



NOAA Coral Reef Watch's Next-Generation 5 km Satellite Coral Bleaching Thermal Stress Monitoring

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Satellite remote sensing has become an essential tool for coral reef environment monitoring. Since 1997, the U.S. National Oceanic and Atmospheric Administration (NOAA) Coral Reef Watch (CRW) has provided satellite-based sea surface temperature (SST) products to pinpoint areas where reefs are at risk for coral bleaching around the globe (<http://coralreefwatch.noaa.gov/satellite/index.php>). This is the world's first and only near-real-time global decision support system (DSS) informing management of tropical coral reef ecosystems.

Although highly successful and widely used by the global coral reef community, the currently operational CRW DSS uses relatively coarse SST data (50 km spatial resolution and twice-weekly temporal resolution) from only one polar-orbiting satellite. Addressing the demand for high-resolution monitoring of thermal stress that leads to bleaching and taking advantage of new satellites, sensors, algorithms, and our growing understanding of coral biology, CRW has developed a suite of next-generation, daily global 5 km products. These experimental products were officially released in May 2014 (<http://coralreefwatch.noaa.gov/satellite/bleaching5km/index.php>). Developed with support from NASA and NOAA, these products use the NOAA National Environmental Satellite, Data, and Information Service's (NESDIS) operational daily global 5 km geostationary-polar-orbiting (geo-polar) blended night-only SST analysis and a climatology (i.e., SST threshold for detecting bleaching related thermal stress) based on the 4 km AVHRR Pathfinder Version 5.2 SST dataset.

The high-resolution products currently include SST (Fig. 1) and SST Anomaly (not shown), as well as coral bleaching-specific products: Coral Bleaching HotSpots (Fig. 2), Degree Heating Weeks (DHW, Fig. 3), and Bleaching Alert Area (BAA, Fig. 4). These products presently use the same algorithms and stress levels used in CRW's established operational twice-weekly 50 km products (Liu *et al.* 2013; <http://coralreefwatch.noaa.gov/satellite/index.php>).

Like CRW's operational 50 km products, the 5 km Coral Bleaching HotSpots product (Fig. 2) measures the occurrence and magnitude of current thermal stress that can lead to bleaching. It is calculated as the difference between the night-time SST value and the average night-time temperature of the warmest month of the year (maximum monthly mean climatology, or MMM) at the same location. CRW's 5 km Degree Heating Weeks (DHW) product (Fig. 3) measures the cumulative impact of thermal stress experienced by corals. The DHW for a given location represents the accumulation of HotSpots of 1 °C or greater at that location over a rolling 12-week period. CRW's 5 km Bleaching Alert Area (BAA) product (Fig. 4) identifies areas where bleaching thermal stress meets or exceeds predefined levels based on CRW's HotSpot and DHW values. This is updated daily but shows the maximum thermal stress of the preceding seven days. The BAA provides coral reef ecosystem managers and other stakeholders with a single, convenient tool for monitoring recent thermal conditions. These daily global 5 km satellite monitoring products significantly advance CRW's ability to accurately monitor near-real-time coral bleaching thermal stress and account for episodes of localized, minor or no coral bleaching. CRW can now provide its services at or close to reef-scales with data from directly over coral reefs all over the world.

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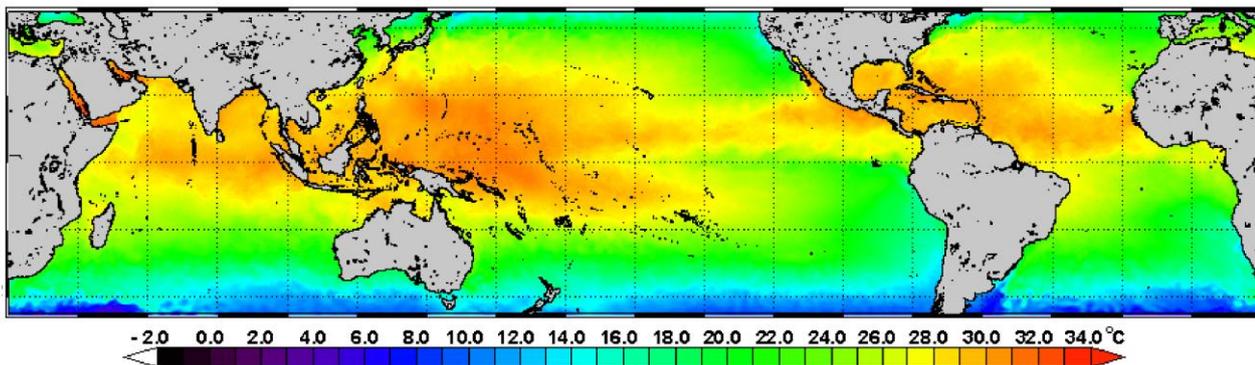


