Science Mission Directorate

Weekly Highlights

December 4, 2015

NASA's Van Allen Probes provide new clues regarding the mysterious hiss in Earth's plasmasphere

Summers et al., 2015: Fine structure of plasmaspheric hiss. doi: 10.1002/2014JA020437

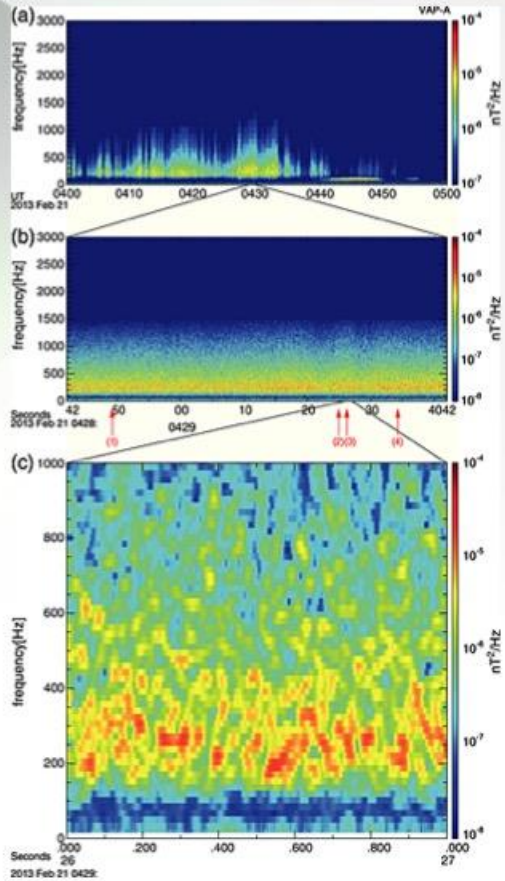
JGR Spotlight, Mark Zastrow, http://agupubs.onlinelibrary.wiley.com/agu/article/10.1002/2014JA020437/editor-highlight/

An analysis of the electromagnetic "hiss" that surrounds Earth reveals it's not just static; there's a signal hidden within, which may help scientists uncover its source.

In space, no one can hear you scream—but if you have the right radio equipment, you can "hear" the electromagnetic waves undulating through the void. Now, scientists have found previously unheard signals in this static that might help them uncover the source of a particular kind of hiss. All of the waves examined in this study were generated by the particles of plasma trapped in Earth's magnetic field. They spiral, gyrate, resonate, and stock up energy and release it—which creates tiny ripples in the electric and magnetic field surrounding Earth. When these waves are converted to sound—like a radio playing FM broadcasts—the space around Earth sounds like a jungle filled with different species of particles and electromagnetic behaviors, all emitting distinctive calls. For example, lightning can trigger waves called whistlers, which, as the name suggests, sound like whistling falling tones. Spectacular auroral displays amplify the so-called dawn chorus—chirpy waves that sound similar to birds in the morning

One of the most mysterious of these noises is plasmaspheric hiss—an ever-present sibilance in the inner regions of Earth's magnetic field. It sounds like pure static spanning 100 Hz to several kiloHertz, a frequency range roughly equivalent to that produced by the middle third of a piano. Scientists know that plasmaspheric hiss plays a crucial role in shaping the structure of Earth's radiation belts, disrupting them by knocking their energetic particles out into the atmosphere. However, the source of the hiss is unknown. One theory says it is the direct result of spiraling electrons high over Earth's equator. Others propose that it consists of the remnants of distant whistlers or chorus waves that devolve into incoherence, like the expressionless chop far out at sea.

Previously, scientists assumed that this hiss was random white noise with no coherent features. However, when Summers et al. analyzed NASA Van Allen Probes measurements of the hiss from 2013, they discovered barely detectable rising and falling tones similar to the whistlers, at frequencies rising to roughly middle C and falling for about two octaves. The authors say this detection was made possible by the high resolution of the instruments on the satellites and their particularly useful orbit, which keeps them mostly within Earth's radiation belts. Although the waves within plasmaspheric hiss resemble whistler tones and may share similarities in mathematical wave theory, the physical mechanism that generates the hiss is still wide open for debate. The authors expect that this fine structure will renew interest in the subject, and may contain the clues to pin down its source.

