Datasets for Earth, Mars, Mercury, and the Moon

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Earth Surface Datasets

VIIRS Combo (Clouds)

Figure 1: Earth with the VIIRS Combo (Clouds) layer enabled. This shows the true-color images of the surface, oceans, and atmospheric features — specifically clouds.

This Earth dataset shows true-color images of the surface, oceans, and atmospheric features – specifically clouds. The combination of wavelengths taken by the Visible Infrared Imaging Radiometer Suite (VIIRS) are analogous to what human eyes would see. This instrument is part of the NASA/NOAA Suomi National Polar orbiting Partnership (Suomi NPP) satellite. The resolution of the image is 250 meters per pixel, with daily temporal resolution. However, the temporal coverage of this layer begins on November 2015.

To learn more about the VIIRS instrument and the data provided by the satellite, visit: https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/viirs/.

VIIRS Combo (Surface)

Figure 2: Earth with the VIIRS Combo (Surface) layer enabled. This layer combines the VIIRS World Imagery and Suomi NPP layers, removing the clouds when close to the surface of Earth.

By zooming closer to the surface of Earth, the clouds layers fade out, and we are left with the Visible Infrared Imaging Radiometer Suite (VIIRS) World Imagery. The reason this color layer is called "Combo" is that it combines features from the World Imagery and Suomi NPP layers taken with the VIIRS instrument. To preserve the rendering of land features, the software automatically removes the cloud layers, but the same dataset is still showing. The individual layers can be activated separately if desired.

Earth at Night

Figure 3: Earth at Night layer is a composite layer showing city lights as well as gas flares, wildfires, auroras, and moonlight reflecting from the surface of Earth.

This is a layer that allows us to visualize the light pollution emanating from the surface of Earth caused by human activity and other phenomena. The light comes from sources such as (mainly) city lights, as well as gas flares, wildfires, auroras, and moonlight reflecting from the surface. This dataset is also a composite from the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument assembled from cloudless images taken in April and October of 2012.

To learn more about the implications and effects of light pollution, visit: https://www.darksky.org/light-pollution/.

MODIS Terra Chlorophyll-A

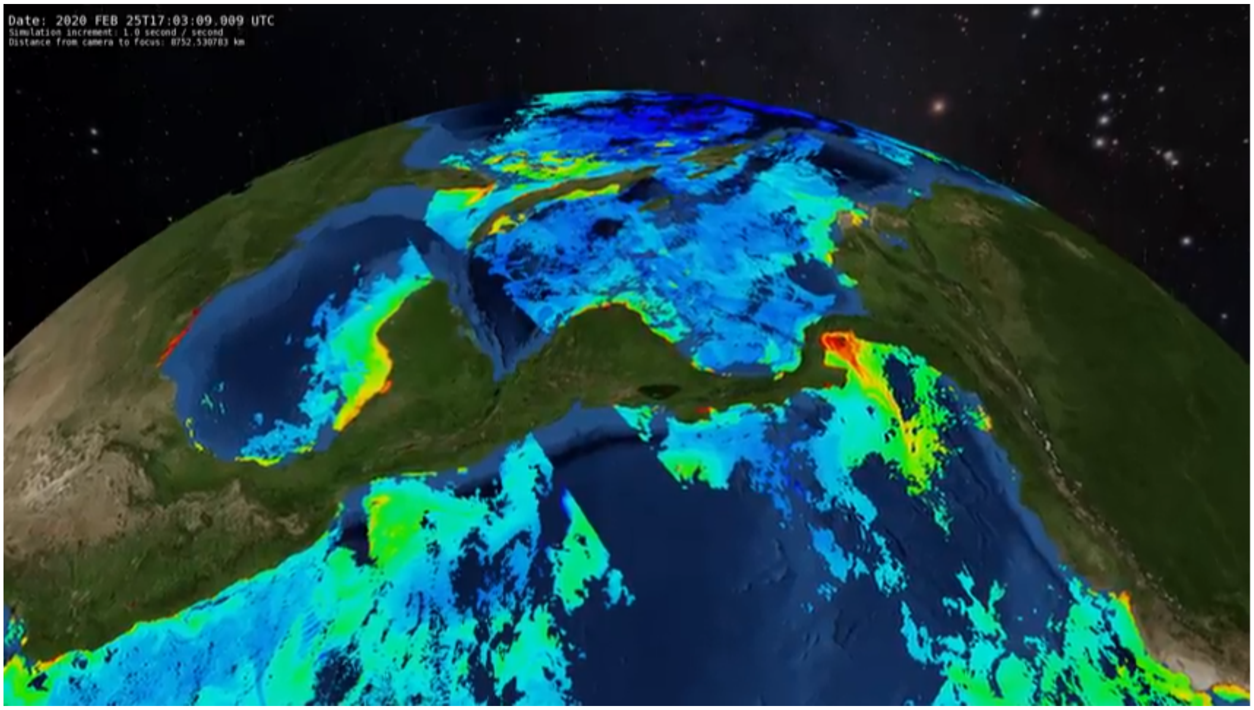

Figure 4: The MODIS Terra Chlorophyll-A layer shows the near-surface concentration of Chlorophyll-a, a tracer of phytoplankton activity. Purple and blue indicate the lowest concentrations, and red and white indicate the highest.

This datasets shows the near-surface concentration of Chlorophyll-a in milligrams per cubic meter in Earth's water bodies, with purple = 0.01 milligrams per cubic meter, red = greater than 20 milligrams per cubic meter.

This pigment, found in most photosynthetic organisms, is a tracer of phytoplankton biomass (i.e. photosynthetic bacteria, protists, and single-celled plants). These organisms, through photosynthesis, take in carbon dioxide and produce oxygen.

Studying phytoplankton activity through the Chlorophyll-a tracer indicates changes in the ocean's productivity, and informs global climate change modeling, as chlorophyll concentration plays an important role in the global carbon cycle. Photosynthesis of the phytoplankton takes in atmospheric CO_2, thus helping to cool the planet.

The presence of phytoplankton indicates sufficient nutrients in the areas they are found, but too much phytoplankton production can lead to harmful algal blooms. These blooms have a severe impact on ecosystem health, as well as human health and economic prosperity. However, a healthy presence of these photosynthetic organisms my result in a higher carbon dioxide capture rate in the ocean.

This data was made available by NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) Terra and Aqua satellites, with an imagery resolution of 1 km and a daily temporal coverage beginning on July 2, 2013.

To learn more about the MODIS Terra Chlorophyll-A dataset, visit:
https://worldview.earthdata.nasa.gov/?l=MODIS_Aqua_Chlorophyll_A,Coastlines,VIIRS_SNPP_CorrectedReflectance_TrueColor(hidden),MODIS_Aqua_CorrectedReflectance_TrueColor(hidden),MODIS_Terra_CorrectedReflectance_TrueColor.

To add more overlays of datasets, click Add Layers > Scientific Disciplines > choose a dataset. There are also more categories offered in other fields besides scientific disciplines such as hazards and disasters.

AMSR2 GCOM W1 “Sea Ice Concentration”

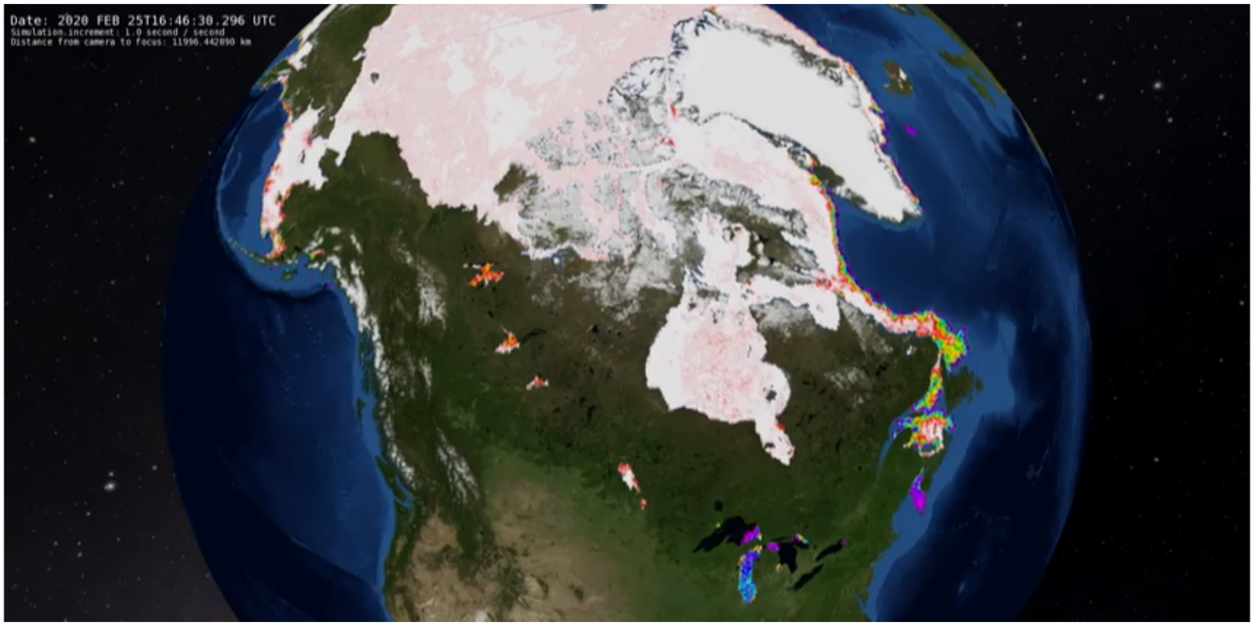

Figure 5: The AMSR2 GCOM W1 “Sea Ice Concentration” layer shows the concentration of sea ice at the North and South poles. Purple and blues indicate the lowest relative sea ice concentration, with red and white indicate the highest.

