EARTH SYSTEM MONITOR

A guide to NOAA's data and information services

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IN THIS ISSUE

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Monitoring Climate and Weather Extremes

Deke Arndt, Chief, Climate Monitoring Branch
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Climate extremes are measures of the limits of how "big" weather events can be for a place: the highest flood, the coldest winter, the longest drought. Extreme climate and weather events are important because they can stress economic conditions, cause damage or even threaten lives.

Extreme events are rare and therefore very unusual, such as the December 2010 storm that brought a total of 6.72 inches of rain to Los Angeles in just two days; an amount equivalent to more than one-third of L.A.'s annual average precipitation. Extremes also differ from one location to another: a snowfall considered extreme in Louisiana would not turn many heads in Vermont.

Yet even rare events can be anticipated. The question is, which extreme events can we prepare for? When building a sea wall, for instance, an engineer will have to make judgments: is it high enough for a 100-year flood? Can we afford to build a wall that can withstand a 500-year flood?

Planners and policy makers must take into consideration the possibility of rare, extreme events. Cities make building codes, zoning rules, and infrastructure decisions that will protect people from harsh effects of extreme events. In New York City, for instance, subway sills and grates were raised a few inches after a series of extreme rain events flooded tunnels and brought the entire subway system to a standstill. Understanding and quantifying climate extremes helps thousands of towns and cities plan for extreme events, affecting policy decisions from watering rules to applications for federal disaster assistance.

In Florida, orange growers know that every once in a while the state will experience a fruit-damaging freeze. Coastal residents know their homes will periodically be threatened by hurricanes. County governments know they will occasionally have to evacuate an area in anticipation of major flooding. Scientists create the records, maps, and analyses of extreme events of the past. In doing so, this helps fruit growers, insurance companies, energy utilities, road builders and others understand where and how often extreme events or disasters are likely to occur in the future. They use the information to plan a safe environment and healthy economy.

How do we define extreme climate and weather events?

Given the significant impact of climate and weather events on people, NOAA tracks these climate and weather extremes to better understand what our climate is capable of delivering as well as how a changing climate impacts these extreme events. There are many ways to monitor extremes, some more complex than others. Perhaps the simplest way to define a weather or climate extreme is by tracking record events: what is the warmest, wettest, driest, or windiest event at a location, for a specific day, or month, or ever? Climate scientists also categorize extreme events according to the probability that they will happen: a flood with a 100-year return period, or "100-year flood" has only a 1 percent chance of occurring in a given year. A 10-year event would have a 10 percent chance of occurring during a given year, and so on.

The Climate Extremes Index (CEI) is one tool developed and used by NOAA's National Climatic Data Center to help us better understand the relationship between climate change and extreme events. Think of the chance, based on a location's historical climate record, weather conditions will occur as a bell curve, with the most common occurrences happening in the middle of the curve,

> *"Yet even rare events can be anticipated. The question is, which extreme events can we prepare for?"*
>
> *-Deke Arndt*

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From the NODC Director


Margarita Conkright Gregg, Ph.D.

Hurricanes, extreme temperatures, coastal inundation and erosion, El Niño Southern Oscillation, coral bleaching, and ocean acidification are just a few of the extreme events that NOAA monitors and predicts. Working with partners, NOAA ensures that climate science and the communication of that science informs decision makers. The National Oceanographic Data Center (NODC) supports these efforts through its mission to provide scientific stewardship to marine data and information.

NODC/National Coastal Data Development Center (NCDDC) produces the NOAA Extreme Weather Information Sheets (NEWIS) each year for the Atlantic hurricane season. NEWIS provides residents with a "one-stop" ready reference containing important contact phone numbers and Internet Web sites for emergency information in their states and local areas. Laminated and waterproof, NEWIS provides an ideal reference to keep at home, in your automobile, or boat. Since points of contact for various agencies change from year to year, NCDDC verifies all contacts, phone numbers, and Web sites listed on each NEWIS annually. NCDDC continues to monitor the information throughout the Atlantic hurricane season and posts any updates as needed. (**www.ncddc.noaa.gov/activities/noaa-extreme-weather-information-sheet-newis**)

Coral reefs are among the most valuable ecosystems on Earth and are facing serious threats from the impacts from climate change, unsustainable fishing, and land-based pollution. Many groups identified climate change and ocean acidification as the most important threats to coral reefs on a global basis. Warmer than usual sea surface temperature (SST) and changes in the ocean water chemistry are two factors that result in the bleaching of corals. NODC helps NOAA monitor the health of the coral reefs by using satellite SST measurements to develop a Coral Reef Temperature Anomaly Database (CoRTAD). Developed in partnership with the University of North Carolina - Chapel Hill and funded by the NOAA Coral Reef Conservation Program, CoRTAD quantifies thermal stress patterns on the world's coral reefs through a collection of global SST data on a weekly time scale. Parameters measured include: SST anomaly (weekly SST minus weekly climatological SST), thermal stress anomaly (weekly SST minus the maximum weekly climatological SST), and other related thermal stress metrics. In addition, NODC hosts NOAA's Coral Reef Information System (CoRIS). CoRIS is designed to be a single point of access to NOAA coral reef information and data products, especially those derived from NOAA's Coral Reef Conservation Program. (**www.nodc.noaa.gov/SatelliteData/Cortad/** and **coris.noaa.gov**)

NOAA produces high-quality ocean products that document the impact of climate on the oceans including estimates of the warming of the ocean. NODC provides estimates of the warming of the world ocean based on historical data. Through acquisition, quality control, and analysis of historical temperature data, NODC's Ocean Climate Laboratory documented a warming trend in Ocean Heat Content that is now featured on NOAA's Climate Portal. (**www.climate.gov**)