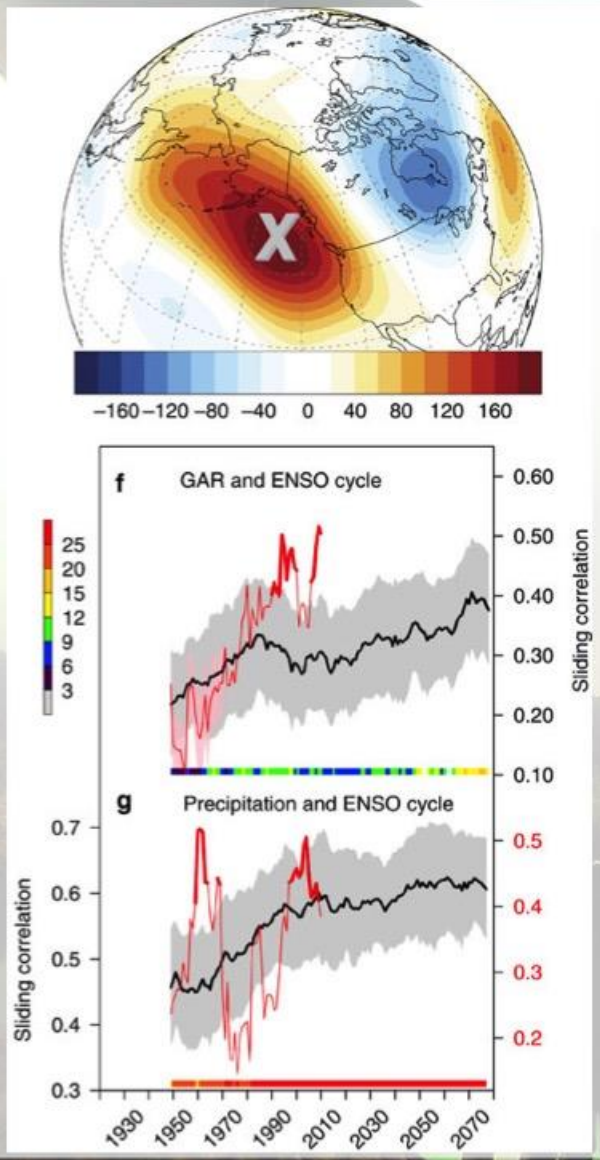


Plasmaspheric hiss spectrum as a function of time and frequency for different time resolutions. 1-hour spectrum in the top panel appears bursty; zooming in a smaller section of time, in the middle panel, the 1-minute spectrum appears largely incoherent. In neither the top or middle panels can any detailed structure be seen. However, the fine structure is revealed in the 1 s spectrum in bottom panel.

Increasing Water Cycle Extremes in California and in Relation to ENSO Cycle under Global Warming

Yoon, J. H., Wang, S. S., Gillies, R. R., Kravitz, B., Hipps, L., and Rasch, P. J. | OCTOBER 2015 | doi: 10.1038/ncomms9657

A new NASA-funded study analyzed multiple projections from the Community Earth System Model version 1 and twenty-five climate models that participated in the Coupled Model Intercomparison Project Phase 5 to project the future of water cycle extremes in California and to understand the associations that pertain to changing climate oscillations under global warming. Since the winter of 2013–2014, California has experienced its most severe drought in recorded history, causing statewide water stress, severe economic loss and an extraordinary increase in wildfires. Identifying the effects of global warming on regional water cycle extremes, such as the ongoing drought in California, remains a challenge. The study noted that both intense drought and excessive flooding are projected to increase by at least 50% towards the end of the twenty-first century. This projected increase is associated with a strengthened relation to El Niño and the Southern Oscillation (ENSO), and in particular, to extreme El Niño and La Niña events that modulate California's climate not only through its warm and cold phases but also its precursor patterns. The role of climate variability in modulating water cycle extremes provides a key for anticipating the occurrence of extreme hydrological events, ultimately driving more informed management practices that pertain to water resource management and supervision practices in California and the rest of the Western US.



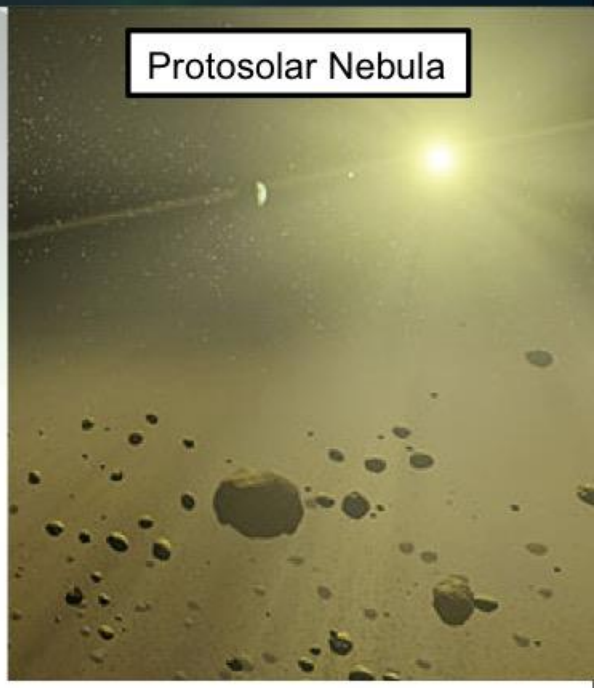
Left: **The map shows the November 2013–January 2014 geopotential height anomaly at 200 hPa depicting the Gulf of Alaska Ridge (GAR) and the center location for the GAR index ("X").**

The panels below show the multivariate correlations between the Niño-3.4, Niño-3.4(*Y+1*) and the GAR index (top) and annual precipitation averaged for water year in California (bottom).

