Galactic Observer

John J. McCarthy Observatory

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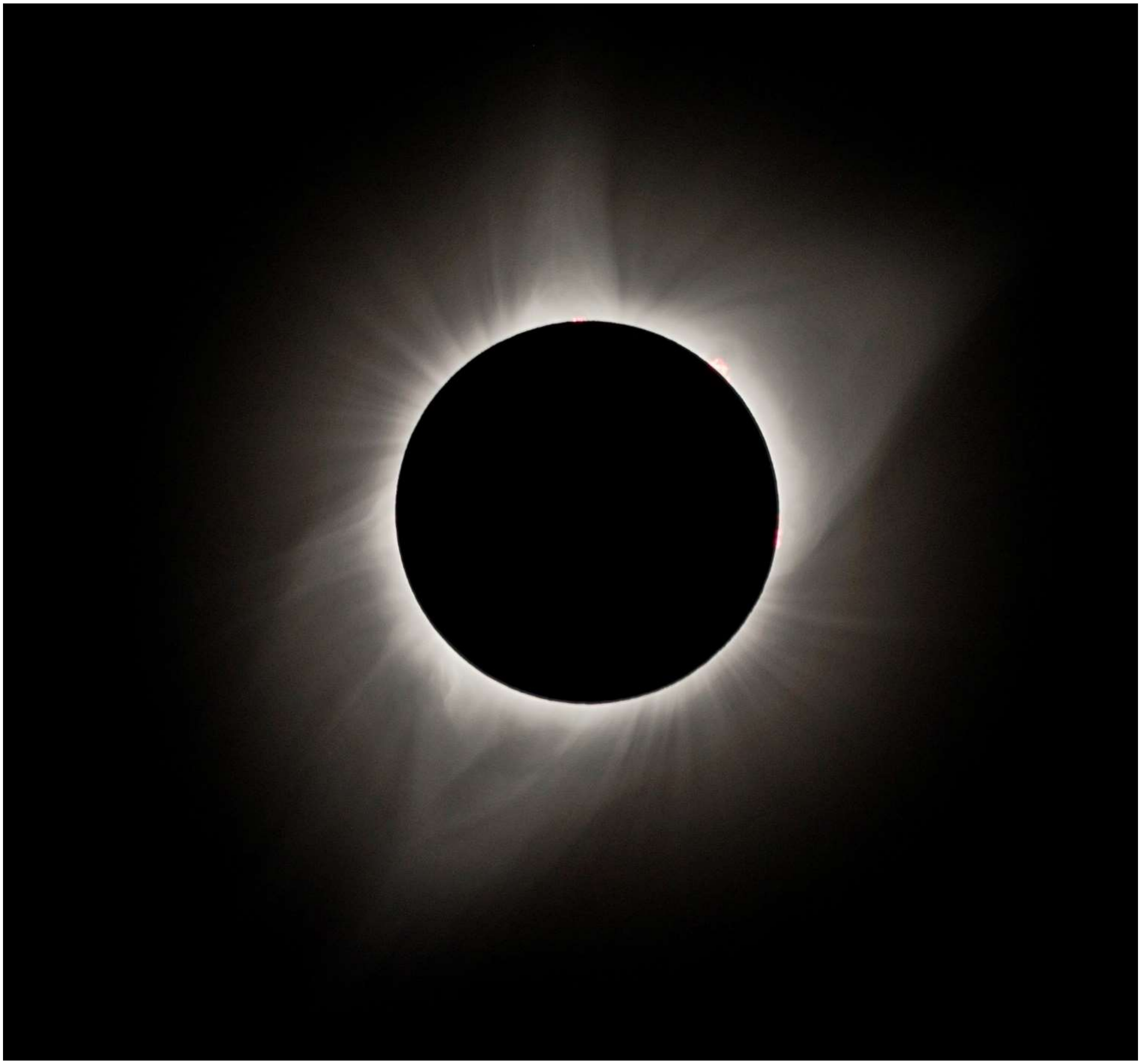
An enhanced color image of a delta remnant, informally named "Kodiak," in Jezero Crater, 1.4 miles (2.2 km) from the Perseverance rover. Image captured with the rover's Mastcam-Z

Credit: NASA/JPL-Caltech/ASU/MSSS

January Astronomy Calendar and Space Exploration Almanac



The Sun's faint corona, the outermost region of the Sun's atmosphere, is visible from Earth during a total eclipse when the Moon moves in front of, and completely blocks, the intense light from the solar disk. The corona consists of plasma (hot ionized gas), extending many thousands of miles (kilometers) above the visible "surface" or photosphere. Its size and shape are affected by the Sun's magnetic field. Researchers have determined that the Parker Solar Probe, for the first time, crossed the "Alfvén Point" in the corona for a brief period during its 8th close encounter in April 2021, and again in August and November. Full story on page 19

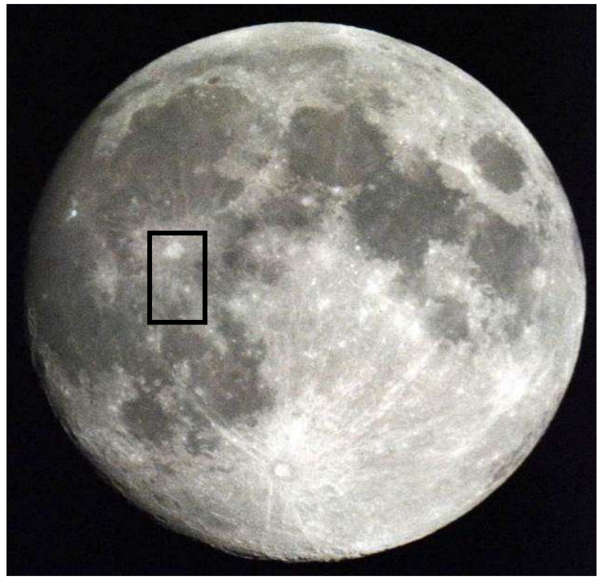
Total Solar Eclipse photo from Rexburg, Idaho in August 2017 by Bill Cloutier

In This Issue

932
McCarthy Observatory
New Milford, CT

“Out the Window on Your Left”

It’s been more than 52 years since Neil Armstrong first stepped onto the Moon’s surface and 49 years since Gene Cernan left the last footprint. As a nation founded on exploration and the conquest of new frontiers, today’s commitment to return to the Moon has been as fleeting as the funding. But what if the average citizen had the means to visit our only natural satellite; what would they see out the window of their spacecraft as they entered orbit around the Moon? This column may provide some thoughts to ponder when planning your visit (if only in your imagination).



Copernicus Crater and the Moon’s Fra Maura Region

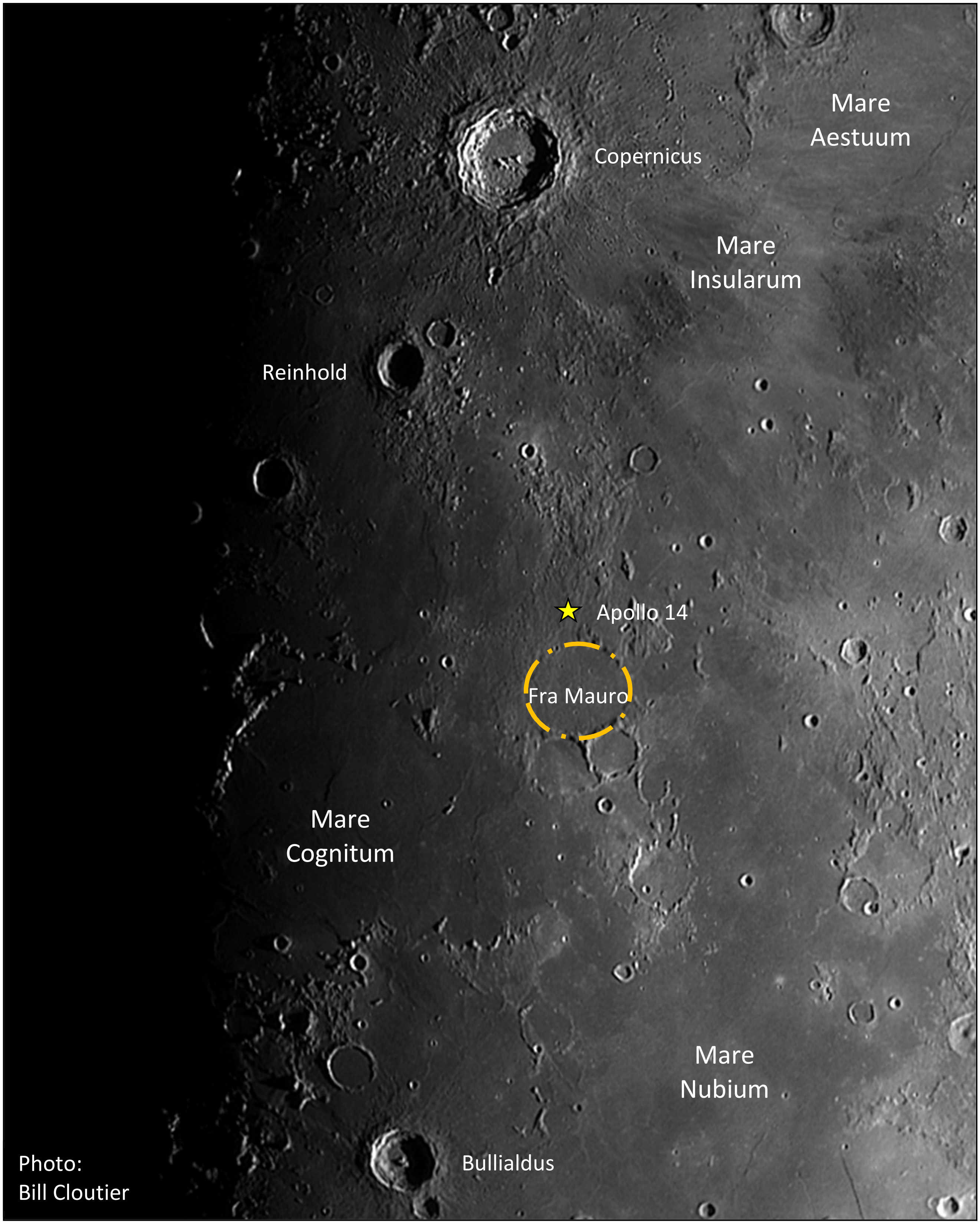
Apollo 14 was launched on January 31, 1971 at 4:03 pm EST. Commanding the mission was Alan B. Shepard Jr., the lone original-seven Mercury astronaut to fly to the Moon. Shepard had been grounded with an inner ear ailment for almost a decade after becoming the first American to reach space in May 1961 with a 15-minute suborbital flight. Accompanying Shepard were rookies Edgar Mitchell as Lunar Module Pilot and Stuart Roosa as Command Module Pilot.

