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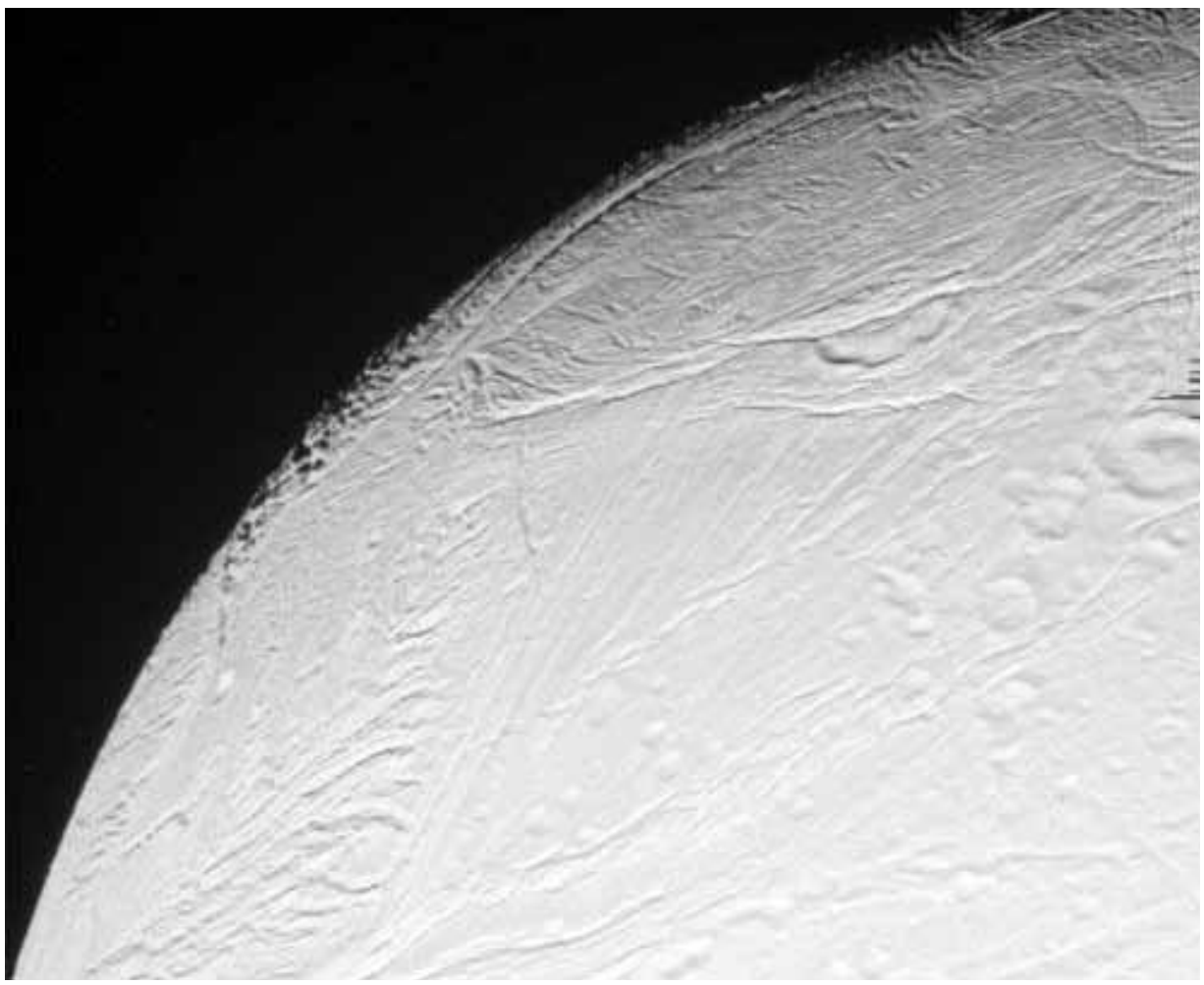
A particularly close shave

Spacecraft operations and navigation teams meet challenges during Cassini's close flybys of Enceladus

By Mark Whalen



Raw image from Cassini taken on March 27, with the camera pointing toward Saturn's moon Enceladus at approximately 19,810 miles (31,881 kilometers) away.

When you're traveling at speeds of up to 17.7 kilometers per second (more than 39,000 mph), you'd better be careful. When the journey is more than a billion kilometers from Earth, it helps to have some experience under your belt.

