JP8.6 COMBINED MODIS / AMSR-E SST Composites for Regional Weather Applications

Gary Jedlovec[1], Jorge Vazquez[2], Ed Armstrong[2], and Stephanie Haines[3]

[1] NASA / Marshall Space Flight Center / Earth Science Office, Huntsville, AL
[2] Jet Propulsion Laboratory, Pasadena, CA
[3] The University of Alabama Huntsville, Earth System Science Center, Huntsville, AL

1. INTRODUCTION

Accurate high resolution specification of sea surface temperature (SST) is important for regional weather forecasting studies and coastal ocean applications. Chelton et al. (2007) and Lacasse et al. (2008) showed that the use of coarse resolution SST products such as from the real-time global (RTG) SST analysis (Thiebaux et al. 2003) in regional weather forecast models do not properly portray the fluxes of heat and moisture from the ocean that drive the formation of low level clouds and precipitation over the ocean. Haines et al. (2007) described a polar orbiting data compositing technique which provides spatially continuous, accurate, high-resolution SST fields using data from the Moderate-resolution Imaging Spectrometer (MODIS) on NASA's Terra and Aqua satellites. The compositing technique generates 4x daily maps of SST using data from the previous days to augment and fill in for clouds and missing data in the current days / times MODIS orbital swath. The approach was limited during periods of long-term cloud cover where latency of past data reduced the accuracy of the data presented in the composites. Additionally, only limited passes of MODIS data were available because of the reliance on two real-time direct broadcast ground stations for data ingest.

The goal of the work presented here is to create an enhanced high resolution MODIS sea surface temperature (SST) composite for use by the community which is not constraint by the limitations above. The data sets will be tested by NASA as part of the Short Term Prediction and Research Transition (SPoRT) program and integration into operational streams for the NOAA National Weather Service.

2. THE NASA SPORT CENTER

The NASA SPoRT project at the Marshall Space Flight Center (MSFC) seeks to accelerate the infusion of NASA Earth science observations, data assimilation, and modeling research into weather forecast operations and decision-making at the regional and local level. It directly supports the NASA strategic plan of using results of scientific discovery to directly benefit society. The program is executed in concert with other government, university, and private sector partners. The primary focus is on the regional scale and emphasizes forecast improvements on a time scale of 0-24 hours. The SPoRT program has facilitated the use of real-time NASA data and products at 13 National Weather Service (NWS) Weather Forecast Offices (WFOs) and several private weather entities primarily in the southeast United States. Numerous new techniques have been developed to transform satellite observations into useful parameters that better describe changing weather conditions.

The unique NASA and NOAA weather products have helped local weather service offices improve forecasts of reduced visibility due to fog, low clouds, and smoke and haze from sources such as forest fires and agricultural burning, of the onset of precipitation, the occurrence and location of severe weather events, and other local weather changes. Additionally, high resolution satellite data provided by SPoRT has been used by the private sector to inform the marine weather community of changing ocean conditions, and by coastal weather offices with tropical storm and hurricane monitoring. Because of its unique ability to transition NASA technologies into NOAA / NWS operations, the SPoRT Center is collaborating with ocean scientists at the Jet Propulsion Laboratory (JPL) to develop an enhanced SST composite product for ocean and atmospheric applications and disseminate it to the community via the JPL Physical Oceanography DAAC (PODAAC).

3. ALGORITHM APPROACH

This paper describes a collaborative effort of research scientists in the Group for High Resolution Sea Surface Temperatures (GHRSST) at JPL and SPoRT at MSFC. The goal is to produce an enhanced high-resolution (1km) SST product which minimizes the limitations of the previous approach.

The current algorithm (Haines et al., 2007) assumes day-to-day changes in SST are relatively small and preceding days values can be used to fill in cloudy regions. The steps in creating the existing composite include remapping MODIS SST swaths of data to 1km grid, applying a cloud mask (Jedlovec et al. 2008) to filter cloud-free pixels, and obtain the three most recent cloud-free SST values for each pixel – called a collection - (from the past weeks of data). For each collection, the coldest SST value is excluded (as a final bad data and extra cloud filter step) and average other two SST values becomes the composite value. The procedure is applied on a pixel by pixel basis to produce a composite SST image. A pixel-based latency map is computed from the average date of the two “good” SST values in the collection.

In Haines et al. (2007), real-time SST data is obtained from the University of South Florida’s Institute for Marine Remote Sensing (IMARS). The IMARS processes the Level 1 data from their direct broadcast ground station in near real-time using EOS science team algorithms. The SST compositing algorithm is applied to the morning and afternoon passes from both Terra and Aqua to produce four composites a day over the Gulf of Mexico and western Atlantic Ocean. Nominal composite times are 0430, 0730, 1630, and 1930 UTC. These real time composites can be found on-line at http://weather.msfc.nasa.gov/sport/sst and ftp://ftp.nsstc.org/outgoing/haines/SSTcomp/ .

