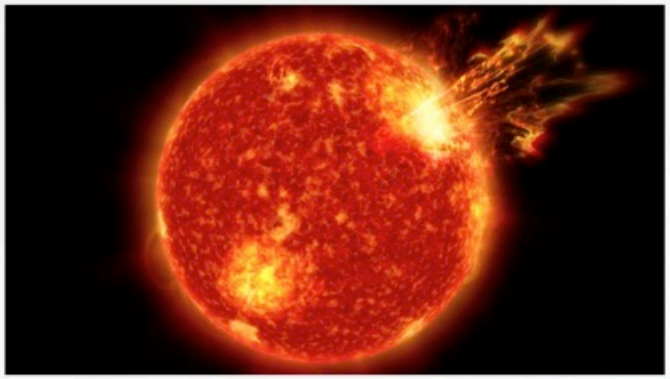

National Aeronautics and
Space Administration
NASA
Science Mission Directorate
Weekly Highlights
May 27, 2016

Solar Storms May Have Been Key to Life on Earth

Airapetian, V. S; et al. (2016)PREBIOTIC CHEMISTRY AND ATMOSPHERIC WARMING OF EARLY EARTH BY AN ACTIVE YOUNG SUN. Nature Geoscience. Online. doi:10.1038/ngeo2719



A 'superflare' visualization. *Credits: NASA's GSFC/Genna Duberstein*

Our sun's adolescence was stormy—and new evidence shows that these tempests may have been just the key to seeding life as we know it. In our sun's adolescence, about 4 billion years ago, its surface roiled with giant eruptions, spewing enormous amounts of solar material and radiation out into space. During this time, Earth was a relatively warm planet covered in water – instead of the icy ball one might predict given that, even though very active, the young sun was fainter than it is today. A team of scientists at NASA may have found some answers as to why Earth was so warm and how the molecular stew that seeded the first life on Earth began to percolate.

They say it had everything to do with something called 'superflares' – colossal explosions each as powerful as a million, billion atomic blasts – so rare today that we only experience them once every 100 years or so. Using data from NASA's Kepler mission, studies have found that young stars similar to our sun also have frequent 'superflares' erupting from their surfaces and produce as many as ten 'superflares' a day. Studying the history of our sun by searching for similar stars in our galaxy helps us map a functional timeline of how our own sun evolved. This led these scientists to believe our sun, too, produced frequent 'superflares' in its young sun days – hurling massive amounts of solar material toward Earth. Earth's magnetic field was actually much weaker at this time, allowing heavy showers of high-energy particles to rain down into Earth's atmosphere.

The atmosphere of early Earth was also different than it is now; molecular nitrogen made up 90 percent of the atmosphere, compared to only 78 percent today. As energetic particles slammed into these nitrogen molecules, the impact broke them up into individual nitrogen atoms. They, in turn, collided with carbon dioxide, separating those molecules into carbon monoxide and oxygen. The free-floating nitrogen and oxygen combined into nitrous oxide – a powerful greenhouse gas.

A video capture of a visualization showing young Earth being impacted by solar energy from our adolescent sun. Credits: NASA's GSFC/Genna Duberstein
http://svs.gsfc.nasa.gov/11853

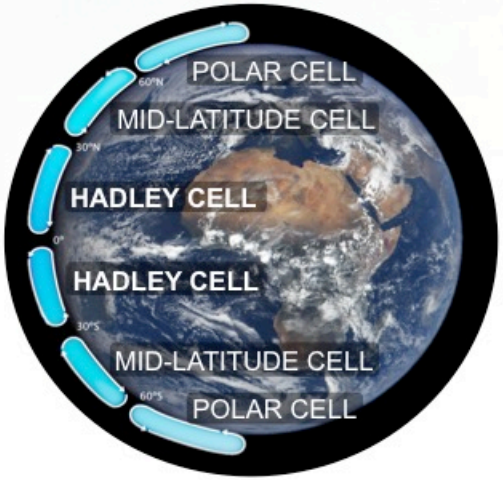
Nitrous oxide is some 300 times more powerful than carbon dioxide and the team's calculations show that even with the fainter young sun, if the early atmosphere housed less than one percent as much nitrous oxide as it did carbon dioxide, it would warm the planet enough for liquid water to exist. These powerful solar explosions may have provided the crucial energy needed to warm Earth. The eruptions also may have furnished the energy needed to turn simple molecules into the complex molecules such as RNA and DNA that were necessary for life. The research was published in Nature Geoscience on May 23, 2016, by a team of heliophysicists and chemists from NASA.

