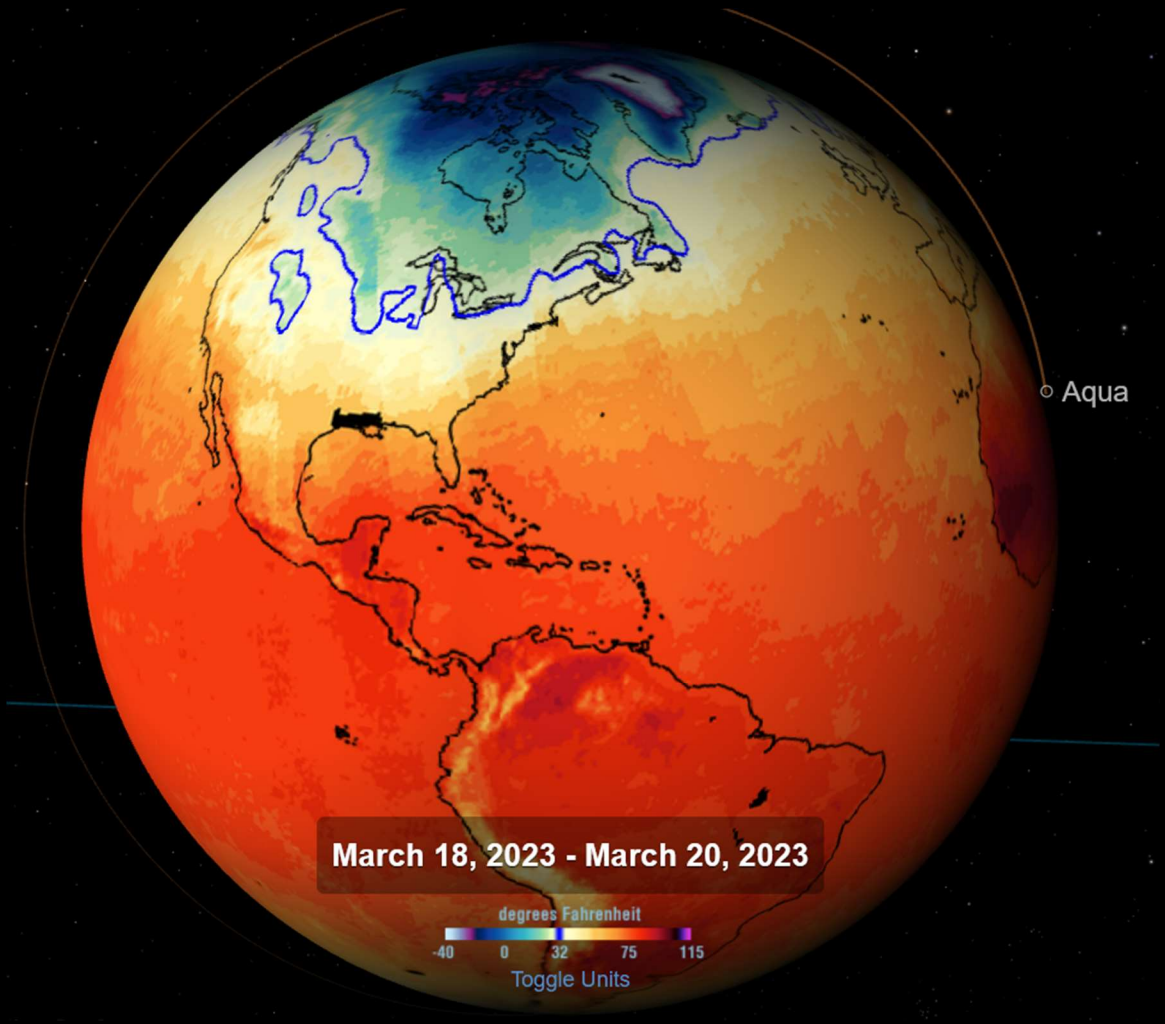
Galactic Observer

John J. McCarthy Observatory

Volume 16, No. 4 April 2023

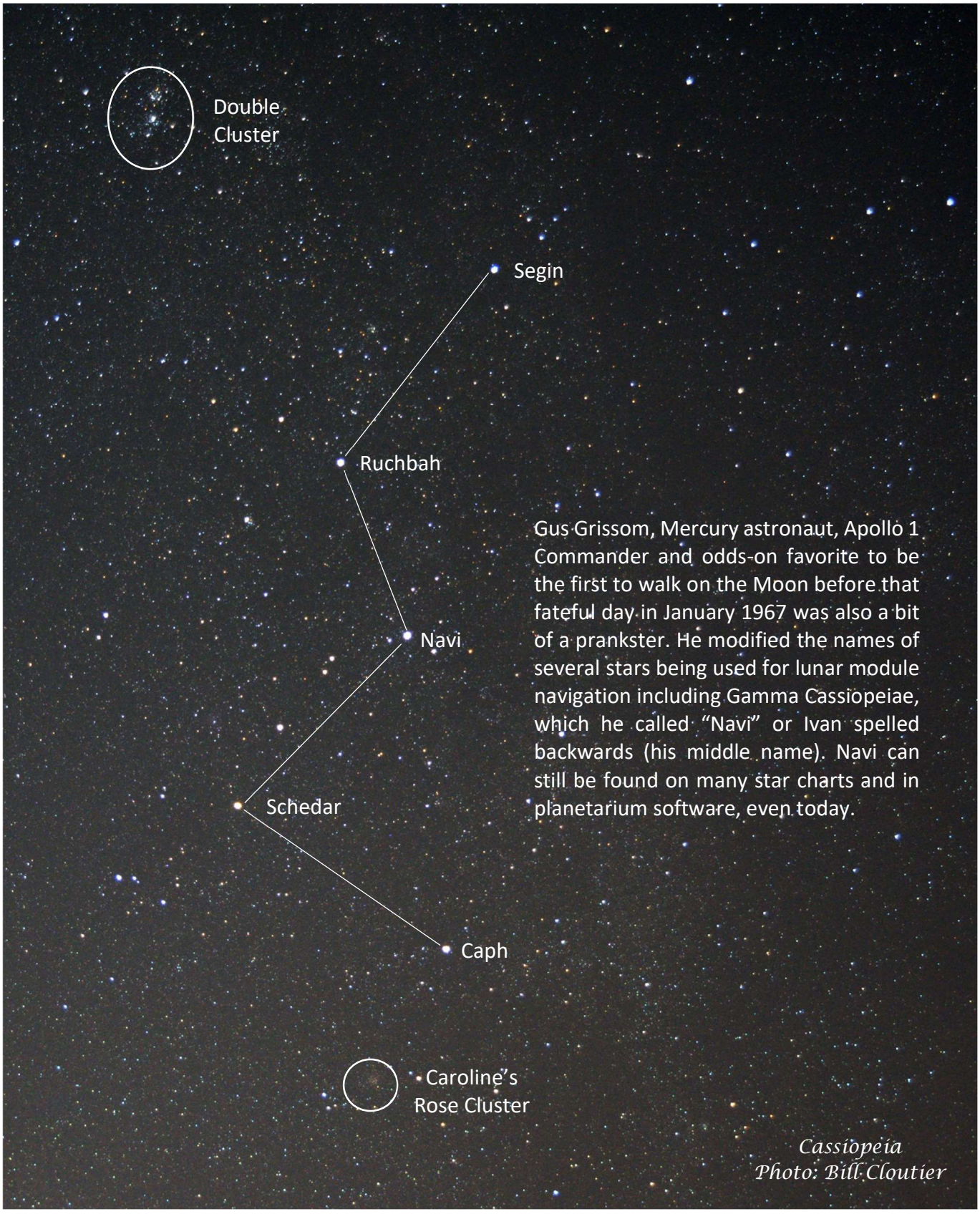


Daytime Surface Temperature of Planet Earth

Three-day average of daytime temperatures about 6 feet about the Earth's surface, as measured by NASA's spaceborne AIRS instrument. Purple and blue areas indicate cooler temperatures; yellow and red denote warmer regions. The year 2022 was the sixth warmest on record.

Source: NASA "Eyes on the Earth"

April Astronomy Calendar and Space Exploration Almanac



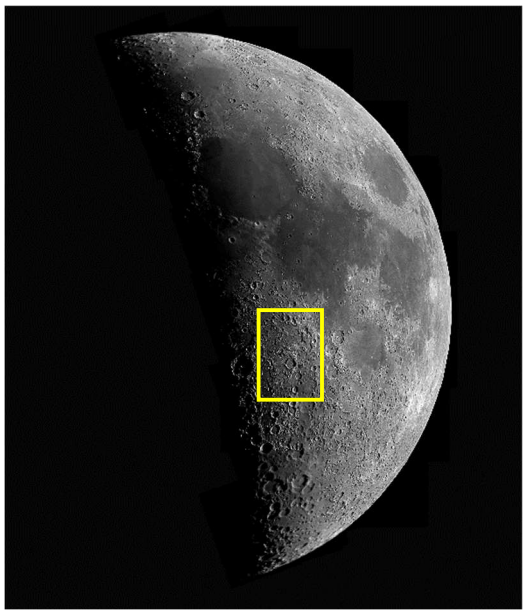
Gus Grissom, Mercury astronaut, Apollo 1 Commander and odds-on favorite to be the first to walk on the Moon before that fateful day in January 1967 was also a bit of a prankster. He modified the names of several stars being used for lunar module navigation including Gamma Cassiopeiae, which he called "Navi" or Ivan spelled backwards (his middle name). Navi can still be found on many star charts and in planetarium software, even today.

Cassiopeia
Photo: Bill Cloutier

In This Issue

"Out the Window on Your Left"

It's been more than 50 years since Gene Cernan left the last bootprint on the Moon's surface. 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).



Central lunar highlands and location of the Apollo 16 landing

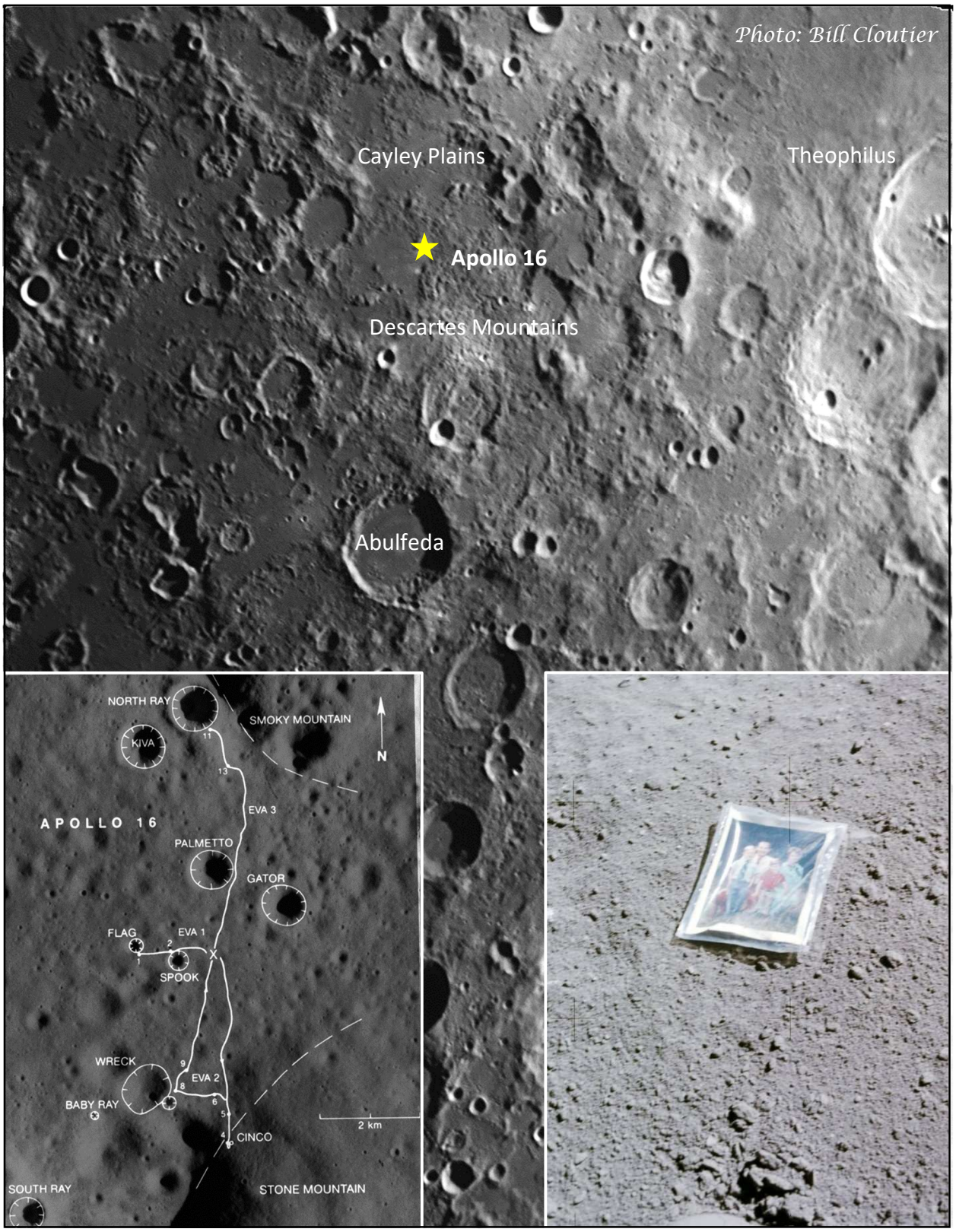
In April 1973, Commander John Young set the Apollo 16 lunar module (named Orion) down between two geologic units – the Cayley Plains and the Descartes Mountains, in the central lunar highlands. Apollo 16 was the second J-type mission, characterized by larger scientific payloads, extended surface times, and longer excursions with the lunar rover. During their stay, John Young put the battery-powered rover through its paces in a "Grand Prix" exercise - consisting of a series of S-turns, hairpin turns and hard stops.