JPL's Cassini spacecraft has benefited in both areas, as its recent forays above Saturn's snow-white moon Enceladus have once again shown the mission's ability to acquire key data by flying extremely close to the body's surface. Cassini executed a flyby of Enceladus on April 14, its second in about two weeks' time, passing Enceladus at an altitude of about 74 kilometers (46 miles).

Via a combination of ultra-precise orbit determination and impeccable flight-path control and spacecraft operations, the Cassini team successfully pulled off the spacecraft's 19th flyby of Enceladus, the 112th pass it has made by one of Saturn's.

"This was a very hard observation because we were going by very fast," said Cassini investigation scientist Bonnie Buratti, who is analyzing Visual and Infrared Mapping Spectrometer data. "It will take a long time to analyze.

"One of the raw images shows us an area like a boulder field, which is really awesome," she added. "We can measure the boulders' size, so we can understand the size of the particles that come out of the geologically active regions of Enceladus. We're starting to better understand the morphology of that whole area."

As is often the case, the most desirable observations and measurements are also the most difficult to execute. For many of the instruments on Cassini, the closer the Enceladus flyby, the better.

Continued on page 2

Encouraging signs in Congress as NASA budget moves forward

By Mark Whalen

Encouraging signs have emerged from a couple of recent Congressional votes on next year's NASA budget, although JPL officials caution that the budget is far from finalized.

Both houses of Congress called for significant increases for funding of planetary science in revised budget proposals for NASA for fiscal year 2013. A new version of the budget that passed the House Appropriations Committee April 26 would restore $200 million for planetary science, of which $88 million would be targeted for the Mars Exploration Program. Nine days earlier, the Senate Appropriations Committee on Commerce, Justice, Science and Related Agencies voted to restore $100 million to its budget proposal.

The Obama administration's initial proposal for the 2013 NASA budget would have cut planetary science funding by $300 million. NASA's planetary science budget provides a significant share of JPL's funding.

A new strategy for the Mars Exploration Program is being developed by NASA's Mars Program Planning Group, a committee led by former veteran NASA program manager Orlando Figueroa. The group, which will include participation by JPL, will report to NASA's associate administrator for the Science Mission Directorate, John Grunsfeld.

Overall, the NASA budget as proposed by the Senate is $17.759 billion, about $48 million more than the administration's request. To the benefit of JPL, Earth science was clearly a major priority in the administration's budget, with a requested increase of more than $20 million to $1.785 billion for FY13, the same as in the Senate's request. The House version came in at $1.775 billion.

