Temecula Valley Astronomer

The monthly newsletter of the Temecula Valley Astronomers Dec 2017

Events:

General Meeting : No meeting in December but join us on Monday, Jan 8, 2018 at the Temecula Library, Room B, 30600 Pauba Rd, at 7 pm.

Please consider helping out at one of the many Star Parties coming up in December and January. For the latest schedule, check the Calendar on the web page.

James Web Space Telescope Main mirror assembled at Goddard Spaceflight Center, May 2016.

Source : Wikipedia

WHAT'S INSIDE THIS MONTH:

Send newsletter submissions to Mark DiVecchio <markd@silogic.com> by the 20th of the month for the next month's issue.

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General information:
Subscription to the TVA is included in the annual $25 membership (regular members) donation ($9 student; $35 family).

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Cosmic Comments
by President Mark Baker

What a whirlwind year it has been for Astronomy and related sciences…our knowledge and experience has grown a hundredfold, but the questions arising have also increased, exponentially!!! And new tools are just around the corner that will serve to provide more answers and promulgate questions as well, such as the First Light of the Zwicky Transient Facility (ZTF) at our own neighboring Palomar Observatory…pretty exciting stuff!!

Two main highlights for me were the culmination of the very successful Cassini / Huygens mission, and the creation of the new science of Multi-Messenger Astronomy, driven by the simultaneous observation of a "kilonova" by so many of our space-based platforms – Fermi, LIGO, Hubble, CHANDRA, Swift, Spitzer, etc. - as well as many ground based observatories working across the EM spectrum.

So what about your highlights?? There is so much to choose from…

On somewhat of a down side, the inability of the USA to launch and orbit scientific packages has already sidetracked a few missions, like the James Webb Space Telescope, but efforts are underway to correct that problem…commercially if need be!!

So looking forward to 2018 and the opportunities for advancement "on the books"… I hope you share my enthusiasm for what the future will teach us!!

Here's to all you do, in every way you do it…keep looking up because you may never know who sees you, and looks up themselves!!!

Clear, Dark Skies my Friends…

Looking Up Redux – November
by Clark Williams

ALL TIMES ARE LOCAL PST WILDOMAR

Times are given in 24-hour time either as hh:mm:ss or hhmmss. A time given as hhmm+ indicates that it is the hour of the next day. Similarly a time hhmm− indicates a time in a previous day.

Moon Phases for the month by date:

2017-12-03 Sunday @ 07:48:05 PST FULL — COLD MOON
2017-12-09 Saturday @ 23:52:36 PST LAST QTR
2017-12-17 Sunday @ 22:31:40 PST NEW
2017-12-26 Tuesday @ 01:21:11 PST FIRST QTR
Perigee comes on 2017-12-04 @ 00:43 PDT – 357, 495 km (222, 137 mi)
Apogee comes on 2017-12-19 @ 17:28 PDT – 406, 604 km (252, 652 mi)

2017 has: (12) new moons, (13) 1st Qtr moons, (12) Full moons, (12) 3rd Qtr moons
(0) Blue moons and (0) Black moons

Luna:

The Cold Moon will wax into the beginning of December in Aries moving through Scorpius by the 15th as Luna gets close to New and then moves into the new year via Taurus close to its Full glory.

Planets:

