



# HOKKAIDO UNIVERSITY

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| Title            | Development of wildfire alert system for efficient fire fighting                                                                                                                                                                                                   |
| Author(s)        | Nakau, Koji; Takeuchi, Wataru; Segah, Henderik et al.                                                                                                                                                                                                              |
| Relation         | 泥炭地管理国際会議：熱帯および冷温帯泥炭地管理の在り方とその未来像 人と自然の調和とその持続性 (International Workshop on Peatland Management: Future Aspect of Management in Tropical and Cool Temperate Peatlands : Harmonious and Sustainable Relationship with Nature). 2013年10月10日 (木). 北海道大学百年記念会館会議室. 札幌市. |
| Issue Date       | 2013-10-10                                                                                                                                                                                                                                                         |
| Doc URL          | <a href="https://hdl.handle.net/2115/53549">https://hdl.handle.net/2115/53549</a>                                                                                                                                                                                  |
| Type             | conference presentation                                                                                                                                                                                                                                            |
| File Information | No.7_K.Nakau.pdf                                                                                                                                                                                                                                                   |



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# DEVELOPMENT OF WILDFIRE ALERT SYSTEM FOR EFFICIENT FIRE FIGHTING

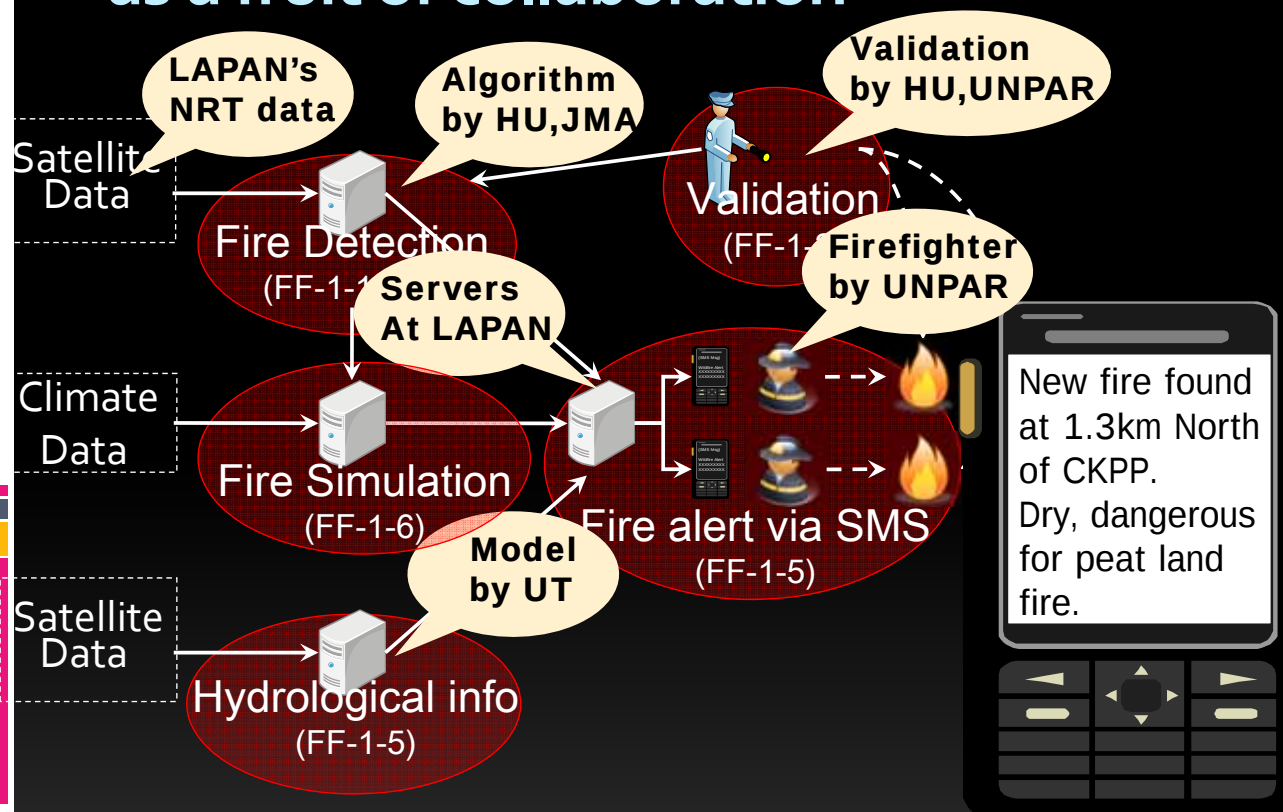
## Topics

- Fire Alert System
  - Data Flow of This System
  - Wildfire Detection Algorithm
  - Data Integration for SMS Alert
- Fire Monitoring in Near Future
- Summary

