Remote Sensing Observations for Flood Monitoring and Socioeconomic Data for Flood Management

Objective

To present NASA remote sensing observations and concepts used for flood monitoring and mapping; and introduce socioeconomic data useful for flood management

Outline

- Key Concepts for Using Remote Sensing Observations for Flood Monitoring
- Hydrological Parameters Relevant to Flood Monitoring
- NASA Earth Science Missions and Sensors Relevant to Flood Monitoring
- NASA Flood Monitoring Web-Tools ***(selected tools will be covered in detail today)***
- NASA Socioeconomic Data for Flood Management
- Introduction to the UN Disaster Risk Reduction: Global Assessment Report 2015

Key Concepts for Using Remote Sensing Observations for Flood Monitoring

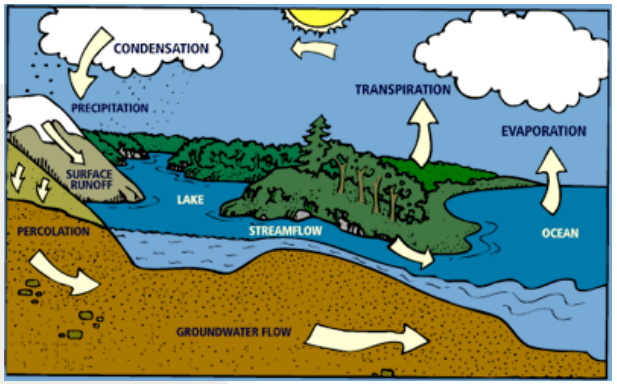
There are two basic concepts of using remote sensing observations for flood monitoring

1) Use of satellite-derived rainfall to infer flooding conditions or use the rainfall and surface weather data in a hydrology model to derive streamflow or runoff to monitor flooding conditions.

2) Use satellite-derived land-cover observations to detect flood water on previously dry land surface.

Hydrological Parameters Relevant to Flood Monitoring

Hydrological Information Crucial for Flood Monitoring



- Rain Rate and Accumulated Rain Amount
- Snow Melt Rate
- Soil Condition: soil moisture, temperature, land cover
- Reservoir/River Level
- Storm Water Drainage System (urban floods)
- Terrain

NASA Satellites and Atmosphere-land Models for Flood Monitoring

- Rain
- Surface Temperature
- Soil Moisture
- Snow/Ice
- Clouds
- Terrain*
- Ground Water
- **Land Cover***
- Evapotranspiration
- Run off

Useful for direct observations of flooding conditions and/or for inputs to hydrology models

*Terrain Data are available from the Shuttle Radar Topography Mission

*Land Cover is used for detecting inundated surface surface

All these quantities are available from satellite observations as well as from models
Quantities in green are derived from satellite observations
Quantities in red are from land and atmosphere-land models in which satellite observations are assimilated

NASA Earth Science Missions and Sensors Relevant to Flood Monitoring

NASA Satellites for Flood Monitoring

Landsat (07/1972-present)

TRMM (11/1997-present)

GPM (2/27/2014-present)

Terra (12/1999-present)

Aqua (5/2002-present)

SMAP (1/31/2015-present)

GRACE (3/2002-present)

TRMM: Tropical Rainfall Measuring Mission
GRACE: Gravity Recovery and Climate Experiment
GPM: Global Precipitation Measurements
SMAP: Soil Moisture Active Passive

NASA Satellites for Flood Monitoring

- The focus of this training will be on TRMM/GPM and Terra/Aqua Data Used for Flood Monitoring
- The training will include web-based tools that provide access to TRMM and Terra/Aqua observations for near-real time flood monitoring and inundation mapping

Landsat (07/1972-present)

TRMM (11/1997-present)

GPM (2/27/2014-present)

Terra (12/1999-present)

Aqua (5/2002-present)

SMAP (1/31/2015-present)

GRACE (3/2002-present)

TRMM: Tropical Rainfall Measuring Mission
GRACE: Gravity Recovery and Climate Experiment
GPM: Global Precipitation Measurements
SMAP: Soil Moisture Active Passive

TRMM: Most Used for Flood Monitoring and Modeling
GPM: Successor of TRMM will Replace TRMM in Late 2015

Review

TRMM (11/1997-Present)

- One active and two passive rain sensors:

  Precipitation Radar (PR)
  TRMM Microwave Imager (TMI)
  Visible and Infrared Scanner (VIRS)

- There are 16 TRMM orbits a day covering the global tropics between 35° S to 35°N.

- Spatial resolution varies from: 5 to 45 km

http://pmm.nasa.gov/TRMM

GPM (2/2014-Present)

- One active and one passive rain sensors:

  Dual Frequency *Precipitation Radar (DPR)*
  GPM Microwave Imager (GMI)

- There are 16 TRMM orbits a day covering global tropical and higher latitudes between 65°S to 65°N

- Spatial resolution varies from: 4 to 32 km

http://pmm.nasa.gov/GPM

Terra and Aqua Satellites Carry a Suite of Sensors MODIS is used for Inundation Mapping

Review

Terra (12/1999-Present)

- Multiple Passive Sensors:

Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)
Clouds and Earth's Radiant Energy System (CERES)
Multi-angle Imaging Spectroradiometer (MISR)
Measurements of Pollution in the Troposphere (MOPITT)
Moderate Resolution Imaging Spectroradiometer **(MODIS)**

- Polar, Sun-Synchronous Orbit, Global Coverage, Twice-daily Observations **10:30 AM/PM** Descending Orbits

http://aqua.nasa.gov

Aqua (5/2002-Present)

- Multiple Passive Sensors:

Atmospheric Infrared Sounder (AIRS)
Advanced Microwave Sounding Unit (AMSU-A)
Advanced Microwave Scanning Radiometer for EOS (AMSR-E)
Clouds and the Earth's Radiant Energy System (CERES)
Moderate Resolution Imaging Spectroradiometer **(MODIS)**

- Polar, Sun-Synchronous Orbit, Global Coverage, Twice-daily Observations **1:30 AM/PM** Ascending Orbits

http://aqua.nasa.gov

Hydrological and Land Parameters from TRMM, GPM, Terra & Aqua/ MODIS for Flood Monitoring

Satellite	Sensors	Quantities
TRMM	Precipitation Radar (PR) TRMM Microwave Imager (TMI) Visible Infrared Scanner (VIRS)	Rain Rate, Vertical Rain Rate Profile,
GPM	Dual-frequency Precipitation Radar (DPR) GPM Microwave Imager (GMI)	Rain Rate, Vertical Rain Rate Profile,
Terra and Aqua	MODerate Resolution Imaging Spectroradiometer (MODIS) (Note: MOIDS is one of several sensors flying on these satellites)	Snow Cover, Vegetation Index, Leaf Area Index, Land Cover, Cloud Cover

Products useful for Flood Monitoring

NASA Flood Monitoring Tools

Flood Monitoring: TRMM/GPM
Inundation Mapping: Terra & Aqua/MODIS

TRMM/GPM provide direct observations of surface rainfall. The rainfall data:

i) are used to infer flooding conditions

ii)are used in conjunction with a hydrology model to derive streamflow or runoff

MODIS provides observations of land-surface characteristics. MODIS reflectance from various bands indicates the presence of water on land surface.

TRMM-based Flooding Tools

- TRMM Current Heavy Rain, Flood and Landslide Estimates Tool (http://trmm.gsfc.nasa.gov/publications_dir/potential_flood_hydro.html)
- Extreme Rainfall Detection System – Version 2 **(ERDS2)** (http://www.ithacaweb.org/projects/erds/)
- Global Flood Monitoring System (http://flood.umd.edu/)
- Dartmouth Flood Observatory and Global Disaster Alert and Coordination System (GDACS) : *Experimental River Discharge Data using TRMM Imager*

MODIS-based
Inundation Mapping Tools

- MODIS NRT Global Flood Mapping
  (*http://oas.gsfc.nasa.gov/floodmap/*)

- Dartmouth Flood Observatory
(http://floodobservatory.colorado.edu/)

Summary of Flood Tools

Flood Tools Using TRMM and Hydrologic Models

Most of these tools have interactive, near-real time flood mapping capability with flood potential and/or streamflow/run-off

Flood Tool	Satellite/ Instrument Or Model	Quantities Used as Inputs	Hydrological Model
NASA-TRMM	TRMM/ TMPA-RT	Rain Rate	NRC-CN[1]
ERDS	TRMM/ TMPA-RT	Rain rate	----------
GFMS	TRMM/ TMPA-RT MERRA	Rain Rate Surface Temperature Winds	VIC- UMD DRTR[2]

[1]Natural Resources Conservation Service (NRCS) runoff curve number (CN) method
[2]The University of Washington Variable Infiltration Capacity (VIC) land surface model coupled with the University of Maryland Dominant River Tracing Routing (DRTR) model

Summary of Flood Tools

MODIS-based Flood Inundation Mapping Tools

These tools have interactive, near-real time inundation mapping capability

Flood Tool	Satellite/ (Instrument	Quantity Used
MODIS NRT	Terra and Aqua/ MODIS	Reflectance Bands 1, 2, 7
DFO	Terra and Aqua / MODIS	Reflectance Bands 1, 2, 7

Summary of Flood Tools

Flooding Monitoring Output

Flood Tool	Rainfall (Used as Input)	Flood potential/ Intensity	River Discharge/ Streamflow	Inundation Map
NASA-TRMM ERDS	X	X		
GFMS	X	X	X	
MODIS/NRT				X
DFO			X (Experimental limited number of river basins)	X

- MODIS provides surface inundation only, can not view the surface in the presence of clouds, mountain and cloud shadows may get interpreted as water
- TRMM Rain, used along with hydrologic model and other weather and surface data provide quantitative river streamflow and runoff information but regional calibration and validation are recommended with regional stream gauge data

Summary
More About the Flood Tools

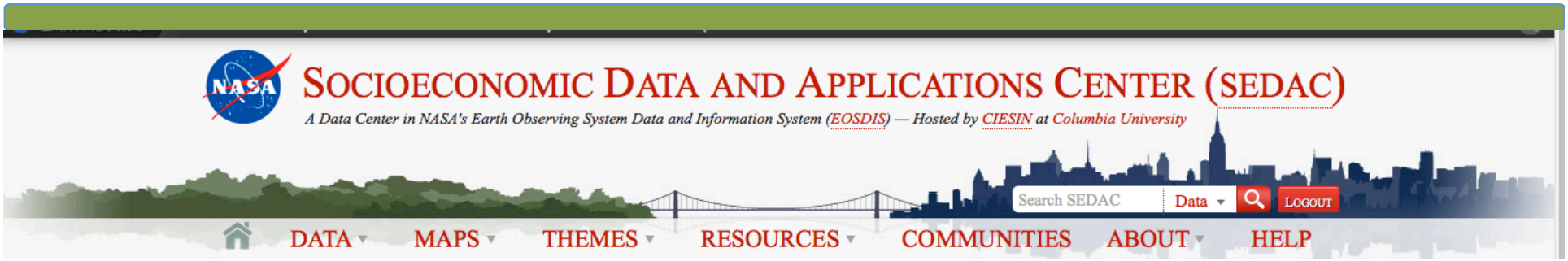
Flood Monitoring Tool	Spatial Coverage and Resolution	Comment
NASA-TRMM NRT	50°S-50°N 12 Km	Includes GFMS, Landslide Potential
GFMS	50°S-50°N 12 Km	Will be available at 1Km resolution. Predictive capability will be added soon
MODIS NRT	Global 250 M	May not be effective in presence of clouds
DFO Experimental	Global 250 m and 10 km	Same as MODIS NRT. River discharge data derived from TMI and AMSR/AMSR2*