These are just some of the examples of how NODC preserves the data that documents extreme events in the oceans. A list of major products and information can be found at **www.nodc.noaa.gov/General/NODC-About/NODC-Major-Products.html**. ■

Margarita

EARTH SYSTEM MONITOR

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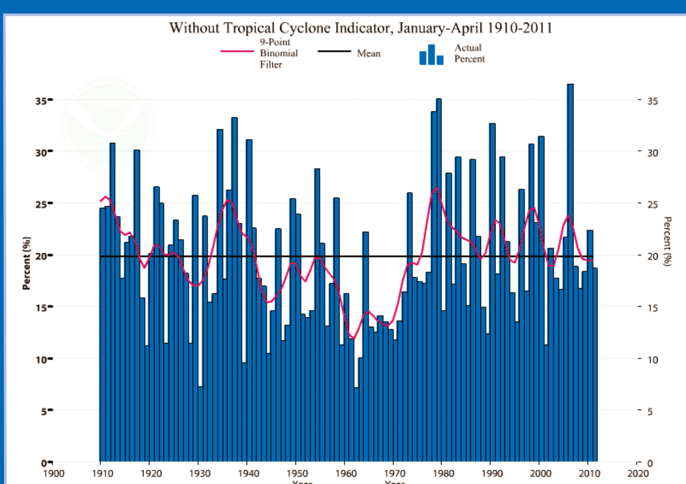
(Monitoring Climate continued from page 1)
and the least common happening in the "tails" on either end. The CEI tracks events that occur in the "tails" of that distribution. Specifically, it tracks "outliers" in the high and low 10 percent of that curve. Or, put another way, the CEI uses this "tenth percentile" approach to define events that are "much below" or "much above" average. The extremes that are part of the CEI include:

- monthly maximum and minimum temperature
- daily precipitation
- monthly drought severity

An "extreme" occurrence is one where the indicator is either much above or much below the average expected. In any given month or year, we expect each of the conditions (in both the "much above" or "much below" category), to have an "extreme" occurrence about 20 percent of the time. We then measure actual occurrences and see if it is more or less than the expected 20 percent. When extreme events occur more than 20 percent of the time in a given year, it can be an important indicator that something is happening in our climate – perhaps due to natural variability like El Niño or the Arctic Oscillation. When it happens over multiple years and decades, it helps us see how human-induced climate change is impacting extreme events.



In the CEI graphic here, we see that 2010 had more than the expected number of extreme events. The CEI score of about 28.6 means that 28.6 percent of the country had weather and climate conditions defined as "extreme". This is almost half again more than the long-term expectation of 20 percent.

Diving deeper into the CEI allows us to see which events, and which seasons, are getting more extreme, by allowing scientists to quantify how our country's climate is changing over time. In recent years, scientists tracking climate extremes have noticed that there have been more warm extremes, such as heat waves, occurring, but fewer cold extremes. For example, a major driver of 2010's higher-than normal value was the broad coverage of much warmer than normal overnight lows, especially in the summer. This has major implications for energy consumption and public health. In addition, the water cycle is becoming more extreme; both the number of extreme single-day rainfall events and the number of days with precipitation are on the rise. Averaged across the country, 2010 was the fourth most extreme year of the last 100 years in terms of extreme single-day precipitation events.

Tools to Help Monitor Climate Extremes – The U.S. Drought Monitor

Drought is another extreme that combines what is going on with the physical climate system versus what people have come to expect. When drought develops it has serious impacts on agriculture, the energy industry, and water supply management. Drought varies according to region and time of year. As temperatures increase, some areas of the United States are likely to see increasing periods of drought. This spring, Texas and other parts of the South and Southwest have experienced record drought conditions, which led to some of the worst wildfires in the history of Texas.

To provide the most up to date climate information on drought, NOAA, in partnership with the U.S. Department of Agriculture, National Drought Mitigation Center, and the Western Regional Climate Center, develops the weekly U.S. Drought Monitor. The U.S. Drought Monitor indicates which areas of the United States are in drought conditions and how severe the drought is. It also points out areas that are dry and could devolve into drought conditions. This weekly information provides people the information to make decisions about current drought, where drought might be developing, and the ability to look at historical drought trends. ■

Additional input from Katy Vincent, NCDC and Jennifer Freeman, American Meteorological Society

2010 Top Ten National Weather/Climate Events

The following table lists the top ten U.S. weather/climate events of 2010. These events are listed according to their overall rank, as voted on by a panel of weather/climate experts. The voters considered factors such as the scope and unusualness of the event, its immediate human and economic impact, and whether it is emblematic of climate trends or variability.