# Objects of FF-1 Subgroup

- FF1-1 **Fire detection algorithms** for MODIS data
- FF1-2 **Local validation** fire product
- FF1-3 **Simulation of fire propagation**
- FF1-4 **Water regime** for the fire prediction and water level of canals
- FF1-5 Provide fire **information to firefighting teams** and other stakeholder agencies

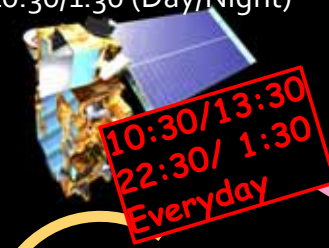
## Fire Alert System as a fruit of collaboration



# Procedure of Fire Monitoring

## Satellite observation

Currently, NASA's satellite  
10:30/1:30 (Day/Night)



10:30/13:30  
22:30/ 1:30  
Everyday

## Reception

Sulawesi



Real-time

## Transfer, Preprocess

Jakarta



1-4hour

## Fire Detection Integration



<1hour



Real-time

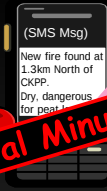


IR radiation  
from fire



In Several Minutes

Fire-fighter  
Palangkaraya



(SMS Msg)  
New fire found at  
1.3km North of  
CKPP.  
Dry, dangerous  
for peat fire

Morning / Evening

SMS server  
Jakarta



## Soil-moisture

Tokyo



Peatland fire database <http://jica-jst.lapanrs.com/>



# Peatland fire database <http://jica-jst.lapanrs.com/>

[Wildfire Map](#)

[Wildfire Text Data](#)

## Description of Wildfire location data:

Observation Period: Sep 2012

Province: Kalimantan Tengah

Regency: Pulang Pisau

District: Jabiren Raya

Village: Pilang

Satellite/Sensor: Terra/MODIS and Aqua/MODIS

**Yr. Mon. SMS Villages**

[2013 Dec Tarunajaya](#)

[2012 Nov Tumbang  
Nusa](#)

[2011 Oct Pilang](#)

[2010 Sep Djabiren](#)

[2009 Aug](#)

**Other regions**

+--[Kalimantan Tengah](#)

|+--[Katingan](#)

|+--[Gunung Mas](#)

|+--[Kotawaringin](#)

[Timur](#)

|+--[Palangkaraya](#)

|+--[Pulang Pisau](#)

|+--[Kapuas](#)

|+--[Seruyan](#)

|+--[Murung Raya](#)

|+--[Kotawaringin](#)

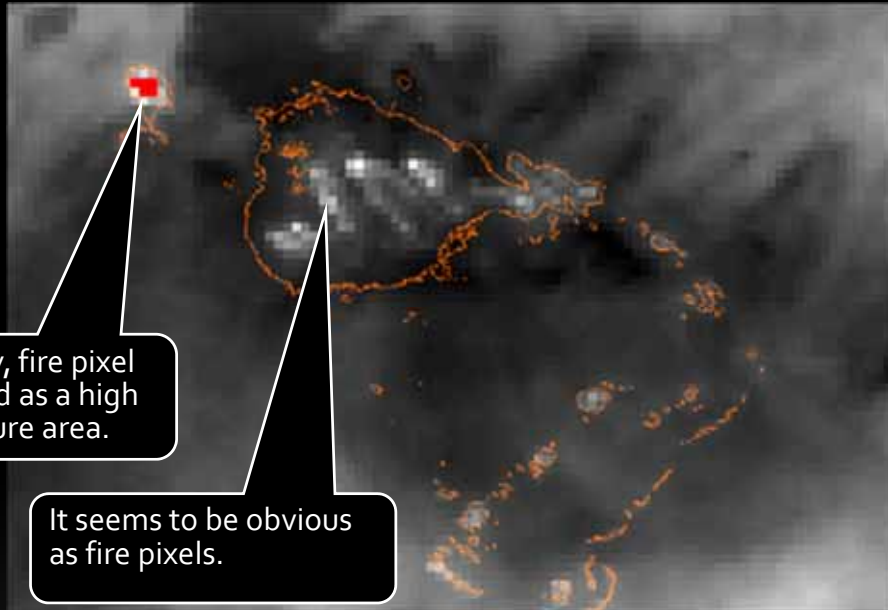
[Barat](#)

