

# NESDIS Center for Satellite Applications and Research (STAR)

## Highlights: Science Research & Applications in calendar Year 2005

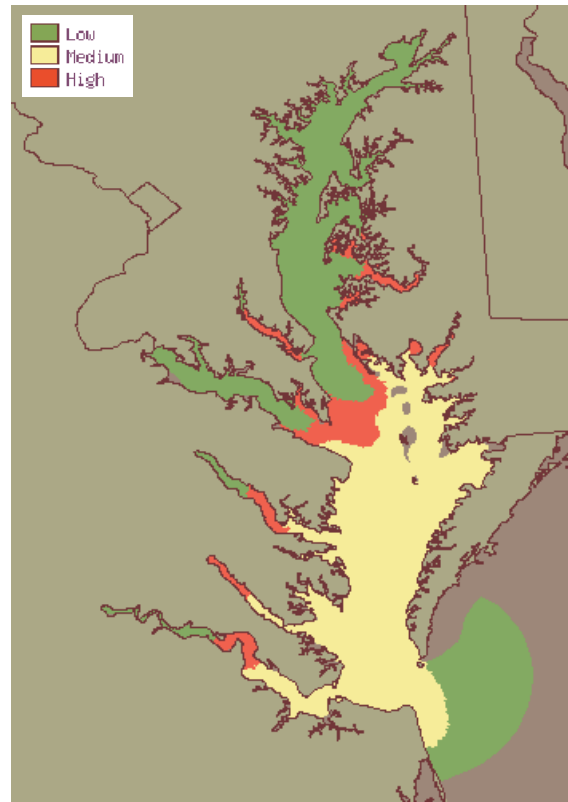
Submitted September 30, 2005

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**Nowcasting Harmful Algal Blooms in Chesapeake Bay (GOAL 1) (CORP)**

Daily nowcasts illustrating the relative abundance of *Karlodinium micrum*, a harmful algal bloom (HAB) species, in Chesapeake Bay (Fig. 1) are currently generated by applying a statistical habitat model for *K. micrum* to near-real time estimates of salinity and sea-surface temperature in the bay. The preliminary *K. micrum* habitat model quantitatively relates these ambient conditions, as well as time of year, to the relative abundance of *K. micrum*. The most current *K. micrum* nowcast, as well as information describing the procedure used in creating the maps, are staged on a Web site ([http://coastwatch.noaa.gov/cbay\\_hab](http://coastwatch.noaa.gov/cbay_hab)) for dissemination.



The procedure to nowcast the distribution pattern of *K. micrum* exploits our ability to both estimate the relative abundance of *K. micrum* from salinity and temperature and acquire these two environmental variables in near-real time using hydrodynamic models and satellite measurements. We plan to develop and implement an operational system that will nowcast and forecast the likelihood of blooms of this and several other HAB species in Chesapeake Bay and its tidal tributaries over the next five years.

Fig. 1. (above): Nowcast of the relative abundance of the ichthyotoxic dinoflagellate *Karlodinium micrum* in Chesapeake Bay on April 20, 2005.

This project represents collaboration between scientists from the Maryland Department of Natural Resources, the University of Maryland Center for Environmental Science, the University of Evansville, and NOAA. Contributed by Christopher Brown, NESDIS / STAR / CoRP / SCSB

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**NOAA-18 Hydrological Products (GOAL 3 and GOAL 5) (CORP)**

The generation of hydrological products continued with the launch of the NOAA-18 satellite on May 20, 2005. Within 120 days of launch, the **Microwave Surface and Precipitation Products System (MSPPS)** began delivering operational products (total precipitable water, cloud liquid water, snow cover and water equivalent, sea ice concentration, precipitation rate, ice water path, land surface temperature and land surface emissivity) to users such as the National Weather Service, Fleet Numerical Meteorology and Oceanography Center and the European Center for Medium-Range Weather Forecasts (see Figure 1). MSPPS relies on the use of the AMSU-A and MHS sensors (<http://www.orbit.nesdis.noaa.gov/corp/scsb/mspps/main.html>).

Contributed by Ralph Ferraro, NESDIS /STAR/ CoRP / SCSB (image, next page)

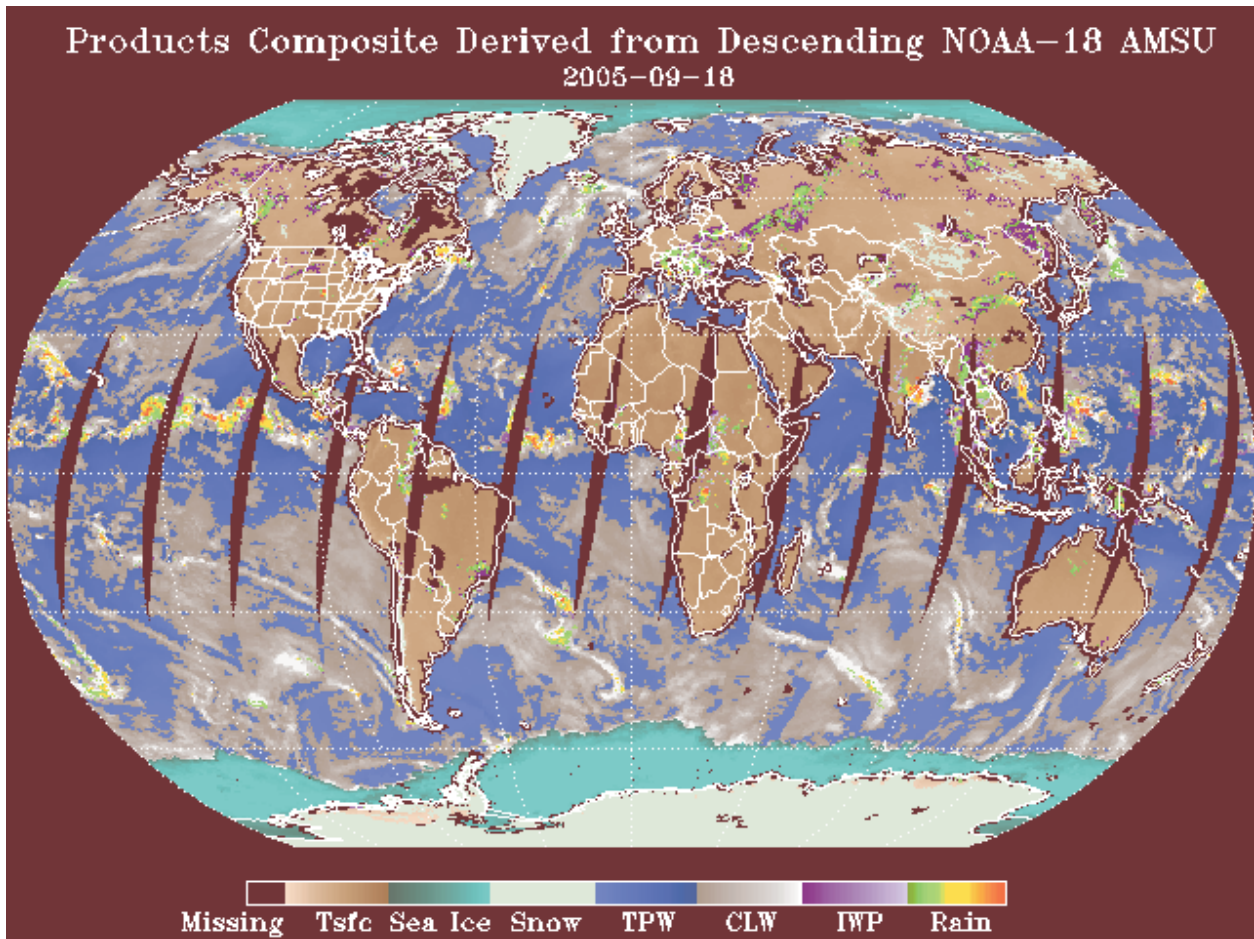
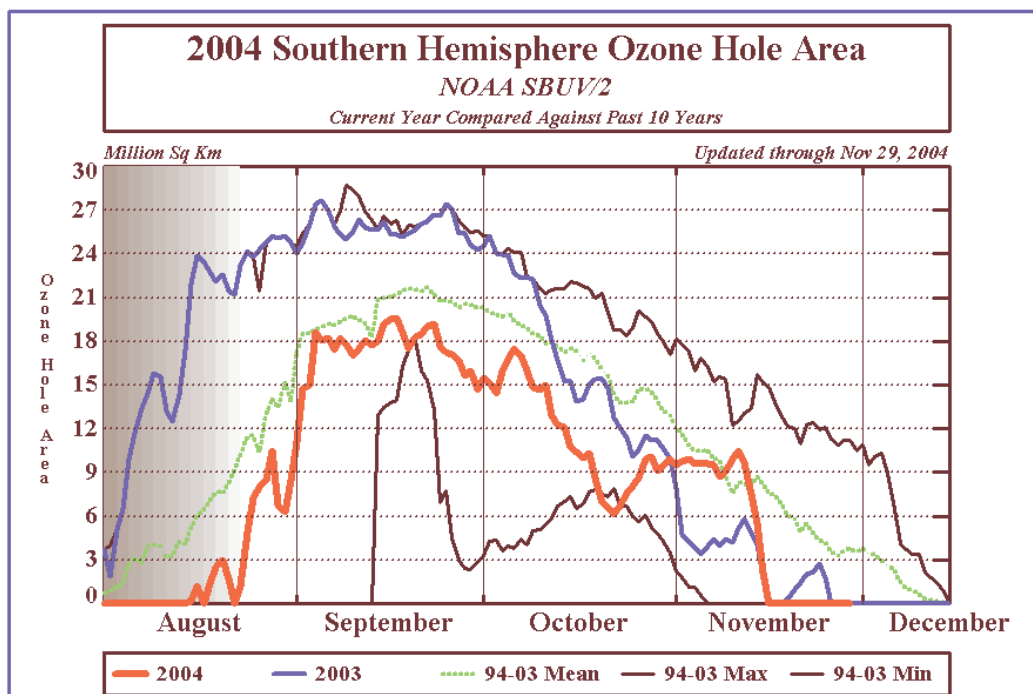


