Investigation on MODIS fire detection algorithms in Kalimantan island

Keiji Kushida (Hokkaido Univ.)

Backgrounds

- NASA fire detection algorithm (Giglio et al., 2003) is based on many pervious studies (e.g., Justice et al., 2002) and experiences for the global application.
- However, it is necessary to study the applicability in a specific region that has its own characteristics (e.g., Liew et al., 2005).
- Especially, the estimation of the background radiance temperature influences on the results of the fire detection, while it is affected by the conditions surround the fire (background fires, the atmosphere, reflected solar illumination, and etc.) (e.g., Wang et al., RSE in press).

Objectives

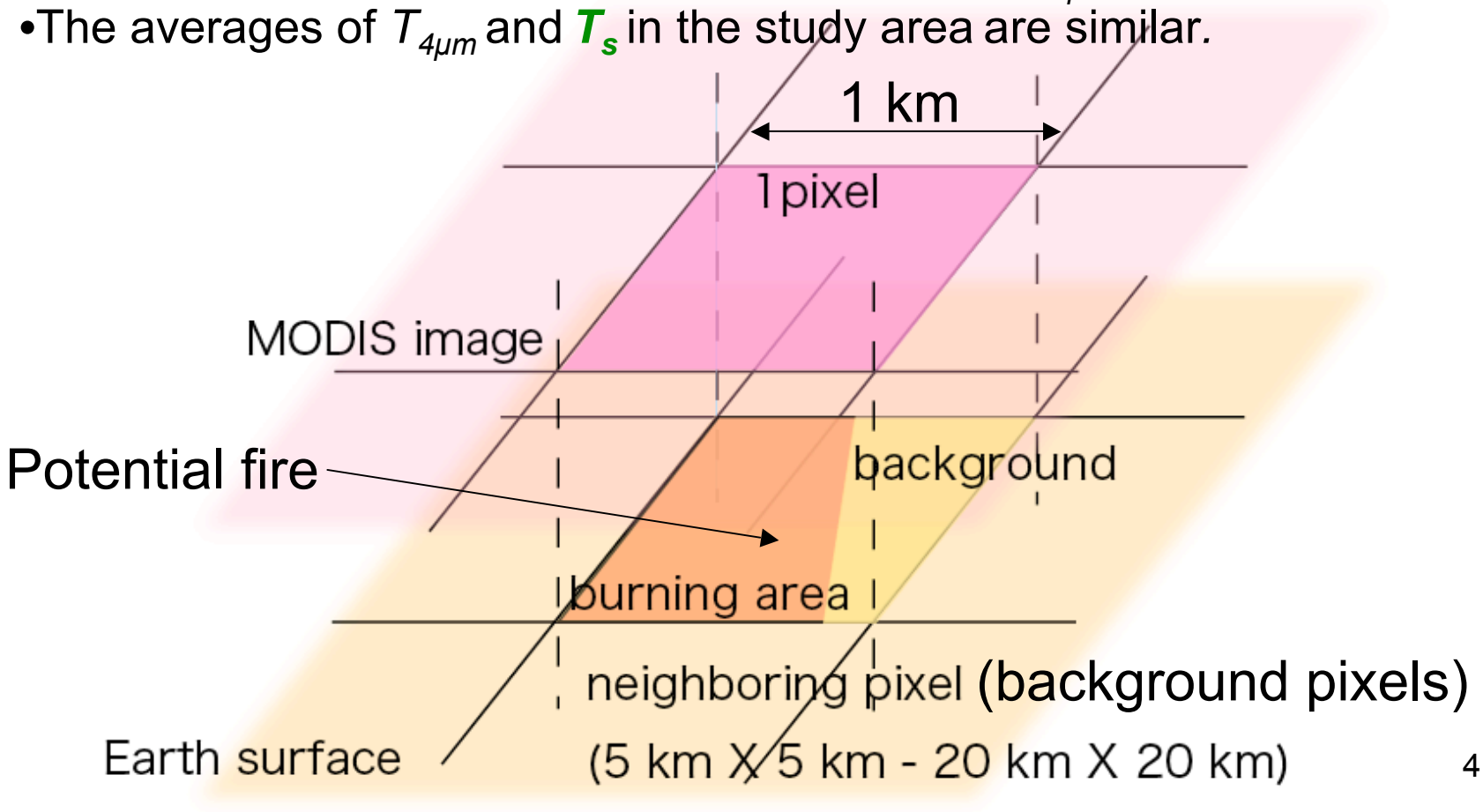
- To investigate the fire detection algorithm for Kalimantan island based on NASA fire detection algorithm (Giglio et al., 2003) using field-observed fire situations in central Kalimantan,
- To investigate the estimation of the background radiance temperature from NDVI (Huh et al., 2006) and visible to near infrared bands (VIS-NIR), and
- （Working hypothesis）(In the NASA algorithm, the radiance temperature of the backgrounds is used.) It is effective for removing the effects of background fires, the atmosphere to use spectral indices such as NDVI and VIS-NIR bands in the place of the radiance temperature of each of the pixels.

Working hypothesis

•Radiance temperatures of the neighboring pixels (Background pixels) ($T_{4\mu m}$) is the total effect of those of background fires (T_{bf}), the atmosphere (T_A), and the ground surface without background fires (T_s) of the background pixels (Wang et al., RSE in press).

•NDVI or VIS-NIR bands explains T_s better than $T_{4\mu m}$ (this study).

•The averages of $T_{4\mu m}$ and T_s in the study area are similar.