## Pilang Fire information

| Fire location                                                                                   |          | Linear Distance |           | Road access                       |  | algorithm | GWT   | Map                 |
|-------------------------------------------------------------------------------------------------|----------|-----------------|-----------|-----------------------------------|--|-----------|-------|---------------------|
| Lat                                                                                             | Long     | Dist            | Direction |                                   |  |           |       |                     |
| <b>2012-09-12</b> (24 hotspots detected, 2 are accessible from the highway) <a href="#">Map</a> |          |                 |           |                                   |  |           |       |                     |
| 2.477S                                                                                          | 114.176E | 1,960m          | 292 W     |                                   |  | kn2 ---   | -79cm | <a href="#">Map</a> |
| 2.485S                                                                                          | 114.166E | 3,024m          | 268 W     |                                   |  | kn2 ---   | -78cm | <a href="#">Map</a> |
| 2.459S                                                                                          | 114.179E | 3,163m          | 331 NW    | 3,400m toward PKY, 647m from road |  | kn2 mod14 | -81cm | <a href="#">Map</a> |
| 2.494S                                                                                          | 114.164E | 3,372m          | 250 W     |                                   |  | kn2 mod14 | -78cm | <a href="#">Map</a> |
| 2.457S                                                                                          | 114.170E | 3,901m          | 319 NW    |                                   |  | kn2 mod14 | -81cm | <a href="#">Map</a> |
| 2.474S                                                                                          | 114.158E | 4,063m          | 285 W     |                                   |  | kn2 mod14 | -78cm | <a href="#">Map</a> |
| 2.493S                                                                                          | 114.155E | 4,339m          | 257 W     |                                   |  | kn2 mod14 | -78cm | <a href="#">Map</a> |
| 2.448S                                                                                          | 114.171E | 4,637m          | 329 NW    | 4,900m toward PKY, 832m from road |  | kn2 mod14 | -81cm | <a href="#">Map</a> |
| 2.473S                                                                                          | 114.148E | 5,124m          | 284 W     |                                   |  | kn2 mod14 | -78cm | <a href="#">Map</a> |
| 2.494S                                                                                          | 114.147E | 5,208m          | 258 W     |                                   |  | kn2 mod14 | -78cm | <a href="#">Map</a> |
| 2.491S                                                                                          | 114.145E | 5,344m          | 261 W     |                                   |  | kn2 mod14 | -78cm | <a href="#">Map</a> |
| 2.457S                                                                                          | 114.249E | 6,951m          | 64 NE     |                                   |  | kn2 mod14 | -88cm | <a href="#">Map</a> |
| 2.481S                                                                                          | 114.263E | 7,782m          | 88 E      |                                   |  | kn2 mod14 | -87cm | <a href="#">Map</a> |
| 2.456S                                                                                          | 114.257E | 7,805m          | 67 NE     |                                   |  | kn2 mod14 | -88cm | <a href="#">Map</a> |
| 2.452S                                                                                          | 114.257E | 8,005m          | 64 NE     |                                   |  | kn2 mod14 | -88cm | <a href="#">Map</a> |

## Fire Detection by Satellite

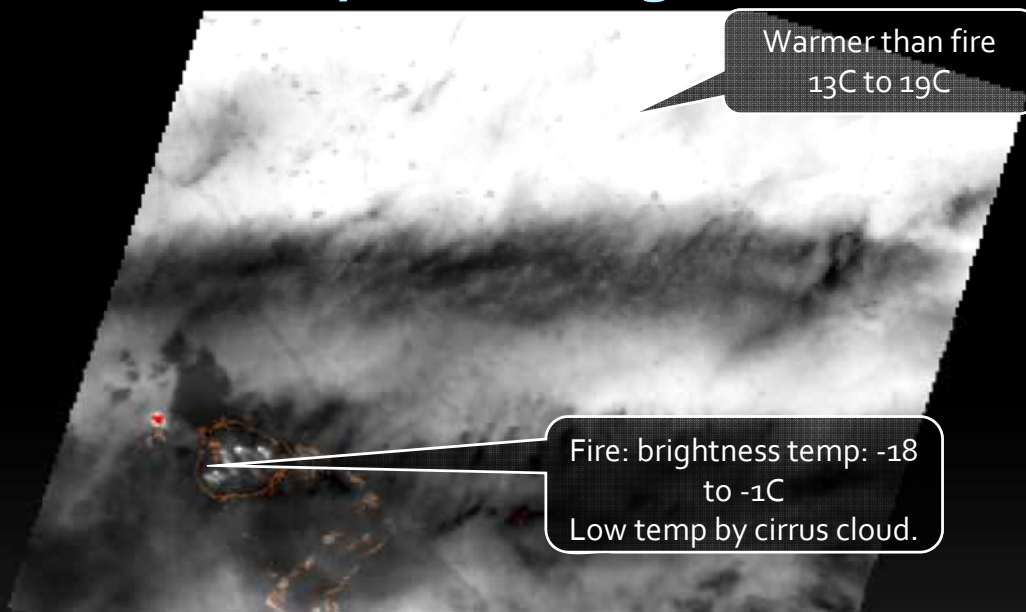
## Wildfire detection: principle is simple.



