in the form of parameters indicating which of three discrete conditions represents the current state of damage and the corresponding action recommended to end users. The three condition/action combinations were denoted "OK" (no damage and no action necessary), "inspect" (initial pitting), and "shutdown" (severe pitting).

The upper part of the figure depicts the FM4, NA4 Reset, and oil-debris data from one experiment during which pitting damage occurred. The lower part of the figure shows the corresponding output of the data-fusion model. Readings were taken once per minute. The triangles indicate when the gear was inspected for damage. As shown in the photograph connected to the second triangle, damage began to occur at approximately reading 2,669 during this experiment. Analysis of the data collected during this and the other experiments confirmed the expectation that it is advantageous to fuse features of data obtained through different sensors and that, as desired, the output of the data-fusion model amounts to clear, reliable information that can be used in making decisions about the health of the affected gears.

This work was done by Paula Dempsey of **Glenn Research Center**. *Further information is contained in a TSP (see page 1).*

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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Refer to LEW-17889-1.

Forecasting of Storm-Surge Floods Using ADCIRC and Optimized DEMs

Maximum water levels are mapped for Hurricanes Camille and Katrina.

Stennis Space Center, Mississippi

Increasing the accuracy of storm-surge flood forecasts is essential for improving preparedness for hurricanes and other severe storms and, in particular, for optimizing evacuation scenarios. An interactive database, developed by WorldWinds, Inc., contains atlases of storm-surge flood levels for the Louisiana/Mississippi gulf coast region. These atlases were developed to improve forecasting of flooding along the coastline and estuaries and in adjacent inland areas. Storm-surge heights depend on a complex interaction of several factors, including: storm size, central minimum pressure, forward speed of motion, bottom topography near the point of landfall, astronomical tides, and, most importantly, maximum wind speed.

The information in the atlases was generated in over 100 computational simulations, partly by use of a parallel-processing version of the ADvanced CIRCulation (ADCIRC) model. ADCIRC is a nonlinear computational model of hydrodynamics, developed by the U.S. Army Corps of Engineers and the US Navy, as a family of two- and three-dimensional finite-element-based codes. It affords a capability for simulating tidal circulation and storm-surge propagation over very large computational domains, while simultaneously providing high-resolution output in areas of complex shoreline and bathymetry. The ADCIRC finite-element grid for this project covered the Gulf of Mexico and contiguous basins, extending into the deep Atlantic Ocean with progressively higher resolution approaching the study area. The advantage of using ADCIRC over other storm-surge models, such as SLOSH, is that input conditions can include all or part of wind stress, tides, wave stress, and river discharge, which serve to make the model output more accurate.

To keep the computational load manageable, this work was conducted using only the wind stress, calculated by using historical data from Hurricane Camille, as the input condition for the model. Hurricane storm-surge simulations were performed on an eight-node Linux computer cluster. Each node contained dual 2-GHz processors, 2GB of memory, and a 40GB hard drive. The digital elevation model (DEM) for this region was specified using a combination of Navy data (over water), NOAA data (for the coastline), and optimized Interferometric Synthetic Aperture Radar data (over land). This high-resolution topographical data of the Mississippi coastal region provided the ADCIRC model with improved input with which to calculate improved storm-surge forecasts.

Also used in the simulations was a commercially developed rainfall inundation model that originated in research performed for a NASA dual-use project. The rainfall model accepts as input an eleva-

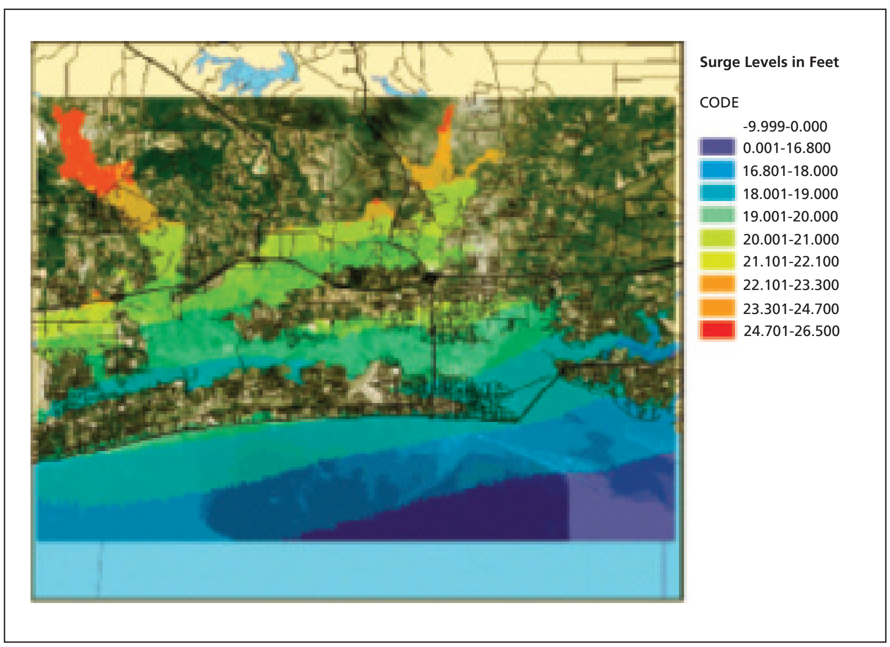

Figure 1. This **MEOW Map** shows the maximum storm surge at each finite-element node based on all simulations of category-3 hurricanes in the affected area.

tion grid, coordinates to a source cell, and the desired inundation level. Software utilities that accompany the model translate United States Geological Survey digital elevation maps, as well as ASCII grids, into the correct format. The source cell is specified in the coordinates of the elevation grid, and the inundation level (a floating-point number) is specified in a unit of measurement compatible with that used for the input elevation. The rainfall simulations were performed for various hurricane landfall scenarios that included different intensities, storm sizes, forward speeds, and landfall locations.

