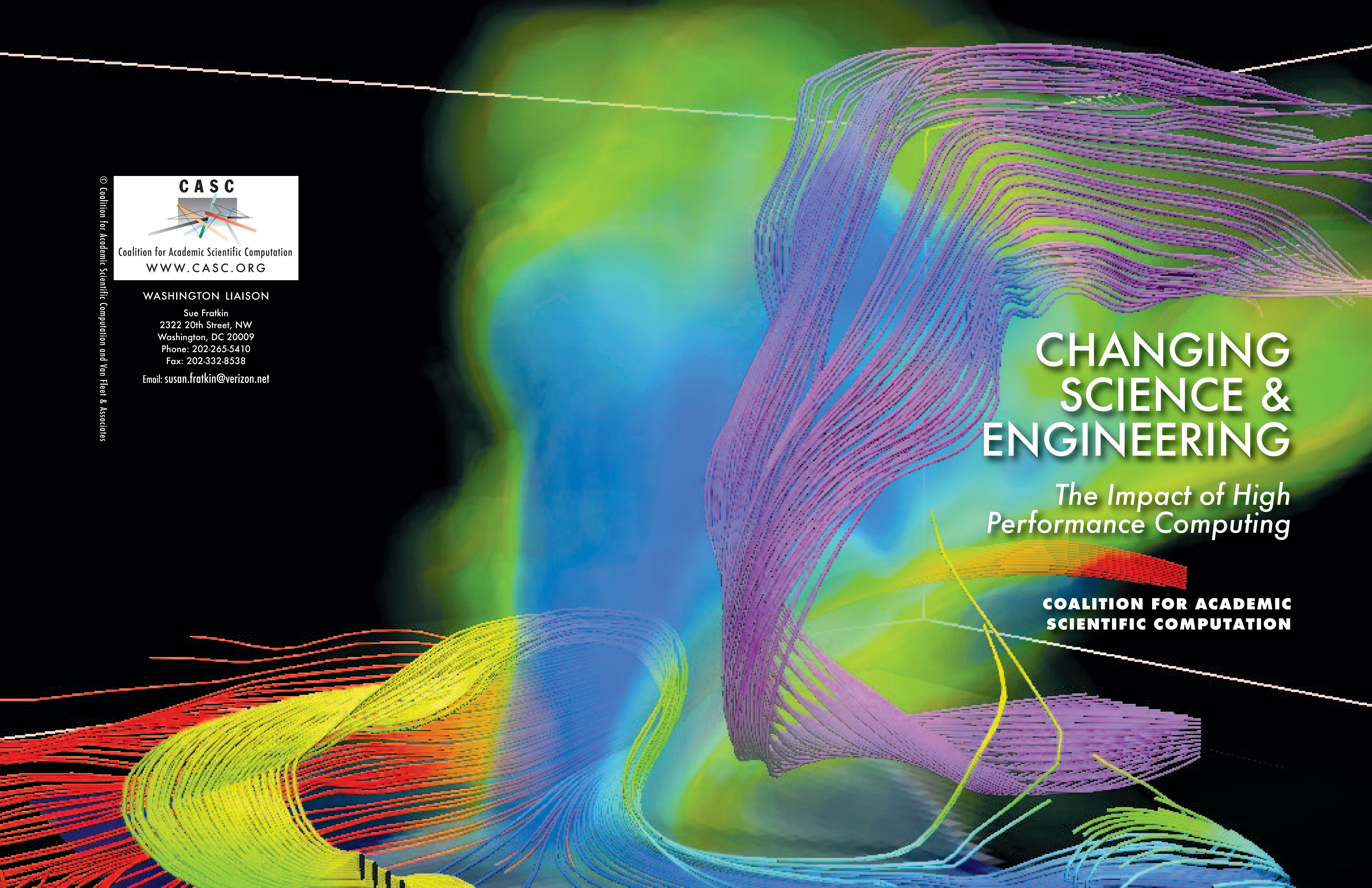

CASC
Coalition for Academic Scientific Computation
WWW.CASC.ORG

WASHINGTON LIAISON

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CHANGING SCIENCE & ENGINEERING

The Impact of High Performance Computing

COALITION FOR ACADEMIC SCIENTIFIC COMPUTATION

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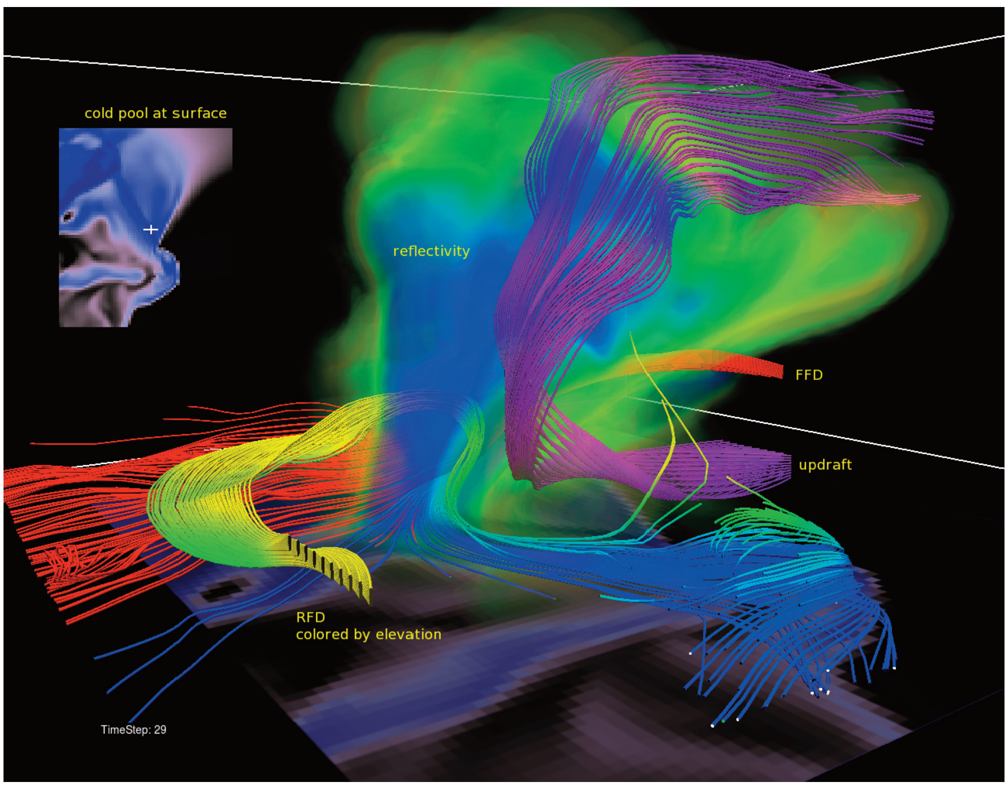


