Flood RGB recipe using MODIS and AHI

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1. Introduction
Background

Outbreak of flood → Exact Detection → Fast reconstruction

Using Satellite

✓ Global observing
✓ Temporally regular observation
  - Near real time observation for geostationary satellite
Previous Works

Previous study: using SAR (Synthetic Aperture Radar)

- **Advantage**
  - High resolution
  - Independent to cloud and day/night

- **Weakness**
  - Low temporal resolution
  (ex) Sentinel-1: 6 days on the equator line

![SAR Image of flooding area](Source: http://www.unspider.org)
1) Flood monitoring using visible and near-infrared channel suggest new RGB composite technique

2) Flood monitoring using reflectance and refractivity index of visible and near-infrared channel
2. Data
Study area

- Pampanga River in Philippine on October 25, 2015 due to Typhoon Koppu
- Latitude: 14.67~15.64, Longitude: 120.5~121.13
Satellite Data

- Terra MODIS (MOderate Resolution Imaging Spectroradiometer) surface reflectance

<table>
<thead>
<tr>
<th>Band</th>
<th>Band width (μm)</th>
<th>Central band width (μm)</th>
<th>Spatial resolution (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.62 – 0.67</td>
<td>0.65</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>0.84 – 0.88</td>
<td>0.86</td>
<td>0.5</td>
</tr>
<tr>
<td>3</td>
<td>0.46 – 0.48</td>
<td>0.47</td>
<td>0.5</td>
</tr>
<tr>
<td>4</td>
<td>0.55 – 0.57</td>
<td>0.56</td>
<td>0.5</td>
</tr>
<tr>
<td>5</td>
<td>1.23 – 1.25</td>
<td>1.24</td>
<td>0.5</td>
</tr>
<tr>
<td>6</td>
<td>1.63 – 1.65</td>
<td>1.64</td>
<td>0.5</td>
</tr>
<tr>
<td>7</td>
<td>2.11 – 2.16</td>
<td>2.13</td>
<td>0.5</td>
</tr>
</tbody>
</table>

- Himawari8 AHI (Advanced Himawari Imager)

<table>
<thead>
<tr>
<th>Band</th>
<th>Wave length (μm)</th>
<th>Central wave length (μm)</th>
<th>Spatial resolution (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.47</td>
<td>0.47063</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.51</td>
<td>0.51000</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>0.64</td>
<td>0.63914</td>
<td>0.5</td>
</tr>
<tr>
<td>4</td>
<td>0.86</td>
<td>0.85670</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>1.6</td>
<td>1.6101</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>2.3</td>
<td>2.2568</td>
<td>2</td>
</tr>
</tbody>
</table>
Validation Data

- Sentinel-1A

<table>
<thead>
<tr>
<th>Data Product</th>
<th>Mode</th>
<th>Resolution</th>
<th>Polarization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range Ground Detected (GRD)</td>
<td>Interferometric Wide swath (IW)</td>
<td>10m X 10m</td>
<td>VH, VV</td>
</tr>
</tbody>
</table>

\[
\sigma_0^{(VH)} \text{ [dB]} \\
\sigma_0^{(VV)} \text{ [dB]}
\]
3. Methods
Research Procedure

1. Satellite data (VIS, IR)
   a) Surface Reflectance
      c) Otsu Method
   b) Refractive Index Retrieval

2. Satellite data (SAR)
   b) Thresholding
   c) Thresholding

3. RGB Imagery

4. Validation & Analysis (Flood Monitoring)
a) Surface Reflectance

- Object: Determine the flood RGB composite and color saturation
- Method
  1. Different materials show the different surface reflectances at the same bands

(2) Histogram of **bimodal distribution** around the flooded area (Flooded vs. unflooded)
b) Refractive Index

- Object: Validate the flooded area

- Method
  1. Decomposition of unpolarized reflectance into polarized surface reflectances (Hong, 2010; Hong, 2013)

(2) Refractive index retrieval (Hong, 2009; Hong, 2013)
c) Otsu Method: Thresholding

- Object: determine the optimal threshold for separating the flooded from non-flooded areas

- Method:
  Otsu’s thresholding method is based on selecting the lowest point between two classes (peaks).

Example of the Otsu method for extracting rice from their background (Nie, 2014)
4.1 Results: MODIS
Reflectances

- Histogram

- Histograms of reflectance at different wavelengths (0.47μm, 0.58μm, 0.63μm, 0.75μm, 0.85μm, 1.24μm, 1.4μm, 1.54μm, 2.13μm, 3.5μm)
Preflooding stage
2015. 09. 16, 02:20 (UTC)

After Flood event
2015. 10. 25, 02:25 (UTC)

True color
(RGB 0.65-0.56-0.47μm)

Proposed RGB
(RGB 1.64-1.24-0.86μm)
**Refractive Index**

- **Refractive index retrieval**

  Real part of refractive index

  ![Real part of refractive index](image)

- **Refractive index in VIS and NIR bands**
  - water: ~1.33
  - minerals: 1.5 – 1.8

  Thus, the estimated $n$ value in the inundation area ranges from 1.3 to 1.6.
Flooded area & Validation

RGB 6-5-2 image of the Pampanga River

σ₀ of VV polarized SENTINEL-1A data
Flooded area & Validation

- Number of pixels: 1,951
- Flooded area
  \[= 1,951 \times 0.5[\text{km}] \times 0.5[\text{km}]\]
  \[= 487.75[\text{km}^2]\]

- Number of pixels: 4,863,657
- Flooded area
  \[= 4,863,657 \times 0.01[\text{km}] \times 0.01[\text{km}]\]
  \[= 486.37[\text{ km}^2]\]
4.2 Results: AHI
Albedo

- Histogram
Albedo

1km  1km  500m

 Proposed RGB
(RGB 1.64–1.24–0.86 μm)

MODIS
RGB

- Proposed RGB (RGB 1.6-0.86-0.64 μm)

2km-2km-2km

2km-1km-500m

2015. 10. 25, 02:30 (UTC)
RGB

Pre-flooding stage
2015. 09. 16, 02:20 (UTC)

After Flood event
2015. 10. 25, 02:30 (UTC)

True color (RGB 3-2-1)  Proposed RGB (RGB 5-4-3)

True color  Proposed RGB
6. Summary
Summary and Discussion

- **Flood monitoring**

  In this study, flood was detected using MODIS surface reflectances at visible and near-infrared wavelength bands.

  The case of flood around the Pampanga River in Philippine October 25, 2015 was tested.

  This study suggested a $1.64 \text{μm} - 1.24 \text{μm} - 0.86 \text{μm}$ RGB composite image for MODIS observation, and also suggested a $1.6 \text{μm} - 0.86 \text{μm} - 0.64 \text{μm}$ RGB composite image for AHI observation (geostationary satellite).

  For the validation, the flooded areas estimated using MODIS RGB imagery and SAR observation were 487.75 km$^2$ and 486.37 km$^2$, respectively.
References

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• Hong, S., 2013, Polarization conversion for specular components of surface reflection, IEEE Geoscience and Remote Sensing Letters, 10(6)


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Thank you for your attention.

Do you have a question?