National Aeronautics and
Space Administration

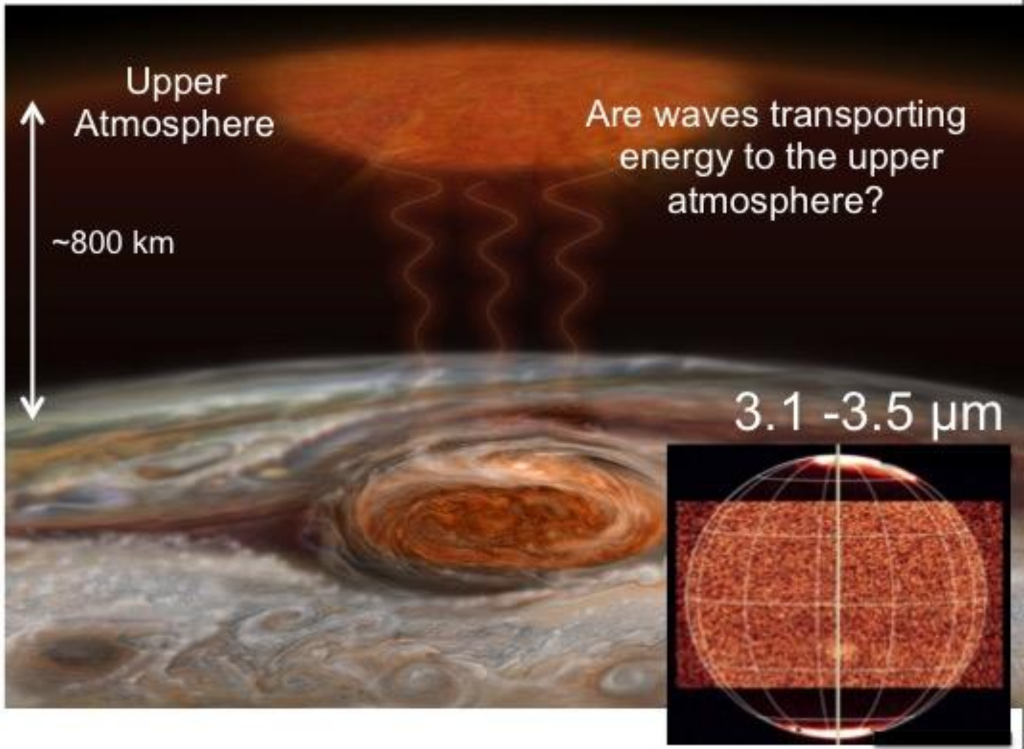
Science Mission Directorate

Weekly Highlights

July 29, 2016

Heating of Jupiter's upper atmosphere above the Great Red Spot

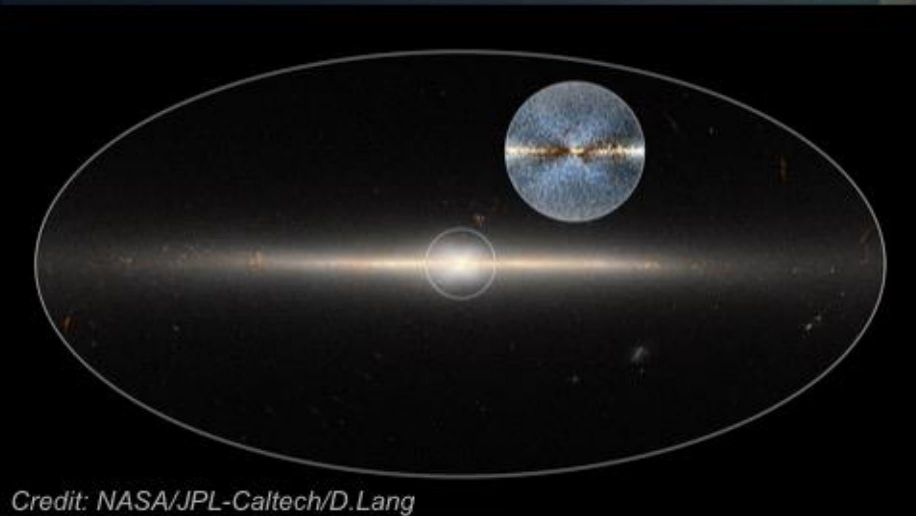
- New temperature maps of Jupiter's upper atmosphere from NASA's Infrared Telescope Facility reveal that the region above the Great Red Spot (the largest storm in the solar system) is hundreds of degrees hotter than its surroundings
- This increase in temperature can not be explained by cooling from its accretion
- Energy from the Sun is too weak, and auroral energy is trapped in the polar regions
- A new, yet unknown, energy source is required to resolve this "energy imbalance"
- Above the Red Spot a storm-driven coupling process may be occurring, wherein acoustic and/or gravity waves transports energy between Jupiter's lower and upper atmosphere
- Juno observations may be able to uncover the answer



O'Donoghue, J., et al., *Nature*, 2016

X Marks the Spot for Milky Way Formation

The results appeared in the June 21, 2016 issue of The Astronomical Journal.



