National Aeronautics and Space Administration

CLOUD IN A BOTTLE

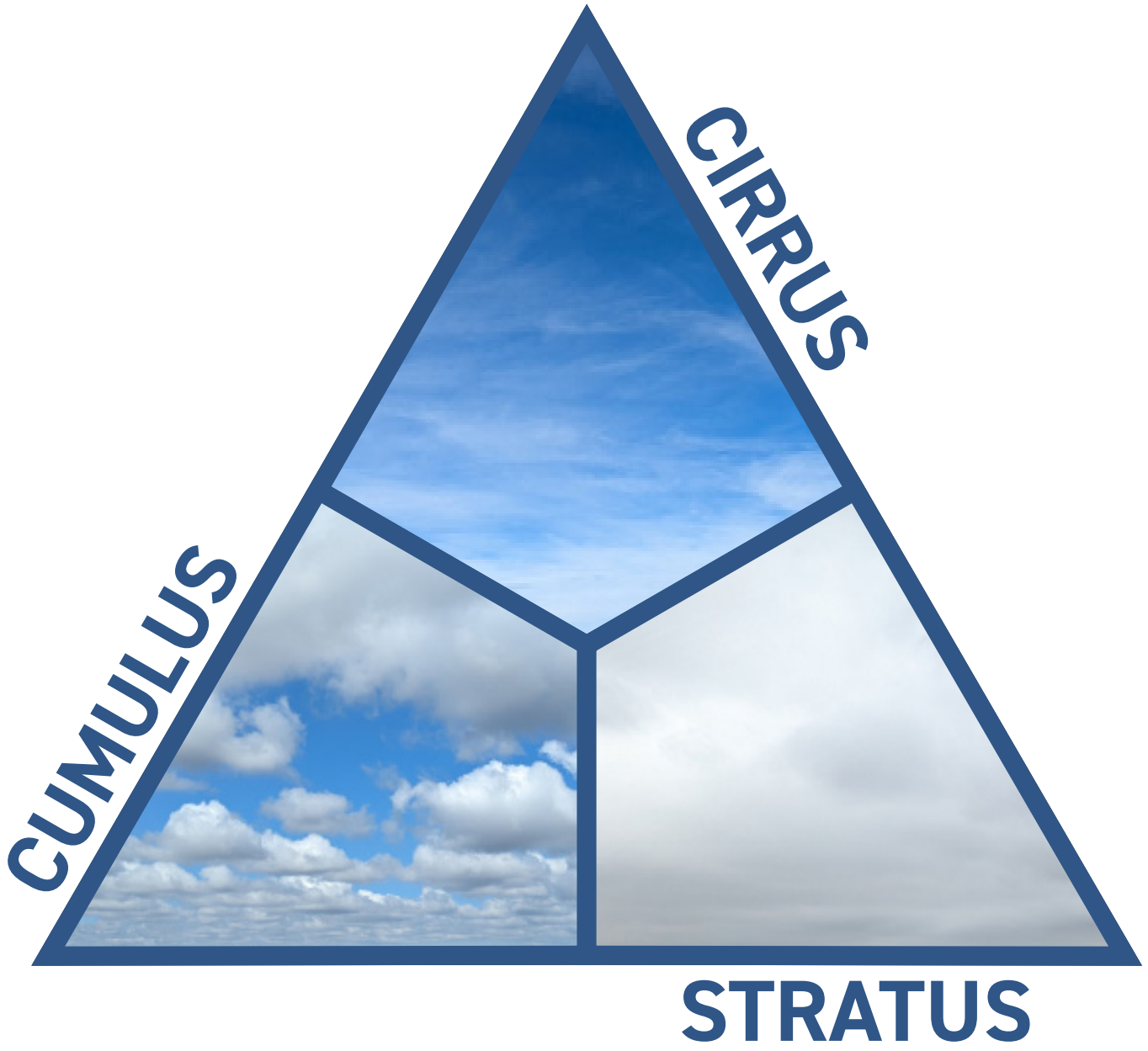
Learn how clouds form in this interactive demonstration.

NOTE: This demonstration creates a loud sound.