- **Mercury:** Mercury begins the month as an early riser popping above the horizon around 0700. It has moved into the daytime and will set about 1900. By the mid month Mercury is rising at around 0500 and setting at 1700. Mercury passes Perihelion on the 12th of December. The innermost planet will leave the month finally giving the early risers and early to slumber folks a glimpse by rising near 0423.
- **Venus:** Venus is a ditto of Mercury this month. She is falling into the Sun's glare in the beginning of the month rising nearly at 0500. Nothing much will change by the middle of the month she is still moving into the sun rising still around 0530. By the end of the month she is dead center in the Sun. Rising near 0600 and setting nearly at 1800. You'll just have to wait until next year for a better glimpse.
- **Mars:** Mars at least is going to be visible if you are an early riser or late-to-bed person. Mars rises about 0250 in the beginning of the month and setting by 1450. Mid-month he is moving a little more into the early morning rising around 0230 for a couple of hours of low horizon viewing. By the close of the year Mars has moved deeper into the night rising around 0200. Our red neighbor will be about 16 light minutes from us with a pleasant +1.5 visual magnitude.
- **Jupiter:** Jove is just gone for the entire month. Rising near to 0352 at months start, 0308 near the mid month and not moving to something reasonable until nearly the new year rising around 0217. Jove has been good to us for the last few months swapping positions with Saturn and Mars but he is resting visually for the month of December.
- **Saturn:** Saturn is in Sagittarius and astrologically these folks like to move a lot (whatever that means). Saturn is up in the late morning for most folks at around 0706 for the beginning of the month. He too is falling into the Sun by mid-month is almost directly in the rising Sun's glare by 0618. Saturn closes the year still stuck in the daylight rising around 0523.
- **Uranus:** So much for the naked eye visible planets. Uranus and Neptune both are VIPs (Visually Interesting Planets) of the December night skies. Uranus starts the month rising at a reasonable 1448. This gives it a good time to climb out of the light muck and move into both a viewing and imaging position. George's planet will transit in the early month at about 2049 and won't be setting until nearly 0255 the next morning. Mid month is just as good with: 1352, 1953 and 0159+ for rise, transit and set. Uranus remains about 120° from the Sun most of the month. But don't wait for the end-of-year gifts to see if you got that wonderful little accessory. You didn't! (big

smile) because by the end of the month Uranus has moved to within 79° and is rising at 1248, transiting at 1850 and setting at 1255+. Don't dally!

- **Neptune:** Neptune like Uranus is a gem for planet watchers this month (and you don't have that much to choose from either). Everything you read about Uranus goes for this hard to image planet as well. Times: (Rise:Transit:Set) Beginning of Month: (1208:1809:1215+) Mid-month: (1114:1715:2316) End of Month: (1012:1613:2214)

  Seriously if you haven't tried your hand at finding Uranus and Neptune visually you should take up the challenge. Uranus has a visual magnitude of about +5.8 and Neptune creeps in at about +7.9. That is tough but not impossible. The feeling you'll get from these two gems is just thrilling. Once you have got them visually really push up the bar and challenge yourself to image these puppies. They are spectacular. You have the whole month to try and they are booth challenging and rewarding.

- **Pluto:** My favorite PLANET (besides earth of course) is unfortunately a waste this month too. Visual Magnitude of +14.3 and spending most of its time in the Sun's glare.

Meteors:

- We were favored with two showers in November and we pay for the abundance by a reduction this month. Just one shower but it is usually REALLY nice. About 200 years ago (1833) on a Mississippi Riverboat a new meteor shower was reported. These are the Geminids. They were washed out in 2016 by the supermoon but they should peak between December 13th and December 14th this year and if the viewing is dark you should see some really nice streaks. With rates as high as 120 meteors an hour you should enjoy the Geminids but as always FIND DARK SKIES! This shower has actually increased over the centuries as Jupiter has pulled the detritus from the asteroid 3200 Phaethon closer to Earth. Find a hammock and dark skies for a very nice show.

Deep Sky:

- The favorites are out this month: Sirius, Aldebaran, Capella, Canopus, Betelgeuse, Rigel, Orion, Winter Circle, almost all of Messier's Catalog. As Autumn's stars fade into the west the winter sky is creeping in, aglow with galaxy light. Many of you may have received imaging devices in the frenetic end-of-year-rush to spend every dime we made during the year. If so you are about to try your hand at astro imaging. If you're new to this endeavor do yourself a favor and start on the easy stuff. It is not like using a digital camera on your phone. Try imaging the moon and some of the craters and especially some of the rilles. The albedo of the moon makes it an easy subject with quick focus and the high contrast shadows on the craters and rilles makes for easy focus and rewarding shots. At some point the moon will wane and you'll want to shoot some wonder shots of the deep sky. Try some of the Messier objects. Especially bright ones. Orion's nebula is a great place to begin. Learn about filters and color and image manipulation on these bright objects. Don't push for the Horse-head Nebula right off. It is smaller than you might think. Move to the clusters and perfect your focus. Parfocalize your eyepieces to your camera and learn all you can. When the galaxy bug bites you, try your hand at M31. It will teach you about the challenges of focus and depth. Then when you think you can't stand it anymore and just need that money shot turn your hand to M57 the Ring Nebula. Once you get these under your belt you can move into the long exposure club and begin imaging some of the moderately challenging galaxies like M98. With these under your belt you'll be ready to try anything you want to do in the astro-imaging world. It won't be easy always but you'll have some clue as to how to approach the problem and what to try. Don't forget that while you're having all this fun your family would probably like to see something of you before the New Year.