This dataset displays the concentration of sea ice at the North and South poles taken by the Advanced Microwave Scanning Radiometer-2 (AMSR2) with a spatial resolution of 12 km. It shows the relative sea ice as a percentage to describe the relative amount of surface area covered by ice, with purple = 0%, red/white = 100%. The temporal coverage spans from July 2, 2012 to present day.

The AMSR2 instrument senses microwave radiation in frequencies ranging from 6.9 GHz to 89 GHz, and is on-board the Global Change Observation mission – Water 1 satellite (GCOM-W1).

To learn more about the AMSR2 system, visit: https://worldview.earthdata.nasa.gov/?l=AMSRU2_Sea_Ice_Concentration_12km,Coastlines,VIIRS_SNPP_CorrectedReflectance_TrueColor(hidden),MODIS_Aqua_CorrectedReflectance_TrueColor(hidden),MODIS_Terra_CorrectedReflectance_TrueColor.

To add more overlays of datasets, click Add Layers > Scientific Disciplines > choose a dataset. There are also more categories offered in other fields besides scientific disciplines such as hazards and disasters.

GHRSST L4 G1SST "Sea Surface Temperature"

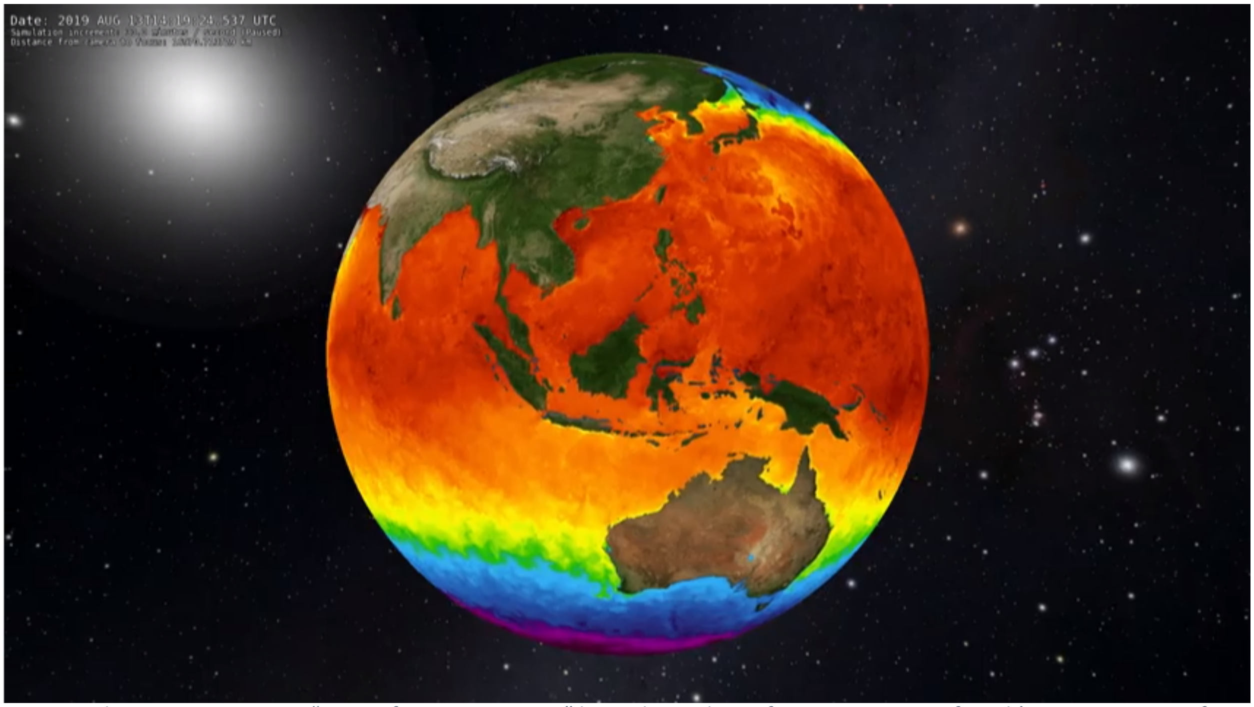

Figure 6: The GHRSST L4 G1SST "Sea Surface Temperature" layer shows the surface temperature of Earth's oceans, ranging from purple (coldest) to red (hottest).

This dataset depicts the surface temperature of Earth's oceans at a depth of about 10-20 micrometers (µm) in Celsius, with purple = less than 0° C, red = greater than 32° C. There is currently only temporal coverage with this layer spanning June 21, 2010 to December 8, 2019.

It is important to study Earth's ocean temperature because of its impact on weather and ecology of land and aquatic life, and as an indicator of the rate of global climate change. Temperatures are typically warmer at the equator and colder near the poles, but current flows lead to local changes in temperature. El Niño occurs every 3-7 years, bringing an increase of about 2-3° C (3-5° F), or more during intense events, to the tropical Pacific Ocean.

This can bring increased precipitation to the southern United States, and droughts to Australia, Indonesia, and Southern Asia. Another effect is the development of tropical cyclones which draw energy from the oceans to form and gain momentum.

To learn more about the GHRSST system, visit:
https://worldview.earthdata.nasa.gov/?l=GHRSST_L4_G1SST_Sea_Surface_Temperature,Coastlines,VIIR

S_SNPP_CorrectedReflectance_TrueColor(hidden),MODIS_Aqua_CorrectedReflectance_TrueColor(hidden),MODIS_Terra_CorrectedReflectance_TrueColor.

To add more overlays of datasets, click Add Layers > Scientific Disciplines > choose a dataset. There are also more categories offered in other fields besides scientific disciplines such as hazards and disasters.