Fig. 1: NOAA-18 AMSU and MHS derived hydrological product composite for 18 Septem 2005.

**The 2004 Antarctic Ozone Hole (Goal 2) (Meteorology/Climate – SMCD)**

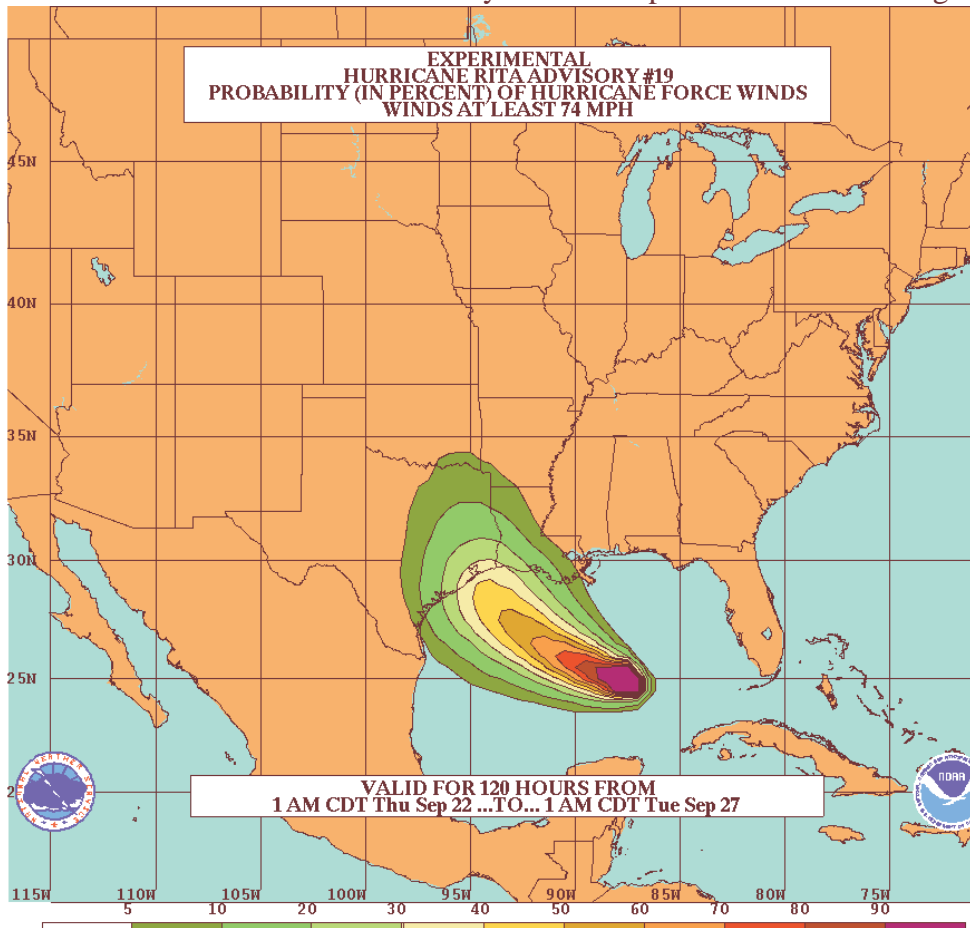


Life cycles of the Antarctic ozone hole, as determined from NOAA SBUV observations. Red curve shows the growth and decline of the ozone hole in 2004. Other curves show the life cycle in 2003 (blue), the mean life cycle (green), the largest events (upper black), and the smallest holes (lower black).

(cont.) NESDIS scientists, working closely with scientists at NOAA's Climate Prediction Center, continue to closely monitor the Antarctic ozone hole. Extensive ozone depletion was again observed over Antarctica during the Southern Hemisphere winter/spring of 2004, with widespread total ozone anomalies of 45 percent or more below the 1979-1986 base period. The area covered by extremely low total ozone values of less than 220 Dobson Units, defined as the Antarctic "ozone hole" area, in September 2004 reached a maximum size of greater than 19 million square kilometers and an average size of September of 17.4 million square km, smaller than most recent years.

### New Hurricane Probability Product (CORP)

Many factors contribute to the errors in hurricane forecasts including uncertainty in satellite position and intensity estimates, and track, intensity and wind structure forecast errors. A method to combine all sources of error based upon historical probability distributions was developed as part of a NESDIS project funded by the NOAA Joint Hurricane Testbed. This new probability model provides estimates of the likelihood of 34, 50 and 64 knot winds at any given location at 12 hour increments from the beginning of each forecast period out to five days. The figure below shows an example of the five day cumulative probability of hurricane force (64 kt) winds for a forecast for Hurricane Rita from September of 2005. The probability code was provided to the National Hurricane Center in Miami, where it was run on experimental basis in real time in 2005. This product will provide emergency managers and other responders a new quantitative tool which can be used for cost benefit analyses and to optimize hurricane mitigation activities.

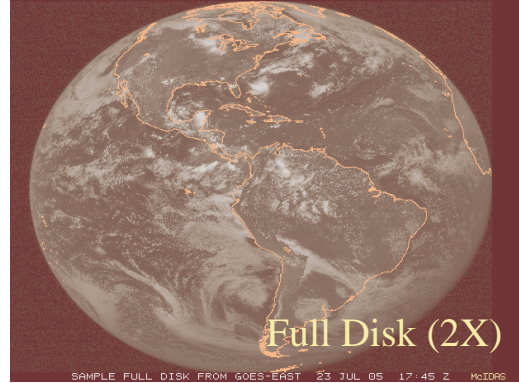
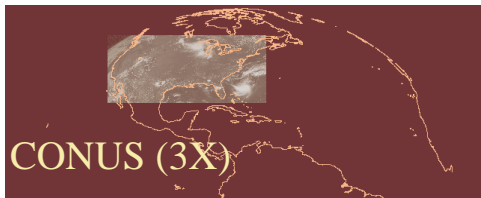
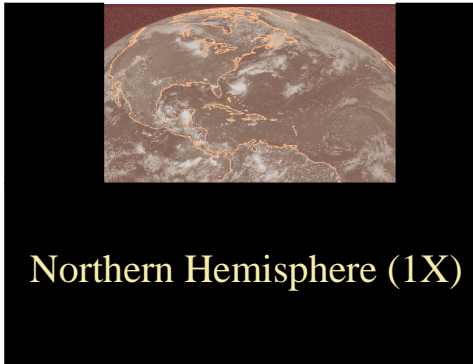


(Figure Caption) The probability of hurricane force winds at any time in a five day period after 1 AM central daylight time on 22 September 2005. This experimental product was available in real time on the National Hurricane Center web for all storms during the 2005 hurricane season. Submitted by Mark DeMaria, CORP/RAMMB