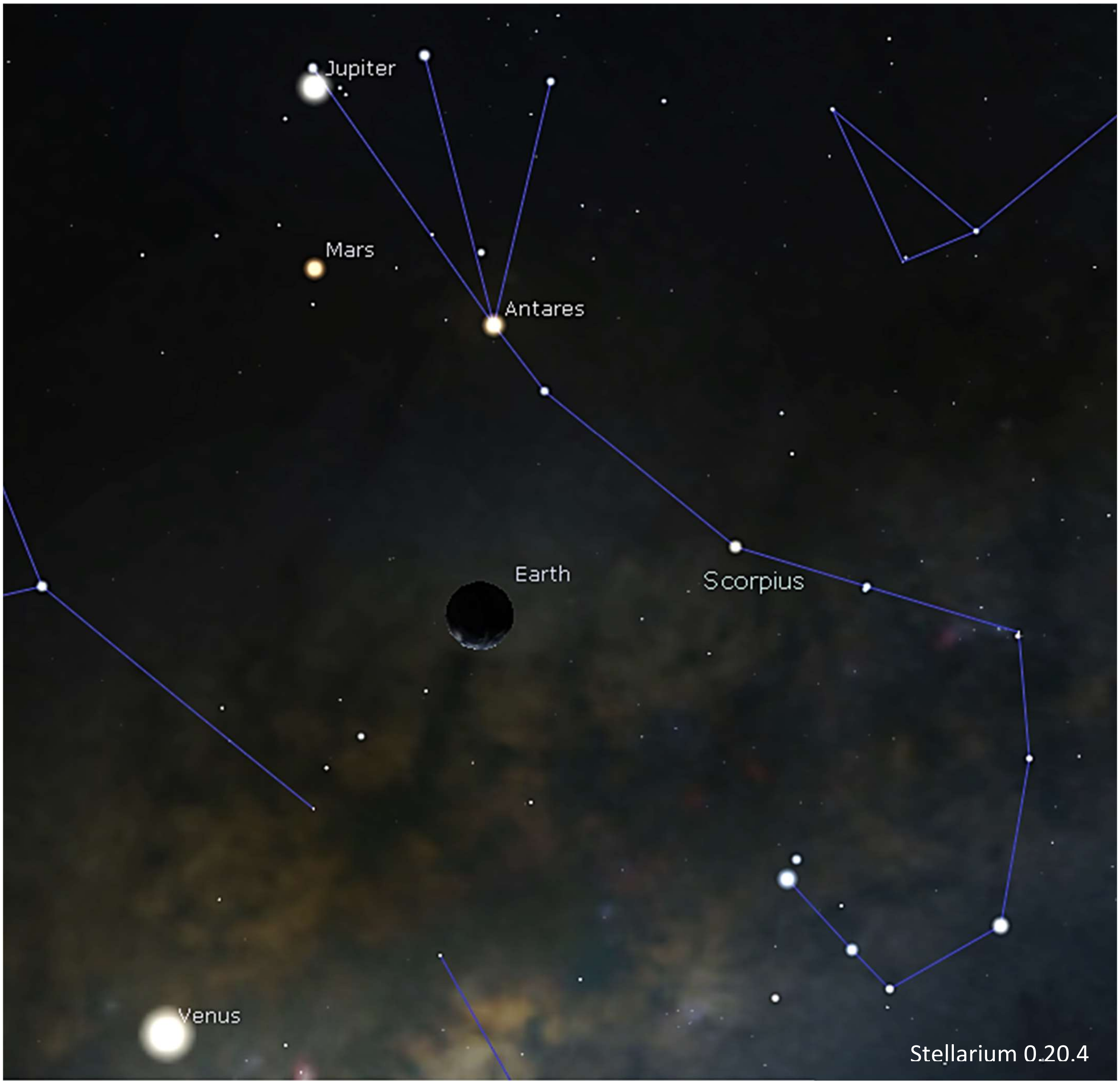
The Apollo 14 landing site (originally the destination of the aborted Apollo 13 mission) was just north of the eroded Fra Mauro impact crater. Bright ray material covered the site from the younger Copernicus crater, approximately 225 miles (360 km) to the north, along with impact ejecta from the Imbrium Basin, 310 miles or 500 km to the north. The landing site was also on the edge of a debris field from Cone crater, 1,093 feet (333 meters) in diameter and less than a mile (1.5 km) away. The relatively recent impact feature penetrated the regolith layer – excavating older material.

On February 5, the lunar lander Antares executed a pinpoint landing (after glitches with the landing radar almost ended the mission) about 110 miles (177 km) east of the Apollo 12 landing site. Shepard and Mitchell spent 33½ hours on the Moon, including almost 9½ hours exploring the surface in two separate excursions. During the second excursion, the two astronauts attempted to summit Cone crater, 300 feet (91 meters) above the landing site. The trek consumed more time and energy than anticipated (the astronauts were also dragging a wheeled cart with tools and samples up the hill), and mission control had Shepard and Mitchell turn back before they were able to reach the rim. Lunar Reconnaissance Orbiter images show the astronauts were less than 135 feet (40 meters) from the rim at turnaround.

The crew of Apollo 14 gathered almost 110 pounds (43 kg) of rock for analysis on Earth. The samples of Imbrium Basin ejecta returned by Shepard and Mitchell were radiometrically dated to approximately 3.85 billion years ago, making it one of the youngest impact basins, possibly second youngest to the Orientale Basin. Recent analysis of Lunar Sample 14321, the largest rock collected by Shepard at nearly 20 pounds (9 kg), found an embedded granite-like fragment of quartz, feldspar and zircon that is likely of terrestrial (Earth) origin and roughly 4 billion years old, suggesting that the oldest Earth rocks may be found on the Moon.

Fra Mauro and Apollo 14





The Apollo 14 lunar lander (LM) was named for the brightest star in the constellation Scorpius (the red supergiant Antares). The star was visible as Shephard and Mitchell descended onto the lunar surface near Fra Mauro. You can recreate their view from the Moon using a program like Stellarium, a free open-source planetarium. The screenshot from Stellarium (above) shows a waning crescent Earth (23% illuminated) in the constellation Ophiuchus, not far from Antares, at 4:18 am EST on February 5, 1971. The Earth was high in the sky (66°) in the east on that morning with the Sun just 10° above the Moon's eastern horizon, and almost directly beneath our home planet and Antares in the lunar sky.

The Moon had set on the east coast by the time the LM landed. However, earlier that evening, Earth-bound viewers would have enjoyed a 10-day old waxing gibbous Moon (77% illuminated) in the constellation Taurus.

Planets in 2022

The superior planets (those that orbit further from the Sun than the Earth) return to the evening sky in the latter half of 2022, appearing at their brightest when they are at, or near, Opposition (when the planet is opposite the Sun in our sky). At Opposition, a planet rises around sunset and is highest in our sky (crosses the meridian) around midnight.

Saturn reaches Opposition on August 14, about 12 days later than in 2021. The ringed planet can be found in the constellation Capricornus, the Sea Goat, shinning at an apparent magnitude of +0.3 at its brightest. It will be 8.86 AU from Earth at that time (approximately 824 million miles or 1.325 billion km). Saturn has an axial tilt of 27°, so our view of the gas giant changes from year to year. This coming year, the planet's rings will be tilted at an angle of +13° to our line of sight.

As seen from Earth, Saturn's ring tilt (the ring plane opening angle to the Earth) has been decreasing since 2017 when it was near maximum at 26°. The rings will be edge-on in March 2025 (as seen from Earth) and not at their full splendor again until May 2032 when the rings will be tilted at their maximum (27°) and planet's south pole will be sunlit and visible to Earth-bound observers.

Neptune reaches Opposition on September 16. The blue ice giant can be found in the constellation Aquarius, the Water Carrier, but at an apparent magnitude of +7.8, you will need binoculars or a telescope to even locate the eighth planet against the background stars. At its closest, Neptune will be a distant 28.91 AUs from the Earth (approximately 2.69 billion miles or 4.32 billion km).

Jupiter reaches Opposition, on average, every 399 days or about 33 days later each successive year. In 2022, Opposition is on September 26 when the gas giant will be 3.95 astronomical units (AU) from Earth (approximately 367 million miles or 591 million km). Jupiter will shine at an apparent magnitude of -2.9 at its brightest (only surpassed by Venus for planetary luminosity) and can be found in the constellation Pisces, the Fish, and to the east of Saturn.

Uranus reaches Opposition on November 9. The first planet to be discovered with the telescope can be found in the constellation Aries, the Ram. At an apparent magnitude of +5.7, you will need perfect viewing conditions (dark, clear skies) to spot the seventh planet. Uranus will be almost a billion miles closer than Neptune, but still a distant 18.69 AUs from the Earth (approximately 1.74 billion miles or 2.80 billion km). Only with the aid of a telescope will you be able to see the blue-green disk of the sideways-spinning planet.

Mercury is best seen when farthest from the Sun in Earth's sky. The best evening views (Greatest Eastern Elongation) will occur on January 7, April 29, August 27 and December 21, when the inner planet is 19°, 20°, 27° and 20° from the Sun, respectively, and visible up to 90 minutes after sunset, shining as bright as -0.6 magnitude. The best morning prospects (Greatest Western Elongation) are on February 16, June 16, and October 8, when Mercury rises up to 2 hours before sunrise and shines as bright as magnitude -0.4.

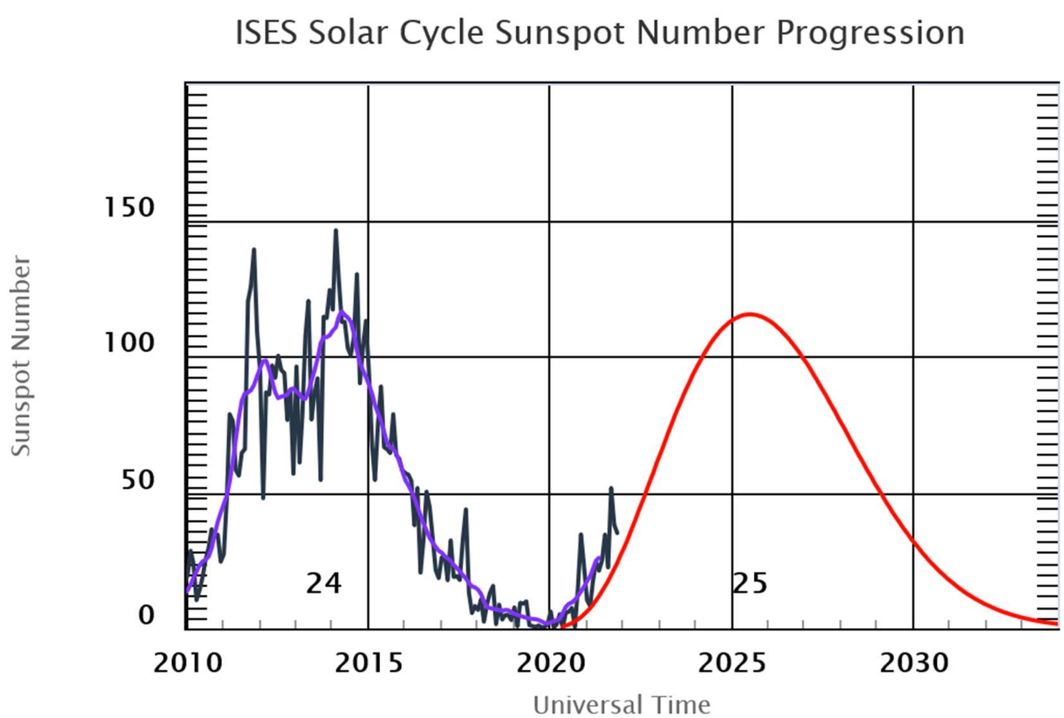
Venus is brightest when closest to Earth (crescent phase) and its separation greatest from the Sun. The planet reaches Greatest Western Elongation on March 20, with an elongation of 46°, although it will be relatively low in the southeast before sunrise. Venus reaches its highest point in the sky almost a month earlier on February 15.

Mars reaches Opposition every 26 months. In 2022, the planets will align once again on the night of December 8 when Mars will shine at magnitude -1.9 in the constellation Taurus. The Red Planet will be closest to Earth 7 days earlier at a distance of 50.6 million miles (81.5 million km). While further away and appearing smaller than in 2020, Mars will be 19° higher in the sky – providing steadier conditions for observing. Mars' orbit is not as circular as Earth's, varying in distance from the Sun by as much as 18% or 28 million miles (45 million km), compared to less than 4% for Earth. As a result, the distance between the two planets can be as little as 35 million miles or 56 million km if Mars is near perihelion or as much as 63 million miles or 101 million km if Mars is near aphelion.

<u>The Sun</u>

The sun's magnetic field changes polarity approximately every 11 years: north becomes south, and south becomes north. The number of sunspots (dark areas on the photosphere) wax and wane over a similar period of time, known as the solar cycle. During the peak (number of sunspots), the Sun is more active with frequent outbursts that can produce significant space weather events, energize Earth's magnetic field and heat up its highest atmospheric layers. The heating of the thermosphere causes it to expand as it absorbs much of the X-ray and ultraviolet radiation from the Sun. While extremely diffuse, it increases the drag on satellites (and the International Space Station) that orbit within this layer, potentially shortening their operational life.

Solar cycles are numbered (since 1755 with cycle 1). We are currently in the beginning stages of cycle 25 which began in December 2019 (solar minimum). The Sun's activity is expected to ramp up to a predicted maximum level in July 2025, although it could happen sooner based on current activity (while 11 years is the average, cycles can be as short as 9 years and as long as 14 years).