Young and Charlie Duke spent over 20 hours on the surface, collecting approximately 212 pounds (96 kg) of rock and soil samples. Although geologists had expected the region to be covered by volcanic material, almost all of the rock samples collected by the astronauts turned out to be breccias (broken fragments of rock that have been cemented together into a matrix). The samples also contained bits of anorthosite (including two of the largest returned by the Apollo missions). Anorthosite crystallized in the magma ocean that covered the Moon shortly after its accretion almost 4.5 billion years ago, forming the bulk of the early lunar crust.

The breccias that covered the landing area likely came from the nearby impact basins. While Nectaris is the closest large impact basin (less than 125 miles or 200 km from the landing site), the samples also included what is believed to be material from the much further but larger Imbrium basin, 620 miles or 1,000 km away. The samples allowed scientists to date the Nectaris impact basin-forming event at 3.92 billion years ago. Bits of basalt, that formed 3.79 billion years ago and that were interspersed with the breccias, likely originated from the mare that overlies the Nectaris impact basin. The basalt was likely ejected by a mare impact, for example, the one that created the 60-mile-diameter (100 km) crater, lying 150 miles (250 km) to the east of the landing site.

Apollo 16 also released a small satellite into lunar orbit from the service module. It was intended to complement a similar satellite released by Apollo 15 eight months earlier. However, unlike the Apollo 15 satellite, which maintained a stable orbit, the orbit of the Apollo 16 satellite decayed rapidly, crashing into the lunar surface after just 35 days. It was later determined, that the inclination of the Apollo 16 satellite's orbit was unstable due to mass concentrations (or mascons) hidden beneath the lunar surface.

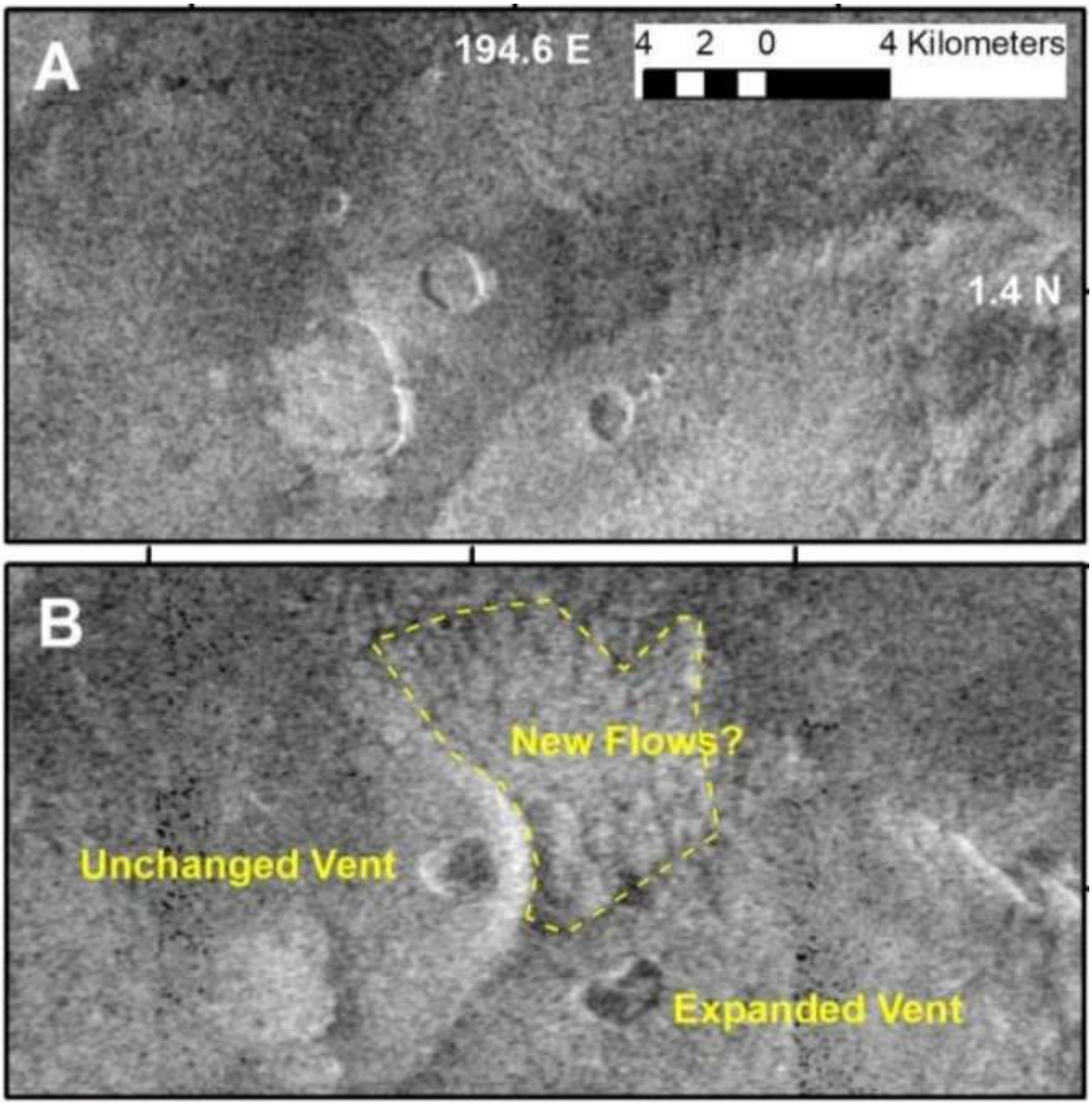
Descartes Highlands



Apollo 16 EVAs (left insert) and photo of Charlie Duke's family left behind on the lunar surface (right insert) Credits: NASA

Active Volcanoes on Venus?

One of the most intriguing announcements at the 54th Lunar and Planetary Science Conference, held in March, was evidence of possible volcanism on the planet Venus. Details are provided in the journal *Science*, released on the 15th, in a research article titled "Surface changes observed on a Venusian volcano during the Magellan mission."



Credits: Robert Herrick/UAF, NASA/JPL-Caltech

NASA's Magellan spacecraft imaged the surface of Venus using synthetic aperture radar from 1990 to 1992. In preparing for NASA's next Venus mapping mission (VERITAS), researchers revisited the Magellan imagery, looking for surface changes over the spacecraft's mapping cycles. They identified an expanded volcanic vent and possible new lava flow in images taken eight months apart on the north side of a domed shield volcano that is part of the larger Maat Mons volcano located in Atla Regio, a vast highland region near Venus' equator. Not only had the vent become larger and more irregular, it also appeared to have been filled with a lava lake.

Rescue Vehicle Arrives

Soyuz-23 on approach to the ISS
Credit: NASA TV

An uncrewed Soyuz spacecraft (MS-23) arrived at the International Space Station (ISS) on February 24th as a replacement for the Soyuz (MS-22) that was damaged by a suspected strike by a micro-meteorite/orbital debris. The vehicle is able conduct to flight operations, including docking to the ISS, autonomously.

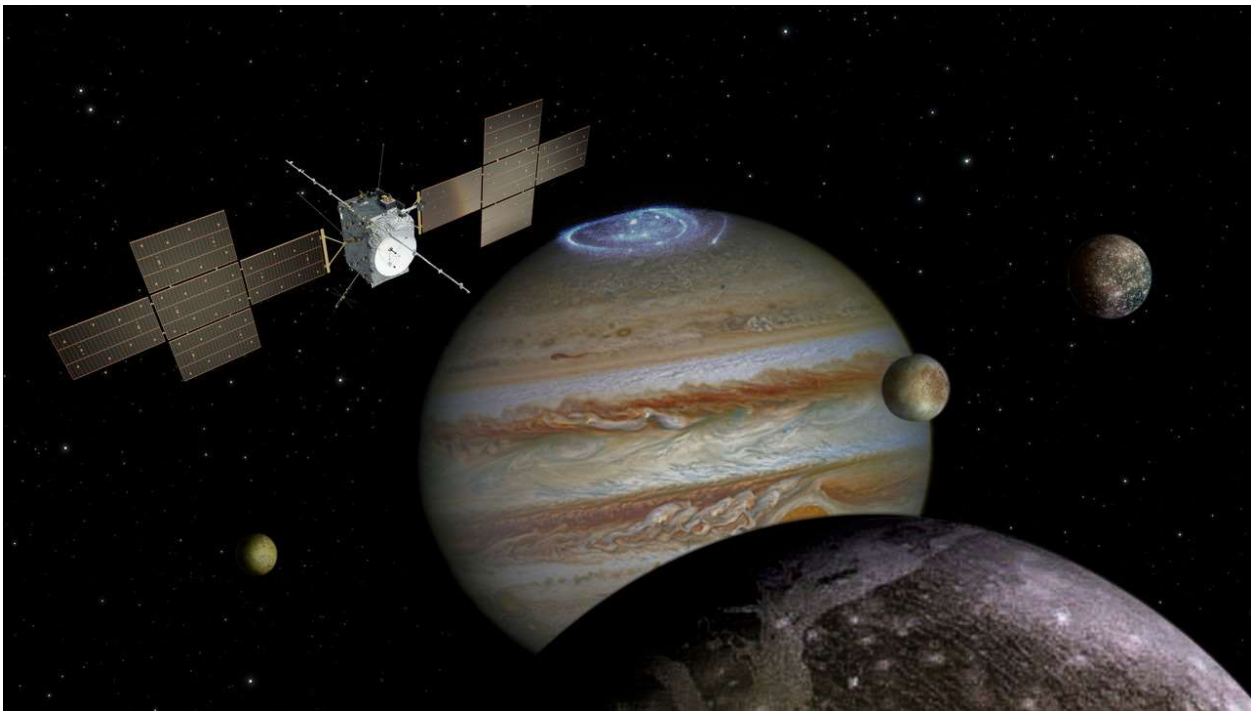
The damaged Soyuz MS-22 had delivered a three person crew (Russian cosmonauts Sergey Prokopyev and Dmitry Petelin, and NASA astronaut Francisco Rubio) to the ISS in September 2022. In December a stream of particles was observed leaking from the Soyuz, followed by a loss of pressure in the vehicle's external radiator.

Location of a coolant leak and suspected meteoroid strike. (Image credit: Roscosmos)

Images captured with a camera on the manipulator on the American segment of the ISS found a 0.8-millimeter-diameter hole in the external radiator on the Soyuz service module. The hole drained the coolant, possibly endangering the return of the crew.

The MS-22 crew will transfer their custom-made seat liners to Soyuz MS-23. Once complete, the uncrewed Soyuz MS-22 will undock and return to Earth uncrewed. The crew that was to fly to the ISS on MS-23 will likely wait until September while the next Soyuz spacecraft (MS-24) is being readied.

JUICE to Go



Artist's concept of JUICE spacecraft at Jupiter. Image Credit: ESA

The European Space Agency's (ESA) JUpiter ICy moons Explorer (JUICE) mission is scheduled to launch on April 13th aboard an Ariane 5 rocket from the spaceport in Kourou, French Guiana. The JUICE spacecraft is powered by two large solar wings, each comprised of five panels in a distinctive cross shape.

The 8-year journey to Jupiter will involve several gravity assists: a flyby of the Earth-Moon system in August 2024, Venus in August 2025, second flyby of Earth in September 2026, and a final third flyby of Earth in January 2029, before arriving at the gas giant in July 2031.

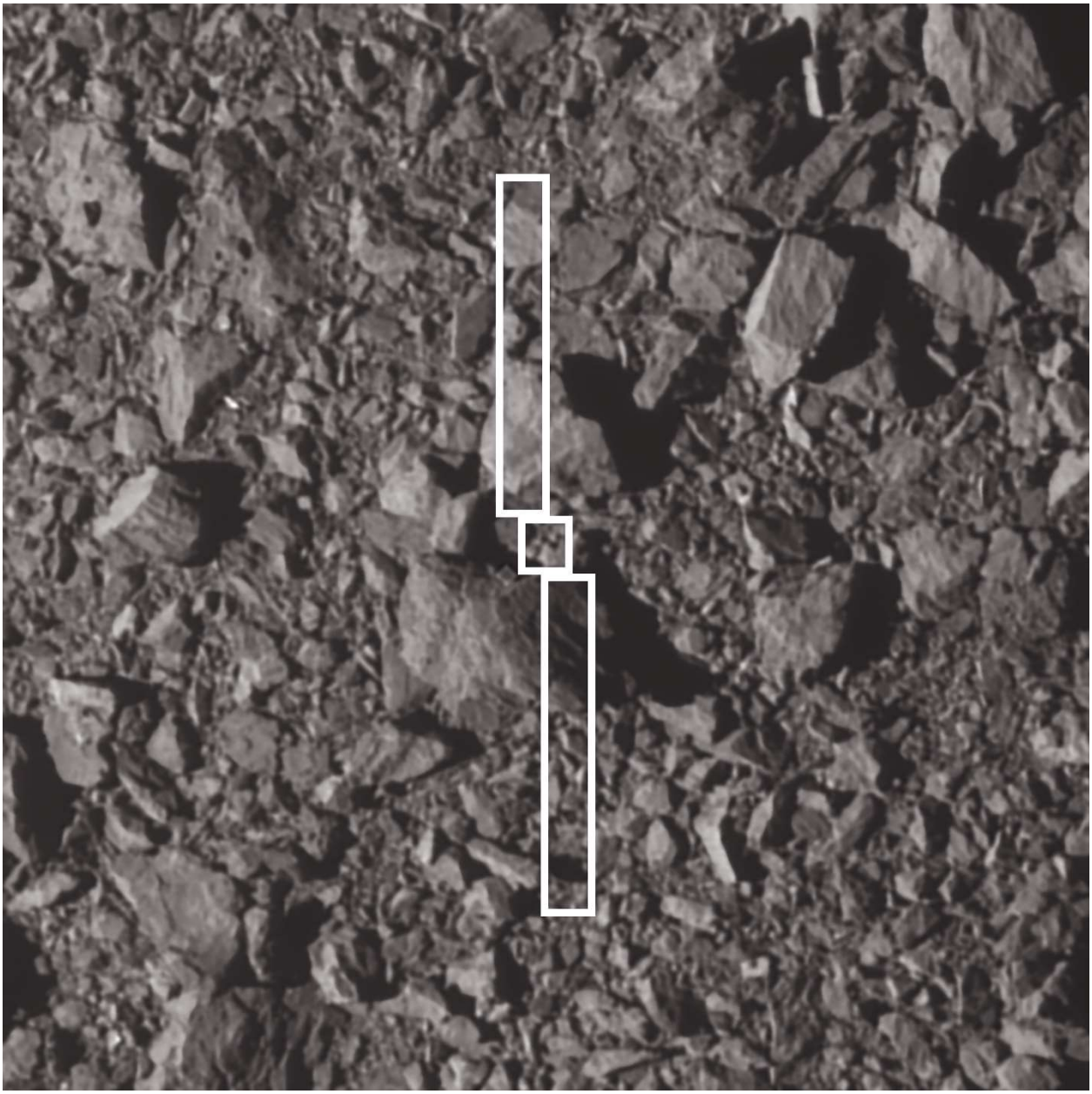
JUICE will make multiple flybys of three of the four Galilean moons (Ganymede, Callisto, and Europa) before going into orbit around Ganymede in December 2034. The three moons, believed to harbor oceans underneath their icy surfaces, will be scanned by the orbiter's ten scientific instruments. Jupiter's atmosphere, magnetic environment, ring system and other satellites (including Io) will also be targeted during the nominal 4-year science mission.

