Science Mission Directorate

Weekly Highlights

February 12, 2016

Monstrous Cloud Boomerangs Back to Our Galaxy

Published in the January 1, 2016 edition of The Astrophysical Journal Letters.

Illustration Credit: NASA, ESA, and Z. Levay (STScI):

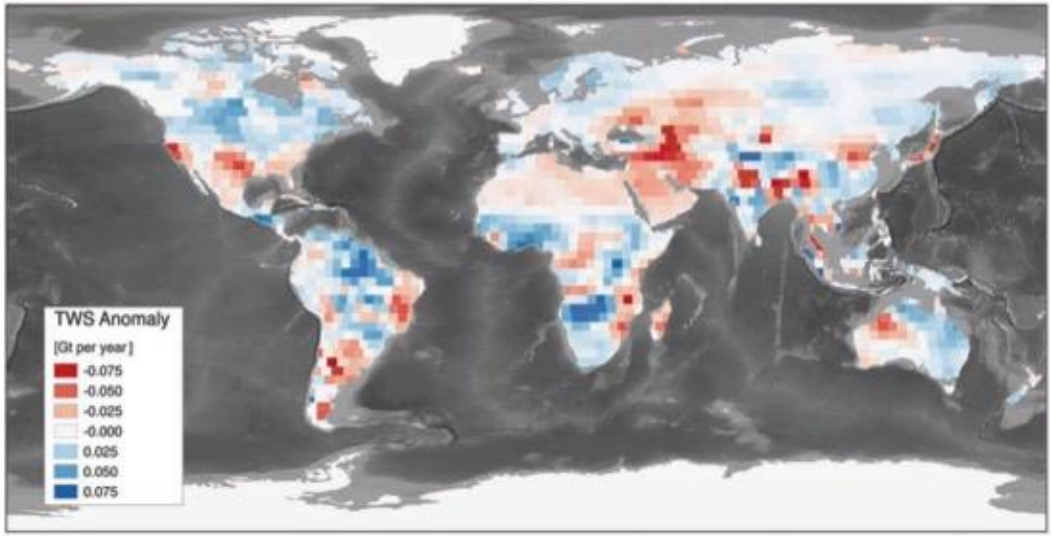
- Hubble Space Telescope astronomers are finding that the old adage "what goes up must come down" even applies to an immense cloud of hydrogen gas outside our Milky Way galaxy. An invisible cloud is plummeting toward our galaxy at nearly 700,000 miles per hour.
- Though hundreds of enormous, high-velocity gas clouds whiz around the outskirts of our galaxy, this so-called "Smith Cloud" is unique because its trajectory is well known. New Hubble observations suggest it was launched from the outer regions of the galactic disk, around 70 million years ago. The cloud was discovered in the early 1960s by doctoral astronomy student Gail Smith, who detected the radio waves emitted by its hydrogen.
- The cloud is on a return collision course and is expected to plow into the Milky Way's disk in about 30 million years. When it does, astronomers believe it will ignite a spectacular burst of star formation, perhaps providing enough gas to make 2 million suns.
- Astronomers have measured this comet-shaped region of gas to be 11,000 light-years long and 2,500 light-years across. If the cloud could be seen in visible light, it would span the sky with an apparent diameter 30 times greater than the size of the full moon.
- Astronomers long thought that the Smith Cloud might be a failed, starless galaxy, or gas falling into the Milky Way from intergalactic space. If either of these scenarios proved true, the cloud would contain mainly hydrogen and helium, not the heavier elements made by stars. But if it came from within the galaxy, it would contain more of the elements found within our sun.
- The team used Hubble to measure the Smith Cloud's chemical composition for the first time, to determine where it came from. They observed the ultraviolet light from the bright cores of three active galaxies that reside billions of light-years beyond the cloud. Using Hubble's Cosmic Origins Spectrograph, they measured how this light filters through the cloud. In particular, they looked for sulfur in the cloud which can absorb ultraviolet light. Sulfur is a good gauge of how many heavier elements reside in the cloud.
- The astronomers found that the Smith Cloud is as rich in sulfur as the Milky Way's outer disk, a region about 40,000 light-years from the galaxy's center (about 15,000 light-years farther out than our sun and solar system). This means that the Smith Cloud was enriched by material from stars. This would not happen if it were pristine hydrogen from outside the galaxy, or if it were the remnant of a failed galaxy devoid of stars. Instead, the cloud appears to have been ejected from within the Milky Way and is now boomeranging back.
- Though this settles the mystery of the Smith Cloud's origin, it raises new questions: How did the cloud get to where it is now? What calamitous event could have catapulted it from the Milky Way's disk, and how did it remain intact? Could it be a region of dark matter — an invisible form of matter — that passed through the disk and captured Milky Way gas? The answers may be found in future research.

