Active fire detection using satellite data

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1. Introduction

Effect of forest fires

Ecological aspects

-Decrease in biodiversity.
-Destruction of wildlife habitats.
-Causing climate change by increasing CO_2.

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

2013, Mar. (Pohang of South Korea).

2013, Jun. (Indonesia).

2013, Oct. (Australia)

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

1. Introduction

Effect of forest fires

< international comparison of forest area in land >

Finland	Sweden	Japan	Republic of Korea	United States of America	Germany	France
72.9%	68.7%	68.5%	63.67%	33.2%	31.8%	29.1%

※ 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

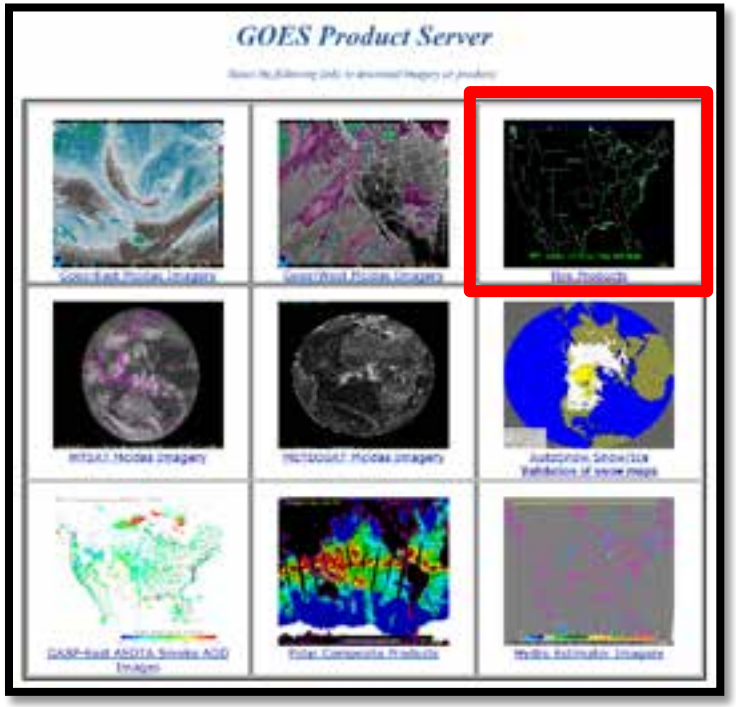
MTSAT(Multifunctional Transport Satellite) - JAPAN
GOES(Geo-stationary Operational Environmental Satellite) - U. S. A
COMS(Communication, Ocean and Meteorological Satellite) - Korea

1. Introduction

Necessity of satellite data.

※ The fire product using MODIS and GOES is offered to users

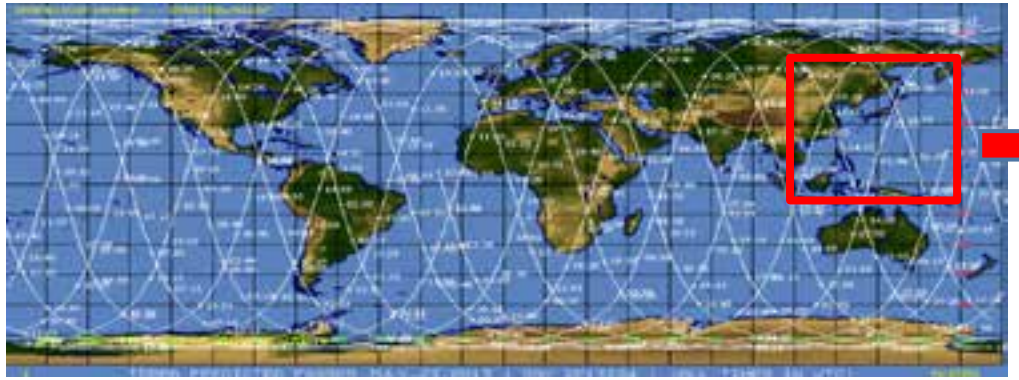
※ COMS can observe South Korea and East Asia but they don't have official fire product.