ABOUT THE COVER: The cover visualization depicts a snapshot in time of a numerically simulated supercell thunderstorm conducted by Associate Professor Leigh Orf at Central Michigan University. Precipitation magnitude is represented by the volume rendered field; the "streamtubes" indicate the storm's updraft, forward flank downdraft, and rear flank downdraft. The Bryan Cloud Model (CM1), developed by George Bryan at the National Center for Atmospheric Research (NCAR), created the simulation, which utilized massively parallel supercomputing resources at the National Center for Supercomputing Applications (NCSA). The goal of this research is to better understand the processes leading to tornado formation in supercells, the most powerful type of thunderstorm. The image was created using NCAR's Vapor software.

ABOUT CASC

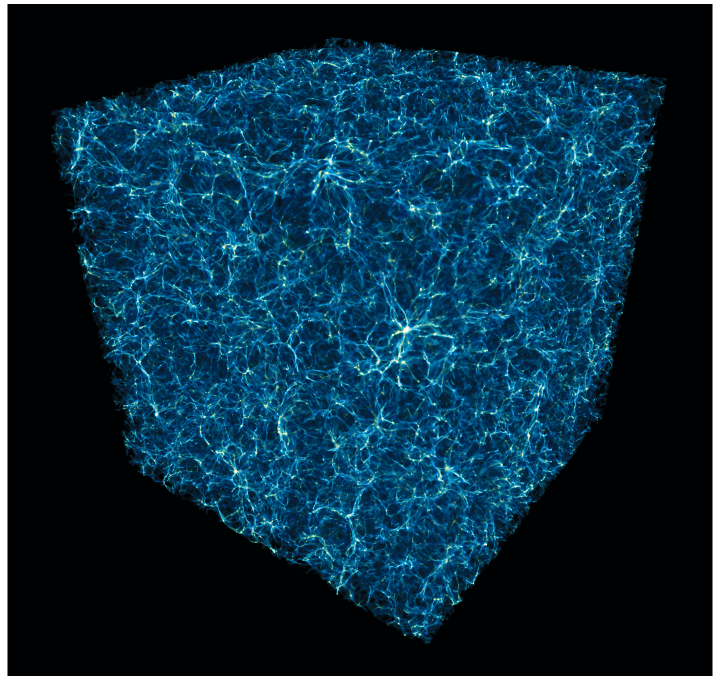
The Coalition for Academic Scientific Computation (CASC) was founded in 1989, when information technology, high performance computing, and the Internet came of age. Today, CASC has grown to 60 members in 37 states and represents many of the nation's most forward-thinking research universities, high-performance computing (HPC) centers, and institution-partnered federal laboratories.

CASC is an educational 501(c)(3) nonprofit organization. Its mission is to:

- disseminate information about the value of high performance computing and advanced communications technologies;
- provide an expert resource for the Executive Office of the President, the Congress, and federal agencies, as well as state and local government bodies; and
- facilitate information exchange within the academic scientific computation and communication communities.

Computational science has become the third pillar of scientific enterprise, fully equal to traditional methods of physical experiments and theoretical investigations. Coalition members provide access to high performance computing resources, massive data storage facilities, analytical instruments, visualization environments, and software.

CASC is dedicated to advocating the use of the most advanced computing technology to accelerate scientific discovery for national competitiveness, global security, quality of life, and economic success. Our members are committed to developing a diverse and skilled 21st century workforce to fuel the nation's technological leadership, as well as supporting regional science and technology economic growth initiatives.



Researchers from Michigan State University, the National Center for Supercomputing Applications and the San Diego Supercomputer Center are advancing knowledge of the early evolution of the universe. The filamentary structure in this simulation in a cube 1.5 billion light years on each side is also seen in real life observations such as the Sloan Digital Sky Survey. A particularly massive galaxy cluster, with a mass 2 quadrillion times that of our sun, can be seen near the center.

This brochure highlights the broad impact of CASC member organizations to solve some of the world's most challenging scientific and engineering problems.

More detailed descriptions of each CASC member's contributions to discovery, innovation, and learning are available at: **www.casc.org/members.html** CASC

FUELING DECADES OF INNOVATION

Over the last two decades CASC members have ridden the crest of the wave of innovation in computer and information technologies. Our members remain at the forefront in the ongoing evolution of a rich computing and information technology ecosystem known as cyberinfrastructure.

Today the technologies pioneered by the U.S. research community impact our nation's economic development and our everyday lives. On the right is a glimpse of the milestones in information technology research that led to a revolution in cyberinfrastructure capabilities.

As we move into the next decade, evolving consumer-oriented products are inspiring new paradigms for "Big Science" that integrate user-friendly technologies such as multimedia visualization platforms and intuitive interfaces for managing data. CASC

Charlie Bender, the director of the Ohio Supercomputer Center (OSC) and one of CASC's founders and early leaders, seated in front of a Cray X-MP in 1987.

