Science Mission Directorate

Weekly Highlights

November 4, 2016

NASA Missions Harvest a Passel of 'Pumpkin' Stars

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Illustration credit: NASA's Goddard Space Flight Center

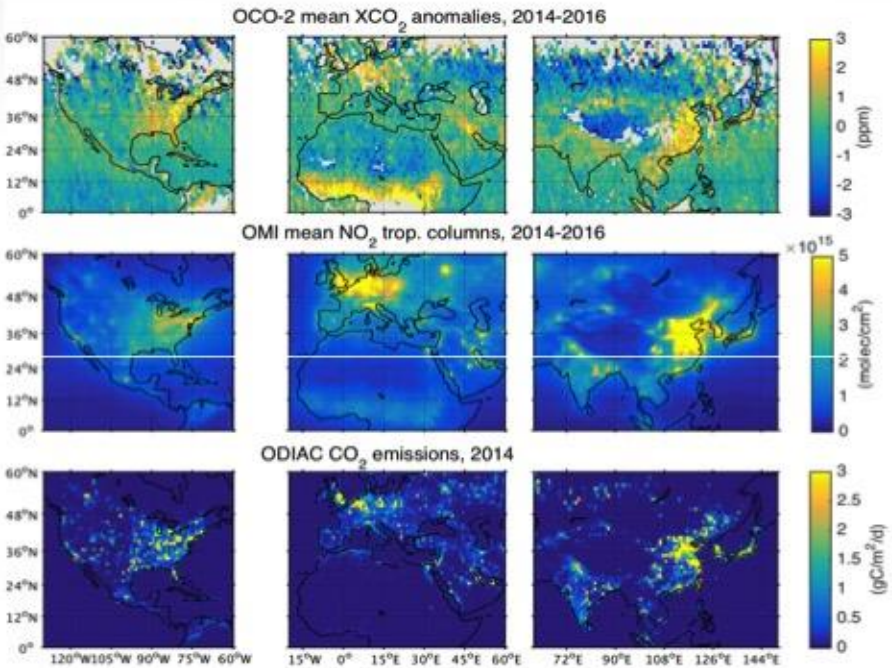
In this illustration, the merging process is nearly complete. Gas ejected from the equatorial region of the combined star forms an excretion disk around it.

- Astronomers using observations from NASA's Kepler and Swift missions have discovered a batch of rapidly spinning stars that produce X-rays at more than 100 times the peak levels ever seen from the sun. The stars, which spin so fast they've been squashed into pumpkin-like shapes, are thought to be the result of close binary systems where two sun-like stars merge.
- These rare stars were found as part of an X-ray survey of the original Kepler field of view, a patch of the sky comprising parts of the constellations Cygnus and Lyra. Using the X-ray and ultraviolet/optical telescopes aboard Swift, the researchers conducted the Kepler–Swift Active Galaxies and Stars Survey (KSwAGS), imaging about six square degrees in the Kepler field. Ninety-three new X-ray sources were found, about evenly split between active galaxies and various types of X-ray stars.
- For the brightest sources, the team obtained spectra using the 200-inch telescope at Palomar Observatory in California. These spectra provide detailed chemical portraits of the stars and show clear evidence of enhanced stellar activity.
- The researchers used Kepler measurements to determine the rotation periods and sizes for 10 of the stars, which range from 2.9 to 10.5 times larger than the sun. Their surface temperatures range from somewhat hotter to slightly cooler than the sun. Astronomers classify the stars as subgiants and giants, which are more advanced evolutionary phases than the sun's caused by greater depletion of their primary fuel source, hydrogen. All of them eventually will become much larger red giant stars.
- Forty years ago, Ronald Webbink at the University of Illinois, Urbana-Champaign noted that close binary systems cannot survive once the fuel supply of one star dwindles and it starts to enlarge. The stars coalesce to form a single rapidly spinning star initially residing in a so-called "excretion" disk formed by gas thrown out during the merger. The disk dissipates over the next 100 million years, leaving behind a very active, rapidly spinning star.
- The researchers suggest that their 18 KSwAGS stars formed by this scenario and have only recently dissipated their disks. To identify so many stars passing through such a cosmically brief phase of development is a real boon to stellar astronomers.

Direct Space-based Observations of Anthropogenic CO_2 Emission Areas From OCO-2

Hakkarainen, J., Ialongo, I., & Tamminen, J.| Geophysical Research Letters| November 2016 | doi: 10.1002/2016GL070885

NASA's Orbiting Carbon Observatory-2 (OCO-2) satellite data were used to produce the first global maps of anthropogenic carbon dioxide (CO_2) over three major pollution regions, the eastern US, central Europe, and East Asia. Scientists from the Finnish Meteorological Institute in Helsinki achieved this by eliminating seasonal changes in carbon dioxide, as well as the background carbon dioxide level in the atmosphere to derive CO_2 anomalies. Several small isolated emission areas (such as large cities) were detectable from the anomaly maps. Additionally, high CO_2 levels over the three highest-emitting regions were consistent with fossil fuel emissions inferred from nitrogen dioxide (NO_2) tropospheric columns based on the Ozone Monitoring Instrument (OMI) onboard NASA's Aura satellite. A cluster analysis confirmed the spatial correlation between CO_2 and NO_2 data over areas with different amounts of pollution. Also, the areas of central Africa Southeast Asia where biomass burning occurs were isolated from the areas affected by the emissions from fossil fuel combustion. The scientists found positive correlation between CO_2 anomalies and emission inventories. CO_2 emissions from fossil fuel extraction activities in the Middle East, however, were evident in OCO-2 maps but not tracked in inventories, suggesting possible missing emission information in the inventories.



