Utilization of Satellite Remote Sensing Data in Supporting Wildfire Early Warning and Monitoring in Indonesia

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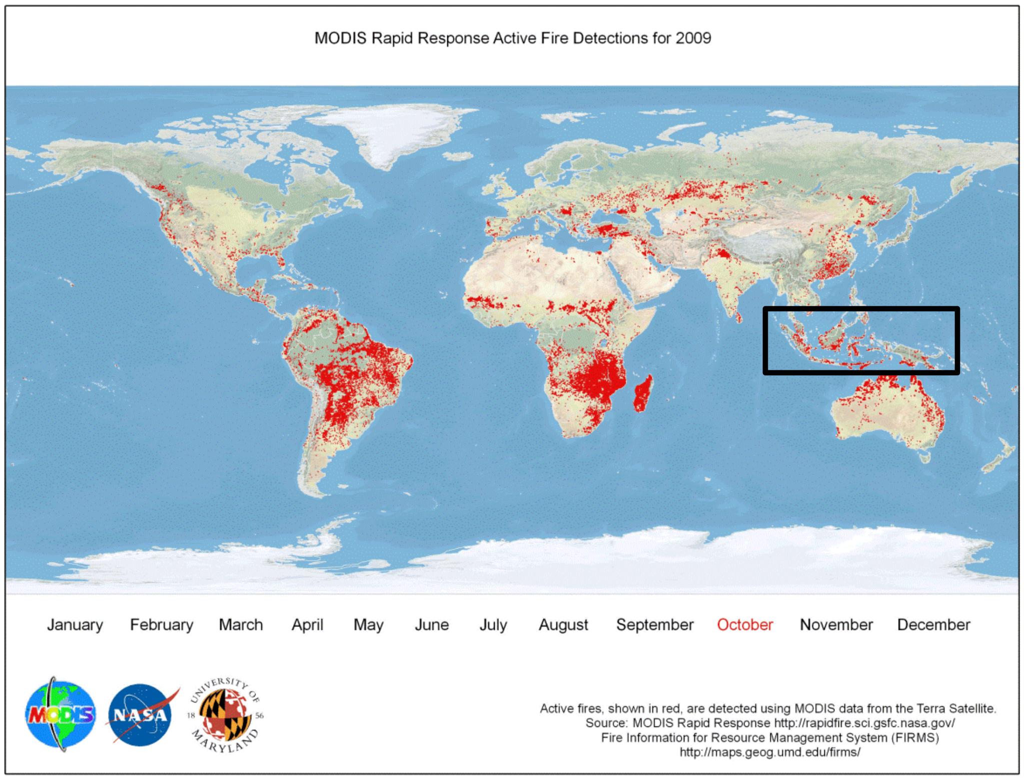
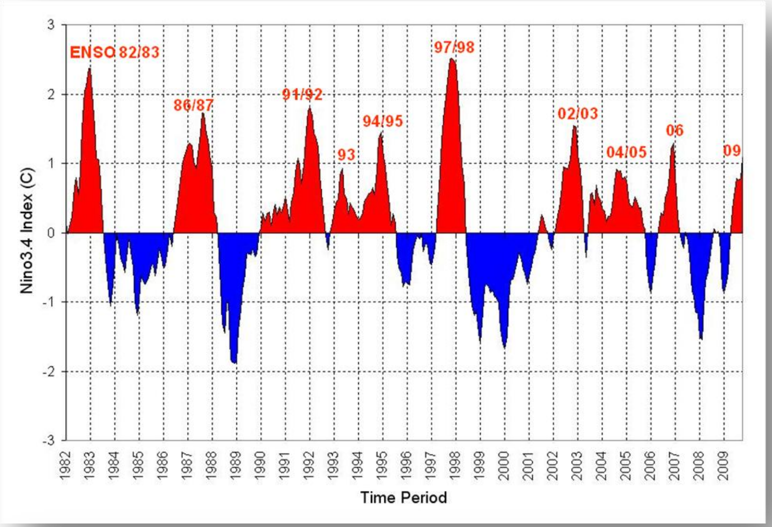
Outline

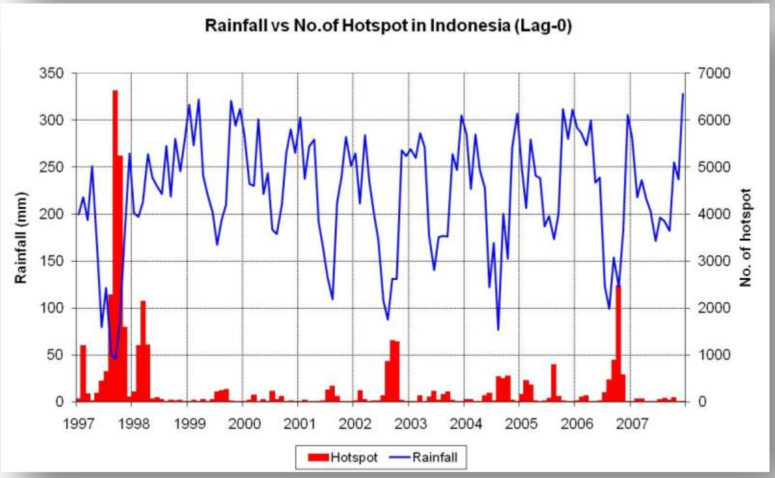
- Introduction
- Remotely-sensed Fire Danger Rating System (FDRS) for early warning
- Remotely-sensed fire hotspot for monitoring
- Development of remotely-sensed burnt area (BA) mapping
- Closing remarks

Introduction
ENSO vs Fire Hotspot

El Niño/Southern Oscillation (ENSO) event was considered as one of significant aggravating factors behind the rise in temperatures and consequent drought in Southeast Asia during major wildfire and haze in the past years.

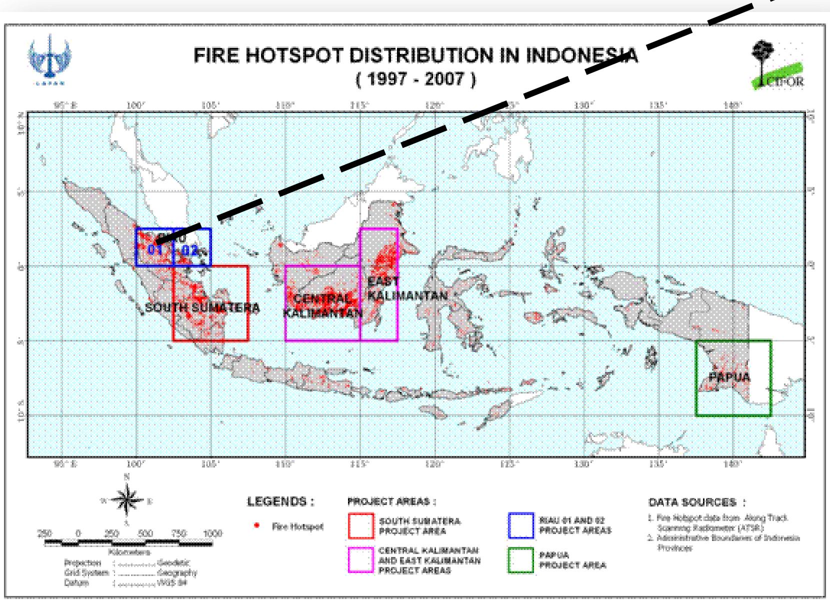


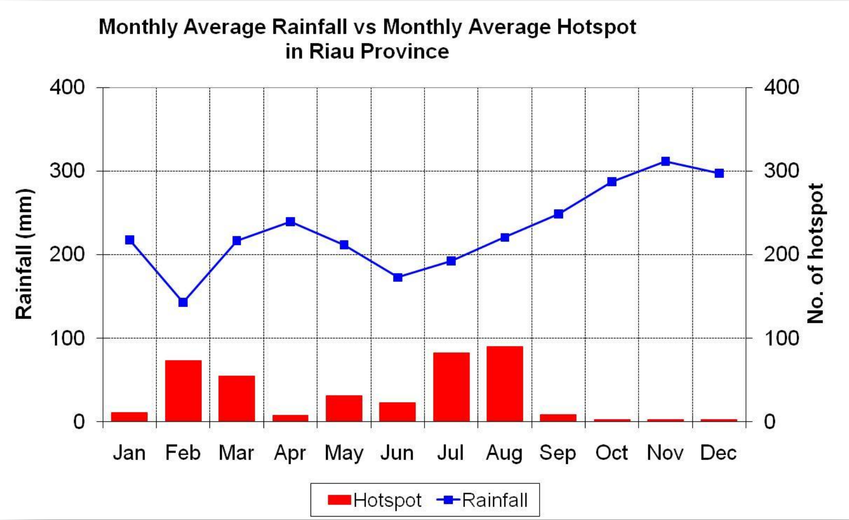


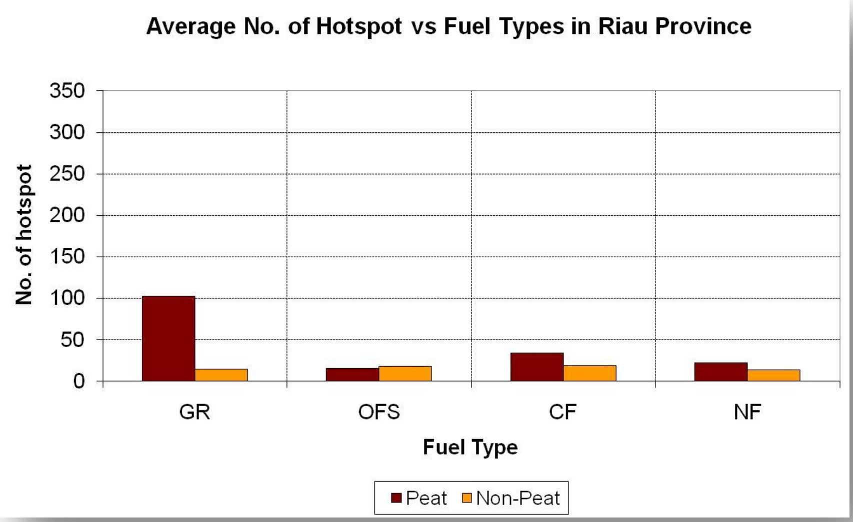


Rainfall vs Fire Hotspot vs Fuel Types in Riau Province

- Riau province has two peaks of fire season, i.e. **Feb-Mar** and **Jul-Aug**.
- Fire mostly occured in **peatland** area.



