

Global Precipitation Measurement Mission

“Water Falls” – Post-Visit Lesson Teacher Guide

Lesson Overview:

This lesson plan is for teachers to use with students after they have seen the Science on a Sphere film, “Water Falls.” The emphasis of this lesson is on deepening students’ understanding of how and why we measure precipitation across the globe. Students will look at TRMM data gathered during Hurricane Sandy, and will learn how this data proved essential in helping scientists to forecast where the hurricane was heading and how much precipitation they might expect. Students will also learn how GPM will enable the collection of new information on hurricanes. This lesson is expected to take about 45 minutes. It has been developed for middle school students, but can be adapted to meet the needs of younger or older participants.

Next Generation Science Standard:

The following NGSS (Next Generation Science Standard) will be taught and assessed through this lesson:

MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).

Background Information:

Climate represents the average state of a location’s temperature, precipitation, etc. over time, similar to a person’s personality. Weather, however, represents the local fluctuations of these atmospheric properties at hourly and daily time scales, similar to a person’s mood at any given time. In order to better understand and forecast the complex interactions of the atmospheric properties and circulation governing weather, scientists collect observational data on precipitation, temperature, humidity and other atmospheric conditions. They then use this data as the basis for developing computer models that can forecast the weather patterns over local areas, the whole country, and even the world. This lesson explores how too much or too little water impacts humans and focuses on how weather and hurricane models can be used to diagnose where and when hurricanes may move and intensify.

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Materials:

Color copies of the satellite images (found at the end of this guide) – 1 set per group of students

[Student Capture Sheet](#) – 1 per student

[Assessment](#)

Optional: downloaded videos

Engage:

1. Hand out the [capture sheet](#) and have the students fill in the Activator graphic organizer. (Slide 2)
2. Go over the activator questions: “How is water helpful to humans?” and “How is water harmful to humans?” (Slide 3)
3. Students answer question 2 on the [Student Capture Sheet](#). Lead the students in a discussion about the natural hazards mentioned in the film. Have students classify the list of natural hazards by those that are caused by too much water and too little water. (Slide 4)
4. Show the video, “Too Much, Too Little.” <http://pmm.nasa.gov/education/videos/gpm-too-much-too-little> (Slide 5)

Explore:

1. Students “Think-Pair-Share,” “How do we measure rainfall?” Record their responses. (Slide 6)
2. Explain that they will now view a short animation (27 seconds) about the number of rain gauges around the world. (Slide 7)
http://svs.gsfc.nasa.gov/vis/a010000/a011100/a011165/Rain_Gauge_Comp_v3.mov
 - a. Students should answer the rain gauge question on their capture sheets.
If you cannot play a WMV movie, go to [this](#) page for GPM Educator Resources. Click on a format and video size that best fits your needs. Use the list to the right of the image with two basketball courts covered in gold colored rain gauges.
<http://svs.gsfc.nasa.gov/vis/a010000/a011100/a011165/index.html>
3. The focus for the rest of this lesson will be on hurricanes (Slide 8) and how technology is being used to help make more accurate predictions about hurricanes. Knowing approximately where and when a hurricane may make landfall is very important for informing the populations in the affected areas and providing information that helps people to make decisions about what to do in the event that a hurricane impacts their area.
4. (Slide 9) Explain that there are a number of factors responsible for hurricanes to either intensify or weaken. One of these factors is the temperature of the ocean, also known as sea surface temperature (SST). Scientists can use sensors aboard satellites to measure SSTs. The temperature of the ocean can help cause a hurricane to either weaken or intensify.
5. Show an image of sea surface temperatures. (Slide 10)

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- a. Have students, Think-Pair-Share effects warmer ocean temperatures can have on the atmosphere as opposed to cooler ones. (Warmer air above the ocean; more evaporation; warmer air will rise, etc.)
 - b. Sea surface temperatures need to reach about 26.5°C (82°F) for hurricanes to form, sustain and even intensify. Student should note this on their capture sheet.
 - c. Students should make observations about the sea surface temperatures in the Gulf of Mexico and along the United States' east coast.
6. Warmer sea surface temperatures can help to “add fuel” to a hurricane, making it grow in size and intensity. Show the two SST maps (Slide 11) - and have color copies for each student group made in advance. They should focus on the Gulf of Mexico and United States East Coast.
- a. Ask students to identify in which of these two data images the ocean temperatures will most likely help a hurricane to intensify in the Atlantic, near the Gulf of Mexico and East Coast of the United States. This area is circled on the images.
 - b. Have students answer question 9 on their capture sheet. (Go over the correct answer, which is August because MUCH more of the ocean is at, or above, 26.5°C.)
7. Have students Think-Pair-Share the question, “What are some dangers posed by hurricanes?” (Slide 12) Record answers. (Flooding and landslides were shown in “Water Falls”.)
- a. *Optional:* Share this quote from Dr. Marshall Shepherd about one danger of rainfall from a tropical storm: “[Hurricane Sandy] will bring significant rains and inland freshwater flooding, ...[which is] often the deadliest threat from tropical systems.”¹ (Underline added for emphasis.) (Slide 13)
8. (Slide 14) Show this History Channel® video (02:38) about the aftermath of Hurricane Katrina, taken from a news helicopter. There is no dialogue, but the images are very dramatic. (Note: You may want to silence the video in advance as there is a commercial that precedes the video trailer. You might also want to advance through the commercial, before class and pause it until you're ready to show it.) <http://www.history.com/topics/hurricane-katrina/videos#hurricane-katrina>
9. (Slide 15) Students “Think-Pair-Share” the question, “What tools do Earth scientists use to gather data about global precipitation?” Be sure that satellites are on their list of answers.