Tundra fire "Anaktuvuk River fire"

Simulation of 270m 11um Thermal IR (by Terra/ASTER IR)

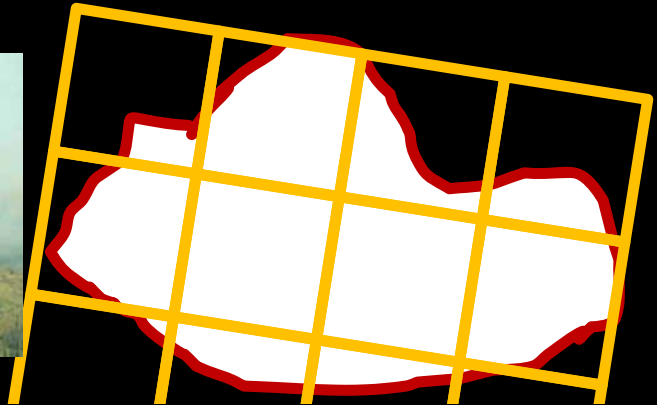
## Wildfire detection: principle is simple, but actually it doesn't go strait.



Tundra fire "Anaktuvuk River fire"

Simulation of 270m 11um Thermal IR (by Terra/ASTER IR)

# Wildfire observation from space

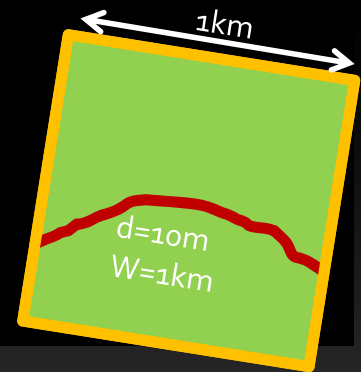


- Hotspot pixel is "Mixcell" of fire and non-fire area

- Depth of fire is 1 m - 10m
- Resolution of IR sensors are  $>100\text{m} - 1\text{km}$
- Only 0.1 – 10% is filled by fire

- Apparent temperature rise are limited

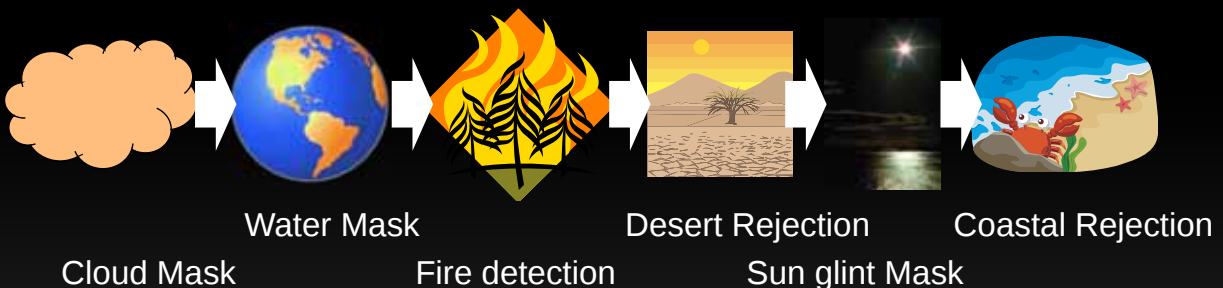
- Width:1km, Depth:10m,Temp: 800K
- $\Delta T$  is 5-20K in TIR, 5-200K in  $4\mu\text{m}$