International Space Environmental Services (ISES) Space Weather Prediction Center
National Oceanic and Atmospheric Administration

Go Webb

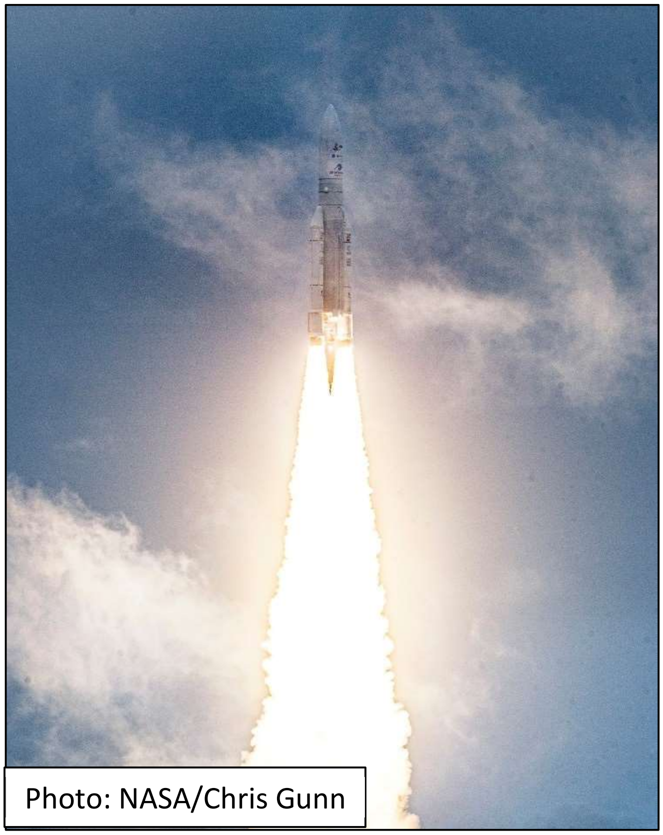
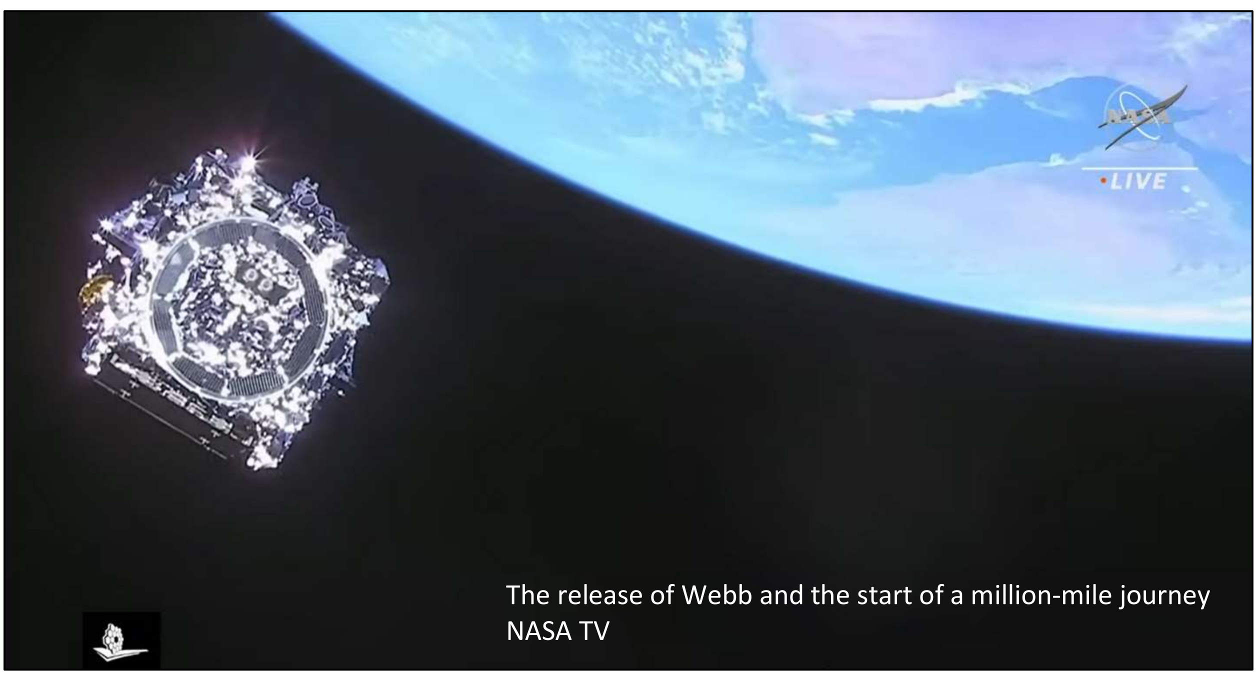


Photo: NASA/Chris Gunn

Christmas morning delivered a long-awaited-for present to astronomers with the successful launch of the James Webb Space Telescope (Webb) from Europe's launch facility in Kourou, French Guiana. The infrared telescope with a 21.3-foot (6.5 meter) diameter primary mirror was released from the Ariane 5 rocket's upper stage about 28 minutes after liftoff. The telescope's solar panel was deployed shortly thereafter, providing power to the spacecraft's attitude control system. Approximately 12 hours later, the spacecraft successfully executed a 65-minute burn, the first of three mid-course corrections (and most critical) that will send the telescope out to the second Lagrange point or L2, a million miles from Earth.

On the following morning, the telescope's high-rate antenna, used to transmit science data, was unstowed and pointed back to Earth. During the first week in space, the two sunshield pallets will be brought into position (the supports for the sunshield), followed by the Deployable Tower Assembly. The sunshield's telescoping booms will then be extended, followed by the unfolding and tensioning of the five-layered, tennis-court-size sun shield. The telescope will be deployed during the second week, starting with the tripod holding the secondary mirror. Once in position, the mirror segments on each side of the primary mirror unfold, exposing all 18 mirrors segments to space. The journey to L2 will take about a month.



The release of Webb and the start of a million-mile journey
NASA TV

2022 Earth Missions

NASA's Earth Observing System (EOS) is "a coordinated series of polar-orbiting and low inclination satellites for long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans." The agency has 30 missions currently flying with four additional Earth science missions scheduled to launch in 2022. NASA's unique perspective of the Earth is shared with the public though media outlets and websites such as the "Earth Observatory."

The four missions will provide high quality data on the environment, providing researchers and climate scientists the information needed to advise policy and decision makers. The four are called TROPICS, EMIT, JPSS-2 and SWOT.

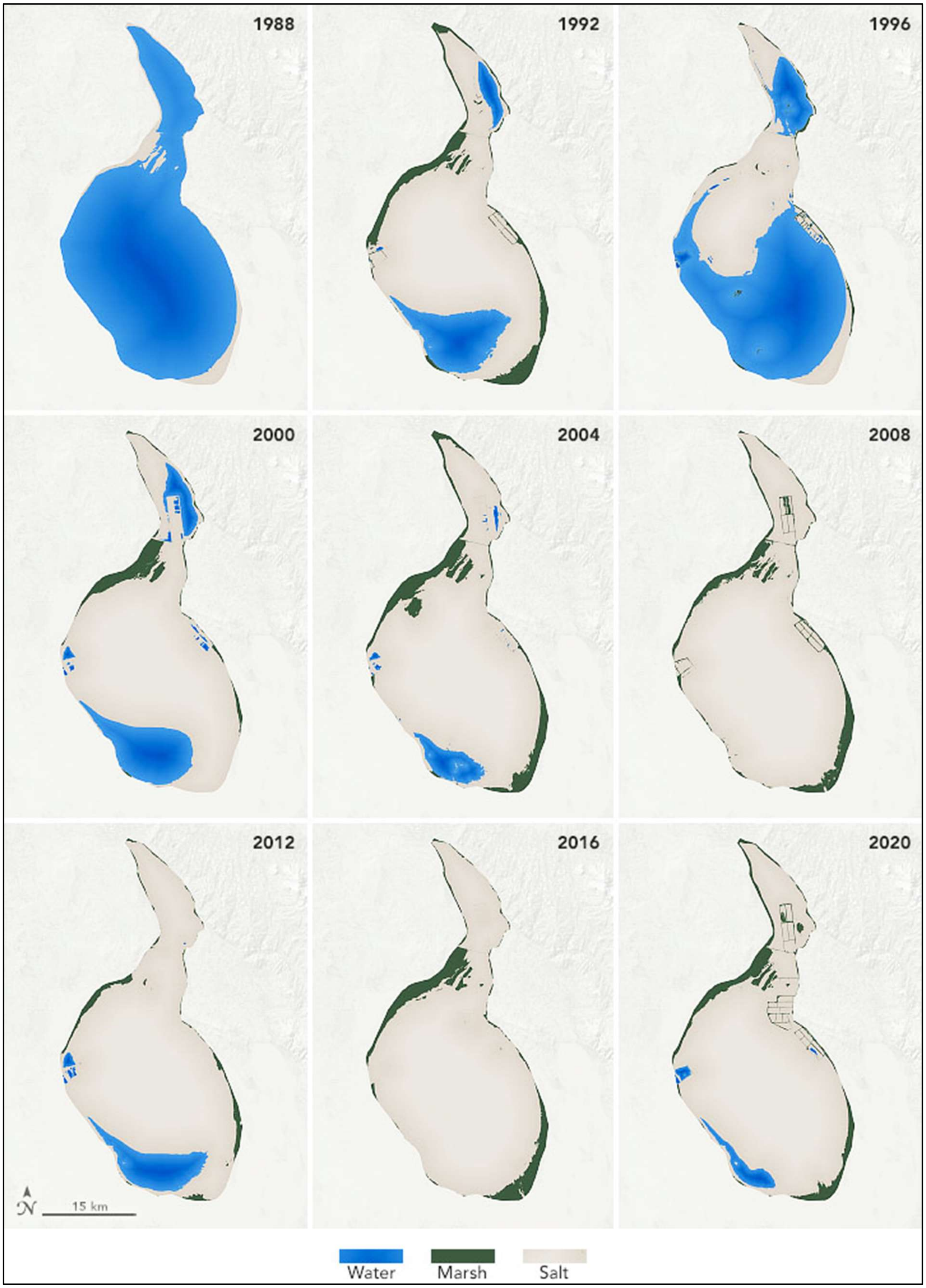
TROPICS (Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats) consists of six small satellites (each about the size of a loaf of bread) designed to monitor tropical cyclones with their miniaturized microwave radiometers. Traveling in pairs in three different orbits, the small fleet will collect data on a storm's precipitation, temperature, and humidity - providing near-real-time measurements. The six TROPICS satellites, deployed in pairs, should be in place by the end of July.

EMIT (Earth Surface Mineral Dust Source Investigation) is a mission to map dust in the Earth's atmosphere, identify where it originates, and estimate its composition so that scientists can better understand how this aerosol affects the planet's air quality and energy balance (darker, iron-laden minerals can absorb energy and contribute to environmental heating while lighter, clay-containing particles scatter light). EMIT will use an imaging spectrometer that measures visible and infrared light reflecting from surfaces below and will be installed on the International Space Station.

JPSS (Joint Polar Satellite System) is a collaborative program between the National Oceanic and Atmospheric Administration (NOAA) and NASA. As the Earth rotates under these satellites in polar orbit, they can observe every part of the planet at least twice a day, capturing data on temperature and moisture in the atmosphere along with the ocean surface temperature. The information collected by JPSS-2, and other members of the satellite constellation, will be used to predict extreme weather conditions, and assist first responders in planning an effective response to floods, wildfires and other weather/climate driven calamities.

SWOT (Surface Water and Ocean Topography) will aid scientists in determining how much water the Earth's oceans, lakes and rivers contain and the effects of climate change on their ability to absorb heat and greenhouse gases like carbon dioxide. A collaboration between NASA and the French space agency Centre National d'Etudes Spatiales, with contributions from the Canadian Space Agency and the United Kingdom Space Agency, the satellite is scheduled for launch in November 2022. It will use a Ka-band Radar Interferometer to bounce radar pulses off the water's surface. The return signals, collected by two different antennas, will be used to accurately determine water height and monitor changes in level and flow.

NASA has leveraged its vantage point from space to monitor global weather, track vital resources, such as fresh water and clean air, and record long-term changes to the climate and the Earth's rising temperature and sea level. With this information, scientists can better ascertain the role of human activity, potentially identify mitigating strategies, as well as ways that we might adapt in a very different future.



Lake Tuz, at one time the second-largest lake in Turkey, over time in August. Credit: NASA Earth Observatory images by Joshua Stevens, using Landsat data from the U.S. Geological Survey and data courtesy of Aydin, F., Erlat, E., & Türkeş, M

Lake Tuz is a saline lake located on the Central Anatolia plateau, about 90 miles (150 km) south-southeast of Ankara. The lake is fed by groundwater, two major streams and springtime rains. The images of the lake every few years (previous page) are from annual maps developed from Landsat satellite data. In recent years, the lake has all but disappeared (along with its wild life) due to more frequent and intense droughts, the diversion of inlet water for irrigations and the extraction of the groundwater to meet the needs of the local population.

