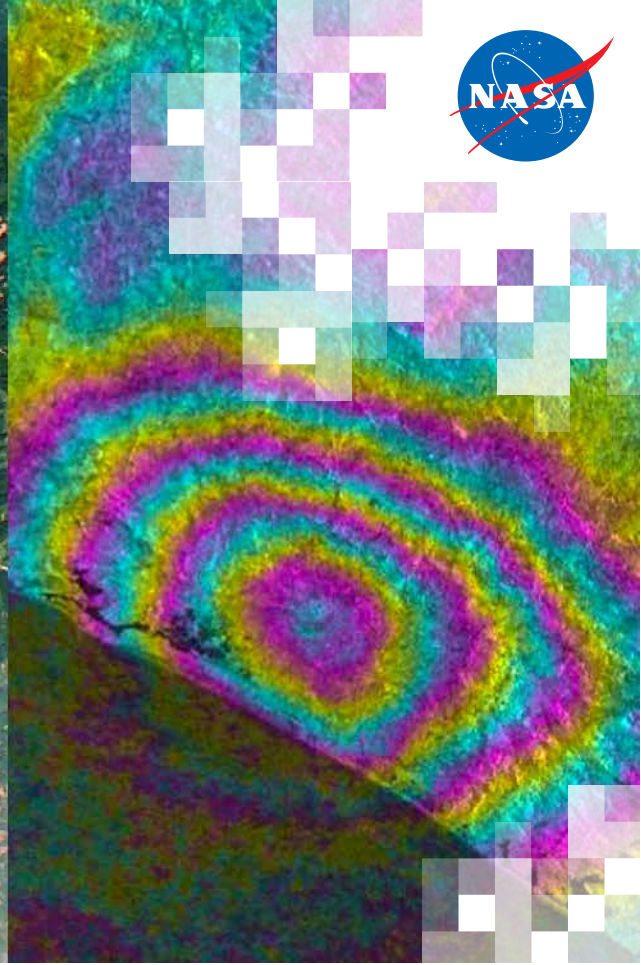
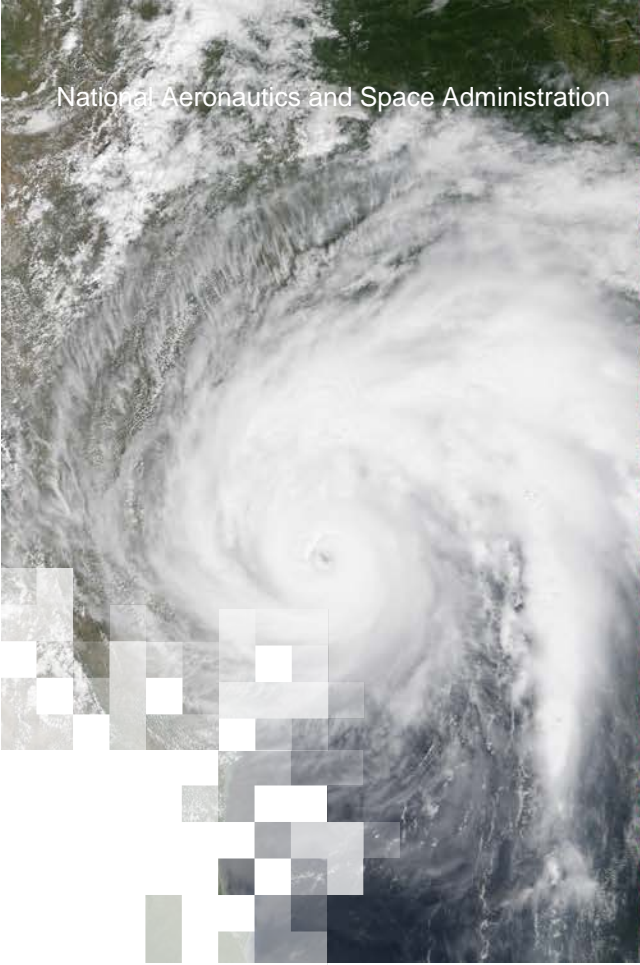


National Aeronautics and Space Administration



# Disasters Scenarios: Flooding

Erika Podest, Elizabeth Hook, Sean McCartney, Amita Mehta

# Learning Objectives

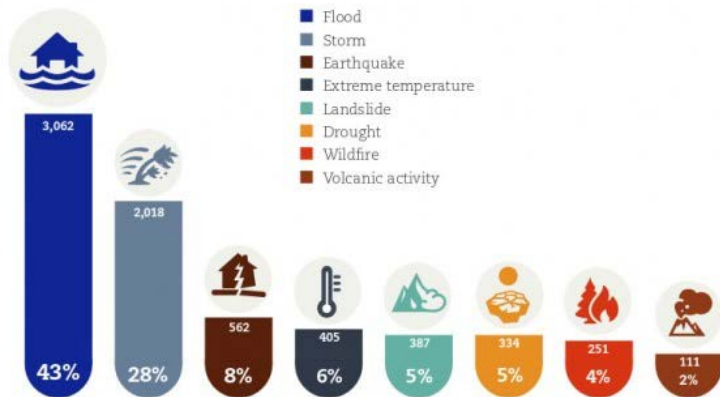
- Identify remote sensing data and models relevant to flooding
- Monitor conditions before, during, and after a storm using remote sensing and modeled data
- Understand how remote sensing and modeled data can be used in decision-making activities



# Flooding Impacts

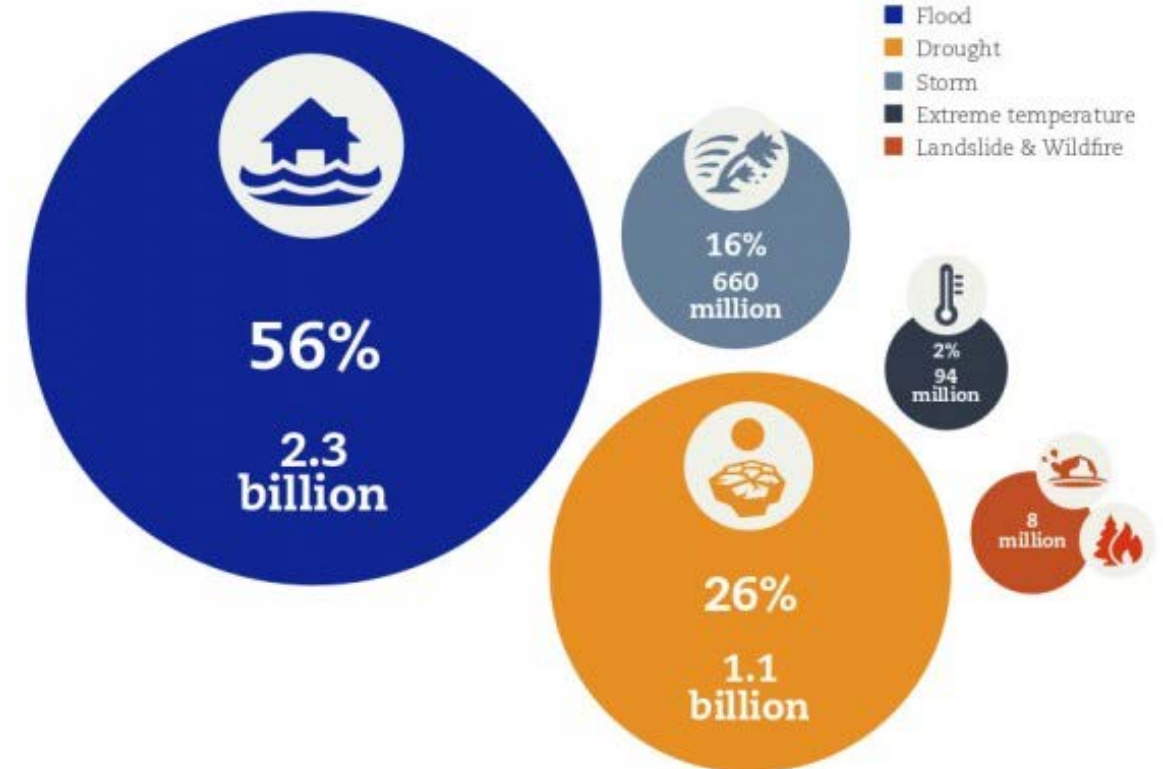
- A 2015 report by the UN stated that **2.3 billion** people were affected by flooding between 1995-2015\*
- The report also indicated that flood trends are affecting larger areas and becoming more severe

Percentage of occurrences of natural disasters by disaster type (1995-2015)



\* UNISDR

Numbers of people affected by weather-related disasters (1995-2015)  
(NB: deaths are excluded from the total affected.)



\*Data Source: National Hurricane Center



# Flooding Impacts in the U.S.

## Flood Fatalities in the U.S. Over the Last 30 Years

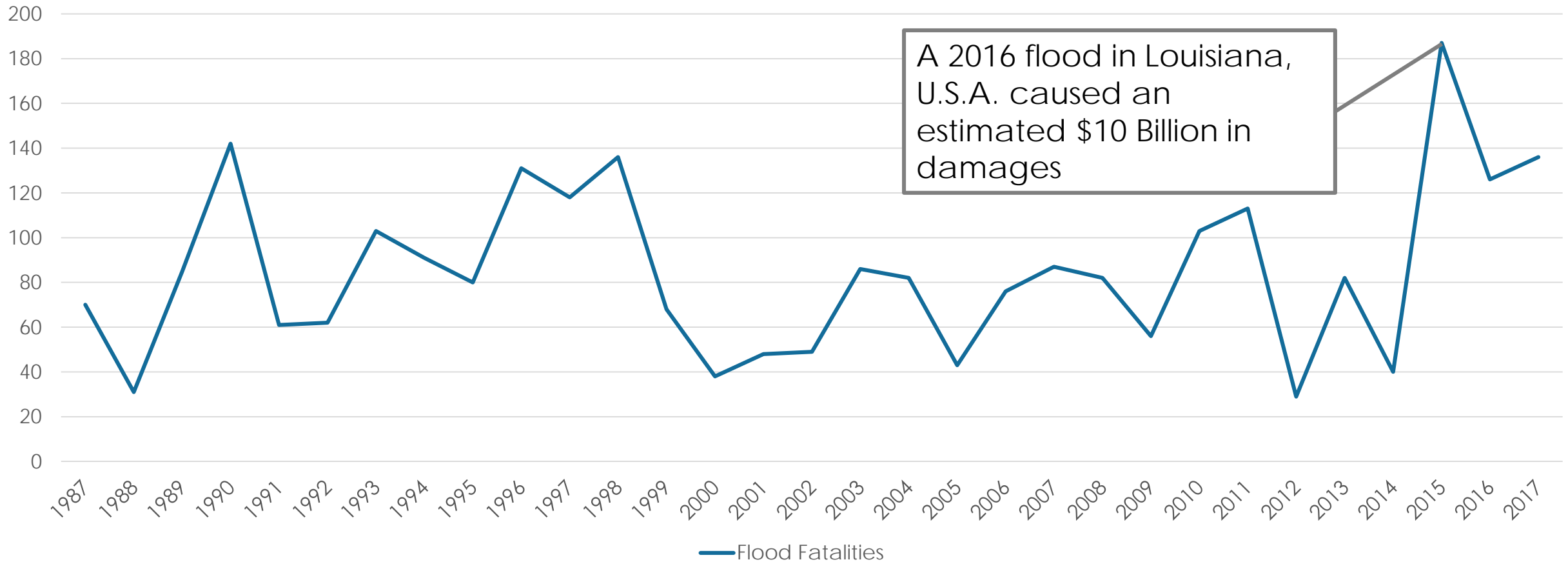


Chart Data Source: National Weather Service



# ARSET Trainings of Interest

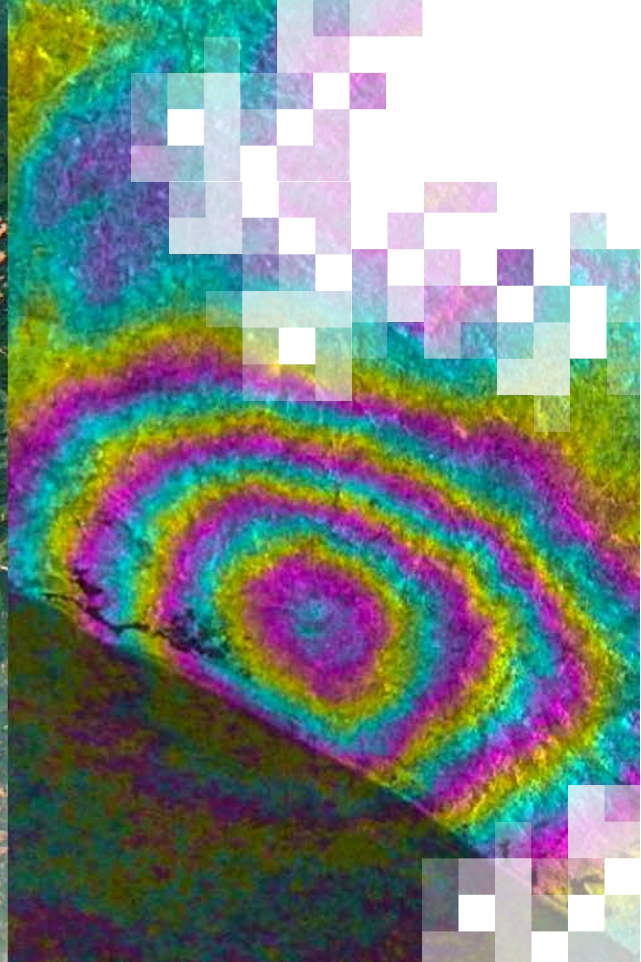
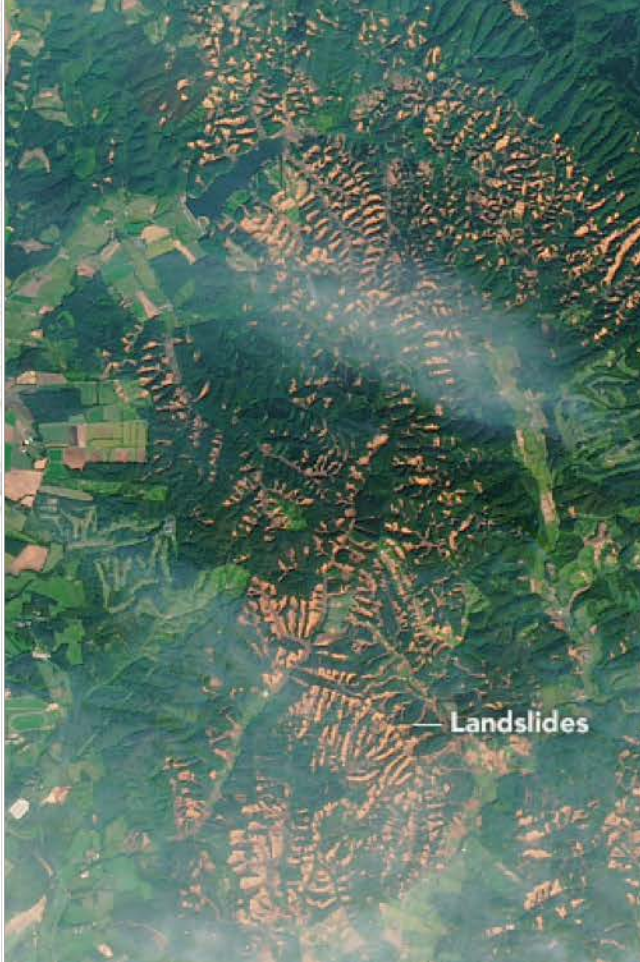
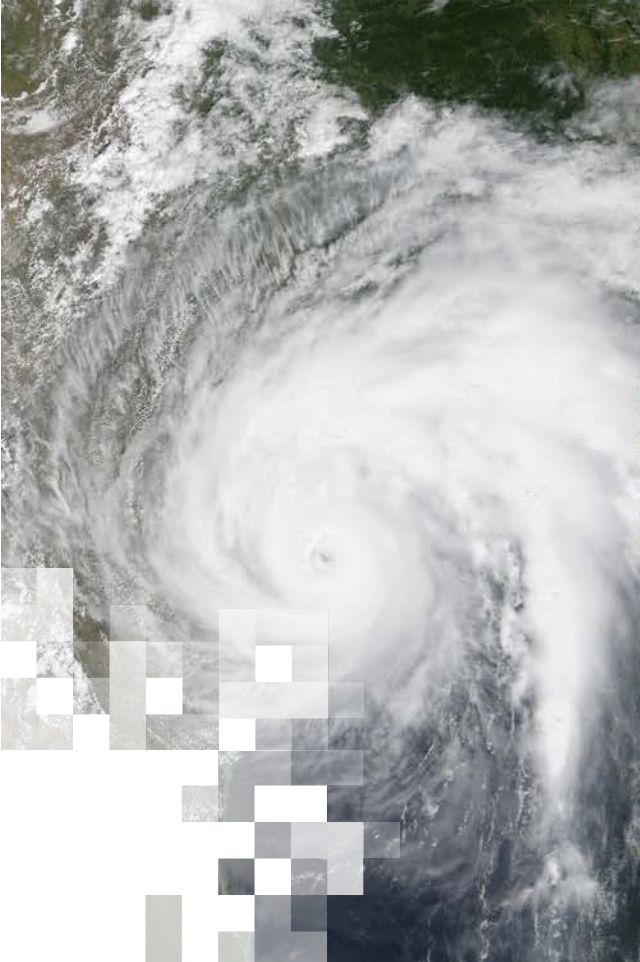
- Advanced Webinar: Using NASA Remote Sensing for Flood Monitoring & Management
  - ARSET offered an advanced, online training in March 2016
  - Four hour training
  - Available at: <https://arset.gsfc.nasa.gov/disasters/webinars/advfloodwebinar>
- Applications of Remote Sensing to Soil Moisture and Evapotranspiration
  - Introductory, online training provided in September 2016
  - Five hour training
  - Available at: <https://arset.gsfc.nasa.gov/water/webinars/apps-et-smap>



# Potential Problems to Address Before/During/After a Flood

- What are the areas at risk for flooding?
- How can flood risk maps be supplemented with satellite data?
- What areas are currently flooded?
- How fast is the water rising/receding?
- What is the flood extent?
- What is the flood damage?





# Flood Risk Maps

# FEMA Flood Risk Maps – USA

- FEMA provides flood maps to communities to set minimum floodplain standards
- Only covers the U.S.
- <https://msc.fema.gov/portal/search>



## HOW IS A FLOOD MAP MADE?

### 1 Identify Area to Map or Re-Map



A watershed is reviewed for development of a new map or to update/re-map the watershed.

### WHY WOULD A COMMUNITY NEED TO “RE-MAP”?



### 2 Select the Project Area

A watershed is selected for Discovery based on evaluations of risk, need, availability of elevation data, regional knowledge of issues, and input from the state, community, and other stakeholders.



#### Watershed

An area or ridge of land that separates waters flowing to different rivers, basins, or seas.