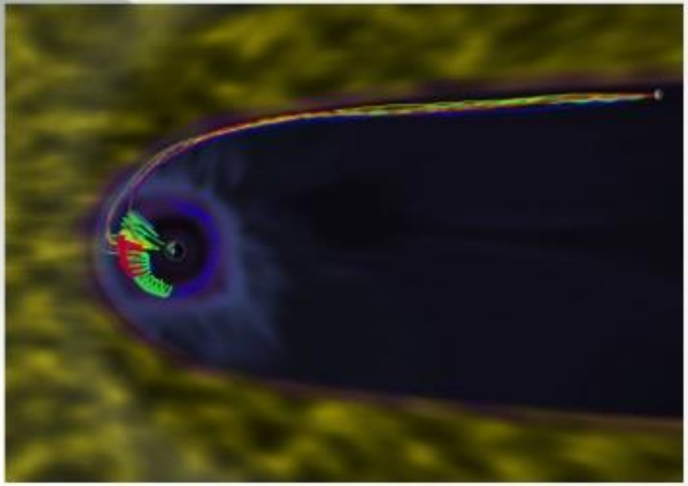
Credit: NASA/JPL-Caltech/D.Lang

- A new understanding of our galaxy's structure began in an unlikely way: on Twitter. A research effort sparked by tweets led scientists to confirm that the Milky Way's central bulge of stars forms an "X" shape.
- The unconventional collaboration started in May 2015 when an astronomer posted galaxy maps to Twitter, using 2010 data from NASA's Wide-field Infrared Survey Explorer's (WISE) two infrared surveys of the entire sky. Infrared light allows astronomers to see the structures of galaxies in spite of dust, which blocks crucial details in visible light. The researcher was using the WISE data in a project to map the web of galaxies far outside our Milky Way.
- But it was the Milky Way's appearance in the tweets that got the attention of other astronomers. Some chimed in about the appearance of the bulge, a football-shaped central structure that is three-dimensional compared to the galaxy's flat disk. Within the bulge, the WISE data seemed to show a surprising X structure, which had never been as clearly demonstrated before in the Milky Way.
- A postdoctoral researcher recognized the significance of the X shape. The scientists met a few weeks later at a conference and decided to collaborate on analyzing the bulge using the WISE maps. Their work resulted in a new study confirming an X-shaped distribution of stars in the bulge.
- The Milky Way is an example of a disk galaxy -- a collection of stars and gas in a rotating disk. In these kinds of galaxies, when the thin disk of gas and stars is sufficiently massive, a "stellar bar" may form, consisting of stars moving in a box-shaped orbit around the center. Our own Milky Way has a bar, as do nearly two-thirds of all nearby disk galaxies.
- Over time, the bar may become unstable and buckle in the center. The resulting "bulge" would contain stars that move around the galactic center, perpendicular to the plane of the galaxy, and in and out radially. When viewed from the side, the stars would appear distributed in a box-like or peanut-like shape as they orbit. Within that structure, according to the new study, there is a giant X-shaped structure of stars crossing at the center of the galaxy.
- A bulge can also form when galaxies merge, but the Milky Way has not merged with any large galaxy in at least 9 billion years.
- The Milky Way's X-shaped bulge had been reported in previous studies. Images from the NASA Cosmic Background Explorer (COBE) satellite suggested a boxy structure for the bulge. In 2013, scientists at the Max Planck Institute for Extraterrestrial Physics published 3-D maps of the Milky Way that also included an X-shaped bulge, but these studies did not show an actual image of the X shape. This latest research uses infrared data to show the clearest indication yet of the X shape.