Random Thoughts
by Chuck Dyson

Understanding Asteroids

"Society grows great when old men plant trees whose shade they know they will never sit in"
Anonymous Greek proverb

Before I found the noted Greek proverb, I thought that missions to the outer planets should be headed up by young researchers because with a decade long planning phase and with the underpowered rockets that we have today requiring four to five years to get the science package to its destination, they were the only ones who had a chance of living to see the mission through to competition; however, the proverb has caused me to realize that it is probably better to have "old hands" start and push the mission forward and then hand the mission off to younger researchers who will finish the mission and then be the "old hands" on the next mission.

The "old hands" scenario is exactly what has happened in the two missions selected by NASA in 2017 to be funded in the low cost discovery class mission program, low cost in NASA speak is less than $400 million dollars. The time length of the missions will be around twenty years from start to finish and that is why I initially thought that younger hands should be on these missions and one should remember the proposed timeline for the missions supposes no extensions on the launch date as has happened to the Mars Insight mission, scheduled for 2016 launch and pushed back to 2018, and the James Webb Space Telescope that was scheduled to launch in 2013 and still sits on the ground.

Development and launching issues aside why would NASA give its entire 2017 Discovery class mission budget to probes of asteroids? Let's start by looking at the asteroids. When you hear the word asteroid you probably think of rocky bodies between Mars and Jupiter these bodies are often referred to as main body asteroids and they come in three main flavors C-Group or Carbonaceous - 75% of all asteroids, S-Type Stony or Silicaceous - 17% of all asteroids, M-Type or Metallic - less than 8% of all asteroids, and of course there are eight or more minor types that combined make up 1 to 2% of all asteroids.

The three main types are not evenly spread throughout the main body of asteroids. The outer part of the main body, the part closest to Jupiter, is dominated by the C-Group and the middle part has most of the M-Type with the S-Type mostly in the inner part, the part closest to Mars. It is thought that the non-random separation of the different types of asteroids was due to the different temperatures at which the chemical compounds, minerals, that solidified from a molten state. The compounds solidifying at the highest temperatures being the closest in and the ones with the lowest solidification temperature forming the outer band of asteroids with a little shuffling occurring over the last four billion or so years.

There is a class of astronomers who do not completely or always agree with the scenario just presented and they are the computer model guys and as usual they have come up with several ways that the asteroid belt could have formed; however, most of these models predict that a particular rare event will occur in the asteroid belt. The models predict that a large asteroid will form and become spherical, a dwarf planet; differentiate to form a rocky/icy outer shell and have an iron/nickel core; and then through a series of destructive encounters with other large asteroids have the rocky/icy mantel blasted away leaving only a naked iron/nickel core. Although we know that the active iron core in our planet is essential for life being on our planet and despite all of the pictures and diagrams in the astronomy books, we are not exactly sure just how that sucker works and what it is made of; so, the chance to actually see and study one is not an opportunity to be missed.

Enter 16 Psyche a roughly 200 kilometer in diameter asteroid that just happens to represent just over 1% of all of the mass in the asteroid belt, this baby is really dense! The Psyche probe will carry three instruments - a high resolution imager with filters in order to understand how the core may have formed; a magnetometer to measure any residual magnetic fields to help us understand if the core was in fact a dynamo, how strong its magnetic fields were, and clues as to how it actually generated its electrical fields; the third instrument is a gamma ray and

neutron spectrometer this instrument will tell the scientists what elements are on the surface of the asteroid and what the concentration of those elements are.

One of the things that scientists hope to discover is the concentration of oxygen in the crustal material because, if there is an abundance of oxygen, then iron oxides will form and that material will not migrate to the core and the planet will have a small core relative to its size, think Mars the red (iron oxide) planet, if the oxygen content of the crustal material is low then much of the iron would have stayed metallic and migrated to form the core and the core would be large relative to the size of the planet, think Mercury.

