

An Overview of Earth Observation Data for Disaster Applications from a NASA Perspective

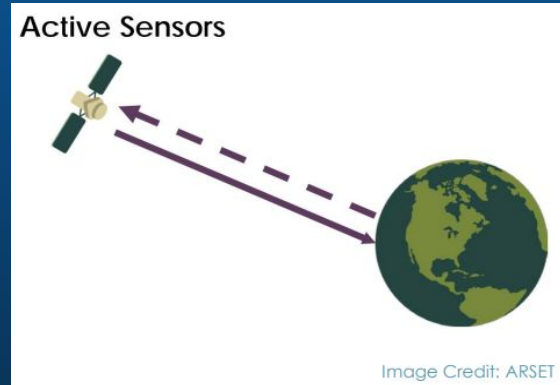
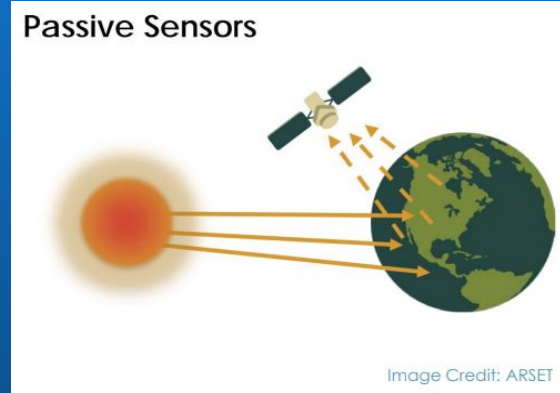
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Ronan Lucey



Types of Remote Sensing

- There are two main types of remote sensing used in Earth Observations:
 - **Passive** instruments rely on energy emitted or reflected from other sources (e.g. the Sun or the Earth) to generate their measurements.
 - **Active** remote sensing instruments emit their own energy and measure what is reflected back.



Passive Remote Sensing

- Optical and thermal imagery are prevalent examples of passive remote sensing
 - **Optical** sensors: Moderate-Resolution Imaging Spectroradiometer (MODIS) [Terra and Aqua], Visible Infrared Imaging Radiometer Suite (VIIRS) [Suomi NPP], Operational Land Imager (OLI) [Landsat 8/9]
 - **Thermal** sensors: Thermal Infrared Sensor (TIRS) [Landsat 8/9], Advanced Baseline Imager (ABI) [GOES-16/17]
- Other examples of passive instruments:
 - Lightning Imaging Sensor (LIS) [ISS]
 - Global Precipitation Measurement Microwave Imager (GMI) [GPM]
 - Tropospheric Emissions: Monitoring Pollution (TEMPO)

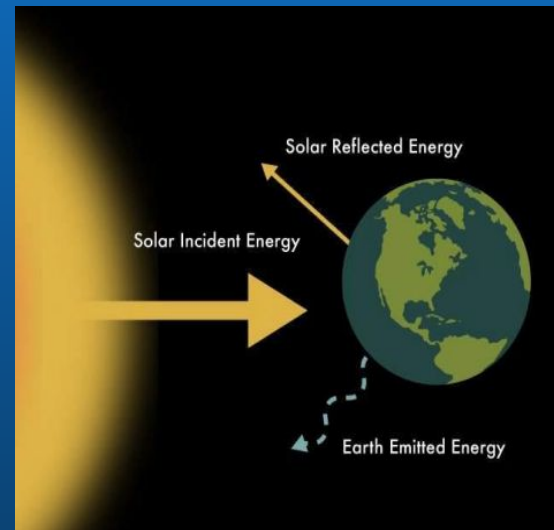


Image Credit: NASA ARSET

Passive Remote Sensing Example

- Optical imagery allows us to take advantage of the spectral signature of energy reflected off of Earth's surface by different types of land cover
 - Available during daylight hours only, can be impacted by cloud cover
- Both water and soil have low reflectance in the visible part of the EM spectrum, but water reflects even less in the near-IR wavelengths

