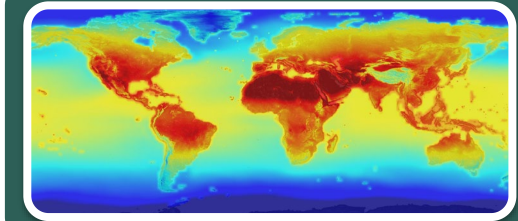
Workshop Agenda

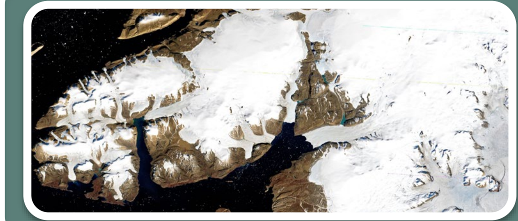


Session I: Introduction to Climate Change

- Overview of climate change
- Monitoring climate change drivers using NASA data

Session II: Earth Observations for Climate Change Impacts (Land & Atmosphere)

- Overview
- Focus Area: Drought
- Focus Area: Urban Heat Islands & Extreme Heat
- Focus Area: Wildfires & Smoke



Session III: Earth Observations for Climate Change Impacts (Ocean & Ice)

- Overview
- Focus Area: Sea Level Rise

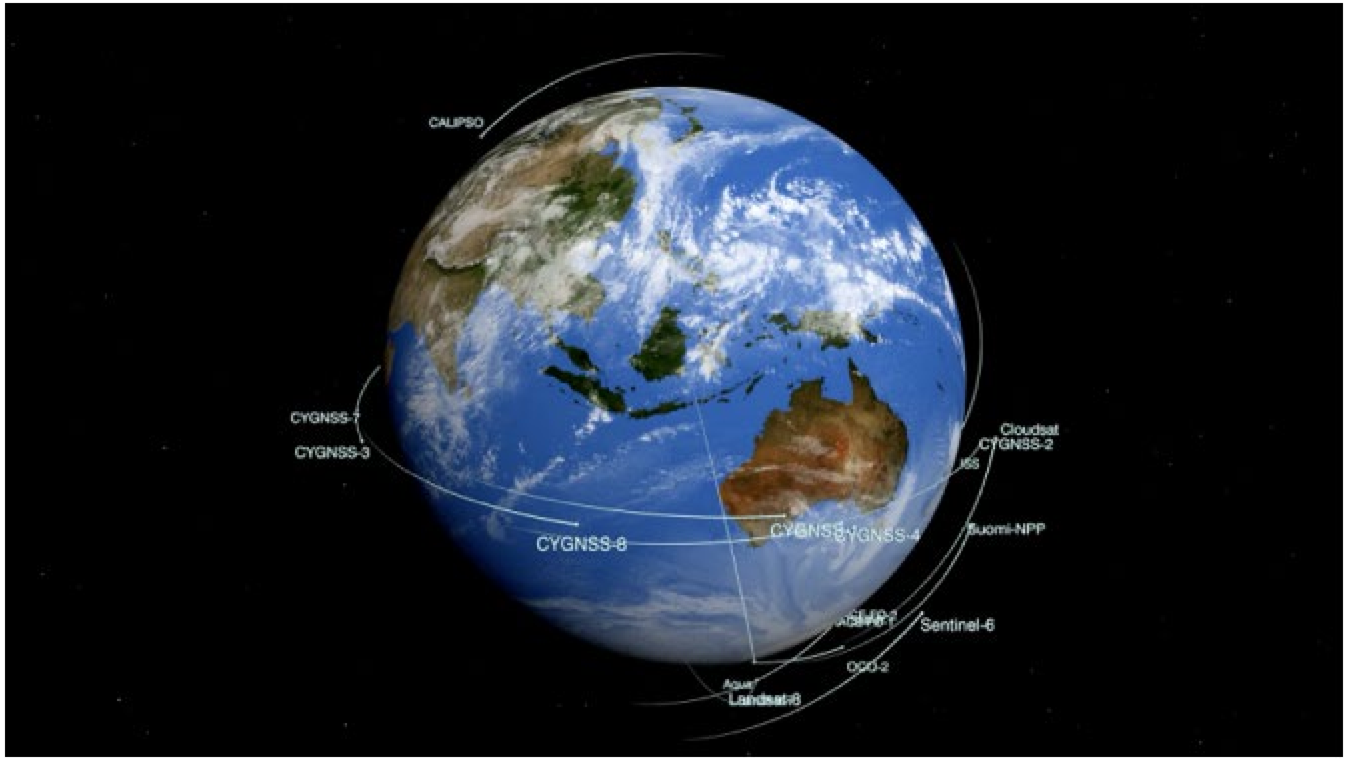
Session IV: Climate Models, Policy & Decision making

- Climate Modeling
- NASA ESO

Session II: Earth Observations for Climate Change Impacts (Land & Atmosphere)

Role of Earth Observations in Climate Change Assessment

- NASA Earth observing satellites observe changes across the entire planet, from the atmosphere, biosphere, hydrosphere, cryosphere, and lithosphere.
- They provide consistent, timely, global, accurate measurements, from the tropics to the polar regions.
- NASA conducts a program of breakthrough research on climate science, enhancing the ability of the international scientific community to advance globally-integrated Earth system science.



NASA’s Earth Observing Fleet (2021). Credit: [NASA's Scientific Visualization Studio]

[https://climate.nasa.gov/nasa_science/history/]

Phenology & Agriculture

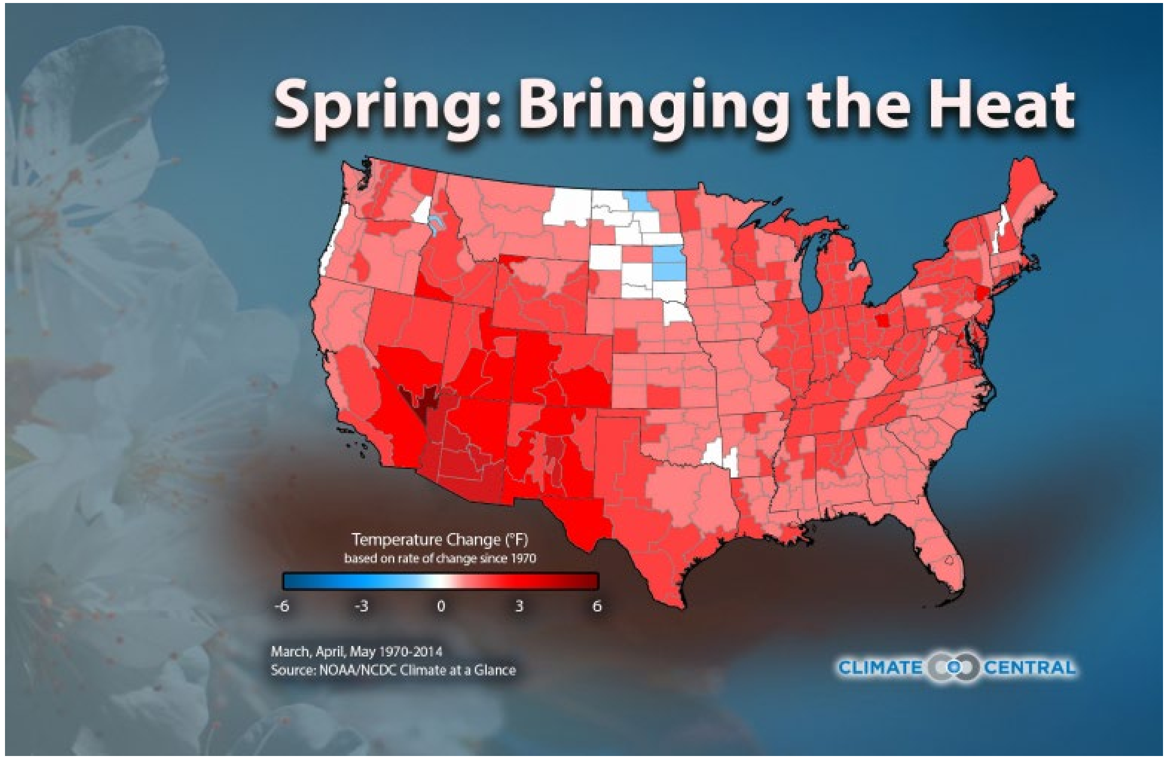
Phenology

- The study of plant and animal life cycles in relation to the seasons.
- Phenological events change from year to year.
- Timing of events (phenophase) such as flowering, leafing, migration, and insect emergence can impact how plants and animals thrive in their environment.

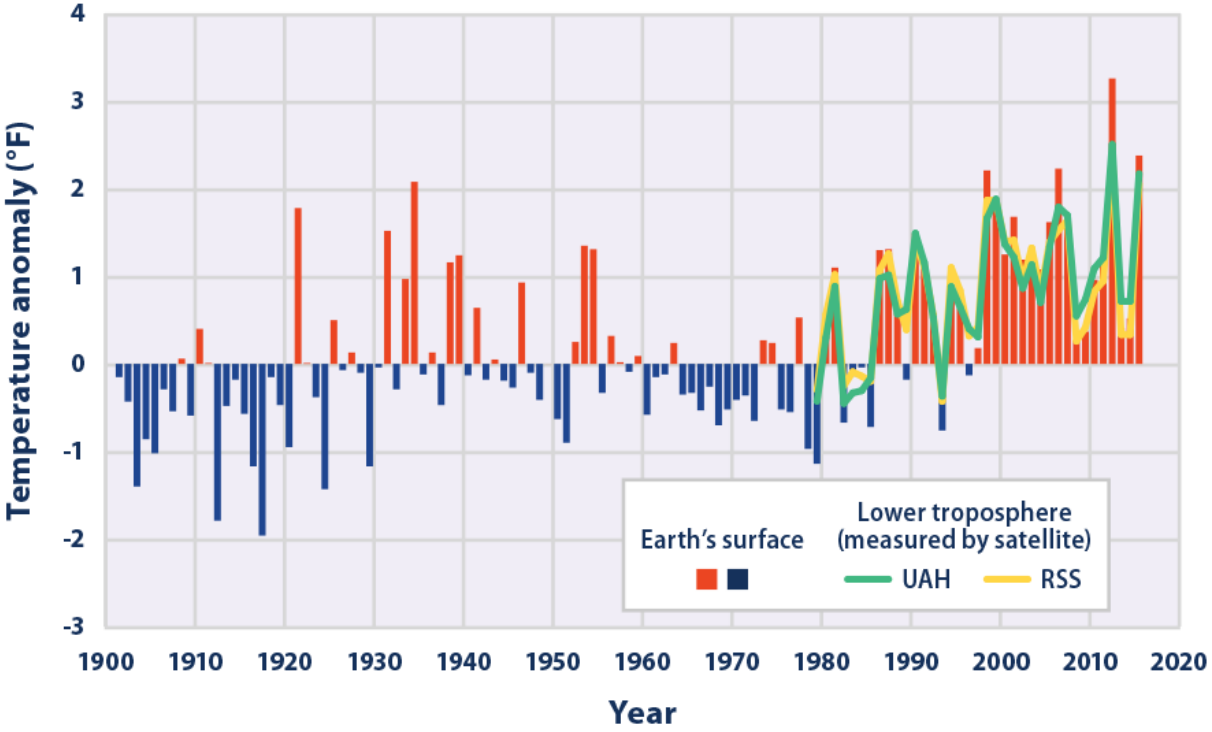
Seasonal cycle of a tree. Image Credit: USGS/NPN)

Drivers of Phenology

Temperature



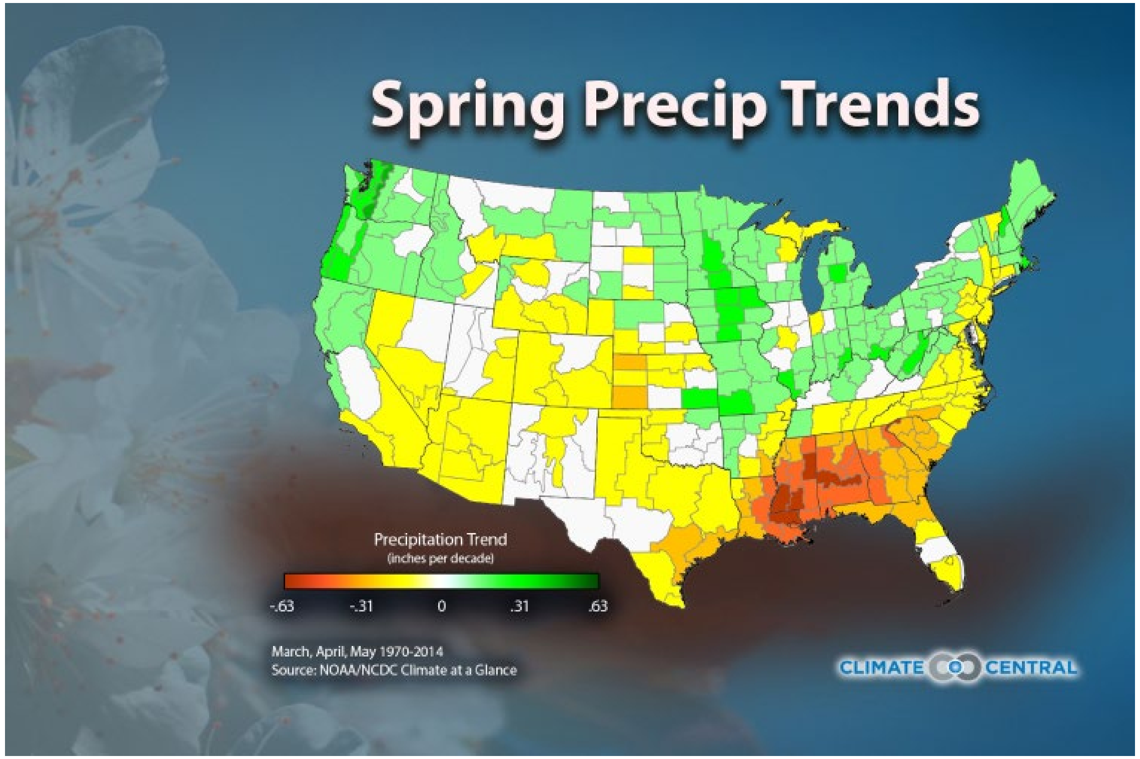
Spring Temperature Change from 1970–2014, Based on Rate of Change from 1970
Image Credit: [Climate Central.]



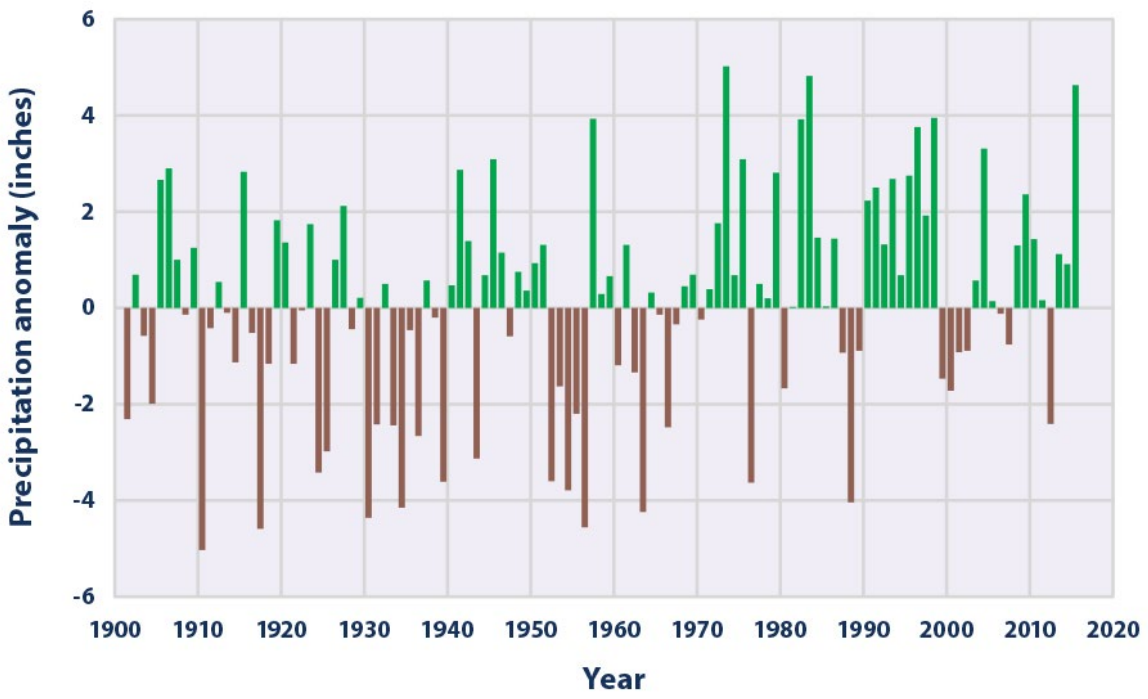
Annual Average Temperatures in the Contiguous 48 States from 1901–2016
Image Credit: [NOAA, 2016].

Drivers of Phenology

Water Availability



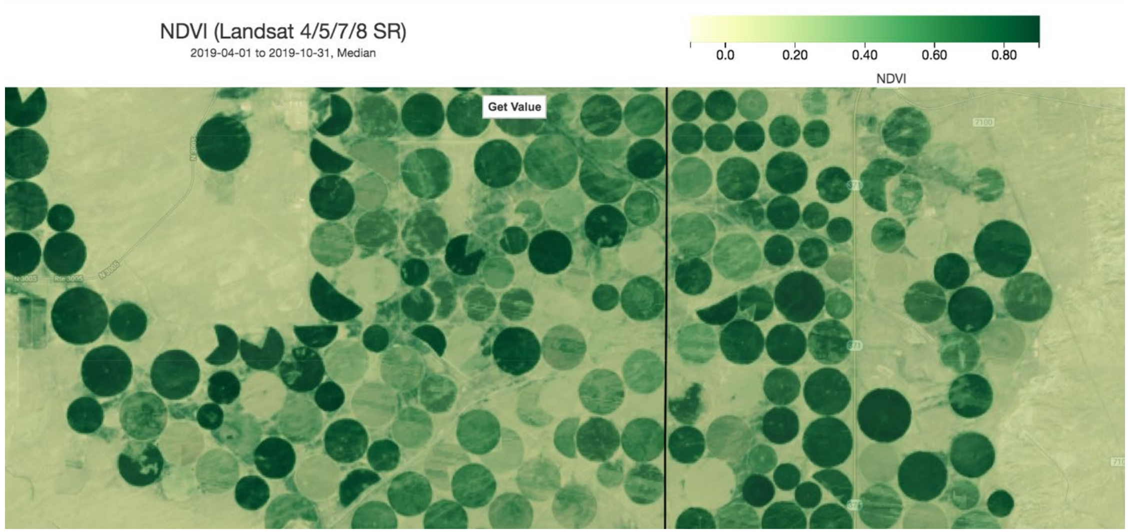
Precipitation Trend in Inches per Decade from 1970–2014
Image Credit: [Climate Central.]



Total Annual Precipitation Anomaly in the Contiguous U.S. from 1901
Image Credit: [NOAA, 2016].

Remote Sensing of Phenology

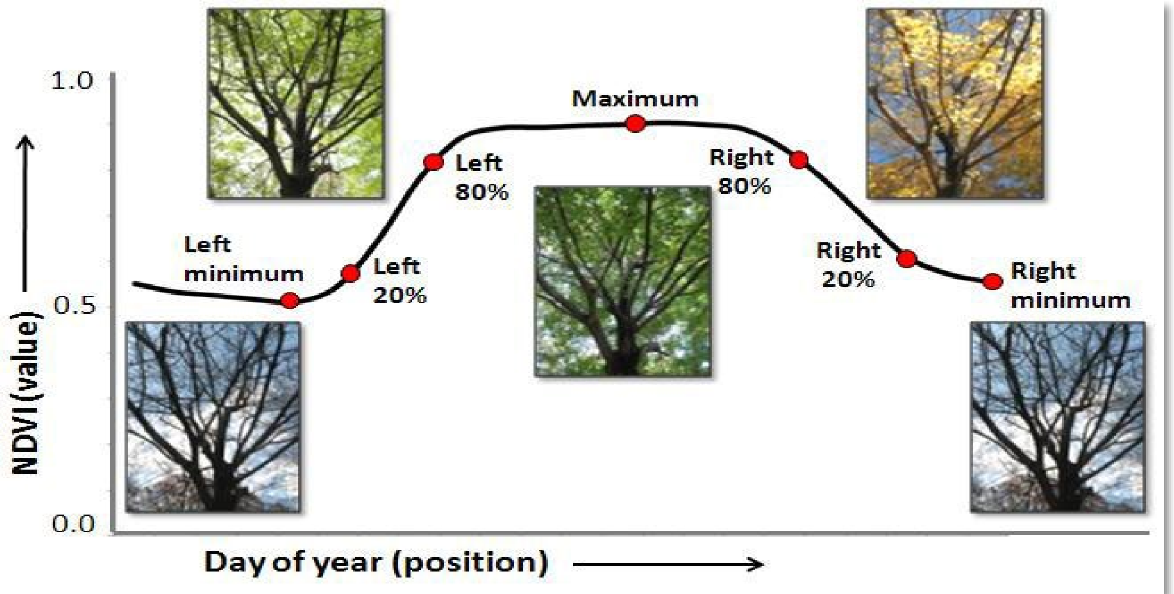
- Use of satellites and sensors to track seasonal patterns of variation in vegetated land surfaces
- **Land Surface Phenology (LSP)**
  - Regular monitoring of the entire global land surface
  - Gather information on entire ecosystems: broad scale trends
- Most useful when linked to ground observation networks
- Uses Include:
  - Crop Health Assessments
  - Drought Severity
  - Wildfire Risks
  - Invasive Species and Pest Tracking
  - Mapping Infectious Disease Risk



Center pivot irrigation with NDVI displayed.
Image Credit: NASA/DRI DSET.

NDVI and Seasonality

- Remote sensing is used to track the seasonal changes in vegetation.
- Monthly NDVI images from MODIS or Landsat can be used to monitor phenology.

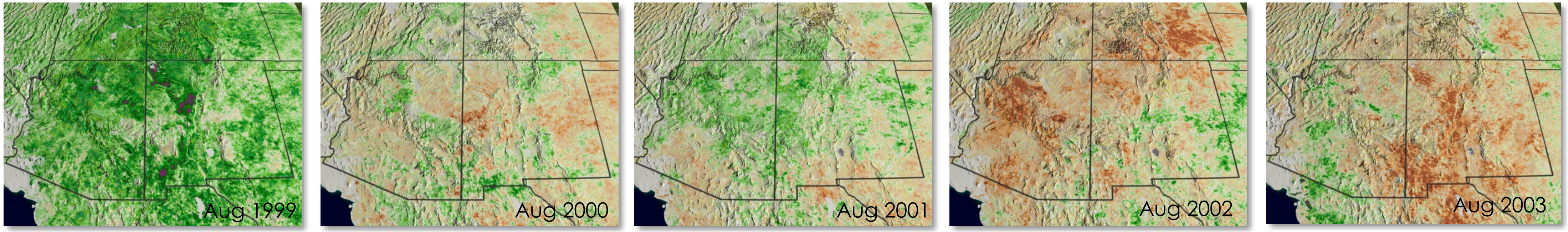


North America NDVI Images in Winter and Summer
Credit: spacegrant.montana.edu

NDVI: Anomalies

- Departure of NDVI from the long-term average, normalized by long-term variability
- Generated by subtracting the long-term mean from the current value for that month of the year for each grid cell
- Indicates if vegetation greenness at a particular location is typical for that period or if the vegetation is more or less green

NDVI Anomalies in the Southwestern United States



Phenological Metrics

- Key variables estimated with remote sensing:
  - Start of Season (SOS)
  - End of Season (EOS)
  - Maximum NDVI
  - Duration
  - Amplitude

Start of Season (SOS) for Kansas, 2018

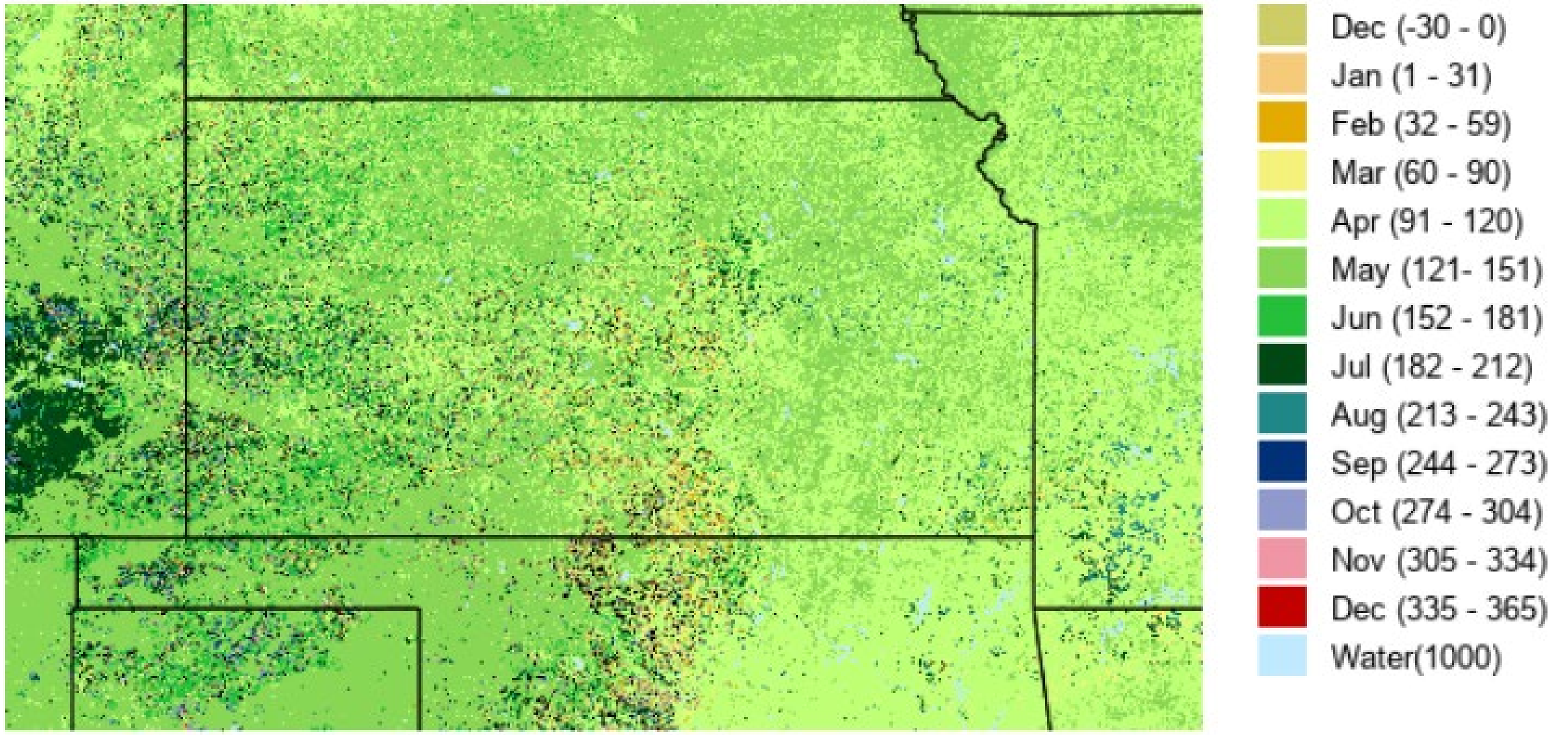


Image Credit: USGS

Start of Season

- **Start of Season Time (SOST)**
  - Day of year identified as having a consistent upward trend in time series NDVI
- **Start of Season NDVI (SOSN)**
  - NDVI value (or baseline) identified at the day of year identified as a consistent upward trend in time series NDVI

