National Aeronautics and
Space Administration

Science Mission Directorate

Weekly Highlights

February 5, 2016

Blast from the Black Hole in a Galaxy Far, Far Away

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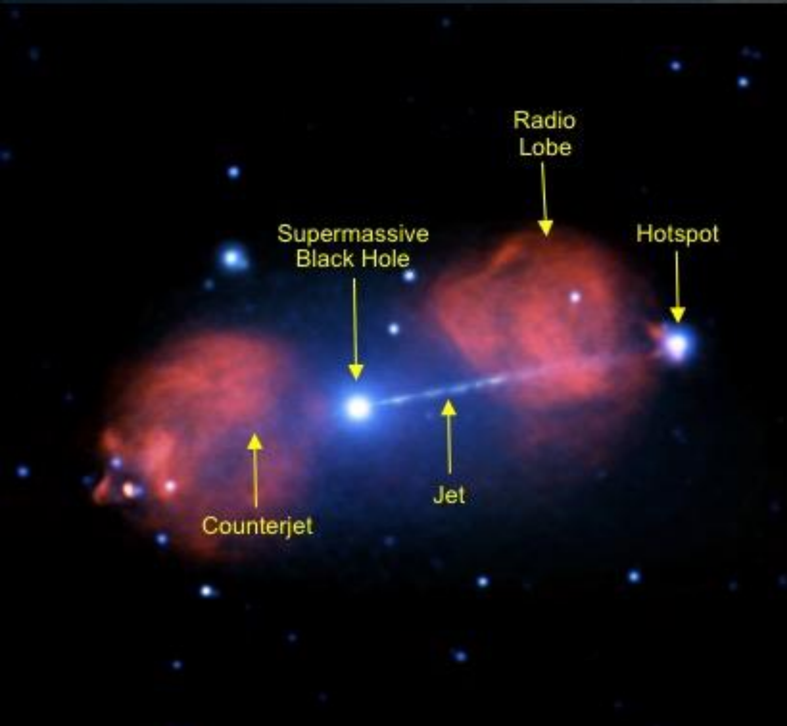


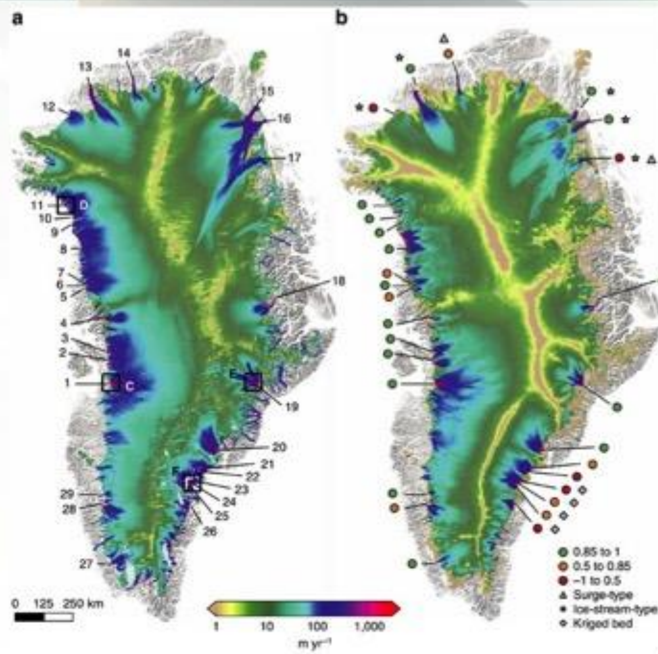
Image credit: X-ray: NASA/CXC/Univ of Hertfordshire/M.Hardcastle et al., Radio: CSIRO/ATNF/ATCA