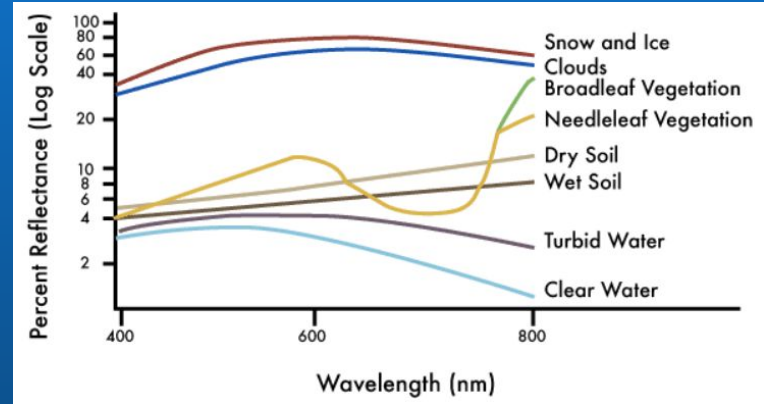


Image Credit: NASA ARSET



R-G-B Composite



NIR-G-B Composite

Image Credit: Planet Labs

Active Remote Sensing

- Common types are Radar (microwave) and Lidar (optical)
 - Synthetic Aperture Radar (SAR)** sensors:
ESA/Copernicus Sentinel-1 (C-band), CSP RADARSAT-2 (C-band), JAXA ALOS-2 (L-band)
 - Lidar** sensors: Global Ecosystem Dynamics Investigation (GEDI) [ISS], Advanced Topographic Laser Altimeter System (ATLAS) [ICESat-2]
- Active instruments can operate day or night, and SAR can penetrate cloud cover (depending on sensor wavelength)

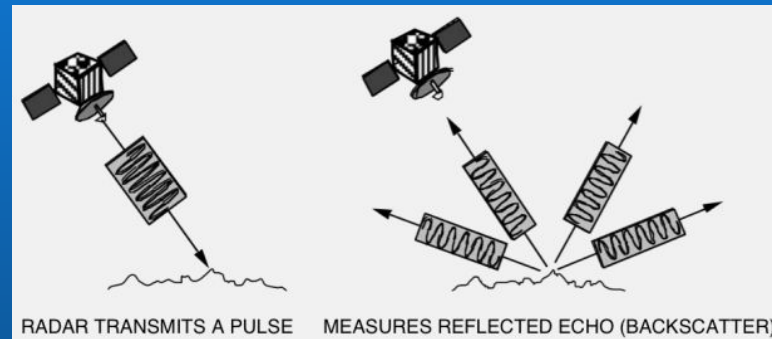
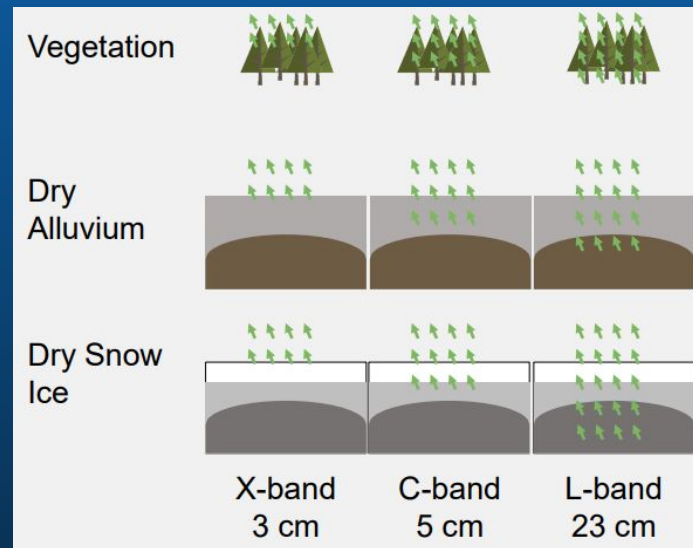
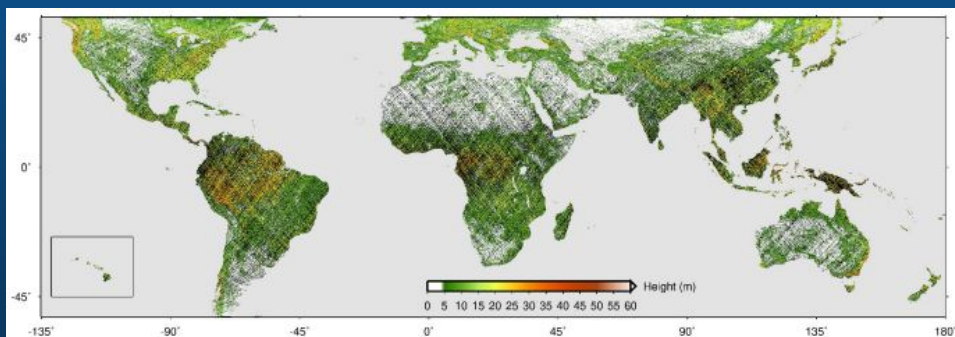


