ARSET
Applied Remote Sensing Training
http://arset.gsfc.nasa.gov
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Disaster Risk Reduction Across the Americas
Discussion Sessions:
NASA Remote Sensing for Monitoring
Hydrometeorological Disasters

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Week 2
Outline

• Remote Sensing and Modeling Data Available for Hydrometeorological Disasters
• Flood and Storm Monitoring Using Remote Sensing and Reanalysis Modeling Data
Remote Sensing and Modeling Data Available for Hydrometeorological Disasters
## Relevant Remote Sensing and Model Data

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>Monitor development and propagation of precipitation systems and intensity to assess potential for flooding</td>
</tr>
<tr>
<td>Land Cover</td>
<td>Detection of inundation on previously dry surfaces</td>
</tr>
<tr>
<td>Terrain</td>
<td>Determine water flow direction and low lying, flood-prone areas</td>
</tr>
<tr>
<td>Soil Moisture</td>
<td>Influence on water infiltration, runoff, and streamflow</td>
</tr>
<tr>
<td>Winds</td>
<td>Monitor and assess storm intensity and spatial extent</td>
</tr>
<tr>
<td>Sea Level Pressure</td>
<td>Monitor and assess storm intensity and track</td>
</tr>
</tbody>
</table>
## Flood Monitoring Data Sources

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Satellite</th>
<th>Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>• GPM (Global Precipitation Measurement)</td>
<td>• GPM Microwave Imager (GMI), Dual-Frequency Precipitation Radar (DPR)</td>
</tr>
<tr>
<td></td>
<td>• TRMM (Tropical Rainfall Measurement Mission)</td>
<td>• TRMM Microwave Imager (TMI), Precipitation Radar (PR), Visible and Infrared Scanner (VIRS)</td>
</tr>
<tr>
<td>Land Cover</td>
<td>• Landsat</td>
<td>• Enhanced Thematic Mapper (ETM+), Operational Land Imager (OLI)</td>
</tr>
<tr>
<td></td>
<td>• Terra</td>
<td>• MODerate Resolution Imaging Spectroradiometer (MODIS)</td>
</tr>
<tr>
<td></td>
<td>• Aqua</td>
<td>• Visible Infrared Imaging Suite (VIIRS)</td>
</tr>
<tr>
<td></td>
<td>• SNPP (Suomi National Polar Partnership)</td>
<td>• C-Band Synthetic Aperture Radar (SAR)</td>
</tr>
<tr>
<td></td>
<td>• Sentinel-1A</td>
<td></td>
</tr>
<tr>
<td>Terrain</td>
<td>Shuttle Radar Topography Mission (SRTM)</td>
<td>C-Band Radar</td>
</tr>
<tr>
<td>Soil Moisture</td>
<td>SMAP (Soil Moisture Active Passive)</td>
<td>Microwave Band Radar</td>
</tr>
</tbody>
</table>
## Flood Monitoring Data Sources

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Satellite</th>
<th>Temporal Coverage; Resolution</th>
<th>Spatial Coverage; Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>• GPM (IMERG)</td>
<td>• 02/2014 – Present; 30 min</td>
<td>• Global, 60°S - 60°N; 0.1° x 0.1°</td>
</tr>
<tr>
<td></td>
<td>• TRMM (TMPA)</td>
<td>• 11/1997 - 04/2015; 3 hrs</td>
<td>• Global, 50°S - 50°N; 0.25° x 0.25°</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 02/2014 – Present; 30 min</td>
<td></td>
</tr>
<tr>
<td>Land Cover</td>
<td>• Landsat</td>
<td>• 07/1972 – Present; 16 days</td>
<td>• Global; 30 m</td>
</tr>
<tr>
<td></td>
<td>• Terra</td>
<td>• 12/1999 – Present; Daily</td>
<td>• Global; 250 m – 1 km</td>
</tr>
<tr>
<td></td>
<td>• Aqua</td>
<td>• 05/2002 – Present; Daily</td>
<td>• Global; 250 m – 1 km</td>
</tr>
<tr>
<td></td>
<td>• SNPP</td>
<td>• 10/20111 – Present; Daily</td>
<td>• Global; 375 m – 750 m</td>
</tr>
<tr>
<td></td>
<td>• Sentinel-1A</td>
<td>• 04/2014 – Present; 12 days</td>
<td>• Global; 5 m x 20 m</td>
</tr>
<tr>
<td>Terrain</td>
<td>SRTM</td>
<td>• February 2000; Static</td>
<td>• Global; 30 m, 90 m</td>
</tr>
<tr>
<td>Soil Moisture</td>
<td>SMAP</td>
<td>• 01/2015 – Present; 3 days</td>
<td>• Global: 36 km</td>
</tr>
</tbody>
</table>
Storm Monitoring Data Sources

