

National Aeronautics and Space Administration



# GodDardView

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A photograph of a Space Shuttle launching at night. The shuttle is illuminated by its own engines, creating a bright orange and yellow glow. The orbiter is visible on top of the external tank and solid rocket boosters. The launch pad structure is visible on the left side of the frame.

**TDRS-L JOINS THE FLEET**

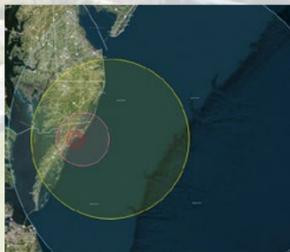
## THE WEEKLY



**Your Name on an Asteroid Mission**  
Everyone can submit their names to be etched on a microchip aboard a spacecraft headed to the asteroid Bennu in 2016. The OSIRIS-Rex spacecraft will collect a sample of Bennu's surface and return it to. To participate, click on the image.

### Wallops Launches Suborbital Rockets

NASA Wallops supported the successful launch of three Terrier-Orion suborbital rockets for DoD on Jan. 15. The next launches scheduled from Wallops are a NASA suborbital sounding rocket in late April and Orbital Sciences Corporation's Antares rocket in May. For more information, click on the image.



**Video Shows GPM's Journey to Japan**  
NASA's new video, "GPM's Journey to Japan," highlights the unique shipment of the Global Precipitation Measurement mission's Core Observatory by air, land and sea. Viewers will see that, GPM traveled by truck, plane and boat to get to the launch site in Japan. Click on the image to learn more.

### Conversations with Goddard

From summer intern to napkin speechwriter, Justin Rice is making waves through the Goddard Community. Learn more about Justin and more people at Goddard by clicking the picture.



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**On the cover:** The United Launch Alliance Atlas V rocket lifts off from Space Launch Complex 41 at Cape Canaveral Air Force Station carrying NASA's Tracking and Data Relay Satellite, or TDRS-L, spacecraft to Earth orbit. Liftoff was at 9:33 p.m. EST. Photo credit: NASA

## GoddardView

*Goddard View* is an official publication of NASA's Goddard Space Flight Center. *Goddard View* showcases people and achievements in the Goddard community that support Goddard's mission to explore, discover, and understand our dynamic universe. *Goddard View* is published weekly by the Office of Communications.

News items for publication in *Goddard View* must be received by noon Wednesday of each week. You may submit contributions to the editor via e-mail at [john.m.putman@nasa.gov](mailto:john.m.putman@nasa.gov). Ideas for new stories are welcome but will be published as space allows. All submissions are subject to editing.

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# NASA LAUNCHES THIRD GENERATION COMMUNICATIONS SATELLITE

By: Joshua Buck, Dewayne Washington and George Diller

**N**ASA's Tracking and Data Relay Satellite L (TDRS-L), the 12th spacecraft in the agency's TDRS Project, is safely in orbit after launching at 9:33 p.m. EST Thursday, Jan. 23, aboard a United Launch Alliance Atlas V rocket from Cape Canaveral Air Force Station in Florida.

Ground controllers report the satellite—part of a network providing high-data-rate communications to the International Space Station, Hubble Space Telescope, launch vehicles and a host of other spacecraft—is in good health at the start of a three-month checkout by its manufacturer, Boeing Space and Intelligence Systems of El Segundo, Calif. NASA will conduct additional tests before putting [TDRS-L](#) into service.

"TDRS-L and the entire TDRS fleet provide a vital service to America's space program by supporting missions that range from Earth-observation to deep space discoveries," said NASA Administrator Charles Bolden. "TDRS also will support the first test of NASA's new deep space spacecraft, the Orion crew module, in September. This test will see Orion travel farther into space than any human spacecraft has gone in more than 40 years."

The mission of the TDRS Project, established in 1973, is to provide follow-on and replacement spacecraft to support NASA's space communications network. This network provides high data-rate communications. The TDRS-L spacecraft is identical to the TDRS-K spacecraft launched in 2013.

"This launch ensures continuity of services for the many missions that rely on the system every day," said Jeffrey Gramling, TDRS project manager at NASA's Goddard Space Flight Center.

The TDRS fleet began operating during the space shuttle era with the launch of TDRS-1 in 1983. Of the 11 TDRS spacecraft placed in service to date, eight still are operational. Four of the eight have exceeded their design life.