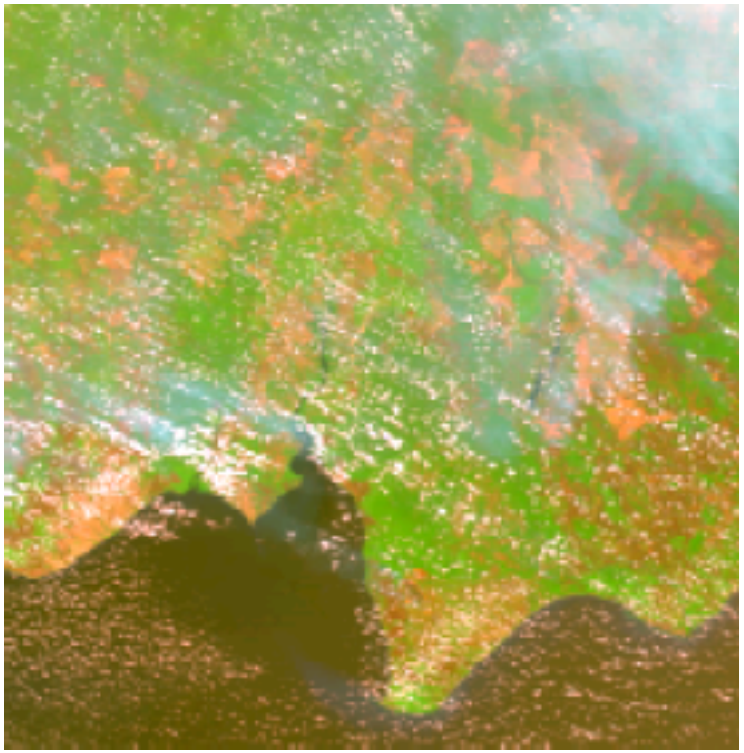


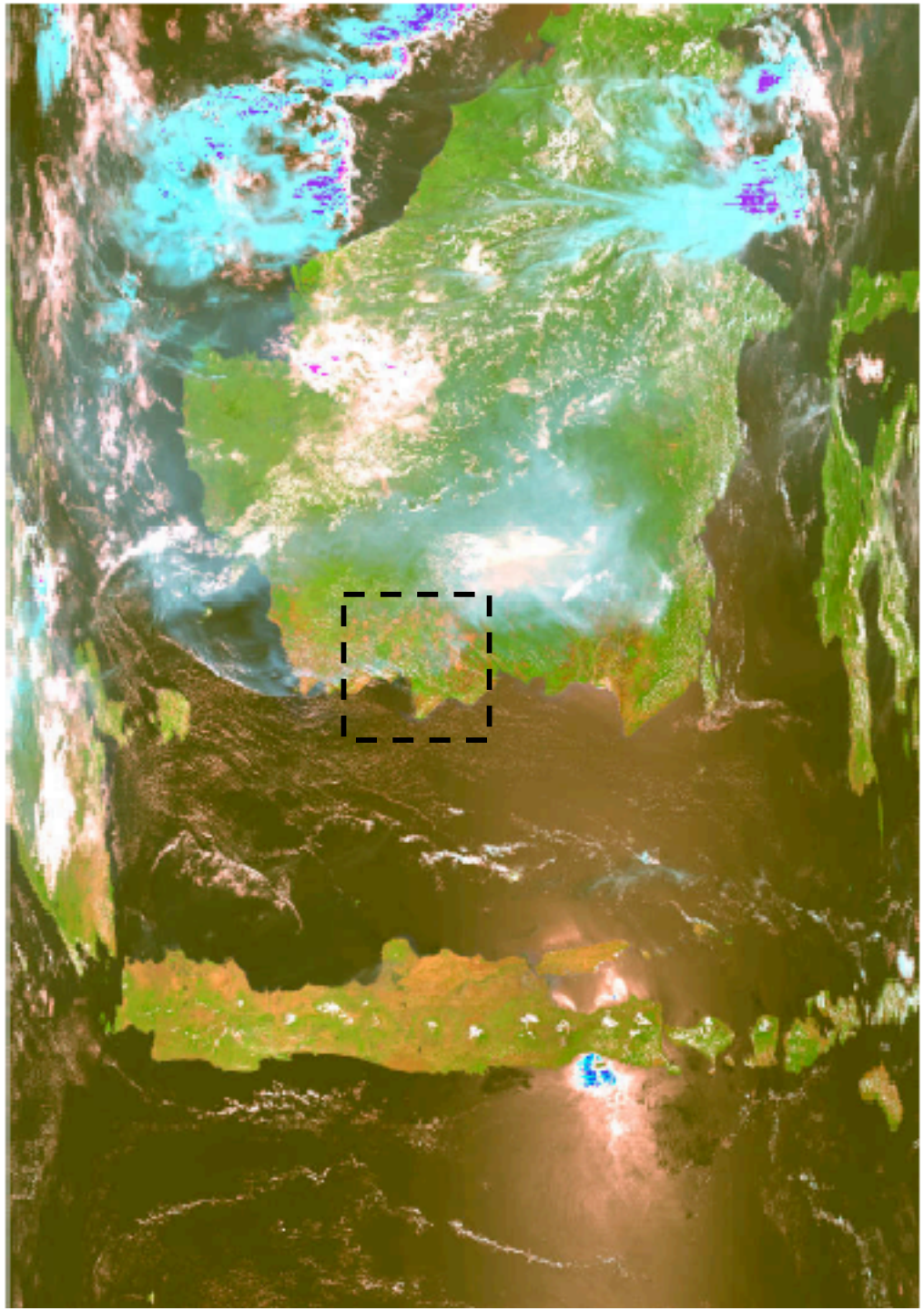
Methods

- Describe the NASA algorithm (Giglio et al., 2003) in C language (Macintosh X) and check the operations using L1B(MOD02), MOD03(geo-location) (downloaded from DAAC/NASA), MODIS SwathTool (WinXP, USGS), Erdas imagine (WinXP),
- Add the algorithm of radiance temperature estimation of the background pixels by NDVI and VIS-NIR bands, and
- Apply to MODIS images of Kalimantan (2006.October) and compare the fire detection results of the NASA and the new algorithms with field-observed fire situations.

MODIS（2006.10.12,
RGB=721）
(band 7: 2.1 μm, band 2: NIR,
band 1: Green)

：200 km X 200 km
area (below)

