Science Mission Directorate

Weekly Highlights

November 20, 2015

NASA's TIMED Mission Observes Unexpected Trends in Carbon Data

Yue et al., , 2015 Increasing carbon dioxide concentration in the upper atmosphere observed by SABER· doi 10.1002/2015GL064696

NASA's TIMED (Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics) mission, has confirmed a surprisingly fast carbon dioxide increase in Earth's upper atmosphere, raising questions about how different layers of the atmosphere are interconnected. Even more curious—though climate models predict carbon dioxide should increase more or less equally across the globe, in its 14 years of data collection, TIMED observed a much faster increase of carbon dioxide above the Northern Hemisphere.

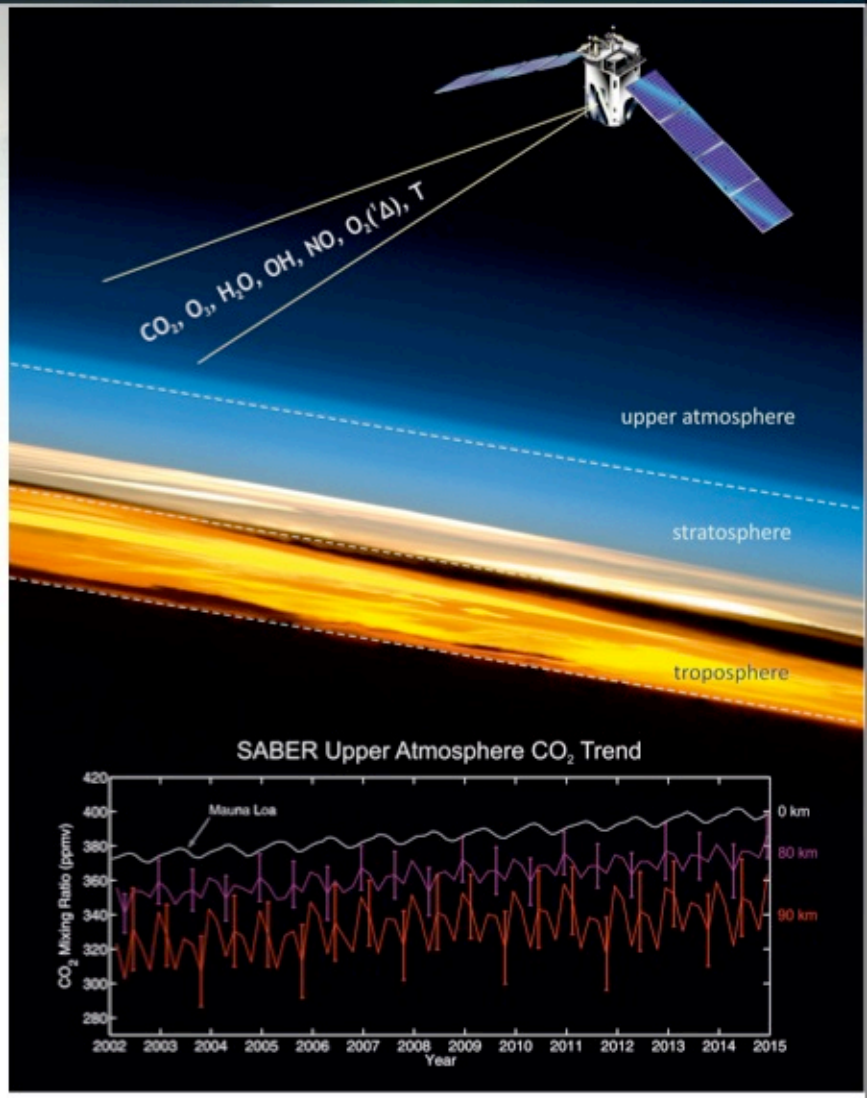
Understanding the way carbon dioxide moves throughout the atmosphere is key, both for making accurate climate models and for planning spacecraft flight paths. Though carbon dioxide raises temperatures near Earth's surface, it actually causes cooling in the upper atmosphere, reducing air density in these outermost reaches of the atmosphere and impacting spacecraft orbits.

Carbon dioxide is being poured into the atmosphere by human activities, like the burning of fossil fuels and deforestation. A 5 percent per decade increase in carbon dioxide concentration in the lower atmosphere is confirmed by some 56 years of measurements at Earth's surface. But in the upper atmosphere, the increase in carbon dioxide concentration was observed reaching rates of 12 percent per decade around 70 miles above the surface.