Boeing Space and Intelligence Systems completed the TDRS-L integration and testing at its satellite factory in El Segundo in November and launch processing began after the spacecraft arrived in Florida Dec. 6.

TDRS-M, the next spacecraft in this series, is on track to be ready for launch in late 2015.

NASA's Space Communications and Navigation Program, part of the Human Exploration and Operations Mission Directorate at the agency's headquarters in Washington, D.C., is responsible for the space network. The TDRS Project Office at Goddard manages the TDRS development program. Launch management of the launch service for TDRS-L is the responsibility of HEOMD's Launch Services Program based at the agency's Kennedy Space Center in Florida. United Launch Alliance provided the Atlas V rocket launch service. ■

Above: At Cape Canaveral Air Force Station's Space Launch Complex 41, a United Launch Alliance Atlas V rocket stands ready to boost NASA's Tracking and Data Relay Satellite spacecraft to Earth orbit. Photo credit: NASA



“curls that look like cream swirling in a cup of coffee.”

## NASA-FUNDED SOUNDING ROCKET TO CATCH AURORA IN THE ACT

By: Karen C. Fox

On Jan. 24, 2014, Marilia Samara will be waiting for the perfect aurora. Samara and her science team will be at the Poker Flat Research Range in Poker Flat, Alaska, looking for classic curls in the aurora in the night sky—curls that look like cream swirling in a cup of coffee. When they spot the appropriate conditions, the team will launch a [sounding rocket](#) for a 10-minute flight right into the heart of the aurora.

Samara is the principal investigator for the NASA-funded Ground-to-Rocket Electron-Electrodynamics Correlative Experiment mission, which seeks to understand what combination of events sets up these auroral curls in the charged, heated gas—or plasma—where aurora form. This is a piece of information, which helps paint a picture of the sun-Earth connection and how energy and particles from the sun interact with Earth’s own magnetic system, the magnetosphere.

“Our overarching goal is to study the transfer of energy from the sun to Earth,” said Samara, a space scientist at the Southwest Research Institute in San Antonio, Texas. “We target a particular manifestation of that connection: the aurora.”

At their simplest, aurorae are caused when particles from the sun funnel over to Earth’s night side, generate electric currents, and trigger a shower of particles that strike oxygen and nitrogen some 60 to 200 miles up in Earth’s atmosphere, releasing a flash of light. But the details are always more complicated. Researchers wish to understand the aurora, and movement of plasma in general, at much smaller scales including such things as how different structures are formed there.

To study the structures, GREECE consists of two parts: ground-based imagers to track the aurora from the ground and the rocket to take measurements from the middle of the aurora itself. The rocket will fly for 600 seconds, reaching its zenith over the native village of Venetie, Alaska. State-of-the-art imagers will be placed in Venetie to watch the development of the curls and help the team decide when to launch—sometime during a

launch window of Jan. 24 to Feb. 6. Instruments on the rocket will gather information on the particles and electric fields within the aurora to be compared to the images gathered from the ground.

“Auroral curls are visible from the ground with high-resolution imaging,” said Samara. “And we can infer from those observations what’s happening farther out. But to truly understand the physics we need to take measurements in the aurora itself.”

Different combinations of information on the particles and fields observed in the aurora would point to a different cause for these swirls in the sky. Auroral curls might be caused by what’s called a Kelvin-Helmholtz instability, the same combination of low and high speed flows that lead to surfer waves near the beach. Or they could be caused by something called Alfvén waves—a type of electromagnetic wave present only in plasmas. Or they could be caused by something else altogether.

Sounding rockets are a perfect tool for tackling the answer. For one thing, sounding rockets are one of the few space-faring vehicles capable of being sent directly through the heights at which auroras exist. Second, sounding rockets can provide a robust set of observations, even in a ten-minute trip, at relatively low-cost.

GREECE is a collaborative effort between SWRI, which developed particle instruments and the ground-based imaging, and the University of California, Berkeley, measuring the electric and magnetic fields. The launch is supported by a sounding rocket team from NASA’s Wallops Flight Facility, Wallops Island, Va. The University of Alaska, Fairbanks operates the Poker Flat Research Range. ■

Opposite: A NASA-funded sounding rocket will launch from Poker Flat Research Range in Alaska to study what causes swirling structures within aurora. This aurora picture was captured in Tromsø, Norway, on Jan. 9, 2014. Photo credit: Copyright Harald Albrigtsen, used with permission.



