

Alabama Supercomputing Authority
Huntsville, Alabama

Arctic Region Supercomputing Center
Fairbanks, Alaska

Arizona State University
Tempe, Arizona

Boston University Center
for Computational Science
Boston, Massachusetts

Center for Advanced Computing Research
Caltech
Pasadena, California

Center for Computational Sciences
Lexington, Kentucky

ORNL Center for Computational Sciences
Oak Ridge, Tennessee

Center for Innovative Computer
Applications at Indiana University
Bloomington, Indiana

Center for Research on
Parallel Computation
Houston, Texas

Cornell Theory Center
Ithaca, New York

High Performance Computing
Education and Research
Albuquerque, New Mexico

National Center for
Atmospheric Research
Boulder, Colorado

National Center for Supercomputing
Applications at UIUC
Champaign, Illinois

National Energy Research
Scientific Computing Center
Berkeley, California

National Supercomputer Center
for Energy and Environment
Las Vegas, Nevada

North Carolina Supercomputing
Center at MCNC
Research Triangle Park, North Carolina

Ohio Supercomputer Center
Columbus, Ohio

Pittsburgh Supercomputing Center
Pittsburgh, Pennsylvania

Purdue University
West Lafayette, Indiana

San Diego Supercomputer Center
San Diego, California

Supercomputer Computations
Research Institute
Tallahassee, Florida

Texas A&M University
Supercomputer Center
College Station, Texas

Texas Advanced Computing Center
Austin, Texas

The Pennsylvania State University
University Park, Pennsylvania

University of Florida
Gainesville, Florida

University of Maryland
College Park, Maryland

University of Southern California
Information Sciences Institute
Marina del Rey, California

University of Utah, Center
for High Performance Computing
Salt Lake City, Utah

University of Wisconsin
Madison, Wisconsin

C A S C



HIGH PERFORMANCE COMPUTING PROVIDES UNDERSTANDING OF CATASTROPHIC WEATHER CONDITIONS AND GLOBAL CLIMATE CHANGE

Each year thousands of Americans are injured, die or suffer serious financial loss from catastrophic conditions such as lightning, flash floods, drought, wind storms, blizzards, hurricanes, tornadoes and earthquakes. When these phenomena occur with little or no advance warning, the loss of life, property and productivity is even more profound.

Severe weather is the cause of more than 6,000 fatalities on U.S. highways annually and at least 800 deaths in aviation accidents. Half of all flight delays are attributable to weather uncertainties, with wind prediction alone estimated to add more than \$250 million to the national aviation fuel bill. More than half a billion dollars per year are spent preparing for snowstorms that never occur. The shipping industry suffers significant losses due to route changes based on inaccurate marine forecasts. Farmers sustain billions of dollars in weather-related crop loss each year.

Human activity, such as deforestation and the use of aerosols, is taking a major toll on the environment -- resulting in confusing and often severe weather patterns. Pollution from the burning of fossil fuel, industrial waste, agricultural chemicals and auto exhaust is playing havoc with regional and global climates, causing ozone depletion, global warming and other processes that endanger water supplies, and threaten plants, animals and even human life.

High performance computing has become an invaluable tool for predicting and responding to climate and environmental change and in formulating balanced regulatory policy. As the technology becomes faster and increasingly precise, the goals remain the same: to save lives and avert costly damage, while also pushing high performance computing beyond known limits.

Volcano Predication -- Computer simulation of a tsunami -- a powerful oceanic wave generated by volcanic action -- has been created by the Arctic Region Supercomputing Center. The model reconstructs a tsunami resulting from the St. Augustine eruption in 1883 as it crossed Crook Inlet, hitting two Alaskan communities. The simulation includes the magnitude of seismic activity, ocean depth and topography of coastal areas -- all factor affecting the speed, intensity and impact of the wave. A tsunami can exceed 600 miles per hour and crest at over 100 feet. High performance computing is providing an excellent predication and emergency planning tool. Recent volcanic buildups in Alaska increase the chance this could occur again.

Global Climate Modeling -- Using the most advanced supercomputing technology available, researchers at the National Environmental Research Supercomputing Center and Lawrence Livermore National Lab in Berkeley, California have developed a comprehensive modeling system for predicting how climates throughout the world will change in response to the combined impact of human activity and natural events. Developing such a framework involves plotting the interaction of atmospheric, oceanic, cryospheric and biospheric systems over many decades. While creating computational models of any kind is challenging, this work pushes the requirement even further because it involves ensembles of up to 20 models. Advances in parallel computing have enabled scientists to run such complex programs 20 to 50 times faster than was possible even five years ago.

San Francisco Earthquake Retrofit -- As part of the Golden Gate Bridge Highway and Transportation District's earthquake retrofit project, the San Diego Supercomputer Center (SDSC) is mounting one of the most detailed computational analysis ever performed on the structural integrity of a bridge. A key challenge is in using modern-day engineering techniques - including computational ones - to retrofit an historic structure, designed and built with older methods. The SDSC simulations are crucial to engineers in verifying the efficacy of retrofit designs in withstanding earthquakes. The demand for computational strategies in structural analysis has increased greatly as a result of such retrofit efforts.

Interaction of Wind and Fire -- Forest fires are dangerous occurrences. Their behavior and course not well understood. A senior scientist at the National Center for Atmospheric Research has created one of the first supercomputer models to trace the impact of wind on fires. The model is a harbinger of better prediction and management capabilities.

Advanced Storm Warning -- Accurately predicting storms six hours in advance rather than 30-minutes, as with current forecasting techniques, will save lives and as much as \$14 billion a year in wind-related loss nationwide. Using high performance computing at the Pittsburgh Supercomputing Center, researchers with the Center for Analysis and Prediction of Storms (CAPS) in Norman, Oklahoma have shown that this is within the realm of reality. This cutting-edge work has garnered national recognition, including the 1997 *Discover* magazine award for Technological Innovation and the *Computer World/ Smithsonian Award in Science*.

Tornado Warnings -- The National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign has pioneered the use of parallel processing to visualize the internal dynamics of a severe thunderstorm and to simulate the development of tornadoes embedded in larger storm supercells. In 1996, NCSA researchers developed the capability to resolve the dynamics of an entire storm system. Equations relying on billions of numbers were updated every 0.4 seconds, tracking a living storm as it raged. A resulting 3-D model of five land spout tornadoes is among the most complex ever seen and has revolutionized the science of tornado prediction.

Global Warming Prediction -- Researchers at the Oak Ridge National Laboratory, in collaboration with the Atmospheric Radiation Measurement Project (ARM), are modeling the interaction of aerosols and other particulate matters with solar and ambient light sources in the atmosphere to predict the impact on global warming. This model, which is designed to integrate with other larger-scale climate modeling systems, will increase the reliability of short and long term warming projections, which are essential to environmental policymakers.

Climate System Model (CSM) -- Researchers at the National Center for Atmospheric Research in Denver, have been praised by the atmospheric community and the scientific press for creating a comprehensive climate model that does not need "flux adjustments" -- that is the arbitrary tweaking of key physical and bio-geo-chemical parameters -- as do other large scale climate models. It is important for researchers to have full confidence in the output of their simulations in determining if global climate changes are indeed reality. Running this CSM for a 300 year simulation has proven that it does not drift from a reasonably realistic climate.