Furthermore, they discovered that the carbon dioxide in these upper layers, long thought to follow the same patterns across the globe, is increasing faster over the Northern Hemisphere. Though the Northern Hemisphere produces much more carbon dioxide because of its greater land area and population, scientists expect the difference to become negligible at such great heights due to diffusion and mixing.

This study's result also confirms results from the Canadian Space Agency's SciSat-1 where an analysis of eight years of data gave the first indication of the accelerated increase of carbon dioxide in the upper atmosphere.

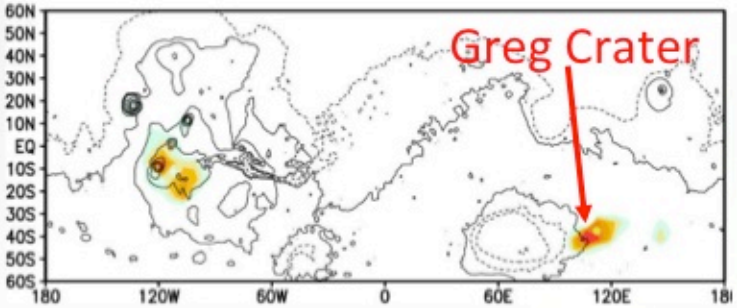
Identifying and confirming these unexpected trends was only possible because of the long lifespan of TIMED's radiometer, which is still operating well. The TIMED satellite, part of the observatory maintained by the Heliophysics Division of NASA, was originally slated for a two-year mission ending in 2003, has been granted six extended missions.



Credit: Instituto de Astrofísica de Andalucía.

Mars Global Climate Modeling Successfully Predicts Ancient Glacial Features

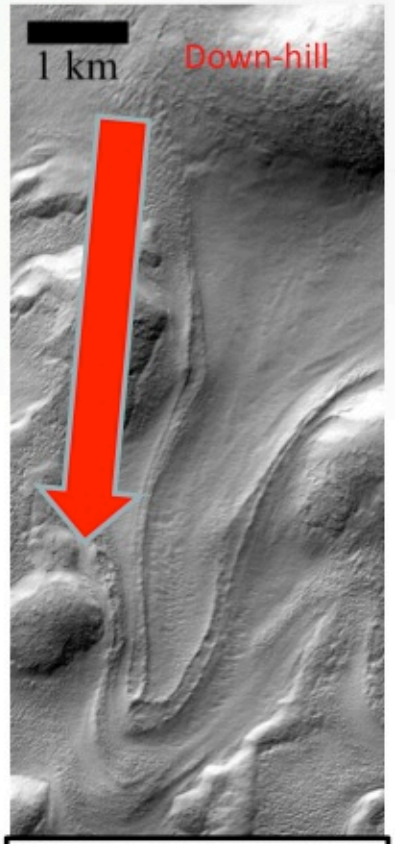
An international project based on data from the Mars Global Surveyor's Mars Orbiter Camera (MOC) and the Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment (HiRISE) reveal a concentration of glaciers that flowed down the wall of Martian crater Greg, at the location and time that global climate models (GCMs) predicted ice deposition.



Mercator sketch map of Mars where red-orange spots indicate the greatest winter ice deposition during periods of high axial tilt, as predicted by Forget et al. (2006). Yellow circle marks crater Greg.

- GCMs suggest that this crater is in one of two non-polar areas where extremes of ice deposition occur when the polar axis leaned toward the sun – at an obliquity of >45 degrees. Astronomical calculations indicate that the last few of these episodes were at 5.5, 8, 9, 15, and 17 million years ago.
- Counts of the impact craters in the surface layers of the glacial features indicate estimated surface ages of a few million years, although these features may have been more ice-rich when they formed and been depleted by volatile loss.
- The ability to predict features on another planet by use of a GCM, is an important support to the credibility using these models to study planetary climate change.