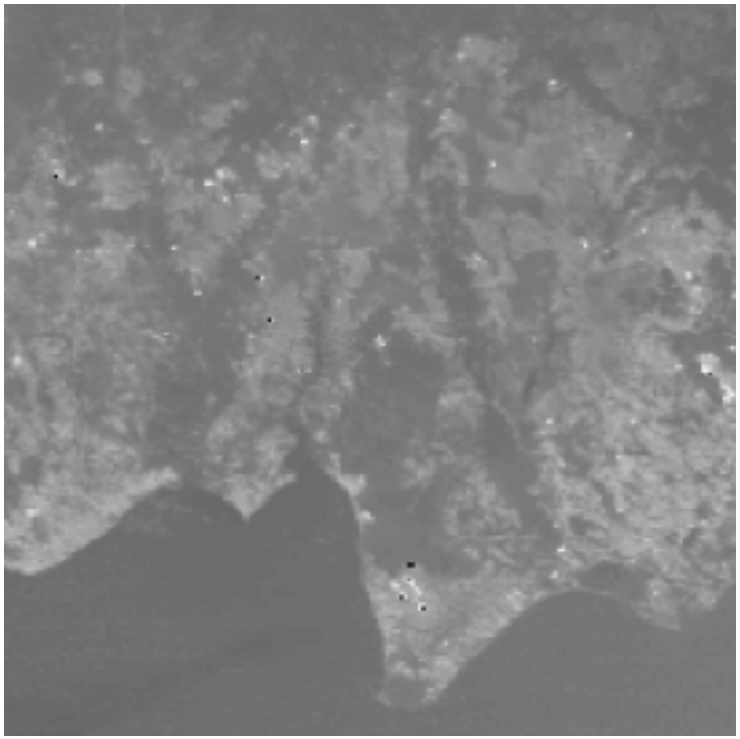


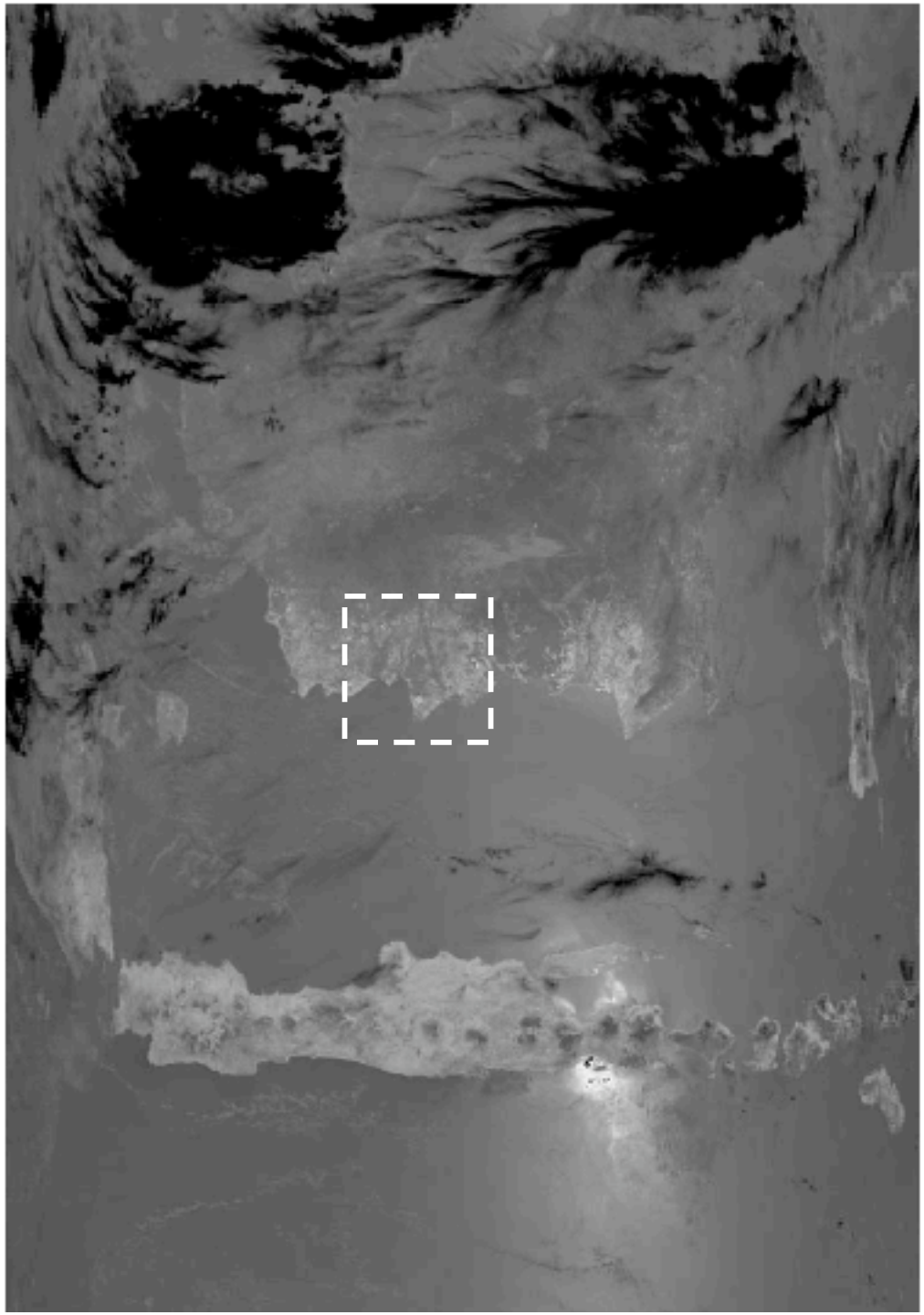


MODIS (2006.10.12)
(4μm thermal band:
band 22(T<=331K), band
21(T>331K))

