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# DEVELOPMENT OF WILDFIRE ALERT SYSTEM FOR EFFICIENT FIRE FIGHTING

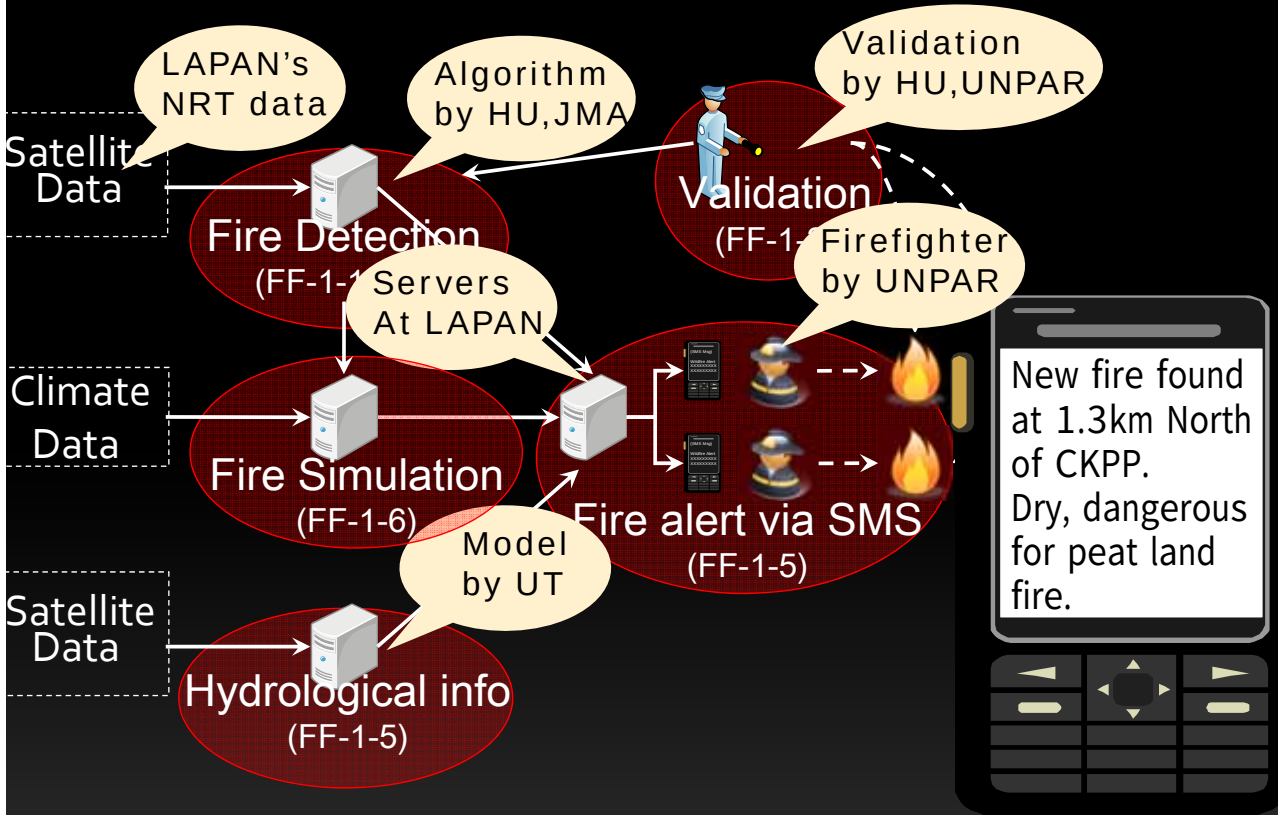
## Topics

- 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

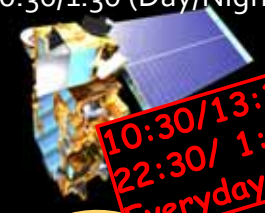
- FF1-1 **Fire detection algorithms** for MODIS data
- FF1-2 **Local validation** fire product
- FF1-3 **Simulation of fire propagation**
- FF1-4 **Water regime** for the fire prediction and water level of canals
- FF1-5 Provide fire **information to firefighting teams** and other stakeholder agencies