- The universe produces phenomena that often surpass what science fiction can conjure. The Pictor A galaxy is one such impressive object. This galaxy, located nearly 500 million light years from Earth, contains a supermassive black hole at its center. A huge amount of gravitational energy is released as material swirls towards the event horizon, the point of no return for infalling material. This energy produces an enormous beam, or jet, of particles traveling at nearly the speed of light into intergalactic space.
- To obtain images of this jet, scientists used NASA's Chandra X-ray Observatory at various times over 15 years. Chandra's X-ray data (blue) have been combined with radio data from the Australia Telescope Compact Array (red) in this new composite image. By studying the details of the structure seen in both X-rays and radio waves, scientists seek to gain a deeper understanding of these huge collimated blasts.
- The jet in Pictor A is the one that is closest to us. It displays continuous X-ray emission over a distance of 300,000 light years. By comparison, the entire Milky Way is about 100,000 light years in diameter. Because of its relative proximity and Chandra's ability to make detailed X-ray images, scientists can look at detailed features in the jet and test ideas of how the X-ray emission is produced.
- In addition to the prominent jet seen pointing to the right in the image, researchers report evidence for another jet pointing in the opposite direction, known as a "counterjet". While tentative evidence for this counterjet had been previously reported, these new Chandra data confirm its existence. The relative faintness of the counterjet compared to the jet is likely due to the motion of the counterjet away from the line of sight to the Earth.
- The above image shows the location of the supermassive black hole, the jet and the counterjet. Also labeled is a "radio lobe" where the jet is pushing into surrounding gas and a "hotspot" caused by shock waves - akin to sonic booms from a supersonic aircraft - near the tip of the jet.
- The detailed properties of the jet and counterjet observed with Chandra show that their X-ray emission likely comes from electrons spiraling around magnetic field lines, a process called synchrotron emission. In this case, the electrons must be continuously re-accelerated as they move out along the jet. How this occurs is not well understood
- The researchers ruled out a different mechanism for producing the jet's X-ray emission. In that scenario, electrons flying away from the black hole in the jet at near the speed of light move through the sea of cosmic background radiation (CMB) left over from the hot early phase of the universe after the Big Bang. When a fast-moving electron collides with one of these CMB photons, it can boost the photon's energy up into the X-ray band.
- The X-ray brightness of the jet depends on the power in the beam of electrons and the intensity of the background radiation. The relative brightness of the X-rays coming from the jet and counterjet in Pictor A do not match what is expected in this process involving the CMB, and effectively eliminate it as the source of the X-ray production in the jet.

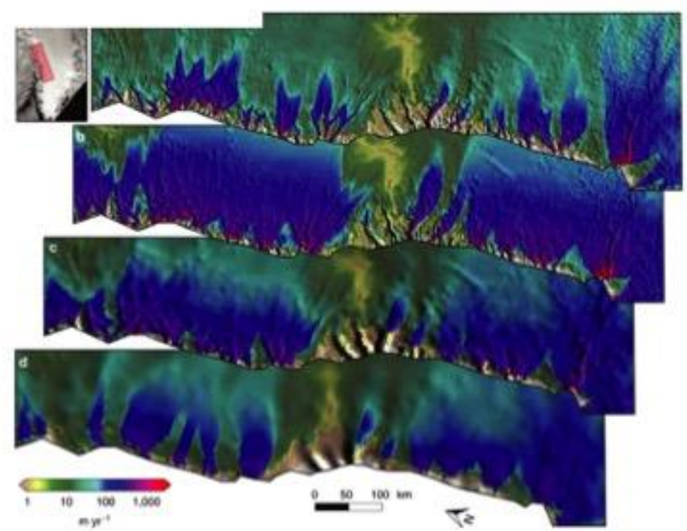
Complex Greenland Outlet Glacier Flow Captured

Aschwanden, Andy, Fahnestock, Mark A., and Truffer, Martin | FEBRUARY 2016 | doi: 10.1038/ncomms10524

NASA-funded scientists combined the high-resolution Parallel Ice Model (PISM) coupled to uniformly applied models of subglacial hydrology and basal sliding, and a new subglacial topography dataset to simulate the flow of the Greenland Ice Sheet. In Greenland, the NASA airborne mission Operation IceBridge (OIB) has added many thousand kilometers of radar-derived ice thickness profiles since 2009, nearly doubling the coverage available at that time. The study used observations of ice thickness from the OIB mission to demonstrate that the flow patterns of many outlet glaciers can be captured with high fidelity, exhibiting fundamental commonalities in outlet glacier flow and highlighting the importance of efforts to map subglacial topography. The result has been a substantial improvement in our knowledge of subglacial topography, particularly in the deep channels feeding outlet glaciers. The Greenland Ice Sheet is losing mass at an accelerating rate due to increased surface melt and flow acceleration in outlet glaciers. Quantifying future dynamic contributions to sea level requires accurate portrayal of outlet glaciers in ice sheet simulations, but previously poor knowledge of subglacial topography and limited model resolution have prevented reproduction of complex spatial patterns of outlet flow.



