Fall 2002

ESDCD news

Code 930 • http://esdcd.gsfc.nasa.gov

Earth and Space Data Computing Division

Earth Sciences Directorate, Goddard Space Flight Center

In This Issue

Integrated Data Products

TerraFly: 2002 World Class Solution

TerraFly, an Internet-based visualization and analysis database system, has received Data Management Review Magazine's "2002 World Class Solutions Award."

William Campbell and Patrick Coronado fostered this collaborative effort from its very beginnings about 5 years ago as a NASA Minority University Research and Education Division (MURED) Institutional Research Award to Florida International University (FIU). Campbell and Coronado guided creation of many of the project's innovative features, including 2D flyovers and zooming into higher-resolution images.

Users enter a street address to access an image of that area. Then, with the click of a mouse, users fly over the region, controlling direction, speed, and image quality. The system uses parallel processing and clustered servers to aid the seamless visualization of spatial and remotely sensed imagery. As one of the world's largest publicly accessible databases of U.S. Geological Survey (USGS) and other data, TerraFly creates integrated digital and hard-copy products useful to government, private industry, educators, and individuals.

A frame from a virtual flyover.

TerraFly was built at FIU's High-Performance Database Research Center with support from NASA, USGS, National Science Foundation (NSF), and IBM. The system has been featured by The New York Times, Yahoo!, Science, and Nature.
http://www.terrafly.com

Engineering and Discovery

UAVs Support Science Missions

Patrick Coronado with the ICE2002 MAGPLANE.
Photo credit: Geoff Bland

With a wingspan of only about 12 feet, Unmanned Aero Vehicles (UAVs) are small, sophisticated airplanes with integrated on-board data gathering sensors. They may appear to be toylike, but their innovative design enables the planes to be customized for use by a wide range of missions in areas that can be difficult to otherwise reach.

Working with UAVs for the last 4 years, Patrick Coronado and his team bring expertise to projects that could benefit from this type of remote sensing. Sometimes, these missions combine science and technology with opportunities for educational outreach.

One such mission is NASA's Iturralde Crater Expedition 2002 (ICE2002). In the mid-1980s, NASA satellite imagery revealed a large circular feature deep in the Amazon jungle in Bolivia. Scientists have theorized that the feature is a complex meteorite impact crater. However, because access to the remote site has proven nearly impossible, ICE2002 tapped Coronado's UAV expertise to help confirm the crater theory.

In just 5 months, Coronado designed and constructed a MAGPLANE—a UAV with a magnetometer that could measure the feature's magnetic field during unmanned flyovers. Mario Acuña of GSFC's Space Sciences Directorate built the magnetometer. Other equipment Coronado integrated into the MAGPLANE included a Global Positioning System, a data collection system, two communications systems (satellite and ground), and an autopilot control system. Geoff Bland and Ted Miles of Wallops Flight Facility assisted with systems integration and vehicle testing. The satellite communication system was provided by David Lassiter, also from Wallops.

The ICE2002 mission holds many educational opportunities, with funding from GSFC's Office of Education, Director's Discretionary Fund, and Minority University-SPace Interdisciplinary Network (MU-SPIN) Program. Through GSFC's Teachers as Scientists Program, MU-SPIN teachers from a Native American school and Baltimore City are participating on teams to analyze mission data side by side with NASA scientists. Local MU-SPIN teachers from Prince George's County elementary schools collaborated on Coronado's MAGPLANE team. MU-SPIN videotaped interviews of research teams to explain the science to the teachers.

Hazards of the jungle, including a patchy dirt runway, vandals, high heat and humidity, and the impending rainy season, halted the MAGPLANE's mission. But, because the MAGPLANE's measurements are still needed to help substantiate the landmark's origins, Coronado anticipates another attempt next year. In the meantime, teacher research teams are analyzing the data gathered by ground teams, and Coronado is preparing the MAGPLANE for the return journey.

Another education-based project to use UAVs is the JASON Project's "From Shore to Sea," which is scheduled for January 2003. Students will use UAV measurements to survey ocean water surrounding Anacapa Island off the coast of California. As a host researcher, Coronado is building five planes from the ground up, with support from NASA's Earth Sciences Technology Office (ESTO). Coronado and his team from GST, Allen Lunsford, Dan Jacob, and Kelvin Brentzel; and from Wallops, Bland and Miles, will build two long-range gas-powered and three short-range electric planes.