*Goal 5: Provide Critical Support for the NOAA Mission*

**GOES-R Sees the Earth Faster (CORP) STAR / CORP / ASPB**

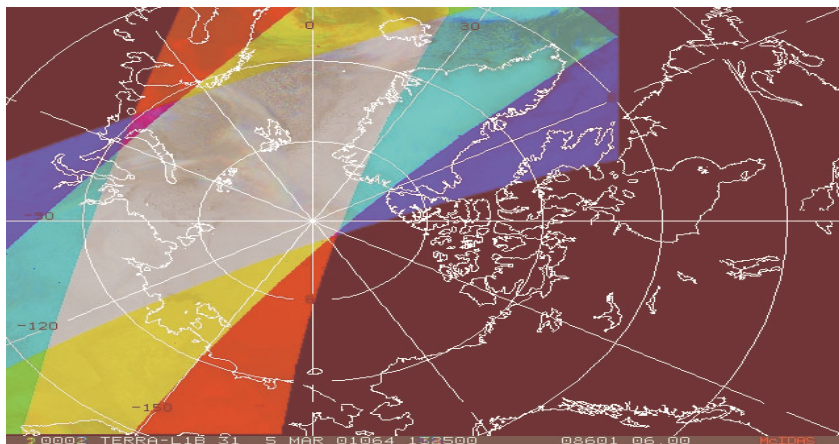
In addition to the improved spatial resolution (by a factor of four) and improved spectral resolution (by a factor of three), the next generation GOES-R imager will scan approximately five times as fast as the current GOES imager. In only 30 minutes in the “flex” scan mode of GOES-R there will be two full disk, and six Continental US and 60 mesoscale images. This is to be compared to only four images from the current system in the “rapid” imaging mode. This faster scanning of the GOES-R imager will eliminate the “global” versus “regional” versus “local” scan conflicts that exist today so that various phenomena (storms, dust, volcanoes, fires, hurricanes, etc) can be scanned at the needed temporal frequencies. Submitted by Jeff Key,



**Current GOES imager in 30 minutes**

**Future GOES imager in 30 minutes**

**MODIS Wind Observations Improve Weather Forecasts (Goal 3) (SMCD)**



The different colors show the observation tracks of three consecutive orbits of the MODIS instrument, about 11/2 hours apart, with the white area representing the overlap area of all three orbits. Tests at the Joint Center for Satellite data Assimilation show that wind observations, obtained from tracking cloud or water vapor features in the images of 2 or 3 overlapping orbits, improve medium range weather predictions. (continues)

(MODIS Winds, continued). The NOAA-NASA-DoD Joint Center for Satellite Data Assimilation (JCSDA) has shown that winds derived from NASA's MODIS observations improve the accuracy of medium range weather predictions. Based on these results, the NWS will start to assimilate these observations in the next upgrade to its global forecast model. The winds are derived using an innovative technique developed by NESDIS researchers. For many years, atmospheric winds have been measured by tracking the movement of cloud and water vapor features in consecutive images of GOES satellites. Hovering over the equator, GOES does not see polar areas. The new technique exploits the capability of the polar orbiting MODIS to take snapshots of polar areas only one to two hours apart, and from these images to track cloud and water vapor features. Unlike geostationary satellites at lower latitudes, it is not possible to obtain complete polar coverage at a snapshot in time with one or two polar-orbiters. Instead, winds must be derived for areas that are covered by two or three successive orbits, an example of which is shown here. The whitish area is the overlap between three orbits. MODIS is the first of a new generation of visible and infrared imagers that is a pre-cursor of the NPOESS VIIRS and the GOES-R imager. NESDIS provides the base funding for the JCSDA, with the other partners contributing additional resources.

### Carbon Cycle Science: An Emerging Product Suite (Goal 2) (Meteor / Climate, SMCD)

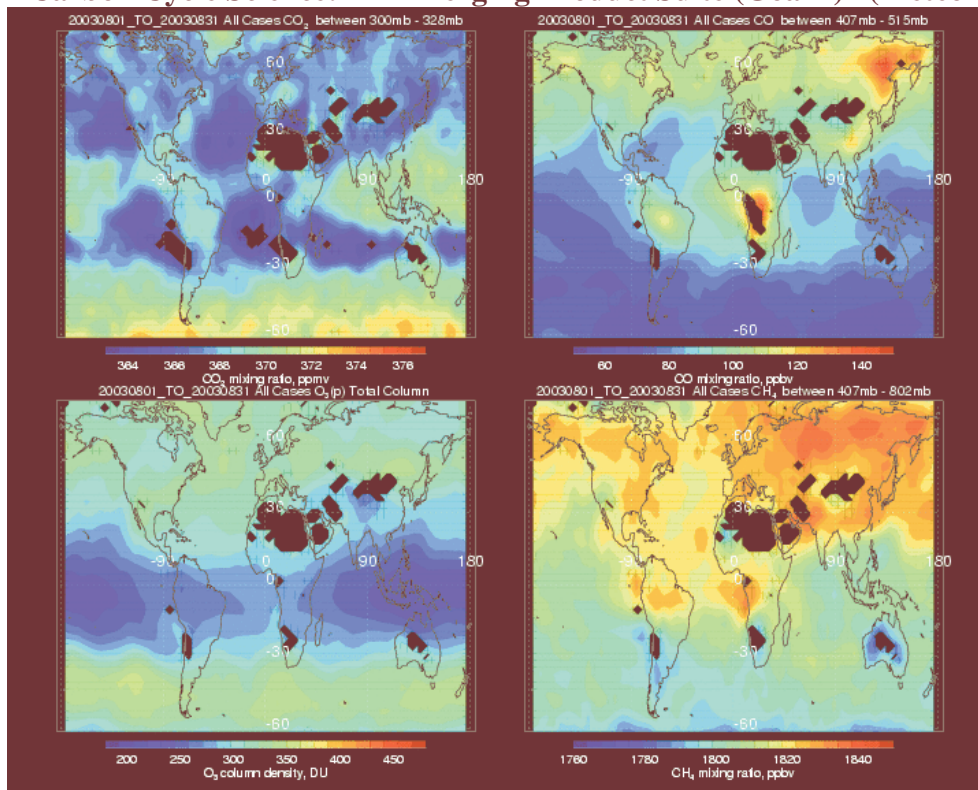


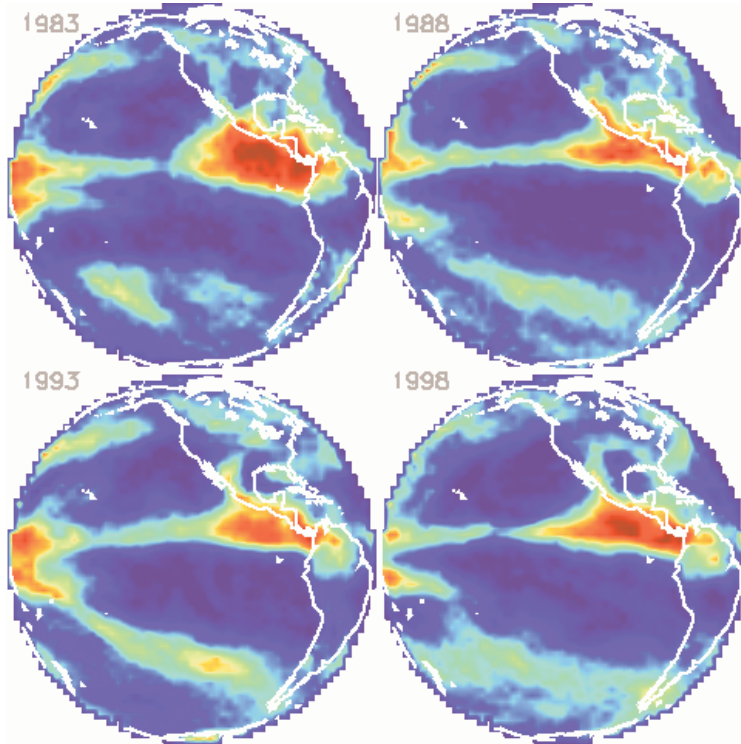
Figure: First ever monthly maps of greenhouse gases from satellites. Clockwise from upper left: CO<sub>2</sub>, CO, O<sub>3</sub>, CH<sub>4</sub>. Data are derived from NASA's AIRS instrument. Future operational hyperspectral atmospheric sounders, such as EUMETSAT's IASI the NPOESS CrIS, and GOES-R, will have similar capabilities.

Working with the NOAA Climate's Global Carbon Cycle Program, NESDIS investigators have developed a suite of greenhouse gas products from NASA's AIRS instrument. The team is producing daily experimental global greenhouse gas maps. Such maps will enable researchers to more clearly define the Earth's carbon cycle, a necessary prerequisite for understanding global climate change. In addition to contributing to atmospheric greenhouse effect, CO is important because it is a component of air pollution and is a measure of biomass burning.

## Reprocessing Satellite Data for Climate Studies (CORP / ASPD)

### Goal 2: Understand climate variability and change

Satellite data now provide a record long enough to study recent climate change, though reprocessing is generally necessary to ensure accurate inter-satellite calibration. The Advanced Very High Resolution Radiometer (AVHRR) is one sensor that can provide invaluable information on clouds, surface properties, and even winds. New climate products from AVHRR data include a higher resolution global vegetation index, a climatology of polar winds, and a new sea surface temperature climatology.