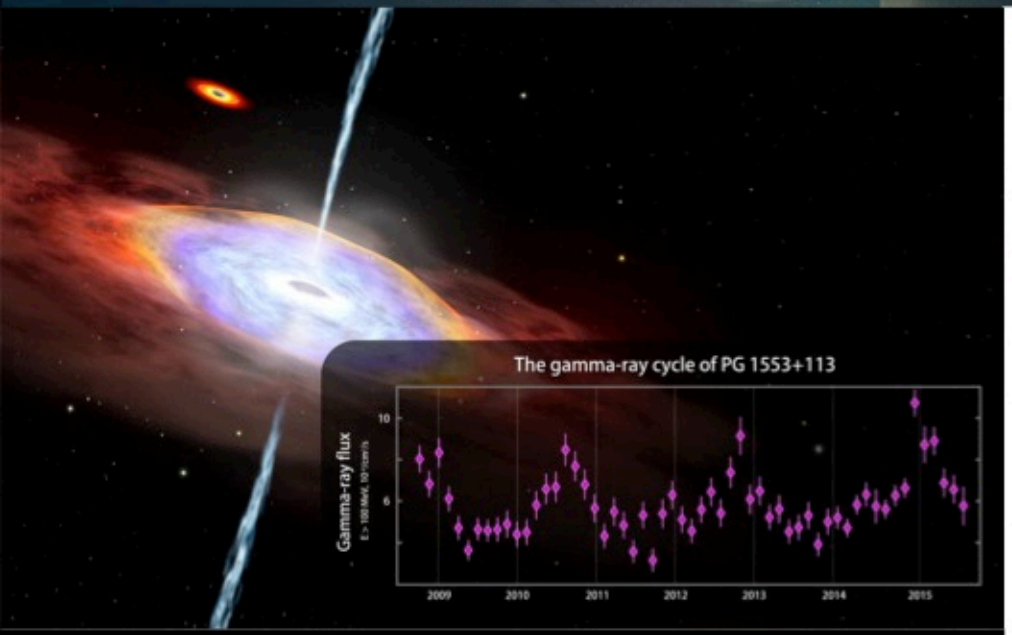
Hartmann et al. *Icarus*, 2014.



One of several glaciers on the wall of Greg

NASA's Fermi Mission Finds Hints of Gamma-ray Cycle in an Active Galaxy

Published in the November 10, 2015 edition of The Astrophysical Journal Letters.



The graph shows Fermi Large Area Telescope data from August 2008 to July 2015 for gamma rays with energies above 100 million electron volts (MeV). For comparison, visible light ranges between 2 and 3 electron volts. Vertical lines on data points are error bars. Background: One possible explanation for the gamma-ray cycle is an oscillation of the jet produced by the gravitational pull of a second massive black hole, seen at top left in this artist's rendering.

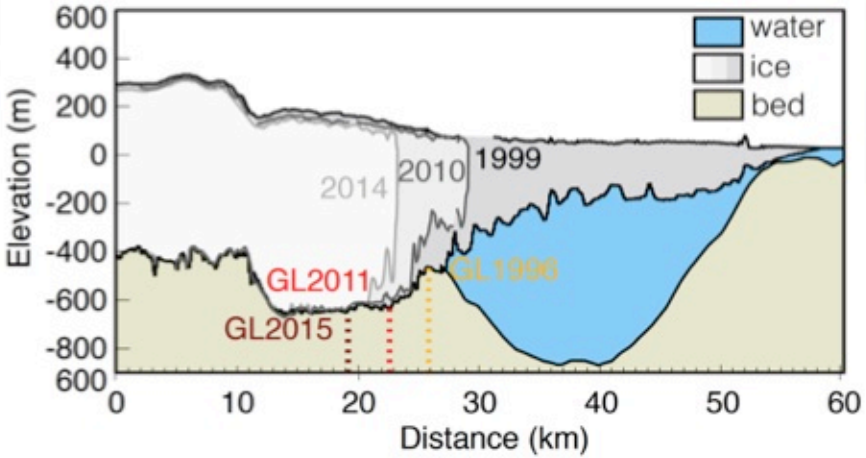
Credits: NASA's Goddard Space Flight Center/CI Lab

- Astronomers using data from NASA's Fermi Gamma-ray Space Telescope have detected hints of periodic changes in the brightness of an "active" galaxy, whose emissions are powered by a supersized black hole. If confirmed, the discovery would mark the first years-long cyclic gamma-ray emission detected from a galaxy.
- Supermassive black holes weighing millions of times the sun's mass lie at the hearts of most large galaxies. In about 1 percent of these galaxies, the black hole radiates billions of times as much energy as the sun, emission that can vary unpredictably on timescales ranging from minutes to years. Astronomers refer to these as active galaxies.
- More than half of the gamma-ray sources seen by Fermi's LAT are active galaxies called blazars, like PG 1553+113. As matter falls toward its supermassive black hole, some subatomic particles escape at nearly the speed of light along a pair of jets pointed in opposite directions. What makes a blazar so bright is that one of these particle jets happens to be aimed almost directly toward us.
- Motivated by the possibility of regular gamma-ray changes, the researchers examined a decade of multiwavelength data. These included long-term optical observations from Tuorla Observatory in Finland, Lick Observatory in California, and the Catalina Sky Survey in Arizona, as well as optical and X-ray data from NASA's Swift spacecraft. The team also studied observations from the Owens Valley Radio Observatory in California, which has observed PG 1553+113 every few weeks since 2008 as part of an ongoing blazar monitoring program in support of the Fermi mission.
- Researchers found that the cyclic variations in visible light and radio waves are similar to what is seen in high-energy gamma-rays from Fermi. The pattern is consistent across such a wide range of wavelengths and is an indication that the periodicity is real and not just a fluctuation seen in the gamma-ray data. If the gamma-ray cycle of PG 1553+113 is in fact real, researchers predict it will peak again in 2017 and 2019.
- The scientists identified several scenarios that could drive periodic emission, including different mechanisms that could produce a years-long wobble in the jet of high-energy particles emanating from the black hole. The most exciting scenario involves the presence of a second supermassive black hole closely orbiting the one producing the jet we observe. The gravitational pull of the neighboring black hole would periodically tilt the inner part of its companion's accretion disk, where gas falling toward the black hole accumulates and heats up. The result would be a slow oscillation of the jet much like that of a lawn sprinkler, which could produce the cyclic gamma-ray changes we observe.
- PG 1553+113 lies in the direction of the constellation Serpens, and its light takes about 5 billion years to reach Earth.