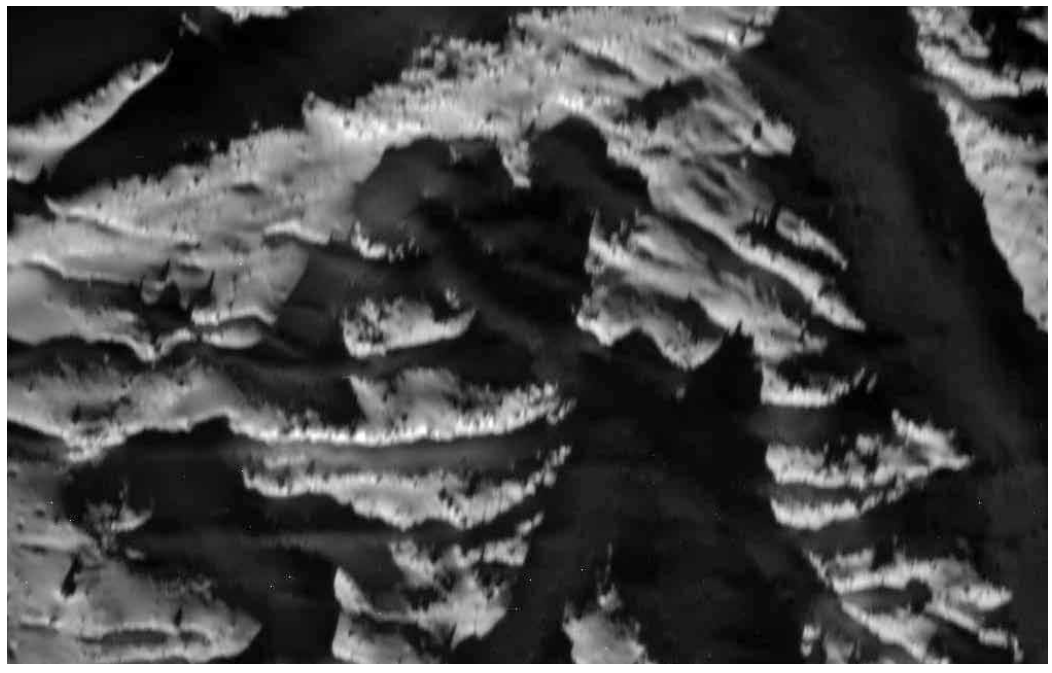
Continued on page 2

CASSINI *Continued from page 1*

"With each close flyby Cassini does of Enceladus, knowledge of its orbit is gained, thus allowing subsequent flybys to be closer," said Brent Buffington, an orbit determination analyst on the Cassini Navigation Team. He said that for the very close flybys, the navigation and spacecraft operations teams have worked very closely to avoid any chance of inadvertently hitting Enceladus due to causes such as a thruster leaking after the final maneuver before the flyby. The teams achieved this by downlinking extra telemetry to verify all thrusters are working properly. "In the event of a verified leaky thruster, contingency plans were in place to promptly react to the anomalous situation," said Buffington.

Another area of high scientific interest is Enceladus' plumes—jets of water ice and vapor, mixed with organic compounds that come out of the moon's active south pole. At Cassini's low altitudes, spacecraft safety is a major consideration, as the plumes might cause the spacecraft to tumble uncontrollably or damage the spacecraft and its components. This is yet another area in which the experience of previous flybys comes in handy.

Spacecraft Operations Manager Julie Webster said concerns over plume damage surfaced before Cassini's seventh flyby of Enceladus, in November 2009 (the deepest excursion into the plume at the time). They prompted the team to execute the targeting maneuver with thrusters rather than reaction wheels, giving them 10 times the ability to overcome any torque imparted from the plumes. After that flyby, the team concluded the plume intensity was low enough that only the reaction wheels were needed for the ninth flyby. Using reaction wheels for that pass significantly improved science observations, Webster said. Models of the plumes' intensity were updated after each flyby, resulting in pinpoint accuracy.



Raw image by Cassini on April 14. The camera was pointing toward Enceladus at about 115 miles (185 kilometers) away.

After Cassini's 18th flyby of Enceladus, said Webster, "We compared how the model predicted the reaction wheel speeds vs. the flight data. Large changes in wheel speeds would indicate unexpected torque from the plumes. For all three wheels, the change in revolutions per minute between predicted and flight was less than 5 rpm. That is less than the day-to-day operational variation in wheel speeds!"

Buffington added that a Plume Working Group comprised of scientists and engineers weighed the safety of flying directly through Enceladus' plume based not only on the plumes' density but also the possible presence of debris large enough to harm the spacecraft. "We have made certain that we can be confident that what we're doing is safe for the spacecraft," he said. "Nonetheless, it's always nice to see the spacecraft re-establish communication with Earth after such close flybys!

"To look through a telescope at Saturn on any given night, and know that we're flying a spacecraft around that distant orb over 1 billion kilometers from Earth, and to know that the spacecraft is regularly flying by bodies with sub-kilometer accuracy, is something that never gets old," Buffington added.

Rounding out a trio of Enceladus flybys over the course of a little more than a month, a final flyby of the moon (also at an altitude of 74 kilometers) was scheduled for Tuesday, May 2.

The May 2 encounter is a radio science gravity flyby, one of three designed to understand the internal structure of the moon. Scientists planned to focus particularly on the concentration of mass under the south polar region, which may provide insight into the moon's plume activity. Three more flybys are scheduled for 2015.

NASA BUDGET *Continued from page 1*

"The good news is that NASA has done fairly well in this environment, when you consider the president gave NASA a pretty good budget," said Richard O'Toole, JPL executive manager of the Office of Legislative Affairs.

NASA's space technology budget, nonexistent just three years ago, has been upped by the administration's request by $125 million, to $699 million. That's good news for JPL, where the Lab's NASA Technology Program Office oversees the Low Density Supersonic Decelerator and Deep Space Atomic Clock projects, which are central to this budget. "We also have a range of mid- and low-technology readiness level projects that benefit from the funding," said NASA Technology Program Office Manager Tom Cwik.

O'Toole noted that a congressional conference committee would probably not meet for some months to reconcile remaining issues after each bill goes to full floor votes in both houses. One point of contention, he said, is the fact that the House and the Senate are allocating their appropriation funds based on different totals. A budget agreement last year among the administration and the leadership for both House and Senate targeted a federal budget of $1.047 trillion; however, the House recently passed a budget bill at $1.028 trillion.