# ENORMOUS AQUIFER DISCOVERED UNDER GREENLAND ICE SHEET

By: Maria-José Viñas

**B**uried underneath compacted snow and ice in Greenland lies a large liquid water reservoir that has now been mapped by researchers using data from NASA's [Operation IceBridge](#) airborne campaign.

A team of glaciologists serendipitously found the aquifer while drilling in southeast Greenland in 2011 to study snow accumulation. Two of their ice cores were dripping water when the scientists lifted them to the surface, despite air temperatures of minus 4 F. The researchers later used NASA's Operation IceBridge radar data to confine the limits of the water reservoir, which spreads over 27,000 square miles—an area larger than the state of West Virginia. The water in the aquifer has the potential to raise global sea level by 0.016 inches.

“When I heard about the aquifer, I had almost the same reaction as when we discovered Lake Vostok (in Antarctica): it blew my mind that something like that is possible,” said Michael Studinger, project scientist for Operation IceBridge, a NASA airborne campaign studying changes in ice at the poles. “It turned my view of the Greenland ice sheet upside down. I don't think anyone had expected that this layer of liquid water could survive the cold winter temperatures without being refrozen.”

Southeast Greenland is a region of high snow accumulation. Researchers now believe that the thick snow cover insulates the aquifer from cold winter surface temperatures, allowing it to remain liquid throughout the year. The aquifer is fed by meltwater that percolates from the surface during the summer.

The new research is being presented in two papers: one led by the University of Utah's Rick Forster that was published on Dec. 22 in the journal *Nature Geoscience* and one led by NASA's Lora Koenig that has been accepted for publication in the journal *Geophysical Research Letters*. The findings will significantly advance the understanding of how melt water flows through the ice sheet and contributes to sea level rise.

When a team led by Forster accidentally drilled into water in 2011, they weren't able to continue studying the aquifer because their tools were not suited to work in an aquatic environment. Afterward, Forster's team determined the extent of the aquifer by studying radar data from Operation IceBridge together with ground-based radar data. The top of the water layer clearly showed in the radar data as a return signal brighter than the ice layers.

Koenig, a glaciologist with NASA's Goddard Space Flight Center, co-led another expedition to southeast Greenland with Forster in April 2013 specifically designed to study the physical characteristics of the newly discovered water reservoir. Koenig's team extracted two cores of firn (aged snow) that were saturated with water. They used a water-resistant thermoelectric drill to study the density of the ice and lowered strings packed with temperature sensors down the holes, and found that the temperature of the aquifer hovers around 32 F, warmer than they had expected it to be.

Koenig and her team measured the top of the aquifer at around 39 feet under the surface. This was the depth at which the boreholes filled with water after extracting the ice cores. They then determined the amount of water in the

water-saturated firn cores by comparing them to dry cores extracted nearby. The researchers determined the depth at which the pores in the firn close, trapping the water inside the bubbles—at this point, there is a change in the density of the ice that the scientists can measure. This depth is about 121 feet and corresponds to the bottom of the aquifer. Once Koenig's team had the density, depth and spatial extent of the aquifer, they were able to come up with an estimated water volume of about 154 billion tons. If this water were to suddenly discharge to the ocean, this would correspond to 0.016 inches of sea level rise.

Researchers think that the perennial aquifer is a heat reservoir for the ice sheet in two ways: melt water carries heat when it percolates from the surface down the ice to reach the aquifer. And if the trapped water were to refreeze, it would release latent heat. Altogether, this makes the ice in the vicinity of the aquifer warmer, and warmer ice flows faster toward the sea.

“Our next big task is to understand how this aquifer is filling and how it's discharging,” said Koenig. “The aquifer could offset some sea level rise if it's storing water for long periods of time. For example after the 2012 extreme surface melt across Greenland, it appears that the aquifer filled a little bit. The question now is how does that water leave the aquifer on its way to the ocean and whether it will leave this year or a hundred years from now.” ■

Above: An ice core segment extracted from the aquifer by Koenig's team, with trapped water collecting at the lower left of the core. Photo credit: NASA/Goddard/Ludovic Brucker

Below: Glaciologist Lora Koenig (left) operates a video recorder that has been lowered into the bore hole to observe the ice structure of the aquifer in April 2013. Photo credit: University of Utah/Clément Miège





The latest tool for checking space weather is an Internet radio station fed by data from NASA's [Lunar Reconnaissance Orbiter](#).

