Galactic Observer

John J. McCarthy Observatory

Volume 14, No. 4 April 2021

Preparing for First Flight on Mars

The Ingenuity helicopter, which rode to Mars on the underside of the Perseverance rover, is in the process of being deployed (gently lowered to the ground). Since landing on February 18, the project team has been scouting for an area to test the vehicle (an “airfield” and flight zone).

Once Ingenuity is positioned, it will have 30 Martian days, or sols, to conduct a test flight campaign. Its first flight will only last 20 to 30 seconds and take the helicopter only a few feet off the ground. If successful, each additional flight will be incrementally further and higher. NASA/JPL is currently targeting April 8 for the earliest flight. Image Credit: NASA/JPL-Caltech

April Astronomy Calendar and Space Exploration Almanac

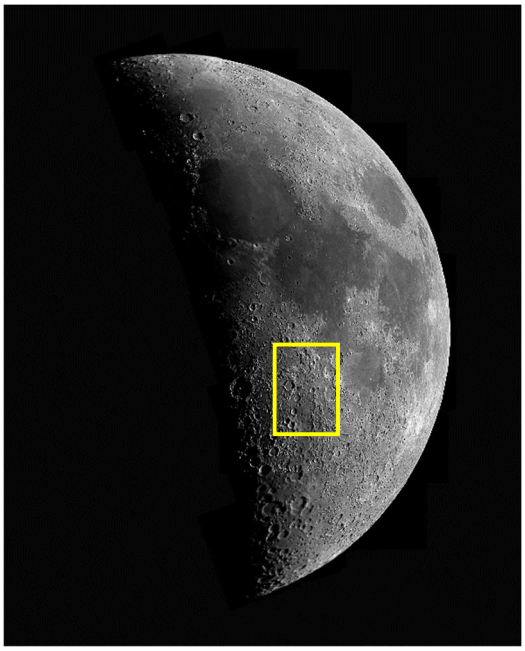
On April 17, 2012, the space shuttle orbiter Discovery was delivered to the National Air and Space's Museum's Udvar-Hazy Center in Chantilly, Virginia - transported by Shuttle Carrier Aircraft (SCA) No. 905 to the adjacent Dulles International Airport. Discovery was the first of three active orbiters retired from the shuttle fleet, with its final mission (STS-133) concluding in March 2011. From 1984 through 2011, the spacecraft spent 365 days in orbit, over a total of 39 missions, circling the Earth 5,830 times and traveling a total of 148,221,675 miles. Its missions included deploying the Hubble Space Telescope and two follow-on servicing calls.

SCA 905 was the first of two Boeing 474 jetliners used by NASA to ferry the shuttle from alternative landing sites back to the Kennedy Space Center launch site. Built in 1970, the aircraft was acquired by NASA in 1974 from American Airlines.

In This Issue

"Out the Window on Your Left"

It's been more almost 52 years since Neil Armstrong first stepped onto the moon's surface and 48 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).



Central lunar highlands and location of the Apollo 16 landing

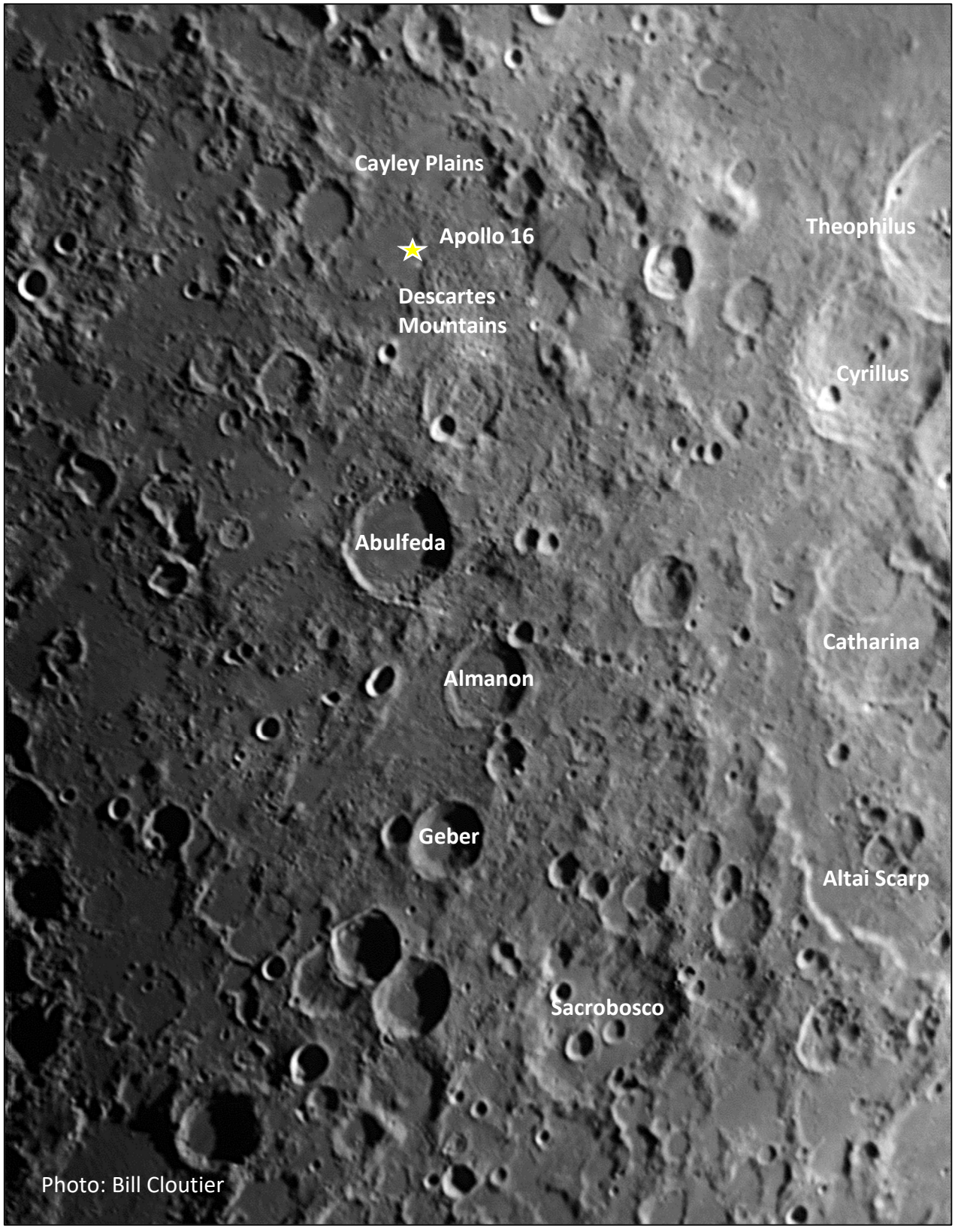
In April 1973, Commander John Young set the Apollo 16 lunar module (named Orion) down between two geologic units – the Cayley Plains and the Descartes Mountains, in the central lunar highlands. Apollo 16 was the second J-type mission, characterized by larger scientific payloads, extended surface time, 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) Theophilus 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