Rank	Event	When Occurred	National Event Description
1	Consecutive Winter Blizzards/ Extreme Snow Season	Winter / February	Winter 2009-10 brought seasonal and storm-total snow records to much of the eastern United States. These were typified by the popularly-named “Snowmageddon” and “Snowpocalypse” events of February.
2	Nashville & Central Tennessee flooding	May 1-5	A stagnant storm system brought 13.53 inches of rain to Nashville May 1-2. By May 2, Nashville had already recorded its wettest May and fifth wettest month on record. Several rivers reached record stages, causing about $1 billion in damage to the area.
3-tie	Hot Summer in the Eastern U.S.	April - September	Warmest summer (June-August) on record for the Southeast U.S. and 10 states. Warmest April–September for 19 states and Southeast, Northeast and Central climate regions. The summer also saw records for energy demand index and the footprint of extreme warm temperatures.
3-tie	Midwest Super Storm	October 26-27	This intense storm system brought heavy rain, hurricane-force winds and tornadoes from the Great Lakes to the Gulf of Mexico. Maximum wave heights exceeded 20 feet on Lakes Superior and Michigan. Wisconsin reported its lowest sea-level pressure in state history.
5	Hawaiian Drought	Throughout 2010	Quite possibly/probably the Drought of Record in modern Hawaiian history. Easily the most significant Hawaiian episode of the U.S. Drought Monitor era (2000-). Nearly one-third of the state in D3+ for most of the year.
6	No hurricanes made U.S. landfall despite active Atlantic	June - November	Despite 19 named Atlantic storms in 2010 (tied for 2nd-most storms during the satellite era), only Bonnie made U.S. landfall (July 23, Miami, as a minimal tropical storm). Hermine existed as a tropical storm over Texas, and made landfall in Mexico.
7	Near Eradication of U.S. Drought	January - September, peaking in July	Never in the ten-year history of the U.S. Drought Monitor did drought conditions cover less than 10% of the U.S. Drought contracted to about 6.6% in January, near the end of winter and again in mid-summer. The mid-summer minimum represents the smallest drought footprint during the history of the USDM.
8	Vivian, SD Hailstone	July 23	This enormous hailstone set national records for diameter (8.0 inches) and weight (1lb. 15 oz). It was preserved for posterity by the National Center for Atmospheric Research. Another stone found Sept. 15 in Wichita, Kan., would have set the national record for diameter if not for the Vivian stone.
9	New England Flooding	February - April	New England had a wet February and a profoundly wet March, when several states hadtheir wettest March on record. This culminated in several historic flood events lasting into April.
10	Minnesota as tornado leader	Calendar year	Minnesota’s 104 tornadoes not only shattered its annual record, but easily led the nation for tornadoes reported (and confirmed) in 2010. In the 60 years prior, Minnesota had finished in the top five just four times, peaking with fourth-most.

For more information go to:
www.ncdc.noaa.gov/special-reports/national-top-ten-2010.html

NOAA’s National Climatic Data Center
Asheville, North Carolina

Protecting the past... Revealing the future

Predicting Extreme Marine Events

Bruce Parker, PhD, Visiting Professor, Center for Maritime Systems, Stevens Institute of Technology

The new book *The Power of the Sea: Tsunamis, Storm Surges, Rogue Waves, and Our Quest to Predict Disasters* begins with these two sentences: "When the sea turns its enormous power against us, our best defense is to get out of its way. But to do that we must first be able to predict when and where the sea will strike."

This is not a new revelation. Ancient peoples living by the sea or traveling on the sea were well aware of its dangers, and they were desperate to find ways to predict when those dangers would occur. Many deadly examples of such dangers are dramatically portrayed in this book: millions killed over the centuries by storm surges ravaging the coasts of Bangladesh, India, and the countries around the North Sea; thousands of ships lost at sea to rogue waves; many millions dying in Asia due to the drought and famine caused by two strong El Niños at the end of the nineteenth century; and more recently 300,000 lives lost in less than two hours on December 26, 2004, due to the Indian Ocean tsunami. Even the tides have killed (before mariners learned how to predict them) – destructive tidal bores and tidal whirlpools, and great tidal heights rapidly covering mudflats and drowning fishermen who were there digging up shellfish.

Yet, with the exception of the tides, none of these marine phenomena were predictable until the twentieth century. Why it took so long and how ocean phenomena came to be very slowly understood over the centuries account for many fascinating stories in the book, interweaved among the compelling stories of marine disasters. One key aspect of all these stories (which should be especially appreciated by the readers of *Earth System Monitor*) was the critical importance of the observations made of the ocean (and the atmosphere) and how these data led to the understanding of ocean dynamics. Eventually such data would also be crucial to a variety of marine prediction techniques.

The tides were the first ocean phenomenon to be observed and then predicted because they were produced by the gravitational effects of the moon and the sun and thus ancient philosophers and mariners could study the night sky and see correlations between the movement of the sea's surface and the movement and phases of the moon. Seleucus, a Hellenistic mathematician in Babylonia, was probably the first person to produce an oceanographic data series when, around 150 BC, he tabulated the times and heights of high and low waters at the northern end of the Persian Gulf. That data record must have been at least a month long because in it he was able to recognize that the two high tides on any given day could be quite different in height. He also saw that this difference varied throughout the month being the greatest when

"Die erschreckliche Wasser-Fluth" ("the terrible flood waters"), an etching of the destruction caused by the 1634 storm surge along the coast of North Friesland (Germany).

the moon is farthest north or farthest south of the equator (this is now known as the diurnal inequality). Even though the cause of the tides would not be understood until two thousand years later when Isaac Newton explained how the gravitational effect of the moon and sun generated the tides, ancient mariners could still crudely predict the tides based on these correlations they saw with the moon. It would be much more difficult to predict other more deadly oceanographic phenomena, such as storms surges, wind waves, and tsunamis.

Storm surges produced by tropical cyclones and gales, sometimes thirty or even forty feet high, have been the most deadly of all ocean phenomena, violently flooding large coastal regions and drowning anyone who had not been warned to leave. Such warnings, however, would not be possible until a great deal of water level, wind, and atmospheric pressure data was obtained and studied. This did not really begin until the mid 1800s, when data from ships on the Bay of Bengal and from along its vulnerable coasts were collected by the British when they first set up a Meteorological Department in India. Over the next century, scientists from all over the world were involved in the stories about our progress in understanding storm surges (while millions continued to die, often in terrifying ways).

