National Aeronautics and
Space Administration

Science Mission Directorate

Weekly Highlights

October 28, 2016

Tracking Waves from Sunspots Provides New Solar Insight

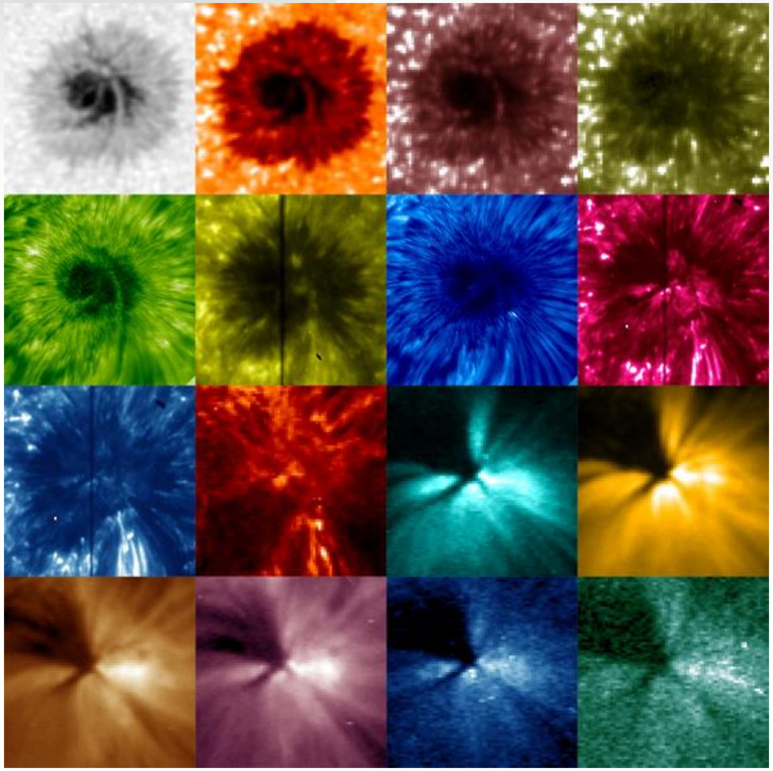
Zhau, J et. al. (2016) TRACING p-MODE WAVES FROM THE PHOTOSPHERE TO THE CORONA IN ACTIVE REGIONS. *The Astrophysical Journal Letters, 830:L17 (7pp). doi:10.3847/2041-8205/830/1/L17*

Combining data returned from NASA's SDO and IRIS heliophysics spaceflight missions and ground based observations from the Big Bear Solar Observatory, researchers have – for the first time – tracked magneto-acoustic seismic waves emerging from a sunspot traveling up through the solar atmosphere.

The sun and its atmosphere are continuously churning and waves have been found to be a ubiquitous phenomenon throughout. However, it has been extremely difficult to determine the relationship between the waves emerging at the surface of the sun, known as the photosphere, and those in the atmosphere because of the tremendous drop in density (density change by a factor of a trillion) over the very short distance between the visible surface of the sun and its corona. Recent efforts to "pipeline" access to data from two NASA solar missions (SDO and IRIS) and the ground-based Big Bear Solar Observatory (BBSO) have produced a research resource that opens the door to a scientific breakthrough relating waves observed at different layers of the sun and its atmosphere. This combined data allows observation of the propagation of waves from the solar surface to the solar atmosphere.

A study using this publicly available data resource was recently published in *The Astrophysical Journal Letters* doing just this – following a solar wave as it propagated out from a sunspot into the solar atmosphere. This study considered acoustic (p-mode or compression) seismic waves emerging in sunspots. Since a significant fraction of all solar material is ionized and the sun has a strong magnetic field, magnetic forces play an important role in any motion of this material; the waves in this study are known as magneto-acoustic waves.

This study provides new information about the temperature, pressure, density, and magnetic field within the layers of solar atmosphere traversed. It also addresses the role of solar seismic waves in coronal heating. The relative importance of the acoustic and magnetic energy changes dramatically with the change in material density with altitude, providing an important diagnostic capability in the technique used in this research.