MILESTONES

1946: ENIAC computer built for $500,000

1960s: NSF begins investing in academic supercomputing centers

DOD funds DARPAnet, the precursor to the Internet

1981: IBM introduces the PC with Microsoft's 16-bit operating system

1985: NSF launches the supercomputer centers program

1986: NSFnet connects supercomputer centers

1988: NSF funds regional networks

1989: Founding of CASC – designed to bring advances in HPC to institution-based centers

1991: NSFnet becomes the first national backbone network at 45 Mbps

1991: Birth of the World Wide Web

1992: First demonstration of tele-microscopy, one of the earliest implementations of cyberinfrastructure

1993: Release of Mosaic, the first browser and graphical user interface for the Web

1997-2004: NSF funds the Partnerships for Advanced Computational Infrastructure (PACI) program, leading the way to ground-breaking grid projects and cyberinfrastructure

2001: NIH establishes the first scalable national computing infrastructure

NSF establishes the TeraGrid, a multi-institutional distributed terascale facility

2007: DOE and NSF fund the deployment of Petaflop supercomputers

INSPIRING AND SUSTAINING THE NATION'S HPC WORKFORCE

Our national capacity to innovate hinges on retaining a skilled workforce with students knowledgeable in science, technology, engineering and mathematics (STEM). CASC members are dedicated to educating and training today's workforce and tomorrow's thought leaders.

Working in cooperation with K-20 educational institutions, industry, and national mentoring organizations, our members are actively engaged in programs to increase the number of students pursuing advanced degrees in computer science and engineering. Our members are also leading programs designed to broaden the participation of groups who have been traditionally underrepresented in HPC. Some member organizations are also working on solutions to retrain the current workforce to use advanced computation.

Our member outreach programs start at the elementary school level, to inspire student interest in math and science careers. Exemplary computational science courses, in-depth workshops, and summer institutes motivate undergraduate and graduate students, as well as established professionals and faculty. CASC members also train our nation's educators to incorporate the most sophisticated science and engineering research tools and approaches in their classrooms, which is critical to innovation and U.S. competitiveness.

Americans are the most productive workers in the world. Sustained investments in human capital directly influence national productivity and our capacity to innovate. CASC

The most powerful computing systems in the world are in the United States, but America lacks sufficient numbers of computational scientists to exploit its leadership position.

—Thrive: The Skills Imperative
Report of the Council on Competitiveness, 2008

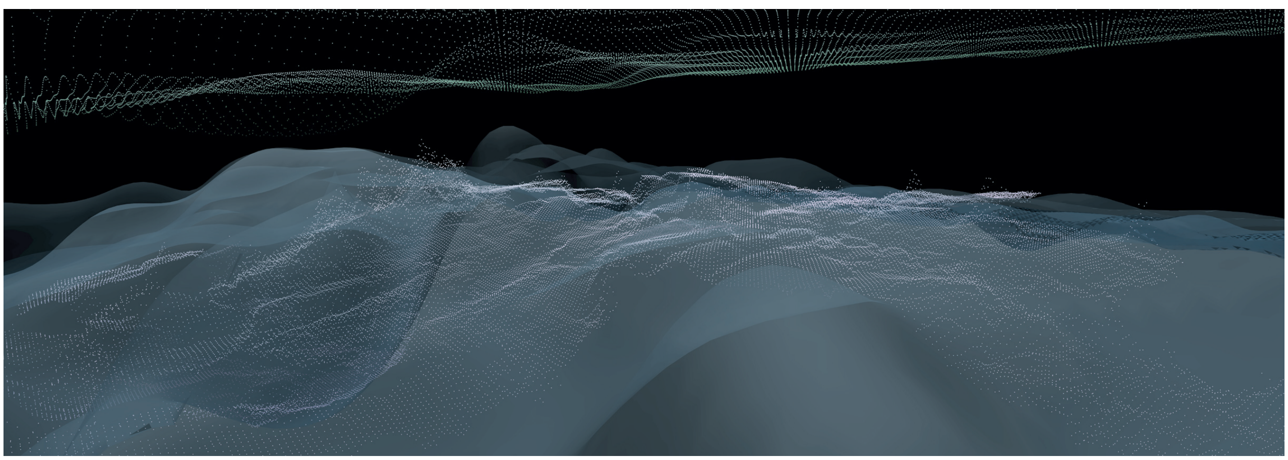
Middle school girls collect samples for a study of Ohio watersheds as part of the Young Women's Summer Institute (YWSI) at the Ohio Supercomputer Center. Created in response to a lack of interest in math, science and engineering among young women, YWSI helps girls develop an interest in these subjects by allowing them to work on a practical, interesting scientific problem using the latest computer technology.

DATA EXPLORATION

The surge of massive data collections has brought to the forefront the need for new tools essential to collecting, organizing, analyzing, and storing data at volumes and rates that push the limits of current technology. Many CASC members are playing crucial roles in the development of the next generation of data management tools. Powerful science gateways provide a logical interface for scientists to access supercomputers and data storage resources essential to support discovery and innovation.

While managing massive data sets is a well-known challenge in the hard sciences, it is also a significant challenge for scholars from the social sciences, art, and humanities.

The Chronopolis Digital Preservation Demonstration Project, one of the Library of Congress' latest efforts to collect and preserve at-risk digital information, is a partnership led by CASC members to meet the archival needs of a wide range of cultural and social domains. Chronopolis leverages the broad experience of the science and engineering community with deep experience from the library and archival communities for the preservation of cultural assets. Current Chronopolis collections include social science and political research data sets, digital geospatial data resources, and historical oceanographic information from research vessels. CASC



This geologic visualization depicts an exploration of the geoid and bathymetry data from the Ninety East Ridge, a chain of "underwater islands" in the Indian Ocean. Texas A&M University oceanographers hope to show how this chain was formed, which will improve understanding of plate tectonics.

The explosive growth in the number and resolution of sensors and scientific instruments has engendered unprecedented volumes of data, presenting historic opportunities for major scientific breakthroughs in the 21st century.