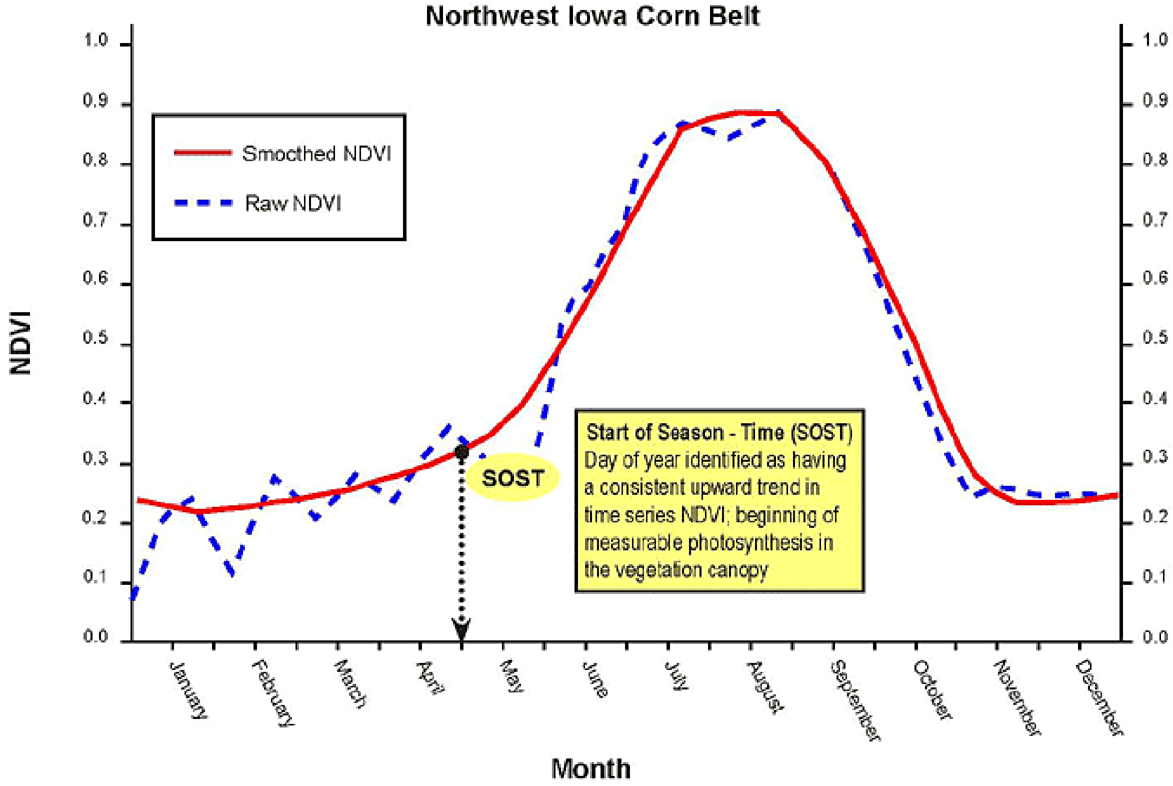


Image Credit: USGS

End of Season

- **End of Season Time (EOST)**
  - Day of year identified at the end of a consistent <u>downward</u> trend in time series NDVI
- **End of Season NDVI (EOSN)**
  - NDVI value corresponding with the day of year identified at the end of a consistent <u>downward</u> trend in time series NDVI

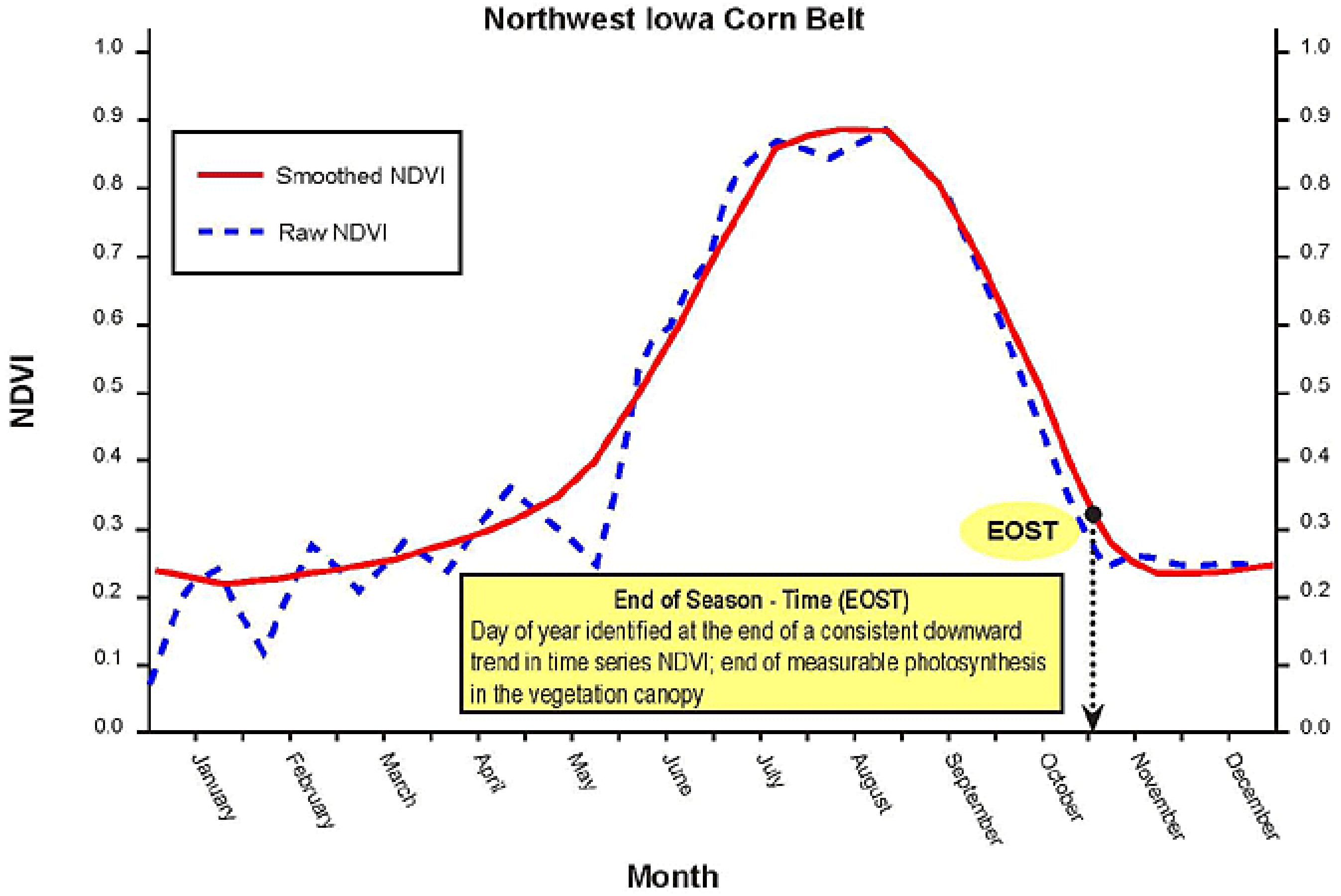


Image Credit: USGS

Max, Duration, Amplitude

- **Maximum NDVI (MAXN)**
  - Maximum NDVI in an annual time series
- **Duration (DUR)**
  - Number of days from the Start of Season Time (SOST) until the End of Season Time (EOST)
- **Amplitude (AMP)**
  - Difference between Maximum NDVI (MAXN) and Start of Season NDVI (SOSN)

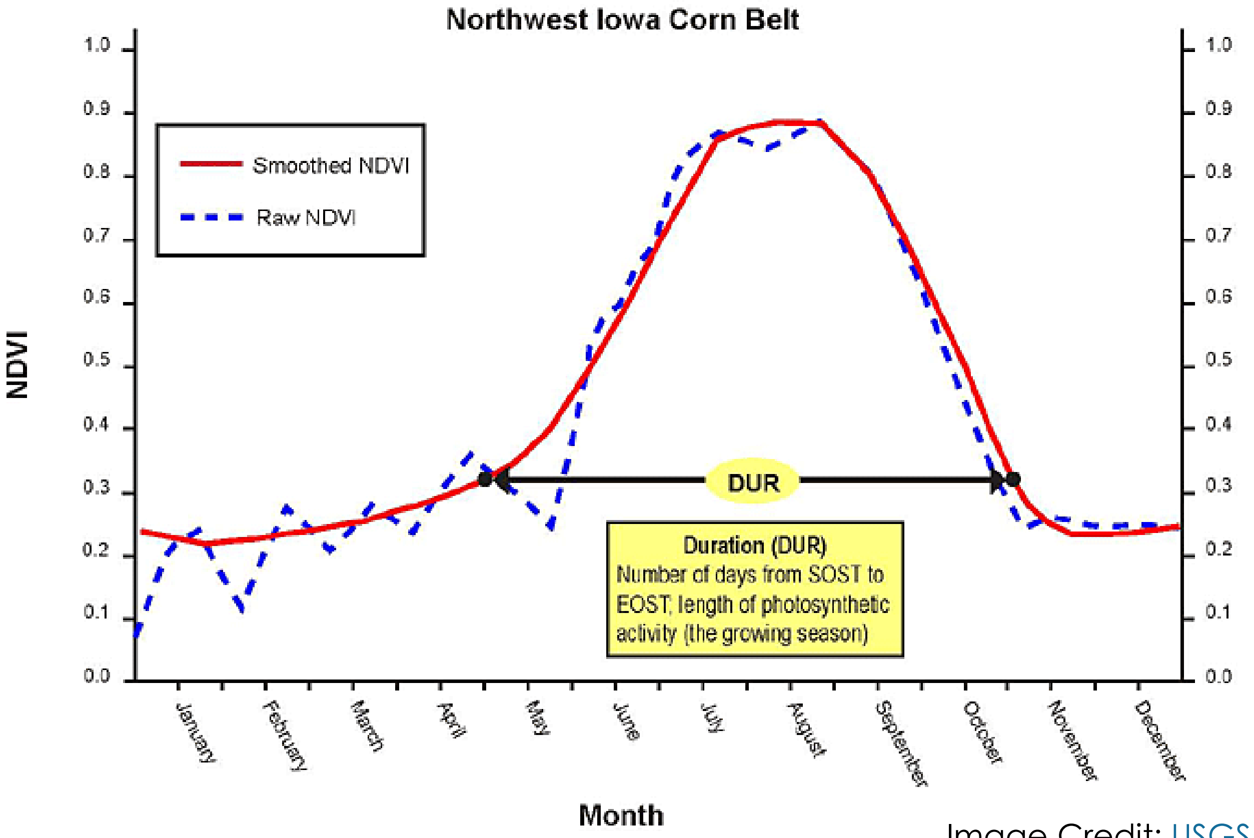


Image Credit: USGS

NPN Overview

https://www.usanpn.org/

Collect • Store • Share
Phenology Data and Information

Advance Science

Inform Decisions

Communicate & Connect

USGS science for a changing world

USA npn National Phenology Network

ARIZONA

NPN Overview

https://www.usanpn.org/

Primary Goal

- ***Create a standardized dataset for use in multiple types of research.***

Mission

- Make phenology data, models, and related information available.
- Encourage people of all ages and backgrounds to observe and record phenology.

UNDERSTAND HOW SPECIES AND LANDSCAPES ARE RESPONDING TO CLIMATE CHANGE.

Photo Credit: C. Enquist

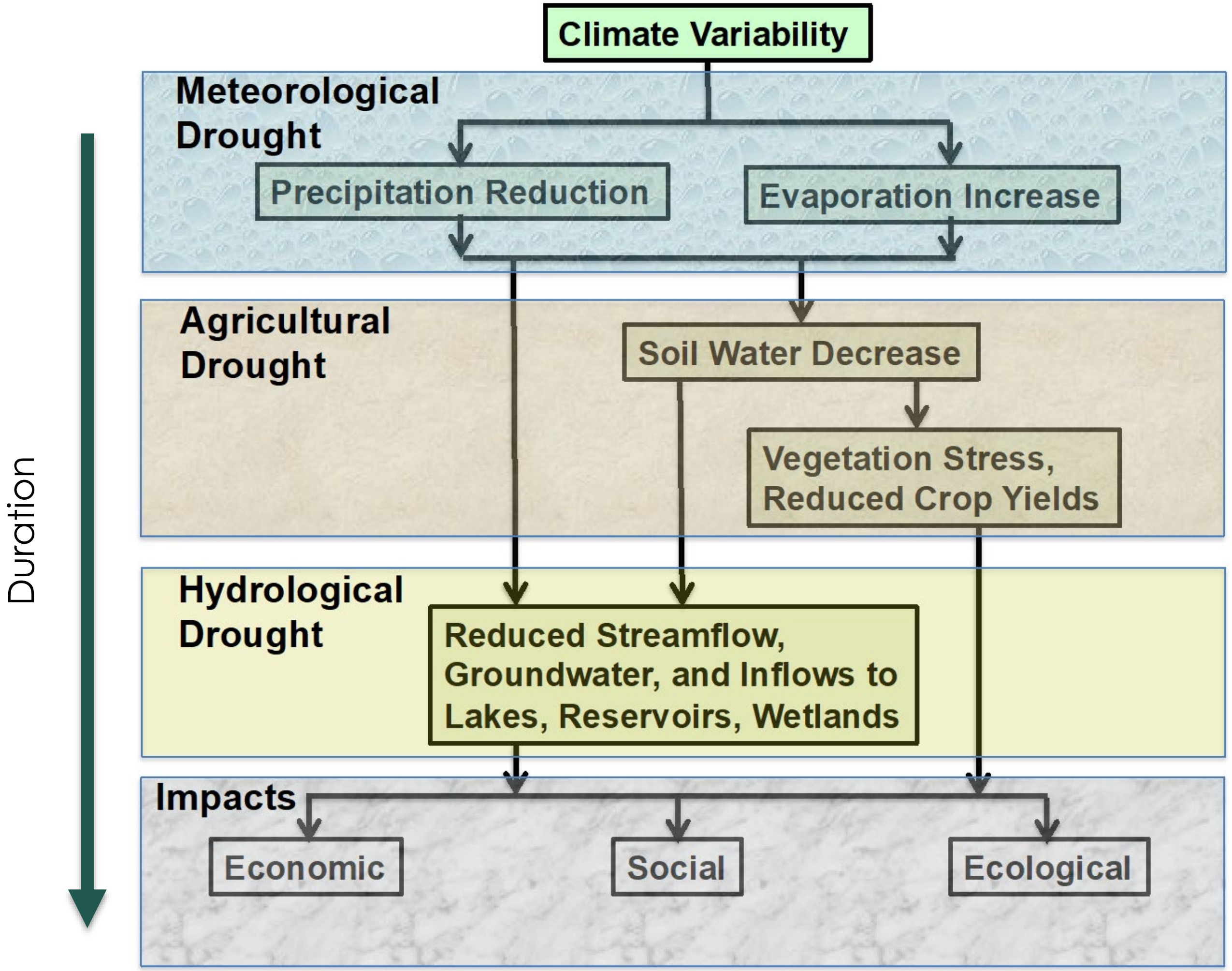
Demo: National Phenology Network

Drought

Types of Droughts

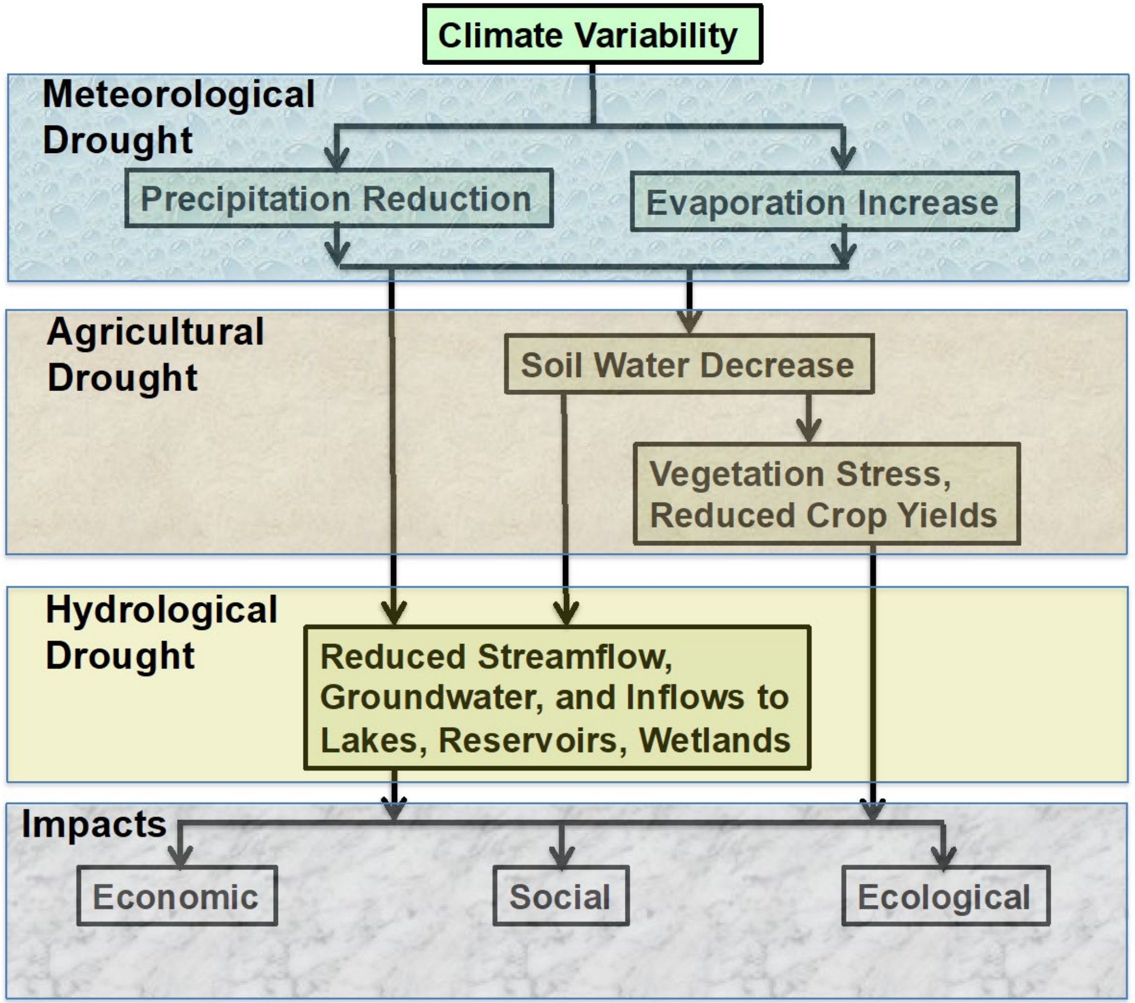
All droughts originate from "below normal" precipitation.

- Meteorological Drought
- Agricultural Drought
- Hydrological Drought
- Socioeconomic Drought



Wilhite, D.A.; and M.H. Glantz. 1985. Understanding the Drought Phenomenon: The Role of Definitions. *Water International* 10(3):111–120
Figure: Mehta, V.M., 2017: Natural Decadal Climate Variability: Societal Impacts. CRC Press, Boca Raton, Florida, 326 pp.

Types of Droughts

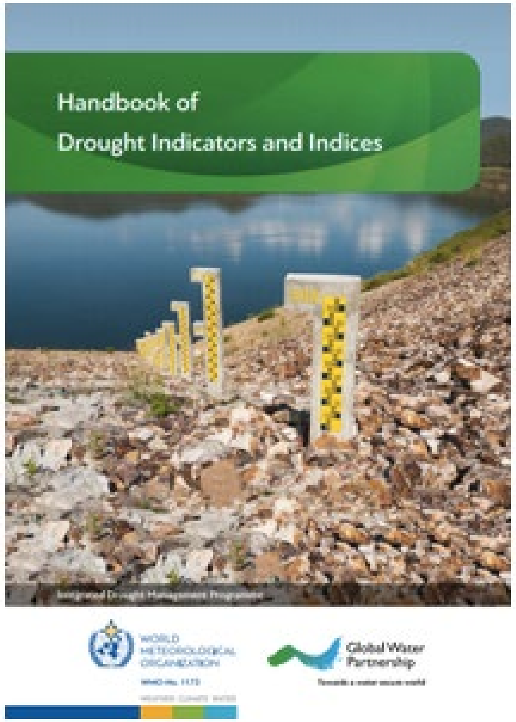


- Meteorological Drought
  - related to degree of dryness compared to 'normal' precipitation
  - region specific and high spatial variability
- Ecological Drought
  - prolonged and widespread deficit in naturally available water supplies that create multiple stresses across ecosystems
- Socioeconomic Drought
  - related to supply and demand
  - affected by agricultural, ecological, and hydrological
  - social and economic changes
- Agricultural Drought
  - related to various conditions like precipitation shortage, evapotranspiration and agricultural impact
- Hydrological Drought
  - related to rainfall and snowfall
  - impact on surface and subsurface water supply
  - affects agricultural drought

Precipitation-Based Drought Indices

- Drought indices are mathematical representations of water deficit (and excess) compared to historical data.
- Help decide when to start implementing water conservation or drought response measures
- Can be used to analyze drought frequency, severity, and duration for a given location and period

- Commonly used operational drought indices are:
  – Standardized Precipitation Index (SPI)
  – Palmer Drought Severity Index (PDSI)



Source: National Drought Mitigation Center;
Image: Handbook of Drought Indicators & Indices

Standardized Precipitation Index (SPI)

http://www.cpc.ncep.noaa.gov/products/Drought/Monitoring/spi.shtml

- Primarily defined to characterize meteorological drought
- Mathematically, historical rainfall data at any location fitted with gamma distribution represent cumulative probability function
- If a rainfall event is a low probability on the cumulative probability function, it is indicative of a drought event
- The SPI values can be interpreted as the number of standard deviations by which the observed rainfall anomaly deviates from the long-term mean

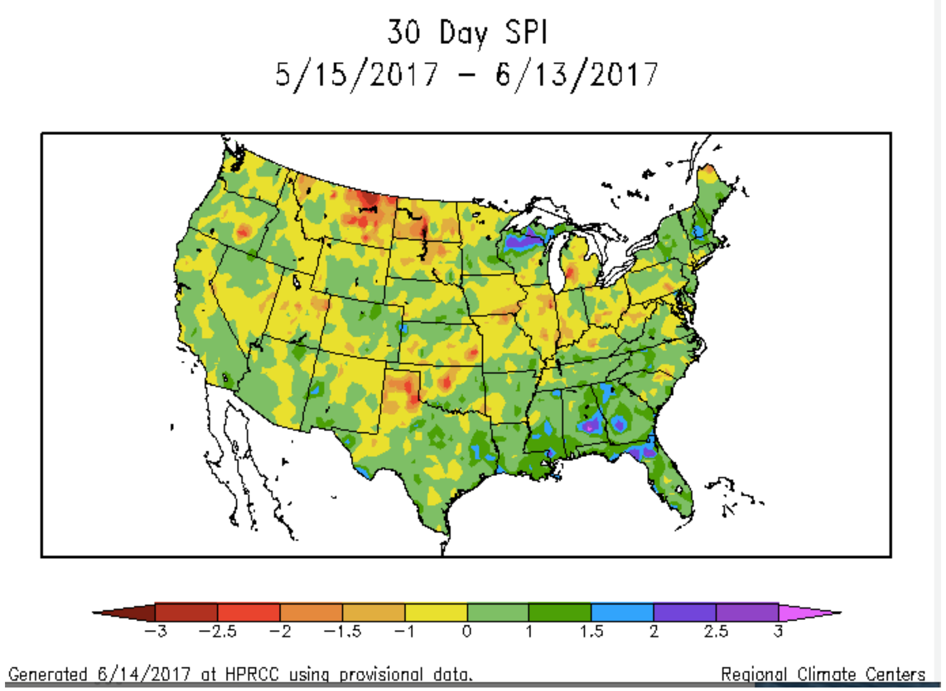


Image Credit: HPRCC ACIS Climate Map http://hprcc.unl.edu/maps.php?map=ACISClimateMaps#
Text Source: NCAR/UCAR Climate Data Guide

Palmer Drought Severity Index (PDSI)

http://climatedataguide.ucar.edu/climate-data/palmer-drought-severity-index-pdsi

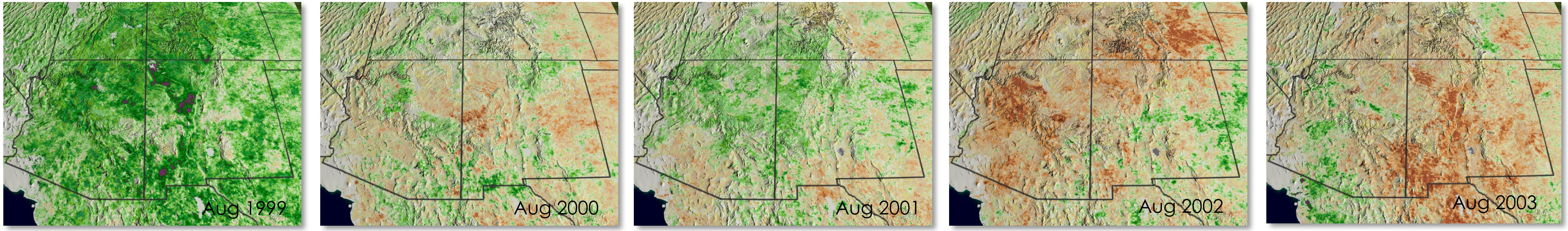
- An index for evaluating the severity and frequency of prolonged periods of abnormally dry or wet conditions
- Uses **temperature** and **precipitation** data and a physical water balance model to estimate relative dryness
- A standardized index that goes from -10 (dry) to +10 (wet)

PDSI(m)=PDSI{m-1+[Z(m)/3-0.103 PDSI(m-1)}
m = month index
Z(m) = moisture anomaly index (based on a water balance model)
Learn more:
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/cdus/palmer_drought/wpdanote.shtml

Palmer, W. C., 1965: Meteorological drought. Research Paper 45, U.S. Dept. of Commerce, 58 pp.
Dai, A., K. E. Trenberth, and T. Qian, 2004: A global data set of Palmer Drought Severity Index for 1870-2002: Relationship with soil moisture and effects of surface warming. J. Hydrometeorology, 5, 1117-1130.