Thermal Anomalies and Fire

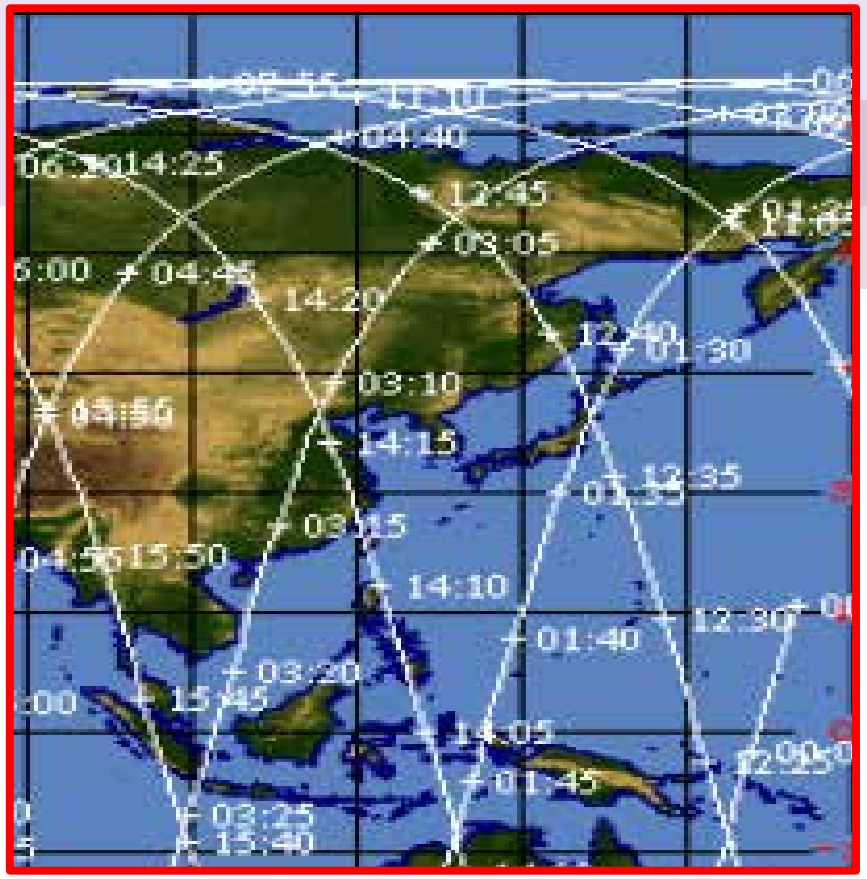
Shortname	Platform	MODIS Product	Raster type	Res (m)	Temporal Granularity
MYD14A1	Aqua	Thermal Anomalies & Fire	Tile	1000m	Daily
MOD14A1	Terra	Thermal Anomalies & Fire	Tile	1000m	Daily
MYD14A2	Aqua	Thermal Anomalies & Fire	Tile	1000m	8 day
MOD14A2	Terra	Thermal Anomalies & Fire	Tile	1000m	8 day
MYD14	Aqua	Thermal Anomalies & Fire	Swath	1000m	5 min
MOD14	Terra	Thermal Anomalies & Fire	Swath	1000m	5 min
MCD45A1	Combined	Burned Area	Tile	500m	Monthly

1. Introduction



MODIS/Terra Orbit Information

(http://landweb.nascom.nasa.gov/cgi-bin/browse/browse.cgi)

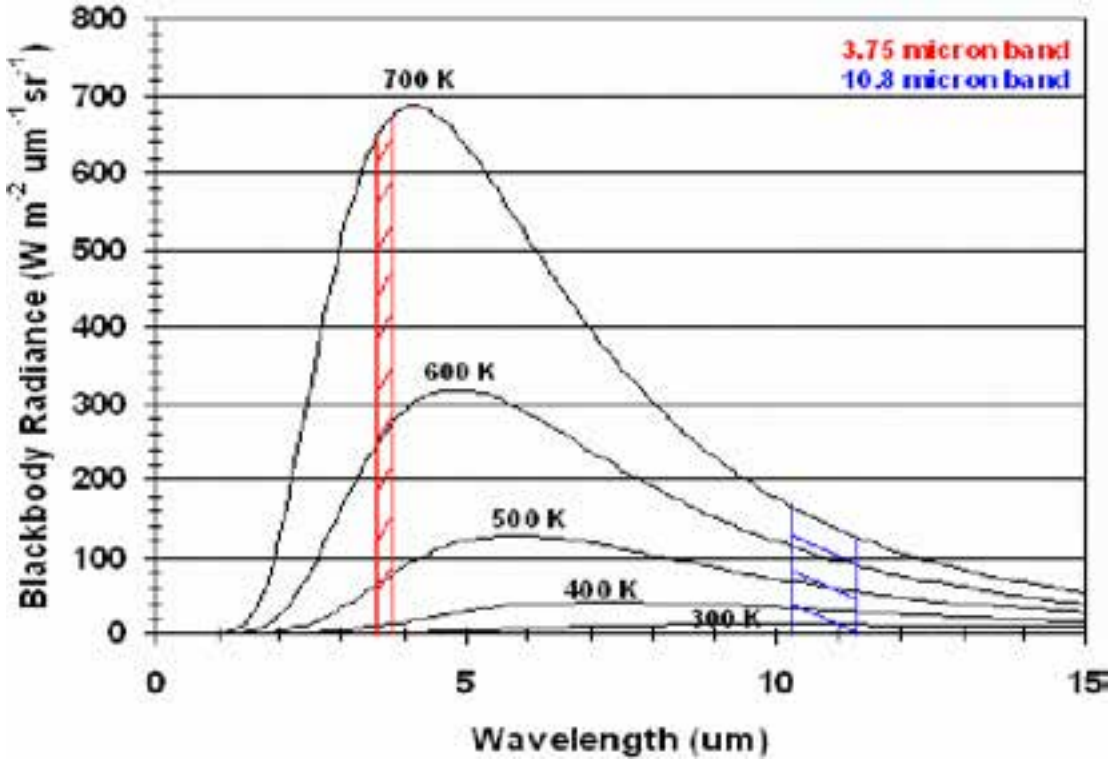


◇ MODIS/Terra can detect Korea once or twice per day.