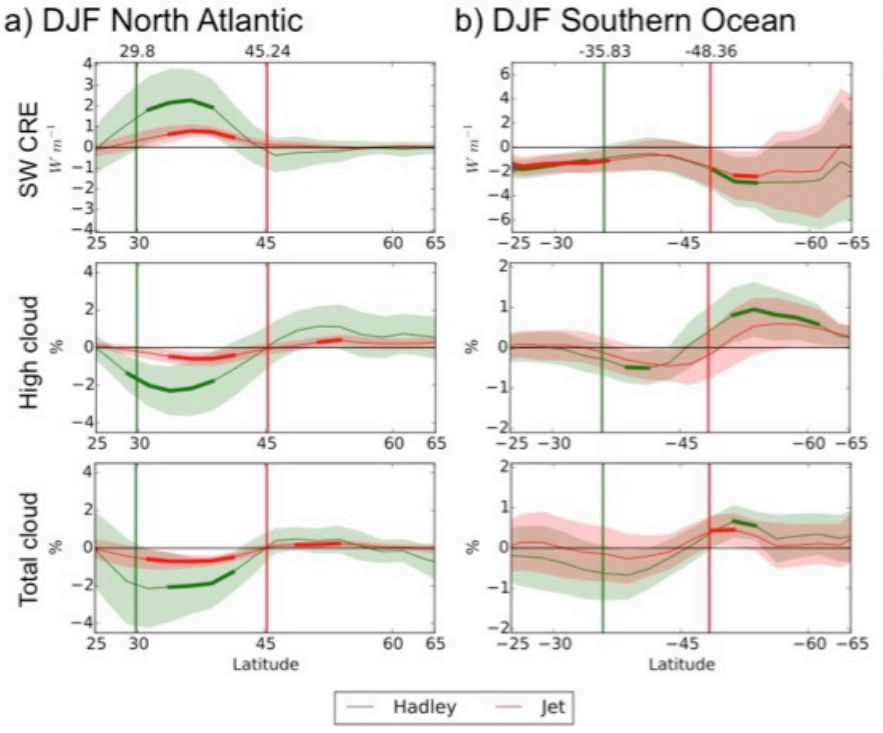
Midlatitude cloud shifts, their primary link to the Hadley cell, and their diverse radiative effects

G. Tselioudis, B. Lipat, D. Konsta, K. Grise, and L. Polvani | Geophysical Research Letters | MAY 2016 | doi: 10.1002/2016GL068242

NASA researchers investigated the interannual relationship among clouds, their radiative effects, and two key indices of the atmospheric circulation: the latitudinal positions of the Hadley cell edge and the midlatitude jet. Using a 30 years satellite data record from the International Satellite Cloud Climatology Project, they found a clear and consistent relationship between the width of the Hadley cell and the high cloud field, statistically significant in nearly all regions and seasons. In contrast, shifts of the midlatitude jet correlate significantly with high cloud shifts only in the North Atlantic region during the winter season. While in that region and season poleward high cloud shifts are associated with shortwave radiative warming, over the Southern Oceans during all seasons they are associated with shortwave radiative cooling. Finally, a trend analysis revealed that poleward high cloud shifts observed over the 1983-2009 period are more likely related to Hadley cell expansion, rather than poleward shifts of the midlatitude jets. The study provides new insight that will likely be used by the climate modeling community, including the scientists who contribute modeling expertise to the Intergovernmental Panel on Climate Change.

Right: The Hadley cell is one of the major ways air is moved around the planet. Existing in both hemispheres, it starts when air in the tropics, which is heated at the surface by intense sunlight, warms and rises. At high altitudes it is pushed away from the equator towards the mid-latitudes to the north and south, then it begins to sink back to Earth's surface, closing the loop.