NASA is contributing an ultraviolet imaging spectrograph to the mission, as well as hardware for two European-provided instruments. Japan's space agency (JAXA) has also contributed hardware for various European-provided instruments.

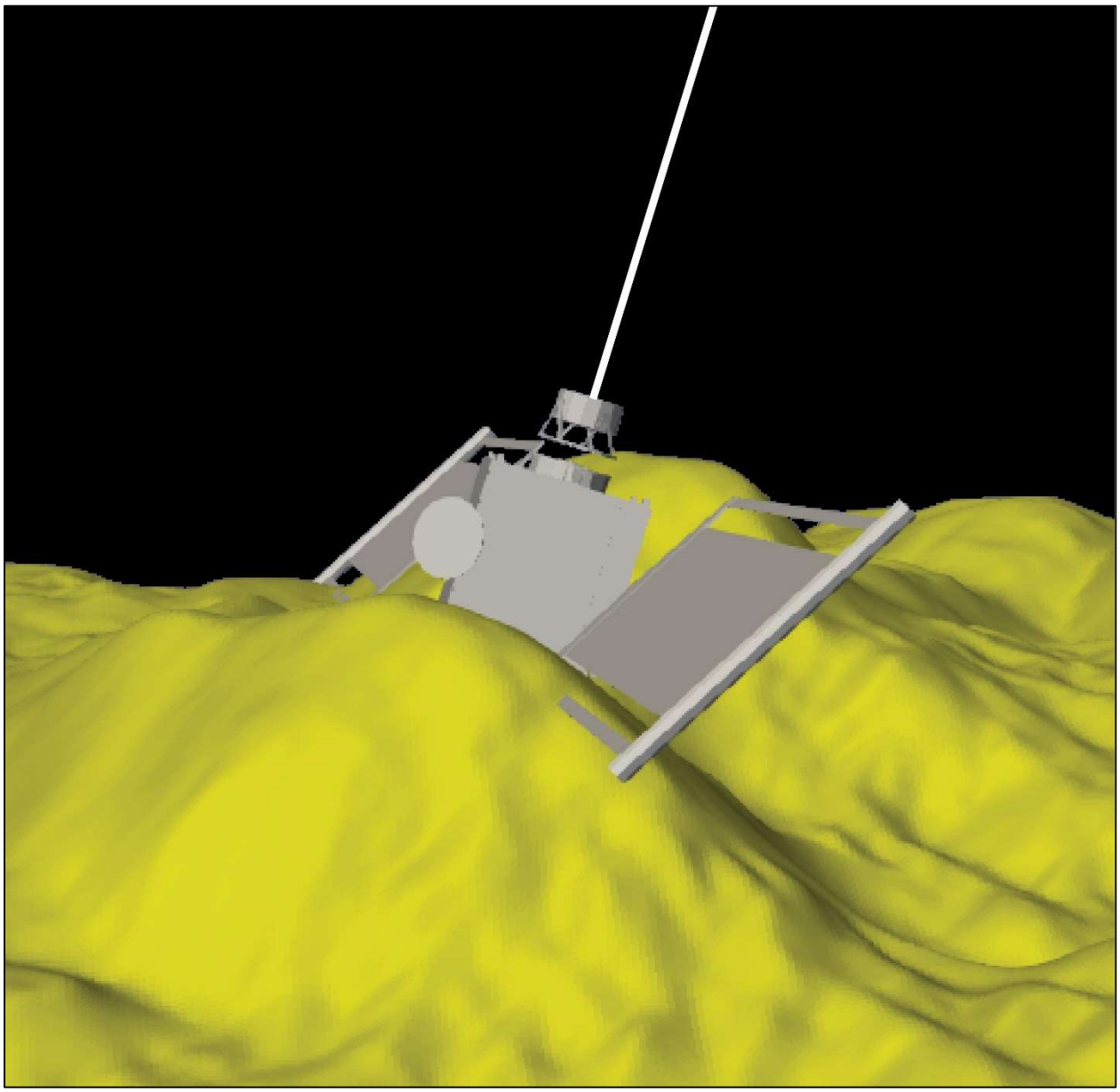
Ganymede is the solar system's largest and most massive moon (larger than the planet Mercury) with an ocean buried under a 60 mile thick crust (100 km) believed to be ten times deeper than Earth's ocean. Its surface, with a patchwork of dark and light terrain, is composed of half water ice and half rock and traversed by long, curved grooves. Ganymede is the only moon known to have its own magnetic field.

DART Update

On September 26, 2022, NASA conducted a successful test of kinetic impact technology for deflecting potentially hazardous asteroids. The test involved the intentional collision of the Double Asteroid Redirection Test (DART) spacecraft with the small asteroid Dimorphos orbiting the near-Earth asteroid (65803) Didymos. While the target posed no threat to the Earth, it was chosen for its proximity, enabling ground-based telescopes to quantify the deflection (change in the orbital period of the moon around the larger body). Since the mission concluded, researchers have been analyzing the results, summarized in a number of papers published over the past month.



Outline of the Double Asteroid Redirection Test (DART) spacecraft and its two long solar panels on the impact site. The largest boulder in the image, taken 3 seconds before impact, is 21 feet across (6.5 meters). Credits: NASA/Johns Hopkins APL



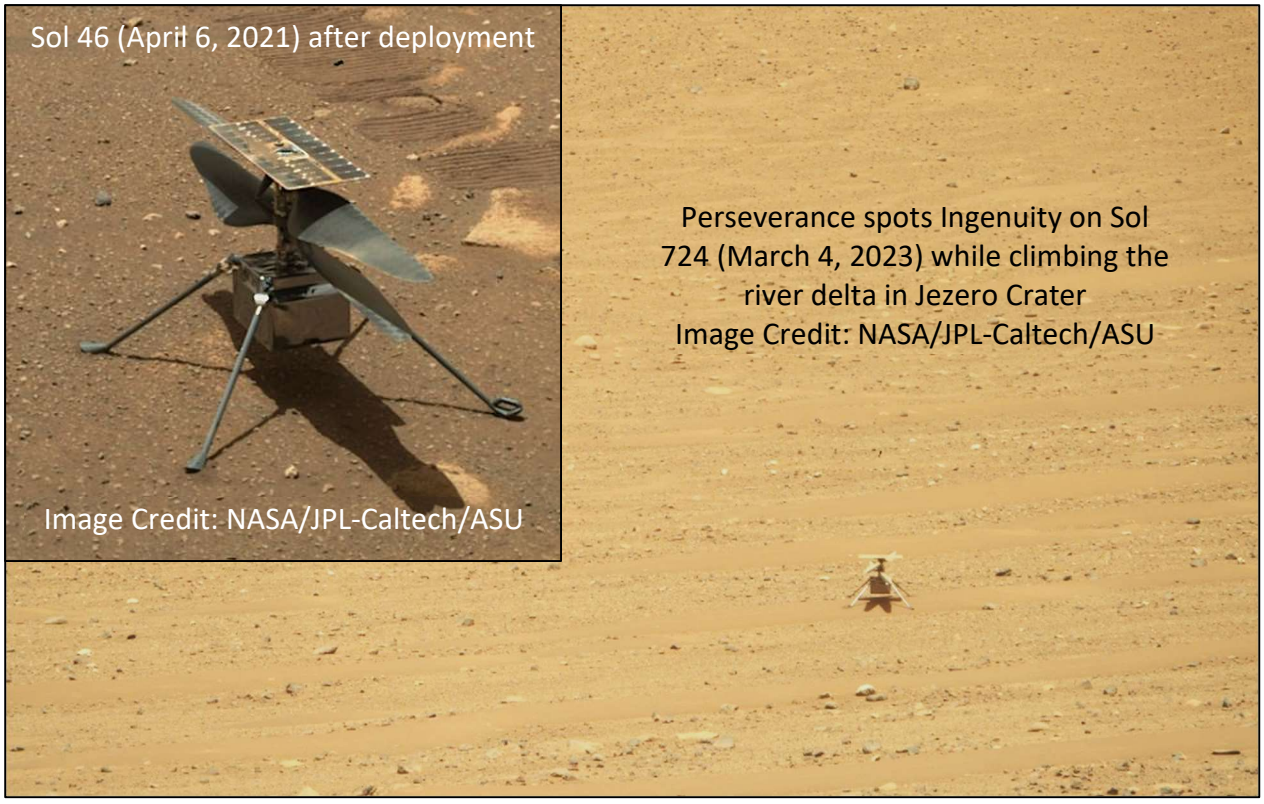
Trajectory of the DART spacecraft (white line) as it impacted the asteroid-moon Dimorphos between two large boulders Credits: NASA/Johns Hopkins APL

The hypervelocity impact experiment was expected to change the moon's orbital period by approximately 7 minutes, in a perfectly inelastic collision. Instead, based on two independent measurements (from Earth-based light curves and radar observations), the aftereffect was a 33± 1.0 minute decrease in Dimorphos' orbital period.

The larger-than-expected change in the orbital period of Dimorphos is attributed to the ejecta from the impact, which contributed a significant amount of momentum to the asteroid. Researchers have projected that the ejecta contained a minimum of 0.3 – 0.5 % Dimorphos' mass. This estimate will likely be refined during the European Space Agency's Hera mission, scheduled to launch in 2024, which will characterize the asteroid(s) and survey the impact site.

Still Flying After Two Earth Years

The Mars Ingenuity helicopter, added to the Mars 2020 mission as a 30-day technology demonstration, is thriving in the rarified atmosphere of the Red Planet after two Earth-years. The diminutive rotorcraft survived a battery-draining Martian winter, windier than expected conditions, periodic dust storms and progressively rougher terrain.



Ingenuity was a late addition to the Mars 2020 mission. It was included as one of the two technology demonstrations accompanying the rover Perseverance to the Martian surface. NASA allocated 30 days for the Earth-bound helicopter team to prove a rotorcraft could operate in the rarified atmosphere. That window opened on April 3, 2021 after the helicopter was deployed in a week-long choreographed sequence at a location designated "Wright Brothers Field."

On April 19th, Ingenuity made history when it became the first aircraft to make a powered, controlled flight on another planet. The solar-powered helicopter executed a flawless flight plan, climbing to an altitude of about 10 feet (3 meters), where it hovered, turned 90 degrees, so that its color camera was pointed towards the Perseverance rover parked about 211 feet (64.3 meters) away, before descending and landing. Three days later, the helicopter team accomplished a second successful flight, this time flying a bit higher and moving laterally for the first time.

On April 30th, after four flights that exceeded all expectations, NASA announced a 30-sol extension and a transition from testing to operations. On Flight 5, Ingenuity took to the air and didn't return to Wright Brothers Field. Two years and 48 flights later, Ingenuity is accompanying Perseverance in its climb up the ancient river delta, scouting the route ahead and surveying promising targets for further exploration. Ingenuity's success has prompted NASA to include helicopter(s) on the Mars Sample Return Mission.