NDVI Anomalies

- Departure of NDVI from the long-term average, normalized by long-term variability
- Generated by subtracting the long-term mean from the current value for that month of the year for each grid cell.
- Indicates if vegetation greenness at a particular location is typical for that period or if the vegetation is more or less green

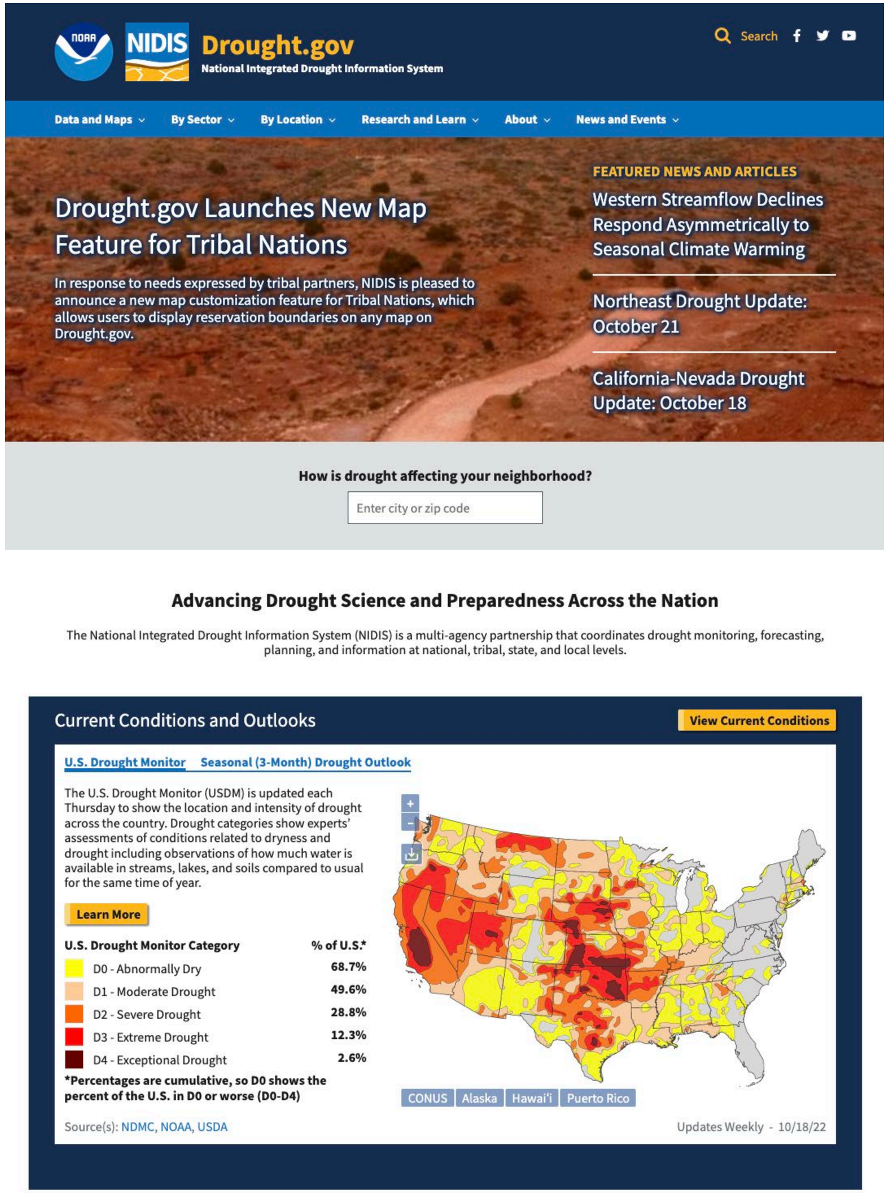


NDVI Anomalies in the southwestern United States. Image Credit: NASA/Goddard Space Flight Center Scientific Visualization Studio.

National Integrated Drought Information System (NIDIS)

http://www.drought.gov/

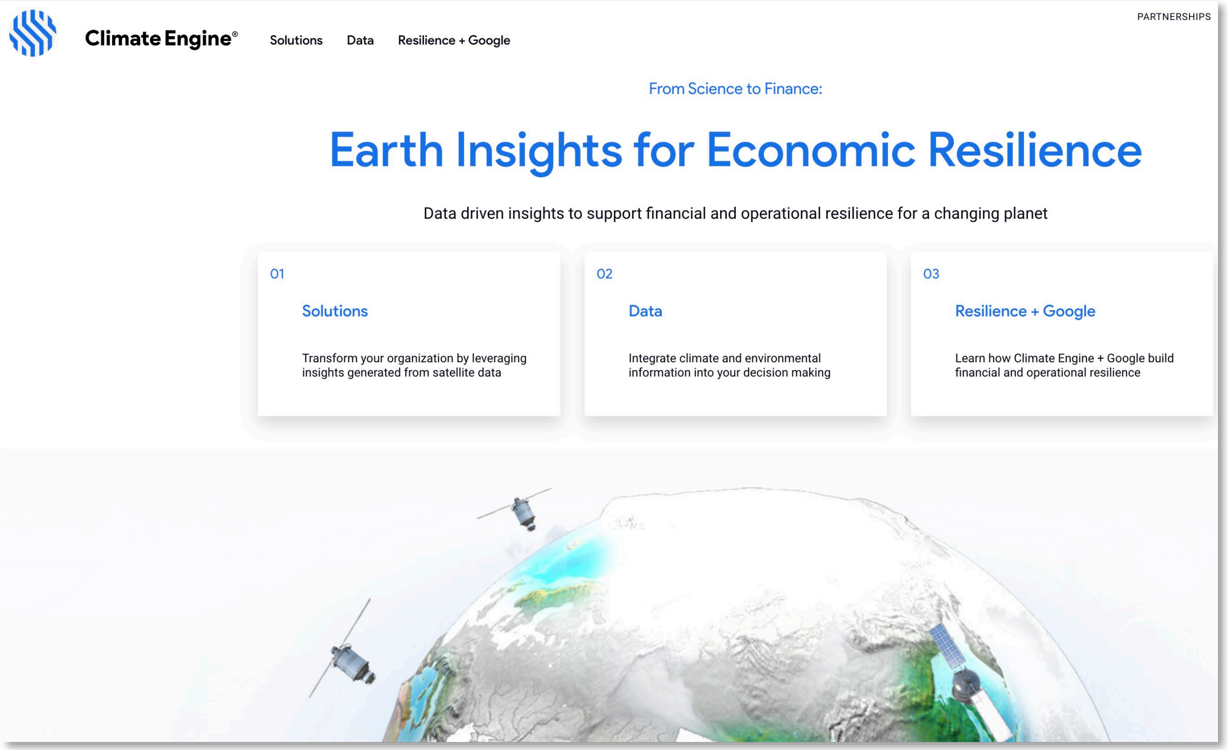
- Multi-agency partnership that coordinates drought monitoring, forecasting, planning, and information at national, tribal, state, and local levels
- Provides a one-stop shop for data, decision-support products, resources, and information on drought—from drought monitoring and prediction, to planning and preparedness, to applied research.
- Local drought information down to the city and county level
- Interactive, easily shareable maps & data



Climate Engine

https://climateengine.com/

- Partnership between the Desert Research Institute, University of Idaho, and Google that started through a Google Faculty Research award White House Climate Initiative.
- Climate Engine enables users to quickly process and visualize satellite Earth observations and gridded weather data for environmental monitoring and to improve early warning of drought, wildfire, and crop-failure risk.
- Instead of processing entire archives, focus on data discovery and answers.



Demo: Climate Engine

Hands-on – Climate Engine

Flooding

Remote Sensing-Based Flood Detection

There are several approaches to using remote sensing observations for flood monitoring:

- Detecting flood water on previously dry land surfaces using satellite-derived land cover observations
- Hydrology models that derive streamflow and runoff using precipitation and weather data from satellites and models
- Inferring flooding conditions using satellite-derived precipitation rate and amount, and soil moisture conditions using statistical methodology

Note: Each flooding approach also uses model and/or surface-based data in addition to satellite data.

Remote Sensing-Based Flood Detection

There are several approaches to using remote sensing observations for flood monitoring:

- **Detecting flood water on previously dry land surfaces using satellite-derived land cover observations**
- Hydrology models that derive streamflow and runoff using precipitation and weather data from satellites and models
- Inferring flooding conditions using satellite-derived precipitation rate and amount, and soil moisture conditions using statistical methodology

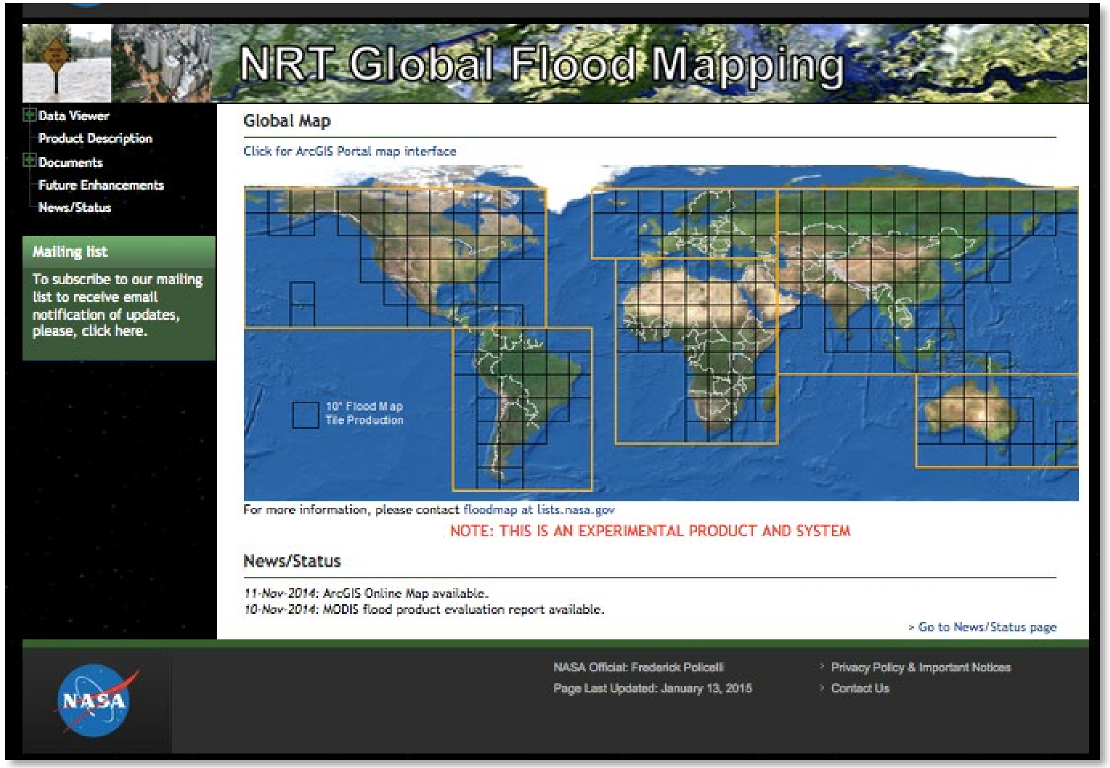
Based on this approach multi-year time series of flood maps are available from:

- **Aqua and Terra MODIS (2013 to present)**
- **Sentinel-1 SAR (2014 to present)**

MODIS Global Flood Mapping Web-Tool (2013–2021)

https://floodmap.modaps.eosdis.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 flood mapping and archived flood mapping from 2013–2021.

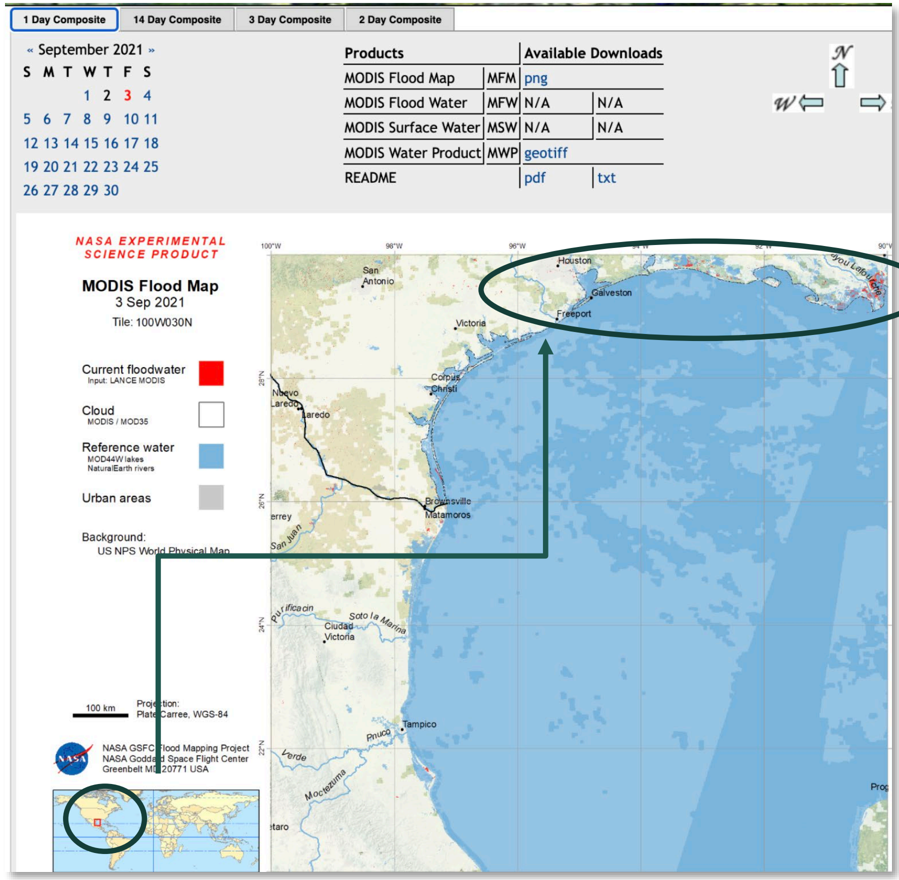


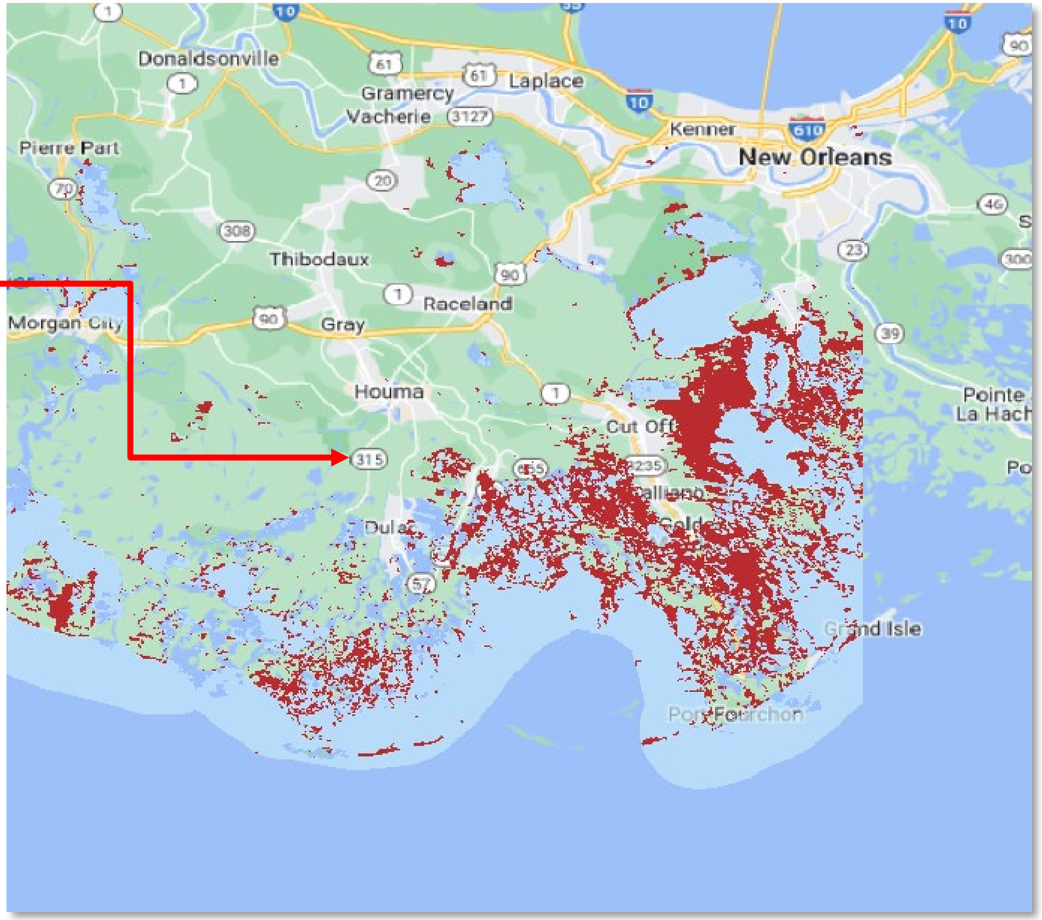
https://earthobservatory.nasa.gov/images/88624/flooding-on-the-ganges-river

MODIS Global Flood Mapping (2013–2021)

https://floodmap.modaps.eosdis.nasa.gov/readme.php

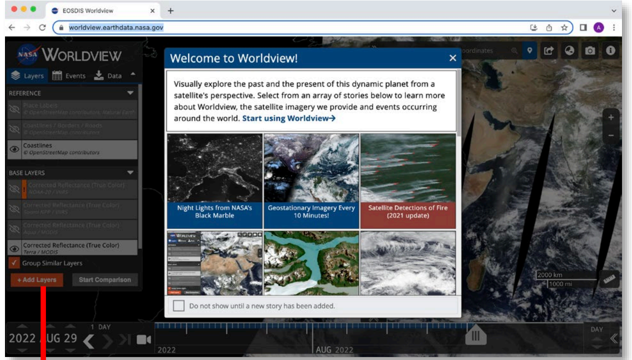
Flooding due to Hurricane Ida (3 September 2021)

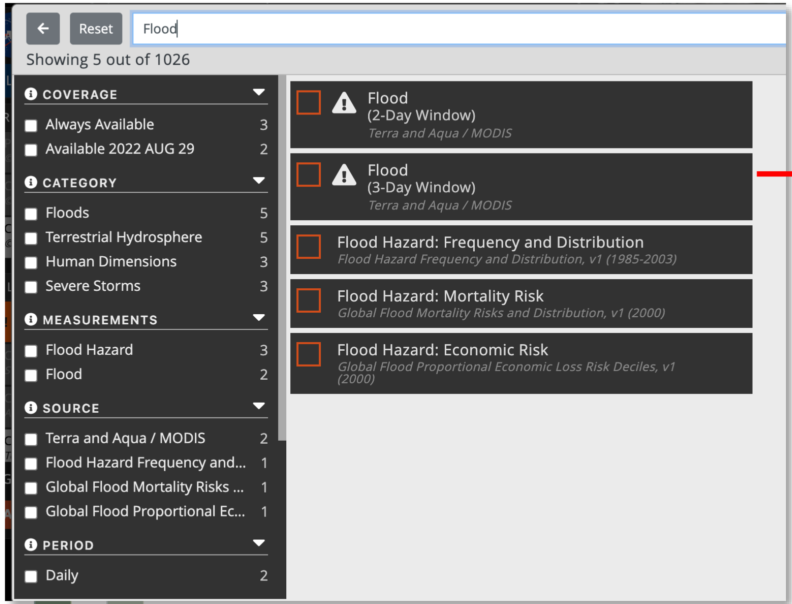




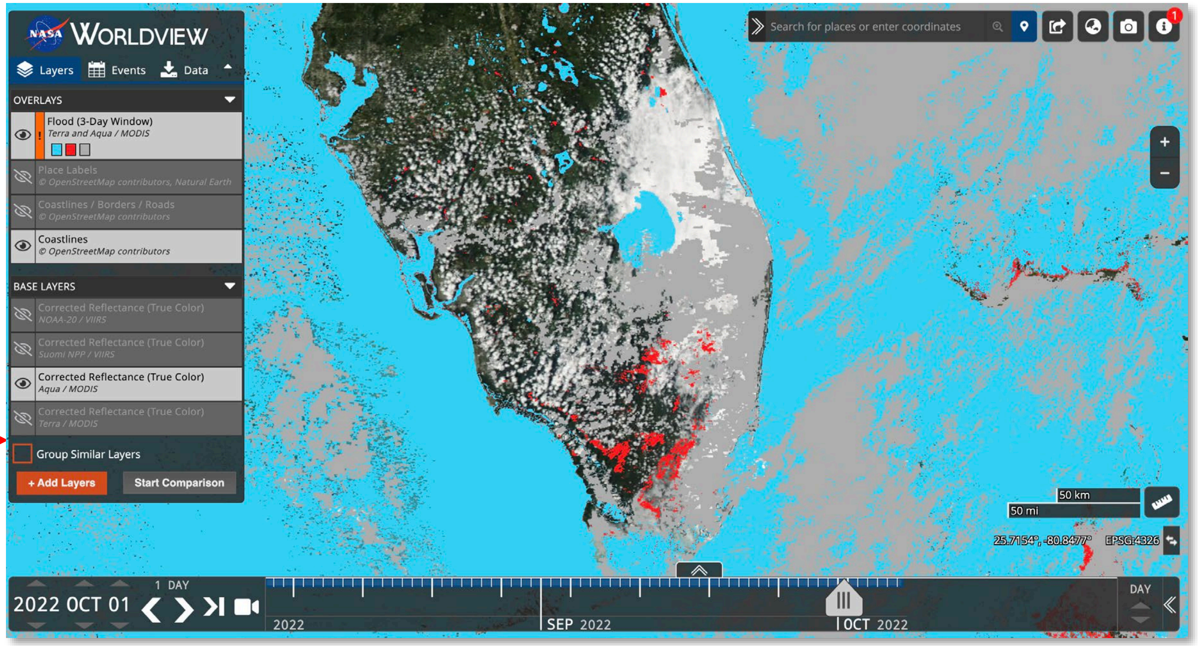
NASA Worldview (2022)

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





3-Day Composite Flooding from MODIS
Flooding due to Hurricane Ian

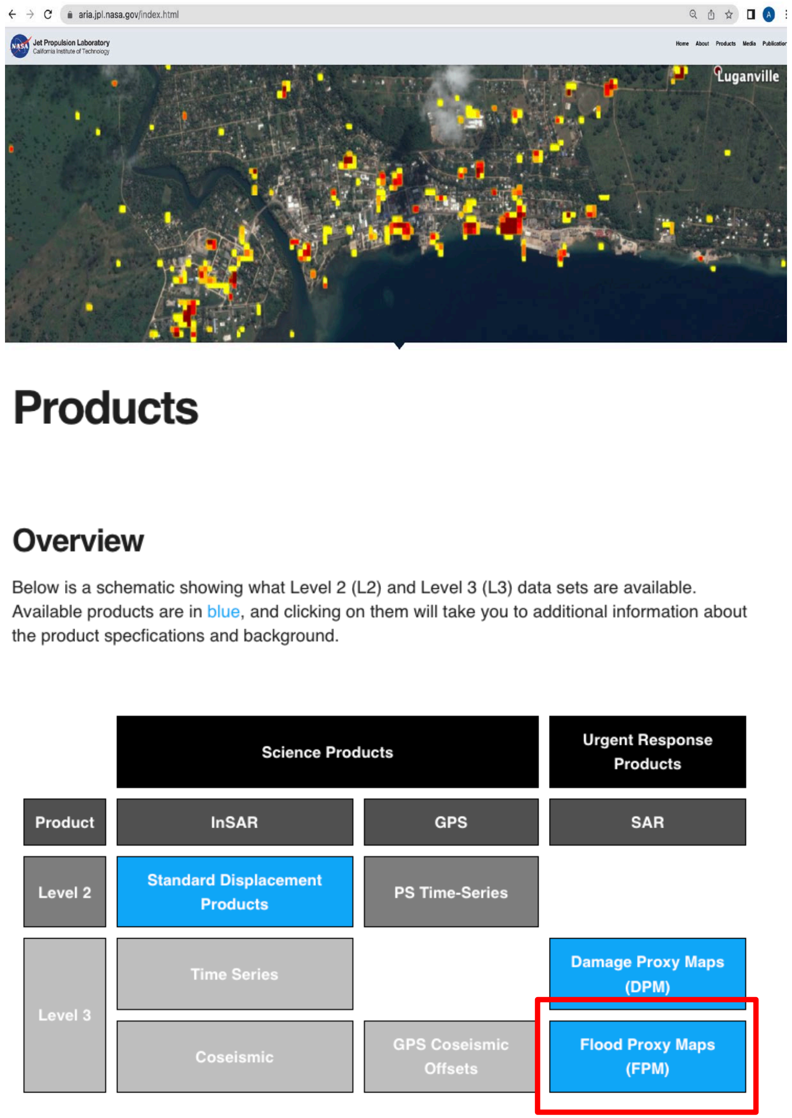


Replacing the MODIS NRT Flood Map Portal
https://floodmap.modaps.eosdis.nasa.gov/

ARIA

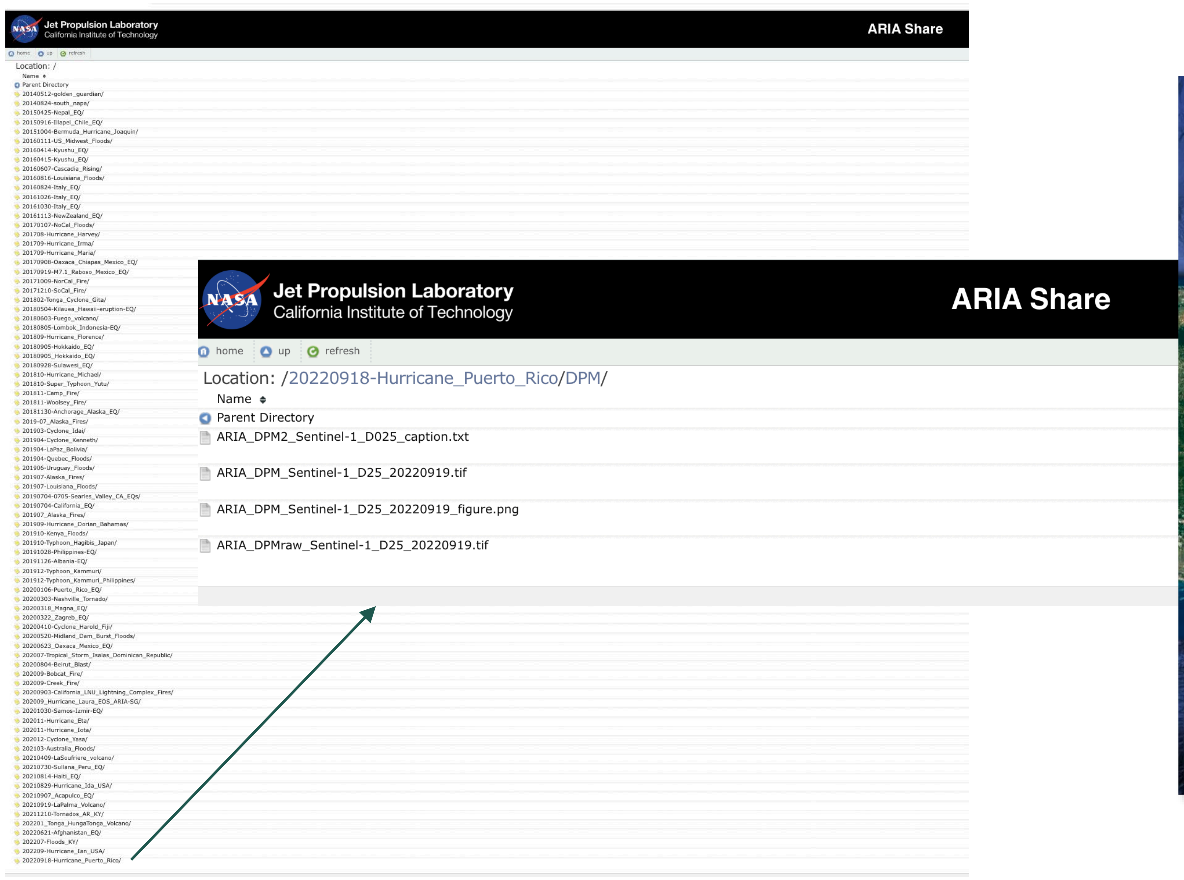
https://aria.jpl.nasa.gov/index.html

- A collaboration between JPL and Caltech to exploit radar and optical remote sensing, GPS, and seismic observations for hazard science and response.
- ARIA investigates the processes and impacts of multiple natural hazards.
- Primarily focused on ground deformation change measurements, also include flood damage proxy maps.

