



# Earth Observations for Disaster Risk Assessment and Resilience

Amita Mehta and Sean McCartney

6 August 2019

### **Learning Objectives**



- Learn about available NASA remote sensing and socioeconomic data and how to combine them for Disaster Risk Assessment (DRA)
- Understand how to apply these data for assessing risk from floods, tropical cyclones, and extreme heat in specific regions
- Demonstrate how operational agencies are using NASA data for risk management



### **Training Outline**









Aug 6, 2019

NASA Remote
Sensing and
Socioeconomic
Data for Disaster
Risk Assessment

Aug 8, 2019

Assessing the Risk of Floods & Cyclones Using NASA Data Aug 13, 2019

Disaster Risk
Assessment Case
Studies Using
Remote Sensing
Data

Aug 15, 2019

Operational
Application of
Remote Sensing for
Disaster
Management

Image Credits (left to right): EM-DAT; NASA; WRI Resource Watch; PDC



#### **Homework and Certificate**



- Homework:
  - 2 homework assignments
  - Answers to homework must be submitted via Google Forms
- Certificate of Completion:
  - Attend all webinars
  - Complete 2 homework assignments by 30 August
- You will receive certificates approximately two months after the completion of the course from: <a href="mailto:marines.martins@ssaihq.com">marines.martins@ssaihq.com</a>

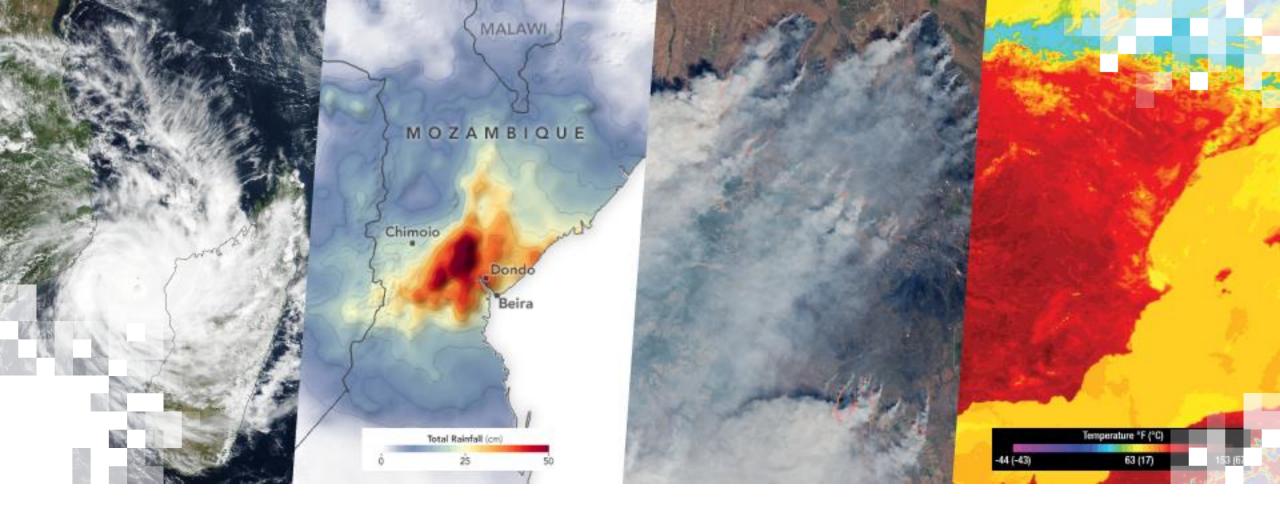


#### Part-1 Outline

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- About ARSET
- Disaster Risk Assessment (DRA): Concept and Definitions
- Remote Sensing and Earth System Model Data Sources Relevant for DRA
- Socioeconomic Data Relevant for DRA