Coronado is excited about both building the planes and fostering in students an appreciation for the power of remote sensing. Says Coronado, "the underlying purpose of these activities is to create an environment that instills interest and a sense of fun in science and engineering. Understanding upwelling and phytoplankton is as important as helping students understand the power of exploration though science and engineering, which can be fueled by their imagination."

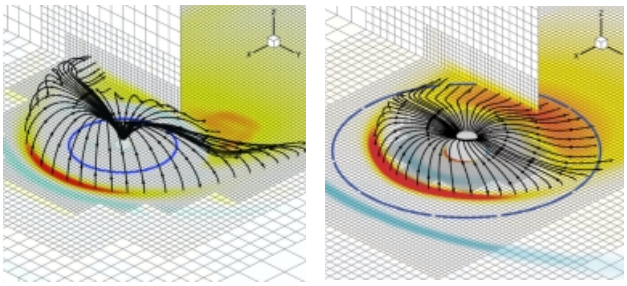
http://www.blueiceonline.org/blueweb/iceexpedition.html
http://www.jason.org/jason14/meet/people/coronado

Computational Technologies Project

Taking on the Superstorm

On September 1, 1859, British astronomer Richard Carrington made the first observation of a solar flare. The next day, auroras appeared in the skies as far south as Cuba, and telegraph wires burst into flames.

The world was experiencing the most powerful solar storm on record. Computational Technologies (CT) Project investigators at the University of Michigan (UM) recently simulated the impact of this "1859 superstorm" on the Earth.



Black lines mark the edge of the magnetosphere of the Earth (grey sphere). The blue circles indicate the orbit geosynchronous satellites follow. With a typical solar storm (left), all satellites are well within the magnetosphere. In the 1859 superstorm (right), almost all satellites (had they existed) would have been outside the magnetosphere and open to possible disorientation. Image Credit: Aaron Ridley, University of Michigan

"It was huge," says Aaron Ridley, assistant research scientist in UM's Space Physics Research Lab. "If we can simulate that event, we can do almost any event ever."

As observed at the time, one marker of the superstorm's power was that two-thirds of the sky was filled with auroras, which normally occur just close to the poles. Even more startling was its speed. The flare propelled a massive cloud of electrically charged gas towards the Earth at 9 million kilometers per hour, about three times faster than any other recorded space weather event.

The UM simulation shows how the superstorm affected the Earth's magnetosphere, a butterfly-shaped magnetic field that protects the globe. From ground-based magnetometers, scientists estimated that magnetic fields inside the storm were 50 times stronger than the normal solar wind that flows around the Earth. A strong solar wind compresses the magnetosphere.

"This compression happens primarily on the side of the Earth facing the Sun," Ridley explains. Packing magnetic fields 10 times stronger than even extreme events, the superstorm squashed the entire magnetosphere.

The results were dire enough in 1859, but today some satellites use the magnetosphere for navigation. Compression could throw every geosynchronous satellite outside the magnetosphere, where "the fields could be reversed or at completely different angles," Ridley says. "Some satellites torque themselves to get into the right orientation. They could be turned away from the Earth, such that operators may not be able to communicate with them anymore." CT Principal Investigator Tamas Gombosi, professor of space science and aerospace engineering at Michigan, estimates that 5 to 10 satellites could be lost in a modern-day superstorm.

To enable collaborative study of many additional solar effects such as atmospheric heating, Gombosi's team is building the Space Weather Modeling Framework that will help NASA, the U.S. Air Force, and others protect their space assets. The CT Project is managed by James Fischer, ESDCD.
http://ct.gsfc.nasa.gov
http://csem.engin.umich.edu

NCCS Highlights

Upgraded NCCS System One of World's Most Powerful

Through a significant upgrade of processors and usable disk, the NASA Center for Computational Sciences' (NCCS) HP/Compaq AlphaServer SC45 is now one of the most powerful supercomputers in the non-classified world. During September, the NCCS installed an additional 880 1.25-Gigahertz (GHz) Alpha processors with three Terabytes (TB) of usable disk to the original 512-processor SC45. The upgrade brought the SC45's peak computational capability to 3.2 TeraFLOPS (TF). Total directly attached disk capacity increased to 8.5 TB.