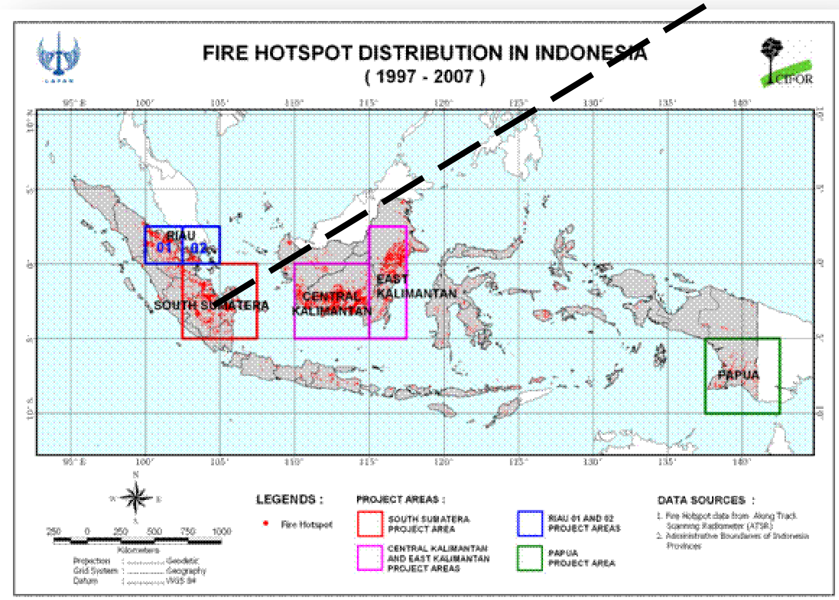


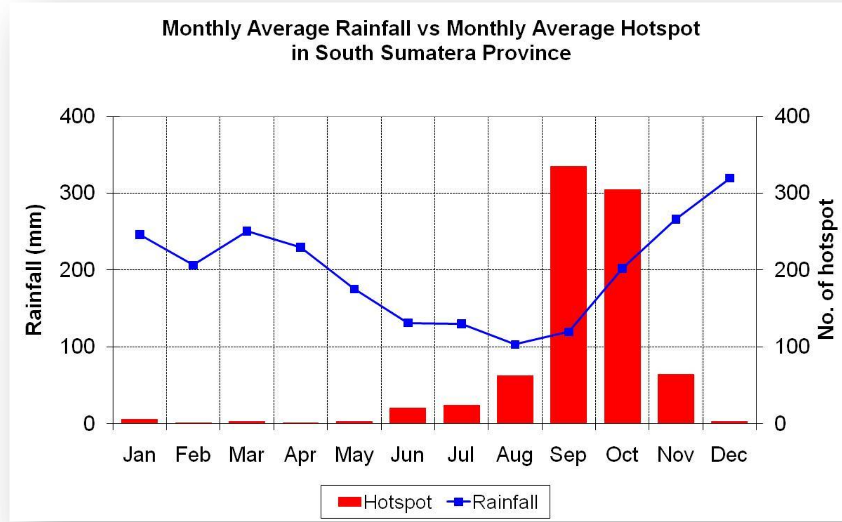


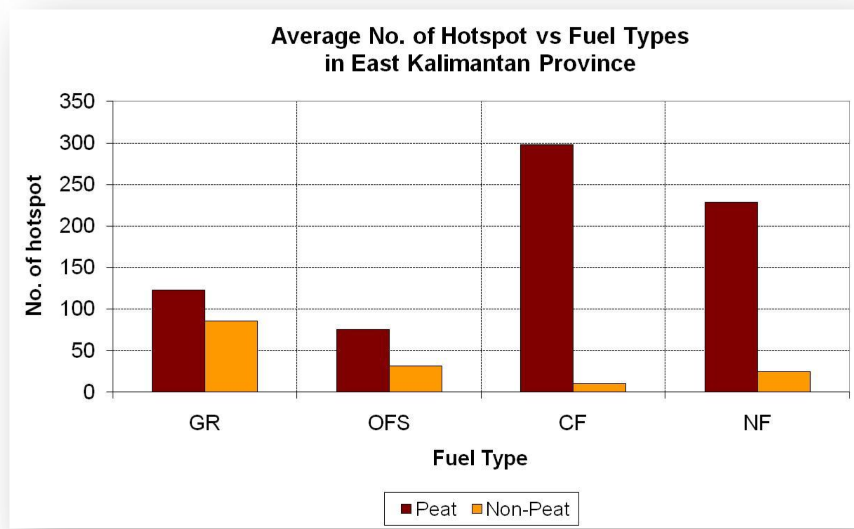
GR: Grassland; OFS: Open Forest/Slash
CF: Closed Forest; NF: Non-Forest

Rainfall vs Fire Hotspot vs Fuel Types in South Sumatera Province

- South Sumatera province has one peak of fire season, i.e. **Sep-Oct**.
- Fire mostly occured in **peatland** area.



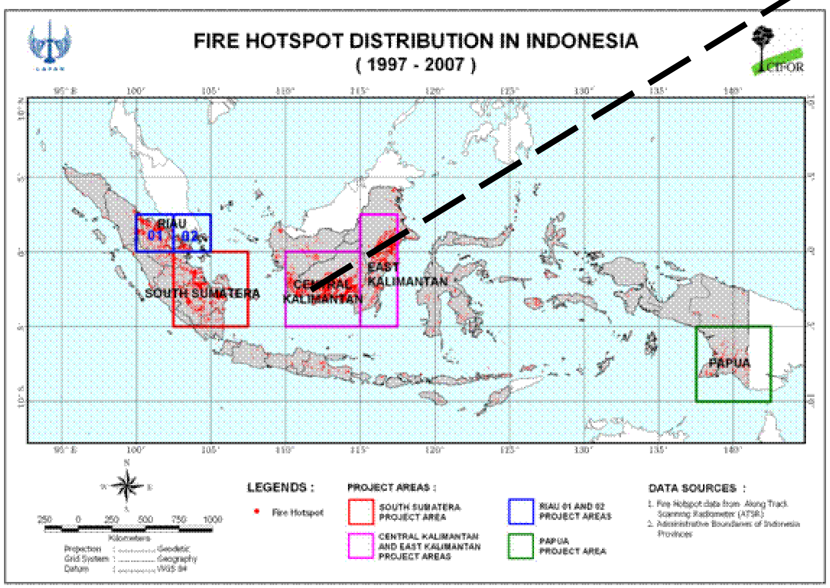


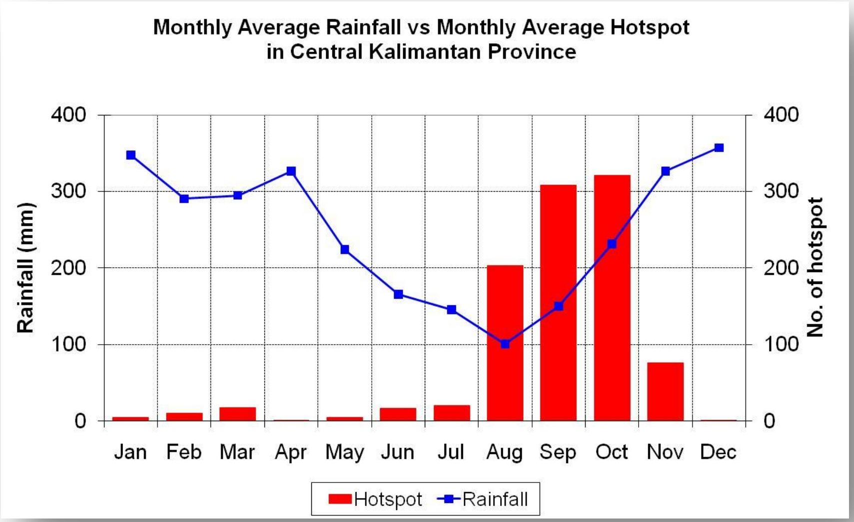


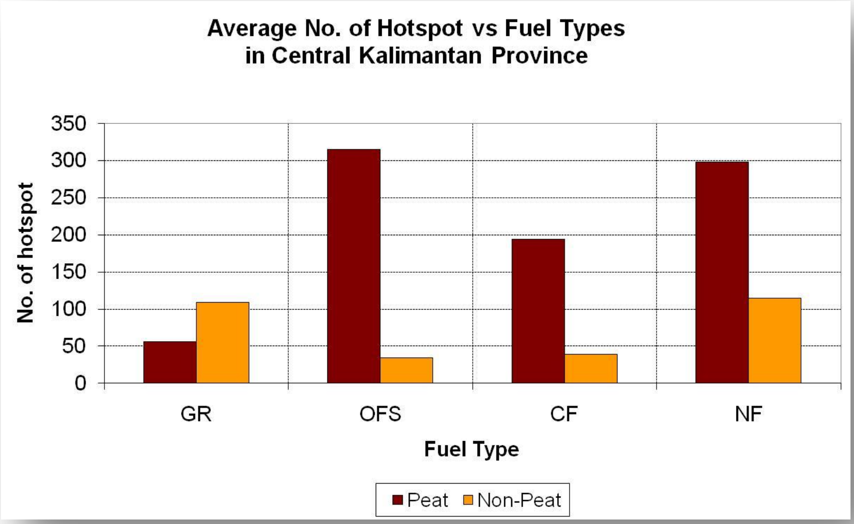
GR: Grassland; OFS: Open Forest/Slash
CF: Closed Forest; NF: Non-Forest

Rainfall vs Fire Hotspot vs Fuel Types in Central Kalimantan Province

- Central Kalimantan province has one peak of fire season, i.e. **Aug-Oct**.
- Fire mostly occured in **peatland** area.