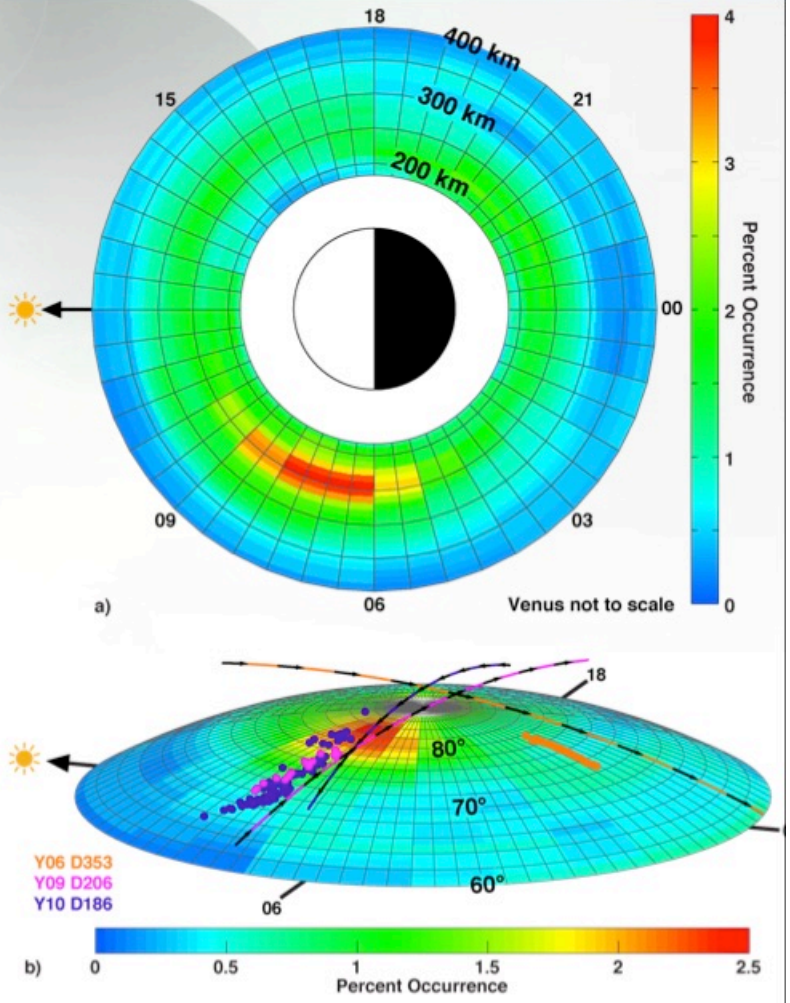


Far Right: The regression on the Hadley cell edge (green) and jet latitude (red) of the shortwave cloud radiative effect (SW CRE, top panels), the high cloud cover (middle panels), and the total cloud cover (low panels), for the December-February season and for a) the N. Atlantic and b) the Southern Ocean. The figure illustrates differences between the Hadley cell and midlatitude jet correlations – except in North Atlantic.

Lightning on Venus Detected via Ionospheric Whistler Waves

While in orbit, the Venus Express (VEX) spacecraft detected low-frequency signals likely produced by lightning in specific regions of the atmosphere.

- Venus's atmosphere, shrouded in a thick cloud layer, has been the subject of a decades-long search for lightning.
- On Earth, lightning produces a type of radio wave known as whistlers. These occur when electromagnetic waves produced by lightning enter the ionosphere of Earth and slow down, allowing the magnetic field of the waves to increase in amplitude and be guided to higher altitudes where they can be detected by spacecraft.
- The VEX magnetometer has detected more than 2200 whistlers over 9 years. Signals were seen at all local times, but most frequently near dawn. The best areas for detecting signals is near 250 km altitude and at high latitudes, which may help inform orbit selection for future missions.
- Lightning catalyzes complex chemical reactions within the atmosphere, and may have been important for the origin of life on Earth. Venus joins Earth, Mars, Jupiter, Saturn, and Uranus as planets in our solar system where lightning has been detected.