The NASA Seasonal-to-Interannual Prediction Project (NSIPP) and the Data Assimilation Office (DAO) will be the primary users of the new upgrade, with the original 512-processor system available for Research & Analysis, ESTO/CT, and Goddard Institute for Space Studies users. This upgrade will allow all the different user groups to perform numerical simulations on a scale not previously possible. As part of the migration to the SC45, users are encouraged to make use of the parallelism of the system and to migrate their data files to standard formats. The NCCS has provided training on migrating both code and data to the new system. Additional training is scheduled through November 2002.

Sponsors must explicitly request/authorize user accounts on the SC45 or Origin systems. CPU-hour allocations are being established for accounting on each system, rather than the previous CU method. Mass storage will be accounted by Gigabyte-years. The NCCS will use full-cost accounting to establish charges for storage. Allocations and usage will be reviewed periodically to ensure effective utilization of the systems.

This upgrade completes the Phase 1 delivery of high-performance computing hardware.
http://esdcd.gsfc.nasa.gov/scb-public/nccs.welcome.html

NCCS Computing Helps Uncover Shift in Earth's Gravity Field

Scientists at GSFC's Space Geodesy Branch used the NCCS Cray SV1 supercomputer to detect a recent change in the shape of the Earth's gravity field. By analyzing measurements from 10 satellites, Christopher Cox and Benjamin Chao observed that the gravity field has extended outward near the equator and contracted near the poles since 1998. This change indicates a shift in the distribution of mass from high latitudes to low latitudes, but the cause of the redistribution remains uncertain. The scientists used the algorithms of the EGM96S model to produce the gravity field geopotential solution. The August 2 issue of Science published the results. CNN, National Geographic, and other media organizations have also covered this research.

NCCS Supports Boost of DAO Assimilation Code Performance

Junping Wang, Colorado School of Mines professor participating in NASA's Summer Faculty Fellowship Program (SFFP), developed an approximation kernel of reduced algorithmic complexity to boost the performance speed of the GSFC DAO assimilation code. In a test on a 1D grid, the approximation achieved a 1000-times increase in speed. Tom Clune, lead for the NCCS' Advanced Software Technology Group, is developing a full 3D prototype to further explore the potential for incorporating Wang's work in the DAO software. With scientists anticipating a 10,000-fold increase in the amount of Earth-related measurements from satellites in the coming decade, the DAO is enthusiastic about this work as a means to reduce the computational load.

NCCS: CRYSTAL-FACE

NCCS Points the Way for Cloud Researchers

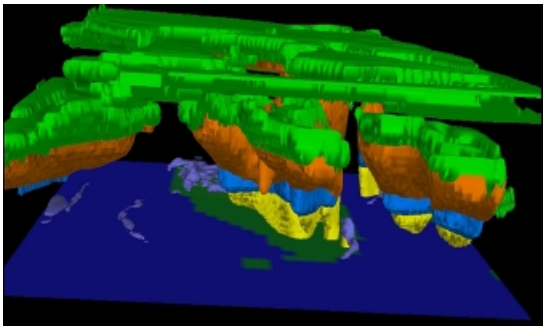
Clouds cast a shadow over an otherwise sunny landscape, and they also cast uncertainty over climate modeling. They affect temperatures by blocking sunlight from the Earth's surface, yet they are so small that they escape the resolution of many atmospheric modeling systems.

The NCCS provided its computing power to the Cirrus Regional Study of Tropical Anvils and Cirrus Layers-Florida Area Cirrus Experiment (CRYSTAL-FACE) to help reduce this uncertainty. The cooperative effort among government organizations and academia studied the composition of high tropical cirrus clouds during July 2002.

The NCCS dedicated a queue of 64 1-GHz processors on its HP/Compaq AlphaServer SC45 to the CRYSTAL-FACE project. The project selected the SC45 "not only for its very powerful high-speed performance, but also for the NCCS' excellent technical services and its UniTree data storage system," says Donghai Wang, CRYSTAL-FACE Principal Investigator, from Hampton University.

During the project, planes flew over southern Florida to analyze air samples. To guide the planes, the CRYSTAL-FACE scientists at NASA Langley Research Center (LaRC) used the SC45 to run reliable forecasts of cloud coverage. "These forecasts were essential for flight planning," said Eric Jensen, CRYSTAL-FACE lead scientist from NASA Ames Research Center. "The forecasts were used to decide takeoff times and where to send the planes."

The SC45 processing queue ran the Advanced Regional Prediction System (ARPS), a multi-scale (from cloud-scale to larger regional-scale) data analysis/assimilation modeling system. ARPS combines the physics of cloud microphysics, radiative transfer, atmospheric circulation, and land-surface effects.