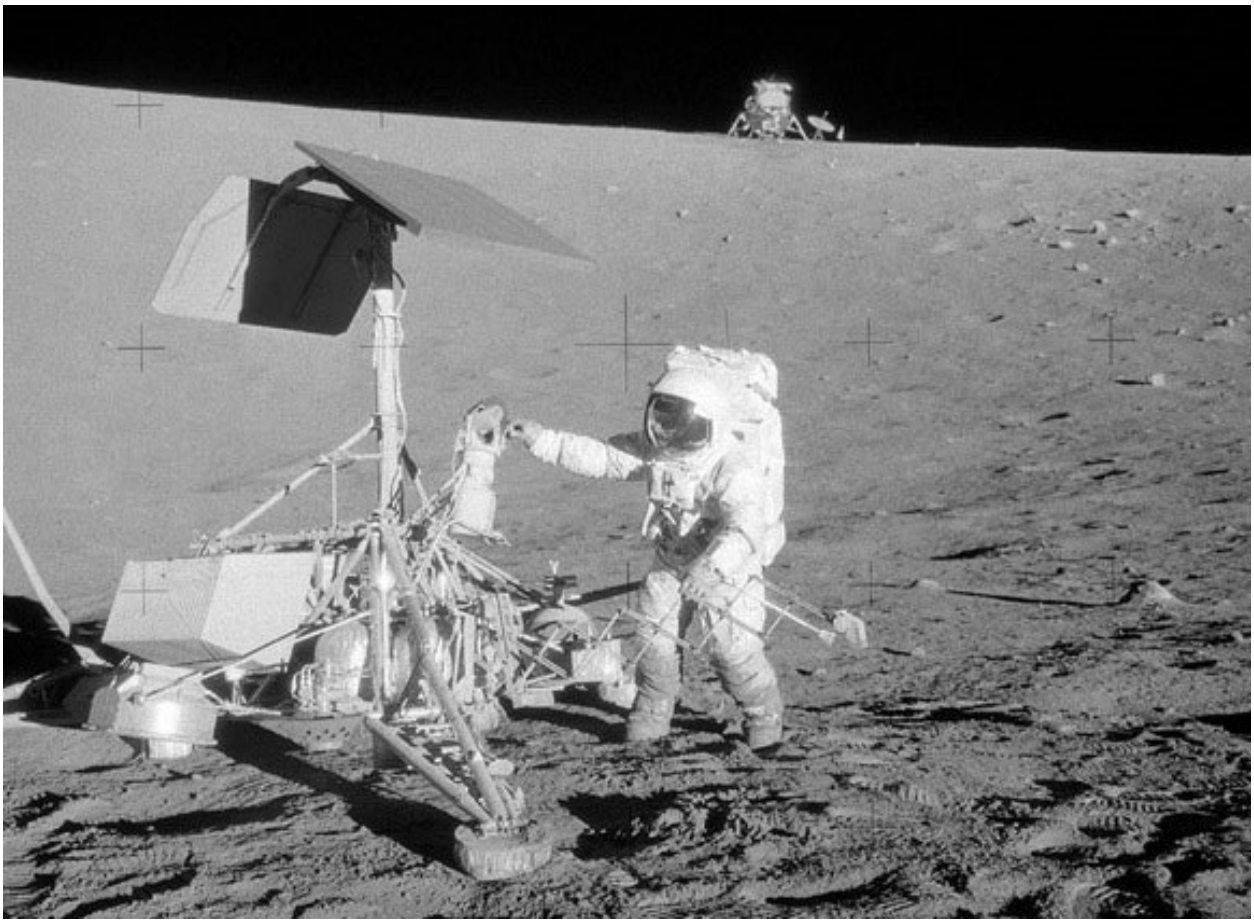
Home World

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

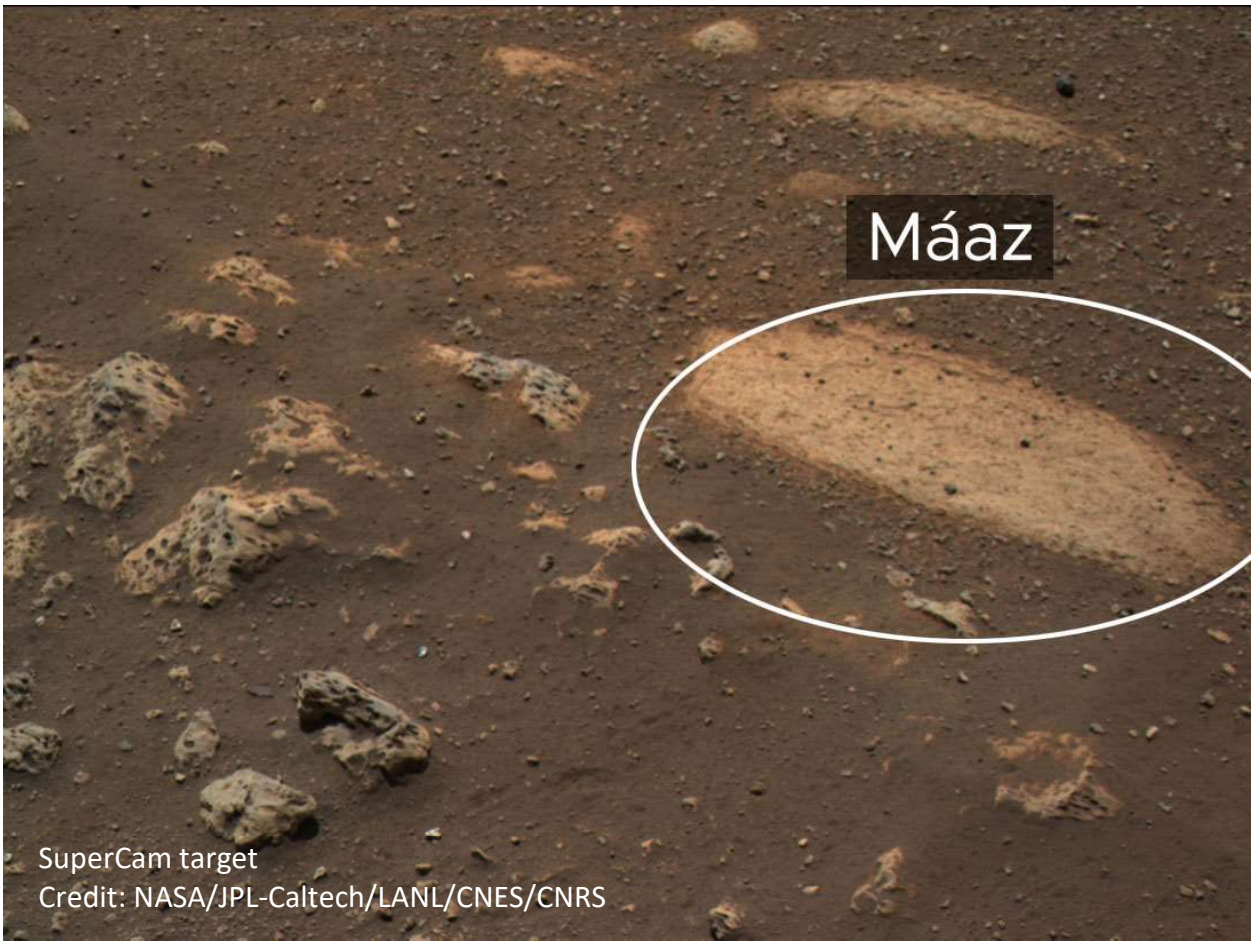
The Apollo 12 astronauts removed several parts from the Surveyor 3 spacecraft during their mission to Oceanus Procellarum. Its camera is now on display in the Smithsonian National Air and Space Museum in Washington, D.C.



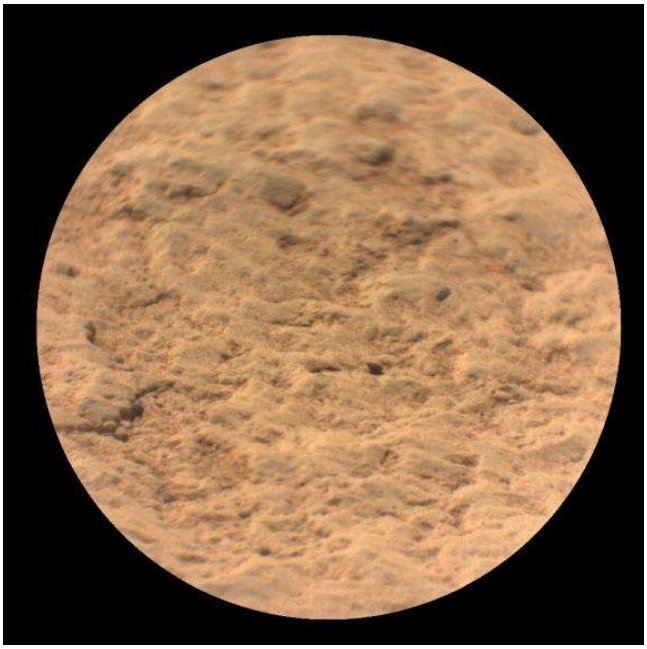
Apollo 12 astronaut Pete Conrad examines Surveyor 3's camera on November 20, 1969 before it was removed for its return to Earth

Image Credit: NASA/Apollo 12 astronaut Alan Bean

Mars 2020 – First Science



SuperCam target
Credit: NASA/JPL-Caltech/LANL/CNES/CNRS

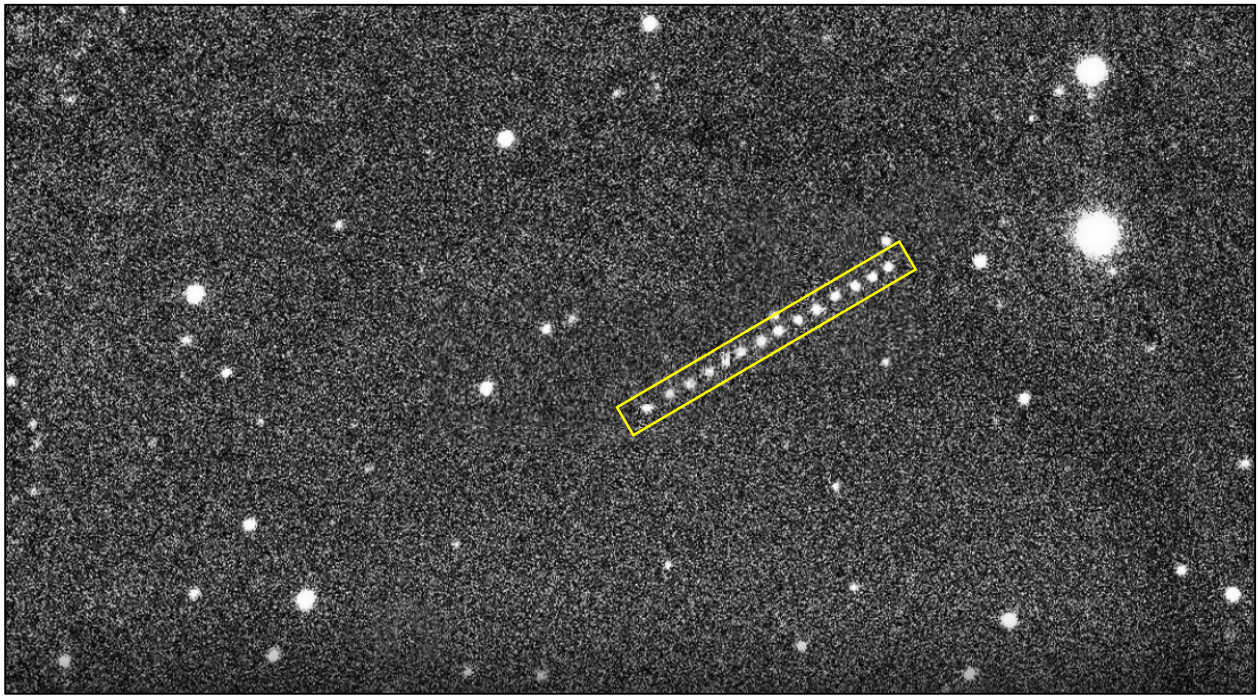


2.3-inch (6.0 cm) diameter field of view
Credit: NASA/JPL-Caltech/LANL/CNES/CNRS

The Perseverance rover was set down on the floor of Mars' Jezero crater on February 18, 2021. For the first several weeks, the project team at NASA's Jet Propulsion Laboratory has put the rover through a post-landing health check, swapped out the cruise software with that for surface operations, deployed the rover's high-gain antennae, mast, and robotic arm and turned-on science instruments.

By early March, project scientists were eager to use the rover's diagnostic tools on nearby rocks. One of the first science targets was a large flat rock named "Máaz" (from the Navaho word for Mars), located about 10.4 feet (3.17 meters) from the rover. Images from the rover's SuperCam's Remote Micro-Imager suggest a basaltic composition - either igneous (from magma), or containing igneous material bound in a rocky matrix.