A Decade of Sea Level Rise Slowed by Climate-driven Hydrology

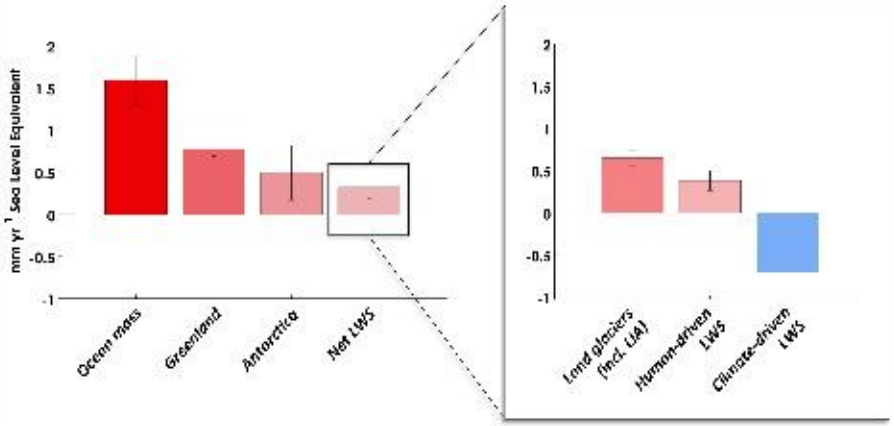
Reager, J.T., A.S. Gardner, J.S. Famiglietti, D.N. Weiss, A. Eicker and M.H. Lo | FEBRUARY 2016 | doi: 10.1126/science.aad8386

A NASA JPL led study used measurements of time-variable gravity from NASA's Gravity Recovery and Climate Experiment (GRACE) satellite mission to assess the role of land water storage in Sea Level Rise (SLR) over the 12-year period from 2002 to 2014. GRACE provides monthly observations of changes in the Earth's gravity field that, after the removal of signals owing to changes in solid earth and atmosphere, result from the movement of water and ice through the Earth system at specific temporal and spatial scales.

Climate-driven changes in land water storage and their contributions to sea level rise have been absent from Intergovernmental Panel on Climate Change sea level budgets owing to observational challenges. However GRACE measurements of time-variable gravity combined with reconciled global glacier loss estimates enable a disaggregation of continental land mass changes and a quantification of this term. The study found that between 2002 and 2014, climate variability resulted in an additional 3200 ± 900 gigatons of water being stored on land. This gain partially offset water losses from ice sheets, glaciers, and groundwater pumping, slowing the rate of sea level rise by 0.71 ± 0.20 millimeters per year. These findings highlight the importance of climate-driven changes in hydrology when assigning attribution to decadal changes in sea level.