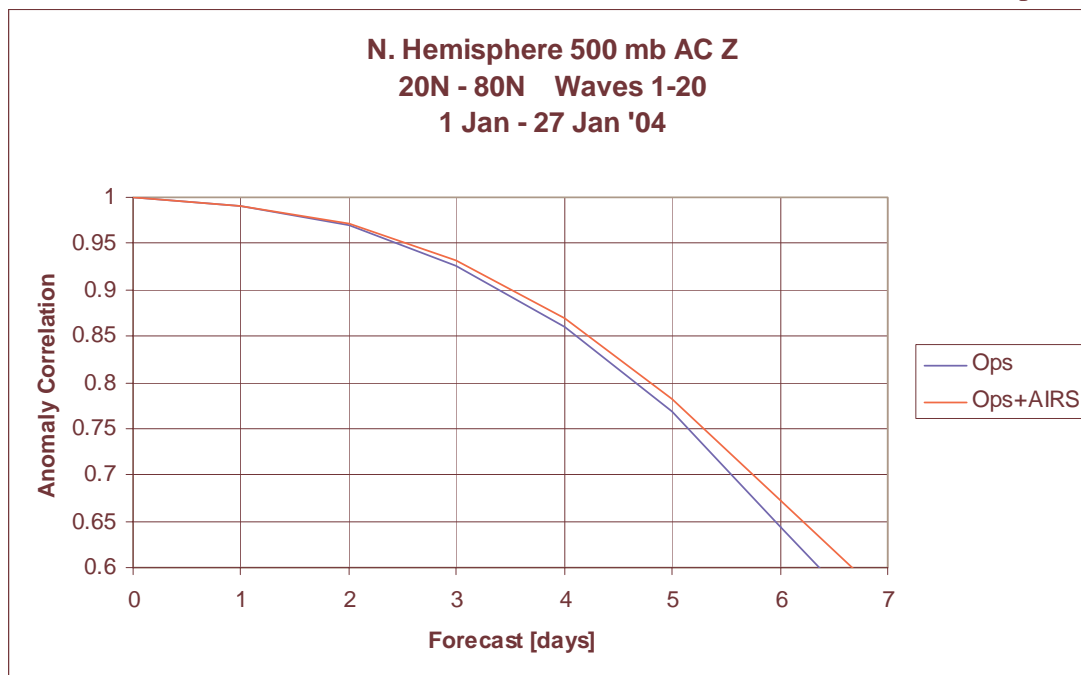
In addition, a new version of the AVHRR Pathfinder Atmospheres Extended (PATMOS-x) is being generated that will provide atmospheric climate records of cloud and aerosol properties. Reprocessed satellite data will greatly enhance the potential of using the AVHRR for decadal climate studies.

← Caption: The interannual variability in high cloud averaged over the month of July for 1983, 1988, 1993 and 1998. Areas with large amounts of high cloud are red; areas with less high cloud are blue.

Submitted by Jeff Key, ASPB.

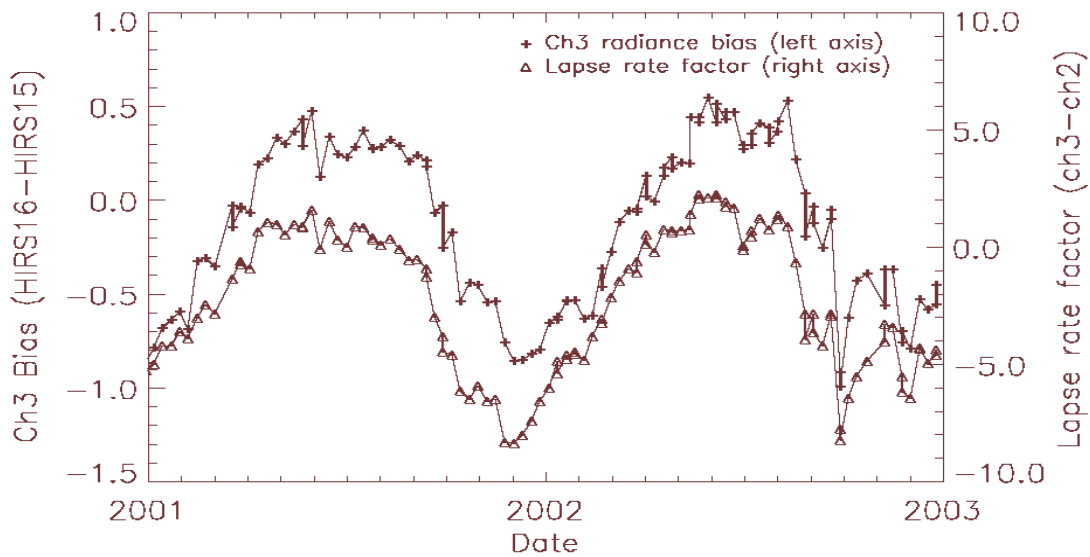
## Hyperspectral Observations Extend Medium Range Weather Forecasts (Goal 3) (SMCD)

Caption: The higher the anomaly correlation, the more skillful the weather forecast. Experimental forecasts using AIRS observations (red) are more accurate than those without, extend the range of skillful forecasts by over 6 hours. (cont.)



(AIRS continues) Experimental weather forecasts at the NOAA-NASA-DoD Joint Center for Satellite Data Assimilation (JCSDA) using NASA's Atmospheric InfraRed Sounder (AIRS) radiance observations indicate significant improvements in global forecast skill compared to the operational system without AIRS data. The improvement in forecast skill at 6 days is equivalent to gaining an extension of forecast capability of about 6 hours. This magnitude of improvement is quite significant when compared to the rate of general forecast improvement over the last decade. A 6 hour increase in forecast range at 5 or 6 days normally takes 5 or 6 years to achieve at operational weather centers. As a result of these positive impacts, the NWS has begun to assimilate AIRS data in its operational numerical weather prediction model. NESDIS provides the base funding for the JCSDA, with the other partners contributing additional resources. AIRS is the first of a new generation of infrared hyperspectral sounding instruments, providing hyperspectral observations measuring atmospheric temperature and moisture profiles with unprecedented accuracy and providing additional information on greenhouse gases. NESDIS plans to provide similar capabilities with the NPOESS CrIS and the GOES-R HESS.

