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Fire Detection and Prediction Systems of Peat-Forest Fires in JST-JICA Project

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Criteria	Evaluation Questions
1 Relevance Very high	· Are the Objectives of the Project still relevant? (Do they meet with the needs of beneficiaries?) · Is the Project consistent with the development policy of the partner country? · Is the Project consistent with Japan's foreign and policy and JICA's plan for country-specific program implementation?
2 Effectiveness Medium to high	· Is the Project purpose specific enough? · Has the Project purpose been achieved? · Did the achievement result from outputs? · Is there any influence of important assumption on attainment of the Project purpose?
3 Efficiency High	· Is the output production adequate? · Were the activities sufficient to produce the output? · Was the input of an adequate quantity and quality performed at the right time to conduct the activities? · Does the output justify the invested cost compared to similar project?
4 Impact Very high	· Has the Overall Goal likely been achieved? · What are the social, economic, technical, environmental and other effects on individuals, communities, and institutions as a result of the Project? · Is there any influence of important assumption on attainment of overall goal? · Is there any unexpected positive or negative influence including ripple effects?
5 Sustainability High	· Are the outcomes (activities and effects) of the Project likely to be maintained after the Project period? · Institutional, technical, human resource, and financial aspect, etc.

【Project Purpose】Before Mid-term Evaluation	【Project Purpose】After Mid-term Evaluation
Peat-forest management model in Indonesia is established.	Peat-forest management method to reduce carbon emission is developed. Indicator: 1) Carbon management method which can contribute to carbon reduction of 1/3 to 1/5 amount compared to current level in peatland is proposed. 2) Peat-forest management method is utilized in policy decision in developing international rules and bilateral off set mechanism. 3) Results of researches are published (Number and quality of research papers is good enough)
【Output 1】 Fire Detection and Fire Prediction System are established. Indicator: Activity 1.1 Improve the hotspot algorithms. 1.2Estimate carbon emission by biomass burning among different ecotypes 1.3Transfer in-situ fire information to each region 1.4 Construct prediction model of wild fire occurrence 1.5 Construct model of water regime 1.6 Make map of land cover/land use change 1.7Establish spectral library (plant/soil) in investigation area	【Output 1】 Fire Detection and Fire Prediction System are established. Indicator: 1) In the event of a fire with more than 1 km^2 coverage, 3 target communities can obtain fire information within 16 hours, and moreover they can obtain information on fire spread prediction within 8hours. 2) Fire detection accuracy can reach the level of more than 80%. 3) Rate between predicted fire spread coverage and real fire coverage can reach the level of more than 50%. Activity 1-1 Improve the hotspot algorithms 1-2 Estimate carbon emission by biomass burning among different ecotypes 1-3 Transfer in-situ fire information to each region 1-4 Construct prediction model of wild fire occurrence 1-5 Construct model of water regime 1-6 Make map of land cover/land use change 1-7 Establish spectral library (plant/soil) in investigation area 1-8 Validate established system

Major achievements to data for output 1 are as follows.

Target has been achieved at 80% completion level. Fire detection and fire prediction system was established and tried. Further calculation of accuracy of models will be elaborated by the end of the project period.

1) In the event of a fire with more than 1 km^2 coverage, **3 target communities** can obtain fire information within **16 hours**, and moreover they can obtain information on fire spread prediction within **8hours.**

In the event of a fire with more than 1 km^2 coverage, 4 target communities (Tarunajaya, Tumbang Nusa, Pilang and Djabiren) can obtain fire information at an average of 13-16 hours (Average satellite detection time is 6-8 hours, hotspot data analysis time is 4 hours, fire information data production time is 1 hour and SMS data transmission time is 2-3 hours). Fire spread prediction time for 2km area from the target villages is about 4 hours applying simplified fire-extension model in accordance with the needs of villages. This current radius (2km) of fire alert target area is adjustable in accordance with demand. MODIS hotspot map and ground water table map are available at http://jica-jst.lapanrs.com/

2) Fire detection accuracy can reach the level of more than 80%.

All record of 10 hotspot data (July 2009) and 2 current firing hotspot data (September 2012) detected by the improved algorithm were confirmed to be burnt or burning area by UAV photographs (100%). Considering both omission and commission errors, hotspot detection accuracy is assumed to be able to achieve 80% level though further monitoring is required for statistic accuracy.

3) Rate between predicted fire spread coverage and real fire coverage can reach the level of more than 50%.

By using the simplified fire-extension model, 1km square hotspot is approximated by either an inscribed circle with the radius 1/2 km or a circumscribed circle with the radius √2/2 km. Considering the interval of satellite image acquisition, predicted fire spread coverage error becomes within 50% if the velocity of hotspot center is less than 2m/min (if it is faster than that, it is detected as different fire, not the extension of the same fire by this algorithm).

Activity

1-1 Improve the hotspot algorithms
1-2 Estimate carbon emission by biomass burning among different ecotypes
1-3 Transfer in-situ fire information to each region
1-4 Construct prediction model of wild fire occurrence
1-5 Construct model of water regime
1-6 Make map of land cover/land use change
1-7 Establish spectral library (plant/soil) in investigation area
1-8 Validate established system

Established Systems

FF1: Construct wild/peat fire control systems

- **Step１：Detection of Fire Hot Spots by Satellites（resolution:1kmx1km)**
- **Step ２：Validation of Hot Spots by UAV（Ground Truth）**
- **Step ３：Transmission of Fire Information by SMS**

FF2: Mapping and modeling the land cover

- **Step ４：Calculation of Burnt Area**
- **Step ５：Estimation of CO2 Emission by Biomass Burning among Different Type Ecosystems**
- **Step ６：Estimation of CO2 Emission from Burnt Area**

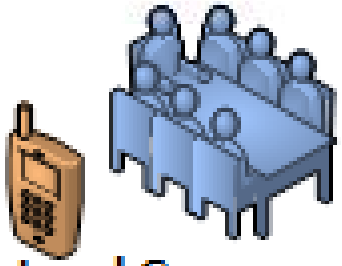
Communication Networks of Fire Detection and Alarm Systems

Peat Fires

① UAV Ground Truth

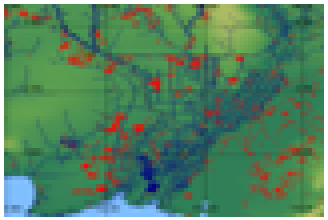
STEP 2

: 2~3 hours



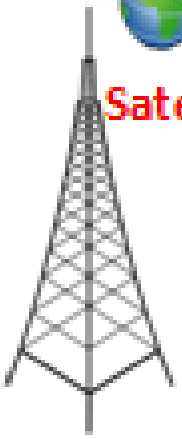
Local Government
Palangkaraya

Satellite Data
: 6~8 hours



STEP 1

① Hotspots Distribution



Data Analysis
: 4~5 hours

Data Collection CPU

LAPAN- UNPAR

SMS

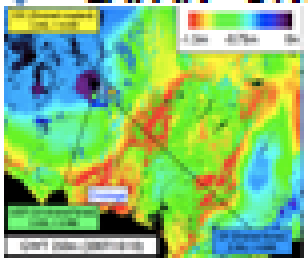
③ Fire Information
distance
direction
dangerous index

