National Aeronautics and
Space Administration

Science Mission Directorate

Weekly Highlights

March 4, 2016

The Sleeping Giant

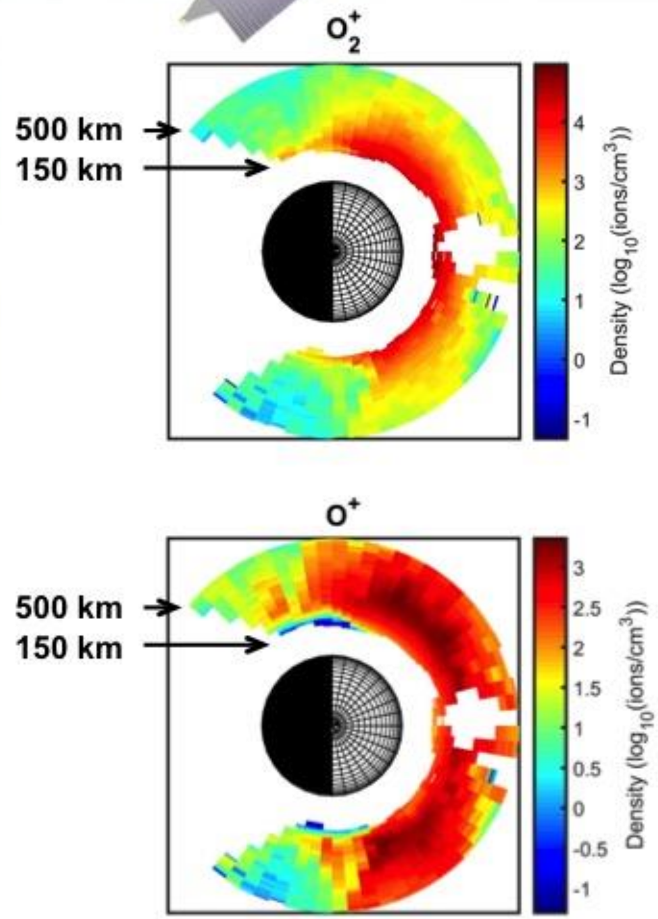
- Located about 300 million light-years away in the Coma Cluster, the giant elliptical galaxy NGC 4889, the brightest and largest galaxy in this Hubble image, is home to a record-breaking supermassive black hole. Twenty-one billion times the mass of the Sun, this black hole has an event horizon — the surface at which even light cannot escape its gravitational grasp — with a diameter of approximately 130 billion kilometers. This is about 15 times the diameter of Neptune's orbit from the Sun. By comparison, the supermassive black hole at the center of our Milky Way galaxy is believed to have a mass about four million times that of the Sun and an event horizon just one fifth the orbit of Mercury.
- But the time when NGC 4889's black hole was swallowing stars and devouring dust is past. Astronomers believe that the black hole has stopped feeding, and is currently resting after feasting on NGC 4889's cosmic cuisine. The environment within the galaxy is now so peaceful that stars are forming from its remaining gas and orbiting undisturbed around the black hole.
- When it was active, NGC 4889's supermassive black hole was fuelled by the process of hot accretion. When galactic material — such as gas, dust and other debris — slowly fell inwards towards the black hole, it accumulated and formed an accretion disc. Orbiting the black hole, this spinning disc of material was accelerated by the black hole's immense gravitational pull and heated to millions of degrees. This heated material also expelled gigantic and very energetic jets. During its active period, astronomers would have classified NGC 4889 as a quasar and the disc around the supermassive black hole would have emitted up to a thousand times the energy output of the Milky Way.
- The accretion disc sustained the supermassive black hole's appetite until the nearby supply of galactic material was exhausted. Now, napping quietly as it waits for its next celestial snack, the supermassive black hole is dormant. However its existence allows astronomers to further their knowledge of how and where quasars, these still mysterious and elusive objects, formed in the early days of the Universe.
- Although it is impossible to directly observe a black hole — as light cannot escape its gravitational pull — its mass can be indirectly determined. Using instruments on the Keck II Observatory and Gemini North Telescope, astronomers measured the velocity of the stars moving around NGC 4889's center. These velocities — which depend on the mass of the object they orbit — revealed the immense mass of the supermassive black hole.

MAVEN Surveys the Ionosphere of Mars

- The ionosphere of Mars plays a critical role in the loss of atmospheric gases and water to space. NASA's Mars Atmosphere and Volatile Evolution (MAVEN) has provided the first measurements of the composition of the ionosphere of Mars since the Viking orbiter in 1976. Unlike Viking, which provided measurements at only one time of day, MAVEN has generated the first map of the full day/night structure of the ionosphere.