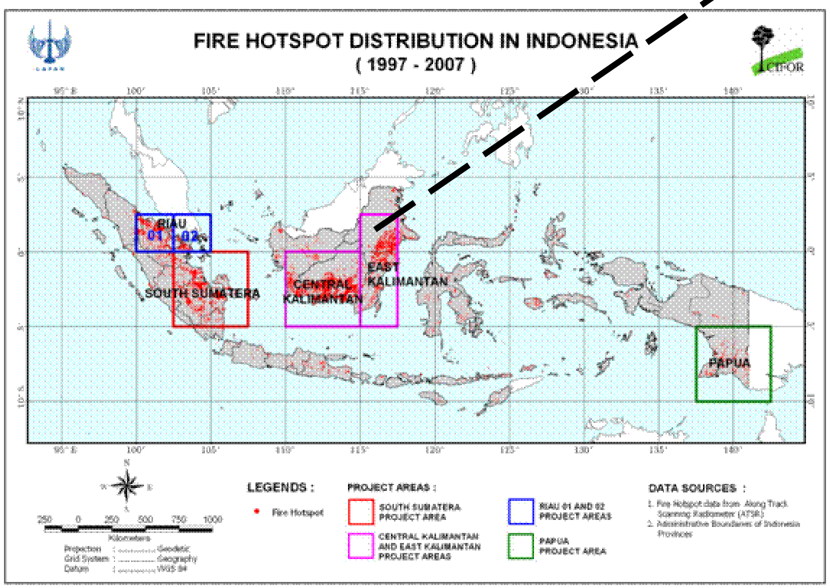


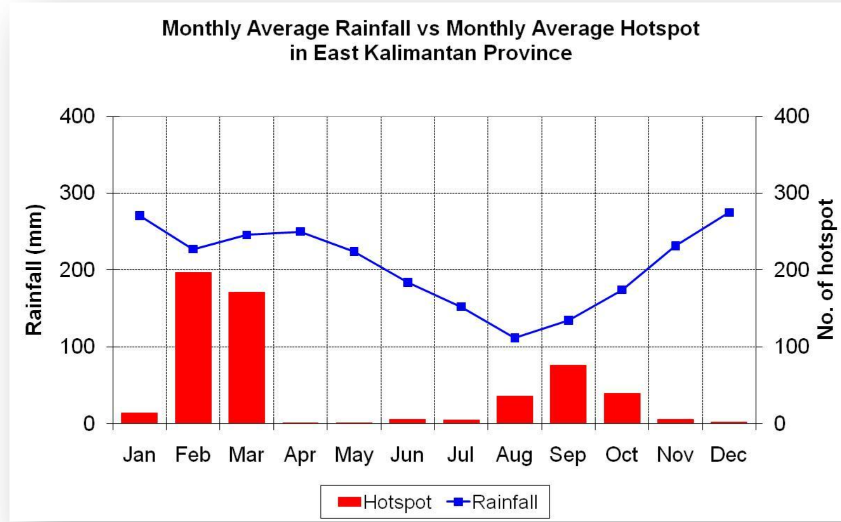


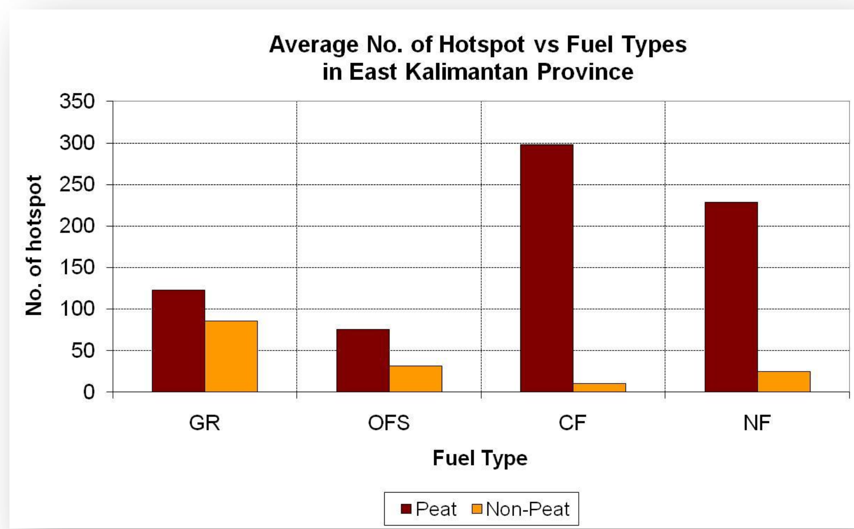
GR: Grassland; OFS: Open Forest/Slash
CF: Closed Forest; NF: Non-Forest

Rainfall vs Fire Hotspot vs Fuel Types in East Kalimantan Province

- East Kalimantan province has two peaks of fire season, i.e. **Feb-Mar** and **Sep-Oct**.
- Fire mostly occured in **peatland** area.



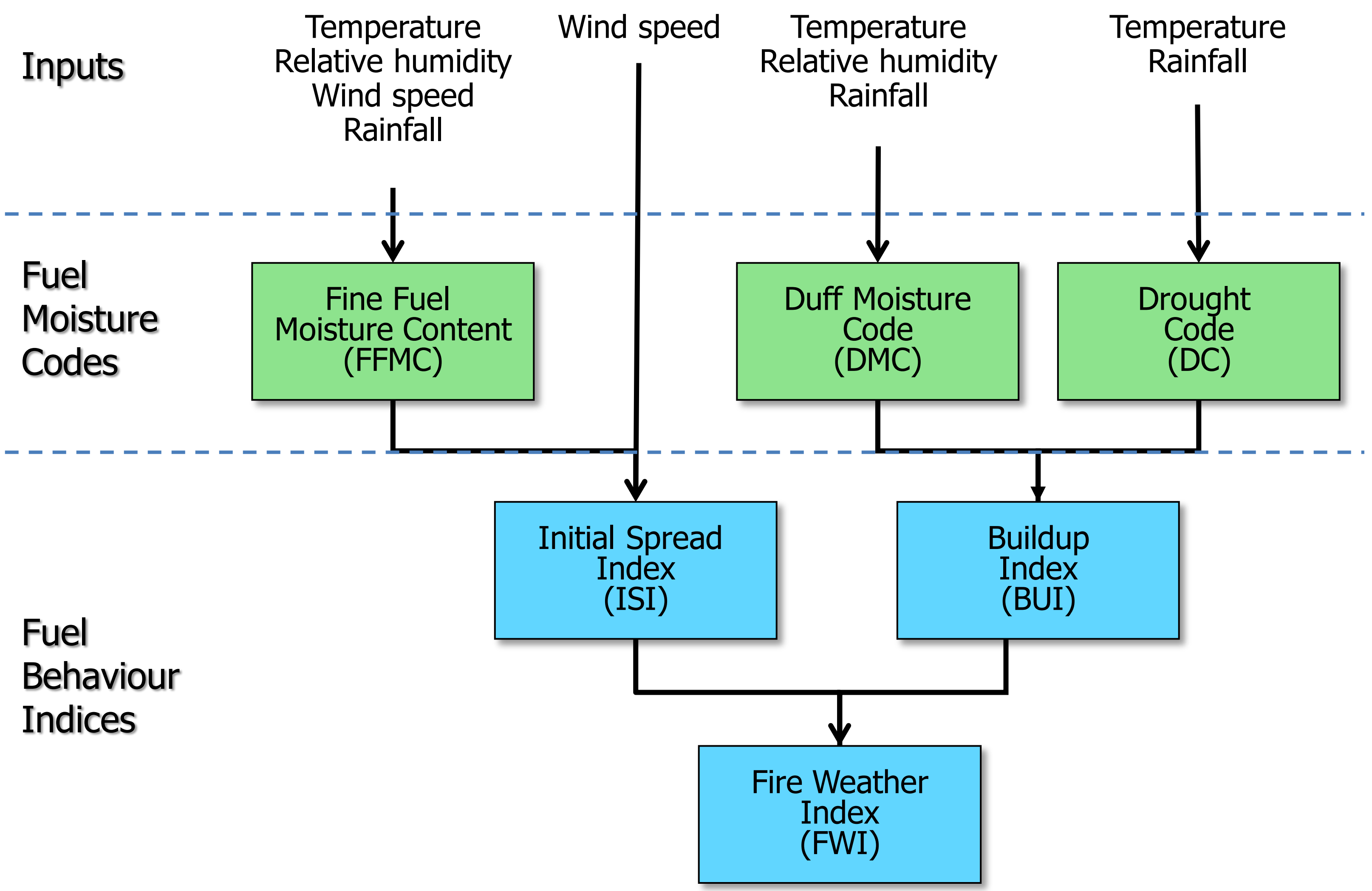




GR: Grassland; OFS: Open Forest/Slash
CF: Closed Forest; NF: Non-Forest

Fire Danger Rating System (FDRS) for early warning

Canadian Fire Weather Index (FWI) System



Interpretation of FFMC

Ignition studies compared against hotspot occurrence. 78% of hotspots occurred when FFMC > 81, but this represented only 20% of all days.

Ignition potential	FFMC	Proportion of an average year[a]	Proportion of fire occurrence[b]	Interpretation
Low	0–72	0.62	0.10	Low probability of fire starts
Moderate	73–77	0.08	0.04	Moderate probability of fire starts in areas of local dryness
High	78–82	0.16	0.13	Cured grass fuels becoming easily ignitable; high probability of fire starts
Extreme	83+	0.13	0.73	Cured grass fuels highly flammable; very high probability of fire starts

Interpretation of DC

Interpretive guidelines based on days without rain required to cross DC threshold.

Smoke potential	DC	Drying days before drought	Interpretation
Low	<140	>30	Typical wet-season conditions. More than 30 dry days until DC reaches threshold. Severe haze periods unlikely.
Moderate	140–260	16–30	Normal mid-dry-season conditions. Between 15 and 30 dry days until DC reaches threshold. Burning should be regulated and monitored as usual.
High	260–350	6–15	Normal dry-season peak conditions. Between 5 and 15 dry days until DC reaches threshold. All burning in peatlands should be restricted. Weather forecasts and seasonal rainfall assessments should be monitored closely for signs of an extended dry season.
Extreme	>350	<6	Approaching disaster-level drought conditions. Fewer than 6 dry days until DC reaches threshold, at which point severe haze is highly likely. Complete burning restriction should be enforced.

Calibrating ISI for Difficulty of Control for Grass

- Based on fire intensity interpretation of the ISI, for locally measured fuel load of 1.8 kg/m^2 and a cured level of 65%.
- ISI > 6 considered extreme in SE Asia, compared to ISI > 15 in Canada.

Difficulty of control	Estimated head fire intensity in grasslands (kW/m)[a]	ISI	Fire rate of spread (m/min)	Proportion of an average year[b]	Fire suppression interpretation[c]
Low	0–250	0–1	0–0.5	0.75	Low fire intensity in grasslands. Fire will spread slowly or be self-extinguishing. Grassland fires can be successfully controlled using hand tools.
Moderate	250–1250	2–3	0.6–2.3	0.23	Moderate fire intensity in grasslands. Hand tools will be effective along the fire's flanks, but water under pressure (pumps, hose) may be required to suppress the head fire in grasslands.
High	1250–2500	4–5	2.4–4.6	0.02	High fire intensity in grasslands. Direct attack at the fire's head will require water under pressure, and mechanized equipment may be required to build control lines (e.g., bulldozer).
Extreme	2500+	6+	4.7+	<0.01	Very high fire intensity in grasslands. Fire control will require construction of control lines by mechanized equipment and water under pressure. Indirect attack by back-burning between control lines and the fire may be required.

