Science Mission Directorate

Weekly Highlights

January 15, 2016

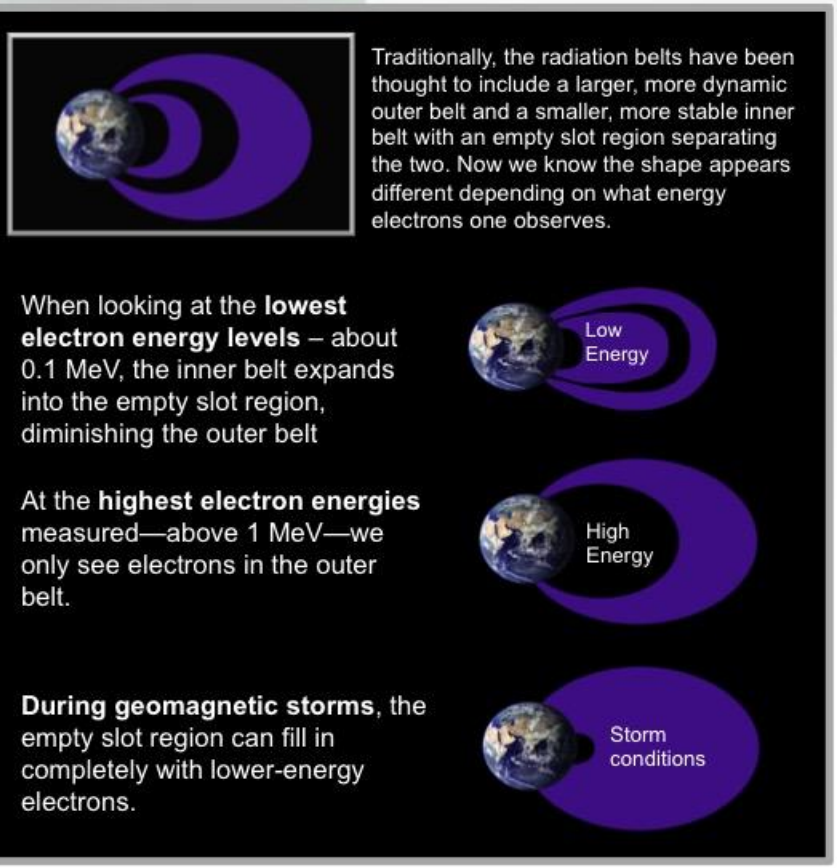
NASA's Van Allen Probes Revolutionize View of Radiation Belts

A new study based on data from NASA's Van Allen Probes shows that all 3 regions—inner belt, slot region, outer belt—can appear different depending on the energy of electrons considered and general conditions in the magnetosphere.

A recent study of data from the Van Allen Probes published on Dec. 28, 2015 in the Journal of Geophysical Research has given us new understandings on the shape of the Van Allen Belts, or radiation belts, and how electrons behave at different energy levels within the belts themselves. This new analysis reveals that the observed shape can vary from a single, continuous belt with no slot region, to a larger inner belt with a smaller outer belt, to no inner belt at all. While the shapes of the belts do change, we now know that most of the observed differences are accounted for by considering electrons at different energy levels separately.

The twin Van Allen Probes satellites expand the range of energetic electron data we can capture. In addition to studying the extremely high-energy electrons—carrying millions of electron volts, the Van Allen Probes can capture information on lower-energy electrons that contain only a few thousand electron volts. Additionally, the spacecraft measure radiation belt electrons at a greater number of distinct energies than was previously possible.

Precise observations like this, from hundreds of energy levels, rather than just a few, will allow scientists to create a more precise and rigorous model of what, exactly, is going on in the radiation belts, both during geomagnetic storms and during periods of relative calm. This information will help us better predict and prepare for dangerous space weather events that have the potential to impact Earth's environs.