Figure 1. NOAA CRW's daily global 5 km SST product (graphic display of NOAA/NESDIS' operational daily global 5 km geo-polar blended night-only SST analysis) for October 3, 2013.

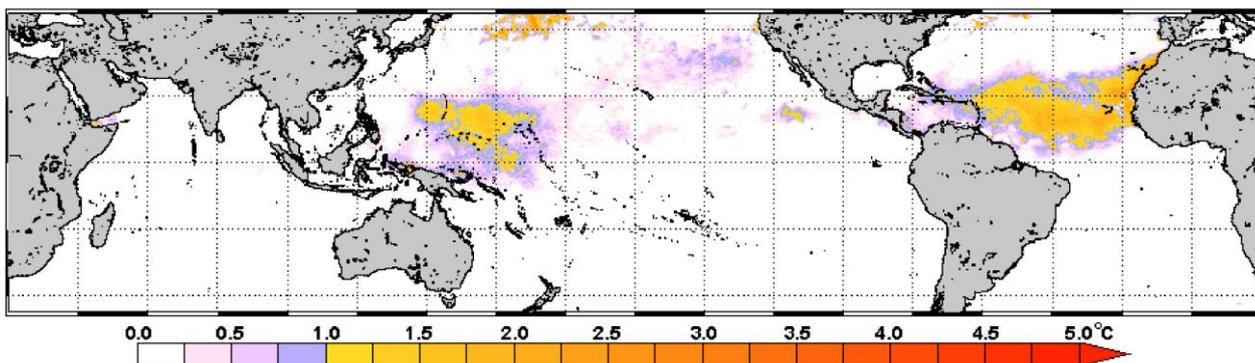


Figure 2. NOAA CRW's daily global 5 km Coral Bleaching HotSpots product for October 3, 2013.

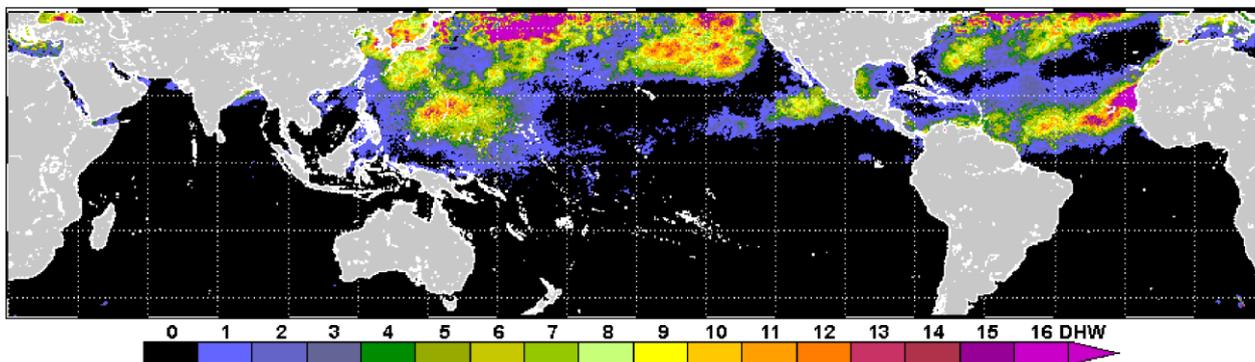


Figure 3. NOAA CRW's daily global 5 km coral bleaching Degree Heating Weeks product for October 3, 2013.