Village Fire Fighters
Taruna- Tumagsa- Jabilan

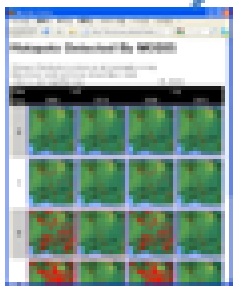
④

Fire History
Data

② STEP 4-6

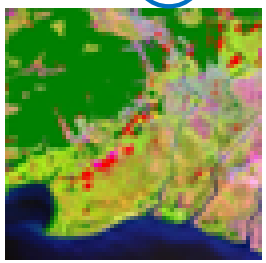


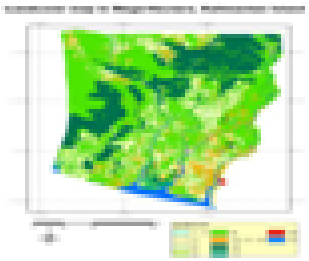
Ground ⑤
Water Level
Distribution



Land Use Data ⑥

Data Base





Vegetation
Spectrum Data ⑦

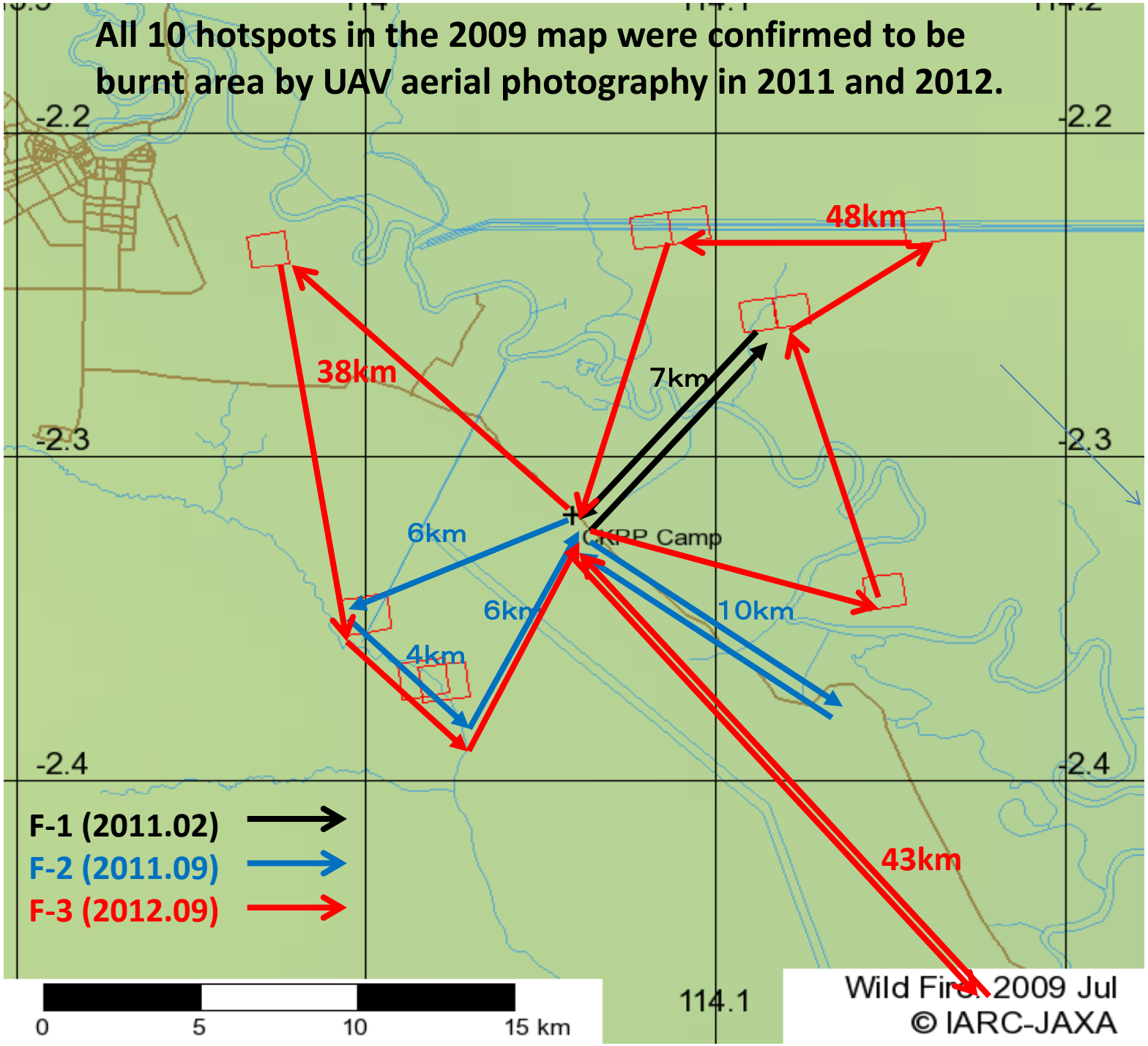
Village People

1. Improve fire hotspot algorithms

MODIS (1 km^2 mesh) fire hot spot detection system was transferred to the server in LAPAN. Data has been accumulated every day since 20 May 2011.

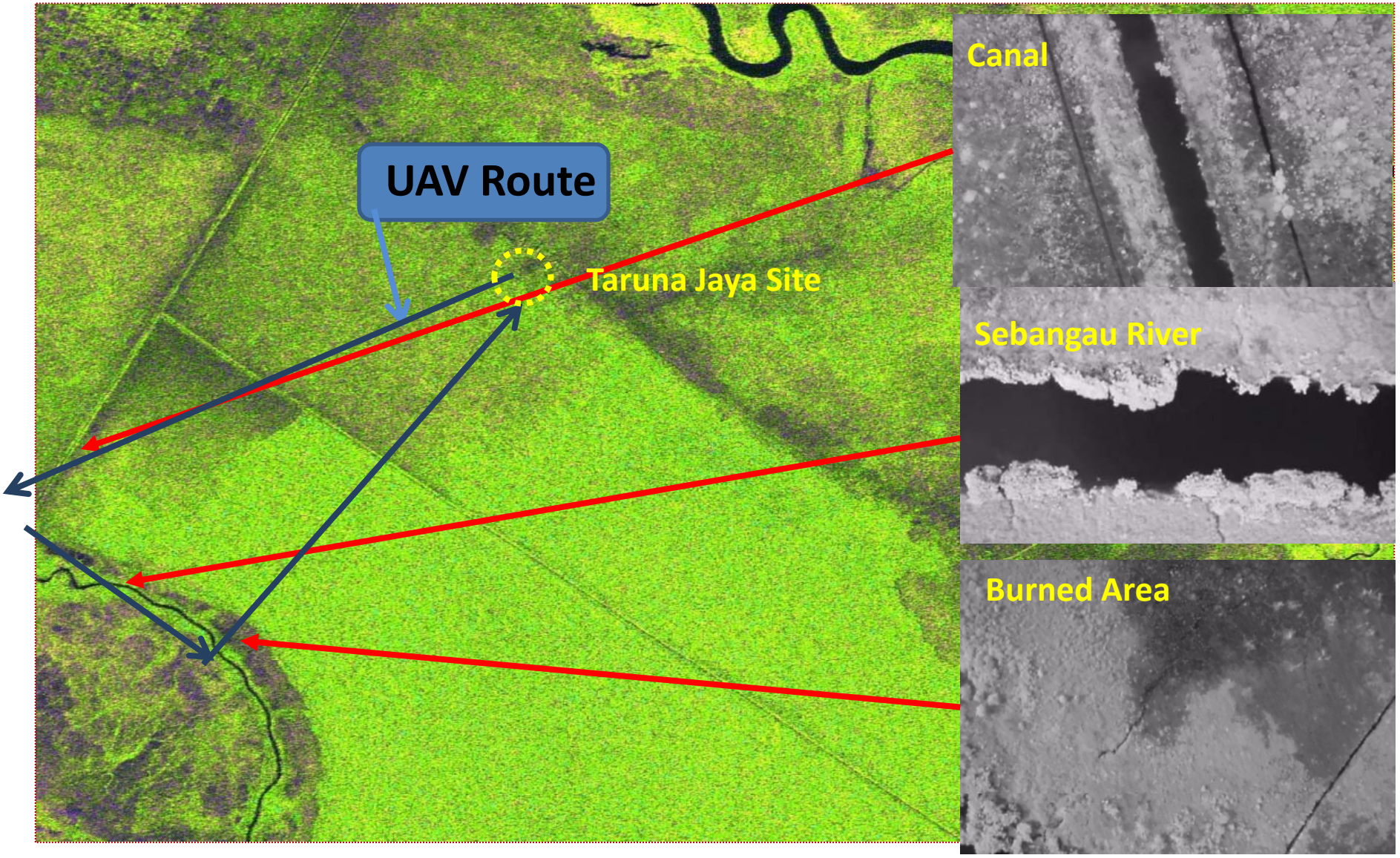
To verify the hot spot data obtained by satellites, aerial photography was taken by the electrically-powered unmanned aerial vehicle (UAV) equipped with optical camera and infrared camera. During the project, two UAV design were developed and tried. The improved UAV which can fly about 1 hour took the forest fire photography detected by the satellite for the first time in September 6, 2012.

In order to validate the satellite detection accuracy of hotspots data, the hotspots map detected in July, 2009 was utilized because there were no fires occurred in study site during dry seasons in 2010-2011.