## Actual wildfire detection

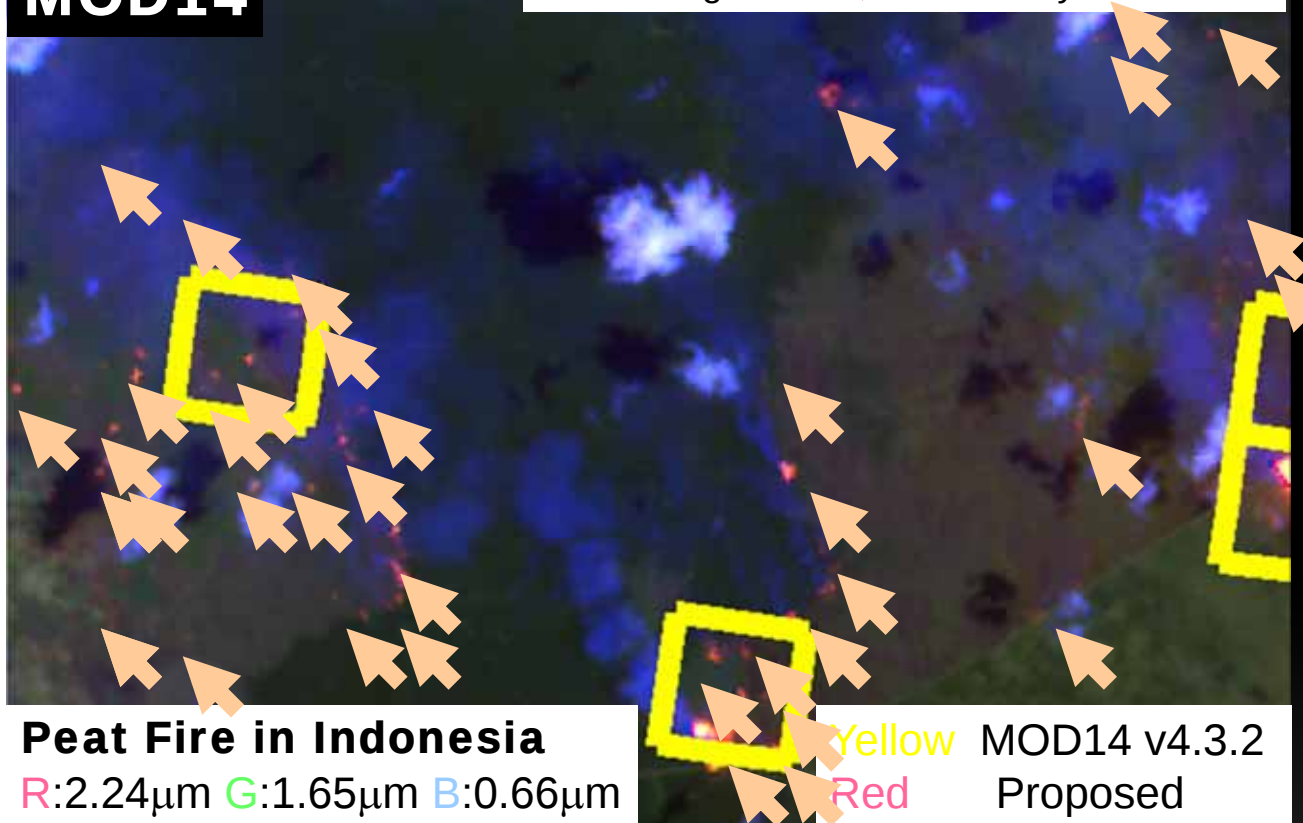
To detect weak signal from wildfire, we utilize contextual threshold.

To reduce false alarms, actual algorithm takes 6 steps in NASA's algorithm.