### 3 Gather Information

FEMA, state, local, and tribal officials collect current and historic flood-related data including:



Existing maps such as:

- ▶ Floodplain
- ▶ Base map
- ▶ Flood Map, if existent

### 4 Hold the Flood Risk Review and Resilience Meetings



If a project is required, FEMA, state, local and tribal officials meet to validate mapping data and supporting research which helps identify areas more prone to flooding and provides spatial orientation to project planners. As well, the mapping data informs Risk MAP products such as the Flood Risk Report, Flood Depth Grids, and Areas of Mitigation Interest.

Community leaders host events to inform residents of their community's current risk of flooding.



The Resilience Meeting is a collaborative discussion with local residents about the risks of flooding. It provides a platform for risk communication and mitigation planning. Resources such as the Resilience Newsletter and the Digital Flood Map Database are created.



The project team reviews the Flood Maps and Flood Insurance Study (FIS), making updates where necessary.

PROJECT NECESSARY

PROJECT UNNECESSARY

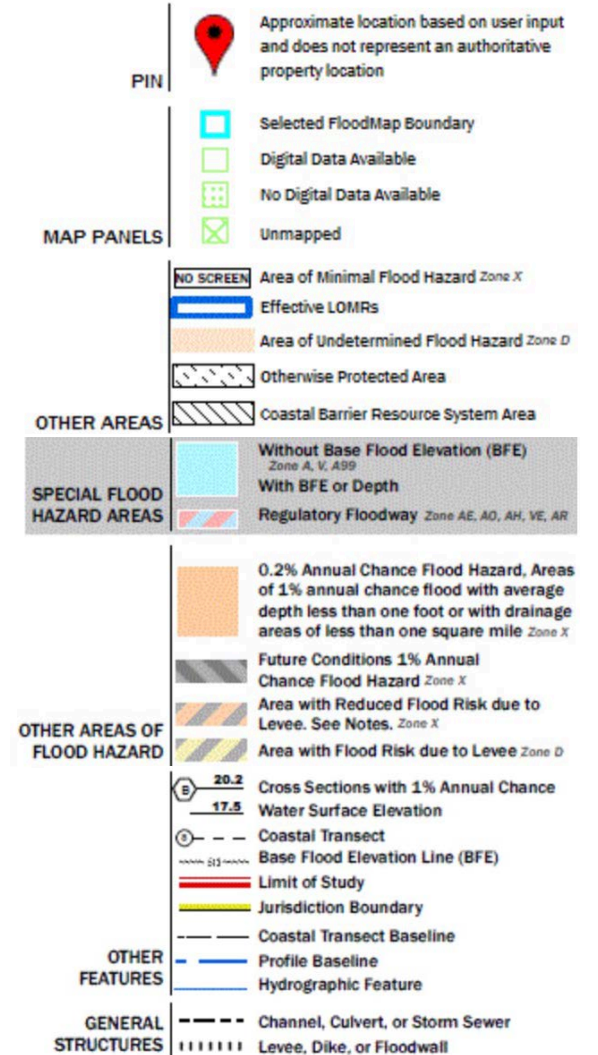
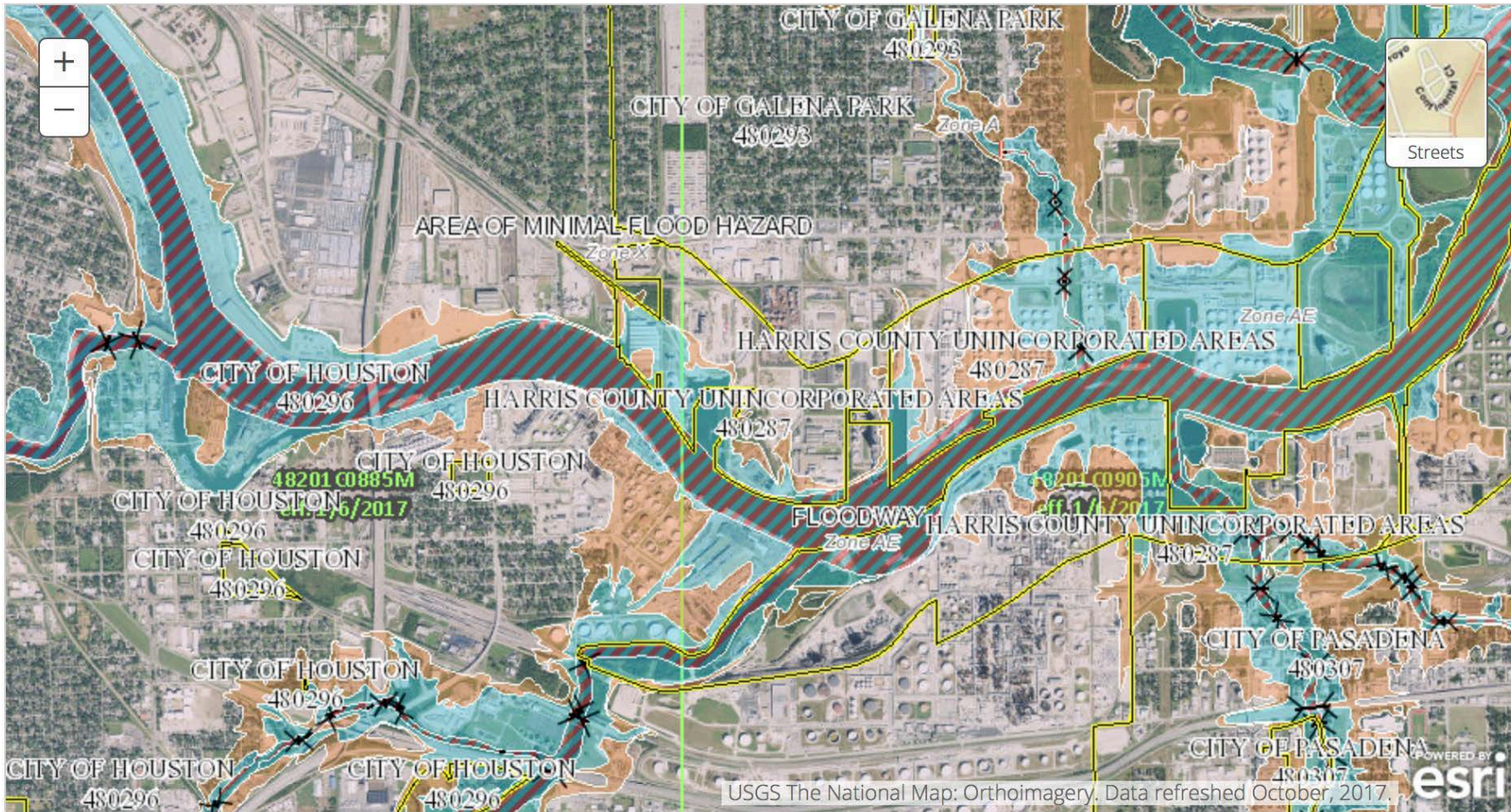
UPDATES REQUIRED

NO UPDATES NEEDED





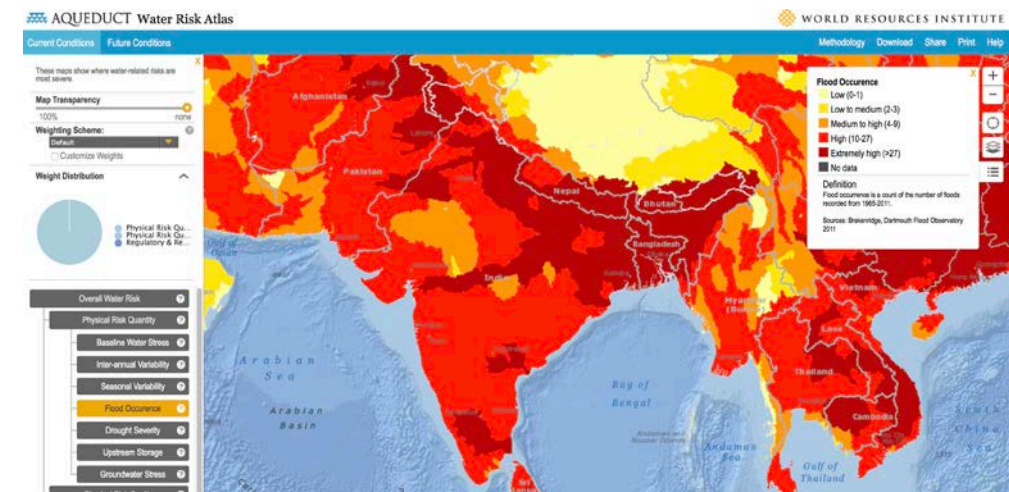
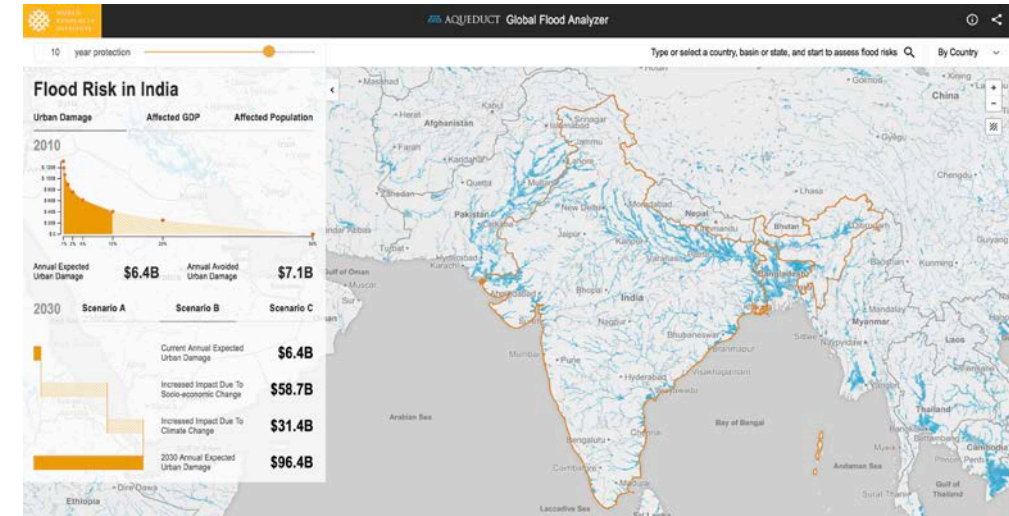
# FEMA Flood Risk Map for Houston, Texas

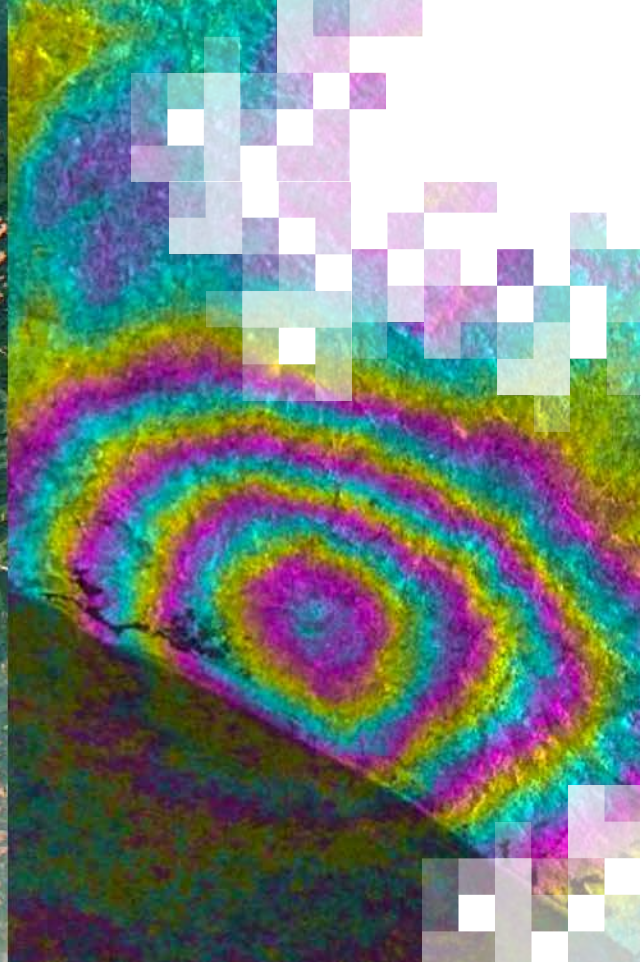
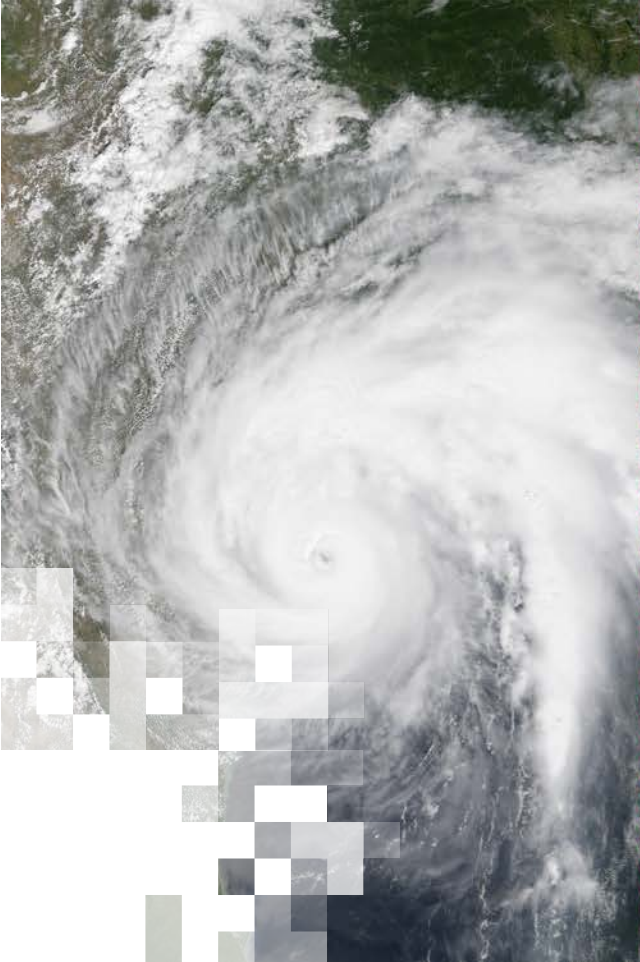


# Global Flood Risk Maps – World Resources Institute (WRI)

<https://www.wri.org/>

- Aqueduct Global Flood Analyzer
  - <https://www.wri.org/resources/maps/aqueduct-global-flood-analyzer>
  - Assess river flood risks:
  - By country, river basin, or state
  - By population, GDP, or urban damage
  - Current or future (2030)
- Aqueduct Water Risk Atlas
  - <https://www.wri.org/our-work/project/aqueduct>
  - Online mapping tool that lets users combine 12 key indicators of water risk to create global overall water risk maps





Identifying Infrastructure at Risk

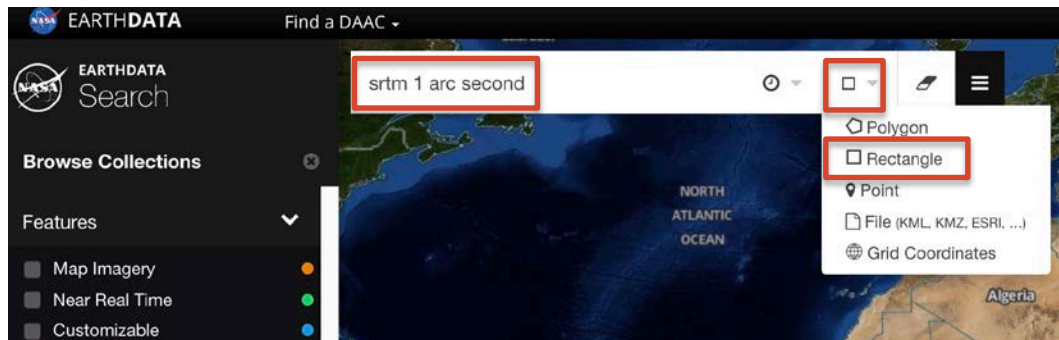
# Terrain, Roads, and Population Data for Planning

- Terrain data from the Shuttle Radar Topography Mission (SRTM) can be accessed at <https://earthdata.nasa.gov/>. Covers land surfaces between 60°N and 56°S latitude, 30 m spatial resolution. Raster size is 1 degree tiles.)
- ASTER Global Digital Elevation Maps (GDEM) can also be accessed at <https://earthdata.nasa.gov/>. Covers land surfaces between 83°N and 83°S latitude, 30 m spatial resolution)
- NASA's Socioeconomic Data and Applications Center (SEDAC) makes global man-made impervious surface & settlement extent data available, generated from Landsat (global coverage, 30 m spatial resolution)
  - <http://sedac.ciesin.columbia.edu/mapping/gmis-hbase/explore-view/>  
Importing data from both of those sites into geospatial software (e.g., QGIS) allows you to identify areas susceptible to flooding
- All above sites require a NASA Earth Observing System Data and Information System (EOSDIS) login to download data



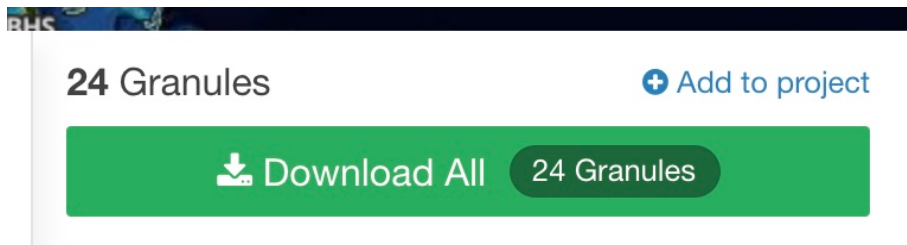
# Data Acquisition: SRTM Global 1 Arc Second DEM

- Log into NASA's Earth Data Search: <https://search.earthdata.nasa.gov/search>
  - (If you don't have an account, you will need to create one)
  - Type "srtm 1 arc second" into the search box
  - Hover your mouse over the spatial icon and select "Rectangle"
  - For coordinates enter "SW: 27.5, -97.5 NE: 30.5, -89.5"
- This places a bounding box around the TX and LA coast




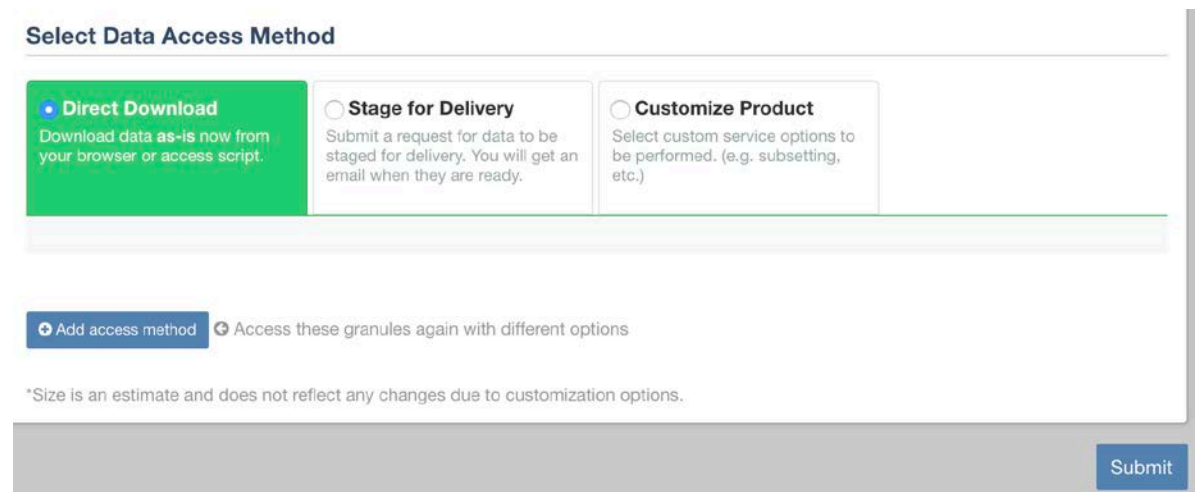
# Data Acquisition: SRTM Global 1 Arc Second DEM

- In matching collections at the bottom of the screen select “NASA Shuttle Radar Topography Mission Global 1 arc second V003”
- There should be 24 granules selected for download. Click “Download All.”
- Select Data Access Method and click Submit



24 Granules + Add to project

 Download All 24 Granules



### Select Data Access Method

**Direct Download**  
Download data as-is now from your browser or access script.

**Stage for Delivery**  
Submit a request for data to be staged for delivery. You will get an email when they are ready.

**Customize Product**  
Select custom service options to be performed. (e.g. subsetting, etc.)

+ Add access method ↻ Access these granules again with different options

\*Size is an estimate and does not reflect any changes due to customization options.

