atmospheric conditions within the tropical cyclone environment.

Global tropical cyclone location, intensity and forecast data from both the Joint Typhoon Warning Center and the National Hurricane Center are obtained roughly every hour by FTP from the Naval Research Lab-Monterey and parsed using Python's built-in FTP control module. These data are used to create satellite data images of regions within 8 degrees of the storm center. The reported sustained surface wind speed and surface pressure are also included in the user interface.

3. SITE LAYOUT

The tropical cyclone microwave data archive is accessed by either clicking on the name of a currently active storm or by clicking the Data Archive button from the Storm Watch section of the RSS web site. Named cyclones within the archive are listed by year and link into the interface, shown in Figure 2.

The archive interface consists of 5 sub-regions shown in Figure 2a-2e. At the top of the interface is a timeline chart (Fig.2a) containing the reported maximum sustained wind speed, pressure, and microwave SST at the storm center at 3 or 6-hour intervals for the life of the storm. This chart also contains symbols showing the time of scatterometer wind vector images. This graphical timeline makes it easy for the user to quickly obtain information about the life cycle of each storm and identify the frequency of satellite overpasses. The user can click between scatterometer images by selecting the symbols. In addition, we include in the timeline the 48 hours prior to official storm identification and create/store any overpass images that occur in this time. Scatterometer images of cyclogenesis storm stages were shown by Katsaros et al (2001) to identify closed surface wind circulation up to 48 hours before official storm warnings were issued.

Tropical cyclone track locations at 3 or 6-hour intervals are plotted over the daily MW OI SSTs (Fig.2b). These center-locations show the user an overview of the storm's movement over time. Each MW OI SST map shown is that closest in time to the scatterometer wind vector map displayed in Figure 2c. By clicking anywhere on the SST map the user flips to the SST anomaly map which more clearly shows any upwelling created by the storm passage.

The large storm-centered scatterometer wind vector region (Fig.2c) contains wind barbs color coded by wind speed. Full barbs represent 10 knots and half barbs are 5 knots. Wind direction is blowing from the barb end of the line to the base. Small gray dots at the base of each wind barb indicate data that are rain-flagged. In regions of very heavy rain the model function typically

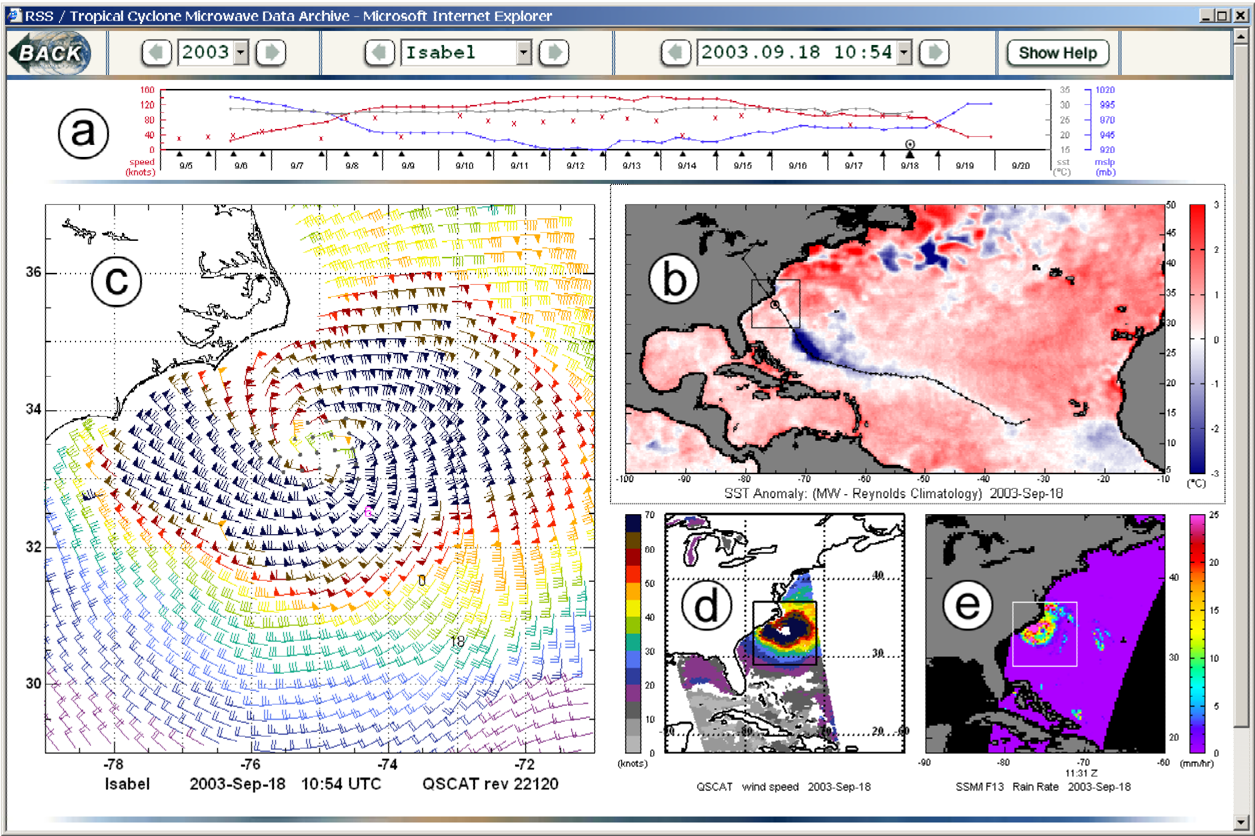

Figure 2. Archive user interface for Hurricane Isabel, September 18, 2003. Regions noted as a-e are further discussed in the text.

retrieves wind vectors aligned in a direction perpendicular to the swath of satellite observation (we call these cross-track vectors). We include in Fig.2c a plot of all solutions found by the model function. Users can access this “ambiguity plot” by clicking anywhere within the large wind vector region.