About ARSET

# NASA's Applied Remote Sensing Training Program (ARSET)

#### http://arset.gsfc.nasa.gov/

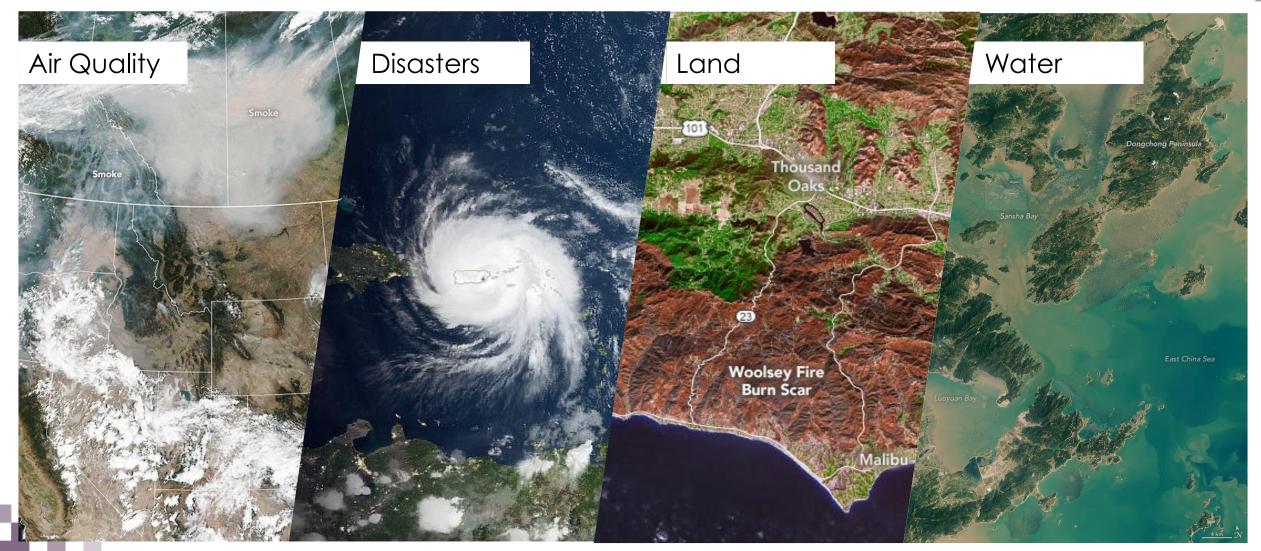
- Empowering the global community through remote sensing training
- Seeks to increase the use of Earth science in decision-making through training for:
  - policy makers
  - environmental managers
  - other professionals in the public and private sector
- Training topics focus on:
  - air qualityland
  - disasterswater

Helping Professionals Solve Problems Including...





# **ARSET Training Focus Areas**



#### **ARSET Team Members**

#### **Program Support**

- Ana Prados, Program Manager (GSFC)
- David Barbato, Spanish Translator (GSFC)
- Brock Blevins, Training Coordinator (GSFC)
- Annelise Carleton-Hug, Program Evaluator (Consultant)
- Elizabeth Hook, Technical Writer/Editor (GSFC)
- Selwyn Hudson-Odoi, Training Coordinator (GSFC)
- Marines Martins, Project Support (GSFC)
- Stephanie Uz, Program Support (GSFC)

#### **Disasters & Water Resources**

- Amita Mehta, Instructor (GSFC)
- Erika Podest, Instructor (JPL)
- Sean McCartney, Instructor (GSFC)

#### **Land & Wildfires**

- Amber Jean McCullum, Lead (ARC)
- Juan Torres-Pérez, Instructor (ARC)

#### **Health & Air Quality**

- Pawan Gupta, Lead (MSFC)
- Melanie Follette-Cook, Instructor (GSFC)

Acknowledgement: We wish to thank Nancy Searby for her continued support

GSFC: Goddard Space Flight Center, JPL: Jet Propulsion Laboratory, ARC: Ames Research Center, MSFC: Marshall Space Flight Center



### **ARSET Training Formats**



#### Online

Free

Online training

1-5 weeks long

1-6 hours a week

Available at all levels

Materials available in English & Spanish

#### In-Person

Hosted with a partner

Typically in a computer lab

2-7 days long

Focus on locally-relevant case studies

Certain topics presented in Spanish



### **ARSET Training Levels**

#### **Advanced (Level 2)**

Requires level 1 training or equivalent knowledge In-depth and highly focused topics Advanced Webinar: SAR Image and Data Processing

#### Basic (Level 1)

Requires level 0 training or equivalent knowledge Covers specific applications Introduction to Synthetic Aperture Radar

#### **Fundamentals (Level 0)**

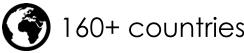
Assumes no prior knowledge of remote sensing Fundamentals of Remote Sensing