Earth's Moon Surface Datasets

Lola Shade

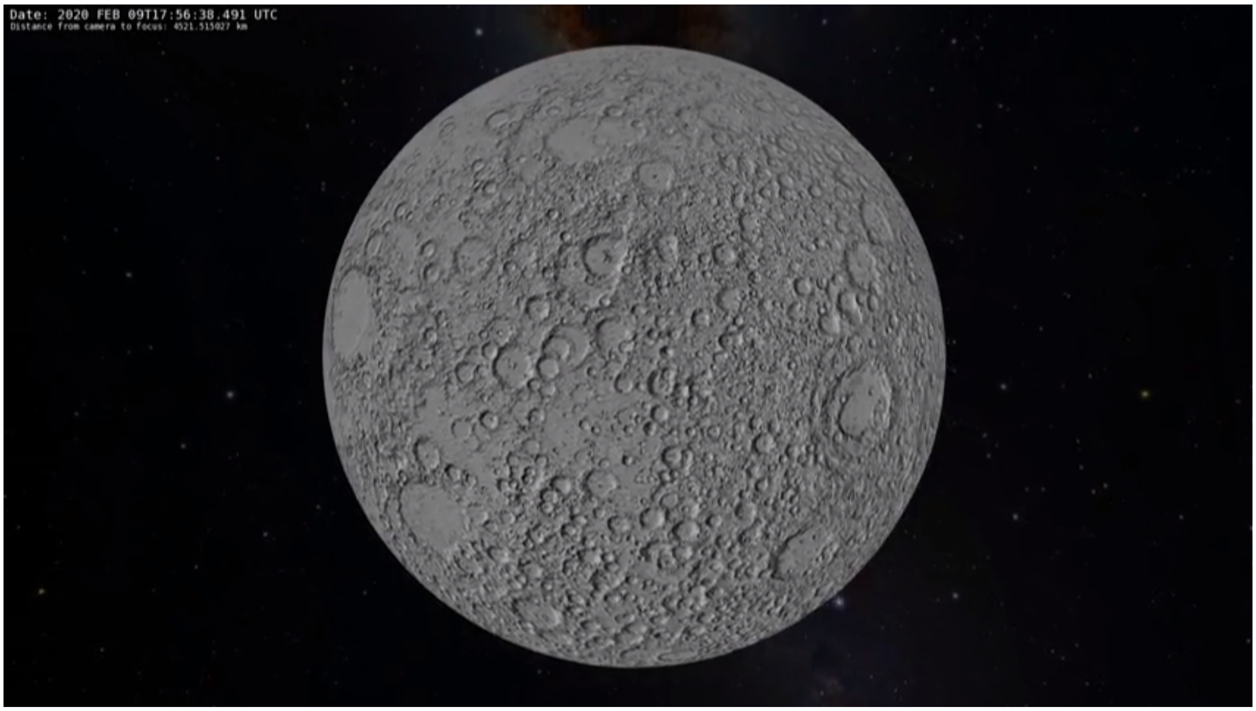

Figure 7: The Lola Shade map shows a grayscale elevation map of the Moon.

This dataset offers a grayscale elevation map of the Moon's surface taken with the Lunar Orbiter Laser Altimeter (LOLA) aboard NASA's Lunar Reconnaissance Orbiter (LRO). This digital elevation map has a resolution of 100 meters per pixel from data acquired by the LOLA instrument in September of 2011. The LRO spacecraft was sent to the moon in June of 2009 and carried a variety of instruments in addition to LOLA, which continue today to return high-resolution images of the lunar surface. The elevation map has a vertical precision of about 10 centimeters, and an accuracy of about 1 meter. This high precision and accuracy have led to the LOLA elevation map being used as the main reference for geodetic study by the lunar community.

To learn more about this dataset, visit: https://astrogeology.usgs.gov/search/map/Moon/LMMP/LOLA-derived/Lunar_LRO_LOLA_ClrShade_Global_128ppd_v04.

Lola Clear Shade

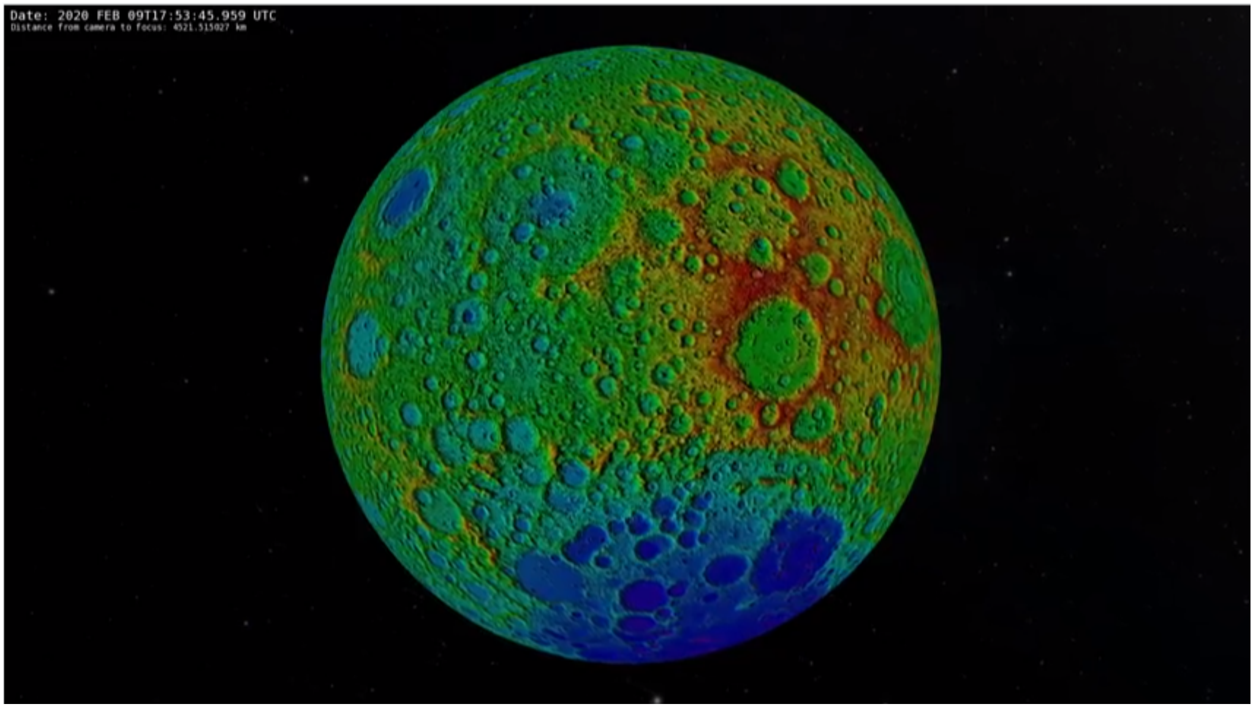

Figure 8: The Lola Clear Shade map shows an elevation map of the Moon that colorizes elevation: Blue at its lowest, red and white at its highest.

This is an identical dataset to the one above but uses a scale of color, from blue to red, to provide a clearer visualization of the variation in the lunar surface's elevation. See the link with the above grayscale elevation map to learn more about this dataset.

Kaguya

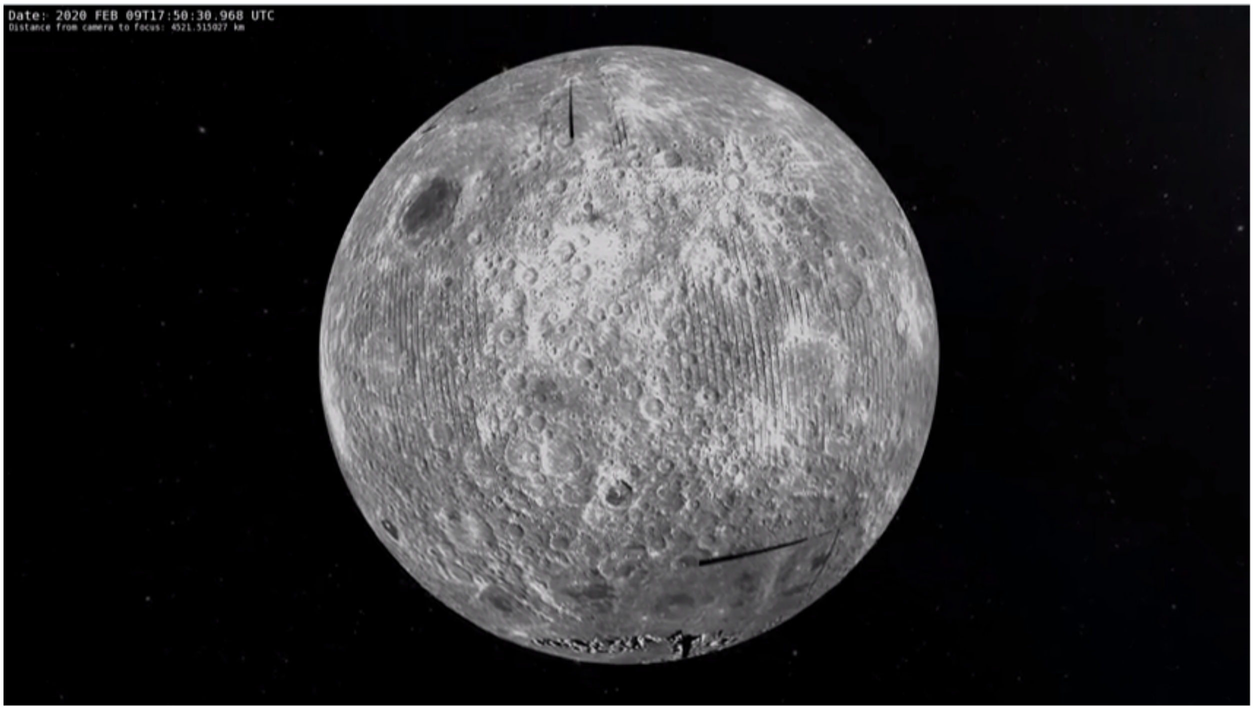

Figure 9: The Kaguya map layer shows the most detailed topographical model of the Moon.