*AMSR : Advanced Microwave Scanning Radiometer flying on Aqua satellite (2002-2011) and and AMSR2 is flying on Global Change Observation Mission (GCOM-W) satellite (May 2012 to present)

NASA Socioeconomic Data for Flood Management

NASA Socioeconomic Data and Applications Center (SEDAC)

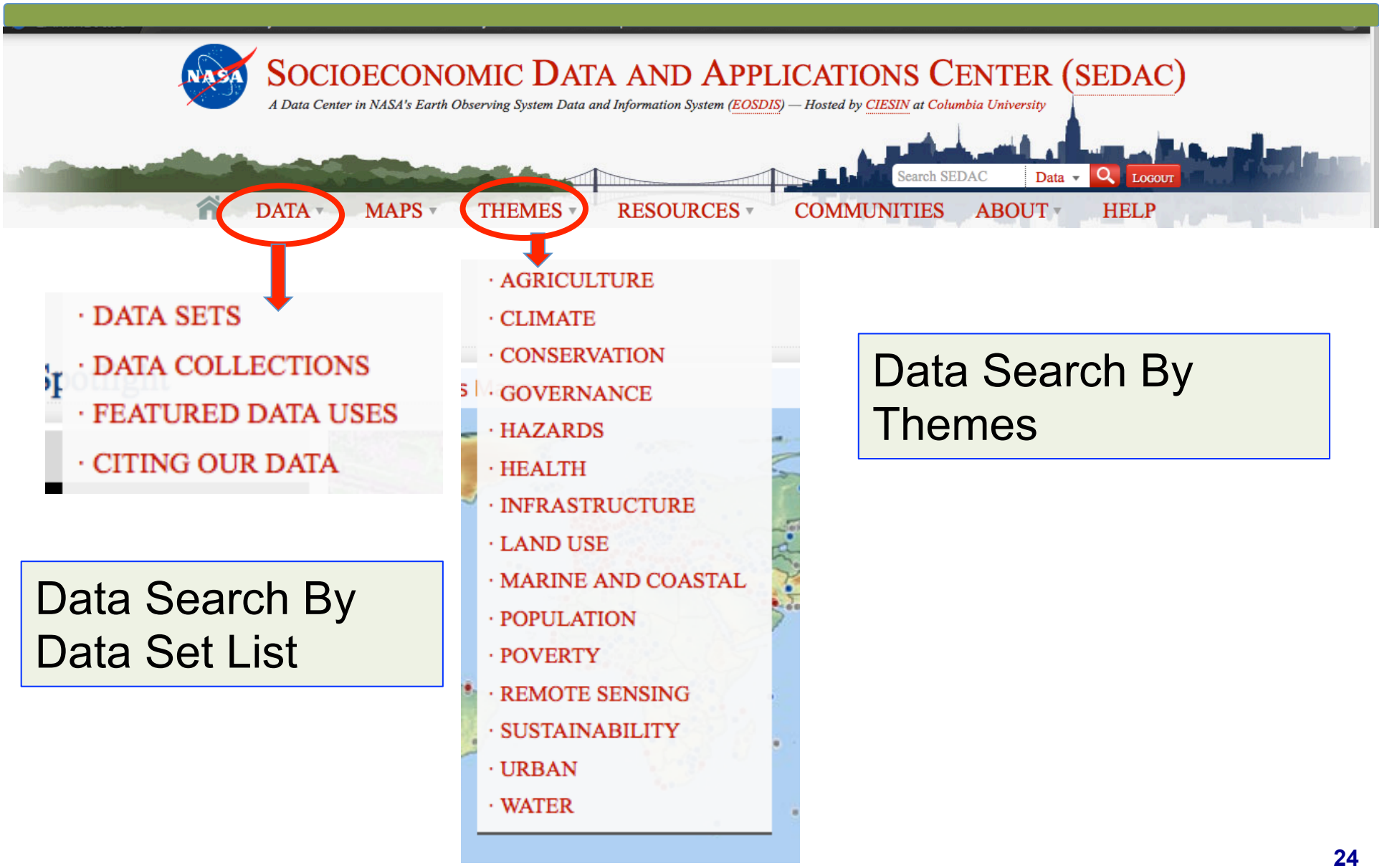
http://sedac.ciesin.columbia.edu/



- NASA Remote sensing data and tools are useful for the flood warning and preparedness phase
- NASA also provides socioeconomic data that can be used along with the flood monitoring tools to facilitate the post-flooding rescue and recovery phases
- These data are available from SEDAC for visualization and download