The radio station operates in real-time, receiving measurements of how much radiation the spacecraft is experiencing and converting those into a constant stream of music. The radiation levels determine which instrument is featured, the musical key being used and the pitches played.

"Our minds love music, so this offers a pleasurable way to interface with the data," said the leader of the music project, Marty Quinn of the University of New Hampshire, Durham. "It also provides accessibility for people with visual impairments."

The radiation levels are determined by LRO's Cosmic Ray Telescope for the Effects of Radiation. Equipped with six detectors, CRaTER monitors the energetic charged particles from galactic cosmic rays and solar events.

The instrument makes two kinds of crucial measurements. One type studies the interaction of radiation in space with a material that is like human tissue; this is helping scientists assess the effects that exposure would have on people and organisms. The other type looks at radiation hitting the moon and the products generated by that interaction.

"CRaTER has discovered wide-ranging and fundamental aspects of such radiation," said Nathan Schwadron, the principal investigator for CRaTER. "For example, we have discovered that tissue-equivalent plastics and other lightweight materials can provide even more effective protection than standard shielding, such as aluminum."

Each detector on CRaTER reports the number of particles registered every second. These counts are relayed to CRaTER Live Radio, where software converts the numbers into

pitches in a four-octave scale. Six pitches are played every second, one for each detector. Higher, tinkly pitches indicate less activity, whereas lower, somber-sounding pitches indicate more activity.

The software selects the primary instrument and a musical key based on recent activity. At the lowest radiation levels, the main instrument will be a piano, playing pitches from one of the major scales. As the peak radiation level climbs, one of the minor scales will be selected instead, and the piano will be replaced by one of seven other instruments.

For example, when CRaTER picked up elevated radiation counts caused by the solar flare on Jan. 7, 2014, the primary instrument changed to a marimba, which is two instruments up from the piano. A steel drum or guitar instead of a marimba would mean the radiation level had ramped up more. A banjo would mean the peak had climbed to the top of the normal operating range.

If the counts climb beyond the top of the normal operating range—as might happen during a very big event—the software would switch into a second operating range. The piano would again represent the bottom of this range, and the banjo would represent the top. To indicate which range is current, a violin and a cello play sustained notes in the background. If those sustained notes are played at the highest pitches on the scale, the normal operating range is in effect; if those notes drop by even one pitch, the second range is being used.

"Music makes it easy for people to take in the data, and it seems to be a natural fit for space missions," said LRO's project scientist, John Keller of NASA Goddard. ■

Above: A screenshot of the controls for instruments used as determined by data from LRO. Image credit: University of New Hampshire

The second year of an unprecedented balloon campaign in Antarctica has just begun. The NASA-funded mission—called the Balloon Array for Radiation belt Relativistic Electron Losses, or [BARREL](#)—is led by Dartmouth College in Hanover, N.H. The mission is unique, as it relies not on one gigantic balloon, but on many smaller ones, 20 in total.

BARREL's job is to help unravel the mysterious radiation belts, two gigantic donuts of particles that surround Earth. The mission works in conjunction with NASA's Van Allen Probes, two spacecraft currently orbiting around Earth to study the belts.