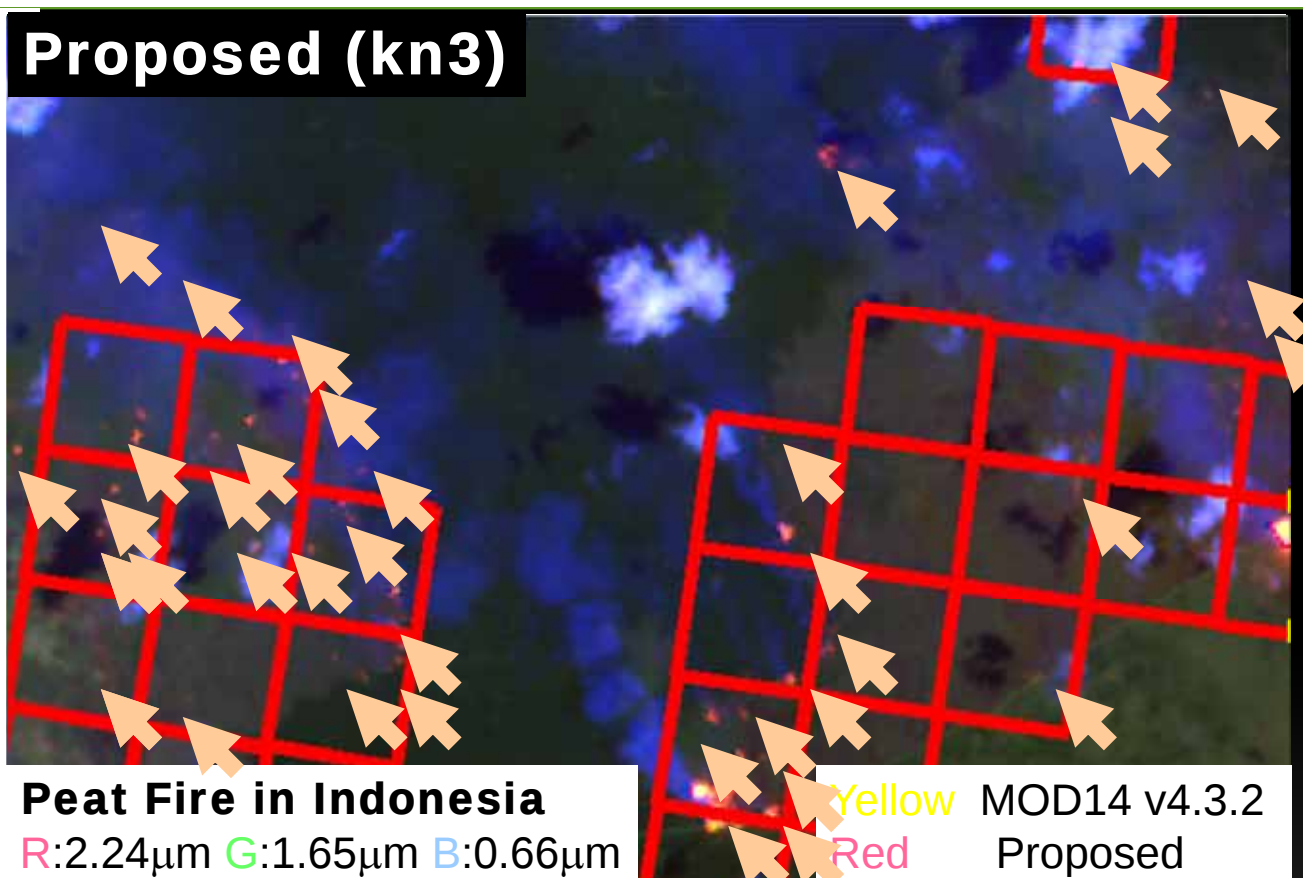


**MOD14**

Smoldering fires are omitted by MOD14.



**Proposed (kn3)**



# Integration of fire information

## Satellite observation

Currently, NASA's satellite  
10:30/1:30 (Day/Night)



IR radiation  
from fire

Reception  
Sulawesi



Real-time

Transfer,  
Preprocess  
Jakarta

1-4hour

Fire Detection Integration

<1hour

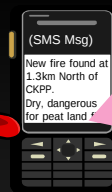
Real-time

## Soil-moisture

Tokyo



Fire-fighter  
Palangkaraya



(SMS Msg)  
New fire found at  
1.3km North of  
CKPP.  
Dry, dangerous  
for peat land

Once a day

SMS server  
Jakarta

# FF1-4 Water Regime

## Keetch-Byram Drought Index (KBDI)



- KBDI is a soil/duff drought index that ranges from 0 (no drought) to 800 (extreme drought) and is based on soil capacity of 20 cm of water. Factors in the index are maximum daily temperature, daily precipitation, and annual precipitation. [Keetch et. al, 1965]

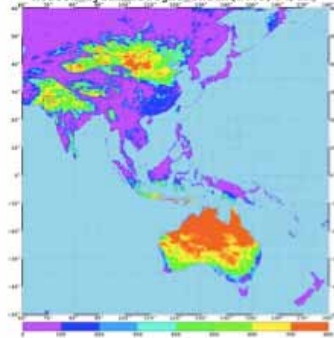


Rain 0.1 0.5 1.0 2.0 3.0 5.0 10.0 15.0 20.0 30.0 (mm/day)

<http://sharaku.eorc.jaxa.jp/GSMaP/>

- Presently, this index is derived from satellite observation of land surface temperature (LST) from MTSAT received at IIS/U-Tokyo and precipitation derived from global satellite mapping (GSMaP) provided by JAXA EROC.

Keetch-Byram Drought Index (2009/07/12)