SEDAC Data Search

http://sedac.ciesin.columbia.edu/

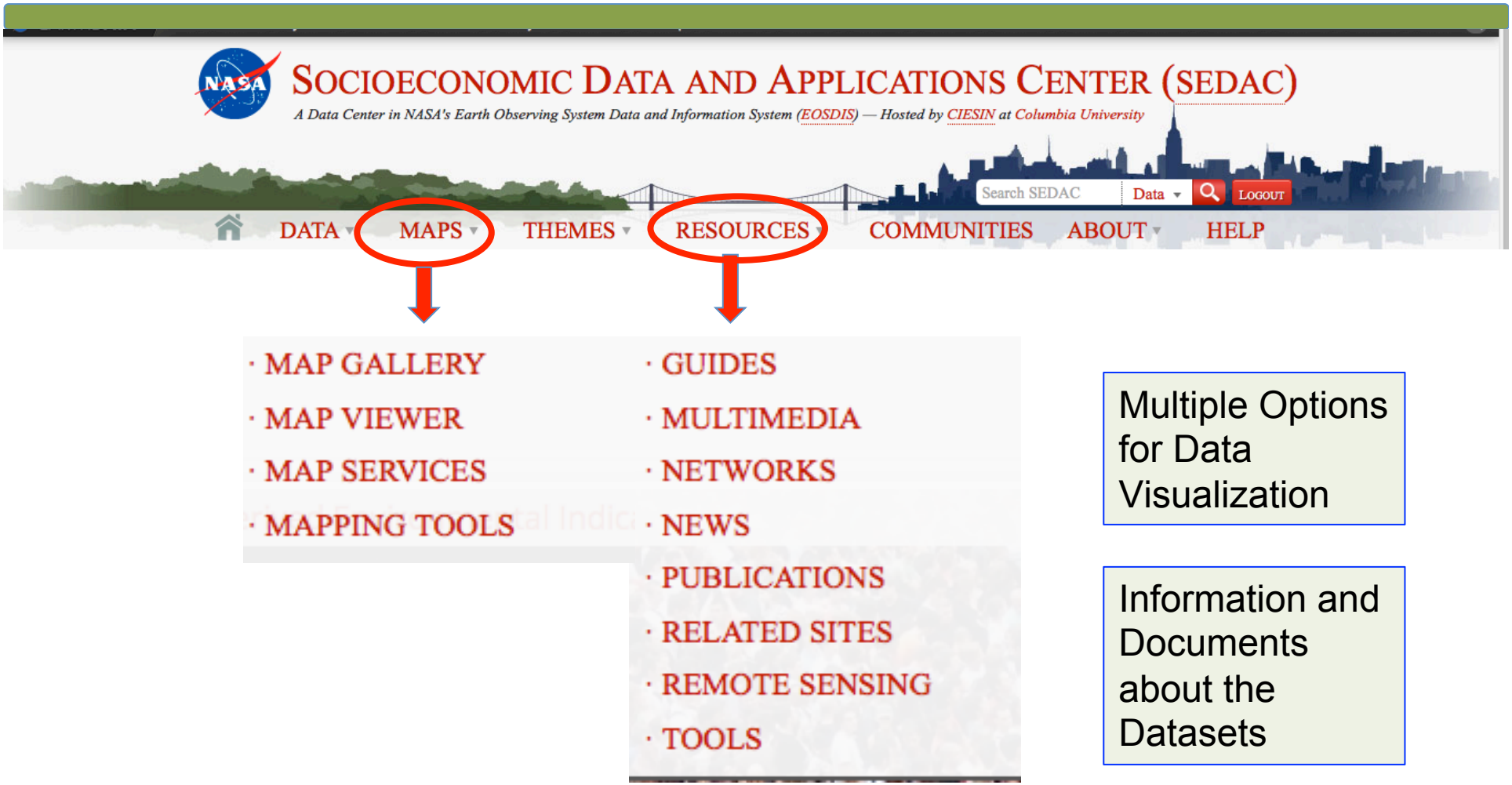


Data Search By Data Set List

Data Search By Themes

SEDAC Data Mapping and Other Resources

http://sedac.ciesin.columbia.edu/

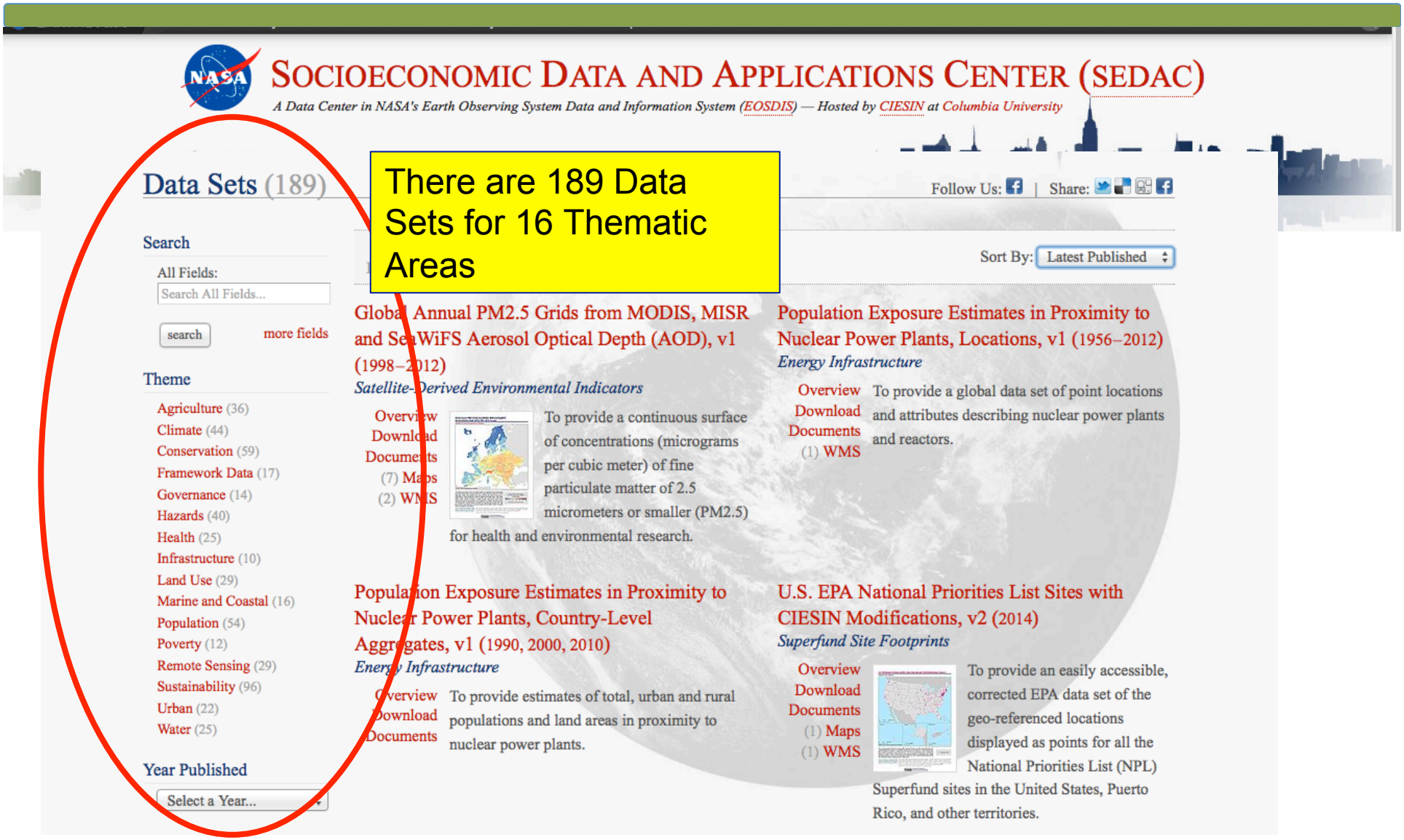


Multiple Options for Data Visualization

Information and Documents about the Datasets

SEDAC Data Sets

http://sedac.ciesin.columbia.edu/



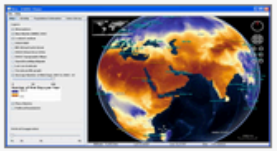
SEDAC Map Tools

http://sedac.ciesin.columbia.edu/maps/tools

NPL Superfund Footprint Mapper

The Columbia University Superfund Research Program "NPL Superfund Footprint: Site, Population, and Environmental Characteristics" Mapper was created to provide researchers, regulators, and the general public with an innovative tool to better visualize and understand the characteristics of vulnerable populations, built and natural features, and environmental exposures near the National Priorities List Superfund sites. Its purpose is to help improve the evaluation of Superfund sites and more effectively address related environmental health concerns.