—Computational Science: Ensuring America's Competitiveness
Report of the President's Information Technology Advisory Committee, 2005

TRANSFORMING RESEARCH IN THE 21ST CENTURY

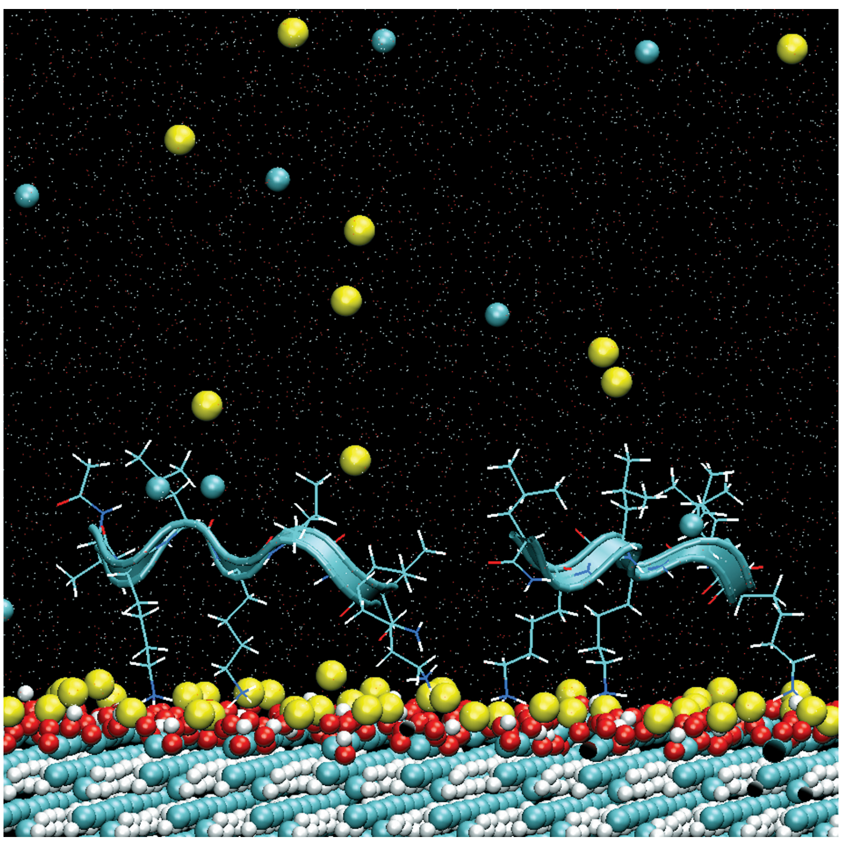
Science and society are being transformed by cyberinfrastructure, which underpins multi-disciplinary, multi-institutional research collaborations in every field of science and engineering. Multi-scale collaborations in many domains are expanding and increasingly demand the highest levels of computing and networking capabilities to deal with the massive amounts of data that are being generated and shared.

These increasingly complex tools of science are unraveling nature's deepest mysteries—from the study of subatomic particles, to atoms and molecules that make up the materials of our everyday world, to DNA, proteins, cells, and entire natural ecosystems.

The ability to image, model, and manipulate matter at the nanoscale level is clearly one of this century's newest, most computationally intensive fields of research. This field is so promising that the U.S. National Nanotechnology Initiative was formed in 2001 to coordinate collaborative R&D across 13 federal agencies to support multidisciplinary research involving academia, industry and government laboratories.

Evolutionary biology…is very much in transition from one based on observation to one based on massive amounts of genomic data. The eventual impacts of HECC are clear and enormous, but the field is only beginning to exploit HECC.

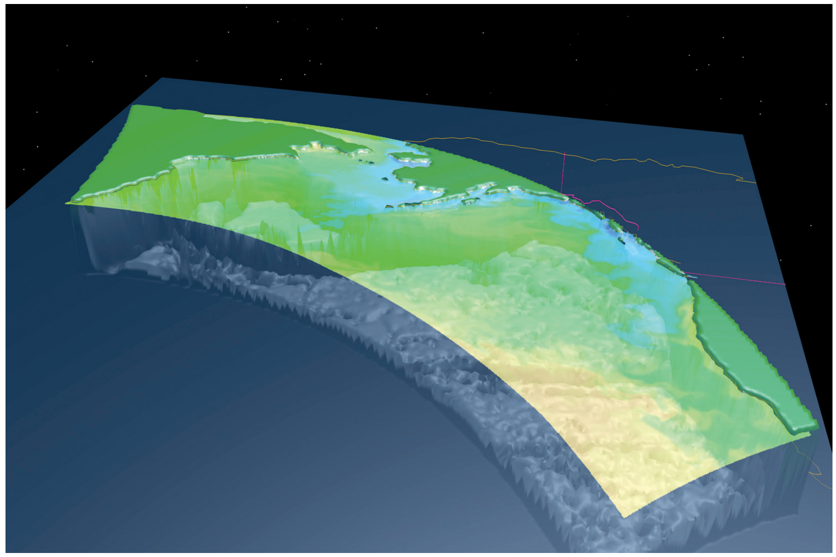
—The Potential Impact of High-End Capability Computing
National Research Council Report
National Academy of Sciences, 2008