Apophis the Destroyer

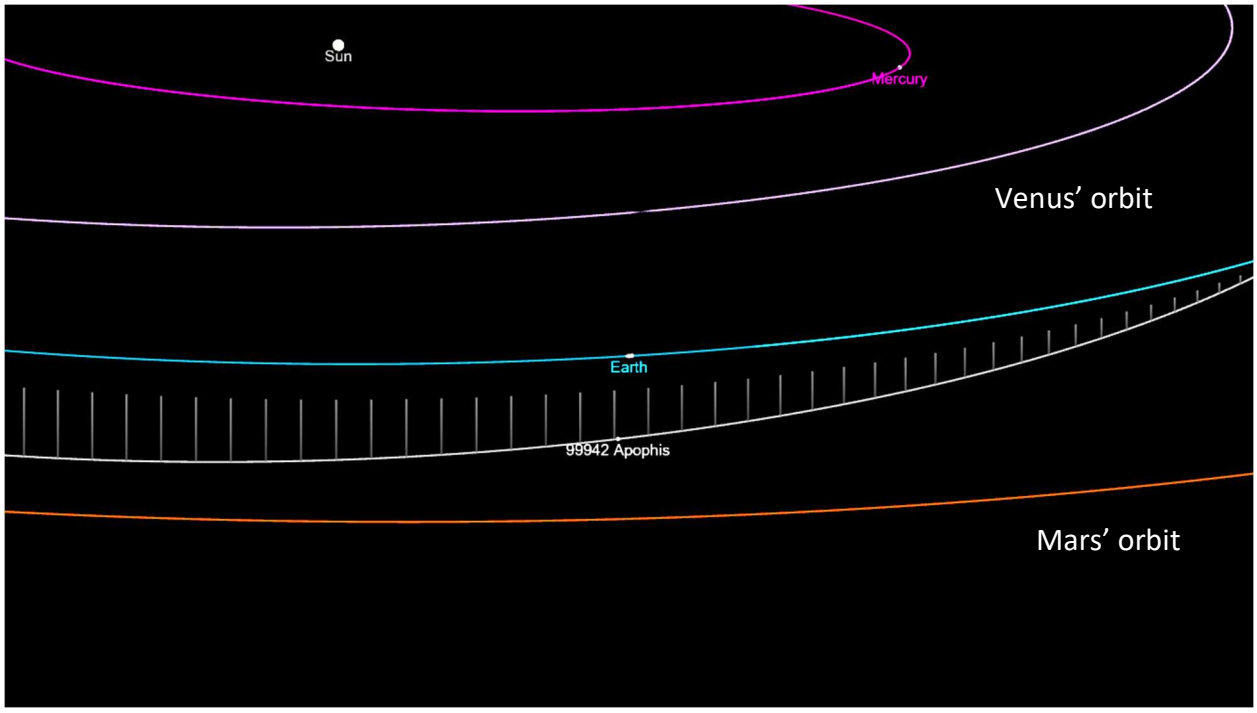


Asteroid 99942 Apophis' motion in the constellation Hydra over a duration of an hour (at 5-minute intervals) on March 5th - closest approach to Earth in 2021 (at approximately 10.5 million miles or 16.8 million km)

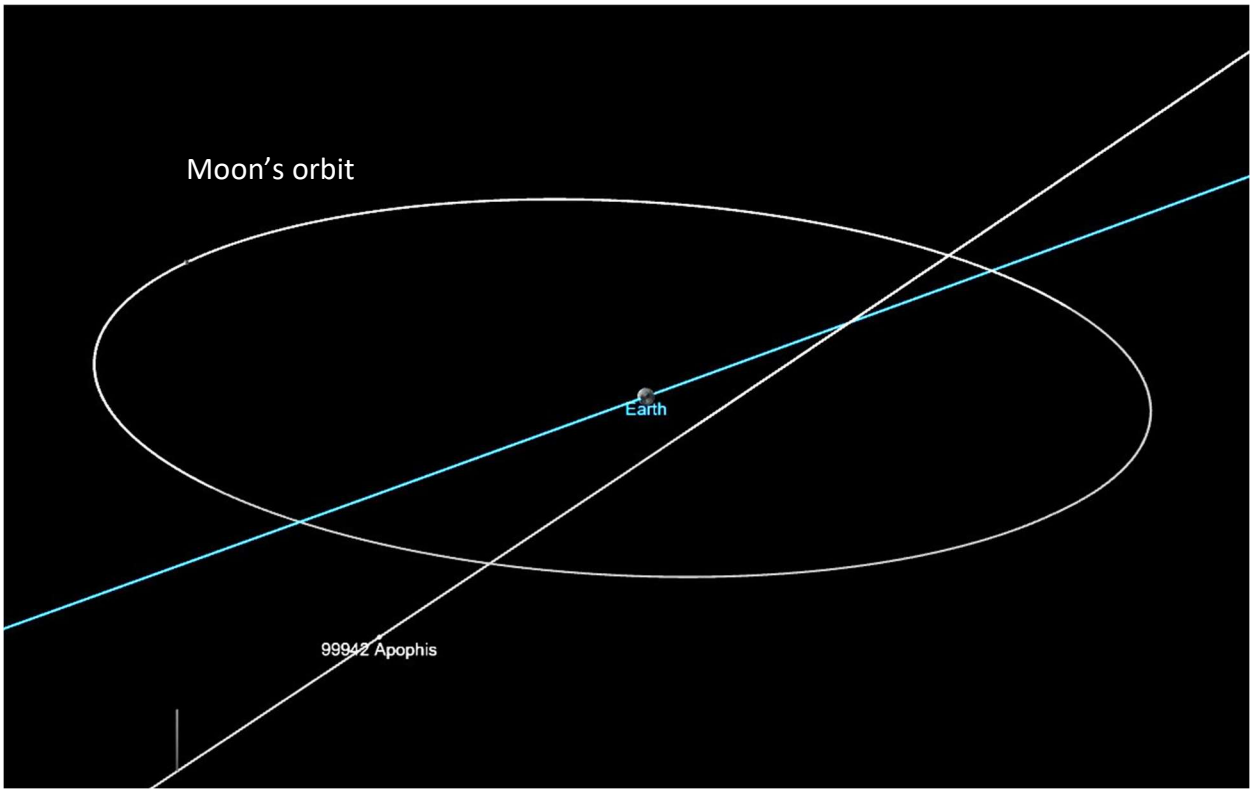
Credit: McCarthy Observatory

Asteroid 99942 Apophis is a near-Earth asteroid discovered in 2004 by astronomers at the Kitt Peak National Observatory in Tucson, Arizona. Apophis, the Greek name for an ancient Egyptian demon serpent and patron of eternal darkness and chaos, is also known as "the Destroyer." The asteroid is classified as potentially hazardous, with future encounters with Earth that have a very slight chance, but non-zero probability, of impacting our planet.

Apophis is a S-type minor planet, likely comprised of silicate (stony) materials, mixed with iron and nickel. Estimated at 1,120 feet in width (340 meters), radar imaging suggests that the asteroid is elongated and may have two lobes. Apophis is an Earth-crosser, completing an orbit around the Sun in just less than a year. It is currently a member of a group of Earth-crossing asteroids known as "Atens" (asteroids with orbits less than 1 astronomical unit or "au" - the average distance of the Earth from the Sun). After its close approach to Earth in 2029, the width of Apophis' orbit will increase to greater than 1 au, moving it into a group of asteroids known at "Apollos." The 2029 approach of Apophis will present astronomers an extraordinary opportunity to observe the asteroid with optical and radar telescopes. On Friday, April 13, 2029, Apophis will come within 20,000 miles (32,000 km) of Earth, closer than communication satellites in geosynchronous orbit. The asteroid will be close enough to be visible in the night sky, as a moving point of light, without any optical aid. Due to the timing, observers in the southern hemisphere and central Europe will have the best view – with the asteroid's pass over North America in daylight. After 2029, the next encounter of interest will occur in 2068, although recent observations by the Goldstone and Green Bank radio telescopes have ruled out any impact risk for that encounter.