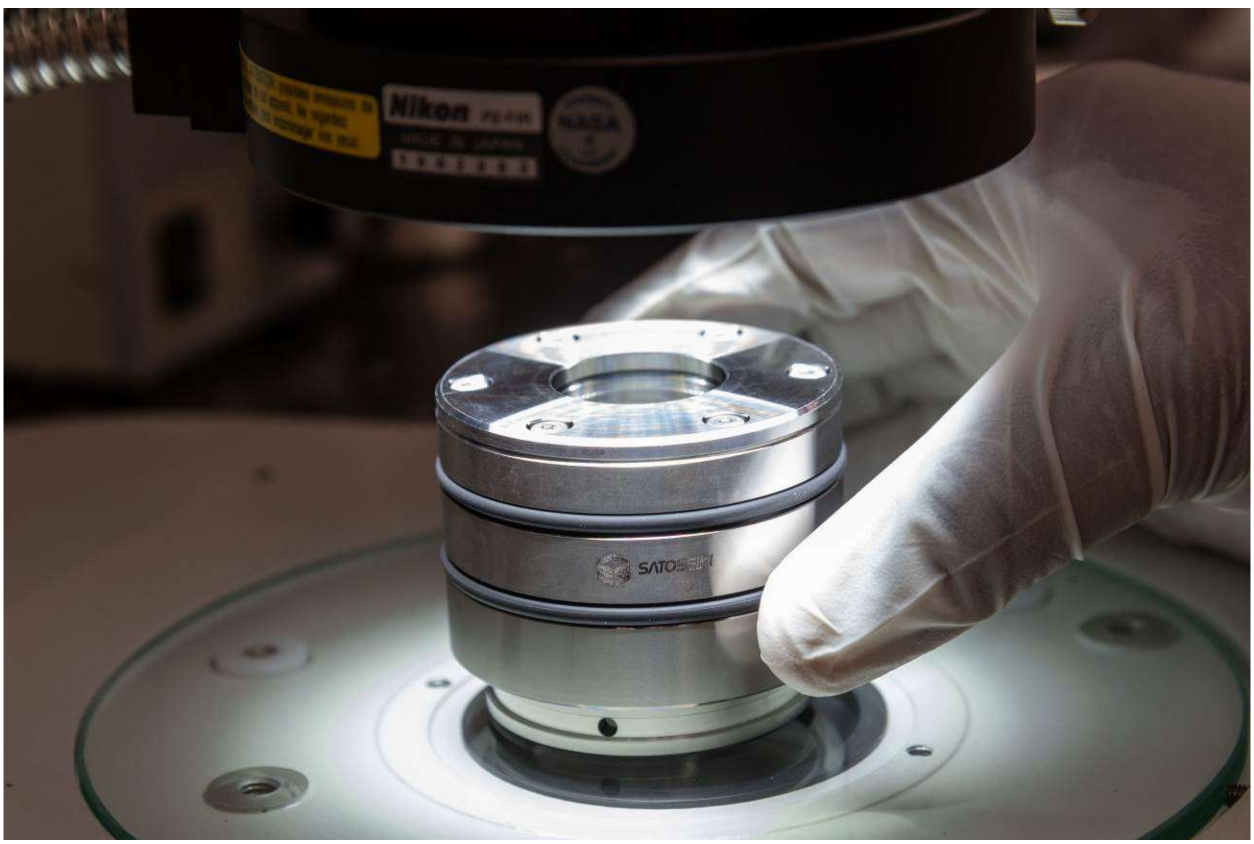
The Mediterranean Basin is considered a global hotspot. The area has warmed more since the pre-industrial period compared to the global average (1.5°C/2.7°F as compared to 1.1°C/2.0°F).

Ryugu Samples Delivered

The Japan Aerospace Exploration Agency (JAXA) and NASA are collaborating on their sample-return missions to the carbonaceous asteroids Ryugu and Bennu, respectively. The agencies are sharing a percentage of the samples collected by the two spacecraft (Hayabusa2 and OSIRIS-REx).

JAXA launched Hayabusa2 in December 2014, arriving at the asteroid Ryugu three and a half years later. During its 17-month stay in orbit, the spacecraft deployed several rovers and a small lander to the asteroid's surface. In February 2019, an impactor was deployed to create an artificial crater, allowing Hayabusa2 to retrieve a fresh sample unaltered by space weather (solar wind and cosmic radiation). The spacecraft delivered that sample to Earth in December 2020.

In late November 2021, JAXA delivered 23 millimeter-sized grains and 4 containers of even finer material from Ryugu (10 percent of the total collected) to the Astromaterials Research and Exploration Science (ARES) Division at NASA's Johnson Space Center in Houston. In exchange, NASA will provide JAXA a percentage of the sample collected from Bennu when OSIRIS-REx returns its payload to Earth in September 2023.



Canister containing Ryugu sample
Credits: NASA/Robert Markowitz

The ARES facility includes a state-of-the-art laboratory for studying extraterrestrial materials. It houses an extensive collection of material from asteroids, comets, Mars, the Moon, Sun, and dust from the solar system. NASA is currently expanding and upgrading the facility, which should be compete in time to receive the OSIRIS-REx samples. The agency is also planning on working with JAXA on their mission to retrieve samples from one of the Martian moons, Phobos or Deimos (the MMX or Martian Moon Exploration) sometime around 2029.

Starship Update

Starship and the
Super Heavy booster
on Orbital Platform
Credit: SpaceX

The Federal Communications Commission (FCC) has granted SpaceX a license to conduct an experimental orbital demonstration and recovery test of its Starship rocket in the first quarter of 2022. The launch is contingent, however, upon the Federal Aviation Administration's (FAA or lead agency) completion of a Programmatic Environmental Assessment (and a finding of no significant impact). The assessment, which is not as comprehensive as an environment impact study, is a broad review of the effects of the launch on the local area (air quality, visual effects, noise, resources, pollution) and other potential issues/consequences such as debris recovery. Should the FAA determine that a full study be required, Space X could incur significant delays in getting Elon Musk's Mars Starship operational. The agency issued a draft assessment in September for public comment and has targeted the end of February for the completion of its review.

Mating of the Starship (Serial No. 20) with the Super Heavy booster during a fit check
Image credit: Elon Musk/Twitter

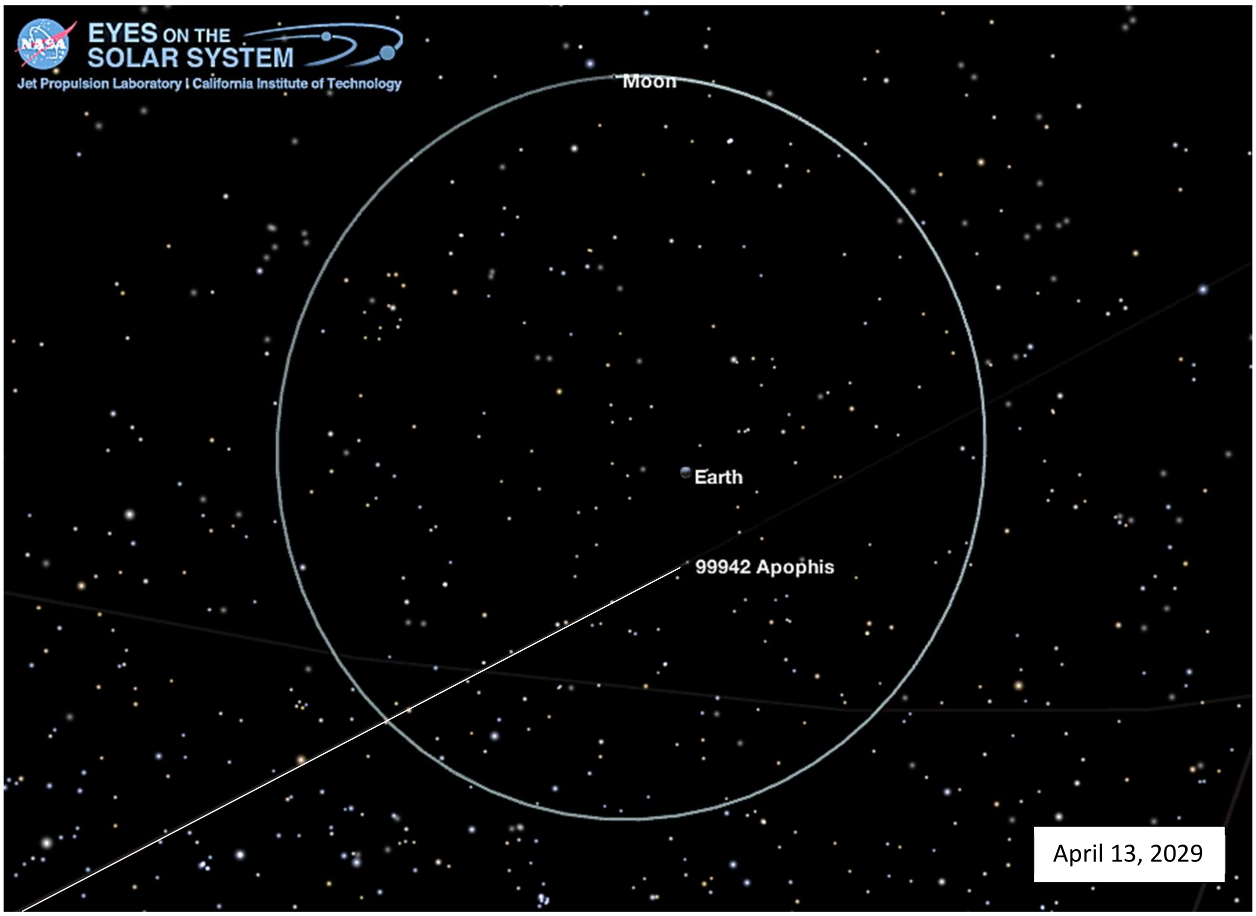
The Super Heavy booster (first stage) stands 230 feet (70 meters) tall and will be powered by up to 32 methane-powered Raptor engines (with a liquid oxygen oxidizer). The Starship, with its six Raptors, adds another 165 feet (50 m) of height for a total of 395 feet (120 m). By comparison, the tallest rocket to fly, NASA's Saturn V moon rocket, stood 363 feet in height (110 m).

According to the FAA application, the first Starship test flight will launch to orbit atop a Super Heavy booster from the Boca Chica, Texas, site. The Starship will separate from the Super Heavy about 3 minutes into flight with the first stage landing (controlled splashdown) in the Gulf of Mexico, no closer than 19 miles from shore, about 5 minutes later. The Starship will continue into orbit, circling the Earth before coming down 90 minutes later for a controlled landing (powered splashdown) off the coast of Hawaii, approximately 62 nautical miles north of Kauai, in the Pacific Missile Range Facility.

Mission to Apophis

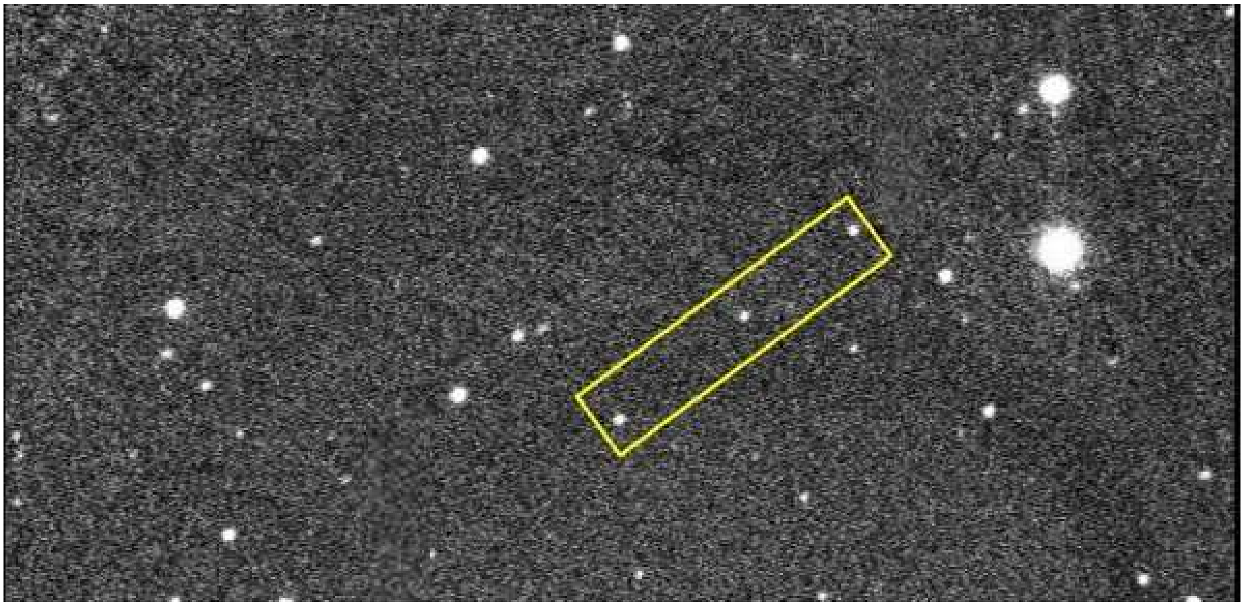
The asteroid 99942 Apophis is classified as "potentially hazardous" due to its Earth-crossing orbit and size (1,120-foot or 340-meter-wide). It was discovered in 2003 and named for the ancient Egyptian demon-serpent god of chaos. The asteroid is believed to be comprised of a mixture of metallic nickel and iron.

While there are no impact solutions in the near future, Apophis the Destroyer will make an uncomfortably close pass to Earth in 2029. On April 13 (a Friday) Apophis will come within 20,000 miles (32,000 km), closer than communications satellites in geostationary orbits. South Korean scientists hope to take advantage of this rare flyby by launching an intercept mission that would follow Apophis during its passage through the Earth-Moon space.