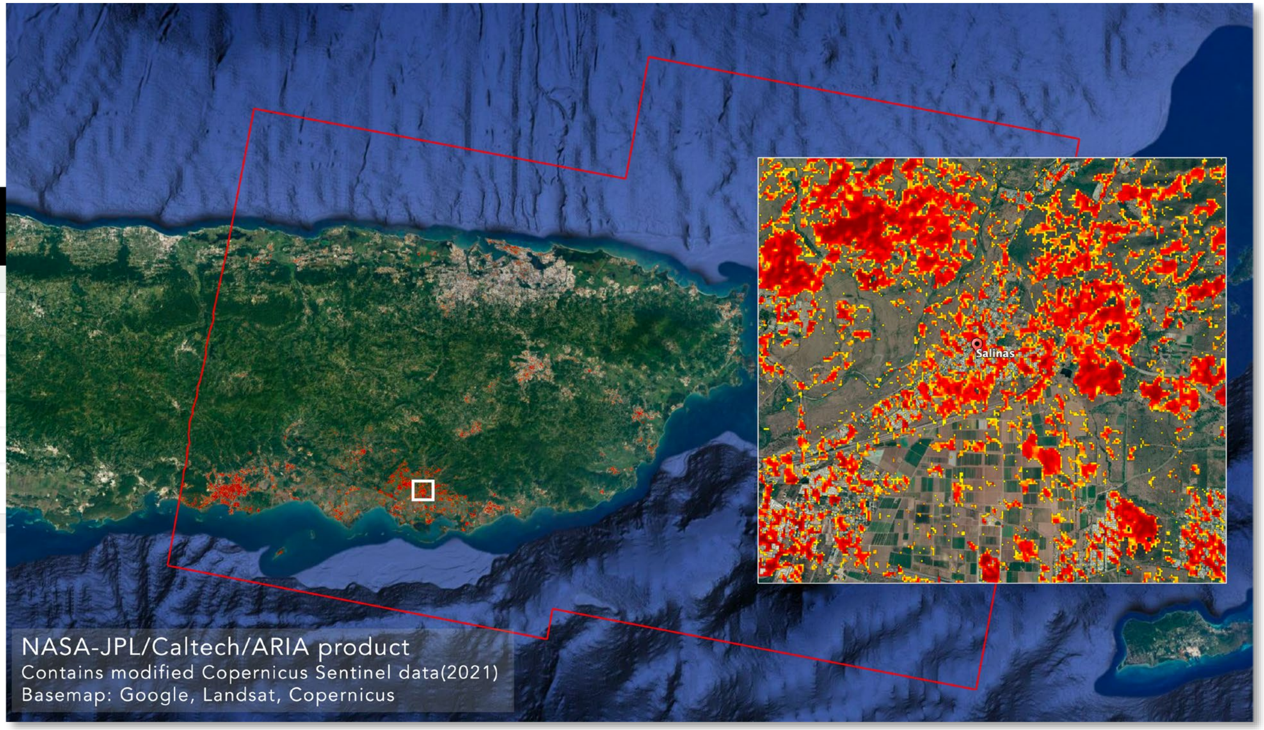


ARIA Flood List (2014 to Present)

https://aria-share.jpl.nasa.gov/



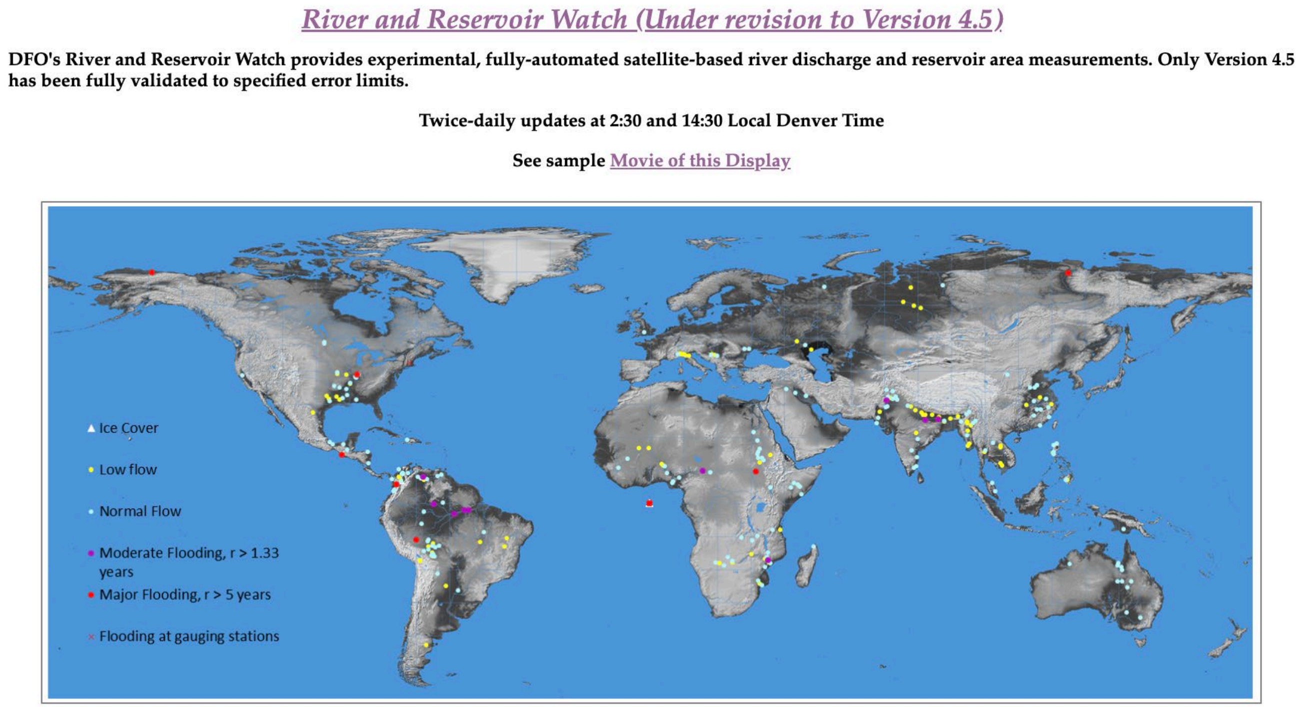
Hurricane Ian Flooding, Puerto Rico



The Flood Observatory (DFO River Watch: 1998–Present)

http://floodobservatory.colorado.edu/

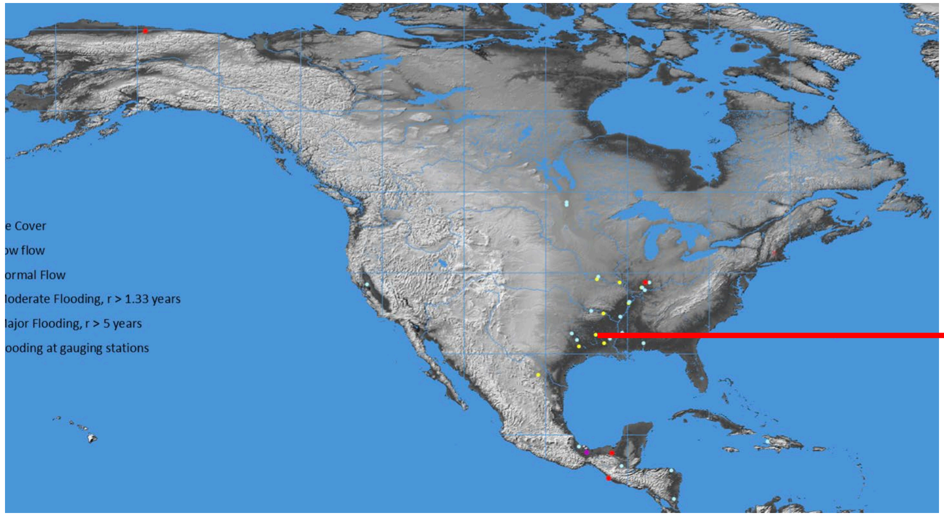
- Based on passive microwave observations from TRMM/GPM and river gauge measurements.
- Currently, a new version and validation of river discharge methodology is underway.
- Provides river discharge and monthly and annual runoff time series.



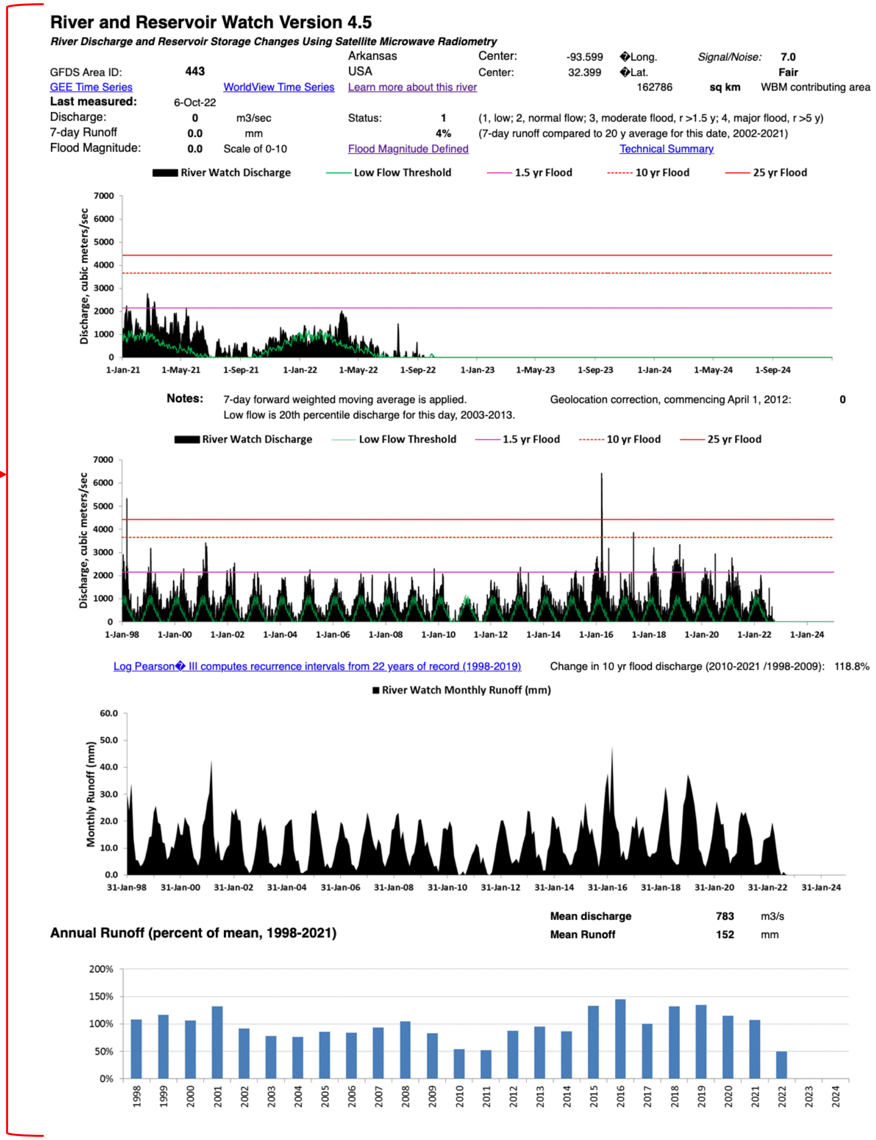
https://floodobservatory.colorado.edu/DischargeAccess.html

The Flood Observatory (DFO River Watch: 1998 – Present)

http://floodobservatory.colorado.edu/



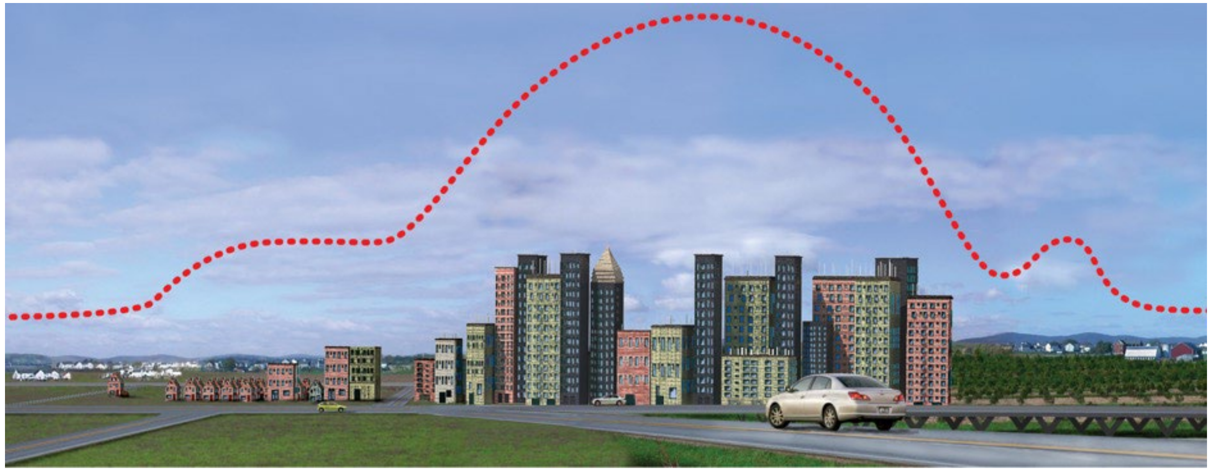
Arkansas River Watch



Urban Heat Islands

Urban Heat Islands

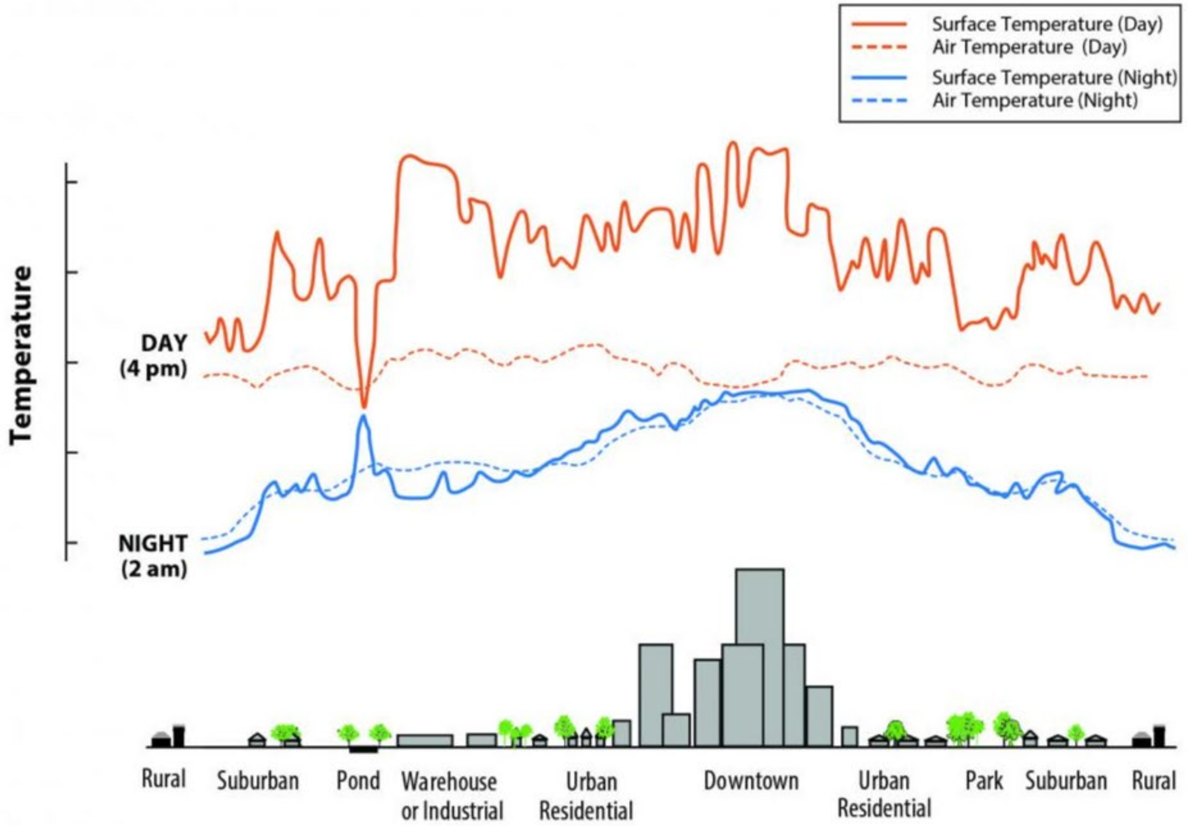
- Urban areas experience higher temperatures than outlying areas. This difference in temperature is what constitutes an urban heat island (UHI).
- Difference in temperature has to do with changes in radiative and thermal properties of impervious surfaces (i.e., heat-absorbing buildings and pavement).
- Temperatures vary within cities due to the spatial distribution of water, soil, vegetation, and impervious surfaces.



Land surface temperatures in cities, particularly densely-developed cities, tend to be elevated in comparison to surrounding areas. Credit: NASA

Urban Heat Islands

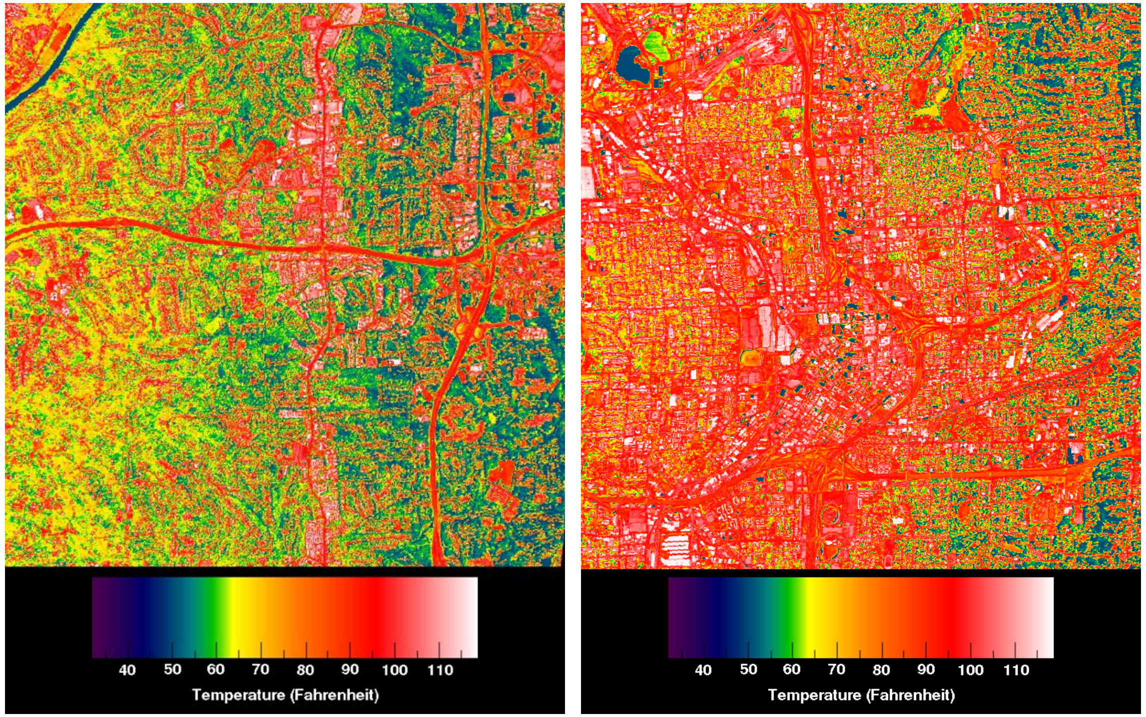
- Urban heat islands can form during the day or night, in small or large cities, and in any season.
- There are two types of urban heat islands:
  – Surface Urban Heat Islands
  – Atmospheric (i.e., air) Urban Heat Islands
- Surface temperatures vary more than air temperatures during the day, but they are generally similar at night.



Parks, open land, and bodies of water can create cooler areas within a city. Temperatures are typically lower at suburban-rural borders than in downtown areas. Credit: EPA

Surface Urban Heat Islands

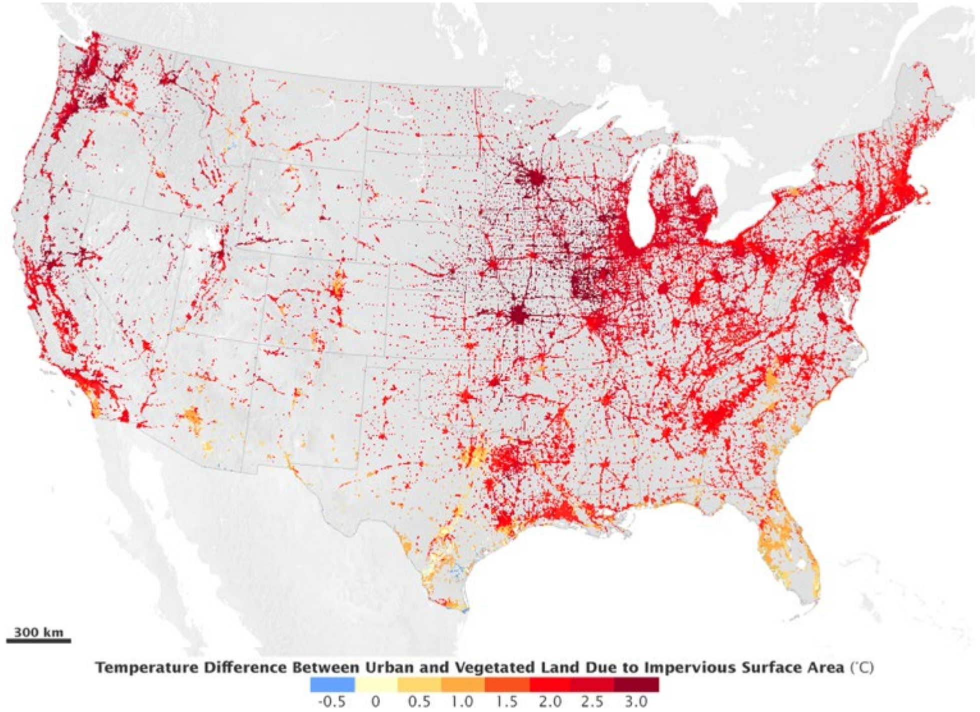
- Surface Urban Heat Islands (SUHI) represent the radiative temperature difference between impervious and natural surfaces.
  - SUHIs tend to be most intense during the day when the sun is shining.
  - Magnitude varies with seasons, but it is typically largest in the summer.
  - SUHIs are primarily measured by remote sensing in the thermal infrared (TIR) region of the electromagnetic (EM) spectrum.



Satellite imagery of suburban (left) and urban (right) Atlanta, Georgia (USA) shows the differences in daytime heating, as caused by the urban heat island effect.
Credit: NASA Goddard Scientific Visualization Studio

Monitoring Urban Heat Islands – SUHI

- Satellite thermal remote sensing measures SUHI and provides consistent and repeatable observations of the Earth's surface.
- Remote sensing offers the ability to study the urban thermal environment at various spatial (from local to global) and temporal (diurnal, seasonal, and inter-annual) scales (Weng, 2009).