All 10 hotspots in the 2009 map were confirmed to be burnt area by UAV aerial photography in 2011 and 2012.
-2.2
-2.3
-2.4
114.1
48km
38km
7km
6km
6km
10km
4km
43km
F-1 (2011.02)
F-2 (2011.09)
F-3 (2012.09)
0
5
10
15 km
Wild Fire 2009 Jul
© IARC-JAXA

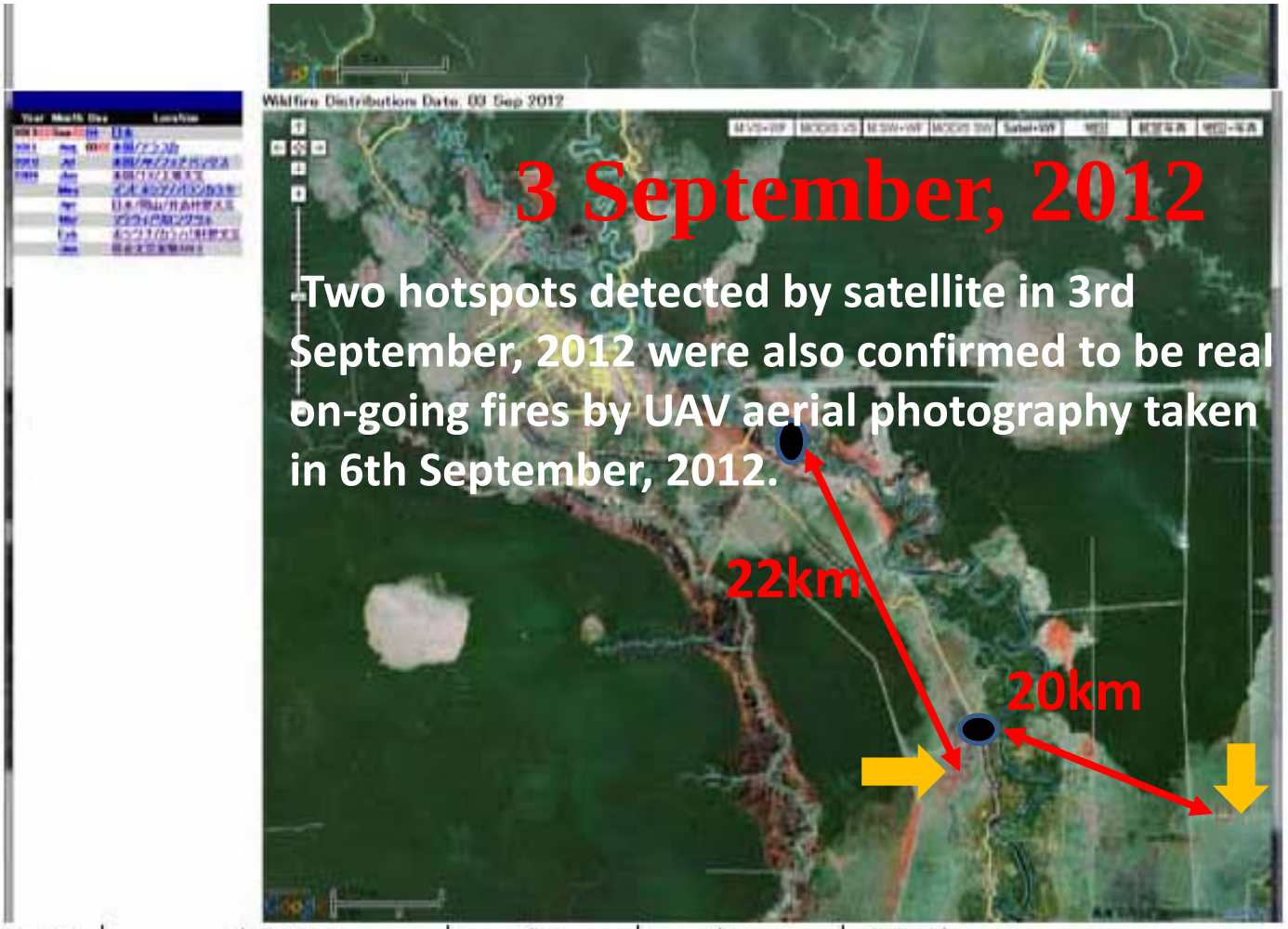
F-2(2011)

Ground Validation with UAV(Sep. 2011)



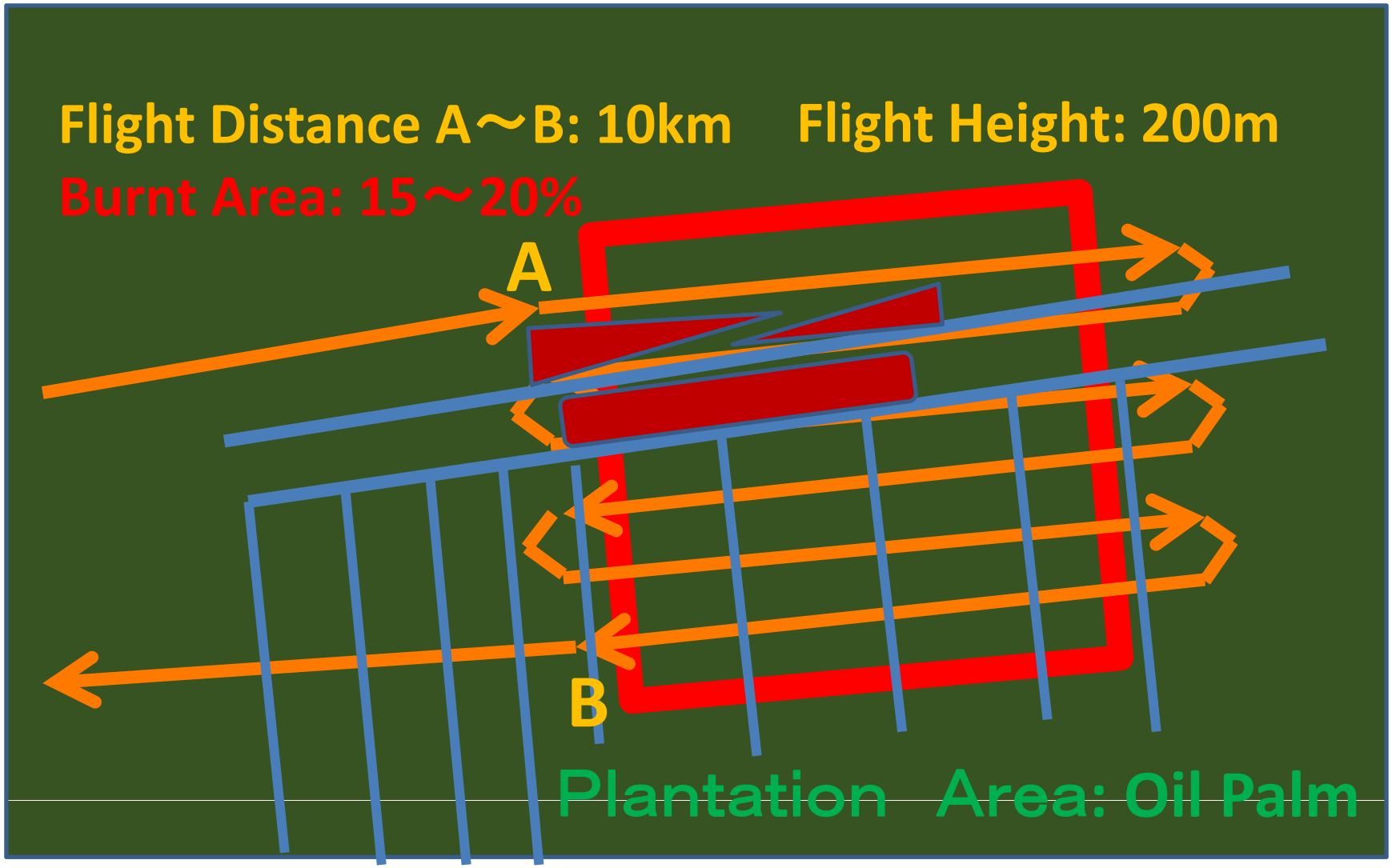
Mapping Source : JAXA, PALSAR 10m Mosaic Image, Central Kalimantan

F-3 (2012)



count	obstime	lat	lon	round
2	2012-09-03 02:50:00	-2.492693	114.162888	19866
2	2012-09-03 15:10:00	-2.490092	114.159622	19435
2	2012-09-03 02:50:00	-2.485049	114.173065	19742
2	2012-09-03 15:10:00	-2.4671	114.149696	16669
2	2012-09-03 02:50:00	-2.466162	114.173103	18041
2	2012-09-03 15:10:00	-2.46509	114.163597	17318
2	2012-09-03 15:10:00	-2.463078	114.177513	18079