Explain:

1. Explain that while tropical storms are a natural process that moves land masses, replenishes or reduces beaches, creates new ecosystems, and distributes heat in the atmosphere and ocean, they can also be very dangerous. Satellites in space can provide important information to help scientists predict when and where hurricanes will be and how they will intensify. Fifteen years ago, NASA Earth scientists and engineers developed

¹ NASA/Goddard Space Flight Center (2012, October 26). Hurricane Sandy looks as 'Frankenstorm' approaching U.S. East

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and built the Tropical Rainfall Measuring Mission, TRMM. The GPM mission will allow scientists to look at hurricanes beyond the tropics.

2. (Slide 16) Show the video, “Hurricanes Beyond the Tropics” (04:14) at: <http://pmm.nasa.gov/education/videos/gpm-hurricanes-beyond-tropics> (It might be best if you download it first.)
3. Students “Think-Pair-Share” the question, “How can data gathered by TRMM be useful to those who are responsible for deciding what actions should be taken before a big storm hits?” (Slide 17)
 - a. Solicit responses.
 - b. Show the damage (Slide 18) and death totals (Slide 19) of the deadliest tropical storms. Point out Katrina on each and show how devastating a storm it was.
 - c. Ask, “Why do you think the storms the late 1800s and early 1900s were so deadly?” Be sure to emphasize there were not nearly as many ways to measure a storm at sea; therefore, predictions were not nearly as good as today. Also, there were not as many ways to get information out to the public as efficiently as there are today. These are two reasons scientists developed better tools – and continue to do so today.
4. Next, have students look at these two images of rainfall data collected by the TRMM (pronounced ‘trim’) satellite sensors. (Slide 20)
 - a. Project the images and have color copies for each group of students.
 - b. Have students answer question 10 on their capture sheets, “Which of the two storms most likely poses the greatest danger to life on land? Why?”
 - c. Solicit responses. Point out that Rainfall Image 1 is correct because of the red and yellow areas, which contain greater amounts of rainfall.

Evaluate:

1. Hand out the rainfall data images of two different storms and the sea surface temperature data image. (Slide 21)
 - a. Ask students to answer the question, “If each of the storms were to cross over an ocean with these sea surface temperatures, which one would most likely be the greatest threat to life on land, where it makes landfall?”
 - i. Evaluate students’ answers based upon them choosing the correct storm, using SST information properly in their answers, using precipitation data information correctly in their answers, and understanding how this information can help protect human life.

Elaborate/Extend:

1. Show, “Towers in the Tempest.” (Slide 22) http://svs.gsfc.nasa.gov/vis/a000000/a003700/a003773/3413_Towers_in_the_Tempest-MASTER_high.mp4

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2. Explain that “hot towers” are one of the factors scientists analyze when studying tropical storms. Data about hot towers help to determine how a tropical storm might intensify or weaken. TRMM has allowed scientist to look inside a tropical storm in 3-D and see these hot towers. By adding information about hot towers to a host of other data, such as sea surface temperatures and rainfall rates, the models used by scientists will be even more accurate.
3. Show graph of storm heights for Hurricane Henriette. (Slide 23) The graph on the left is the storm at its peak intensity. The one on the right is the storm as its intensity is waning. Ask, “What happened to the height of the storm and its hot towers, as it weakened?”
4. Show images of hot towers in two storms. (Slide 24) “Which of these two storms is most likely the most intense?” (Typhoon Talim is more intense because of the greater amount of hot towers. It was a category 3 typhoon. Henriette was a category 1 storm.)
5. Winds are another major factor in the development of hurricanes. These winds can help the storm to organize or blow their tops off and break them up. The following web site will give you more information about how winds can help to organize or break up hurricanes.
<http://kids.earth.nasa.gov/archive/hurricane/creation.html> (paragraphs 1 and 2)
<http://www.wunderground.com/education/shear.asp> (Wind shear tutorial)

Additional Resources:

TRMM: Extreme Weather Page – contains links to data images of many storms.
<http://pmm.nasa.gov/trmm/news>

Monthly Mean SST Charts (1984-1998)
http://www.ospo.noaa.gov/Products/ocean/sst/monthly_mean.html

Hurricanes in History: A list and description of historic hurricanes on the National Hurricane Center website.
<http://www.nhc.noaa.gov/outreach/history/>

My NASA Data - Hurricane Frequency and Intensity
http://mynasadata.larc.nasa.gov/lesson-plans/1332-2/?page_id=474?&passid=105

Article: GPM Takes Rain Measurements Global – This is good background information.
<http://pmm.nasa.gov/articles/gpm-takes-rain-measurements-global>

Article: “Hot Towers Intensify Hurricanes”
<http://earthobservatory.nasa.gov/IOTD/view.php?id=7733>

Article: Comparing the winds of Katrina and Sandy, NASA’s Hurricane and Tropical Storm page:
http://www.nasa.gov/mission_pages/hurricanes/archives/2012/h2012_Sandy.html