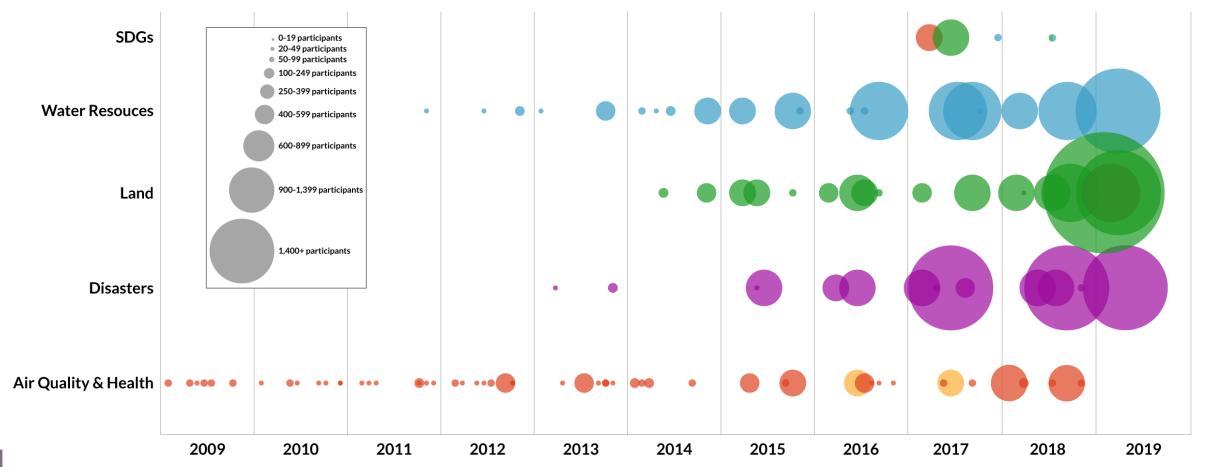




110+ trainings 19,400+ participants







<sup>\*</sup> size of circle corresponds to number of participants



#### Sign up for the ARSET Listserv

#### https://lists.nasa.gov/mailman/listinfo/arset



As the weather warms in the Northern Hemisphere, many will notice an increase in algal blooms like <u>this one</u> which occurred in Washington last year. <u>Learn the basics of aquatic remote sensing, including how to access satellite-derived chlorophyll data</u>,

#### **UN Sustainable Development Goals**

In the 2030 Agenda for Sustainable Development, the United Nations established a series of goals for protecting the planet and ending global poverty. In a recent ARSET webinar, nearly 400 participants learned to use satellite observations of air quality in support of the goals. The training was featured on the <u>SDG Knowledge Hub</u>, and materials from the training are now available on the <u>ARSET website</u>. This June, the program is offering a three day webinar on remote sensing of land indicators for Sustainable Development Goal 15.

Register Here

NASA EOSDIS recently announced that Reverb data search would be replaced with Earthdata Search by the end of the year. The new system will be faster and easier to use. Read the full announcement here.

Remote Sensing of Aquatic Environments





#### Introduction to Synthetic Aperture Radar Introducción al Radar de Apertura Sintética

June 28, 29 and July 5, 6 English: 21:00-22:00 EDT (UTC-4)

SAR can observe the Earth's surface day and night, through most weather conditions, and the signal can penetrate the vegetation canopy. There are a number of existing SAR datasets from current and past airborne and satellite missions, as well as exciting upcoming missions. This online webinar will focus on building the skills needed to acquire and understand SAR data, including polarimetric and interferometric SAR (PolSAR and InSAR), as well as potential applications.

Register

28, 29 de junio y 5, 6 de julio Español: 12:00-13:00 EDT (UTC-4)

SAR puede observar la superficie terrestre de día y de noche y a través de la mayoría de las condiciones meteorológicas. Además, la señal puede penetrar la cubierta vegetal y proporcionar información relacionada al estado de inundación de la vegetación. Existen datos de SAR del presente y del pasado obtenidos desde satélites y aviones y habrá más con futuras misiones. Esta capacitación en línea se enfocará en desarrollar los conocimientos necesarios para adquirir y entender datos de SAR incluyendo polarimetría e interferometría y sus potenciales aplicaciones.



The MODIS Image above (Credit: NASA Earth Observatory) shows a wildfire burning in Greenland. Many areas around the world are experiencing above average wildfire activity this year. <u>Learn to forecast, monitor,</u> and manage wildfires using satellite observations.