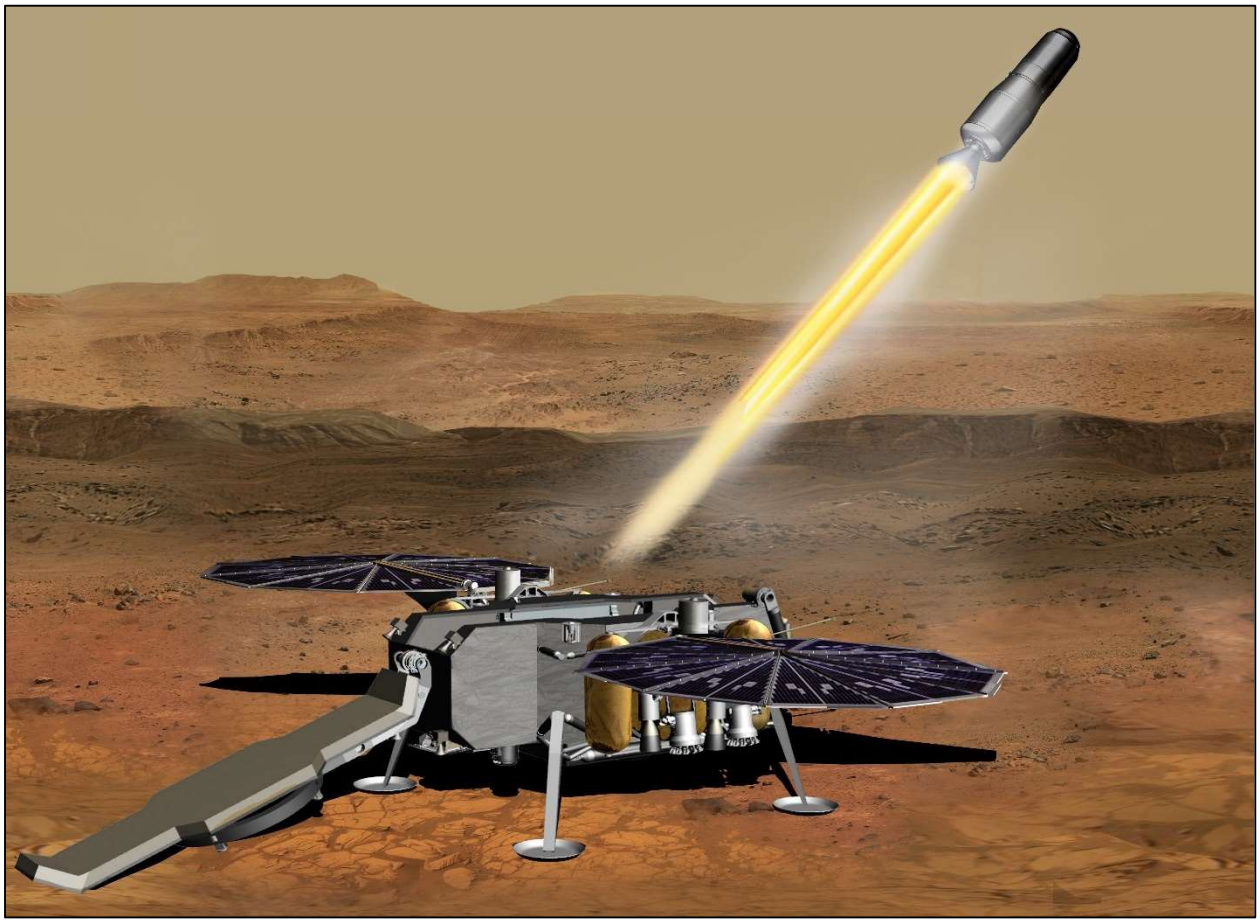


Orbital diagrams for the closest approach of 99942 Apophis on March 5, 2021 (above), when it passed by at a distance of 10.5 million miles (16.9 million km), and the much closer approach on April 13, 2029 (below), when the asteroid will pass within 20,000 miles (32,000 km) of Earth. Credit: JPL Small-Body Database Browser



MAV Contract

NASA's Perseverance rover is designed to collect and package samples of Martian rock and dust for a return to Earth, at some time in the future (the rover is equipped with the most complex sample caching system to be sent to another world, with more than 3,000 parts). Scientists expect that more than a dozen hermetically sealed sample tubes will be strategically staged on the surface for collection. NASA and the European Space Agency are currently collaborating on the retrieval mission to be launched as early as 2027 or 2028.



Conceptual launch of Perseverance's samples on a rocket from a future lander to orbit
Credits: NASA/JPL-Caltech

The current concept includes solar-powered Sample Retrieval Lander(s), a Sample Fetch Rover, Sample Transfer Arm, Mars Ascent Vehicle (MAV), an Earth Return Orbiter, and Capture and Containment and Earth Return modules. The rover would collect Perseverance's sample tubes before returning to the lander. A robotic arm on the lander (or on one of two landers) will then transfer the samples into a container in the nose of a solid rocket-powered MAV. The two stage MAV would be launched from the lander into orbit where it would rendezvous with the Earth Return Orbiter. While in Mars orbit, the sample container would be placed in a containment capsule for its return to Earth, likely in the early 2030s.

In 2020, an Independent Review Board recommended that NASA proceed with the mission. A contract to Northrop Grumman was subsequently issued for the Mars Ascent Propulsion System.

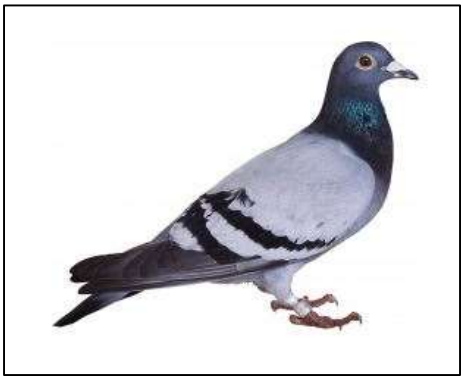
Pigeons and Brooms

The third stage of the Saturn V moon rocket was instrumental in getting astronauts to the Moon. Designated the S-IVB for the second stage of the Saturn IB and third stage of the Saturn V rockets, it was the only stage designed to restart - firing the first time to place the Command/Service Module into orbit around the Earth, and the second time to take the spacecraft out of orbit and send it on its way to the Moon.

Assembly area at Huntington Beach NASA Photo

The S-IVB evolved from an earlier version built as the second stage for the Saturn I rocket. All three versions were manufactured by the Douglas Aircraft Company and used liquid hydrogen and liquid oxygen as a propellant. The Saturn I version, called S-IV, was powered by a cluster of six Pratt & Whitney Aircraft engines, while the Saturn IB and V versions used a much larger, single J-2 engine supplied by Rocketdyne.

The different versions of the rocket stage shared a common design and manufacturing process. While the propellant tank components were manufactured at several California locations, Douglas Aircraft built a dedicated facility at Huntington Beach for the final assembly. Building architecture was designed to keep dust and dirt from accumulating, as maintaining a clean environment was essential in minimizing contamination of these complex machines. However, despite best efforts, the building with its large bay doors and tracks, was beset by visiting birds – creating a sanitation issue for both man and machine.



A special task force was assembled to tackle the pigeon infestation. High frequency whistles and an occasional shotgun blast provided temporary relief (and a ventilated roof). It wasn't until ornithologists suggested using bird seed treated with a mild nerve agent that the pigeons finally abandoned their post.

The pigeon hazard was a minor inconvenience compared to the dangers of working with, and handling, liquid hydrogen (with the potential for fires and explosions). Hydrogen leaks produced an intense flame which was invisible in the daylight. While the company used infrared cameras, there were gaps in coverage of the booster that could have proved deadly. A special crew in protective gear would walk the scaffolding that surrounded the S-IVB at the test site with a broom in hand. If the straw broom suddenly burst into flame, there was danger ahead.

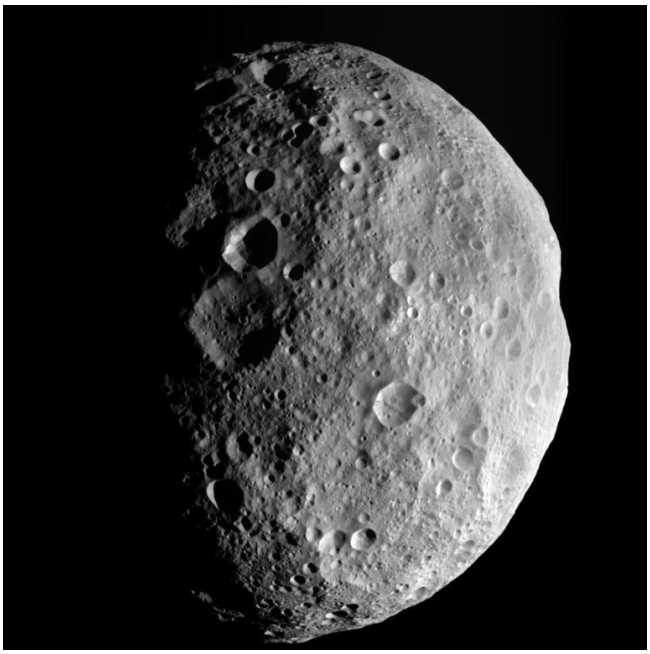
Meteorite Spotlight - Kapoeta

In the summer of 2018, the Observatory greatly expanded its meteorite teaching collection with the addition of a diverse and comprehensive set of meteoritic specimens from a reputable collector looking to convey his collection to someone who would maintain its integrity and capitalize on its intrinsic educational value. The collection includes whole stones, slices and fragments, numbering more than 200, from historic and scientifically-significant falls and meteorite finds dating back to 1492. From time to time, we will highlight one or more of the specimens from the collection in this newsletter.

McCarthy Observatory's samples of Kapoeta
Image: Gerard Bianchi

On April 22, 1942, a 25-pound (11.36 kg) stone fell in the Sudan. Its name, Kapoeta, comes from the Kapoeta-Nathalani road upon which it fell (landing in front of a British convoy during World War II).

Kapoeta has been classified as a howardite – a brecciated mixture of diogenite and eucrite basaltic igneous rocks, as well as other material such as carbonaceous chondrite clasts. These relatively rare meteorites (howardites represent less than 1% of the total recovered stones), are believed to have come from the asteroid 4-Vesta, visited by NASA's Dawn spacecraft between 2011 and 2012.



Dawn's last view of Vesta's north pole
Credit: NASA/JPL-Caltech/UCLA/MPS/ DLR/ IDA

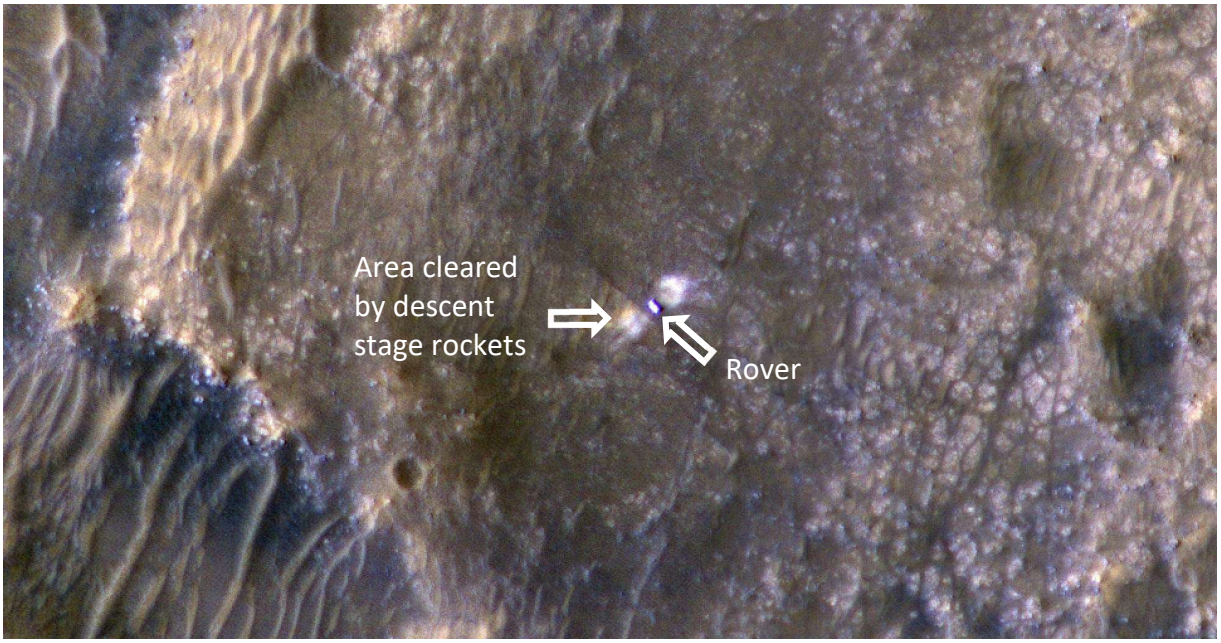
Vesta is the second most massive body in the Main Asteroid Belt (Ceres having the largest mass) and large enough to have become differentiated, with its interior separated into a crust, mantle and core. Howardites are likely from the asteroid's surface, based on their high content of solar wind-implanted noble gases. Having been blasted off the primitive body by one or more impacts, the meteorites can also be rich in impact melt.