Credit: NASA

Monitoring Urban Heat Islands – SUHI

- Surface Urban Heat Islands (SUHI) represent the difference of land surface temperature (LST) in urban relative to non-urban areas, as well as "hot spots" within urban areas, and are usually measured using satellite data.

$$\Delta T_{u-r} = T_u - T_r$$

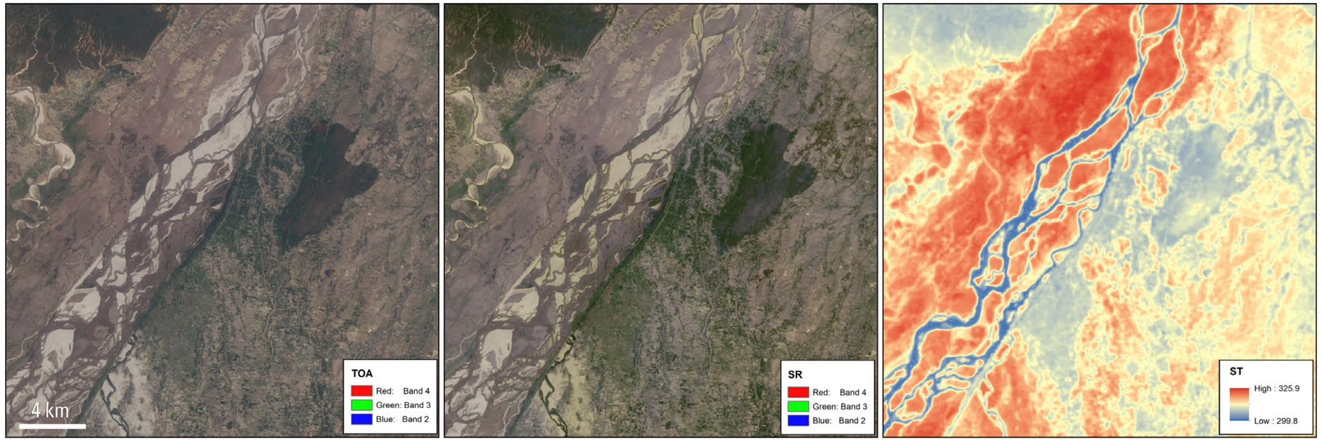
- where ΔT_{u-r} is UHI intensity, T_u is urban temperature and T_r is rural temperature.

- The intensity of the heat island is the simplest quantitative indicator of the thermal modification imposed by urban relative to non-urban areas.

Landsat Collection 2

Second major reprocessing effort of the Landsat archive

- Global Level-2 Science and Atmospheric Auxiliary Products:
  - Surface Reflectance
  - **Surface Temperature**
- Improved Geometric Accuracy
- Improved Digital Elevation Modeling
- Improved Radiometric Calibration
- Consistent Quality Assessment Bands
- Updated and Consistent Metadata Files
- Cloud Optimized File Format

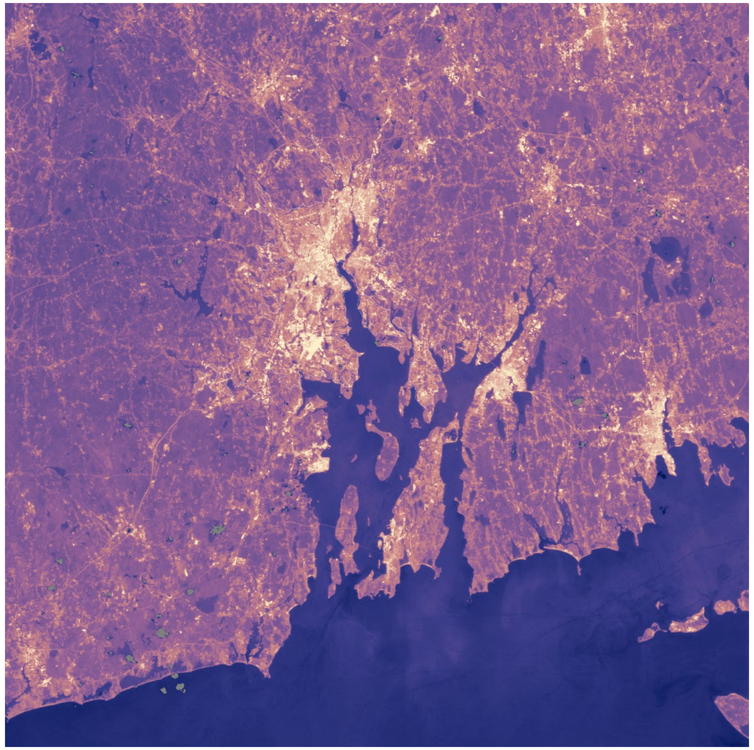


Left: Landsat 8 Collection 2 level-1 top of atmosphere reflectance image, Center: Landsat 8 Collection 2 level-2 atmospherically corrected surface reflectance image, and Right: Landsat 8 Collection 2 level-2 surface temperature image for an area over the Sapta Koshi River in Bairawa, Nepal acquired on May 3, 2013. Credit: USGS

https://www.usgs.gov/landsat-missions/landsat-collection-2

Landsat Collection 2 – Surface Temperature

- Measures the Earth's surface temperature in Kelvin
- Useful for monitoring:
  - Crop and vegetation health
  - Heat waves
  - Natural disasters (e.g., volcanic eruptions, wildfires)
  - **Urban heat island effects**
- Product availability:
  - Landsat 9: February 2022 to present
  - Landsat 8: April 2013 to present
  - Landsat 7: July 1999 to April 2022
  - Landsat 5: March 1984 to May 2012
  - Landsat 4 : August 1982 to December 1993



Land surface temperature for Providence, Rhode Island (USA) collected by Landsat ETM+ on July 31, 2002. The highest temperatures are shown in yellow, while cool temperatures are shown in deep purple. Credit: NASA

Limitations of Satellite Remote Sensing for Urban Heat Islands

- Data acquisition times of sun-synchronous satellites usually do not coincide with the time of day where the SUHI is at a minimum or maximum.
- Most widely used satellite for SUHI detection (i.e., Landsat) only has daytime data.
- Optical sensors cannot penetrate clouds or vegetative cover, which can lead to data gaps or a decrease in data utility.
- The accuracy of land surface temperature (LST) estimates depends strongly on corrections for atmospheric effects and an accurate estimate of surface emissivity.
- Radiances received by sensors are influenced by the sensor-viewing angle.
- It is difficult to obtain high spectral, spatial, and temporal resolution with the same instrument.
- A large amount of data exists in various spatial and temporal resolutions, file formats, sizes, and from multiple sources.

Computing Land Surface Temperature in GEE

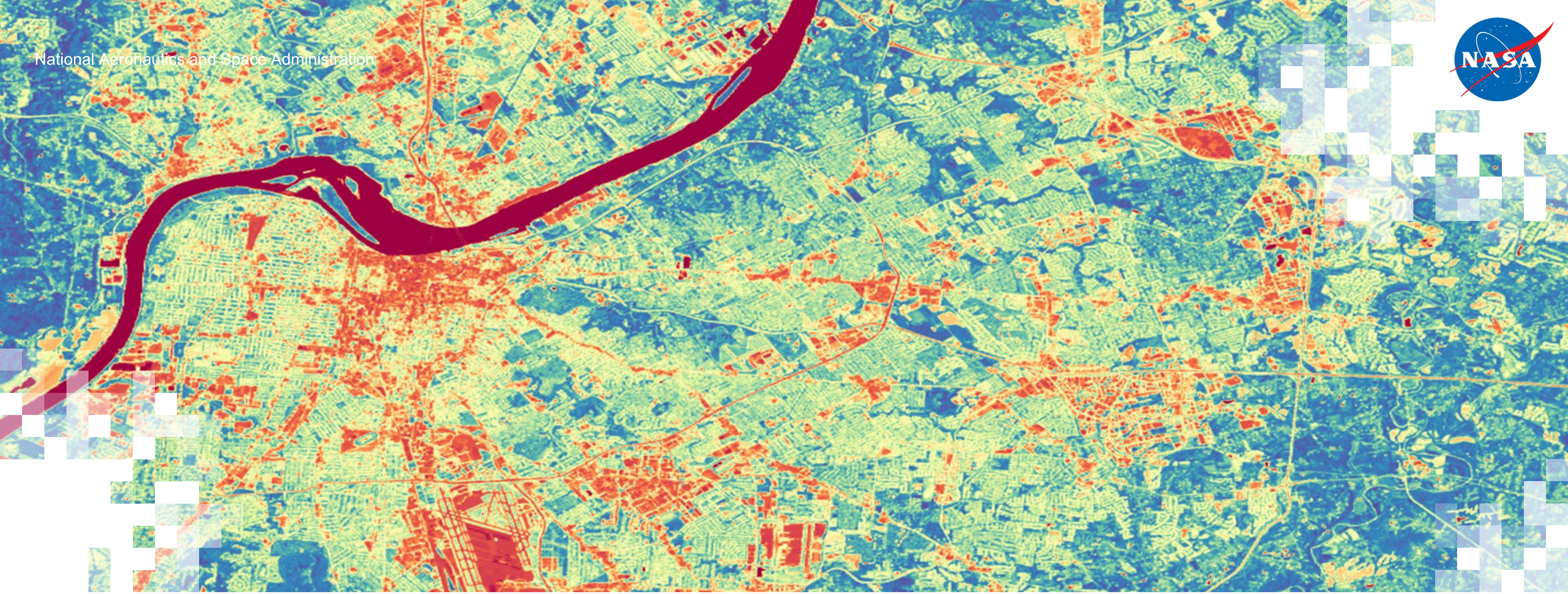
Below are 3 scripts for assessing urban heat islands using satellite data.

- **Landsat_LST_Time_Series_Pixel.js**
  - Example code showing how to graph a **LST time series** from Landsat 8 & 9
  - https://code.earthengine.google.com/2eae305edb229ae171391b341094fa81
- **Landsat_LST_SUHI.js**
  - Example code showing how to process **Landsat-derived SUHI** over Washington, DC (USA)
  - https://code.earthengine.google.com/8f8a363aa18fa9d16c1fe84991aa4154
- **MODIS_LST_Day_Night.js**
  - Example code showing how to process **MODIS-derived SUHI** for **day** and **night** over Washington, DC (USA)
  - https://code.earthengine.google.com/63c37316806efa35321f7e8651429bb2

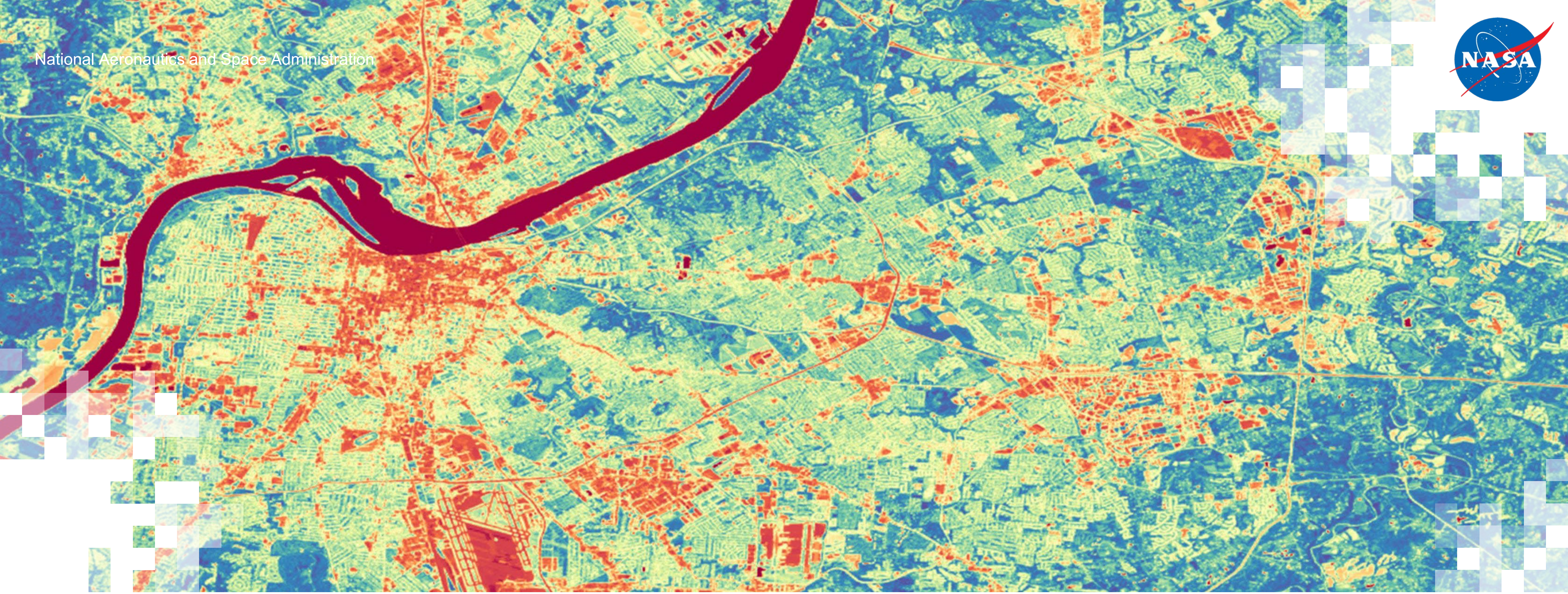
Computing Land Surface Temperature in GEE

- To modify the different scripts for your study area, users will need to change the following parameters:
  - DATE_RANGE
  - YEAR_RANGE
  - STUDYBOUNDS
  - DISPLAY
  - point: Longitude/latitude for area of interest
  - aoi: Delineated rectangle for area of interest
  - Rural: Delineated polygon(s) for rural areas
  - Urban: Delineated polygon(s) for urban areas

```
// Assign a variable to filter the day of year from July 1 t
// Adjust the DATE_RANGE for your own UHI study.
var DATE_RANGE = ee.Filter.dayOfYear(182, 243);
// Assign a variable to filter years from 2010 – 2022.
// Adjust the YEAR_RANGE for your own UHI study.
var YEAR_RANGE = ee.Filter.calendarRange(2010, 2022,'year');
// Assign a variable to delineate your area of interest
// Create your own aoi using the Geometry tools in the map w
var STUDYBOUNDS = aoi;
// Assign a variable to display images in the map window
var DISPLAY = true;
```



Demo – Measuring Land Surface Temperature from Landsat



Hands On – Measuring Land Surface Temperature from Landsat

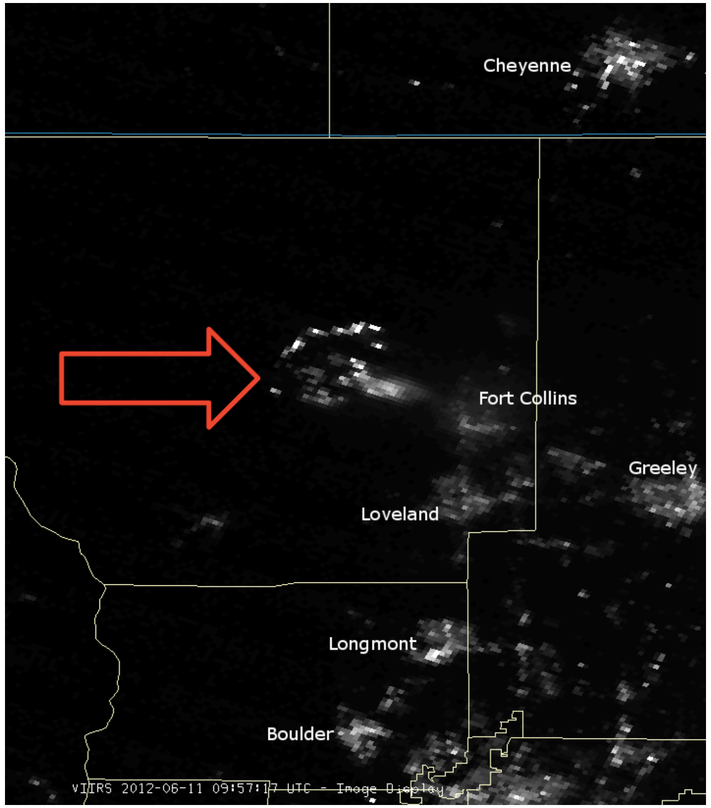
Wildfires & Smoke

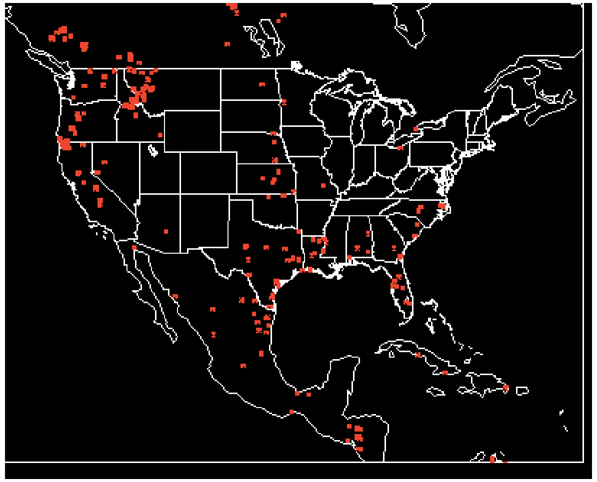
Fire Detection

Fire Detection From Satellites

Can be accomplished by detecting:

- Smoke
- Temperature Anomalies
- Light

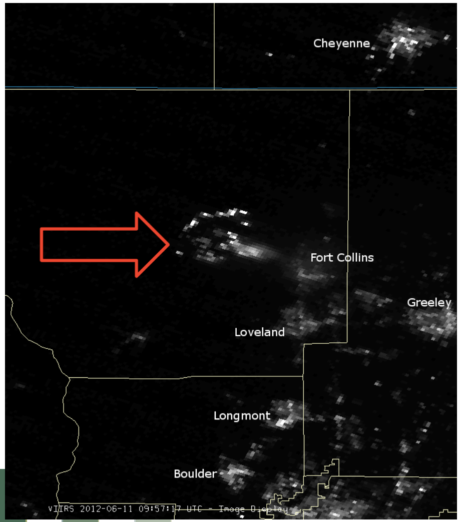




Fire Detection From Satellites

Can be accomplished by detecting:

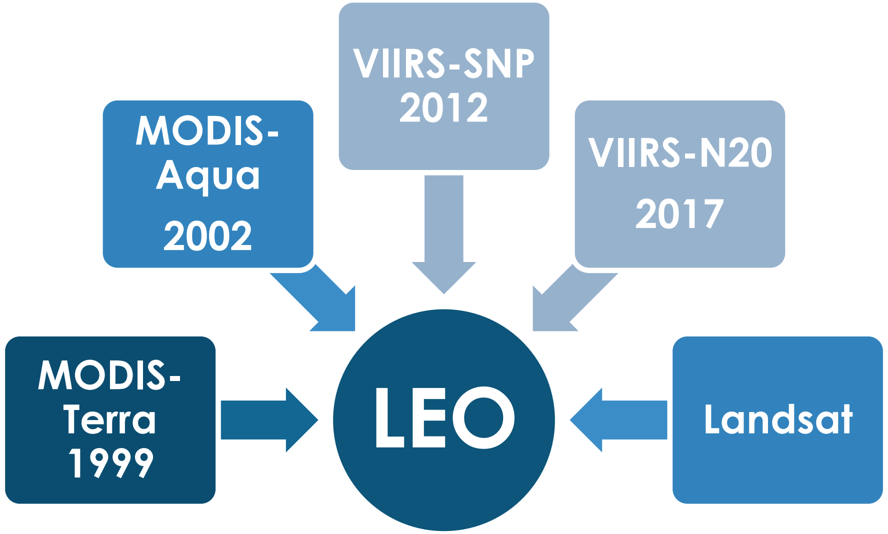
- Temperature Anomalies
- Smoke
- Light



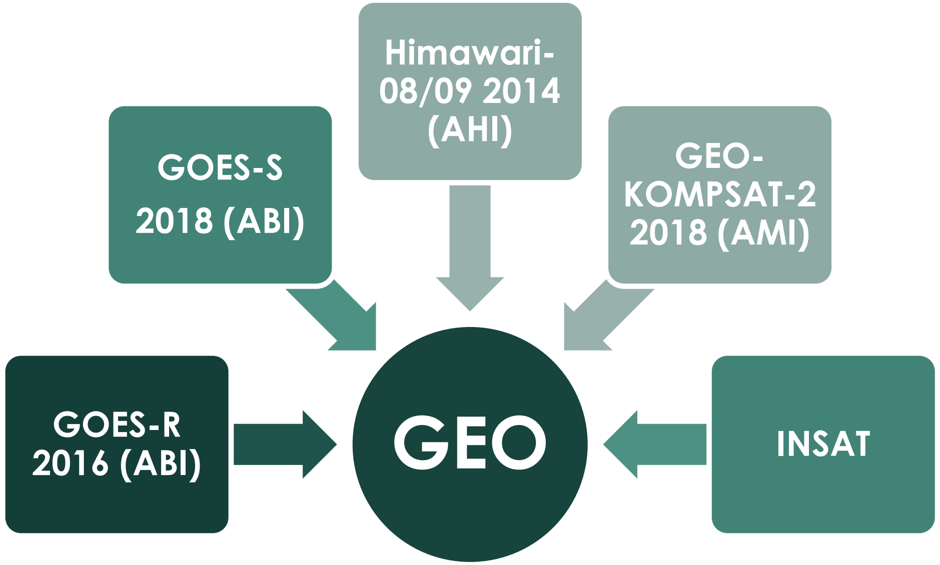
VIIRS-SNPP Fire Detections, January – September 2021

https://svs.gsfc.nasa.gov/4945

Satellites and Sensors for Fire and Smoke Detection



Global Coverage, typically twice per 24 hours

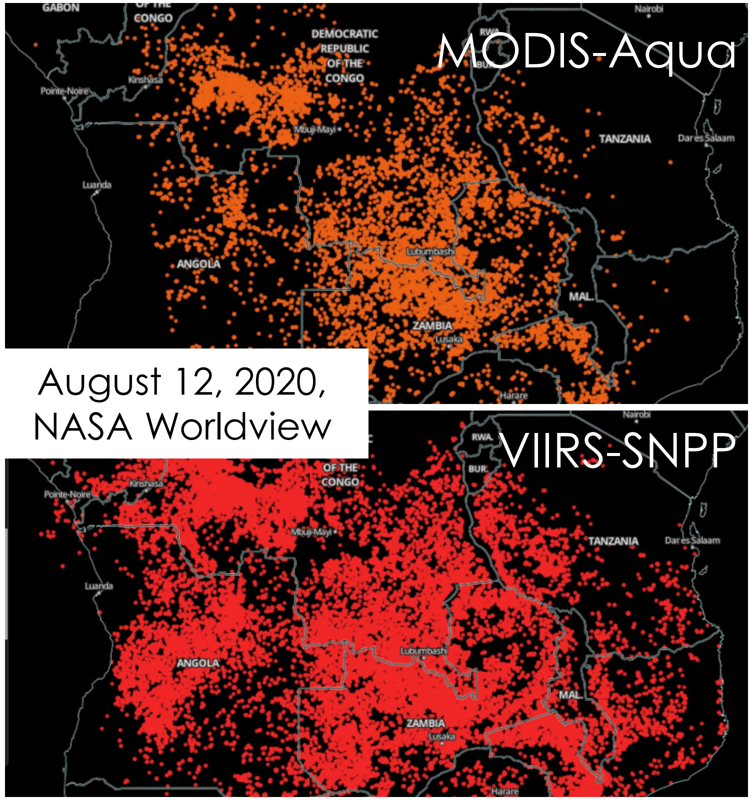


Regional Coverage, minutes to hours

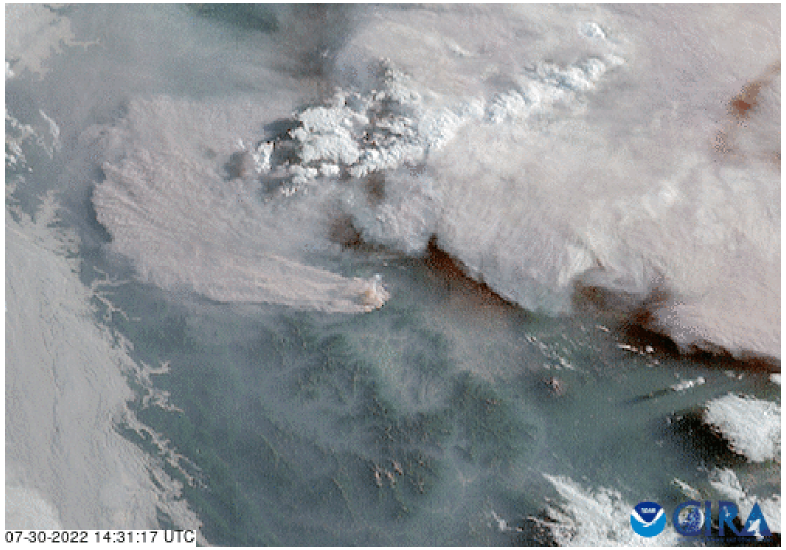
LEO – Low Earth Orbit
GEO – Geostationary
ABI – Advanced Baseline Imager

Fire Detection

- Fire Detection:
  - Pixel flagged as containing one or more fires
  - MODIS: 1 km
  - VIIRS: 750 m and 375 m
  - ABI: 2 km
  - Can also detect volcanic signatures
  - VIIRS Detects 3-4x more fires than MODIS globally
  - ABI has coarser resolution, but much higher temporal resolution



August 12, 2020, NASA Worldview



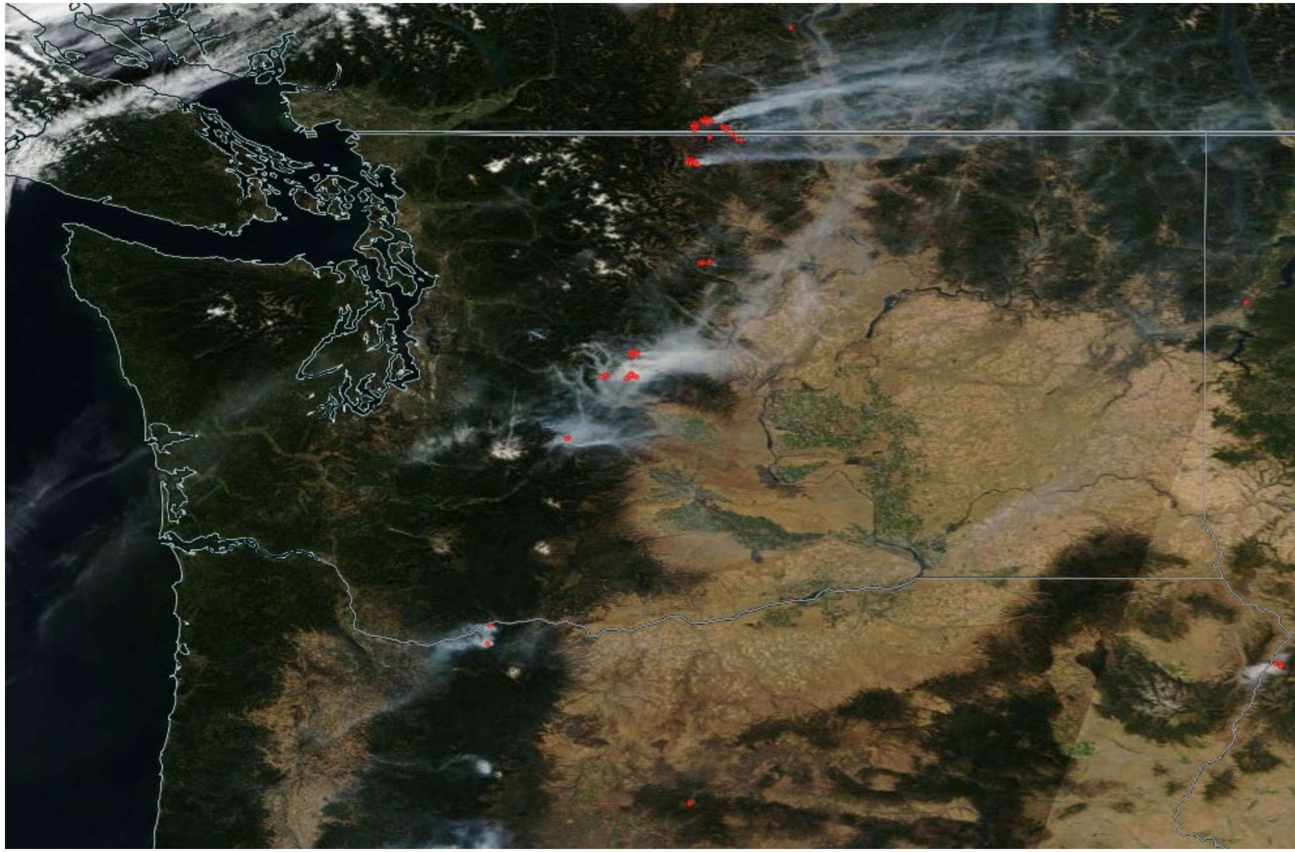
https://rammb.cira.colostate.edu/ramsdis/online/loop_of_the_day/