Article: Joanne Simpson, “Hot Tower” Hypothesis
<http://earthobservatory.nasa.gov/Features/Simpson/simpson3.php>

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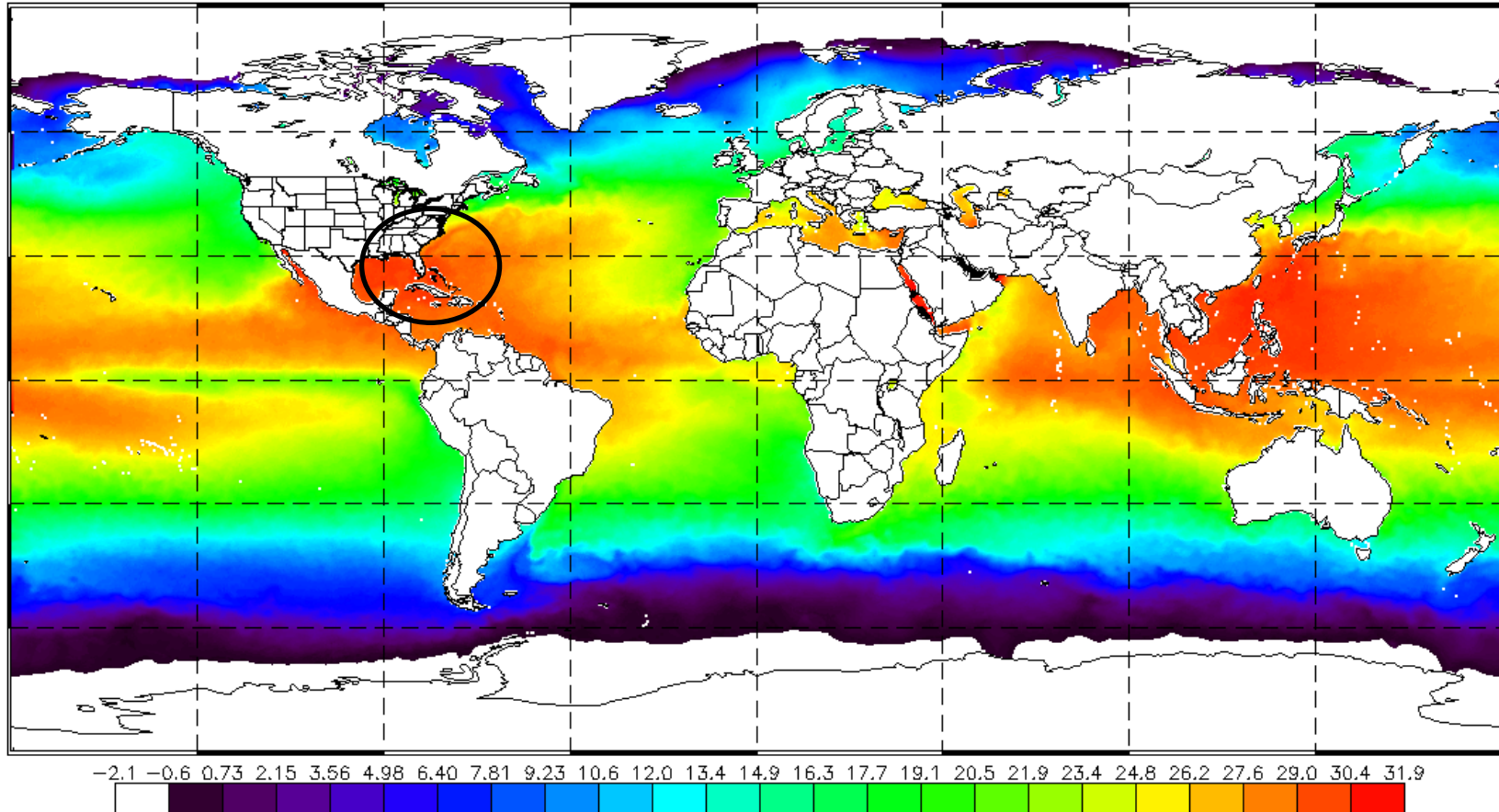
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Explain - Sea Surface Temperatures 1 (sst)

