National Aeronautics and
Space Administration

Science Mission Directorate

Weekly Highlights

February 19, 2016

Coordinated Rapid Response to a New Near-Earth Asteroid Discovery and Flyby

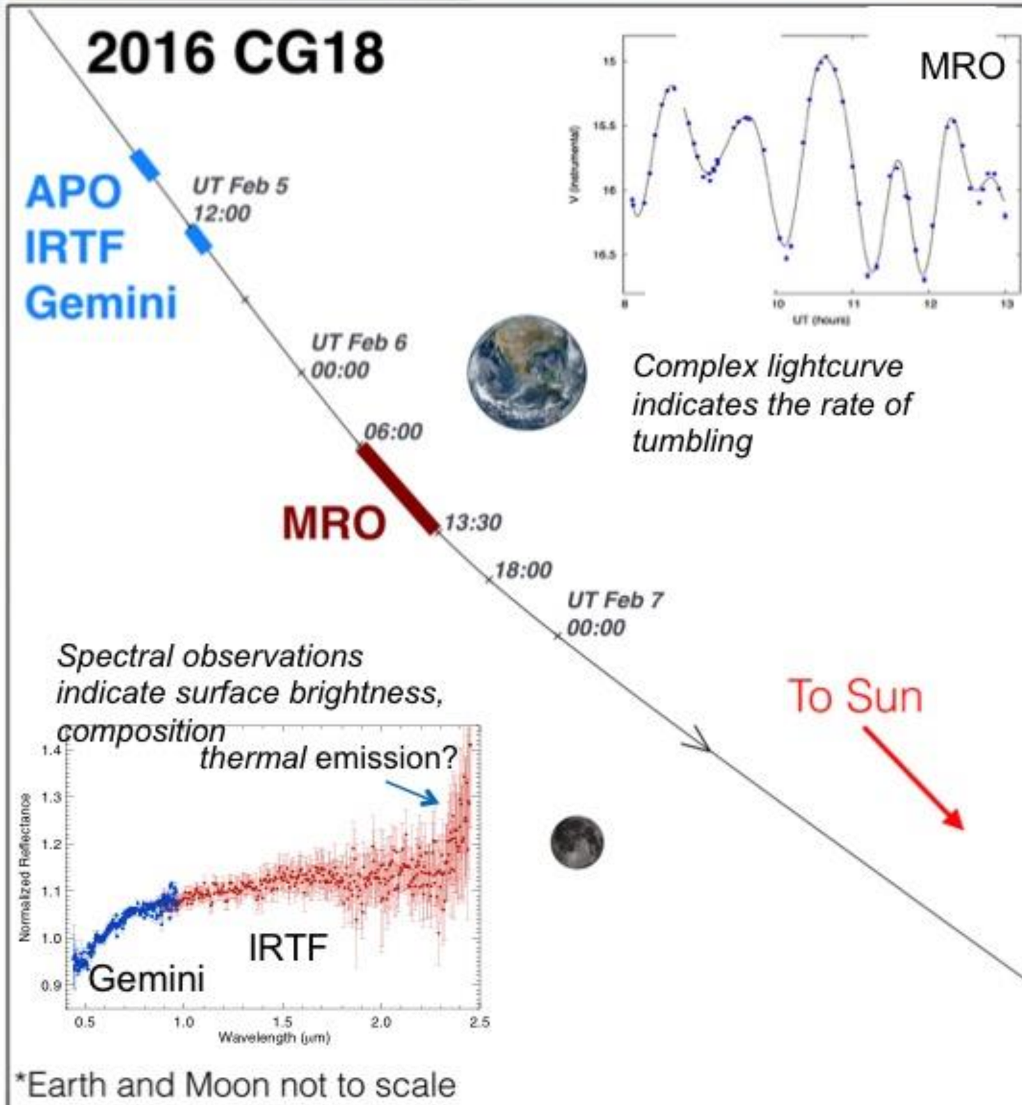
Observations & data analysis: N. Moskovitz (Lowell Obs.), D. Polishook (Weizmann Inst.), M. Hinkle (NAU), B. Ryan (MRO), M. Brucker (Adler), K. Nault (Adler), V. Reddy (PSI), B. Burt (Lowell)