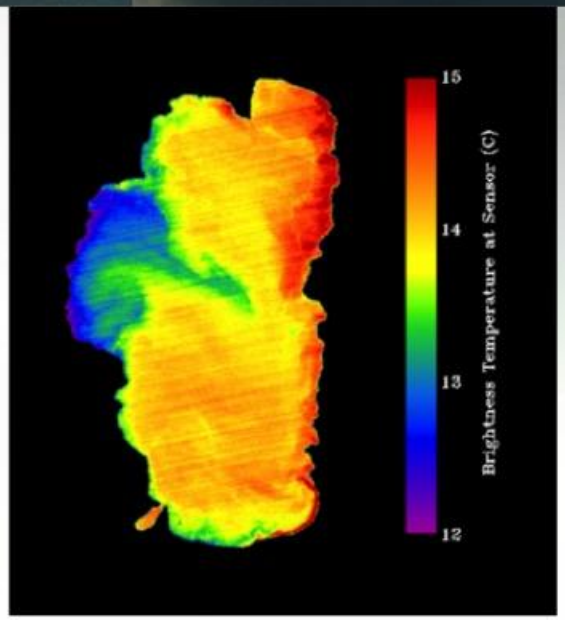


The Johns Hopkins Applied Physics Laboratory in Laurel, Md., built and operates the Van Allen Probes for NASA's Science Mission Directorate. The mission is the second mission in NASA's Living With a Star program, managed by NASA's Goddard Space Flight Center in Greenbelt, Md.

Rapid and highly variable warming of lake surface waters around the globe

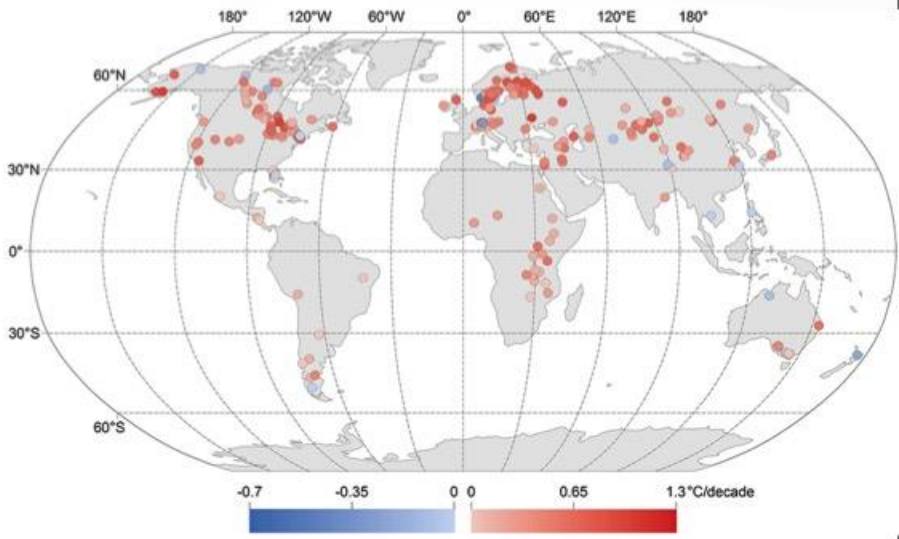
O'Reilly, C. M., Sharma, S., Gray, D. K., Hampton, S. E., Read, J. S., Rowley, R. J., ... & Weyhenmeyer, G. A. |
Geophysical Research Letters DECEMBER 2015 | doi: 10.1002/2015GL066235

A new NASA/ NSF-funded study used more than 25 years of in situ and satellite-derived lake data, including measurements from the ASTER instrument on NASA's Terra satellite, to find that lake summer surface water temperatures rose rapidly between 1985 and 2009. This first, worldwide analysis- the largest of its kind- showed that surface water warming rates are dependent on combinations of climate and local characteristics, rather than just lake location, leading to the counterintuitive result that regional consistency in lake warming is the exception, rather than the rule. The most rapidly warming lakes are widely geographically distributed, and their warming is associated with interactions among different climatic factors—from seasonally ice-covered lakes in areas where temperature and solar radiation are increasing while cloud cover is diminishing, to ice-free lakes experiencing increases in air temperature and solar radiation. Lakes hold a large majority of Earth's liquid freshwater, support enormous biodiversity, and provide key provisioning and cultural ecosystem services to people around the world. The pervasive and rapid warming observed in this study signals the urgent need to incorporate climate impacts into vulnerability assessments and adaptation efforts for lakes.