Development of Remotely-sensed FDRS for Western Indonesia

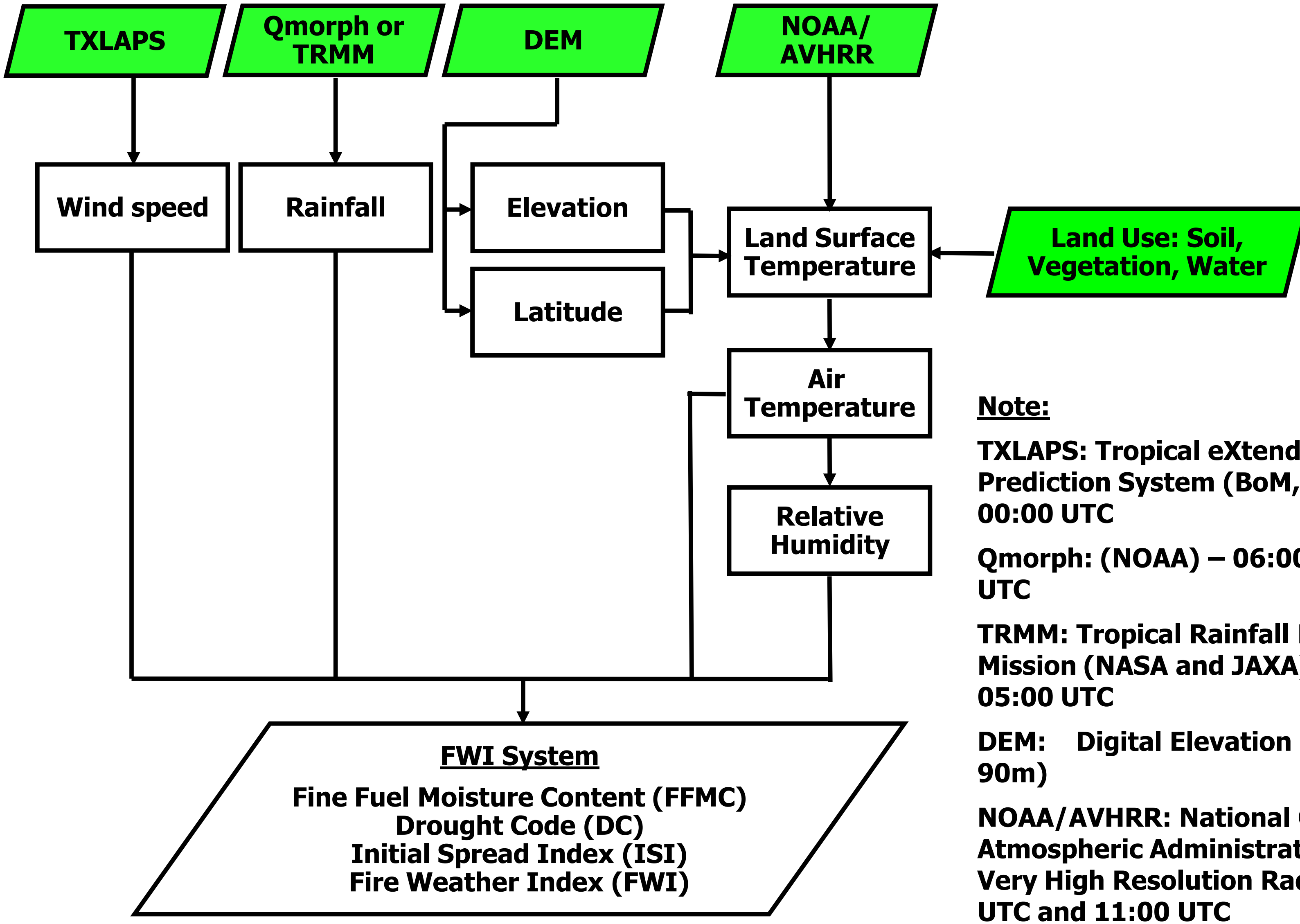
Motivation:

- The number of weather stations over Indonesia are still very limited.
- The distributions of these weather stations are sparse.
- The local scales (provincial/district scales) of FDR information is often needed by the local government.
- The use of satellite remote sensing data becomes the best alternative:
  - Advantages:

    Provide comprehensive and multi-temporal coverage of large areas in real-time and at frequent intervals, mapping at a regular spatial resolution, and cost-effective.
  - Limitations:

    Do not directly estimate the meteorological parameters, data processing is more complex, and clouds often cover land observation.

NOAA/AVHRR-based Inputs



Note:

TXLAPS: Tropical eXtended Area Prediction System (BoM, Australia) – 00:00 UTC

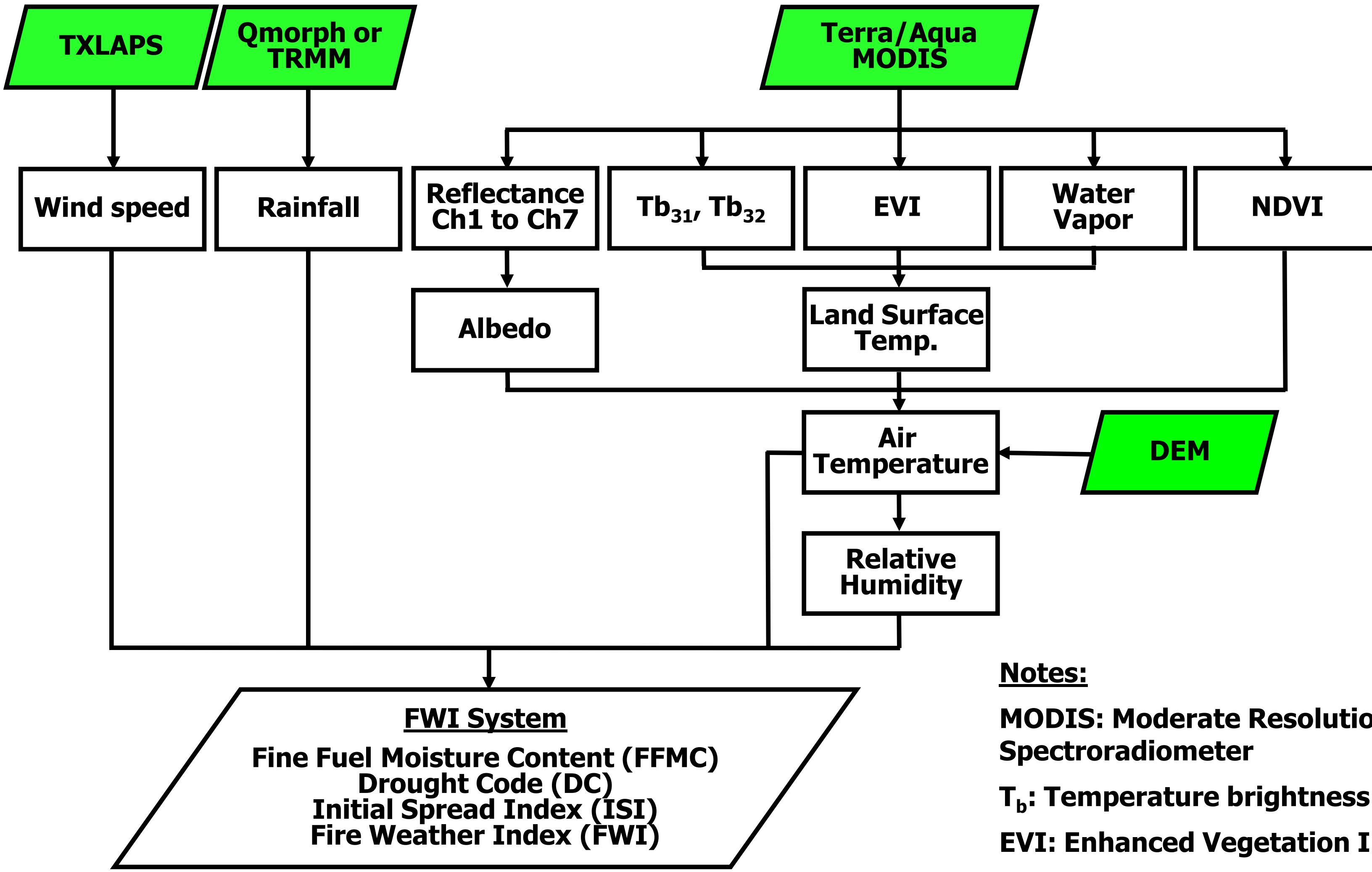
Qmorph: (NOAA) – 06:00 UTC to 05:00 UTC

TRMM: Tropical Rainfall Measuring Mission (NASA and JAXA) – 06:00 UTC to 05:00 UTC

DEM: Digital Elevation Model (SRTM 90m)

NOAA/AVHRR: National Oceanic and Atmospheric Administration/Advanced Very High Resolution Radiometer - 08:00 UTC and 11:00 UTC

MODIS-based Inputs



Notes:

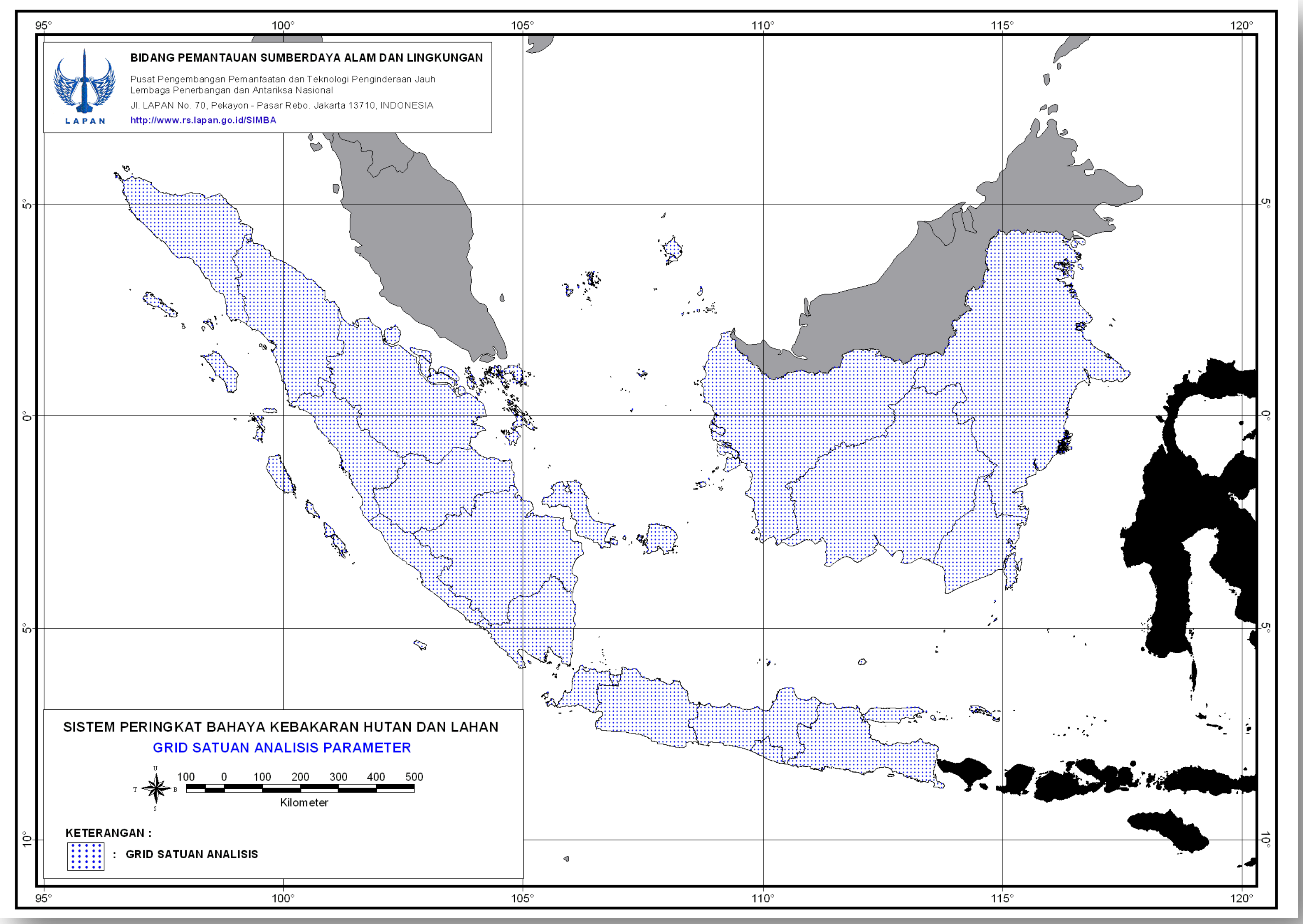
MODIS: Moderate Resolution Imaging Spectroradiometer