Monthly Mean Satellite-only Nighttime SST for August, 1998



1 Credit NOAA OSPO http://www.ospo.noaa.gov/data/sst/mean_mon/August.98.monmean.gif



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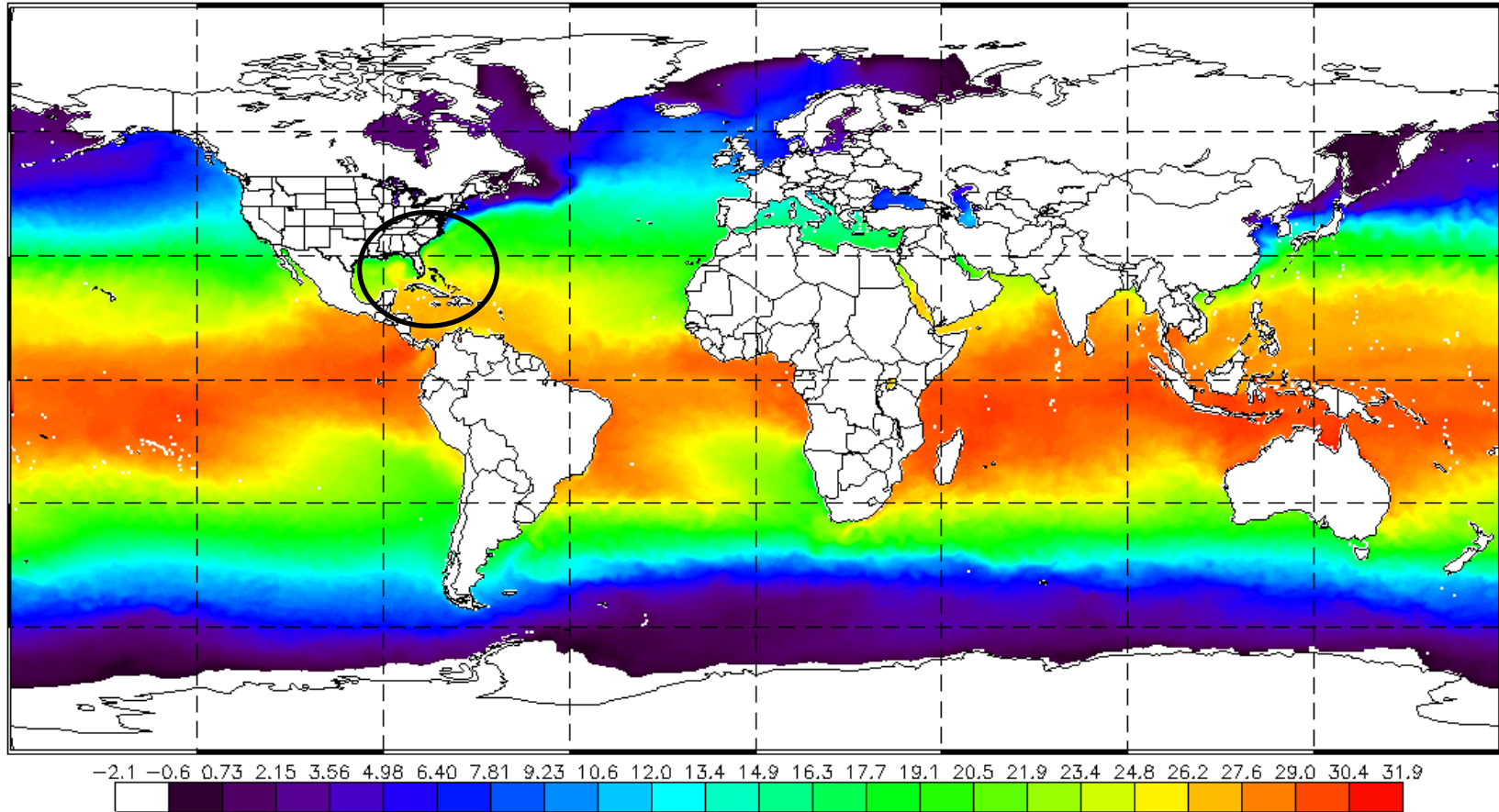
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Explain - Sea Surface Temperatures 2 (sst)

Monthly Mean Satellite-only Nighttime SST for February, 1998



2 Credit NOAA OSPO http://www.ospo.noaa.gov/data/sst/mean_mon/February.98.monmean.gif



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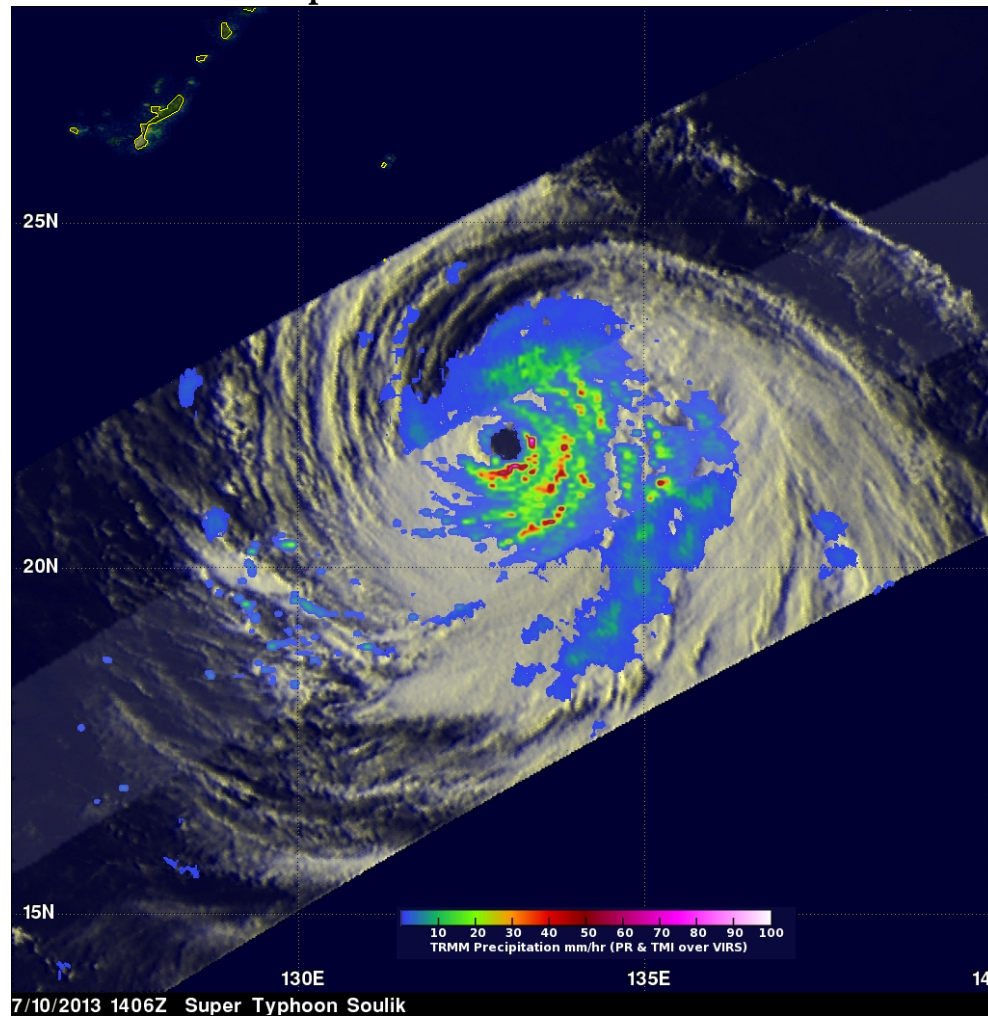
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Explain - Rainfall Data 1