Researchers have also found presolar grains embedded in the Kapoeta meteorite. They believe that the grains were likely delivered by micrometeorites – about 3.5 billion years ago.

The McCarthy Observatory's two samples of Kapoeta are a 0.350-gram fragment and 0.115-gram part slice.

History of Mars Imaging

Hanging in one of the back hallways at NASA's Jet Propulsion Laboratory is the first close-up image of the surface of Mars. One of 22 images returned by a TV camera on the Mariner 4 spacecraft in 1965, the mission team color-coded the binary data as it was received to create the collage. Mariner 4's rudimentary images revealed a disappointing, cratered and desolate landscape. (Photo: NASA/JPL/Dan Goods)



Sixty-one years later, the Mars Reconnaissance Orbiter's camera is able to resolve the 10-foot-long (not including the arm), 9-foot-wide (about 3 meters by 2.7 meters) Perseverance rover from an altitude of 180 miles (290 km). (Image Credit: NASA/JPL-Caltech/University of Arizona)

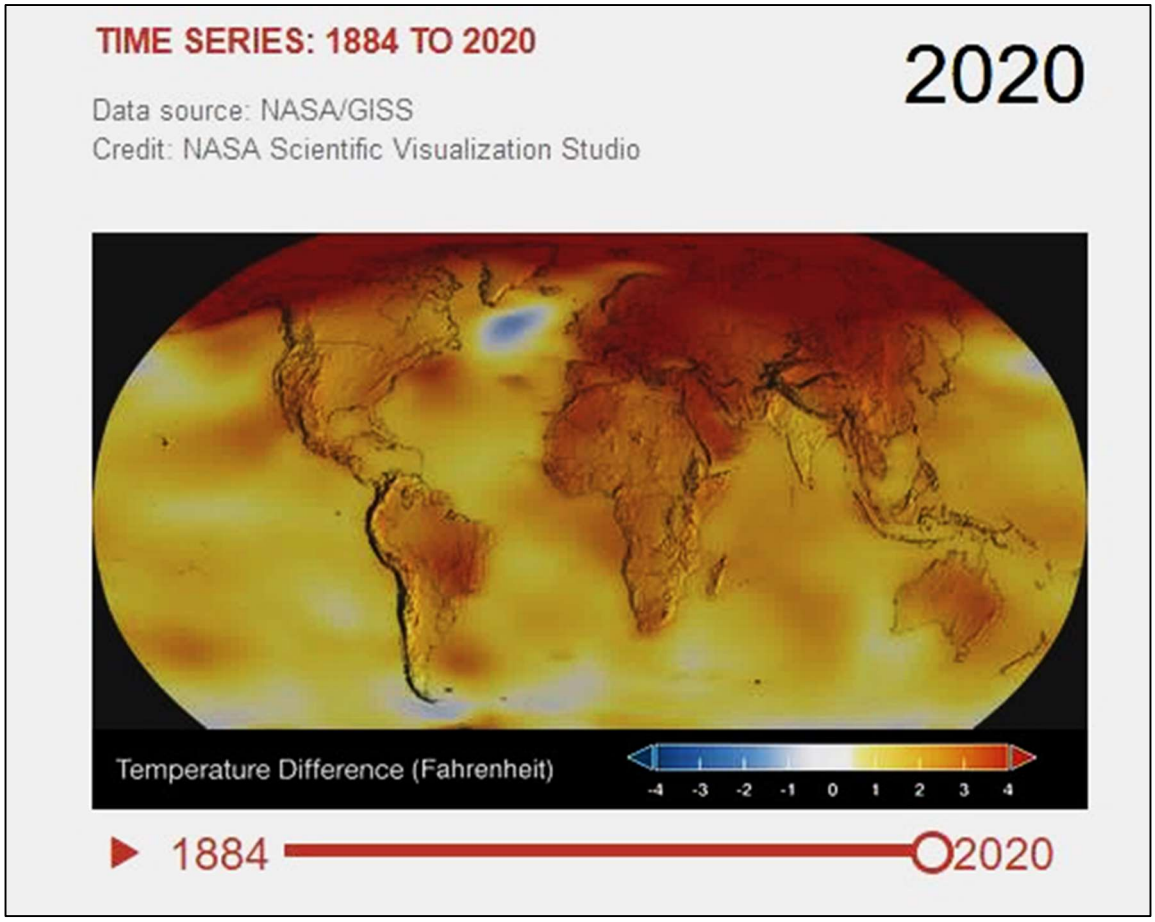
Earth Day 2021

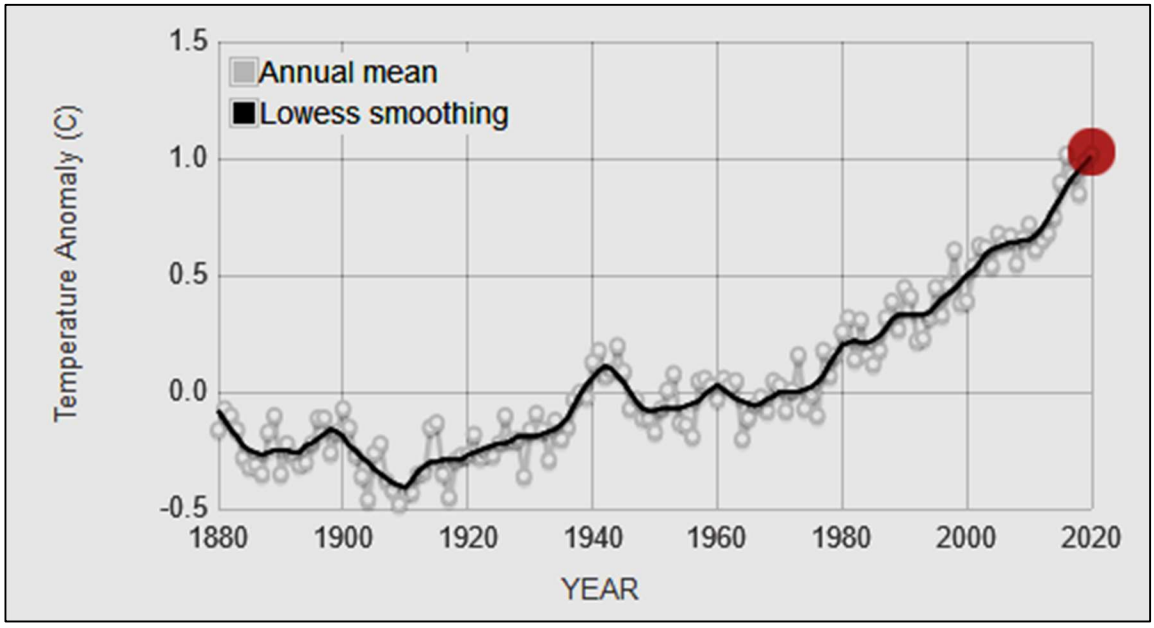
Setting aside a day to focus on spaceship Earth, its natural environment and the impact that humans have had on its fragile biosphere, was the idea of U.S. Senator Gaylord Nelson after witnessing the aftermath of the 1969 Santa Barbara oil spill (a well blowout in an off-shore drilling platform that 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 2021 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.


TIME SERIES: 1884 TO 2020
2020
Data source: NASA/GISS
Credit: NASA Scientific Visualization Studio
Temperature Difference (Fahrenheit)
-4 -3 -2 -1 0 1 2 3 4
1884
2020


Annual mean
Lowess smoothing
Temperature Anomaly (C)
1.5
1.0
0.5
0.0
-0.5
1880
1900
1920
1940
1960
1980
2000
2020
YEAR

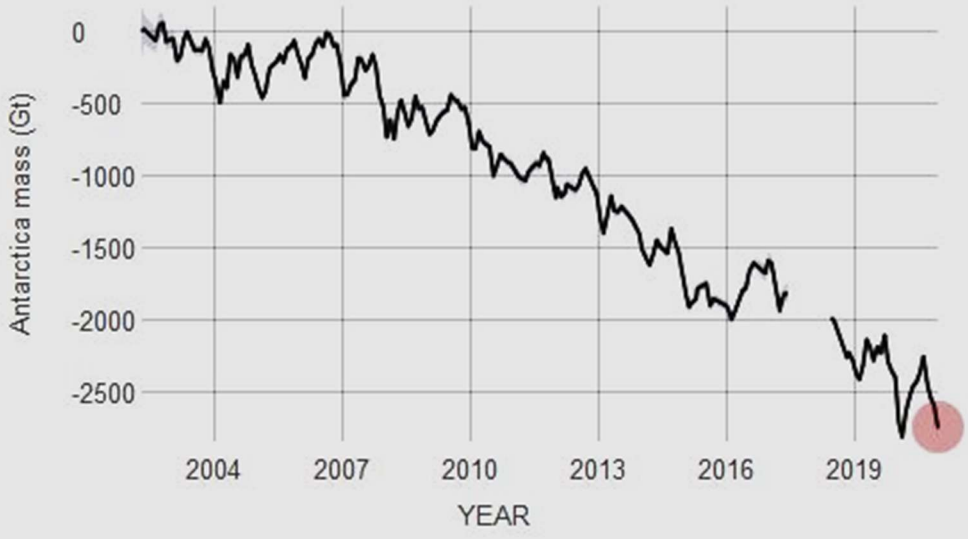
ANTARCTICA MASS VARIATION SINCE 2002

RATE OF CHANGE

↓ 150.0

billion metric tons per year

Data source: Ice mass measurement by NASA's GRACE satellites. **Gap represents time between missions.**
Credit: NASA