GLOBE Observer

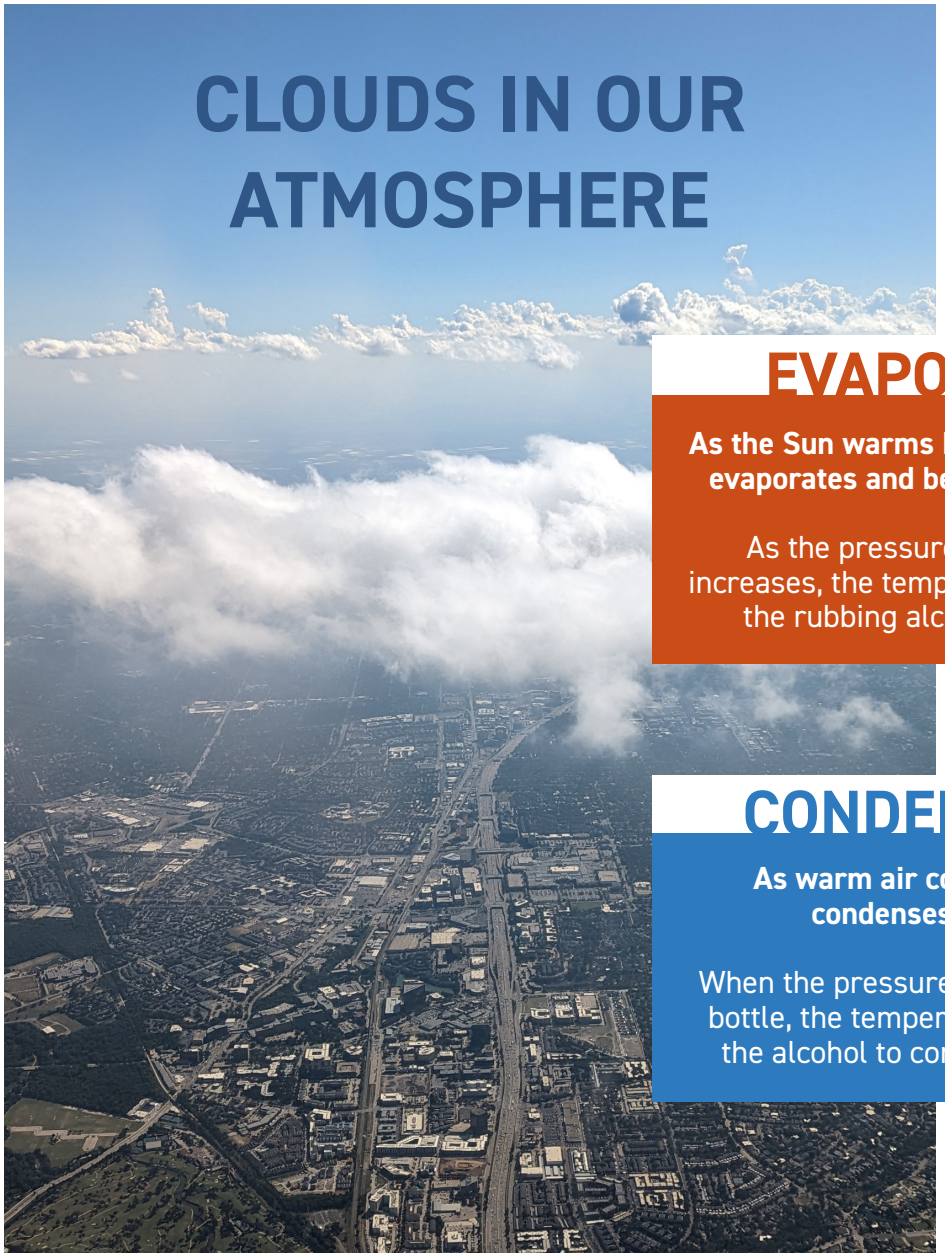
the app of THE GLOBE PROGRAM

CLOUD TRIANGLE

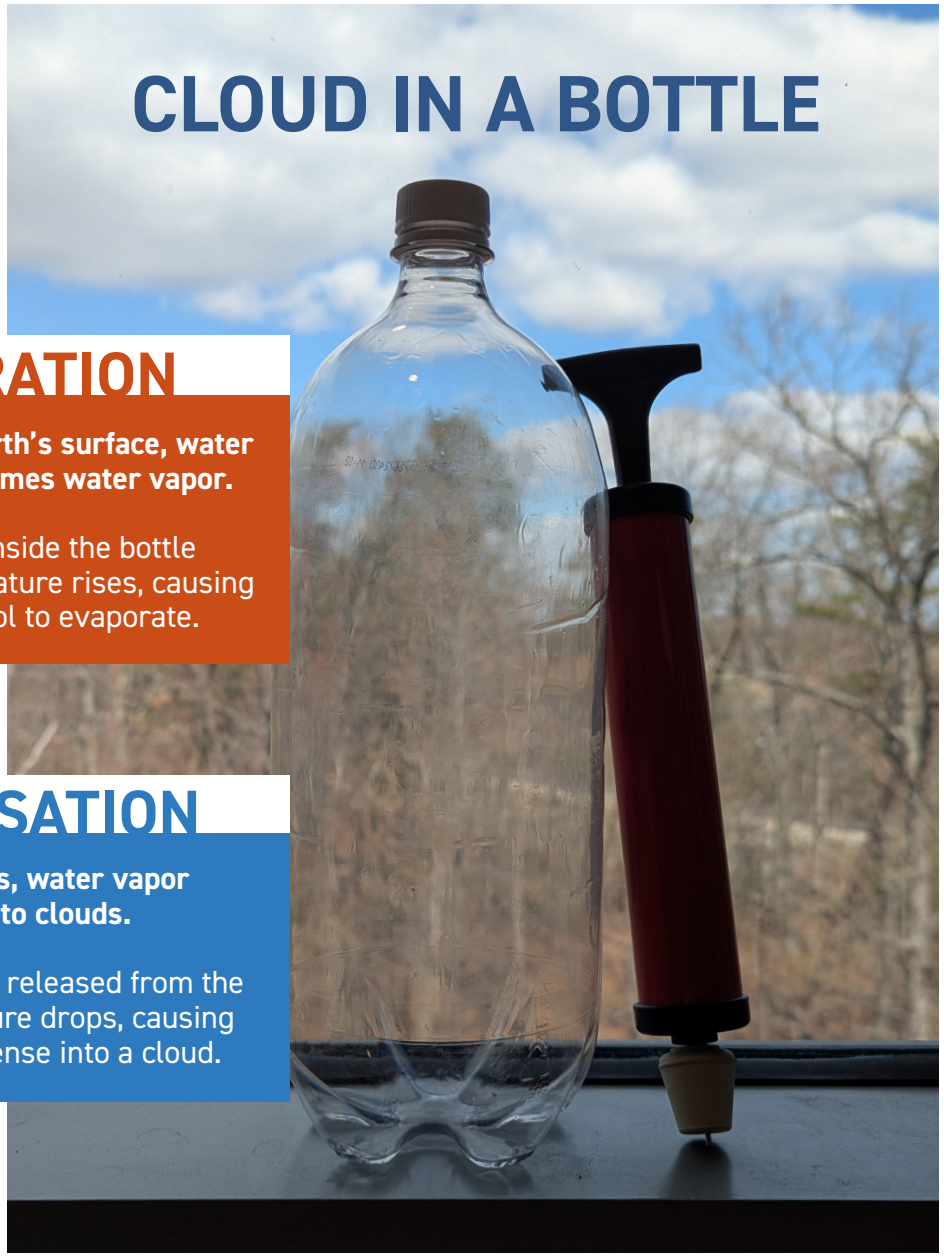


CLOUD FORMATION

CLOUDS IN OUR ATMOSPHERE



CLOUD IN A BOTTLE



EVAPORATION

As the Sun warms Earth's surface, water evaporates and becomes water vapor.

As the pressure inside the bottle increases, the temperature rises, causing the rubbing alcohol to evaporate.

CONDENSATION

As warm air cools, water vapor condenses into clouds.

When the pressure is released from the bottle, the temperature drops, causing the alcohol to condense into a cloud.

Clouds in Our Atmosphere

Cloud Ingredients

Clouds form in Earth's atmosphere when water vapor condenses onto aerosols. Heat from the Sun warms Earth's surface, causing water vapor to evaporate from open water, soil, and vegetation. Aerosols come from a variety of sources, including smoke, dust, sea spray, and air pollution.

The Right Conditions

Clouds form when the air temperature reaches the dew point, or when the relative humidity reaches 100%. Relative humidity is the ratio of water vapor in the air to the maximum amount of water vapor that the air can hold at a particular temperature. Warmer air can hold more water.

Cool Down

When the air cools, water vapor condenses to form clouds. There are several different ways that the air cools, resulting in clouds with different characteristics. The most common lifting methods are: convection, convergence, lifting along fronts, and lifting caused by topography.