Predicting large wind waves was even more difficult because, as we now know, in addition to waves generated by winds in a local storm, waves can reach a particular location as long swell from many distant storms around the oceans. It would not be until World War II, when the Allies needed to be able to predict the size of the surf on the beaches where they would land their troops (such as on the beaches of Normandy on D-day), that the first successful wave forecasting technique was developed by Walter Munk and Harold Sverdrup at Scripps. It was based on a great deal of wave data measured under a variety of wind conditions. A hundred years earlier in 1852 Thomas Stevenson, one of four generations of the lighthouse-building Stevenson family of Scotland, measured wave heights every day. That data demonstrating for the first time the importance of fetch (the distance over which the wind blows) in determining wave heights. But it took the much more detailed data of Munk and Sverdrup to produce the wave prediction algorithm eventually used for Allied amphibious landings. Now with global wave models and data from satellites, wave buoys, and other instruments, we finally do a good job of wave prediction, although we have not yet been able to predict when rogue waves will occur (but we are getting closer).

Predicting tsunamis has been even more difficult. Since we cannot predict earthquakes, we must wait for an underwater earthquake to occur and then wait for a tide gauge or a DART buoy to indicate that a tsunami has been generated (since most underwater earthquakes do not generate tsunamis) before we can use that data in hydrodynamic models to predict when the tsunami will strike particular coasts. But for an earthquake epicenter very close to the coast there is not enough time. The 2004 Indian Ocean tsunami hit northwest Sumatra only 15 minutes after the initial earthquake. The 2011 Japan tsunami first hit the Japanese coast only 30 minutes after the earthquake began. Still, we have come a long way since 1755 when the tsunami produced by the submarine earthquake near Lisbon, Portugal, provided data from all over Europe, North Africa, and even across the Atlantic in the Caribbean. That data allowed John Michell (at Queen's College in Cambridge, England) to first show that tsunamis were very, very long waves that traveled faster in deep water than in shallow water (which was why the tsunami reached islands in the Caribbean before it reached Wales).

Of course, trying to predict El Niño and climate change requires huge amounts of data of all types. We have had some success in predicting El Niños (the prediction models doing well only if great amounts of global data are input into them). We have had less success with detailed regional prediction of climate change, a problem with great complexity and chaotic influences, and less data available over the very long relevant timescale of the problem (and hence the importance of paleo data and data archaeology).

This very short overview, of course, leaves out many fascinating stories (found in the book) of how particular scientists and mariners learned—usually from data—how and why these phenomena occurred. But even from this short article it should be clear how critical ocean and atmospheric data are to our understanding and prediction of geophysical phenomena. ■

Etching of the 1755 tsunami striking Lisbon, Portugal (from the 1887 book by G. Hartwig, *Volcanoes and Earthquakes*).

The History of Ocean Instrumentation - The First Half of the Twentieth Century

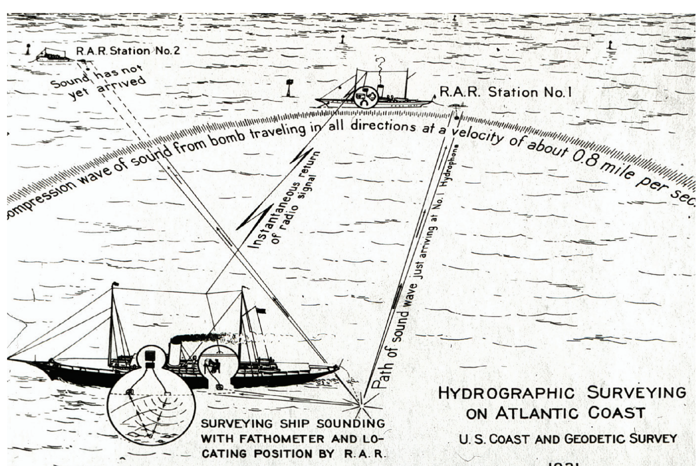
Captain Albert E. Theberge, Jr., NOAA Corps (Ret.), Acting Chief of Reference, NOAA Central Library

The Twentieth Century began with literal whisperings from two technologies that would profoundly influence oceanography and our ability to observe and measure various parameters within the oceanic environment. Wireless telegraphy—better known as radio—was in its infancy as was the first practical use of underwater acoustics, developed by American engineers at Submarine Signal Company (a forerunner of Raytheon Corporation). From the standpoint of oceanography, the use of acoustics developed much quicker as it was not until just prior to World War II that oceanography benefited directly from radio transmission.

At the turn of the Twentieth Century Submarine Signal Company, led by Arthur Mundy and Elisha Gray, began experimenting with horizontal sound transmission in the ocean for both undersea communication and as a means of positioning vessels. Tests in 1901 demonstrated that sound could be transmitted and received at a distance of up to eight miles. Following this success, Submarine Signal placed its sound sources on buoys and lightships and equipped merchant and naval vessels with receiving equipment that helped guide ships to port by a system somewhat akin to radio direction finding. Because of the TITANIC disaster in 1912, interest was generated in developing a system of locating hazards to navigation. Reginald Fessenden, a Canadian scientist, was hired by Submarine Signal and within a short time had developed an electro-acoustic transducer that was capable of both transmitting and receiving acoustic signals. The birth of modern ocean acoustics could be fairly said to have begun with Fessenden's test of his "Fessenden Oscillator" off the Coast Guard Cutter Miami on April 27, 1914, when this 1500-pound transducer reflected sound off both the bottom and an iceberg at distances up to two miles.

