Active fire detection using satellite data

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Contents

◇ 1. Introduction
◇ 2. Method of study
◇ 3. Algorithm test
◇ 4. Validation
◇ 5. Further works
◇ 6. Conclusion & Summary
1. Introduction

Effect of forest fires

**Ecological aspects**
- Decrease in biodiversity.
- Destruction of wildlife habitats.
- Causing climate change by increasing CO₂.

**Economic aspects**
- Loss of environmental function of forests
- Loss of livestock and forest products

**Social aspects**
- Decrease in tourists.
- Disturbance of industry
- Deleterious effects on respiratory organs

Via: Korea Forest Service (http://www.forest.go.kr)

- 2013, Mar. (Pohang of South Korea).
- 2013, Jun. (Indonesia).
- 2013, Oct. (Australia)
1. Introduction

Effect of forest fires

<table>
<thead>
<tr>
<th>Country</th>
<th>Forest Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finland</td>
<td>72.9%</td>
</tr>
<tr>
<td>Sweden</td>
<td>68.7%</td>
</tr>
<tr>
<td>Japan</td>
<td>68.5%</td>
</tr>
<tr>
<td>Republic of Korea</td>
<td>63.67%</td>
</tr>
<tr>
<td>United States of America</td>
<td>33.2%</td>
</tr>
<tr>
<td>Germany</td>
<td>31.8%</td>
</tr>
<tr>
<td>France</td>
<td>29.1%</td>
</tr>
</tbody>
</table>

Via: (http://www.index.go.kr)

- South Korea is 4th among OECD countries about forest area.
- Fire occurrence frequency has been on the rise in South Korea.
- The ratio of Coniferous forest among total forest area is about 40%.
- Coniferous forest leads to more damage than other forests in case of occurrence of wildfires.
1. Introduction

Necessity of satellite data.

- Occurrence of wildfires is abrupt and unpredictable.
- Satellites which are in outer space can observe extensive areas efficiently.
- Detection using satellite may be efficient about natural disaster like wildfires.
- Satellite can be divided into two types according to orbit.

Polar orbiting satellite
Terra - U. S. A
Aqua - U. S. A

Geostationary satellite
MTSAT (Multifunctional Transport Satellite) - J APAN
GOES (Geo-stationary Operational Environmental Satellite) - U. S. A
COMS (Communication, Ocean and Meteorological Satellite) - Korea
1. Introduction

Necessity of satellite data.

- The fire product using MODIS and GOES is offered to users
- COMS can observe South Korea and East Asia but they don’t have official fire product.
1. Introduction

MODIS/Terra can detect Korea once or twice per day.

◊ MODIS/Terra can detect Korea once or twice per day.

**Purpose** of this study is
development of real time algorithm which can detect active fire
every 15 minutes about South Korea.
2. Method of study

Spectral characteristics of fire

- Principle of active fire detection

Typically the difference in brightness temperatures between the two infrared windows at about 4 and 11 micrometer is due to reflected solar radiation, surface emissivity differences, and water vapor attenuation.

Fire-pixels tend to have a significant increase in 4 micrometer brightness temperature.

But they do not tend to have a significant increase in 11 micrometer brightness temperature.
2. Method of study

COMS (Communication Ocean and Meteorological Satellite)
Specifications

<table>
<thead>
<tr>
<th>Channels</th>
<th>Wavelength (μm)</th>
<th>Spatial Resolution</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visible</td>
<td>0.67</td>
<td>1Km</td>
<td>Weekly cloud images, Asian dust, forest fires, fog observation, atmospheric motion vector</td>
</tr>
<tr>
<td>Shortwave infrared</td>
<td>3.7</td>
<td>4Km</td>
<td>Night fog &amp; low-level clouds, forest fire detection, land surface temperature</td>
</tr>
<tr>
<td>Water vapor</td>
<td>6.7</td>
<td>4Km</td>
<td>Observation of mid and upper atmospheric humidity &amp; upper atmospheric motions</td>
</tr>
<tr>
<td>Infrared 1</td>
<td>10.8</td>
<td>4Km</td>
<td>Cloud information, sea surface temperature, Asian dust observation</td>
</tr>
<tr>
<td>Infrared 2</td>
<td>12.0</td>
<td>4Km</td>
<td>Cloud information, sea surface temperature, Asian dust observation</td>
</tr>
</tbody>
</table>

- COMS data are offered since April 2011.
- Data of study.
  → the northern hemisphere Extend Area (every 15-minute intervals)
2. Method of study

