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A new study by NASA and University of California, Irvine, scientists finds more than 75 percent of the water loss in the drought-stricken Colorado River Basin since late 2004 came from underground resources. The extent of groundwater loss may pose a greater threat to the water supply of the western United States than previously thought.

This study is the first to quantify the amount that groundwater contributes to the water needs of western states. According to the U.S. Bureau of Reclamation, the federal water management agency, the basin has been suffering from prolonged, severe drought since 2000 and has experienced the driest 14-year period in the last hundred years.

The research team used data from NASA's Gravity Recovery and Climate Experiment (GRACE) satellite mission to track changes in the mass of the Colorado River Basin, which are related to changes in water amount on and below the surface. Monthly measurements of the change in water mass from December 2004 to November 2013 revealed the basin lost nearly 53 million acre feet (65 cubic kilometers) of freshwater, almost double the volume of the nation's largest reservoir, Nevada's Lake Mead. More than three-quarters of the total -- about 41 million acre feet (50 cubic kilometers) -- was from groundwater.

"We don't know exactly how much groundwater we have left, so we don't know when we're going to run out," said Stephanie Castle, a water resources specialist at the University of California, Irvine, and the study's lead author. "This is a lot of water to lose. We thought that the picture could be pretty bad, but this was shocking."

Water above ground in the basin's rivers and lakes is managed by the U.S. Bureau of Reclamation, and its losses are documented. Pumping from underground aquifers is regulated by individual states and is often not well documented.

"There's only one way to put together a very large-area study like this, and that is with satellites," said senior author Jay Famiglietti, senior water cycle scientist at JPL on leave from UC Irvine, where he is an Earth system science professor. "There's just not enough information available from well data to put together a consistent, basin-wide picture."
Famiglietti said GRACE is like having a giant scale in the sky. Within a given region, the change in mass due to rising or falling water reserves influences the strength of the local gravitational attraction. By periodically measuring gravity regionally, GRACE reveals how much a region's water storage changes over time.

The Colorado River is the only major river in the southwestern United States. Its basin supplies water to about 40 million people in seven states, as well as irrigating roughly four million acres of farmland.

"The Colorado River Basin is the water lifeline of the western United States," said Famiglietti. "With Lake Mead at its lowest level ever, we wanted to explore whether the basin, like most other regions around the world, was relying on groundwater to make up for the limited surface-water supply. We found a surprisingly high and long-term reliance on groundwater to bridge the gap between supply and demand."

Famiglietti noted that the rapid depletion rate will compound the problem of short supply by leading to further declines in streamflow in the Colorado River.

"Combined with declining snowpack and population growth, this will likely threaten the long-term ability of the basin to meet its water allocation commitments to the seven basin states and to Mexico," Famiglietti said.

The study has been accepted for publication in the journal Geophysical Research Letters, which posted the manuscript online Thursday. Coauthors included other scientists from NASA's Goddard Space Flight Center, Greenbelt, Maryland, and the National Center for Atmospheric Research, Boulder, Colorado. The research was funded by NASA and the University of California.

For more information on NASA's GRACE satellite mission, see:  http://www.nasa.gov/grace and http://www.csr.utexas.edu/grace

GRACE is a joint mission with the German Aerospace Center and the German Research Center for Geosciences, in partnership with the University of Texas at Austin. JPL developed the GRACE spacecraft and manages the mission for NASA's Science Mission Directorate, Washington.

NASA monitors Earth's vital signs from land, air and space with a fleet of satellites and ambitious airborne and ground-based observation campaigns. NASA develops new ways to observe and study Earth's interconnected natural systems with long-term data records and computer analysis tools to better see how our planet is changing. The agency shares this unique knowledge with the global community and works with institutions in the United States and around the world that contribute to understanding and protecting our home planet.

To learn more about NASA's Earth science activities in 2014, visit:  http://www.nasa.gov/earthrightnow

Source:  NASA
2. Hubble Space Telescope Data Generates New Mass Map of a Distant Galaxy Cluster

Astronomers using the NASA/ESA Hubble Space Telescope have mapped the mass within a galaxy cluster more precisely than ever before.