#### **SAR** Success

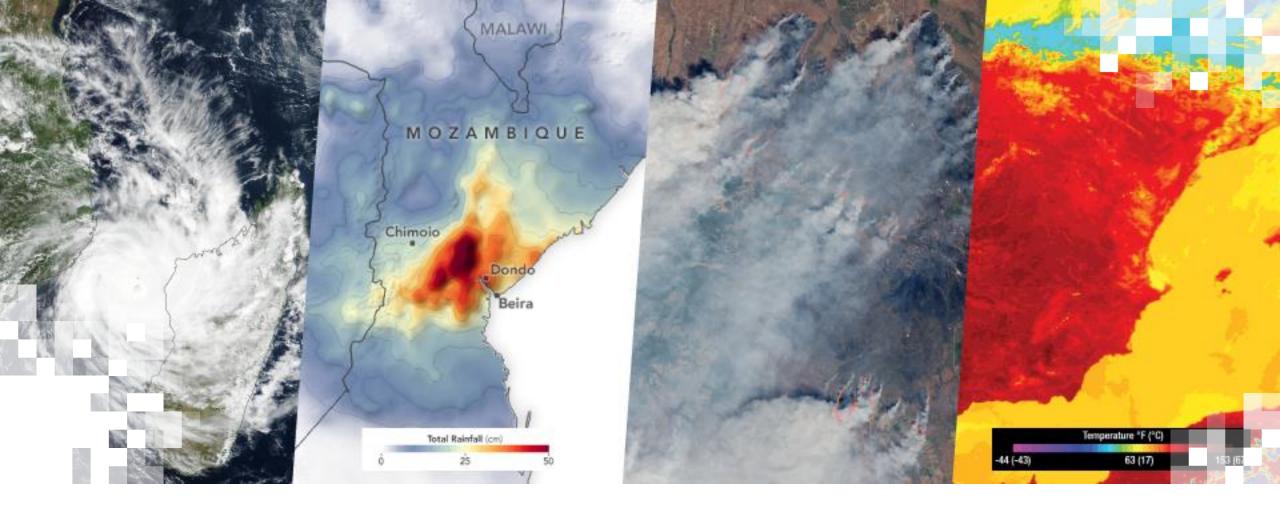
We just wrapped up our first training focused on Synthetic Aperture Radar. Unlike optical sensors, SAR can penetrate through cloud cover and vegetation and is useful for nighttime observations. This four-session webinar, offered in both English and Spanish, was ARSET's largest training to date. Missed the live webinar? You can watch it on demand.

Watch Now

#### Have You Heard of AppEEARS?

Application for Extracting and Exploring Analysis Ready Samples, or AppEEARS, is a useful tool for downloading remote sensing data. Download just the data you need by subsetting spatially (by point or area), temporally, and spectrally. The application also allows you to visualize the results before downloading them.

Learn More



Disaster Risk Assessment: Concept and Definitions



- Disaster Risk Assessment (DRA)
- Hazard
- Exposure
- Vulnerability
- Disaster
- Disaster Risk
- Resilience
- Disaster Risk Reduction (DRR)
- Disaster Risk Management (DRM)

- A process to determine the nature and extent of risks
- Requires analysis of hazards and existing conditions of exposure and vulnerability
- Focuses on potential harm to
  - people
  - property
  - services
  - livelihoods
  - and the environment people depend on







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- A comprehensive DRA evaluates the magnitude and likelihood of potential losses
- It provides full understanding of the causes and impact of those losses
- DRA is an integral part of Disaster Risk
   Management, decision and policy-making processes, and requires close collaboration among various parts of society







- Disaster Risk Assessment
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- Disaster Risk Reduction (DRR)
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- A process, phenomenon, or human activity that may cause:
  - loss of life
  - injury or other health impacts
  - property damage
  - social and economic disruption
  - environmental degradation
- A hazard is characterized by:
  - location or geographic area
  - intensity or magnitude
  - frequency or return period
  - probability of occurrence





- Disaster Risk Assessment
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- Natural hazards arise from events, sometimes acting in combination, including:
  - geological (earthquakes, landslides, volcanoes)
  - meteorological (storms, extreme temperatures, wildfires)
  - hydrological (floods, droughts)
  - oceanic (wave surge)
  - biological (disease epidemics)
- Human induced hazards include:
  - industrial and transportation accidents
  - environmental pollution
  - human conflicts
  - migration







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- The situation of people, infrastructure, housing, production capacities, and other tangible human assets located in hazardprone areas
- Exposure can be measured by the number of people or types of assets in an area
- To estimate quantitative risks associated with a hazard, exposure measurements can be combined with specific vulnerability and capacity of exposed elements



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- Determined by physical, social, economic, and environmental factors or processes
- Assesses the susceptibility of an individual, community, asset, or system to the impact of hazards
- Depends on cultural and institutional factors, including:
  - poor design and construction of buildings
  - poor environmental management
  - inadequate protection of assets
  - lack of public information and awareness
  - levels of poverty and education
  - limited official recognition of risks and preparedness
  - weak governance



- Disaster Risk Assessment
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- A serious disruption of the functioning of a community or a society at any scale due to hazardous events leading to one or more of the following losses and impacts:
  - human
  - material
  - economic
  - environmental







- Disaster Risk Assessment
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- The potential loss of life, injury, or destroyed or damaged assets that could occur to a community as a function of a hazard, exposure, or vulnerability
- Made up of different types of potential losses that can be difficult to quantify







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- Ability of a system, community, or society exposed to hazards to:
  - resist
  - absorb
  - accommodate
  - adapt to
  - recover from effects
- Refers to the timely and efficient response, including through preservation & restoration of basic structures and functions





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- Aimed at
  - preventing new disasters
  - reducing existing disaster risk
  - managing residual risk
- These contribute to strengthening resilience
- Involves developing strategies and policy objectives
  - across different timescales
  - with concrete targets, indicators, and timeframes