Finally the space craft itself will be a gravity probe of the asteroid by sending signals that enable scientists on Earth to measure its changes in speed as it passes over different parts of the asteroid and this will help scientists understand the interior structure, if any, of the metallic core.

In addition to main belt asteroids there are many other families of asteroids, asteroids that have very similar orbits are called families. Apollo, Earth orbit crossing, asteroids; Amor, Mars but not Earth orbit crossing, asteroids; Centaur, short lived Saturn and Uranus orbit crossing, asteroids (moral of this story is if you are an asteroid don't you go messen around with the big planets). And, of course, the Trojan asteroids found at the L4 and L5 Lagrangian points.

Now a word about Lagrange points. First off there are five of them and the first three are collinear, they line up with the Earth and Sun and represent points where the forces of gravity from the Sun and Earth on an object are balanced or equal and were actually described first by Leonhard Euler and represent convex points of stability; another words, an object at the L1 point will be perfectly balanced between the Sun and Earth but if it moves off of that point it will be closer either to the Earth or the Sun and the gravitational forces acting on it will move it farther and farther from the Lagrange point. Even though the L1 and L2 points are not perfectly stable over long periods of time they do represent areas or relative stability and are favorite parking places for some of NASA's long duration space probes. To date no one has found a use for L3 except to inspire science fiction writers to create hidden alien worlds. L4 and L5 were the points actually first described by Joseph-Louis Lagrange in his paper of 1772 where he described and explained the characteristics of all five points and that is why all five points are today called Lagrange points. L4 and L5 are not collinear points but represent points of an equilateral triangle between a planet the Sun and either L4 or L5 and unlike L1 L2 and L3 these points represent concave rather than convex points of equilibrium. Because L4 and L5 represent concave points in the gravity field when objects move away from them they are not pushed further away by gravity but are pushed back to the point by gravity. Residence at L4 and L5 tends to be a permanent situation.

With asteroids in the main belt whizzing around and smashing into each other there are large numbers of asteroid chunks flying in all directions and some of these chunks find their way to Earth and become meteorites on the surface of our planet and by studying these meteorites we have a good idea of what the composition and history is of main belt asteroids. In contrast to the main belt asteroids the Trojan asteroids are not in excited orbits and their impacts are low energy and the chunks produced are not encouraged by gravity to go wandering all over the solar system; thus, as of today, we have no verified specimens of Trojan asteroid origin meteorites on Earth.

This almost total lack of knowledge of the origin and chemical makeup of the Jupiter Trojan asteroids is the impetus for the Lucy mission as the probe is named. Yes, the name Lucy comes indirectly from the Beatles song Lucy In The Sky With Diamonds. A group of paleontologists were searching for early hominid remains in Ethiopia in 1974 and found a skeleton of a 3.8 million year old hominid that was 40% complete and this skeleton completely changed our ideas of how human development occurred; one of the researchers was obsessed with the Beatles song and played the song Lucy over and over and so the team named the skeleton Lucy. Hal Levison the mission lead scientist named the probe Lucy hoping that it too will be a watershed event in our understanding of the composition and formation of the outer solar system planets.

What will Lucy do? A basic survey of what is in the two Trojan asteroid populations. To do this Lucy will study the surface composition or the size and distribution of rocks, study the surface geology focusing on craters their distribution and looking for evidence of surface layering of materials over time, study the interior and bulk of the asteroids by measuring mass and density and looking into fractures and looking for ejecta blankets, and finally

doing a satellite search to determine the actual number and sizes of the Trojan asteroid population. The actual mission will last 12 years and includes a 2021 launch the journey out to L4 the leading Trojan group then a return trip back to Earth for a gravity boost and vector change a second trip back to Jupiter this time to the L5 or trailing Trojan population and then in 2033 end of mission. Expect both of these missions to rewrite several chapters in your favorite astronomy text book.

Cheers
Chuck

Some Astronomical Tools For *.nix Platforms

by Clark Williams

I have been programming computers for over forty-years now professionally. I've seen a great deal of changes in that time in both hardware and software and the combinations of the two. When you combine the two (hardware and software) together it is known in the technology industry as a platform. There is no such thing as a “best” platform (which is not the same thing as there being no such thing as a “worst” platform).