The plan for the South Korean spacecraft would be to map the asteroid and monitor any gravitational affects in the minor planet during its close encounter (physical as well as trajectory). Apophis is currently classified as an "Aten," a group of Earth-crossing asteroids that have an orbit less than 1 astronomical unit or au (the width of Earth's orbit). With the 2029 encounter, the asteroid's orbit will widen to one slightly larger than 1 au, at which time it will be reclassified as a member of the "Apollo" group.

Apophis will first become visible in the night sky on April 13 over Australia (mid-morning on the east coast of the U.S.). It will then cross the Indian Ocean and Africa, moving north across the equator. It will only take an hour to traverse the Atlantic Ocean, passing over the U.S. while still daylight. Closest approach to Earth is just before 6 p.m. EDT.



Apophis' motion in the star field (framed by the yellow box) during its March 5, 2021 encounter (captured at 5-minute intervals) at a distance of 10.5 million miles (17 million km) Credit: M. Robson and B. Cloutier, McCarthy Observatory

NEODyS-2

Near Earth Objects - Dynamic Site

Sponsored by esa SpaceDyS

932-John J. McCarthy Obs., New Milford

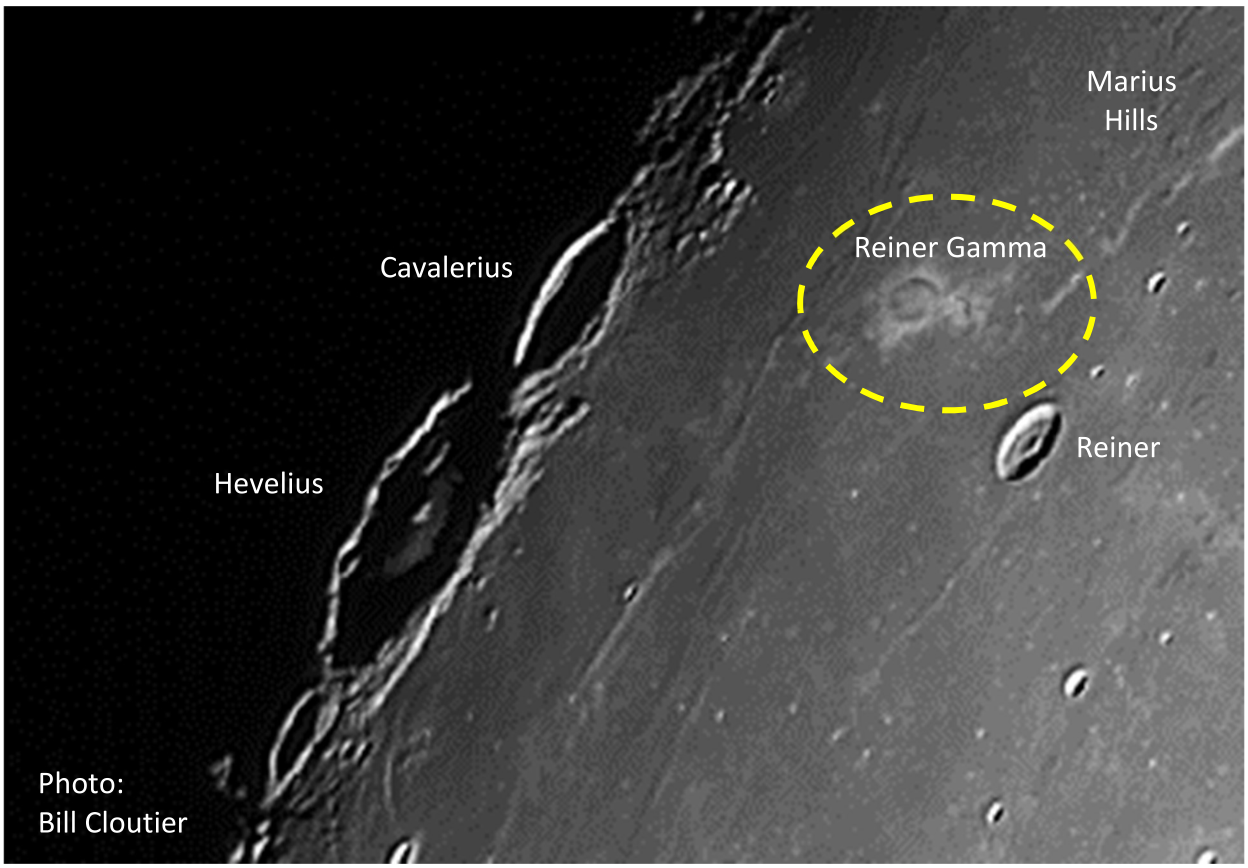
Designation	T	Tech	N	Date yr-mo-day	Date precision	Apparent Magnitude mag/col	Apparent Magnitude rms	Apparent Magnitude residual	Star Catalog	Site code	χ	Used A	Used M
Apophis	O	C	K	2021-03-03.09499	1.000E-05	15.2 R	0.70	0.09	S	932	0.36	Yes	Yes
Apophis	O	C	K	2021-03-03.10409	1.000E-05	15.2 R	0.70	0.09	S	932	0.02	Yes	Yes
Apophis	O	C	K	2021-03-03.11401	1.000E-05	15.3 R	0.70	0.19	S	932	0.16	Yes	Yes
Apophis	O	C	K	2021-03-06.01157	1.000E-05	14.8 R	0.70	-0.37	S	932	0.17	Yes	Yes
Apophis	O	C	K	2021-03-06.02382	1.000E-05	14.8 R	0.70	-0.38	S	932	0.28	Yes	Yes
Apophis	O	C	K	2021-03-06.03607	1.000E-05	14.8 R	0.70	-0.38	S	932	0.11	Yes	Yes
Apophis	O	C	K	2021-03-08.01156	1.000E-05	14.9 R	0.70	-0.35	S	932	0.25	Yes	Yes
Apophis	O	C	K	2021-03-08.02026	1.000E-05	15.0 R	0.70	-0.25	S	932	0.19	Yes	Yes
Apophis	O	C	K	2021-03-08.03192	1.000E-05	15.0 R	0.70	-0.25	S	932	0.06	Yes	Yes
Apophis	O	C	K	2021-03-10.05803	1.000E-05	15.0 R	0.70	-0.34	S	932	0.17	Yes	Yes
Apophis	O	C	K	2021-03-10.07855	1.000E-05	15.2 R	0.70	-0.14	S	932	0.10	Yes	Yes
Apophis	O	C	K	2021-03-10.12061	1.000E-05	15.4 R	0.70	0.06	S	932	0.25	Yes	Yes

Until recently, there was a slight chance that Apophis would impact the Earth in 2068. Additional observations during the March 2021 encounter, including radar observations by the Goldstone and Green Bank radio telescopes, have now ruled out such an event. The McCarthy Observatory contributed to the refinement of Apophis' orbit with observations submitted to the Minor Planet Center on several different nights (above).

Lunar Swirls

The Moon is reluctant to give up her secrets. Across the lunar surface there are light-colored patches that appear to be associated with localized, magnetic anomalies (which may explain the absence of weathering from the solar wind and their higher albedo as compared to adjacent areas). Called "lunar swirls," their origin is the subject of many theories, including ones that invoke impact debris or volcanism, but for now, how the swirls came to be remain one of the Moon's more enduring mysteries.

Reiner Gamma is one of the most prominent swirls and easiest to locate for Earth-bound observers. The diameter of the tadpole-shaped swirl is listed at 45.6 miles or 73.4 km and is located on the western edge of Oceanus Procellarum, not far from the lunar equator and the Marius Hills (an extensive field of volcanic domes). It is best seen in days preceding a Full Moon.



In June 2021, NASA selected three new scientific investigation payloads to be delivered to the lunar surface as part of the agency's Commercial Lunar Payload Services. One of the three, called Lunar Vertex ("Vertex" comes from the Latin for "whirl" or "eddy"), is destined for Reiner Gamma. The payload consisting of a lander and small rover will take magnetic and spectral measurements in an effort to determine the origin of lunar swirls. The solar-powered mission will last just one lunar day (14 Earth days) as it won't be designed to survive the lunar night.

NASA awarded Intuitive Machines of Houston a contract to deliver Lunar Vertex to the Moon in 2024, along with three other science investigations and technology demonstrations; Cooperative Autonomous Distributed Robotic Exploration, MoonLIGHT and Lunar Space Environment Monitor.

Therapeutic Sleeping Bag

Astronauts that spend any extended time in space are at risk of developing a condition called Spaceflight-Associated Neuro-Ocular Syndrome or SANS. The condition is caused by a shift of bodily fluids from the lower body to the head – creating pressure on the back of the eye. The pressure flattens the back of the eye, causes swelling of the optic nerve, choroidal and retinal folds, cotton wool spots, and overall vision impairment. SANS, just one of the medical problems linked to microgravity, progressively worsens with time, a real concern for long duration spaceflight, for example, to Mars.

Dr Benjamin Levine, professor of internal medicine at University of Texas (UT) Southwestern Medical Center in Dallas has been exploring different ways of "unloading" the cranial pressure. Since the effects of weightlessness on the human body are difficult to measure on Earth, Dr. Levine recruited cancer survivors for his study that still had ports in their heads used to deliver chemotherapy drugs. The ports provided access for the instrumentation that allowed researchers to measure brain pressure during parabolic aircraft flights that simulated zero-gravity.

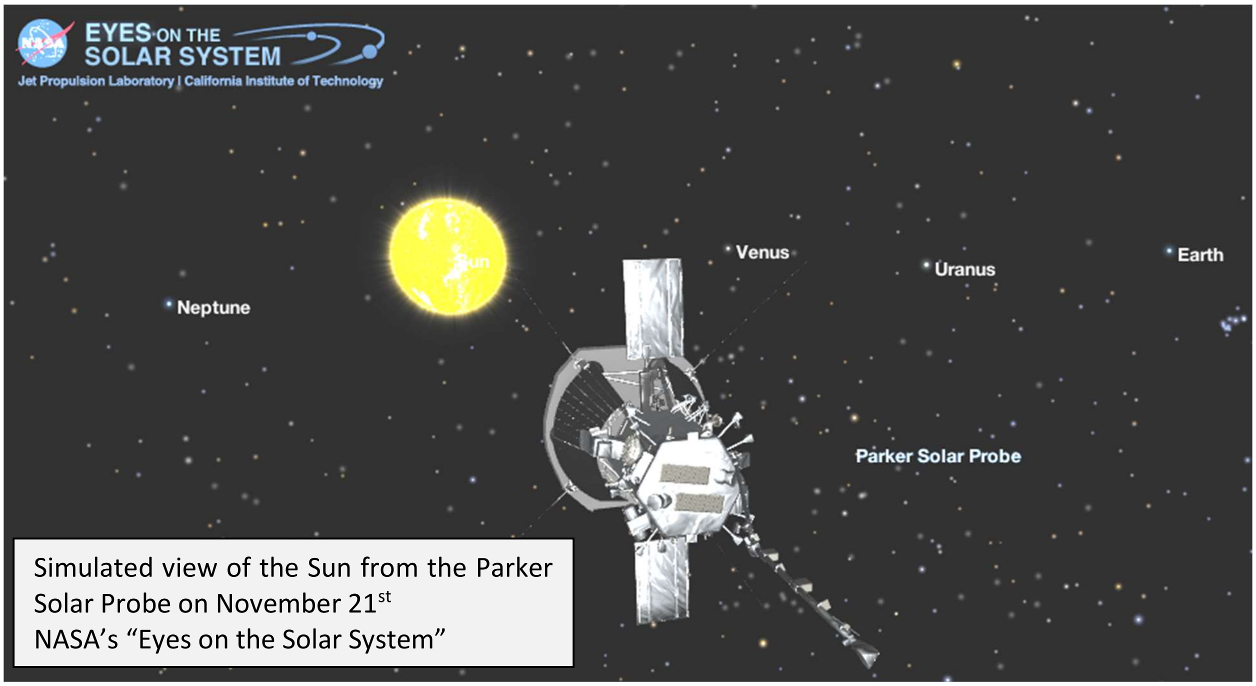
Working with REI, the outdoor retail co-op and recreational equipment manufacturer, researchers designed a sleeping bag that fits around the waist and encloses a person's lower body. A suction device creates a pressure differential that draws fluid down from the brain towards the feet. Dr. Levin is working on having the high-tech sleeping bag deployed on the International Space Station so they can determine its effectiveness, the optimal amount of time needed in the sleeping bag to ward off SANS, and whether it has other medical benefits.