Two smaller plots are included in the archive; the first (Fig 2d) is a 30-degree lat/lon regional plot showing the orbital data colored by wind speed. The second plot (Fig.2e) shows the nearest (in time) SSM/I rain rates. Clicking on the rain rate image will flip between a regional rain rate plot and an 8-degree close-up rain plot. These two images assist the user in interpreting the rain-affected QuikSCAT winds. For example, the regional plot shows the overall swath direction making it easier to determine those QuikSCAT vectors that are cross-track.

4. SITE DESIGN

In approaching the development of the site we began by identifying our users and understanding their needs. To do this we worked with field meteorologists to find out what features they might find useful in a scatterometer data archive. These users identified needs such as wanting wind barbs instead of wind vectors in the display and desire to have access to multiple ambiguity solutions from the model function. The timeline shown in Figure 2a, was developed to address requests for more information about data observation time. In addition to labeling the UTC time of observation on each image, we found the timeline to be very effective at quickly and easily placing many satellite overpasses into temporal context. It also serves as an intuitive navigation device.

During development of the site we focused on producing a fast, simple and easy-to-use interface. We considered the use of a database as this could provide power and flexibility in mining and displaying the satellite data, but may have also resulted in slower site functioning, increased backend complexity, and steeper learning curves for the users. We chose instead to create static, pre-rendered images in which we made some decisions for our users in order to keep the site simple and easy to use For example, we discovered that an 8-degree lat/lon region worked for most storms instead of providing the user the flexibility to select the zoom region of their choice. A context-based help page (Figure 3) assists the users in understanding the functionality of the site and helps them quickly learn to use its features.

The static data images are produced from SSM/I and QuikSCAT data using IDL (a scientific plotting program) and the ATCF track locations. JavaScript files are simultaneously generated to automatically update the web site display. The front end is built with standards-based implementations of HTML and JavaScript, enabling the site to function with most modern web browsers. Client-side JavaScript provides the ability to quickly display cached images. For example, clicking and flipping between wind barbs and ambiguities allows a seamless visual comparison without the interruption involved with reloading a page in the browser.

We used a flexible design strategy that allows for easy implementation of any changes, such as the inclusion of SeaWinds (on Midori-II) data. We anticipate adding features to this archive environment as we continue to receive feedback from the users.

5. SUMMARY

We have described a tropical cyclone archive consisting of satellite microwave data that makes tropical cyclone images visually accessible to the research community, students, and storm enthusiasts within the general public. It is a popular site that has experienced increasing usage since it's launch. We anticipate adding new features in the future such as scatterometer sigma0 data for better center location and radiometer wind speeds to assist in determining outer wind radii. This is available at www.remss.com/hurricane/data_archive.html. Any feedback or questions you may have about this interface can be addressed to Marty Brewer.

6. REFERENCES

Katsaros, K.B., et al., QuikSCAT's SeaWinds facilitates early identification of tropical depressions in 1999 hurricane season, *Geophysical Research Letters*, *28* (6), 1043-1046, 2001.

Wentz, F., et al., Satellite measurements of sea surface temperature through clouds, *Science*, *288* (5467), 847-850, 2000.

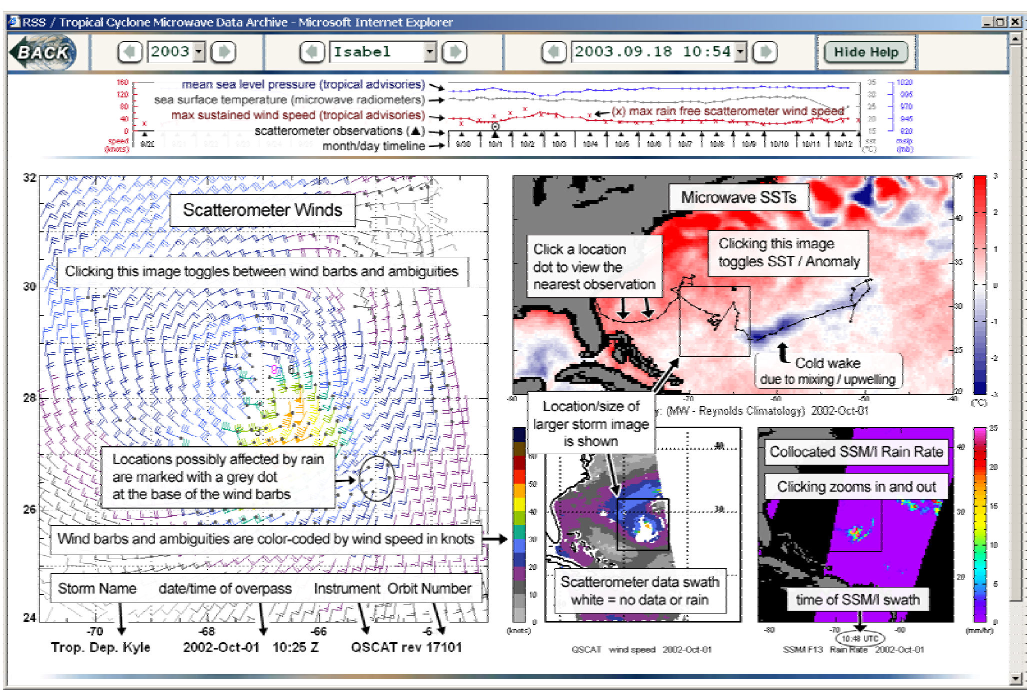

Figure 3. Help page available to users of the microwave tropical cyclone archive.