Source:

https://www.nasa.gov/wp-content/uploads/2015/03/135641main_clouds_trifold21.pdf

Cloud in a Bottle

Materials:

- Rubbing Alcohol
- Clear 2-Liter Bottle
- Air Pump with Needle Attachment (like a bicycle pump or ball pump)
- Rubber Cork (use a push pin to create a hole for inserting the needle attachment)

Step 1:

Add a small amount of rubbing alcohol to a clear plastic bottle. We use rubbing alcohol for this demonstration because it evaporates more easily than water, which creates a more dramatic cloud.

Step 2:

Using an air pump attached to a rubber cork, increase the air pressure inside of the bottle. Increasing the pressure causes the temperature to rise, which causes more rubbing alcohol to evaporate.

Step 3:

Once the bottle feels firm, pull the cork out to release the pressure. This will cause the temperature to drop, and the evaporated rubbing alcohol will condense into a cloud!

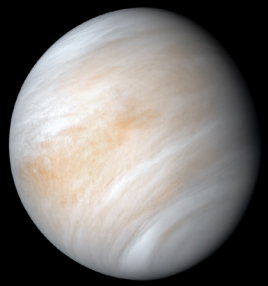
WHAT IS A CLOUD?

cloud noun

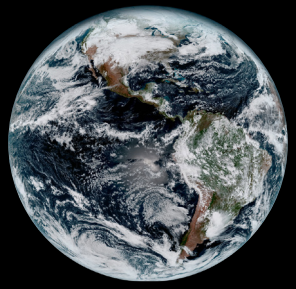
a visible mass of particles of condensed vapor (such as water or ice) suspended in the atmosphere of a planet (such as the earth) or moon

Merriam-Webster

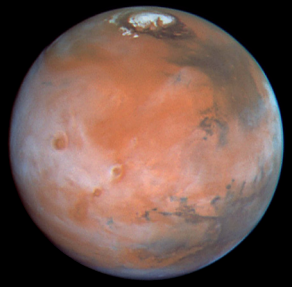
WHAT ARE CLOUDS MADE OF?