# 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

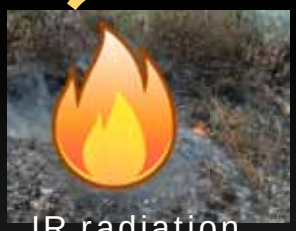
Fire Detection

<1hour

Integration

Real-time

Soil-moisture
Tokyo



IR radiation
from fire

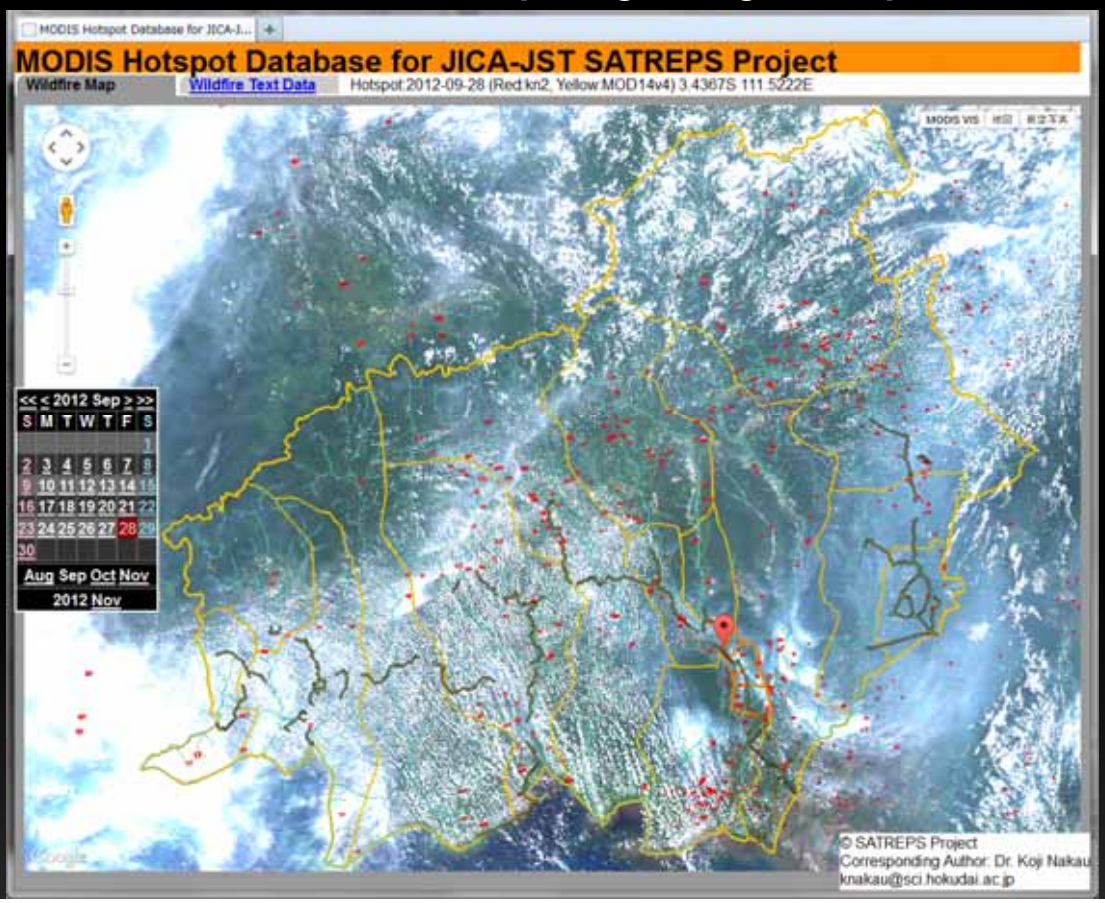

in Several Minutes

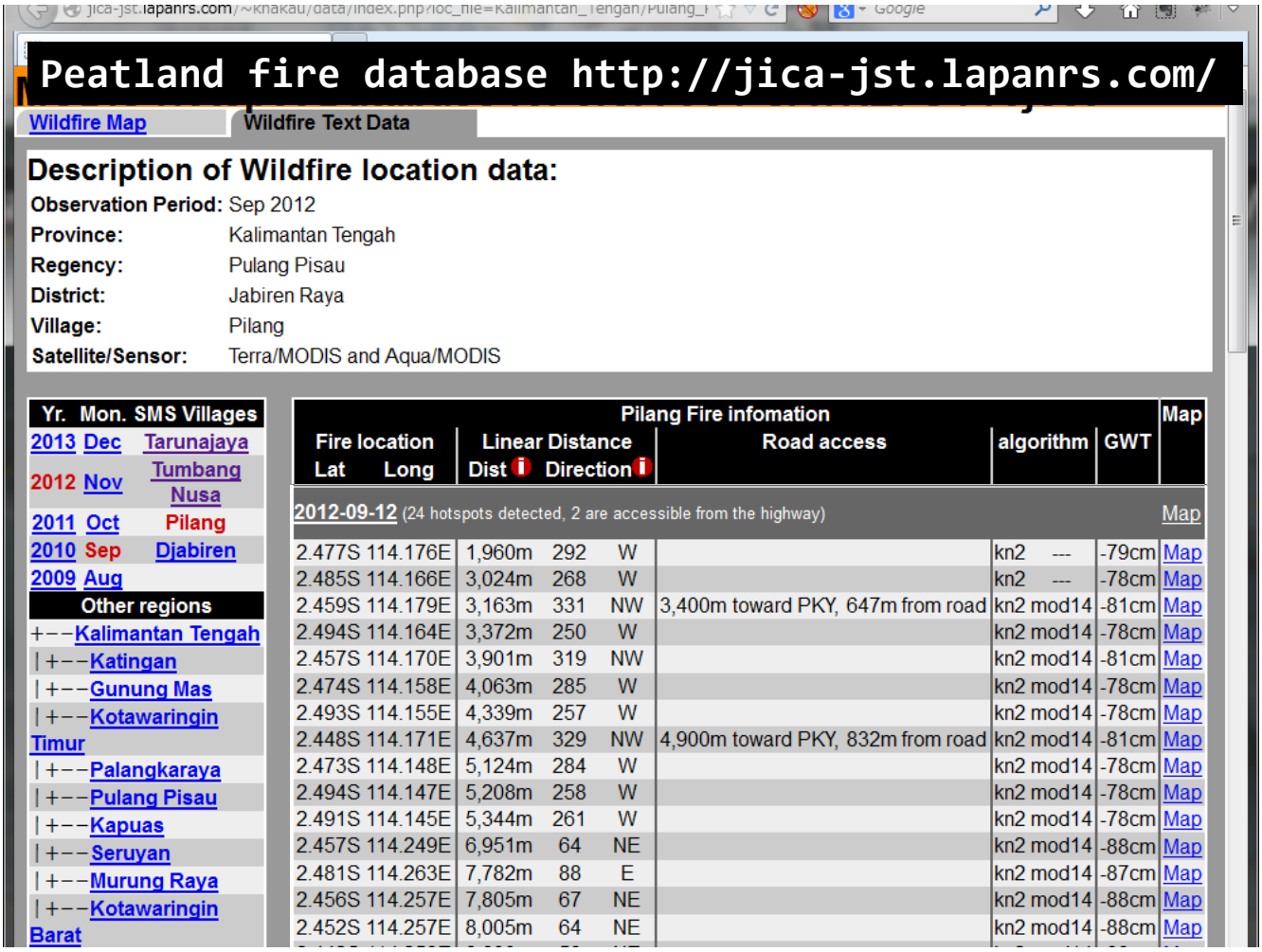