Image Credits: NASA ARSET



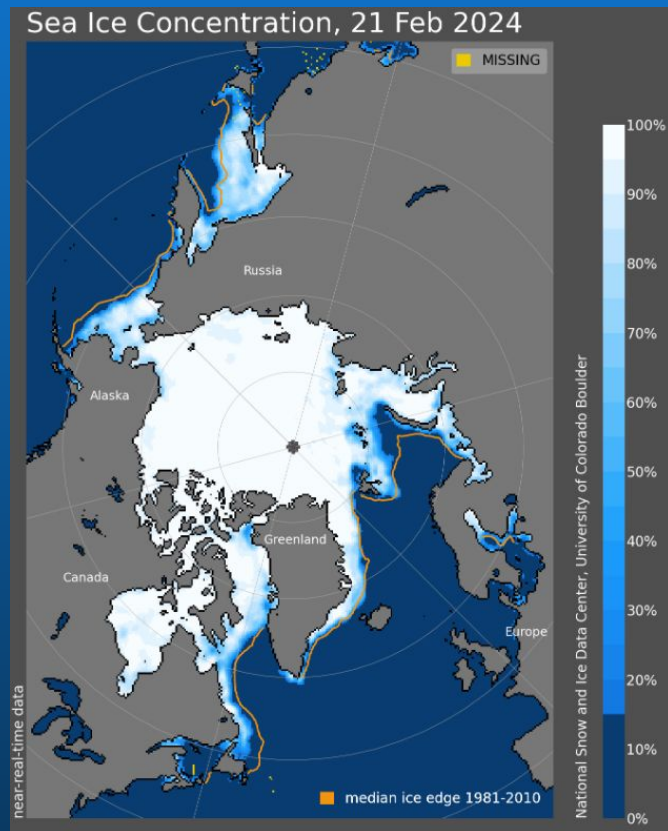
Active Remote Sensing Example

- Lidar instruments measure ground elevation by sending a pulse of light to the ground and recording how long it takes to return.
- Useful for monitoring vegetative cover, thickness of land and sea ice sheets, mapping topography, etc.



GEDI Canopy Heights (2019)