**Step A**: Selection of fire possibility pixels by thresholding.

**Step B**: Potential fire pixels by absolute thresholding.

**Step C**: Compare spectral characteristics between potential fire pixels and background pixels.

**Step D**: Eliminate false alarm pixels

Active fire detection algorithm.
2. Method of study

- Day Time: $\{BT_4 > 305K, \Delta BT > 10K, \rho_{0.05} < 0.16\}$
  - Step A: $BT_4 > 315K$ → Fire
  - Contextual Test of Surrounding window:
    - $\Delta T > \overline{\Delta T} + 3.5\delta_{\Delta T}$
    - $\Delta T > \overline{\Delta T} + 3\delta_{\Delta T}$

- Night Time: $\{BT_4 > 295K, \Delta BT > 10K\}$
  - Step A: $BT_4 > 305K$ → Fire
  - Contextual Test of Surrounding window:
    - $\Delta T > \overline{\Delta T} + 3.5\delta_{\Delta T}$
    - $\Delta T > \overline{\Delta T} + 3\delta_{\Delta T}$

\[\Delta BT = BT_4 - BT_{11}\]

- Step B: $\overline{T}_4$ (Mean of T4)
- Step C: $\overline{\Delta T}$ (Mean of $\Delta T$)
2. Method of study

\[ \text{Step D. The false alarm rejection} \]

- **Sunglint false alarm**

\[ \begin{align*}
\theta_g < 2^\circ \\
\theta_g < 8^\circ \text{ and } \rho_{0.85} > 0.1 \text{ and } \rho_{0.88} > 0.2 \text{ and } \rho_{2.1} > 0.12 \\
\theta_g < 12^\circ \text{ and } (N_{sw} + N_w) > 0
\end{align*} \rightarrow \text{false alarm} \]

- \( \theta_g \): surface-to-satellite vector and specular reflection direction
- \( \cos \theta_g = \cos \theta_v \cos \theta_s - \sin \theta_v \sin \theta_s \cos \varnothing \)
- \( \theta_v \): view zenith angle
- \( \theta_s \): solar zenith angle
- \( \varnothing \): relative azimuth angle
- \( N_{sw} \): The number of water pixels among neighbor 8 pixels.
- \( N_w \): The number of water pixels of surrounding window.

1. If values of \( \theta_g \) are very small, the Sun reflects off the surface at almost the same angle that a satellite sensor is viewing the surface.
2. If values of \( \theta_g \) are a little small and reflectance of Visible and Infrared channel has over some values, it is sunglint false alarm.
3. If values of \( \theta_g \) are a little small and there are water pixels around some pixel, it is sunglint false alarm.
2. Method of study

The false alarms can occur in the incineration plants because incineration plants may have high heat.

Generally, water pixels have low 4-micrometer brightness temperature. When there are water or mixed water pixels around some pixel, they may decrease mean of ΔT.

Step D. The false alarm rejection

- Incineration plant false alarm
- Coastline false alarm

The false alarms can occur in the incineration plants because incineration plants may have high heat.
3. Algorithm test

ASTER VISIBLE Image

COMS Data On Apr 2011

KFS (Korea Forest Service) data

Algorithm

TEST

Display

ArcGIS

Result
3. Algorithm test

We adjusted all necessary threshold values by training 192 scenes at intervals of 15 min on 1 and 2 April 2011.
4. Validation

We can detect forest fire 13 out of 15.

Detection rate is 86.6 %.
5. Further works

Area: Indonesia, Riau
Jun. 19th-20th 2013, the number of reported fires is about 6,677.

Area: Russia, Amur
Apr. 17th 2012, damaged area: 2,000 hectare.

- We can't get precise address of these fires.
- We conducted the visual comparison between MODIS products and our COMS result.
5. Further works

- Each of the HDF files has a lot of information.
- Repetitive work was needed to mark position of wildfires into a map.
5. Further works

- We used Python for ArcGIS for batch processing.
5. Further works

- We was able to confirm that result of two satellite is similar.
6. Conclusion & Summary

1. It is possible to detect forest fire using COMS and detection rate is 86.6% in 2013

2. Can help initial reaction of forest fire extinguishment

3. Geostationary satellite may be more useful than polar orbit satellite because of the difference of data production cycle about same area.

4. Visual comparison between COMS and MODIS was similar

5. Need to analyze and verify the algorithm using other East Asia data.
Thank you