- The images to the right show how the densities of the two main ions, O2+ and O+, depend on altitude and time of day. The global structure of the ionosphere, which is illustrated by these images, affects how much water escapes from Mars. In these images, the view is from the North Pole looking down.

- These observations follow Oxygen as it escapes into space primarily on the dayside and are used to determine how much water was present on ancient Mars when life could have existed.

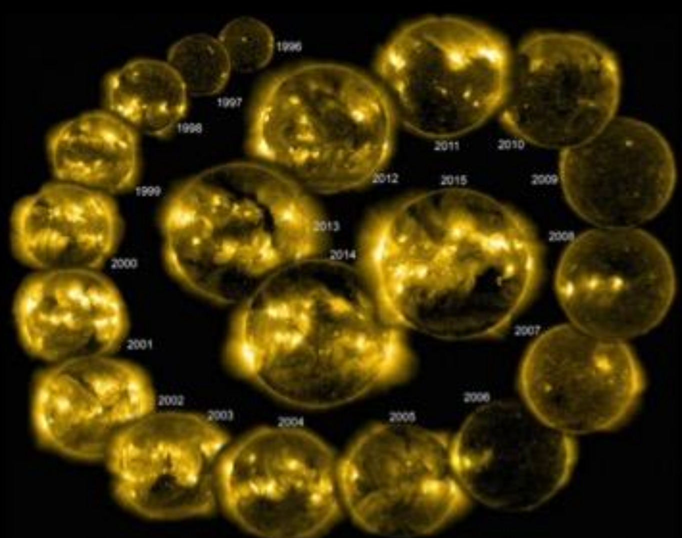


- Note: Mars is not to scale.

Solar Cycle 25: What might we expect?

A paper written by Dean Pesnell, project scientist for SDO at GSFC, explores the relationship between solar cycle predictions and models using what we know from previous cycles

Pesnell, W. D. (2016), *Predictions of Solar Cycle 24: How are we doing?,* Space Weather, 14, 10–21



Space Weather is driven by solar activity making predictions of solar activity an essential part of forecasting space weather. Long-term predictions of the level of solar activity are needed to help us anticipate how space weather might affect us, our planet and our missions. Pesnell analyzed 105 predictions regarding the amplitude of solar activity for Solar Cycle 24, weighing them each against different modeling systems and comparing their output with data we have on Solar Cycle 24.

Scientists used the historical record of the sunspot number as a primary predictor as well as combinations of the sunspot number with other measurements, such as the geomagnetic activity level or the strength of the magnetic fields at the sun's poles during solar minimum. For Solar Cycle 24, models combining the strength of the polar magnetic field strength with the sunspot number produced the best predictions.

Several longer-term forecasts of solar activity have appeared, including predictions of the amplitude of Solar Cycle 25. Correlations between the number of spotless days and the upcoming solar maximum anticipate Solar Cycle 25 will peak four years after the upcoming solar minimum. There is one prediction that uses symmetries from the 22-year solar magnetic cycle rather than only using the 11-year sunspot cycle based on theories that even-numbered cycles tend to be lower in amplitude than one or both of the adjacent odd-numbered cycles. If this is accurate for Solar Cycle 25, that cycle will be better at shielding the Earth from cosmic rays which are a potent source of space weather.

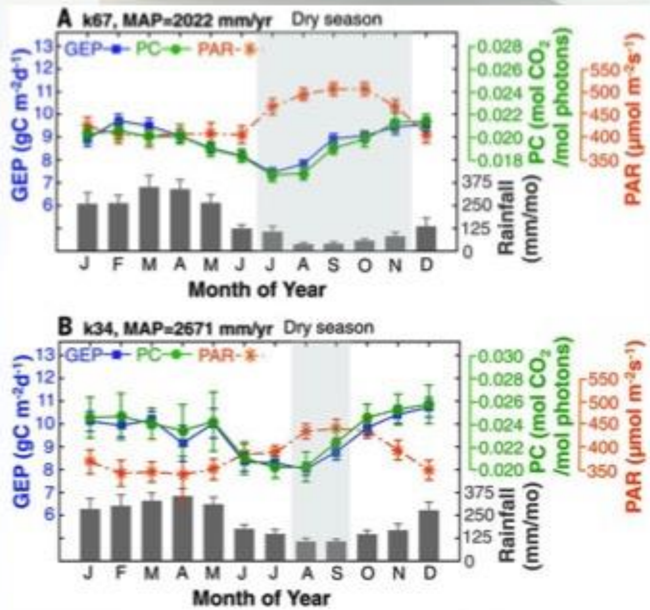
Although these predictions have links to models of the solar dynamo, scientists still need more information about the sun's magnetic field to increase the accuracy of those models. The Helioseismic and Magnetic Imager (HMI) aboard the Solar Dynamics Observatory makes high resolution full disk maps of the solar magnetic fields. This data continues to improve our research models and our understanding of how solar activity produces space weather.