A new version of the budget that passed the House Appropriations Committee April 26 would restore $200 million for planetary science, of which $88 million would be targeted for the Mars Exploration Program.

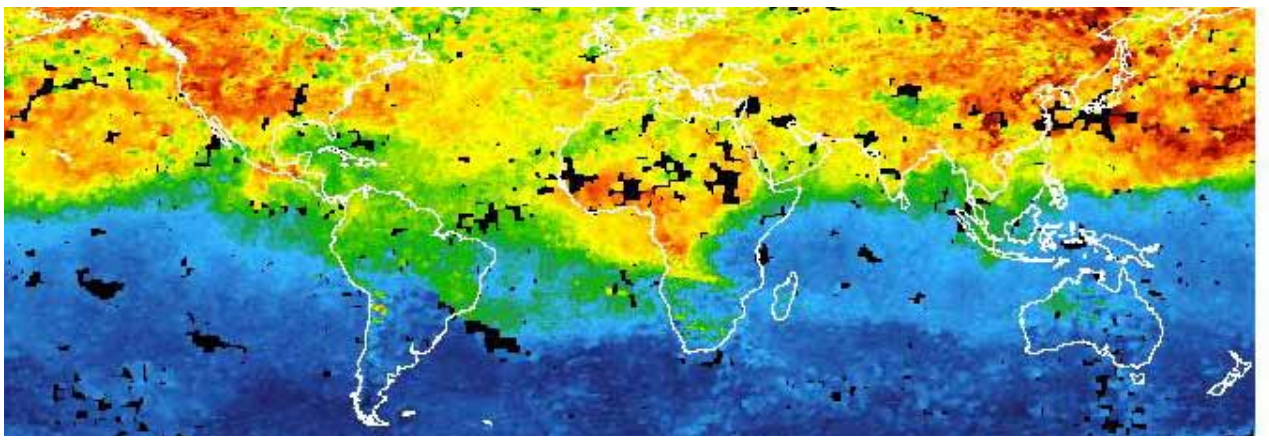
"The president and the Senate agree that they should stick with last year's deal," O'Toole said. "The House has said that's not enough budget austerity; we need to cut it back. There has to be a compromise there."

Noting that the presidential election this year would not hasten a budget agreement, O'Toole believes there's a good chance for Congress to adopt a continuing resolution at least through the election, which means that the agency's programs would be funded at current or reduced levels if a formal appropriations bill has not been signed into law by the end of the fiscal year.

O'Toole noted the importance of the continued support of California members of the appropriations committees—Rep. Adam Schiff and Senator Dianne Feinstein—as well as U.S. Rep. John Culberson of Texas, who have gone to bat for NASA's planetary program.

Sounder celebrates 10 years of helping to improve weather forecasts

By Erik Conway



An Atmospheric Infrared Sounder map shows global carbon monoxide levels in mid-April.

May marks the 10th anniversary of JPL's Atmospheric Infrared Sounder, which launched into orbit aboard the Aqua satellite May 4, 2002. AIRS was the brainchild of the late Moustafa Chahine, who served as JPL's chief scientist for many years. In the late 1970s, he had the idea of improving weather forecasting through a technique called hyperspectral sounding—the use of many infrared channels to better discern temperature and water vapor variations in the atmosphere. NASA funded an airborne prototype that operated in the early 1980s; when NASA's program of Earth Observing System satellites was established in 1988, AIRS was selected as its infrared sounder.

Fred O'Callaghan, who Chahine hired as project manager, recalls that the development was technically challenging. AIRS needed small, but very reliable, cryocoolers to keep the instrument cold. And it needed a new generation of infrared detectors. O'Callaghan contracted with an instrument supplier in Boston, Loral Infrared Systems, now BAE Systems, to build the detectors and the instrument itself. "It was a good team, we had worked together over the years on the ATMOS instrument. We understood each other. Together we accomplished a lot of hard things."

After launch, Chahine's science team turned first to validating the data that the instrument was collecting. "We demonstrated their reality by reference to other observations, primarily weather balloons, aircraft, and ground-based observation systems," said Eric Fetzer, the AIRS validation scientist, who coordinated dozens of investigations made up of thousands of individual measurements around the globe. These even extended to the poles, using a Department of Energy site on the North Slope of Alaska and Antarctica's "Dome C," a drilling site for ancient ice cores.