T_b: Temperature brightness

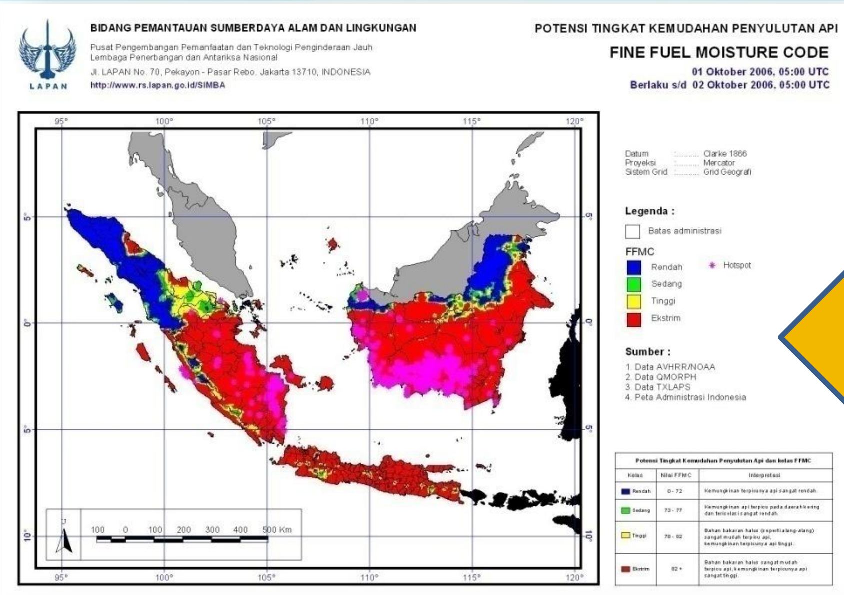
EVI: Enhanced Vegetation Index

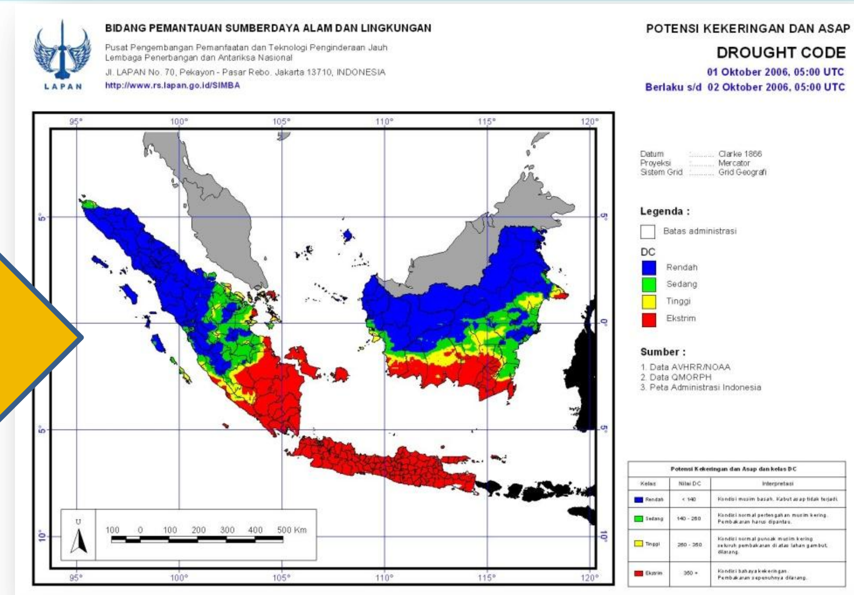
NDVI: Normalized Difference Vegetation Index

Data Grid (2.5 km x 2.5 km)

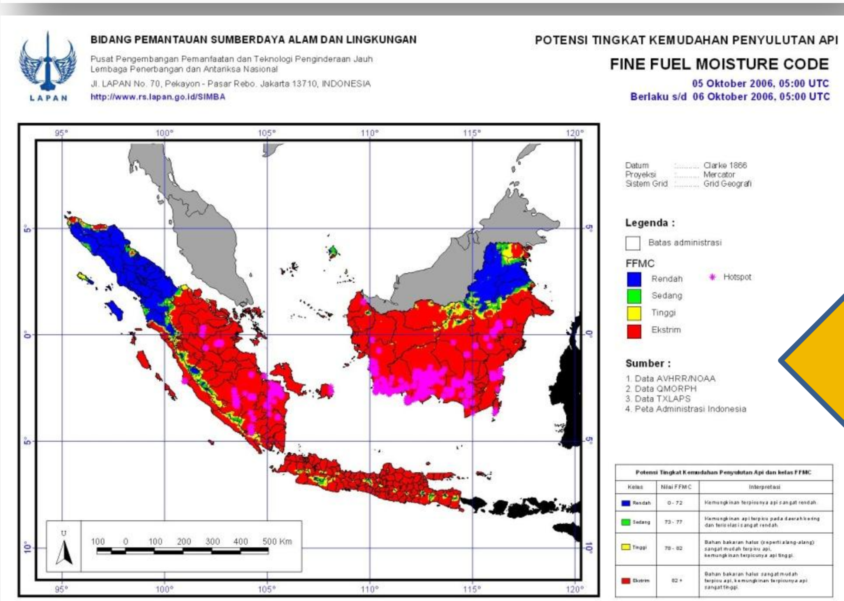


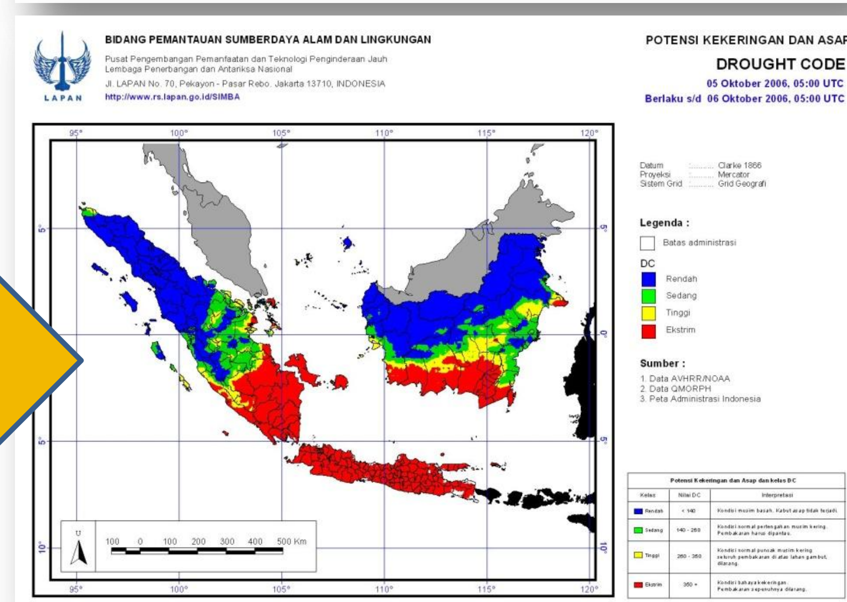
FFMC and DC during ENSO 2006 (1 Oct and 5 Oct 2006)