**Powerful New Tool for Inter-satellite Instrument Calibration (Goal 2) (SMCD)**

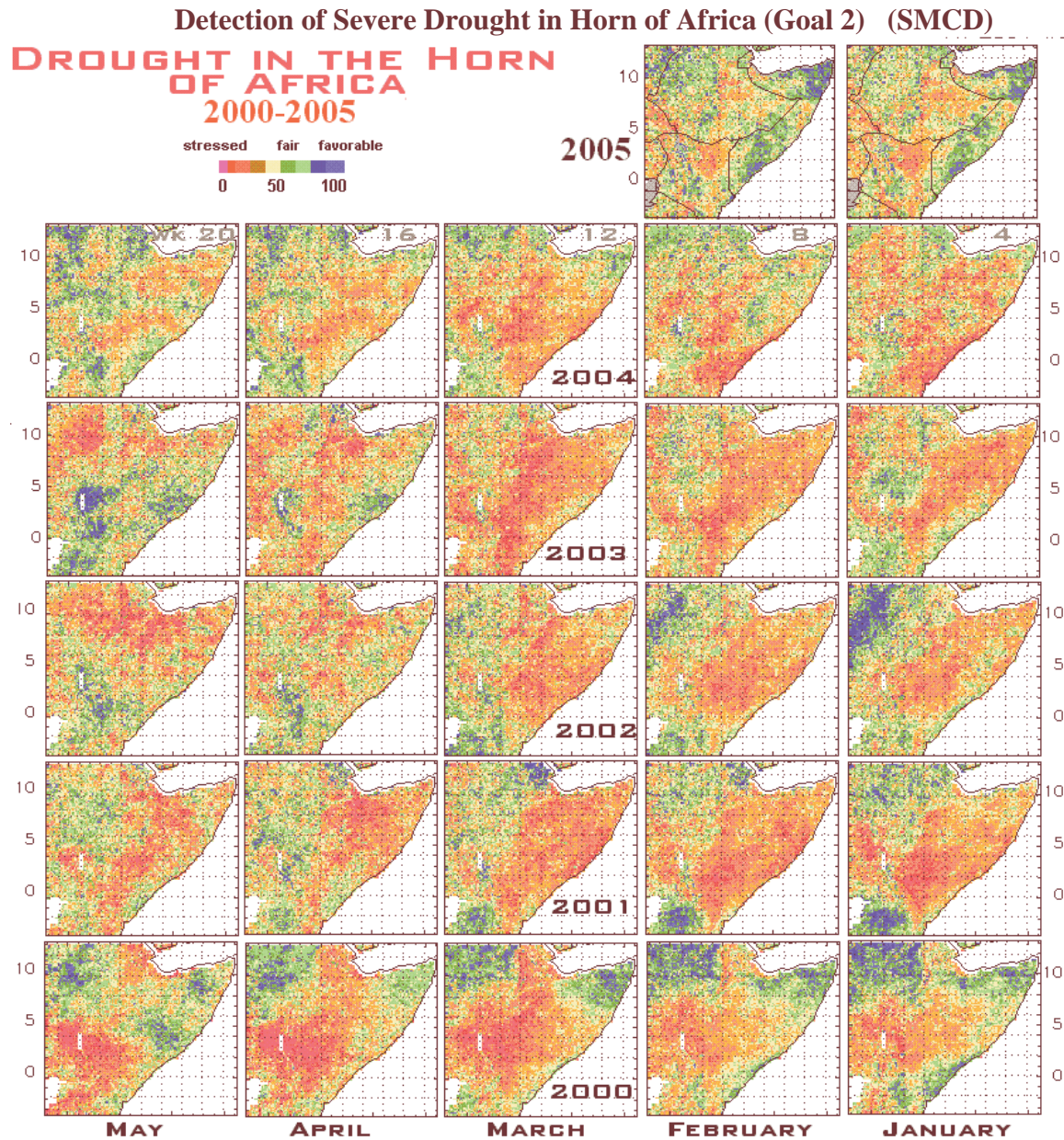


Intersatellite radiance biases between HIRS Channel 3 on NOAA-15 and -16 (top curve) as determined from Simultaneous Nadir Overpass (SNO) observations. The graph also shows that seasonal variations in the bias are highly correlated with the lapse rate (lower curve), indicating small spectral response differences between the two satellite instruments.

A powerful method has been developed to quantify the inter-satellite calibration biases for radiometers on polar-orbiting satellites. Application of the method to the instruments of all historic NOAA POES observations will permit the construction of high quality Climate Data Records for climate monitoring and reanalyses. The method is based on Simultaneous Nadir Overpass (SNO) observations. A SNO occurs when the nadir points of two polar-orbiting satellites cross each other within a few seconds. Such crossings occur at the orbital intersections of the satellites in Polar Regions. At each SNO, radiometers from each pair of satellites view the same place at the same time at nadir, thus eliminating uncertainties associated with the atmospheric path, view geometry, and time differences. Their



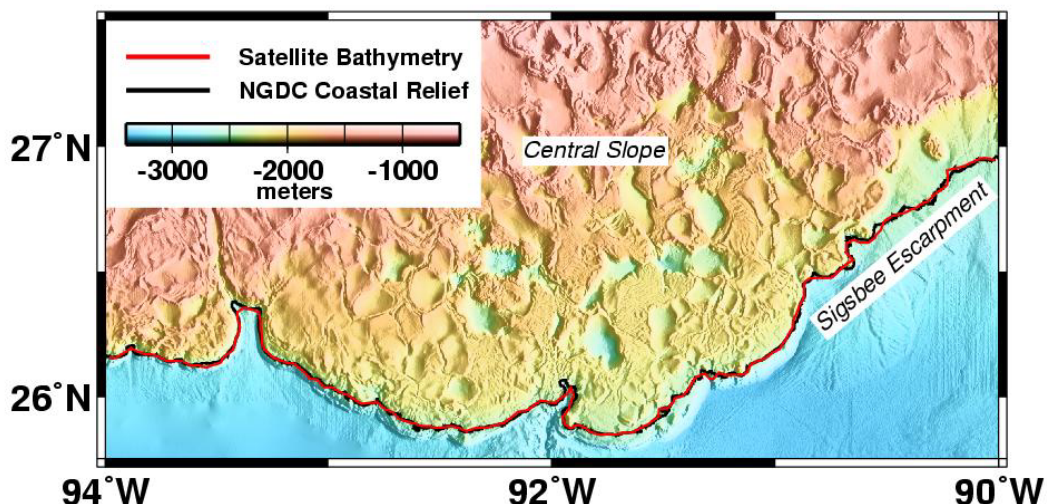
measurements should be identical. By comparing the measurements of the two satellites during SNOs, it is possible to determine the bias of one instrument with respect to the other.



Vegetation conditions in the Horn of Africa from January – May for the years 200 to 2005. Drought conditions are indicated by red shading.

NOAA satellites detected areas of stifling drought conditions in parts of Kenya, Ethiopia and Somalia for the sixth year in a row in 2005. These conditions left the region with threats of starvation, water shortages, widespread crop losses and disease outbreaks, according to NESDIS researchers. The 2005 drought gripped the region, known as the Horn of Africa, in January and continued to impact areas of eastern Kenya, southeastern Ethiopia and northern and central Somalia. At stake was the minor agricultural season, which runs from March through May, and normally provides enough food to sustain the population through the fall when the next harvest becomes

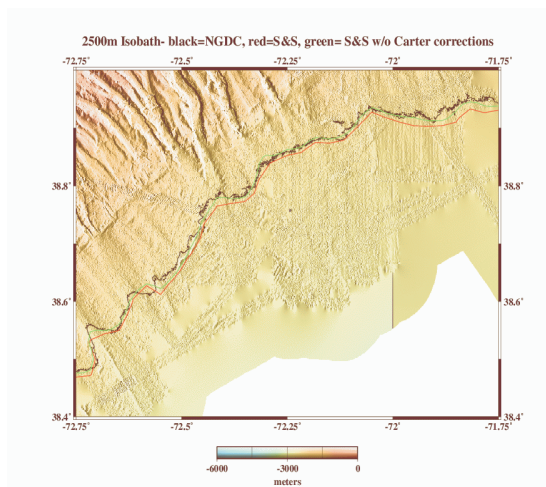
**Satellite Bathymetry May Aid Offshore Territorial Claims: the 2500 m depth line is a key element in a nation's offshore territorial claim. (Oceanography, SOCD)**



The satellite bathymetry depth line (in red) correlates well with that from ship soundings (in black). Most areas have only sparse ship data, so depths from satellite help locate the 2500 m line.

Satellite depth estimates by NESDIS scientists very nearly meet the Commission on the Limits of the Continental Shelf guidelines.

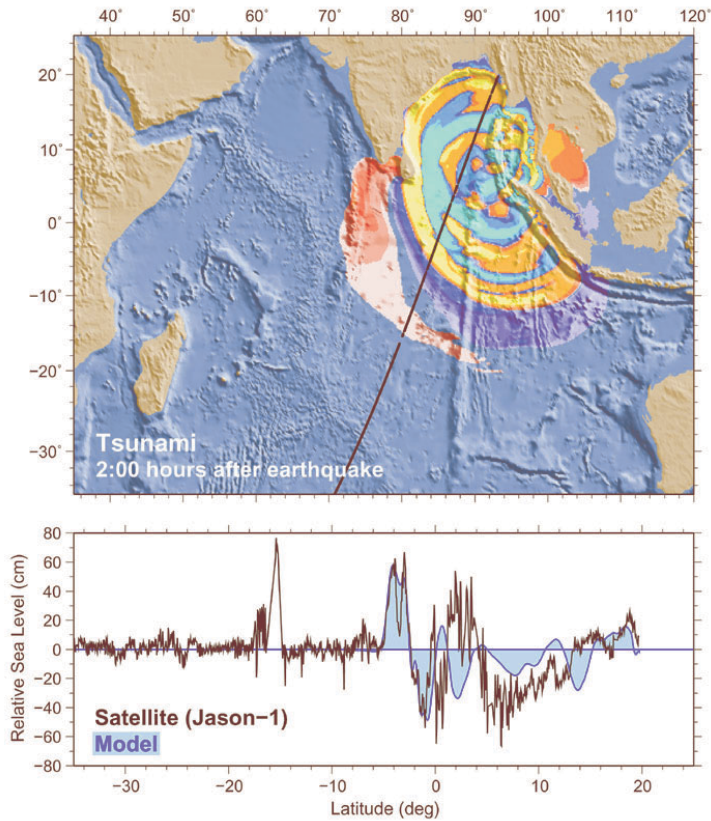
Additionally, systematic difference in depth between estimated and multibeam bathymetry have been examined. A comparison of multibeam bathymetry data from NGDC (Coastal Relief Model) with estimated bathymetry from the Sandwell and Smith 1997 (S&S) grid, for a region offshore New Jersey was completed. In the figure below, the 2500m isobath from S&S (red line) was found to lie systematically seaward of the 2500m isobath from the NGDC model (black line) (see figure). An analysis of data processing corrections and errors was completed in support of the NGDC data base.