As computers became a commodity the number of market choices fell. Today there are only two real choices for platforms: the **Unix** OS choice available on a variety of hardware choices and **Windows** available on Intel. Of these **Unix** has always been the dominant choice among professional astronomers and institutions.

Unix was developed as a side project by Kernnigan, Thompson and Richey and released eventually as open source in the 1970s. A student in Finland named Linus Torvalds used the basic concepts of **Unix** and produced a variant that eventually was named after him called **Linux**. In the meantime UC Berkley modified **Unix** as well and released what they called a “better” **Unix** named BSD. The California Regents told them to release BSD as open source since the public had paid for its development and **Free-BSD** was born.

Linux and **Free-BSD** have been modified and adopted by many manufacturers. Apple's modification added a front-end module called **Darwin** and a graphical interface called **Aqua** and **Mac OS X** was born which is now called **macOS**. **macOS** is at its core **Free-BSD**. It will run all of the **Unix** and **Linux** astronomy programs available.

Linux is issued as a free software package known as “the kernel”. It is maintained and updated by a dedicated user base that must pass a rigorous submission gauntlet to be included in the next release of “the kernel”.

The “kernel” is a bare-bones operating system in the sense that it is extremely clean. A user may add their own window management system(s) and graphical user interfaces with whatever bells and whistles they consider necessary. In fact some companies do just that. They take “the kernel” and re-package it with added bells and whistles. These packages are called “distributions” of the kernel or “distros” for short.

All distros must be offered as free downloads although the manufacturers are also allowed to beg for donations and may charge for any media used to ship or package the media. In general then packages of software additions (Apps) are offered for installation on a distro. There are standard installation packages and about every six months or so a new distro is released that sometimes becomes a “hot” new distro.

Look at the big table starting on the next page. I have tried all of these software packages on the two distros: **debian** and **Ubuntu**. I have also tried certain packages on **macOS**. In the table below each software packages is followed by some combination of the three letters: MUD. The “M” means tried and works with **Macintosh**, “U” is for **Ubuntu** and “D” is for **debian**. Thus the entry (shown in this example):

Celestia	Space Simulator Software	https://celestiaproject.net	M	U	D	

Left-most column indicates the name of the software “Celestia”. To the right of that column is a short description of the package. The location of the software's home page is given next followed by the claim by the manufacturer that it works on **Macintosh**, **Ubuntu** and **debian** distros. The underline indicates that I have run it on **macOS 10.10** and above and on **Ubuntu 64-bit**. No underline on the “D” indicates I have ***not*** tried the software on the **debian 64-bit** distro. Finally there is a cost column. If it is freeware or shareware there will be no entry in this column. If there is a $, it is inexpensive, $15 or less. $$ is between $16 and $60 while $$$ is above $60.

I have some quick notes of interest to all whether *.nix users or not, besides software.

- First if you can't afford $15 per year for a S&T calendar (I'm speaking here to those younger than 15 and older than 65) you can download a calendar that looks just as nice from **NASA**. You'll have to print your own pages or have them printed but that isn't as expensive as you might think. The images are from **NASA**'s Astronomy Picture Of the Day (**APOD**) site and the calendar can be found at: https://apod.nasa.gov/apod/fap/APODcalendar2017NASAv5.pdf
- Next if you have access to a 3D printer and want to try your hand at some **NASA** mission craft or memorabilia try: https://nasa3d.arc.nasa.gov/models/printable. Note that you may have to really slow your prints down to get an accurate and strong object.
- Most of these are also free and they are really fun to build. Try a paper model of a **NASA** mission. You can investigate these at the following URL: https://solarsystem.nasa.gov/kids/index.cfm?Filename=papermodels.
- Apps – Apps – Apps **NASA** has several very cool apps available for both **iOS** devices and **Android** devices. See the App store for your device. They are all Shiny!

Okay, lets get to some software:

(Some of these packages will require **X11** for **macOS**. An install program can be fund at the open-source URL: https://www.xquartz.org).

