Near Real-Time and Historic MODIS Flood Detection and Impact Assessment Systems for Southeast Asia

Dr. John D. Bolten
Aakash Ahamed
Colin Doyle
Jessica Fayne

Disasters Working Group
May 18th, 2016
NASA GSFC
Identifying 2011 Floods

False color MODIS NDVI composite (Sept – Nov 2011)

Flooding

Day of Year

-- NDVI

-- Q

Kratie, Cambodia

Laos

Thailand

Vietnam

Cambodia

Flooding

False color MODIS NDVI composite (Sept – Nov 2011)
Near Real-Time Flood Detection

Annual Average January NDVI Composite (2003 – 2011)
Courtesy Joe Spruce (MSFC)

Near Real-Time NDVI
LANCE-MODIS MOD/MYD09GQ
Cloud/Shadow Identification: MOD/MYD09GQ 1km bit fields

Automated comparison

“Baseline” MODIS NDVI

\[ \Delta NDVI = \left( \frac{NDVI_{\text{Flood}} - NDVI_{\text{Dry}}}{NDVI_{\text{Dry}}} \right) \times 100 \]

< - 75% == Flood

Daily, 4-day, 8-day Composites
Flood Detection Product Methodology

Cloud Mask (MOD/MYD09GA Bit)

SRTM DEM

Permanent Water Mask (MOD44W)

Near Real Time NDVI (MOD/MYD09 GQ)

Dry Season Baseline NDVI
Flood Detection Results
Flood Detection

Validated Against:
1) Landsat (Top Right)
2) UNOSAT SAR (Above)
3) ISERV (ISS) (Not Shown)

<table>
<thead>
<tr>
<th>Validation Date</th>
<th>MODIS Composite</th>
<th>Reference Data</th>
<th>Class</th>
<th>Producer’s Agreement</th>
<th>User’s Agreement</th>
<th>Overall Agreement</th>
<th>Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date 1</td>
<td>8/29 - 9/5/2006</td>
<td>Landsat 5 9/3/2006</td>
<td>Flood</td>
<td>95.00%</td>
<td>89.33%</td>
<td>92.33% (277/300)</td>
<td>0.8467</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not Flood</td>
<td>89.90%</td>
<td>95.33%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date 2</td>
<td>10/16 - 10/23/2006</td>
<td>Landsat 5 10/21/2006</td>
<td>Flood</td>
<td>94.67%</td>
<td>94.67%</td>
<td>94.67% (284/300)</td>
<td>0.8933</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not Flood</td>
<td>94.67%</td>
<td>94.67%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date 3</td>
<td>11/1-11/8/2006</td>
<td>Landsat 5 11/6/2006</td>
<td>Flood</td>
<td>95.74%</td>
<td>90.00%</td>
<td>93.00% (279/300)</td>
<td>0.8600</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not Flood</td>
<td>90.57%</td>
<td>96.00%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2011 Flood Progression
2011 Flood Progression

*In case video on previous slide does not work

September

% Decrease NDVI

Permanent Water

October

Courtesy: C. Doyle
## Affected Population Estimates

<table>
<thead>
<tr>
<th>2011 Flooding</th>
<th>Cambodia</th>
<th>Thailand</th>
<th>Vietnam</th>
<th>Laos</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Population Affected (MODIS Est.)</strong></td>
<td>1,864,988</td>
<td>1,409,507</td>
<td>4,078,799</td>
<td>25,386</td>
</tr>
<tr>
<td><strong>Population Affected (Agency Est.)</strong></td>
<td>1,500,000</td>
<td>2,100,000</td>
<td>700,000</td>
<td>430,000</td>
</tr>
</tbody>
</table>

Table 1. Estimates of Population Impacted by 2011 Flooding modeled from 4 day image composited on October 16, 2011.


Population Density in flooded areas, Phnom Penh, Cambodia (Above), Vietnam Delta (Left)

**Input MODIS Data:** 4 Day Terra composite, October 12 – 16, 2011  
**Population Data:** Worldpop (Stevens et al., 2015)
## Infrastructure in Cambodia

### 2011 Flood Metric

<table>
<thead>
<tr>
<th>2011 Flood Metric</th>
<th>Estimate</th>
<th>Other Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Roadways (km)</td>
<td>208</td>
<td>180(^2)</td>
</tr>
<tr>
<td>Schools (count)</td>
<td>818</td>
<td>1,132(^2)</td>
</tr>
<tr>
<td>Hospitals</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td>Airports</td>
<td>0</td>
<td>N/A</td>
</tr>
</tbody>
</table>

2. National Center for Disaster Management, Cambodia.
NDVI Anomaly Tool

**Inputs:** Day of year: 1-365, Product: GQ (Daily), Q1 (8day), NRT

Collects MODIS imagery on input day (or nearest 8day composite) for length of record, creating ~30 image stack. Masks clouds and shadows, computes average NDVI differences relative to historic averages.

- **Flood ID**
- **Drought ID?**
- **Vegetation Phenology?**
- **LU/LUC?**
Preliminary Result: Drought

Deviation from mean NDVI (2000 - 2015)

-1.4 - -0.28
-0.27 - -0.13
-0.12 - -0.02
-0.019 - 0.087
0.088 - 1.1

April 14, 2016

Source: NOAA STAR

Source: Phnom Penh Post 22/04/2016

NOAA STAR Data: AVHRR
MODIS Data: MOD09Q12016121
Web Interface (In development)
http://mekongflood.appspot.com

Near Real Time Flooding in Southeast Asia
Flood Extent Derived from MODIS NDVI Change Detection Algorithms

Algorithms and website currently under development at NASA Goddard Space Flight Center

Population At Risk Time Series (Beta)

Building Footprints At Risk (Beta)

Data Source: Worldpop

Data Source: Open Street Map
Further Information

Submitted Publications:

Conference Presentations:

Funding: NASA Applied Sciences, NASA DEVELOP
Computational Infrastructure: Open Science Data Cloud
Knowledge Exchange: Stack Overflow