Validating data has proven to be a never-ending task. Whenever the science team changes the software that converts the instrument's infrared measurements into temperatures, it has to be revalidated. "Revalidation also enables us to check for long-term trends," Fetzer said. "We had a spurious cooling compared to radiosondes for awhile."

The AIRS team reached one of its major goals in 2006, when a group led by the National Oceanic and Atmospheric Administration's John Le Marshall showed using AIRS temperature data could be udemonstrated that use of the AIRS temperature data in weather forecasting models significantly improved what weather professionals call forecast "skill." Skill is the name for a calculation meteorologists use to quantify how close a forecast is to the observed weather; AIRS improved skill after the second forecast day. More recent research at the European Center for Medium Range Forecasting showed that AIRS provided the largest improvement in forecast skill of any single instrument during the 2000s, and was second in forecast impact only a set of microwave sounding instruments in orbit.

A critical factor that enabled the accomplishment was the project's decision to require delivery of data in near-real-time. According to JPL's Joao Teixeira, "Operational weather prediction centers have to produce a forecast in a few hours. They have about two hours to ingest the data, then they run the model for about two hours to make a ten-day forecast, and it takes about two hours more to disseminate the results." So in order to affect routine weather forecasts, the team had to build a data system that operated in real-time—normal for NOAA, but very unusual for NASA.

As the first of a series of hyperspectral sounders for weather forecasting, AIRS was a trailblazer in understanding and assimilating data produced by the new class of instruments. Another AIRS will probably not be built, but it is being followed by other hyperspectral sounders that use different techniques to preserve the forecasting gains. The new generation of European meteorological satellites now host an AIRS-like sounder called the Infrared Atmospheric Sounding Interferometer, and a similar instrument known as the Cross-track Infrared Sounder is aboard the recently launched NASA satellite Suomi NPP, planned as the forerunner of the next generation of U.S. weather satellites.

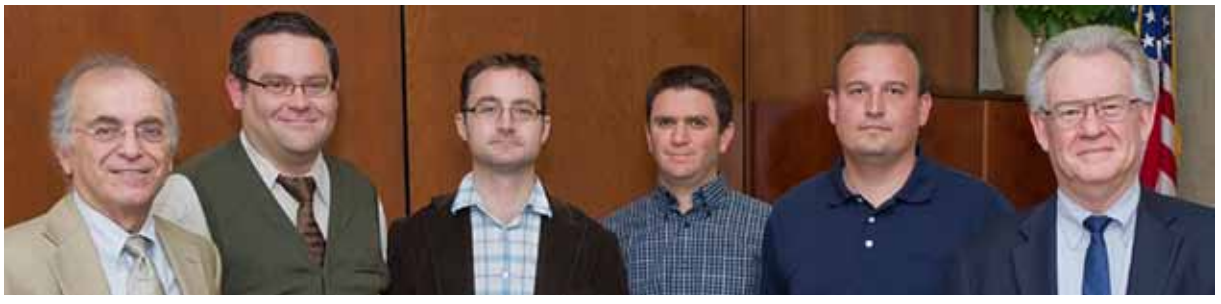
AIRS has also had important scientific results. One of the most significant has been quantifying what's called the water vapor feedback effect. "As the surface warms and the atmosphere with it, the atmosphere can hold a little more water vapor," Fetzer explained. "Water vapor is itself a greenhouse gas, it traps heat the same way carbon dioxide does. So if there's a slight warming, there will be a slight increase in water vapor, and that water vapor itself will cause a continuing increase." This vicious circle of warming is known as a positive feedback.

The idea was well rooted in theory dating back to the 19th century, but theory does not always play out as scientists expect in the real world. A team led by Andrew Dessler of Texas A&M tested the theory using AIRS' humidity data product. AIRS was able to quantify the amount of water vapor at different levels of the atmosphere globally, permitting them to derive the average strength of the water vapor feedback across the globe. Dessler found that the water vapor feedback "is extraordinarily strong, capable of doubling the warming due to carbon dioxide alone."

Another important result from AIRS was the development of data products that quantify the amount of several climatically active trace gases—carbon dioxide, carbon monoxide, methane and some others—globally. This has provided a clearer picture of trends such as the human-driven increase in atmospheric carbon dioxide.