273K
0℃

353K
80℃

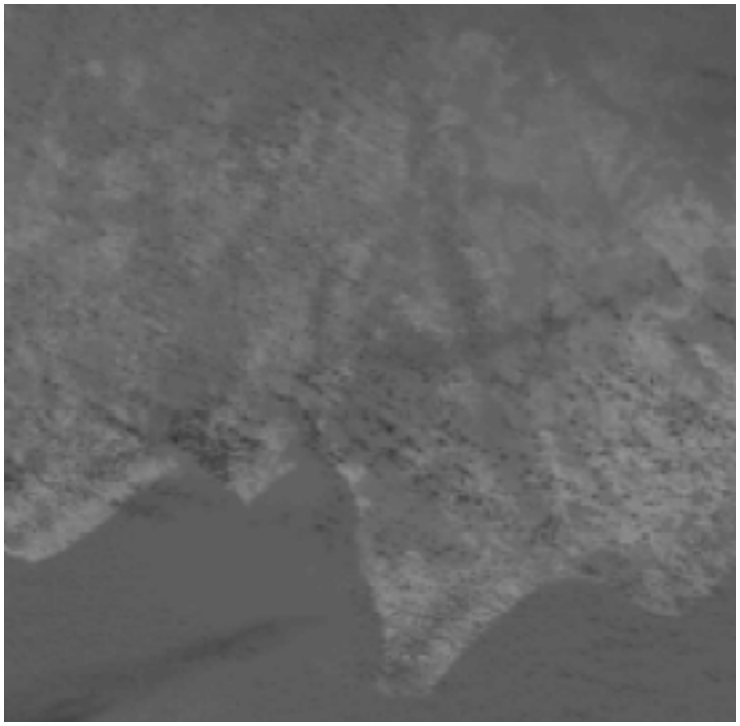


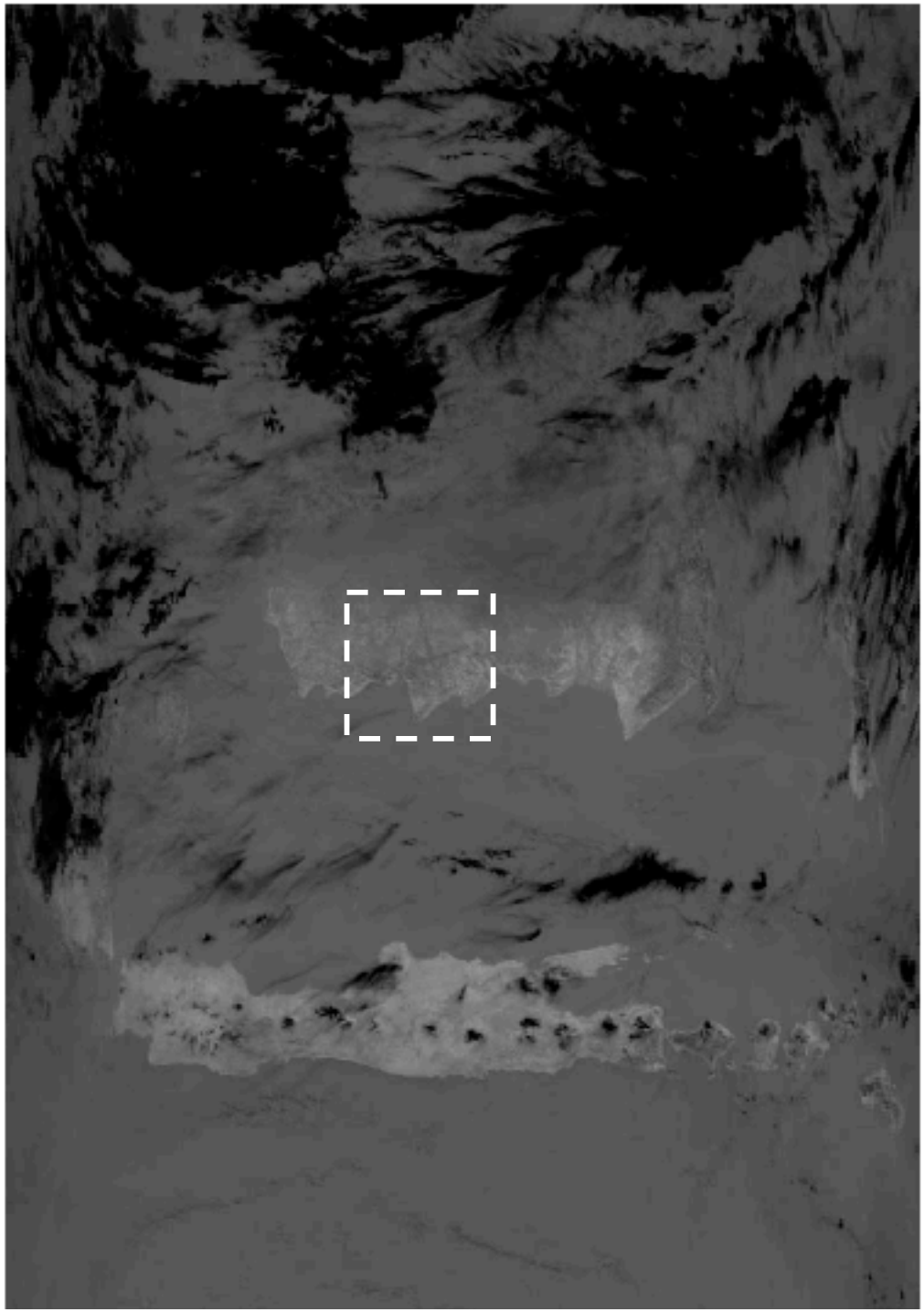


MODIS (2006.10.12)
(11 μm thermal band:
band 31)