3 Credit NASA TRMM <http://pmm.nasa.gov/mission-updates/trmm-news/super-typhoon-soulik-forms-pacific>



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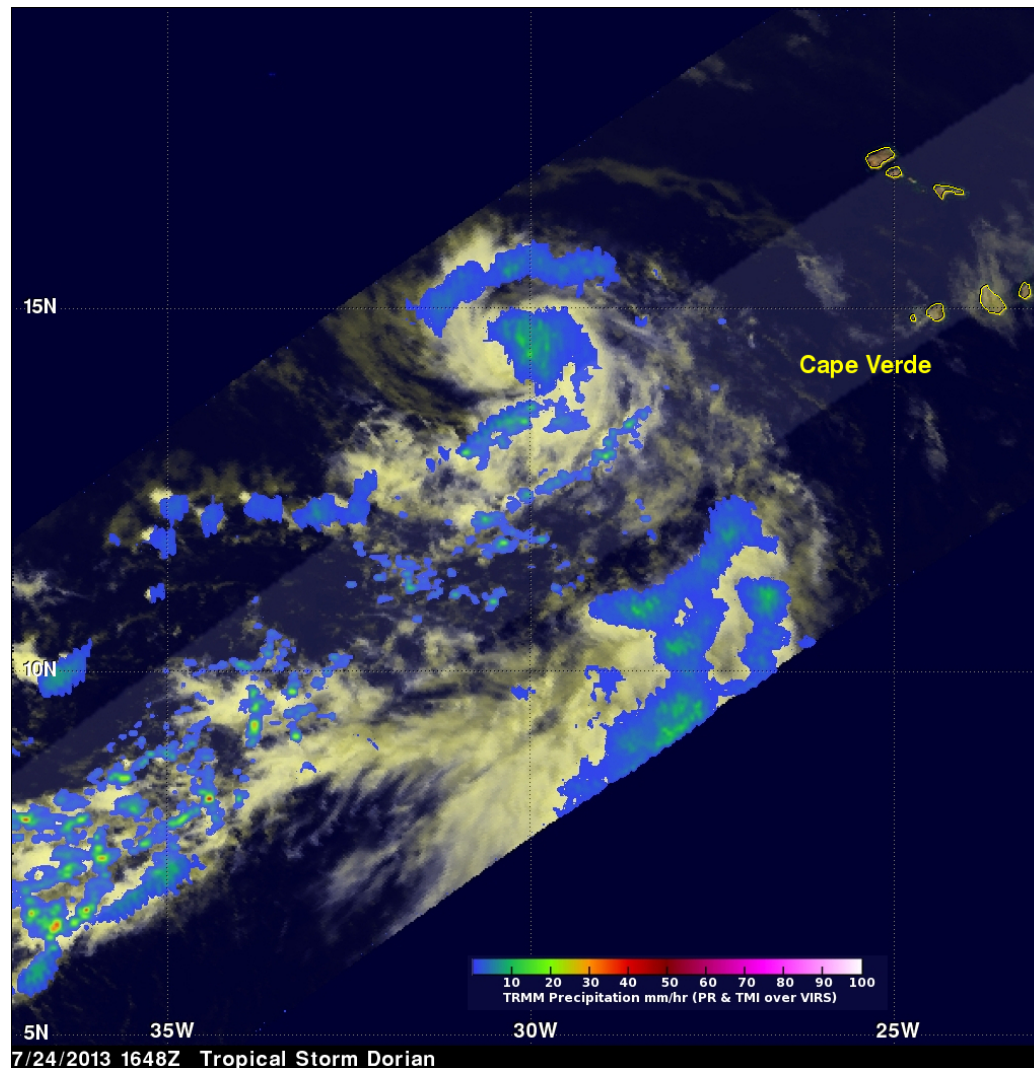
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Explain - Rainfall 2