Submit



# Data Acquisition: SRTM Global 1 Arc Second DEM

- Click "View/Download Data Links"
- This takes you to a FTP site to download each file using the links provided

- Bring downloaded files into QGIS and merge these into a single mosaic file to get a seamless dataset for study area

**Direct Download**  
Click the "View/Download Data Links" button to view or download a file containing links to your data.

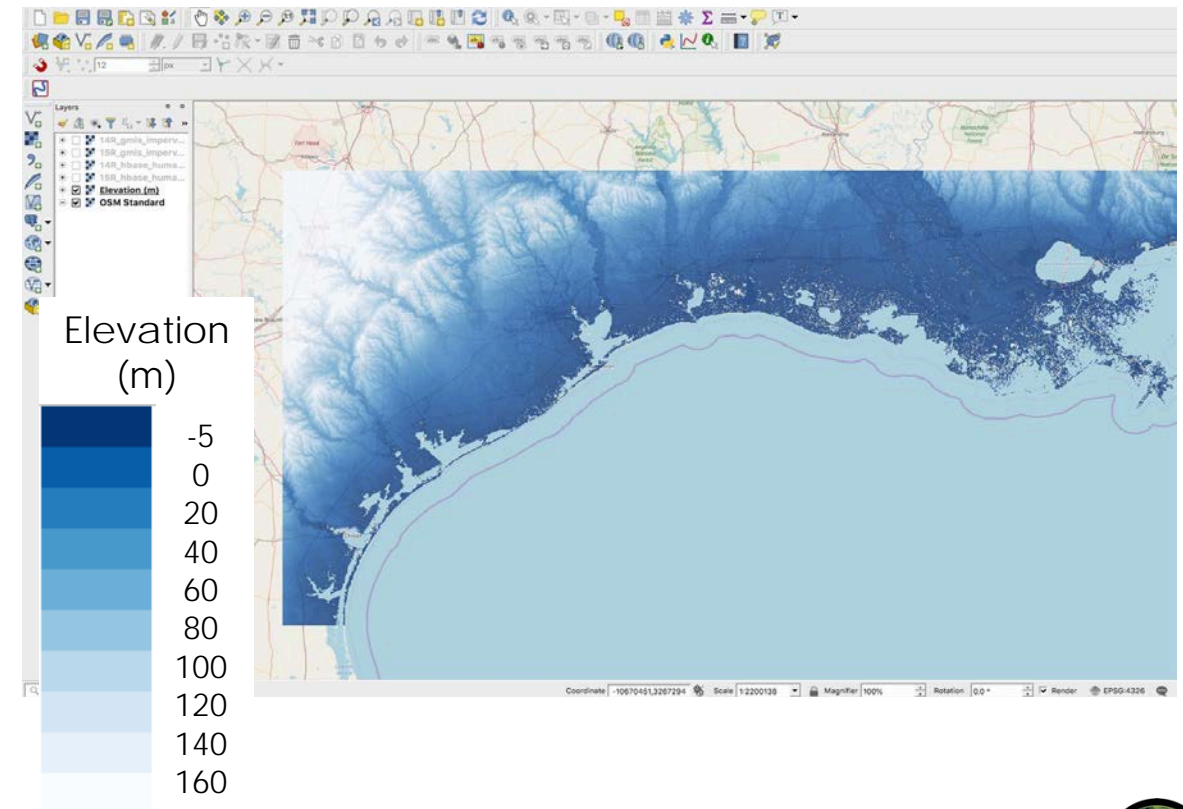
**NASA Shuttle Radar Topography Mission Global 1 arc second V003**

[View/Download Data Links](#) [Download Access Script](#) [View Browse Image Links](#)

**Collection granule links have been retrieved**

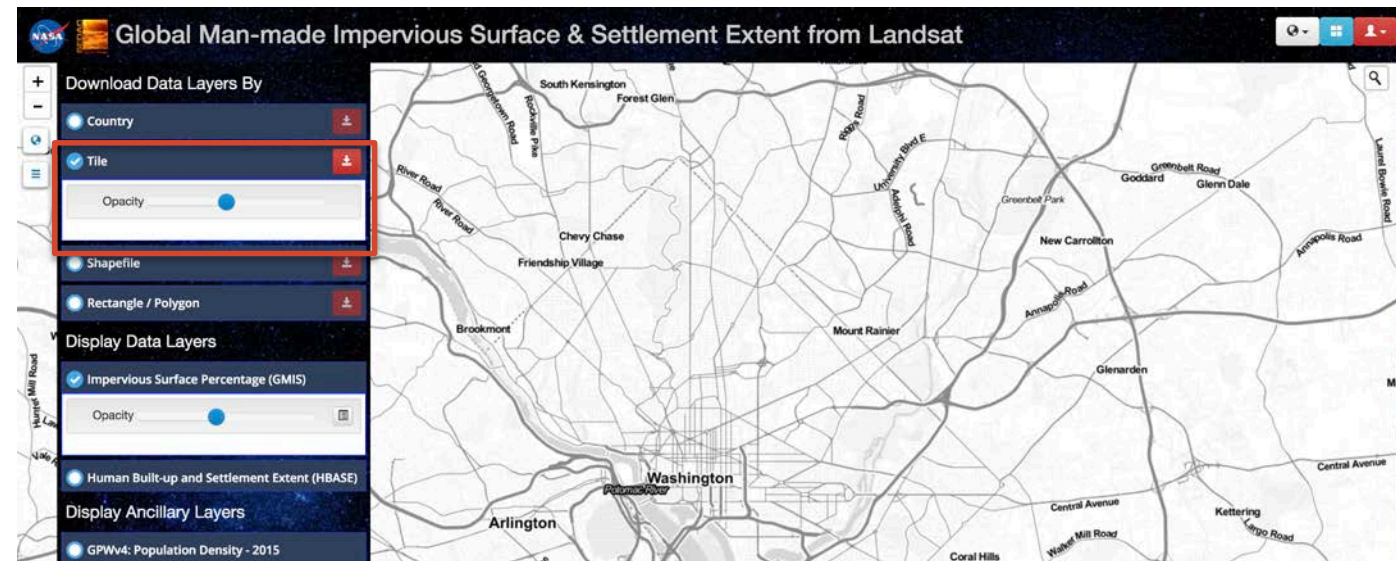
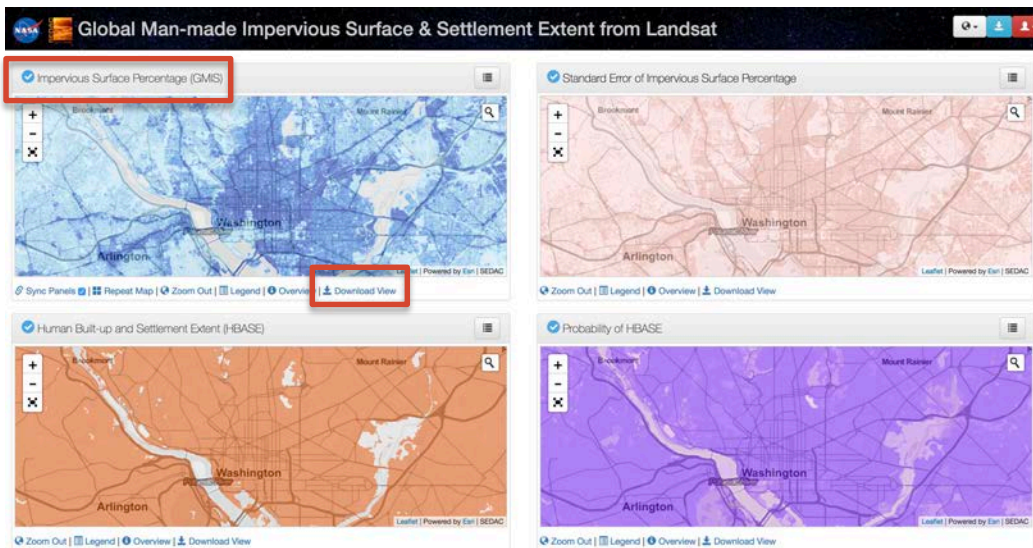
Please click the button to download these links. [Download Links File](#)

- [http://e4ftl01.cr.usgs.gov/MODV6\\_Dal\\_D/SRTM/SRTMGL1.003/2000.02.11/N29W098.SRTMGL1.hgt.zip](http://e4ftl01.cr.usgs.gov/MODV6_Dal_D/SRTM/SRTMGL1.003/2000.02.11/N29W098.SRTMGL1.hgt.zip)
- [http://e4ftl01.cr.usgs.gov/MODV6\\_Dal\\_D/SRTM/SRTMGL1.003/2000.02.11/N27W097.SRTMGL1.hgt.zip](http://e4ftl01.cr.usgs.gov/MODV6_Dal_D/SRTM/SRTMGL1.003/2000.02.11/N27W097.SRTMGL1.hgt.zip)
- [http://e4ftl01.cr.usgs.gov/MODV6\\_Dal\\_D/SRTM/SRTMGL1.003/2000.02.11/N28W097.SRTMGL1.hgt.zip](http://e4ftl01.cr.usgs.gov/MODV6_Dal_D/SRTM/SRTMGL1.003/2000.02.11/N28W097.SRTMGL1.hgt.zip)



# Data Acquisition: Impervious Surface Data

- Log into NASA's Socioeconomic Data and Applications Center (SEDAC): <http://sedac.ciesin.columbia.edu/mapping/gmis-hbase/explore-view/>
  - (If you don't have an account, you will need to create one)
  - Using the window "Impervious Surface Percentage (GMIS)" click on "Download View"



- Click on the bubble next to "Tile" and then click "Download by Tiles"



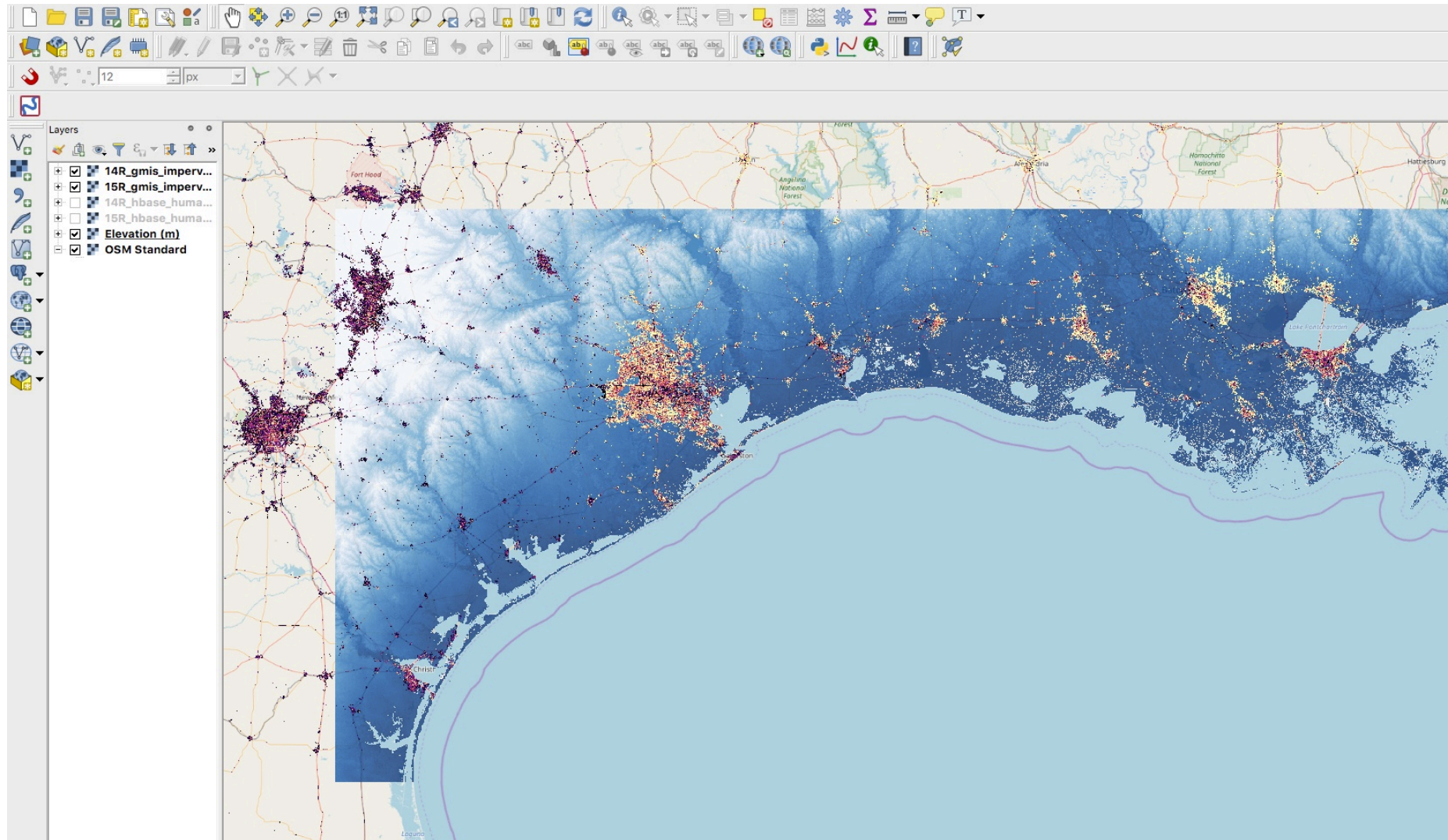


# Data Acquisition: Impervious Surface Data

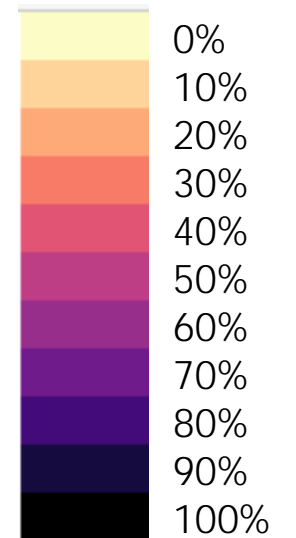
- Download data from tiles **14R** and **15R** by clicking on each tile, checking the box for “Impervious Surface Percentage (GMIS)” and click “Save”
- Open the files using QGIS
- For more information on Global Man-made Impervious Surface (GMIS) dataset, refer to the link below:  
<http://sedac.ciesin.columbia.edu/data/set/ulandsat-gmis-v1>



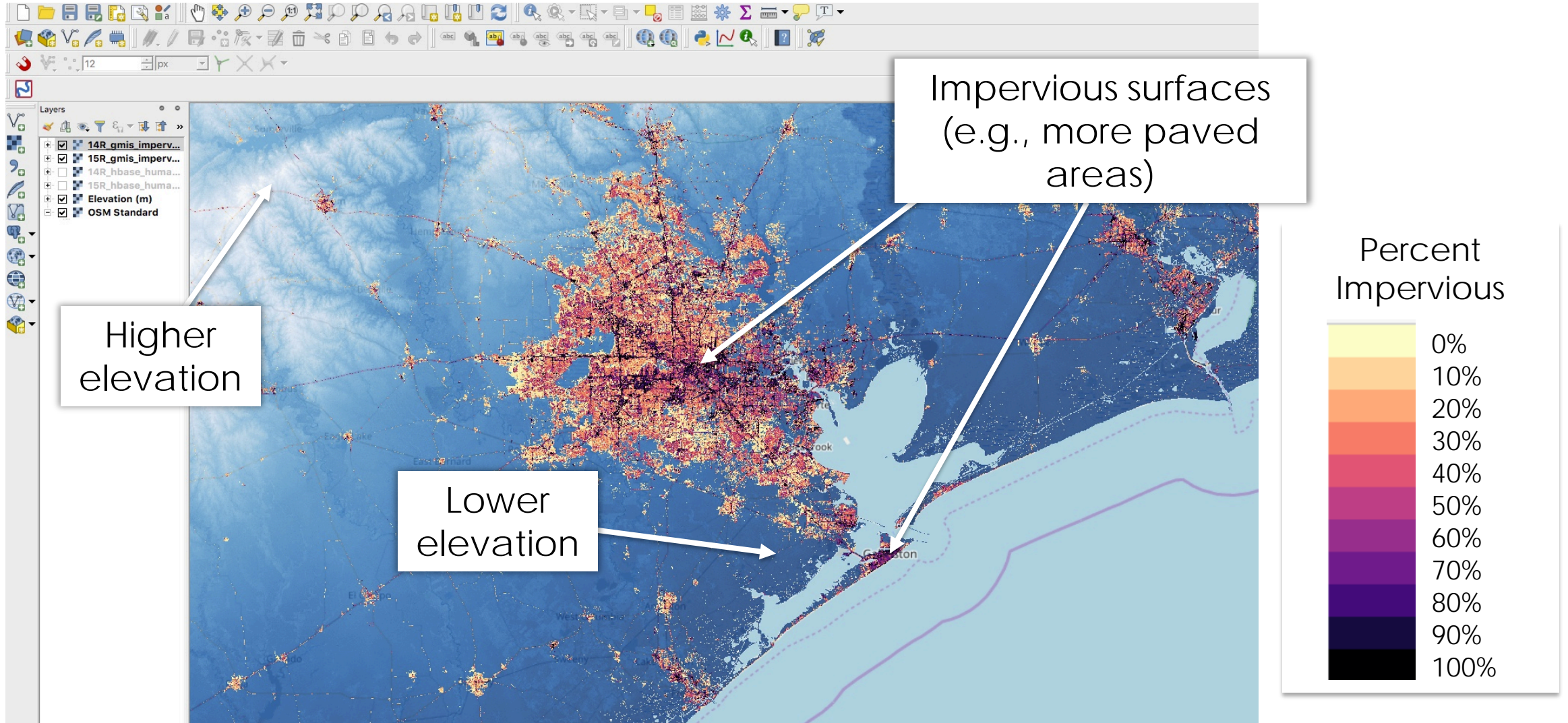
# SRTM DEM + Impervious Surface Data: Hurricane Harvey