In the United States these efforts were led by Submarine Signal and inspired scientists such as Harvey Hayes of the United States Navy Hydrographic Office, who developed the Hayes Sonic Depth Finder. In 1923 the USS Stewart, which was equipped with a Hayes system, made a transit of the Atlantic Ocean from Boston to Gibraltar taking 900 soundings along the way. The soundings were taken at will and did not require the ship to slow or stop. The ocean science community took note and piano-wire sounding ceased to exist soon after. It was also only a short time until continuously recording devices were developed that allowed graphical displays of bottom profiles to be made, eliminating a source of human error in depth measurement. The German Meteor Expedition of 1925 to 1927, and subsequent Meteor expeditions, used this new technology to map the Mid-Atlantic Ridge along a series of transects that led to the discovery of abyssal hills, numerous seamounts, and even the ridge median valley by Gunter Dietrich prior to World War II. Concurrently, the United States Coast and Geodetic Survey began surveying the continental shelf and slope off the United States, discovering numerous canyons far offshore. They also ran a number of transects across the Gulf of Alaska that determined the configuration of the Aleutian Trench and discovered numerous chains of seamounts. Suddenly the seafloor was no longer a flat featureless plain but was peppered instead with great mountains and ridges; canyons as grand as the Grand Canyon running down the continental slopes; and the first hint of what later became known as fracture zones with discovery of the Mendocino Escarpment in 1935.

While depth measuring devices were being developed, the use of acoustics for navigation and detection of objects in the water continued. In 1923, Submarine Signal improved its acoustic navigation system by transmitting a coded radio signal prior to transmitting an underwater acoustic signal. The Coast and Geodetic Survey inverted this system for surveying, used explosives for the sound source, and placed hydrophones at known locations. Reception from two or more hydrophone stations gave a position by intersecting ranges. The system, called Radio Acoustic Ranging (RAR), was used to survey at distances up to 200 miles from shore stations. RAR and acoustic depth measurement led to developments in other aspects of oceanography including better understanding of the sound velocity structure of the ocean; the development of telemetering oceanographic instruments; and, because of experience using explosives, a step towards developing



Graphic demonstrating Radio Acoustic Ranging (RAR). Developed in 1923, RAR was the first non-visual navigation system. Combined velocity of sound in water with radio to obtain fix.

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NEWS BRIEFS

IODE Celebrates 50 Years

To mark its 50th anniversary, the International Oceanographic Data and Information Exchange Programme (IODE) organized an Anniversary International Conference to demonstrate its vision to new challenges faced by the data and information management communities and its contribution to the capacity building and the society's needs for data and information products. IODE is part of the Intergovernmental Oceanographic Commission (IOC) under the United Nations Educational Scientific and Cultural Organization (UNESCO). Its purpose is to enhance marine research and development, by facilitating the exchange of oceanographic data and information between participating Member States, and by meeting the needs of users for data and information products.

Formally, IODE started out as the Working Group on Oceanographic Data Exchange, which was created by the First IOC Assembly in 1961. The IODE system forms a worldwide service oriented network consisting of Designated National Agencies (DNAs), National Oceanographic Data Centres (NODCs), Responsible National Oceanographic Data Centres (RNODCs), and World Data Centres – Oceanography (WDCs). During the past 50 years, IOC Member States have established more than 80 oceanographic data centers in as many countries. This network has been able to collect, quality control, and archive millions of ocean observations, making them available to Member States. The IODE Program reviews all ocean-related data including physical, chemical, biological, etc. Another major long-term commitment of the IODE Program is the long-term accessibility and archival of oceanographic data, metadata, and information to safeguard present and future holdings against loss or degradation. In today's information-rich environment the IODE program, due to IOC's role as UN focal point for ocean matters, will also increasingly play an active role in guiding users to information through the development and maintenance of specialized Portals and clearing-house mechanisms. For more information on IODE, see **www.iode.org**.

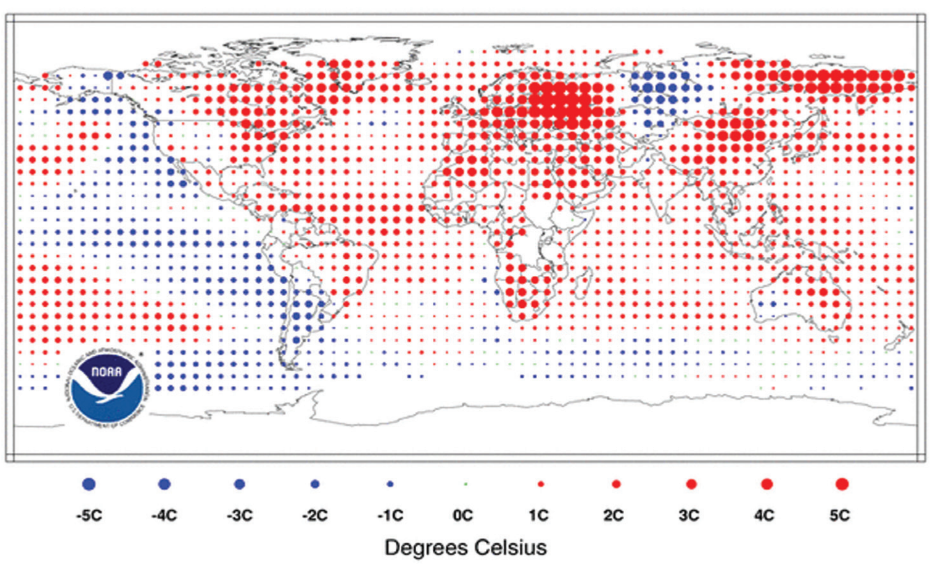
Natural Variability Main Culprit of Deadly Russian Heat Wave

A natural atmospheric phenomenon often associated with weather extremes caused the deadly Russian heat wave that killed thousands of people in summer 2010, according to a new NOAA study. While scientists could not attribute the intensity of this particular heat wave to climate change, they found that extreme heat waves are likely to become increasingly frequent in the region in coming decades.