273K
0℃

353K
80℃

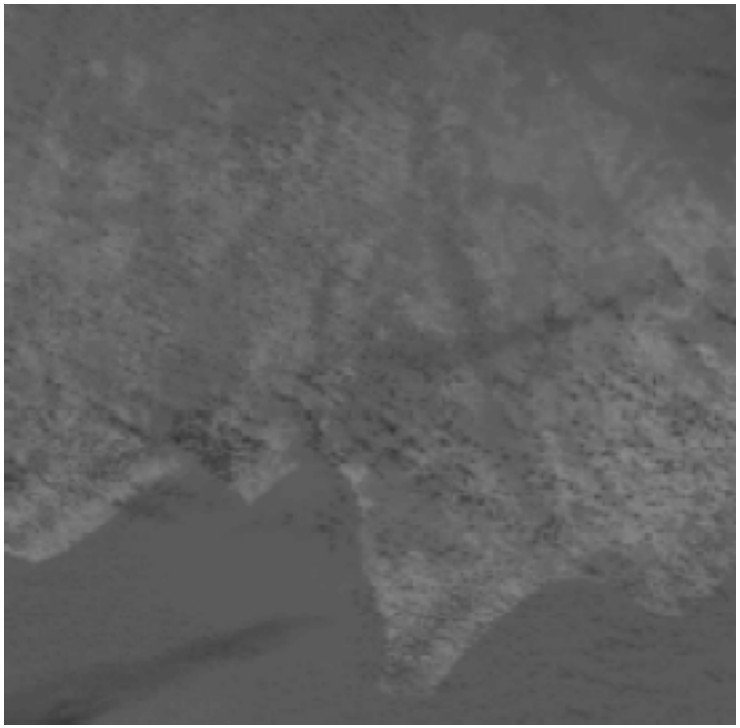


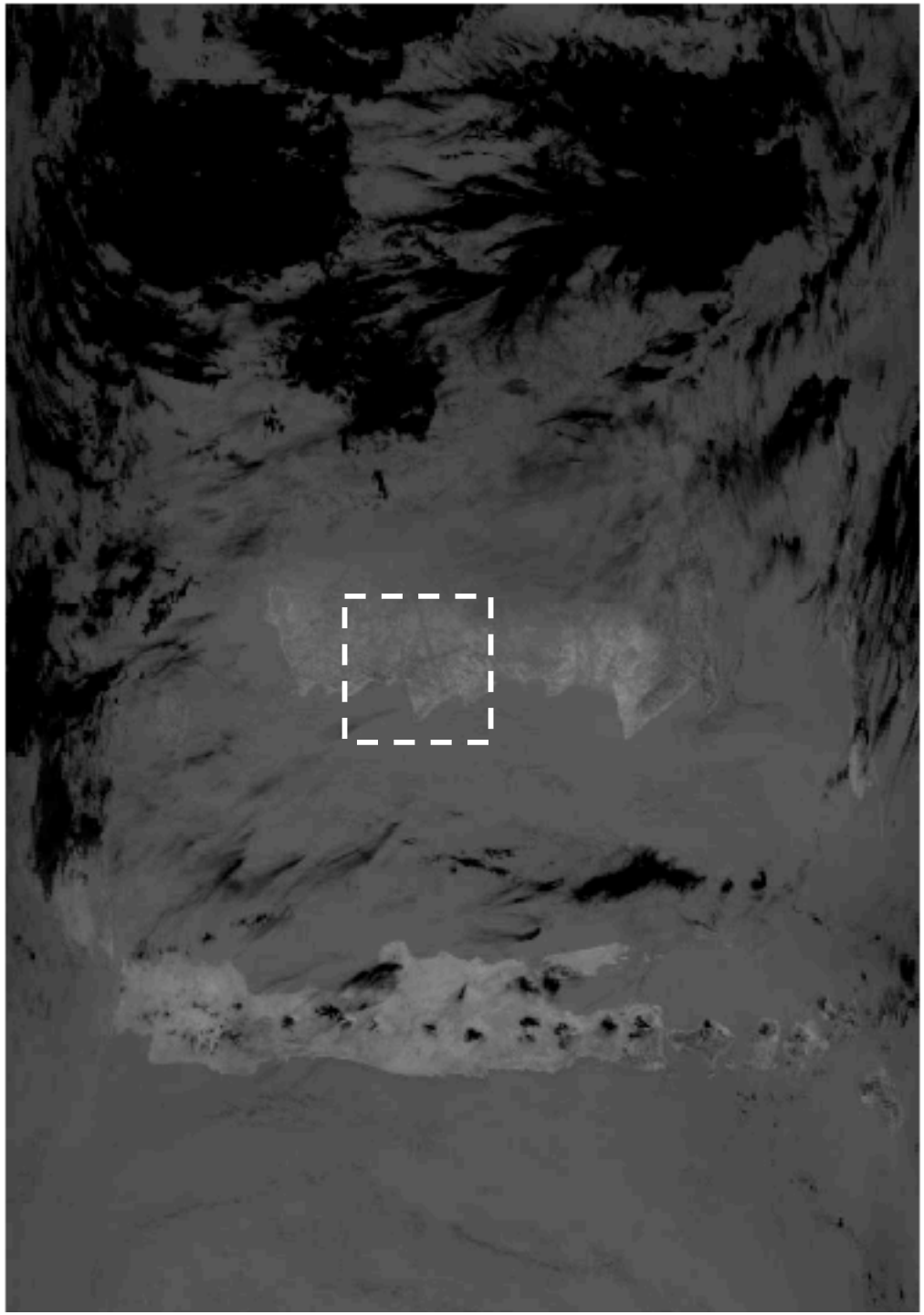


MODIS (2006.10.12)
(12 μm thermal band:
band 32)

273K
0℃

353K
80℃





The NASA algorithm (Giglio et al., 2003) (1)

Cloud/water

$$(\rho_{0.65} + \rho_{0.86} > 0.9) \text{ or } (T_{12} < 265 \text{ K}) \text{ or}$$
$$(\rho_{0.65} + \rho_{0.86} > 0.7 \text{ and } T_{12} < 285 \text{ K})$$

Heavy fire

$$T_4 > 360 \text{ K (320 K at night)}$$

Fire by contextual algorithm - compare with background *T*

ΔT: difference between T_4 and T_{11}

$$\Delta T > \overline{\Delta T} + 3.5\delta_{\Delta T} \quad (2)$$

$$\Delta T > \overline{\Delta T} + 6 \text{ K} \quad (3)$$

$$T_4 > \bar{T}_4 + 3\delta_4 \quad (4)$$

$$T_{11} > \bar{T}_{11} + \delta_{11} - 4 \text{ K} \quad (5)$$

$$\delta_4' > 5 \text{ K} \quad (6)$$

(5) or (6)

The NASA algorithm (Giglio et al., 2003) (2)

Desert

$$N_f > 0.1 N_v \quad (11)$$

$$N_f \geq 4 \quad (12)$$

$$\rho_{0.86} > 0.15 \quad (13)$$

$$\bar{T}_4' < 345 \text{ K} \quad (14)$$

$$\delta_4' < 3 \text{ K} \quad (15)$$

$$T_4 < \bar{T}_4' + 6\delta_4' \quad (16)$$

Water correction

Valid background pixels having $\rho_{2.1} < 0.05$ and $\rho_{0.86} < 0.15$ and an NDVI < 0 are considered to be unmasked water pixels, i.e. water pixels incorrectly classified as land in the MODIS land/sea mask. The number of such pixels is