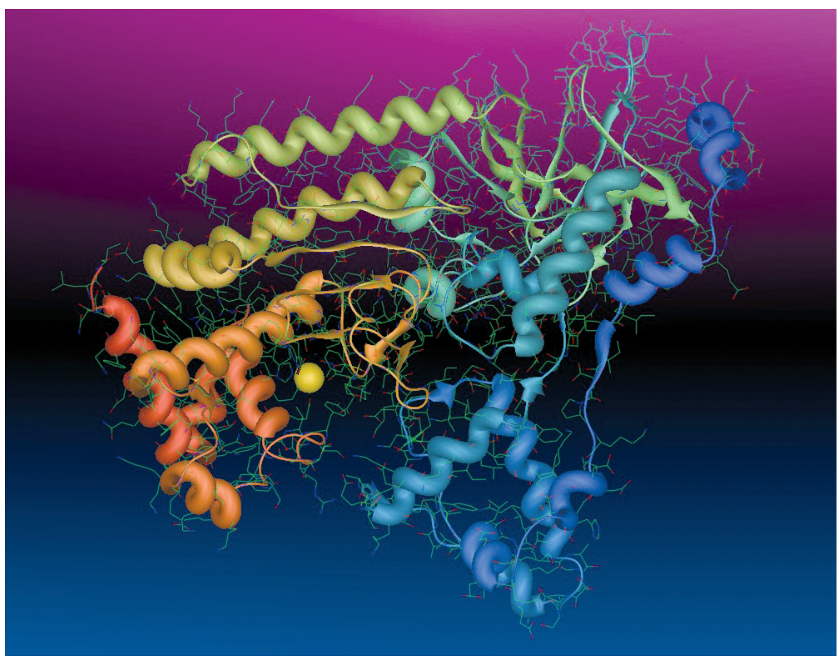
Advances in bionanotechnology for medicine require an understanding of the interactions between biomolecules in the body and surfaces of bioactive nanoparticles at the molecular level. Researchers at Clemson University use molecular simulations to predict how proteins and peptides interact with a nanoparticle surface to design better-performing devices for cardiovascular applications, biosensors for disease detection, and drug delivery systems for treatment.

We're entering a new era in which biotechnology and nanotechnology are making manufactured products lighter, stronger, cleaner, and less expensive. In addition, bioscience and nanomedicine are bringing clarity to the mysteries of diseases and challenges in health, as well as new treatments and therapies to change people's lives.

The increasing sophistication and demands of engineering and science have led to a nationwide, production-scale collaboration in computational science. Using ultra high-performance network connections, the NSF TeraGrid brings together leadership-class resources at eleven CASC member sites to create an integrated, persistent computational resource. With steady, sustained federal support, the U.S. research community is achieving the vision of a national cyberinfrastructure for open scientific discovery. CASC



Researchers at the Arctic Region Supercomputing Center are coupling the Regional Ocean Modeling System with Bering Sea ecological models to better understand North Pacific ecosystems. The fresh water influx from springtime snowmelt, shown in light blue, brings nutrients from the land, changes ocean salinity and drives currents in the Bering Sea, one of the world's largest commercial fisheries.



The anthrax lethal factor (LF) enzyme, which is potentially fatal if it gets into the bloodstream, can remain in the body for days after the anthrax bacterium is killed with antibiotics. Currently, there is no clinical therapy to combat LF. Researchers from the University of Minnesota Supercomputing Institute are using molecular modeling to investigate compounds that might be used for future anti-LF drugs.

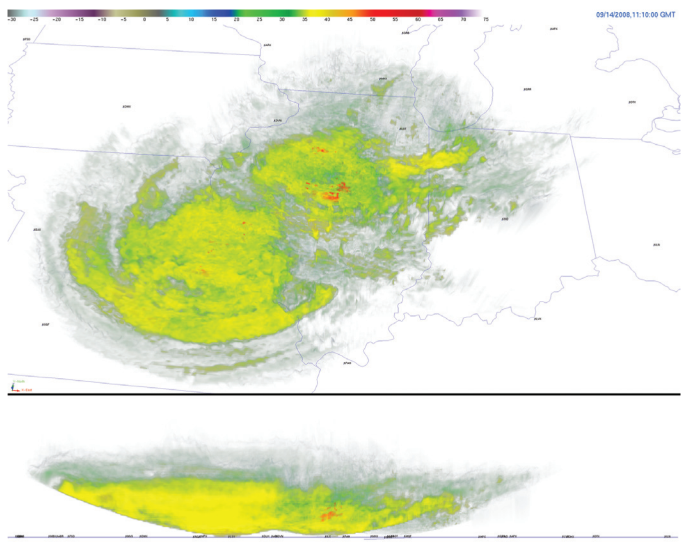
ENSURING U.S. LEADERSHIP IN SCIENCE AND ENGINEERING

Our nation's universities, centers and federal labs support the cyberinfrastructure that enables and enhances science and engineering research. Advanced computational methods catalyze new ways of interacting with data to explore solutions for our toughest problems and to understand natural phenomena.

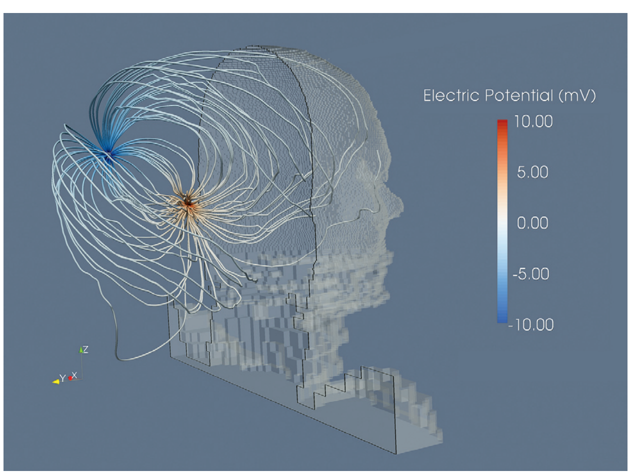
Federal and state investments in HPC have spurred innovation and created a national fabric to accelerate research. Whether too hazardous to study in a laboratory or too time consuming or expensive to solve by traditional experimental methods, cyberinfrastructure is enabling the multi-disciplinary, collaborative research that leads to rapid and systematic advancements to ignite innovation, strengthen the economy, and improve our quality of life.

The most scientifically important and economically promising research frontiers in the 21st century will be conquered by those most skilled with advanced computing technologies and computational science applications.