Image Credit: NASA ARSET





EARTH FLEET

INVEST/CUBESATS

- NACHOS 2022
- CTIM 2022
- NACHOS-2 2022
- MURI-FD 2023
- SNOOPi* 2024
- HYTI* 2024
- ARGOS* 2024

JPSS INSTRUMENTS

- OMPS-LIMB 2022
- LIBERA 2027
- OMPS-LIMB 2027
- OMPS-LIMB 2032

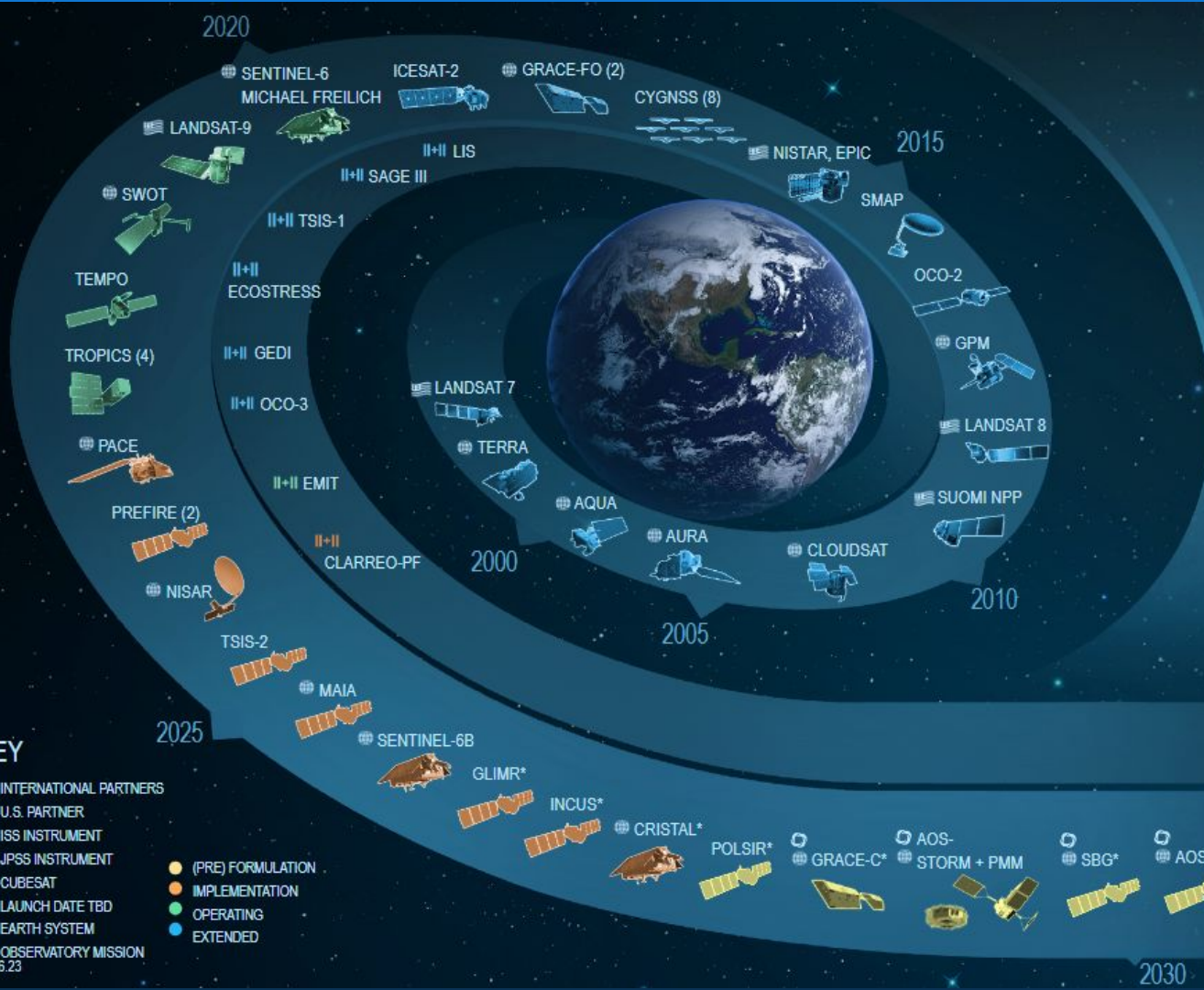
ISS INSTRUMENTS

MISSIONS

KEY

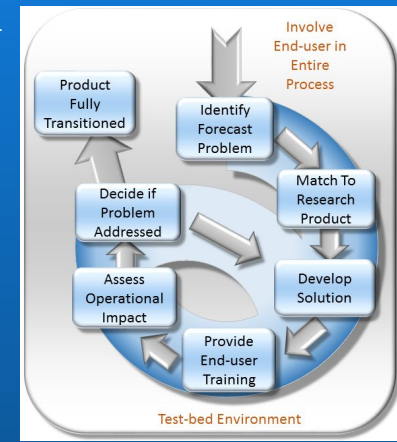
- INTERNATIONAL PARTNERS
- U.S. PARTNER
- ISS INSTRUMENT
- JPSS INSTRUMENT
- CUBESAT
- LAUNCH DATE TBD
- EARTH SYSTEM
- OBSERVATORY MISSION