Thus, after a decade in orbit, AIRS has continued to make its mark in a number of research areas. And its impact will continue on in other instruments that carry on the observations that AIRS innovated.

Lew Allen Award winners honored



Thom Wynne / JPL Photo Lab

From left: JPL Director Charles Elachi, Richard Hofer, Kevin Hand, Ken Cooper, Eric Larour, Chief Scientist Dan McCleese.

Four JPLers have been named recipients of the Lew Allen Award for Excellence, which recognizes and encourages significant individual accomplishments or leadership in scientific research or technological innovation by JPL employees during the early years of their professional careers.

Ken Cooper of the Submillimeter-Wave Advanced Technology Group was selected for the development and demonstration of the world's first terahertz imaging radar system.

Kevin Hand of the Solar System Exploration Directorate was selected for outstanding leadership in the field of astrobiology.

Richard Hofer of the Electric Propulsion Group was selected for outstanding technical contributions and leadership in establishing JPL as a world leader in Hall thruster research and development.

Eric Larour of the Applied Low Temperature Physics Group was selected for outstanding accomplishment in developing the ice sheet system model that significantly contributes to the knowledge of global change.

The award, named in honor of the former JPL director who retired in 1990, includes $25,000 from the JPL Research and Technology Development Fund to be used at the Lab to enhance awardees' professional efforts.

News Briefs

Marc Goettel

New deputy CFO named

Marc Goettel will join JPL as the deputy chief financial officer and deputy director for business operations effective May 14.

Prior to joining JPL, Goettel completed 15 years with Southern California Edison at the San Onofre Nuclear Generating Station. His most recent position at Edison was director for financial management and site support, where he managed a staff of more than 1,000 employees and led business operations and finance organizations comparable in scope and size to JPL's Business Operations Directorate. At Edison he also held the positions of director for process integration and asset management, and director for business planning and financial services. Previously, Goettel taught corporate finance, investments and competitive analysis for five years at the University of Oregon.

Goettel received a master's of science in finance from University of Oregon and a master's of business administration and bachelor's of science in finance from Arizona State University.

Instrument upgrade awarded

C. Darren Dowell of the Astronomical Instrumentation Group has been selected as principal investigator of a science instrument upgrade for NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) airborne observatory.

The instrument, the High-resolution Airborne Wideband Camera, will provide a sensitive, versatile and reliable imaging capability to the SOFIA user community.

The investigation upgrades the instrument to include the capability to make polarimetric observations at far-infrared wavelengths for the purpose of characterizing magnetic fields in the interstellar medium, star-forming regions and the center of the Milky Way.

"Magnetic fields can be mapped for dust column densities as low as 1 visual magnitude of extinction, allowing us to explore all of the stages of molecular cloud and protostellar evolution," Dowell said. "We have assembled a team of experts in polarimetry, magnetic field theory and observation, physics of the interstellar medium, and dust grain alignment theory for the purpose of fully exploiting the data from this instrument."

Dowell's proposal was one of two selected from a NASA Announcement of Opportunity last August for SOFIA second-generation instrument investigations that received 11 proposals. The second selected investigation, from Johannes Staguhn of Johns Hopkins University in Baltimore, will provide a sensitive, large-format detector array to Dowell's investigation, increasing its observing efficiency and providing a broader range of targets.

SOFIA is a joint project of NASA and the German Aerospace Center and is based and managed at NASA's Dryden Aircraft Operations Facility in Palmdale. For more information about the SOFIA program, visit *http://www.nasa.gov/sofia*.

Instrument proposal selected

A JPL-led proposal has been selected for funding to support the NASA Earth Science Division's Applied Sciences Program in the area of water resources, with an emphasis on drought prediction and mitigation.

Thomas Painter of the Water and Carbon Cycles Group is principal investigator for "Integration of Precision NASA Snow Products with the Operations of the Colorado Basin River Forecast Center to Improve Decision Making Under Drought Conditions."

The primary objective of the proposal is to integrate real-time, high-precision Moderate Resolution Imaging Spectroradiometer snow-covered areas and grain size fractional snow-covered areas into Colorado Basin River Forecast Center modeling and analysis systems and into stakeholder-oriented data products, drastically reducing snow-covered area uncertainties that have hampered forecasting operations for decades.

The collaboration directly addresses drought prediction, assessment, adaptation and mitigation in support of energy security and efficiency, natural resource conservation and water demand, and will also improve access and availability of actionable water monitoring, hence drought information.