The near-Earth asteroid 2016 CG_{18} was discovered by the Catalina Sky Survey on Feb 3, 2016 and flew by the Earth three days later at less than half the distance to the Moon. A coordinated response by astronomers was made from several observatories:

- NASA's Infrared Telescope Facility (IRTF)
- Gemini North Observatory
- Magdalena Ridge Observatory (MRO)
- Apache Point Observatory (APO)

IRTF and Gemini target-of-opportunity spectroscopic observations give clues to the composition and surface brightness. Light curve observations from APO and MRO show that **this 4-9 meter object is an unusually slow tumbler for an object of its size, possibly the slowest measured to date at ~2 hours per revolution**.

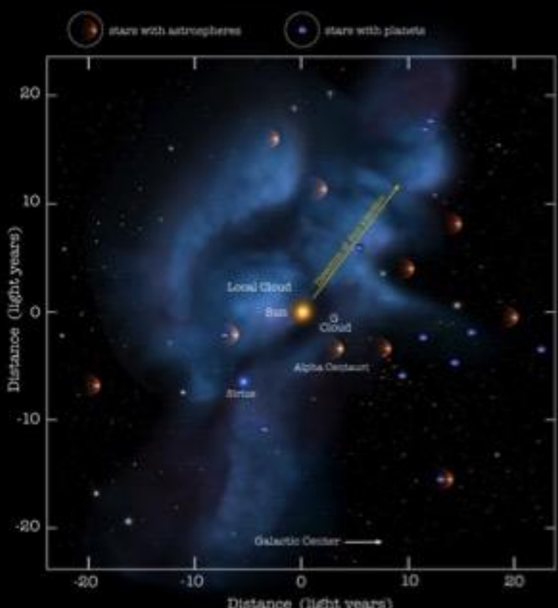
This campaign tested rapid response observing protocols and coordination for difficult, fast moving objects in preparation for future time-critical events similar to the discovery and impact of 2008 TC_3. This effort also added critical data to the catalog of physical properties for potential Earth impactors as well as spacecraft-accessible targets for future exploration.



Which Way the Wind Blows

Analyzing IBEX and Ulysses measurements of neutral (He) particles to understand which direction we are traveling through the Interstellar Medium

Revisiting Ulysses Observations of Interstellar Helium, The Astrophysical Journal, 801:62 (15pp), 2015 March 1

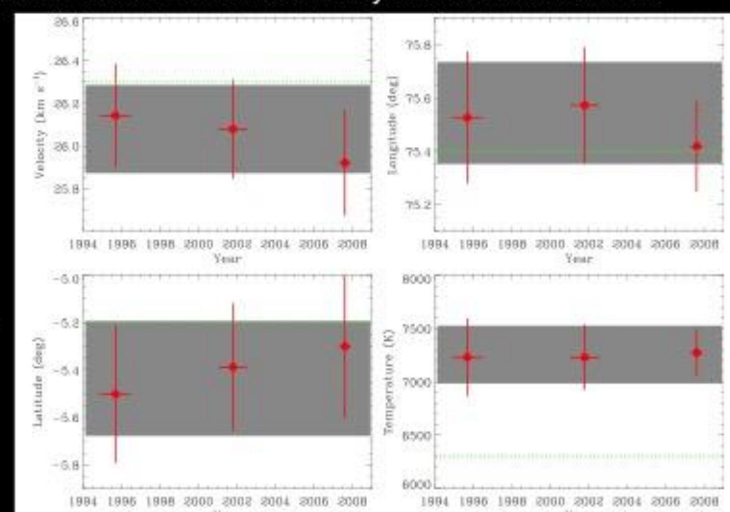


Just as the planets orbit the sun, the sun orbits the center of galaxy as we travel through the Interstellar Medium (ISM). The question is, in what direction are we going? This is a critical input for our models and will help us better understand our heliosphere's interactions with the ISM itself.