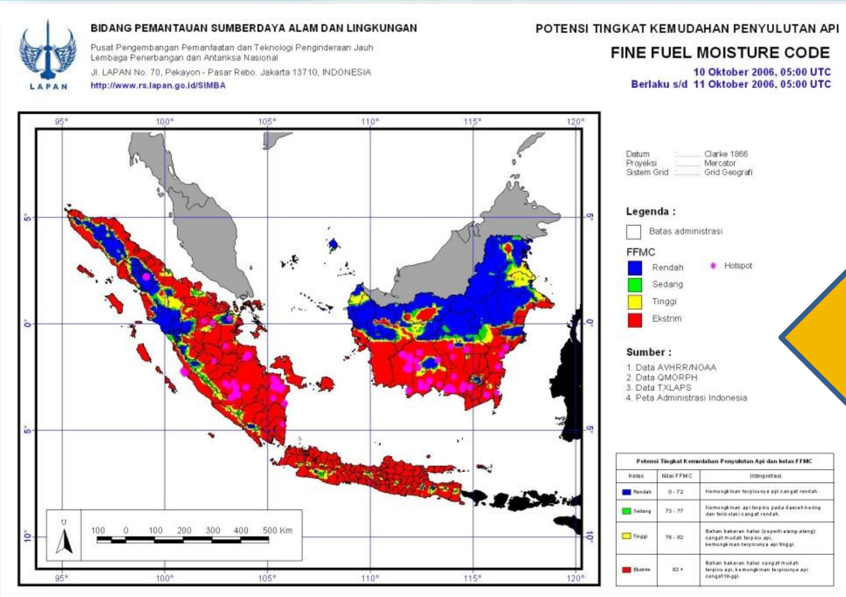
1 Oct 2006

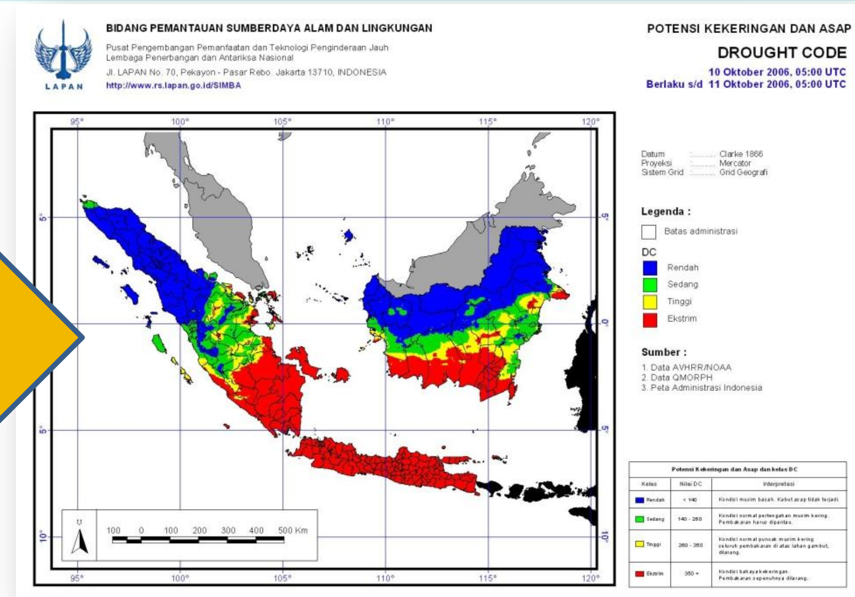




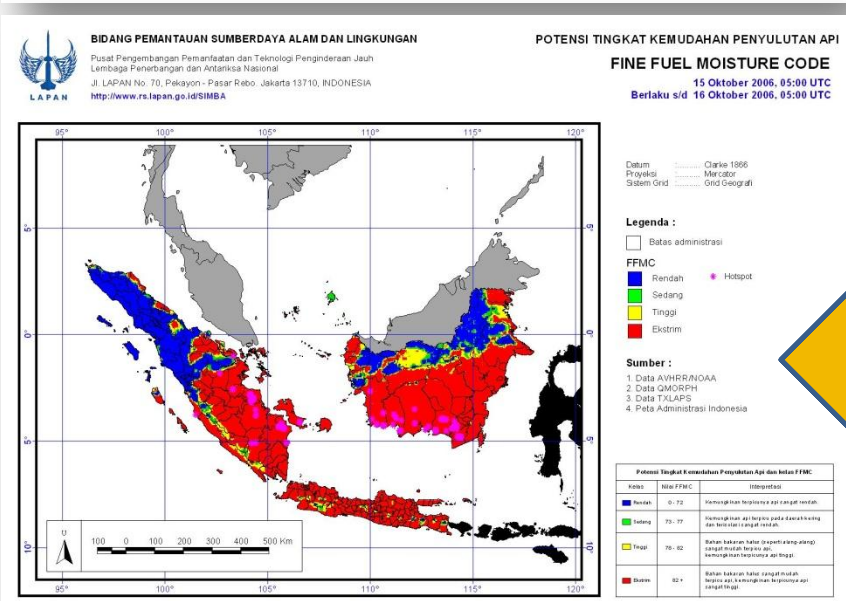
5 Oct 2006

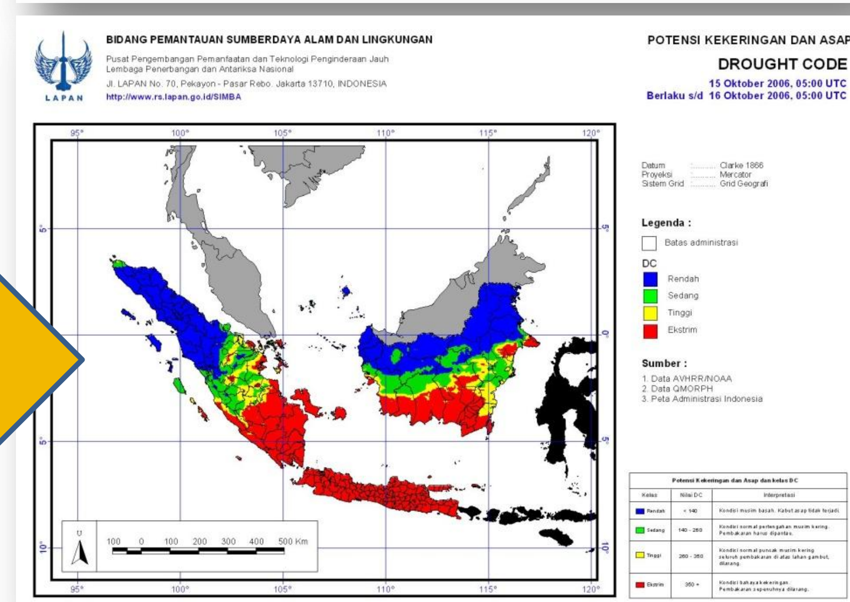
FFMC and DC during ENSO 2006 (10 Oct and 15 Oct 2006)