Fire-fighter
Palangkaraya

Morning / Evening

SMS server
Jakarta

## 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 | |

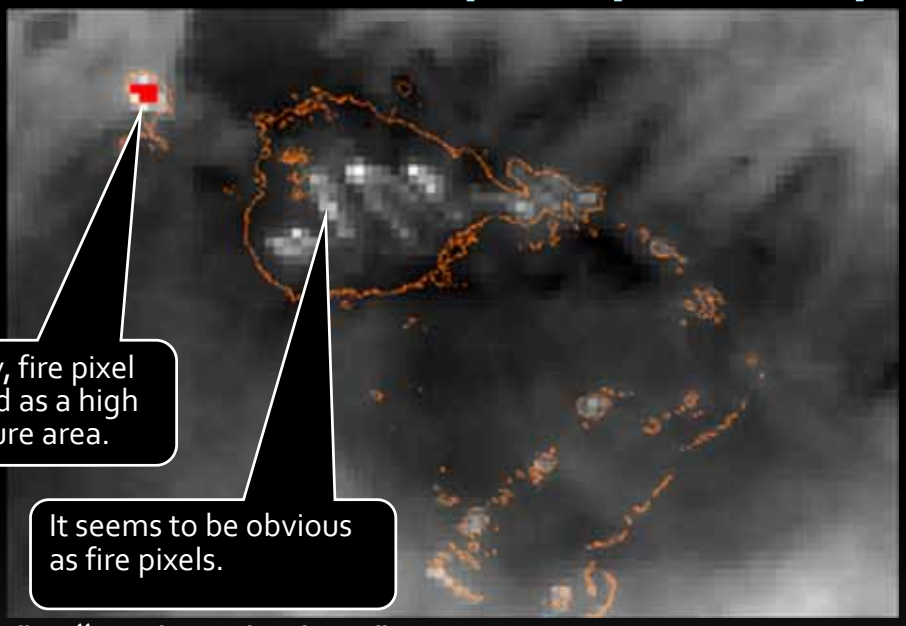
**Other regions**

+--Kalimantan Tengah
| +--Katingan
| +--Gunung Mas
| +--Kotawaringin Timur
| +--Palangkaraya