This dataset is from Japan Aerospace Exploration Agency (JAXA)'s Kaguya mission, its second mission to the Moon, which produced the most detailed topographical model of the lunar surface. The mission was launched in September of 2007 with 15 scientific instruments, including two high-definition 2.2 megapixel tv cameras that took the images that were assembled into this map mosaic.

For the purposes of its use in OpenSpace, the Kaguya color layer can be combined with the default Moon color layer to produce a higher-resolution picture of the Moon's surface. This allows the software user to achieve close vantage points to the surface, producing impressive high-resolution views for programs dealing with specific surface locations.

To learn more about the Kaguya mission and everything it offers, visit: https://solarsystem.nasa.gov/missions/kaguya/in-depth/.

Artificial Earth Satellites

GPS, geo

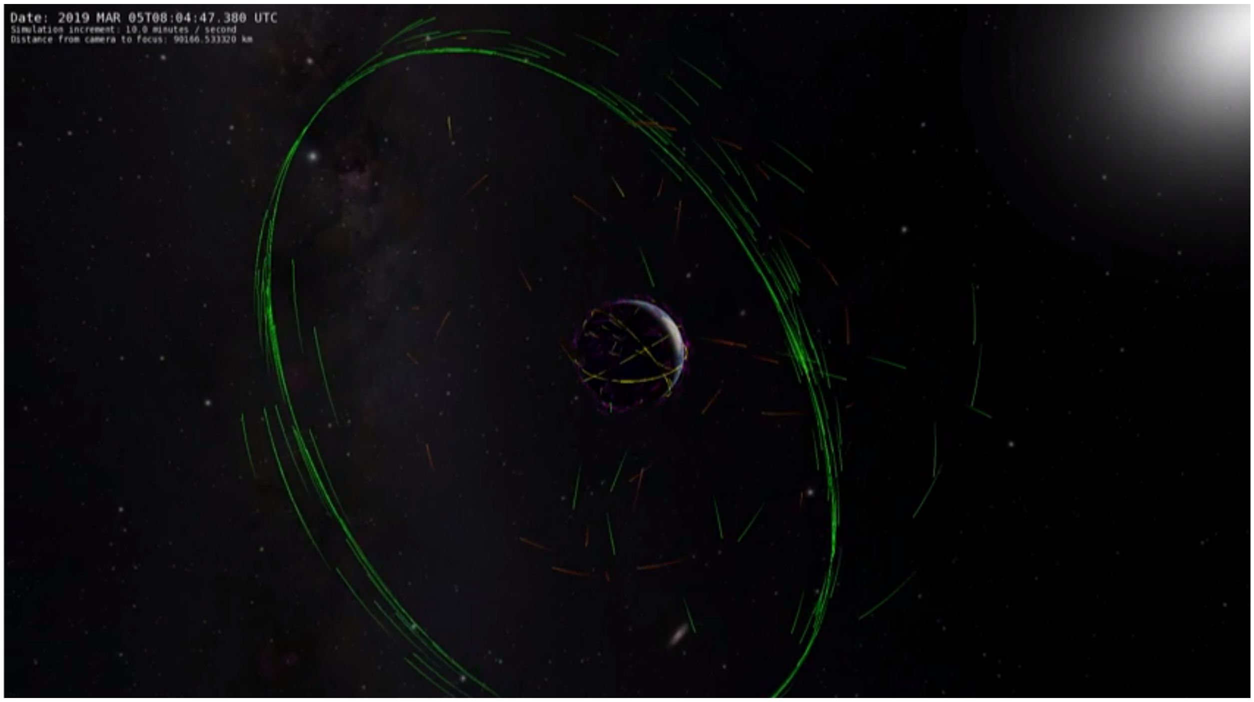

Figure 10: GPS and geo satellites are shown in orbits around the Earth in orange and green.

The Global Positioning System (orange markers) is a network of 24 artificial satellites orbiting at an altitude of 13,000 miles (20,900 km) from the Earth's surface. This network of satellites orbit Earth twice per day. The geo satellites (green markers) are in a geostationary orbit, and are used to provide visible spectrum and infrared images of Earth's surface and atmosphere for meteorological and oceanographic observation and study. These satellites are responsible for providing the means to track the atmospheric conditions and to make weather predictions.

Visual, TLE, stations

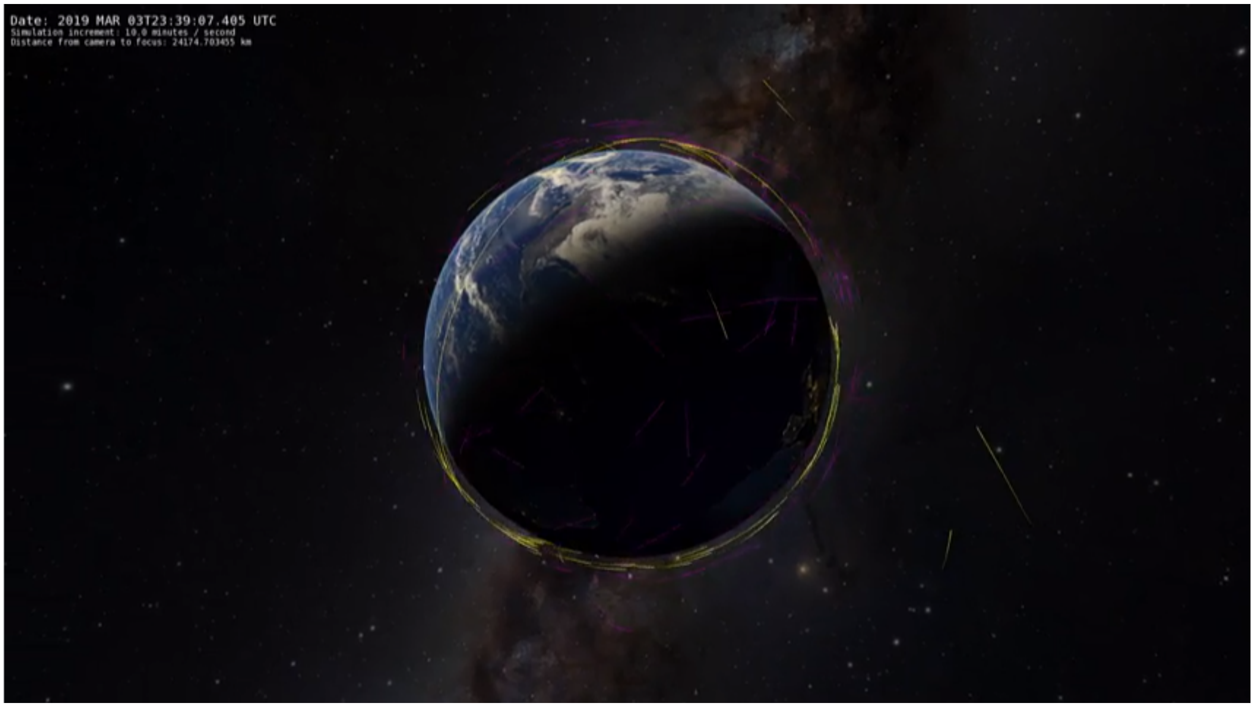

Figure 11: This layer shows the orbits of artificial satellites in yellow and orange.

These artificial satellites are in low Earth orbit (LEO), and produce visual images of the surface for multiple purposes. Others in this category include two-line element sets (TLEs) and telecommunication satellites, as well as various unmanned stations. The most famous of these satellites is the International Space Station (ISS).