Volunteer in the Negative-Pressure Sleeping Bag
Photo: UT Southwestern Medical Center

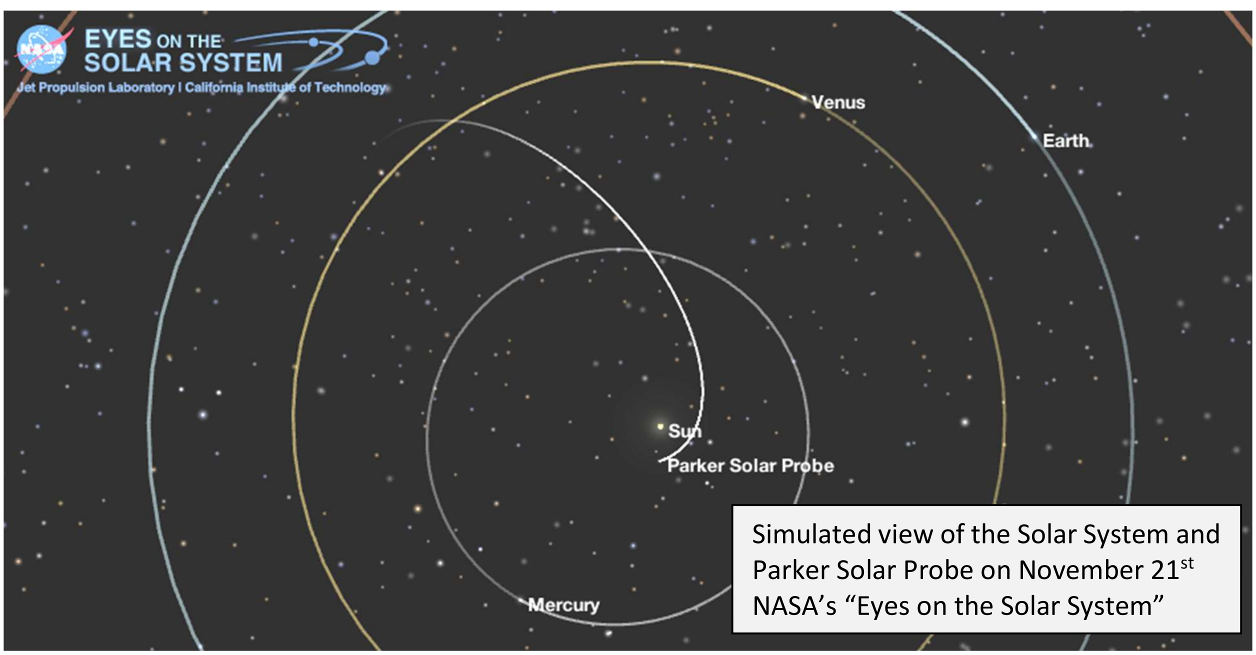
Researchers have also found that the heart shrinks in microgravity. This can lead to a condition called atrial fibrillation (an irregular heart beat). Dr. Levine's sleeping bag also may be effective in reducing that risk by counteracting the abnormal blood flow.

Perihelion No. 10

On November 21, 2021, NASA's Parker Solar Probe completed its 10th close approach to the Sun (known as perihelion), coming within 5.3 million miles (8.5 million km) of the solar surface (defined as the photosphere). Closest approach (a record distance) occurred at 4:25 a.m. EST, with the spacecraft moving 364,660 miles per hour (586,864 kph). Data from the close encounter (structure of the solar wind, as well as the dust environment around the Sun) will be transmitted back to Earth in late December/early January.



Simulated view of the Sun from the Parker Solar Probe on November 21st
NASA's "Eyes on the Solar System"



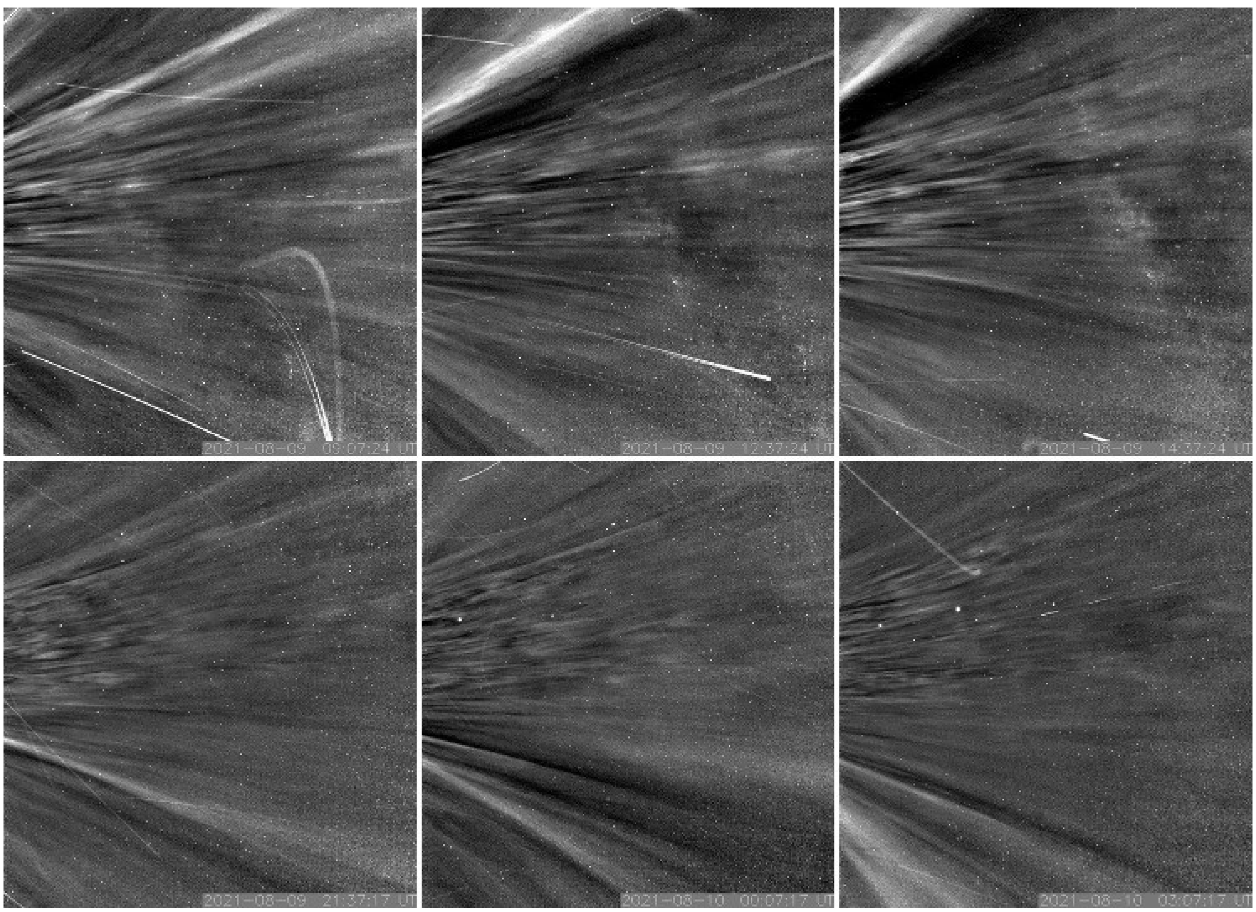
Simulated view of the Solar System and Parker Solar Probe on November 21st
NASA's "Eyes on the Solar System"

The Parker Solar Probe is expected to operate through 2025 and complete as many as 24 flybys – getting successively closer to the Sun as the mission progresses (ultimately as close as 4 million miles or 6 million km).

Notwithstanding the extraordinary achievements of the mission to date - contrary to the melodramatic news' headlines, the Parker Solar Probe **has not** "touched the Sun." What it has accomplished is no less remarkable.

During encounter 8 in April 2021, the spacecraft briefly crossed a somewhat imprecise boundary known as the "Alfvén Point" (named for the Swedish plasma physicist Hans Alfvén) at a distance of 8.1 million miles (13 million km) from the Sun's photosphere. Since then, it has passed through the boundary twice more, during the August and November close approaches.

Also referred to as the threshold between the "open" and "closed" solar atmosphere, inside the Alfvén Point (closer to the Sun), material and waves both rise up and fall back onto the surface – bound by Sun's gravity and magnetic forces. Beyond the Alfvén Point, there is no exchange of energy and momentum with the Sun. This transition region is where magnetic switchbacks are believed to originate (rotations in the Sun's magnetic field). The switchbacks are thought to be associated with the "fast" solar wind (plasma comprised mainly of protons and electrons) that flows from the Sun throughout the solar system.



Coronal streamers (bright features moving upward in the upper images and angled downward in the lower row) inside the corona. Streamers are loops of electrically charged gas and plasma that connect two regions of opposite polarity, anchored on the Sun and extended by the solar wind. While visible from Earth during total solar eclipses, this is the first up close view of the massive structures.

Credits: NASA/Johns Hopkins APL/Naval Research Laboratory

Explorer 1

Sixty-four years ago, on January 31, 1958, the United States successfully launched its first satellite, Explorer 1. The launch occurred during the International Geophysical Year, a global initiative which actually ran from July 1957 to December 1958 and coincided with the peak in the 11-year solar cycle. Unlike Sputnik 1, which had been launched by the Soviet Union in October of 1957 and designed to only broadcast radio pulses (or Sputnik 2 which carried a dog into space as a crude biological demonstration), Explorer 1 carried a suite of instruments to study cosmic rays, micrometeoroids, and the satellite's temperature. It was the first artificial satellite designed to return scientific data.

The launch of Explorer 1 followed the unsuccessful launch of a U.S. satellite on a Navy Vanguard rocket in December (the rocket fell back to the pad and exploded shortly after liftoff). Following the humiliating loss of Vanguard, which was widely publicized by the Soviets, the competing Army's rocket team (headed by Wernher von Braun) offered their Jupiter C ballistic missile as an alternative launch vehicle. Teamed with the Jet Propulsion Laboratory (JPL) which designed and constructed the satellite and James Van Allen who designed the cosmic ray detector, the 31-pound (14 kg) satellite was successfully placed into an orbit around Earth with an apogee of 1,563 miles (2,515 km) and a perigee of 220 miles (354 km).

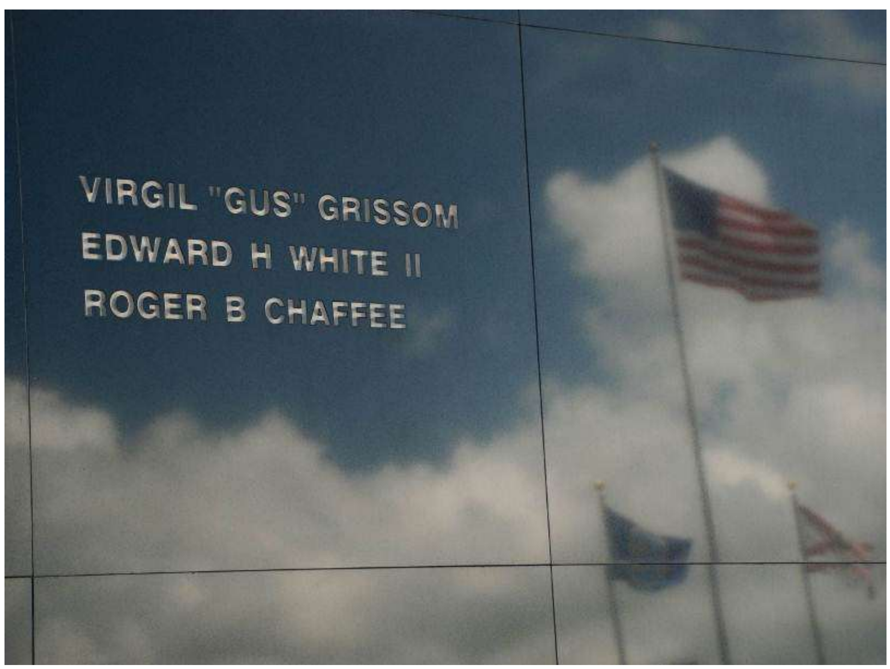
L to R: Pickering, Van Allen and von Braun
Credit: NASA

During a 1:00 am press conference at the National Academy of Sciences on February 1, shortly after the successful night launch of Explorer 1, the three team leaders Bill Pickering (JPL), James Van Allen (State University of Iowa) and Wernher von Braun (Army's Redstone Arsenal) celebrate by holding aloft a model of the satellite.

Explorer 1 would end up completing more than 58,000 orbits before reentering the Earth's atmosphere on March 31, 1970. The lower-than-expected counts recorded by the cosmic ray detector led Van Allen to theorize that the instrument had been affected by charged particles trapped by the Earth's magnetic field. The existence of two and sometimes three toroidal "radiation belts" encircling the Earth were later confirmed by subsequent missions and named the Van Allen Belts.

In August 2012, NASA launched the Van Allen Probes to study this dynamic region of space (http://vanallenprobes.jhuapl.edu/). With two identical spacecraft, traveling in tandem, scientists were able to measure changes in the belts over time and space. The probes have provided researchers a new understanding of how the belts respond to fluctuations in the Sun's output. The two-year mission was later extended to seven years as the probes continued to return ground-breaking results. The orbits of the two probes were lowered in 2019, before they ran out of fuel, to ensure that they would eventually burn up in the Earth's atmosphere and not add to the growing orbital debris fields that pose hazards to spacecraft and space travelers. NASA's mission to explore Earth's radiation belts ended when ground controllers shut down the first probe in July 2019 and the second in October.

