Science Mission Directorate

Weekly Highlights

March 25, 2016

The Early Flash of an Exploding Star

The research paper reporting this discovery has been accepted for publication in The Astrophysical Journal.

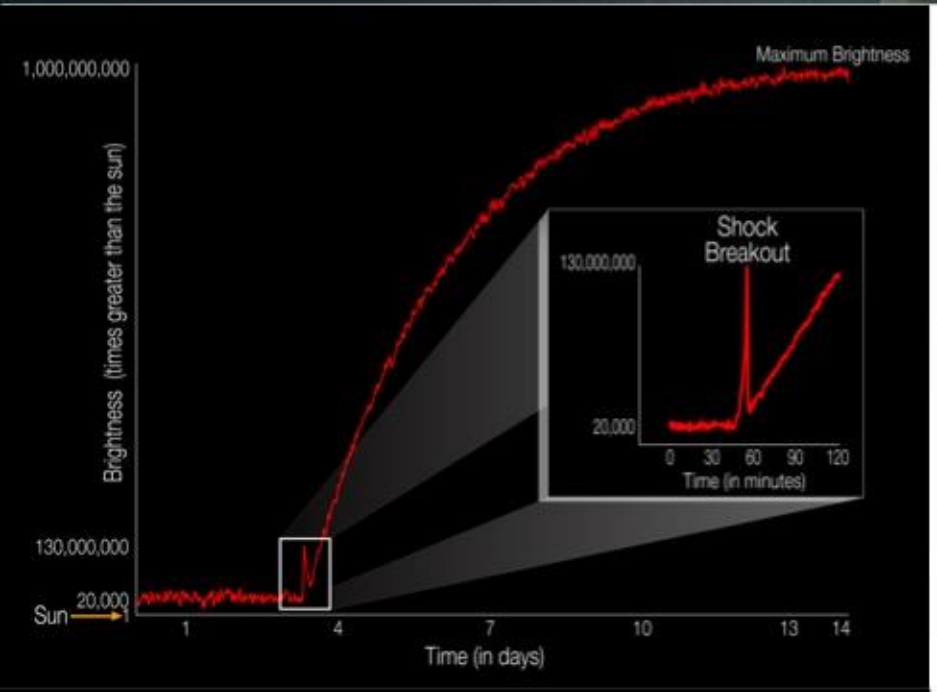


Diagram Credit: NASA Ames/W. Stenzel

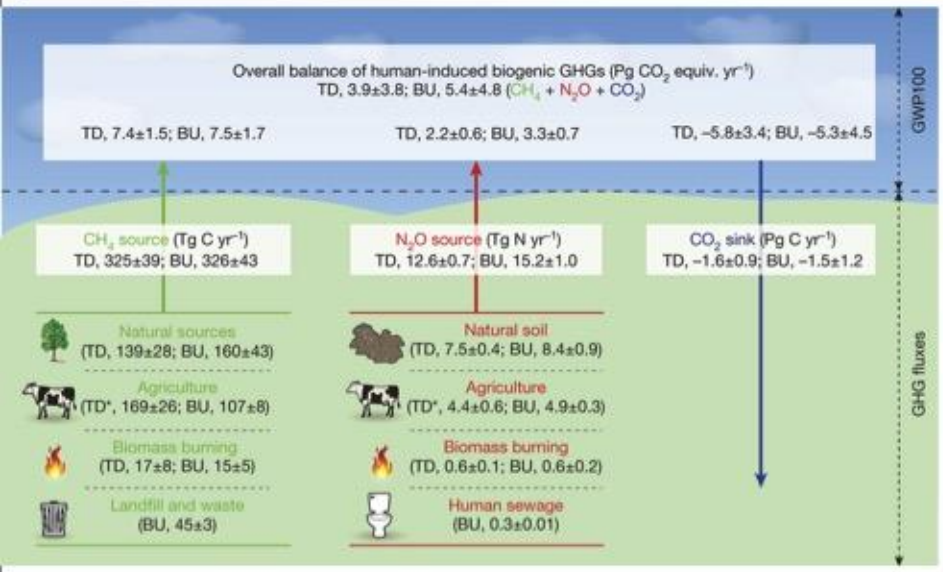
The diagram illustrates the brightness of a supernova event relative to the sun as it unfolds. The explosive death KSN 2011d, as it reaches its maximum brightness, takes 14 days. The shock breakout itself lasts only about 20 minutes.