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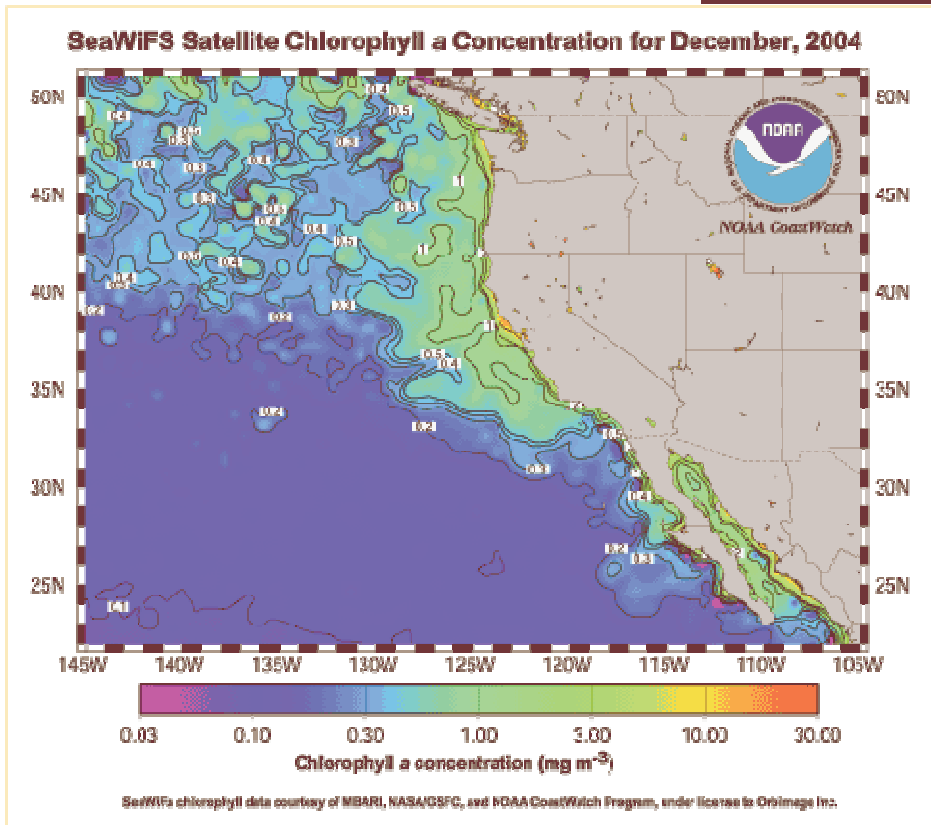
**Nesdis/Ora Scientists First With Sea Level Observations Of Indian Ocean Tsunami From Satellite Altimetry (Oceanography, SOCD)**

The attached figure shows a map of the NOAA/OAR/PMEL model for the December 26, Indian Ocean tsunami at a time slice when the Jason-w satellite altimeter flew across the Indian Ocean, and a comparison of the PMEL model and the NOAA Lab for Satellite Altimetry analysis of the altimeter data. LSA is working with PMEL to use these data to refine our understanding of how tsunamis move across ocean basins. These satellite data are important because the height of the



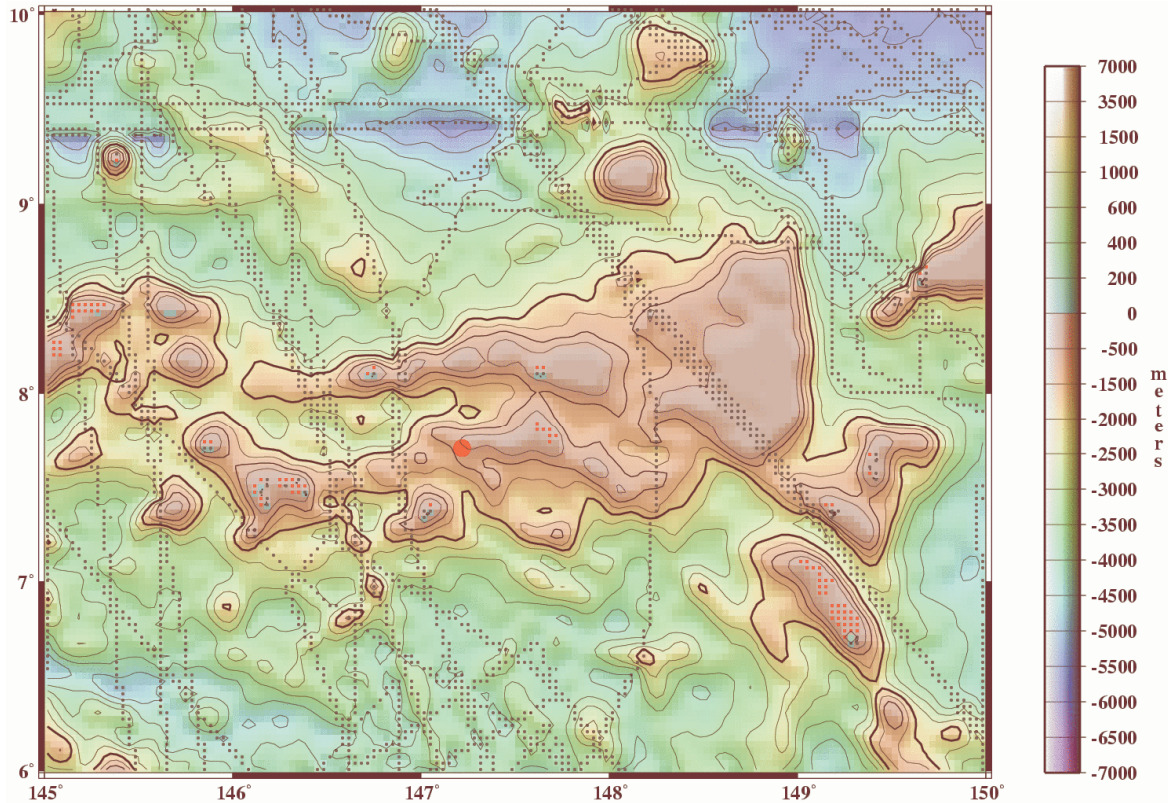
tsunami in the open sea could not be measured by any other means. These data are not received in real time and are not accurate enough to be used for a monitoring and warning system. Altimeter data can be used to improve tsunami hazard forecasting by (1) helping calibrate and validate tsunami wave models and (2) providing better ocean bathymetry maps from which wave energy patterns can be estimated. This is important for demonstrating the use of altimetry for natural hazard for detection and mitigation.

← (caption) Sea level observations from the Jason1 altimeter shows multiple wave crests and troughs radiating across the Indian Ocean with amplitudes as large as 60 cm.



←-- Incorporation of a chlorophyll-a concentration product and a wind stress curl product into the El Niño Watch Report. (Oceanography, SOCD)

**NOAA Satellite Altimeter-Derived Bathymetry Had Mapped Shallows Near Crash Site of *San Francisco*, demonstrating the value of using satellite altimetry to detect submarine hazards. (Oceanography, SOCD).**