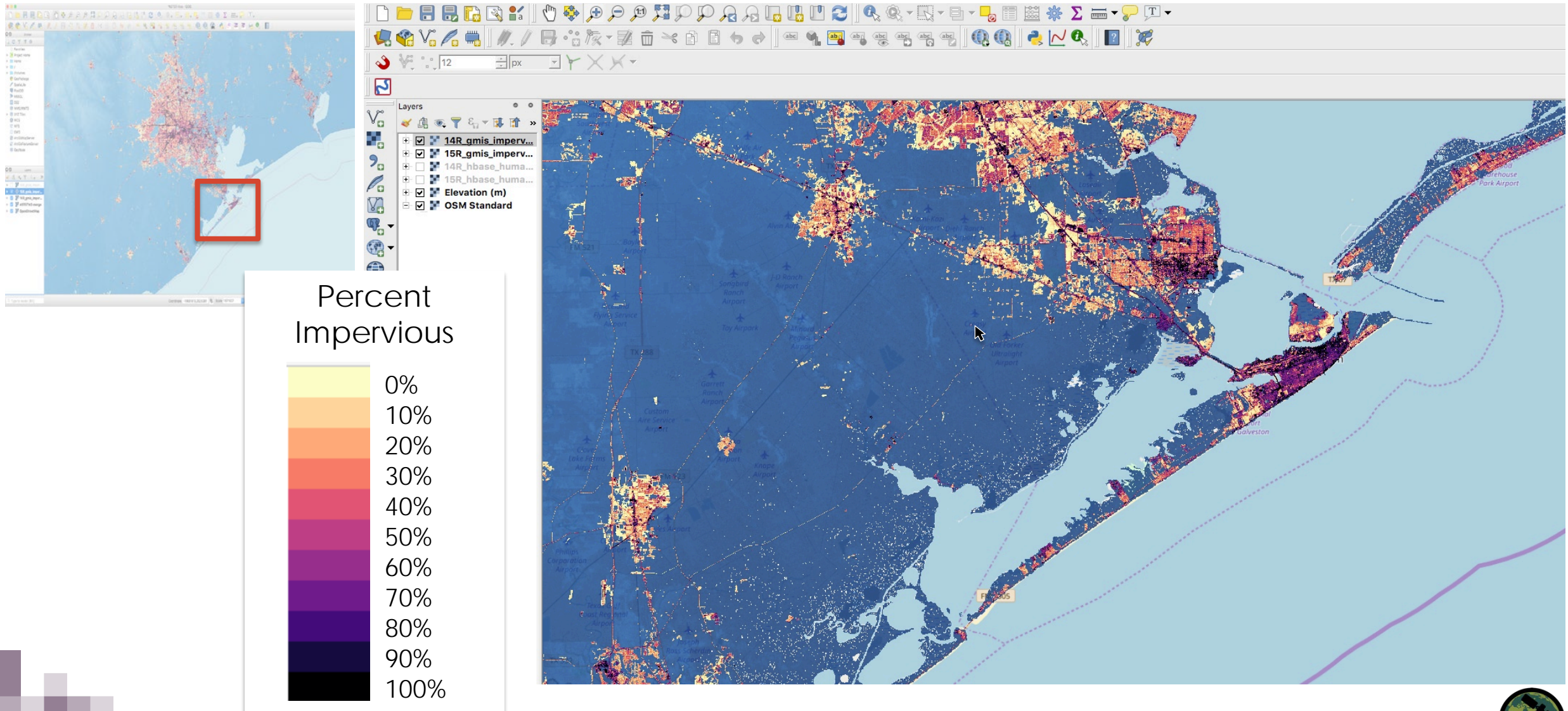
Percent  
Impervious

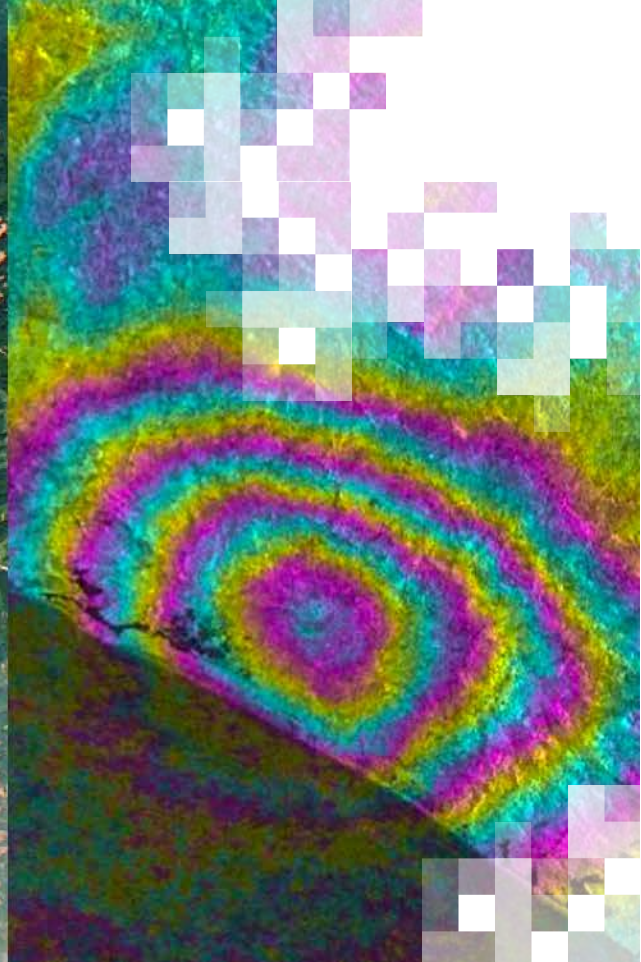
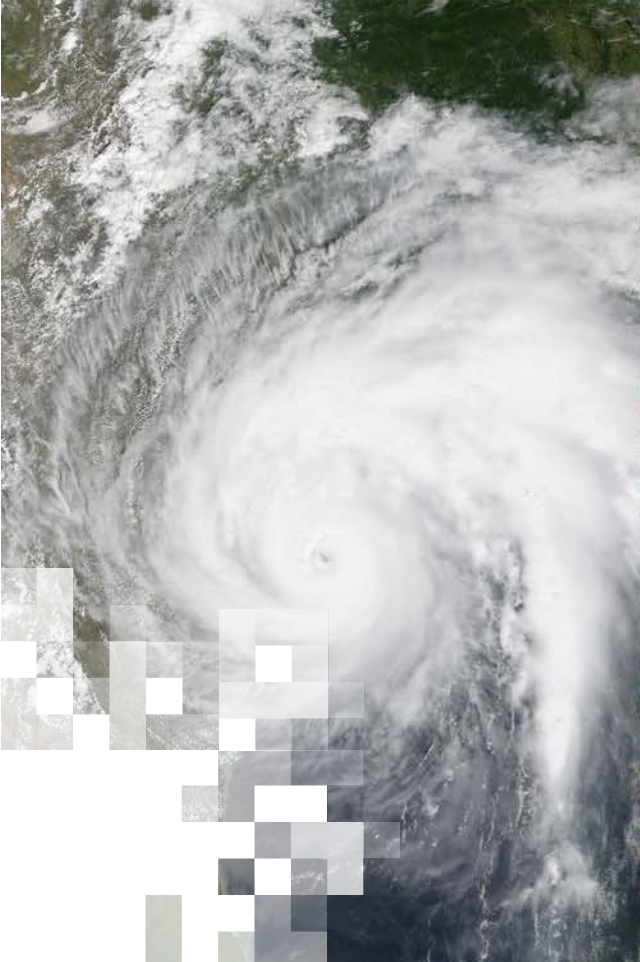


# SRTM DEM + Impervious Surface Data: Hurricane Harvey



# SRTM DEM + Impervious Surface Data: Hurricane Harvey





## Soil Moisture in High Risk Areas

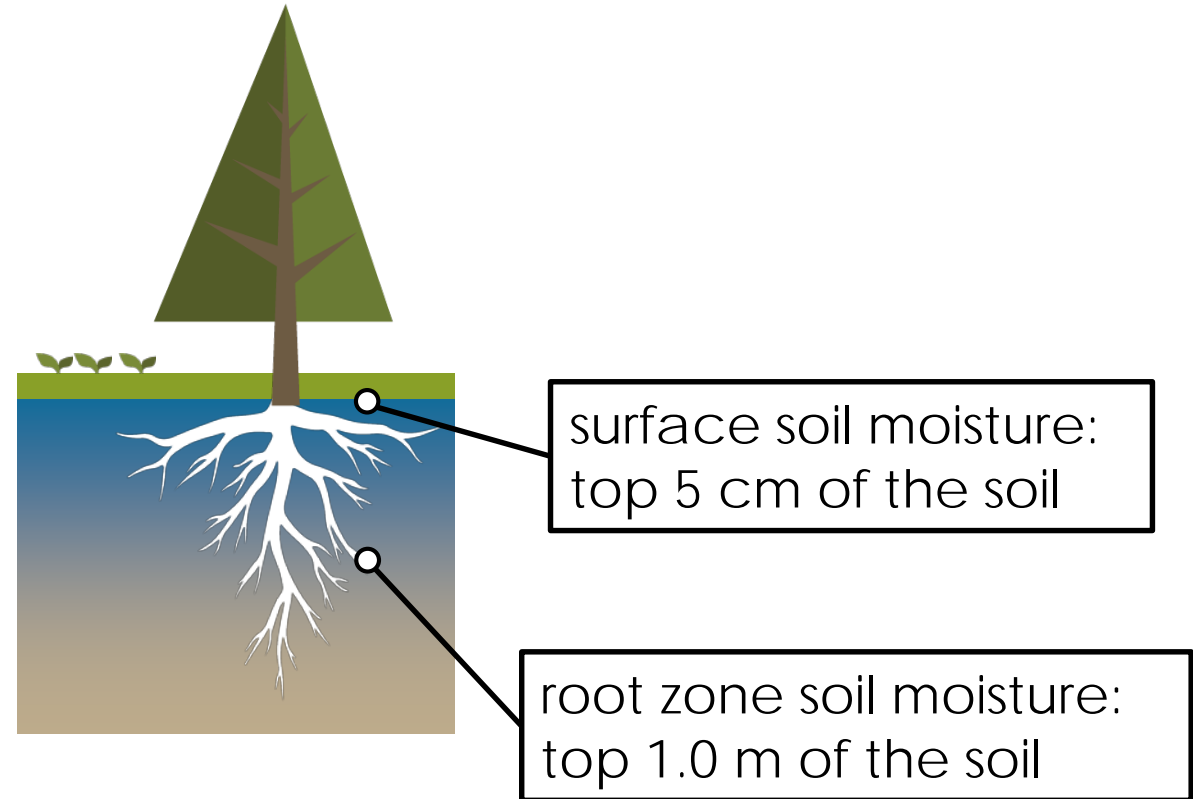
# Soil Moisture

- Flood severity can be impacted by how wet soils are before a rainstorm
  - High soil moisture can increase the chance of inundation
- The National Weather Service's flash flood guidance is updated at least every 24 hours based on surface soil moisture
- NASA's Soil Moisture Active Passive (SMAP) mission makes measurements of surface soil moisture globally every 3 days

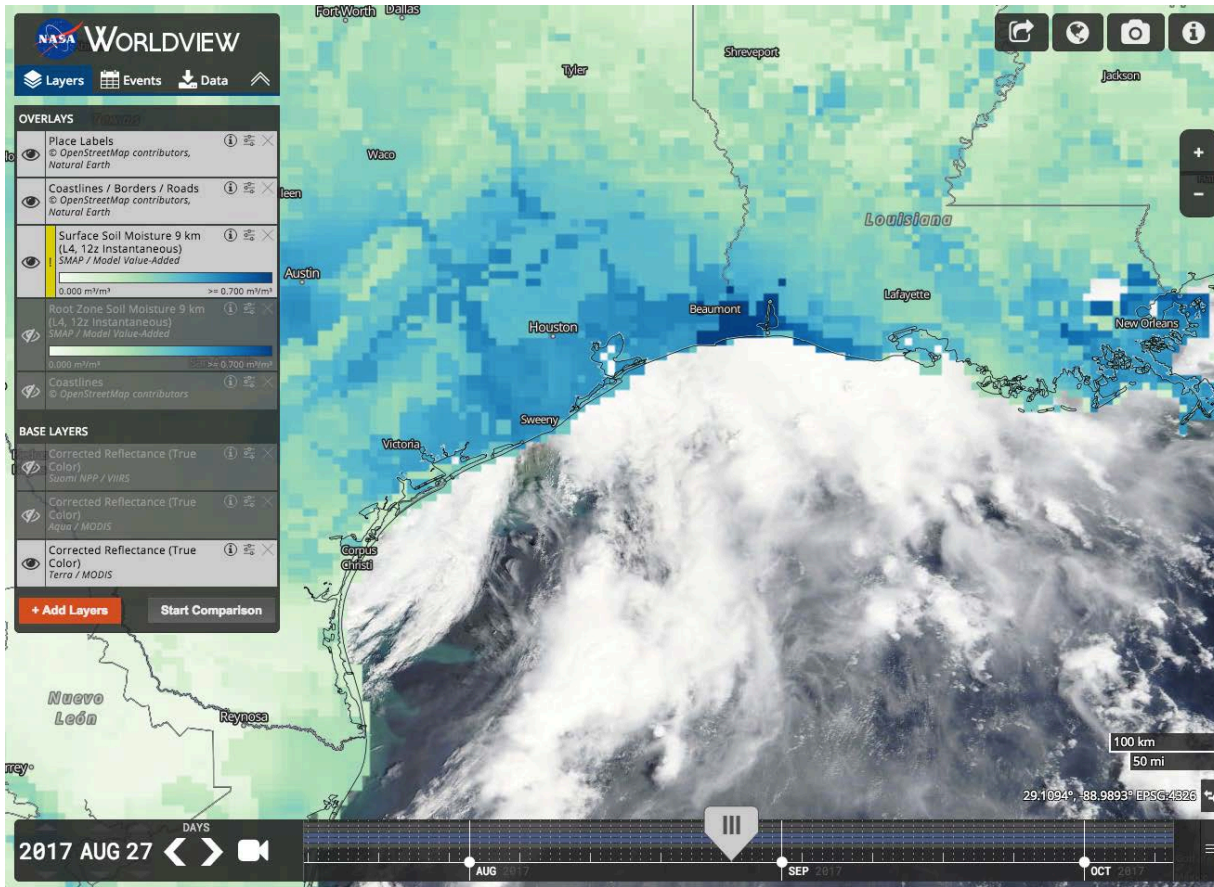


# NASA's Soil Moisture Active Passive (SMAP) Mission

- Measures moisture in the top 5 cm of the soil globally every 3 days
- Uses a microwave remote sensing instrument
- Easily accessible data:
  - surface soil moisture (9 km, 36 km)
  - root zone soil moisture (9 km, 36 km)



# Accessing SMAP Data



The screenshot shows the NSIDC National Snow & Ice Data Center 'Download Data' page. The page header includes the NSIDC logo and 'National Snow & Ice Data Center' text. The main content is a table listing data files for download. The table has three columns: 'Name', 'Last modified', and 'Size'. The files listed are SMAP L4 SM data for August 2017, with various file formats (h5, iso.xml, qa) and sizes ranging from 20K to 114K. The table is sorted by 'Last modified' date, which is 2018-10-08 17:42 for most files.

Name	Last modified	Size
Parent Directory		-
SMAP_L4_SM_aup_20170827T030000_Vv4030_001.h5	2018-10-08 17:42	85M
SMAP_L4_SM_aup_20170827T030000_Vv4030_001.h5.iso.xml	2018-10-08 17:42	114K
SMAP_L4_SM_aup_20170827T030000_Vv4030_001.qa	2018-10-08 17:41	20K
SMAP_L4_SM_aup_20170827T060000_Vv4030_001.h5	2018-10-08 17:42	86M
SMAP_L4_SM_aup_20170827T060000_Vv4030_001.h5.iso.xml	2018-10-08 17:42	114K
SMAP_L4_SM_aup_20170827T060000_Vv4030_001.qa	2018-10-08 17:42	20K
SMAP_L4_SM_aup_20170827T090000_Vv4030_001.h5	2018-10-08 17:42	86M
SMAP_L4_SM_aup_20170827T090000_Vv4030_001.h5.iso.xml	2018-10-08 17:42	106K
SMAP_L4_SM_aup_20170827T090000_Vv4030_001.qa	2018-10-08 17:42	20K
SMAP_L4_SM_aup_20170827T120000_Vv4030_001.h5	2018-10-08 17:42	86M
SMAP_L4_SM_aup_20170827T120000_Vv4030_001.h5.iso.xml	2018-10-08 17:42	114K
SMAP_L4_SM_aup_20170827T120000_Vv4030_001.qa	2018-10-08 17:41	20K
SMAP_L4_SM_aup_20170827T150000_Vv4030_001.h5	2018-10-08 17:43	86M
SMAP_L4_SM_aup_20170827T150000_Vv4030_001.h5.iso.xml	2018-10-08 17:43	114K

<https://worldview.earthdata.nasa.gov/>

<https://nsidc.org/data/smap/smap-data.html>





# Accessing SMAP Surface Soil Moisture

**NASA WORLDVIEW**

Layers Events Data

**OVERLAYS**

- Place Labels
- Coastlines / Borders / Roads
- Coastlines

**BASE LAYERS**

- Corrected Reflectance (True Color) - Suomi NPP / VIIRS
- Corrected Reflectance (True Color) - Aqua / MODIS
- Corrected Reflectance (True Color) - Terra / MODIS

+ Add Layers Start Comparison

Search

Hazards And Disasters Science Disciplines

All

- Absolute Dynamic Topography
- Aerosol Index
- Aerosol Optical Depth
- Aerosol Albedo
- Amphibian Richness
- Areas of No Data (mask)

Air Quality

- Aerosol Index
- Aerosol Optical Depth
- Carbon Monoxide
- Corrected Reflectance
- Dust
- Fires and Thermal Anomalies

Ash Plumes

- Aerosol Optical Depth
- Corrected Reflectance
- Fires and Thermal Anomalies
- Land Surface Reflectance
- Sulfur Dioxide
- Volcano Hazard

Drought

- Corrected Reflectance
- Dams
- Drought Hazard
- Land Surface Reflectance
- Land Surface Temperature
- Precipitation Estimate

Dust Storms

- Aerosol Optical Depth
- Dust
- Corrected Reflectance
- Land Surface Reflectance

Fires

- Aerosol Index
- Aerosol Optical Depth
- Fires and Thermal Anomalies
- Carbon Monoxide
- Corrected Reflectance
- Earth at Night

Floods

- Corrected Reflectance
- Cloud Fraction
- Cloud Multi Layer Flag
- Cloud Phase
- Cloud Pressure
- Cloud Effective Radius

Severe Storms

- Corrected Reflectance
- Cloud Fraction
- Cloud Multi Layer Flag
- Cloud Phase
- Cloud Pressure
- Cloud Effective Radius

Shipping

- Corrected Reflectance
- Brightness Temperature
- Land Surface Reflectance
- Sea Ice
- Sea Surface Temperature