- The brilliant flash of an exploding star's shockwave—what astronomers call the "shock breakout"—has been captured for the first time in visible light by NASA's Kepler space telescope.
- An international science team analyzed light captured by Kepler every 30 minutes over a three-year period from 500 distant galaxies, searching some 50 trillion stars. They were hunting for signs supernovae.
- In 2011, two of these red supergiants exploded while in Kepler's view. The first behemoth, KSN 2011a, is nearly 300 times the size of our sun and a mere 700 million light years from Earth. The second, KSN 2011d, is roughly 500 times the size of our sun and around 1.2 billion light years away.
- The steady gaze of Kepler allowed astronomers to see a supernova shockwave as it reached the surface of a star. The shock breakout itself lasts only about 20 minutes, so catching the flash of energy is an investigative milestone for astronomers.
- Supernovae like these — known as Type II — begin when the internal furnace of a star runs out of nuclear fuel causing its core to collapse as gravity takes over.
- The two supernovae matched up well with mathematical models of Type II explosions reinforcing existing theories. But they also revealed what could turn out to be an unexpected variety in the individual details of these cataclysmic stellar events.
- While both explosions delivered a similar energetic punch, no shock breakout was seen in the smaller of the supergiants. Scientists think that is likely due to the smaller star being surrounded by gas, perhaps enough to mask the shockwave when it reached the star's surface.
- Understanding the physics of these violent events allows scientists to better understand how the seeds of chemical complexity and life itself have been scattered in space and time in our Milky Way galaxy

The Terrestrial Biosphere as a Net Source of Greenhouse Gases to the Atmosphere

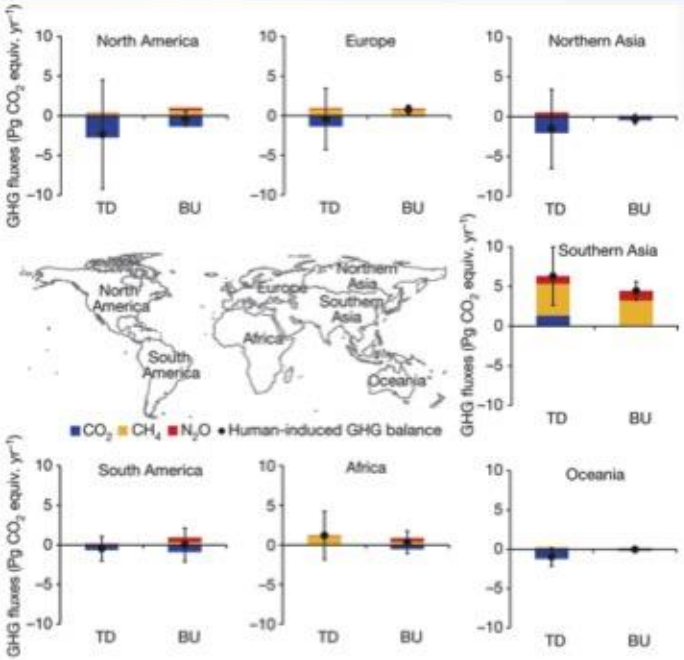
Tian, H., Lu, C., Ciais, P., Michalak, A. M., Canadell, J. G., Saikawa, E. ,... & Wofsy, S. |Nature 531, 225–228 (10 March 2016) doi:10.1038/nature16946

NASA and NSF-funded researchers used bottom-up (inventory, statistical extrapolation of local flux measurements, and process-based modelling) and top-down (atmospheric inversions) approaches to quantify the global net biogenic greenhouse gas balance resulting from anthropogenic activities and its effect on the climate system, between 1981 and 2010. They found that the cumulative warming capacity of concurrent biogenic methane and nitrous oxide emissions is a factor of about two times larger than the cooling effect resulting from the global land carbon dioxide uptake from 2001 to 2010. This results in a net positive cumulative impact of the three greenhouse gases on the planetary energy budget, with a best estimate of 3.9 ± 3.8 (top down) and 5.4 ± 4.8 (bottom up) (in Petagrams of CO_2 equivalent per year) based on the global warming potential on a 100-year time horizon. The concentration of atmospheric CO_2 has increased by nearly 40% since the start of the industrial era, while CH_4 and N_2O concentrations have increased by 150% and 20%, respectively. Although thermogenic sources (for example, fossil fuel combustion and usage, cement production, geological and industrial processes) represent the single largest perturbation of climate forcing, biogenic sources and sinks also account for a significant portion of the land–atmosphere exchange of these gases. Land biogenic greenhouse gas (GHG) fluxes are those originating from plants, animals and microbial communities, with changes driven by both natural and anthropogenic perturbations.



Above: The overall biogenic GHG balance of the terrestrial biosphere in the 2000s.

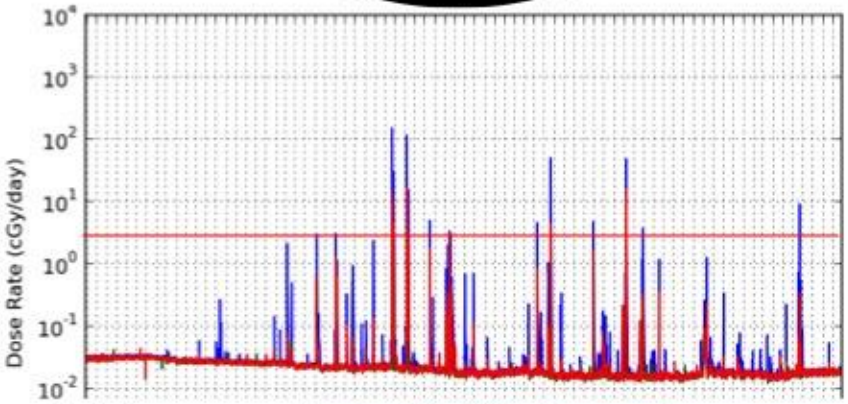
Right: The balance of human-induced biogenic GHGs for different continents in the 2000s.