Global Topography, Version 8.2 C.I.=500m

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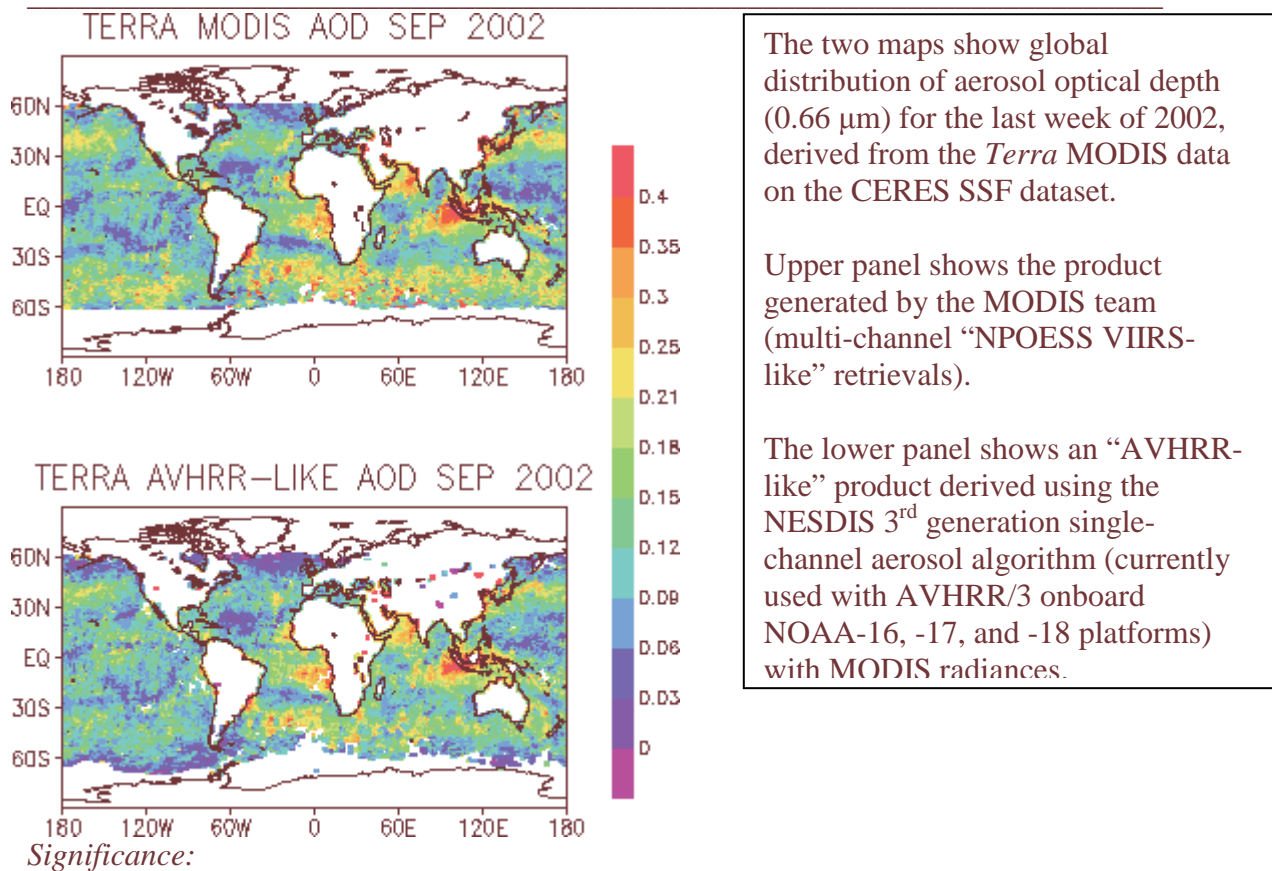
**Soundings (black dots),reefs (small red dots), Depth contours based on combination of altimeter derived gravity anomalies and conventional soundings shows ridge running westward from Tarang Reef to submarine crash site, at estimated depth of ~300m..**

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**Synthetic Aperture Radar Marine User's Manual Published (SOCD)**

The Synthetic Aperture Radar (SAR) Marine User's Manual has just been published by the Government Printing Office. This 464-page manual was developed under the sponsorship of the NOAA/NESDIS/Office of Research and Applications. The intended audience is current and future users of SAR data and derived coastal, ocean, and ice products. The manual consists of twenty peer-reviewed chapters written by an international group of authors from Europe, Canada, and the U.S. There are three overview chapters on the principles of SAR and its use for ocean and sea ice applications. The overview is followed by nine chapters on ocean applications, five chapters on atmospheric applications, and three chapters on sea-ice applications.

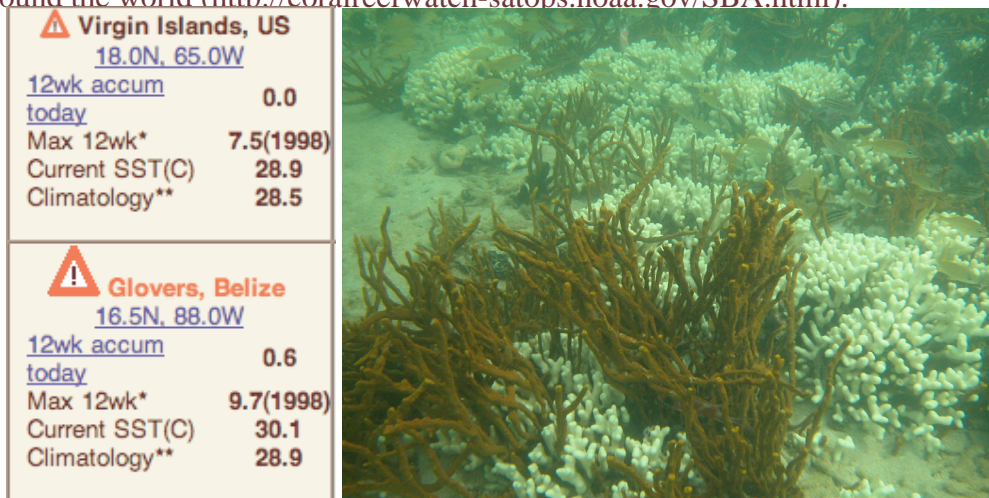
SAR data which show so many oceanic phenomena and the surface manifestation of so many atmospheric boundary layer phenomena are difficult to interpret, especially for inexperienced users. The objective of the manual is: “to lay out, for a wide range of users, the types of information that may be obtained from SAR images of the ocean, and methods of analyzing the imagery. It is intended for non-expert but scientifically literate workers who wish to use synthetic aperture data in their studies but who do not quite know what to make of the data.” This manual will help users of NOAA and National Ice Center SAR products to better understand and use the products we produce. These products include (1) ice analyses and forecasts for safety of vessels at sea and on the Great Lakes, (2) high-resolution coastal winds for safety of coastal ocean transportation and aviation, and (3) vessel positions for fisheries management, monitoring, and enforcement.



**Satellite Bleaching Alerts – Coral Reef Watch’s new operational product for coral reefs:  
(Oceanography, SOCD)**

The NOAA Coral Reef Watch (CRW) just released a new operational satellite warning product for monitoring coral reef health. NOAA's Coral Reef Watch (CRW) Satellite Bleaching Alert (SBA) system is an automated coral bleaching e-mail alert system designed to monitor the status of thermal stress conducive to coral bleaching via the use of the CRW global satellite near-real time HotSpot suite of products. Coral bleaching is an important problem plaguing reefs around the world. Corals “bleach” or lose the algae that live in their tissues when exposed to severe stress, usually high ocean temperatures. If severe enough, bleached corals will die, damaging the entire ecosystem. The SBA was developed by the NOAA CRW satellite team as a tool for coral reef managers, scientists and other interested people. This team includes scientists and

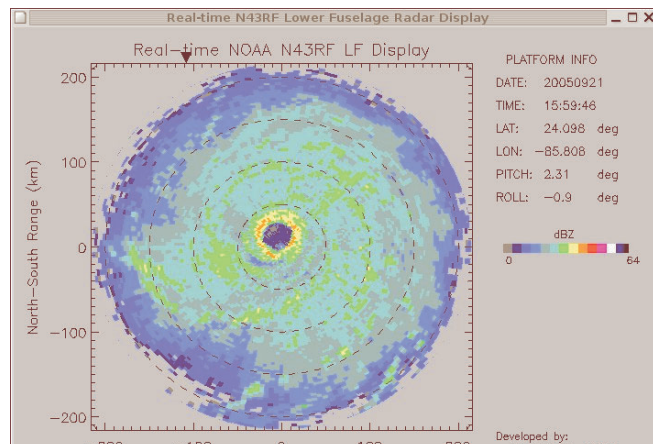
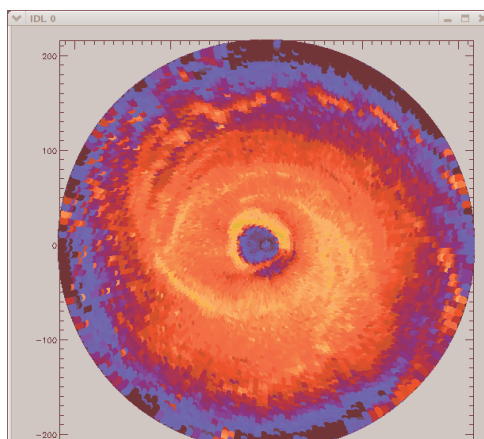
programmers in the NESDIS Office of Research and Applications and programmers in the NESDIS Office of Satellite Data Processing & Distribution. The SBA became officially operational on July 20, 2005. Currently, the alert messages are available for 24 coral reefs around the world (<http://coralreefwatch-satops.noaa.gov/SBA.html>).



Current bleaching alerts from Coral Reef Watch website indicating alert status for reefs in Belize and a photo of current bleaching near Cartagena, off the Caribbean coast of Columbia (image by Szen Zea, Instituto de Investigaciones Marinas).