Smoke Plumes

- Aerosol Optical Depth
- Carbon Monoxide

Vegetation

- Corrected Reflectance
- Forests, Mangrove

Other

- Areas of No Data (mask)
- Blue Marble

Land Surface Reflectance

Precipitation Estimate

Precipitation Rate

Reservoirs

**Soil Moisture**

Snow Cover

Snow Water Equivalent

Categories / Floods Search

**Soil Moisture**

- Soil Moisture 9 km (L2, Passive, Day, Single Channel Algorithm, H-pol)
- Soil Moisture 9 km (L2, Passive, Day, Single Channel Algorithm, V-pol)
- Soil Moisture 9 km (L2, Passive, Day, Dual Channel Algorithm)
- Soil Moisture 9 km (L2, Passive, Night, Single Channel Algorithm, H-pol)
- Soil Moisture 9 km (L2, Passive, Night, Single Channel Algorithm, V-pol)
- Soil Moisture 9 km (L2, Passive, Night, Dual Channel Algorithm)
- Soil Moisture 36 km (L2, Passive, Day, Single Channel Algorithm, H-pol)
- Soil Moisture 36 km (L2, Passive, Day, Single Channel Algorithm, V-pol)
- Soil Moisture 36 km (L2, Passive, Day, Dual Channel Algorithm)
- Soil Moisture 36 km (L2, Passive, Night, Single Channel Algorithm, H-pol)
- Soil Moisture 36 km (L2, Passive, Night, Single Channel Algorithm, V-pol)
- Soil Moisture 36 km (L2, Passive, Night, Dual Channel Algorithm)
- Soil Moisture 9 km (L3, Passive, Day)**
- Soil Moisture 9 km (L3, Passive, Night)
- Soil Moisture 36 km (L3, Passive, Day)
- Soil Moisture 36 km (L3, Passive, Night)

**Orbital Tracks:**

- Ascending/Night
- Descending/Day**



# Accessing SMAP Root Zone Soil Moisture

**NASA WORLDVIEW**

Layers Events Data

**OVERLAYS**

- Place Labels
- Coastlines / Borders / Roads
- Coastlines

**BASE LAYERS**

- Corrected Reflectance (True Color)
- Corrected Reflectance (True Color)
- Corrected Reflectance (True Color)

**+ Add Layers** Start Comparison

Search

Hazards And Disasters Science Disciplines

All

- Absolute Dynamic Topography
- Aerosol Index
- Aerosol Optical Depth
- Aerosol Albedo
- Amphibian Richness
- Areas of No Data (mask)

Drought

- Corrected Reflectance
- Dams
- Drought Hazard
- Land Surface Reflectance
- Land Surface Temperature
- Precipitation Estimate

Floods

- Corrected Reflectance
- Cloud Fraction
- Cloud Multi Layer Flag
- Cloud Phase
- Cloud Pressure
- Cloud Effective Radius

Smoke Plumes

- Aerosol Optical Depth
- Carbon Monoxide

Land Surface Reflectance

Precipitation Estimate

Precipitation Rate

Reservoirs

**Soil Moisture**

Snow Cover

Snow Water Equivalent

Urban Rural Extents Below 10m Elevation

**Soil Moisture**

- GCOM-W1 / AMSR2
- GLDAS
- MERRA-2
- NLDAS
- SAC-D/Aquarius
- SMAP / Model Value-Added**
- SMAP / Radar
- SMAP / Radar/Radiometer
- SMAP / Radiometer
- SMAP / Sentinel-1

Root Zone Soil Moisture 9 km (L4, 12z Instantaneous)

Root Zone Soil Moisture Uncertainty 9 km (L4, 12z Instantaneous)

Surface Soil Moisture 9 km (L4, 12z Instantaneous)

Surface Soil Moisture Uncertainty 9 km (L4, 12z Instantaneous)

**Root Zone Soil Moisture 9 km (L4, 12z Instantaneous, Model Value-Added)**

Temporal coverage: 31 March 2015 - present

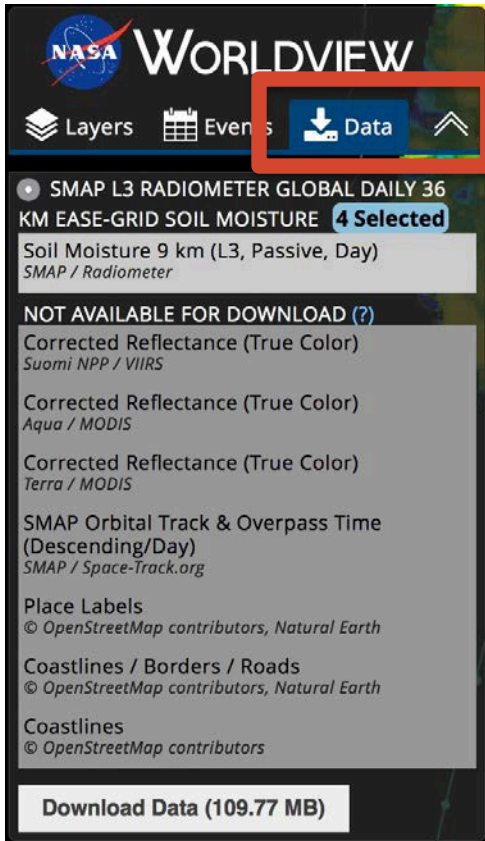
The Soil Moisture Active Passive (SMAP) "Root Zone Soil Moisture 9 km (L4, 12z Instantaneous, Model Value-Added)" layer displays model-derived global estimates of root zone soil moisture of the top 100



# Visualizing SMAP Soil Moisture on Worldview



# Downloading and Displaying SMAP Soil Moisture Data



**NASA WORLDVIEW**

Layers Events **Data**

SMAP L3 RADIOMETER GLOBAL DAILY 36 KM EASE-GRID SOIL MOISTURE **4 Selected**

Soil Moisture 9 km (L3, Passive, Day)  
SMAP / Radiometer

NOT AVAILABLE FOR DOWNLOAD (?)

Corrected Reflectance (True Color)  
Suomi NPP / VIIRS

Corrected Reflectance (True Color)  
Aqua / MODIS

Corrected Reflectance (True Color)  
Terra / MODIS

SMAP Orbital Track & Overpass Time (Descending/Day)  
SMAP / Space-Track.org

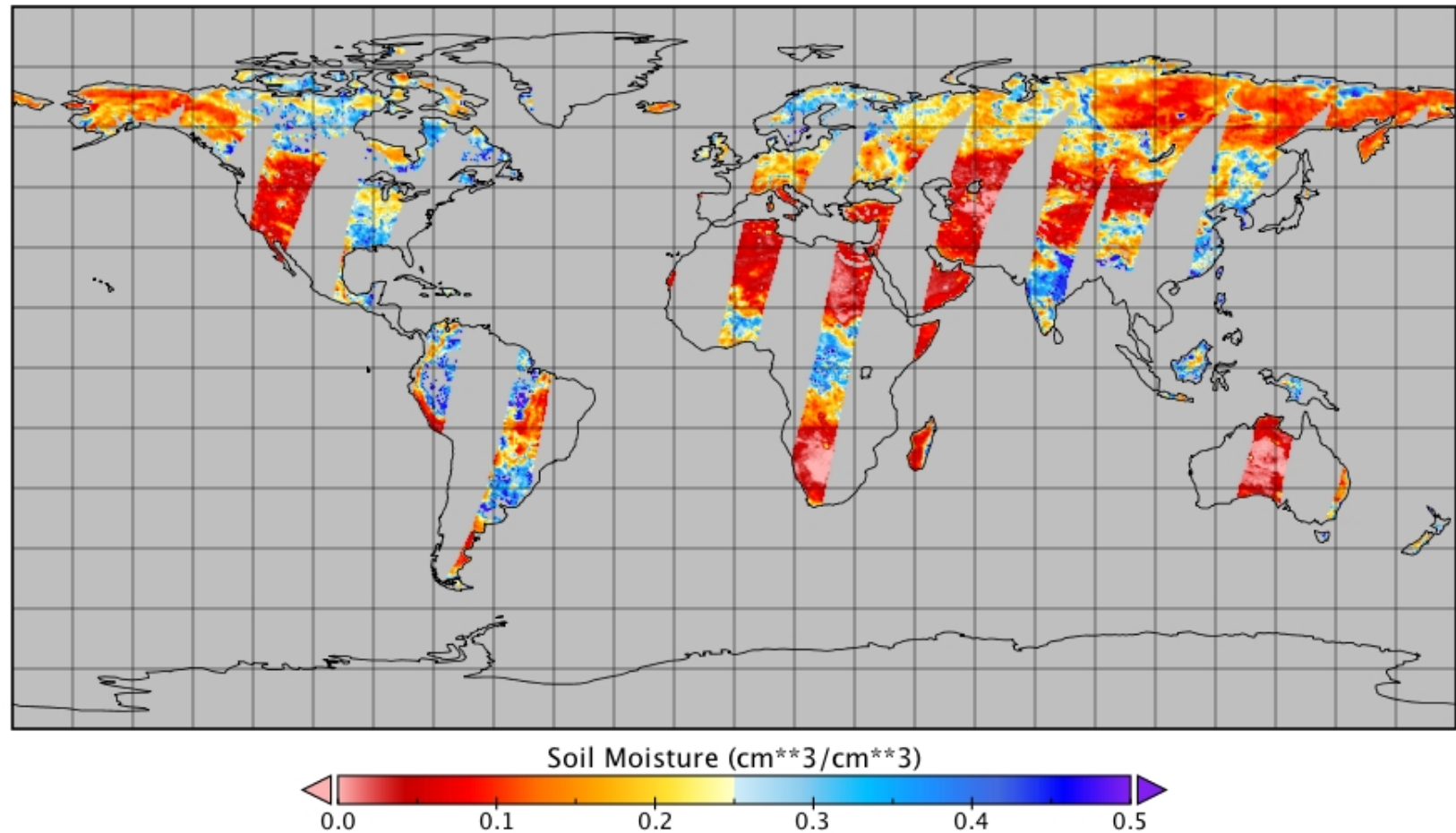
Place Labels  
© OpenStreetMap contributors, Natural Earth

Coastlines / Borders / Roads  
© OpenStreetMap contributors, Natural Earth

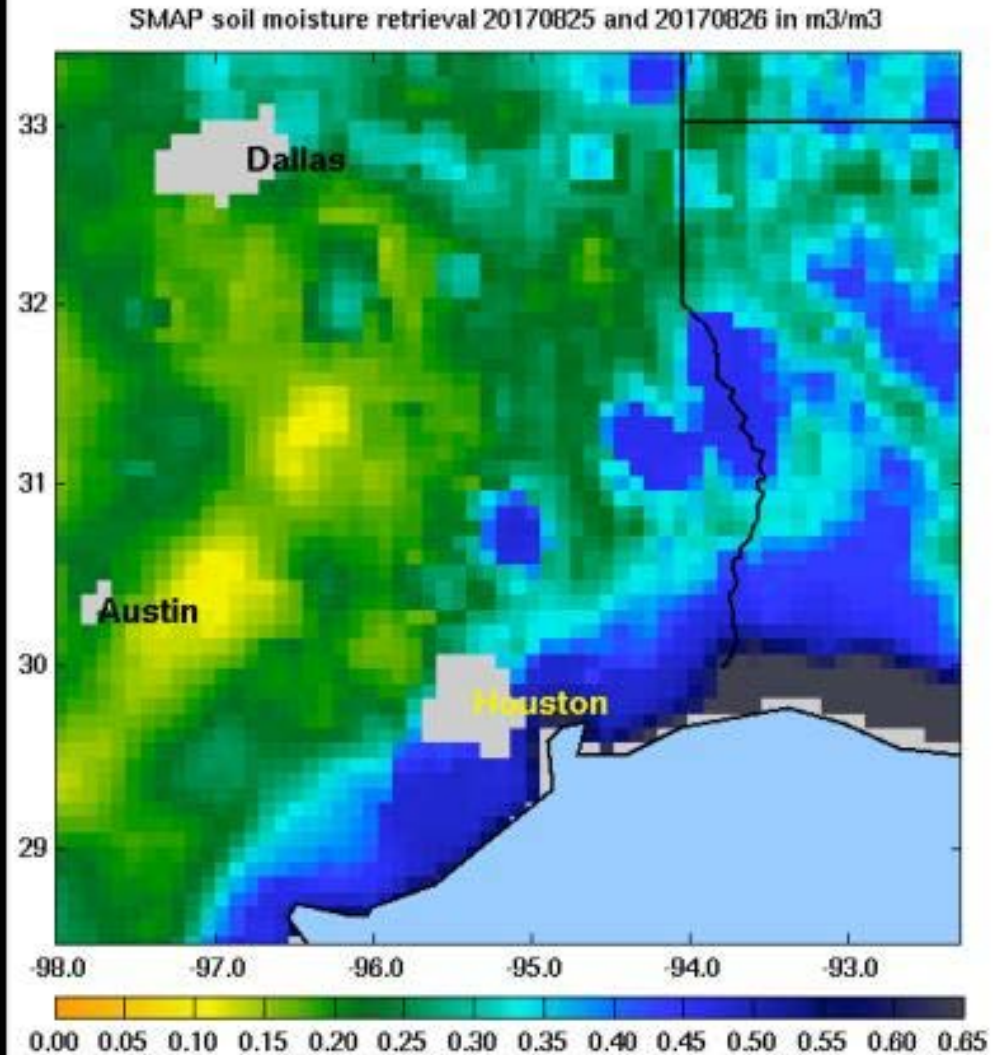
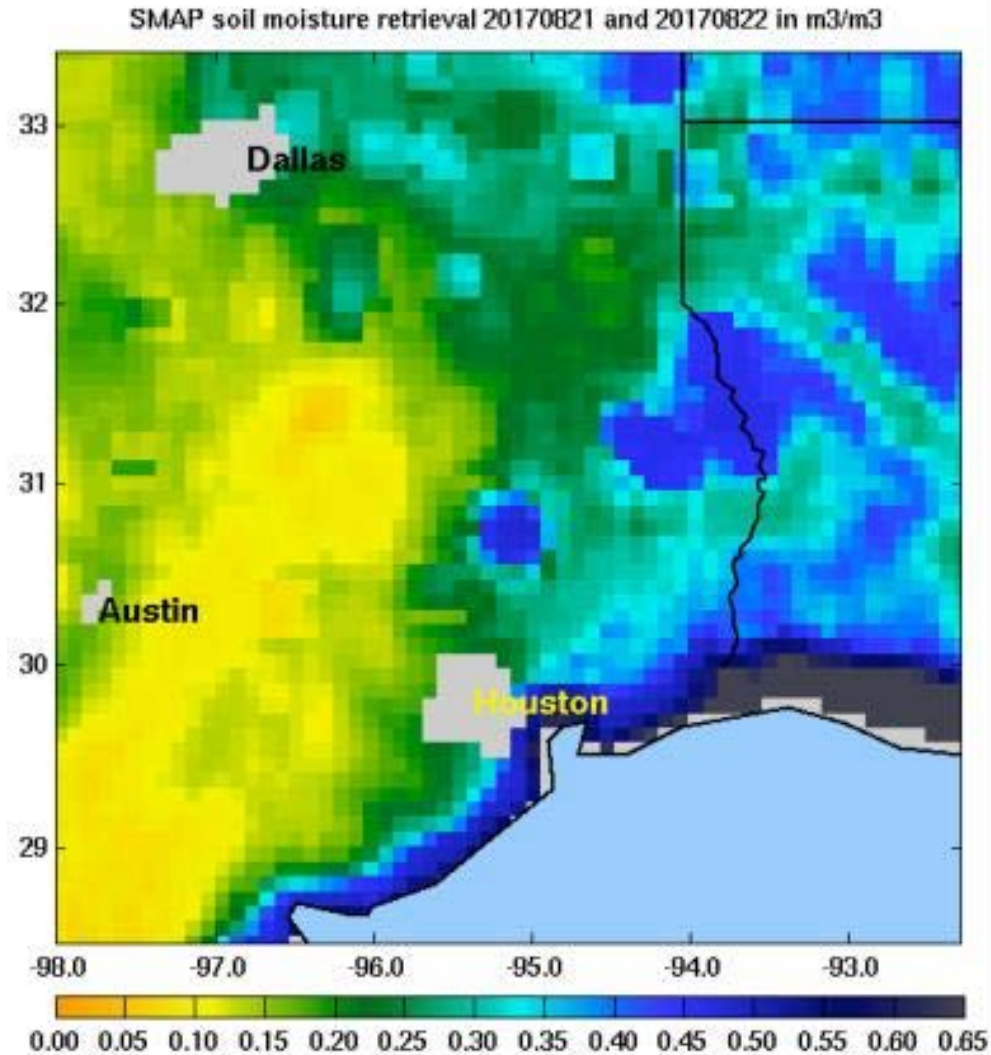
Coastlines  
© OpenStreetMap contributors