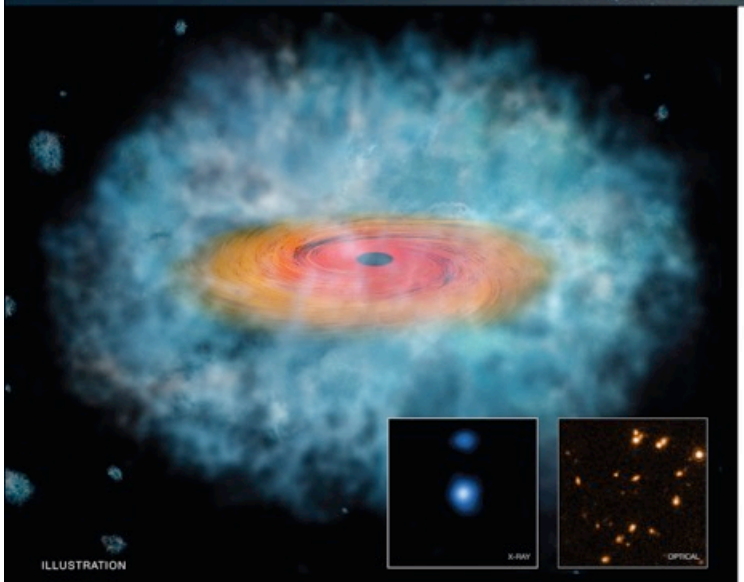


The occurrence rate of whistler waves on Venus projected onto maps of local time with (tpp) altitude and (bottom) latitude. The bottom figure also shows the satellite tracks and source locations of the lightning.

Hart, et al., Proceedings of the International Venus Conference, April 2016.

NASA Telescopes Find Clues for How Giant Black Holes Formed so Quickly

These results will appear in the June 21st issue of the Monthly Notices of the Royal Astronomical Society.



Credit :X-ray: NASA/CXC/Scuola Normale Superiore/Pacucci, F. et al, Optical: NASA/STScI; Illustration: NASA/CXC/M.Weiss

- Using data from three of NASA's Great Observatories, scientists have found the best evidence to date of a mechanism that produced supermassive black holes in the early Universe. If confirmed, this result could lead to new insight into how black holes were formed and grew billions of years ago.
- The artist's illustration depicts a possible "seed" for the formation of a supermassive black hole, that is an object that contains millions or even billions of times the mass of the Sun. In the artist's illustration, the gas cloud is shown as the wispy blue material, while the orange and red disk is showing material being funneled toward the growing black hole through its gravitational pull.
- Researchers found evidence that two objects could have formed in this way, by directly collapsing into a black hole from a large cloud of gas. These two candidates for being "direct collapse black holes" are so distant that they may have formed less than one billion years after the Big Bang.
- The inset boxes show data from the Chandra X-ray Observatory (left) and the Hubble Space Telescope (right) of one of the objects described above. The Hubble image shows the faint, distant galaxy at the center of the image and the Chandra image shows X-ray emission from material falling onto the black hole in the same galaxy.
- The researchers used computer models of black hole seeds combined with a new method to select candidates for these objects from long-exposure images from Chandra, Hubble, and Spitzer (not shown in this graphic). By analyzing the combined light from the three telescopes, the team was able to search through thousands of objects to look for any that had properties that matched those predicted by their models.
- Two candidates emerged that had the expected red color, seen by Hubble and Spitzer, as well as the X-ray profile predicted from Chandra. These objects were found in the Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey and the Great Observatories Origins Deep Survey-South surveys. The next steps will involve getting more data on these two intriguing objects as well as extending the analysis to other surveys to look for more direct collapse black hole candidates.

Girl Scouts: Bridging at the Golden Gate Bridge

Golden Gate Bridging is the biggest event of the year for Girl Scouts of Northern California. Over 6,000 girls, both local and out of state, walked across the iconic Golden Gate Bridge as they bridged from "Juniors to Cadettes" on April 30, 2016. The Bridge walk is followed by a celebration on Crissy Field with music, snacks, and fun activity booths. The "*Reaching for the Stars: NASA Science for Girl Scouts*" team, led by the Search for Extraterrestrial Intelligence (SETI) Institute and Astronomical Society of the Pacific, offered space science activities.

"Girls Go To Mars" table experiments start girls on their Journey to Mars

Solar telescope viewing

Cadette led solar viewing