Typically, each hurricane simulation, started 3 days of simulated time before Camille's landfall, took about 5 hours of computing time in parallel processing on all sixteen processors. The results of the ADCIRC and rainfall simulations were composited to determine the highest storm-surge value possible for each grid node; the resulting maps are known as maximum envelope of water (MEOW) maps.

Figure 1 shows the maximum storm surge for a Category 3 storm in the vicinity of the back bay of Biloxi, MS. The maximum storm surge is approximately 20 ft (≈6 m) inside the bay. Over most of the bay area, the storm surge varies between 15 and 25 ft (≈4.5 and 7.6 m). Published ground measurements at various discrete locations during Hurricane Camille show that a maximum storm surge of over 22 ft (≈6.7 m) occurred at Pass Christian, MS, west of Biloxi. Emergency planners and local government officials make public evacuation plans based on MEOW maps.

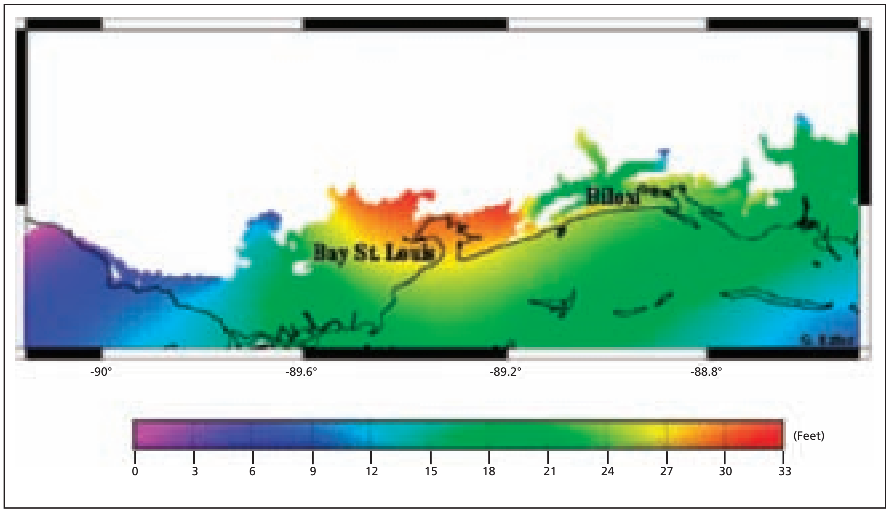

Figure 2. **ADCIRC Calculated Storm-Surge Heights** for Hurricane Katrina on August 29, 2005, at 11 a.m. local time. This image shows a 25- to 30-ft (≈4.5- to 9.1-m) storm surge in the Bay St. Louis and Pass Christian communities.

Figure 2 depicts ADCIRC computer model simulation of Hurricane Katrina's storm surge, showing a 25- to 30-ft (≈4.5- to 9.1-m) wall of water, pushed by 140-mph (≈225-km/h) winds, slamming into the Louisiana/Mississippi Gulf Coast. The maximum surge from Katrina was higher than Camille and covered a wider region, even though the intensity of the wind was slightly less. This happened because Katrina's strong winds covered a larger area and Katrina moved more slowly than Camille, allowing more time for the water to accumulate.

At the time of this reporting, technical support and parallel-computing resources have been provided to the Louisiana Department of Natural Resources, one private firm, and NASA, to model hurricane storm-surge flooding in southeastern Louisiana and along the Mississippi Gulf Coast.

This work was done by Elizabeth Valenti and Patrick Fitzpatrick of WorldWinds, Inc. for **Stennis Space Center**.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for the commercial use should be addressed to:

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Refer to SSC-00229, volume and number of this NASA Tech Briefs *issue, and the page number.*

User Interactive Software for Analysis of Human Physiological Data

Ames Research Center, Moffett Field, California

Ambulatory physiological monitoring has been used to study human health and performance in space and in a variety of Earth-based environments (e.g., military aircraft, armored vehicles, small groups in isolation, and patients). Large, multi-channel data files are typically recorded in these environments, and these files often require the removal of contaminated data prior to processing and analyses.

Physiological data processing can now be performed with user-friendly, interactive software developed by the Ames Psychophysiology Research Laboratory. This software, which runs on a Windows platform, contains various signal-processing routines for both time- and frequency-domain data analyses (e.g., peak detection, differentiation and integration, digital filtering, adaptive thresholds, Fast Fourier Transform power spectrum, auto-correlation, etc.). Data acquired with any ambulatory monitoring system that provides text or binary file format are easily imported to the processing software.

The application provides a graphical user interface where one can manually select and correct data artifacts utilizing linear and zero interpolation and adding trigger points for missed peaks. Block and moving average routines are also provided for data reduction. Processed data in numeric and graphic format can be exported to Excel. This software, PostProc (for post-processing) requires the Dadisp engineering spreadsheet (DSP Development Corp), or equivalent, for implementation. Specific processing routines were written for electrocardiography, electroencephalography, electromyography, blood pressure, skin conductance level, impedance cardiography (cardiac output, stroke volume, thoracic fluid volume), temperature, and respiration.