Created using observations from Hubble's Frontier Fields observing programme, the map shows the amount and distribution of mass within MCS J0416.1-2403, a massive galaxy cluster found to be 160 trillion times the mass of the Sun. The detail in this mass map was made possible thanks to the unprecedented depth of data provided by new Hubble observations, and the cosmic phenomenon known as strong gravitational lensing.

Measuring the amount and distribution of mass within distant objects in the Universe can be very difficult. A trick often used by astronomers is to explore the contents of large clusters of galaxies by studying the gravitational effects they have on the light from very distant objects beyond them. This is one of the main goals of Hubble's Frontier Fields, an ambitious observing programme scanning six different galaxy clusters -- including MCS J0416.1-2403, the cluster shown in this stunning new image [1].

Large clumps of mass in the Universe warp and distort the space-time around them. Acting like lenses, they appear to magnify and bend light that travels through them from more distant objects [2].

Despite their large masses, the effect of galaxy clusters on their surroundings is usually quite minimal. For the most part they cause what is known as weak lensing, making even more distant sources appear as only slightly more elliptical or smeared across the sky. However, when the cluster is large and dense enough and the alignment of cluster and distant object is just right, the effects can be more dramatic. The images of normal galaxies can be transformed into rings and sweeping arcs of light, even appearing several times within the same image. This effect is known as strong lensing, and it is this phenomenon, seen around the six galaxy
clusters targeted by the Frontier Fields programme, that has been used to map the mass distribution of MCS J0416.1-2403, using the new Hubble data.

"The depth of the data lets us see very faint objects and has allowed us to identify more strongly lensed galaxies than ever before," explains Mathilde Jauzac of Durham University, UK, and Astrophysics & Cosmology Research Unit, South Africa, lead author of the new Frontier Fields paper. "Even though strong lensing magnifies the background galaxies they are still very far away and very faint. The depth of these data means that we can identify incredibly distant background galaxies. We now know of more than four times as many strongly lensed galaxies in the cluster than we did before."

Using Hubble's Advanced Camera for Surveys, the astronomers identified 51 new multiply imaged galaxies around the cluster, quadrupling the number found in previous surveys and bringing the grand total of lensed galaxies to 68. Because these galaxies are seen several times this equates to almost 200 individual strongly lensed images which can be seen across the frame. This effect has allowed Jauzac and her colleagues to calculate the distribution of visible and dark matter in the cluster and produce a highly constrained map of its mass [3].

"Although we've known how to map the mass of a cluster using strong lensing for more than twenty years, it's taken a long time to get telescopes that can make sufficiently deep and sharp observations, and for our models to become sophisticated enough for us to map, in such unprecedented detail, a system as complicated as MCS J0416.1-2403," says team member Jean-Paul Kneib.

By studying 57 of the most reliably and clearly lensed galaxies, the astronomers modelled the mass of both normal and dark matter within MCS J0416.1-2403. "Our map is twice as good as any previous models of this cluster!" adds Jauzac.

The total mass within MCS J0416.1-2403 -- modelled to be over 650 000 light-years across -- was found to be 160 trillion times the mass of the Sun. This measurement is several times more precise than any other cluster map, and is the most precise ever produced [4]. By precisely pinpointing where the mass resides within clusters like this one, the astronomers are also measuring the warping of space-time with high precision.

"Frontier Fields' observations and gravitational lensing techniques have opened up a way to very precisely characterise distant objects -- in this case a cluster so far away that its light has taken four and a half billion years to reach us," adds Jean-Paul Kneib. "But, we will not stop here. To get a full picture of the mass we need to include weak lensing measurements too. Whilst it can only give a rough estimate of the inner core mass of a cluster, weak lensing provides valuable information about the mass surrounding the cluster core."