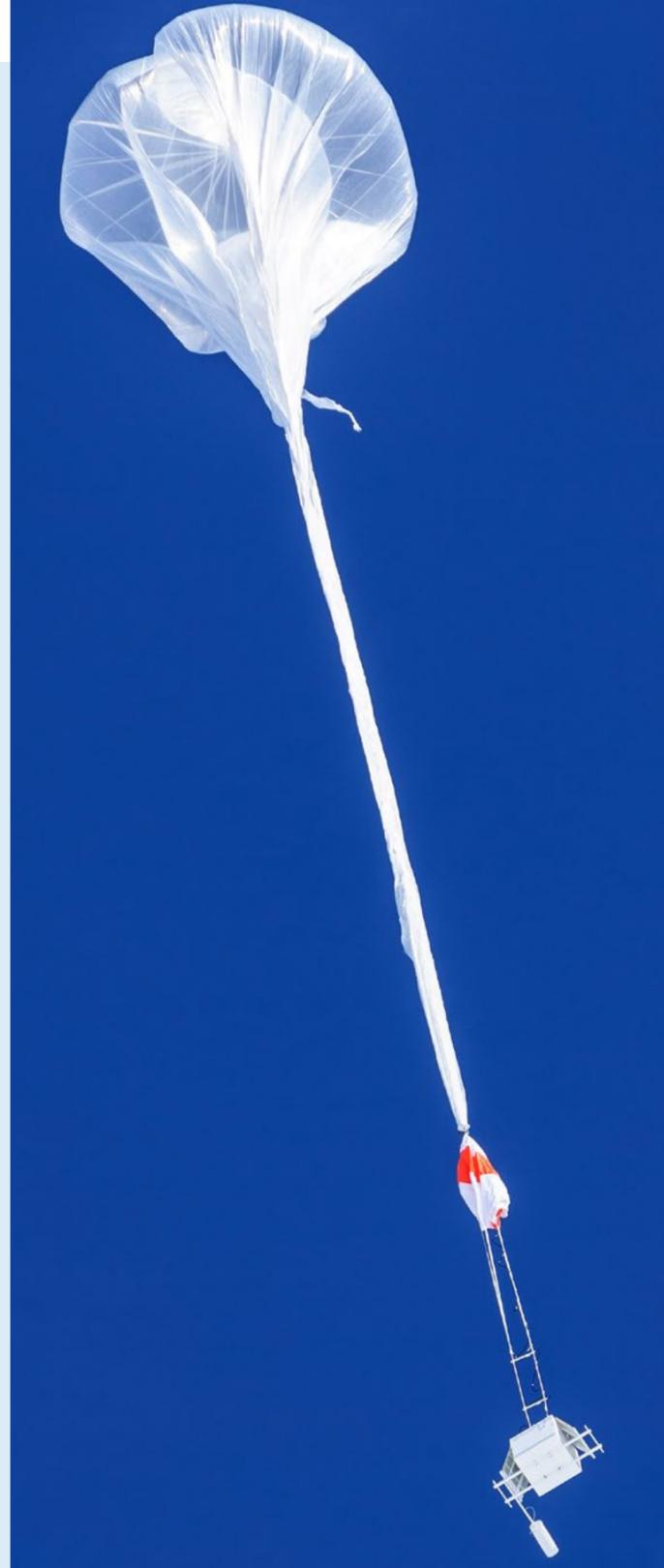
"This year the Van Allen Probes and the BARREL balloons will be exploring what happens at dusk," said Robyn Millan, principal investigator for BARREL at Dartmouth. "Balloon campaigns in the Antarctic region have long seen these bursts of particles precipitating down toward Earth at dusk. This year, the spacecraft and the balloons will have coordinated measurements to determine what's happening up in the belts during these events."

Millan and her team traveled to Antarctica in mid-December 2013, and they launched their first balloon on Dec. 27, 2013. They will launch a single balloon on any given day, which will float leisurely around the South Pole for up to a week or two afterwards. Instruments aboard the balloon will send back data on the magnetic systems it floats through, as well as the kinds of particles it observes. By coordinating with the Van Allen Probes data, orbiting high above, the team hopes to determine what's happening in the belts that correlate with the precipitation bursts near Earth. Such information will ultimately help scientists understand how particles get ejected from the belts.

"The spacecraft will be taking measurements in the right place to observe the radiation belt environment during these precipitation events," said Millan. "We should be able to tell what is causing these events, and that is really one of the main goals of BARREL."

In addition to Dartmouth, the BARREL mission is supported by scientists from the University of California-Berkeley, the University of Washington and the University of California-Santa Cruz. Field operations are being conducted at the British research station Halley VI and the South African research station, SANAE IV. In addition to NASA and National Science Foundation support, the National Environmental Research Council in the United Kingdom and the South African National Space Agency support the campaigns. ■

Right: The 2013-2014 BARREL balloon campaign is underway. This balloon was launched on Dec. 31, 2013. BARREL's job is to help unravel the mysterious radiation belts, two gigantic donuts of particles that surround Earth. Photo credit: BARREL/M. Krzysztofowicz



## INTERNET RADIO PROVIDES MUSICAL SPACE-WEATHER REPORTS

By: Elizabeth Zubritsky

## MORE BARREL BALLOONS TAKE TO THE SKIES

By: Karen C. Fox

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# KIDS LEARN ABOUT GPM WITH CRACKERS, MARSHMALLOWS AND BOARD GAMES

By: Kasha Patel



On Jan 19, over two hundred children and adults participated in a series of games, crafts and presentations at the Goddard Visitor Center to learn more about the water cycle, ways to measure precipitation and NASA's [Global Precipitation Measurement](#) mission scheduled to launch next month.