Name	Description	URL (WEB site)	M	U	D	$
AstoGrav [1]	A full-featured, high precision solar system simulator that calculates the gravitational interactions between all astronomical bodies, so that the motions of asteroids and comets are simulated much more accurately than with planetarium applications. The effects of general relativity and radiation pressure can be taken into account, and superb interactive 3D viewing allows you to easily rotate and zoom your view while the solar system evolves.	http://www.astrograv.co.uk	M	U	D	$ $
Universe Sandbox [2]	A physics-based space simulator. It merges gravity, climate, collision, and material interactions to reveal the beauty of our universe and the fragility of our planet.	http://universesandbox.com	M	U	D	$ $
SAOImage DS9	SAOImage DS9 is an astronomical imaging and data visualization application.	http://ds9.si.edu/site/Download.html	M	U	D	
Fv	*Fv* is the easy to use graphical program for viewing and editing any FITS format image or table.	https://heasarc.gsfc.nasa.gov/ftools/fv/fv.html	M	U	D	
<multiple>	A cornucopia of software available from NASA Goddard Space Flight Center	https://heasarc.gsfc.nasa.gov/docs/software.html	M	U	D	
gimp	Poor man's Photoshop	https://www.gimp.org	M	U	D	

openSCAD	The Programmers Solid 3D CAD Modeler	http://www.openscad.org	M	U	D	
FreeCAD	FreeCAD is a parametric 3D modeler	https://www.freecadweb.org	M	U	D	
Celestia	Travel throughout the solar system, to any of over 100,000 stars, or even beyond the galaxy.	https://celestiaproject.net	M	U	D	
Stellerium	Stellarium is a free open source planetarium	http://www.stellarium.org	M	U	D	
StarryNight	StarryNight College is a FULL featured planetarium software package and curriculum.	http://starrynighteducation.com	M			$ $ $
The Sky Professional	A full featured planetarium software package	http://www.bisque.com/sc/	M			$ $ $
Sky Safari Pro	A full featured planetarium software package	http://www.skysafariastronomy.com	M			$ $
Keith's Image Stacker	Image Stacker	http://keithwiley.com/software/keithsImageStacker.shtml	M			
Keith's AstroImager	Camera Control for Macintosh	http://keithwiley.com/software/keithsAstroImager.shtml	M			
Solar Eclipse Maestro	Can handle any solar eclipse, provide you Bailey's beads preview and animation, simulate an all-sky view or weather statistics, and a lot more. Helps you to enjoy the event. It can also control up to four USB or Firewire connected cameras (Nikon, Cano and Panasonic DSLRs, Ricoh, plus Nikon Coolpix line) and up to four USB or Ethernet connected SBIG CCD cameras with their filter wheels during a solar eclipse, so that you can be free to concentrate on observing the event visually. DSUSB (Shoestring Astronomy) shutter control cables are also supported.	http://xjubier.free.fr/en/site_pages/solar_eclipses/Solar_Eclipse_Maestro_Photography_Software.html	M			
TVA App	Star Party and Temecula Valley Astronomer's Club App.	iOS App Store – search for “TVA App”	M			

Download the free software packages and spend some time learning them. It will be well worth your time.

Special notes:

1 - AstroGrav: this software ackage is just shiny! It is a time machine though. You know hoe you sit down to do some viewing at sunset and spend a few minutes looking and/or imaging some objects in the night sky when you suddenly notice that the sky seems to be getting too light for viewing? It is that kind of time machine. Hours of fun and learning go by in a few femto-seconds. However if you have wondered why gas clouds collapse or flatten into disks – this stunning visual aid is just unbeatable.

2 - Universe Sandbox: This software is also a time machine and fascinating to play. It is very graphics intensive and needs a wire with some bandwidth to fully utilize. Again. simply stunning to play and a LOT of FUN, however it can be a nightmare to install. You end up using this thing through a second piece of software called “Steam”. *Steam* is an engine allowing you to play purchased games on any of your devices. This does mean that you can play on your desktop, mobile device or somewhere remote if you install *Steam* on that device first but the real goal is to weasel some monthly fee out of you. You can avoid the fee but it requires a fair amount of effort and be prepared for a deluge of spam after *Steam* is installed. The installation procedure is painful enough that *Universe Sandbox* ^{2} barely creeps by getting mentioned on this list at all.

To those of you insistent on using Windoze. most of the software listed here is also available on Windows XP, 7, 8 and 10.