Several Satellite Instruments Observe Fire Detections

	MODIS	VIIRS	ABI
Platform	Terra , Aqua	Suomi NPP, NOAA-20	GOES 16, GOES 17
Launched	Dec 1999, May 2002	Oct 2011, Nov 2017	Nov 2016, Mar 2018
Swath	2,330 km	3,040 km	---
Equator Crossing Time	10:30 am (des), 1:30 pm (asc)	1:30 pm (asc), 1:30 pm (asc)	Geostationary
Spatial Resolution	250 m, 500 m, 1 km	375 m, 750 m	500 m, 1km, 2km
Temporal Resolution	Global Coverage: 1-2 days	Global Coverage: Daily	Full Disk: 15 min CONUS: 5 min
Spectral Coverage	36 bands (VIS, IR, NIR, MIR) Band 1-2: 250 m Band 3-7: 500 m Band 8-36: 1 km	22 bands (VIS, IR, NIR,MIR) I-Bands (1-4): 375 m M-Bands (1-16): 750 m Day/Night Band: 750 m	16 bands (VIS, IR, NIR, MIR) 500 m – 2 km

Thermal Anomalies Algorithms

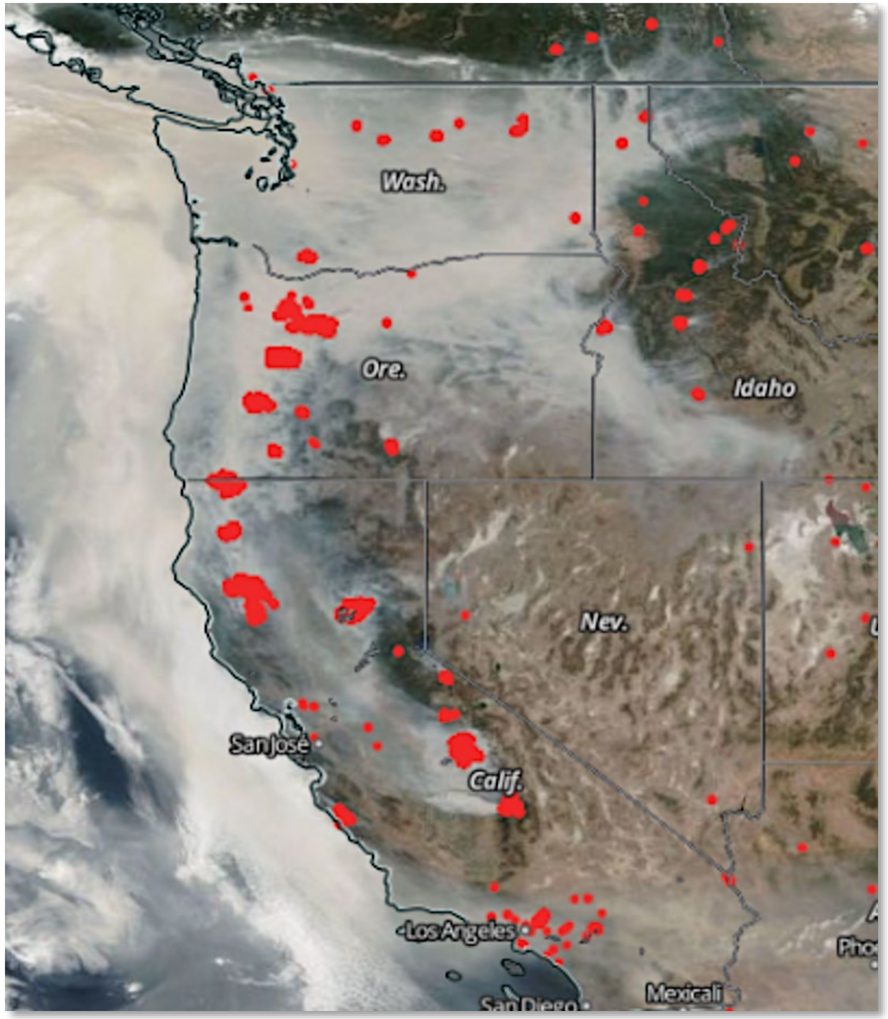
- Limitations:
  - False Positives: Small forest clearings (bare soil)
  - Large fire omissions due to thick smoke
  - Larger pixel size of MODIS and ABI can miss small fires
- MODIS Collection 6 (most recent) improves upon these errors.
  - Global commission error of 1.2%
  - Similar error for VIIRS



MODIS Fire Detections, NASA Worldview

What is a fire count?

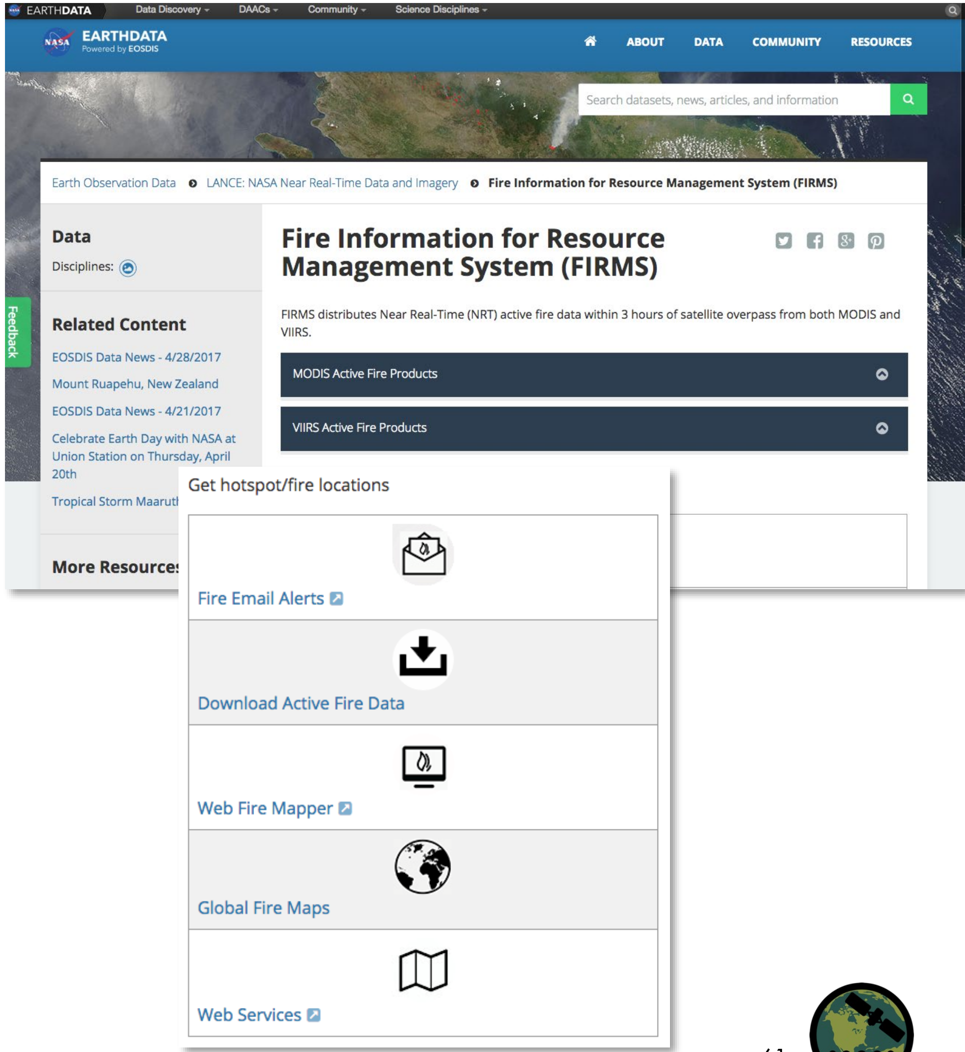
- Number of hotspots (or pixels) detected by a satellite/sensor in a certain region of interest over a fixed period is called fire count.
- The region of interest can be a regular or irregular polygon defined by boundaries in terms of latitude and longitude. For example:
  - Rectangular box
  - A city boundary
  - A county/province/district
  - State/country/continent
- The fixed period can be 1 hour, 24 hours, 3 days, 7 days, 1 year, and so on.



Download Fire Data – Fire Information for Resource Management System (FIRMS)

https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms

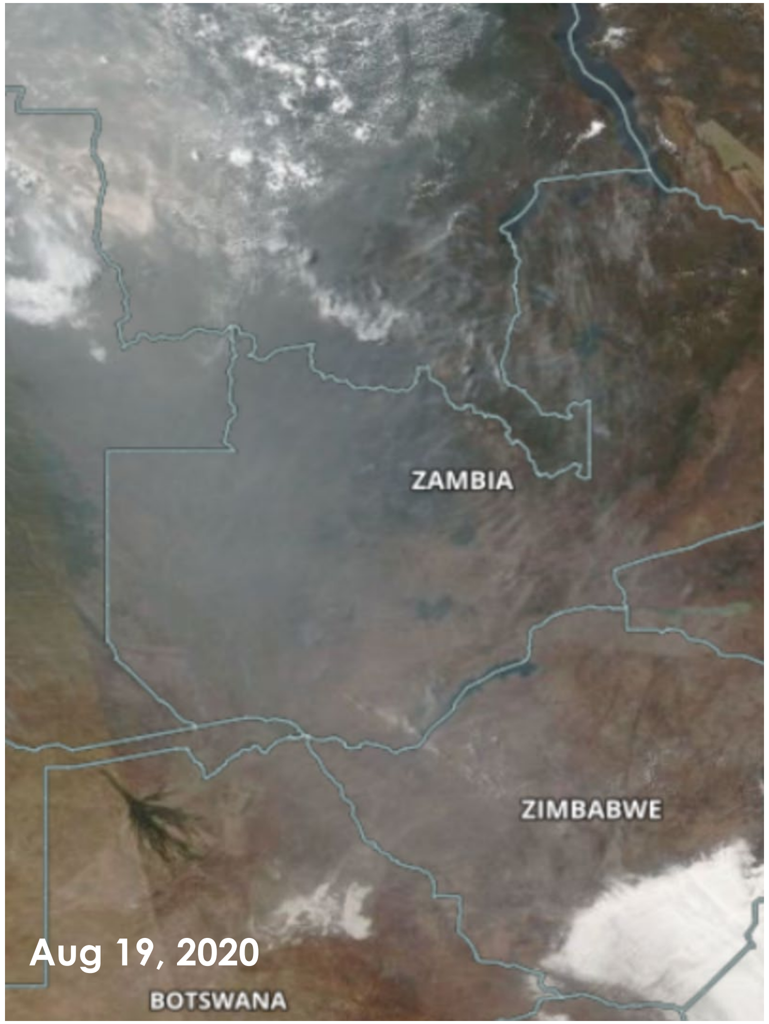
- Near real-time (NRT) active fire data within 3 hours of satellite overpass
- Global MODIS and VIIRS fire locations
- Historical data available
- Available In:
  - Email Alerts
  - Download Shapefile, WMS, KML, or txt
  - Visualization in Web Fire Mapper or Worldview
- FIRMS Webinar:
  - https://www.youtube.com/watch?v=0fPVmnY6pBs&feature=youtu.be



Aerosols and Smoke

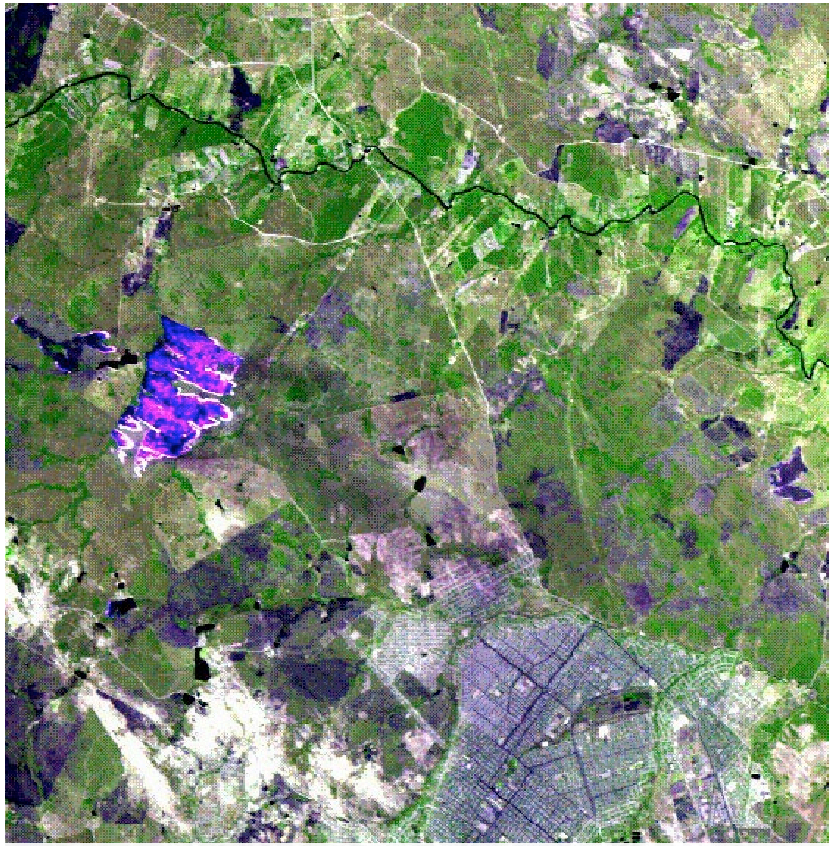
Visible Smoke from Fires

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



Selection of Spectral Bands for Smoke Detection

R = 0.66 μm
G = 0.55 μm
B = 0.47 μm



R = 1.6 μm
G = 1.2 μm
B = 2.1 μm

NOAA's Aerosol Detection Product (ADP)

- Absorption Aerosols Index
- Dust, Smoke Discrimination Index
- 6 Type Flags: (1-presence; 0-absence)
    1. Volcanic Ash Flag
    2. Dust Flag
    3. Smoke Flag
    4. None/Unknown/Clear
    5. Cloud Flag
    6. Snow/Ice Flag
- Quality Flags

Low, medium, and high confidence for each type

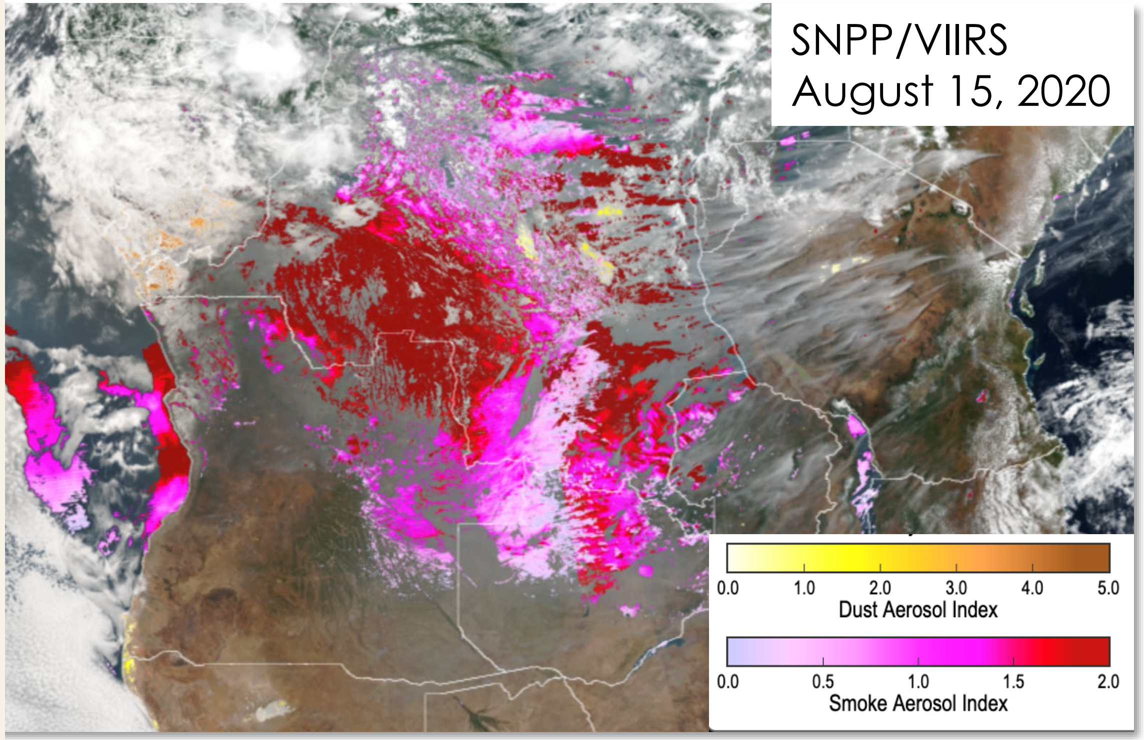


Image: https://www.star.nesdis.noaa.gov/jpss/mapper

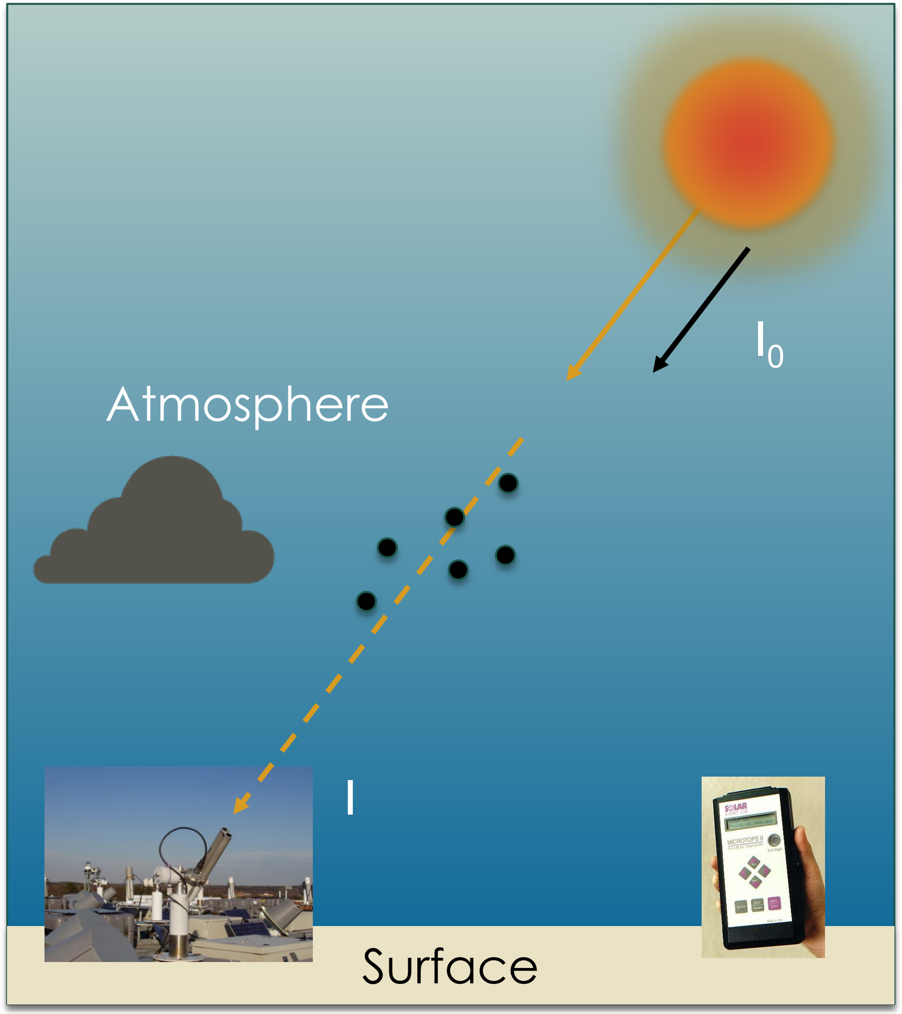
Reference:

1. Algorithm Theoretical Basis Document
https://www.star.nesdis.noaa.gov/jpss/documents/ATBD/ATBD_EPS_Aerosol_ADP_v1.1.pdf

2. Hai et al., Evaluation of VIIRS dust detection algorithms over land, J. of Applied Remote Sensing, 12(4), 042609 (2018).

Side Courtesy of Pubu Seren and Shobha Kondragunta

Aerosol Optical Depth



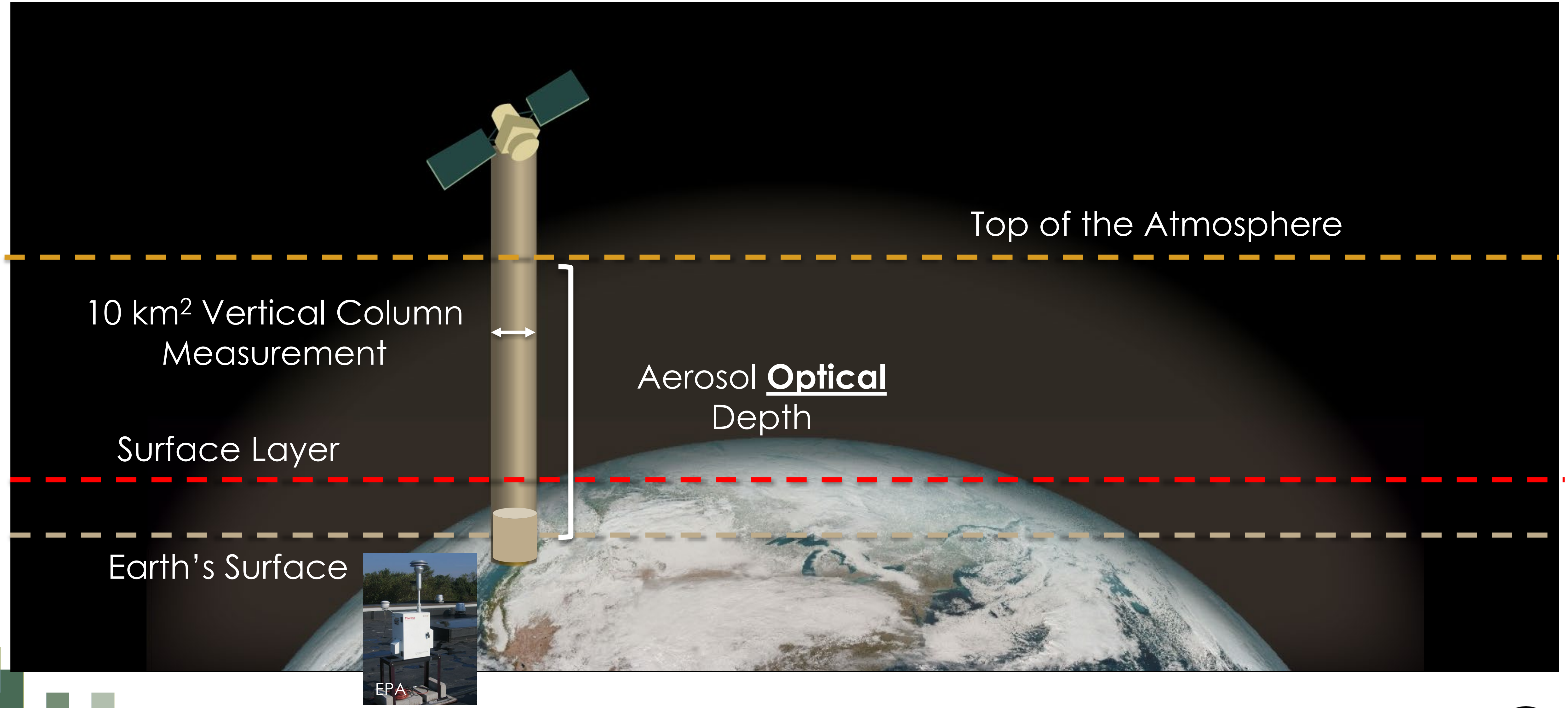
Aerosol optical depth expresses the quantity of light at a certain wavelength removed by aerosols from a beam by **scattering** and/or **absorption** during its path through a medium.