The team will continue to study the cluster using ultra-deep Hubble imaging and detailed strong and weak lensing information to map the outer regions of the cluster as well as its inner core, and will thus be able to detect substructures in the cluster's surroundings. They will also take advantage of X-ray measurements of hot gas and spectroscopic redshifts to map the contents of the cluster, evaluating the respective contribution of dark matter, gas and stars [5].

Combining these sources of data will further enhance the detail of this mass distribution map, showing it in 3D and including the relative velocities of the galaxies within it. This paves the way to understanding the history and evolution of this galaxy cluster.

The results of the study will be published online in Monthly Notices of the Royal Astronomical Society on 24 July 2014.
Notes

[1] The cluster is also known as MACS J0416.1-2403.

[2] The warping of space-time by large objects in the Universe was one of the predictions of Albert Einstein's theory of general relativity.

[3] Gravitational lensing is one of the few methods astronomers have to find out about dark matter. Dark matter, which makes up around three quarters of all matter in the Universe, cannot be seen directly as it does not emit or reflect any light, and can pass through other matter without friction (it is collisionless). It interacts only by gravity, and its presence must be deduced from its gravitational effects.

[4] The uncertainty on the measurement is only around 0.5%, or 1 trillion times the mass of the sun. This may not seem precise but it is for a measurement such as this.

[5] NASA's Chandra X-ray Observatory was used to obtain X-ray measurements of hot gas in the cluster and ground based observatories provide the data needed to measure spectroscopic redshifts.

Source: Spaceref.com
Surface structures are becoming visible in new images of comet 67P/Churyumov-Gerasimenko taken by the scientific imaging system OSIRIS onboard the European Space Agency’s Rosetta spacecraft. The resolution of these images is now 330 feet (100 meters) per pixel. One of the most striking features is currently found in the comet’s neck region. This part of 67P seems to be brighter than the rest of the nucleus.

As earlier images had already shown, 67P may consist of two parts: a smaller head connected to a larger body. The connecting region, the neck, is proving to be especially intriguing. “The only thing we know for sure at this point is that this neck region appears brighter compared to the head and body of the nucleus,” says OSIRIS Principal Investigator Holger Sierks from the Max Planck Institute for Solar System Research in Germany. This collar-like appearance could be caused by differences in material or grain size, or could be a topographical effect.

Even though the images taken from a distance of 3,400 miles (5,500 kilometers) are still not highly resolved, the scientists are remotely reminded of comet 103P/Hartley, which was visited in a flyby by NASA’s EPOXI mission in 2010. While Hartley’s ends show a rather rough surface, its middle is much smoother. Scientists believe this waist to be a gravitational low: since it contains the body’s center of mass, emitted material that cannot leave the comet’s gravitational field is most likely to be re-deposited there.

Whether this also holds true for 67P’s neck region is still unclear. Another explanation for the high reflectivity could be a different surface composition. In coming weeks, the OSIRIS team hopes to analyze the spectral data of this region obtained with the help of the imaging system’s filters. These can select several wavelength regions from the reflected light, allowing scientists to identify the characteristic fingerprints of certain materials and compositional features.

At the same time, the team is currently modeling the comet’s three-dimensional shape from the camera data. Such a model can help to get a better impression of the body’s shape. Rosetta will be the first mission in history to rendezvous with a comet, escort it as it orbits the sun, and deploy a lander to its surface.

For more information on the U.S. instruments aboard Rosetta, visit: [http://rosetta.jpl.nasa.gov](http://rosetta.jpl.nasa.gov)

Source: NASA
The Night Sky

Friday, July 25

Mars and Spica shine in the southwest at nightfall. Mars keeps pulling farther away from Spica; they're now 6° apart. Saturn glows pale yellow to their upper left. Arcturus sparkles high to their upper right.

Saturday, July 26

New Moon (exact at 6:42 p.m. EDT).

Summer is hardly more than a third over, astronomically speaking. But already the Great Square of Pegasus, symbol of the coming fall, heaves up from behind the east-northeast horizon at dusk and climbs higher in the east through the evening. It's balancing on one corner.