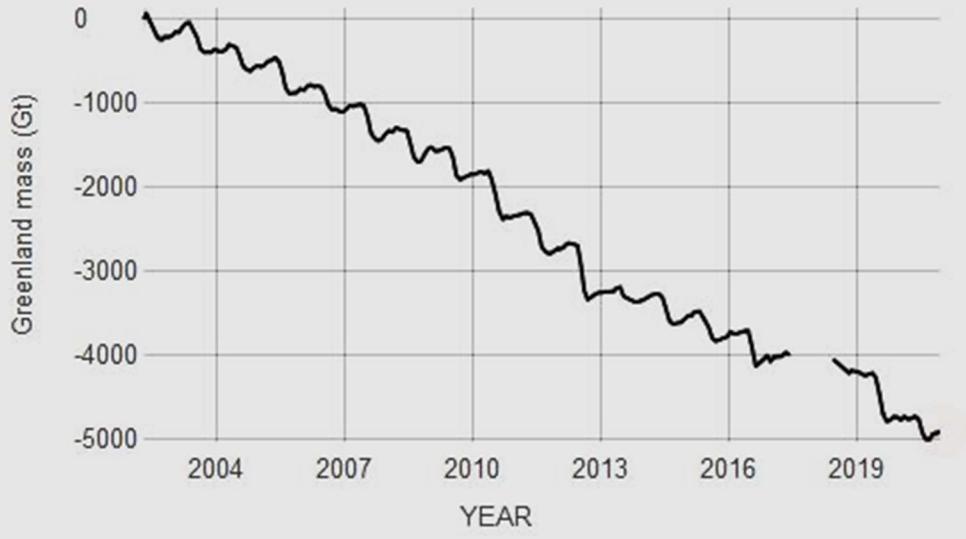
GREENLAND MASS VARIATION SINCE 2002

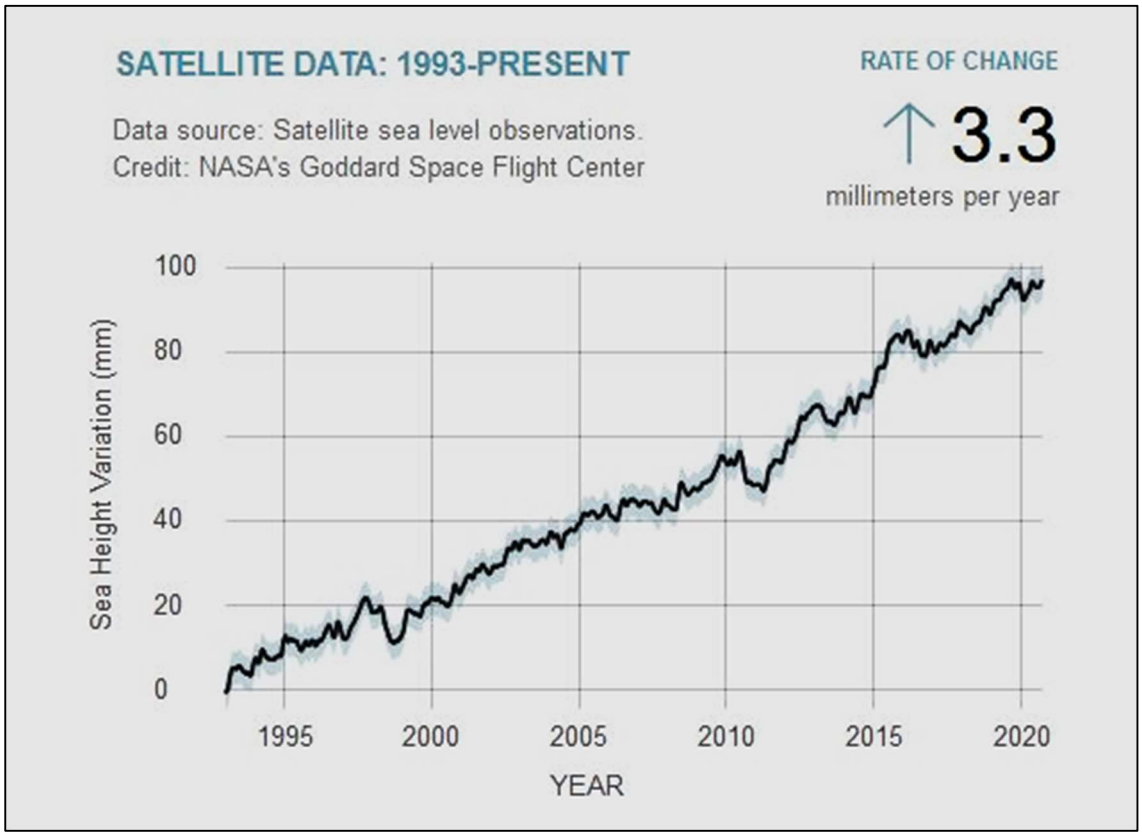
RATE OF CHANGE

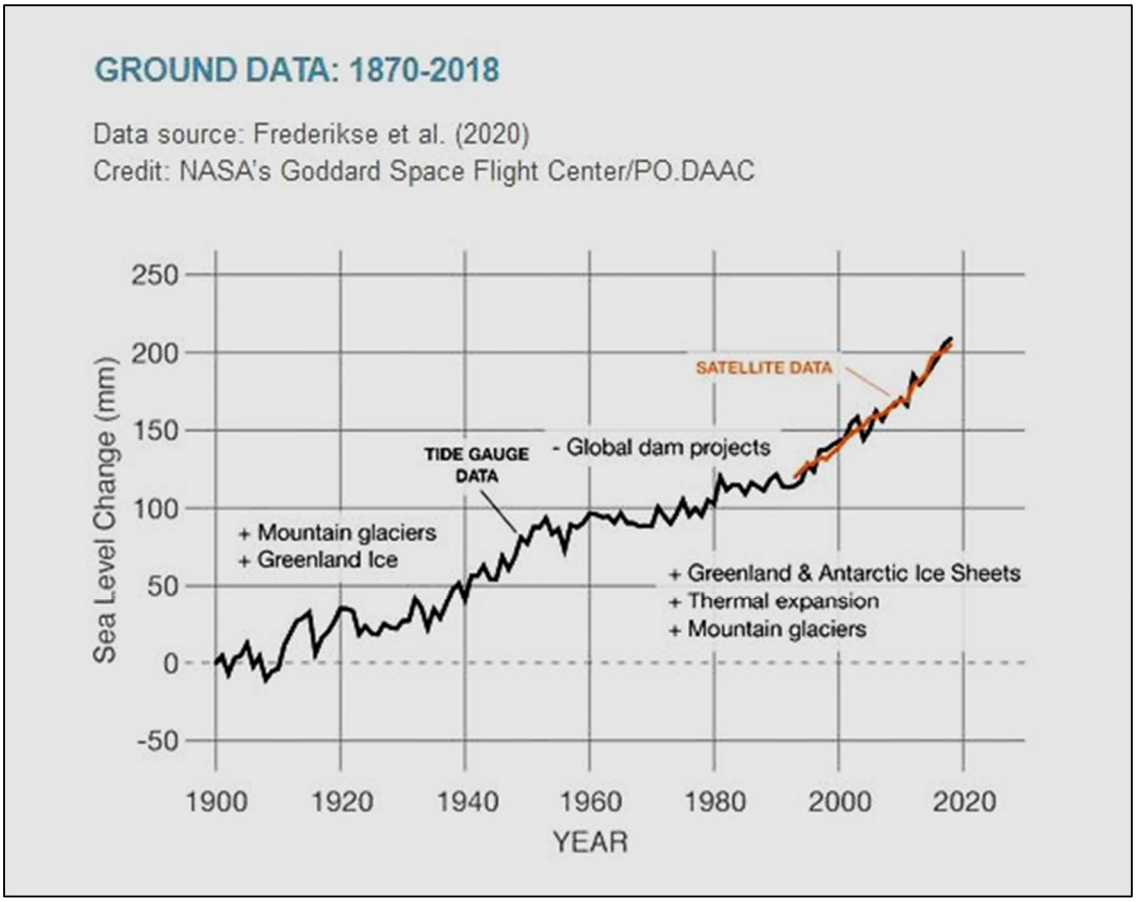
↓ 278.0

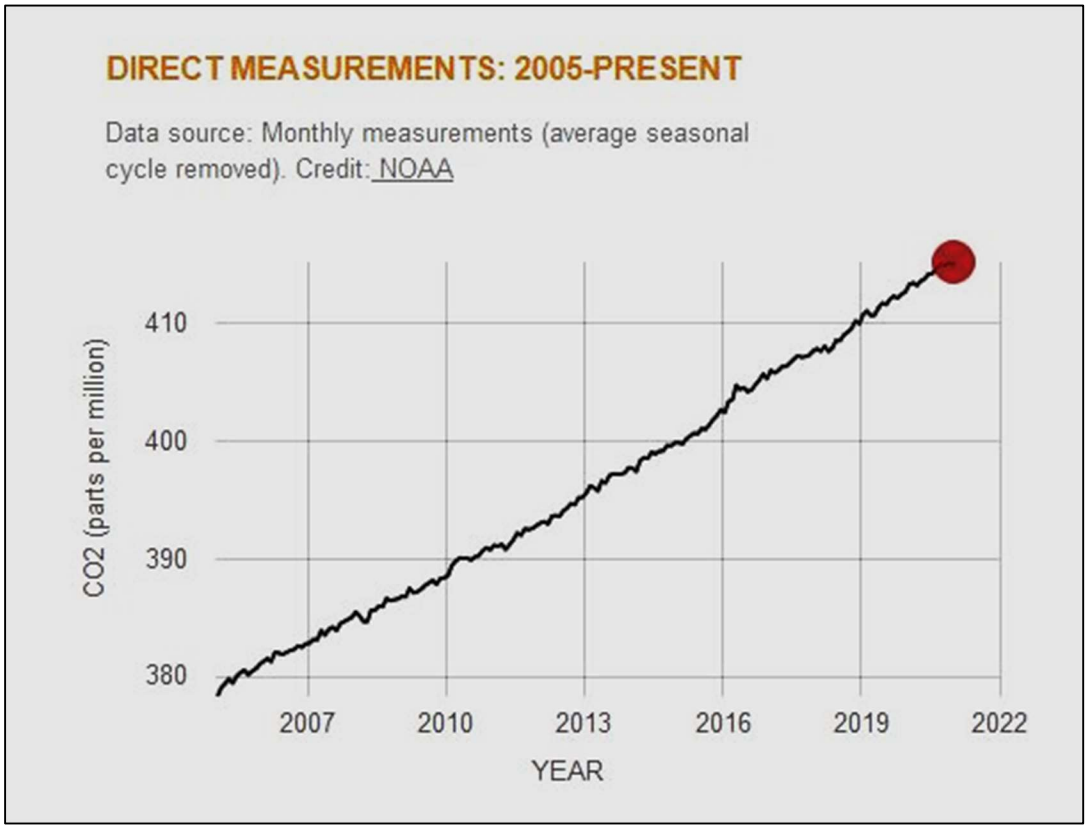
billion metric tons per year

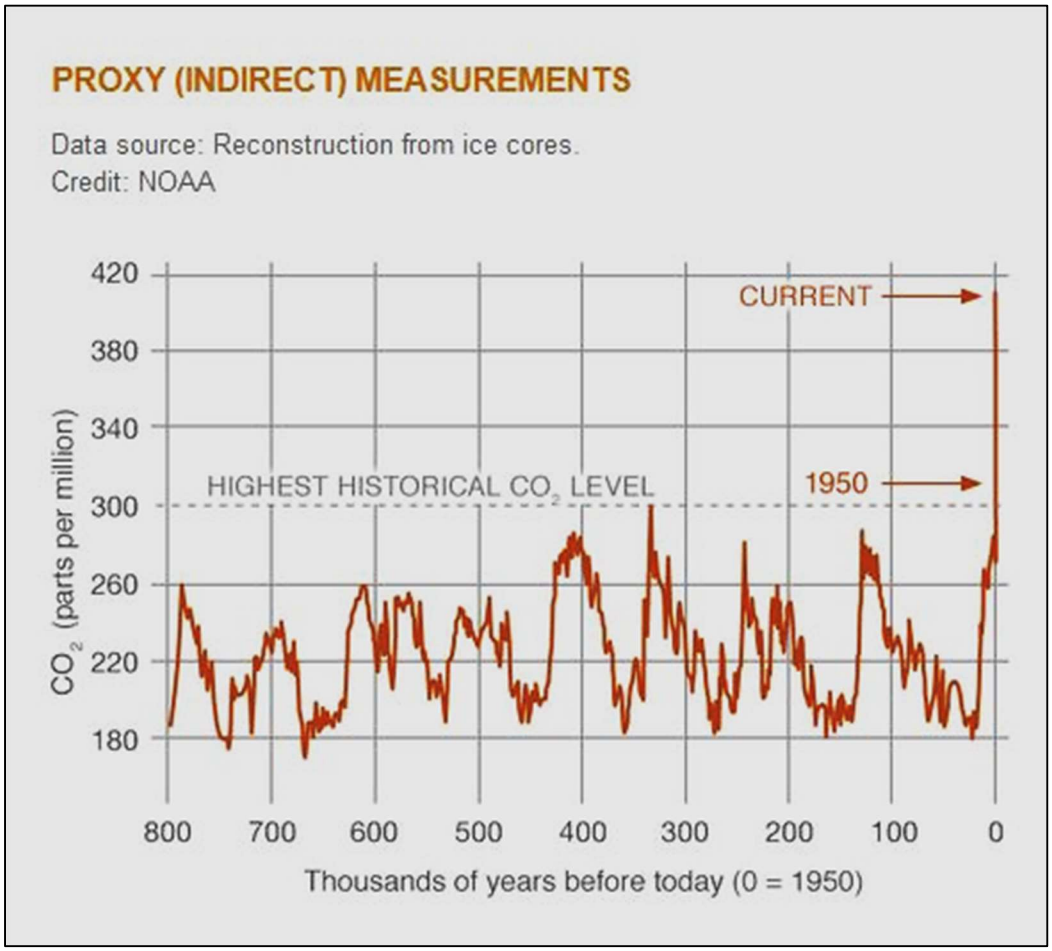
Data source: Ice mass measurement by NASA's GRACE satellites. **Gap represents time between missions.**
Credit: NASA




SATELLITE DATA: 1993-PRESENT
Data source: Satellite sea level observations.
Credit: NASA's Goddard Space Flight Center
RATE OF CHANGE
3.3
millimeters per year
Sea Height Variation (mm)
100
80
60
40
20
0
1995
2000
2005
2010
2015
2020
YEAR


GROUND DATA: 1870-2018
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


DIRECT MEASUREMENTS: 2005-PRESENT
Data source: Monthly measurements (average seasonal cycle removed). Credit: NOAA
CO2 (parts per million)
410
400
390
380
2007
2010
2013
2016
2019
2022
YEAR


PROXY (INDIRECT) MEASUREMENTS
Data source: Reconstruction from ice cores.
Credit: NOAA
CO2 (parts per million)
420
380
340
300
260
220
180
CURRENT
HIGHEST HISTORICAL CO2 LEVEL
1950
800
700
600
500
400
300
200
100
0
Thousands of years before today (0 = 1950)

