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1. Giant Tsunamis Battered the Coastlines of an Early Martian Ocean

New NASA-funded research indicates that giant tsunamis played a fundamental role in forming Martian coastal terrain, removing much of the controversy that for decades shrouded the hypothesis that oceans existed early in Mars’ history.

“Imagine a huge wall of red water the size of a high-rise building moving towards you at the speed of a jetliner,” said J. Alexis P. Rodriguez, former NASA Postdoctoral Program fellow at NASA’s Ames Research Center in California’s Silicon Valley, and senior research scientist at the Planetary Science Institute in Tucson, Arizona. “That could be a fair way to picture it in your mind.”

It is now widely accepted by the Mars research community that approximately 3.4 billion years ago, an extremely cold and dry desert existed at the surface of Mars, while enormous subsurface aquifers overlain by ice-rich permafrost retained most of the water on the Red Planet. Researchers think that, at that time in the planet’s history, several large aquifers catastrophically ruptured, carving large outflow channels and flooding Mars’ northern plains to form an ocean. However, an apparent lack of definite shoreline features made this uncertain. This new research shows that the shorelines exist below the present surface and were modified and buried by two mega-tsunami events.

“We were surprised to find that the older and younger tsunami deposits look so different,” said Rodriguez. “The older tsunami washed ashore and deposited enormous volumes of debris, and evidence for the water hurtling back into the ocean is represented in widespread ‘backwash.’”

Following the formation of the ocean, and in the absence of widespread river systems that could have refilled it, its coastline receded to a lower elevation. The research documents two mega-tsunami events – giant waves that may have formed as a result of impacts slamming into Mars’ ocean.

“We think that after the ocean shoreline receded to a lower elevation – which likely resulted during a period of extreme climatic cooling lasting several million years – the younger tsunami occurred with enormous waves freezing as it washed over the frozen Martian landscape. The waves froze rapidly, even before they had a chance to flow back into the ocean,” Rodriguez said.

A key implication of the study is that the tsunami deposits can be used to reconstruct the evolution of the Martian climate during the lifetime of the ocean, and the younger deposits likely contain ice remnants from the ancient ocean itself. From a bystander’s viewpoint, if Mars was also covered by red dust then, as it is today, the ocean might have looked red while the particles settled to the bottom.

“The tsunami deposits likely contain rocks and sediments from the ocean floor that were picked up and transported landward by the enormous waves,” said Virginia Gulick, senior research scientist at the SETI Institute and NASA Ames, and a co-author on the paper. “Tsunami deposits are similar to flood deposits except that they are moving in the reverse – landward – direction.”
The researchers believe the ocean floor might have provided habitable environments, if the ocean persisted long enough. “On Earth, tsunami deposits contain a significant mud or fine-grained component; on Mars, this finer-grained component could have preserved physical or chemical evidence of past microbial activity, if it existed,” said Gulick. “If there were habitable environments, then biosignatures also could have been preserved in the large boulders visible in the older flow deposits.”

The research was conducted using visible and thermal images, combined with digital topography from Mars Odyssey, the Mars Reconnaissance Orbiter (MRO), and the Mars Global Surveyor. The research team was supported by the NASA Postdoctoral Program, NASA’s Planetary Geology and Geophysics Program, NASA’s MRO HiRISE and the NASA Astrobiology Institute.

Source: NASA
Since its launch five years ago, there have been three forces tugging at NASA’s Juno spacecraft as it speeds through the solar system. The sun, Earth and Jupiter have all been influential -- a gravitational trifecta of sorts. At times, Earth was close enough to be the frontrunner. More recently, the sun has had the most clout when it comes to Juno’s trajectory. Today, it can be reported that Jupiter is now in the gravitational driver’s seat, and the basketball court-sized spacecraft is not looking back.

“Today the gravitational influence of Jupiter is neck and neck with that of the sun,” said Rick Nybakken, Juno project manager at NASA’s Jet Propulsion Laboratory in Pasadena, California. "As of tomorrow, and for the rest of the mission, we project Jupiter’s gravity will dominate as the trajectory-perturbing effects by other celestial bodies are reduced to insignificant roles."