<http://webgms.iis.u-tokyo.ac.jp/KBDI/>

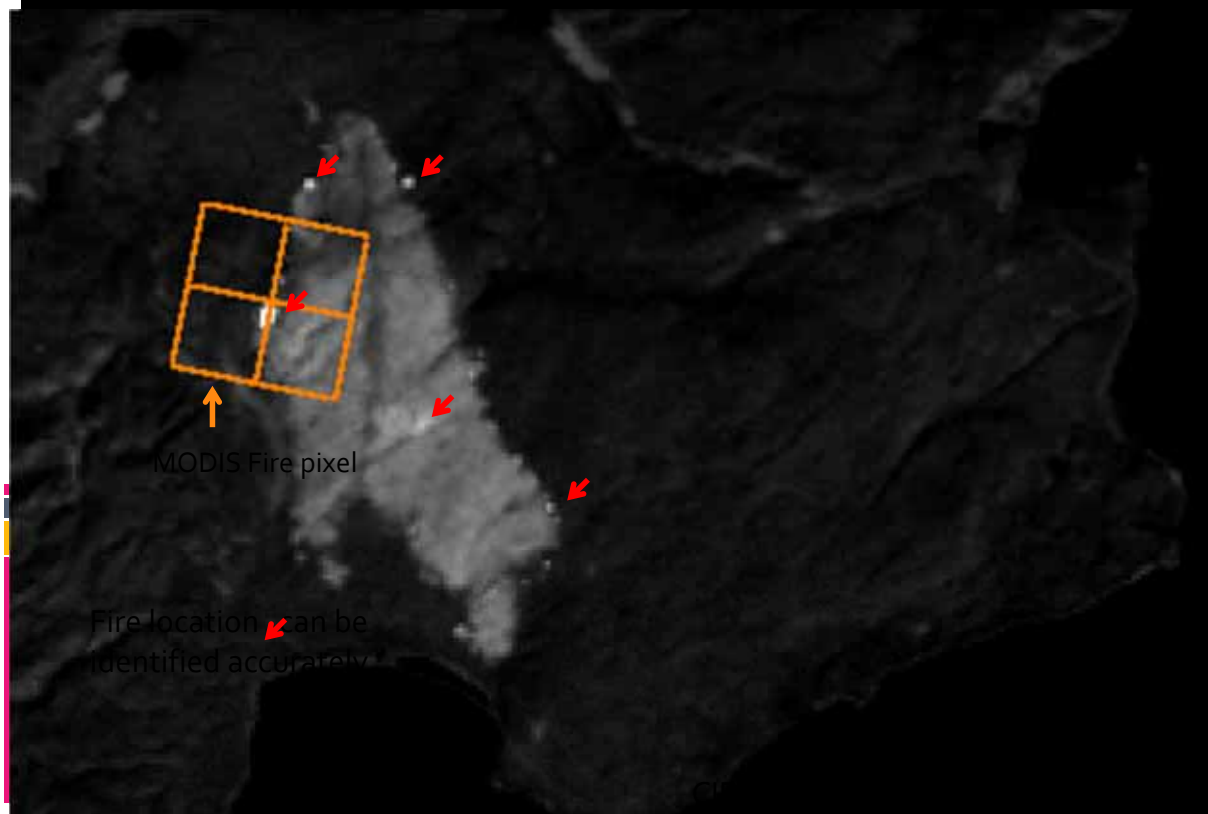
# Fire Monitoring in Near Future

## UNIFORM satellite fire monitoring



- Focused on wild fire monitoring
  - Thermal InfraRed sensor  $11\mu\text{m}$  / 150m GSD
  - 100km swath ()
- Walking to Suppress
  - Resolution & Frequency
  - Accuracy for 1km is NOT enough for fire suppression
- Efficient fire suppression
  - International Cooperation

## Advantage of mid-high res IR images



## Satellites for Wildfire Monitoring

Past

High frequency / Mid-resolution

Low frequency / High-resolution



**MODIS**  
3-4 times a day  
1km resolution

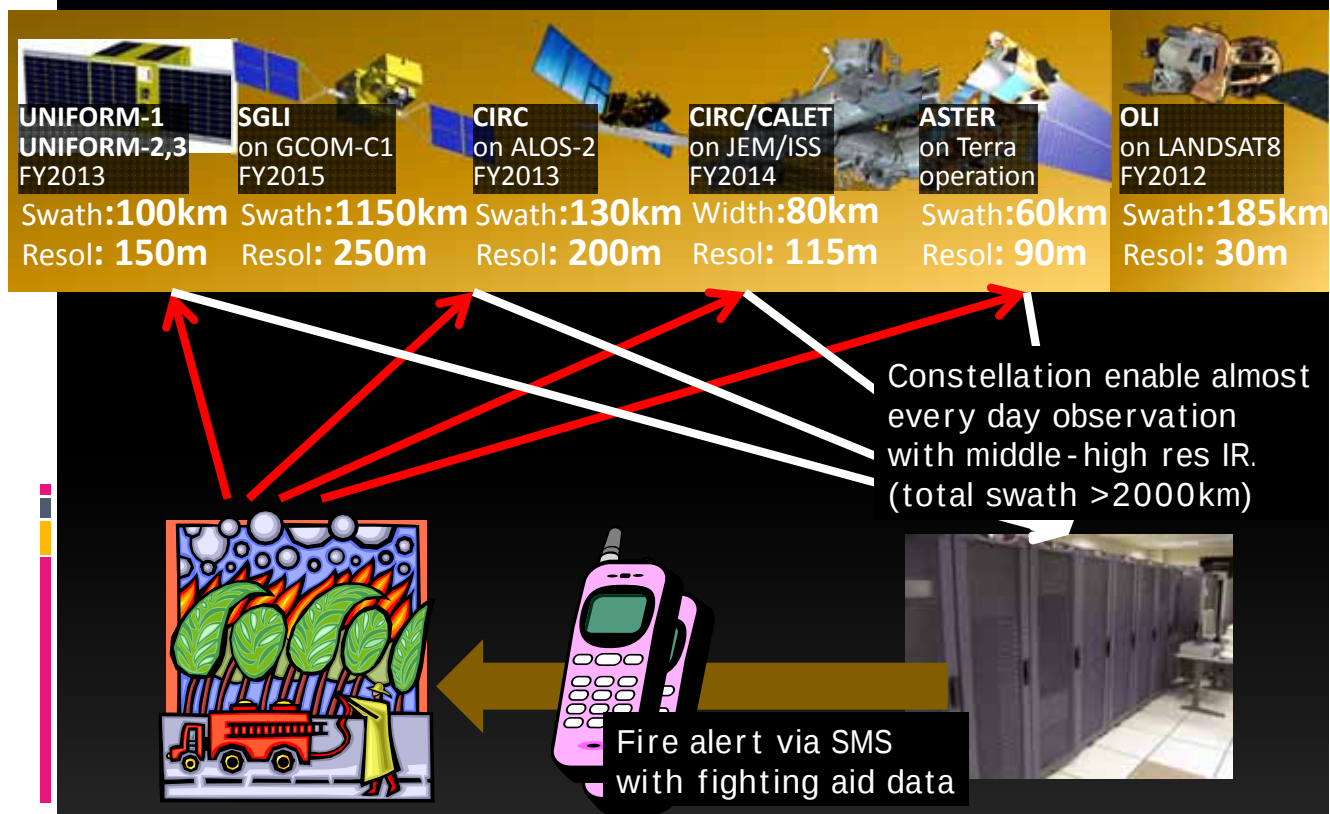
No satellite with  
mid-frequency and  
mid-high resolution!