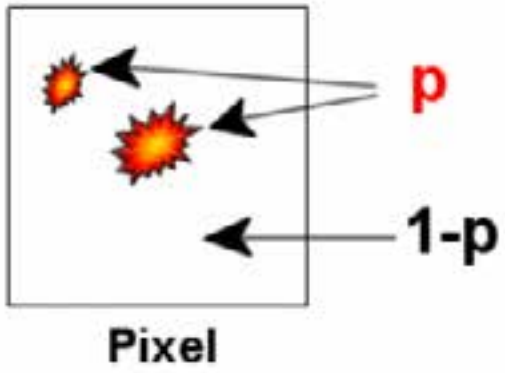
Purpose of this study is
development of real time algorithm which can detect active fire
every 15 minutes about South Korea.

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

Number of Channels	5 channels (1 visible, 4 infrared)
Observation Period	Less than 27 minutes

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

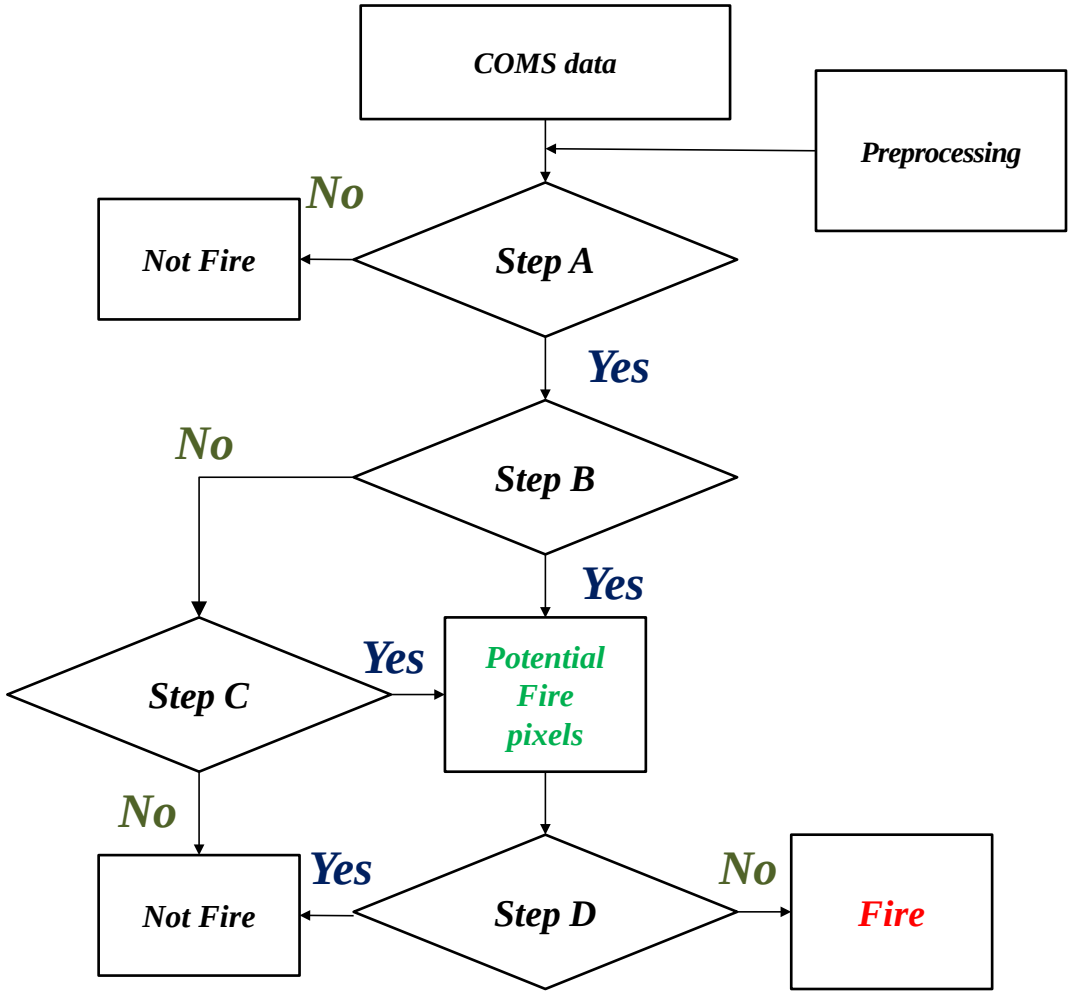
▶ COMS data are offered since April 2011.

▶ Data of study.

→ the northern hemisphere Extend Area

(every 15-minute intervals)

2.Method of study



Active fire detection algorithm.