VENUS
SULPHURIC ACID

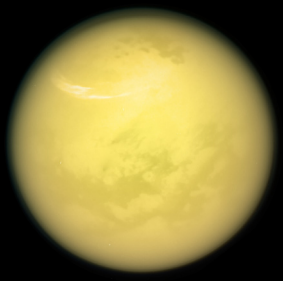


EARTH
WATER

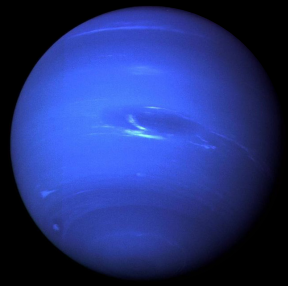


MARS
CARBON DIOXIDE AND WATER

JUPITER
AMMONIA AND WATER



TITAN
METHANE



NEPTUNE
HYDROGEN SULFIDE AND METHANE

Venus

Venus is often called “Earth’s twin” because they’re similar in size and structure, but Venus has extreme surface heat and a dense, toxic atmosphere. Venus is permanently shrouded in thick, toxic clouds of sulfuric acid that start at an altitude of 28 to 43 miles (45 to 70 kilometers). The clouds smell like rotten eggs!

(from https://science.nasa.gov/venus/)

Mars

Cloudy days are rare in the thin, dry atmosphere of Mars. Clouds are typically found at the planet’s equator in the coldest time of year, when Mars is the farthest from the Sun in its oval-shaped orbit. Most Martian clouds hover no more than about 37 miles (60 kilometers) in the sky and are composed of water ice. But the clouds Curiosity has imaged are at a higher altitude, where it’s very cold, indicating that they are likely made of frozen carbon dioxide, or dry ice.

(from https://www.jpl.nasa.gov/news/nasas-curiosity-rover-captures-shining-clouds-on-mars/)

Jupiter

Jupiter’s signature stripes and swirls are actually cold, windy clouds of ammonia and water, floating in an atmosphere of hydrogen and helium. Jupiter’s iconic Great Red Spot is a giant storm bigger than Earth that has raged for hundreds of years. The gas planet likely has three distinct cloud layers in its “skies” that, taken together, span about 44 miles (71 kilometers). The top cloud is probably made of ammonia ice, while the middle layer is likely made of ammonium hydrosulfide crystals. The innermost layer may be made of water ice and vapor.

(from https://science.nasa.gov/jupiter/jupiter-facts/)

Titan

Among our solar system’s hundreds of known moons, Saturn’s largest moon Titan is the only one with a substantial atmosphere. And of all the places in the solar system, Titan is the only place besides Earth known to have liquids in the form of rivers, lakes and seas on its surface. Titan has clouds, rain, rivers, lakes and seas of liquid hydrocarbons like methane and ethane.

(from https://science.nasa.gov/saturn/moons/titan/)

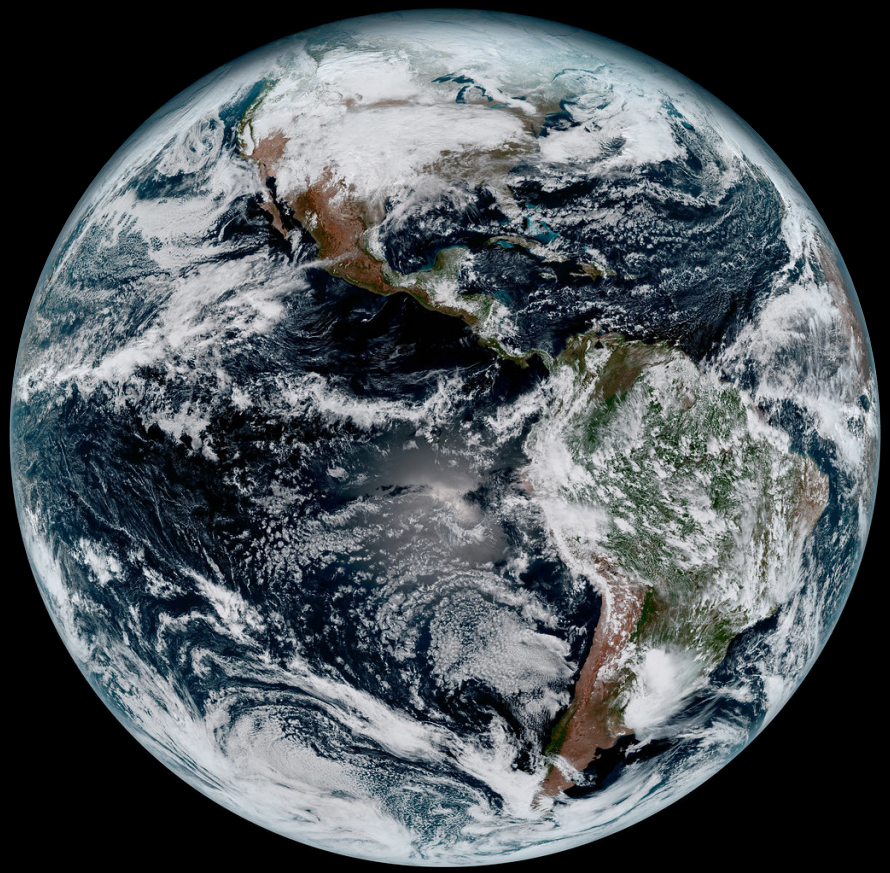
Neptune

Neptune’s clouds are hydrogen sulfide (main cloud deck) and/or methane (highest clouds) ice. On Neptune, there is an apparent correlation between solar activity and cloud cover; however, we don’t yet know if all the variability in cloud cover is due to increased UV irradiation, other photochemical reactions, or seasonal changes.