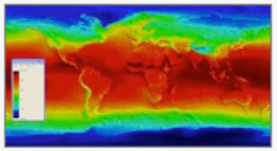
CHANGE Viewer



The Climate and Health Analysis for Global Education Viewer (CHANGE Viewer) was built using NASA World Wind, an open source, 3-D geo-visualization tool. CHANGE Viewer allows the exploration of climate science, human, and socio-economic data sets made available through the Data Library.

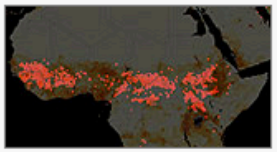
More advanced tools

TerraViva! SEDAC Viewer



This map viewer and standalone software application (Microsoft Windows-based) uses a powerful data-viewing engine and tools to enable the visualization and integration of hundreds of socioeconomic and environmental variables and layers, including a range of satellite-based data.

NASA Worldview



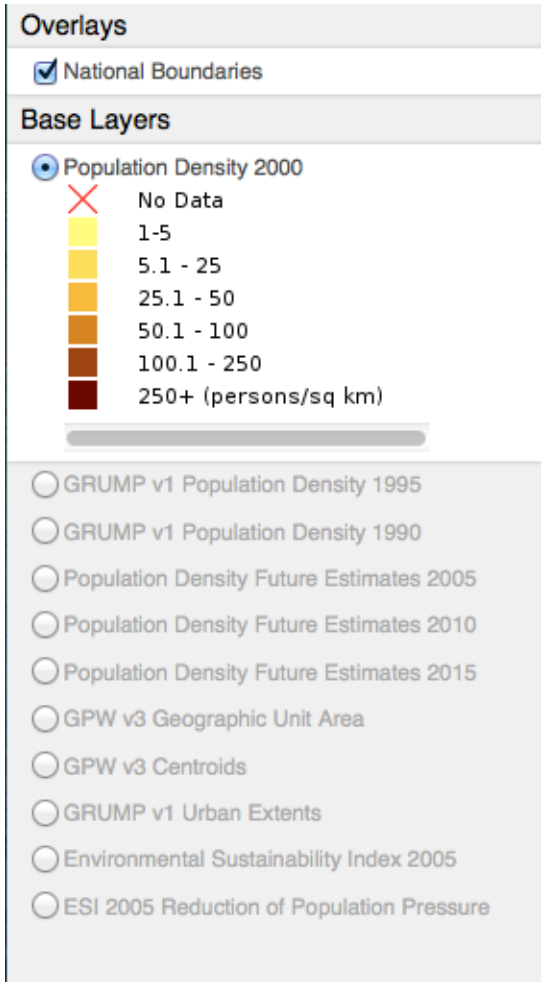
This tool developed by NASA's EOSDIS allows you to interactively browse global satellite imagery within hours of it being acquired. Users can overlay and visualize a subset of SEDAC map layers in conjunction with satellite images - for example, the NASA MODIS imagery showing active fires, integrated with the SEDAC GRUMP population density layer.