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- Disaster Risk Assessment
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- Application of Disaster Risk Reduction policies and strategies to:
  - prevent new disaster risk
  - reduce existing disaster risk
  - manage residual risk
- Can be categorized into:
  - Prospective Disaster Risk Management
  - Corrective Disaster Risk Management
  - Compensatory Disaster Risk Management (also referred to as Residual Risk Management)





#### How to Conduct a Disaster Risk Assessment

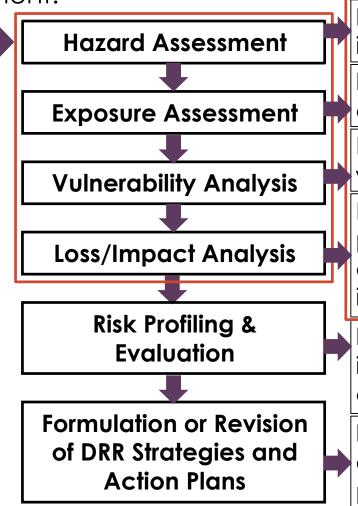
According to the UN Development Program (UNDP) the following steps are required for a comprehensive risk assessment:

# Understanding of Current Situation, Needs, and Gaps:

 systematic inventory and evaluation of existing risk assessment studies, available data and information, and current institutional framework and capabilities

Steps within red boxes can be derived from data freely available from NASA

Text Credit: **UNDP** 



Identify the prevailing nature, location, intensity, and likelihood of major hazards

Identify population & assets at risk and delineate disaster-prone areas

Determine the capacity of a system to withstand given hazard scenarios

Estimate potential losses of exposed population, property, services, livelihoods, and environment. Assess their potential impacts.

Identify cost-effective risk reduction options in terms of socio-economic concerns and capacity

Include setting priorities, allocating financial and human resources, and installing a DRR program

### Types of Natural Hazards

- Cyclones
- Droughts
- Earthquakes
- Extreme Precipitation
- Extreme Temperatures
- Floods
- Landslides
- Tsunamis
- Volcanoes
- Wildfires