- (PRE) FORMULATION
- IMPLEMENTATION
- OPERATING
- EXTENDED



Disaster Applications using EO data

EO can inform decisions before, during, and after a disaster occurs



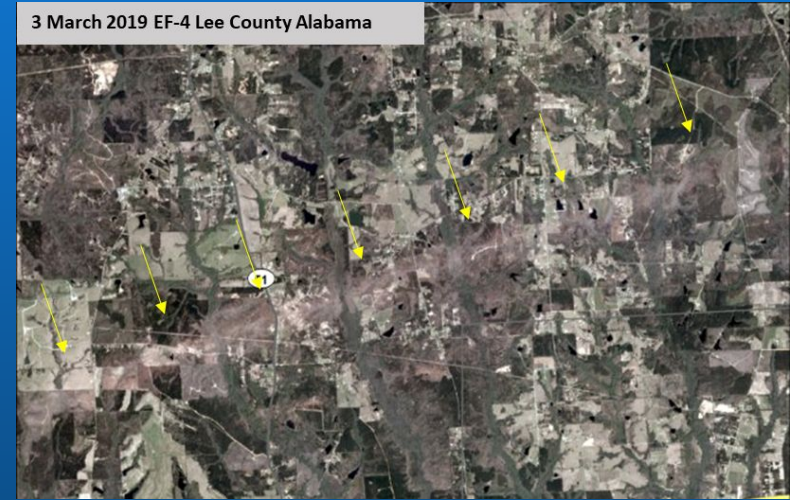
Lots of disaster applications using EO data are derived from questions from decision makers and end users, which lead to research activities and then a transition of the research to operational use

Q: What are some benefits of using EO data for disaster applications?

Non-exhaustive list: Complement land-based measurements, answer questions where in situ data is unavailable, data can be acquired free and EO data is becoming increasingly accessible, provides situational awareness or early warning, efficiency vs. on the ground surveying, increasing number of EO sensors and satellites to utilize, low barrier of entry (especially if a decision maker is working with a EO scientist or applications expert)

Application Example - Tornado

Right: The NASA CSDA program allows the Disasters team and our partners at NWS offices to leverage high resolution commercial data from Planet Labs to finalize tornado tracks after ground surveys have been completed.