Coronal Mass Ejections Measured at the Moon

Despite the minimal solar activity during the current sunspot cycle, a low unprecedented in the past century, recent large solar events indicate that, while calmer, this cycle is also more extended than prior cycles.

- On 10-29-2015 the Lunar Reconnaissance Orbiter's Cosmic Ray Telescope for the Effects of Radiation (CRaTER) instrument measured a large coronal mass ejection (CME), one of the top events measured during the past six years of the mission. During this event, measured radiation dose rates were on the scale of 5 rad/day (bottom right).
- Despite being a period of relative quiescence, this solar cycle is prolonged compared to previous cycles. Although low overall, the solar maximum in this cycle has continued for nearly three years, and has featured the first example of a double peak where the second peak was higher than the first.
- CRaTER continues to monitor this unique solar cycle and its direct effects on the lunar surface as well as on the experimental tissue equivalent plastic to determine the effects of radiation on human tissue.



Radiation measured by the CRaTER detectors from Sept. 2009 to Oct. 2015. Dose levels from the 10-29-15 event is marked with a red line

Connecting the Dots: Furthering our Understanding of 'Sympathetic Solar Events' with NASA SDO and STEREO Data

Jin, M., Schrijver, C., Cheung, M., DeRosa, M., Nitta, N., & Title, A. (2016).
A NUMERICAL STUDY OF LONG-RANGE MAGNETIC IMPACTS DURING CORONAL MASS EJECTIONS. The Astrophysical Journal, 820(1)

The term "sympathetic solar events," or SSEs, refers to sequences of eruptions from the solar corona that have causal relations, even though they are far apart.

With the simultaneous operation of the NASA Heliophysics Solar TErrestrial RElations Observatory (STEREO) from behind the sun and the Solar Dynamics Observatory (SDO) near Earth, we have reached, for the first time, nearly complete coverage of the sun from multiple perspectives. This gives us an unprecedented opportunity to investigate sympathetic solar events on a global scale. SSEs may also present important implications in understanding space weather.

The physical mechanisms of how CMEs spread from one region of the sun to another, and how they interact with the large-scale magnetic field around them to cause SSEs, remain largely unknown.

The "flux ropes" of a CME, which refer to erupting structures of magnetized plasma that form loops of different orientations and strengths, seem to play a role in how and why CME's spread and SSEs are triggered. It is thought that flux ropes of a CME connect through magnetic coupling to other CME flux ropes, either directly or through connecting to the large-scale magnetic field around it, causing SSEs.

New research by Jin, et. al published in the Astrophysical Journal this week used data on solar activity from February 15, 2011 as inputs into the Space Weather Modeling Framework model to investigate what mechanisms contribute to the creation and existence of this solar phenomenon. They show that a CME's impact on surrounding solar structures, particularly in causing SSEs, depends not only on the intrinsic magnetic strength of those surrounding structures and the distance to the CME source region, but also on the interaction of the CME with the large-scale solar magnetic field. The orientation of the connecting flux ropes also plays a large role in whether or not magnetic coupling will occur to trigger an SSE. With continued research and analysis, it may be possible to establish an empirical relationship to predict regions that are likely to be more active due to SSEs. Understanding what causes active regions to erupt would greatly aid space weather forecasting.

Image from SDO instruments, July 2012
http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=11180

SciFest 2016 in Grahamstown, South Africa

- Dr. William Edmonson, Samuel P. Langley Distinguished Professor from North Carolina A&T (NCA&T) State University at the National Institute of Aerospace (NIA), was an invited presenter and workshop facilitator supporting NASA outreach for SciFest Africa in March 2016
- 10 NASA workshops were conducted at regional schools as part of the outreach program to conduct during the National Science Festival, held at Settlers National Monument in Grahamstown, South Africa
- The workshops showcased current innovations in small satellites and demonstrating how NASA plans to use smallsats in the future, engaged participants to solve communications challenges and create an orbiting satellite using modular kits designed by LittleBits Kits
- The NIA Media Communications Group helped plan the middle and high school workshops, using modified activities designed from the LittleBits Space Kit which features ten activities created in collaboration with NASA Goddard Space Flight Center
- At the conclusion of the event, NIA and NCA&T received the SciFest Africa 2016 Award for, “Best Workshop: Innovation.”
- SciFest was established in 1996 to promote public awareness, understanding and appreciation of science, technology and innovation. SciFest is supported by the National Research Foundation, South African Agency for Science and Technology Development, and the Grahamstown Foundation

THINK · TOUCH · TALK · SCIENCE

Scifest Africa

CREATING A CULTURE OF CURIOSITY & LEARNING IN AFRICA

The Minister of Science and Technology, Ms Naledi Pandor MP was in attendance at the opening, and lauded SciFest Africa for it contribution to the sciences. She applauded the festival for its ability to create excitement around science, technology and innovation. “The main purpose of SciFest is to introduce young people to the exciting world of science and technology and to encourage them to choose to be part of this community of science and innovation”, she said.