NASA Heliophysics ARTEMIS Observes Terrestrial Molecular Ions at the Moon

Poppe, A. R., M.O. Fillingim, J. S. Halekas, J. Raeder, and V. Angelopoulos, ARTEMIS observations of terrestrial molecular ion outflow at the Moon, *Geophys. Res. Lett.*, 43, 2016. (http://artemis.igpp.ucla.edu/nuggets/nuggets_2016/Poppe2/Poppe_16_2.html)

Recent observations from the NASA Heliophysics Acceleration, Reconnection, Turbulence, and Electrodynamics of the Moon's Interaction with the Sun (ARTEMIS) spacecraft reveal the presence of rare, terrestrial heavy ion outflow at the moon. In the journal, *Geophysical Research Letters*, Poppe et al. (2016) report ARTEMIS observations of molecular ions - N_2^+, NO^+, O_2^+, flowing down the Earth's magnetic field lines past the Moon. These heavy ions originate from the Earth's ionosphere and, during strong geomagnetic storms, can be energized and injected into Earth's magnetosphere. They then circulate within Earth's magnetic fields, before finding an "escape route" that takes them away from the Earth and they pass by the Moon on their way out. Observations of these escaping molecular ions are relatively rare. ARTEMIS data provide an exciting opportunity to learn more about how Earth loses part of its atmosphere to space, made possible by the satellites' distant perspective around the Moon.



Artist depiction of the magnetosphere viewed from above Earth, with the sun on the left and moon on the right. The magnetosphere is compressed due to increased solar wind pressure, and the colored lines show modeled paths of ions escaping Earth's ionosphere and traveling along the magnetopause to be ultimately detected by ARTEMIS at the moon. Credit: E. Masongsong, UCLA EPSS

Both the solar wind (the continuous stream of charged particles flowing out from the sun) and the terrestrial ionosphere contribute plasma to the terrestrial magnetosphere. The solar wind can provide protons and alpha particles (doubly-charged helium) while the terrestrial ionosphere serves as a source of protons, singly-charged helium, oxygen ions, and occasionally, heavier molecular ions such as N_2^+, NO^+, O_2^+. While atomic oxygen ions have been routinely observed and characterized inside Earth's magnetosphere, observations of molecular ions are much more rare. Present knowledge indicates that outflow of molecular ions is strongly associated with high levels of geomagnetic activity; however, much of the subsequent molecular ion dynamics within the magnetosphere, including the eventual loss of these ions, is unclear.

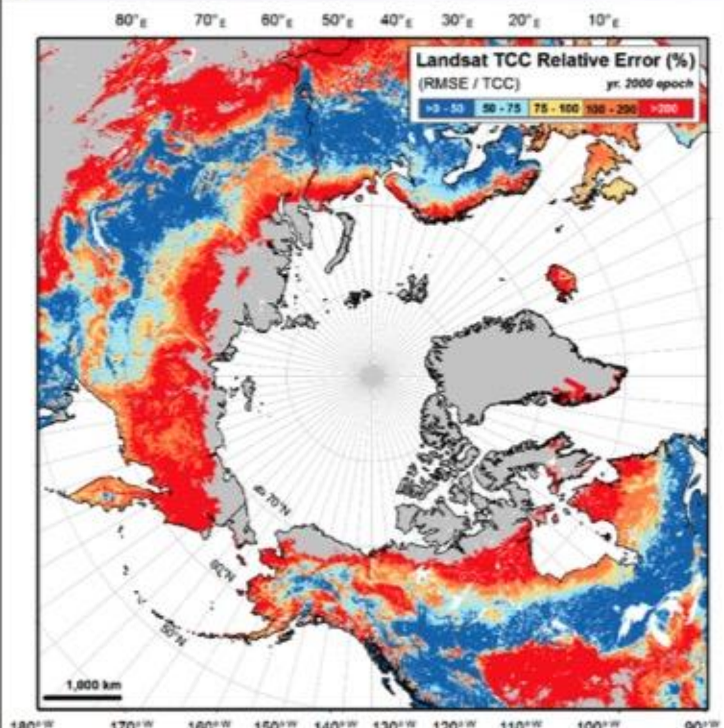
The authors report and analyze two observations of molecular ion outflow observed by ARTEMIS at lunar distances downstream in the night-side terrestrial magnetosphere. To investigate the dynamics and origins of these molecular ions, they use a global model of the Earth's magnetosphere to define the electromagnetic fields and perform backwards ion tracing from the ARTEMIS position to the inner magnetosphere. The simulations reveal an important loss channel for terrestrial molecular ions, one that has not previously been fully explored. These ARTEMIS observations of terrestrial molecular ions add a new and exciting method of understanding the production, circulation, and loss of ionospheric plasma.

These ions also have an impact on the Moon itself. When these ions impact the solid surface of the Moon, they carry enough momentum to sputter (i.e., eject) neutral lunar atoms from the lunar soil, contributing significantly to the density of the lunar exosphere. The nitrogen and oxygen composition of these molecular ions is also significant, because both species are important volatile species at the Moon that may eventually migrate across the lunar surface and be trapped within polar cold trap regions for millennia or more. Thus, it seems quite possible based on these ARTEMIS observations that significant amounts of terrestrial atmosphere have found their way to a near permanent home on the Moon. Further work will aim to more accurately quantify the influx and subsequent behavior of these molecules within the lunar environment.