MODIS pixel Observed by UAV

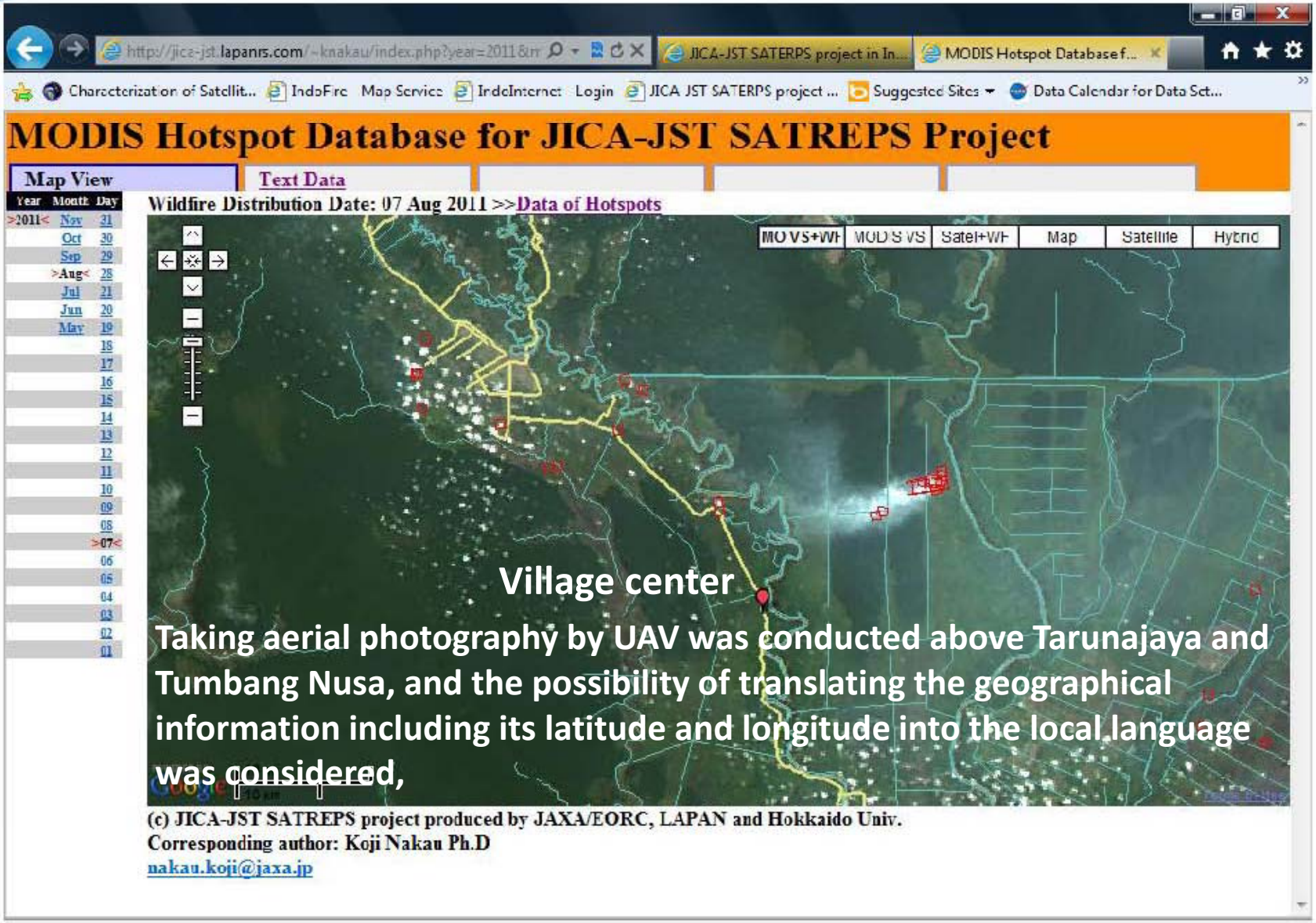


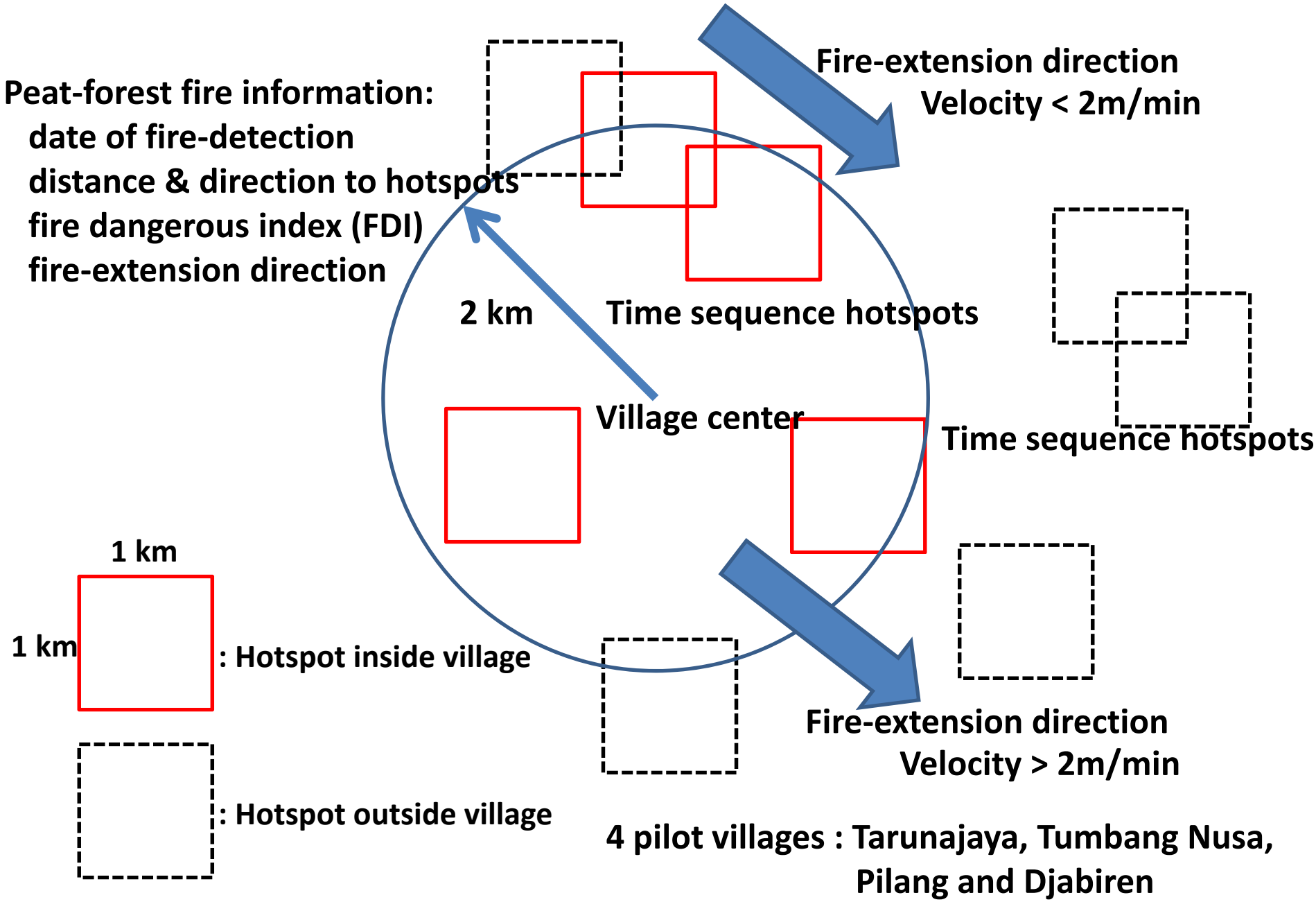
The improved hotspot detection algorithm could find the fire at 100% accuracy though the sample cases are limited.

It is concluded that hotspots are detected by the algorithm with the very high precision.

3. Transfer in-situ fire information to each region

FF1-1 MODIS Hotspot Database *(cont.)*




Peat-forest fire information:
date of fire-detection
distance & direction to hotspots
fire dangerous index (FDI)
fire-extension direction
Fire-extension direction
Velocity < 2m/min
2 km
Time sequence hotspots
Village center
Time sequence hotspots
1 km
1 km
: Hotspot inside village
: Hotspot outside village
Fire-extension direction
Velocity > 2m/min
4 pilot villages : Tarunajaya, Tumbang Nusa,
Pilang and Djabiren

SMS Messaging server

- **Hard/Software to be purchaced**

SMS will be sent through http access

http://127.0.0.1:9333/ozeki?action=sendMessage&ozmsUserInfo=admin
:abc123&recepient=062031053366& messageData=hello+world