Juno was launched on Aug. 5, 2011. On July 4 of this year, it will perform a Jupiter orbit insertion maneuver -- a 35-minute burn of its main engine, which will impart a mean change in velocity of 1,212 mph (542 meters per second) on the spacecraft. Once in orbit, the spacecraft will circle the Jovian world 37 times, skimming to within 3,100 miles (5,000 kilometers) above the planet’s cloud tops. During the flybys, Juno will probe beneath the obscuring cloud cover of Jupiter and study its auroras to learn more about the planet’s origins, structure, atmosphere and magnetosphere.

Juno’s name comes from Greek and Roman mythology. The mythical god Jupiter drew a veil of clouds around himself to hide his mischief, and his wife -- the goddess Juno -- was able to peer through the clouds and reveal Jupiter’s true nature.

NASA’s Jet Propulsion Laboratory, Pasadena, California, manages the Juno mission for the principal investigator, Scott Bolton, of Southwest Research Institute in San Antonio. Juno is part of NASA’s New Frontiers Program, which is managed at NASA's Marshall Space Flight Center in Huntsville, Alabama, for NASA’s Science Mission Directorate. Lockheed Martin Space Systems, Denver, built the spacecraft. The California Institute of Technology in Pasadena manages JPL for NASA.

For more information about Juno visit http://www.nasa.gov/juno and http://missionjuno.swri.edu.

Source: NASA
3. Supermassive Black Hole Winds Can Stop New Stars from Forming

Scientists have uncovered a new class of galaxies with supermassive black hole winds that are energetic enough to suppress future star formation.

Devoid of fresh young stars, red and dead galaxies make up a large fraction of galaxies in our nearby universe, but a mystery that has plagued astronomers for years has been how these systems remain inactive despite having all of the ingredients needed to form stars. Now, an international team of researchers have used optical imaging spectroscopy from the Sloan Digital Sky Survey-IV Mapping Nearby Galaxies at Apache Point Observatory (SDSS-IV MaNGA) to catch a supermassive black hole in the act of heating gas within its host galaxy, leading to the prevention of star formation.

"Stars are created by the cooling and collapse of gas, but in these galaxies there are no new stars despite an abundance of gas. It's like we have rain clouds hanging over a desert, but none of the rainwater is reaching the ground." said Edmond Cheung, Project Researcher at the Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU), and lead author of a new study published in Nature on May 26.

The team studied a galaxy nicknamed Akira, the prototypical example of the newly discovered class of galaxies called "red geysers" -- red referring to the color of galaxies that lack young blue stars, and geyser referring to the episodic wind outbursts from the supermassive black hole. Akira showed intriguing and complex patterns of warm gas, implying the presence of an outflowing wind from the supermassive black hole in its center. The researchers say the fuel for Akira's supermassive black hole likely came from the interaction with a smaller galaxy, nicknamed Tetsuo. The outflowing wind had enough energy to heat the surrounding gas through shocks and turbulence and could ultimately prevent any future star formation.
These are some of the early results from the Kavli IPMU-led SDSS-IV MaNGA survey, which began observations in 2014. The technology involved in the new survey allows scientists to map galaxies ten to one hundred times faster than before, making it possible to build large enough samples required to catch galaxies undergoing rapidly changing phenomena.

"The critical power of MaNGA is the ability to observe thousands of galaxies in three dimensions, by mapping not only how they appear on the sky, but also how their stars and gas move inside them," said Kevin Bundy, MaNGA's Principal Investigator and Kavli IPMU Project Assistant Professor.

The team will continue to analyze the survey's data and plans a number of follow-up studies to further reveal the role of red geysers on the evolution of galaxies.

Image: An artist's rendition of the galaxies Akira (right) and Tetsuo (left) in action. Akira's gravity pulls Tetsuo's gas into its central supermassive black hole, fueling winds that have the power to heat Akira's gas. Because of the action of the black hole winds, Tetsuo's donated gas is rendered inert, preventing a new cycle of star formation in Akira. (Credit: Kavli IPMU)

Source:  Spaceref.com
The Night Sky

Friday, May 27

• Have you been watching the Mars-Antares-Saturn triangle change shape? It's stretching as Mars moves westward away from the head of Scorpius. This will continue until the end of June. Then Mars will start to slingshot back to fly right between Antares and Saturn in late August. Plan to watch this slow summer drama!