Enhancements to be incorporated into the algorithm as part of this project include the use of sensor and data error characteristics, an improved cloud detection approach, supplemental AMSR-E SST data, and an error weighting scheme to more optimally combine a collection of SST values for each pixel. The enhanced method is depicted in Figure 1. The top row of boxes (in the figure) indicates the MODIS processing steps and the middle row the AMSR-E procedures. The procedures are similar for the two data sets and the MODIS processing is similar to Haines et al. (2007) through box 3 (production of remapped cloud-free (MODIS) and rain-free (AMSR-E) images for a given time / pass). The difference begins in the generation of the collections at each pixel based on the histories files (box 4). Here the addition of AMSR-E SSTs for Aqua passes / composite times is included in the collections. In box 5, the composites are generated on a pixel by pixel basis from the collections using the enhanced compositing approach presented (in a general form) in the lower right portion of the figure. The composite is the weighted average of the points in the collection, where the weights are determined by both latency and data quality. In this way, older data in the collection is not weighted as much as more recent data. Additionally, quality differences between AMSR-E and MODIS SST values can be included in the error estimate.

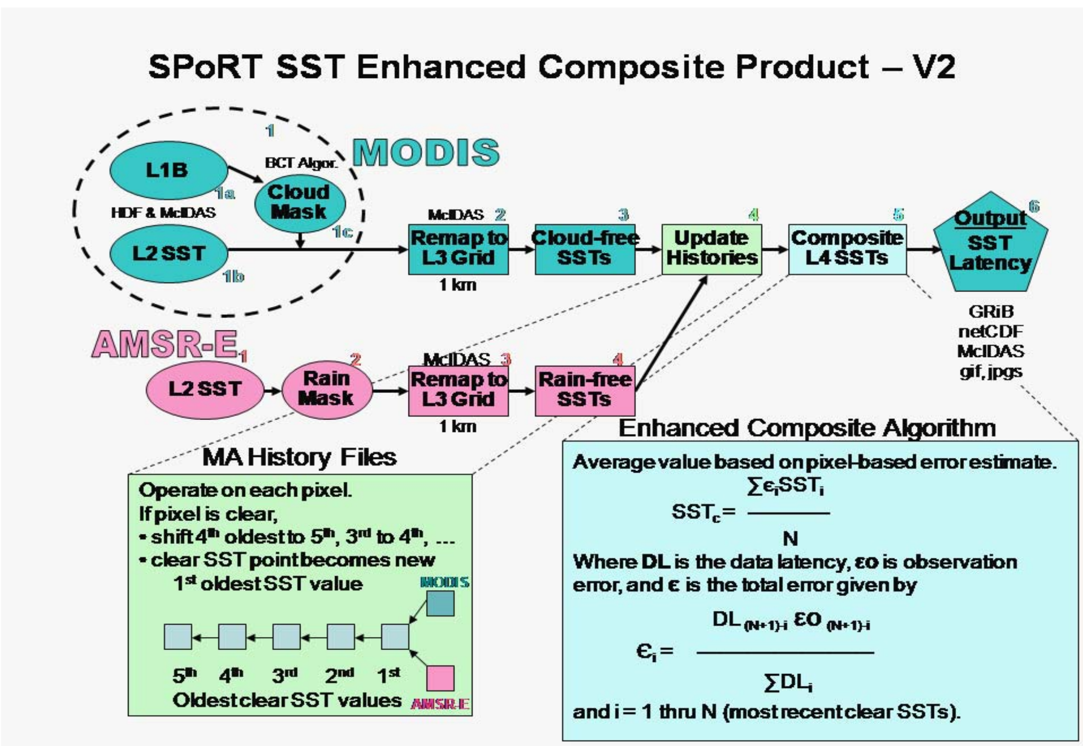

Figure 1. Diagram depicting the enhanced MODIS / AMSR-E SST compositing algorithm.

The use of the GHRSST data stream benefits the compositing procedure in several ways. First, all MODIS passes (not just those obtained by a single ground station) are included in the processing. This will serve to reduce the potential latency in the existing SST composite data set. It also allows for an expanded coverage of the SST product to include the ocean regions surrounding North America (plans for a global product are being formulated). The GHRSST data stream also includes a robust set of quality flags which can be used to produce an accurate cloud mask to be used in the processing algorithm. LaFontaine 2008 (personal communication) has indicated that the use of the quality flags in this way produces a more accurate but a bit more conservative cloud mask compared to the Jedlovec et al. (2008) approach applied to MODIS data.

4. PRELIMINARY RESULTS

The enhanced SST compositing algorithm is being applied to selected periods of time during the developmental stage of the activity. An example of the enhanced composite is presented in Figure 2. The MODIS / AMSR-E SST composite presents a detailed view of the SST patterns on May 14, 2008. Clearly visible is the detailed resolution provided by the MODIS data. The latency map indicates that most of the data comes from the preceding two days and data from the western Gulf of Mexico up to 6 days old.