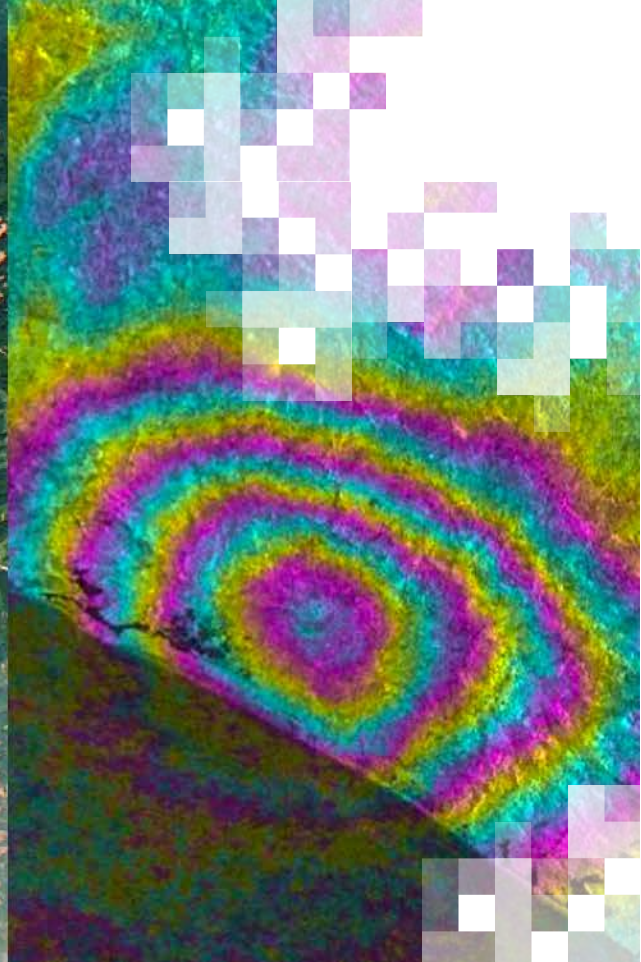
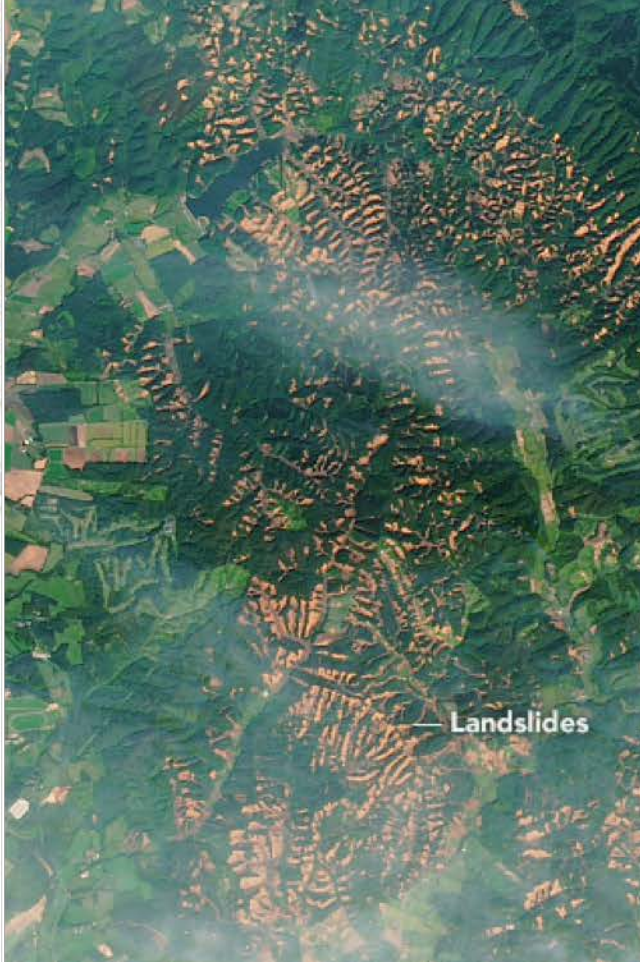
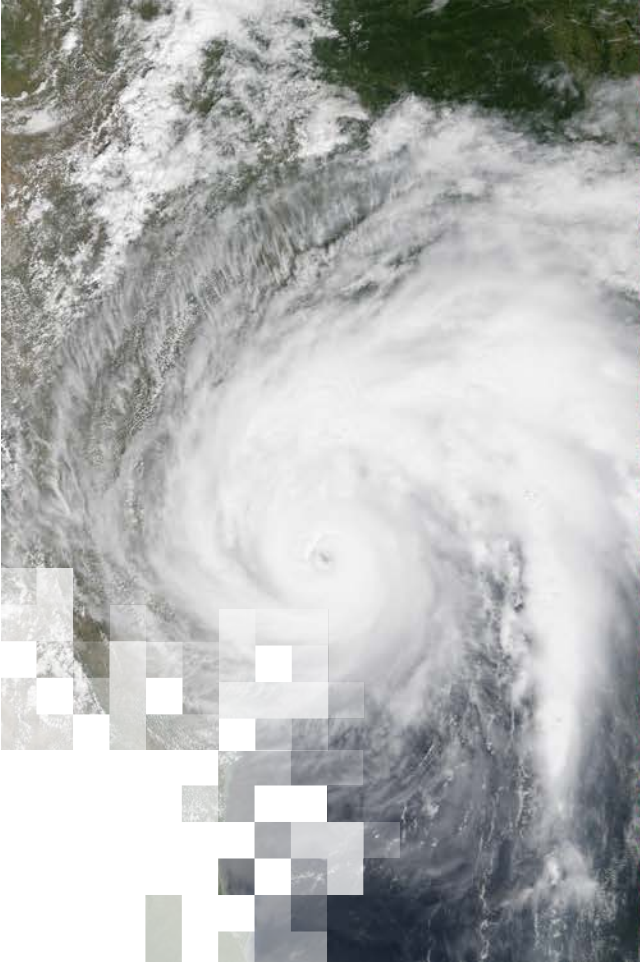
**Download Data (109.77 MB)**

SMAP Soil Moisture (L3 - Radiometer - 9km) for Aug. 24, 2017



# SMAP Soil Moisture Before and During Hurricane Harvey





# Tracking Flooding

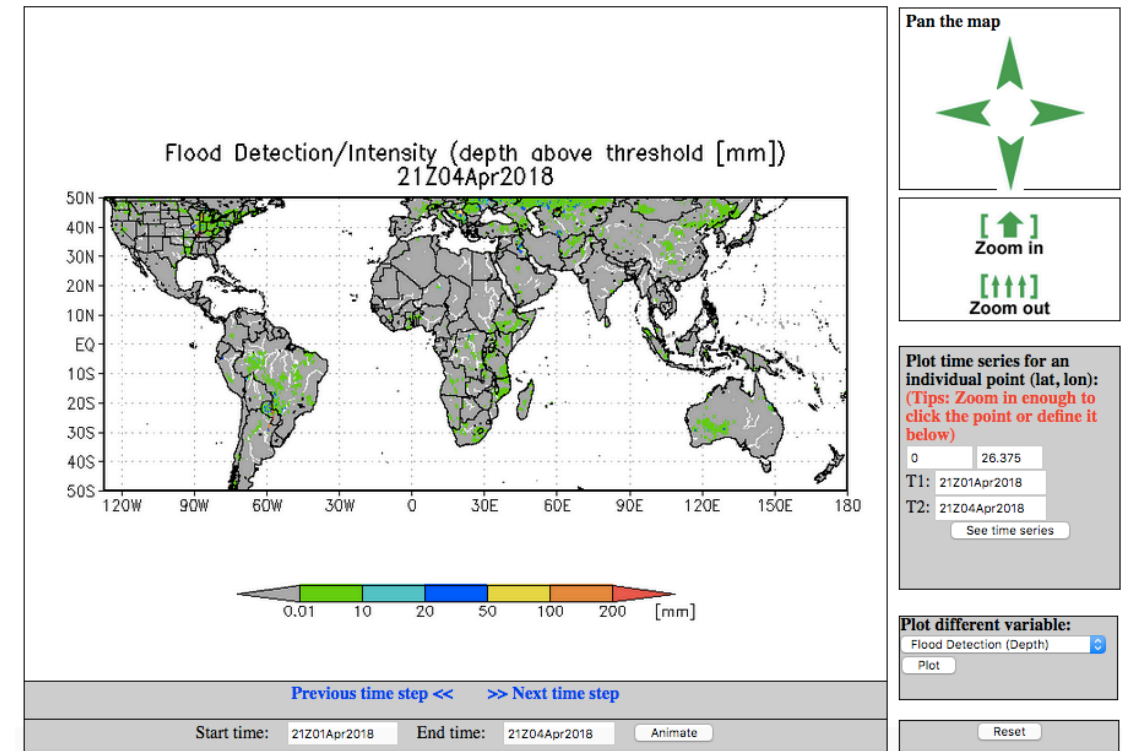
# Global Flood Monitoring System (GFMS)

<http://flood.umd.edu/>

- Provides global maps, time series, and animations (50°S-50°N) of:
  - instantaneous rain rate every 3 hours with about a 10 hour latency
  - accumulated rain over 24, 72, and 168 hours
  - streamflow rates and flood intensity at 1/8th degree (~12 km) and 1 km
  - Near real-time and archives since 2013

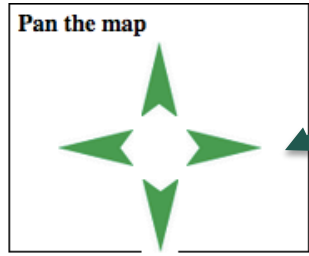
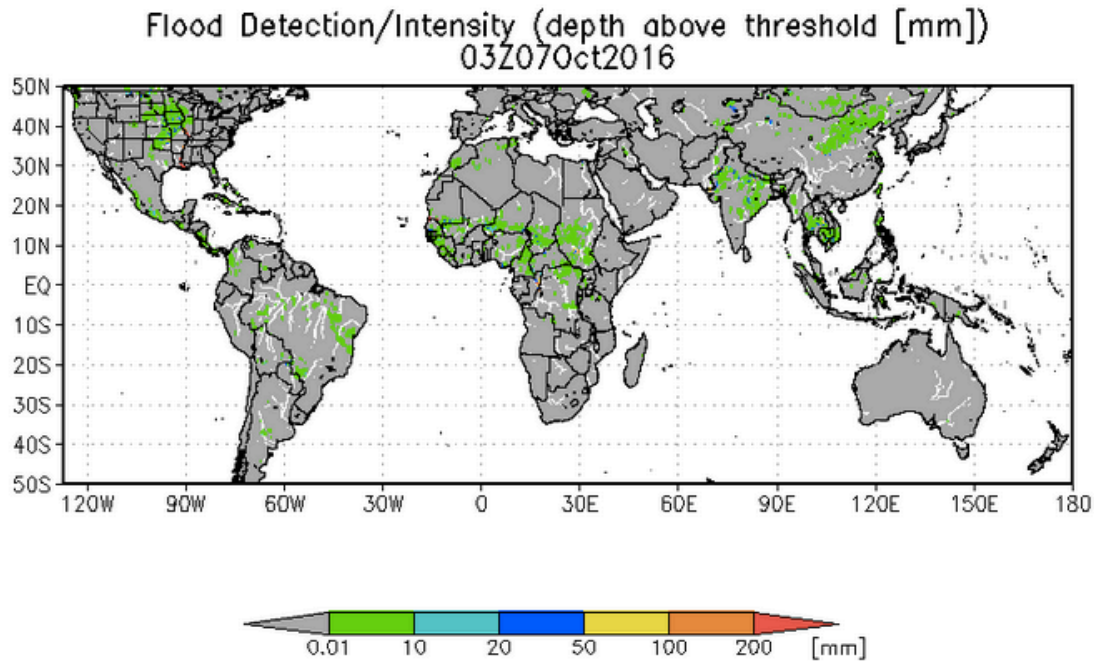
Note: TRMM is no longer flying, but TRMM-based calibration is used to provide near real-time rainfall from a constellation of national & international satellites for flooding applications. Near real-time IMERG data available from: <ftp://jsimpson.pps.eosdis.nasa.gov>

## Interactive Features

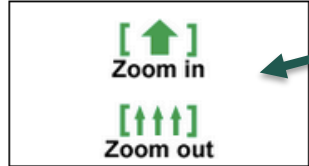


# GFMS

<http://flood.umd.edu/>



Map Navigation



Zoom in/out

Plot time series for an individual point (lat, lon):  
(Tips: Zoom in enough to click the point or define it below)

61.76 -152.4

T1: 03Z07Oct2016  
T2: 21Z07Oct2016

See time series

Select individual grid point for time series data

Plot different variable:

- Flood Detection (Depth)
- Streamflow 12km res.
- Streamflow above Threshold
- Streamflow 1km res.
- Surface storage 1km res.
- Inundation map 1km res.
- Routed runoff 12km res.
- Rainfall (Inst.)
- Rainfall (1-day)
- Rainfall (3-day)
- Rainfall (7-day)

Plot different variables

Plot different variable:

Flood Detection (Depth)

Plot

Reset

Animation

Previous time step << >> Next time step

Start time: 03Z07Oct2016 End time: 21Z07Oct2016 Animate

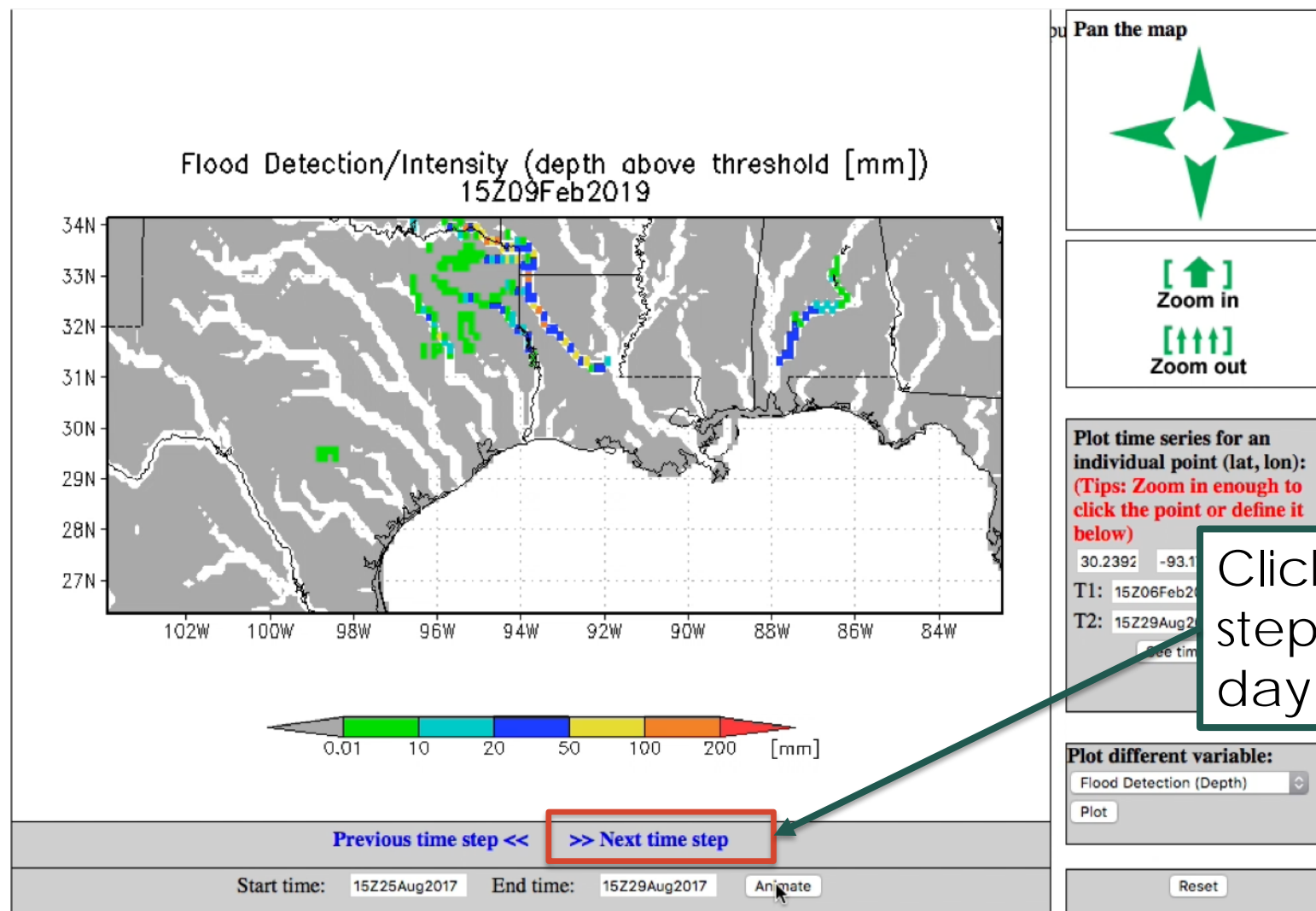




# GFMS: Flooding from Hurricane Harvey



# GFMS: Flood Forecasts



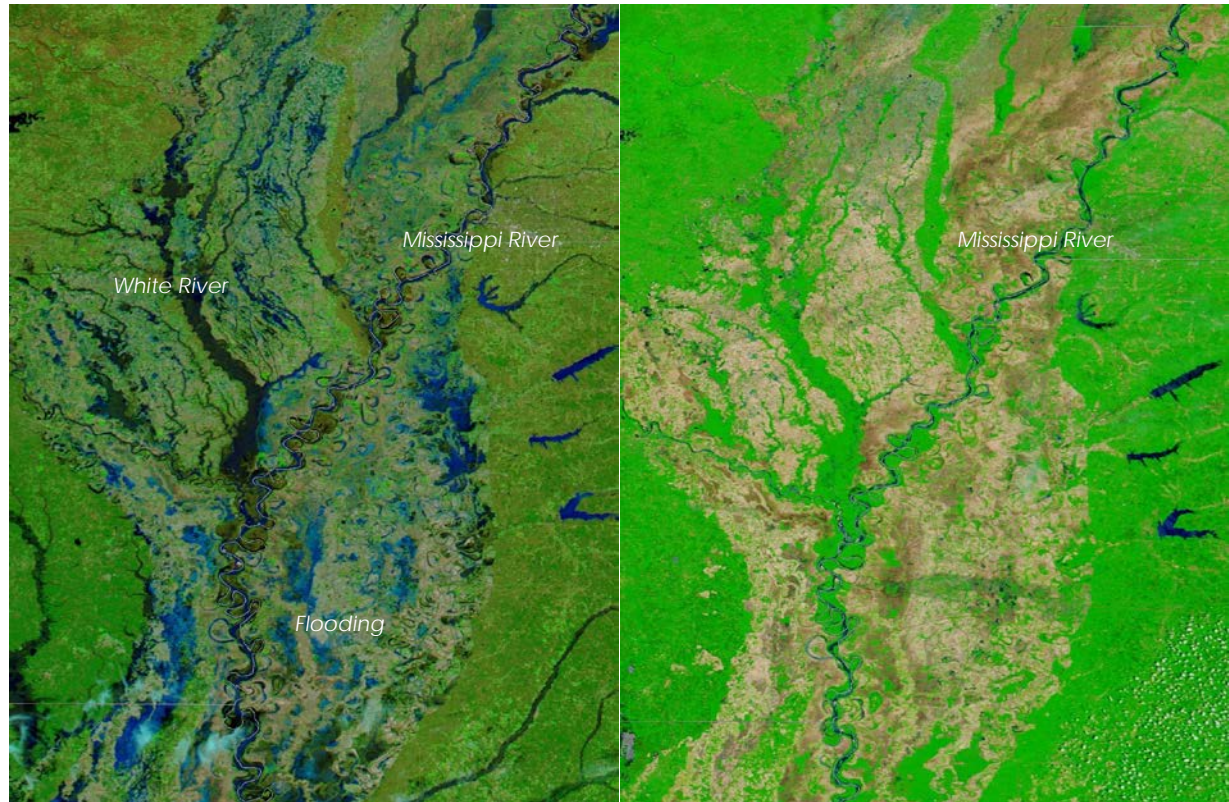
Click on "next time step" to view 4-5 day forecasts



# MODIS-Based Inundation Mapping

- MODIS provides observations 1-2 times per day
- Certain bands indicate water on previously dry surfaces:
  - Band 1: 620-670 nm
  - Band 2: 841-876 nm
  - Band 7: 2105-2155 nm
- Mapped with respect to a global reference database of water bodies
- MODIS cannot see the surface in the presence of clouds

## Mississippi River Flooding 2016



MODIS (Aqua)  
Mar 15, 2016

MODIS (Terra)  
May 13, 2016



# MODIS NRT Global Flood Mapping

<http://oas.gsfc.nasa.gov/>

- Based on MODIS reflectance at 250 m resolution composited on 2, 3, and 14 days
- Flood maps available on 10°x10° tile
- Permanent and surface flood water data available
- Cloud or terrain shadows can be misinterpreted as surface water
- Provides near real-time (up to the previous day) flood mapping since Jan 2013

**NRT Global Flood Mapping**

**Global Map**  
Click for ArcGIS Portal map interface

10° Flood Map Tile Production

For more information, please contact floodmap at [lists.nasa.gov](mailto:lists.nasa.gov)  
**NOTE: THIS IS AN EXPERIMENTAL PRODUCT AND SYSTEM**

**News/Status**

11-Nov-2014: ArcGIS Online Map available.  
10-Nov-2014: MODIS flood product evaluation report available.