Artemis I Flight Review

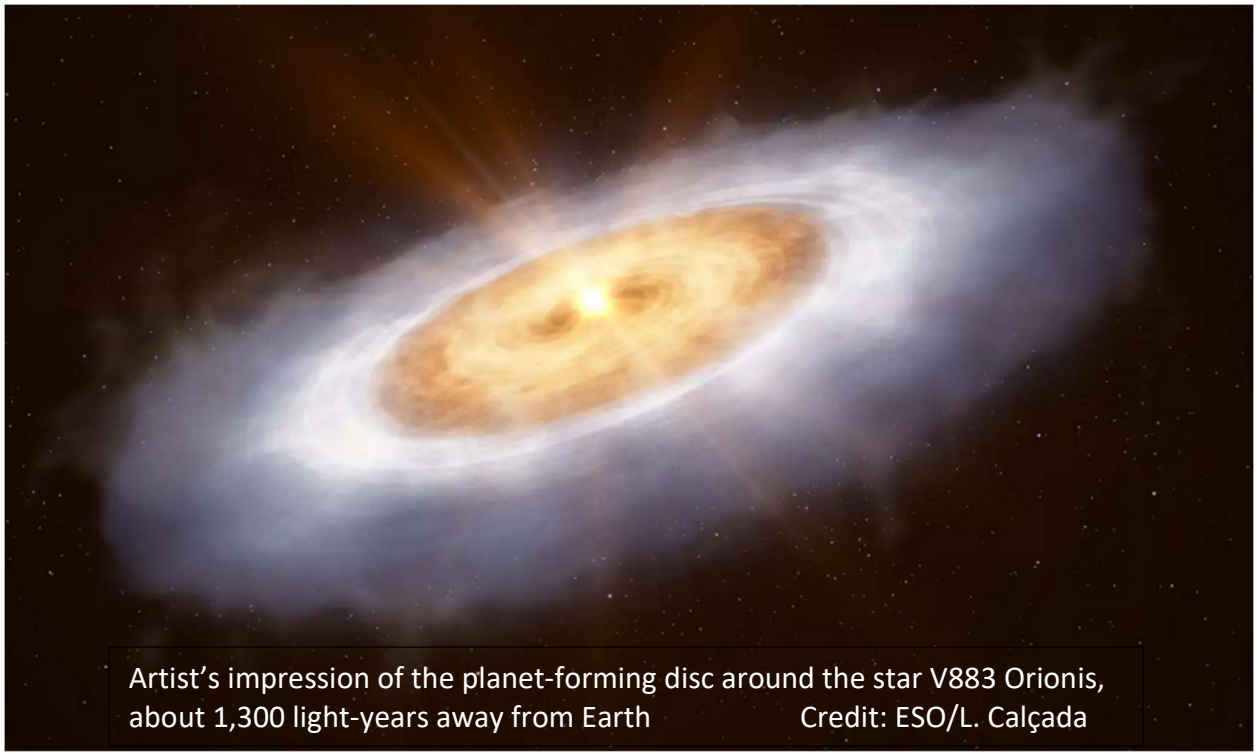
Technicians examine Orion's heat shield as part of post-flight analysis. Credit: NASA

NASA has been reviewing the performance of its Artemis I mission since the Orion spacecraft splashed down in the Pacific Ocean off the coast of Baja California on December 11th. Despite several issues that had to be worked through prior to launch, the 25.5-day mission that covered 1.4 million miles (2.25 million km), including traveling further from Earth than any other human-rated spacecraft, exceeded all expectations for a maiden voyage.

The Space Launch System, NASA's new Moon rocket, performed flawlessly. It delivered the Orion spacecraft into orbit and on to the Moon with a near-perfect trans-lunar injection burn. The mobile launcher sitting out on Pad 39B did sustain more damage than expected from 8.8 million pounds of thrust generated by the rocket at liftoff, destroying several elevators, 60 panels and cabinets and damaging fueling and other service lines. It is currently undergoing repairs and upgrades for the Artemis II launch sometime in 2024.

The fully-instrumented Orion spacecraft accomplished 161 test objectives, generating 155 gigabytes of performance data. The European-built service module generated 20% more power than initial expectations and consumed about 25% less power than predicted. The 375 pyrotechnic devices used for dynamic separation events (for example, parachute deployment) executed with no issue. One of the few anomalies was the 16.5-foot diameter (5 meter), ablative heat shield used to protect the spacecraft from the 5,000°F reentry temperature. The thermal protection system material called AVCOAT (also used in the Apollo missions) wore away at a higher rate and had a greater variance in performance than had been predicted (did not match simulations), and experienced irregular charring.

Have We Found the Source of Earth's Water?



Artist's impression of the planet-forming disc around the star V883 Orionis, about 1,300 light-years away from Earth Credit: ESO/L. Calçada

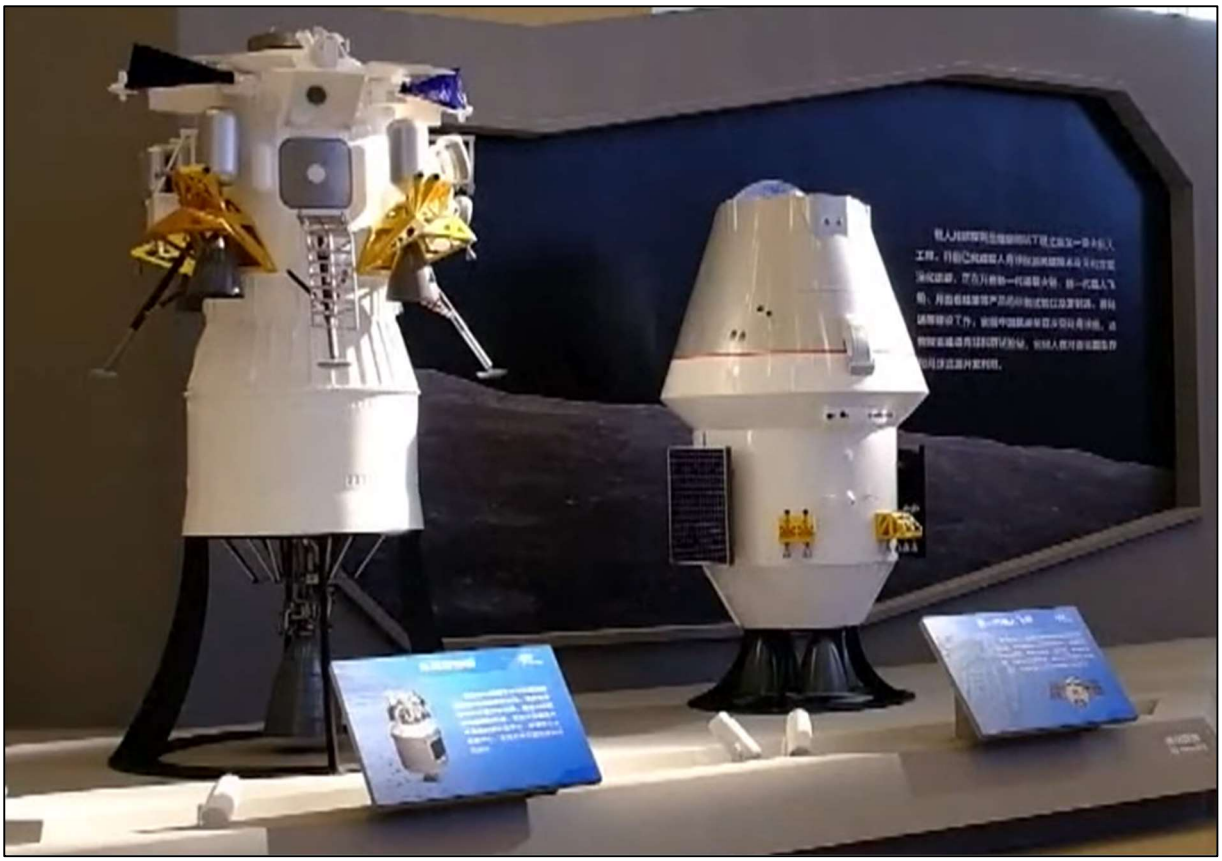
Stars form from cold interstellar molecular clouds when turbulence or a shock wave triggers a localized gravitational collapse of the gas and dust to form a protostar. Once the star stops accumulating material, the remaining matter evolves over a few million years into a large spinning disk from which planets, asteroids and comets arise.

Astronomers studying the composition of a planet-forming disc around the star V883 Orionis may have found the answer to the origins of water in our own solar system. Using the Atacama Large Millimeter/submillimeter Array (ALMA), gaseous water has been detected in the cloud. Generally, water in the form of ice is difficult to detect, and any water vapor closest to the star is hidden by dust. However, any outbursts from the newborn star can warm up the inner disc to a temperature where water is gaseous, a more easily detected form. V883 Orionis is now very energetic, heating up the surrounding media. This has defrosted the disc's icy constituents and allowed detection with ALMA.

Water molecules generally consists of one oxygen atom and two hydrogen atoms. In its most simplistic form, the hydrogen atom contains one proton and one electron. A less abundant, slightly heavier version, called deuterium, adds a neutron to the mix. Because the two versions of hydrogen form under different circumstances, their ratio can be used to map the disc and trace their origins. For example, some of the comets in our solar system have a hydrogen/deuterium ratio similar to that in the water on Earth, suggesting a possible source.

The presence of water in the V883 Orionis disc, at least 1,200 times the amount of water in all Earth's oceans, supports the idea that Earth's water was present in our Sun's protoplanetary disk and that the water is even older than our Sun, i.e., that it formed in the interstellar cloud and was later incorporated in the worlds we see around us.

China Unveils Moon Lander



Lunar lander model on display (left) and orbiter (right)
Credit: China Central Television/China Aerospace Science and Technology Corporation

China unveiled their latest design concept for a lunar lander at an exhibition celebrating 30 years of human spaceflight at the National Museum of China in Beijing. China is currently aiming to land astronauts, or taikonauts, on the Moon by the end of the decade.

Different than the two-stage Apollo design, where the both the descent and ascent stages landed on the Moon, China's descent stage is discarded prior to landing after providing the propulsion for most of the excursion to the surface from orbit. Engines in the upper ascent stage would provide the power for a soft landing, as well as the return trip to orbit.

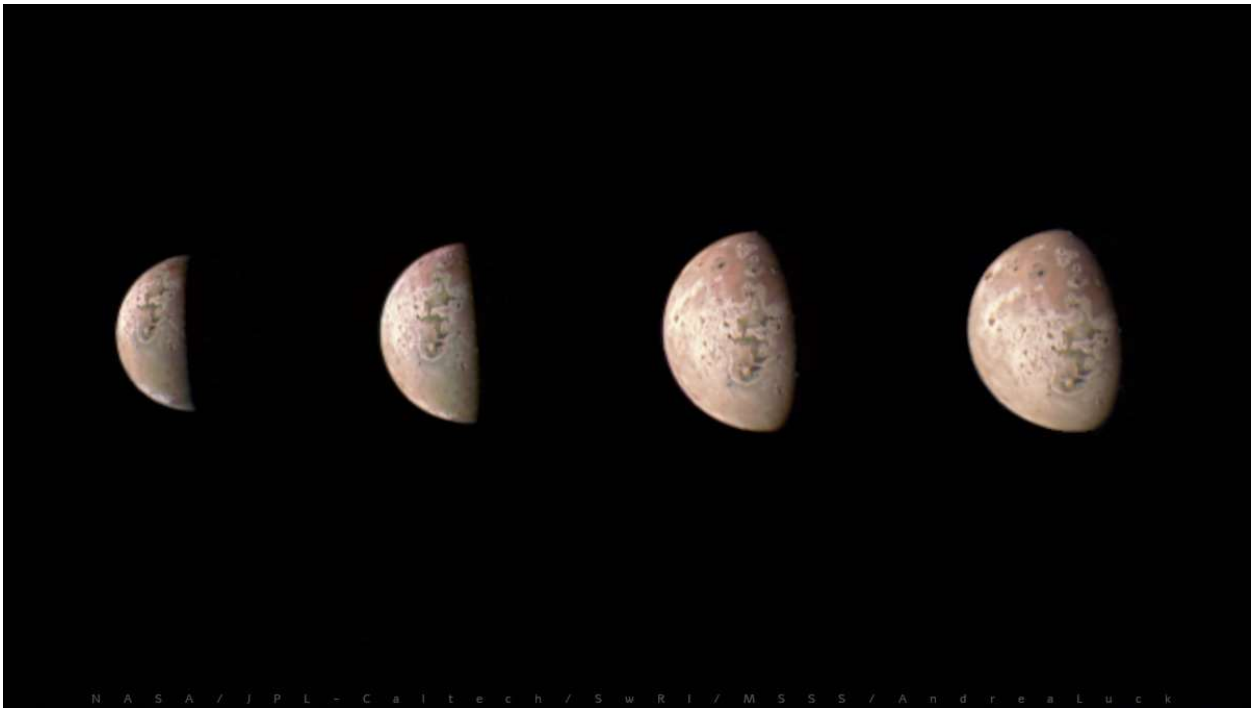
The model on display included a stowed lunar rover, docking mechanisms, a crew hatch, a ladder for access to the surface, communication and other equipment. Chinese space authorities have previously revealed that their lander would be used to transport two astronauts to the lunar surface with the initial landing lasting only a few hours in duration (much like Apollo 11 which was a proof-of-concept mission). This first mission, much like NASA's Artemis program, will be a prelude to future, longer duration stays with plans for a future, permanent lunar habitat.

To support its lunar ambitions, China had previously unveiled plans for its next generation of heavy-lift rockets capable of sending payload (and crews) directly to the Moon and to Mars. China also intends to integrate reusability technology into their new boosters for greater efficiency.

Io Flyby

Io, the innermost and third-largest of the four Galilean moons
Credit: NASA/JPL-Caltech/SwRI/MSSS/Kevin M. Gill

On March 1, 2023, the Juno spacecraft flew by Jupiter's moon Io at a distance of 32,030 miles (51,500 km). It was latest encounter of the volcanic moon by the spacecraft and the third of nine planned flybys. Each flyby will be progressively closer, with the closest in February 2024 when Juno will fly by within 930 miles (1,500 km) of the moon's surface.



Juno's JunoCAM is providing the best views of Io since the New Horizons mission flew past the Jupiter system in February 2007, a year after launch, on its way to Pluto. Researchers are already studying the images of the solar system's most active moon for surface changes from that encounter, as well as the Galileo mission in 1999.
Credit: NASA/JPL-Caltech/SwRI/MSSS /AndreaLuck

Earth Day 2023

Setting aside a day to focus on spaceship Earth, its natural environment and the impact that humans have had on its fragile biosphere, was the idea of U.S. Senator Gaylord Nelson after witnessing the aftermath of the 1969 Santa Barbara oil spill (a well blowout in an off-shore drilling platform that spilled an estimated 80,000 to 100,000 barrels along the southern California coastline). In the first Earth Day, on April 22, 1970, 20 million Americans participated in country-wide events. The public awakening was credited for the establishment of the Environmental Protection Agency and the passage of important clean air and water legislation.