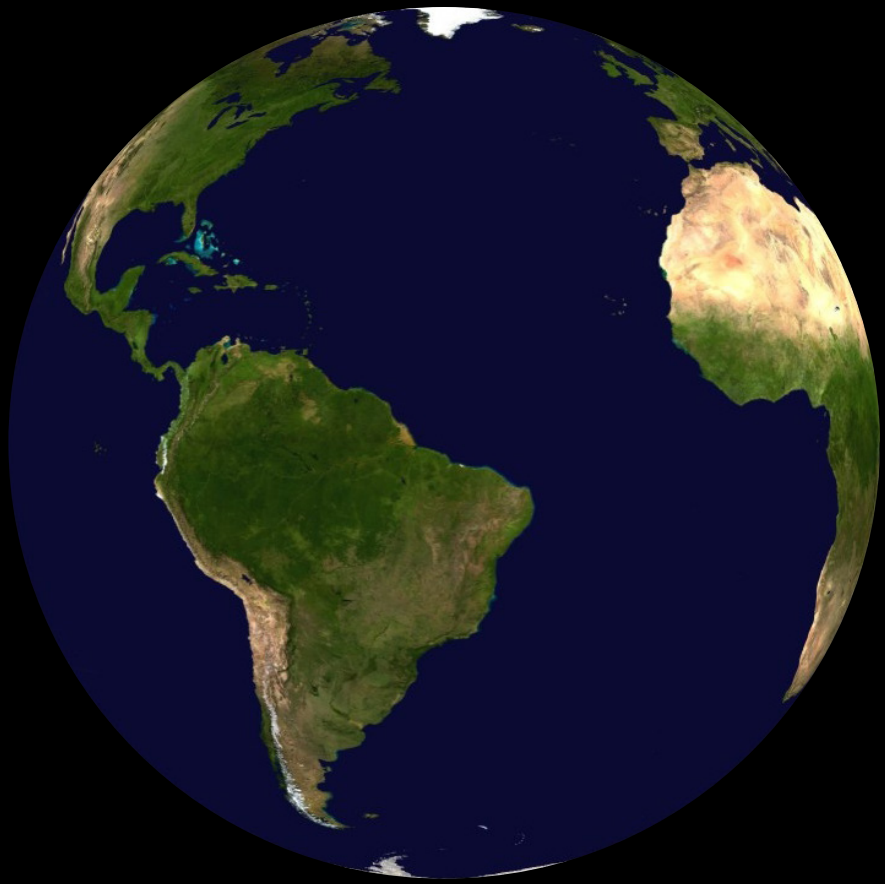
(from https://hubblesite.org/contents/media/images/2023/019/01H7DNQN1TP9W0TSP1M51PDPEN and Dr. Amy Simon)

EARTH

Clouds on Earth are made of **water** droplets and ice crystals.



Earth from GOES-16
GOES-16 observes Earth from an equatorial view approximately 22,300 miles high, creating full disk images like this visible image from January 15, 2017.

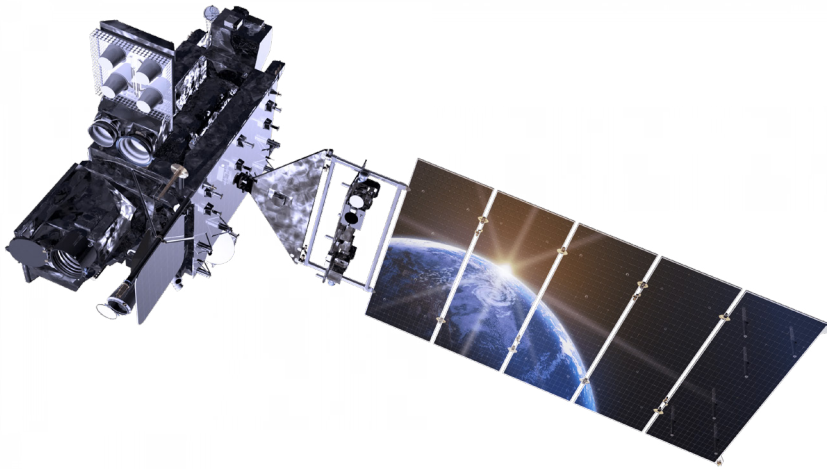


Cloud-Free Mosaic of Earth's Surface
This true-color depiction of the Earth is made from a compilation of MODIS images collected throughout 2001. MODIS is an instrument aboard the Terra satellite 435 miles above Earth.

Earth from GOES-16

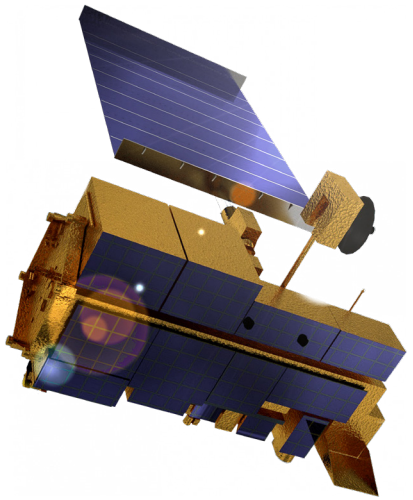
Full Caption:
This composite color full-disk visible image is from 1:07 p.m. EDT on January 15, 2017 and was created using several of the 16 spectral channels available on the GOES-16 Advanced Baseline Imager (ABI) instrument. The image shows North and South America and the surrounding oceans. GOES-16 observes Earth from an equatorial view approximately 22,300 miles high, creating full disk images like these, extending from the coast of West Africa, to Guam, and everything in between.