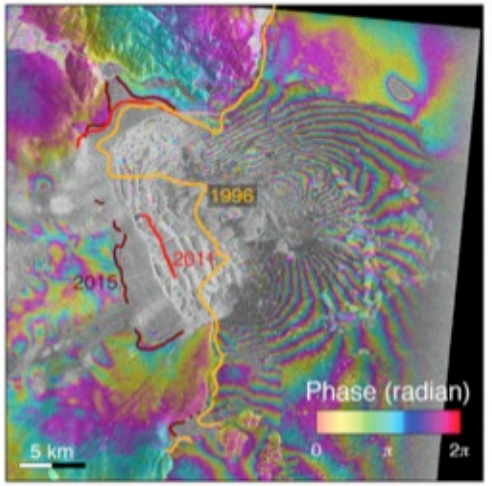
Fast Retreat of Zachariæ Isstrøm, Northeast Greenland

Mouginot, J., E. Rignot, B. Scheuchl, I. Fenty, A. Khazendar, M. Morlighem, A. Buzzi, and J. Paden | NOVEMBER 2015 | doi: 10.1126/science.aac7111

A new JPL-NASA study found that after 8 years of decay of its ice shelf, Zachariæ Isstrøm, a major glacier of northeast Greenland that holds a 0.5-meter sea-level rise equivalent, entered a phase of accelerated retreat in fall 2012. The study used data from aerial surveys conducted by NASA's Operation IceBridge and satellite-based observations acquired by multiple international space agencies and coordinated by the World Meteorological Organization's Polar Space Task Group. The acceleration rate of the glacier's ice velocity was shown to have tripled, with the melting of its residual ice shelf and thinning of its grounded portion having doubled, and calving occurring at its grounding line. Warmer air and ocean temperatures have caused the glacier to detach from a stabilizing sill and retreat rapidly along a downward-sloping, marine-based bed. Its equal-ice-volume neighbor, Nioghalvfjerdsfjorden, has also been melting rapidly but retreating slowly along an upward-sloping bed. These two glaciers together drain the northeast Greenland ice stream, the only large, dynamic feature that extends continuously deep to the ice sheet interior near Greenland's summit. The destabilization of this marine-based sector, which holds a 1.1-m sea-level rise equivalent, is likely to increase sea-level rise from the Greenland Ice Sheet for decades to come.



Above: Evolution of Zachariæ Isstrøm (ZI) between 1999 and 2014 with successive ice front positions, color-coded from dark (1999) to light grey (2014), seawater in blue and bedrock in light brown. Vertical dashed lines locate the grounding lines.



Upper left: Schematic view with Operation IceBridge and other NASA mission flight tracks in grey, and ice front retreat in green. ***Upper right:*** Differential interferogram showing the tide-induced motion of ZI in Dec 2014, and the grounding line migration from 1996 and 2015.

Jet Propulsion Laboratory Open House: "Discovering New Worlds" Exhibits

- On October 10-11, 2015, Jet Propulsion Laboratory (JPL's) Open House drew a record number of visitors
- Despite temperatures close to 100°F, approximately 45,000 visitors toured the Lab and 'Discovering New Worlds' exhibits
  - Over 34 missions represented
  - Hyperwall talks every 15 minutes
  - Climate Jeopardy games
  - 3D movie
  - Inaugural tours of the Earth Orbiting Missions Operations Center
- Over 270 volunteers engaged people of all ages, including visitors from neighboring states and Mexico