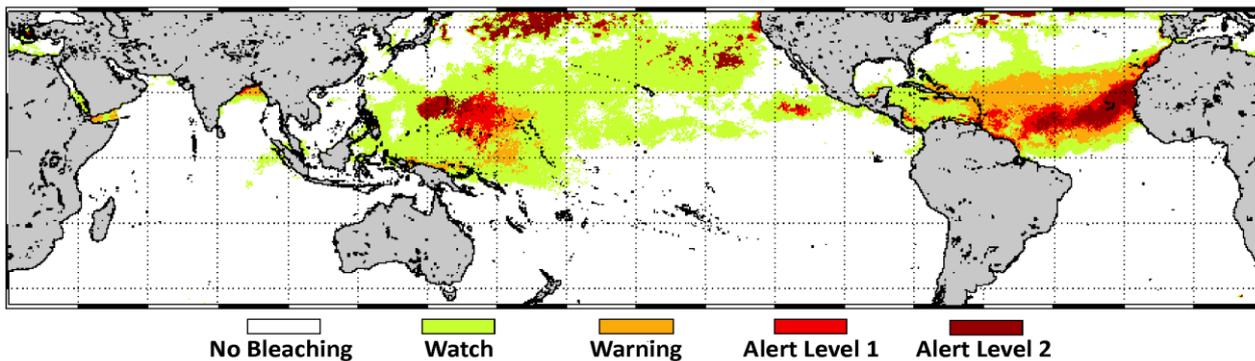


Figure 4. NOAA CRW's 7-day maximum composite of the daily global 5 km Bleaching Alert Area product for October 3, 2013. Note Alert Level 1 and 2 values around Guam and the Commonwealth of the Northern Mariana Islands where bleaching was underway at that time.

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The 5 km products provide two major improvements over CRW's 50 km products:

1. Next-generation Geo-Polar Blended SST Analysis

The products are based on NESDIS' new operational daily global 5 km geo-polar blended night-only SST analysis (gap-free) using observations from multiple operational geostationary and polar-orbiting satellites operated by NOAA, the Japan Meteorological Agency, and the European Organisation for the Exploitation of Meteorological Satellites. Unlike the current operational twice-weekly global 50 km SST analysis, which is based on at most one pass of a single polar-orbiting satellite each day in the tropical region, the new 5 km blended analysis includes as many as 50 SST observations per day from a combination of geostationary and polar-orbiting satellites. Application of the latest algorithms improves aspects such as cloud screening, gap-filling, and retrieval quality. As a result, the high-resolution 5 km SST analysis is based on more data of higher quality than the 50 km SST. In both the 5 km and 50 km SST analyses, only night-time SST retrievals are employed to ensure consistency of temperature anomalies at the very surface of the ocean with those experienced by corals at depth (Heron *et al.* 2013).

2. Improved Climatology

CRW's products are very sensitive to the quality and compatibility of the climatology (long-term average conditions) used in the analysis. A new climatology at 5 km resolution, matching NESDIS' 5 km SST analysis, was developed and implemented based on years 1985-2012 from the Version 5.2 AVHRR Pathfinder 4 km SST dataset, (i) adjusting for differences between the statistical characteristics of the Pathfinder SST data and the NESDIS 5 km operational SST analysis and (ii) employing the local SST trend through the data record to account for any influence of global warming to ensure consistency of derived products with the established interpretation of CRW's existing 50 km products. The new 5 km climatology also resolves known errors in the operational 50 km climatology in certain areas, such as the Gulf of Panama and Gulf of Oman.

These 5 km products will undergo continuous improvements over the next year as they are tested and ultimately transitioned to full operational support. Development of high-resolution versions of CRW's other operational products, such as the Virtual Stations and the automated Satellite Bleaching Alert (SBA) e-mail system, based on CRW's 5 km products is also underway. CRW will continue to produce the current 50 km products until the 5 km products become operational. We anticipate that there will be some differences between the two sets of products in certain areas, and user discretion is advised.

We encourage users worldwide to report bleaching and non-bleaching events to help us calibrate and validate the new system. Please email bleaching observations to coralreefwatch@noaa.gov and/or enter them into the NOAA/ReefBase online bleaching report form found at <http://www.reefbase.org/contribute/bleachingreport.aspx>. Your feedback is important for us to improve our monitoring products. Please send your comments and suggestions to coralreefwatch@noaa.gov.

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