**ASTER · LANDSAT**  
1 time a two weeks  
30m/90m resolution

- Wildfire **expands everyday** → **Once a day** is important
- Suppression by human → **Location accuracy** important

# Fire monitoring with multi satellites



## New Japanese satellites for wildfire

|                             | Launch year        | Sensor   | Satellite | 4-1.6μ | 11μm | Swath  | Interval |
|-----------------------------|--------------------|----------|-----------|--------|------|--------|----------|
| Mid res.                    | Operational (1998) | MODIS    | Terra     | 1km    | 1km  | 2330km | 0.5d     |
|                             | Operational (2002) | MODIS    | Aqua      | 1km    | 1km  | 2330km | 0.5d     |
|                             | Operational (2010) | VIIRS    | NPP       | 750m   | 750m | 3000km | 0.5d     |
| High res (Interval 0.7 day) | Operational (1999) | ETM+     | LANDSAT 7 | ---    | 60m  | 185km  | 16d      |
|                             | Operational (1998) | ASTER    | Terra     | ---    | 90m  | 60km   | 48d      |
|                             | Operational (2013) | OLI/TIRS | LANDSAT 8 | 30m    | 100m | 185km  | 16d      |
|                             | 2014               | CIRC     | ALOS 2    | ---    | 200m | 130km  | 7d       |
|                             | 2014               | BOL      | UNIFORM1  | ---    | 150m | 100km  | 7d       |
|                             | 2014-              | CIRC     | JEM/CALET | ---    | 120m | 70km   | 7d       |
|                             | 2015               | BOL      | UNIFORM2  | ---    | 150m | 100km  | 7d       |
|                             | 2016-              | SGLI     | GCOM-C1   | 250m   | 250m | 1150km | 1.5d     |
|                             | 2015-              | BOL      | UNIFORM3  | ---    | 150m | 100km  | 7d       |

Image available once a 3 days with determined launch schedule

At Image available Everyday when all planned satellites launched

Wildfire will be observed once a two to three days.

3 high resolution IR sensors among 5 are Japanese.

# Satellites for Wildfire Monitoring

## Near Future

High frequency / Mid-resolution      Low frequency / High-resolution



**MODIS**  
3-4 times a day  
1km resolution



**New Satellites**  
**Almost once a day**  
**200m resolution**



**ASTER · LANDSAT**  
1 time a two weeks  
30m/90m resolution

- Wildfire **expands everyday** → **Once a day** is important
- Suppression **by human** → **Location accuracy** important
- New satellites observe TIR with **100-250m resolution once a day**

## Summary

- Wildfire monitoring system developed
  - in operation
  - LAPAN's Near Real-time Imagery
  - Daily wildfire / GWT maps on Web
- Development under the Collaboration
  - LAPAN: NRT images, Maintenance
  - UNPAR: Coordination with fire fighting team
  - HU, JMA, UT: Models and Algorithms
- New Japanese sensors will be available soon
  - Completely different information will be available