Aerosol optical depth τ as:

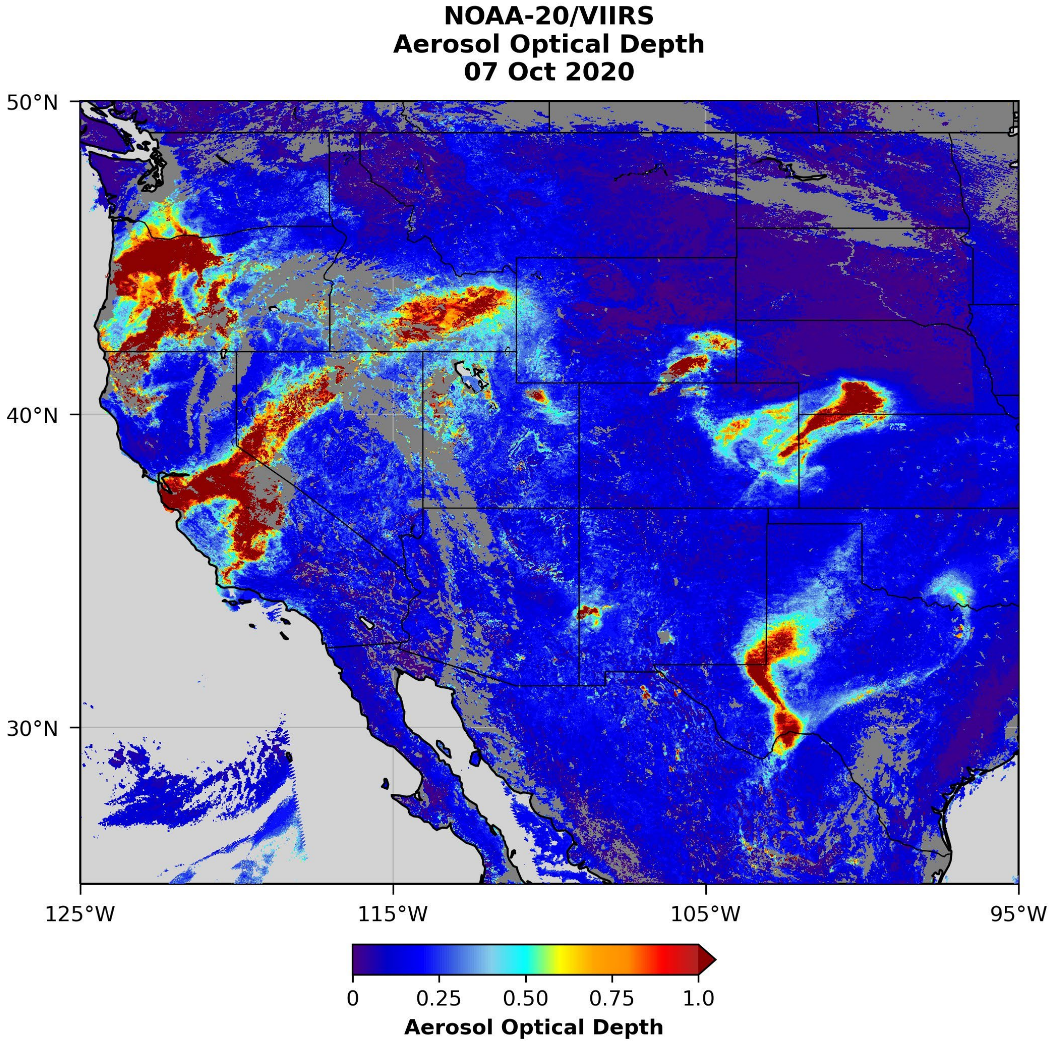
$$I = I_o e^{-m\tau}$$
$$m = \sec\theta_0$$

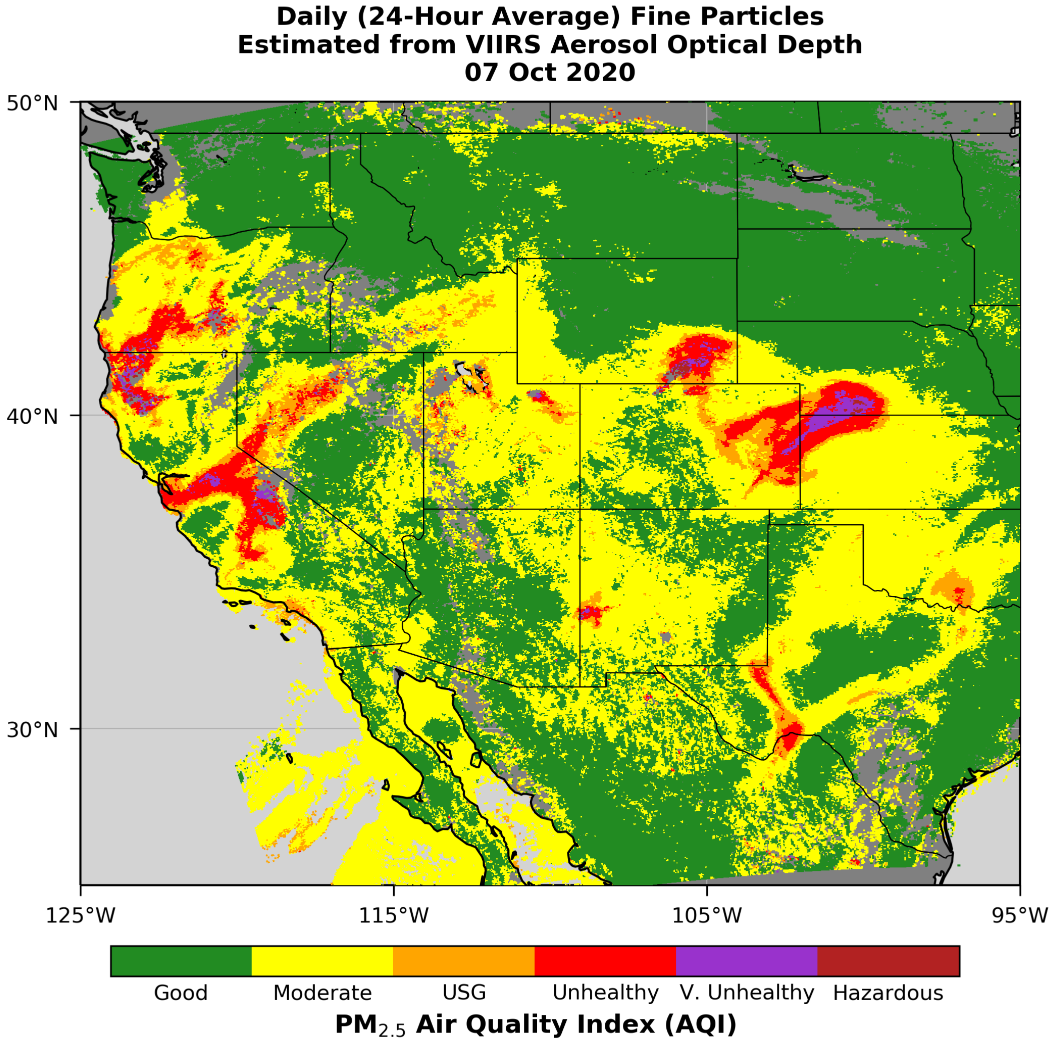
- AOD or AOT
- Typically reported at 550 nm
- unitless

Aerosol Optical Depth



Aerosol Optical Depth to PM2.5





https://twitter.com/AerosolWatch/status/1314208278222569472

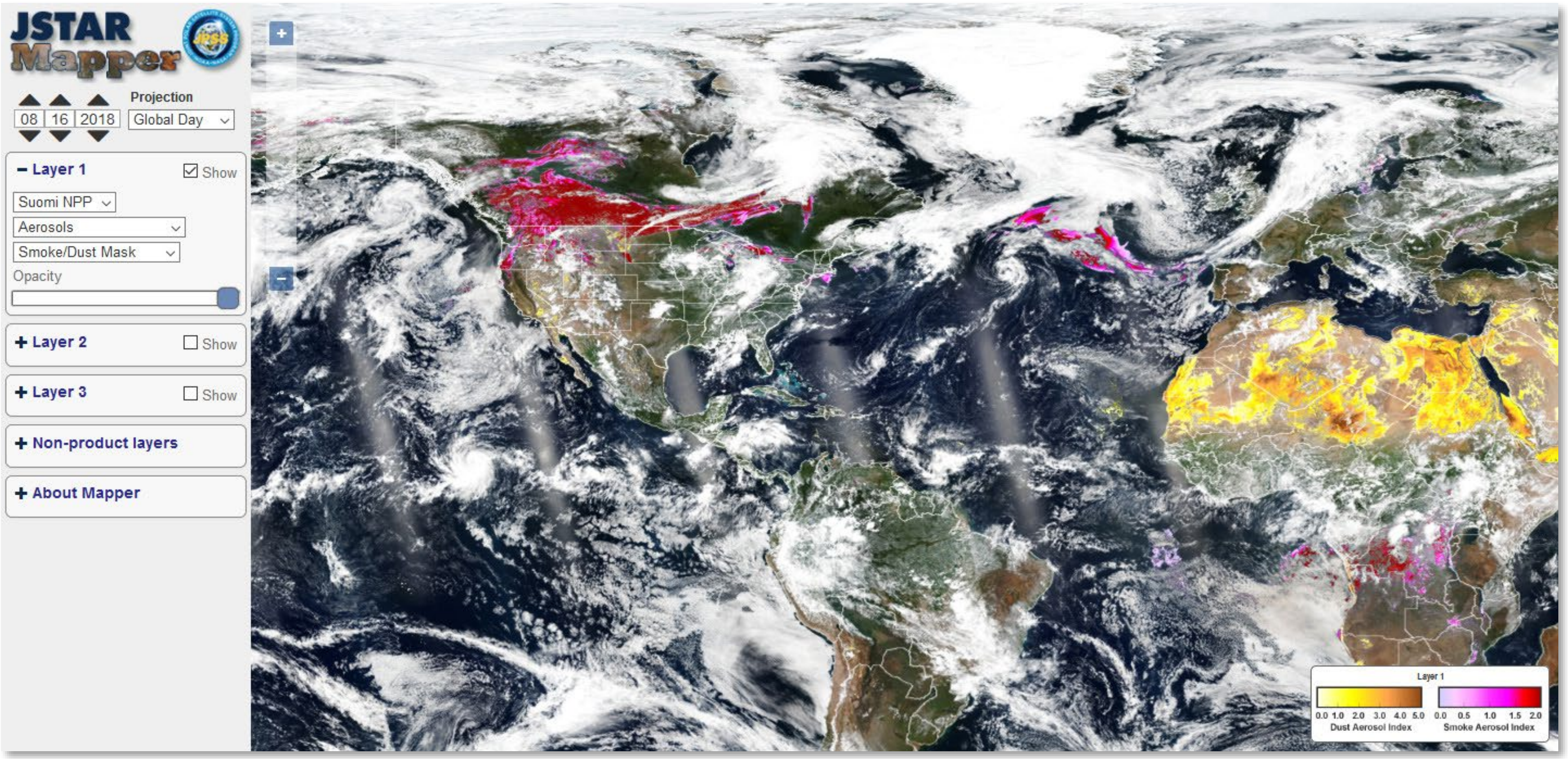
Hai and Kondragunta, 2021 - https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020EA001599

Smoke Monitoring Tools – JSTAR Mapper

https://www.star.nesdis.noaa.gov/jpss/mapper/

Aerosol Watch
https://www.star.nesdis.noaa.gov/smcd/spb/aq/AerosolWatch/

Data Access: NOAA CLASS (The Comprehensive Large Array-data Stewardship System)
https://www.class.ngdc.noaa.gov/saa/products/welcome

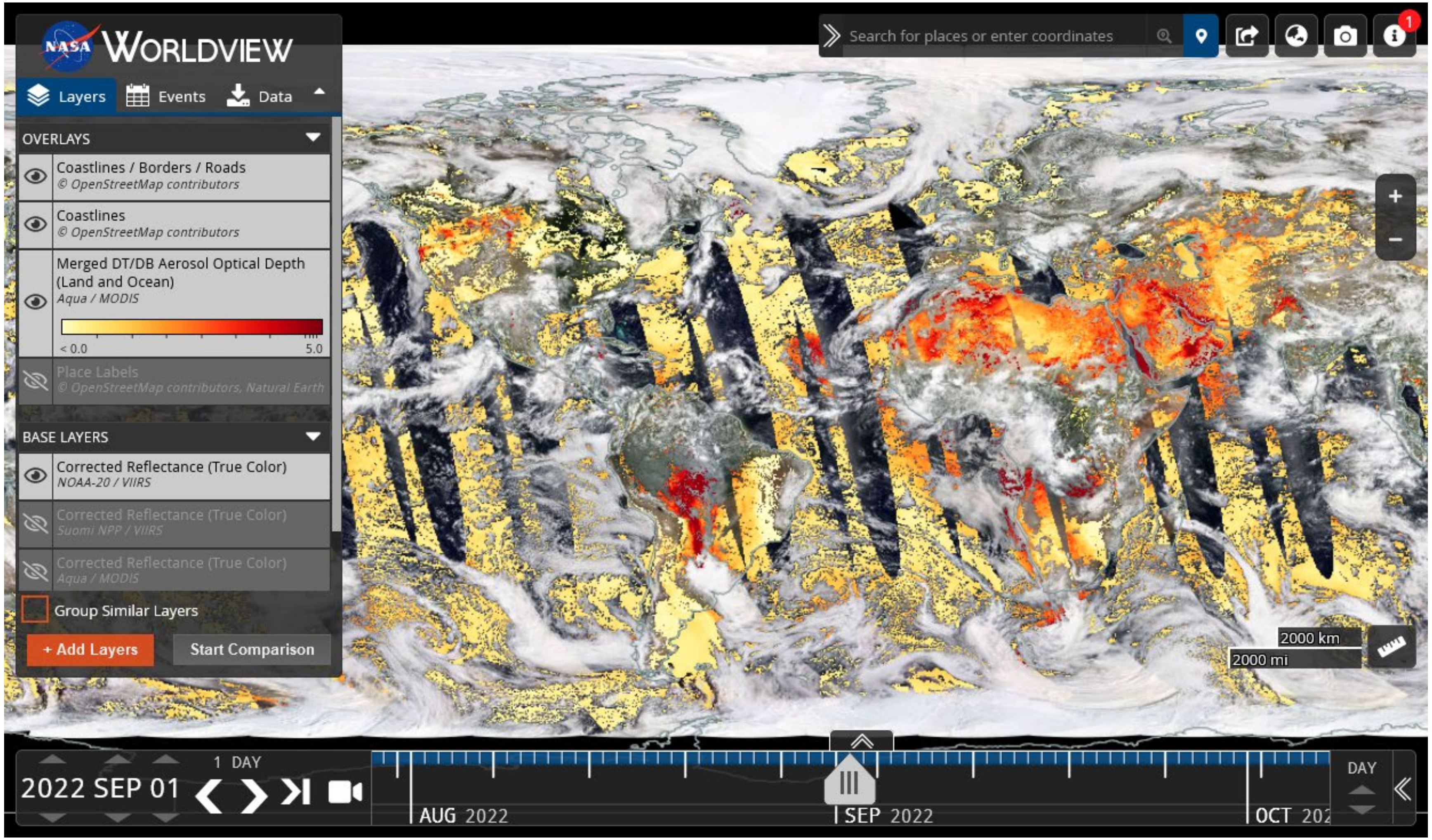


ARSET Training material and recording provide more details on the tool and data

https://appliedsciences.nasa.gov/join-mission/training/english/arset-modis-viirs-transition-air-quality-applications

NASA Worldview

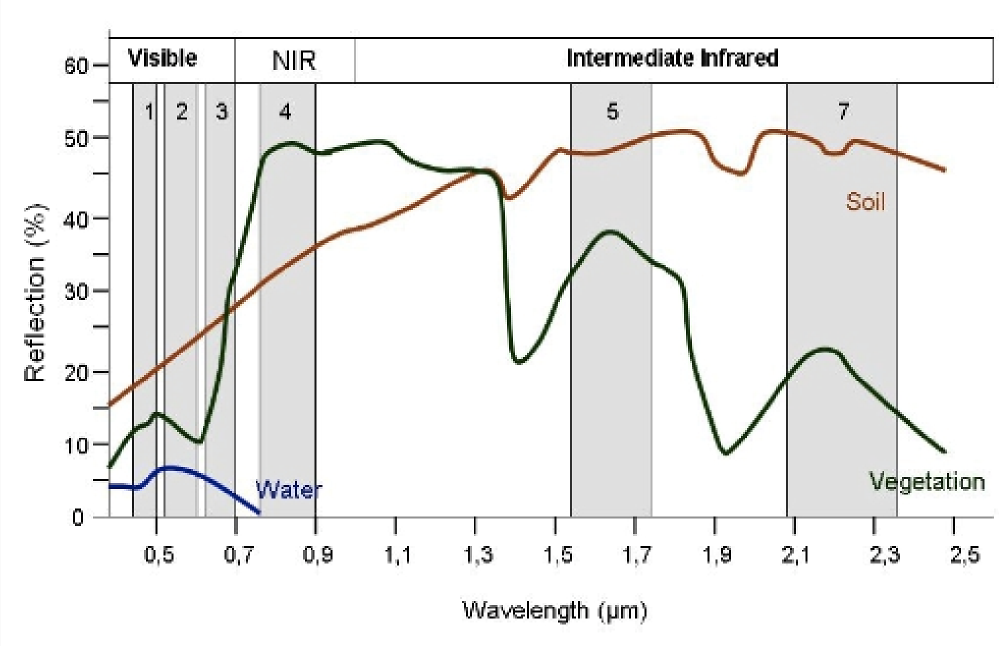
https://worldview.earthdata.nasa.gov/



Appendix

Land Cover Monitoring for Flood Detection

Optical Radiation: Reflected by the surface and depends on the surface type

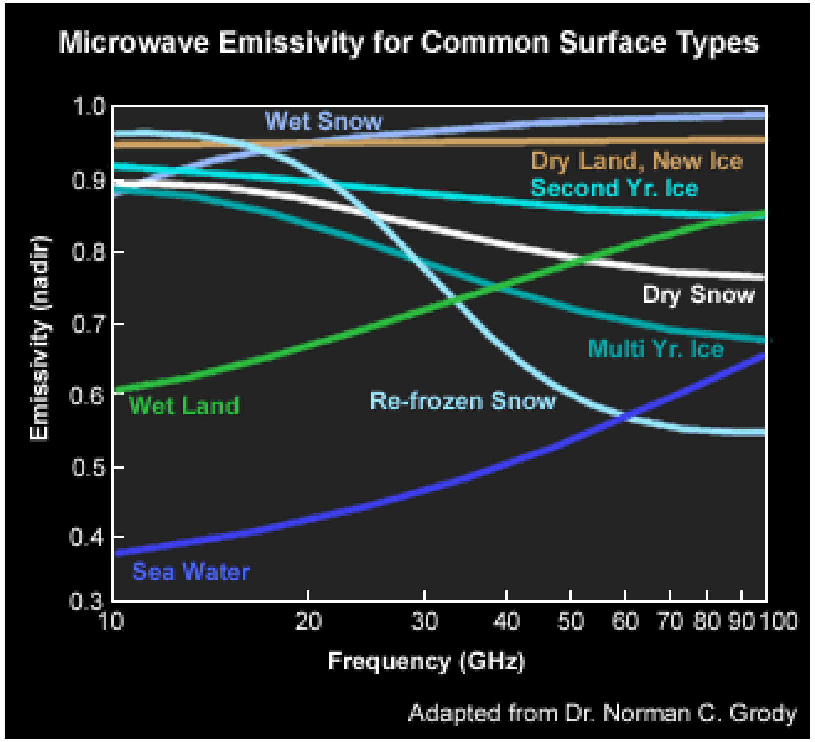


Optical Radiation

- Used for flood detection:
  - Terra/Aqua MODerate Resolution Imaging Spectroradiometer (MODIS) reflectance changes
- Used by:
  - MODIS NRT Flood Mapping
  - Dartmouth Flood Observatory(DFO)
- Used to observe land cover changes:
  - Reflectance from Landsat
- Used by: DFO

Land Cover Monitoring for Flood Detection

Passive Microwave Radiation: Emitted by the surface and influenced by the presence of water

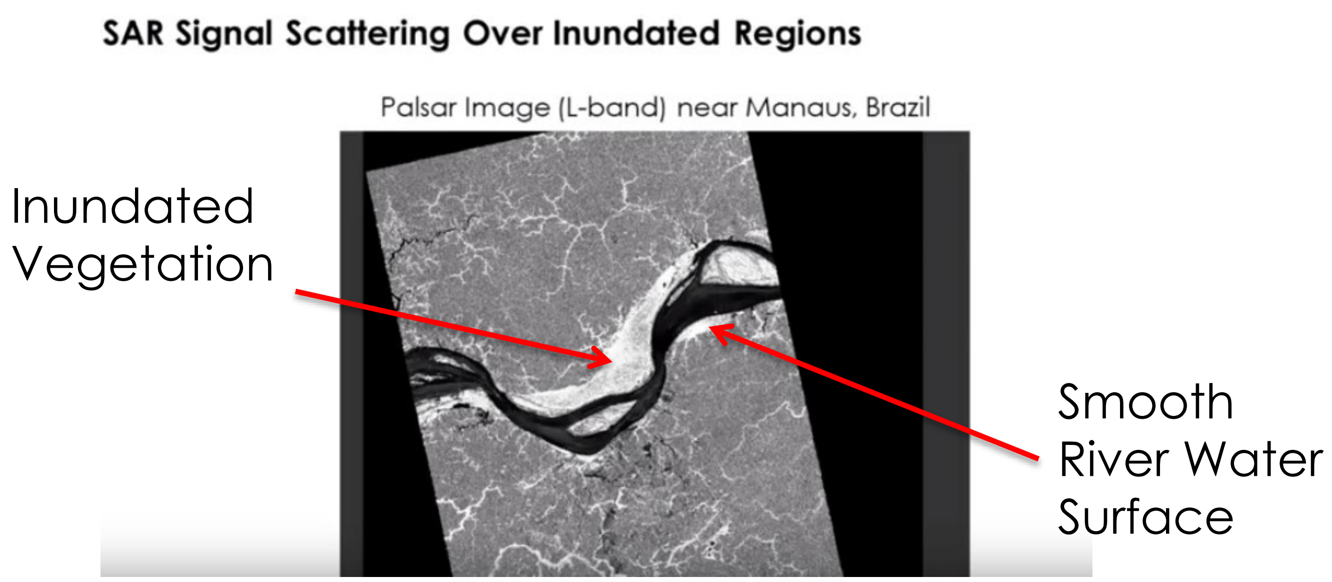


Passive Microwave Radiation

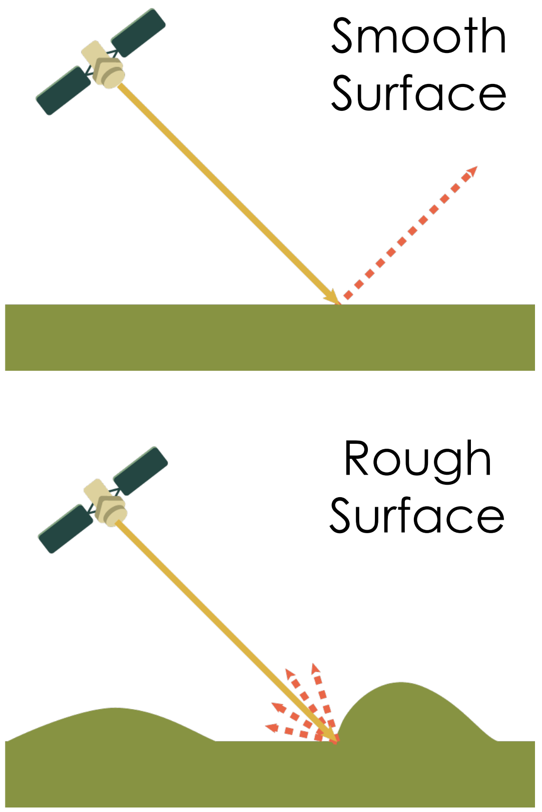
- Sources:
  - Microwave (37 GHz) brightness temperatures from TRMM Microwave Imager (TMI)
  - GPM Microwave Imager (GMI)
  - GCOM-W based Advanced Microwave Scanning Radiometer 2 (AMSR2)
- Tools:
  - GFDS2 (GDACS)
  - DFO River Watch

Land Cover Monitoring For Flood detection

- Active Microwave Radar (Synthetic Aperture Radar): The backscattered signal is primarily sensitive to surface structure



Backscattering Mechanisms

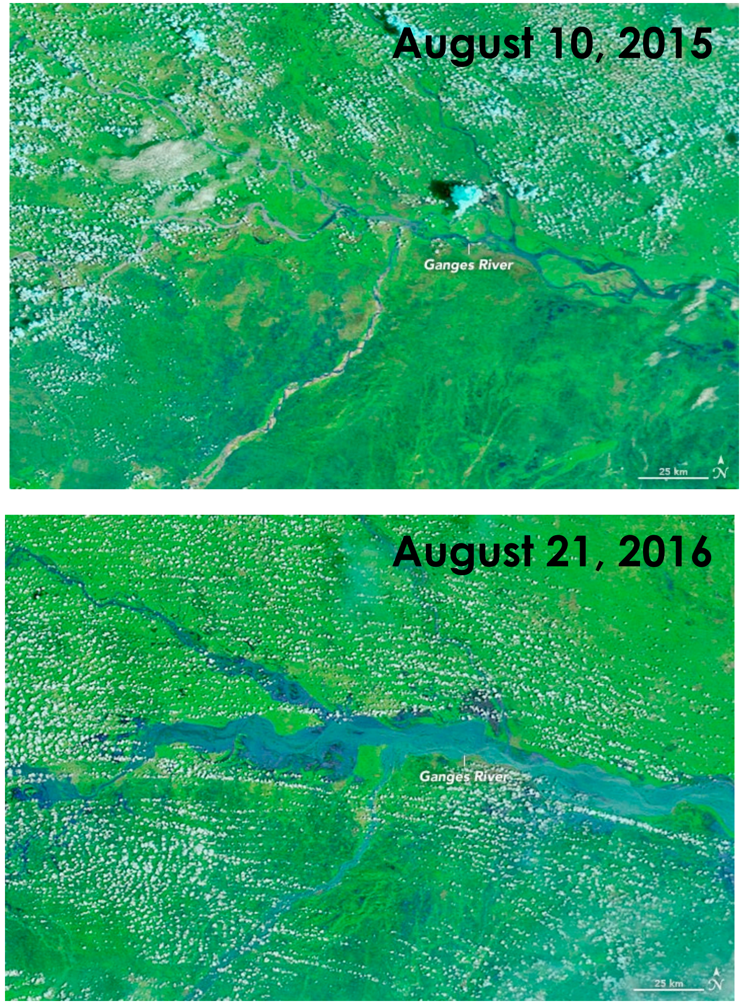


Details in next presentation

MODIS-Based Inundation Mapping [Optical Radiation]

- 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.