| +--Pulang Pisau
| +--Kapuas
| +--Seruyan
| +--Murung Raya
| +--Kotawaringin Barat

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

# Fire Detection by Satellite

# Wildfire detection: principle is simple.

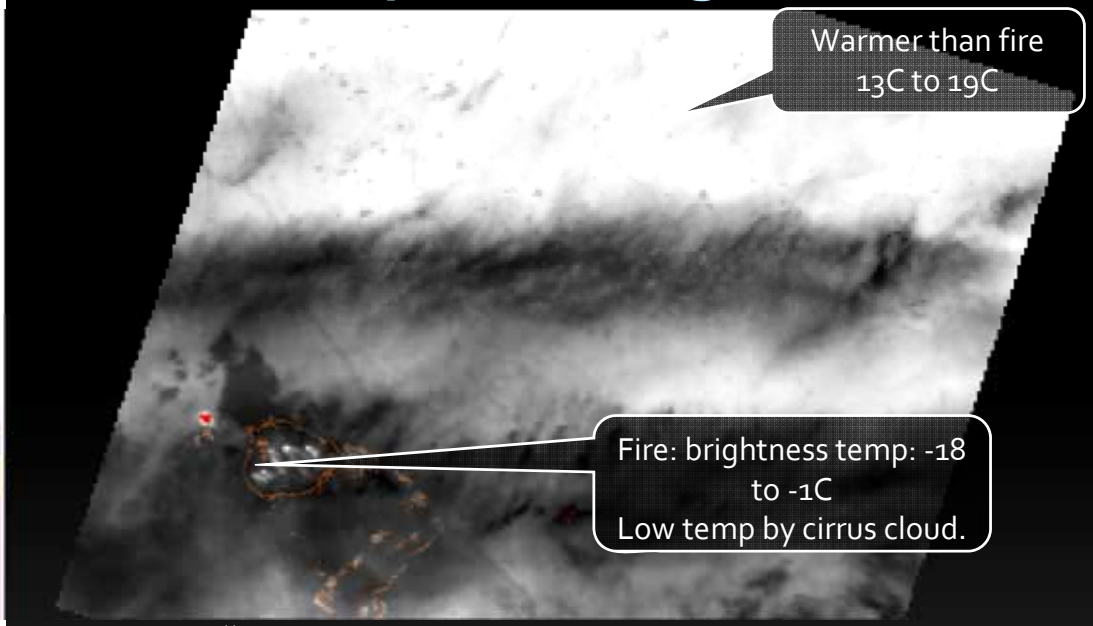



Tundra fire “Anaktuvuk River fire”