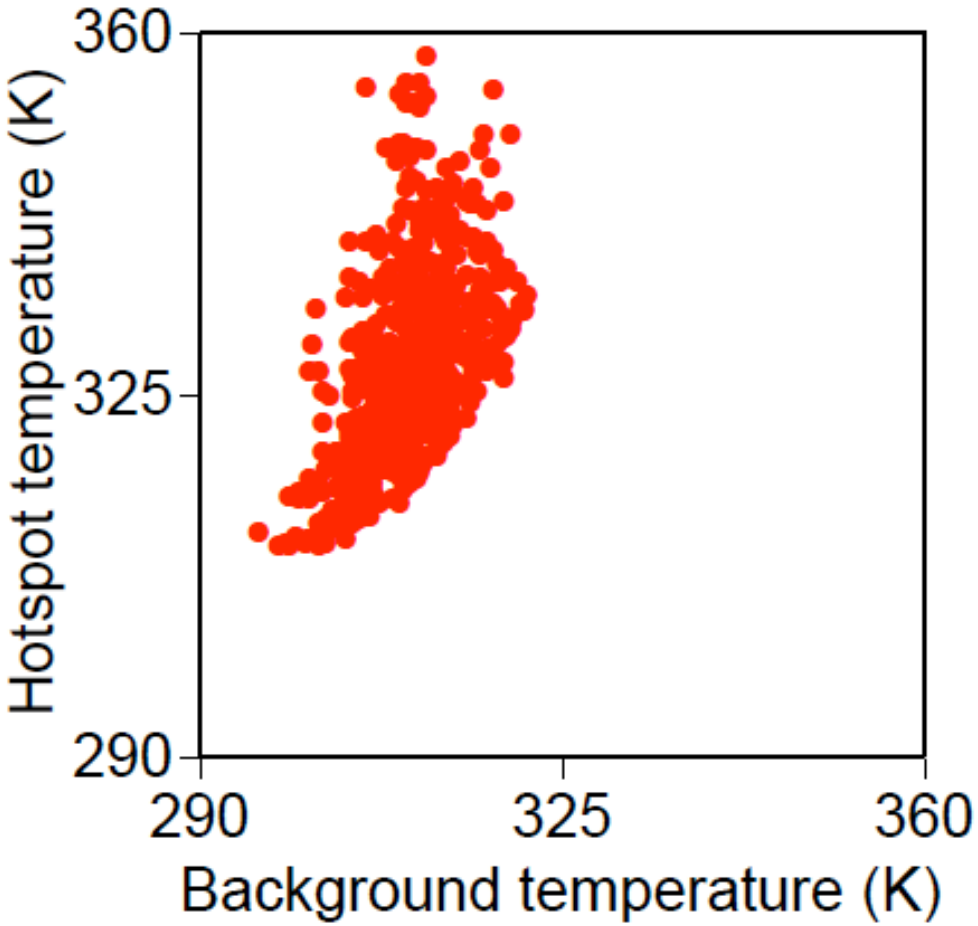


Figure. Hotspot temperatures v.s. background temperatures of hotspots (below 360 K) detected by Giglio et al. (2003) in Kalimantan island (MODIS Terra 4μm band on 12 October 2006).

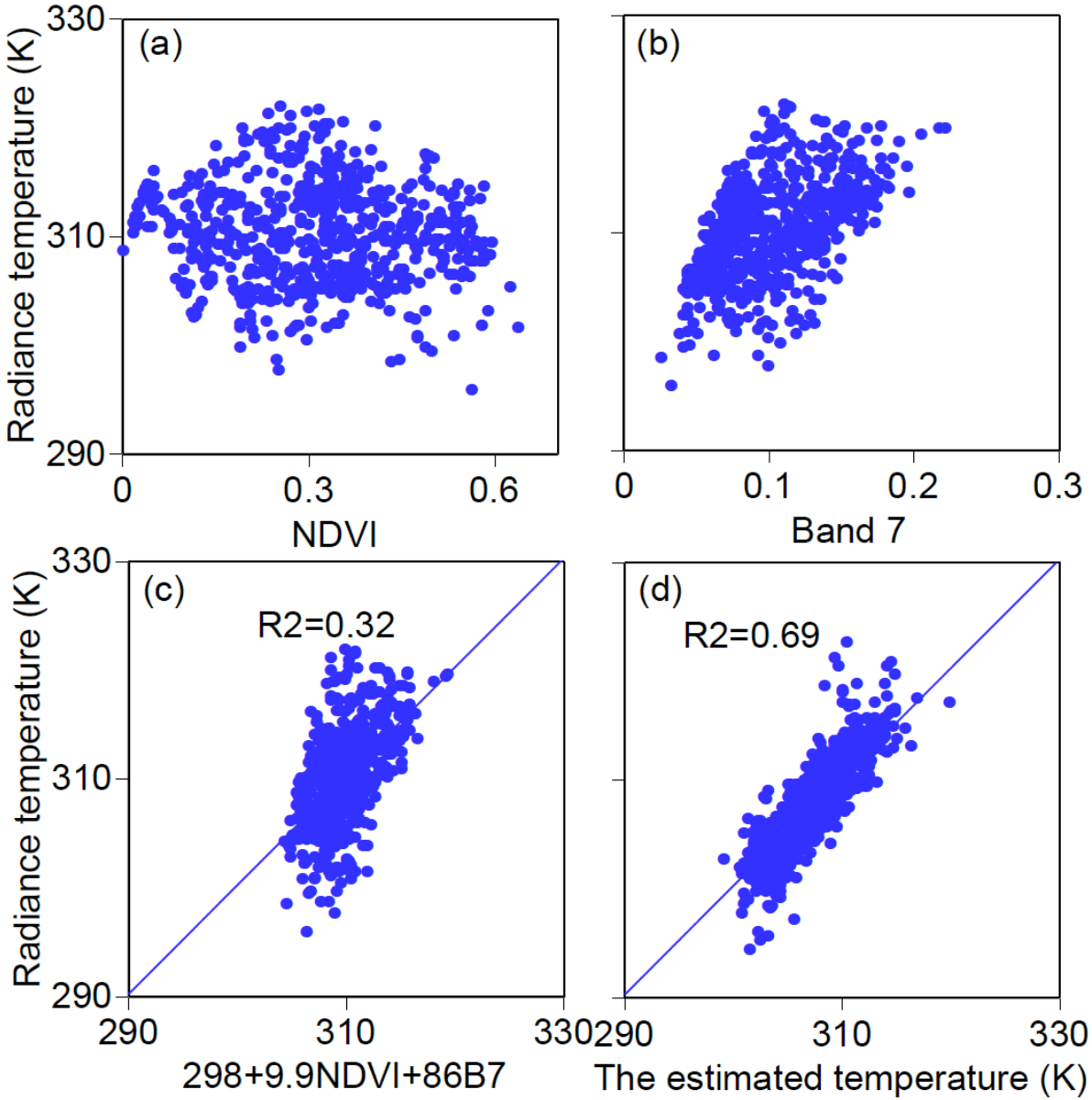
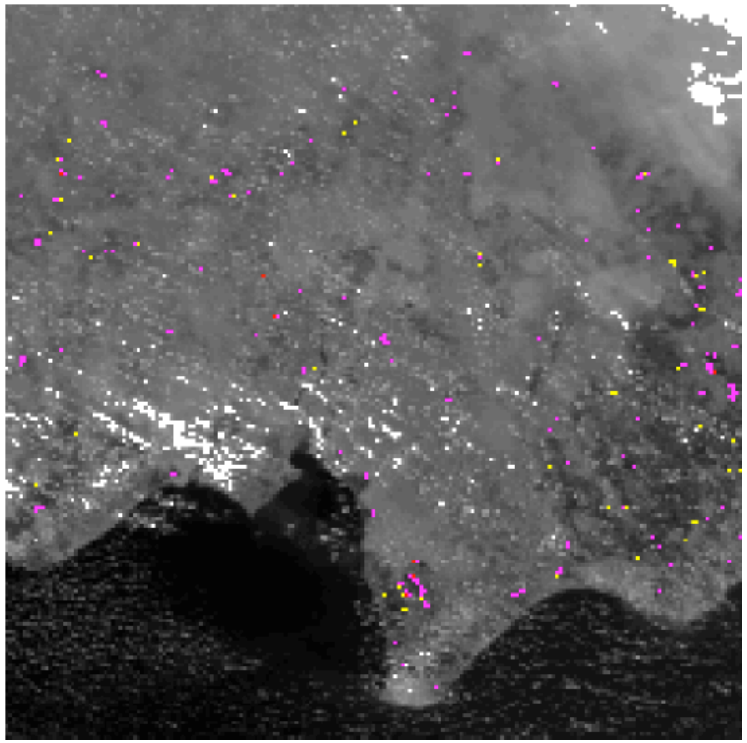