Image Credits (Clockwise from Top Left): NOAA, USAF, USDA, Kieran Wood



### Global Disaster Statistics (1998-2017)

In this time frame, floods and storms were the most dominant hazards

Numbers of disasters per type 1998-2017

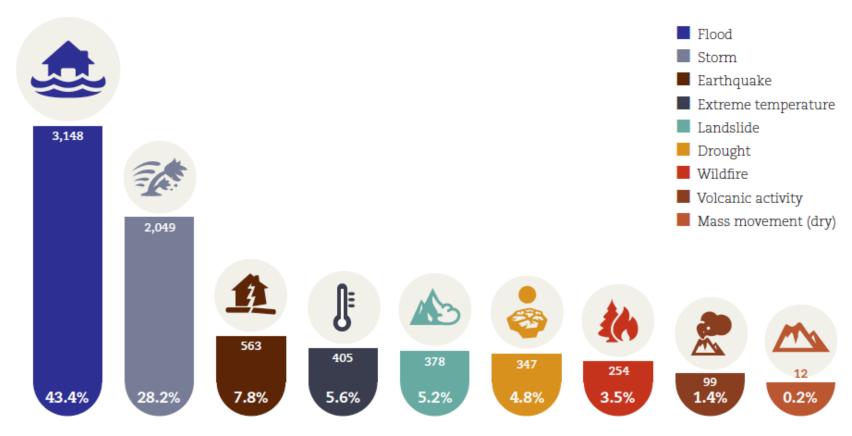


Image Credit: CRED and UNISDR



### Global Disaster Statistics (1998-2017)

Floods, droughts, and storms affected the highest number of people

Number of people affected per disaster type 1998-2017

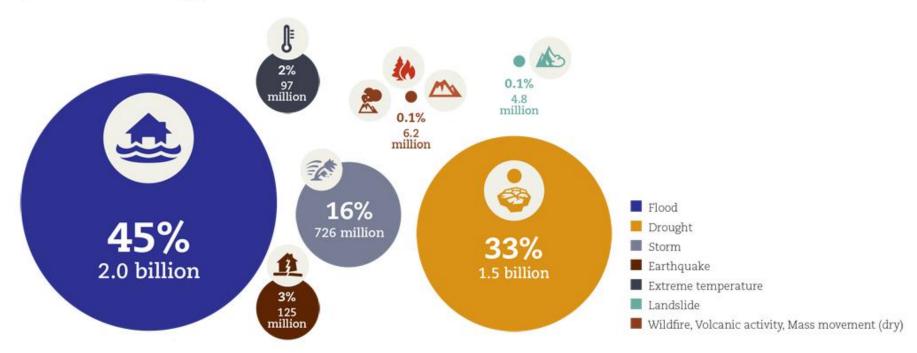
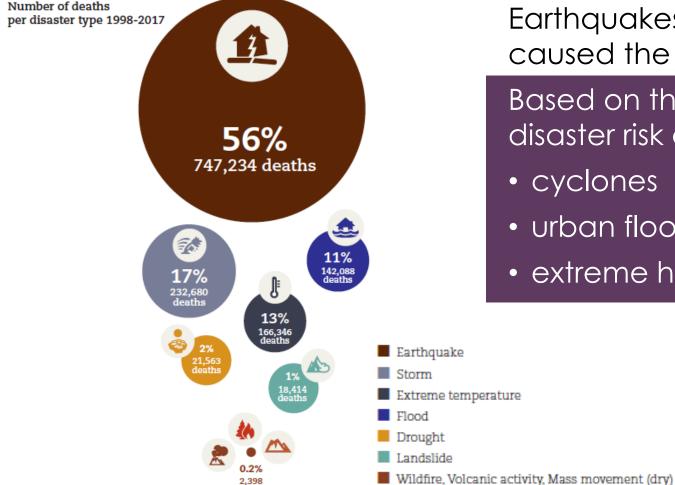


Image Credit: <u>UNDRR</u>, data from <u>CRED and UNISDR</u>

### Global Disaster Statistics (1998-2017)



Earthquakes, storms, extreme heat, and floods caused the most number of deaths

Based on these statistics, this webinar will focus on disaster risk assessment (DRA) for:

- urban floods (Extreme Precipitation)
- extreme heat



### Assessing the Potential Risk of a Hazard



# Identify the nature, location, intensity, and likelihood of major hazards prevailing in a community or environment

- Requires data and information about a type of hazard or multiple hazards:
  - Past/historical data
    - identify hazard-prone regions
    - assess frequency and intensity of hazards
    - establish strategies for DRR
  - Current data for near-real time actions for DRR
  - Future data (forecast) for assessing potential risk to an approaching hazard, planning near-future actions for DRR
  - Quantitative analysis of past-current-forecast data



#### **Hazard Assessment Data Needs**

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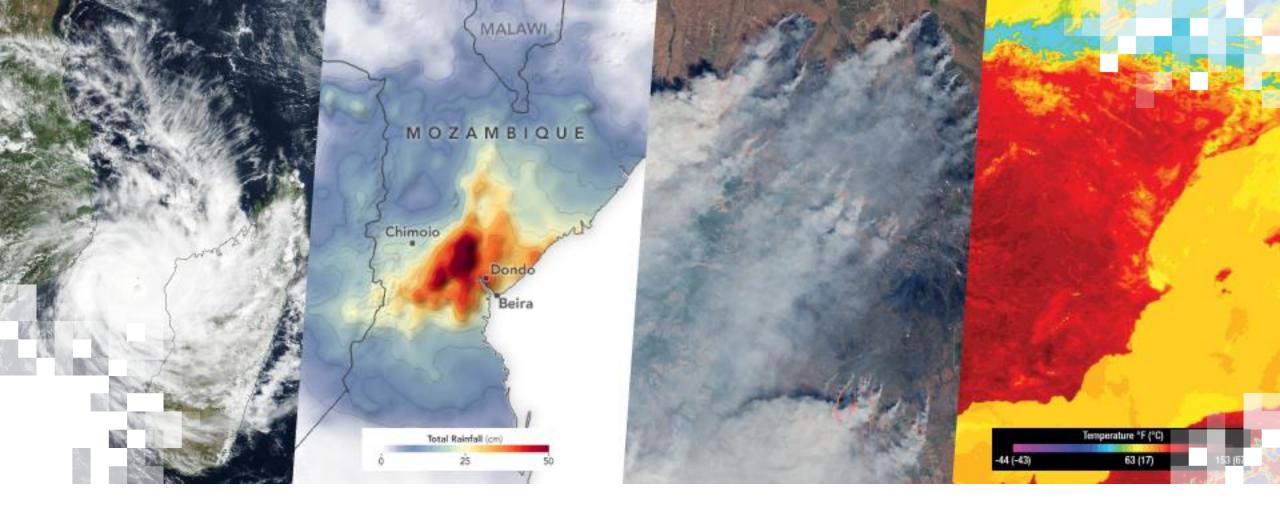
- Cyclones: frequency, probability, intensity
  - based on tracks, landfall locations, storm surge, sea level pressure, winds, precipitation
- Floods: flood plain extent, frequency, intensity, duration
  - based on precipitation, soil moisture, terrain/slope, impermeable surface
- Extreme Heat: frequency, probability, duration
  - based on surface temperature, surface humidity