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

2.Method of study

- Day Time $\begin{cases} BT_4 > 305K \\ \Delta BT > 10K \\ \rho_{0.86} < 0.16 \end{cases}$

→ $BT_4 > 315K$ → **Fire**

→ *Contextual Test of Surrounding window*
② *AND* ③ *AND* ④ *AND* (⑤ *OR* ⑥) → **Fire**

- Night Time $\begin{cases} BT_4 > 295K \\ \Delta BT > 10K \end{cases}$

→ $BT_4 > 305K$ → **Fire**

→ *Contextual Test of Surrounding window*
❷ *AND* ③ *AND* ④ → **Fire**

$\Delta BT = BT_4 - BT_{11}$

② $\Delta T > \overline{\Delta T} + 3.5\delta_{\Delta T}$ ❷ $\Delta T > \overline{\Delta T} + 3\delta_{\Delta T}$
③ $\Delta T > \overline{\Delta T} + 6K$
④ $T_4 > \overline{T_4} + 3\delta_4$
⑤ $T_{11} > \overline{T_{11}} + \delta_{11} - 1.9K$
⑥ $\delta'_4 > 8.2K$

: Step A

: Step B

: Step C

$\overline{T_4}$: Mean of T4
δ_4 : Mean absolute deviation of T4
$\overline{T_4'}$: Mean of T4 about not fire pixels
δ'_4 : Mean absolute deviation of T4 about not fire pixels
$\overline{T_{11}}$: Mean of T11
δ_{11} : Mean absolute deviation of T11
$\overline{\Delta T}$: Mean of ΔT
$\delta_{\Delta T}$: Mean absolute deviation of ΔT

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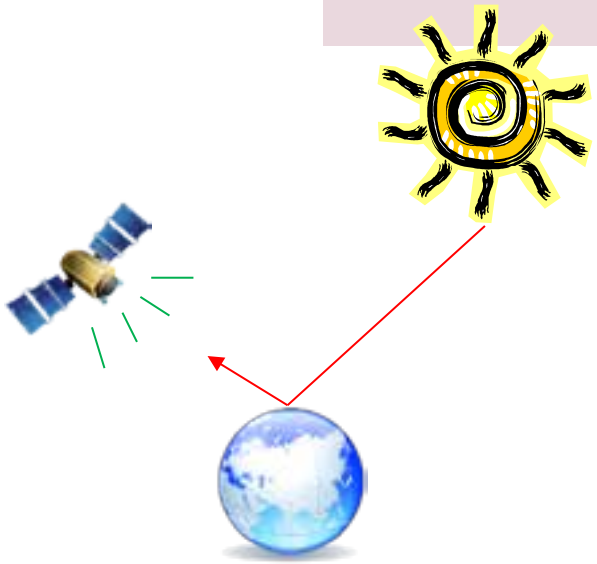
2.Method of study

- Step D . The false alarm rejection
  - Sunglint false alarm

$$\left\{\begin{array}{l} ① \ \theta_g < 2^\circ \\ \qquad\qquad\qquad\qquad OR \\ ② \ \theta_g < 8^\circ \text{ and } \rho_{0.65} > 0.1 \text{ and } \rho_{0.86} > 0.2 \text{ and } \rho_{2.1} > 0.12 \\ \qquad\qquad\qquad\qquad OR \\ ③ \ \theta_g < 12^\circ \text{ and } (N_{aw} + N_w) > 0 \end{array}\right\} \rightarrow \textit{false alarm}$$



$\cos\theta_g = \cos\theta_v \cos\theta_s - \sin\theta_v \sin\theta_s \cos\varnothing$

- θ_v : *view zenith angle*
- θ_s : *solar zenith angle*
- $\varnothing$: *relative azimuth angle*

- N_{aw} : The number of water pixels among neighbor 8 pixels.
- N_w : The number of water pixels of surrounding window.

θ_g: surface-to-satellite vector and specular reflection direction

① If values of $\boldsymbol{\theta_g}$ 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 $\boldsymbol{\theta_g}$ are a little small and reflectance of Visible and Infrared channel has over some values, it is sunglint false alarm.
③ If values of $\boldsymbol{\theta_g}$ are a little small and there are water pixels around some pixel, it is sunglint false alarm.