village heads
leaders of fire fighting teams

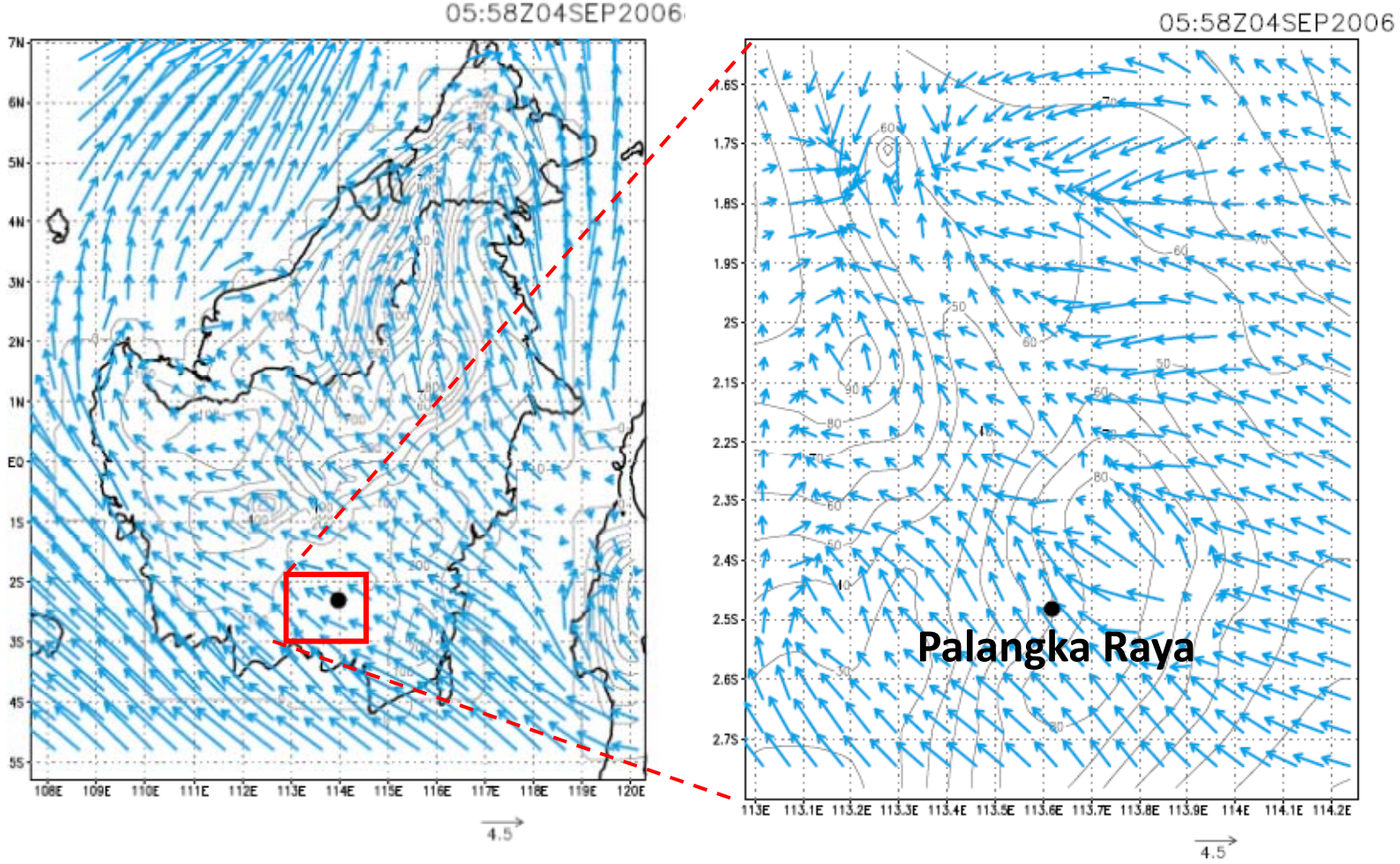
LAPAN

NTT Indonesia will produce as a package.

The first trial to send SMS was successfully conducted in September 26 2013 through the activity 8.

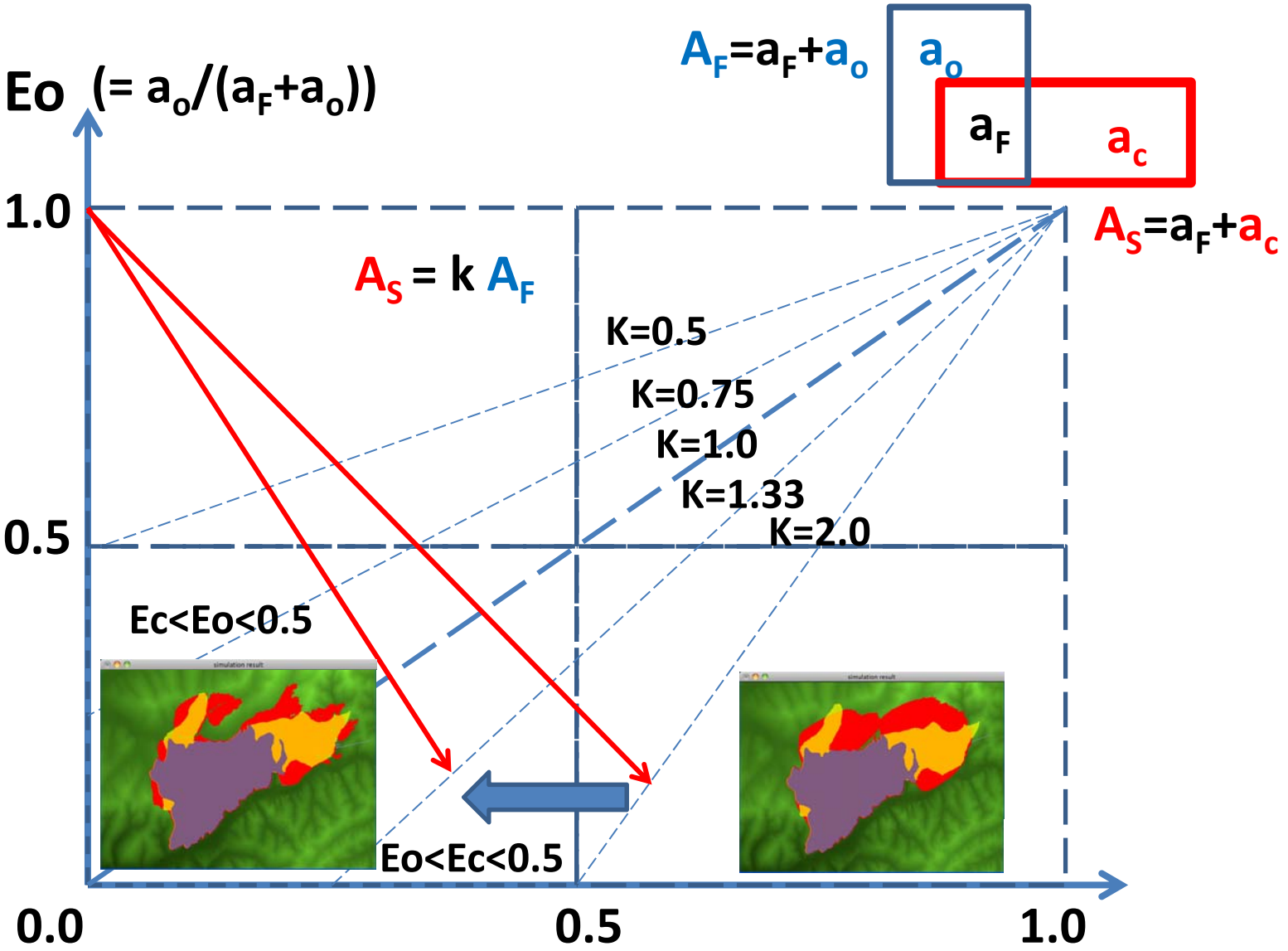
4. Construct prediction model of wild fire occurrence

Wind field around Palangka Raya, at 13:00 local time, 4 September 2006



A climate prediction model, MM5, was installed in the server in Hokkaido University, and data inputs as well as parameter setting which reflect the weather condition in Indonesia was examined, and a wind atlas was developed with 5km resolution.