ISS

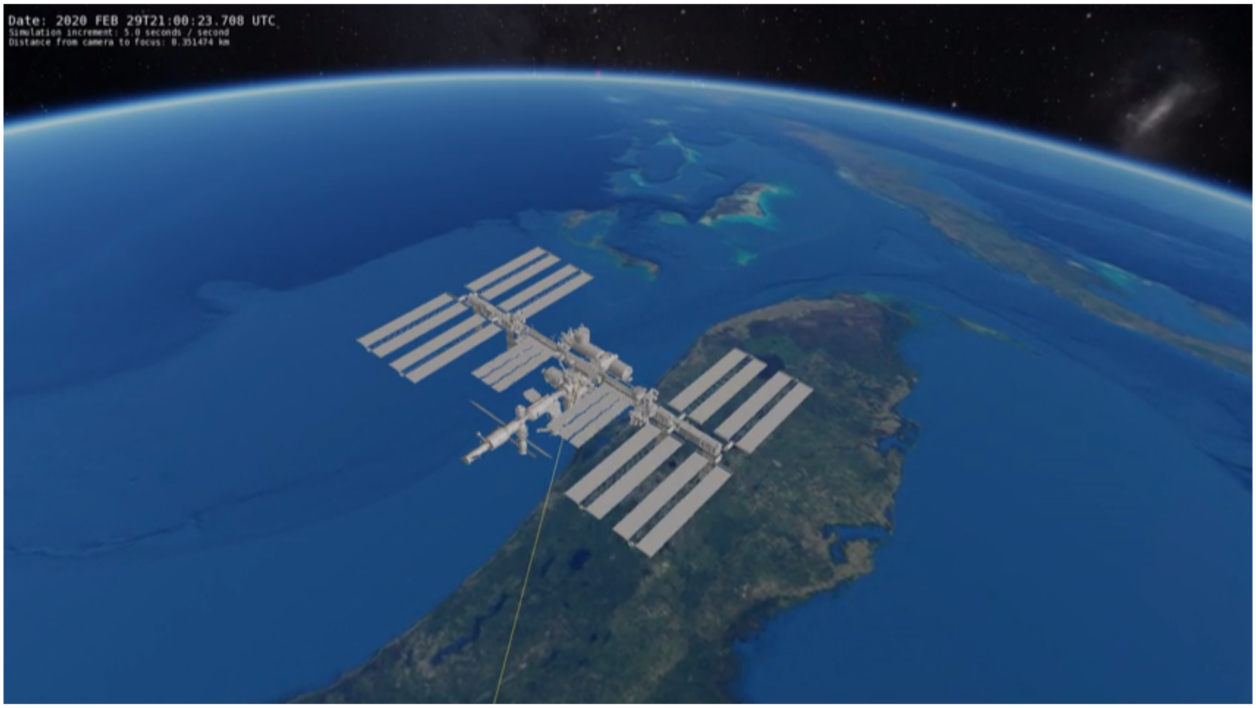

Figure 12: The International Space Station (ISS) is shown orbiting above the Earth.

The International Space Station (ISS) is currently the only space mission that involves astronauts. In low-Earth orbit, the ISS revolves around Earth at an altitude of 250 miles from the surface, and orbits the planet about 15.5 times a day on average.

The ISS is a joint project involving the participation of agencies from the United States, Russia, Japan, Europe, and Canada. The ISS is a research laboratory for microgravity and the effects of the space environment in various aspects of biology, human biology, physics, and other fields. It serves as a testing ground for the equipment required for missions to Mars and the Moon.

The stations have been continuously occupied since November 2000, and hold the record for the longest continuous human presence in low-Earth-orbit. As of September 2019, 239 people from 19 countries have visited the ISS. The record-holding astronaut for the longest presence on the ISS is currently Valery Polyakov, who stayed on the station for 437 days. Scott Kelly set the American record with a 340-day trip.

Potentially Hazardous Asteroids

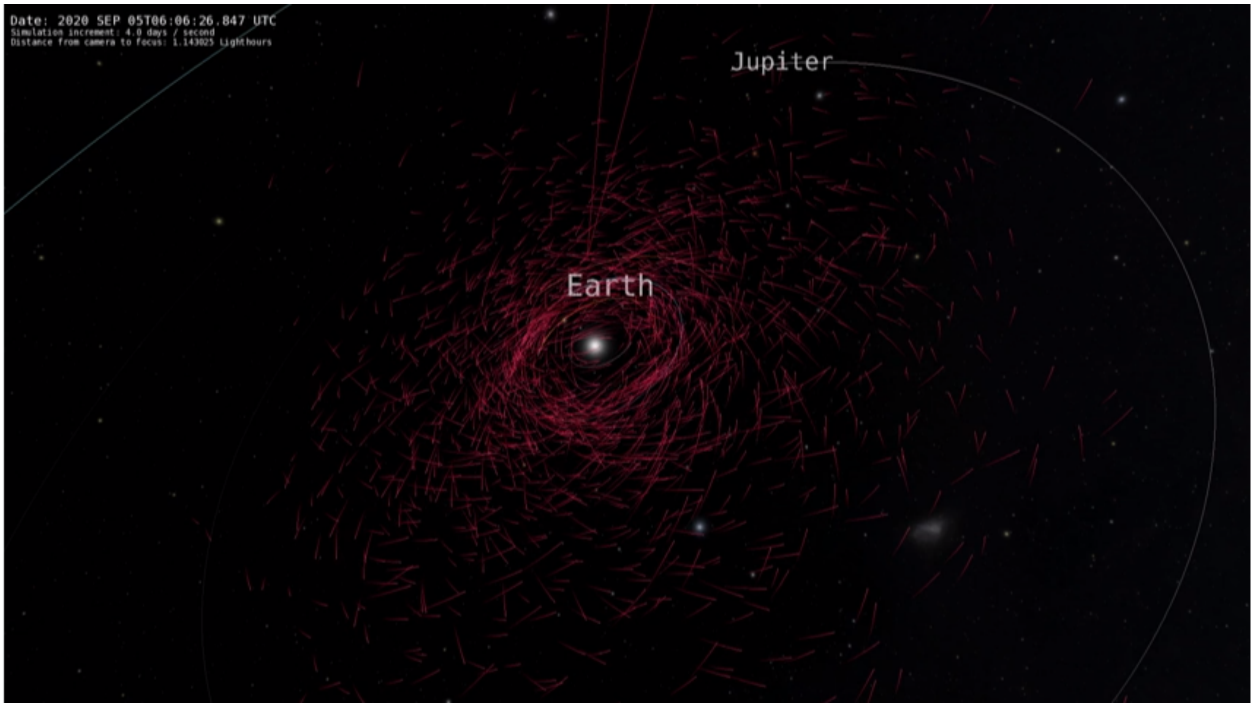

Figure 13: The orbits of over 2,000 potentially hazardous asteroids (PHAs) are visualized in OpenSpace in red.

This dataset shows the orbital paths of more than 2,000 potentially hazardous asteroids (PHAs). These are named "potentially hazardous" because of their large size and close proximity to Earth.

PHAs are members of the asteroid belt between the orbits of Mars and Jupiter and the remnants of the early historical period of the Solar System in which planets were forming. In fact, planets formed out of similar bodies called "planetessimals" which collided with one another and stuck together over a long period of time to eventually form the inner rocky planets we see today.

There are many more asteroids than the ones shown here, and they all potentially pose a threat to the safety of life on Earth. This necessitates investments into the detection of these asteroids and the protection of Earth to hopefully prevent another catastrophic extinction event similar to that which led to the extinction of the dinosaurs and other organisms during that time period.

Venus' Atmosphere

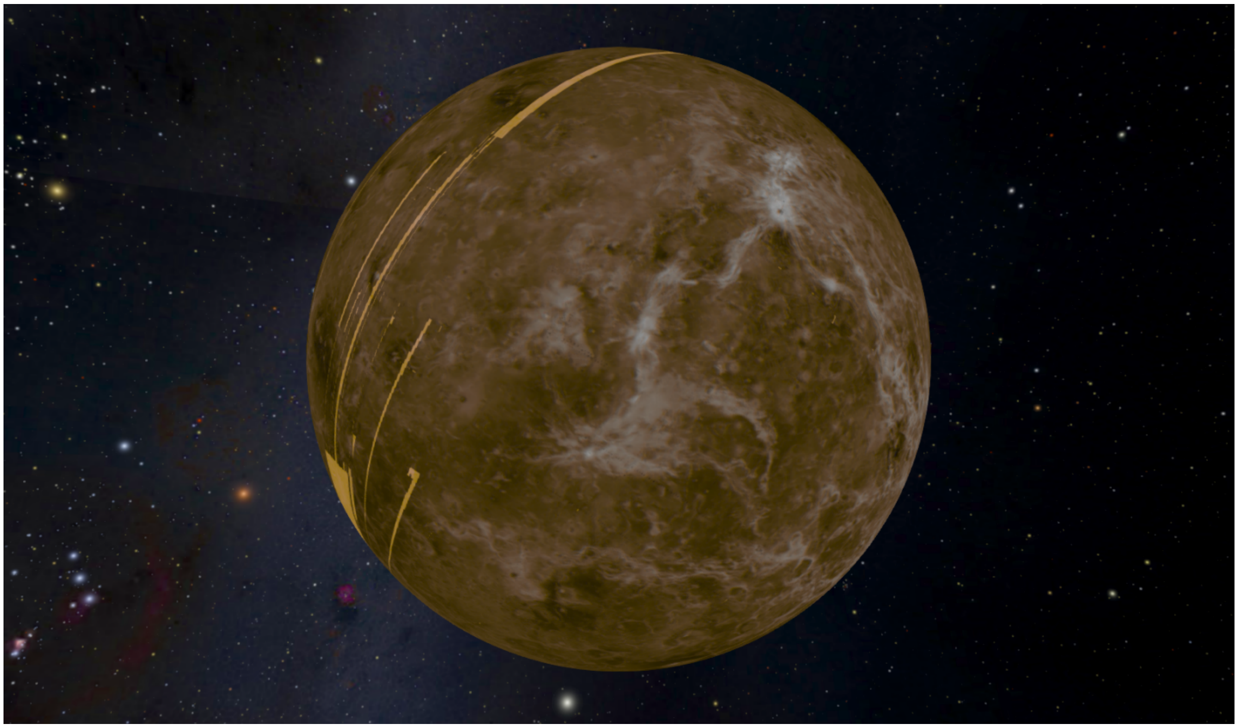

Figure 14: Venus in OpenSpace without its atmosphere enabled.