Globally, 2020 was one of the hottest years on record, tied with the year 2016 which held the previous record (nineteen of the years since 2000 have set records for warmth). The planet's average surface temperature has risen about 2.12°F (1.18°C) since the late 19th century – a trend 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 top layer of the ocean (top 300 feet or 100 meters) has warmed more than 0.6°F (0.33°C) since 1969. 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 according to study published February in the journal Nature Geoscience.

The ice sheets covering Greenland and Antarctic have also decreased in mass. Satellite observations (by NASA's Gravity Recovery and Climate Experiment) have documented an average of 279 billion tons of ice lost each year between 1993 and 2019 for the Greenland ice sheet, while Antarctica lost ice at a rate of about 148 billion tons per year over the same period.

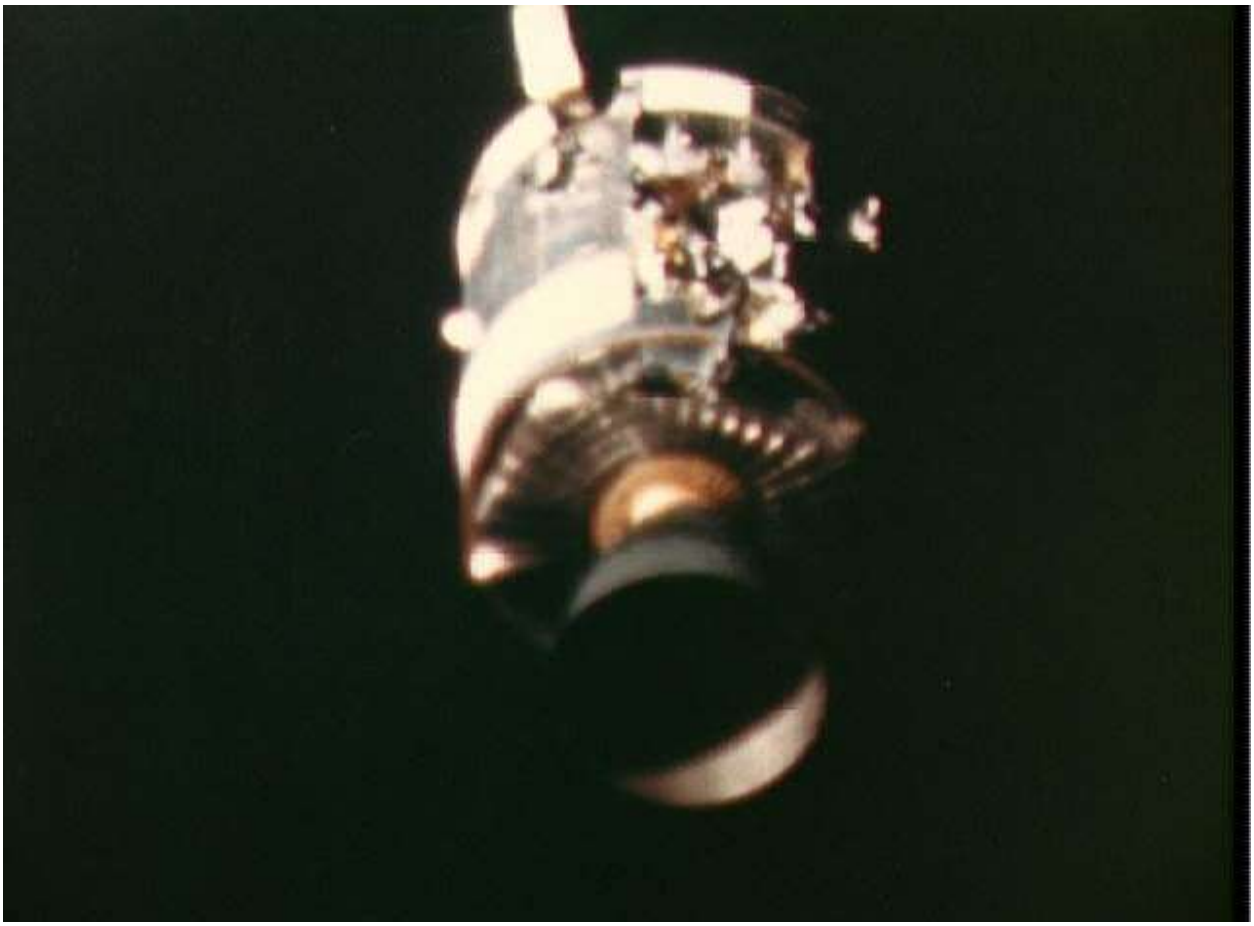
Global sea level rose about 8 inches (20 centimeters) in the last century - recorded by tidal gauges and, more recently, by satellites. The rate of increase has nearly doubled over the past two decades. A hotter planet is likely contributing to long-term climate changes (desertification and coastal flooding) 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. Future Earth Systematic Missions include the Surface Water & Ocean Topography (SWOT) satellite, currently scheduled for launch in the first half of 2022.