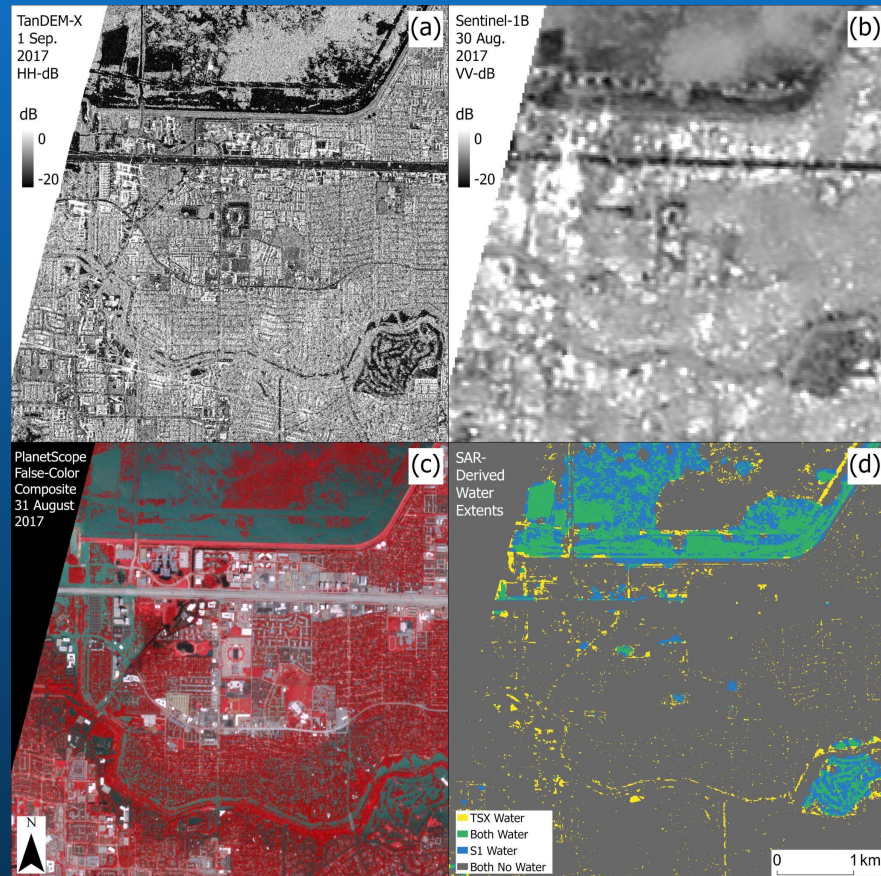


Left: Research is ongoing toward identifying tornado damage tracks with SAR using changes in backscatter. A linear feature can be seen in the C-band Sentinel-1 scene (top) which correlates with damage indicators from NWS ground surveys (bottom).



Application Example - Flooding

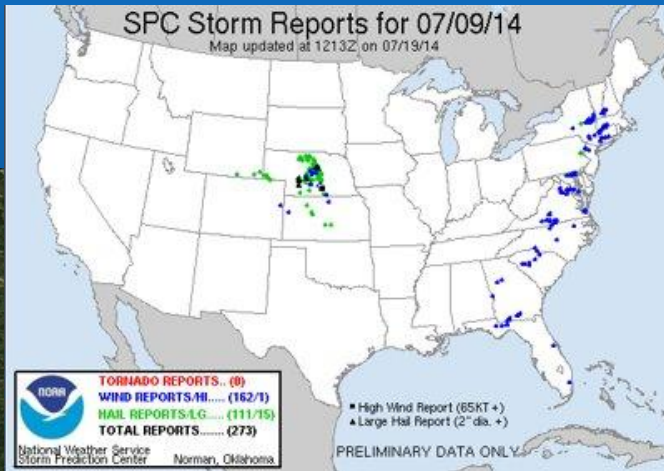
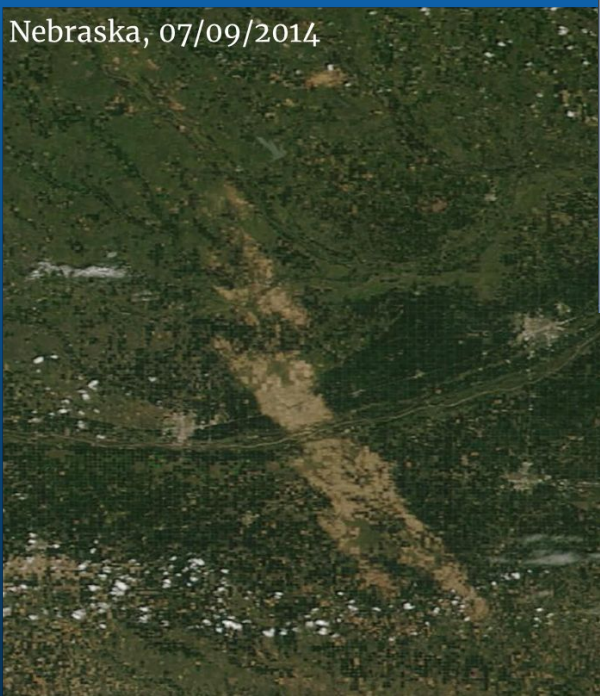
- The CSDA program also allows us to analyze and compare the performance of different SAR band wavelengths for mapping flood extent.
- In this example, water maps are derived from X-band TanDEM-X (Airbus) and C-band Sentinel-1 (ESA/Copernicus) using identical methods to examine the influence of wavelength and spatial resolution on flood mapping accuracy.