Data in **blue** are derived from NASA Earth Observations and Models

Data in **brown** are available from NOAA, the Joint Typhoon Warning Center, and Worldwide Tropical Cyclone Centers







Remote Sensing Data Sources Relevant for Disaster Risk Assessment

### Data for Hazard Assessment: Past Data (>18 Years)

Data Parameter	Hazard	Source	Spatial Resolution	*Temporal Information
Land Surface Temperature Surface Air Temperature	Extreme Heat	modis, Gldas, merra-2	1 Km 0.25° x 0.25° 0.5° x 0.667°	2000-present 2000-present 1980-Present
Surface Humidity	Extreme Heat	GLDAS, MERRA-2	0.25° x 0.25° 0.5° x 0.667°	2000-present 1980-Present
Winds	Cyclone	MERRA-2	0.5° x 0.667°	1980-Present
Precipitation	Flood, Cyclone	*TRMM TMPA GPM/IMERG- Final	0.25° x 0.25° 0.1° x 0.1°	1998-present 2000-present
Soil Moisture	Flood	GLDAS MERRA-2	0.25° x 0.25° 0.5° x 0.667°	2000-present 1980-Present
Elevation	Flood	SRTM	1-arc second 3-arc second	2000-present

<sup>\*</sup>A combined TRMM/GPM precipitation data product is now available spanning 2000-present





## Data for Hazard Assessment: Past Data (4-5 Years)



Data Parameter	Hazard	Source	Spatial Resolution	*Temporal Information
Precipitation	Flood, Cyclone	GPM/IMERG- Early and Late	0.1° x 0.1°	3/2014 - present
Storm Surge	Cyclone	*SLOSH (US Only)	Tens of meters to 1 km	2014 - present
Soil Moisture	Flood	GEOS-5 SMAP	0.3125° x 0.25° 36 km, 9 km	4/2015 - present

<sup>\*</sup>All data have global coverage except for \$LOSH



#### Data for Hazard Assessment: Near-Real Time and Forecasts

Data Parameter	Hazard	Source	Spatial Resolution	Temporal Information
Land Surface and Surface Air Temperature	Extreme Heat	MODIS, GEOS-5	1 Km 0.3125° x 0.25°	NRT NRT and 10-day Forecast
Surface Humidity	Extreme Heat	GEOS-5	0.3125° x 0.25°	
Winds	Cyclone	GEOS-5	0.3125° x 0.25°	
Soil Moisture	Flood	GEOS-5 SMAP	0.3125° x 0.25° 36 km, 9 km	
Precipitation	Flood Cyclone	GEOS-5 GPM/IMERG	0.3125° x 0.25° 0.1° x 0.1°	
Storm Surge	Cyclone	*SLOSH (US Only)	Tens of meters to 1 km	NRT and 48-hour Forecast

<sup>\*</sup> All data have global coverage except for SLOSH



#### For More Information on Data for Hazard Assessment



- Past Data (>18 Years)
  - <u>Fundamentals of Remote Sensing, Water Resources Management</u>
  - Intermediate Webinar: Remote Sensing for Disaster Scenarios (2019)
  - Introductory Webinar: Monitoring Tropical Storms for Emergency Preparedness (2018)
- Past Data (4-5 Years) & Near-Real Time Forecasts
  - Intermediate Webinar: Remote Sensing for Disaster Scenarios (2019)
  - Introductory Webinar: Monitoring Tropical Storms for Emergency Preparedness (2018)



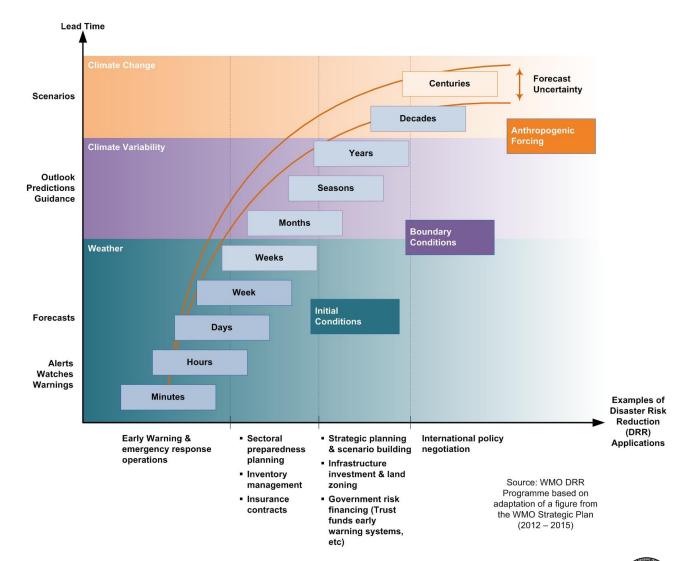
#### **Data Access for Hazard Assessment**