Sunday, July 27

Quick, can you name the star cluster just off the handle of the Teaspoon in Sagittarius? If you said NGC 6774, you qualify for a tiny inner sanctum of the sky elite. And yet it's visible in binoculars — Gary Seronik calls it "an easy catch in my 10×30 image-stabilized binos." See his Binocular Highlight column and chart for this V-shaped object in the August Sky & Telescope, page 45.

Monday, July 28

Mars continues its eastward trek against the cosmic backdrop. Look southwest at dusk. You'll notice that it's now definitely closer to Saturn than Antares is. Mars is to Saturn's lower right; Antares is to Saturn's lower left.

Source: Sky & Telescope

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ISS Sighting Opportunities

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Sighting information for other cities can be found at NASA’s [Satellite Sighting Information](#)

**NASA-TV Highlights**  
(all times Eastern Daylight Time)

**Tuesday, July 29** –

8:15 a.m., ISS Expedition 40 In-Flight Event with Flight Engineer Alexander Gerst for ESA and the German ARD Network (all channels)

7:15 p.m., Coverage of the Launch of the European Space Agency’s “Georges Lemaitre” Automated Transfer Vehicle to the ISS (all channels)

Watch NASA TV on the Net by going to the [NASA website](#).
- Jul 25 - Comet P/2014 L3 (Hill) Closest Approach To Earth (0.874 AU)
- Jul 25 - Comet P/2003 O3 (LINEAR) Perihelion (1.253 AU)
- Jul 25 - Comet 193P/LINEAR-NEAT At Opposition (1.334 AU)
- Jul 25 - Asteroid 2014 MG55 Near-Earth Flyby (0.066 AU)
- Jul 25 - Asteroid 8672 Morse Closest Approach To Earth (1.059 AU)
- Jul 25 - Asteroid 4257 Ubasti Closest Approach To Earth (1.653 AU)
- Jul 25 - Asteroid 16626 Thumper Closest Approach To Earth (1.960 AU)
- Jul 25 - Discover The Moon Day, Washington DC
- Jul 25 - 30th Anniversary (1984), 1st Woman Spacewalk (Svetlana Savitskaya)
- Jul 26 - Comet 117P/Helin-Roman-Alu Closest Approach To Earth (2.115 AU)
- Jul 26 - Comet 182P/LONEOS At Opposition (3.918 AU)
- Jul 26 - Asteroid 2013 ND15 Closest Approach To Earth (0.857 AU)
- Jul 26 - Asteroid 2013 EC20 Closest Approach To Earth (0.919 AU)
- Jul 26 - Asteroid 1541 Estonia Closest Approach To Earth (1.814 AU)
- Jul 26 - Asteroid 2169 Taiwan Closest Approach To Earth (1.850 AU)
- Jul 27 - Comet 196P/Tichy At Opposition (2.178 AU)
- Jul 27 - Comet P/2003 WC7 (LINEAR-Catalina) At Opposition (3.568 AU)
- Jul 28 - Comet 67P/Churyumov-Gerasimenko Closest Approach To Earth (2.694 AU)
- Jul 28 - Comet 33P/Daniel At Opposition (3.904 AU)
- Jul 28 - Comet C/2014 M1 (PANSTARRS) Closest Approach To Earth (5.302 AU)
- Jul 28 - Asteroid 433 Eros Occults TYC 6840-01293-1 (10.4 Magnitude Star)
- Jul 28 - Asteroid 4341 Poseidon Closest Approach To Earth (1.591 AU)
- Jul 28 - 50th Anniversary (1964), Ranger 7 Launch (Moon Impact Mission)

Source: JPL Space Calendar
Food for Thought

NASA's Chandra X-ray Observatory Celebrates 15th Anniversary

Fifteen years ago, NASA's Chandra X-ray Observatory was launched into space aboard the Space Shuttle Columbia. Since its deployment on July 23, 1999, Chandra has helped revolutionize our understanding of the universe through its unrivaled X-ray vision.