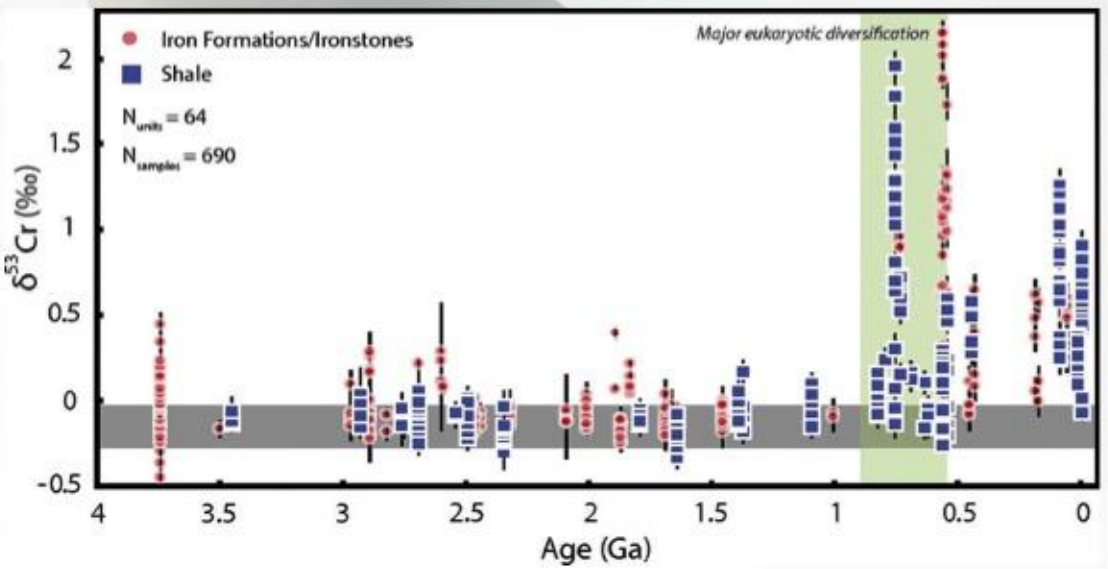
Carbon dioxide (CO_2) is the most significant greenhouse gas (GHG) and it plays an important role in the Earth's radiative budget and climate. Global atmospheric CO_2 concentrations have increased since pre-industrial era from 280 ppm to current levels of about 400 ppm. The study's results demonstrate the power of spaceborne data for monitoring anthropogenic CO2 emissions and providing more and more accurate information on pollution levels on global scale.

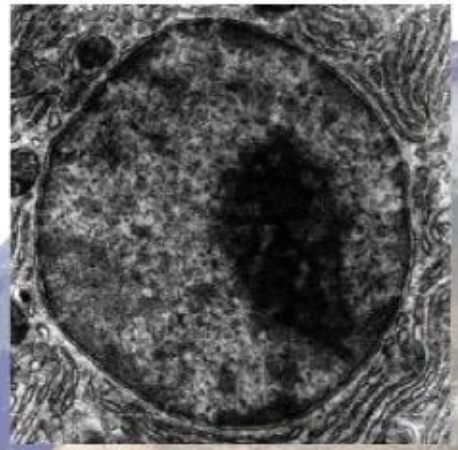
Left: (top row) mean OCO-2 measurements of column mean dry mole fraction of CO_2 (XCO_2) anomalies for 3 major pollution regions. (middle row) mean tropospheric OMI NO_2 columns. (bottom row) latest Open-source Data Inventory for Anthropogenic CO_2 (ODIAC) emission inventory map from 2014.

Rise in Earth's Oxygen Timed to the Rise of Animals

An evolutionary burst 540 million years ago filled planet Earth with an astonishing diversity of animals, that is related to a rise in atmospheric oxygen.