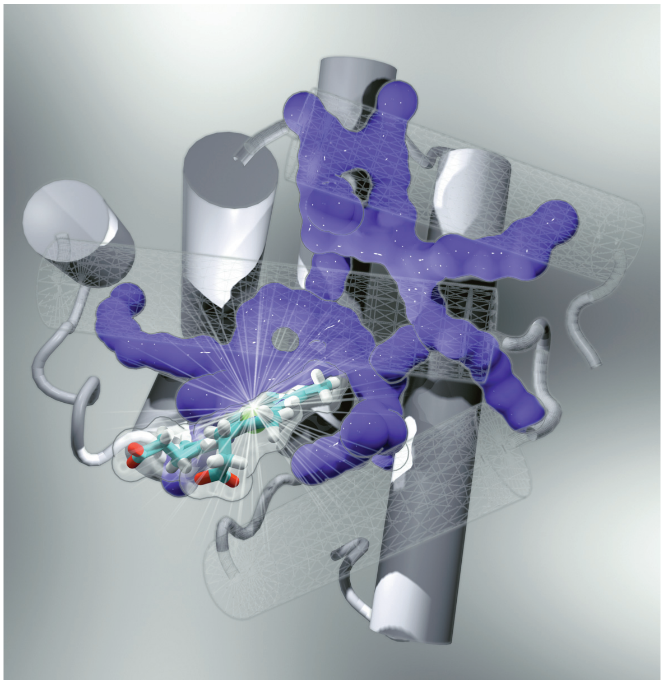
—Computational Science:
Ensuring America's Competitiveness
Report of the President's Information
Technology Advisory Committee, 2005



A volumetric rainfall visualization of Hurricane Ike over the Midwest shows regions with medium to heavy rainfall. The 3D visualization is based on real-time data from the National Weather Service NEXRAD Weather Surveillance Doppler radars that was collected and processed using computational resources at Purdue and TeraGrid.



Simulations and visualizations from the Renaissance Computing Institute help researchers build better cochlear implants and improve hearing for those with profound hearing losses. With cochlear implants, a receiver on the exterior of the skull collects sound and passes electric impulses to the implant, which in turn generates electric impulses to stimulate nerve cells in the inner ear that are perceived as sound.



Myoglobin, one of the most studied proteins, carries oxygen for smooth muscle cells. It is released from damaged muscle tissue, and is a potential marker for heart attacks in patients with chest pains. Researchers at Virginia Tech are trying to understand how molecules like carbon dioxide (CO_2) and the dioxygen molecule (O_2) travel from outside the protein, through its interior and bind at the heme group (iron).

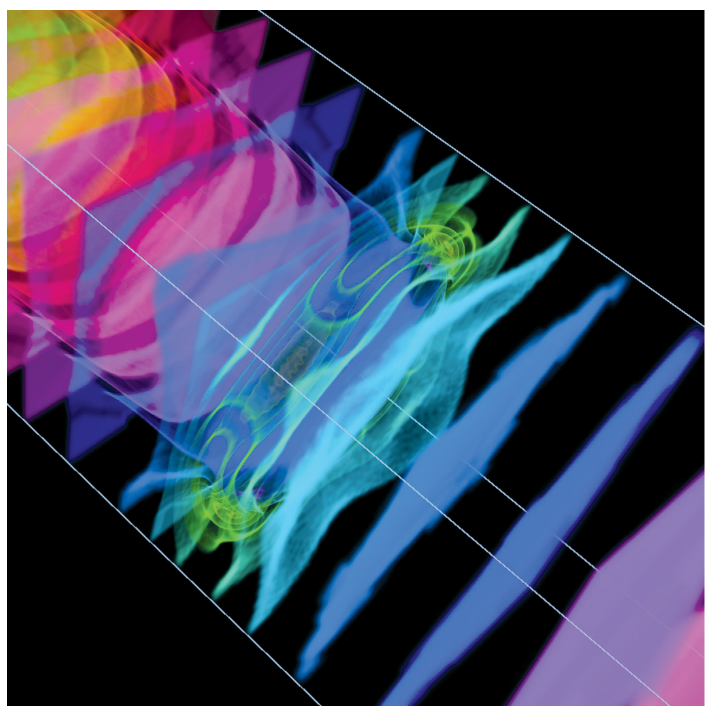
Thirty years ago, many supercomputers were used only for national security, defending the lives of our citizens. Today's supercomputers are driving innovation and saving lives. Modern supercomputers are analyzing the structure of proteins and the function of biological pathways to help scientists fight disease and improve human health.

From modeling phenomena that are difficult or impossible to measure, to accelerating the time to insight, advanced computing and communications are essential elements in scientific methods and discovery techniques.

Scientists at CASC member institutions working to predict severe weather have one simple goal: to determine the likely occurrence and path of tornadoes and hurricanes quickly and accurately enough for people in affected areas to get out of harm's way. ▶

Threat-based operational forecasting is possible...there is a significant opportunity for such forecasts to predict at high-resolution impending snowstorms, severe weather complexes, serious air quality events, and emergency situations such as wildfires, release of toxic plumes, or severe icing events.

—The Potential Impact of High-End Capability Computing
National Research Council Report
National Academy of Sciences, 2008



Fluid flows in nature are quite complex, requiring advanced algorithms for modeling and simulation. Scientists at the Louisiana State University Center for Computation & Technology use computational fluid dynamics (CFD) simulations to show fluid flow and bubble formation within a contained environment.