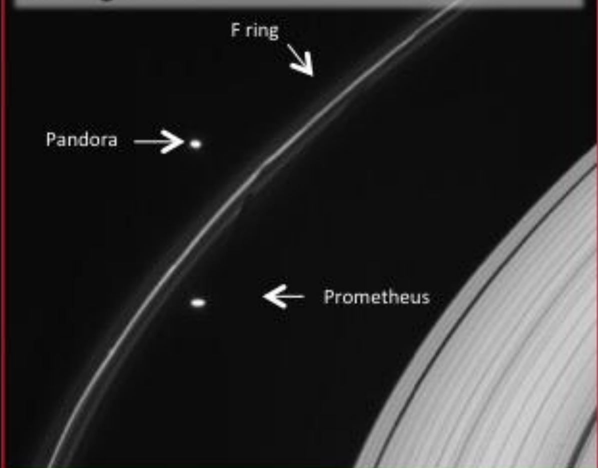
Left: Surface speeds for Greenland for 2008–2009. **a.** Observed speeds, adjusted to represent annual averages; **b.** Calibrated model speeds at 600-m grid resolution.



Right: Simulated surface speeds for the northwest coast of Greenland. (**a**) Overview. (**b**) **and (c)** 600-m / 4,500-m grid resolution and OIB-based subglacial topography. (**d**) **/ (e)** 600-m / 4,500-m grid resolution respectively and pre-OIB bed topography.

Saturn's F Ring: A Calm Core in the Midst of Chaos

Prometheus and Pandora, create chaotic lumps and tendrils in the ring. They also are responsible for narrow stable zones including the F ring core.

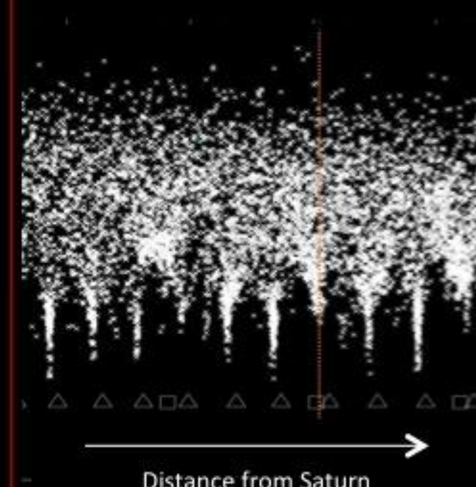


These top-down views, with Saturn removed from the images, show both the stability of the F ring core and the chaos of the ring's edges.

The long-term stability of Saturn's narrow F ring core has been difficult to explain, but new models show that there are several high-stability points within a very chaotic region.

- Prometheus and Pandora each stir the region into a chaotic state in which orbits of particles and moonlets sporadically change in unpredictable ways. This has complicated tracking of small objects occasionally seen in the region for the last decade.
- However, at select, very narrow locations, orbits of particles can remain essentially constant for long periods of time because Prometheus' perturbations at one encounter are promptly cancelled during the next encounter.
- Cassini scientists generated numerical integrations of 10000s of test particles over 10000s of Prometheus orbits to map out the effect. Findings show that one novel kind of "anti-resonance" with Prometheus alone, with no help from Pandora, can help the ring particles maintain stable orbits.

Computer simulations reveal the presence of narrow, stable zones (the icicle-like clusters of points). These stable zones are slightly offset from traditional gravitational resonances with Prometheus and Pandora (triangle and square symbols). The orange, dotted line shows the observed location of the F ring core, lying in one of the theoretically stable zones. **A question remains: why only this one?**



Cuzzi, et al. (2014), Icarus.