Source:
https://www.goes-r.gov/multimedia/dataAndImageryImagesGoes-16.html



Cloud-Free Mosaic of Earth's Surface

Full Caption:
The Blue Marble is an incredibly detailed, true-color depiction of the Earth. NASA is responsible for this dataset made from a compilation of satellite images throughout 2001. Most of the information came from NASA's MODIS, the Moderate Resolution Imaging Spectroradiometer, which is attached to the Terra satellite 435 miles above Earth. The background image of the land and oceans was created using data from June through September of 2001. This could not be done in a single day or even a week because on any given day clouds are blocking a significant portion of the surface.



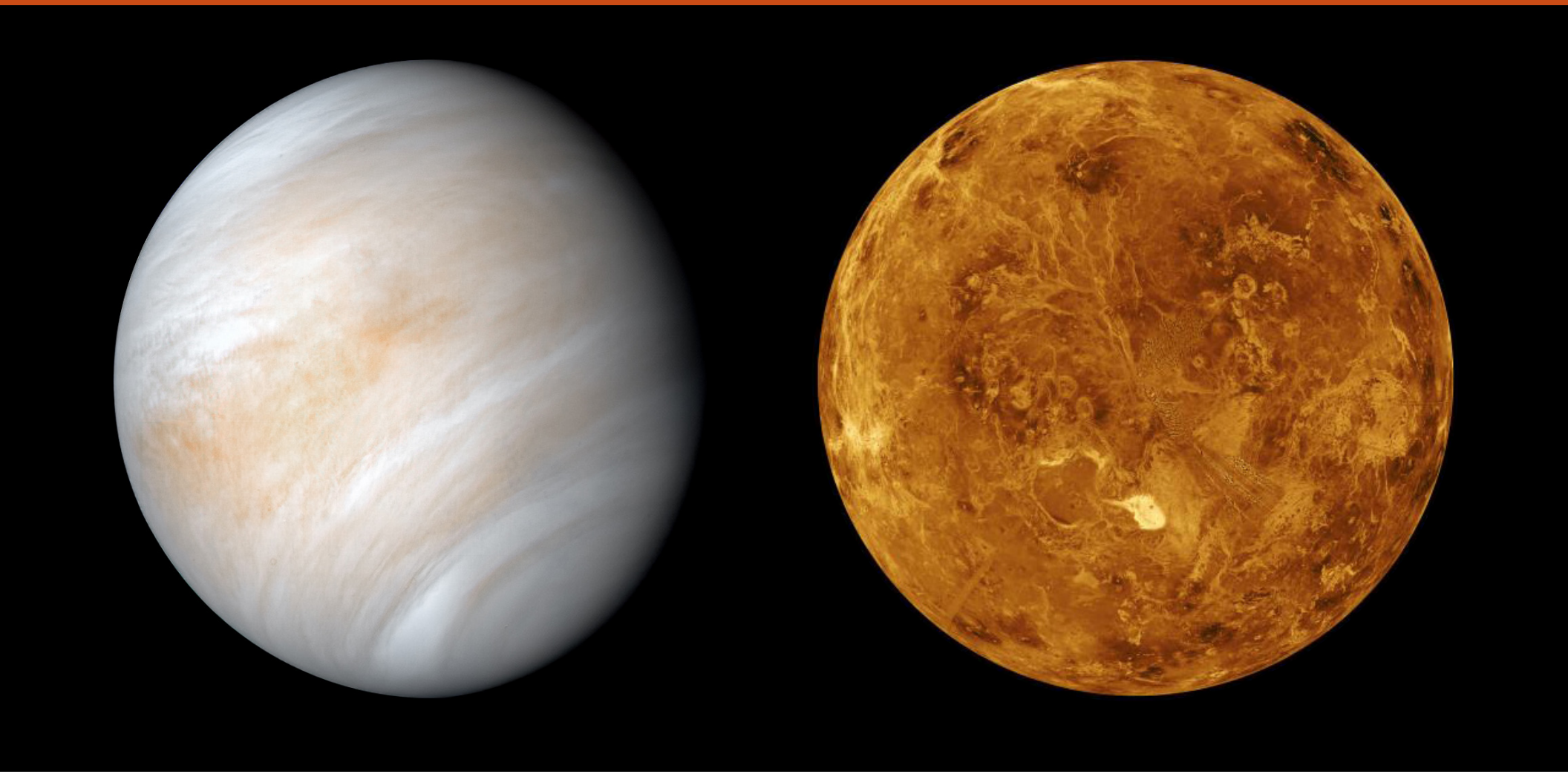
The shading is true color with the oceans shades of blue, the lands varying from green to brown. The brown areas are the sands of the deserts. The shading of the land was done using a dataset compiled by the U.S. Geological Survey's Earth Resources Observation and Science Data Center.

Earth with Vegetation shows the Earth without cloud cover so that the vegetation can be clearly seen. It is a mosaic image therefore it doesn't represent any particular season.