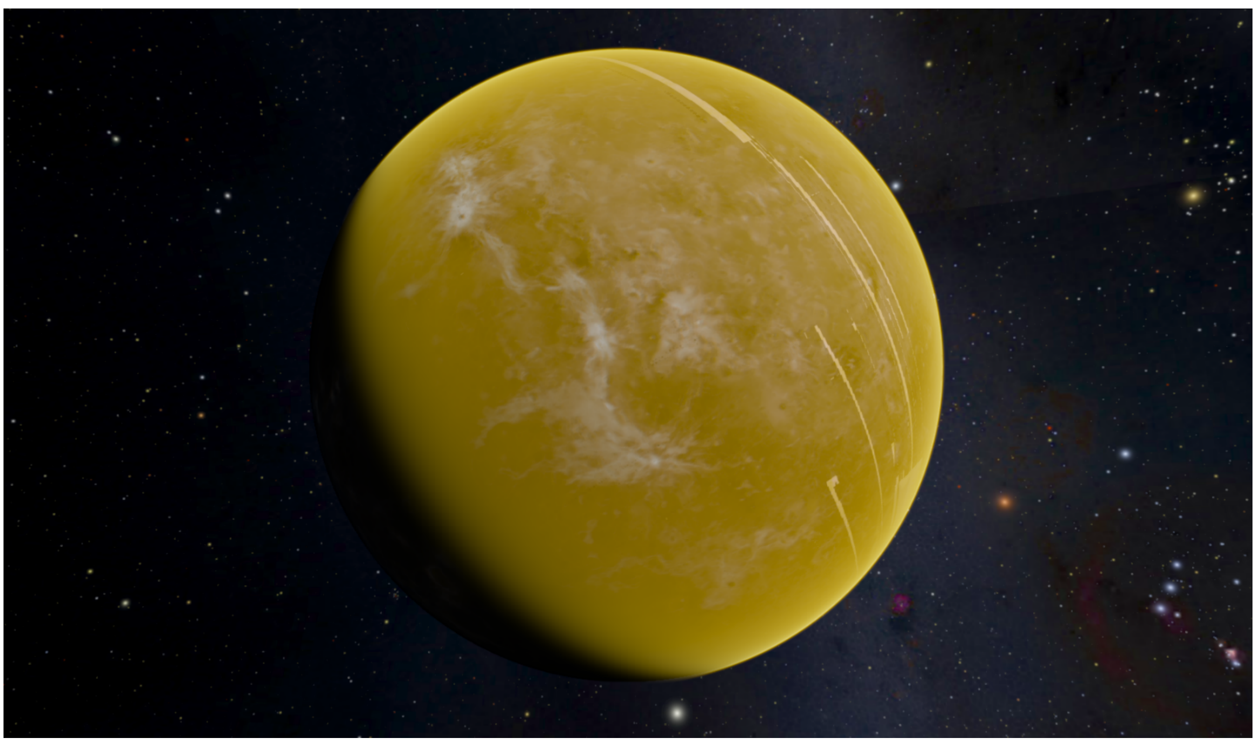

Figure 15: Venus in OpenSpace with its atmosphere enabled.

Venus' runaway greenhouse effect serves as a good analogue for comparison to one of Earth's possible future paths because of harmful human activity. While the causes of Venus's runaway greenhouse were natural, it still allows us to study how this phenomenon works and possibly how to prevent it from happening on Earth.

The majority (~ 95%) of Venus's atmosphere is CO_2, one of many greenhouse gases that humans are responsible for releasing into the atmosphere at alarming rates. The immense presence of this atmospheric gas traps infrared radiation from the sun and the surface, heightening the surface to temperatures between 425° and 485° C (800 and 900°F), and a crushing atmospheric pressure of almost 100 atm. This pressure is equivalent to underwater pressures on Earth at a depth of almost a half mile (0.8 km). Though there is speculation that life could exist in the high clouds of the atmosphere, the environment is still quite acidic.

Russia's Venera 4 spacecraft, along with a few successive crafts, completed a successful landing on the surface of Venus in 1967. However, this feat was short-lived due to the extreme temperatures and pressures on the surface of Venus. Russia promptly lost communication with the craft as it began to melt and become crushed under the immense temperature and pressure.

The first screenshot of Venus above demonstrate the extreme density of the atmosphere, which is activated in the second screenshot. These mosaics were provided by images taken by NASA's Magellan spacecraft, which visited the planet in 1994.

To learn more about Venus's atmosphere and the planet's conditions, visit: https://www.nasa.gov/audience/forstudents/5-8/features/F_The_Planet_Venus_5-8.html.

Mercury Surface Datasets

The following datasets (Alsimap, Casimap, Ssimap, Mgsimap, and Fesimap) show various aspects of Mercury's geochemical terrain taken by Mercury Surface, Space Environment, Geochemistry and Ranging (MESSENGER), an orbiter sent to study Mercury by NASA in 2011. The various surface data maps were taken with the on-board X-Ray Spectrometer and Gamma-Ray Spectrometer.

Though many other chemical aspects of Mercury's surface were studied with the instruments, the datasets offered through OpenSpace are combinations of aluminum, calcium, sodium, magnesium, and iron in relative ratios with silicon. The datasets are visualized by assigning on a color scale, where red indicates high concentration of a particular element, and blue indicates low concentration.

The spectra were achieved by means of X-ray fluorescence in which X-rays emitted from the Sun's atmosphere collide with the surface of Mercury, allowing these metals to be observed. The spectra not only inform the surface composition of the planet, they also inform the geochemical evolution experienced on the surface of the planet's thin silicate shell.

The MESSENGER spacecraft was built, operated, and monitored by the Johns Hopkins University Applied Physics Laboratory.

To learn more about the mission and its datasets, visit: https://carnegiescience.edu/news/new-mercury-surface-composition-maps-illuminate-planet%E2%80%99s-history.

AlSimap: This dataset shows Aluminum-Silicon surface concentrations on Mercury, taken by the MESSENGER orbiter mission.

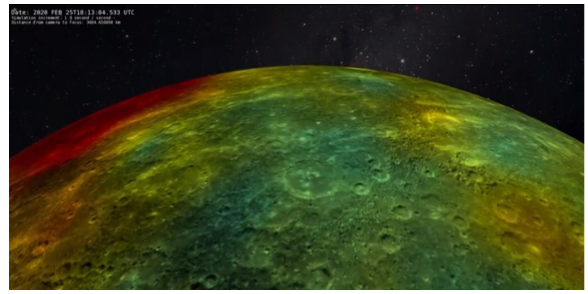

Figure 16: The AlSi map on Mercury.

CaSimap: This dataset shows Calcium-Silicon surface concentrations on Mercury, taken by the MESSENGER orbiter mission.

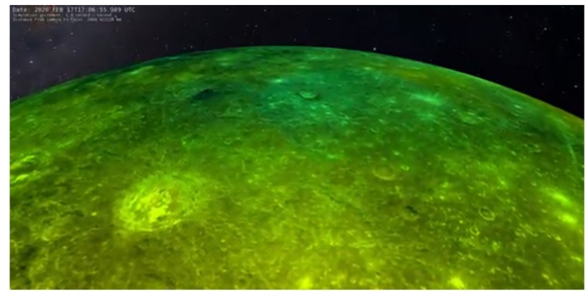

Figure 17: The CaSi map on Mercury.

SSimap: This dataset shows Sodium-Silicon surface concentrations on Mercury, taken by the MESSENGER orbiter mission.