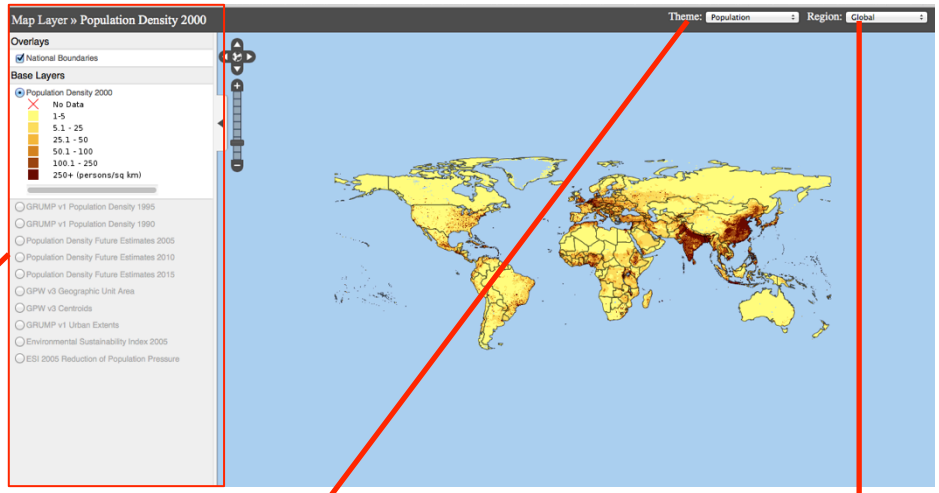
Interactive and easy to use

SEDAC Map Viewer

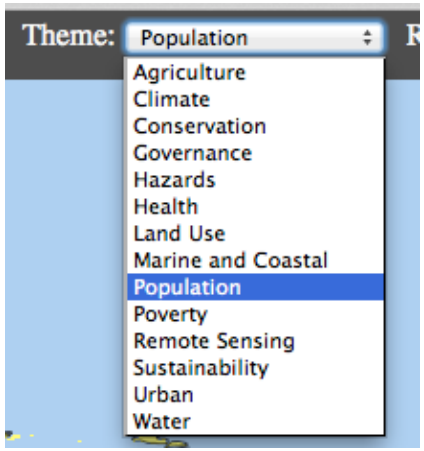
http://sedac.ciesin.columbia.edu/maps/client