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Model</th>
<th>Temporal Coverage; Resolution</th>
<th>Spatial Coverage; Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winds and Sea Level Pressure</td>
<td>• Modern Era Retrospective-Analysis for Research and Application (MERRA)</td>
<td>• 1979 – Present; Hour, Month</td>
<td>• Global; 0.5° x 0.625°</td>
</tr>
</tbody>
</table>

For more information about satellites, sensors, and models see Sessions 1, 2A, and 2B on the Fundamentals of Remote Sensing: [https://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing](https://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing)
Flood and Storm Monitoring Using Remote Sensing and Reanalysis Modeling Data
Flood Monitoring Tools

• Flooding Tools Based on Precipitation Observations
  – Global Flood Monitoring System (GFMS)
  – Extreme Rainfall Detection System-2 (ERDS2)

• Flooding Tools Based on Land Cover Observations
  – MODIS Near Real-Time (NRT) Flood Mapping
  – Dartmouth Flood Observatory (DFO, DFO River Watch)
  – Global Flood Detection System 2 (GFDS2)

• Global Disasters Alert and Coordination System (GDACS)

GFMS, ERDS2 (before and during flooding events)
MODIS-NRT, DFO, GDACS (during and after flooding events)
Global Flood Monitoring System (GFMS)

http://flood.umd.edu/

• Based on TMPA, provides global maps, time series, and animations (50°S-50°N) of:
  – instantaneous rain rate every 3 hrs
  – accumulated rain over 24, 72, and 168 hrs
  – streamflow rates and flood intensity at 1/8th degree (~12 km) and 1 km
  – Near real-time and archives since 2013

Interactive Features

Flooding in Peru, 19 March 2017

Note: TRMM is no longer flying, but TRMM-based calibration is used to provide near real-time rainfall from a constellation of national & international satellites for flooding applications. Near real-time IMERG data are available from: ftp://jsimpson.pps.eosdis.nasa.gov
Extreme Rainfall Detection System-2 (ERDS2)

http://erds.ithacaweb.org/

- Uses near real-time TRMM-TMPA and NOAA-Global Forecasting System (GFS) rainfall for monitoring and forecasting accumulated rainfall
- The TMPA historical archive is used as reference data to calculate extreme rainfall thresholds
- The combination of TMPA rainfall amount, GFS forecasted rainfall information, and the reference data, generates flooding information

- ERDS is one of the tools used by the UN World Food Programme (WFP) Emergency Preparedness Unit
Extreme Rainfall Detection System-2 (ERDS2)

http://erds.ithacaweb.org/

- Global maps and time series of near real-time (50°S-50°N) and forecasted accumulated rainfall
  - 24, 48, 72, 96, 120, and 144 hours
- Extreme rainfall alerts at 0.25°x0.25° levels and administrative district levels
- Event-specific information
  - list of affected countries
  - an estimation of affected population

Value-Added Flood Information
MODIS NRT Global Flood Mapping

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 since Jan 2013
MODIS Flood Mapping: Southern Brazil, June 12-14, 2016

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

3-Day Composites

### Filename Convention

- **product_date_tile_composite_xtra.ext**
- **MSW_2012009_020E000S_3D3O_V.shp**
- **MFM_2012009_020E000S_2D2O.png**

**yyyydoy** (year, day of year)

**lon-lat**

2 or 3 day observations

<table>
<thead>
<tr>
<th>Products</th>
<th>Available Downloads</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODIS Flood Map</td>
<td>MFM .png</td>
</tr>
<tr>
<td>MODIS Flood Water</td>
<td>MFW .shapefile (.zip) KMZ</td>
</tr>
<tr>
<td>MODIS Surface Water</td>
<td>MSW .shapefile (.zip) KMZ</td>
</tr>
<tr>
<td>MODIS Water Product</td>
<td>MWP .geotiff</td>
</tr>
<tr>
<td>README</td>
<td>.pdf .txt</td>
</tr>
</tbody>
</table>

Check slide show for the last 10 days.
Dartmouth Flood Observatory (DFO)

http://floodobservatory.colorado.edu/

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

- Provides near real-time, current, and past flood event mapping
- Red areas (above) indicate inundated surface
DFO Flood Event: Peru

http://floodobservatory.colorado.edu/

Coastal flooding during local El Nino conditions (middle, Mar 27, 2017), compared to previous year (left image, Mar 27, 2016). Source: MODIS

