How was this image created?

The human brain is the very best image processor known. To take advantage of this great human ability, researchers at NASA's Goddard Space Flight Center (GSFC) have designed tools to make images of complex datasets. These images help scientists (and you!) better understand natural processes. The image on the front of this poster is a combination of data collected by three different satellites. The cloud data and the image of the moon were collected by a NOAA-GOES satellite (National Oceanic and Atmospheric Administration's Geostationary Operational Environmental Satellite). The ocean data was collected by the NASA SeaWiFS satellite (Sea-viewing Wide Field-of-view Sensor). The land image is a depiction of NDVI (Normalized Difference Vegetation Index) which is calculated from data collected by the NOAA-AVHRR instrument (Advanced Very High Resolution Radiometer). The topography of the land (mountains, valleys, etc.) is contained in a Digital Elevation Model (DEM for short) produced by the US Geological Survey.

The GOES satellite can collect an image of the full disk of the Earth in just a few minutes. The cloud data used in this image was collected on September 9, 1997 at 17:45 UTC (see the activity below "What Time is it in Space" for an explanation of UTC time). The AVHRR and SeaWiFS satellites see only a small strip of the Earth at any one time, and so the full-disk data from these two satellites was merged from cloud-free scans collected over a period of 10 days starting on September 9 for AVHRR and 15 days starting on September 18 for SeaWiFS. Data merged from lots of scans over a period of time is called a "mosaic", because the small strips of data look like the small tiles in a mosaic sculpture. The presence of the moon in this image is purely an artistic addition: the moon was not in the visible field of view when Hurricane Linda was occurring. The GOES satellite collected the moon image on September 20, 1994 (see "That's the Moon?" below).

Seems like a lot of trouble to put all that together. It is! We go to all that trouble because we want this poster to look like what we would see if we could get our eyes way out there in space. The trouble is, satellites don't generally see what we would see with our own eyes. Satellites are often designed to "see" radiation that we can't see with our eyes. One simple reason for this is to allow satellites to see things on the Earth even when they are looking at the half of the Earth that is in darkness. More importantly, different wavelengths of radiation can give us more information than what our eyes can give. So the data from the GOES satellite is especially good for telling us where the clouds are and how much water vapor is in the atmosphere. The data from SeaWiFS is especially good for telling us where algae are growing or sediments are being carried by currents in the oceans. Note the sediments around the mouth of the Amazon River and the shallow water in the Caribbean. AVHRR data can be used to tell us about how much vegetation is present. For this poster, green indicates a lot of vegetation and yellow indicates only sparse vegetation.

After all the data are collected, the artistry begins. Keep in mind that all of the data that comes from satellites is digital data. Digital means numbers. Satellites don't send us a picture--they send us numbers that we portray as a picture! We have chosen to depict lots of vegetation as green and sparse vegetation as yellow. We could have chosen red to blue instead, but everyone expects vegetation to look green. That does not mean that the vegetation looks *exactly* like this poster from space. Dry deserts are not yellow. This color scheme merely gives an approximation of what was really occurring.

Likewise, reality is sometimes disappointing or perhaps not even visible. In this image, the heights of the mountains and depths of valleys have been exaggerated 50 times their actual height and depths. The shadows for the mountains were calculated from the exaggerated height in order to better portray the vertical relief of the land. Without such exaggeration, the vertical relief of the land would not be visible!

The addition of the moon and stars into this image is purely artistic license. Though GOES collected the moon's image, the moon was not in that position while Hurricane Linda was raging in the Pacific Ocean. The moon has been magnified as well. If displayed at its proper size in relationship to the full disc of the Earth, the Moon would be just slightly half as large as you see it. The original GOES image of the moon (a portion of which is reproduced at the bottom of this document) can be found online at http://rsd.gsfc.nasa.gov/goes/text/goes8results.html#goes8.moon.20sept94.jpeg.

Scientific visualization converts the flood of numbers coming from satellites into useful images. The creation of such images is truly a combination of science, engineering and artistry. Many other examples of scientific visualizations of hurricane images can be found online in the image catalog at http://rsd.gsfc.nasa.gov/rsd/

"That's the Moon?"

That lopsided, football-shaped image is indeed the Moon. Looking closely at the image can tell you a lot about how GOES (Geostationary Operational Environmental Satellite) collects its data. An important concept here is "Geostationary". In fact, nothing is stationary. The Earth is rotating once a day, GOES is revolving around the Earth once a day, and the Moon is revolving around the Earth about once a month. GOES is carefully placed into an orbit above the equator at a height that makes it revolve around the Earth in exactly the same amount of time it takes the Earth to rotate one time. This allows the satellite to hover continuously over one position on the surface. Such an orbit, which is called a geostationary orbit, is about 35,800 km (22,300 miles) above the Earth.

But the Moon is not synched up with the Earth and GOES. So as GOES scans across the Moon, each successive scan appears slightly to the right of the one above it. That is why the edge of the Moon is jagged and why the bottom of the Moon appears to be to the right of the top of the Moon! For the round image of the Moon on the front of this poster, each of the scan rows of the original image was moved to the left to match up with the previous scan. Then the resulting oblong shape was scrunched together until it was round.

One last trick of the scientific visualization trade: that black line going across the Moon is the result of one line of data not being received correctly from the satellite. To fill it in, the line of data right next to the gap was copied and duplicated in the gap to cover it up.