Left: This image of Lake Tahoe, from the ASTER instrument on Terra, shows the lake's temperature variations (cold is blue, warm is red).
Below: Instrumented buoy in Lake Tahoe on the California/Nevada border. Credits: Limnotech

Right: Map of trends in lake summer surface temperatures from 1985 to 2009. Most lakes are warming, and there is large spatial heterogeneity in lake trends.



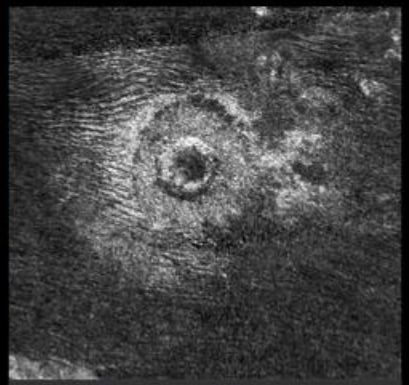
Impacts on Titan: Do They Splash or Thud?

The lack of craters on Titan at mid-to-high latitudes where the elevation is lower has been perplexing, but a comparison to Earth environments could provide a potential answer.

- After observing the unequal crater distribution on Titan, the team examined seven scenarios that could account for this correlation with elevation. The explanation that was deemed most reasonable was that comets and other solar system debris that impact Saturn's moon Titan splash into wetlands, leaving only subtle traces in a marine environment.
- Similar to terrestrial submarine impacts, on Titan many impacts could have fallen on extensive wetlands or a global sea that could have existed on Titan in the last few hundred million years. Such wetlands would be fed by an aquifer of liquid methane or ethane.
- Since the inventory of these hydrocarbons likely fluctuated over time, the preservation of features in some impacts at lower elevations would also be an expected feature.

An Example of an Earth Crater that Disappeared in a Shallow Sea

A 35 million-year-impact crater (outlined in white) went undiscovered in Chesapeake Bay until 1994. The hidden 50-mile wide crater hints at how some of Titan's impact craters could have disappeared into a shallow ocean.

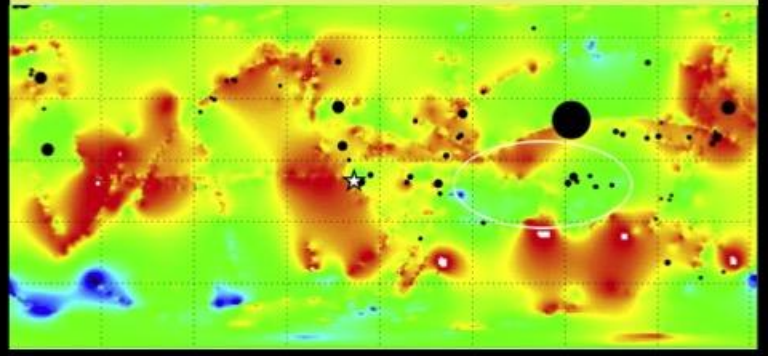


Momoy Crater: One of many seen at high elevations

C.D. Neish and R.D. Lorenz (2014), Icarus.