Calibration and Validation of Landsat Tree Cover in the Taiga−Tundra Ecotone

Montesano, P. M., Neigh, C. S., Sexton, J., Feng, M., Channan, S., Ranson, K. J., & Townshend, J. R. | Remote Sensing | June 2016 | doi: 10.3390/rs8070551

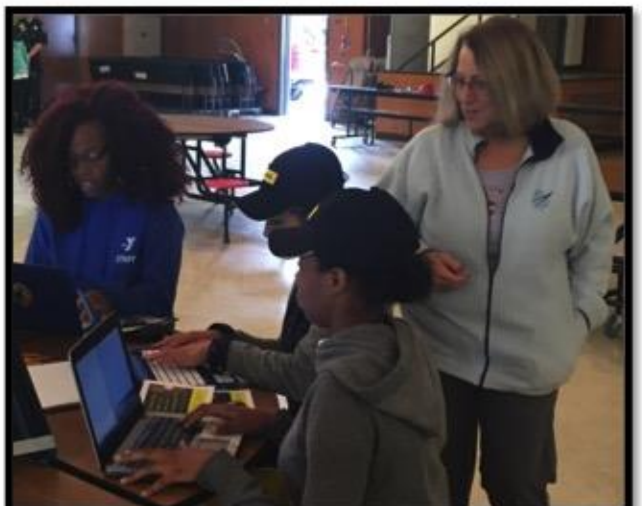
NASA-funded scientists calibrated and validated a 30 m spatial resolution Landsat-based tree canopy cover (TCC) map in the taiga-tundra ecotone (TTE), with reference tree cover data from airborne LiDAR and high resolution spaceborne images across the full range of boreal forest tree cover. This domain-specific calibration model used estimates of forest height to determine reference forest cover that best matched Landsat estimates. The model removed the systematic under-estimation of above 80% TCC, and indicated that Landsat estimates of tree canopy cover more closely matched canopies at least 2 meters tall, rather than 5 meters. Furthermore, the validation improved estimates of uncertainty in tree canopy cover in discontinuous TTE forests for three temporal epochs (2000, 2005, and 2010) by reducing systematic errors. Maps from these calibrated data improve the uncertainty associated with Landsat tree canopy cover estimates in the discontinuous forests of the circumpolar TTE.



An ecotone is a transition area between two biomes, where two communities meet and integrate. The Tundra-Taiga Ecotone (TTE) is the earth's longest vegetation transition zone and stretches for more than 13,400 km around Arctic North America, Scandinavia, and Eurasia. The TTE covers more than 1.9 million square kilometers across northern portions of North America and Eurasia. It features a gradient of forest structure and species' composition whose changes may serve as a bellwether for the effects of climate change on terrestrial ecosystems globally. This biome boundary is among the fastest-warming regions of the planet, where predictions and observations suggest extensive yet site-dependent changes in vegetation cover, structure, and composition.

Left: Map showing circumpolar boreal and TTE forest structure reference data. Mapped categories of TCC relative error from the 2000 epoch of Landsat TCC estimates in the circumpolar boreal and TTE regions.

Rosie's Girls Workshop in Richmond, CA



Lynn Cominsky/Sonoma State University

- Rosie's Girls, is a STEM (science, technology, engineering and math) and Trades exploration program for middle school girls
- On June 29, 2016, Lynn Cominsky, Carolyn Peruta and Claire Shudde put on a mini-workshop teaching Rosie's Girls in grades 6-8 how to write simple programs using Turtle Logo as part of their Summer Camp's Career Day in Richmond, CA
- Turtle Logo is also used in Sonoma State University's (SSU's) Department of Education-funded program "Learning by Making" and the Chandra X-ray Center's Girls Who Code workshops
- Partnering through NASA's Universe of Learning

Rosie's Girls takes its name from Rosie the Riveter, the fictional World War II icon who represented the women who went to work in the shipyards and factories to fill shortages while men fought overseas.

Rosie's Girls
Summer Program™

A summer camp that helps girls develop grit, connection and expanded possibilities as they explore hands-on STEM- and trades-related activities. Girls entering 6, 7 and 8th grades practice the skills of carpenters and engineers as they invent, design and build cooperative projects. It's a safe, supportive, girl-centered environment and emphasizes friendship, teamwork and healthy body image – with tons of fun woven in! A place where girls can get their hands dirty, take positive risks and try something new.