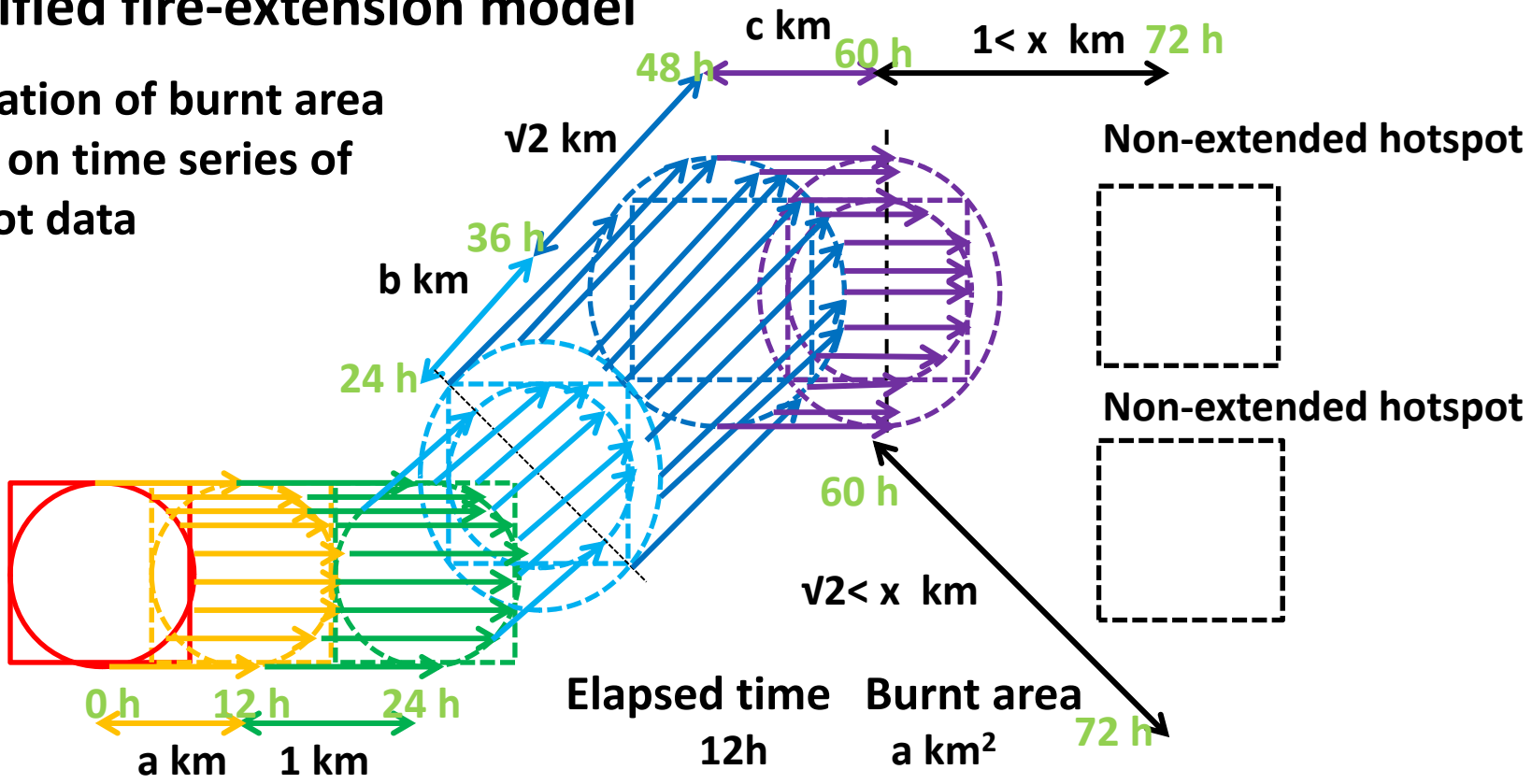
by Mr.Hatanaka



A simulation model on forest fire spread, taking into consideration the vegetation data, was developed and its validity was examined.

Simplified fire-extension model

Calculation of burnt area based on time series of hotspot data



Movement distance of hotspot center x(km)

0 km < x < 1 km : an inscribed circle approx.

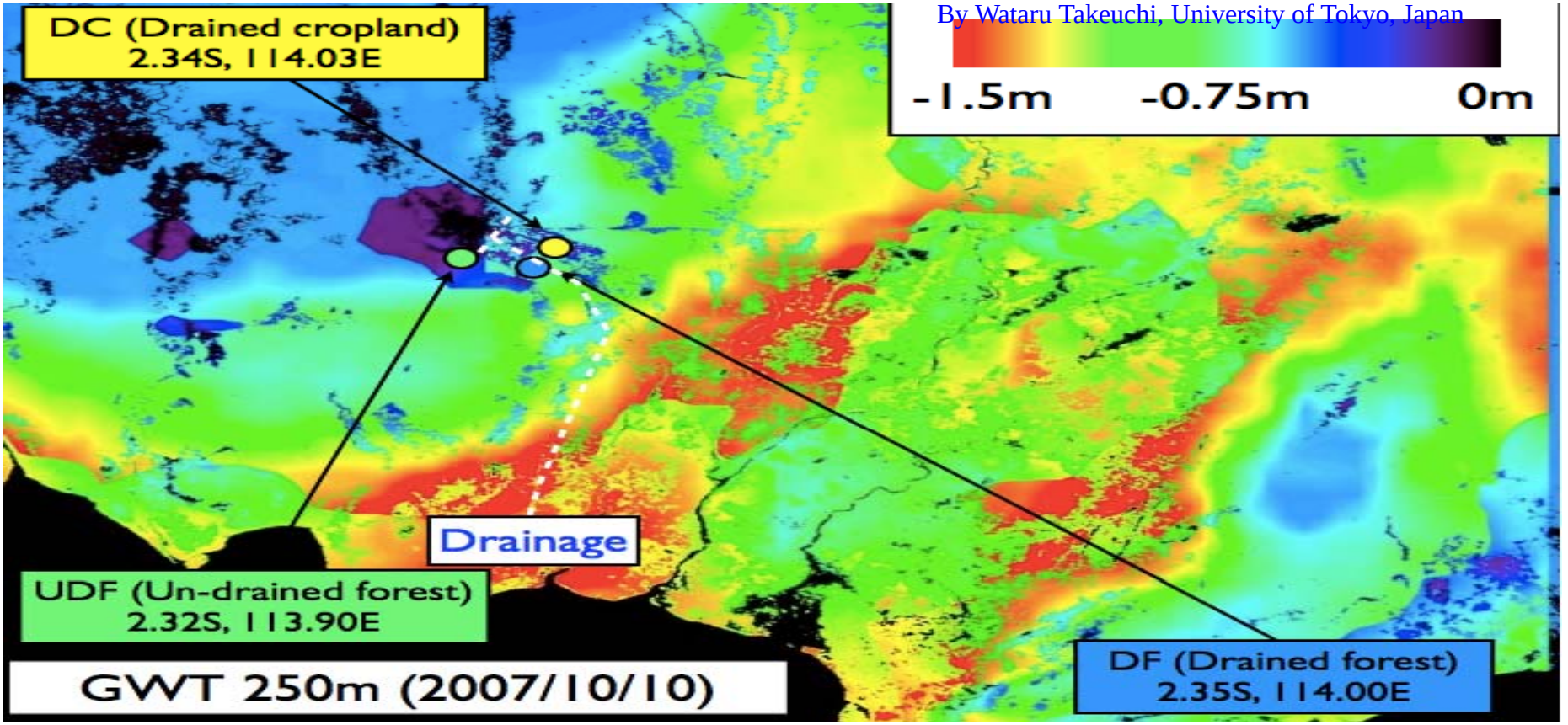
1 km < x < √2 km: a circumscribed circle approx.

Elapsed time	Burnt area
12h	a km^2
24h	(a + 1) km^2
36h	(a + 1 + b) km^2
48h	(a + 1 + b + √2 + π/8) km^2
60h	(a + 1 + b + √2 + π/8 + c - π/8) km^2

The time sequence of 1km^2 hotspot data was examined and the fire occurrence process in time was clarified.

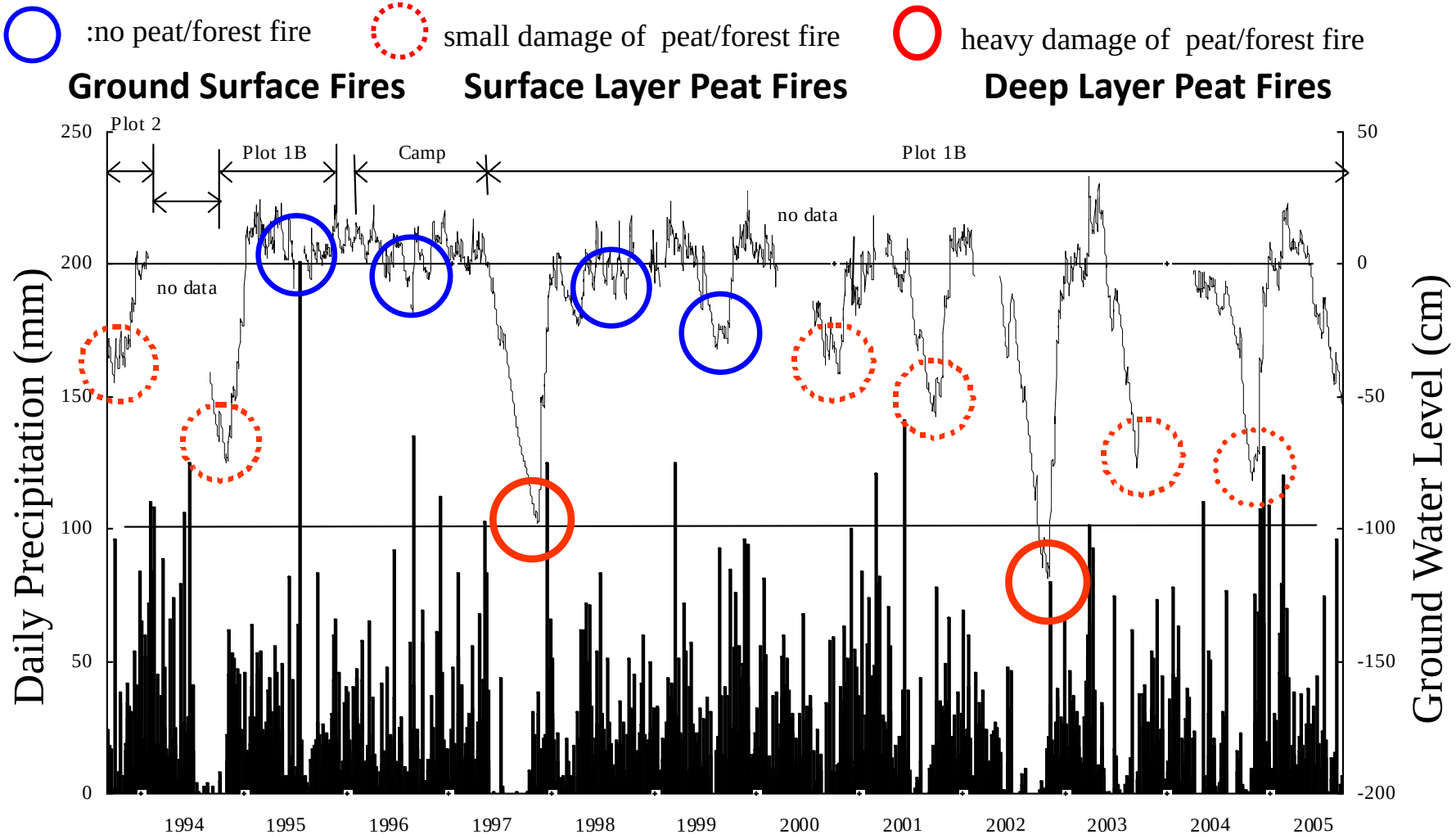
The simplified fire-extension model was developed based on time-series hotspot data and the fire extension area was estimated as the movement distance of the hotspot center.