The research team reviewed scientific observations and computer climate model runs to evaluate the possible roles of natural and human-caused climate influences on the severity of the heat wave. The study was accepted for publication in Geophysical Research Letters, a publication of the American Geophysical Union.

Scientists at NOAA's Earth System Research Laboratory (ESRL) mentioned that "knowledge of prior regional climate trends and current levels of greenhouse gas concentrations would not have helped us anticipate the 2010 summer heat wave in Russia."

Temperatures in the upper 90s to above 100 °F scorched western Russia and surrounding areas from July to mid-August 2010. In Moscow, the long-term daily average temperatures for July range from 65 °F to 67 °F. In 2010, daily average July temperatures soared up to 87 °F. These included night measurements. The exceptional heat over such a long duration combined with poor air quality from wildfires increased deaths by at least 56,000



Map of observed global temperature anomalies for July 2010, from NOAA analyses produced by the National Climatic Data Center (NCDC). Anomalies are determined with respective to the base period 1971 to 2000.

in Moscow and other parts of western Russia, according to a Russian insurance company. These factors also led to massive crop failures in the region.

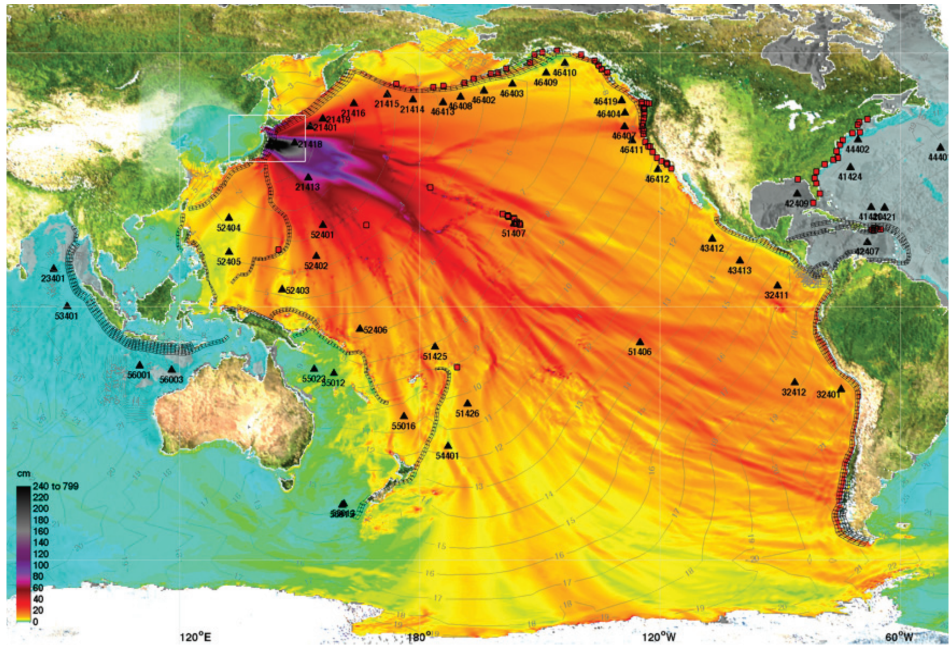
While a contribution to the heat wave from climate change could not be entirely ruled out, if it was present, it played a much smaller role than naturally occurring meteorological processes in explaining this heat wave's intensity.

The researchers cautioned that this extreme event provides a glimpse into the region's future as greenhouse gases continue to increase, and the signal of a warming climate, even at this regional scale, begins to emerge more clearly from natural variability in coming decades. Climate models evaluated for the new study show a rapidly increasing risk of such heat waves in western Russia, from less than 1 percent in 2010, to 10 percent or more by the end of this century.

NOAA Promotes Tsunami Preparedness

In the wake of Japan's tsunami disaster, NOAA is urging Americans who live and vacation at the coast to take the threat of tsunamis seriously. With more coastline than any other country in the world and a close proximity to several major fault lines, the Pacific, Atlantic, Gulf, and Caribbean coasts of the United States are vulnerable to tsunamis. NOAA's National Weather Service (NWS), which operates the U.S. tsunami detection and warning system, says that when a tsunami threatens the key to survival is staying informed and moving quickly to higher ground.

In a message issued by the White House, President Barack Obama acknowledged that although the danger posed by tsunamis cannot be eliminated, NOAA's efforts within the National Tsunami Hazard Mitigation Program to work with local communities on hazard assessment, evacuation planning, and educational outreach can help save lives by equipping citizens to effectively respond to emergency situations.



The Honshu, Japan tsunami was generated by a 9.0 earthquake. In approximately 25 minutes, the tsunami was first recorded at DART® buoy 21418. The graphic above was created with the NOAA forecast method using MOST model with the tsunami source inferred from DART® data.