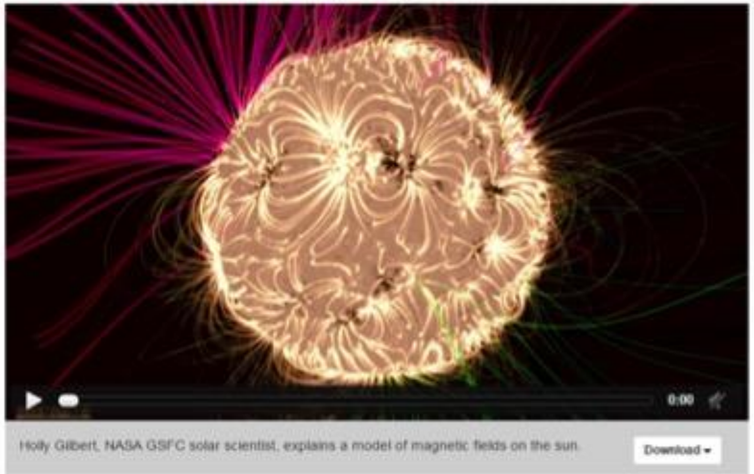
Making Our Science More Accessible: Visualizing SDO Data

Solar Dynamics Observatory (SDO) data was recently used to highlight the science behind our local magnetic star, the sun, in a NASA.gov feature released last week: The constant dance of magnetic fields lines on our star is ultimately responsible for everything from the solar explosions that cause space weather on Earth – such as auroras, GPS disturbances and power grid fluctuations– to the interplanetary magnetic field and radiation through which our spacecraft journeying around the solar system must travel.

Using this kind of outreach is not only visually attractive but has the capacity to encourage a deeper and more easily digestible understanding of the science itself than text or a single image might; and also attracting a much wider audience than text itself would. **For example, "SDO – Year 5," a video created by the Science Visualization Studio (SVS) was GSFC's most visited YouTube video in 2015, attracting over 4.5 million hits.**

For this visualization, the SVS at Goddard used models regularly used by researchers to illustrate how the magnetic field from the sun drives the approximately-11-year solar activity cycle. The visualization shows the shape of the magnetic fields above the sun's surface as they guide the motion of solar material – loops and prominences glowing brightly in EUV images of the million degree solar atmosphere, the corona. By using measurements from solar instruments in the visualization itself, we can see the footpoints on the sun's surface, or photosphere, of these magnetic loops. These footpoints were identified and measured using an instrument on-board SDO, called the Helioseismic and Magnetic Imager, or HMI, which measures the strength and direction of magnetic fields. This data can then serve as the seeds for a detailed computer simulation -- like the Potential Field Source Surface, or PFSS, model shown in the video -- which combines those observations with an understanding of the laws of magnetism and of how solar material moves to fill in the gaps.

In combination, the observation and model help illustrate exactly how magnetic fields undulate around the sun **– creating a visualization that is useful not just for scientists, but also to help non-experts get insight into something that is fundamentally hard to observe, yet so impactful to our technological society.**

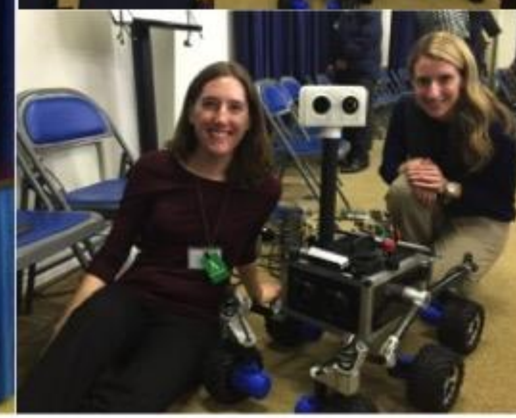


Since the story went live one week ago, 800 people retweeted this video, leading to an audience of 465K!

Link to the feature and video: http://www.nasa.gov/feature/goddard/2016/understanding-the-magnetic-sun

For other great visualizations, visit http://svs.gsfc.nasa.gov

Mars Exploration Program Outreach Rover "ROV-E" Goes to Washington, D.C.



- On January 13, 2016, two Jet Propulsion Laboratory early-career hires, Molly Bittner and Christine Fuller, served as role models and showcased the new Mars Exploration Program outreach rover, ROV-E
- More than 130 students, grades 6th -12th, participated in the White House Office of Science Technology Policy's "State of Science, Engineering, Technology and Math (STEM)" Event #SoSTEM Tweets
- Students shown above are Science Fair winners from the Washington, DC area