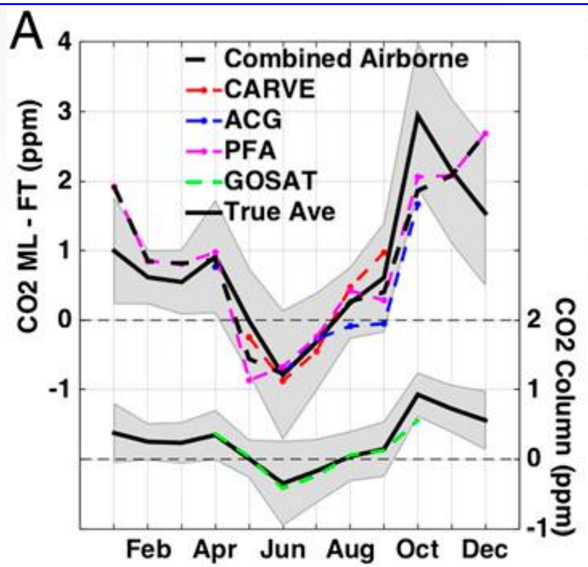
These are the 16 different wavelengths used to observe the propagation of a magneto-acoustic wave as it emerges and ascends in altitude through the solar atmosphere.

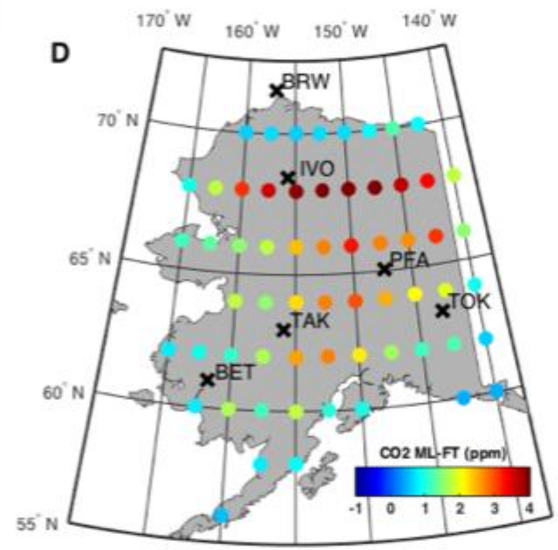
Credits: SDO/IRIS/BBSO

Detecting Patterns of Changing CO_2 Flux in Alaska

Parazoo, N. C., Commane, R., Wofsy, S. C., Koven, C. D., Sweeney, C., Lawrence, D. M., ... & Miller, C. E| Proceedings of the National Academy of Sciences| October 2016 | doi: 10.1073/pnas.1601085113

NASA co-funded scientists used satellite and airborne observations of atmospheric carbon dioxide (CO_2) with climatically forced CO_2 flux simulations to assess the detectability of Alaskan carbon cycle signals as future warming evolves. They leveraged remote sensing observations from JAXA's Greenhouse Gases Observing Satellite (GOSAT), and airborne in situ data from NASA's Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE), NOAA's Arctic Coast Guard (ACG) flights, and weekly NOAA airborne vertical profile measurements at Poker Flat, AK (PFA). The study showed that current satellite remote sensing technologies can accurately detect changing uptake during the growing season, but lack sufficient cold season coverage and near-surface sensitivity to constrain annual carbon balance changes at regional scale. Additionally, current airborne strategies that target regular vertical profile measurements within continental interiors are more sensitive to regional flux deeper into the cold season but lack sufficient spatial coverage throughout the entire cold season. These results suggest that the current CO_2 observing network is unlikely to detect potentially large CO_2 sources associated with deep permafrost thaw and cold season respiration expected over the next 50 years.





Dramatic warming in northern high latitudes has led to increased photosynthetic carbon uptake during the short, intense growing season; however, microbial decomposition of soil carbon and increased emissions during the long cold season may offset summer uptake and impart a positive feedback on the global climate system.

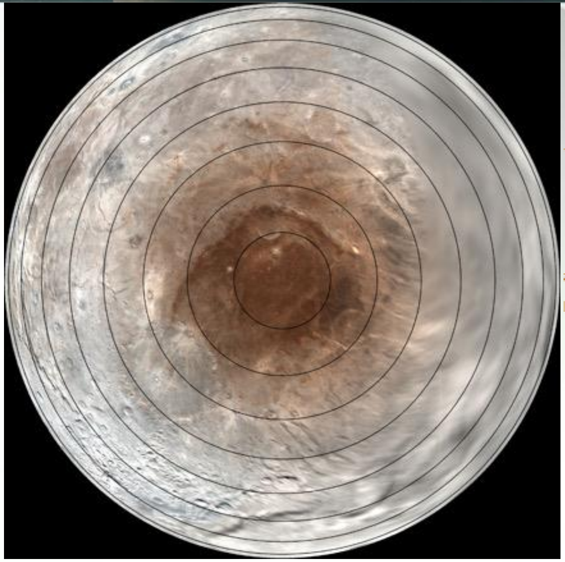
Above: Hypothetical CO_2 seasonal cycle changes based on CARVE, ACG, and PFA sampling under future warming scenarios. (left) Difference in CO_2 vertical gradient seasonal cycle between the subsampled "observed" mean (100 YR) and the "true" mean calculated from sampling all Alaskan land points (100 YR-HIST). (right) Difference in CO2 vertical gradient seasonal cycle between 100YR and HIST (100YR − HIST for fall average (September to December).