• Jupiter's Great Red Spot transits Jupiter's central meridian tonight around 2:02 a.m. Eastern Daylight Time; 11:02 p.m. Pacific Daylight Time. It's positioned in good view for about an hour before and after transiting.

Saturday, May 28

• Constellations seem to twist around fast as they pass your zenith, if you're comparing them to the direction "down." Just a week ago, the Big Dipper floated horizontally in late twilight an hour after sunset (as seen from near 40° N latitude). Now it's strongly tilted at that time, bowl down. Another two weeks and it will be hanging straight down by its handle.

• Jupiter's Great Red Spot transits Jupiter's central meridian around 9:54 p.m. EDT.

Sunday, May 29

• Last-quarter Moon (exact at 8:12 a.m. EDT). Tonight the Moon doesn't rise until around 2 a.m. It'll be between the Aquarius's dim spilling bucket and the dim Circlet of Pisces.

• With the Moon gone from the evening sky, meanwhile, hunt out the little-known galaxy bunches at the legs of Virgo using Sue French's Deep-Sky Wonders article, charts, and photos in the June Sky & Telescope, page 54.

Monday, May 30

• Mars is closest to Earth tonight (0.503 a.u.) and appears 18.6 arcseconds in diameter, though for all practical purposes it remains this close for at least another week. Cloudy? You can watch a live telescopic feed from Slooh tonight from 9 to 10 p.m. EDT (1:00 to 2:00 May 31st UT).

• Jupiter's Great Red Spot transits Jupiter's central meridian around 11:33 p.m. EDT. Just off Jupiter's eastern limb, Ganymede disappears into eclipse by Jupiter's shadow around 9:48 p.m. EDT, then re-emerges somewhat farther east of the planet around 12:59 a.m. EDT. Meanwhile, Io reappears out of eclipse in the same general area at 12:27 p.m. EDT.

Source: Sky & Telescope
ISS Sighting Opportunities

For Denver:

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Sighting information for other cities can be found at NASA's [Satellite Sighting Information](https://www.nasa.gov/space-station/satellite-sighting).

**NASA-TV Highlights**

(all times Eastern Daylight Time)

**Saturday, May 28**

8:30 a.m., Coverage of the Expansion of the Bigelow Expandable Activity Module (BEAM) at the ISS (Expansion scheduled to begin at approximately 9 a.m. ET) (starts at 8:45 a.m.) (all channels)

**Tuesday, May 31**

9:30 a.m., ISS Expedition 47 In-Flight Interview with ITV News and Flight Engineer Tim Peake of the European Space Agency (starts at 9:40 a.m. ET) (all channels)

Watch NASA TV on the Net by going to the [NASA website](https://www.nasa.gov/tv).
Space Calendar