A 3D cloud structure of a model forecast for July 11, 2002, that ran on the NCCS' HP/Compaq AlphaServer SC45. Image credit: NASA LaRC

With the computing capacity of the NCCS, ARPS assimilated observation data into a 15 km-resolution grid that covered the southeast U.S. At midnight and noon, the SC45 ran this grid, producing a 36-hour forecast of broad precipitation and cloud system patterns. The SC45 resolved the grid, which contained more than 1.1 million calculation points, after only 75 minutes of computation time.

For a finer prediction of convection location and timing over southern Florida, CRYSTAL-FACE used the SC45 to run a 3 km-resolution ARPS grid that contained nearly twice as many calculation points as the previous grid. After 3 hours of computation time, the SC45 generated up to 18-hour forecasts.

Furthermore, the SC45 ran a data analysis/ assimilation system that used satellite data and other weather observations to enhance initial conditions for the CRYSTAL-FACE forecast model.

The project flights carried sensors that analyzed readings of cloud composition, precipitation, aerosols, radiative fluxes, and ice crystals. The analyses will help verify remote sensor readings from NASA's Earth Observing System Terra and Aqua satellites as well as the Tropical Rainfall Measurement Mission.

The model output, 3D cloud fields that categorize several types of airborne precipitation, and related graphic products are available online. They can be customized to initialize other numerical models that simulate atmospheric circulation, cloud system formation, and aerosol dispersion. For example,

Jensen's research group used ARPS output to form more realistic boundary conditions for its own simulation of cloud systems.

Government agencies collaborating on CRYSTAL-FACE included seven of the NASA centers, National Oceanic and Atmospheric Administration, NSF, and U.S. Department of Energy.
http://asd-www.larc.nasa.gov/model/crystal

Student Enrichment

Summer Student Achievements

This past summer, 25 students from universities, colleges, and high schools extended their education through the Visiting Student Enrichment Program (VSEP). Managed by the Science Communications Technology Branch, students were matched with mentors in 10 divisions across 4 GSFC directorates for projects involving information technology, computer science, and Earth and space sciences.

ESDCD personnel have benefited by mentoring VSEP students who can assist in their research. Anthony Gualtieri says that a student can "challenge you to think clearly about what you're trying to do."

ESDCD graduate and undergraduate projects included the following:

- Jules Kouatchou mentored Emmanuel Cephas, Frostburg State College, as they completed a benchmark evaluation and documentation of the Mesoscale Model MM5 version 3 code. These test results, which will be available on the Web after verification, quantify the speed and efficiency of the NCCS parallel computing systems when they run the atmospheric model.

- Anthony Gualtieri and student Martha Buckley, Massachusetts Institute of Technology, used MATLAB and image processing techniques to implement an algorithm that distinguishes among different types of vegetation in hyperspectral data.

- John Dorband worked with students Shean McMahon and David Wangerin, University of California at Irvine; and Ernest Fessenden, Michigan Technological University, to test the capabilities of aCe, a programming extension that Dorband developed to adapt the C language to parallel computing. Their work included a comparison between aCe and the Unified Parallel C extension, an adaptive mesh refinement code in aCe, and automatic calculation for the optimal number of threads in a parallel-computing program.

- Extending the work of David Batchelor, Lori Petty, University of Kansas, developed a new model that calculates the lifetime of quark-anti-quark virtual pairs. Since this model does not assume the same initial conditions as previous models, it is anticipated to be more accurate.

- For Udaya Ranawake, Daniel Signorini, University of Maryland, created a graphical user interface (GUI) that can manage the compiling and execution of applications from a single window. The interface is a convenient aid to benchmarking code performance on parallel-processor computing systems.

- Under the supervision of Igor Eberstein, Ashley Thrall, Vassar College, calculated the potential energy curves for molecules found in the tail of a comet. These calculations can be used to study photo-dissociation in comets.

- Phil Bording supervised John Charles Holloway, University of Kentucky, as he compared the efficiency of compilers for Fortran 90 and Fortran 77.

HDTV frame of fires, Terra/MODIS data.
Image Credit: SVS

SVS

HDTV Images Featured on IMAX Screen at Congressional Event

The Scientific Visualization Studio (SVS) produced over 80,000 High Definition Television (HDTV) frames of satellite images for "The Earth: Lessons from Space," a formal evening of talks held September 12 at the National Air and Space Museum in Washington, DC. Organized by GSFC's Public Affairs Office, the talks showcased to Congressional attendees NASA's preeminent capabilities in Earth science via remote sensing. The event also stood as NASA's first major demonstration of its initiative to convert to HDTV as its principal communications medium.