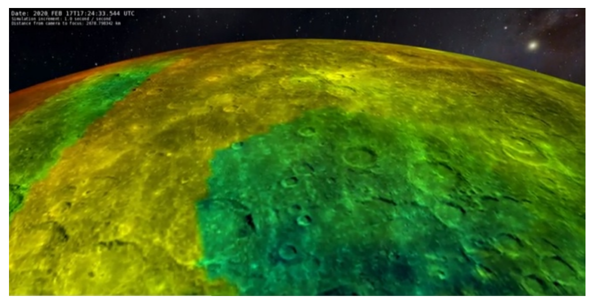

Figure 1815: The SSi map on Mercury.

MgSimap: This dataset shows Magnesium-Silicon surface concentrations on Mercury, taken by the MESSENGER orbiter mission.

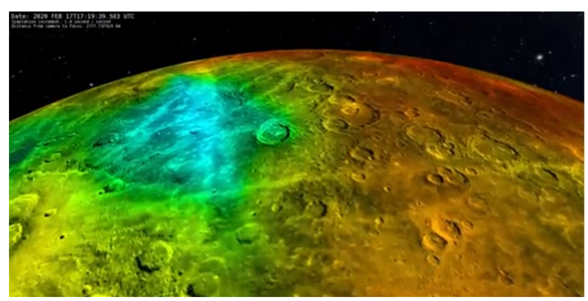

Figure 19: The MgSi map on Mercury.

FeSimap: This dataset shows Iron-Silicon surface concentrations on Mercury, taken by the MESSENGER orbiter mission.

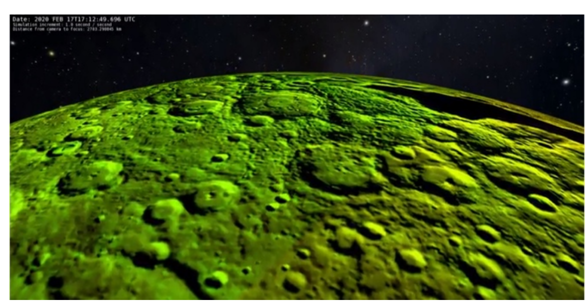

Figure 2016: The FeSi map on Mercury.

SHADE

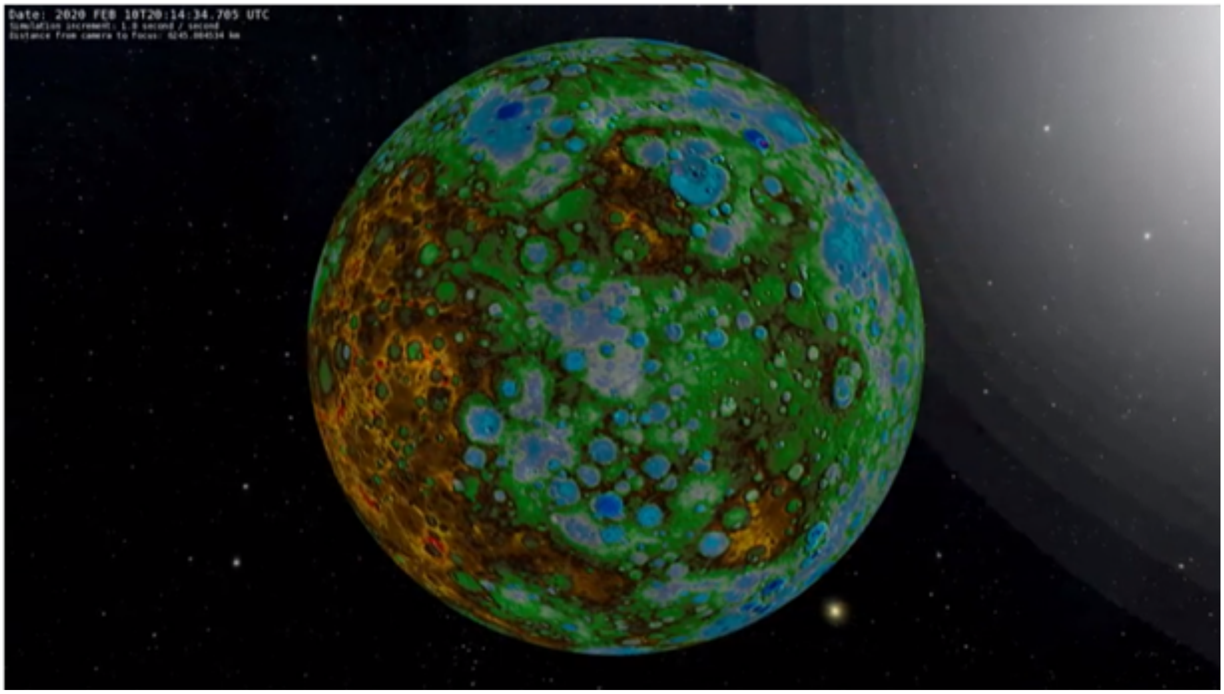

Figure 21: The SHADE map on Mercury.

This dataset is the first global topographical map of Mercury showing elevation on a visual spectrum color scale. White and red indicate high elevation at just over 4,000 meters, where blue and purple indicate low elevation at -5,000 meters below Mercury's average.

This data was also taken by the MESSENGER orbiter in effort to understand and characterize Mercury's geologic evolution, and one of many products from the Planetary Data System (https://pds.nasa.gov/). This particular elevation map was derived from data taken with the Mercury Laser Altimeter.
To learn more about Mercury's "SHADE" topographical dataset, visit: https://www.nasa.gov/feature/first-global-topographic-model-of-mercury.

MOLA HRSC

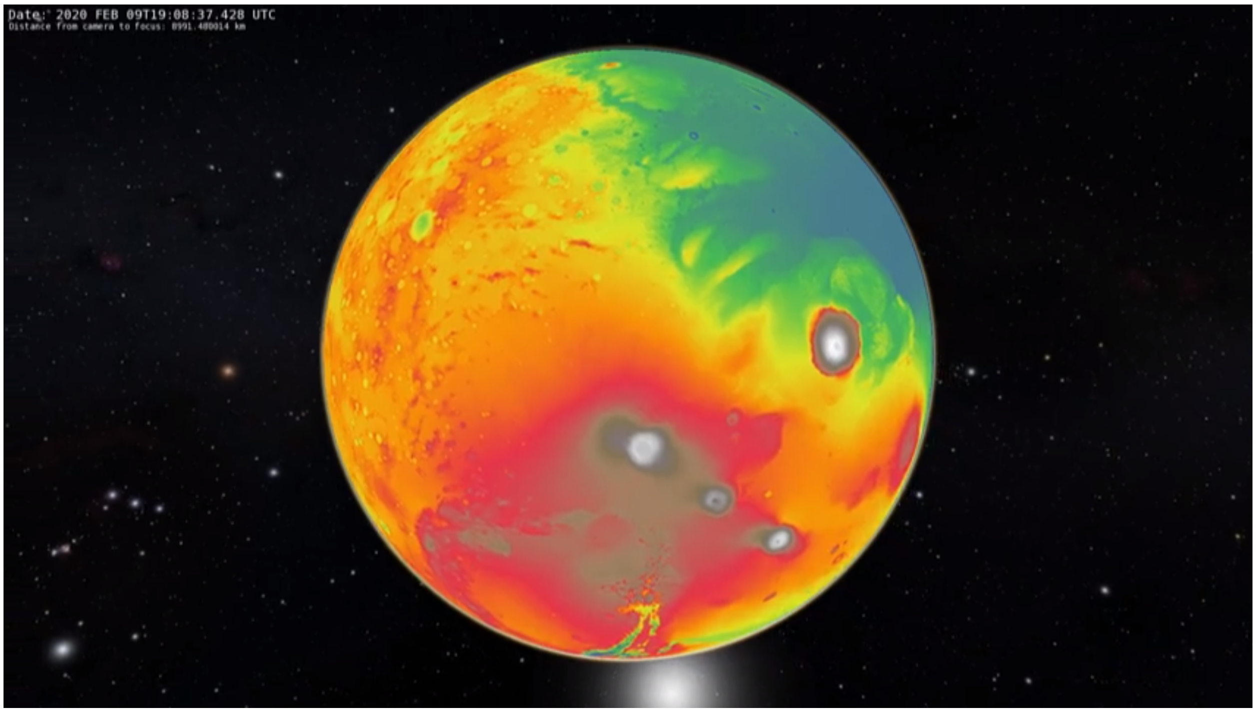

Figure 22: The MOLA HRSC map layer on Mars shows the height of the Martian surface from blue and purple, at its lowest, to red and white, its highest.