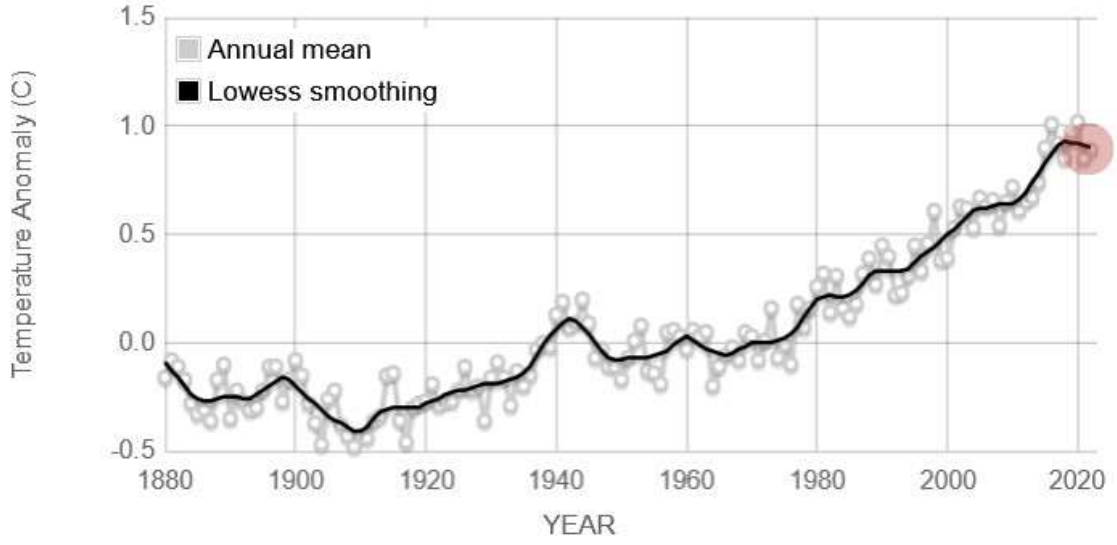
ISS Photo of Earth's Limb
Credit: NASA

Sunset image of the Earth's limb taken from the International Space Station showing several layers of the Earth's atmosphere (the Earth's atmosphere has several distinct layers). The majority (75% by mass and 99% of the water vapor) of the atmosphere (troposphere), highlighted in yellows and oranges, extends 5 to 10 miles above the surface (wider at the equator). Above the troposphere (pink and white region) is the stratosphere which extends to an altitude of 31 miles. Overlying layers - the mesosphere, thermosphere and exosphere become progressively thinner as the Earth's atmosphere transitions to the vacuum of space.

Earth Day 2023 finds the threats to the environment infinitely more challenging than an oil spill and their consequences potentially irreversible. Unlike a breached oil well, there are no quick fixes or easy answers if we do decide to address the source(s) of Earth's rapidly changing climate. Earth's health report is presented in the following graphs. It's not that the climate is changing - change is inevitable in such a complex, dynamic system over eons - it's the rate of change over such a short period of time that should be reawakening public consciousness.

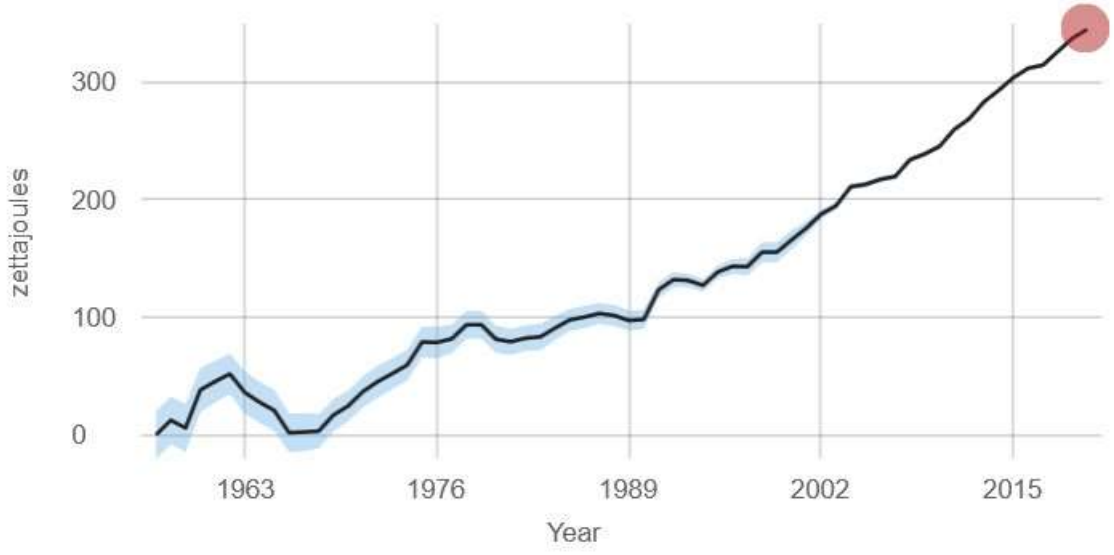
GLOBAL LAND-OCEAN TEMPERATURE INDEX

Data source: NASA's Goddard Institute for Space Studies (GISS). Credit: NASA/GISS



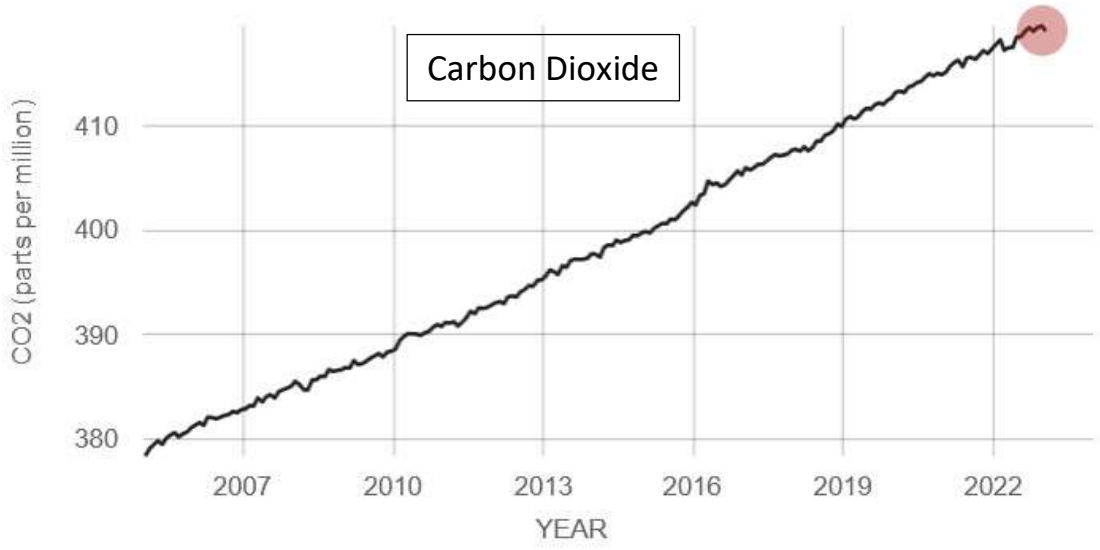
OCEAN HEAT CONTENT CHANGES SINCE 1955 (NOAA)

Data source: Observations from various ocean measurement devices, including conductivity-temperature-depth instruments (CTDs), Argo profiling floats, and eXpendable BathyThermographs (XBTs). Credit: NOAA/NCEI World Ocean Database



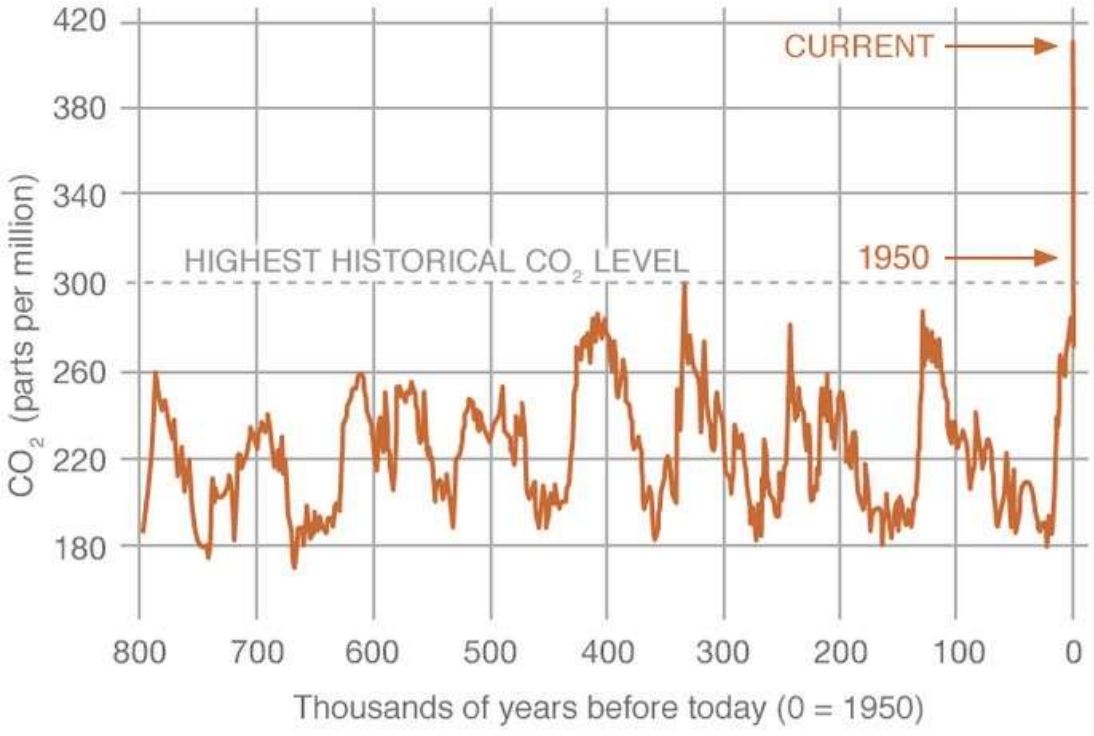
DIRECT MEASUREMENTS: 2005-PRESENT

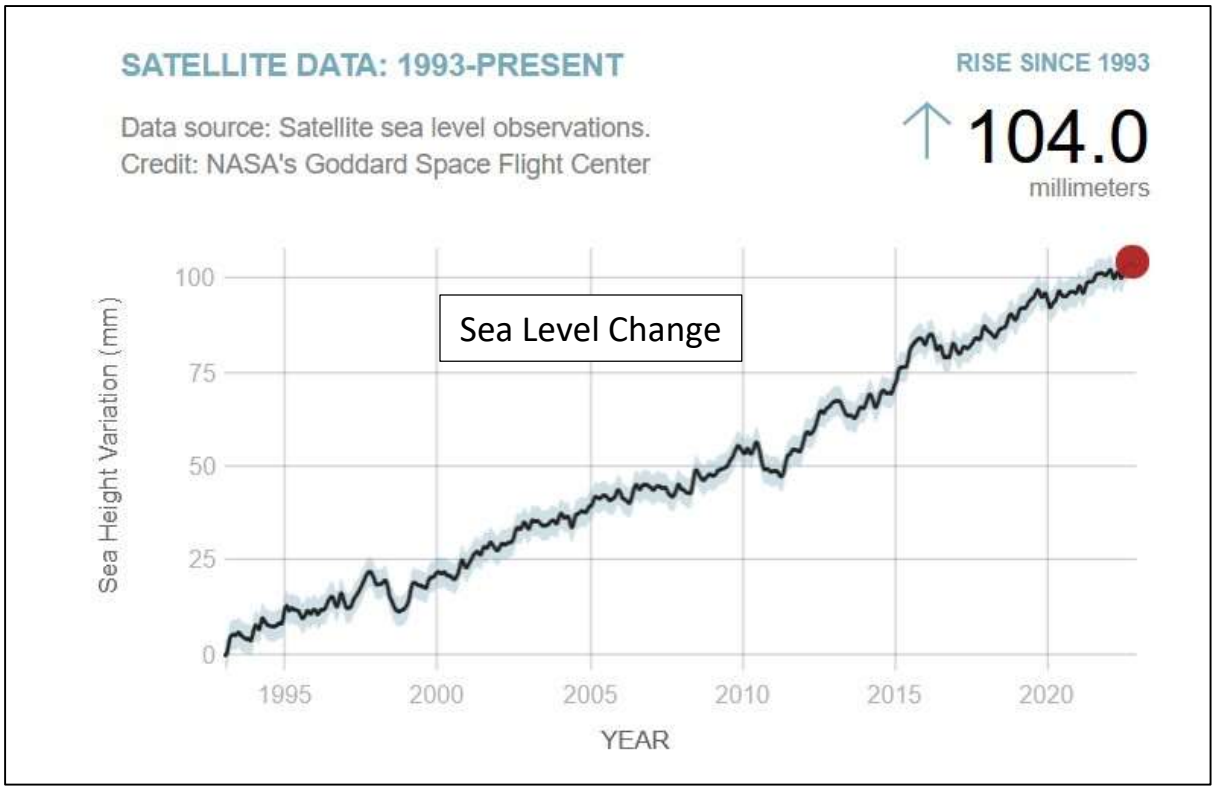
Data source: Monthly measurements (average seasonal cycle removed). Credit: NOAA