- May 27 - Comet P/2016 A7 (PANSTARRS) At Opposition (1.317 AU)
- May 27 - Comet P/2007 R3 (Gibbs) Perihelion (2.521 AU)
- May 27 - Comet P/2004 FY140 (LINEAR) Closest Approach To Earth (3.184 AU)
- May 27 - Comet C/2011 KP36 (Spacewatch) Perihelion (4.882 AU)
- May 27 - Asteroid 3414 Champollion Closest Approach To Earth (1.388 AU)
- May 27 - 85th Anniversary (1931), 1st US Full Scale Wind Tunnel Opened at Langley Field Research Center
- May 28 - Pluto Stamps Dedicated
- May 28 - Intelsat 31 Proton-M Briz-M P4 Launch
- May 28 - Comet 140P/Bowell-Skiff At Opposition (2.358 AU)
- May 28 - Comet P/2010 P4 (WISE) Closest Approach To Earth (2.813 AU)
- May 28 - Comet P/2000 S1 (Skiff) At Opposition (3.005 AU)
- May 28 - Asteroid 2016 GZ240 Near-Earth Flyby (0.074 AU)
- May 28 - Asteroid 9523 Torino Closest Approach To Earth (1.737 AU)
- May 28 - Asteroid 11020 Orwell Closest Approach To Earth (1.743 AU)
- May 28 - Asteroid 88705 Potato Closest Approach To Earth (1.894 AU)
- May 28 - Asteroid 2742 Gibson Closest Approach To Earth (2.085 AU)
- May 28 - Asteroid 6676 Monet Closest Approach To Earth (2.216 AU)
- May 28 - Asteroid 588 Achilles (Jupiter Trojan) Closest Approach To Earth (4.895 AU)
- May 28 - Kuiper Belt Object 2007 J H43 At Opposition (39.549 AU)
- May 28 - 45th Anniversary (1971), Mars 3 Launch (USSR Mars Orbiter/Lander)
- May 28 - Alfred Nier's 105th Birthday (1911)
- May 28 - Placidus Fixmillner's 295th Birthday (1721)
- May 29 - Comet P/2004 FY140 (LINEAR) At Opposition (3.185 AU)
- May 29 - Asteroid 3852 Glennford Closest Approach To Earth (2.488 AU)
- May 30 - Ziyuan-3/NuNat 1 (Aleph-1 1)/Nusat 2 (Aleph-1 2) CZ-4B Launch
- May 30 - Comet P/2014 W2 (PANSTARRS) Closest Approach To Earth (2.631 AU)
- May 30 - Comet 210P/Christensen At Opposition (4.259 AU)
- May 30 - Amor Asteroid 2016 JT Near-Earth Flyby (0.077 AU)
- May 30 - Asteroid 4125 Lew Allen Closest Approach To Earth (0.868 AU)
- May 30 - Asteroid 9253 Oberth Closest Approach To Earth (1.357 AU)
- May 30 - Asteroid 14061 Nagincox Closest Approach To Earth (1.700 AU)
- May 30 - Asteroid 241 Germany Closest Approach To Earth (2.088 AU)
- May 30 - Asteroid 2598 Merlin Closest Approach To Earth (2.357 AU)
- May 30 - 45th Anniversary (1971), Mariner 9 Launch (USA Mars Orbiter)
- May 30 - 50th Anniversary (1966), Surveyor 1 Launch (USA Moon Lander)
- May 30 - Joseph Kennedy's 100th Birthday (1916)
Food for Thought

NASA Scientists Explain the Art of Creating Digital Hurricanes

Every day, scientists at NASA work on creating better hurricanes – on a computer screen. At NASA’s Goddard Space Flight Center in Greenbelt, Maryland, a team of scientists spends its days incorporating millions of atmospheric observations, sophisticated graphic tools and lines of computer code to create computer models simulating the weather and climate conditions responsible for hurricanes. Scientists use these models to study the complex environment and structure of tropical storms and hurricanes.

Getting the simulations right has huge societal implications, which is why one Goddard scientist chose this line of work.

“Freshwater floods, often caused by hurricanes, are the number one cause of death by natural disasters in the world, even above earthquakes and volcanoes,” tropical meteorologist Oreste Reale with Goddard’s Global Modeling and Assimilation Office (GMAO) said. “Seeing how the research we do could have an impact on these things is very rewarding.”

Improved models can lead to better prediction and warning for these natural disasters, mitigating loss of life and property.

Getting to the point of being able to accurately study hurricanes using computer models, however, is not easy. Because hurricanes are such complex storm systems, capturing their full nature in detail using a computer simulation is far from simple. “We need to add complexity all the time and nobody here is afraid of doing that,” Reale said. “You don’t want a simple solution. If it’s simple, chances are it’s not true.”

Adding complexity can include updating the models, incorporating data from new satellites, replacing old satellites and more.

Reale and his colleague, Goddard tropical meteorologist Marangelly Fuentes, have more than 25 years’ combined experience looking at modeled storms. In fact, Fuentes was Reale’s student intern while she was earning her doctorate degree at Howard University in Washington, D.C. They belong to a team in the GMAO whose goal is to assess whether new data types are used efficiently in computer models, and to ensure that changes and updates improve the performance of models and their data assimilation systems compared to previous versions. Data assimilation refers to the process through which data or observations are incorporated into an existing model.

“Mostly I look at tropical forecasting and the analysis of tropical cyclones in the models, so we monitor how the different models are performing with tropical storms,” Fuentes said. This includes comparing the performance of GMAO’s weather and climate models with others in the U.S. and around the world. Fuentes looks at current versions of the GMAO model and compares them with newer, updated versions in development. By comparing the results of newer simulations on past, well-known storms, she can verify if the updated model version will be more effective at predicting the track and intensity of future storms.