> Go to News/Status page

NASA Official: Frederick Policell  
Page Last Updated: January 13, 2015  
Privacy Policy & Important Notices  
Contact Us



# MODIS NRT Global Flood Mapping: Available Quantities

<http://oas.gsfc.nasa.gov/>

Products		Available Downloads	
MODIS Flood Map	MFM	png	
MODIS Flood Water	MFW	shapefile (.zip)	KMZ
MODIS Surface Water	MSW	shapefile (.zip)	KMZ
MODIS Water Product	MWP	geotiff	
README		pdf	txt

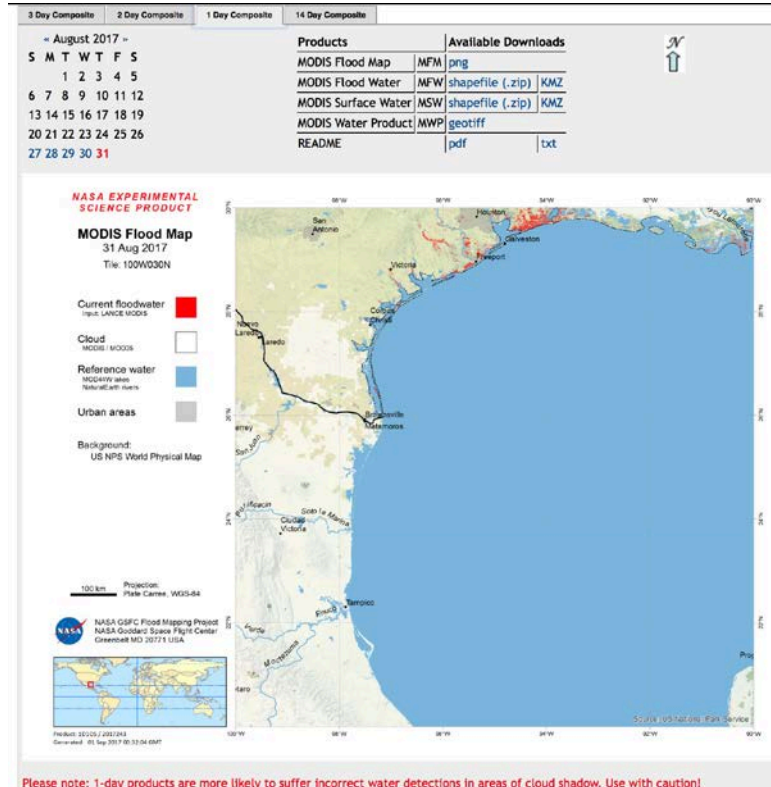


# MODIS NRT Global Flood Mapping: Houston Area, Post Harvey

<http://oas.gsfc.nasa.gov/>

Tile 100W 30N

Aug. 31, 2017



Inundated Surface  
Post-Hurricane Harvey

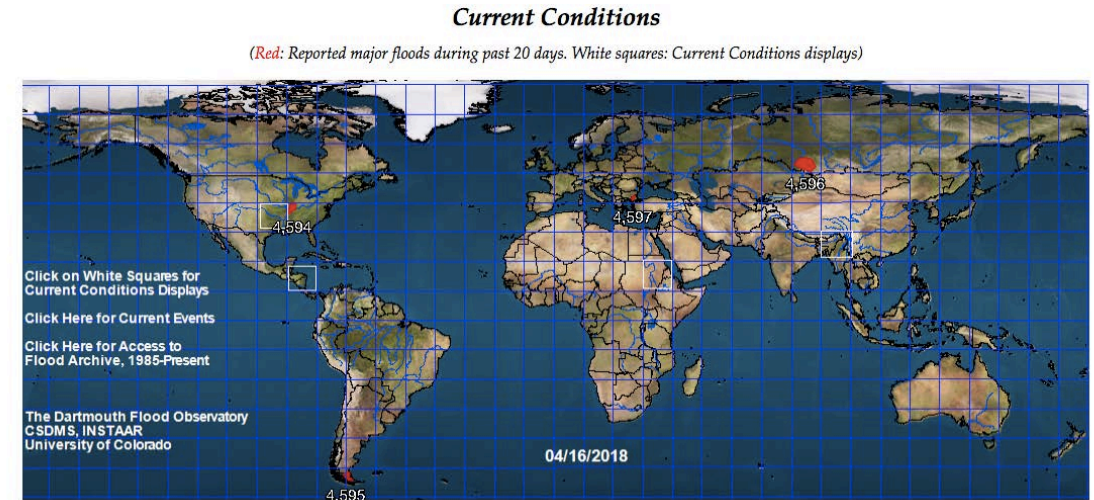
Note: MODIS cannot see the surface when clouds are present



# Dartmouth Flood Observatory (DFO)

<http://floodobservatory.colorado.edu/>

- Uses flood mapping based on MODIS reflectance
  - same as MODIS NRT
- Also uses Landsat 8, EO-1, and ASTER images
  - uses COSMO-SkyMed and Sentinel-1 synthetic aperture radar (SAR) when available
- Current flood events are analyzed with multiple data sources, including media report

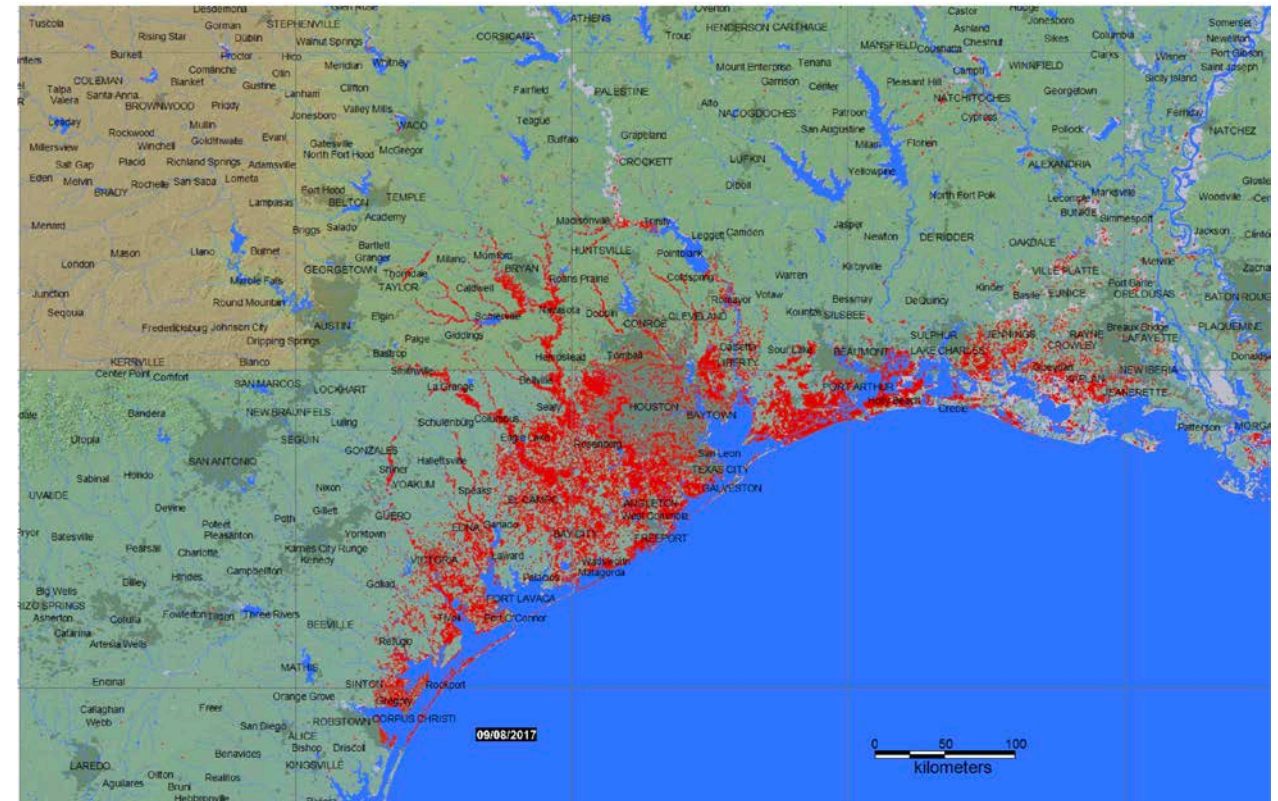


# DFO: Flooding Due to Hurricane Harvey

<https://floodobservatory.colorado.edu/Events/2017USA4510/2017USA4510.html>

## Flood Map (Hurricane Harvey)

Red is flooding mapped from NASA MODIS, ESA Sentinel 1, ASI Cosmo SkyMed, and Radarsat 2 data. Blue is a reference normal water extent.





# NASA Disasters Portal

<https://disasters.nasa.gov/home>

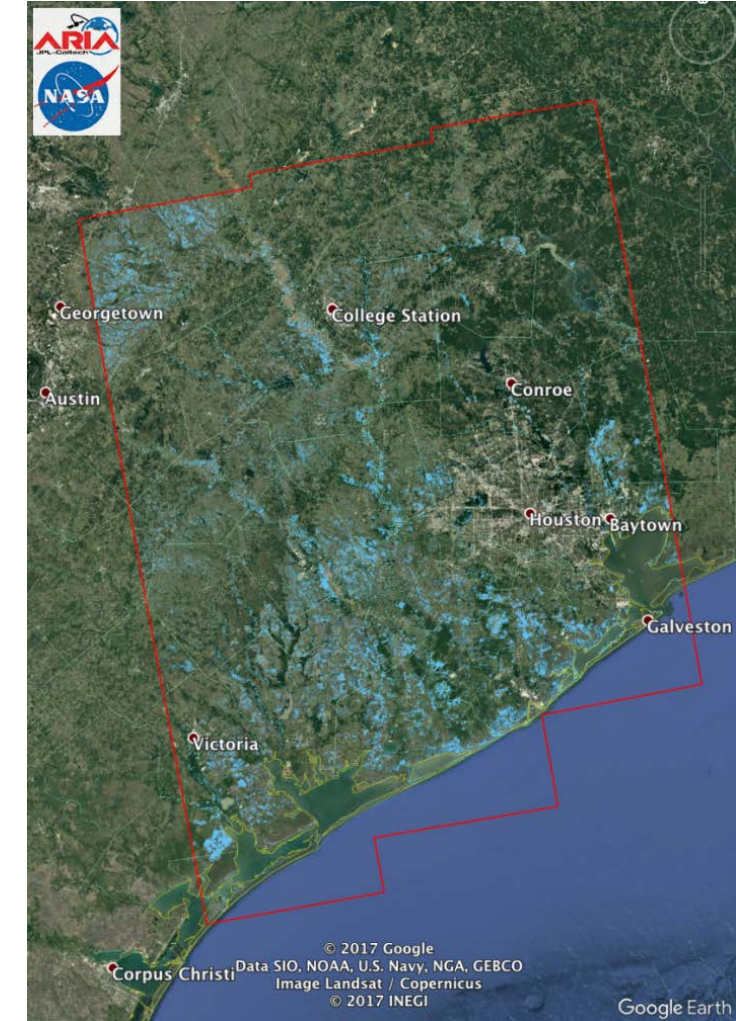
The screenshot displays the NASA Disasters Portal interface. At the top left, the 'NASA Earth Science DISASTERS PROGRAM' logo is visible. The top right features the 'NASA Applied Sciences Program | www.nasa.gov' text and the NASA logo. A search bar is located in the top right corner. Below the header is a navigation menu with the following items: ORGANIZATION, DISASTERS, RESILIENCE, and RESOURCES. The 'DISASTERS' menu is open, showing a list of disaster types: Earthquakes, Fires, Floods (highlighted with a red box), Industrial Accidents, Landslides, Oil Spills, Severe Weather, Tropical Cyclones, Volcanoes, and Winter Weather. The main content area is divided into several sections. On the left, there is a featured article titled 'NASA Tests Tsunami Detection Prototype' with a sub-headline 'The circles in Fig. 2 indicate the data uncertainty range; signals beyond the circles are meaningful.' Below the article is a 'Read More' link. In the center, there is a map of Alaska with a red circle highlighting a specific location. On the right, there is a red alert box stating 'NASA Disasters Mapping Portal will be down for scheduled maintenance on Wednesday, February 13th from 9:30am to 3:30pm ET. Please contact us if you have any questions.' Below the alert is a section titled 'Recent Responses' with a list of events: Alaska Earthquake 2018, November 2018 California Wildfires, Super Typhoon Yutu 2018, and Hurricane Willa 2018. At the bottom, there are three smaller maps: 'ARIA Wildfire Damage Proxy Map', 'GPM Precipitation', and 'About the NASA Disasters Program'. The 'About the NASA Disasters Program' section states: 'The Disasters Applications area promotes the use of Earth observations to improve prediction of, preparation for, response to, and recovery from natural and technological disasters. Disaster'.



# ARIA Flood Extent Map

<https://disasters.nasa.gov/hurricane-harvey-2017/aria-flood-extent-map-harvey-sentinel-1-sar-data>

- This map is derived from Synthetic Aperture Radar (SAR) amplitude images from the Japan Aerospace Exploration Agency's (JAXA) ALOS-2 PALSAR-2 satellite, taken before (Jul 30, 2017) and after (Aug 27, 2017) Hurricane Harvey made landfall
- The map covers an area of 135 km<sup>2</sup>. Each pixel measures about 538 ft<sup>2</sup>. Local ground observations provided anecdotal preliminary validation.
- This flood proxy map should be used as guidance to identify areas that are likely flooded, and may be less reliable over urban areas. ALOS-2 data were accessed through the International Charter



Text Credit: [ARIA](#); Credit: NASA/JPL-Caltech/JAXA/METI/Google Earth



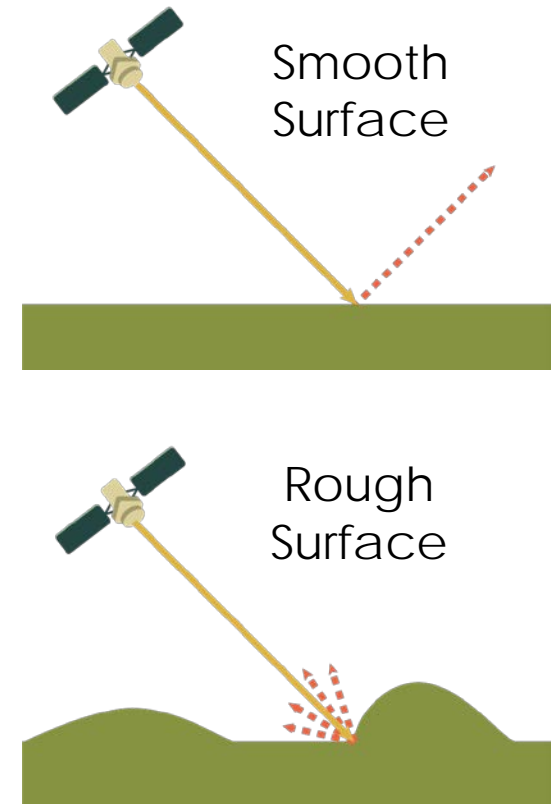
# Synthetic Aperture Radar (SAR) Imagery For Flood Detection

<https://arset.gsfc.nasa.gov/disasters/webinars/intro-SAR>

- SAR is an active sensor operating in microwave frequencies – collect backscattered signal

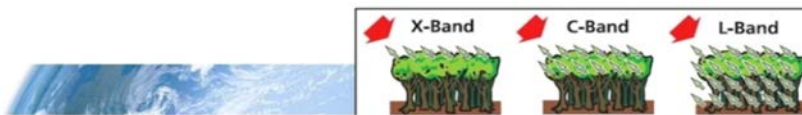
- The backscatter signal is primarily sensitive to surface structure
- The scale of the objects on the surface relative to the wavelength determine how rough or smooth they appear to the radar signal and how bright or dark they will appear on the image

## Backscattering Mechanisms



### Commonly Used Frequency Bands



Frequency band	Frequency range	Application Example
• VHF	300 KHz - 300 MHz	Foliage/Ground penetration, biomass
• P-Band	300 MHz - 1 GHz	biomass, soil moisture, penetration
• L-Band	1 GHz - 2 GHz	agriculture, forestry, soil moisture
• C-Band	4 GHz - 8 GHz	ocean, agriculture
• X-Band	8 GHz - 12 GHz	agriculture, ocean, high resolution radar
• Ku-Band	14 GHz - 18 GHz	glaciology (snow cover mapping)
• Ka-Band	27 GHz - 47 GHz	high resolution radars



# Radar Data from Different Satellites

■ freely accessible  
■ freely accessible & reliably repeated acquisition plan



The Legacy:

 1978  
  
 SeaSAT

 1991-2011  
  
 ERS 1/2

 2002-2012  
  
 ENVISAT


● 2006-2011  
  
 ALOS-1

 1995-2013  
  
 Radarsat-1

The New:

 2007  
  
 TanDEM-X

 2007  
  
 Radarsat-2

 2007  
  
 COSMO-SkyMed

● 2014  


 2014  
  
 Sentinel-1



 2018  
  
 SAOCOM

 2018  
  
 PAZ SAR

The Future:

 2019  
  
 RCM

 2021  
  
 NISAR

 2021  
  
 Biomass

Credit: Franz Meyer,  
University of Alaska

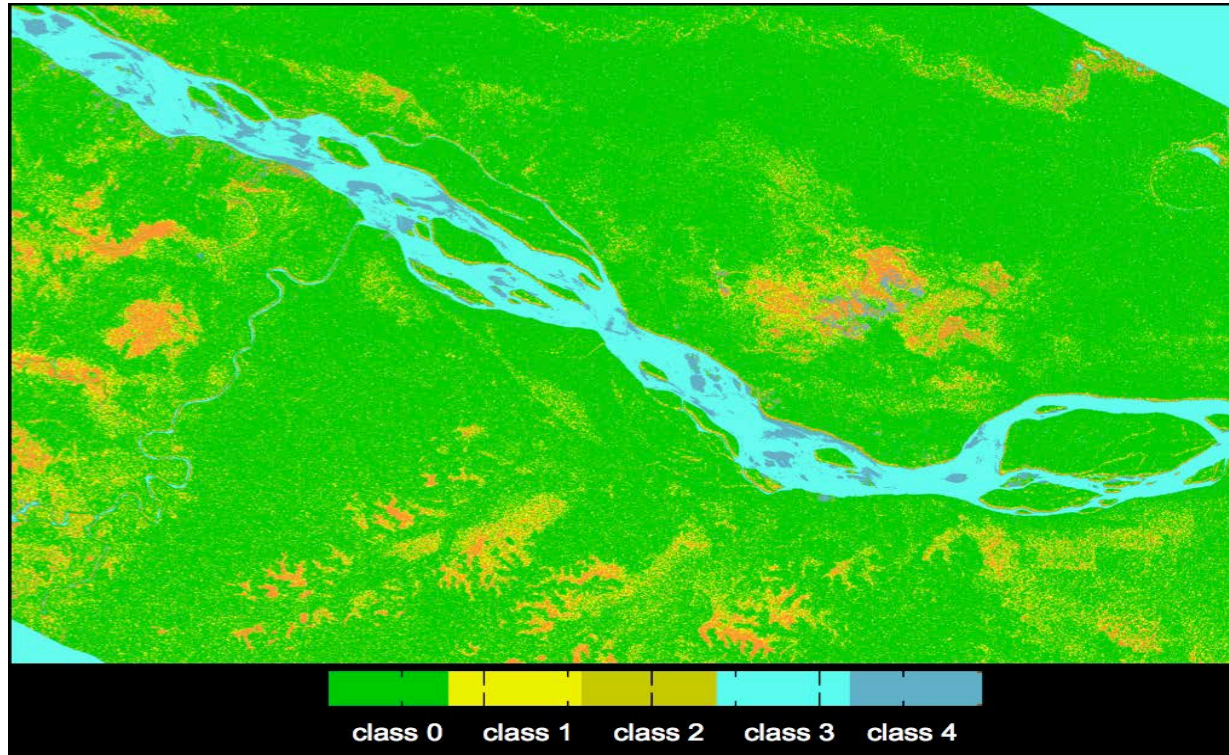


# SAR Applications

1. Wetland Ecosystems
2. Vegetation Studies
3. **Disaster Monitoring**
4. Ground Subsidence
5. Cryosphere
6. Oceans
7. Urban Area/Infrastructure Change

Unlike optical sensors, such as MODIS and VIIRS, microwave SAR can see through clouds!