Multiple Layers

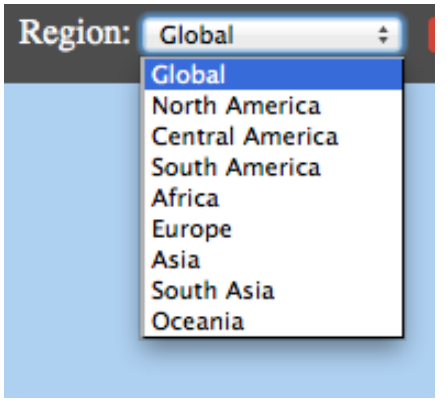




Theme Selection



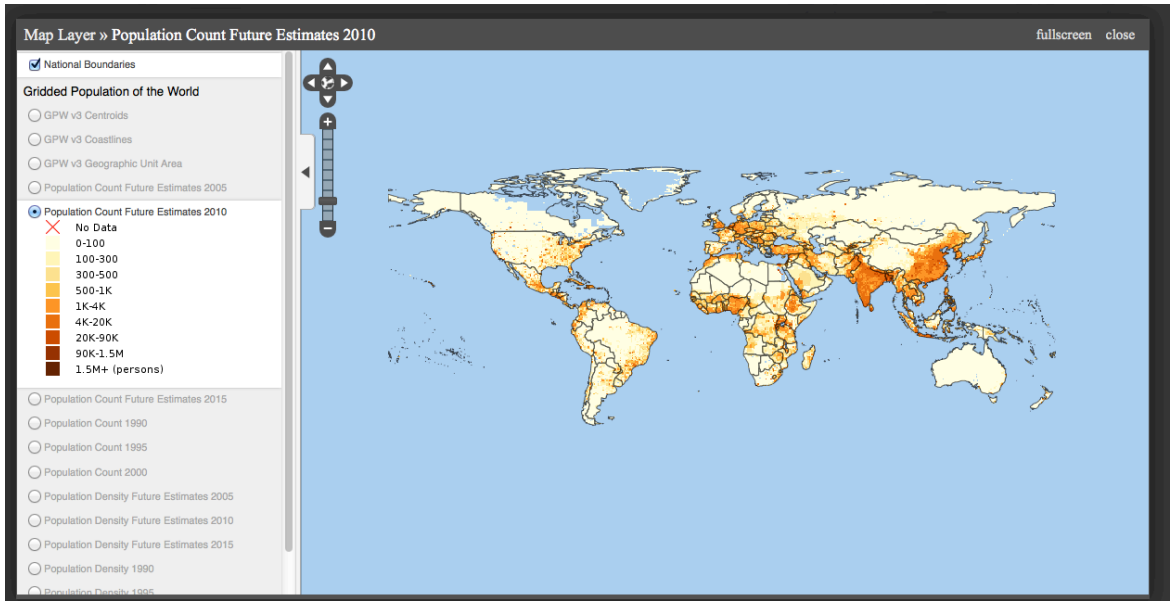
Global and Regional Selections



SEDAC Population Data for Flood Management

http://sedac.ciesin.columbia.edu/theme/population

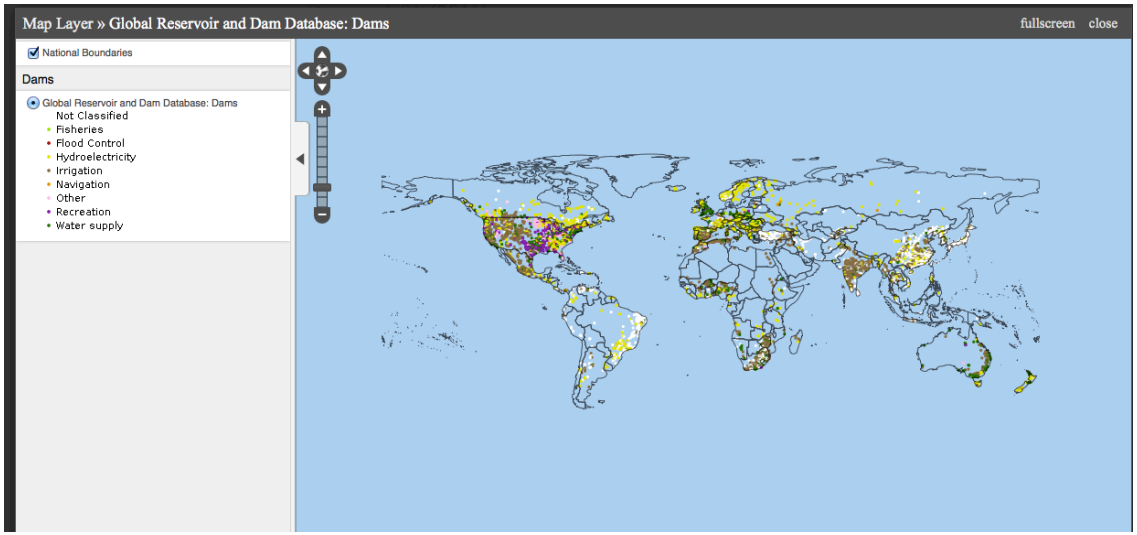
- Gridded Population of the World (2005, 2010, 2015)
  Population Count and Density



SEDAC Infrastructure Data Sets for Flood Management

http://sedac.ciesin.columbia.edu/data/sets/browse?facets=theme:infrastructure

- Global Roads
- Global Dams and Reservoirs
- Nuclear Power Plant Locations, Population Exposure Estimates in Proximity



Introduction to the UN Disaster Risk Reduction Global Assessment Report 2015

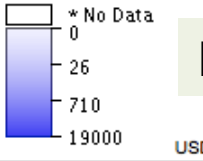
UNISDR Global Assessment

http://risk.preventionweb.net/capraviewer/main.jsp?countrycode=g15

Flood-related Losses in Latin America

http://risk.preventionweb.net/capraviewer/main.jsp?countrycode=g15

- Exposed economic stock
- Exposed population
- Exposed urban stock
- Exposed rural stock
- Catalog of Earthquakes1970-2014
- Cyclone tracks (1969-2009)
- Multi-hazard Average Annual Loss
- Social Expenditure
- Gross Fixed Capital Formation
- Earthquake Average Annual Loss
- Cyclone wind Average Annual Loss
- Storm Surge Average Annual Loss
- Tsunami Average Annual Loss
- Flood Average Annual Loss



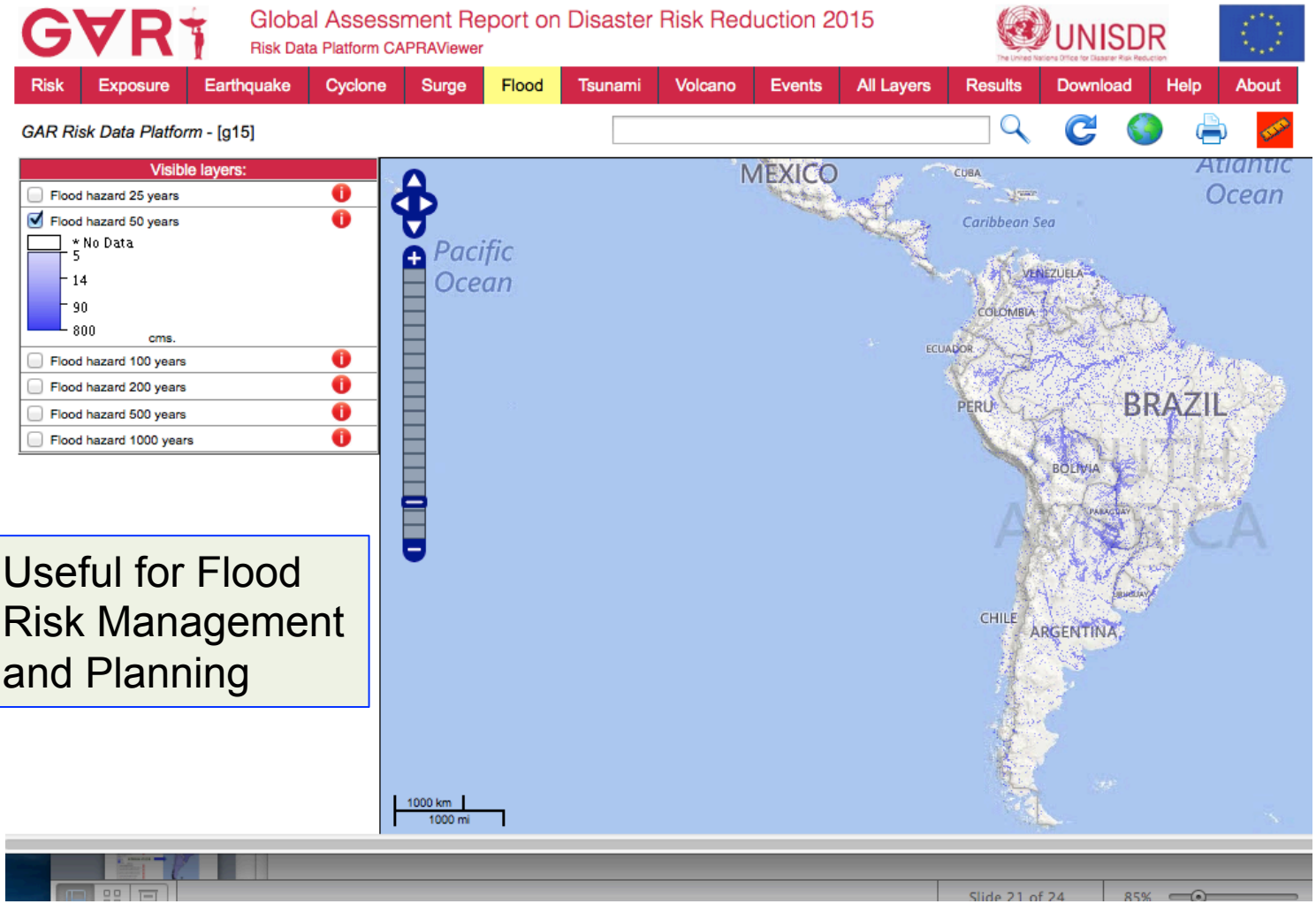
- Volcano Average Annual Loss
- Multi-hazard Relative Average Annual Loss ‰
- Earthquake relative Average Annual Loss ‰
- Cyclone wind relative Average Annual Loss ‰
- Storm Surge relative Average Annual Loss ‰
- Tsunami relative Average Annual Loss ‰
- Flood relative Average Annual Loss ‰
- Volcano relative Average Annual Loss ‰
- Earthquake Probable Maximum Loss - 500 years
- Cyclone Probable Maximum Loss 100 year
- Tsunami Probable Maximum Loss 500 years
- Storm Surge Probable Maximum Loss 100 yr.
- Population 2014