Flooding (red) from comparing Mar 20, 2017 and Jan 19, 2017. Source: ESA Sentinel 1 SAR data

Image Sources: DFO
Global Flood Detection System 2 (GFDS2)

http://www.gdacs.org/flooddetection/

GFDS2 flooding information is used by GDACS

Developed for GDACS in collaboration with DFO

Interactive current flood map and flood list
Global Disasters Alert and Coordination System (GDACS)

http://www.gdacs.org/

- **Floods**
  - inundation
  - deaths
  - displacement

- **Tropical Cyclones**
  - winds
  - heavy rains
  - storm surge

- **Earthquakes and Tsunamis**
  - intensity and magnitude
  - hypocenter depth
  - population within 100 km of epicenter
  - vulnerability of affected countries

Various models and data are used to obtain this information: [http://portal.gdacs.org/Models](http://portal.gdacs.org/Models)
GDACS Approach for Disaster Alerts: Floods

http://portal.gdacs.org/Models/

Issues flood alerts and maps using satellite-based information from the GFDS2 and population data

- **Red Alert**
  - more than 1,000 dead or 800,000 displaced

- **Orange Alert**
  - more than 100 dead or 80,000 displaced

- **Green Alert**
  - All other floods

Hurricane Irene Information in GDACS


- Storm Intensity and Alert
- Storm Track, Extent
- Multiple Data Sources
- Storm Surge
- Media reports
Hurricane Irene from TRMM and MERRA
August 25, 2011

- Track storms with MERRA hourly data
- Monitor precipitation with GPM (after 2014) with half-hourly data
- Web tools to animate storm to monitor track and extent
Monitor Disaster-related Power Outage by Using VIIRS Night Imagery

http://go.nasa.gov/2iFEzX8
For More Details

• NASA Remote Sensing for Flood Monitoring and Management:
  – https://arset.gsfc.nasa.gov/disasters/workshops/flood-17

• Overview of the Global Disaster Alert and Coordination System (GDACS):
  – https://arset.gsfc.nasa.gov/disasters/webinars/GDACS17
Thank You
Summary of Flooding Web Tools Based on Precipitation

<table>
<thead>
<tr>
<th>Flood Tool, Satellite, Instrument, or Model</th>
<th>Quantities Used as Inputs</th>
<th>Hydrological Model</th>
<th>Output</th>
<th>Spatial Coverage and Temporal Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>GFMS</td>
<td>• Rain rate</td>
<td>• VIC-UMD DRTR</td>
<td>• Flood intensity</td>
<td>• 50°S-50°N</td>
</tr>
<tr>
<td></td>
<td>• Surface temperature</td>
<td></td>
<td>• Streamflow</td>
<td>• 12 km and 1 km</td>
</tr>
<tr>
<td></td>
<td>• Winds</td>
<td></td>
<td>• Accumulated rainfall</td>
<td>• Jan 2001 – NRT 3 hr updates</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ERDS</td>
<td>• Rain rate</td>
<td></td>
<td>• NRT &amp; Forecast flood alerts</td>
<td>• 50°S-50°N</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Accumulated rainfall</td>
<td>• 0.25°x0.25°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Population affected</td>
<td>• NRT and up to 72 hr forecast, 3 hr updates</td>
</tr>
</tbody>
</table>
# Summary of Flooding Web Tools Based on Land Surface Observations

<table>
<thead>
<tr>
<th>Flood Tool, Satellite, Instrument, or Model</th>
<th>Quantities Used as Inputs</th>
<th>Output</th>
<th>Spatial Coverage and Temporal Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODIS-NRT</td>
<td>• Reflectance Bands 1, 2, 7</td>
<td>• Inundation map • Flood water • Surface water</td>
<td>• Global 250 m • NRT 2, 3, and 14 day composites • 2013-present</td>
</tr>
<tr>
<td>DFO</td>
<td>• Reflectance Bands 1, 2, 7</td>
<td>• MODIS Inundation map • Images when available: SAR EO-1 Landsat</td>
<td>• Global 250 m • 14 day composite • Flood catalog (since 1985)</td>
</tr>
<tr>
<td>GFDS2 &amp; DFO River Watch</td>
<td>• Microwave Brightness Temperature (37 GHz) • Water Balance Model • River Gauge Discharge</td>
<td>• Flood Magnitude • River discharge time series at selected locations</td>
<td>• Global, NRT • Past flood since 2003</td>
</tr>
</tbody>
</table>