10 Oct 2006

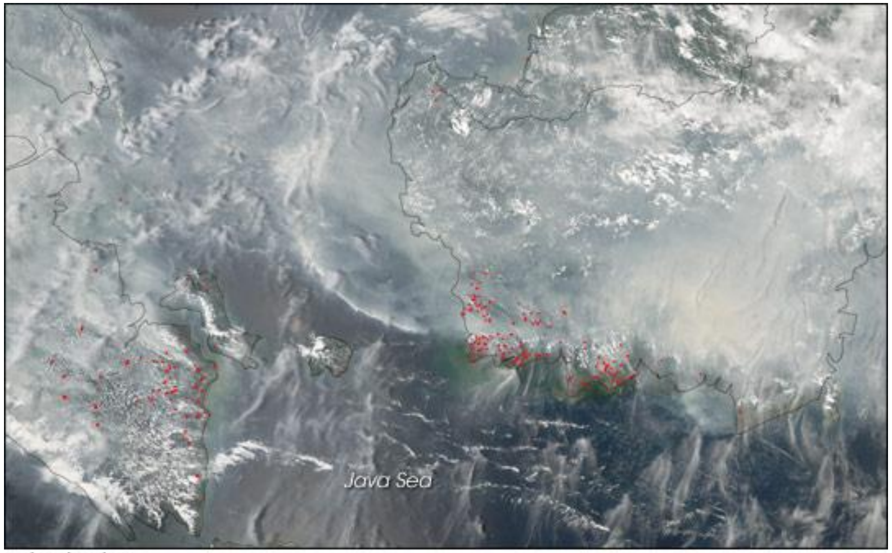




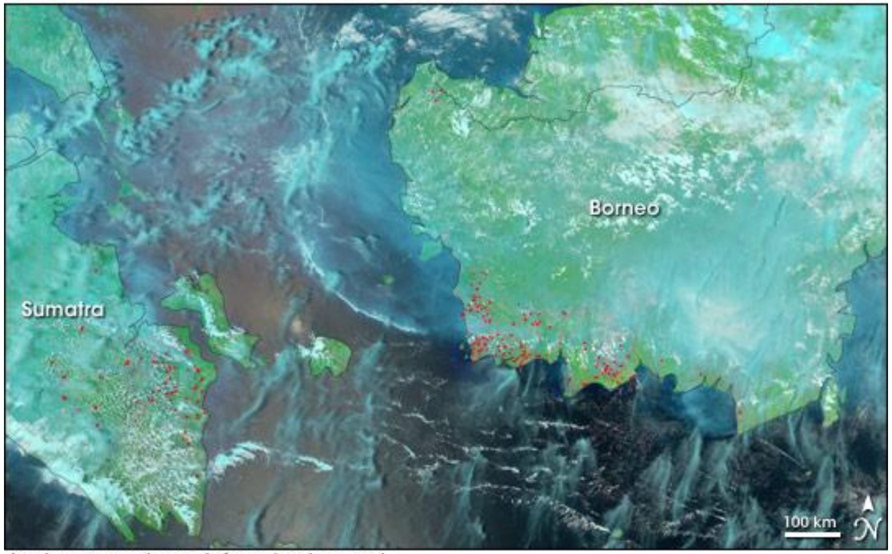
15 Oct 2006

Hotspots and Haze during ENSO 2006 in Sumatera and Kalimantan

8 Oct 2006

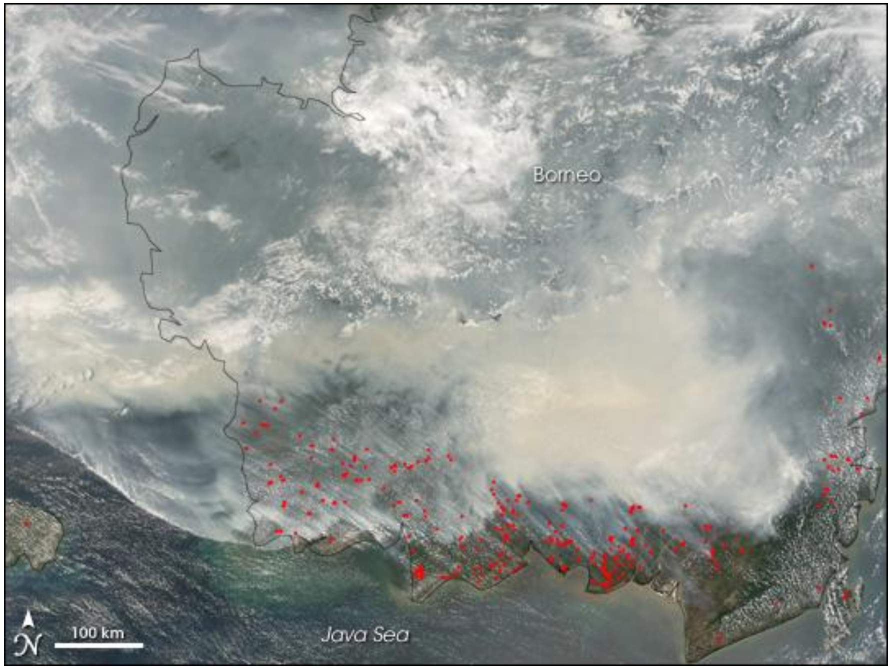


natural color

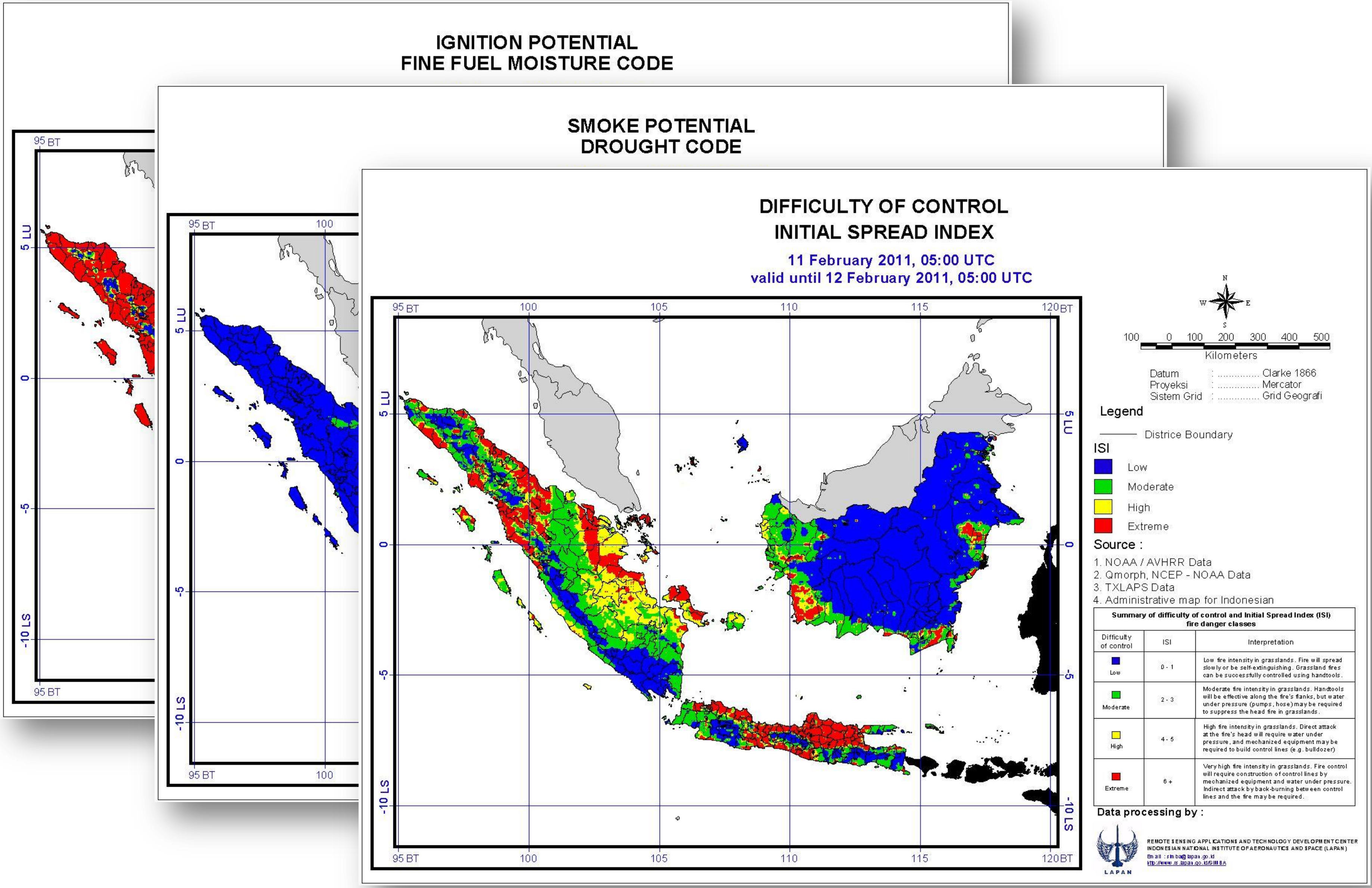


shortwave- and near-infrared enhanced

12 Oct 2006



Example of remote sensing-based FDRS (11 Feb 2011)



Remotely-sensed fire hotspot for monitoring INDOFIRE

http://www.lapan.go.id/indofire/
http://indofire.dephut.go.id/indofire.asp
http://indofire.landgate.wa.gov.au/indofire.asp

INDOFIRE

IndoFire Map Service

The FireWatch Indonesia Project is a collaborative project between Indonesia's Ministry of Forestry, the Institute of Aeronautics and Space LAPAN and Ministry of Environment, and the Australian Government through AusAID and the Western Australian Government Department Landgate.

Based on Landgate's Firewatch System for Australia, the project has designed, built and installed a fire monitoring system covering the whole of Indonesia to enable the generation of valuable fire monitoring information to effectively fight fires. This information will enable early detection of fires leading to their suppression and minimising the spread of fires into Indonesia's forest and peatland habitats.

It will generate valuable fire monitoring information for the whole of Indonesia including near-real time monitoring of active fires using the MODIS satellite sensor on board the Terra and Aqua satellites. It will provide access to burnt area mapping datasets developed by Ministry of Forestry and enable Time Series Analysis of hot spots overlaid with other mapping information to identify the origin and track the spread of fires. The ability to access this information will assist in the development of strategy and policy to reduce the incidence and severity of fires.

FireWatch Indonesia delivers essential fire monitoring information via a web based data delivery system called IndoFire. The system will provide free and open access to all stakeholder groups including public and private sector agencies at all levels. Indofire is being designed to Integrate with Indonesia's developing Forest Monitoring Systems (FRIS).

To access IndoFire please click on the links below.

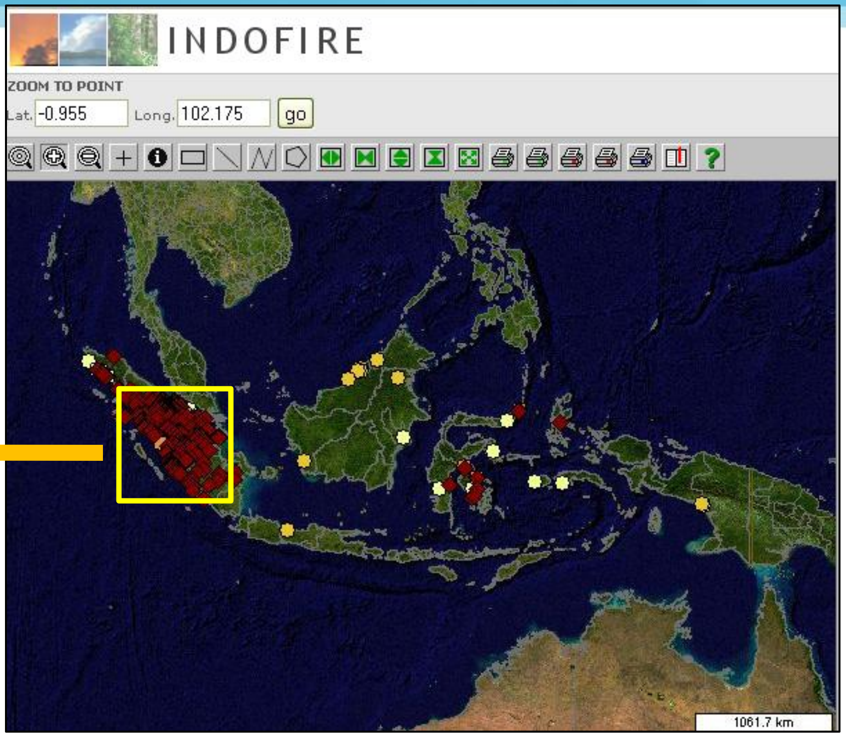
Indofire Map Service - Server 1 at LAPAN

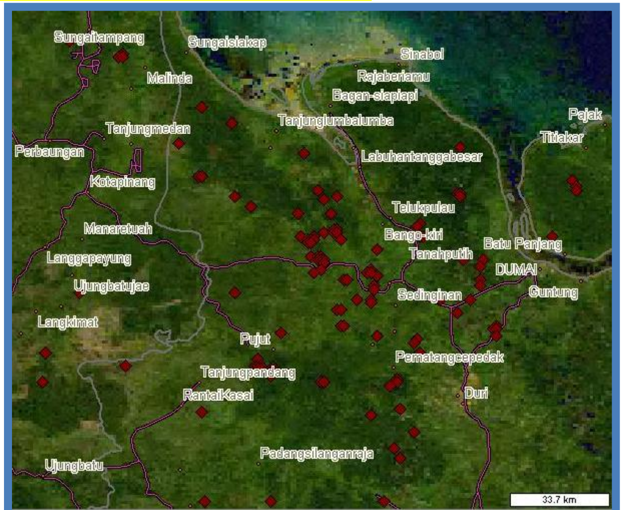
Indofire Map Service - Server 2 at Ministry of Forestry

Indofire Map Service - Server 3 at Landgate Perth

Fire hotspot monitoring (11 Feb 2011)

Hotspot in Riau Province (11 Feb 2011)





No. of fire hotspot (11 Feb 2011):

Sumatera : 425

Riau Province : 189

Development of remotely-sensed burnt area (BA) mapping using SPOT-4 data

- **SPOT-4 data:**
  - Band XI1: 0.50-0.59 μm (GREEN)
  - Band XI2: 0.61-0.68 μm (RED)
  - Band XI3: 0.79-0.89 μm (NIR)
  - Band XI4: 1.53-1.75 μm (SWIR)
- **Normalized Burn Ratio (NBR):**

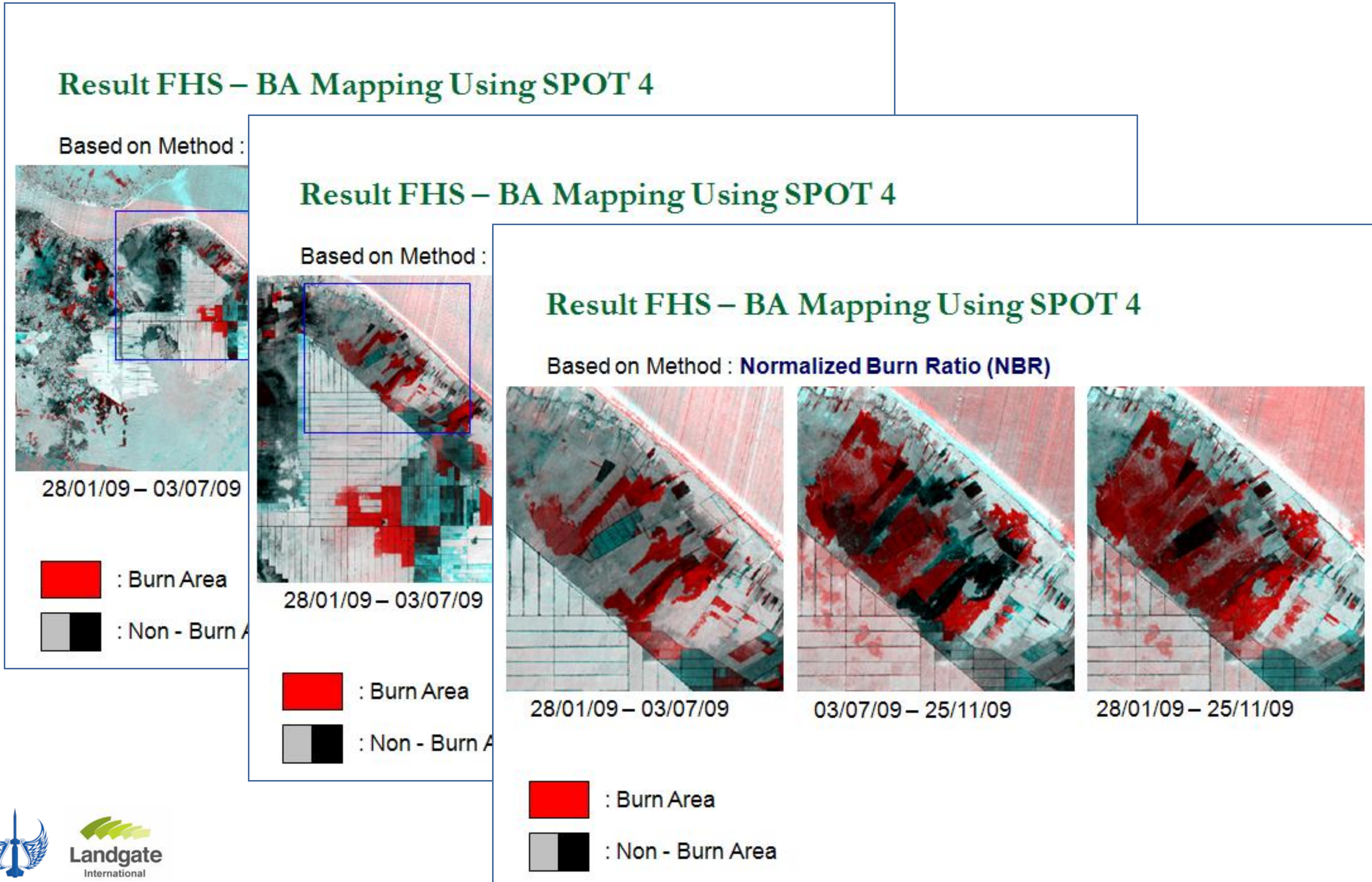
  NBR = (NIR – SWIR)/(NIR + SWIR)