The ISM is the tenuous gas and dust between the stars. Although the density is low, the atoms are actually quite hot (7000° C). It is so hot, in fact, that some, but not all, of the atoms lose their electrons and become ionized. When this happens, the gas is called a plasma. Because the ISM is not hot enough to ionize *all* the atoms, it gives us an opportunity to "see" into the ISM by looking at the "non-ionized" or neutral atoms. Instead of being deflected by the sun's magnetic field like the other charged particles in the ISM, these neutral atoms pass right through the magnetic field, giving us an opportunity to detect them in the heliosphere.

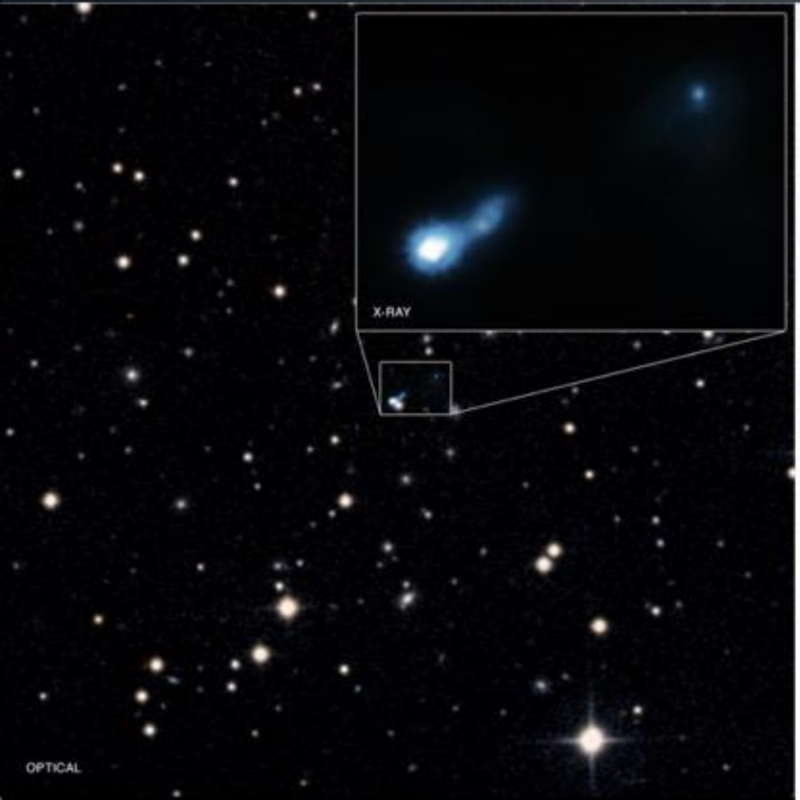
The IBEX mission is equipped with instruments to detect the neutral atoms in near-earth space, particularly neutral helium (He). And, with these measurements scientists can compute which direction the atoms were going before they entered the heliosphere. The Ulysses spacecraft also made similar measurements when it was active. However, there are differences between the ISM properties derived from the newer IBEX measurements and those derived from the older Ulysses measurements, and we aren't sure why. Although the discrepancy between the two results is not very large, it is large enough to make us question why it exists. Has the flow direction changed over time? Did we cross into a new region of space like the G Cloud nearby, shown in the picture to the left? Or are there simply unknown systematic errors in the IBEX and Ulysses measurements?