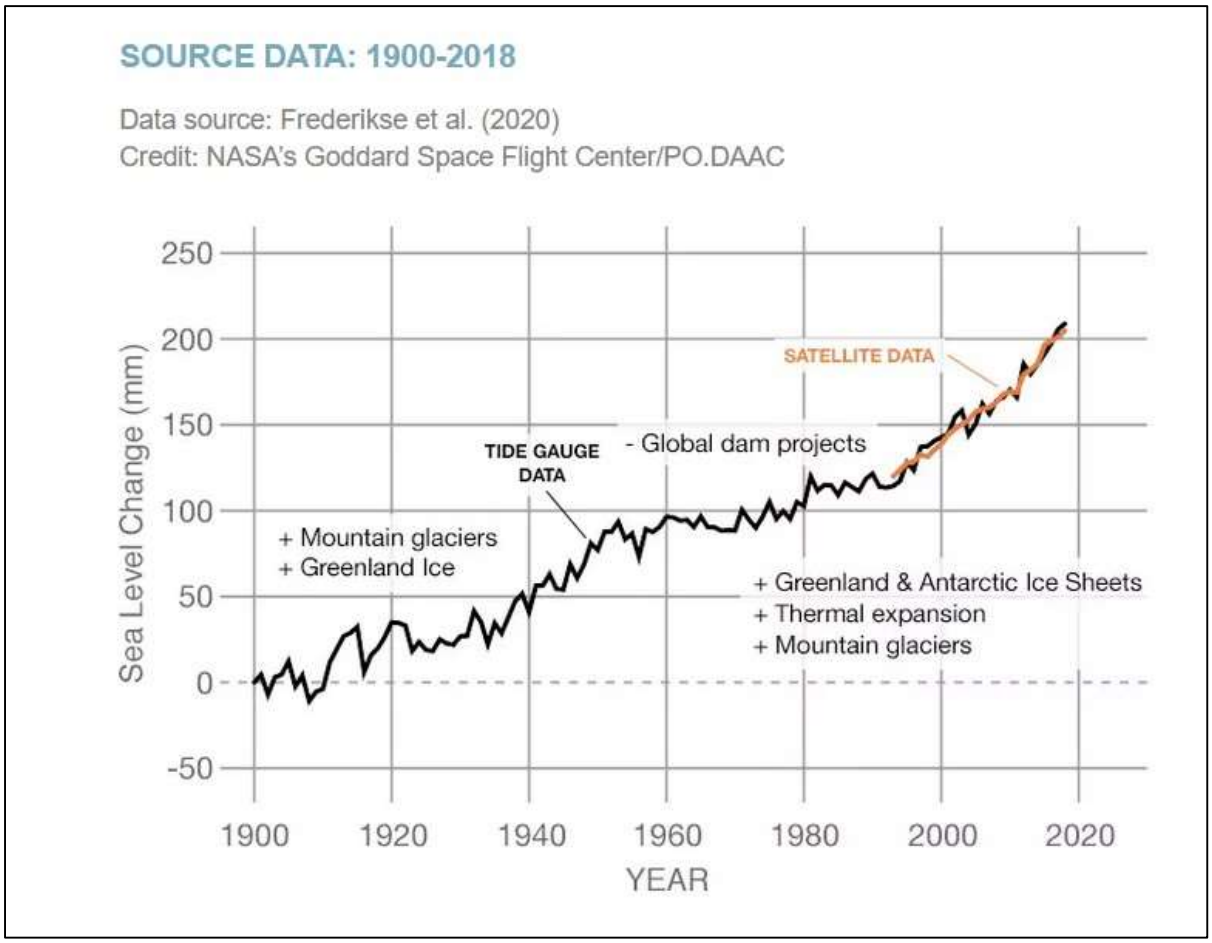


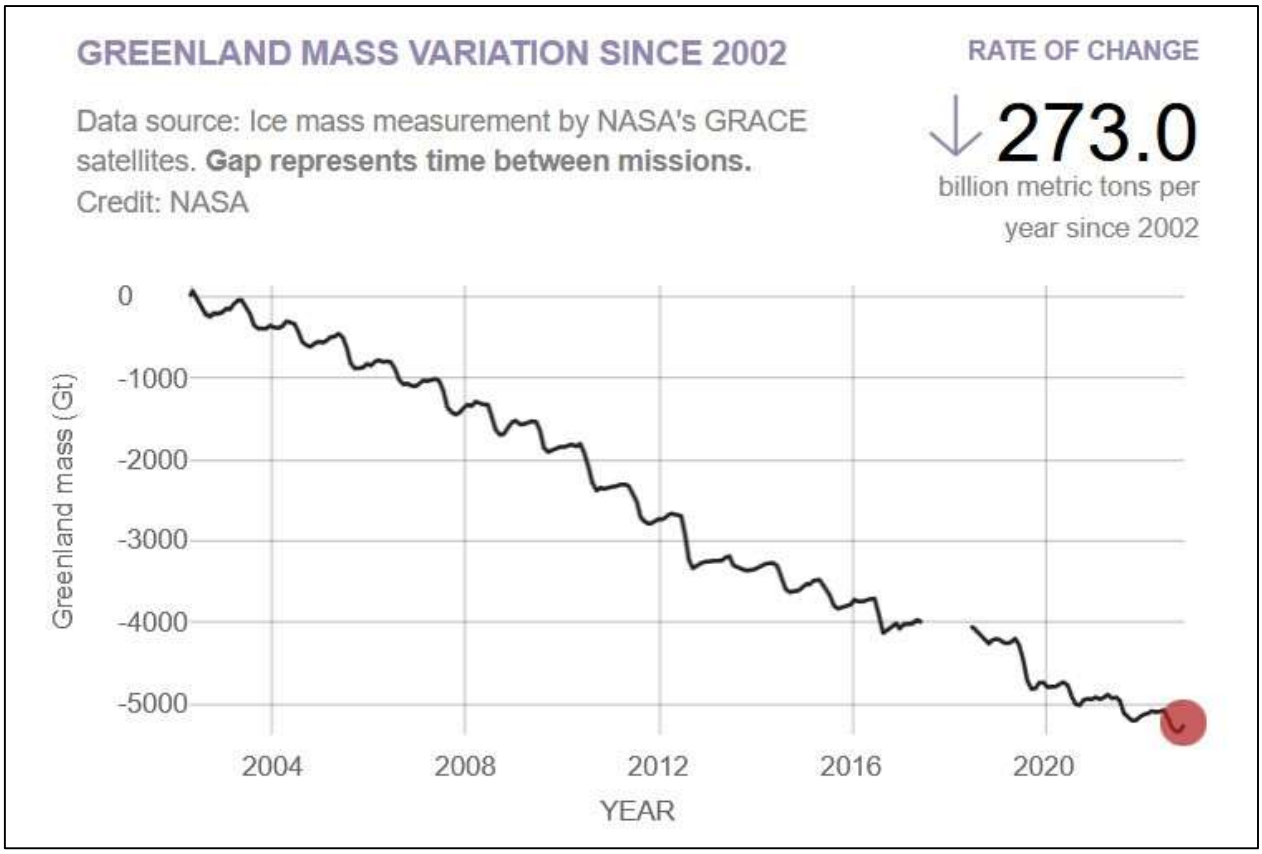
PROXY (INDIRECT) MEASUREMENTS

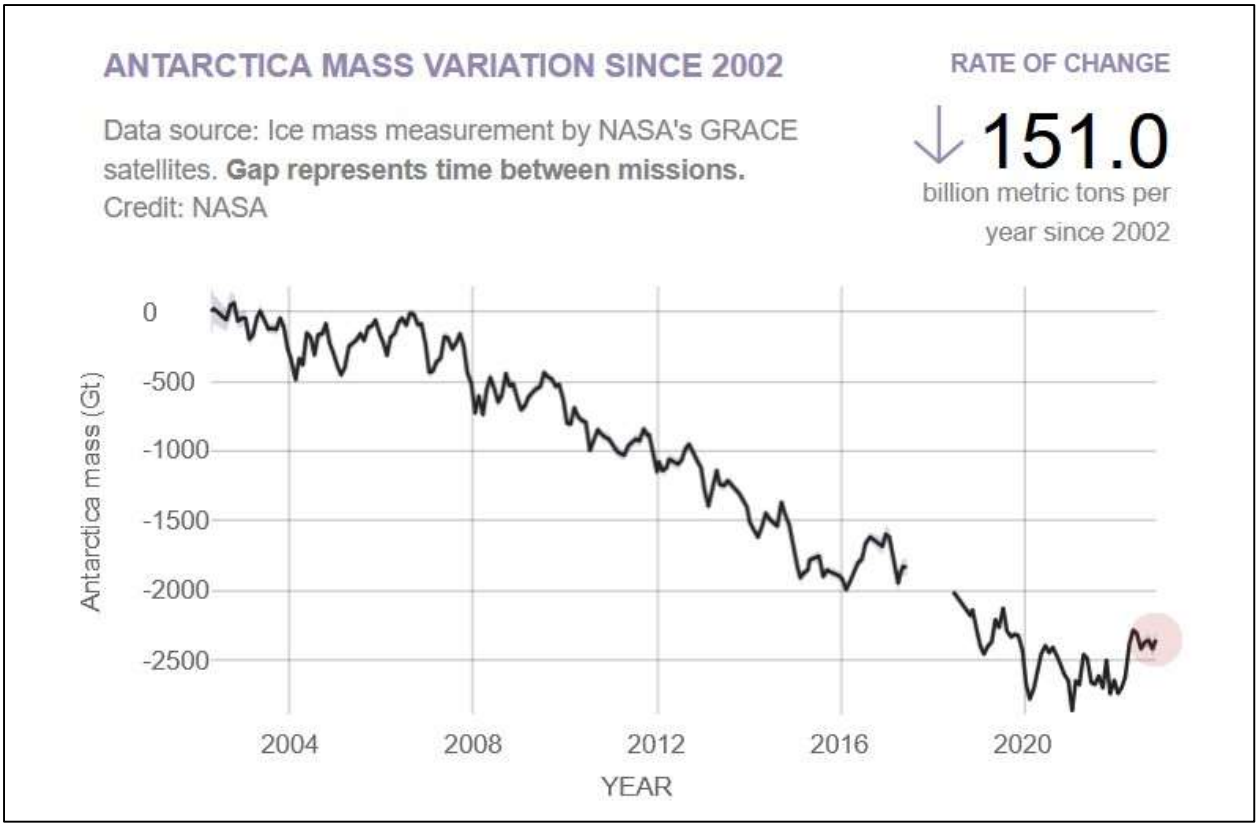
Data source: Reconstruction from ice cores.
Credit: NOAA

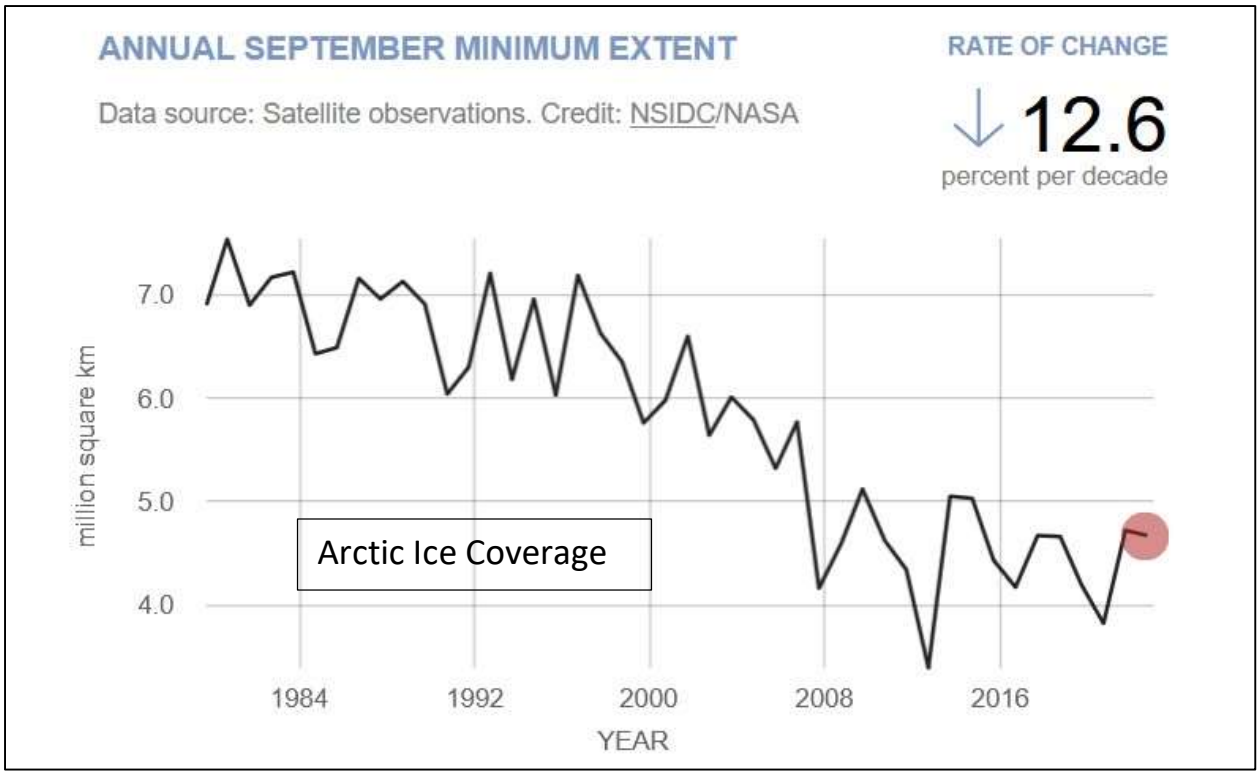



SATELLITE DATA: 1993-PRESENT
Data source: Satellite sea level observations.
Credit: NASA's Goddard Space Flight Center
RISE SINCE 1993
104.0
millimeters
Sea Level Change
Sea Height Variation (mm)
100
75
50
25
0
1995
2000
2005
2010
2015
2020
YEAR


SOURCE DATA: 1900-2018
Data source: Frederikse et al. (2020)
Credit: NASA's Goddard Space Flight Center/PO.DAAC
Sea Level Change (mm)
250
200
150
100
50
0
-50
1900
1920
1940
1960
1980
2000
2020
YEAR
SATELLITE DATA
TIDE GAUGE DATA
- Global dam projects
+ Mountain glaciers
+ Greenland Ice
+ Greenland & Antarctic Ice Sheets
+ Thermal expansion
+ Mountain glaciers


GREENLAND MASS VARIATION SINCE 2002
Data source: Ice mass measurement by NASA's GRACE satellites. Gap represents time between missions.
Credit: NASA
RATE OF CHANGE
273.0
billion metric tons per year since 2002
0
-1000
-2000
-3000
-4000
-5000
Greenland mass (Gt)
2004
2008
2012
2016
2020
YEAR


ANTARCTICA MASS VARIATION SINCE 2002
Data source: Ice mass measurement by NASA's GRACE satellites. Gap represents time between missions.
Credit: NASA
RATE OF CHANGE
151.0
billion metric tons per year since 2002
0
-500
-1000
-1500
-2000
-2500
Antarctica mass (Gt)
2004
2008
2012
2016
2020
YEAR



Earth's global average surface temperature in 2022 was the sixth warmest on record, according to an analysis done by the National Oceanic and Atmospheric Administration (NOAA) while NASA and the European Commission's Copernicus website ranked the year as the fifth warmest. Global temperatures for 2022 were 1.55°F (or 0.86°C) above the 20th-century average of 57.0°F (13.9°C). The 10-warmest years on record have all occurred since 2010, with the last nine years (2014-2022) among the 10-warmest years. The warming is attributed to human activities, including the emission of greenhouse gases, such as carbon dioxide and methane.