Leaf Development And Demography Explain Photosynthetic Seasonality In Amazon Evergreen Forests

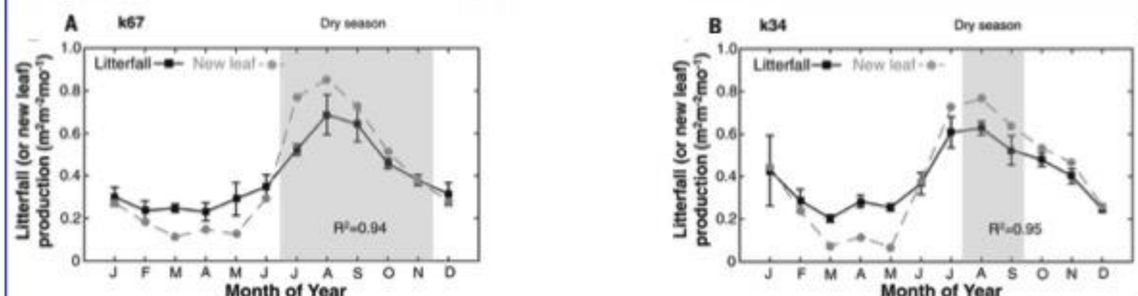
Wu, J., Albert, L. P., Lopes, A. P., Restrepo-Coupe, N., Hayek, M., Wiedemann, K. T., ... & Tavares, J. V. | February 2016 | doi: 10.1126/science.aad5068

A NASA co-funded study showed that aggregate canopy phenology is the primary cause of photosynthetic seasonality in forests across rainfall gradients in Amazônia, and not climate seasonality. The scientists used tower-mounted cameras to observe the dynamics of leaf quantity metrics, and MODIS-derived vegetation activity to closely track the magnitude and timing of leaf area index seasonality. The study showed that synchronization of new leaf growth with dry season litterfall shifts canopy composition toward younger, more light-use efficient leaves, explaining large seasonal increases (~27%) in ecosystem photosynthesis. Coordinated leaf development and demography therefore reconcile seemingly disparate observations at different scales and indicate that accounting for leaf-level phenology is critical for accurately simulating ecosystem-scale responses to climate change.

The seasonal rhythm of ecosystem metabolism — the aggregated photosynthesis, transpiration, or respiration of all organisms in a landscape — emerges from interactions among climate, ecology of individuals and communities, and biosphere-atmosphere exchange. In evergreen tropical forests, the extent, magnitude, and controls on photosynthetic seasonality are poorly resolved and inadequately represented in Earth system models.



Left: Gross ecosystem productivity (GEP) seasonality at two Amazon forests is highly correlated with seasonality in intrinsic canopy photosynthetic capacity (PC), but not with seasonality in environmental driving variables (rainfall and photosynthetically active radiation, PAR).



Above: Average annual cycle of litterfall (black squares) and new leaf production (gray dots) at the same two sites shows that modest dry-season increases in LAI are associated with rapid leaf turnover due to coordinated leaf loss and new leaf production

2016 American Camp Association (ACA) Conference
Atlanta, GA

- On February 9-12, 2016, NASA Science Mission Directorate shared resources and activities at the 2016 ACA Conference in Atlanta, GA.
- Andy Shaner/Lunar and Planetary Institute (LPI), hosted a booth which disseminated NASA resources to about 100 ACA attendees, and demonstrated activities from *Explore "Jupiter's Family Secrets"* (www.nasa.gov/mission_pages/juno/education/explore.html) to highlight the upcoming arrival of the Juno mission.
- Also included activities and resources from Earth Science, Heliophysics, and Astrophysics
- Samantha Williams/Institute for Global Environmental Strategies (IGES) assembled a tailored list from the online Wavelength catalog for participants:
  http://nasawavelength.org/list/1316

Attendees weighed themselves on scales modified to show their weight on Mars, Jupiter, and the Moon

Attendees made models of planetary magnetic fields using Styrofoam balls, staples, and a cow magnet