Chandra, one of NASA's current "Great Observatories," along with the Hubble Space Telescope and Spitzer Space Telescope, is specially designed to detect X-ray emission from hot and energetic regions of the universe.

With its superb sensitivity and resolution, Chandra has observed objects ranging from the closest planets and comets to the most distant known quasars. It has imaged the remains of exploded stars, or supernova remnants, observed the region around the supermassive black hole at the center of the Milky Way, and discovered black holes across the universe. Chandra also has made a major advance in the study of dark matter by tracing the separation of dark matter from normal matter in collisions between galaxy clusters. It is also contributing to research on the nature of dark energy.

To celebrate Chandra's 15th anniversary, four new images of supernova remnants – the Crab Nebula, Tycho, G292.0+1.8, and 3C58 – are being released. These supernova remnants are very hot and energetic and glow brightly in X-ray light, which allows Chandra to capture them in exquisite detail.

"Chandra changed the way we do astronomy. It showed that precision observation of the X-rays from cosmic sources is critical to understanding what is going on," said Paul Hertz, NASA's Astrophysics Division director in Washington. "We're fortunate we've had 15 years – so far – to use Chandra to advance our understanding of stars, galaxies, black holes, dark energy, and the origin of the elements necessary for life."
Chandra orbits far above Earth's X-ray absorbing atmosphere at an altitude up to 139,000 km (86,500 mi), allowing for long observations unobscured by Earth's shadow. When it was carried into space in 1999, it was the largest satellite ever launched by the shuttle.

"We are thrilled at how well Chandra continues to perform," said Belinda Wilkes, director of the Chandra X-ray Center (CXC) in Cambridge, Massachusetts. "The science and operations teams work very hard to ensure that Chandra delivers its astounding results, just as it has for the past decade and a half. We are looking forward to more ground-breaking science over the next decade and beyond."

Originally called the Advanced X-ray Astrophysics Facility (AXAF), the telescope was first proposed to NASA in 1976. Prior to its launch aboard the shuttle, the observatory was renamed in honor of the late Indian-American Nobel laureate, Subrahmanyan Chandrasekhar. Known to the world as Chandra (which means "moon" or "luminous" in Sanskrit), he was widely regarded as one of the foremost astrophysicists of the 20th century.

"Chandra continues to be one of the most successful missions that NASA has ever flown as measured against any metric – cost, schedule, technical success and, most of all, scientific discoveries," said Martin Weisskopf, Chandra Project Scientist at the Marshall Space Flight Center in Huntsville, Ala. "It has been a privilege to work on developing and maintaining this scientific powerhouse, and we look forward to many years to come."


For Chandra images, multimedia and related materials, visit: http://www.nasa.gov/chandra

Additional information on Chandra and the 15th anniversary can be found at: http://chandra.si.edu/15th

Source: NASA
IC 4603: Reflection Nebula in Ophiuchus

**Explanation:** Why does this starfield photograph resemble an *impressionistic painting*? The effect is created not by *digital trickery* but by large amounts of *interstellar dust*. Dust, minute globs rich in *carbon* and similar in size to *cigarette smoke*, frequently starts in the outer atmospheres of large, cool, evolved stars. The *dust* is dispersed as the star dies and grows as things stick to it in the *interstellar medium*. Dense dust clouds are *opaque* to *visible light* and can completely hide background stars. For less dense clouds, the capacity of dust to *preferentially reflect blue* starlight becomes important, effectively blooming the stars blue light out and marking the surrounding dust. Nebular gas emissions, typically brightest in *red light*, can combine to form areas seemingly created on an artist's canvas. *Photographed above* is the central part of the nebula IC 4603 surrounding the bright star *SAO 184376* (actually 8th *magnitude*) which mostly illuminates the *blue reflection nebula*. IC 4603 can be seen near the very bright star *Antares* (1st magnitude) toward the *constellation* of Ophiuchus.

**Image Credit & Copyright:** Rolf Olsen

Source: Astronomy Picture of the Day