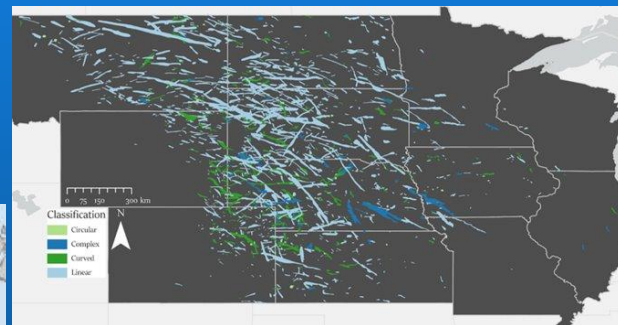
Application Example - Hail

Below: NASA MODIS True Color Image, notable hail scar in center of image.

Nebraska, 07/09/2014

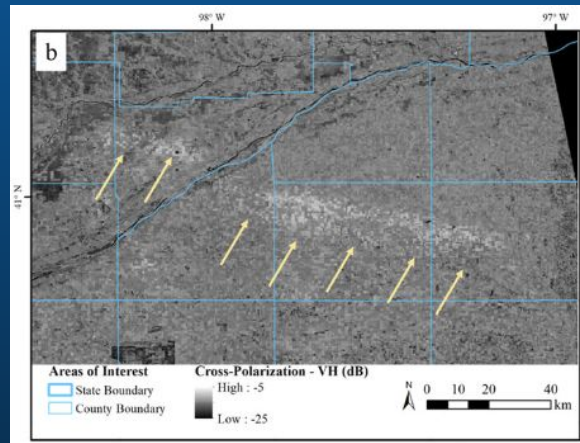


Above: NWS SPC Storm Reports from the same day as the true color image on the left was taken. Note the hail reports in central Nebraska.