2.Method of study

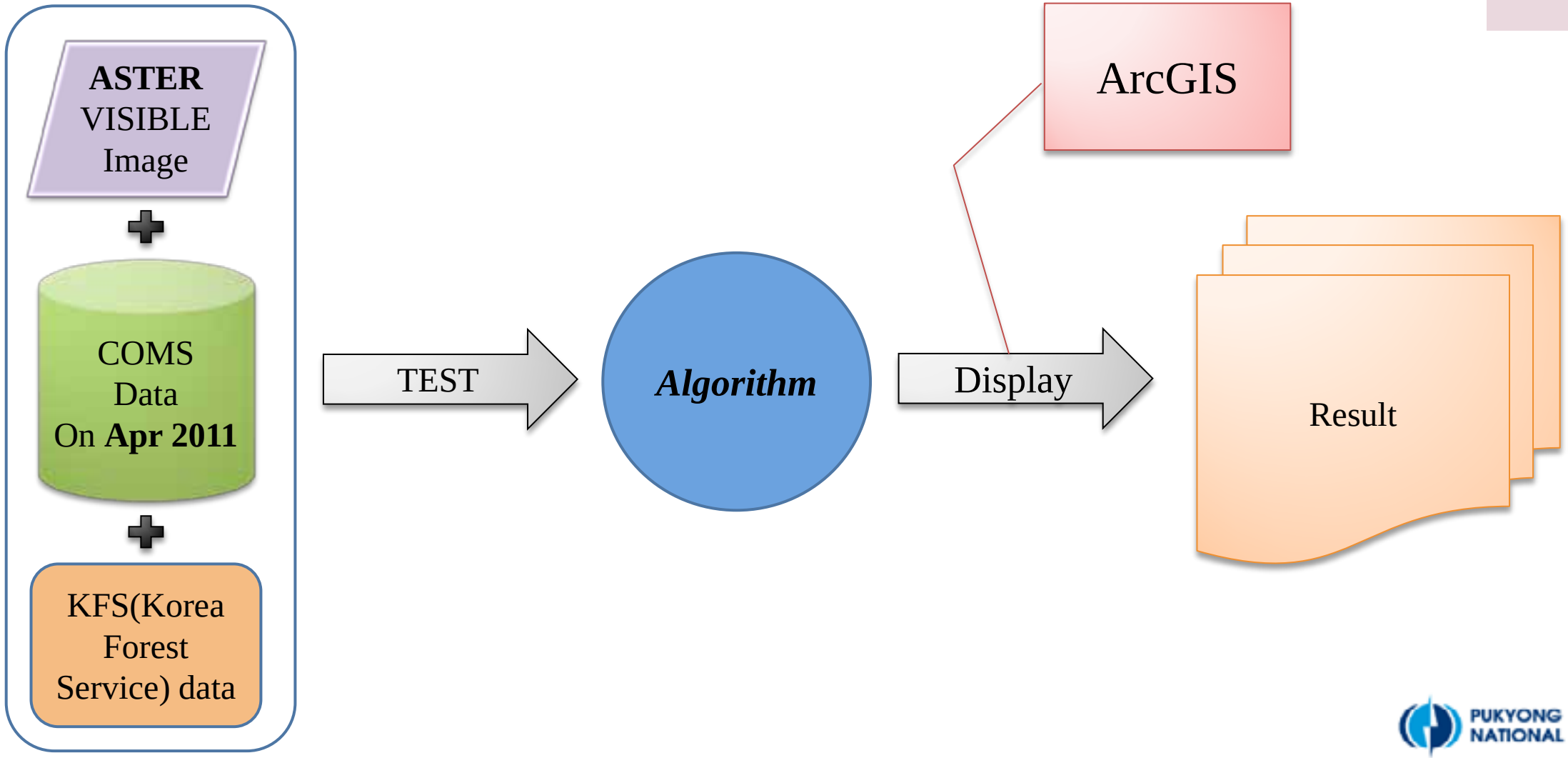
- Step D . The false alarm rejection
  - Coastline false alarm

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

  - Incineration plant false alarm

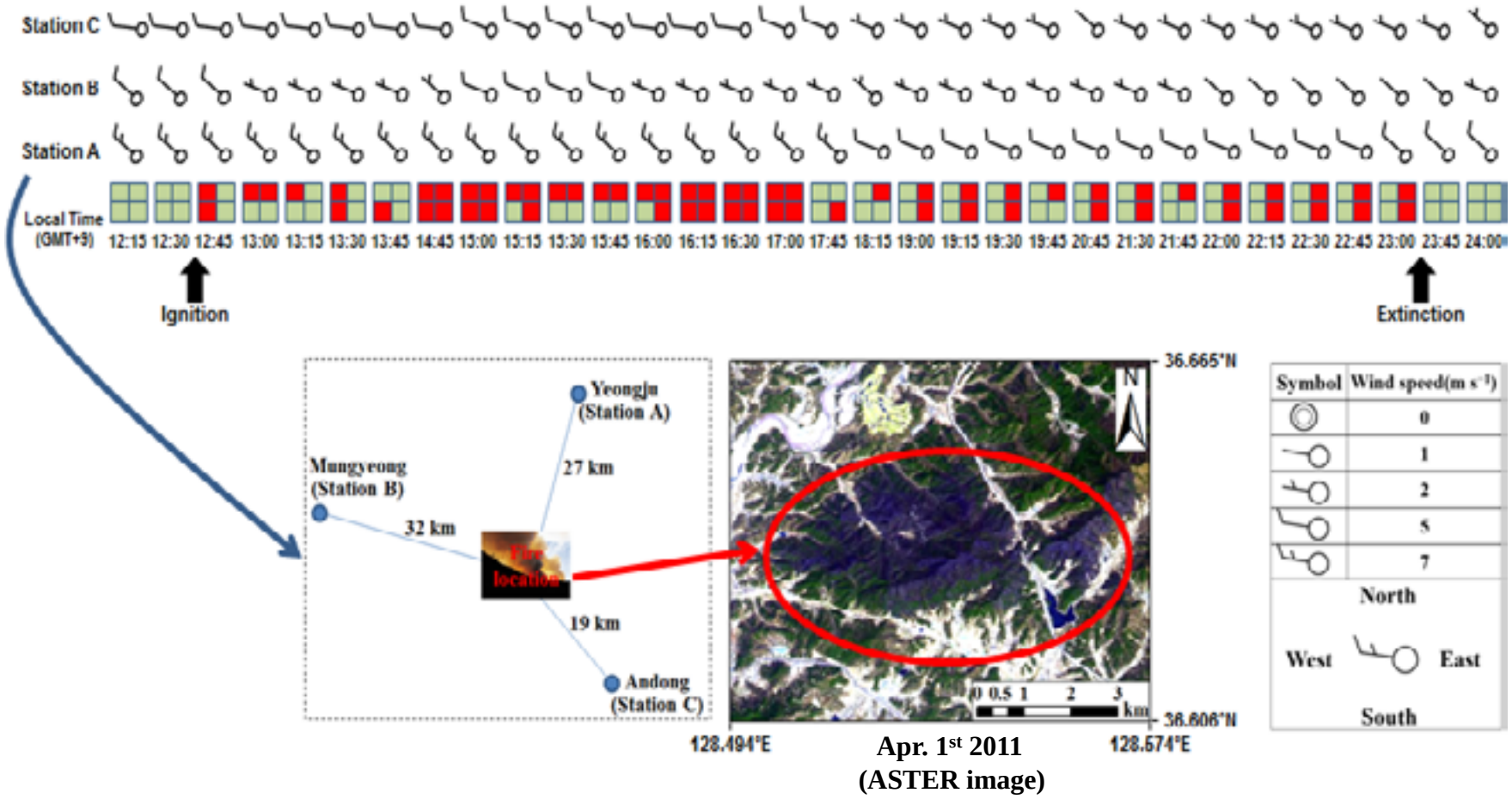
The false alarms can occur in the incineration plants because incineration plants may have high heat.