NASA SpacePlace

Studying Storms from the Sky

By Teagan Wall

The United States had a rough hurricane season this year. Scientists collect information before and during hurricanes to understand the storms and help people stay safe. However, collecting information during a violent storm is very difficult.

Hurricanes are constantly changing. This means that we need a lot of really precise data about the storm. It's pretty hard to learn about hurricanes while inside the storm, and instruments on the ground can be broken by high winds and flooding. One solution is to study hurricanes from above. NASA and NOAA can use satellites to keep an eye on storms that are difficult to study on the ground.

In Puerto Rico, Hurricane Maria was so strong that it knocked out radar before it even hit land. Radar can be used to predict a storm's path and intensity—and without radar, it is difficult to tell how intense a storm will be. Luckily, scientists were able to use information from a weather satellite called GOES-16, short for Geostationary Operational Environmental Satellite – 16.

The "G" in GOES-16 stands for geostationary. This means that the satellite is always above the same place on the Earth, so during Hurricane Maria, it never lost sight of the storm. GOES-16's job as a weather satellite hasn't officially started yet, but it was collecting information and was able to help.

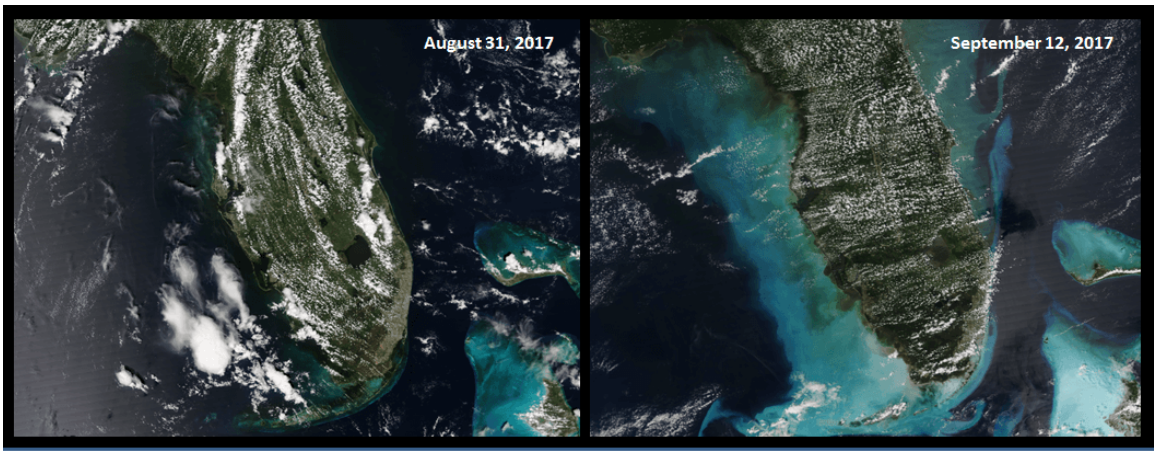
From 22,000 miles above Earth, GOES-16 watched Hurricane Maria, and kept scientists on the ground up to date. Knowing where a storm is—and what it's doing—can help keep people safe, and get help to the people that need it.

Hurricanes can also have a huge impact on the environment—even after they're gone. To learn about how Hurricane Irma affected the Florida coast, scientists used images from an environmental satellite called Suomi National Polar-orbiting Partnership, or Suomi-NPP. One of the instruments on this satellite, called VIIRS (Visible Infrared Imaging Radiometer Suite), took pictures of Florida before and after the Hurricane.

Hurricane Irma was so big and powerful, that it moved massive amounts of dirt, water and pollution. The information captured by VIIRS can tell scientists how and where these particles are moving in the water. This can help with recovery efforts, and help us design better ways to prepare for hurricanes in the future.

By using satellites like GOES-16 and Suomi-NPP to observe severe storms, researchers and experts stay up to date in a safe and fast way. The more we know about hurricanes, the more effectively we can protect people and the environment from them in the future.

To learn more about hurricanes, check out NASA Space Place: https://spaceplace.nasa.gov/hurricanes/



Caption: These images of Florida and the Bahamas were captured by a satellite called Suomi-NPP. The image on the left was taken before Hurricane Irma and the image on the right was taken after the hurricane. The light color along the coast is dirt, sand and garbage brought up by the storm. Image credit: NASA/NOAA

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