Researchers funded through the Heliophysics Supporting Research Program, led by Dr. Brian Wood at NRL, looked into one piece of this perplexing puzzle: is the ISM He flow vector changing with time? They re-analyzed the Ulysses data, including data from 2007 that had not been analyzed before. The final measurements for Ulysses (shown right in red) are mostly consistent with previous Ulysses measurements (shown as the green dashed lines), but with a significantly higher ISM temperature (6990° C +/-270° C instead of 6030° C +/-34° C). These values are now in better agreement with IBEX data, though still ~1000 ° C too low. They found no evidence for a change in the ISM He flow direction from 1994-2007 in contrast to previous authors, who suggested that such a trend might exist. This finding "sets the record straight -- or at least firmly crooked," as Douglas Adams once said. While this study speaks to another piece of the puzzle, it still leaves unanswered questions in our pursuit to better understand the heliosphere and its interaction with the ISM.



Glow from the Big Bang Allows Discovery of Distant Black Hole Jet

Published in the January 1, 2016 edition of The Astrophysical Journal Letters.



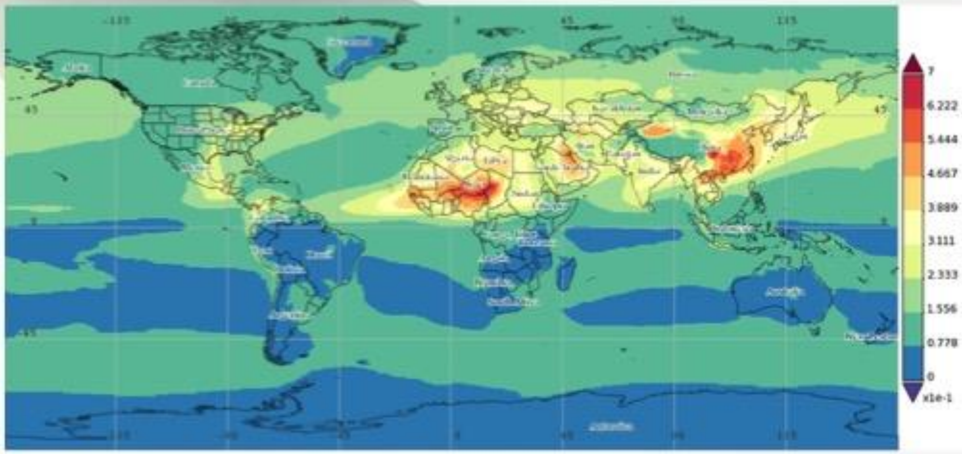
Credit: X-ray: NASA/CXC/ISAS/A.Simionescu et al, Optical: DSS

- A jet from a very distant black hole being illuminated by the leftover glow from the Big Bang, known as the cosmic microwave background (CMB), has been found. Astronomers using NASA's Chandra X-ray Observatory discovered this faraway jet serendipitously when looking at another source in Chandra's field of view.
- Jets in the early Universe such as this one, known as B3 0727+409, give astronomers a way to probe the growth of black holes at a very early epoch in the cosmos. The light from B3 0727+409 was emitted about 2.7 billion years after the Big Bang when the Universe was only about one fifth of its current age.
- This main panel graphic shows Chandra's X-ray data that have been combined with an optical image from the Digitized Sky Survey. (Note that the two sources near the center of the image do not represent a double source, but rather a coincidental alignment of the distant jet and a foreground galaxy.)
- The inset shows more detail of the X-ray emission from the jet detected by Chandra. The length of the jet in 0727+409 is at least 300,000 light years. Many long jets emitted by supermassive black holes have been detected in the nearby Universe, but exactly how these jets give off X-rays has remained a matter of debate. In B3 0727+409, it appears that the CMB is being boosted to X-ray wavelengths.
- Scientists think that as the electrons in the jet fly from the black hole at close to the speed of light, they move through the sea of CMB radiation and collide with microwave photons. This boosts the energy of the photons up into the X-ray band to be detected by Chandra. If this is the case, it implies that the electrons in the B3 0727+409 jet must keep moving at nearly the speed of light for hundreds of thousands of light years.
- The significance of this discovery is heightened because astronomers essentially stumbled across this jet while observing a galaxy cluster in the field. Historically, such distant jets have been discovered in radio waves first, and then followed up with X-ray observations to look for high-energy emission. If bright X-ray jets can exist with very faint or undetected radio counterparts, it means that there could be many more of them out there because astronomers haven't been systematically looking for them.