3.Algorithm test



3.Algorithm test

▶ Algorithm training



Apr. 1st 2011
(ASTER image)

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

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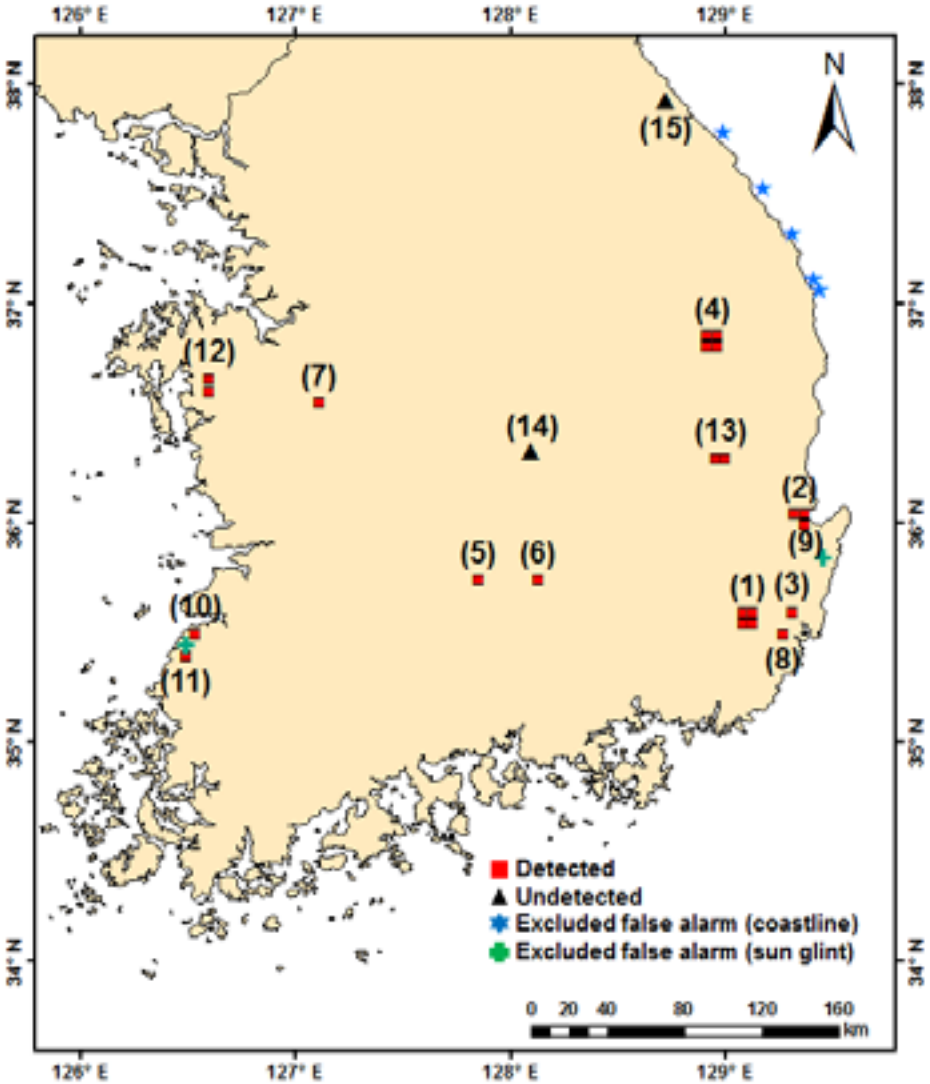
4. Validation



Forest fire occurrences
On Mar 2013.

No	Area damaged(ha)	Detected
1	280	Yes
2	79	Yes
3	33.2	Yes
4	15	Yes
5	10	Yes
6	10	Yes
7	5	Yes
8	5	Yes
9	3	Yes
10	2.4	Yes
11	2.2	Yes
12	2	Yes
13	1	Yes
14	1	No
15	1	No

We can detect forest fire 13 out of 15.

Detection rate is 86.6 %.