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



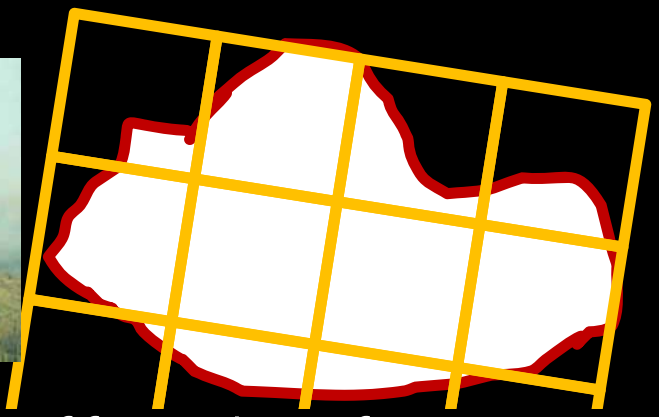
# Wildfire detection: principle is simple, but actually it doesn’t go strait.



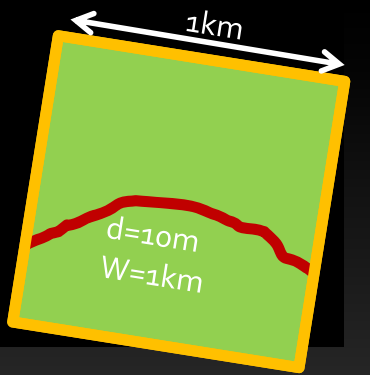

Tundra fire “Anaktuvuk River fire”

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

# Wildfire observation from space



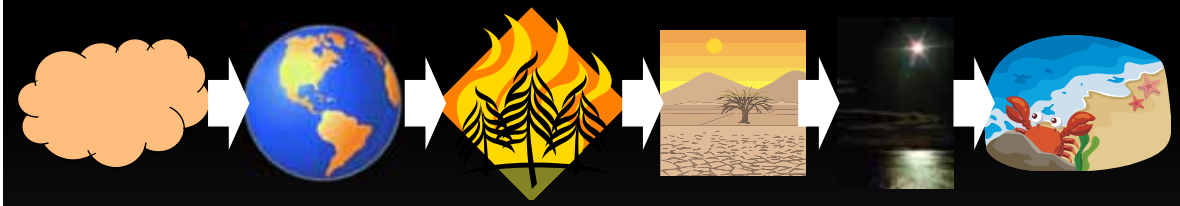
- Hotspot pixel is "Mixcell" of fire and non-fire area
  - Depth of fire is 1 m - 10m
  - Resolution of IR sensors are >100m – 1km
  - Only 0.1 – 10% is filled by fire
- Apparent temperature rise are limited
  - Width:1km, Depth:10m,Temp: 800K
  - ΔT is 5-20K in TIR, 5-200K in 4μm