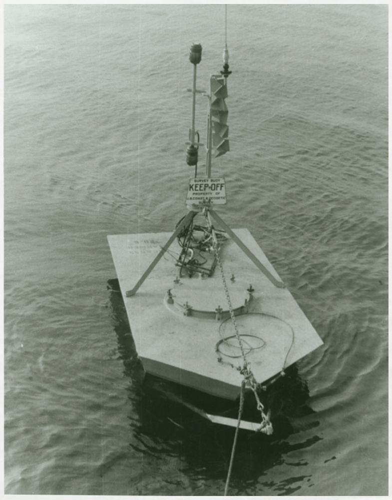
Following the deadly 2004 Indian Ocean tsunami, Congress provided NOAA with more than $150 million to expand the Nation's tsunami detection and warning capabilities, as well as outreach and research. Congress also provided support for a global tsunami warning and education network. As a result of this investment, the Nation and the world are better prepared for the next tsunami. For example, 83 U.S. coastal communities have earned the NWS TsunamiReady™ designation, up from only 11 in 2004. This program prepares emergency managers to warn citizens during a tsunami emergency.

NWS operates two tsunami warning centers: one in Palmer, Alaska, and the other in Ewa Beach, Hawaii. The centers, staffed 24/7, issue tsunami alerts (watches, warnings, advisories, and information statements) as early as two minutes after an earthquake. Upon receipt of tsunami alerts, state and local emergency management agencies determine the appropriate response, including whether to clear the beaches, sound sirens, or evacuate people.

NOAA's NWS is the primary source of weather data, forecasts and warnings for the United States and its territories. NOAA's NWS operates the most advanced weather and flood warning and forecast system in the world, helping to protect lives and property and enhance the national economy.

The tsunami in Japan should also serve as a crucial reminder for all Americans to take the time to get prepared before disaster strikes. Visit **www.ready.gov** to learn how.

(Ocean Instrumentation continued from page 7)
oceanic seismic reflection and seismic refraction techniques. During World War II, the exploitation of the Sound Fixing and Ranging (SOFAR) long-distance sound channel by Maurice Ewing can be traced directly to RAR and associated studies of acoustic ray-paths.



Buoy for deploying Roberts Radio Current meter.

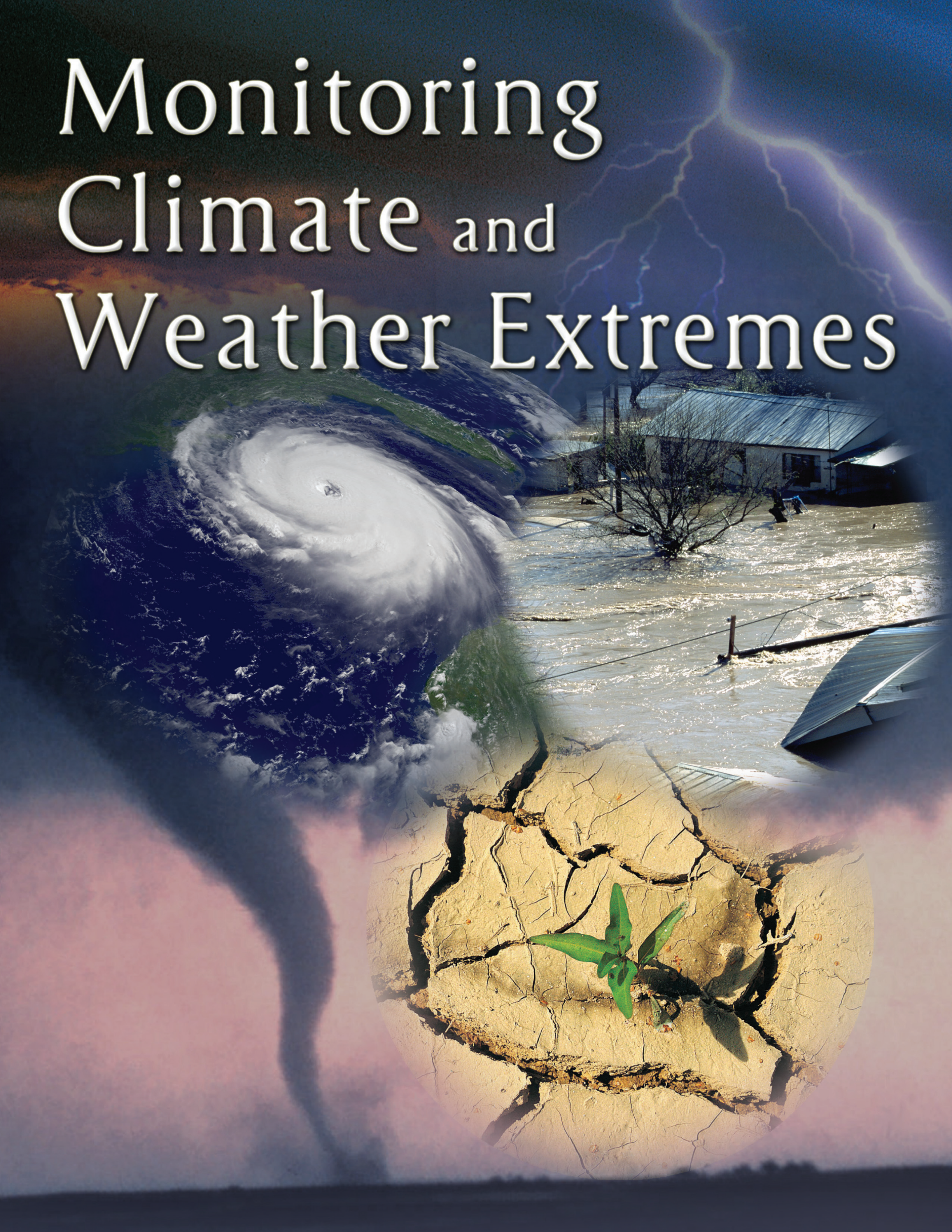
Perhaps the first remotely operated telemetering oceanographic instruments were the radio sono-buoys developed for RAR hydrophone stations. These buoys were developed for use in lieu of manned station vessels and were equipped with a hydrophone strung below the buoy, a radio-transmitter, and battery pack for power. By 1942, the concept of equipping buoys with current measuring devices and transmitting information automatically acquired to a processing shore station came to fruition with the development of the Roberts Radio Current Meter—named for its inventor, Lieutenant Elliott B. Roberts, an officer of the Coast and Geodetic Survey. As with RAR sono-buoys, these buoys replaced manned vessels that had to remain on-site at a single station for a series of observations.