4 Credit NASA TRMM <http://pmm.nasa.gov/mission-updates/trmm-news/trmm-sees-weak-tropical-storm-dorian>



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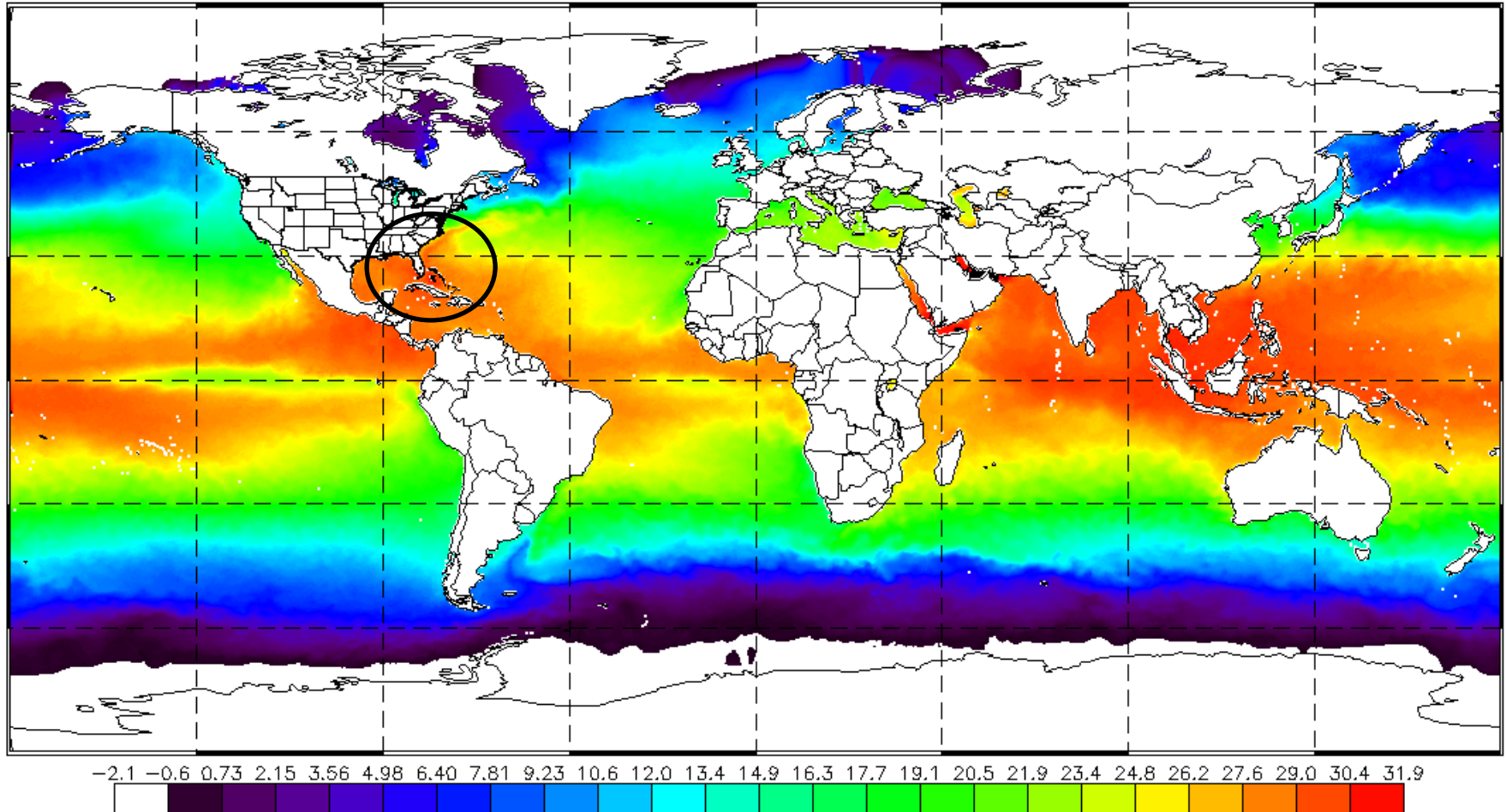
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Evaluate - Sea Surface Temperatures