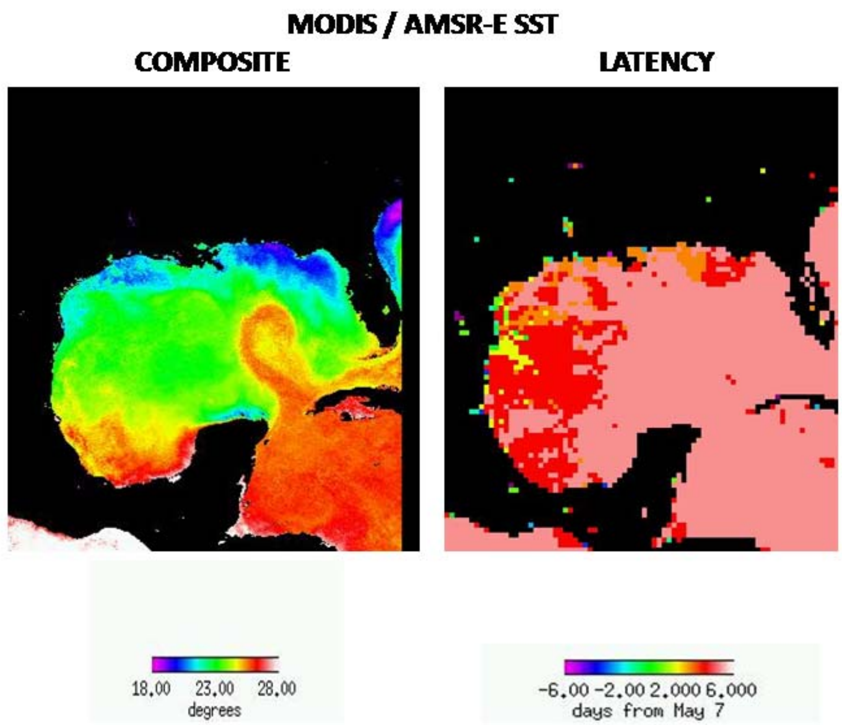

Figure 2. An example of an SST composite (left) from MODIS and AMSR-E in the Gulf of Mexico between May 1 and May 14 2008, along with the computed latency map (right).

5. SUMMARY

This work focuses on improvements to an SST compositing algorithm which is used by the operational weather community to improve short-term weather forecasts in coastal regions. The improvements being implemented include the use of sensor and data error characteristics to weight the individual SST values, improved data quality indicators tuned for cloud detection over oceans, supplemental AMSR-E SST data, and an error weighting scheme to more optimally combine a collection of SST values for each pixel. The resulting product will be available to the user community via the SPoRT web and anonymous ftp sites and via the PODAAC at JPL.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Frank LaFontaine for his recent contributions to this project. This research was funded by Dr. Tsengdar Lee of the NASA Science Mission Directorate's Earth Science Division through NASA's research to operations proposal solicitation, a part of NASA's Research Opportunities in Space and Earth Science (ROSES) program.

REFERENCES

Case, J. L., P. Santos, M. E. Splitt, S. M. Lazarus, K. K. Fuell, S. L. Haines, S. R. Dembek, and W. M. Lapenta, 2008a: A multi-season study of the effects of MODIS sea-surface temperatures on operational WRF forecasts at NWS Miami, FL. Preprints, *12th Conf. on Integrated Observing and Assimilation Systems for Atmosphere, Oceans, and Land Surface,* New Orleans, LA, Amer. Meteor. Soc., 14.1. [Available online at http://ams.confex.com/ams/pdfpapers/131892.pdf]

Chelton, D. B., M. G. Schlax, and R. M. Samelson, Summertime Coupling between Sea Surface Temperature and Wind Stress in the California Current System, *J. Phys. Oceano*, **37** (3), 495-517, 2007.

Haines, S. L., G. J. Jedlovec, and S.M. Lazurus, 2007: A MODIS Sea Surface Temperature Composite for Regional Applications, Trans. Geosci. Rem. Sens., **45**, No. 9, IEEE, 2919-2927.

Jedlovec, G. J., S. L. Haines, and F. J. LaFontaine, 2008: Spatial and Temporal Varying Thresholds for Cloud Detection in GOES Imagery, *Transactions in Geoscience and Remote Sensing,* **45**, No. 9, IEEE, 2919-2917.

LaCasse, K. M., M. E. Splitt, S. M. Lazarus, and W. M. Lapenta, 2008: The impact of high resolution sea surface temperatures on short-term model simulations of the nocturnal Florida marine boundary layer*. Mon Wea. Rev*., **136**, 4, 1349-1372.

Thiebaux, J., E. Rogers, Q. Wang, and B. Katz, 2003: A new high-resolution blended real-time global sea surface temperature analysis. *Bull. Amer. Met. Soc***, 84**, 5, 645-656.