## Classification Based on SAR Observables



**Green:** not inundated  
**Yellow & Orange:** inundated vegetation  
**Blue** (light & dark): open water



# Sentinel 1 SAR Image Processing

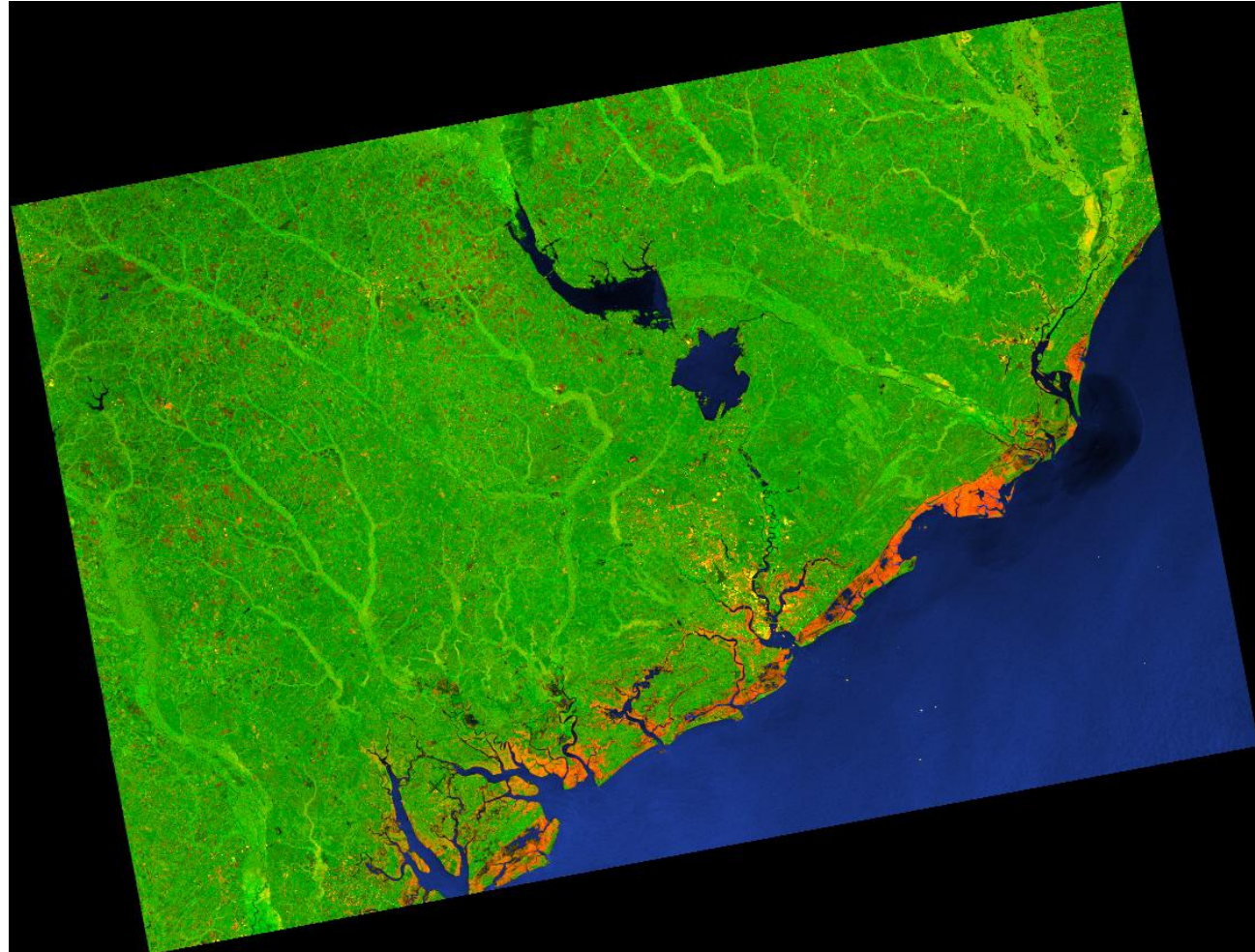
- Sentinel-1 SAR data are available from:
  - <https://vertex.daac.asf.alaska.edu/>
- Sentinel-1 SAR data can be processed by using Sentinel-1 Application Toolbox (SNAP)
- SNAP is an open source toolbox and can be downloaded from:
  - <http://step.esa.int/main/download/>
- Processing SAR images is complex and requires advanced training
- For more information see
  - <https://arset.gsfc.nasa.gov/disasters/webinars/intro-SAR>

ARSET hosted an advanced webinar on SAR data and applications in July 2018



# Sentinel 1 SAR Images: Before and After Hurricane Matthew

## Inundation in Coastal North Carolina



# Sentinel-1 Preprocessing on Google Earth Engine

- Google Earth Engine uses the following preprocessing steps (as implemented by the [Sentinel-1 Toolbox](#)) to derive the backscatter coefficient in each pixel:
- **Apply orbit file**
  - Updates orbit metadata with a [restituted orbit file](#).
- **GRD border noise removal**
  - Removes low intensity noise and invalid data on scene edges. (As of January 12, 2018)
- **Thermal noise removal**
  - Removes additive noise in sub-swaths to help reduce discontinuities between sub-swaths for scenes in multi-swath acquisition modes. (This operation cannot be applied to images produced before July 2015)
- **Radiometric calibration**
  - Computes backscatter intensity using sensor calibration parameters in the GRD metadata.
- **Terrain correction** (orthorectification)
  - Converts data from ground range geometry, which does not take terrain into account, to  $\sigma^{\circ}$  using the [SRTM 30 meter DEM](#) or the [ASTER DEM](#) for high latitudes (greater than  $60^{\circ}$  or less than  $-60^{\circ}$ ).





# Google Earth Engine for Classifying Flood Extent with Sentinel-1

```
new_flooding * Get Link Save Run Reset ⋮ ⚙️
1 // Load Sentinel-1 images to map a flooding in Kerala in 2018.
2 // This script was originally written by Simon Ilyushchenko (GEE team)
3 // Default location
4 var geometry = /* color: #d63000 */ee.Geometry.Point([76.40, 9.53]);
5 var pt = geometry
6
7 // Load Sentinel-1 C-band SAR Ground Range collection (log scaling, VV co-polar)
8 var collection = ee.ImageCollection('COPERNICUS/S1_GRD').filterBounds(pt)
9 .filter(ee.Filter.listContains('transmitterReceiverPolarisation', 'VH'))
10 .filter(ee.Filter.eq('instrumentMode', 'IW'))
11 .filter(ee.Filter.eq('orbitProperties_pass', 'DESCENDING'))
12 .select('VH');
13
14 // Filter by date
15 var before = collection.filterDate('2018-07-04', '2018-07-06').mosaic();
16 var after = collection.filterDate('2018-08-21', '2018-08-23').mosaic();
17
18 // Threshold smoothed radar intensities to identify "flooded" areas.
19 var SMOOTHING_RADIUS = 100;
20 var DIFF_UPPER_THRESHOLD = -3;
21 var diff_smoothed = after.focal_median(SMOOTHING_RADIUS, 'circle', 'meters')
22 .subtract(before.focal_median(SMOOTHING_RADIUS, 'circle', 'meters'));
23 var diff_thresholded = diff_smoothed.lt(DIFF_UPPER_THRESHOLD);
24
25 // Display map
26 Map.centerObject(pt, 13);
27 Map.addLayer(before, {min:-30,max:0}, 'Before flood');
28 Map.addLayer(after, {min:-30,max:0}, 'After flood');
29 Map.addLayer(after.subtract(before), {min:-10,max:10}, 'After - before', 0);
30 Map.addLayer(diff_smoothed, {min:-10,max:10}, 'diff smoothed', 0);
31 Map.addLayer(diff_thresholded.updateMask(diff_thresholded),
32 {palette:"0000FF"}, 'flooded areas - blue', 1);
33
```



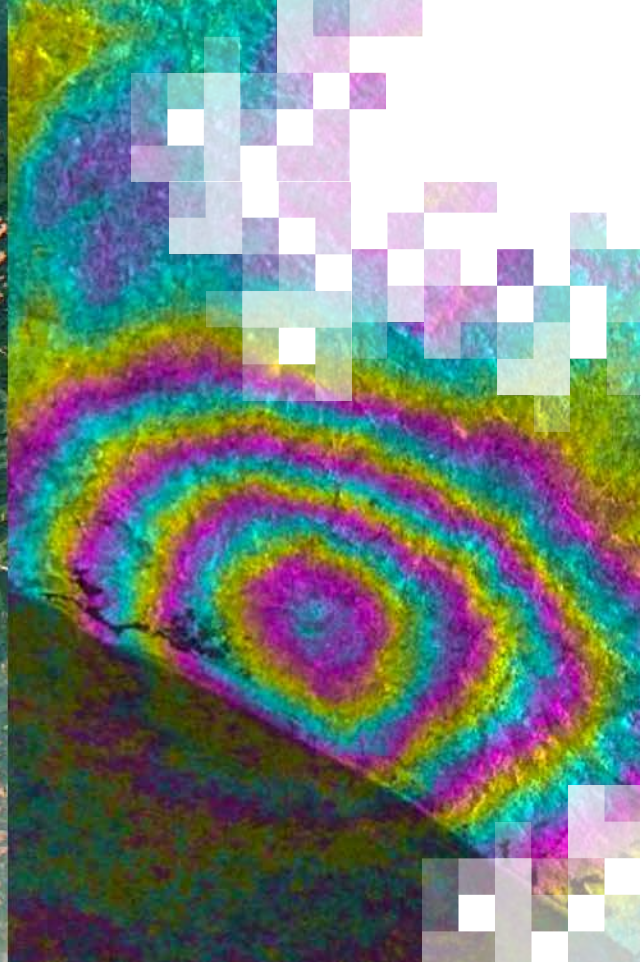
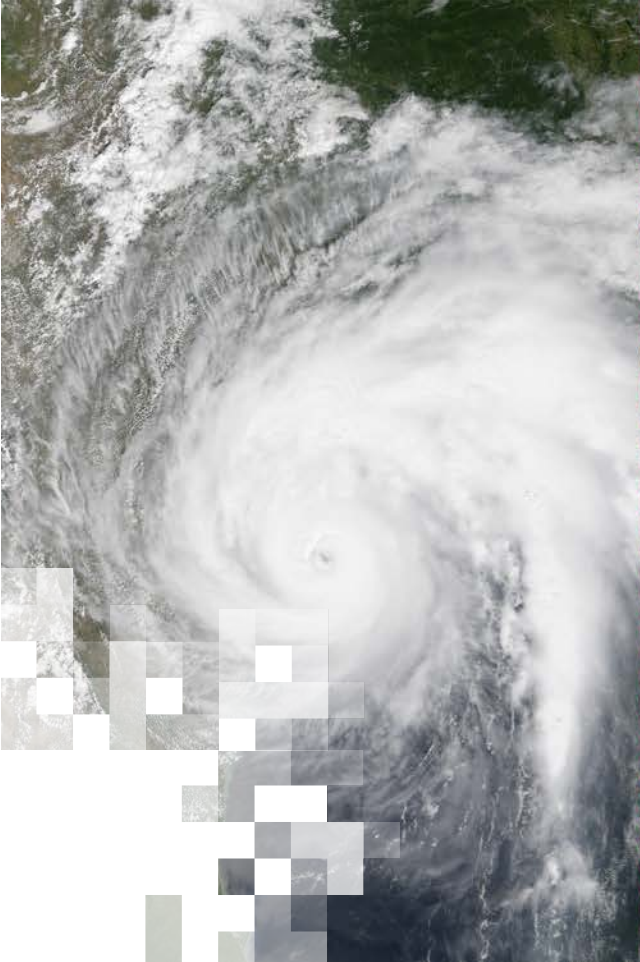
# Flood Mapping Results

The screenshot displays the Google Earth Engine (GEE) interface. On the left, the 'Scripts' panel shows a folder structure under 'users/erikap/sentinel\_kerala' containing 'Kerala\_Sentinel', 'Sentinel1 Composite', 'UntitledFile', 'UntitledFile2', and 'new\_flooding'. The 'new\_flooding' script is selected. The main panel shows the script code:

```
1 // Load Sentinel-1 images to map a flooding in Kerala in 2018.
2 // This script was originally written by Simon Ilyushchenko (GEE team)
3 // Default location
4 var geometry = /* color: #d63000 */ ee.Geometry.Point([76.40, 9.53]);
5 var pt = geometry
6
7 // Load Sentinel-1 C-band SAR Ground Range collection (log scaling, VV co-polar)
8 var collection = ee.ImageCollection('COPERNICUS/S1_GRD').filterBounds(pt)
9 .filter(ee.Filter.listContains('transmitterReceiverPolarisation', 'VH'))
10 .filter(ee.Filter.eq('instrumentMode', 'IW'))
11 .filter(ee.Filter.eq('orbitProperties_pass', 'DESCENDING'))
12 .select('VH');
13
14 // Filter by date
```

The map view shows a grayscale SAR image of a coastal region. A large black area on the left represents the ocean. The land area is shown in shades of gray, with blue highlights indicating flooded regions. The map includes labels for 'Alappuzha' and 'Changanassery'.

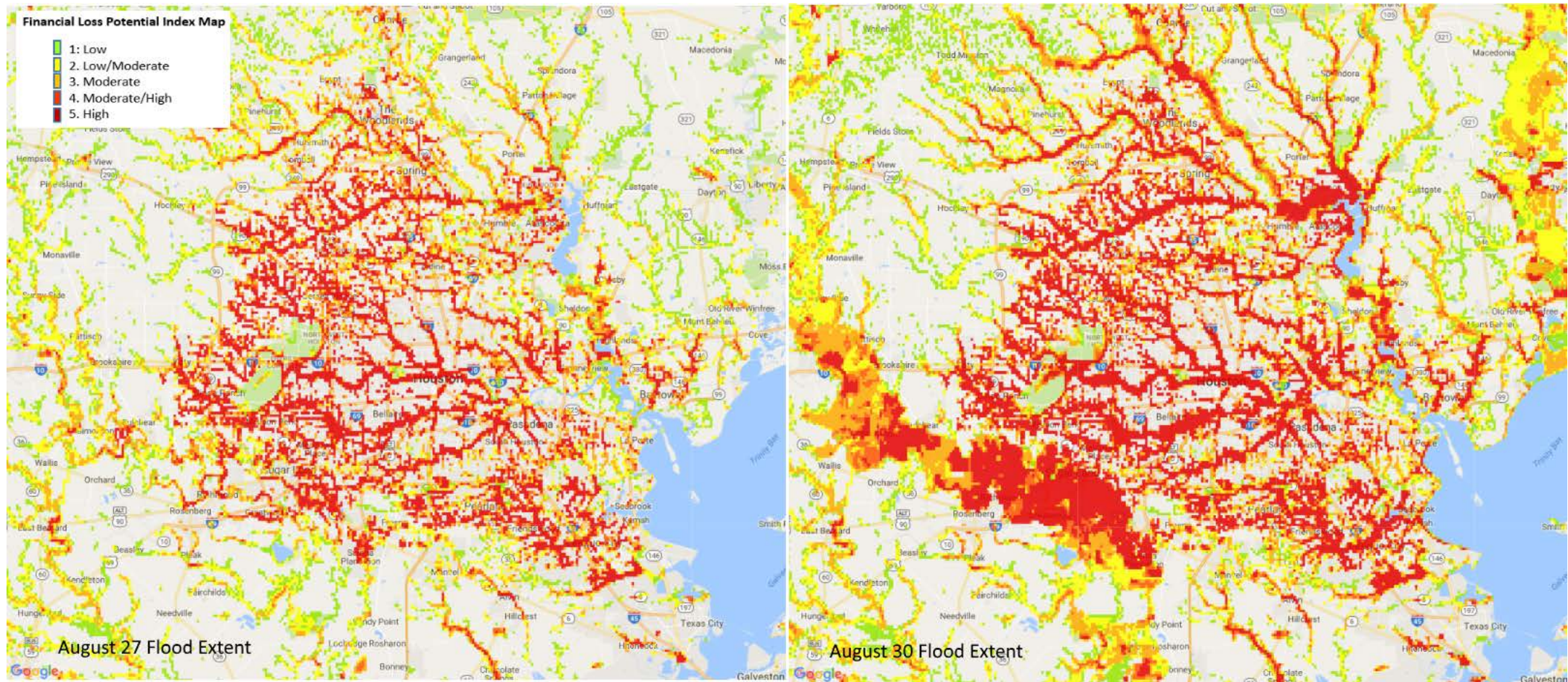




Financial Loss

# Financial Loss Potential Index for Hurricane Harvey, Sept. 1<sup>st</sup> 2017

<https://disasters.nasa.gov/hurricane-harvey-2017/financial-loss-potential-index-hurricane-harvey-v3-sept-1st-2017>



# Global Disaster Alert and Coordination System

<http://www.gdacs.org/>

## Integrated Data and Information Portal

Includes:

- Near real-time and past storm information
- Data and maps from models and satellites
- Media reports and impacts

GDACS  
Global Disaster Alert and Coordination System

GDACS is a cooperation framework between the United Nations, the European Commission and disaster managers worldwide to improve alerts, information exchange and coordination in the first phase after major sudden-onset disasters.

contact us register

HOME ALERTS VIRTUAL OSOCC MAPS & SATELLITE IMAGERY SCIENCE PORTAL ABOUT GDACS

Latest news **ar Coast Of Central Chile** **Tropical Cyclones KENI-18** Im

Map of disaster alerts in the past 4 days. Last 24 hours events are highlighted in yellow. Small earthquakes are shown as green boxes. European Union, 2015. Map produced by EC-JRC. The boundaries and the names shown on this map do not imply official endorsement or acceptance by the European Union.

**EARTHQUAKES**

- Near Coast Of Central Chile** (6.2M) - 10 Apr 10:19
- South Georgia and the South Sandwich

**TROPICAL CYCLONES**

- KENI-18** (139km/h) - 11 Apr 00:00

**FLOODS**

- Fiji|Tonga|Vanuatu - 09 Apr 00:00



# International Charter Space & Major Disasters

- Worldwide collaboration making satellite data available for disaster management
- Composed of global space agencies & space system operators
- 34 contributing satellites
- Available at: <https://disasterscharter.org/>