January History

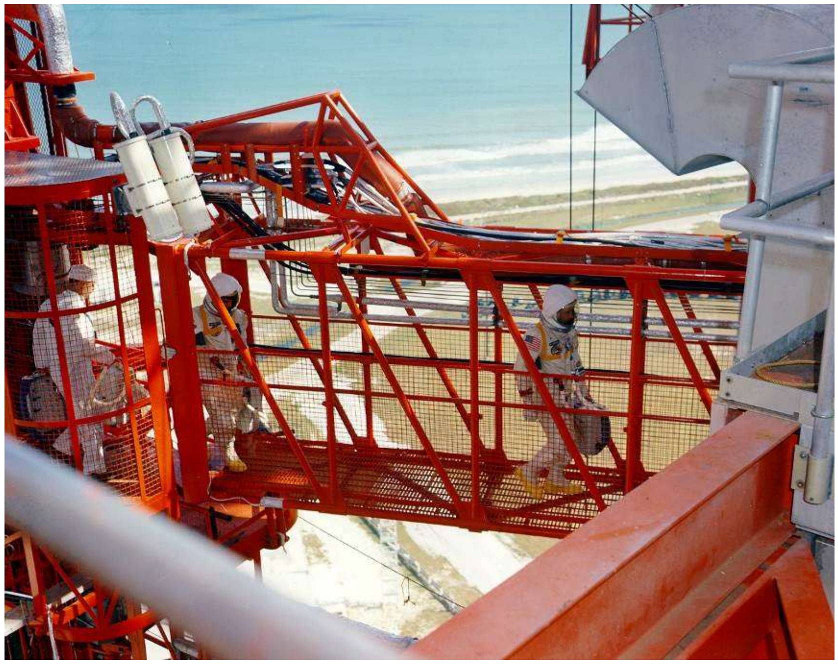


Space Mirror Memorial on the grounds of the Kennedy Space Center Visitor Complex Photo: Bill Cloutier

The month of January has been a difficult one for both the American and Soviet space programs. Untimely deaths set back both the American and Soviet moon programs. The two space shuttles that have been lost were also launched in January.

Sergei Korolyov, the "Chief Designer" of the Soviet space program, died on January 14, 1966 from a botched medical procedure. Korolyov co-founded the Moscow rocketry organization in the 1930s before being thrown into prison during the peak of Stalin's purges. He spent a year in the Kolyma gold mine, the most dreaded part of the Gulag in Siberia before he was recalled to Moscow to aid the Red Army in developing new weapons. Korolyov went on to lead the Soviet space effort.

Unfortunately, the Soviet Moon program died with Korolyov in 1966. While the race continued for some time after his death, his N-1 moon rocket never made a successful flight.



The crew of Apollo 1 crosses the gantry to the spacecraft on the day of the fire, Jan. 27, 1967 Credit: NASA

In January of 1967, after a successful conclusion to the Gemini program, NASA was moving forward with testing the new Apollo spacecraft. On the afternoon of the 27th, Gus Grissom, Ed White and Roger Chaffee were sealed inside the Apollo 1 command module sitting on top of an unfueled Saturn rocket in a simulated countdown. The command module had been plagued with problems and was in a state of constant redesign. At 6:31 pm, a spark from a damaged wire ignited the pure oxygen atmosphere in the spacecraft. Within seconds the temperature reached 2,500°. The astronauts never had a chance to undo the bolts of the hatch before they were asphyxiated. Following their deaths, the spacecraft was completely redesigned. Lessons learned from this accident served to make the spacecraft much safer and contributed to the success of the six moon landings.

Thirty-six years ago, on January 28, 1986, the United States lost its first space shuttle, the Challenger. Due to the low temperature on the launch pad, a rubber-like O-Ring used to seal the joints of the solid rocket boosters failed to seat and stop the hot gasses from escaping. The gas produced a blowtorch-like flame that penetrated the external tank filled with liquid oxygen and hydrogen. The tank exploded 73 seconds after liftoff, destroying the shuttle and killing all seven crew members. Among the crew was Christa McAuliffe, a New Hampshire teacher. Christa graduated from Framingham State College (Framingham, Massachusetts) in 1970. Following her death, the college established *The Christa McAuliffe Center* on the campus as a means to continue the educational mission which was Christa's life's work.

On February 1, 2003, a second space shuttle, the Columbia, was lost. The Columbia was the oldest shuttle in the fleet, having been first flown in 1981 by astronauts John Young and Robert Crippen. On its 28th flight, Columbia broke apart during reentry at an altitude of some 200,000 feet and a speed of 12,500 miles per hour. The shuttle and its crew of seven had just completed a 16-day science mission. The most likely cause of the accident was damage to a seal on the left wing from a piece of insulating foam that broke loose from the external fuel tank at launch, striking the wing. The resulting gap in the wing allowed the superheated atmosphere to penetrate the wing during reentry and destroy the spacecraft. The Columbia accident ultimately led to the decision to stop flying the space shuttle once the International Space Station was complete and spurred efforts to develop a safer manned vehicle.

The "Forever Remembered" memorial in the Space Shuttle Atlantis exhibit at the Kennedy Space Center Visitor Complex in Florida. Visitors entering the darkened room will see a section of the fuselage recovered from space shuttle Challenger (left) and the flight deck window frames recovered from the space shuttle Columbia.

Photo: Bill Cloutier

January Nights

January nights can be clear and cold with frigid blasts of polar wind. They also present an opportunity to see stars at every stage in their life cycle, from birth (Orion Nebula) to fiery demise (Crab supernova remnant).

If you are out observing the open star clusters Pleiades or Hyades (in mythology, half-sisters to the Pleiades) in the constellation Taurus, don't overlook the orange-colored star Aldebaran (spectral type of K5 with a surface temperature of 4,010° K as compared to the Sun's 5,780° K temperature). While not part of the Hyades cluster (which is more than twice as far away as the red giant), the "eye of the bull," and the brightest star in Taurus, is estimated to be about 67 light years away and the fourteenth brightest star in our sky.

Sunrise and Sunset (from New Milford)

Sun	Sunrise	Sunset
January 1st (EST)	07:19	16:32
January 15th	07:16	16:47
January 31st	07:05	17:06

Astronomical and Historical Events

1st Moon at perigee (closest distance from Earth)
1st History: flyby of the Kuiper Belt Object 486958 *Arrokoth* (2014 MU69) by the New Horizons spacecraft (2018)
1st History: GRAIL-B spacecraft enters lunar orbit (2012)
1st History: Giuseppe Piazzi discovers the first asteroid, now dwarf planet, *Ceres* (1801)
2nd New Moon
2nd History: flyby of comet *Wild 2* by the Stardust spacecraft (2004)
2nd History: launch of the Soviet spacecraft Luna 1; first probe to fly by the Moon (1959)
3rd Quadrantids meteor shower peaks; radiates from the constellation Boötes (name from an obsolete constellation called Quadrans Muralis)
3rd Comet C/2021 A1 (*Leonard*) Perihelion (0.615 AU) – closest to the Sun
3rd Asteroid *281 Lucretia* closest approach to Earth (1.036 AU)
3rd Apollo Asteroid *1863 Antinous* closest approach to Earth (2.436 AU)
3rd History: exploration rover Spirit lands on Mars in Gusev Crater; operational for six years before getting bogged down in loose soil at a winter haven called Troy (2004)
3rd History: Stephen Synnott discovers Uranus' moons *Juliet* and *Portia* (1986)
4th Earth at Perihelion – closest distance from Sun (0.983 AU)
4th History: Isaac Newton born; inventor of the reflecting telescope, described universal gravitation, compiled the laws of motion, and invented calculus (1643)
5th History: discovery of dwarf planet *Eris* (the Pluto killer) by Mike Brown, et al. (2005)
5th History: President Nixon announces the development of the space shuttle; "a space vehicle that can shuttle repeatedly from Earth to orbit and back" (1972)
5th History: launch of the Soviet atmospheric probe, Venera 5, to Venus (1969)
5th History: discovery of Jupiter's moon *Elara* by Charles Perrine (1905)
6th Aten Asteroid 2014 YE15 near-Earth flyby (0.049 AU)
6th History: launch of the Lunar Prospector spacecraft; detected signs of water ice in permanently shadowed craters, mapped surface composition and Moon's gravity field and detected outgassing events in the vicinity of craters Aristarchus and Kepler (1998)
6th History: launch of Surveyor 7, the last of the unmanned Surveyor spacecrafts; soft-landed near Tycho crater (1968)
7th Mercury at its Greatest Eastern Elongation (19°) – apparent separation from the Sun in the evening sky
7th Apollo Asteroid 2020 AP1 near-Earth flyby (0.012 AU)
7th Apollo Asteroid 410777 (2009 FD) closest approach to Earth (1.433 AU)
7th Kuiper Belt Object 2014 WP509 at Opposition (41.862 AU)
7th History: discovery and first recorded observations of Jupiter's four largest moons *Io*, *Europa*, *Ganymede* and *Callisto* by Galileo Galilei (1610)
8th Second Saturday Stars – Open House at the McCarthy Observatory, 7 PM
8th History: launch of Japanese spacecraft Sakigake with mission to rendezvous with Comet *Halley*; measured the solar wind and magnetic field (1985)
8th History: launch of Luna 21 and the Lunokhod 2 moon rover (1973)
8th History: Stephen Hawking born (exactly 300 years after the death of Galileo); discovered that black holes could emit radiation - subsequently known as Hawking radiation (1942)
9th First Quarter Moon
9th Apollo Asteroid *3671 Dionysus* closest approach to Earth (2.411 AU)

Astronomical and Historical Events (continued)

9th History: Alex Wolszczan and Dale Frail discover two exoplanets (Poltergeist and Phobetor) orbiting a pulsar PSR B1257+12 (1992)
9th History: Voyager 2/Stephen Synnott discovers Uranus' moon *Cressida* (1986)
10th Aten Asteroid 341843 (2008 EV5) closest approach to Earth (0.793 AU)
10th Apollo Asteroid *4450 Pan* closest approach to Earth (0.819 AU)
10th History: launch of the Soviet atmospheric probe, Venera 6, to Venus (1969)
10th History: U.S. Army first bounces radio waves off the Moon (1946)
11th Apollo Asteroid 2013 YD48 near-Earth flyby (0.037 AU)
11th Asteroid *5392 Parker* closest approach to Earth (0.786 AU)
11th Atira Asteroid 481817 (2008 UL90) closest approach to Earth (1.111 AU)
11th Binary Amor Asteroid *15745 Yuliya* closest approach to Earth (1.164 AU)
11th History: Lunar Prospector spacecraft enters lunar orbit for a nineteen-month chemical mapping mission (1998)
11th History: William Herschell discovers Uranus' moons *Titania* and *Oberon* (1787)
12th Atira Asteroid 2013 JX28 closest approach to Earth (0.606 AU)
12th Amor Asteroid *8013 Gordonmoore* closest approach to Earth (1.862 AU)
12th History: launch of the Deep Impact spacecraft for a flyby of comet *Tempel 1*; a small "impactor" was later released from the main spacecraft for a July 4th collision with the comet's nucleus (2005)
12th History: Sergei Pavlovich Korolyov born, Chief Designer of the Soviet space program (1907)
12th History: Astronomical Society of London conceived with Sir William Herschel first President (chartered in 1831 as the Royal Astronomical Society) (1820)
13th Amor Asteroid *9950 ESA* closest approach to Earth (1.765 AU)
13th History: Stephen Synnott discovers Uranus' moons *Desdemona*, *Rosalind* and *Belinda* (1986)
13th History: discovery of the Martian meteorite EETA 79001 in Antarctica; second largest Martian meteorite recovered after *Zagami* (1980)
14th Moon at apogee (furthest distance from Earth)
14th Kuiper Belt Object 230965 (2004 XA192) at Opposition (34.609 AU)
14th History: first of three flybys of the planet Mercury by the Messenger spacecraft (2008)
14th History: landing of the Huygens probe on Saturn's largest moon *Titan* (2005)
15th Apollo Asteroid *3360 Syrinx* closest approach to Earth (3.322 AU)
15th Apollo Asteroid *14827 Hypnos* closest approach to Earth (3.750 AU)
15th History: Stardust spacecraft returns samples of Comet P/*Wild 2* (2006)
15th History: launch of the spacecraft Helios 2, solar orbiter (1976)
15th History: Lunokhod 2, the second of two Soviet unmanned lunar rovers, lands in Le Monnier crater; covered a total distance of 23 miles (37 km) in almost five months of exploring the floor of the crater and its southern rim (1973)
16th History: final launch of space shuttle Columbia (STS-107); lost on re-entry (2003)
17th Full Moon
17th History: Astronomer Edwin Hubble publishes paper that the Universe is expanding – "*A Relation Between Distance and Radial Velocity Among Extra-Galactic Nebulae*" (1929)
17th History: launch of Jason 3, an ocean altimetry satellite from the Vandenberg Air Force Base, California (2016)