### Real-Time Transmission of NOAA P-3 Radar Data During Hurricane Katrina (SOCD)

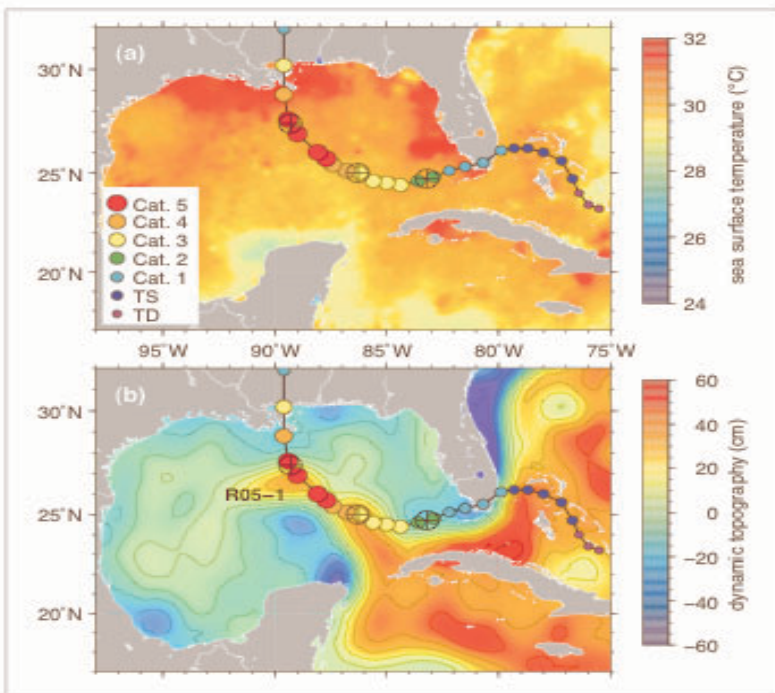
Lower fuselage radar packet data from the NOAA P-3 aircraft was transmitted off the aircraft and displayed sweep by sweep in real-time on the ground for the first time ever. This groundbreaking event is the first step toward the next-generation of real-time transmission of environmental remote sensing data from the NOAA aircraft. This represents a vast improvement over the current antiquated Aircraft-to-Satellite-Data-Link (ASDL) system (300 baud) currently used to transmit limited data off the aircraft for operational use by National Weather Service (NWS). This effort is a collaboration between the NESDIS Ocean Winds program, NOAA Aircraft Operations Center and Remote Sensing Solutions, Inc. In addition to being an invaluable mission planning tool for ocean wind calibration/validation experiment flights, the transmission of even more complex and information rich data from the NOAA P-3 aircraft and, ultimately, the NOAA Gulfstream IV aircraft will prove very important to operational forecasters and the next generation of NWS numerical weather models. The left image below is a lower fuselage radar (C-band) scan of Hurricane Katrina from the NOAA P-3 N43RF (Miss Piggy) on Sunday, August 28<sup>th</sup> prior to landfall in Louisiana before Katrina was in range of the land based NEXRAD systems. The red and yellow colors indicate higher reflectivity values.



The real-time lower fuselage radar data was brought into the National Hurricane Center for the first time via a satellite phone data link. The right image illustrates what was viewable at NHC on a sweep-by-sweep basis from the NOAA P-3 aircraft during a pass through the eye of Hurricane Rita, creating essentially a virtual seat aboard the P-3 on the ground. Getting this data to NHC in real-time was made possible through a collaborative efforts of Remote Sensing Solutions, Inc., NWS/NCO, NHC, AOC, and ORA personnel. While this year's effort was just a demonstration, this sets the stage for significant advancements in the quantity and quality of data that can be made available to assist NHC forecasters/analysts in their decision making process.

**Hurricane Intensification Forecast Tool** *(Oceanography, SOCD)*

The sea level measured by an altimeter is the combined effect of geoid undulations, dynamic ocean topography produced by currents in geostrophic balance, tides, and the ocean's response to meteorological forcing. Popular press suggest that warm ocean surface waters intensified Katrina, but sea surface temperatures were around 30°C almost everywhere along Katrina's path through the ocean (top figure). If intensification was driven predominantly by sea surface temperature, Katrina would have strengthened gradually over time. Instead, Katrina intensified most rapidly when she was over anomalously high areas of dynamic topography measured by altimeters (Figure 2b): first over a warm-core eddy east of Florida as she grew from a tropical depression to a Category-1 hurricane, and then over the Loop Current and warm-core ring R05-1 in the Gulf of Mexico as she intensified from Category 1 to Category 5. These dynamic topography highs are a proxy for the vertically integrated heat content within the water column. It is the depth of the warm water pool, and not merely the temperature at the surface, that provides the reservoir of energy to intensify a storm. Since the dynamic topography changes only slowly over weeks, altimeter data collected long in advance of a hurricane can be used to forecast the potential for intensification.



←- *(Image at left):* The intensification of Hurricane Katrina occurred when the cyclone crossed regions of high oceanic heat content, in regions of high dynamic topography detected by altimetry.

Coincident SST data alone does NOT reveal the threat of hurricane intensification due to the presence of the Loop Current and warm-core rings.

Satellite altimeter measurements of sea surface height are routinely used by NOAA to estimate tropical cyclone heat potential (TCHP),

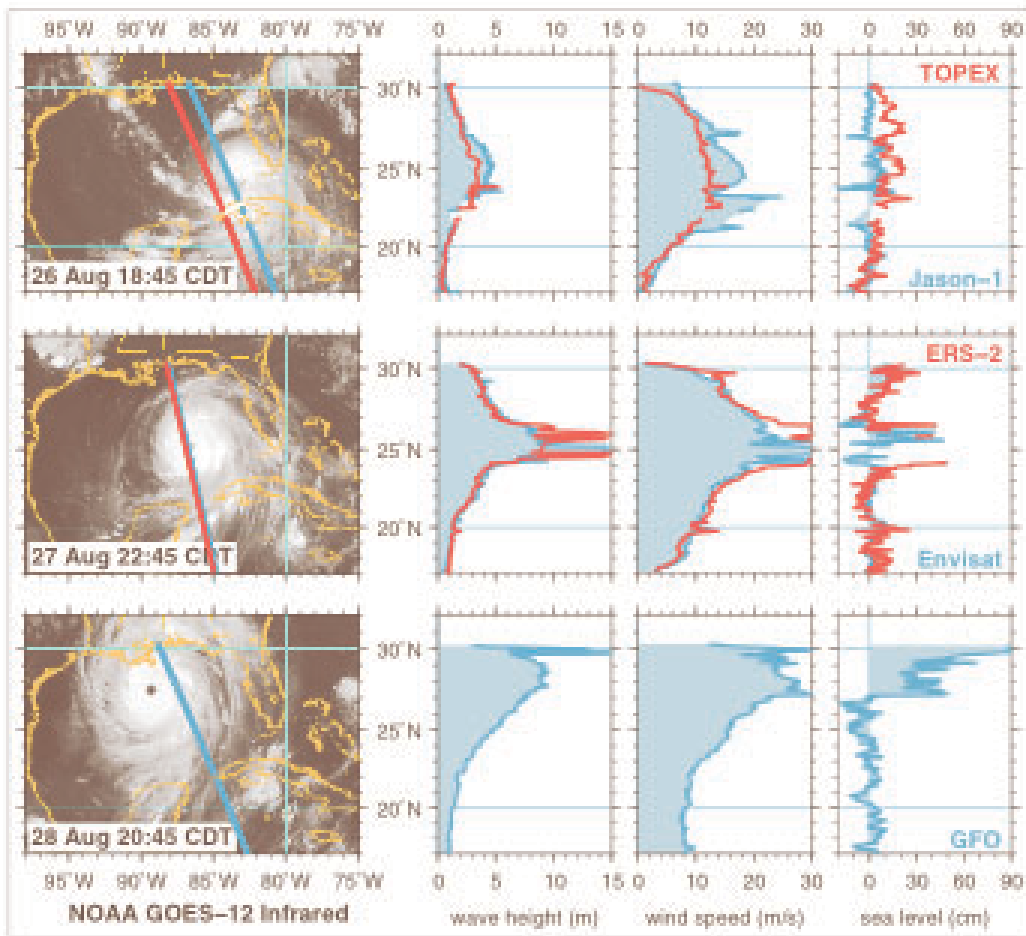
essentially a measure of the amount of heat stored in the upper ocean, and its impact on hurricane intensity. The plot on the bottom shows Katrina intensified to a Category 5 hurricane

as it passed over a region of high TCHP in the Gulf of Mexico. In contrast, the plot on the top shows uniformly warm sea surface temperatures along Katrina's path.

### Hurricane Storm Surge

*(Oceanography, SOCD)*

The panels below show the residual sea level anomaly after removing the geoidal, tidal and geostrophic signals, and an inverse barometer response to atmospheric pressure changes. The bottom of these panels, from the GFO altimeter, shows sea level rising approaching the coast and windward of the eye, reaching 90 cm at the coast; this apparently is the wind-driven storm surge. To our knowledge, this is the first observation of this kind by altimetry.



*(Figure caption):* Observations of wind speed, wave height, and sea level were taken by several altimeters as Hurricane Katrina approached the Gulf Coast. These may be the first direct satellite observations of the storm surge that inundated the region.