The Earth's oceans have absorbed much of the excess heat and carbon dioxide (warmer water also expands, contributing to rising sea levels). The annual global ocean heat content (OHC) for 2022 for the upper 2000 meters was record high, surpassing the previous record set in 2021. The four highest OHC have all occurred in the last four years (2019–2022). In 2022, the world's oceans, as given by OHC, were again the hottest in the historical record and exceeded the previous 2021 record maximum.

Carbon dioxide and water also combine to form carbonic acid, which has increased the ocean's acidity by about 30% since the beginning of the Industrial Revolution. Between 7.2 and 10.8 billion metric tons of carbon dioxide are taken up by the oceans every year, impacting many ocean species (particularly those with shells and skeletons) and weakening coral reefs.

Cold water is more dense than warm water. This difference in density is responsible for ocean's currents (along with the global winds) and, to some degree, its level (the process is known as thermohaline circulation). Ocean currents regulate the Earth's temperature, transporting warm water and precipitation from the equator toward the poles and cold water from the poles back to the equator. Without currents, land temperatures would be more extreme and some areas, that currently benefit from the moderation, would not be habitable. The warming of the oceans reduces

the temperature differential between the hot and cold regions and the energy available to drive circulation and upwelling (sinking cold water replaced by rising warm water). The Gulf Stream, which moves billion of tons of water up the east coast of North America every second, is becoming weaker and moving slower than it has in thousands of years.

The ice sheets covering Greenland and Antarctica have also decreased in mass. Satellite observations by NASA's Gravity Recovery and Climate Experiment (GRACE) and GRACE Follow-On satellites have documented an average of 273 billion metric tons of ice lost each year between 2002 and 2022 for the Greenland ice sheet, while Antarctica lost ice at a rate of about 151 billion metric tons per year over the same period.

Global sea level rose about 8 inches (20 centimeters) in the last century - recorded by tidal gauges and, more recently, by satellites. The rate of increase has nearly doubled over the past two decades. A hotter planet is likely contributing to long-term climate changes (desertification and coastal flooding) and fueling extreme weather events that will impact our quality of life.

In 2018, NASA launched two missions that will provide decision makers (and the public) the latest information on the effects of climate change. The Gravity Recovery and Climate Experiment Follow-On mission (GRACE-FO), in partnership with the German Research Centre for Geosciences, continues the work of predecessor missions and is a significant improvement in the accuracy in tracking the movement of water (for example, from glaciers and ice sheets to the ocean). NASA also launched the Ice, Cloud, and Land Elevation Satellite-2, or ICESat-2, a mission that provides precise elevation measurements on the Earth's ice sheets, glaciers and sea ice. In November 2020, Sentinel-6 was launched, the latest in a series of satellites (starting with TOPEX-Poseidon and the Jason series) that have been monitoring global mean sea level since 1992.

In December 2022, the Surface Water & Ocean Topography (SWOT) satellite joined the Earth-monitoring fleet. Jointly developed by NASA and Centre National D'Etudes Spatiales, with contributions from the Canadian Space Agency and United Kingdom Space Agency, SWOT will measure the height of water in freshwater bodies and the ocean on more than 90% of Earth's surface.

Local

The year 2022 was the Northeast's 16th warmest year since records began in 1895 and for Connecticut, the 12th warmest. August 2022 was the hottest August on record for Connecticut with Harford having a record three days where the temperature did not drop below 75°F and Bridgeport having a record-tying six straight days above 75°F.

Multiple Northeast sites experienced their warmest November 1 to 7 period on record. Bridgeport had the warmest day on record during this time span.

Ten of the 12 Northeast states experienced a drier-than-normal year. Annual precipitation for Connecticut was 89 percent of normal.

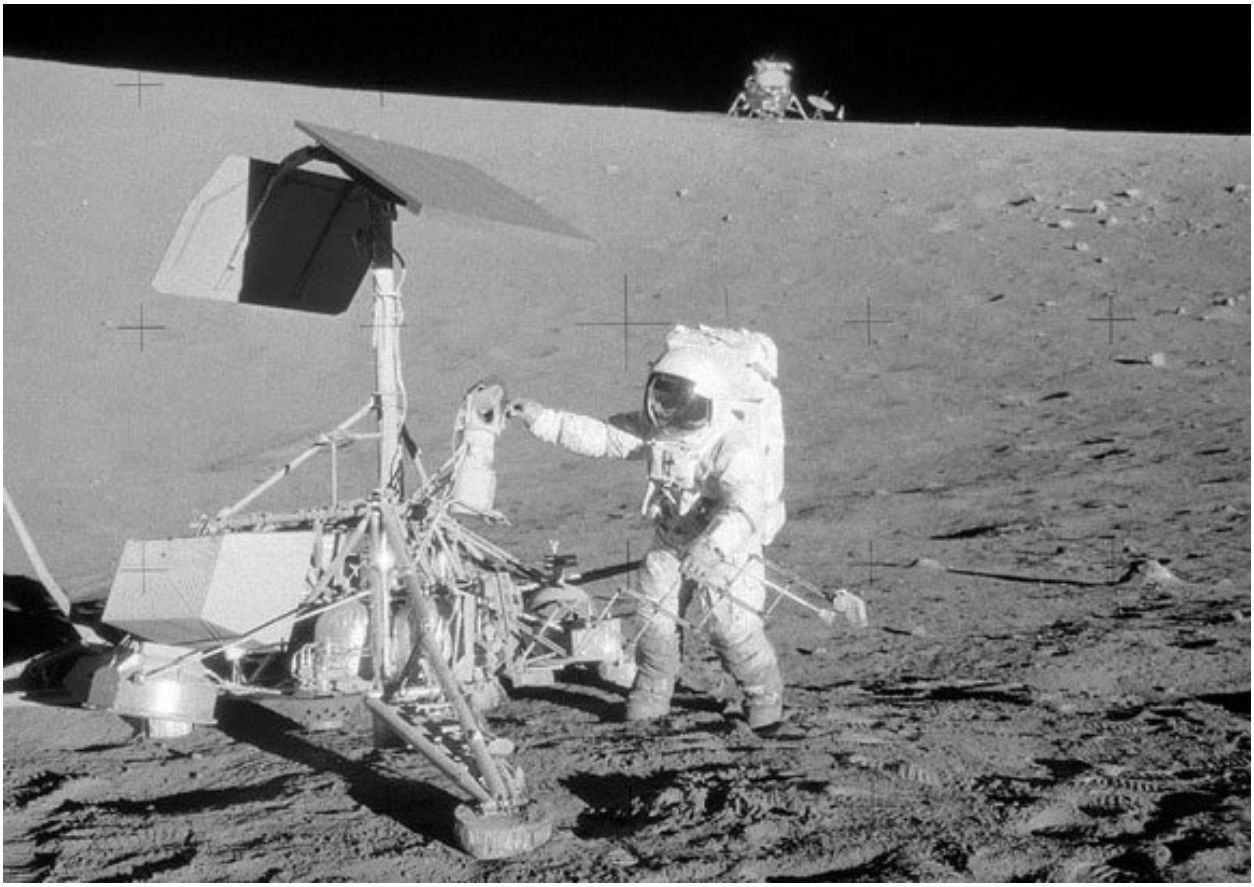
Home World

The Surveyor 3 spacecraft was launched on April 17, 1967, and was the second of the Surveyor series to successfully soft-land on the moon. The robotic spacecraft landed three days later inside an eroded crater in Oceanus Procellarum (Ocean of Storms), 230 miles (370 km) south of the crater Copernicus. The robotic lander returned 6,000 photographs of its surroundings including the first photo of Earth taken from the lunar surface. Surveyor 3 also provided data on the lunar soil, including its ability to support the weight of the Apollo lunar landing module, soil reflectivity and thermal properties.

Surveyor 3 photo of Earth

Credit: NASA

The Apollo 12 astronauts removed several parts from the Surveyor 3 spacecraft during their mission to Oceanus Procellarum. Its camera is now on display in the Smithsonian National Air and Space Museum in Washington, D.C.



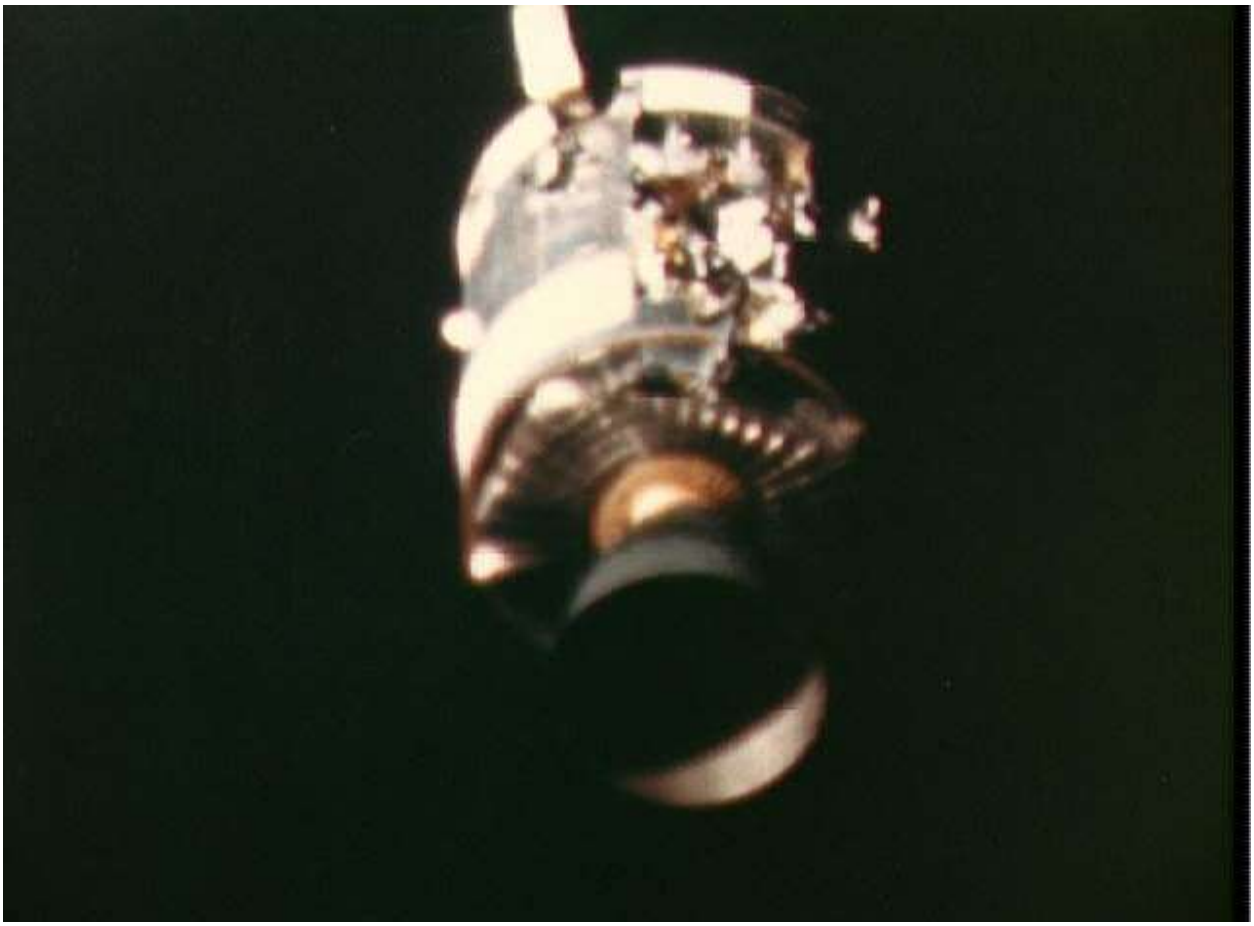
Apollo 12 astronaut Pete Conrad examines Surveyor 3's camera on November 20, 1969 before it was removed for its return to Earth

Image Credit: NASA/Apollo 12 astronaut Alan Bean

April History

Apollo 16 wasn't the only lunar mission launched in the month of April. Two years earlier, on April 11, 1970, Apollo 13 lifted off from Cape Canaveral in what was intended to be the third manned mission to the Moon. The crew of James Lovell, Fred Haise and Jack Swigert never got their chance.

Two days later and almost 200,000 miles from Earth, the No. 2 oxygen tank exploded, cracking the feed pipe to the No. 1 oxygen tank and crippling the fuel cells providing the electrical power to the Command Module. The next four days would become the greatest human drama in space history.