Astronomical and Historical Events (continued)

17th History: Pierre Mechain's discovery of Comet 2P/*Encke* (1786); short period comet that completes a circuit around the Sun every 3.3 years, named after Johann Encke who computed the comet's orbit, recognizing it as a periodic comet
18th Apollo Asteroid 7482 (1994 PC1) near-Earth flyby (0.013 AU)
18th Atira Asteroid 2019 AQ3 closest approach to Earth (1.187 AU)
19th History: launch of the New Horizons spacecraft to Pluto; executed a close encounter with the dwarf planet in July 2015 (2006)
19th History: Mars Exploration Rover "Opportunity" discovers first meteorite on Mars (Heat Shield Rock) (2005)
19th History: discovery of the Martian meteorite SAU 090, a basaltic shergottite, in Oman (2002)
19th History: discovery of Saturn's moon *Janus* by the Voyager 1 spacecraft (1980)
19th History: launch of Gemini 2, an unmanned suborbital flight designed to test the spacecraft's heat shield (1965)
19th History: Johann Bode born, popularized an empirical law on planetary distances originally developed by J.D. Titius, known as "Bode's Law" or "Titius-Bode Law" (1747)
20th Atira Asteroid 2010 XB11 closest approach to Earth (0.545 AU)
20th Apollo Asteroid *1566 Icarus* closest approach to Earth (0.803 AU)
20th History: Rich Terrile discovers Uranus' moons *Cordelia* and *Ophelia* (1986)
21st Aten Asteroid 2018 PN22 near-Earth flyby (0.029 AU)
21st Amor Asteroid *4954 Eric* closest approach to Earth (1.227 AU)
21st Amor Asteroid *7336 Saunders* closest approach to Earth (1.739 AU)
21st Centaur Object *52975 Cyllarus* at Opposition (28.216 AU)
21st History: launch of the rocket Little Joe-1B and a rhesus monkey named "Miss Sam" in a successful test of the Mercury capsule's escape system (1960)
21st History: John Couch Adams born, astronomer and mathematician who was the first person to predict the position of a planet beyond Uranus (1792)
22nd Atira Asteroid 2017 YH closest approach to Earth (0.120 AU)
22nd Apollo Asteroid *11311 Peleus* closest approach to Earth (1.508 AU)
22nd Amor Asteroid *3552 Don Quixote* closest approach to Earth (6.268 AU)
22nd Kuiper Belt Object 2018 AG37 at Opposition (132.052 AU)
22nd History: launch of Apollo 5, the first Lunar Module flight (1968)
23rd History: Brad Smith discovers Uranus' moon *Bianca* (1986)
24th Amor Asteroid 2017 XC62 near-Earth flyby (0.048 AU)
24th Apollo Asteroid *12711 Tukmit* closest approach to Earth (0.391 AU)
24th History: launch of space shuttle Discovery (STS-51-C); 100th human spaceflight to achieve orbit (1985)
24th History: discovery of the Martian meteorite Dhofar 019 in Oman (2000)
24th History: launch of Japan's Hiten spacecraft; first use of a low-energy transfer to modify an orbit and the first demonstration of a transfer to the Moon requiring no change in velocity for capture (1990)
24th History: flyby of Uranus by the Voyager 2 spacecraft (1986)
25th Last Quarter Moon
25th Atira Asteroid 2012 VE46 closest approach to Earth (0.425 AU)
25th Amor Asteroid *20460 Robwhiteley* closest approach to Earth (0.562 AU)
25th Apollo Asteroid *137052 Tjelvar* closest approach to Earth (0.970 AU)

Astronomical and Historical Events (continued)

25th History: exploration rover Opportunity lands on Mars at Meridiani Planum; operated for over 14 years before being crippled by a global dust storm in 2018 (2004)
25th History: launch of the Infrared Astronomical Satellite (IRAS); first space telescope to survey of the entire sky at infrared wavelengths (1983)
25th History: launch of the U.S. Moon orbiter Clementine (1994)
25th History: Joseph Lagrange born (1736); mathematician who discovered five special points in the vicinity of two orbiting masses where a third, smaller mass can orbit at a fixed distance from the larger masses. The L1 Lagrange Point of the Earth-Sun system is the current home of the Solar and Heliospheric Observatory Satellite (SOHO), the James Webb Space Telescope is heading for L2 (1 million miles beyond the Earth and away from the Sun).
26th Apollo Asteroid *38086 Beowulf* closest approach to Earth (0.962 AU)
26th Kuiper Belt Object 482824 (2013 XC26) at Opposition (35.644 AU)
26th Kuiper Belt Object *20000 Varuna* at Opposition (43.085 AU)
26th History: discovery of dwarf planet *Haumea*'s moon *Hi'laka* by Mike Brown, et al. (2005)
26th History: discovery of Saturn's moon *Epimetheus* by the Voyager 1 spacecraft (1980)
26th History: launch of the International Ultraviolet Explorer (IUE); space telescope and spectrographs; designed to take ultraviolet spectra (1978)
27th History: fire in the Apollo 1 spacecraft kills astronauts Gus Grissom, Edward White and Roger Chaffee (1967)
27th History: Philibert Melotte discovers Jupiter's moon *Pasiphae* (1908)
28th Apollo Asteroid *3103 Eger* closest approach to Earth (0.537 AU)
28th Amor Asteroid *3988 Huma* closest approach to Earth (1.074 AU)
28th Apollo Asteroid 136617 (1994 CC) (2 Moons) closest approach to Earth (1.903 AU)
28th Plutino 208996 (2003 AZ84) at Opposition (43.143 AU)
28th History: final launch of the space shuttle Challenger (STS-51L); lost on lift-off (1986)
28th History: Johannes Hevelius born; leading observational astronomer of the 17th century, published detailed maps of the Moon and determined the rotational period of the Sun (1611)
29th History: Soviet spacecraft Phobos 2 enter orbit around Mars; successfully returned 38 images before contact was lost; its lander was not deployed (1989)
30th Moon at perigee (closest distance from Earth)
30th Atira Asteroid 2021 PH27 Perihelion (0.134 AU)
30th History: Yuji Hyakutake discovers the Great Comet of 1996 (1996)
31st Apollo Asteroid 65803 *Didymos* closest approach to Earth (0.695 AU)
31st History: launch of SMAP (Soil Moisture Active Passive) satellite into a polar orbit around Earth (2015)
31st History: launch of Apollo 14; third manned moon landing with astronauts Alan Shepard, Stuart Roosa and Edgar Mitchell (1971)
31st History: launch of Soviet Moon lander Luna 9; first spacecraft to land and to transmit photographs from the Moon's surface (1966)
31st History: launch of Mercury-Redstone 2 rocket with Ham the chimpanzee (1961)
31st History: launch of the first U.S. satellite, Explorer 1; detected inner radiation belt encircling the Earth (1958)

Commonly Used Terms

- Apollo: a group of near-Earth asteroids whose orbits also cross Earth's orbit; Apollo asteroids spend most of their time outside Earth orbit.
- Aten: a group of near-Earth asteroids whose orbits also cross Earth's orbit, but unlike Apollos, Atens spend most of their time inside Earth orbit.
- Atira: a group of near-Earth asteroids whose orbits are entirely within Earth’s orbit
- Centaur: icy planetesimals with characteristics of both asteroids and comets
- Kuiper Belt: region of the solar system beyond the orbit of Neptune (30 AUs to 50 AUs) with a vast population of small bodies orbiting the Sun
- Opposition: celestial bodies on opposite sides of the sky, typically as viewed from Earth
- Plutino: an asteroid-sized body that orbits the Sun in a 2:3 resonance with Neptune
- Trojan: asteroids orbiting in the 4th and 5th Lagrange points (leading and trailing) of major planets in the Solar System

References on Distances

- the apparent width of the Moon (and Sun) is approximately one-half a degree (½°), less than the width of your little finger at arm’s length which covers approximately one degree (1°); three fingers span approximately five degrees (5°)
- 1 astronomical unit (AU) is the distance from the Sun to the Earth or approximately 93 million miles

International Space Station and Starlink Satellites

Visit www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and the bright flares from Iridium satellites.

Solar Activity

For the latest on what’s happening on the Sun and the current forecast for flares and aurora, check out www.spaceweather.com

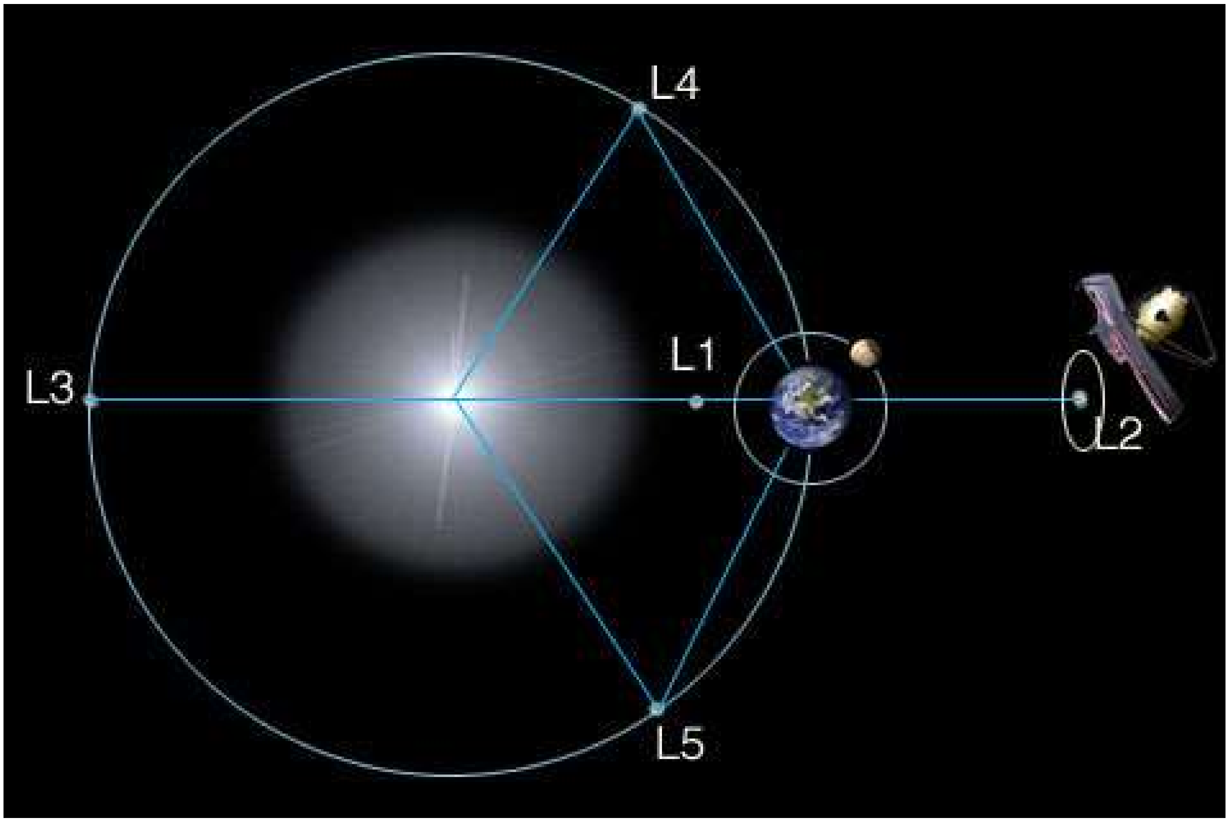
NASA’s Global Climate Change Resource

Vital Signs of the Planet: https://climate.nasa.gov/

James Webb Space Telescope

https://webb.nasa.gov/index.html

Lagrange Points



Five locations discovered by mathematician Joseph Lagrange where the gravitational forces of the Sun and Earth (or other large body) and the orbital motion of the spacecraft are balanced, allowing the spacecraft to hover or orbit around the point with minimal expenditure of energy. The L2 point (and location of the Webb telescope) is located 1 million miles (1.5 million km) beyond the Earth (as viewed from the Sun).

Mars – Mission Websites

Mars 2020 (Perseverance rover): https://mars.nasa.gov/mars2020/

Mars Helicopter (Ingenuity): https://mars.nasa.gov/technology/helicopter/

Mars Science Laboratory (Curiosity rover): https://mars.nasa.gov/msl/home/

Mars InSight (lander): https://mars.nasa.gov/insight/

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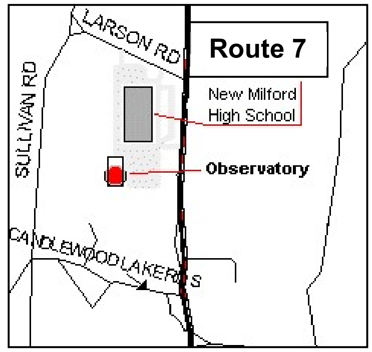

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