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."

Comet History

Comet Hale-Bopp graced the evening sky in the spring of 1997. It was brighter than the brightest stars in the sky, with a dust tail that stretched almost 45 degrees across the sky. The photo, taken

on April 2, 1997, one day after perihelion (closest approach to the Sun). shows the brighter, yellow dust tail and the dimmer, blue ion (gas) tail.

The orbital period of *Hale-Bopp* as it entered the inner solar system was 4,206 years. A close encounter with Jupiter in April of 1996 modified its orbit, shortening its orbital period to 2,380 years as it returned to the outer solar system.

April Showers

The Lyrid meteor shower is expected to peak just before dawn on April 22nd. The dust producing the shooting stars is from *Comet Thatcher*. Expect to see 10 to 20 meteors per hour if light from an early morning moon doesn't interfere. 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)	06:36 am	7:19 pm
April 15th	06:13 am	7:34 pm
April 30th	05:51 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 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)
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 Last Quarter Moon
4th Easter Sunday
4th Aten Asteroid *326290 Akhenaten* closest approach to Earth (0.264 AU)
4th Apollo Asteroid *4581 Asciepius* closest approach to Earth (0.281 AU)
4th History: launch of Apollo 6, last test flight of the Saturn V rocket (1968)
5th Amor Asteroid *7480 Norwan* closest approach to Earth (1.083 AU)
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 Apollo Asteroid 2015 MB54 near-Earth flyby (0.035 AU)
6th History: launch of Intelsat 1, first commercial communications satellite (1965)
7th Aten Asteroid 2014 FO38 near-Earth flyby (0.043 AU)
7th History: launch of the Mars Odyssey orbiter (2001)

Astronomical and Historical Events (continued)

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 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 Scheduled launch of a Russian Soyuz spacecraft from the Baikonur Cosmodrome in, Kazakhstan to the International Space Station with the next Expedition Crew
9th Apollo Asteroid *469219 Kamo`oalewa* closest approach to Earth (0.161 AU)
9th Apollo Asteroid *9162 Kwiila* closest approach to Earth (1.086 AU)
10th **Second Saturday Stars - Open House at McCarthy Observatory**
10th Centaur Object *31824 Elatus* at Opposition (15.109 AU)
10th Kuiper Belt Object 2013 FS28 at Opposition (81.927 AU)
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 New Moon
11th Amor Asteroid *9950 ESA* closest approach to Earth (2.057 AU)
11th Kuiper Belt Object 523693 (2014 FT71) at Opposition (46.391 AU)
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 Amor Asteroid *5869 Tanith* closest approach to Earth (0.863 AU)
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 History: launch of Transit 1B, first experimental navigation satellite (1960)
14th Moon at apogee (furthest distance from Earth)
14th History: Christiaan Huygens born, Dutch scientist and discoverer of Saturn's rings and largest moon *Titan* (1629)
15th Apollo Asteroid 2020 UY1 near-Earth flyby (0.041 AU)
16th Aten Asteroid 2017 HG4 near-Earth flyby (0.019 AU)
16th History: launch of Apollo 16 with astronauts John Young, Ken Mattingly and Charles Duke, the only mission to the lunar highlands (1972)

Astronomical and Historical Events (continued)

16th History: Leonardo Da Vinci born, first to correctly explain Earthshine (1452)
17th Apollo Asteroid 2020 HE5 near-Earth flyby (0.022 AU)
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 Apollo Asteroid *24761 Ahau* closest approach to Earth (0.866 AU)
18th Dwarf Planet *136108 Haumea* at Opposition (49.370 AU)
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 Amor Asteroid *13553 Masaakikoyama* closest approach to Earth (1.112 AU)
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 First Quarter Moon
20th Aten Asteroid 2019 HQ near-Earth flyby (0.038 AU)
20th Apollo Asteroid *2329 Orthos* closest approach to Earth (0.904 AU)
22nd Scheduled launch of SpaceX's Crew Dragon (2nd operational flight) with a crew of four from the Kennedy Space Center to the International Space Station
22nd Lyrids Meteor Shower peak
22nd Earth Day
22nd Aten Asteroid 2020 HO5 near-Earth flyby (0.042 AU)
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)
23rd Apollo Asteroid 2019 PS1 near-Earth flyby (0.037 AU)
24th Apollo Asteroid 2016 QE45 near-Earth flyby (0.032 AU)
24th Apollo Asteroid *1866 Sisyphus* closest approach to Earth (1.975 AU)
24th Centaur Object *944 Hidalgo* at Opposition (5.560 AU)
24th Kuiper Belt Object 2020 FY30 at Opposition (98.012 AU)
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)
25th Centaur Object *472235 Zhulong* at Opposition (32.256 AU)
25th Kuiper Belt Object *38083 Rhadamanthus* at Opposition (40.652 AU)
26th Full Moon (Full Pink Moon)
26th Apollo Asteroid 2019 HF4 near-Earth flyby (0.020 AU)
26th Apollo Asteroid 2015 HA177 near-Earth flyby (0.048 AU)
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

Astronomical and Historical Events (continued)

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 Moon at perigee (closest distance from Earth)
28th History: launch of the Cloudsat/Calipso cloud imaging and profiling satellites (2006)
29th Parker Solar Probe, 8th Perihelion – coming within 6.5 million miles (10.4 million km) of the solar surface
29th Amor Asteroid *6456 Golombek* closest approach to Earth (0.992 AU)
30th Kuiper Belt Object 2014 FC69 at Opposition (84.487 AU)
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

Mars 2020 Mission

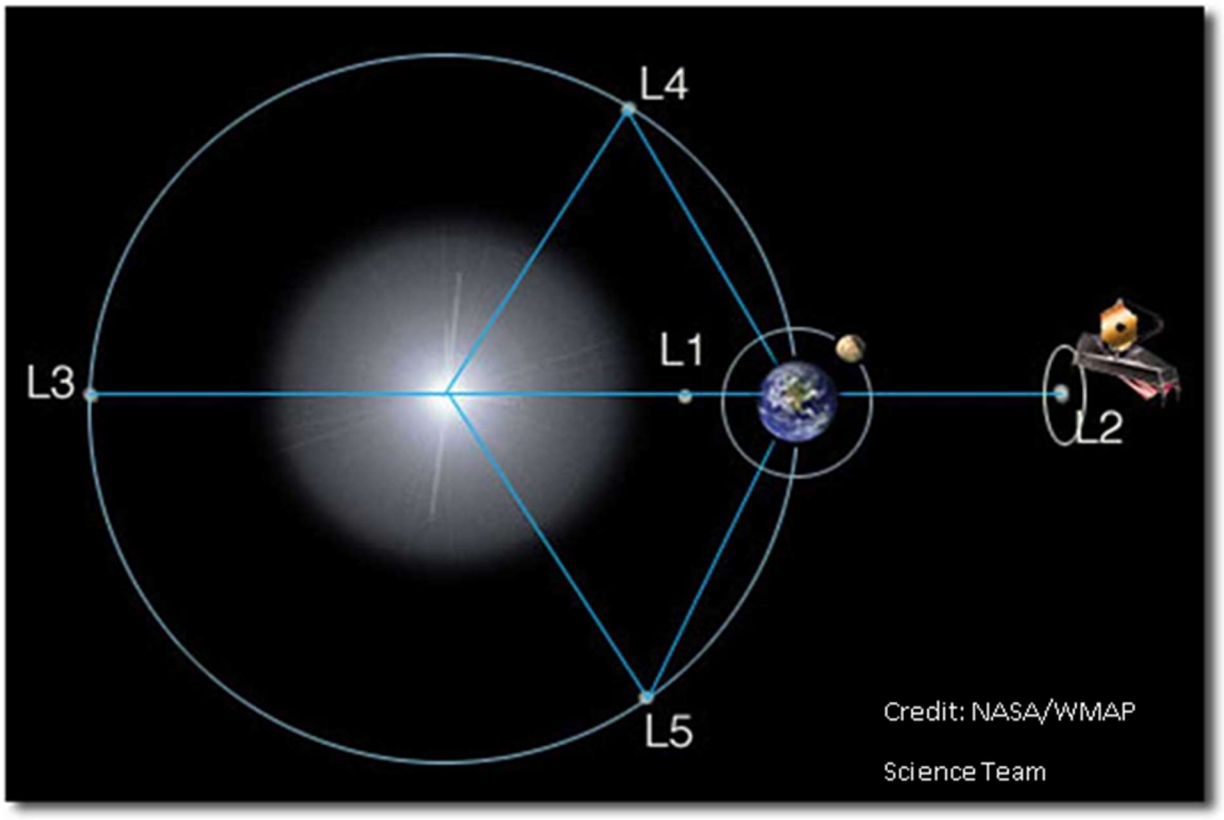
The latest information on the Perseverance rover and the Ingenuity helicopter can be found at https://mars.nasa.gov/mars2020/ and https://mars.nasa.gov/technology/helicopter/

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 future location of the James Webb telescope) is located 1.5 million kilometers beyond the Earth (as viewed from the Sun).



International Space Station and Artificial Satellites

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

NASA's Global Climate Change Resource

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

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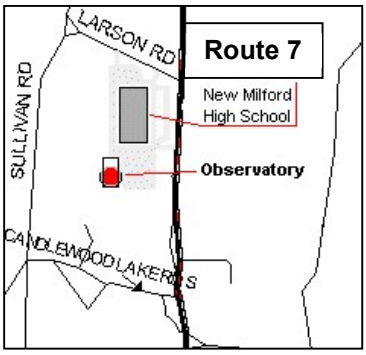

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