In Millions of US $

UNISDR Global Assessment

http://risk.preventionweb.net/capraviewer/main.jsp?countrycode=g15

Probabilistic Riverine Flood Return Period Based on SRTM and Streamflow Data

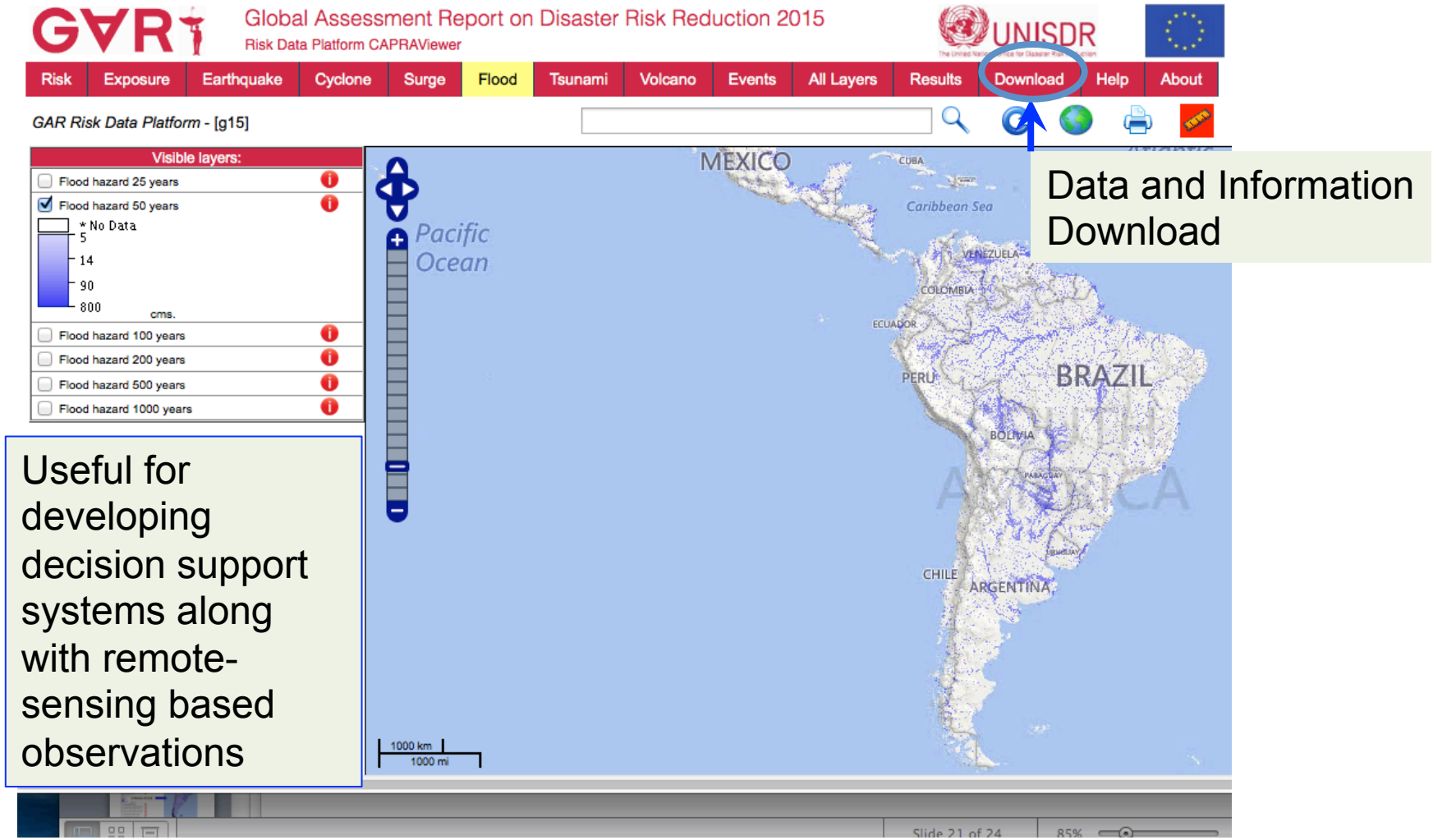


Useful for Flood Risk Management and Planning

UNISDR Global Assessment

http://risk.preventionweb.net/capraviewer/main.jsp?countrycode=g15

Probabilistic Riverine Flood Return Period Based on SRTM and Streamflow Data



Next:

Introduction to MODIS-based Inundation Mapping