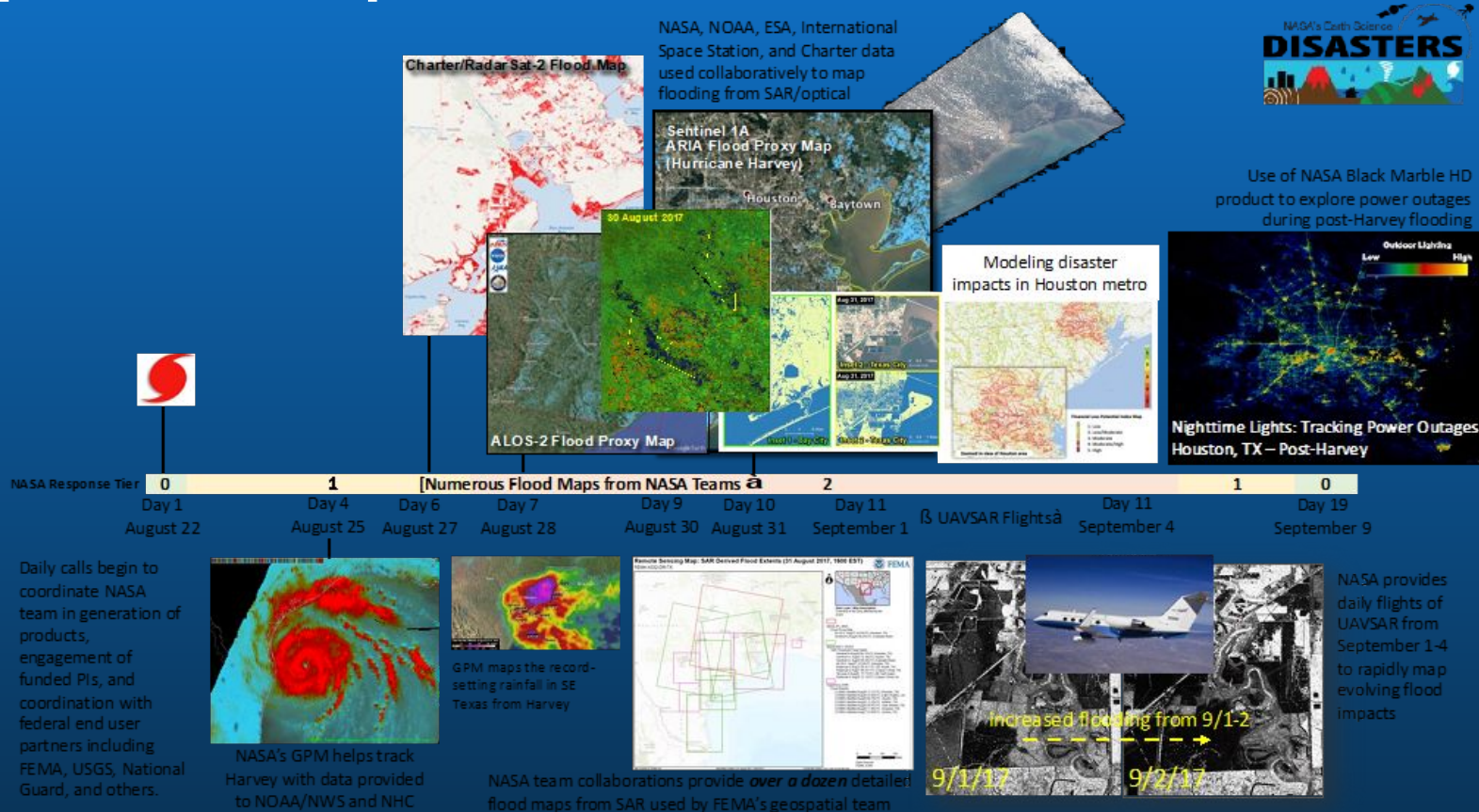


Map of confirmed hail and wind damage swaths between 2000-2020 classified by the shape of the swath ([Bell et al. 2023](#))

ESA Sentinel-1 SAR hail damage swath from a 2018 hail event in NE ([Bell et al. 2022](#))



Application Example - Hurricane Harvey



Where can I find NASA Earth Observation data?

data.nasa.gov - NASA's clearinghouse site for open-data provided to the public

[DAACs](#) - 12 centers that process, archive and distribute NASA Earth Observation data

[EarthData](#) - Gateway to NASA Earth Observation Data

[Worldview](#) - Interactively browse & download satellite imagery from 1000+ products

Disaster Specific Data

[NASA Disasters Portal](#) an option for viewing and downloading data

[Esri Living Atlas](#) - maps, applications, and data layers from NASA and beyond

And there are many more places to find NASA EO data!

Accessing and using NASA Earth Observation data

NASA [Transition to Open Science \(TOPS\)](#) - NASA EO data follow FAIR principles

Findable (data identifier, searchable, metadata)

Accessible (retrievable, open & free, public domain license)

Interoperable (data format, metadata has applicable language and references to other data)

Reusable (metadata well described, public domain license, meet community standards)

Lots of resources out there to learn about accessing and using NASA EO data

Tutorials, Trainings ([NASA ARSET](#)), How-To's and more!

What NASA EO data related to disasters is new or coming soon?

[TEMPO](#) - launched April 2023. Improves monitoring of air pollutants across North America by providing hourly UV-visible spectrometer measurements of ozone, nitrogen dioxide, and other pollutants

[TROPICS](#) - launched May 2023. Improves forecasting for tropical hurricanes and cyclones by providing rapid-refresh microwave measurements over the tropics

[PACE](#) - launched February 2024. Improves our knowledge of the ocean and the interactions between the ocean and atmosphere by providing hyperspectral and polarimetric measurements

[NISAR](#) - expected to launch in 2024. Will improve our understanding of Earth's changing ecosystems, dynamic surfaces, and ice masses by providing L-band and S-band Synthetic Aperture Radar (SAR) measurements, sampling Earth on average every 6 days

[Earth System Observatory](#) - A set of Earth-focused NASA missions (currently in formulation other than the trailblazer mission, NISAR) to provide key information related to aerosols, clouds, convection and precipitation, mass change, surface biology and geology, and surface deformation and change

Other NASA efforts related to Disaster Applications

Commercial Sector - there are an increasing number of commercial companies launching satellites and sensors that provide measurements of our Earth

[NASA Commercial Smallsat Data Acquisition \(CSDA\) Program](#) - identifies, evaluates, and acquires commercial data that supports NASA's Earth Science research and application goals

Increased advocacy for applications in NASA mission formulation: the [NASA Directive on Project Applications Program](#) aims to maximize the benefit of NASA investments by enhancing the applications value and societal benefits of NASA missions (including for disaster applications)

Thank you! Questions?

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