Source:
https://sos.noaa.gov/catalog/datasets/blue-marble-without-clouds/

VENUS

Venus is permanently shrouded in thick clouds made of **sulfuric acid.**



Venus from Mariner 10
As it sped away, Mariner 10 captured this view of Venus wrapped in a dense, global cloud layer. This contrast-enhanced view makes features in the planet's thick cloud cover more visible.

Cloud-Free Mosaic of Venus's Surface
This cloud-free view of Venus was created by mapping synthetic aperture rader mosaics from Magellan onto a computer-simulated globe. The colors are based on images from Venera 13 and 14.

Venus from Mariner 10

Abridged Caption:

As it sped away from Venus, NASA's Mariner 10 spacecraft captured this seemingly peaceful view of a planet the size of Earth, wrapped in a dense, global cloud layer. But, contrary to its serene appearance, the clouded globe of Venus is a world of intense heat, crushing atmospheric pressure and clouds of corrosive acid. This newly processed image revisits the original data with modern image processing software. A contrast-enhanced version of this view, also provided here, makes features in the planet's thick cloud cover visible in greater detail.

The clouds seen here are located about 40 miles (60 kilometers) above the planet's surface, at altitudes where Earth-like atmospheric pressures and temperatures exist. They are comprised of sulfuric acid particles, as opposed to water droplets or ice crystals, as on Earth. These cloud particles are mostly white in appearance; however, patches of red-tinted clouds also can be seen. This is due to the presence of a mysterious material that absorbs light at blue and ultraviolet wavelengths. Many chemicals have been suggested for this mystery component, from sulfur compounds to even biological materials, but a consensus has yet to be reached among researchers.

The winds and clouds also blow to the west, not to the east as on the Earth. This is because the planet itself rotates to the west, backward compared to Earth and most of the other planets. As the clouds travel westward, they also typically progress toward the poles; this can be seen in the Mariner 10 view as a curved spiral pattern at mid latitudes. Near the equator, instead of long streaks, areas of more clumpy, discrete clouds can be seen, indicating enhanced upwelling and cloud formation in the equatorial region, spurred on by the enhanced power of sunlight there.

This view is a false color composite created by combining images taken using orange and ultraviolet spectral filters on the spacecraft's imaging camera. These were used for the red and blue channels of the color image, respectively, with the green channel synthesized by combining the other two images.

Despite their many differences, comparisons between Earth and Venus are valuable for helping to understand their distinct climate histories.

Source:

https://photojournal.jpl.nasa.gov/catalog/PIA23791

Cloud-Free Mosaic of Venus's Surface

Full Caption:

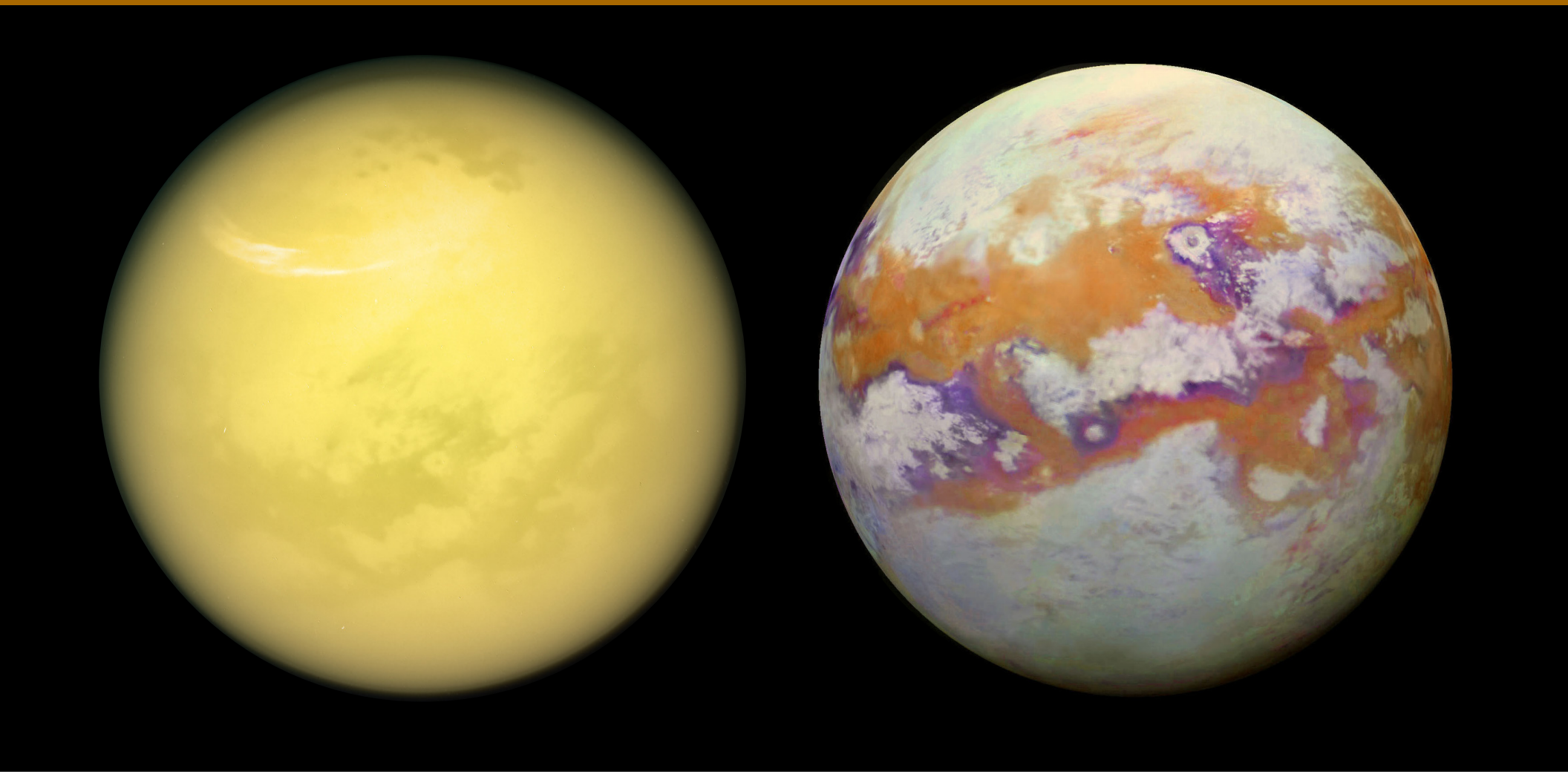
The northern hemisphere is displayed in this global view of the surface of Venus. The north pole is at the center of the image, with 0 degrees, 90 degrees, 180 degrees, 270 degrees east longitudes at the 6, 3, 12, and 9 o'clock positions, respectively, of an imaginary clock face. Magellan synthetic aperture radar mosaics from the three eight-month cycles of Magellan radar mapping are mapped onto a computer-simulated globe to create this image. Magellan obtained coverage of 98 percent of the surface of Venus. Remaining gaps are filled with data from previous missions, (the Soviet Venera 15 and 16 radar and Pioneer Venus Orbiter altimetry) and data from Earth-based radar observations from the Arecibo radio telescope. Simulated color is used to enhance small-scale structures. The simulated hues are based on color images recorded by the Venera 13 and 14 landing craft. Maxwell Montes, the planet's highest mountain at 11 kilometers (6.6 miles) above the average elevation, is the bright feature in the lower center of the image. Other terrain types visible in this image include tessera, ridge belts, lava flows, impact craters and coronae. The image was produced by the Solar System Visualization Project and the Magellan Science team at the Jet Propulsion Laboratory Multimission Image Processing Laboratory. The Magellan mission is managed by JPL for NASA's Office of Space Science.