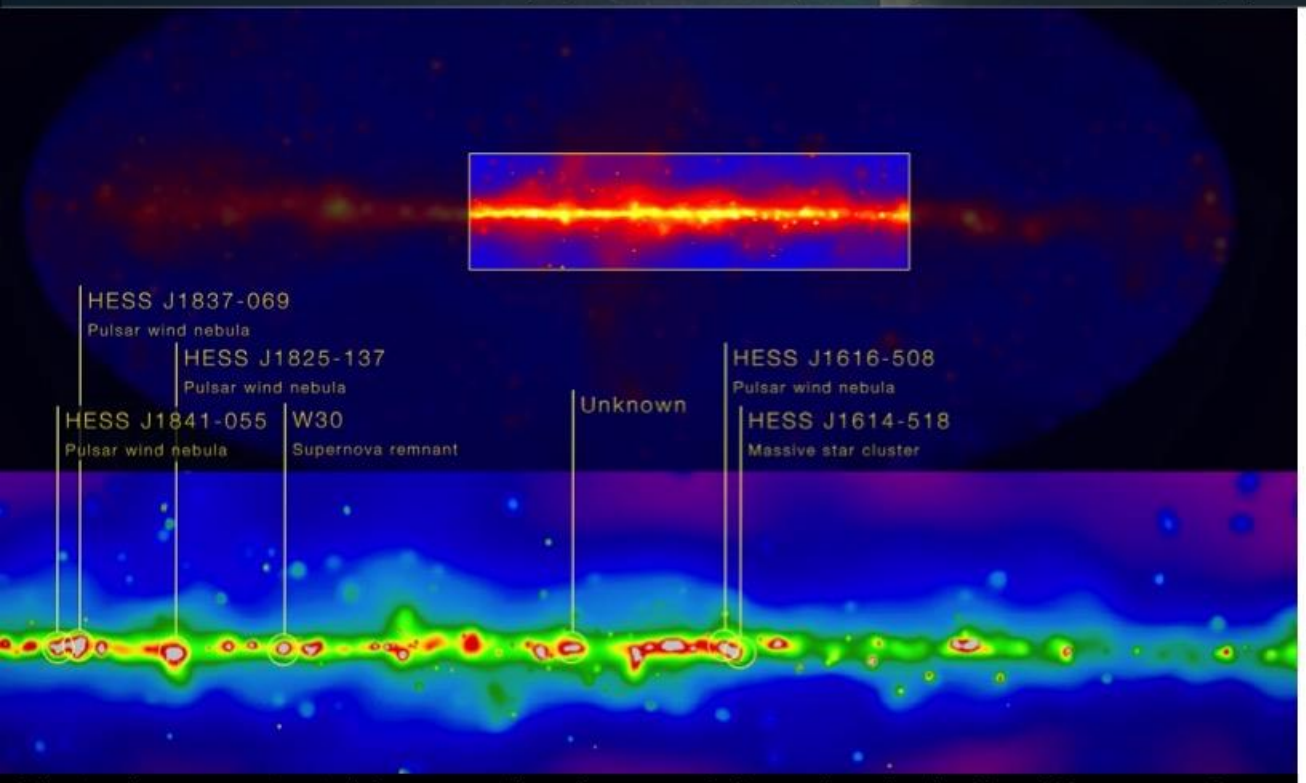
Could Impact Craters be Hiding in Wetlands?

There are fewer craters (black dots) in Titan's lower elevations (regions in green), which may signal the presence of past or present wetlands. Xanadu (inside the white oval) is the only low-lying area with numerous craters. A white star marks the 2005 landing spot of the Huygens Probe.



NASA's Fermi Space Telescope Sharpens its High-energy Vision

Presented at the recent 227th meeting of the American Astronomical Society in Kissimmee, Florida.
The associated paper has been accepted for publication in *The Astrophysical Journal Supplement*.



The top image, constructed from more than six years of observations by the Fermi Gamma-ray Space Telescope, is the first to show how the entire sky appears at energies between 50 billion (GeV) and 2 trillion electron volts (TeV). The image below highlights the plane of our galaxy and identifies objects producing gamma rays with energies greater than 1 TeV.
Credit: NASA's Goddard Space Flight Center/CI Lab

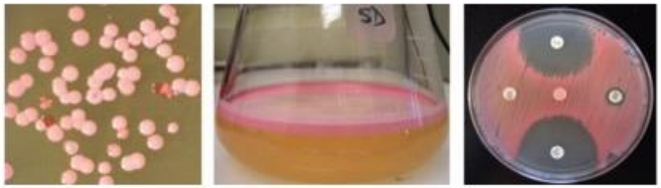
- Major improvements to methods used to process observations from NASA's Fermi Gamma-ray Space Telescope have yielded an expanded, higher-quality set of data that allows astronomers to produce the most detailed census of the sky yet made at extreme energies.
- By carefully reexamining every gamma-ray and particle detection by Fermi's Large Area Telescope (LAT) since its launch in 2008, scientists have improved their knowledge of the detector's response to each event and to the background environment in which it was measured.
- This enabled the Fermi team to find many gamma rays that previously had been missed while simultaneously improving the LAT's ability to determine the directions of incoming gamma rays.
- These improvements sharpen the LAT's view while also significantly widening its useful energy range.