Flooding in the Ganges-- Aug 2016



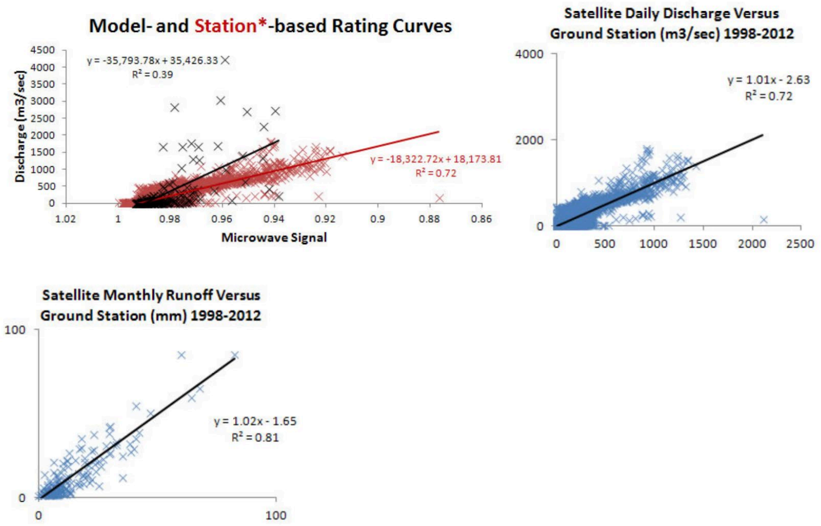
https://earthobservatory.nasa.gov/images/88624/flooding-on-the-ganges-river

Flood Detection and River Discharge Based on Passive Microwave Radiation

https://floodobservatory.colorado.edu/Measuring%20Discharge.pdf

Based on:

- Station discharge data
- Microwave (37 GHz) brightness temperatures from TRMM Microwave Imager (TMI)
- GPM Microwave Imager (GMI)
- GCOM-W-based Advanced Microwave Scanning Radiometer 2 (AMSR2)

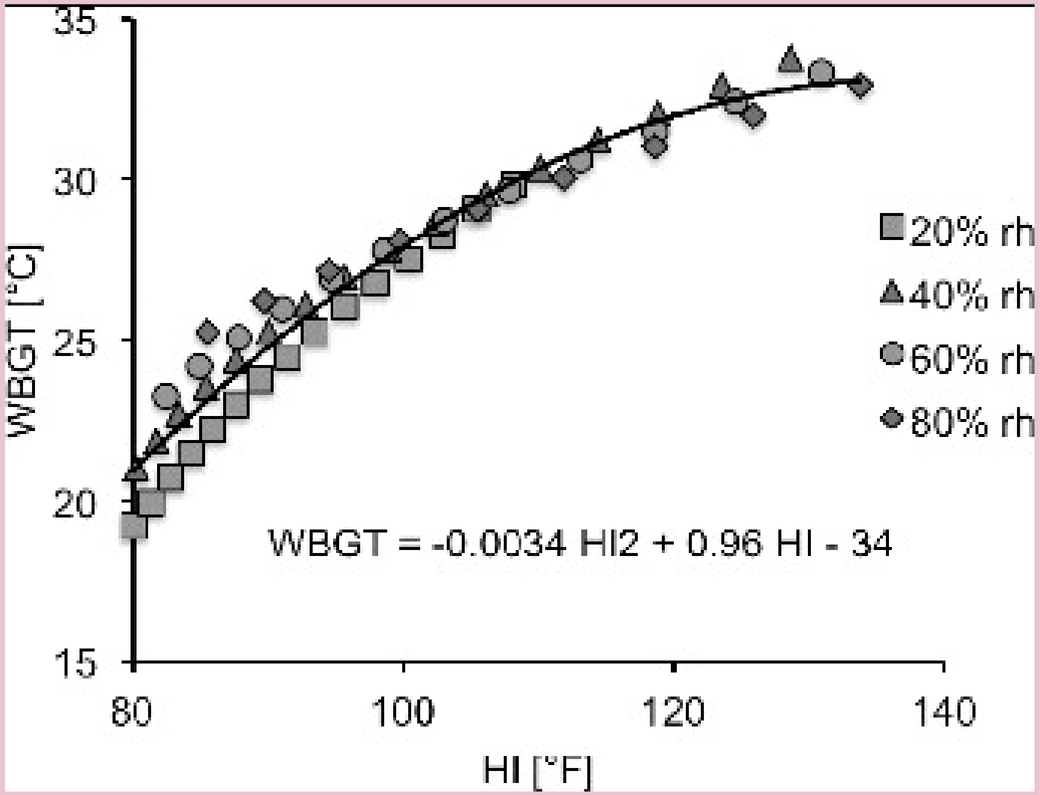


SGR 446, Trinity River, Texas, USA: Top Left shows two scatter plots and associated model- and ground-based rating equations and simple linear regression Rsquared values. Top right shows the independent daily discharge output of River Watch remote sensing at this site, as compared with the ground gauging station. Bottom shows the independent monthly runoff output, again as compared to that of the ground station.

Extreme Heat

Global High-Resolution Daily Extreme Urban Heat Exposure (UHE-Daily), v1 (1983–2016)

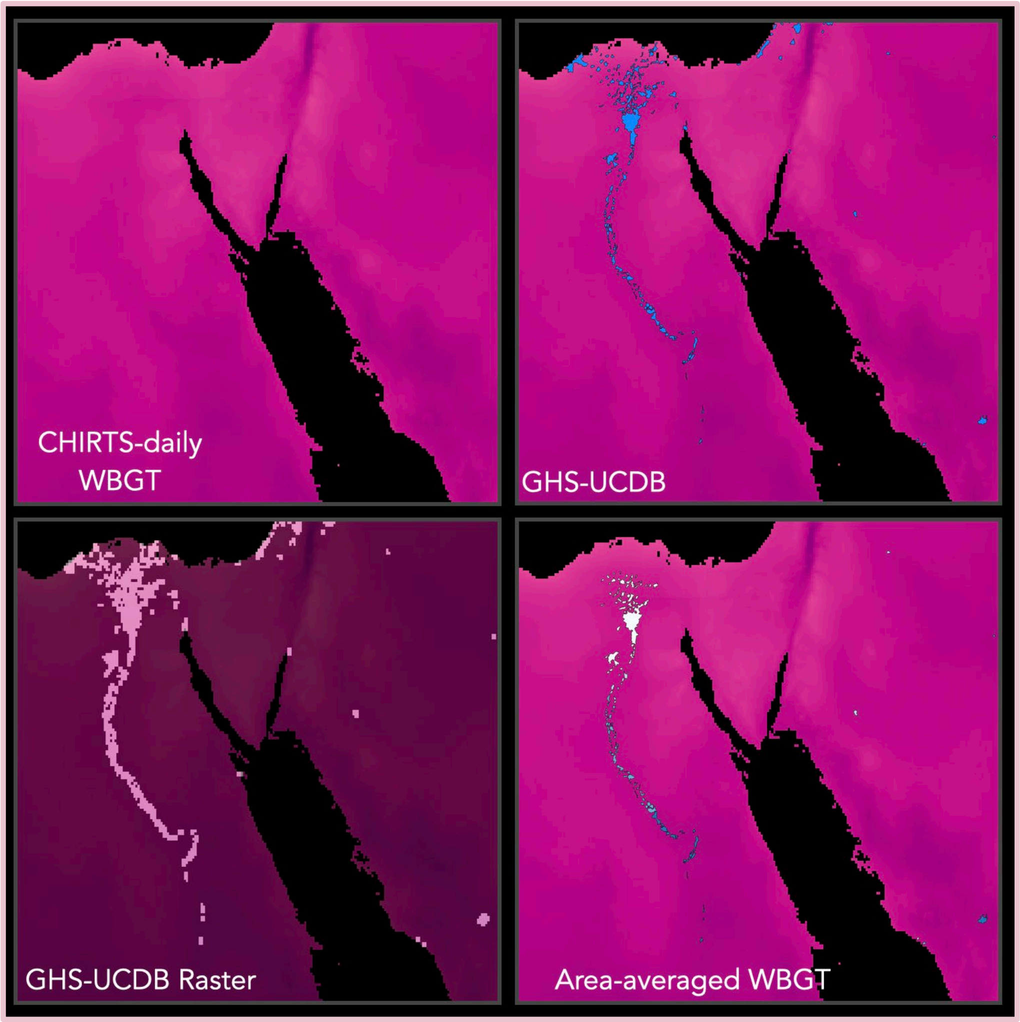
- Use CHIRTS-daily to calculate daily maximum heat index, following the US National Weather Service procedure.
  - Daily maximum air temperature
  - Daily minimum relative humidity
- Then convert HImax to WBGTmax, following Bernard & Iheanacho 2015.
- Assumes a fixed wind speed and radiation.



Bernard & Iheanacho 2015.

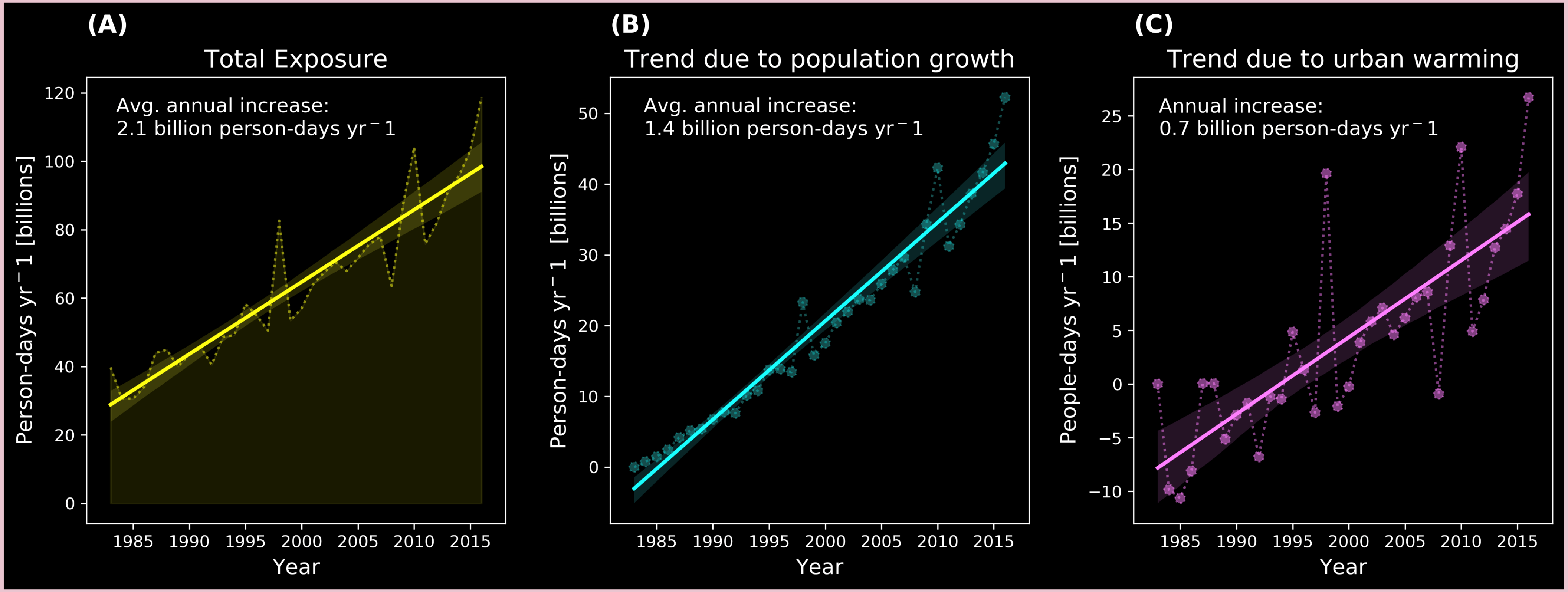
Global High-Resolution Daily Extreme Urban Heat Exposure (UHE-Daily), v1 (1983–2016)

- Combine CHIRTS-daily WBGTmax record with the Global Human Settlement Layer Urban Centre Data Base (Florczyk et al. 2019)
- Create a record of WBGTmax for every urban settlement on the planet from 1983 – 2016 (150 million observations).
- Apply ISO threshold to identify dangerous hot-humid days (e.g., WBGTmax > 30°C) for each city on the planet, from 1983 – 2016 **to produce a record of all urban hot-humid heat waves**.



Global High-Resolution Daily Extreme Urban Heat Exposure (UHE-Daily), v1 (1983–2016)

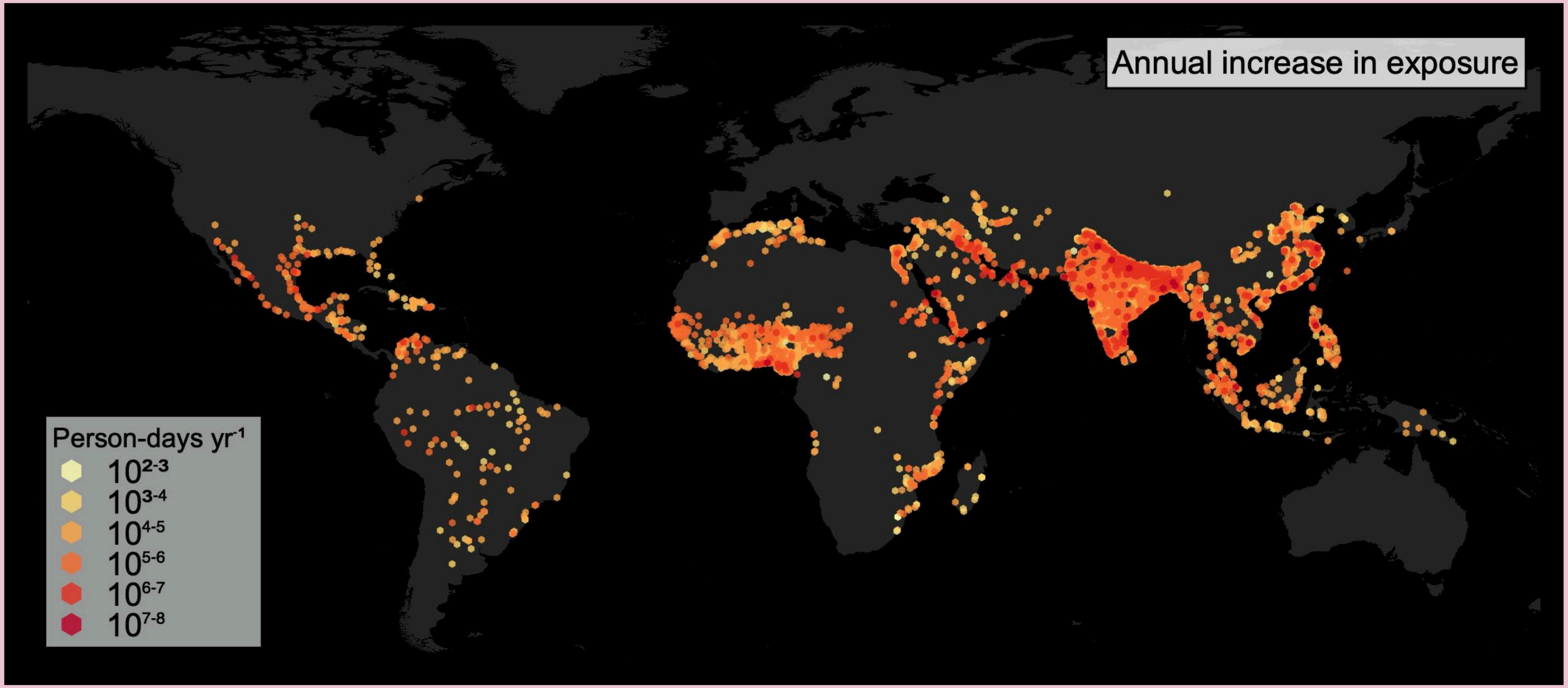
Global High-Resolution Daily Extreme Urban Heat Exposure (UHE-Daily), v1 (1983–2016)



Tuholske et al. 2021

Global exposure increased 200% from 1983 – 2016. Total urban warming contributed a **third** of the annual increase in exposure.

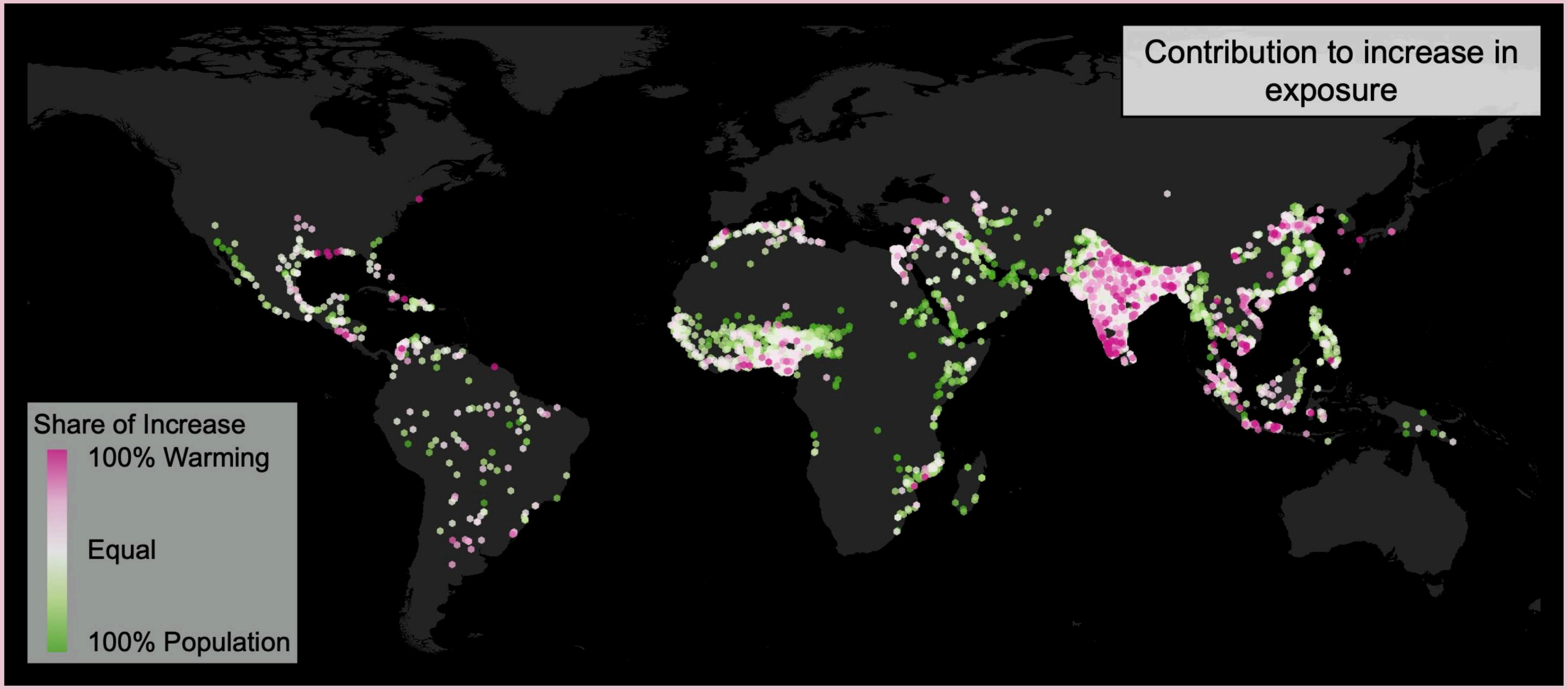
Global High-Resolution Daily Extreme Urban Heat Exposure (UHE-Daily), v1 (1983–2016)



Tuholske et al. 2021

Nearly 6,000 urban settlements had an increase in exposure, which housed 1.7 billion people in 2016.

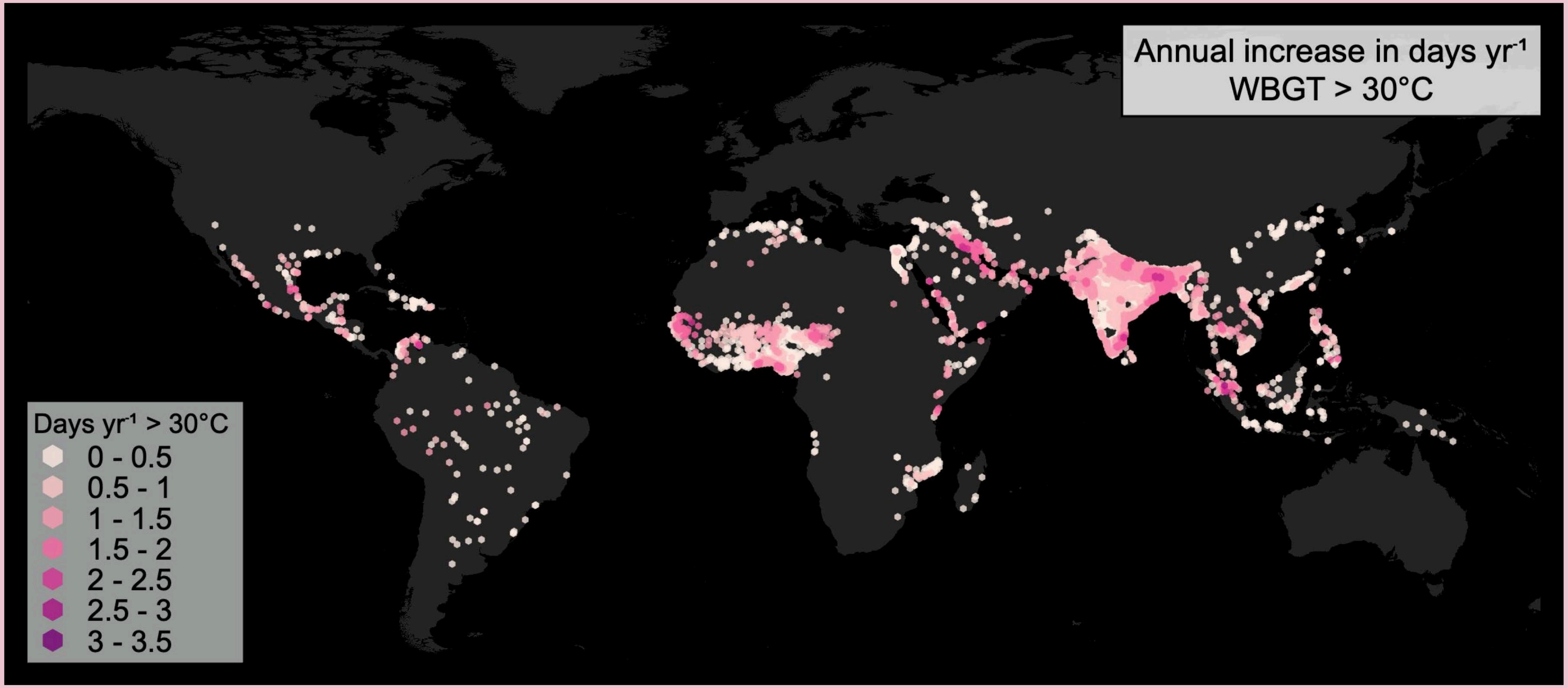
Global High-Resolution Daily Extreme Urban Heat Exposure (UHE-Daily), v1 (1983–2016)



Tuholske et al. 2021

Heterogenous contribution of population growth vs. total urban warming.

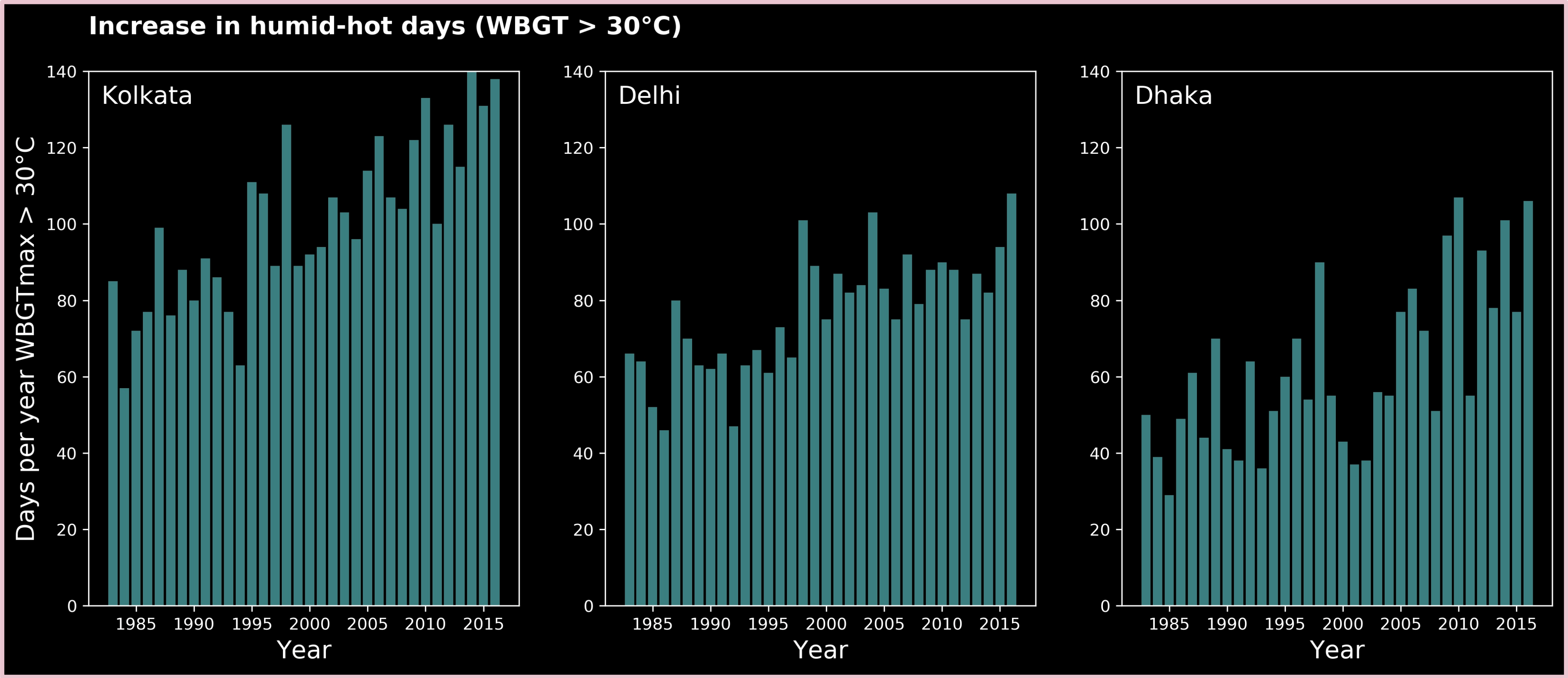
Global High-Resolution Daily Extreme Urban Heat Exposure (UHE-Daily), v1 (1983–2016)



Tuholske et al. 2021

Important Note: Urban warming is both climate change and the urban heat island effect.

Global High-Resolution Daily Extreme Urban Heat Exposure (UHE-Daily), v1 (1983–2016)



Tuholske et al. 2021

"Proximate" urban settlements of similar size populations and levels of economic development have much different increase in the number of dangerous hot-humid days per year.

Global High-Resolution Daily Extreme Urban Heat Exposure (UHE-Daily), v1 (1983–2016)

https://sedac.ciesin.columbia.edu/data/set/sdei-high-res-daily-uhe-1983-2016

- UHE-Daily, v1 dataset is available from the NASA Socioeconomic Data and Applications Center (SEDAC).
- Record Includes:
  - Every hot-humid urban heat wave, including dates and WBGTmax estimates, from 1983 – 2016 for three ISO thresholds (WBGTmax 28°C, 30°C, & 32°C)

Global High-Resolution Daily Extreme Urban Heat Exposure (UHE-Daily), v1 (1983–2016)

https://sedac.ciesin.columbia.edu/data/set/sdei-high-res-daily-uhe-1983-2016

- Annual person-day estimates for each urban settlement.
- Exposure + warming trends for each urban settlement.
- Dataset available in .json, .csv. & .shp file formats.
- DOI: https://doi.org/10.7927/fq7g-ny13