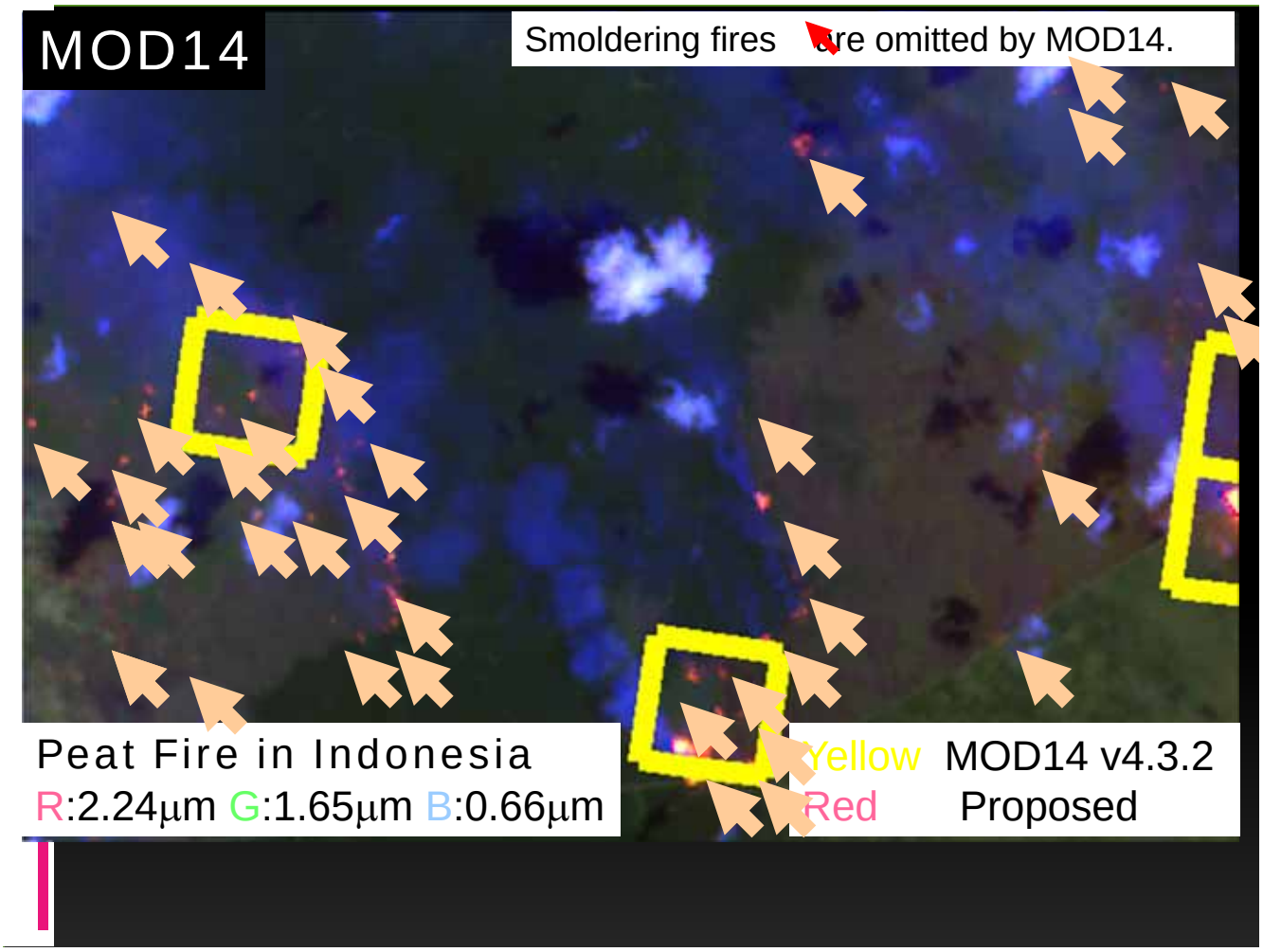

# Actual wildfire detection

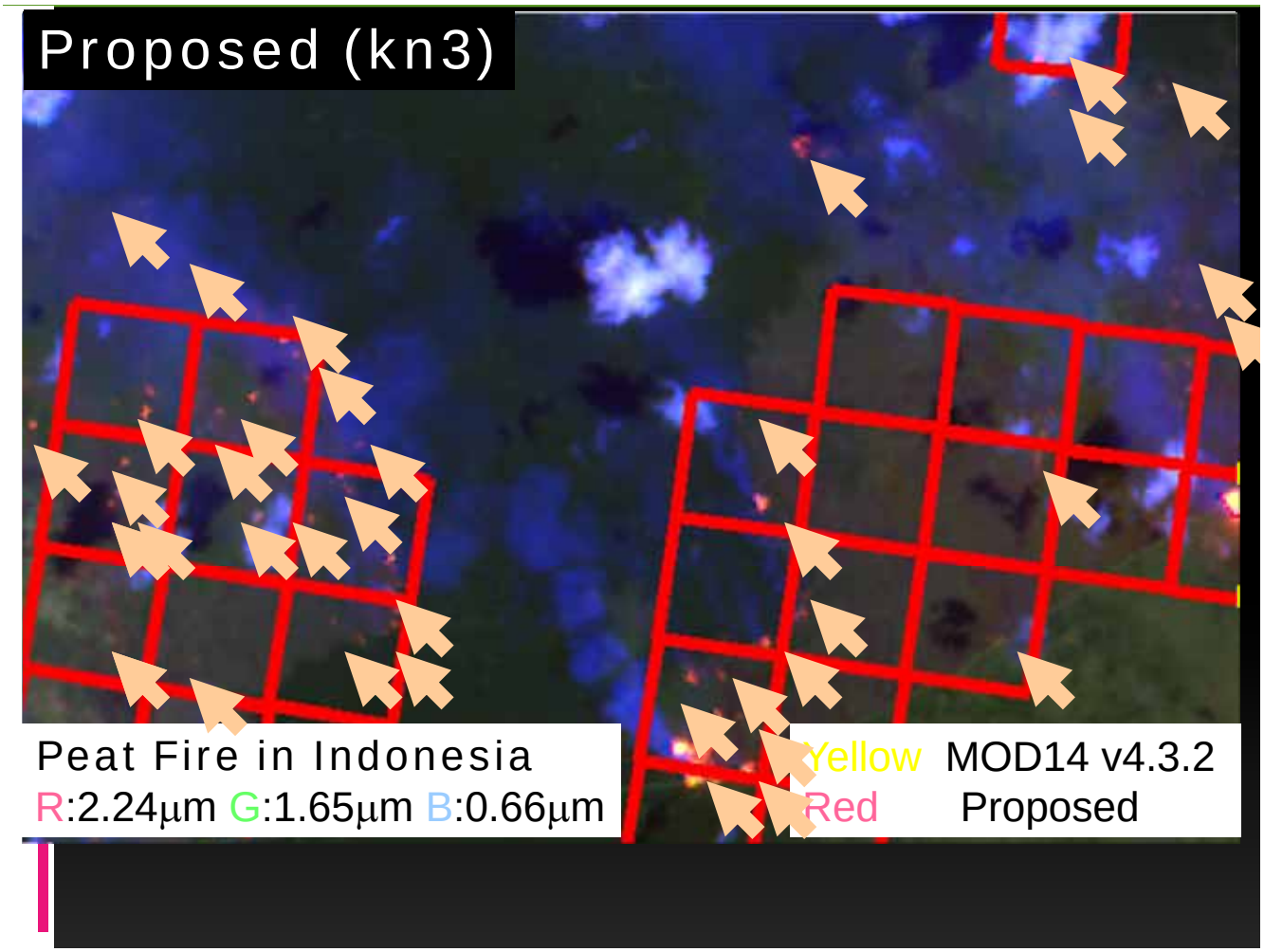
To detect weak signal from wildfire,
we utilize contextual threshold.

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



Cloud Mask | Water Mask | Fire detection | Desert Rejection | Sun glint Mask | Coastal Rejection


MOD14
Smoldering fires are omitted by MOD14.
Peat Fire in Indonesia
R:2.24μm G:1.65μm B:0.66μm
Yellow MOD14 v4.3.2
Red Proposed


Proposed (kn3)
Peat Fire in Indonesia
R:2.24μm G:1.65μm B:0.66μm
Yellow MOD14 v4.3.2
Red Proposed