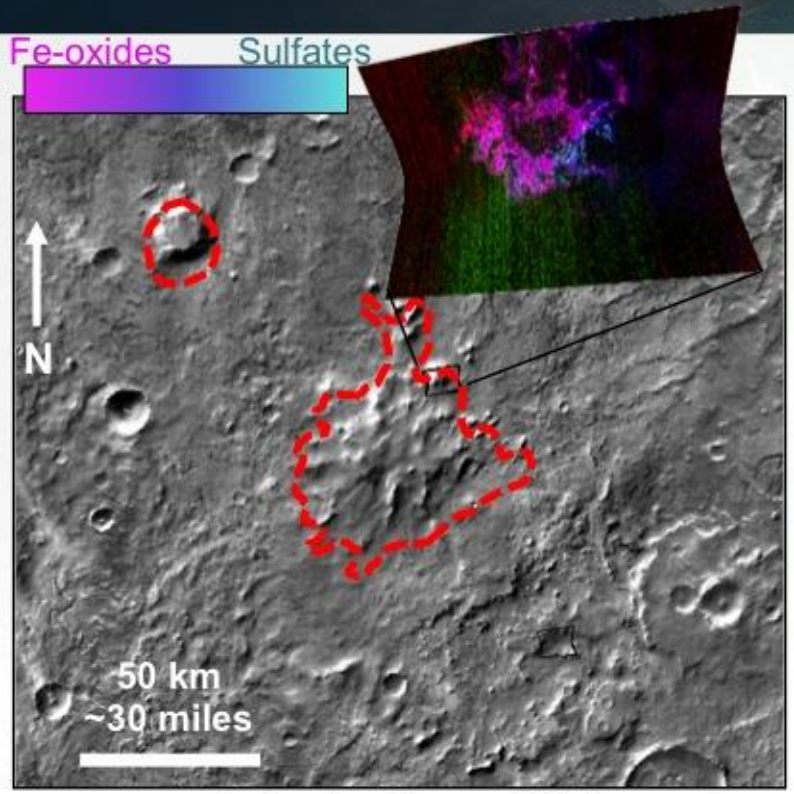


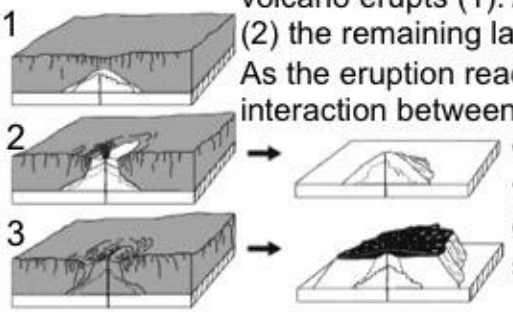
Above: Trends in land water storage from GRACE observations, April 2002 to November 2014. Glaciers and ice sheets are excluded. The strongest gains and losses are associated with climate-driven variability in precipitation.



Left: Observed global mass contributions to sea level rise (2002-2014) including the disaggregated land water storage term.

Volcanoes Must Have Erupted Through Ancient Mars Ice Sheet





An ice sheet (in grey, left) is present as a volcano erupts (1). As the volcano grows (2) the remaining land form (right) remains. As the eruption reaches the ice surface (3), interaction between the magma and the water gives these volcanoes their characteristic cap, steep slopes, and flat tops.

A new analysis of CRISM data has revealed a combination of sulfate-, zeolite-, and iron oxide-rich rocks on volcanoes in ancient terrain near Mars' South Pole, supporting the past occurrence of large ice sheets that have since disappeared.