Data Access Tool	Web Address		
Giovanni & NASA Earthdata GES DISC (MERRA-2, GLDAS, TRMM-TMPA, GPM-IMERG)	https://giovanni.gsfc.nasa.gov/giovanni/ https://disc.gsfc.nasa.gov/		
Precipitation Measurement Mission (GPM-IMERG)	https://pmm.nasa.gov/data-access/downloads/		
AppEARS (SMAP, MODIS)	https://nsidc.org/support/how/point-and-area-samples- smap-data-using-appeears		
NCCS Data Portal-Data Share (GEOS-5)	https://fluid.nccs.nasa.gov/weather/ https://portal.nccs.nasa.gov/datashare/gmao_ops/pu b/fp/forecast/		
Probabilistic Tropical Storm Surge (P-Surge)	https://slosh.nws.noaa.gov/psurge2.0/		



#### **Hazard Assessment and DRR**

- Analysis of past data help identify hazard-prone areas, intensity, and frequency of hazard(s)
- Based on past hazard analysis together with exposure, vulnerability, and socioeconomic impact (DRA), this helps prepare for current and future DRR
- Useful for planning overall DRM







#### Disaster Risk Assessment



• DRA requires analysis of hazard assessment together with exposure (i.e. elements at risk) and vulnerability (physical, social, economic, and environmental)

 Next Susana Adamo from SEDAC will present socioeconomic data relevant for exposure and vulnerability for Disaster Risk Assessment



#### Reference

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**GEOS-5**: Goddard Earth Observing System Model, Version 5

GLDAS: Global Land Data Assimilation System, version 2.1

**GPM**: Global Precipitation Measurement

IMERG: Integrated Multi-satellitE Retrievals for GPM

MERRA-2: Modern-Era Retrospective analysis for Research and Applications, Version 2

**MODIS**: MODerate-resolution Imaging Spectroradiometer

**SLOSH**: Sea Lake and Overland Surge from Hurricanes

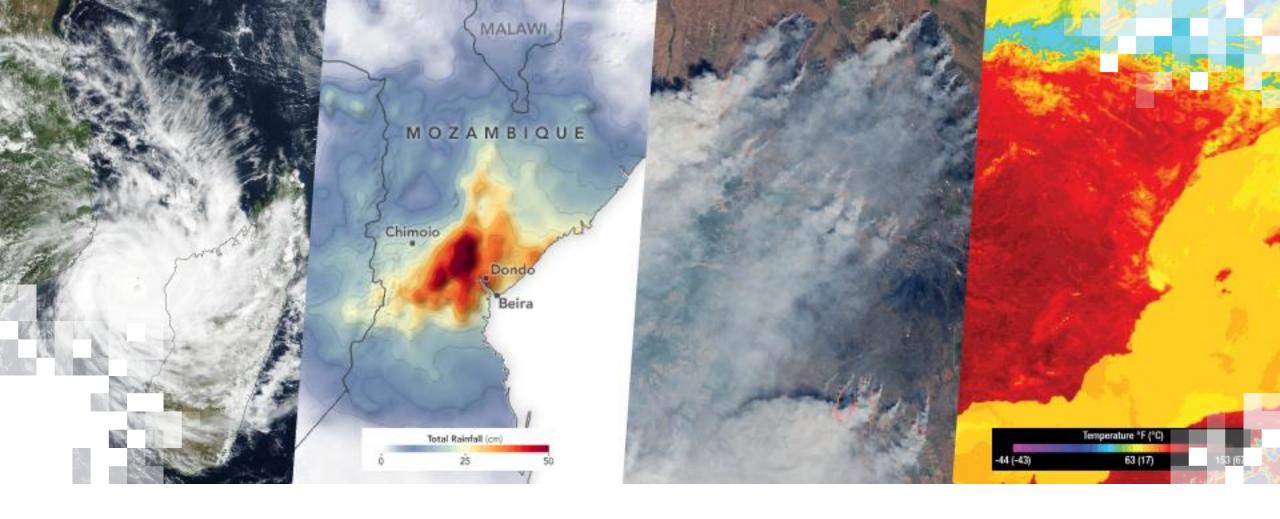
**SMAP**: Soil Moisture Active Passive

**SRTM**: Shuttle Radar Topography Mission

TMPA: TRMM Multi-satellite Precipitation Analysis

**TRMM**: Tropical Rainfall Measuring Mission





# Socioeconomic Data Relevant for Disaster Risk Assessment

Dr. Susana Adamo, CIESIN, Columbia University

# Coming up Next Week -

- DRA from past earth observations
- DRA in near real-time and from 10-day forecast