- Using 61,000 gamma rays collected over 80 months, scientists constructed a map of the entire sky at energies ranging from 50 billion (GeV) to 2 trillion electron volts (TeV). For comparison, the energy of visible light ranges from about 2 to 3 electron volts.
- The new sky map reveals hundreds of high energy sources, including 12 that produce gamma rays with energies exceeding a trillion times the energy of visible light. The survey also discovered three new pulsar wind nebulae, two new supernova remnants, and four dozen new sources that remain undetected at any other wavelength.
- This study provides ground-based telescopes with more than 280 new targets for follow-up observations.

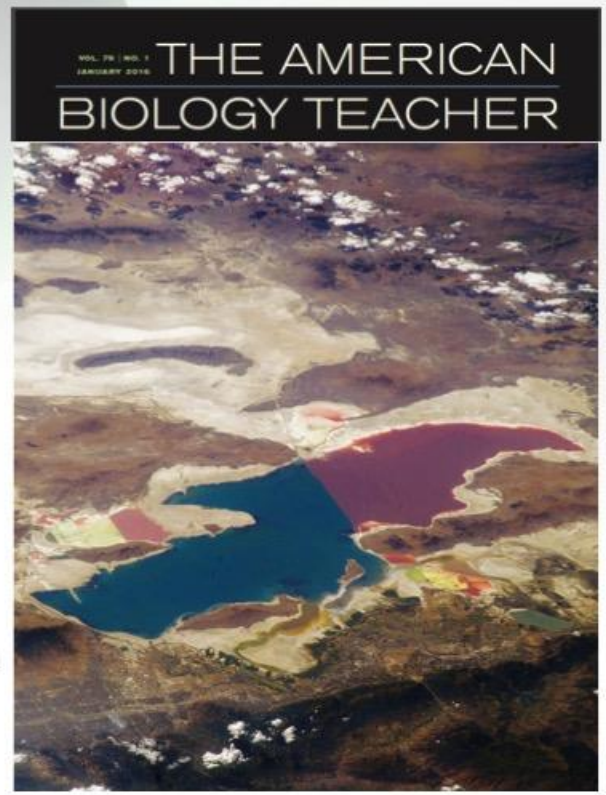
The Power of Astrobiology in the Classroom
…inspiring a new generation of STEM learners

***American Biology Teacher,* the journal of the National Association of Biology Teachers, recently highlighted two articles about Astrobiology**

- The cover article of *American Biology Teache*r (ABT) January 2016 issue "Inquiry-driven Teaching & Learning Using the Archaeal Microorganism Halobacterium NRC-1" is a featured article about astrobiologically-relevant extremophiles. (Vol. 78, No 1, pages. 7–13, ISSN 0002-7685 DOI: 10.1525/abt.2016.78.1.7)
- The lead authors, Shiladitya and Priya DasSarma, PhD, are NASA-funded researchers and educators at the University of Maryland
- As detailed in the cover article, the vibrancy of one such spectacular extremophile, Halobacterium NRC-1, can now be brought into the classroom and many modern principles of biology become accessible to students
- An earlier issue of *ABT* (October 2015), featured "Bringing Astrobiology Down to Earth." The author, Catherine L. Quinlan, PhD, is a high school biology teacher in New Jersey. Dr. Quinlan contextualizes astrobiology topics such as the origin of life within the three dimensions of learning promoted by the Next Generation Science Standards, and gives examples of how these topics can be used in a biology classroom



Halobacterium NRC-1. (Left) Colonies grown on an agar plate (Center) A liquid culture; (Right) A lawn of NRC-1 grown on an agar plate showing areas with and without antibiotic treatment.



The cover photo showing Utah's Great Salt Lake was taken by NASA astronauts from the International Space Station, 222 nautical miles above the Earth's surface. The red color stems from blooms of tiny "extremophiles" (salt loving microbes) in the northern, hyper saline lake, which is 8x saltier than the oceans.

http://www.nabt.org/websites/institution/File/pdfs/american_biology_teacher/2015/ABT_Online_Oct_2015.pdf, ISSN 0002-7685, electronic ISSN 1938-4211

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