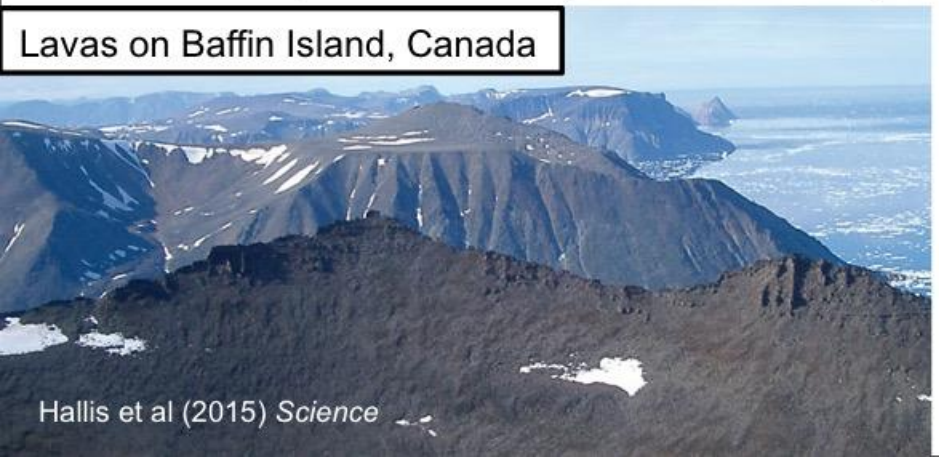
Primordial Water from Earth's Deep Mantle

Lava flows originating from deep within Earth's mantle show a composition of hydrogen isotopes that indicate a water source that could trace back to the protosolar nebula.

- Scientists measured the ratio of deuterium to hydrogen (expressed as δD) in small pockets formed in olivine crystals collected from lava flows on Baffin Island, Canada. The δDof these rocks was the lowest ever measured in terrestrial samples.
- Large variations in δD across different bodies in the solar system suggest that this could be used to track the original source of the water to the early Earth, but preferential loss of the lighter hydrogen isotope in the Earth's atmosphere over geologic time can skew these measurements. The material studied here comes from very deep in the mantle, close to the boundary with the core, and the deep sources likely reflect a more primordial composition.



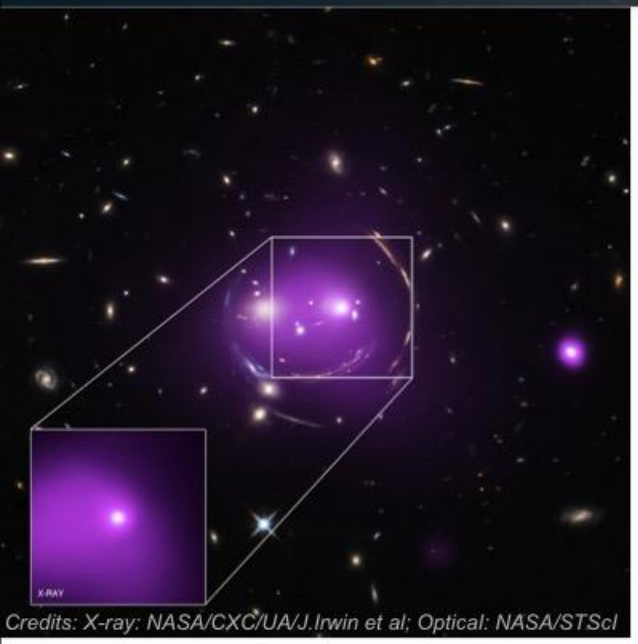
Lavas on Baffin Island, Canada



- Previous measurements of the Baffin Island lavas showed that they had helium isotopes indicative of primordial components, and lead isotope dating indicated that these lavas formed between 4.45 and 4.55 billion years ago – very shortly after the Earth coalesced.
- These ancient signatures may help scientists better understand the different sources of the earliest Earth-forming materials.

Where Alice in Wonderland Meets Albert Einstein

Published in the June 23, 2015 edition of The Astrophysical Journal.