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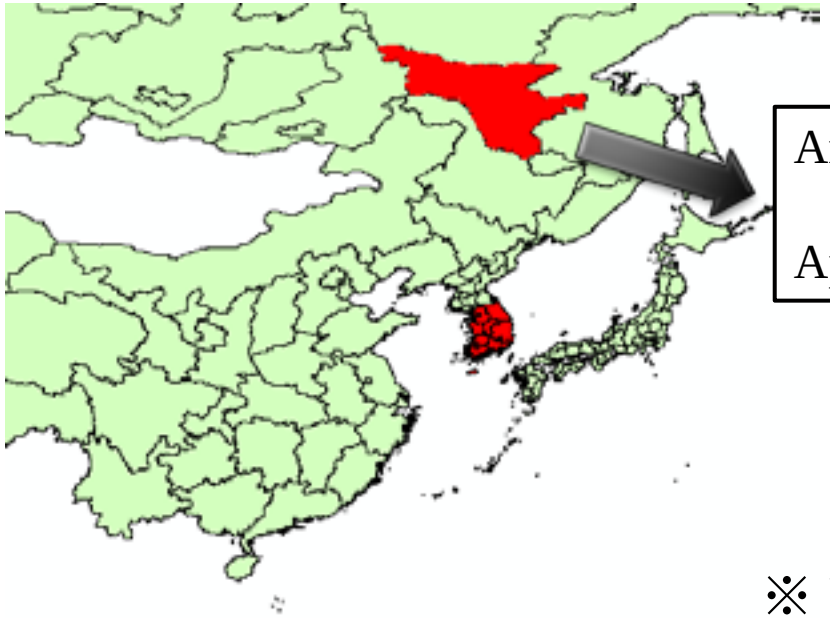
5.Further works



Area : **Russia, Amur**

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

Area : **Indonesia, Riau**

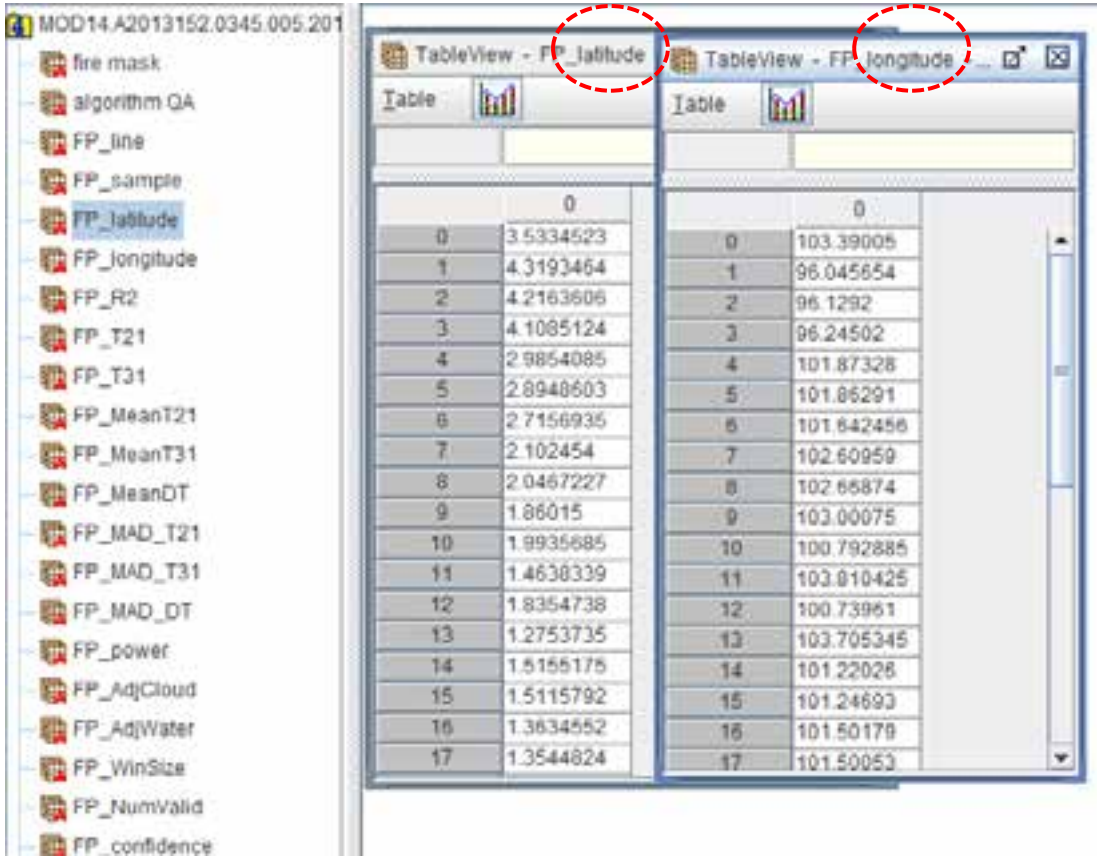
Jun. 19th-20th 2013,
the number of reported fires is
about 6,677.

※ We can't get precise address of these fires.

※ We conducted the visual comparison between MODIS products and our COMS result.