This dataset is a combination of digital elevation data derived from the Mars Orbiter Laser Altimeter (MOLA) aboard NASA's Mars Global Surveyor and the High-Resolution Stereo Camera (HRSC) on the European Space Agency (ESA)'s Mars Express. The HRSC instrument is the only stereo camera orbiting Mars and has a resolution of 200 meters per pixel. The elevation data was produced by the MOLA instrument by shooting a laser toward the surface of Mars at 10 times per second, and then measuring the return time of the light as it reflected back from the surface.

These measurements were assigned colors to illustrate the height variation on the surface of Mars: Red and white colors on the surface indicate the highest elevations, and blue and purple indicate the areas of low elevation. The average accuracy is about 100 meters, with an elevation uncertainty of at least 3 meters, achieving a precision of about 30 vertical centimeters in some areas.

The Mars Global Surveyor mission relayed essential scientific data for nearly a decade, beginning its scientific discovery in September 1997 and ending in November 2006. In addition to this elevation data, MOLA also revealed seasonal changes of Mars' surface, detecting the distributions of condensed carbon dioxide and frozen water.

To learn more about the MOLA HRSC dataset, visit https://astrogeology.usgs.gov/search/map/Mars/Topography/HRSC_MOLA_Blend/Mars_HRSC_MOLA_BlendDEM_Global_200mp_v2.

MOLA pseudo color

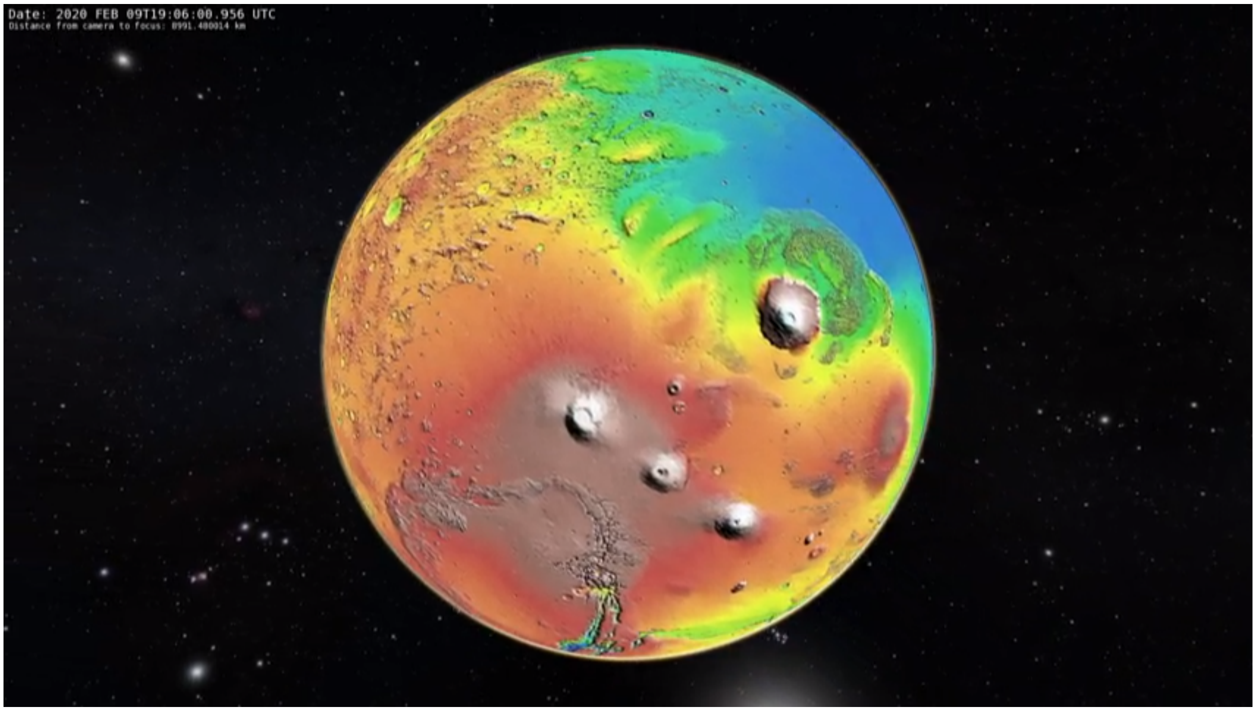

Figure 2317: The MOLA pseudo color map shows the elevation of the Martian surface from blue and purple, at its lowest, to red and white, its highest.

The following dataset is the same as the above MOLA HRSC data, however it also includes clear surface features by combining it with other Mars color layers. The pseudo coloring method is the result of the mapping of an alternative color palette to the images, giving us a clear visualization of Mars's surface height variations. Blue and purple indicate the lowest elevations, and red and white indicate the highest elevations. It can be used in OpenSpace to achieve higher resolution viewpoints of Mars' surface.

CTX blended beta01

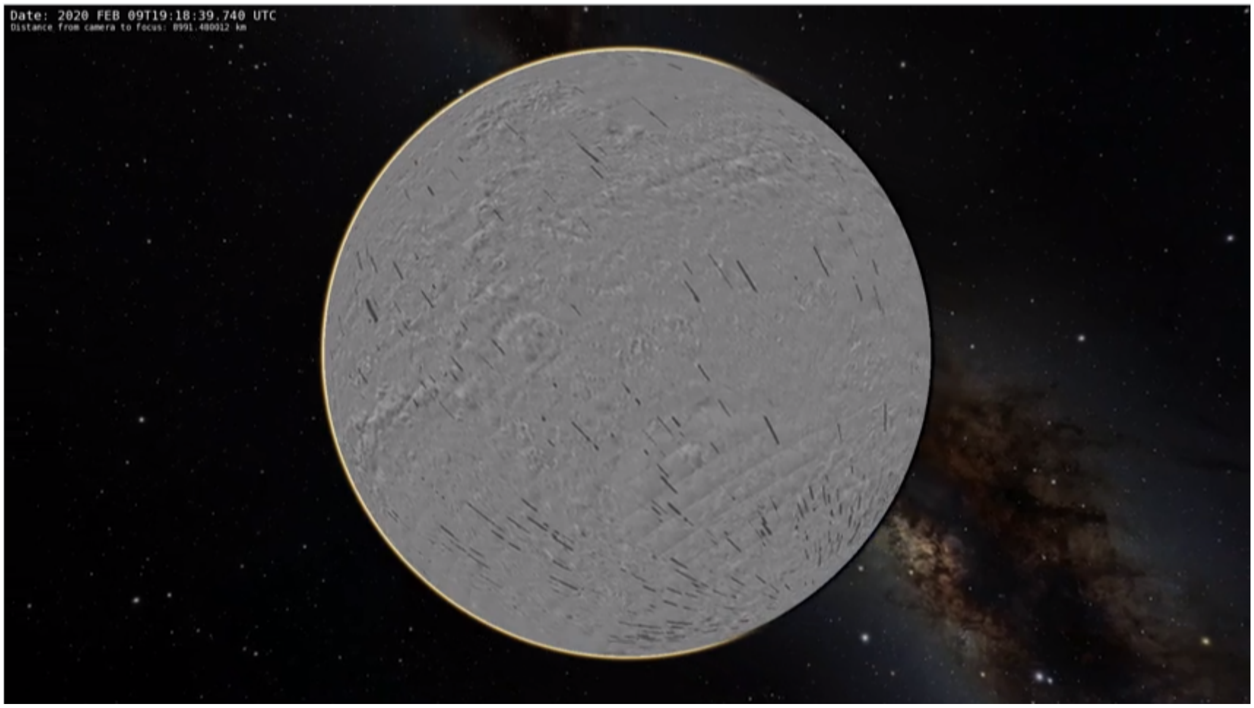

Figure 24: The CTX blended beta01 shows high-resolution views of the Martian surface in grayscale.

This dataset, much like the Kaguya dataset for the Moon, is used within the OpenSpace software to achieve high-resolution views when “driving” close to Mars’ surface. The grayscale data was taken with the Context Camera (CTX) simultaneously with High Resolution Imaging Experiment (HiRise, a very high-resolution imaging system), tools that are part of the Mars Orbital Camera onboard the Mars Global Surveyor spacecraft. Its spacial resolution is 6 meters per pixel.

Scientists use this data to better understand the geophysical processes that shape the planet’s surface, including water-deposited sediments, volcanic activities, wind-deposited sediments, and more. The various MGS data provide a means to narrow down the possibilities of how the planet’s surface has evolved.

To learn more about the CTX data and others, visit: https://mars.nasa.gov/mro/mission/instruments/ctx/.

For more about OpenSpace, visit: https://www.openspaceproject.com/

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