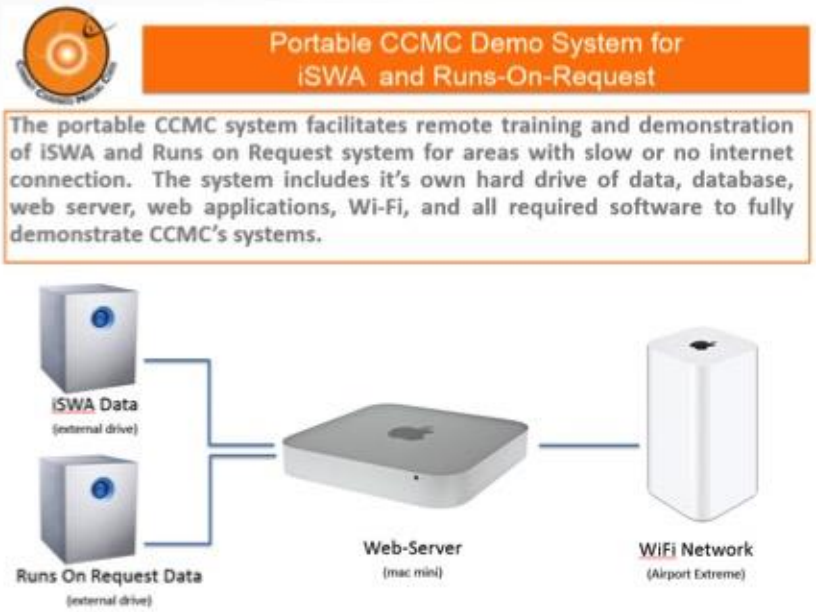
- On Earth, volcanoes that erupt beneath ice sheets, called subglacial volcanoes, produce a wide variety of minerals and mineraloids including glass, clay-like minerals (phyllosilicates), sulfates, iron oxides, and zeolites. The volcanoes themselves also have a characteristic flat-topped shaped created by lava interacting with ice and forming a cap at the top of the ice (bottom left).
- The new analysis found a subset of these minerals on flat-topped volcanoes (top left), indicating that an ice sheet had been present when they erupted. This lent further support to an earlier suggestion by previous researchers that had been based on landforms in the same area.
- These studies can be used to reconstruct the ice sheet that was once present, and reveal information about Martian paleoclimate.

Ackiss et al. [2016] LPSC

Collaborating with our International Partners on Space Weather: ILWS meets with CESSI in India

Science for/of Space Weather: The international heliophysics community held a workshop on January 24-29th in Goa, India that also included hands on modeling training for students through NASA's Community Coordinated Modeling Center (CCMC). This workshop was sponsored by the International Living With a Star (ILWS) organization in partnership with the Indian Space Research Organization (ISRO), COSPAR, the Center for Excellence in Space Studies in India (CESSI) and many other national and international entities. NASA/Heliophysics has been collaborating with international partners on heliophysics research with a focus on relevance to life and society for over a decade and half. This workshop (second of its kind in India) was a huge success with 57 talks and 47 poster sessions from 21 countries. Over 112 people participated including 25 students. The workshop resulted in a resolution to cooperate with India's first mission to observe the Sun from the vantage point of L1 (Aditya-L1).

To enable hands-on activities, the CCMC built an experimental portable demo system for Runs-on-Request and Integrated Space Weather Analysis system.



Feedback from participants and workshop organizers was extremely positive. The CCMC was acknowledged by SCOSTEP, COSPAR, ILWS and ISRO as a tremendous asset for the international heliophysics science community and for enabling understanding and forecasting of space weather.

North Atlantic Aerosols and Marine Ecosystems Study (NAAMES) Connects with K-12 Classrooms Across North America

Image Credit: Marianne Moore

Reid Elementary School fifth graders from Middletown, PA chat live with the NAAMES team on November 18, 2015. Students tracked the locations of the NASA C-130 and the *Atlantis* Research Vessel.

Image Credit: Aneek DeGama

Discovery School sixth graders from Lancaster, CA chat with the NAAMES team on November 20, 2015. Students connected directly with scientists onboard the *Atlantis* and tracked its location using the NASA Mission Tools Suite.

Image Credit: Alfonso Alatorre

Sir Winston Churchill Institute fifth graders from Guanajuato, Mexico chat live with the NAAMES team onboard the *Atlantis* on November 20, 2015

During the NAAMES 2015 campaign, 23 different classrooms (508 total students in CA, IL, KS, MD, MO, NC, NJ, PA, and Mexico) connected directly with scientists onboard the *Atlantis* Research Vessel, an onboard the NASA C-130 aircraft -- providing a unique authentic science experience not soon forgotten

Coordinated by Emily Schaller, NSERC, NASA Airborne Science Program