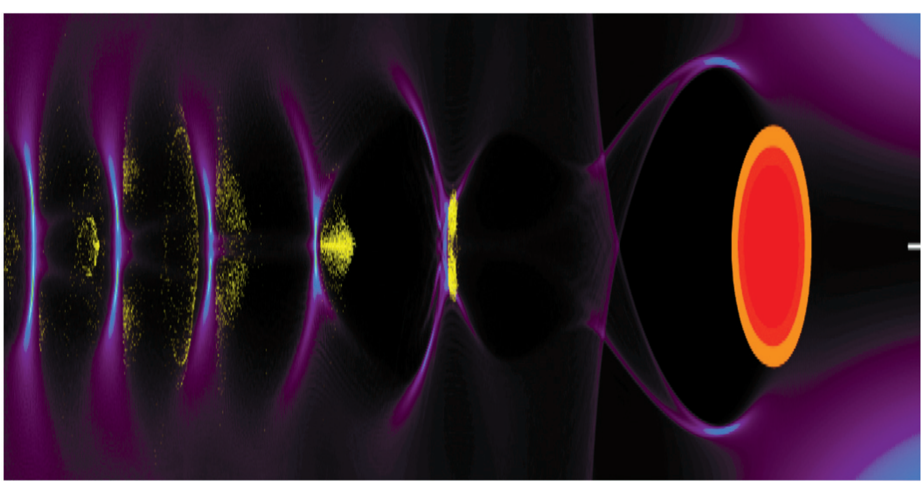
In an effort to find a treatment for neurodegenerative disorders, Ohio State University biochemists are studying the activities of chemicals that thwart messages sent to the brain by modeling proteins called nicotinic acetylcholine receptors (nAChRs). These figures show a portion of a nAChR, its activating compound, and the dynamics that occur when the two bind to each other.

America faces the dual challenge of reducing national health care costs while providing affordable, quality services for its citizens. High performance computing is increasingly important to achieving both goals.

CASC institutions are at the forefront of medical research, using their resources to expand knowledge, increase collaboration, and improve personalized health care delivery. As a result, medical providers routinely employ high bandwidth networks for real-time, remote diagnostics. Federal support for research that applies advanced computer and networking technologies to health care delivery is proving a sound investment.

Federal government should make critical investments in enabling tools and resources moving beyond genomic discoveries to personalized medicine... NIH should promote methods for validating the clinical utility of molecular diagnostics based on genomic correlations with disease.

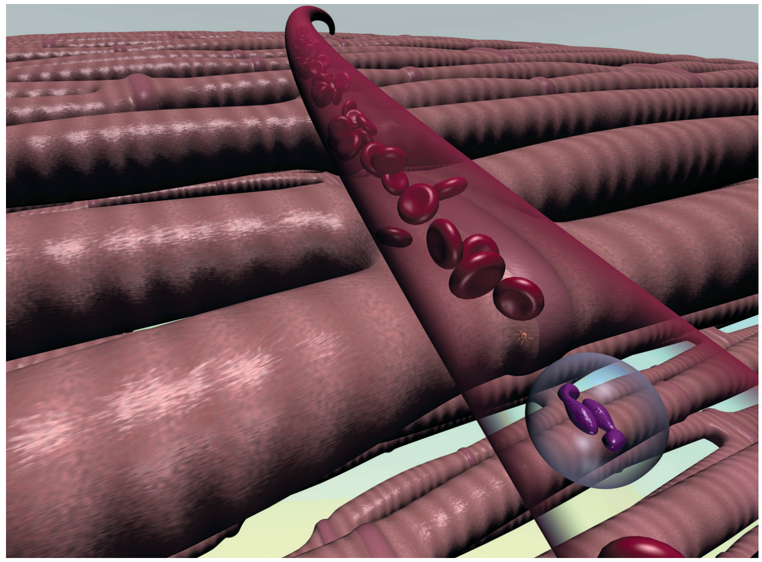
—Priorities for Personalized Medicine
Report of the President's Council of Advisors
on Science and Technology, 2008



Laser driven plasma waves may enable a new generation of compact particle accelerators. Researchers at Lawrence Berkeley National Laboratory created this simulation at the National Energy Research Scientific Computing Center showing the laser pulse (red), plasma wake density (purple-blue), and accelerating particles (yellow).

Supercomputers have so greatly transformed the conduct of scientific work that many physicists and chemists speak of computational science as an intellectual revolution equal in impact to the observational paradigm of Galileo and the theoretical insight of Newton.

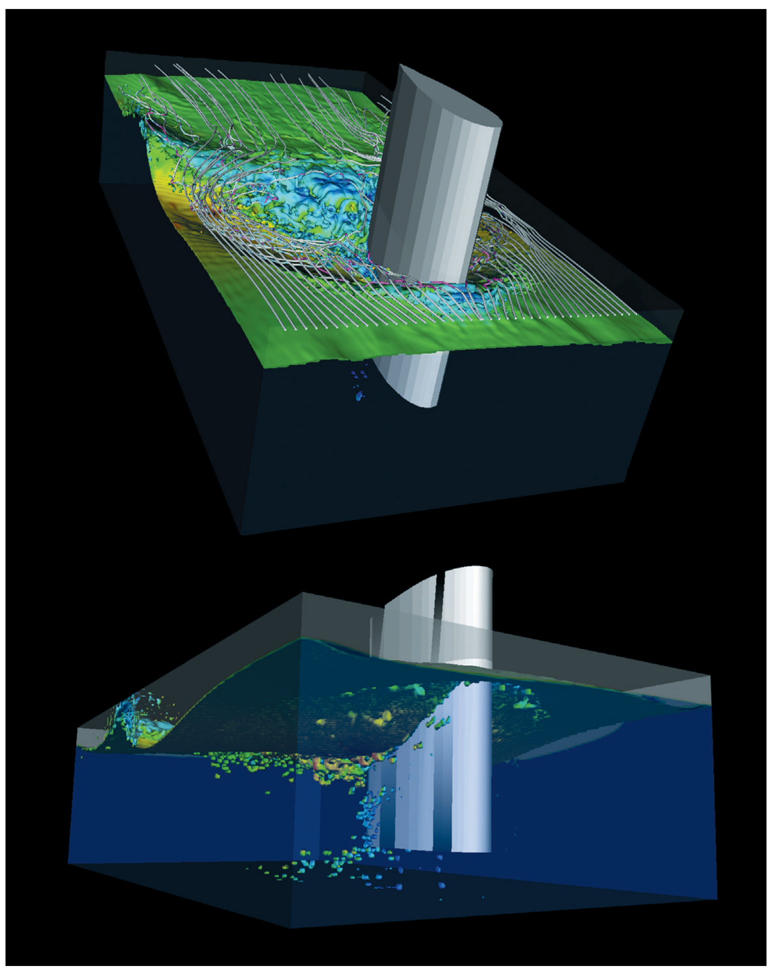
—The National Challenge in
Computer Science and Technology
Report of the National Research Council
National Academies of Science, 1988