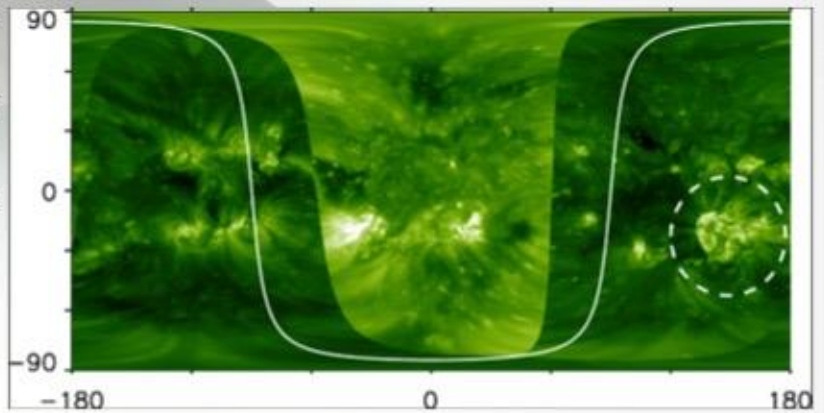
- Chromium (Cr) cycling in soils is dependent on atmospheric oxygen (O_2), and measuring Cr isotopes provides a way to track O_2 in ancient marine sedimentary rocks.
- Eukaryotic cells - those with distinct nucleus and internal structures – evolved nearly a billion years before fossils of complex animals first appeared in the rock record. The cause of this lag was unclear and many hypotheses have been suggested.
- Newly presented data demonstrate that oxygen was low enough during the long period prior to this increase in animal diversity (the mid-Proterozoic) to have directly hindered the emergence of advanced animals until approximately 800 million years ago.





360 Sun: Highlighting 10 Years of Heliophysics STEREO Mission Data and Observations

Before the Heliophysics STEREO mission was launched ten years ago, we were only able to take observations of the sun and solar wind from Earth's perspective. STEREO's revolutionary mission design has afforded us different views of the sun – simultaneously. STEREO's two nearly identical space-based observatories – one ahead of Earth in its orbit, the other trailing behind –have provided the first-ever stereoscopic measurements of the sun. STEREO was launched to improve our understanding of the solar corona, the origins and propagation of Coronal Mass Ejections (CMEs) and the solar wind, and to better understand the trajectory of Solar Energetic Particles (SEPs) traveling from the sun into the interplanetary magnetic field. All of these events and phenomena drive the space weather conditions impacting Earth, other objects and other planetary systems in our solar system. Since STEREO has been in orbit it has contributed a wealth of data **including multi-point observations only STEREO could provide of one of the fastest CMEs on record and the most intense SEP event in decades.** On July 23rd, 2012, the CME originated on the far side of the sun, and, without STEREO, researchers might not have known the event occurred at all.



This is a Carrington map which provides a Mercator projection-like view of the sun using STEREO A, STEREO B and SDO data on 23 July 2012. The dashed circle indicates the area in which the CME occurred. The white, u-shaped line distinguishes the area visible from Earth and uses the SDO data. Without STEREO we wouldn't have been able to observe this historical CME or any of the areas outside the white, u-shaped line. The degrees on each axis represent heliolatitude verically and heliolongitude horizontally.

Credit: NASA STEREO/SDO

STEREO has made it possible to track CMEs, and the solar wind, from the sun to Earth while at the same time measuring them in-situ (or locally), enhancing our understanding of CME and solar wind structures as they travel through space. STEREO data has been combined with SDO data to determine CME speeds and trajectories more accurately, **resulting in a 50% improvement in CME prediction times.** STEREO data analyzed alongside ACE data on the July 2012 CME show distinct differences in space weather impacts at different locations in the solar system, giving scientists deeper insight into the physics of space weather and impacts on the local environment.

STEREO data has been used to analyze and model the distribution of SEPs, a significant space weather hazard, from their origins in solar flares and CMEs into the interplanetary medium. CME shocks accelerate SEPs and STEREO data has been used to model this as well. Mapping multipoint magnetic polarity and comparing STEREO data to global solar wind models like ENLIL has also advanced space weather science and understanding.

The two points of observation STEREO provided made it possible to model the magnetic fields of structures in the solar corona – including active regions, jets and erupting prominences – for the first time in 3D. This capability **of the STEREO mission also brought us the first-ever simultaneous view of the entire star at once.** The STEREO spacecraft are a part of the larger Heliophysics Systems Observatory (HSO), which includes missions like SDO, SOHO and ACE. STEREO data and observations have added new and unique perspectives to the HSO. STEREO's 10th anniversary in orbit was celebrated on October 25, 2016 at the National Air and Space Museum with a public panel highlighting the mission's contributions to the science of space weather and space weather hazards.

Connecting GLOBE to Local Citizen Science Projects

- Every year for the past 27 years on the first Wednesday of October, teachers and students in northwest Ohio load up buses and cars with water testing equipment and travelled to a local body of water
- Toledo Metropolitan Area Council of Governments (TMACOG) has solicited their help to monitor the quality of their local streams in the Maumee River and Lake Erie basin in the *Student Watershed Watch Program*
- Using the GLOBE protocols and GLOBE Observer App in the field, students collected data about the site and the water then upload cloud data immediately
- The students then go back to their classrooms and analyze their data, compare it to other schools' data and present their findings at the Student Summit in November 2016
- Toledo Public Schools teachers, Laura Schetter (teacher at the Natural Science Technology Center), Melody Tsapranis (teacher at Navarre Elementary School) and their students participated in the *Student Watershed Watch*
- Both attended GLOBE Professional Development at the University of Toledo last June
- The University of Toledo assisted with equipment and staffing

This is just one example of how GLOBE can be incorporated into local citizen action projects

Laura Schetter with students doing Hydrology Protocols

Melody Tsapranis and students preparing for the collection of data

https://www.facebook.com/globemissionearth/