# Integration of fire information

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

Soil-moisture
Tokyo

Reception
Sulawesi

Transfer,
Preprocess
Jakarta

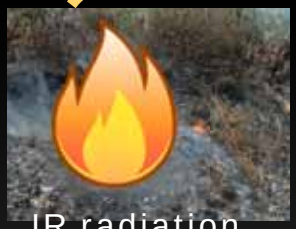
Fire Detection Integration

Real-time

1-4hour

<1hour

Real-time



IR radiation
from fire


Fire-fighter
Palangkaraya

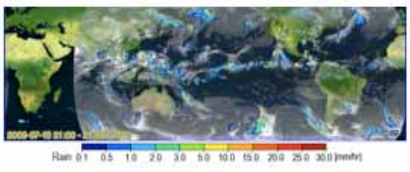
Once a day

SMS server
Jakarta

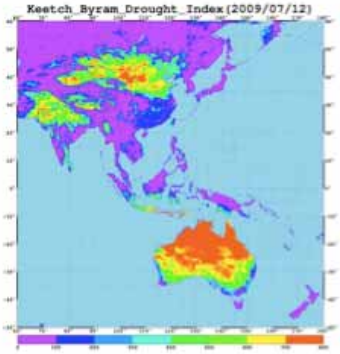
# FF1-4 Water Regime

## 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]
- 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.



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



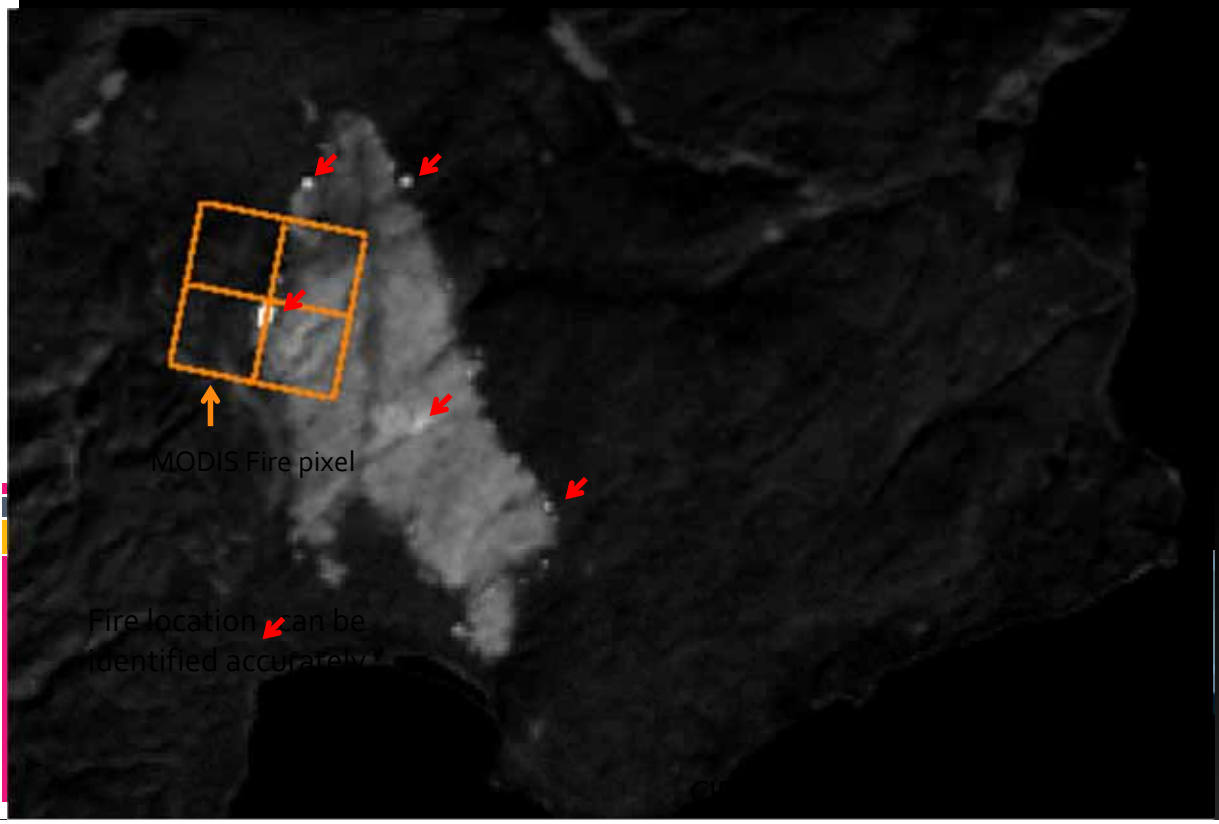

http://webgms.iis.u-tokyo.ac.jp/KBDI/

# Fire Monitoring in Near Future

# UNIFORM satellite fire monitoring


- Focused on wild fire monitoring
  - Thermal InfraRed sensor 11μm / 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

| UNIFORM-1<br>UNIFORM-2,3<br>FY2013 | SGLI<br>on GCOM-C1<br>FY2015 | CIRC<br>on ALOS-2<br>FY2013 | CIRC/CALET<br>on JEM/ISS<br>FY2014 | ASTER<br>on Terra<br>operation | OLI<br>on LANDSAT8<br>FY2012 |
|---|---|---|---|---|---|
| Swath:100km<br>Resol: 150m | Swath:1150km<br>Resol: 250m | Swath:130km<br>Resol: 200m | Width:80km<br>Resol: 115m | Swath:60km<br>Resol: 90m | Swath:185km<br>Resol: 30m |

Constellation enable almost every day observation with middle-high res IR. (total swath >2000km)

Fire alert via SMS with fighting aid data

# 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 0.7day) | 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

Image available Everyday when all planned satellites launched

At
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


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 observes 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