Researchers at the Pittsburgh Supercomputing Center created a 3D rendering of red blood cells flowing through a blood vessel in the heart to deliver oxygen to underlying muscle cells (myocytes). The Computational Modules in Science Teaching program creates innovative science tutorials using high quality, biologically-realistic 3D animations.

High performance computing is one of America's greatest competitive strengths. It provides unique opportunities for scientific breakthroughs, allowing industry to maintain an edge in R&D, to pursue "high-risk, high-payoff" ideas, and to speed proof-of-concept of new products to the global marketplace. We're working with U.S. industry to spur innovation and productivity across all business sectors, to reinvigorate our national economy and to grow highly skilled, high-paying jobs.

CASC members are accelerating the capacity of supercomputers, networks, and software, bringing about the next generation of America's information technology ecosystem. CASC



Researchers from the Texas Advanced Computing Center created this 3D visualization that shows water flowing past an airfoil that approximates a ship's hull. The simulation of breaking waves, spray sheets, and air entrainment play a key role in the design and operation of naval combatants. These phenomena are among the most challenging problems in computational fluid dynamics today.

CASC MEMBERS

Advanced Research Computing (ARC), Virginia Tech, Blacksburg, Virginia

Advanced Scientific Computation Center (ASCC), Northeastern University, Boston, Massachusetts

Arctic Region Supercomputing Center (ARSC), Fairbanks, Alaska

Arizona State University, Tempe, Arizona

Arkansas High Performance Computing Center, University of Arkansas, Fayetteville, Arkansas

Army High Performance Computing Research Center, Reston, Virginia

Boston University Center for Computational Science, Boston, Massachusetts

Center for Advanced Computing, University of Michigan, Ann Arbor, Michigan

Center for Advanced Computing Research, California Institute of Technology, Pasadena, California

Center for Advanced Research Computing, University of New Mexico, Albuquerque, New Mexico

Center for Computation & Technology (CCT), Louisiana State University, Baton Rouge, Louisiana

Center for Computational Research, University at Buffalo, Buffalo, New York

Center for Computational Sciences, University of Kentucky, Lexington, Kentucky

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

Center for High Performance Computing, HPC@USU, Utah State University, Logan, Utah

Center for Research Computing, University of Notre Dame, Notre Dame, Indiana

Clemson Computing and Information Technology (CCIT), Clemson, South Carolina

Computation Institute, University of Chicago & Argonne National Laboratory, Chicago, Illinois

Core Facility in Advanced Research Computing, Case Western Reserve University, Cleveland, Ohio

Cornell University Center for Advanced Computing, Ithaca, New York

CUNY High Performance Computing, Staten Island, New York

Florida State University Department of Scientific Computing, Tallahassee, Florida

Georgetown University's Advanced Research Computing (ARC) Washington, DC

Georgia Institute of Technology, Atlanta, Georgia

High Performance Computing Center, Michigan State University, East Lansing, Michigan

High Performance Computing Center, Texas Tech University, Lubbock, Texas

High Performance Computing Collaboratory (HPC^2) Mississippi State University, Mississippi State, Mississippi

Indiana University, Bloomington, Indiana

Ken Kennedy Institute for Information Technology (K_2I), Rice University, Houston, Texas

Lawrence Berkeley National Laboratory Berkeley, California

Maui High Performance Computing Center, University of Hawaii, Honolulu, Hawaii

Minnesota Supercomputing Institute, University of Minnesota, Minneapolis, Minnesota

National Center for Atmospheric Research, (NCAR), Boulder, Colorado

National Center for Supercomputing Applications (NCSA), Champaign, Illinois

National Institute for Computational Sciences (NICS), University of Tennessee, Knoxville, Tennessee

National Supercomputing Center for Energy and the Environment (NSCEE), University of Nevada, Las Vegas, Nevada

NDSU Center for High Performance Computing, North Dakota State University, Fargo, North Dakota

Oak Ridge National Laboratory Center for Computational Sciences, Oak Ridge, Tennessee

Ohio Supercomputer Center (OSC), Columbus, Ohio

OU Supercomputing Center for Education and Research, University of Oklahoma, Norman, Oklahoma

Pacific Northwest National Laboratory (PNNL) Richland, Washington

Pennsylvania State University, University Park, Pennsylvania

Pittsburgh Supercomputing Center, Pittsburgh, Pennsylvania

Princeton University, Princeton, New Jersey

Purdue University, West Lafayette, Indiana

Renaissance Computing Institute, University of North Carolina, Chapel Hill, North Carolina

San Diego Supercomputer Center, La Jolla, California

Scientific Computation Research Center (SCOREC), Rensselaer Polytechnic Institute, Troy, New York

Texas A&M University Institute for Scientific Computation, College Station, Texas

Texas Advanced Computing Center (TACC), University of Texas at Austin, Austin, Texas

Texas Learning and Computation Center, The University of Houston, Houston, Texas

University of Florida, Gainesville, Florida

University of Iowa, Iowa City, Iowa

University of Louisville, Louisville, Kentucky

University of Maryland, College Park, Maryland

University of Miami, Miami, Florida

University of Nebraska, Omaha, Nebraska

University of South Florida Research Computing, Tampa, Florida

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

University of Wisconsin-Milwaukee, Milwaukee, Wisconsin