The SVS HDTV frames were from data obtained from Moderate-Resolution Imaging Spectrometer (MODIS), Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Project, Landsat, and Defense Meteorological Satellite Program (DMSP)/Special Sensor Microwave Imager, as well as from simulat-

ed Aqua data. These and other frames were projected on an IMAX screen. Participants included Sean O'Keefe, NASA Administrator, and Ghassem Asrar, NASA Associate Administrator for Earth Science. Principal speakers included Michael King, GSFC Senior Project Scientist for the Earth Observing System; Sylvia Earle, Explorer in Residence, National Geographic; and Eric Barron, Dean, College of Earth and Mineral Science at Penn State. http://svs.gsfc.nasa.gov

ESDCD Updates

Appointments

John Schnase was selected as a Fellow of the American Association for the Advancement of Science.

Schnase was named Co-Chair of the Science Advisory Committee of the National Academy of Sciences/International Conference of Scientific Unions World Data Center for Biodiversity and Ecology.

Richard Lyon chaired the High-Contrast Imaging for Exo-Planet Detection Conference, as part of The International Society for Optical Engineering's (SPIE) Astronomical Telescopes and Instrumentation Conference held in Hawaii.

Tom Clune joined the Science Computing Branch as lead for the Advanced Software Technology Group.

Jacqueline LeMoigne was converted from a 4-year term to a permanent position at the Applied Information Sciences and Technology Branch.

Grants

Jacqueline LeMoigne selected Loyola College in Maryland to receive $15,000 per year for 3 years in response to Loyola's unsolicited proposal: "System Engineering Issues in Implementation of Image Registration Algorithms with Emphasis on Gradient Descent Techniques." The grant supports NRA2-37143 on Research in Intelligent Systems: "Image Registration and Fusion for Future Formation Flying Systems," Principal Investigator: LeMoigne.

"Thunderhead" PC Cluster to Exceed 1 TF

John Dorband, Josephine Palencia of Raytheon, and Udaya Ranawake of UMBC designed a next-generation ESTO/CT commodity PC cluster that is their first to exceed a peak performance of over 1 TF. The 536 2.2-GHz Pentium 4 Xeon system named "Thunderhead" will be connected with 2.0-GHz Myrinet. This cluster, the third in the HIVE series, will be available to ESTO/CT principal investigators by early Winter.

In September, Dorband and his group helped to design and procure a separate Pentium 4 cluster named "BLISS" built by GSFC's Space Science Directorate. The 148 2.2-GHz processor cluster with a peak performance of approximately 325 GigaFLOPS will support the Space Science Data Operations Office's computational needs, including astrophysics modeling.

Networking Forefronts

Pat Gary, Networking Project Manager and leader of GSFC's High End Computer Network (HECN) team, was quoted in Information Week on upgrading NASA's high-speed network despite the telecom meltdown.
http://www.informationweek.com/story/IWK20020607S0004

The HECN team will help MIT Haystack Observatory connect Germany and Japan to the "electronic" Very-Long Baseline Interferometry (eVLBI) network through the Next Generation Internet. Haystack Observatory was awarded $3M to perform this work through an NSF proposal that referenced the HECN team's eVLBI sustained performance of 900 megabits per second. The HECN team will test network infrastructure and hardware with funding provided by ESTO/CT.

MU-SPIN Workshop to Help Increase Minority Participation in Astrobiology

MU-SPIN held a 3-day workshop at GSFC to strengthen the participation of minority institutions in the field of astrobiology. The 35 participants developed a strategic plan for the Minority Institution Astrobiology Collaboratory (MIAC). The strategic plan includes identifying eight faculty members to participate in the NASA Astrobiology Institute (NAI) fellowship program, evaluating current astrobiology curriculum for undergraduate and precollege partners, partnering with the University of Washington for graduate studies, and creating a student astrobiology society at all participating institutions. Workshop participants were from minority institutions, NAI, NASA Headquarters, and GSFC. MU-SPIN co-hosted the workshop with MURED and GSFC's University Programs Office. SFFP participant Benita Bell, Bennett College professor, Greensboro, NC, worked with MU-SPIN to coordinate the workshop. http://muspin.gsfc.nasa.gov

For information or questions contact:
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