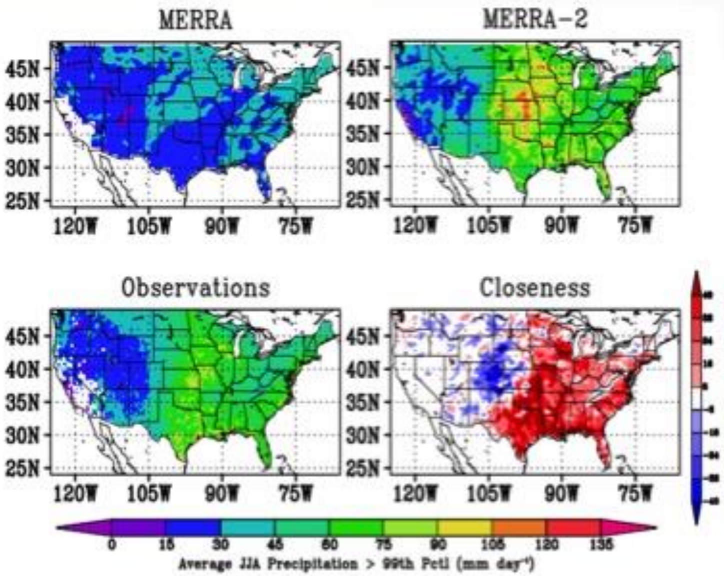
New version of the Modern Era Retrospective-analysis for Research and Analysis (MERRA) data set Released

NASA Global Modeling and Assimilation Office | http://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/

The NASA Global Modeling and Assimilation Office (GMAO) and the Goddard Earth Sciences Data and Information Services Center recently announced the availability of a new version of the Modern Era Retrospective-analysis for Research and Analysis (MERRA) data set, MERRA-2. MERRA is a NASA reanalysis for the satellite era using the Goddard Earth Observing System Data Assimilation System. Notable differences with MERRA include the use of observation-based precipitation data as forcing for the land surface parameterization and the assimilation of aerosol information based on the off-line "MERRAero" dataset, a feature of the Earth system that has been absent from previous reanalyses. MERRA-2 also includes a mass balance over glaciated land surfaces, allowing for fractional snow cover, runoff, and a prognostic surface albedo. Initial evaluation of the MERRA-2 extreme precipitation climate record across the U.S. shows that the patterns of extreme precipitation in MERRA-2 are much more comparable to the observations than the ones reproduced by MERRA. This may be an indication that the atmospheric dynamics that generate extreme precipitation are reproduced well in MERRA-2, making it, thus, a useful tool for investigating the weather and climatology of extreme precipitating events. Reanalyses rely on global models and their parameterizations to provide the quantity and frequency of precipitation, in conjunction with the assimilation of the large scale observation data.



Above: MERRA-2 Monthly Total Aerosol Scattering at 550 nm for the month of April, averaged over the 1980-2014 period.



Left: The average of the amount of precipitation that exceeds the 99th percentile in summer for MERRA, MERRA-2, and observations. Lower right panel shows which reanalysis is closer to observations - red indicates that MERRA-2 is closer.

Science, Technology, Engineering and Math (STEM) Expo at John Burroughs Elementary in Washington, DC

On December 10, 2015, NASA's Mars Exploration Program outreach specialist, Janelle Turner, and Susan Kennedy, Einstein Fellow, represented NASA at John Burroughs Elementary STEM expo. Over 100 students attended the expo targeted to grades K-8. The event hosted 25 organizations who provided a variety of hands-on, interactive STEM experiments and demonstrations.

NASA exhibits included:

- Pressurization chamber to demonstrate the effect of wearing an astronaut suit in deep space
- Mars Rock kit for students to observe Earth rock samples characteristic of rocks on Mars
- "Mars in 3D" for students to observe images of Mars landscape through 3D glasses