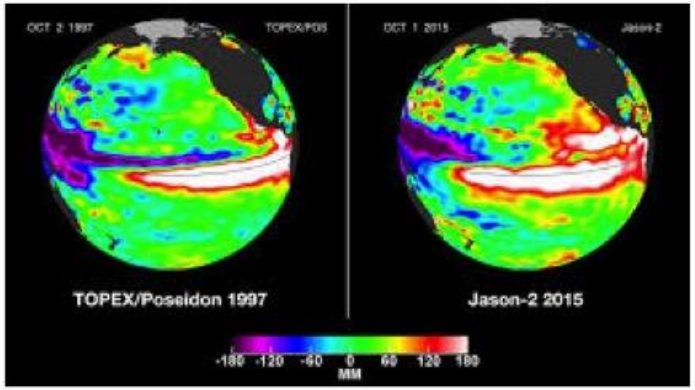


Credits: X-ray: NASA/CXC/UA/J.Irwin et al; Optical: NASA/STScI

- One hundred years ago, Albert Einstein published his theory of general relativity, one of the most important scientific achievements in the last century. A key result of Einstein's theory is that matter warps space-time, and thus a massive object can cause an observable bending of light from a background object.
- Astronomers have found many examples of this phenomenon, known as "gravitational lensing." More than just a cosmic illusion, gravitational lensing provides astronomers with a way of probing extremely distant galaxies and groups of galaxies in ways that would otherwise be impossible even with the most powerful telescopes.
- The latest results from the "Cheshire Cat" group of galaxies show how manifestations of Einstein's 100-year-old theory can lead to new discoveries today. Astronomers have given the group this name because of the smiling cat-like appearance. Some of the feline features are actually distant galaxies whose light has been stretched and bent by the large amounts of mass, most of which is in the form of dark matter detectable only through its gravitational effect, found in the system.
- More specifically, the mass that distorts the faraway galactic light is found surrounding the two giant "eye" galaxies and a "nose" galaxy. The multiple arcs of the circular "face" arise from gravitational lensing of four different background galaxies well behind the "eye" galaxies. The individual galaxies of the system, as well as the gravitationally lensed arcs, are seen in optical light from NASA's Hubble Space Telescope.
- Each "eye" galaxy is the brightest member of its own group of galaxies and these two groups are racing toward one another at over 300,000 miles per hour. Data from NASA's Chandra X-ray Observatory (purple) show hot gas that has been heated to millions of degrees, which is evidence that the galaxy groups are slamming into one another. Chandra's X-ray data also reveal that the left "eye" of the Cheshire Cat group contains an actively feeding supermassive black hole at the center of the galaxy.
- Astronomers think the Cheshire Cat group will become what is known as a fossil group, defined as a gathering of galaxies that contains one giant elliptical galaxy and other much smaller, fainter ones. Fossil groups may represent a temporary stage that nearly all galaxy groups pass through at some point in their evolution. Therefore, astronomers are eager to better understand the properties and behavior of these groups.
- The Cheshire Cat represents the first opportunity for astronomers to study a fossil group progenitor. Astronomers estimate that the two "eyes" of the cat will merge in about one billion years, leaving one very large galaxy and dozens of much smaller ones in a combined group. At that point it will have become a fossil group and a more appropriate name may be the "Cyclops" group.

Global Precipitation Measurement Mission Master Teachers Learn about the El Nino

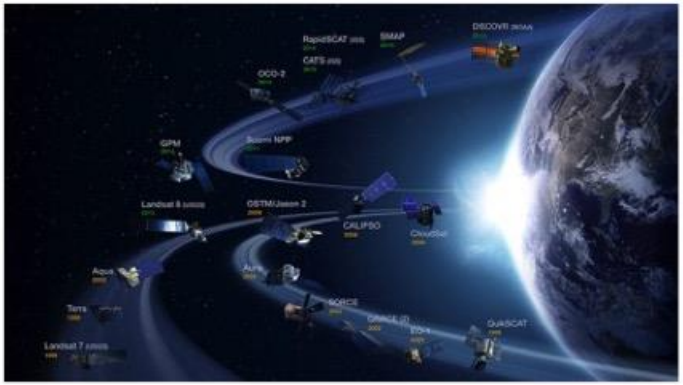
On Saturday, October 17, 2015, Global Precipitation Measurement's (GPM) cadre of 26 teachers from around the world along with many GPM Alumni, met virtually to learn about the upcoming El Nino.



NASA scientist, Dr. Stephanie Schollaert Uz along with GPM Educaiton/Communication Specialists Dorian Janney and Kristen Weaver led the event.

GPM Master teachers self-organized and designed a collaborative investigation for their students around the world to

- Collect authentic data related to El Nino conditions
- Share this data biweekly throughout the winter season
- Investigate conditions to determine if they observe changes in normal weather patterns due to the El Nino event in their local area



GPM Education/Communications Specialists developed a specific El Nino *webquest* for students designed to frontload their knowledge about this natural phenomenon. A data collection spreadsheet was also created.

Any school and/or individual is welcome to participate- contact Dorian Janney for more information.

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