NASA selected 12 awards from 65 proposals submitted for this solicitation, totaling about $2 million over the first-year feasibility stage of the projects. For more information, visit *http://appliedsciences.nasa.gov* and *http://nspires.nasaprs.com*.

Open House coming up

JPL's annual Open House will be held Saturday and Sunday, June 9 and 10, from 9 a.m. to 4 p.m.

This year's theme is "Great Journeys," inviting visitors to share in the wonders of space through high-definition and 3-D videos, live demonstrations, and a first look at JPL's new Earth Science Center.

For more information, please visit *http://www.jpl.nasa.gov/events/open-house.cfm*.

Passings

Robert Raskin

Robert Raskin, 55, supervisor of the Science Data Engineering and Archiving Group, died March 2.

Raskin had worked at the Lab since 1997. He devoted his career to promoting ontology, which captures and organizes common knowledge about a domain to improve discovery and fusion of information sources. He was principal investigator for the Semantic Web for Earth and Environmental Terminology project to develop an upper-level ontology for Earth system science, and was lead developer of the Poet user interface for online data access from the Physical Oceanography Distributed Active Archive Center. He also served as vice president of the Earth Science Information Partner Federation.

Raskin is survived by his sister Lisa Steele, nephew Dan Steele and niece Jessica Steele. His ashes were spread over the ocean in Hawaii. A memorial was held in Pasadena March 24.

Former JPL researcher **David Glackin**, 59, died March 3.

A 1974 Caltech astronomy graduate, Glackin served as a member of the technical staff from 1978 to 1986. He was experiment scientist for the X-Ray/XUV/Visible imager on the International Solar Polar mission, task manager in the Image Processing Laboratory for Navy meteorological studies and for the application of NASA technologies to art conservation and document preservation, as well as analysis and programming support to the Viking, Voyager, Galileo and Infrared Astronomical Satellite flight projects. He also supported the Geostationary Operational Environmental Satellite program.

David Glackin

Tom Hamilton III, 81, a retired engineer and manager, died March 7.

Hamilton joined JPL in 1953 and supported a range of missions from the Venus Mariner R-2 to his last project with the Gravity Recovery and Climate Experiment gravity mapping satellite system. In the early 1950s, he worked on the Corporal and Sergeant short-range missile guidance systems. In 1958, he switched from Army projects to NASA work. Among his supervisory positions, Hamilton managed JPL's Navigation Program, served as deputy manager of divisions 31 and 39, and was assistant manager for the Solar Energy Program.

In 1993, the year he retired, Hamilton was awarded NASA's Exceptional Achievement Medal.

Hamilton is survived by sisters Betsy Lanoue and Lawrie Hamilton; children Lisa Shenton and Tom Hamilton; stepchildren Dan Burke, Jean Burke-Martinez and Jim Burke; and grandchildren Sam, Alex, Zak, Corin, Elias, Katy, Ilana and Benny. Services were held March 24 in Santa Rosa, Calif.

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Letters

I would like to express my sincere gratitude to all my JPL colleagues and friends for their love and support following the recent passing of my beloved husband, Bruce. Your condolences, cards, gifts, flowers and the plant from ERC were so comforting during this difficult time. Thanks to all of you who attended the service. It meant so much to me to have you there. I am truly blessed to have all of you in my life. Thank you from the bottom of my heart.

Ginger Kemp

Thank you to all my JPL family and co-workers for the kind thoughts and prayers on the passing of my father-in-law. Lisa and I would like to especially thank the ERC for the beautiful plant that was sent to our house in his memory. It's a beautiful plant that will remind us of his continuing presence. Again, thanks to the JPL family for being there in both support and all of your condolences.

John and Lisa Mann

My family and I would like to thank my co-workers at JPL for their heartfelt condolences and the beautiful plant we received from JPL ERC during the recent passing of my beloved mother. Thank you and God bless!

Beatriz Abuata

Retirees

The following employees retired in April: **Robert Kocsis**, 45 years, Section 313E; **Mark Herring**, 43 years, Section 382; **Donald Langford**, 42 years, Section 314B; **Duc Nguyen,** 27 years, Section 5144; **Dennis Byrnes,** 24 years, Section 343; **Wlodzimierz Gawronski,** 23 years, Section 333G; **Sharon Allen,** 15 years, Section 311; **Charles Foehlinger**, 14 years, Section 357C; **James Kipfstuhl**, 11 years, Section 318E.