5. Construct model of water regime



A model was established to estimate the spatial distribution of soil moisture based on satellite data, and the validity of the model was verified by comparing the measurement data of ground water level with the model.

By integrating the data from fixed point observation into the satellite data, the spatial distribution of soil moisture was presented with high precision for the first time in the world.



Ground water level in a peat swamp forest and the level of damages of peat/forest fire for 11 years

The validity of the established water fluctuation/soil moisture estimation model was examined though the accumulation of data and fixed point measurement.

Fire Dangerous Index (FDI)

Ground Water Table, CO2 Emission and Peat Fire Index

FDI-1 : Ground Water Level -20cm～-50cm

Ground Surface Fire

FDI-2 : Ground Water Level -50cm～-100cm

Surface Layer Peat Fire

FDI-3 : Ground Water Level -100cm～

Deep Layer Peat Fire

The level of the peat fire index (PFI) was defined by the correlation of the ground water level with the number of fire occurrence and the fire dangerous index based on PFI was developed.

8. Validate established system

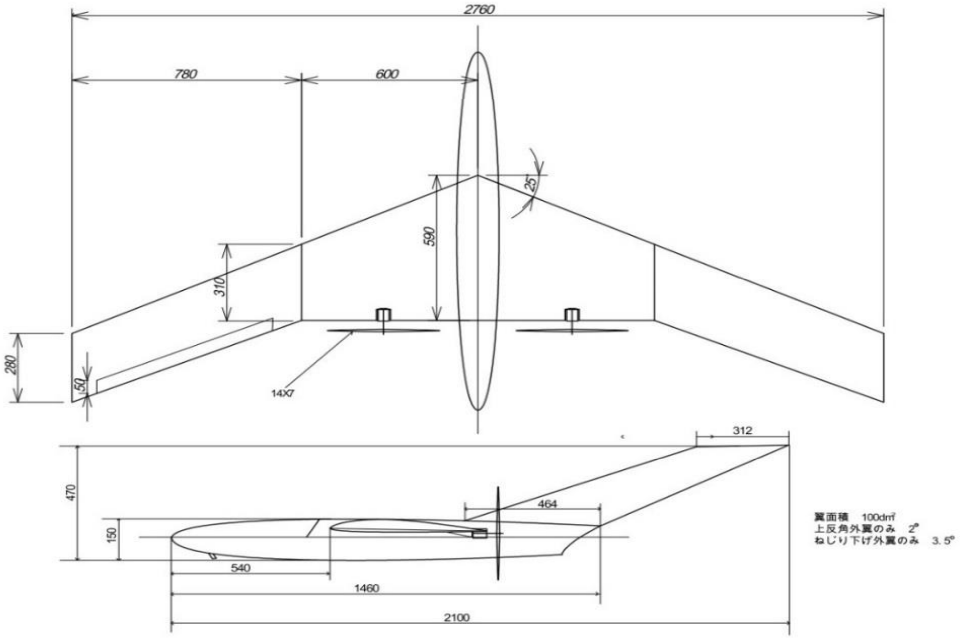
The practical operation of fire detection and prediction based on the integrated systems and SMS, is carried out.

The several fire processes such as satellite hotspot detection, hotspot data analysis, fire information production and delivery, and UAV verification is integrated.