5.Further works

MOD14.A2013152.0345.005.2013152100230.hdf
MOD14.A2013152.1605.005.2013152215157.hdf
MOD14.A2013153.0250.005.2013153061947.hdf
MOD14.A2013153.0425.005.2013153095931.hdf
MOD14.A2013153.0430.005.2013153095916.hdf
MOD14.A2013153.1510.005.2013153215324.hdf
MOD14.A2013154.0330.005.2013154104055.hdf
MOD14.A2013154.0335.005.2013154103057.hdf
MOD14.A2013154.1555.005.2013154220345.hdf
MOD14.A2013155.0415.005.2013155100914.hdf
MOD14.A2013155.1500.005.2013155215717.hdf
MOD14.A2013155.1635.005.2013155215644.hdf
MOD14.A2013156.0320.005.2013156100224.hdf
MOD14.A2013156.1540.005.2013157150837.hdf
MOD14.A2013156.1545.005.2013157150838.hdf
MOD14.A2013157.0400.005.2013157100307.hdf
MOD14.A2013157.0405.005.2013157100358.hdf
MOD14.A2013157.1445.005.2013157174616.hdf



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

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5.Further works

Make XY Event Layer (Data Management)
Creates a new point feature layer based on; italics; and; italics; coordinates defined in a source table. If the source table contains; italics; coordinates...
toolboxes\system toolboxes\data management tools.tbx\layers and table views**make xy** event layer

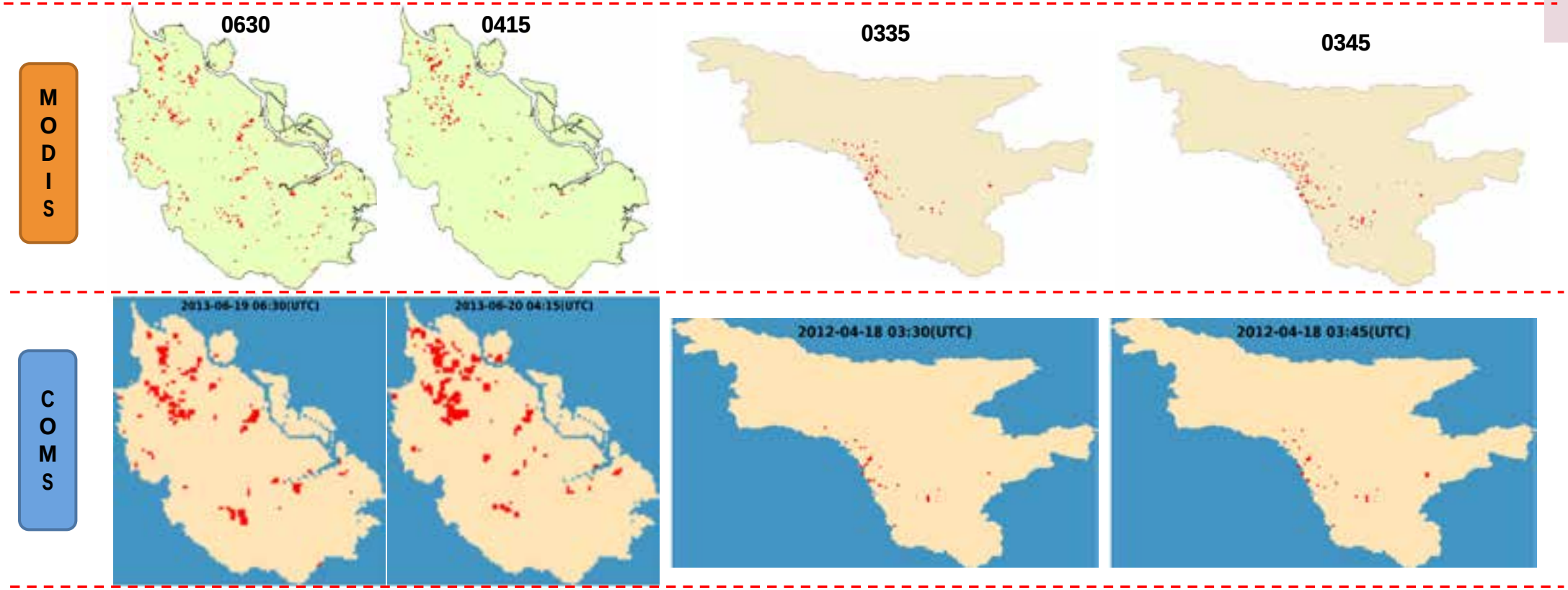
Apply **Symbol**ogy From Layer (Data Management)
This tool applies the **symbol**ogy from a layer to the Input Layer. It can be applied to feature, raster, network analysis, and TIN layer files or layers in the...
toolboxes\system toolboxes\data management tools.tbx\layers and table views\apply **symbol**ogy from layer

Python

```
>>> import arcpy
... from xlrd import open_workbook
... arcpy.env.workspace = "H:/Indonesia_ForestFires/modisData/australia/arc"
...
... book = open_workbook(arcpy.env.workspace+'/aust_firesInfo_myd14.xls')
... for num in range(len(book.sheet_names())):
...     arcpy.MakeXYEventLayer_management("aust_firesInfo_myd14.xls/"+book.sheet_names()[num]+'$',"longitude","latitude",book.sheet_names()[num])
...     arcpy.ApplySymbologyFromLayer_management(book.sheet_names()[num],"FireSymbol.lyr")
...
...
...
...
>>>
>>>
```

※ 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