Monthly Mean Satellite-only Nighttime SST for June, 1998



5 Credit NOAA OSPO http://www.ospo.noaa.gov/data/sst/mean_mon/june.98.monmean.gif



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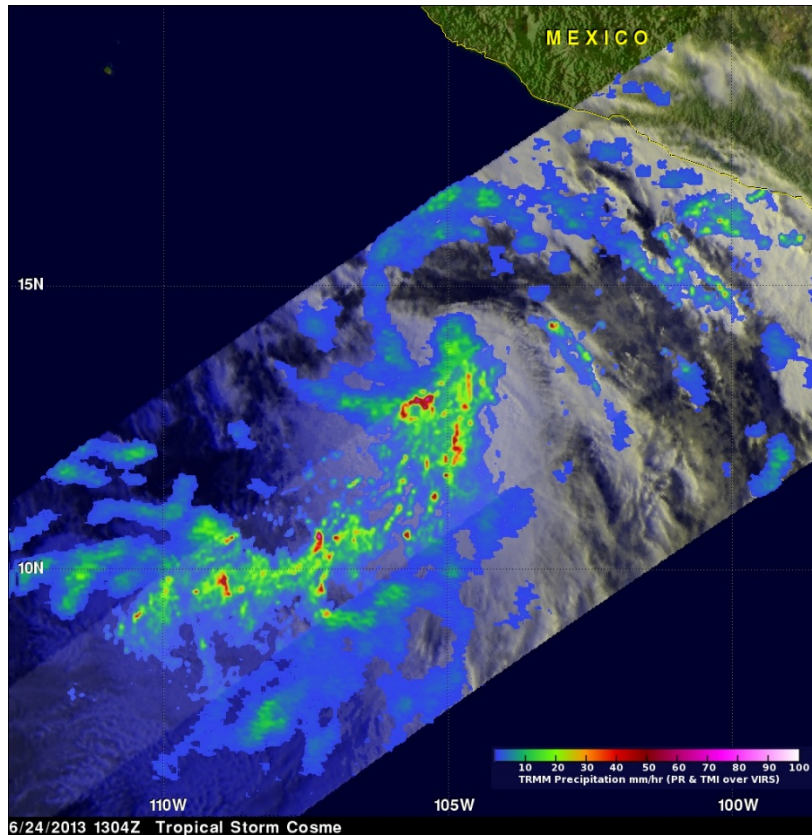
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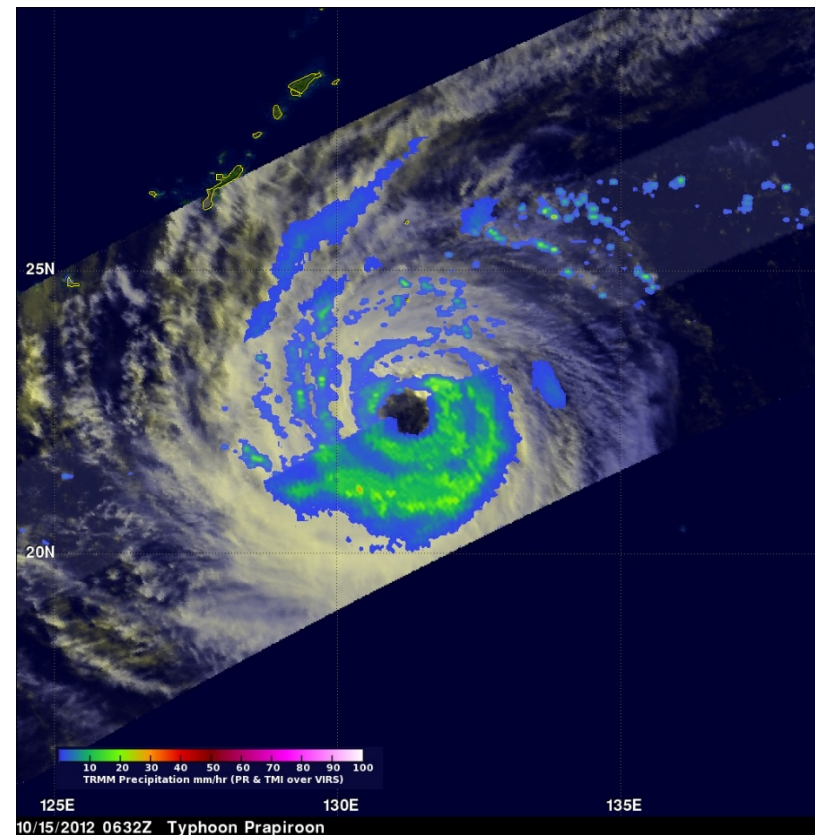
Evaluate - Rainfall Data Sets