  ΔNBR = NBR preFIRE – NBR postFIRE
- **Normalized Difference Vegetation Index (NDVI):**

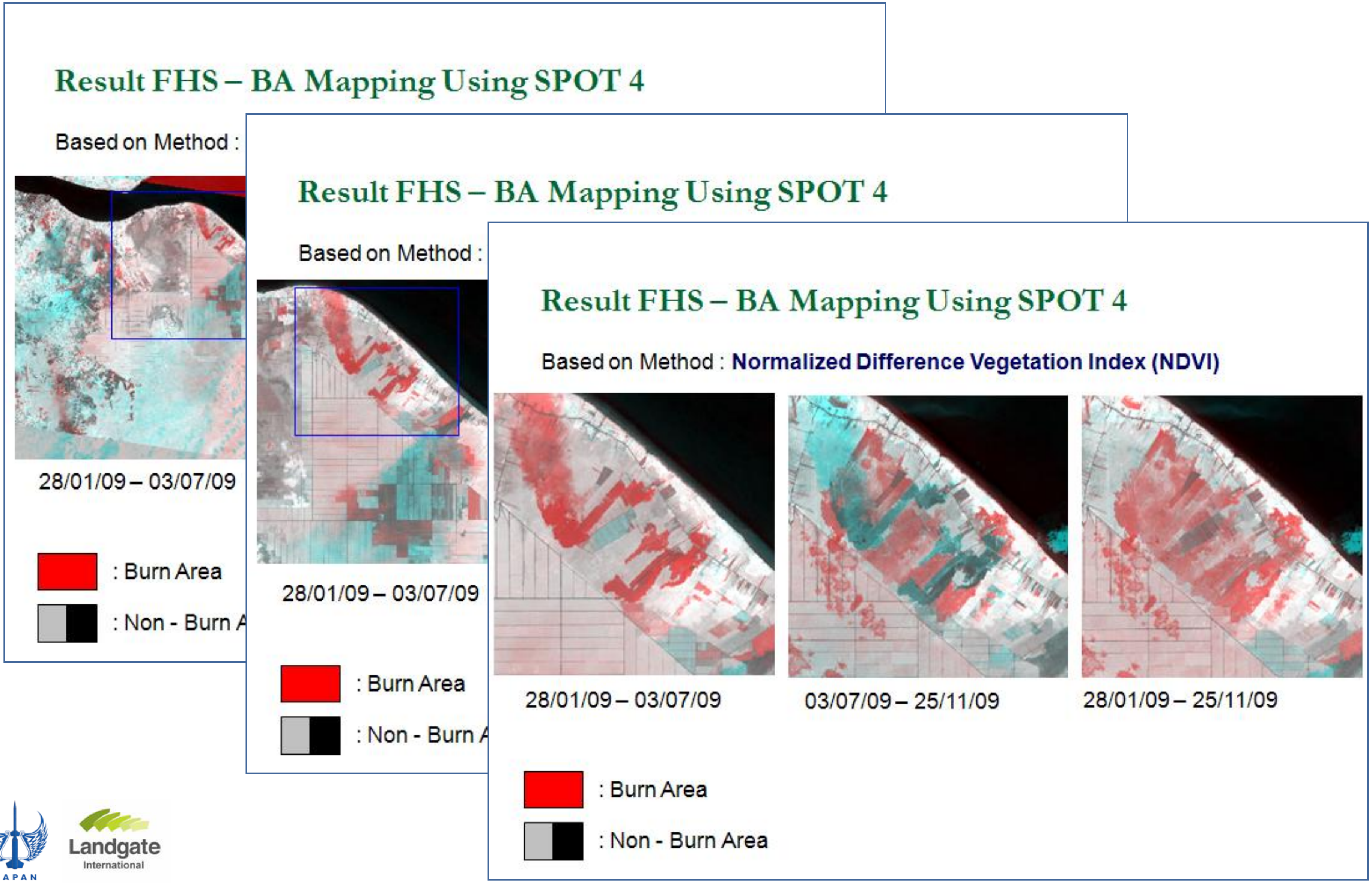
  NDVI = (NIR – RED)/(NIR + RED)

  ΔNDVI = NDVI preFIRE – NDVI postFIRE

BA mapping based on NBR method



BA mapping based on NDVI method



Landgate
International

BA mapping based on visual interpretation

Result FHS – BA Mapping Using SPOT 4

Based on Method : **Visual Interpretation and Process Vector Digitations**

28/01/09 03/07/09 25/11/09

- ● : FHS Jan – July 2009
- ● : FHS July – Nov 2009
- ■ : Burn Area

SPOT 4 DISPLAY COLOR COMPOSIT RGB: 412

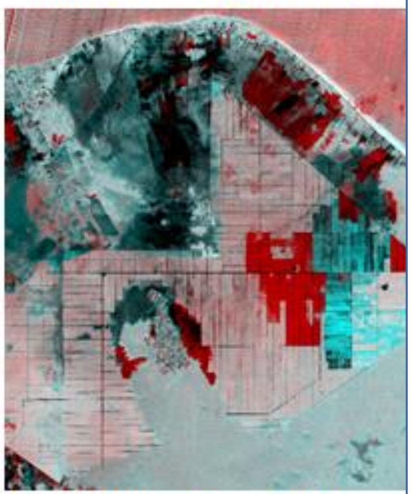
LAPAN

Landgate International

BA mapping based on NBR, NDVI, and visual interpretation

Result Comparison Method FHS – BA Mapping Using SPOT 4

NBR vs. NDVI vs. Visu



NBR Jan – Nov 2009

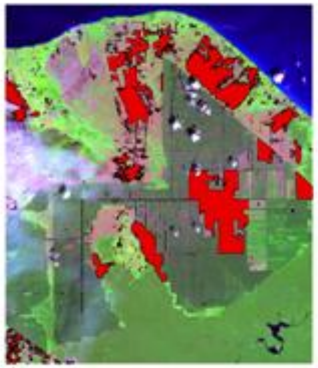
: Burn Area

Result Comparison Method FHS – BA Mapping Using SPOT 4

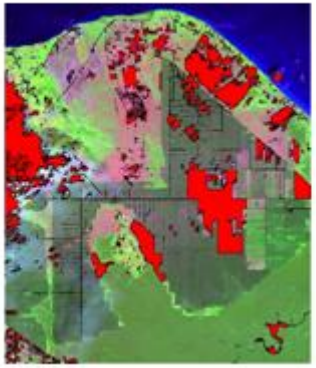
NBR vs. NDVI vs. Visual Interpretation and Process Vector Digitations

	NBR Jan – Nov 2009	NDVI Jan – Nov 2009	Visual Interpretation Jan – Nov 2009
Area (km2)	116.2	148.1	134.2
Intersect area	(93.65/134.2)*100% = 69.78%	(94.65/134.2)*100% = 70.52%	-

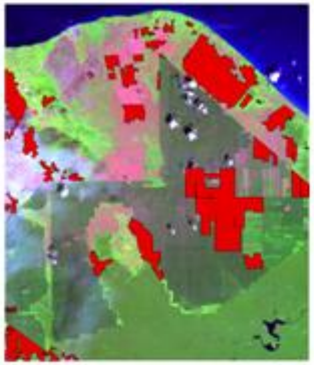
NBR Jan – Nov 2009



NDVI Jan – Nov 2009



Visual Interpretation Jan – Nov 2009

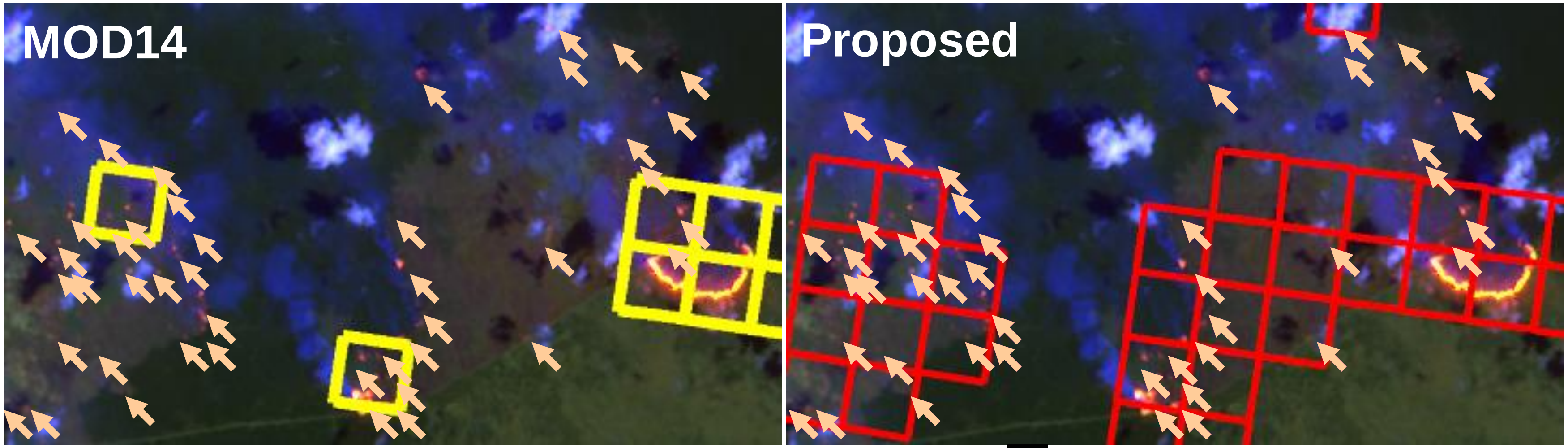


: Burn Area

Landgate International

Closing remarks

- FDRS and fire hotspot have been done operationally for years in Indonesia. Unfortunately, there are still **lack of validation** for this information.
- Efforts for algorithm refinements:
  - Refinement of fire hotspots algorithm:
    - will be done by JAXA under "JST-JICA WildFire Carbon Management in Peat Forest in Indonesia" using a statistical method
    - proposed be implemented in LAPAN in 2011.



ASTER false color R:2.24μm G:1.65μm B:0.66μm Y: MOD14 R: Proposed

Closing remarks

- Efforts for algorithm refinements *(cont.)*:
  - Refinement of remotely-sensed FDRS algorithm:
    - will be conducted through cooperation between JAXA, LAPAN, and Malaysian Meteorological Department (MMD) by determining the suitable emphirical parameters.
    - proposed to be done in 2011
- Methods and results of burnt area mapping from SPOT-4 data need to be compared with those from other satellite remote sensing high-resolution data.

Thank You
for
Your Attention