Damaged Apollo 13 Service Module photographed after the Command Module separation

Photo: NASA

With failing power and a cloud of debris surrounding the space craft, the three astronauts shut down the Command Module and moved into the Lunar Module (LM). The LM was designed to support two astronauts for a maximum of 45 hours. The LM now needed to support the three astronauts for 75 to 100 hours for a safe return to Earth. To conserve supplies, almost all the spacecraft's systems were turned off. The temperature dropped to just above freezing, water condensed on all the internal surfaces and instruments, and the level of carbon monoxide increased to life-threatening levels. Fluids and gases being expelled from the crippled Command Module

acted like small rockets, continually pushing the spacecraft off course. The debris cloud prevented anything more than rudimentary navigation. The astronauts became dehydrated (fuel cells also provide water) and the conditions inside the spacecraft became increasingly unsanitary when the crew, through a misunderstanding, began to accumulate human waste inside the spacecraft (instead of discharging it).

Only through the ingenuity of the engineers back in mission control, the backup crew and hundreds of contractors involved in the assembly and operation of the spacecraft, was the crew returned safely to Earth. The crew and the spacecraft reentered the Earth's atmosphere not knowing whether the heat shield had been damaged in the explosion or whether the parachutes would still deploy after four days of extreme cold. While Houston lost contact with the spacecraft for a minute longer than expected, Apollo 13 splashed down right on target.

The cause of the accident was eventually traced to damage the No. 2 oxygen tank had sustained during its removal from Apollo 10. With a damaged drain, internal heaters were used to empty the tank. Unfortunately, the pad power supply was not compatible with the spacecraft's power systems. The higher voltage melted the insulation leaving bare metal exposed to the pure oxygen environment inside the tank. When Jack Swigert turned on the tank fan, the contents exploded. The story of Apollo 13 is detailed in astronaut Jim Lovell's book "Lost Moon," former Flight Director Gene Kranz's book "Failure is Not an Option," and recreated in the Ron Howard/Tom Hanks film "Apollo 13."

April Showers

The Lyrid meteor shower is expected to peak around April 22nd. The dust producing the shooting stars is from *Comet Thatcher*. Expect to see 10 to 20 meteors per hour and dark skies being only two days past a New Moon. As with all meteor showers, the Lyrids are named for the constellation (Lyra) from which they appear to radiate.

Sunrise and Sunset (New Milford, CT)

Date	Sunrise	Sunset
April 1st (EDT)	06:37 am	7:18 pm
April 15th	06:14 am	7:33 pm
April 30th	05:52 am	7:50 pm

Astronomical and Historical Events

1st History: Comet *Hale-Bopp* reaches perihelion – closest approach to Sun (0.914 AU) (1997)
1st History: launch of the first weather satellite, Tiros 1 (1960)
2nd Closest approach of Apollo asteroid (2022 GO3)
2nd Closest approach of Aten asteroid (2021 GN1)
2nd History: U.S. release of the movie "2001 A Space Odyssey" (1968)
2nd History: launch of Zond 1, Soviet Venus flyby mission (1964)
2nd History: selection of the Mercury 7 astronauts (1959)

Astronomical and Historical Events (continued)

2nd History: French physicists Louis Fizeau and Leon Foucault take first photo of the Sun (1845)
3rd History: Soviet spacecraft Luna 10 becomes the first artificial satellite to orbit the Moon (1966)
4th History: launch of Apollo 6, last test flight of the Saturn V rocket (1968)
5th History: launch of the Compton Gamma Ray Observatory (1991)
5th History: launch of the first Pegasus rocket (1990)
5th History: launch of Pioneer 11, Jupiter and Saturn flyby mission (1973)
6th Full Moon (Full Pink Moon)
6th History: launch of Intelsat 1, first commercial communications satellite (1965)
7th Closest approach of Aten asteroid (2018 FD)
7th History: launch of the Mars Odyssey orbiter (2001)
7th History: first spacewalk from the space shuttle (Story Musgrave, Don Peterson, STS-6) (1983)
7th History: launch of Luna 14, Soviet Moon orbiter mission designed to test radio transmission stability, measure the lunar gravity field, solar wind and cosmic rays (1968)
8th **Second Saturday Stars - Open House at McCarthy Observatory**
8th History: launch of the Bigelow Expandable Activity Module (2016) aboard a SpaceX Dragon cargo vehicle - module was installed on the International Space Station for a two-year long demonstration of the expandable habitat
8th History: discovery of Saturn moon's *Telesto* by the Voyager 1 spacecraft (1980)
8th History: meteorite hits house in Wethersfield, Connecticut (1971)
8th History: launch of the unmanned Gemini 1 (1964)
8th History: Project Ozma, the search for extraterrestrial intelligence, begins as Frank D. Drake, an astronomer at the National Radio Astronomy Observatory in Green Bank, West Virginia, turns the 85-foot Howard Tate telescope toward the star Tau Ceti (1960)
9th Easter Sunday
10th History: Japanese lunar probe Hiten impacts Moon; first non-U.S./Soviet lunar probe, also first to visit the Lagrangian Points L4 and L5 during its three-year mission (1993)
10th History: discovery of asteroid *216 Kleopatra* by Johann Palisa (1880)
11th History: ESA spacecraft Venus Express enters orbit around the planet Venus (2006)
11th History: launch of Apollo 13 with astronauts James Lovell, Fred Haise and Jack Swigert; mission aborted when oxygen tank explodes and cripples the Command Module (1970)
12th History: launch of the first space shuttle (Columbia) with astronauts John Young and Robert Crippen (1981)
12th History: launch of Vostok 1 with cosmonaut Yuri Gagarin, first person to orbit the Earth (1961)
12th History: Edward Maunder born; studied solar cycle and sunspots. Analyzed period between 1645 and 1715 when almost no sunspots where recorded - known as the "Maunder minimum" or "Little Ice Age" because of the severe winters (1851)
12th History: discovery of Asteroid 10 *Hygiea* by Annibale de Gasparis (1849)
13th Last Quarter Moon
13th Closest approach of Aten asteroid (2019 GK21)
13th Closest approach of Apollo asteroid 436774 (2012 KY3)
13th Scheduled launch of the European Space Agency's Jupiter Icy Moons Explorer mission, or JUICE, aboard an Ariane 5 rocket from Kourou, French Guiana

Astronomical and Historical Events (continued)

13th History: launch of Transit 1B, first experimental navigation satellite (1960)
14th History: Christiaan Huygens born, Dutch scientist and discoverer of Saturn's rings and largest moon *Titan* (1629)
15th Moon at perigee (closest distance from Earth)
16th History: launch of Apollo 16 with astronauts John Young, Ken Mattingly and Charles Duke, the only mission to the lunar highlands (1972)
16th History: Leonardo Da Vinci born, first to correctly explain Earthshine (1452)
17th History: closest flyby of the Sun by a spacecraft, Helios 2 (1976)
17th History: launch of Surveyor 3, Moon lander, first to experience a lunar eclipse from the Moon's surface during which the temperature fell 250° F; Apollo 12 would later land near Surveyor 3 in 1969, retrieving pieces of the lander for return to Earth and analysis of the effects of the harsh lunar environment (1967)
18th History: launch of the Transiting Exoplanet Survey Satellite (TESS) by a SpaceX Falcon 9 rocket from the Cape Canaveral Air Force Station, Florida (2018)
19th History: launch of the last Soviet Salyut space station, Salyut 7 (1982)
19th History: launch of the first space station, Soviet Salyut space station, Salyut 1 (1971)
20th New Moon
21st Schedule launch of a Cygnus cargo freighter to the International Space Station aboard a Northrop Grumman Antares rocket from Wallops Island, Virginia
22nd Lyrids Meteor Shower peak
22nd Earth Day
22nd History: Cassini's final close flyby of Saturn's moon Titan, initiating the 22 Grand Finale orbits between the planet and its rings and the end of mission in September (2017)
22nd History: launch of the Air Force's X-37B prototype space plane from Cape Canaveral, Florida; first orbital mission (2010)
24th History: launch of space shuttle Discovery (STS-31) and deployment of the Hubble Space Telescope (1990)
24th History: launch of Mao 1, first Chinese satellite (1970)
24th History: cosmonaut Vladimir Komarov dies during re-entry of a prototype Soviet lunar spacecraft (Soyuz 1) when parachute lines become entangled (1967)
26th Closest approach of Aten asteroid (2006 HV5)
26th History: first flight of the modified Boeing 747 with its 98.4-inch (2.5 meter) diameter infrared telescope – the Stratospheric Observatory for Infrared Astronomy (SOFIA) (2007)
26th History: Venus flyby (gravitation assist) by the Cassini spacecraft (1998)
26th History: Ranger 4 impacts Moon (1962) - while the mission didn't return any scientific data due to an onboard computer failure, Ranger 4 become the first U.S. spacecraft to reach another celestial body when it crashed on the far side of the Moon
26th History: launch of Sputnik 14 (Cosmos 4), first successful Soviet reconnaissance satellite – designed to study upper layers of atmosphere and monitor U.S. nuclear tests (1962)
26th History: discovery of Asteroid 9 *Metis* by Andrew Graham (1848)
27th First Quarter Moon
28th Moon at apogee (furthest distance from Earth)
28th Closest approach of Apollo asteroid (2021 JF2)
28th History: launch of the Cloudsat/Calipso cloud imaging and profiling satellites (2006)

Astronomical and Historical Events (continued)

30th History: Surveyor 3 lander takes the first picture of Earth from the Moon's surface (1967)

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

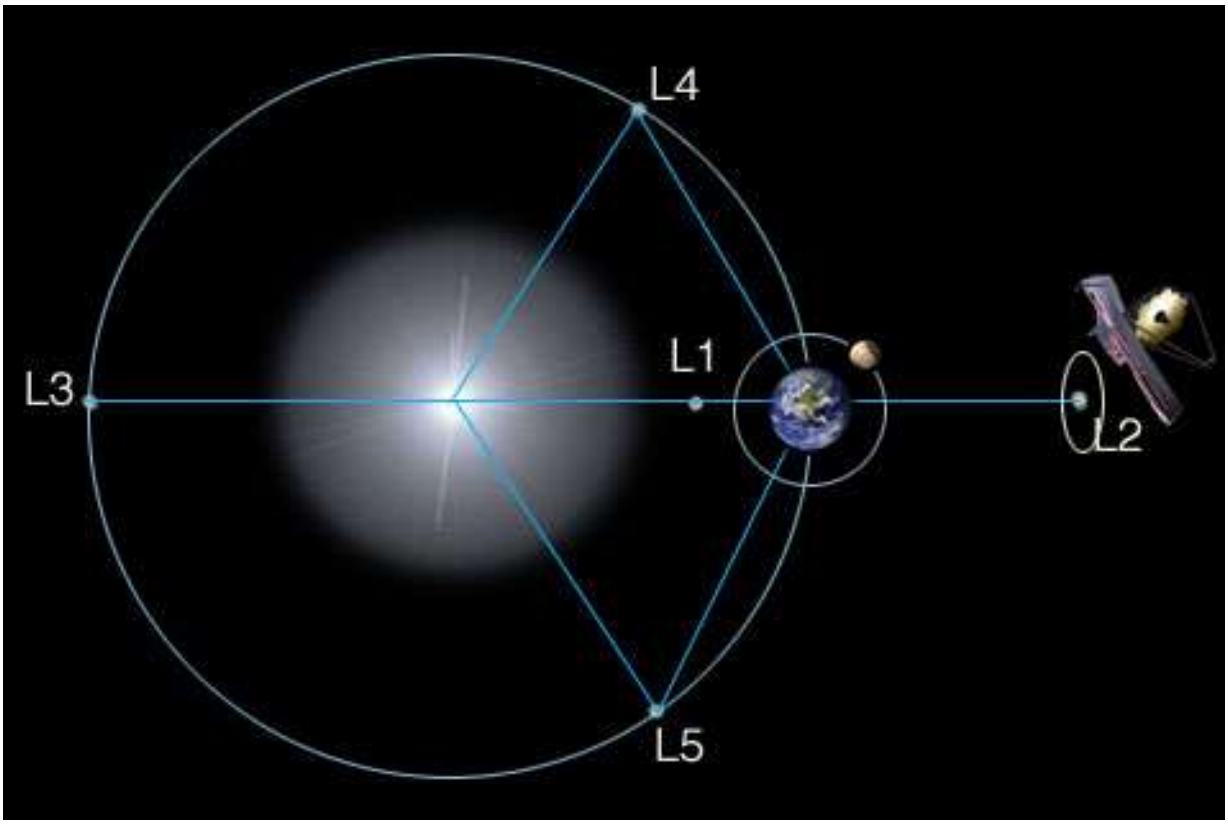
- www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and the bright flares from Iridium satellites.

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

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).



James Webb Space Telescope

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

NASA's Global Climate Change Resource

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

Mars – Mission Websites

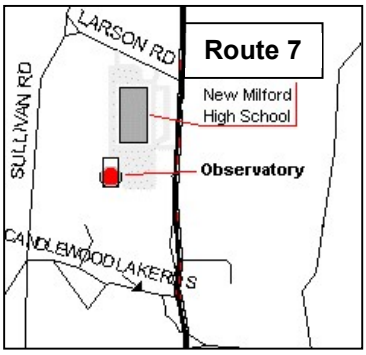
- Mars 2020 (Perseverance rover): https://mars.nasa.gov/mars2020/
- Jezero Crater map: https://mars.nasa.gov/mars2020/mission/where-is-the-rover/
- Mars Helicopter (Ingenuity): https://mars.nasa.gov/technology/helicopter/
- Mars Science Laboratory (Curiosity rover): https://mars.nasa.gov/msl/home/

Contact Information

The John J. McCarthy Observatory
P.O. Box 1144
New Milford, CT 06776

New Milford High School
388 Danbury Road
New Milford, CT 06776

Phone/Message: (860) 946-0312
www.mccarthyobservatory.org



	www.mccarthyobservatory.org
	@McCarthy Observatory
	@McCarthy Observatory
	mccarthy.observatory@gmail.com
	@JJMObservatory
	@mccarthy.observatory