Storm A



6 Credit NASA TRMM <http://pmm.nasa.gov/mission-updates/trmm-news/tropical-storm-cosme-becoming-stronger>

Storm B



7 Credit NASA TRMM <http://pmm.nasa.gov/mission-updates/trmm-news/weakening-typhoon-prapiroon>



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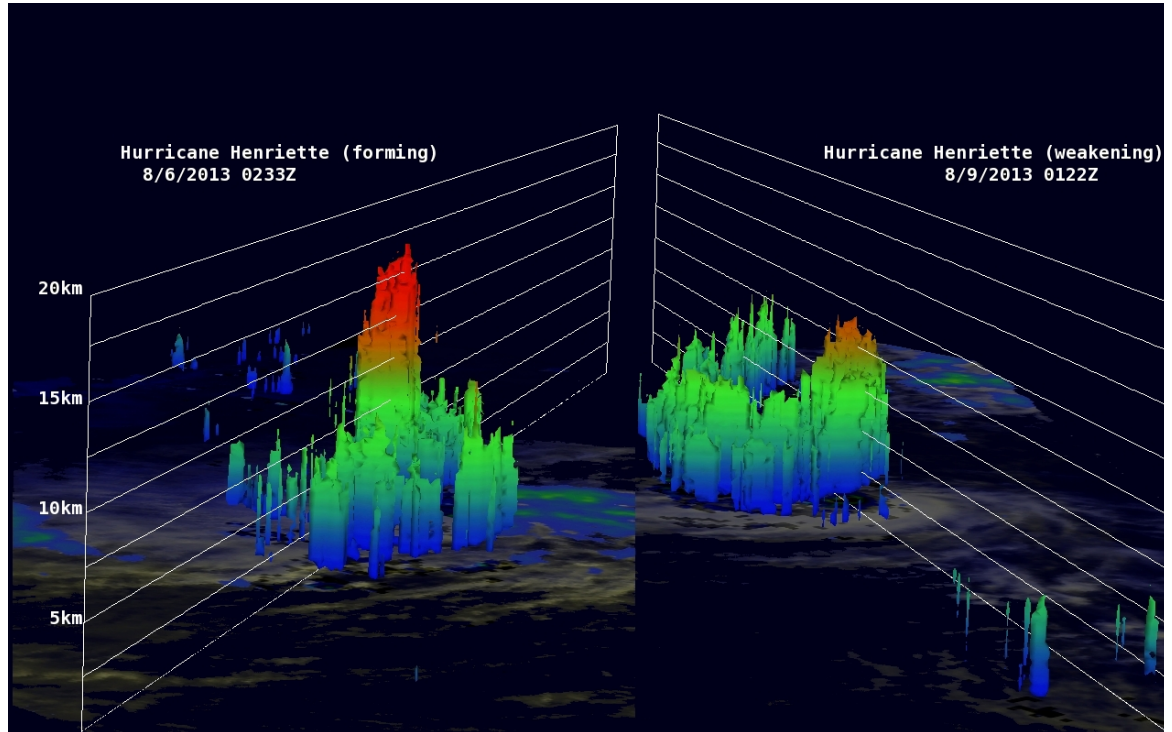
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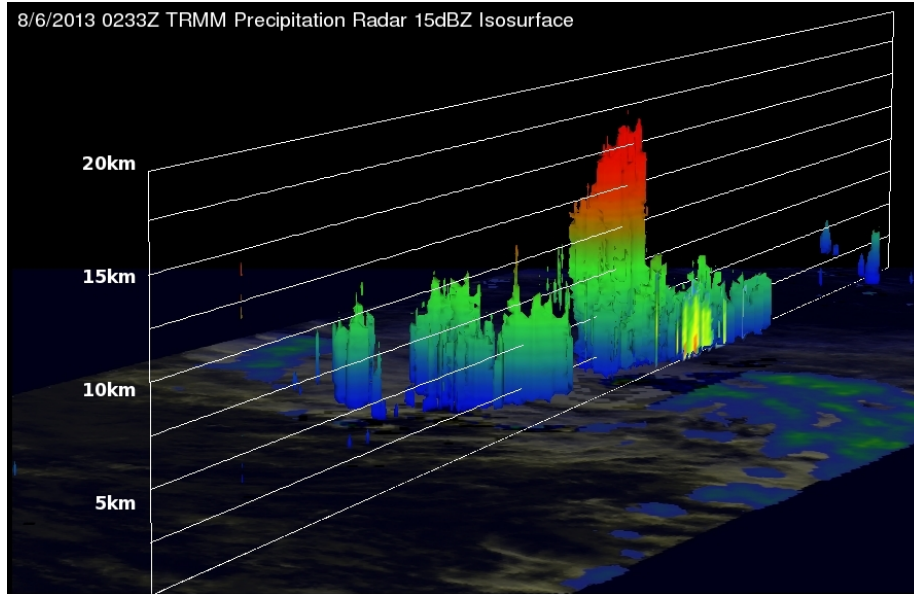
Extend: Hurricane Henriette's Hot Towers



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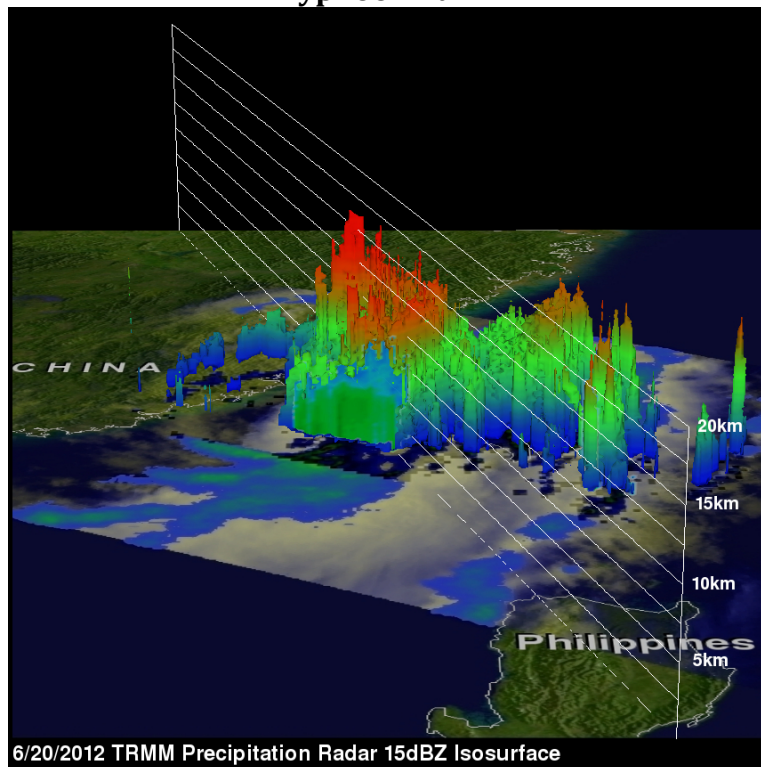
Extend – Comparing the Hot Towers of Two Storms

Hurricane Henriette



<http://pmm.nasa.gov/mission-updates/trmm-news/hurricane-henriette>

Typhoon Talim



<http://pmm.nasa.gov/mission-updates/trmm-news/tropical-storm-talims-heavy-rainfall-over-taiwan>