The event was part of Goddard's Sunday Experiment, a free, monthly event that showcases different scientific and engineering research and developments at Goddard. This Sunday Experiment, which lasted two hours, featured over seven GPM-related activities for parents and children to enjoy.

At various stations, kids learned the different paths of the water cycle through a series of hands-on activities, board games and puzzles. They also assembled miniature paper models of the GPM satellite as well as edible satellites made of graham crackers, vanilla wafers and marshmallows.

The families also learned how scientists currently measure rain on Earth by creating their own rain gauges from plastic water bottles. Currently, all of the rain gauges in the world would only fill up two basketball courts. GPM applications scientist and education and public outreach coordinator Dalia Kirschbaum gave a presentation showing how the GPM satellite will improve precipitation measurements and further our understanding of the water cycle.

The GPM mission is an international satellite mission led by NASA and the Japan Aerospace Exploration Agency. The GPM Core Observatory is set to launch on Feb 27 and will measure when, where and how much it rains or snows around the world every three hours. Data from the mission can be used to improve climate modeling and prediction, weather forecasting and increase our understanding of climate change.

If you are interested in hosting a GPM party or education event, visit the GPM website for a [launch party kit](#). ■

Photo credit: NASA/Goddard/Debra McCallum

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By Talya Lerner

# NASA CHIEF SCIENTIST VISITS GODDARD

Meeting early career scientists was Dr. Ellen Stofan's favorite part of visiting NASA's Goddard Space Flight Center in Greenbelt, Md., on January 23. "They are the real future of this agency and they are the ones that are going to be inspiring the next generation."

Stofan, NASA's chief scientist, grew up around science. Her father worked at NASA Glenn Research Center in Cleveland and her mother was a science teacher. Stofan watched the Viking and Voyager launches and learned from other scientists that geology, what she was interested in studying, could be studied on other planets as well. She was hooked.

Stofan has had other major roles during her time at NASA. "A lot of my role is advocacy, and as a scientist you're an advocate too, because you are coming up with a theory and having to convince your fellow scientists that you're right."

Now, as chief scientist, she does that on a much broader scale. "Instead of being able to look at smaller interesting research projects, I am trying to see the links between all the research NASA does," she said. "For me that's extremely fun because I get to go play and learn about areas of science that I know nothing about."

As Chief Scientist, Stofan has two main goals: improving science communication and science, technology, engineering and math, or STEM, education. To improve science communication she focuses on one big question. "Are we as individuals, and are we as an agency, effectively talking about what we do and effectively talking about the links."

Not only do scientists and researchers need to communicate their advancements, they need to show how the science done across the agency links together, Stofan said. "Communication is an issue where we can improve and if I can do anything to help, I am happy to."

Stofan addressed this issue during her town hall meeting with Goddard staff, entitled, "Looking Outward, Inward and Homeward: The Value of NASA Science." She addressed three fundamental questions: Are we alone? How did we get here? How does our universe work? These questions ring through the four major themes within the scientific community at NASA: astrophysics, heliophysics, planetary science and Earth science. Her discussion focused on how the different themes within NASA tie together and how we can communicate these advances to the public. In order to do this, scientists need to figure out how to tell the story, Stofan said.

The story is getting pretty exciting. Stofan realizes that she has taken on this role at a crucial time in space and Earth science. "We are so on the verge of understanding planets, solar systems, and the potential for life within our solar system and beyond," she said. NASA is taking measure to search for life off Earth with the Kepler Mission, the James Webb Space Telescope, the Mars Curiosity rover and a possible future mission to Europa.

"All that is going to happen in the next 20 years and we are going to all be there to watch it," Stofan said. "It is going to rewrite all the science textbooks, and we are right at this moment in time that I think is

tremendously exciting." ■

Center: NASA Chief Scientist Dr. Ellen Stofan (right) meets with space scientist Melissa Trainer in the Sample Analysis at Mars Testbed Lab during her visit to NASA's Goddard Space Flight Center