Charon’s Dark Red Poles

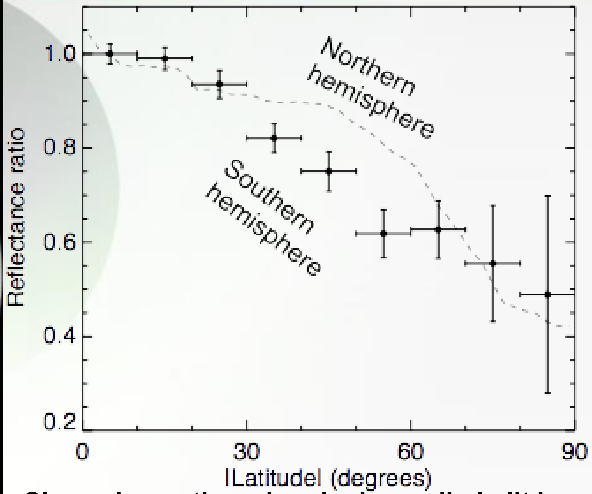
A dark, red deposit on Charon’s north pole is likely formed by seasonal cold-trapping of volatiles coming from Pluto.

- During the 2015 New Horizons flyby a dark, red deposit (top left) was detected on Charon’s north pole, a feature unique in the solar system. The color of the deposit is similar to regions on Pluto that have been attributed to tholin-like organic macromolecules.
- Although the southern pole, currently in winter, is lit only by Pluto-shine, it shows similar darkening (top right).
- The polar location of these deposits and their presence on both hemispheres indicates that the most likely explanation is cold-trapping at Charon’s poles of methane (CH_4) gas escaping from Pluto’s atmosphere (bottom right).
- Modeling of the surface thermal environment (bottom left) and photolytic processes indicate that the gas is subsequently transformed by sunlight into more complex and larger molecules, allowing for their buildup over time.

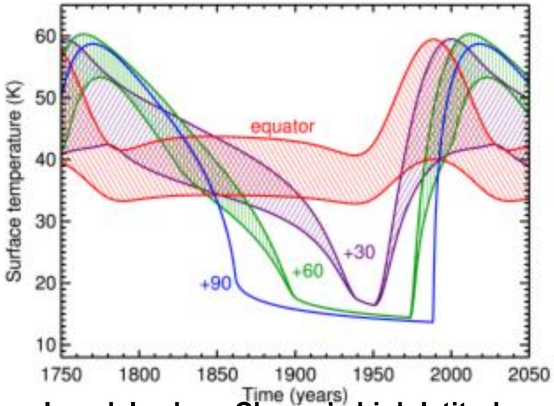
W. M. Grundy et al. (2016), *Nature*



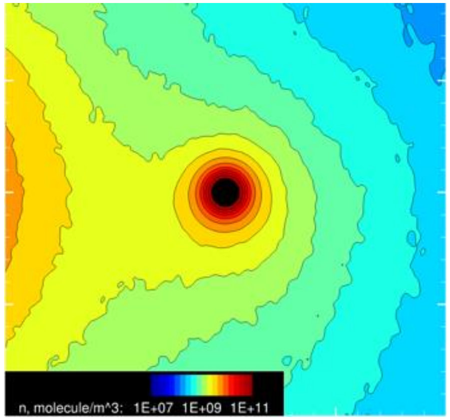
Polar orthographic color mosaic shows dark, reddish deposits centered on the north pole (10˚ latitude bands).



Charon’s southern hemisphere, dimly lit by Pluto-shine, shows similar darkening toward the south pole (points) as toward the sunlit north pole (dashed curve).