“We are able to use cases like Hurricane Katrina to run tests and show us how we can improve, or how this new change affected the forecast or the analysis of the storm system,” Fuentes said.
The closer the results are to the actual behavior of the storm, the more accurate the model.

Fuentes has worked extensively on the intensity prediction of Hurricane Katrina. Weather models in 2005 – the year Katrina struck the Gulf Coast with devastating results – predicted that the storm’s pressure would reach as low as 955 millibars, significantly underestimating how low Katrina’s atmospheric pressure would get, and therefore the storm’s intensity. Observed data show that pressure in Hurricane Katrina’s eye reached a minimum of 902 millibars, one of the 10 lowest pressure readings on record for an Atlantic hurricane. The most modern model produced by the GMAO, which Fuentes has been analyzing, can produce a model of Katrina’s pressure much closer to the actual observed levels from 2005.

Changes to these predictions are caused by improvements in data assimilation and model resolution, made possible by increased computer processing power. Improving the resolution of the model works similarly to increasing the resolution of a photo. The more pixels, or dots of color, in a square inch of a photo, the higher the resolution. High-resolution photos appear sharper and capture more detail than their low-resolution counterparts. Likewise, higher-resolution models produce more detailed simulations of hurricanes, giving researchers a better understanding of their behavior.

"In the model we basically transform Earth's atmosphere into little 'cubes' and in each cube the fundamental equations controlling motion, energy and continuity of the atmosphere are solved," Reale said. "The smaller the size of the cube, the more realistic the representation of the atmosphere."

Reale said that high model resolution is a critical factor in capturing hurricanes accurately. Luckily, there has been much improvement to model resolution in the past 10 years.

In 2005, the record year of 27 named tropical storms or hurricanes in the Atlantic, the size of the "cubes" in GMAO’s model was about 31 miles (50 km). Today, the resolution is three to four times higher at about 8 miles (12.5 km), giving scientists a much clearer and more detailed look at the state of the atmosphere.

Of course, Reale said, there's still work to be done. "There's no such thing as perfect in research and science, but there is certainly a big improvement for the intensity that contemporary models could predict if they had to face a situation like that again," he said.

Reale believes this is the team to do it. "I feel that I’m part of an organization that is extremely successful in facing many different aspects of science,” he said. "There are people from all over the world, and I’m sure that whatever question or issue I may have, there’s someone who knows the answer in this building. I can tap into the knowledge and experience of so many people."

Fuentes and Reale are part of the GMAO, which consists of more than 150 people, all working on different aspects of the Earth-atmosphere-ocean-ice system. NASA collaborates closely with the National Oceanic and Atmospheric Administration, the agency that releases official forecasts to the public, to improve our understanding of hurricanes. Reale is also the principal investigator on a funded NASA project to improve hurricane intensity prediction through a better use of data from the Atmospheric Infrared Sounder (AIRS) onboard the NASA Aqua satellite.

Related links:
- Since Katrina: NASA Advances Storm Models, Science
- Global Modeling and Assimilation Office

Source: NASA
IC 5067 in the Pelican Nebula

**Explanation:** The prominent ridge of emission featured in this sharp, colorful skyscape is cataloged as IC 5067. Part of a larger emission nebula with a distinctive shape, popularly called The Pelican Nebula, the ridge spans about 10 light-years following the curve of the cosmic pelican's head and neck. This false-color view also translates the pervasive glow of narrow emission lines from atoms in the nebula to a color palette made popular in Hubble Space Telescope images of star forming regions. Fantastic, dark shapes inhabiting the 1/2 degree wide field are clouds of cool gas and dust sculpted by the winds and radiation from hot, massive stars. Close-ups of some of the sculpted clouds show clear signs of newly forming stars. The Pelican Nebula, itself cataloged as IC 5070, is about 2,000 light-years away. To find it, look northeast of bright star Deneb in the high flying constellation Cygnus.

*Image Credit & Copyright: Data - Subaru Telescope (NAOJ), R. Colombari, Processing - Roberto Colombari*

Source: [Astronomy Picture of the Day](https://apod.nasa.gov/apod/)

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