Source:

https://photojournal.jpl.nasa.gov/catalog/PIA00271

TITAN

Saturn's largest moon, Titan, has clouds made of **methane.**



Titan from Cassini
A large, bright and feathery band of summer clouds can be seen arcing across high northern latitudes in this false-color image captured by Cassini's narrow-angle camera.

Infrared Mosaic of Titan's Surface
Observing the surface of Titan in visible light is difficult, due to the globe-enshrouding haze around the moon. This view was created using 13 years of infrared data from Cassini's VIMS instrument.

Titan from Cassini

Abridged Caption:
These two views of Saturn's moon Titan exemplify how NASA's Cassini spacecraft has revealed the surface of this fascinating world.Cassini carried several instruments to pierce the veil of hydrocarbon haze that enshrouds Titan. These include the spacecraft's radar and visual and infrared mapping spectrometer, or VIMS. The mission's imaging cameras also have several spectral filters sensitive to specific wavelengths of infrared light that are able to make it through the haze to the surface and back into space.

In addition to Titan's surface, images from both the imaging cameras and VIMS have provided windows into the moon's ever-changing atmosphere, chronicling the appearance and movement of hazes and clouds over the years. A large, bright and feathery band of summer clouds can be seen arcing across high northern latitudes.

Source:
https://svs.gsfc.nasa.gov/30903/

Infrared Mosaic of Titan's Surface

Abridged Caption:
These six infrared images of Saturn's moon Titan represent some of the clearest, most seamless-looking global views of the icy moon's surface produced so far. The views were created using 13 years of data acquired by the Visual and Infrared Mapping Spectrometer (VIMS) instrument on board NASA's Cassini spacecraft. The images are the result of a focused effort to smoothly combine data from the multitude of different observations VIMS made under a wide variety of lighting and viewing conditions over the course of Cassini's mission.

Previous VIMS maps of Titan (for example, Mapping Titan's Changes) display great variation in imaging resolution and lighting conditions, resulting in obvious seams between different areas of the surface. With the seams now gone, this new collection of images is by far the best representation of how the globe of Titan might appear to the casual observer if it weren't for the moon's hazy atmosphere, and it likely will not be superseded for some time to come.

Observing the surface of Titan in the visible region of the spectrum is difficult, due to the globe-enshrouding haze around the moon. This is primarily because small particles called aerosols in Titan's upper atmosphere strongly scatter visible light. But Titan's surface can be more readily imaged in a few infrared "windows" -- infrared wavelengths where scattering and absorption of light is much weaker. This is where the VIMS instrument excelled, parting the haze to obtain clear images of Titan's surface.

Source:
https://science.nasa.gov/resource/seeing-titan-with-infrared-eyes/