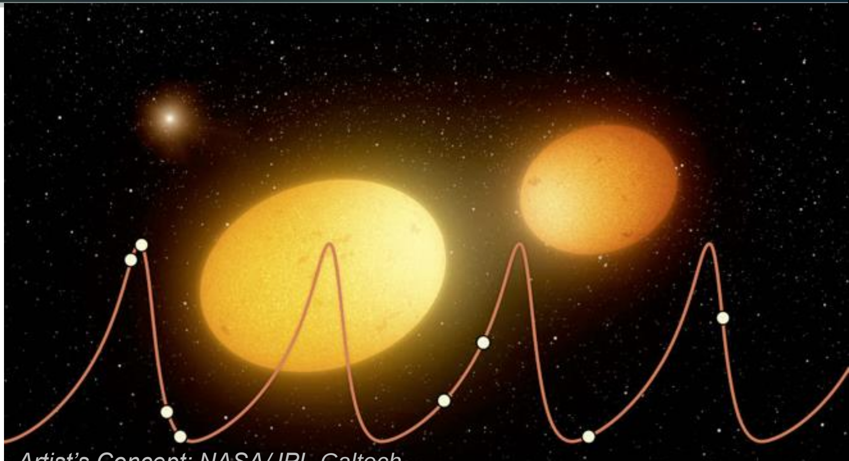
Thermal models show Charon’s high latitudes get extremely cold during the long winters. Colored zones show diurnal T ranges at 4 latitudes.



Gas escaping from Pluto (off left edge of plot) is transiently trapped by Charon’s gravity (center) (Hoey et al., Icarus, 2017, pending).

‘Heartbeat Stars’ Unlocked in New Study

Published in the September 20, 2016 issue of The Astrophysical Journal



Artist’s Concept: NASA/JPL-Caltech

- Heartbeat stars, discovered in large numbers by NASA's Kepler space telescope, are binary stars that got their name because if you were to map out their brightness over time, the result would look like an electrocardiogram, a graph of the electrical activity of the heart. Scientists are interested in them because they are binary systems in elongated elliptical orbits. This makes them natural laboratories for studying the gravitational effects of stars on each other.
- In a heartbeat star system, the distance between the two stars varies drastically as they orbit each other. Heartbeat stars can get as close as a few stellar radii to each other, and as far as 10 times that distance during the course of one orbit.
- At the point of their closest encounter, the stars’ mutual gravitational pull causes them to become slightly ellipsoidal in shape, which is one of the reasons their light is so variable. By studying heartbeat stars, astronomers can gain a better understanding of how this phenomenon works for different kinds of stars.
- Tidal forces also cause heartbeat stars to vibrate or "ring" -- in other words, the diameters of the stars rapidly fluctuate as they orbit each other. This effect is most noticeable at the point of closest approach.
- Kepler, now in its K2 Mission, discovered large numbers of heartbeat stars just in the last several years. A 2011 study discussed a star called KOI-54 that shows an increase in brightness every 41.8 days. In 2012, a subsequent study characterized 17 additional objects in the Kepler data and dubbed them "heartbeat stars." To characterize these unique systems, further data and research were required.
- The new study measured the orbits of 19 heartbeat star systems -- the largest batch ever characterized in a single study. The scientists followed up on known heartbeat stars, previously identified by the Kepler mission. Specifically, they used an instrument on the W.M. Keck Observatory telescope in Hawaii called the High Resolution Echelle Spectrometer (HIRES), which measures the wavelengths of incoming light, which are stretched out when a star is moving away from us and shorter in motion toward us. This information allows astronomers to calculate the speed of the objects along the line of sight, and measure the shape of the orbit.
- The scientists found that the heartbeat stars in the sample tended to be both hotter and larger than our sun. Team members also postulate that some binary systems of heartbeat stars could have a third star in the system that has not yet been detected, or even a fourth star. All of the tidal stretching of these heartbeat stars should have quickly caused the system to evolve into a circular orbit. A third or fourth star in the system is one way to create the highly stretched-out, elliptical orbits observed.
- Researchers are currently pursuing follow-up studies to search for third-star components in heartbeat star systems.

Challenger Center's First Expedition Mars Mission Training is a Success!

- Challenger Center's newest mission, Expedition Mars, has rolled out to our first cohort of Challenger Learning Centers!
- Training took place at the Challenger Learning Center of Northwest Indiana in late September 2016
- Feedback from the 20 attendees, representing eight Challenger Learning Centers from across the country, was tremendous
- Challenger Centers around the globe reach over 250,000 students a year
- The eight Challenger Learning Centers in attendance will now be the first to offer the new Expedition Mars mission in their communities
- Up to 30 Challenger Learning Centers will receive the complete Expedition Mars mission package, training, and supporting classroom materials over the course of the first three years of the NASA Cooperative Agreement
- Challenger Center designed a collaborative regional training model to meet the diverse needs of the Centers that were in attendance
- Two classes from the Hammond Academy of Science and Technology were invited to be the first students in the nation to experience the exciting, hands-on Expedition Mars mission
- The 6th graders had a blast, and graciously posed for a great picture with some of our Center Flight Directors (above)
- Expedition Mars training for the next cohort of Challenger Learning Centers is tentatively scheduled for February 2017