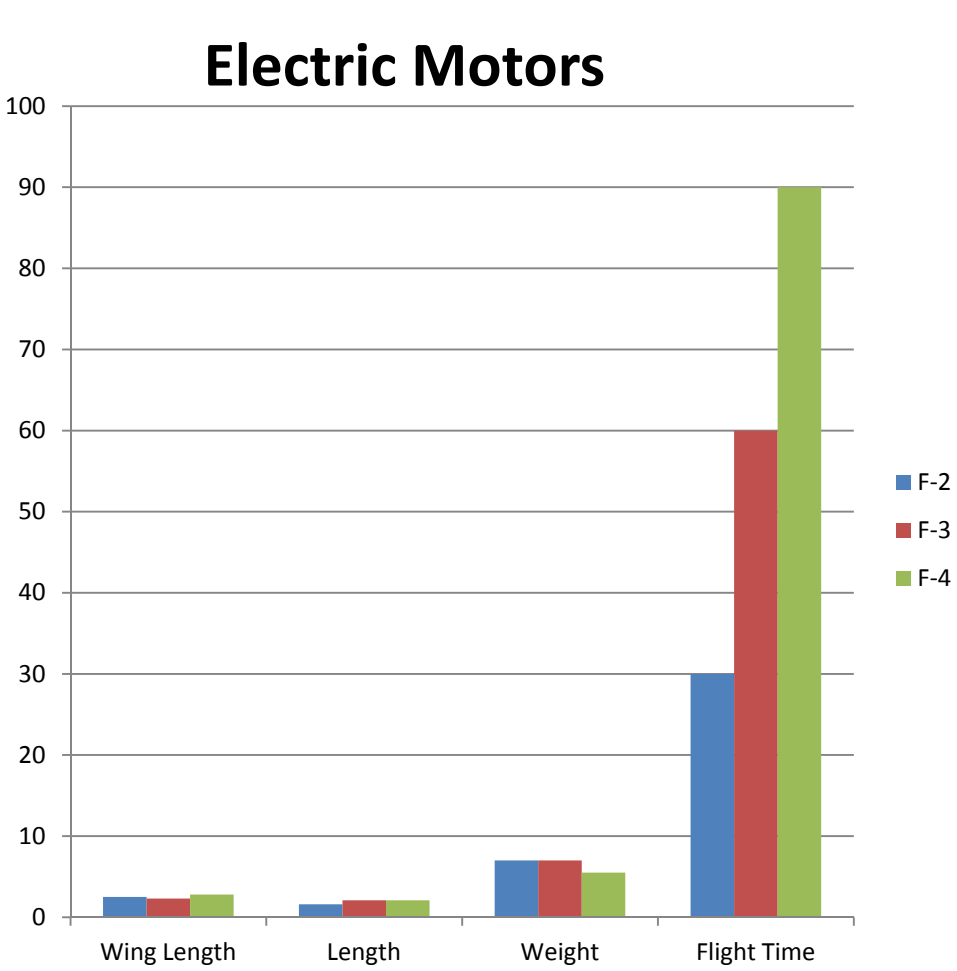
Specification of F-4 UAV : 2013.09

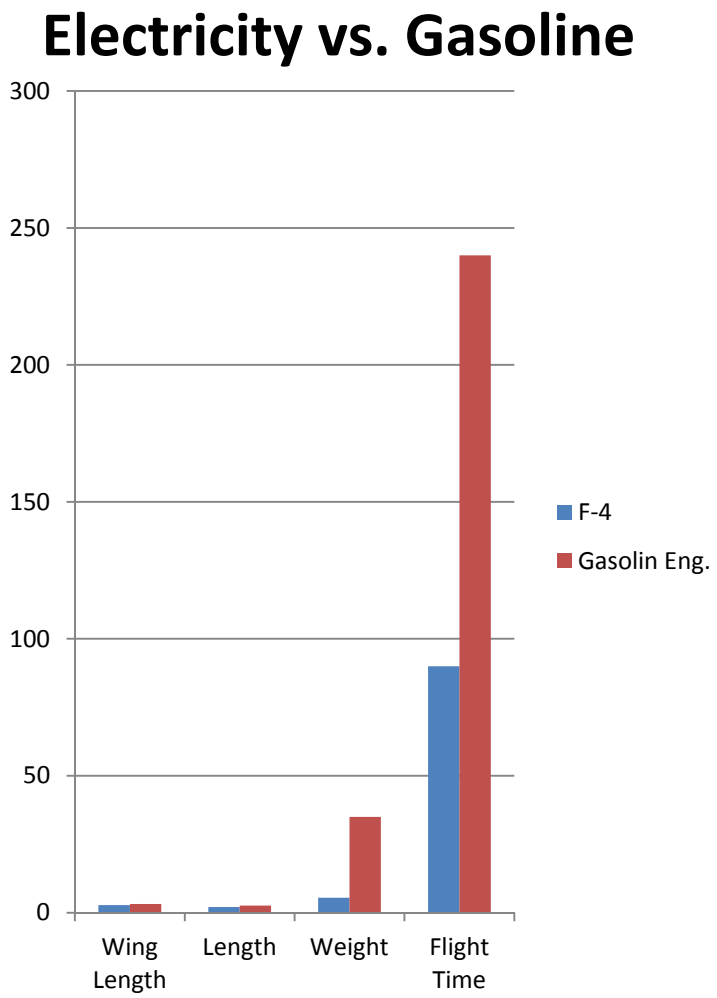
- Length／Wing Length／Height
  2.1m／2.76m／0.47m
- Weight : 5.5kg with Battery
- Power : Brushless Motors : 2 units

- Flight Speed : Max 100km/h
  Cruising Speed 50-80km/h
- Flight Time : **Max 90 min**.
- Payload : **Max 1kg**
- Data Link : 2.4GHz
  (Specified Low Power Wireless)
- Communication Distance: 10km



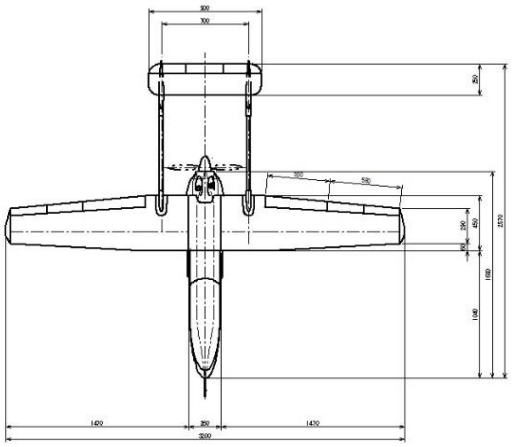
Comparison of UAV Specification

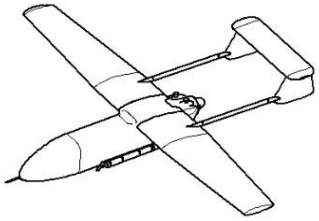


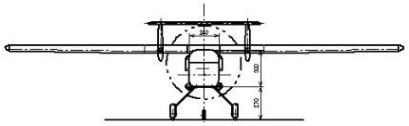


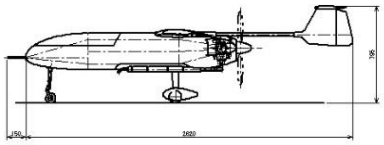
Specification of UAV with Engine

- Length／Wing Length／Height
  2.6m／3.2m／0.9m
- Weight：35kg with Engine
- Engine： BT-86B7.5HP
  86cc 2 Cycle Gasoline Engine 2 Cylinders
- Flight Speed： Max 180km/h
  Cruising Speed: 120km/h
- Flight Time：Max **4 hours**
- Flight Height ：Max **4500m**(14800f)
- Payload： Max **6kg**
- Data Link：2.4GHz
  (Specified Low Power Wireless)
  Distance: 10km










MIAMI

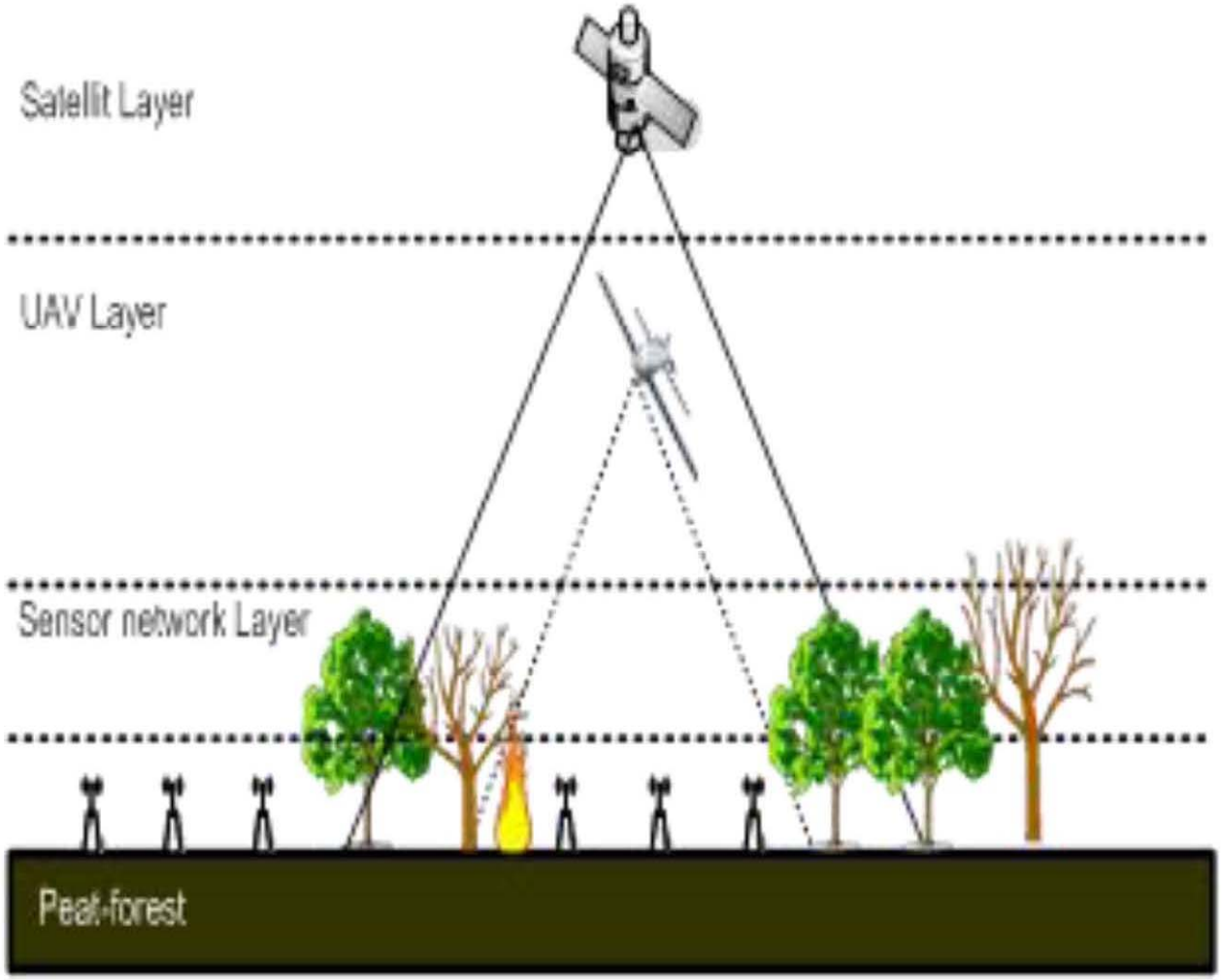
After suppression of fires, leaders of fire fighting teams reported to participants at meeting about the suppression activities based on fire information delivered through SMS, in which suppression starting and ending time, the type of fire, the fire burned area size and personal impression etc. are reported.

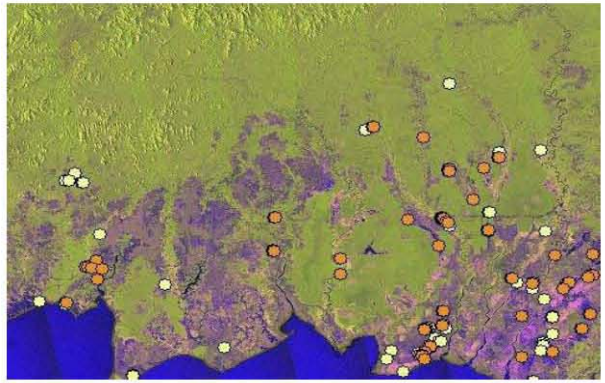
In addition, leader of UAV monitoring team explained the UAV flight performance and current moving images of real fires taken by UAV.

The usefulness of the information system for suppression of real fires by fire fighters is confirmed.

Conclusion

The system architecture monitoring peat forest fires






Thank you for your attention