While acoustic depth-measurement and navigation systems showed steady improvement during the period prior to World War II, the instruments of deep-ocean physical oceanography remained relatively static until the late 1930s. However, this changed radically with Athelstan Spilhaus' invention of the mechanical bathythermograph (MBT), an instrument designed to obtain a continuous temperature profile down to a depth of a few hundred feet. As originally designed, the instrument required that a vessel be stopped for lowering. However, with the looming submarine threat of the war and the necessity to rapidly assess the acoustic environment, Maurice Ewing and Allyn Vine of Woods Hole Oceanographic Institution (WHOI) redesigned the MBT as a torpedo-shaped instrument that could be towed at speeds up to twenty two knots. During the war and for the following twenty years, the MBT was a standard oceanographic tool. However, because of various inaccuracies and limitations, it ultimately gave way to the development of expendable bathythermographs and advanced tethered instruments. Today only a few MBT's survive as museum pieces.

The urge to observe in their natural environment the biota and geology of the deep ocean led to the development of deep ocean photography. Two systems were developed in the late 1930's, the first by E. Newton Harvey, a biologist from Princeton University who was attempting to photograph the biota in the water column of the deep sea. The second system was developed by Maurice Ewing, Allyn Vine, and Joe Worzel of WHOI, who were interested in what the floor of the deep sea looked like. The Harvey pressure case was rated to two miles below the surface while the WHOI system ended up taking pictures at significantly deeper depths. Both systems were lowered by wire, the Harvey system used bait to attract biota (with minimal success), while snapping photos at set intervals. The Ewing camera was basically rigged on a pole and set to activate a flash and take pictures upon touching bottom, and was then retrieved. Ultimately the Ewing camera system, in various iterations, took thousands of still photos of the seafloor while the problems of trying to obtain pictures of creatures that moved and were separated in space, proved insurmountable. Harvey's conclusion after several tests was that "…deep nekton fish are not abundant and not attracted to the luminous lure that was used." The first use of a tethered television system was in 1947 while scientists were checking the damage to surplus ships sunk as a result of nuclear testing at Bikini Atoll.

While remote sensing of the marine environment forged ahead, humans were also making their first direct observations of the deep sea during this period. Beginning in the early 1930s, William Beebe and Otis Barton of the American Museum of Natural History began making a series of descents in their "bathysphere," a spherical steel ball with viewing ports that was suspended by a steel cable from a surface ship. Incredibly brave, approaching foolhardy, Beebe and Barton were lowered as deep as ½ mile below the surface by 1934. Beebe captured the wonder of what he had seen: "It leaves the mind in a maze of wonder - to think of having seen these hidden multitudes, many most delicate and fragile, moving swiftly on their missions in life - avoiding their enemies, searching for food and finding mates; and all amid this black, ice-cold water with nearly a half-ton of weight crushing down upon every square inch." A few short years later Jacques Cousteau and Emil Gagnon developed the self-contained underwater breathing apparatus, now known as SCUBA. At least in shallow water, humans had become untethered from the surface and free to explore and study the sea at will.

By 1950 enough had been discovered of the sea that, to paraphrase Beebe, many minds had been left "in a maze of wonder." What creatures were left to discover, what was the pattern of oceanic circulation, what did the configuration of oceanic mountain ranges and trenches have to tell us of the history of the Earth, and how was life distributed through the sea? These and many other questions remained to be answered. (To be continued next issue.) ■



Monitoring
Climate and
Weather Extremes

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Can a Book Raise Public Awareness About the Importance of Ocean Science and Ocean Data?

Bruce Parker, PhD, Visiting Professor, Center for Maritime Systems, Stevens Institute of Technology

When Bruce Parker left NOAA a few years ago, as the chief scientist of the National Ocean Service (earlier he was Director of the World Data Center A for Oceanography at NODC), his primary motivation was to have time to write some books. Although the first book he wrote was technical—a 400-page introductory text, *Tidal Analysis and Prediction*, published by NOAA—during the couple of years it took to write it, he was busy collecting historical stories for his second book. This second book was aimed at a general audience, and it was meant to raise public awareness about the impact that the oceans have on their lives and thus about the importance of ocean science. But how does a book essentially about ocean physics compete with popular books about whales and porpoises? The idea was to tell dramatic stories of various marine disasters and interweave fascinating stories of how scientists and mariners learned about those ocean phenomena that can destroy millions of lives. The book would essentially be a history of marine prediction, but presented in a way that the science is learned through the stories. The result was *The Power of the Sea: Tsunamis, Storm Surges, Rogue Waves, and Our Quest to Predict Disasters*. How much it will raise public awareness, and how much that might help increase Congressional support for NOAA's programs remains to be seen. During the recent Japan tsunami tragedy, Dr. Parker did many TV, radio, newspaper, and Web interviews, and also wrote an article for The Wall Street Journal. We cannot wait for the next marine disaster to provide us with an opportunity to educate the public, as we should be looking all the time for interesting ways to make them more aware. ■