Figure. Relationships between (a) NDVI, (b) band 7, and (c)&(d) the regression equation and radiance temperature (4 μm) of background pixels for hotspot detection (MODIS Terra, band 7: 2.1 μm, 12 October 2006).The estimation equation of (d) is T4=318-250B1-11B2-0.22B3+0.64B4+0.26B5+0.22B6-81B7. (n=651)

MODIS (2006.10.12)
red: hot spot (T>360)
magenta: fire* and fire**
yellow: non-fire* and fire**
blue: fire* and non-fire**
gray: non-fire
*Giglio et al.(2003), **this study

: 200 km X 200 km area (below)



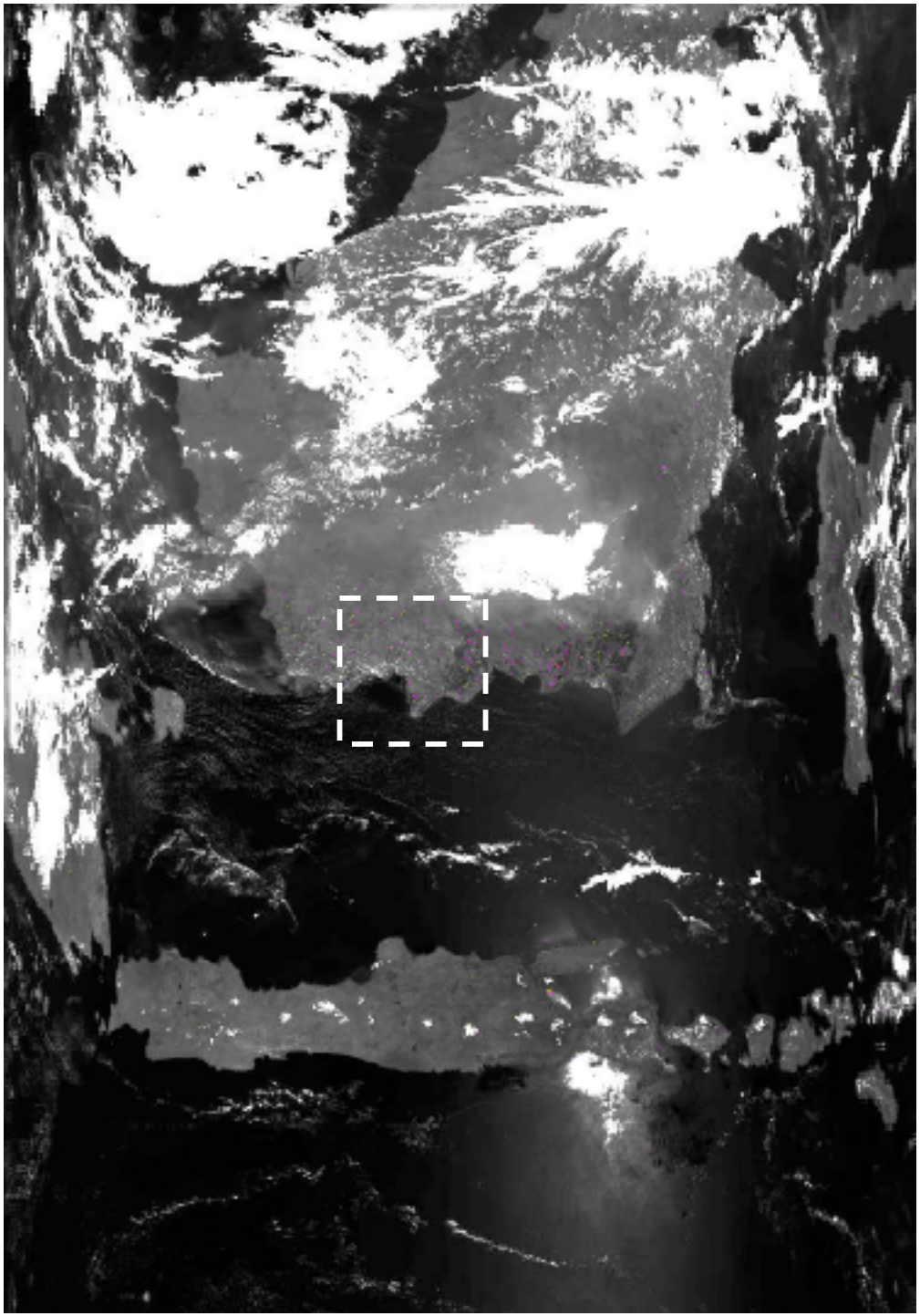
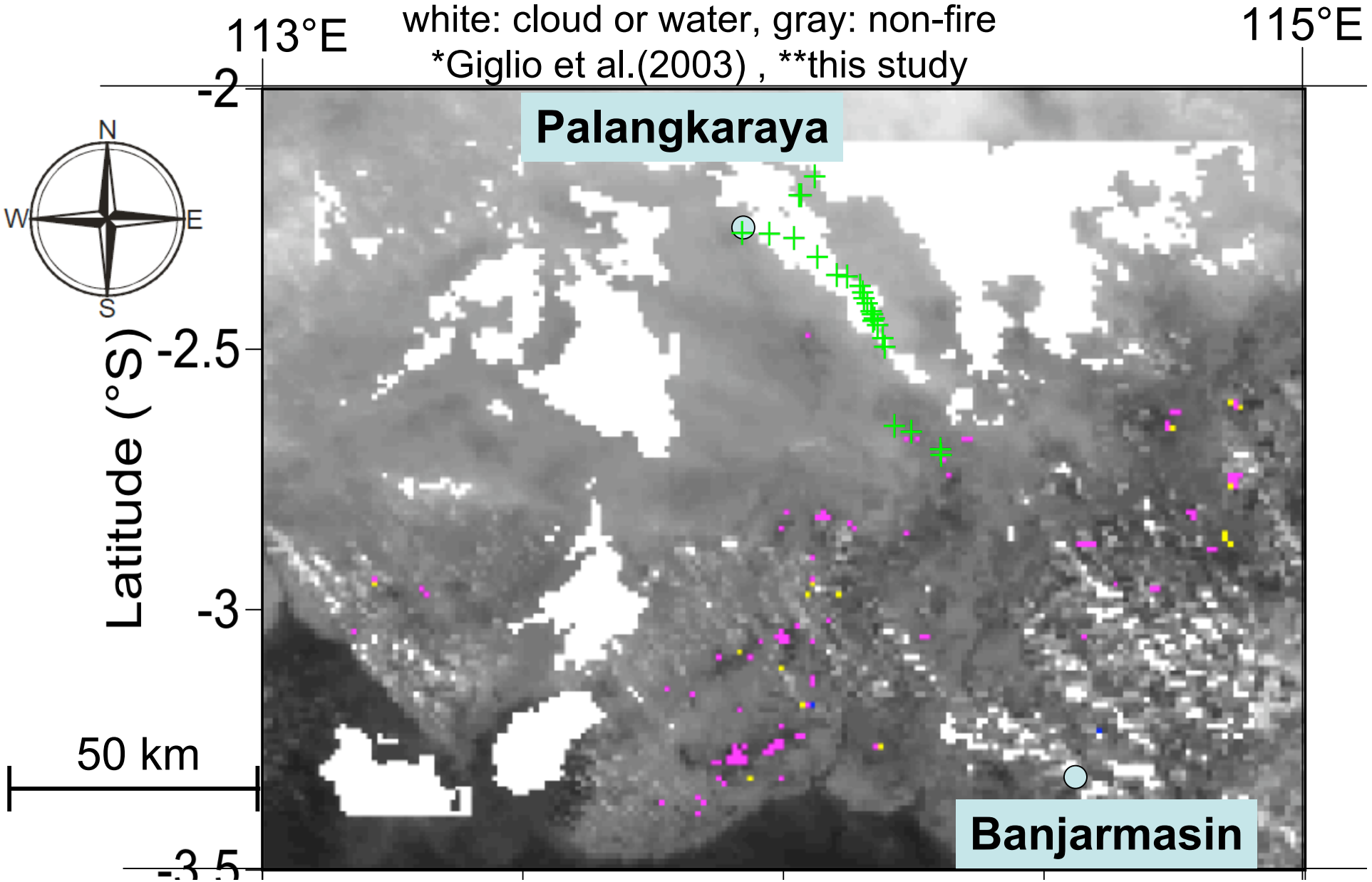
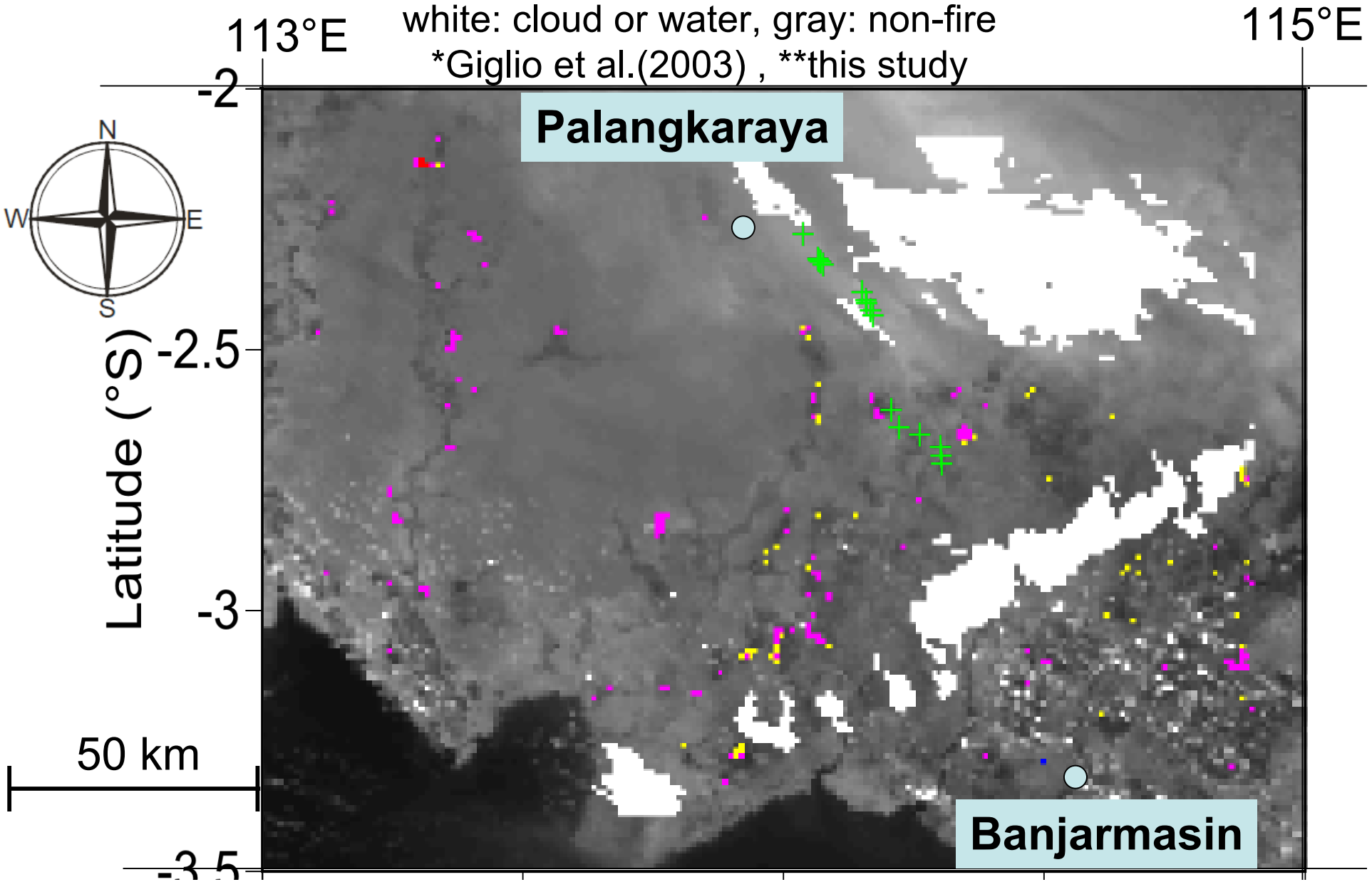


Table. Comparizon of hot spot dettection (unit: number of spots (one spot < 1 km2))

	3.Oct	5.Oct	12.Oct
Giglil et al. (2003): fire	550	707	666
this study: fire	559	738	850
Both Giglio et al. (2003) and this study: heavy fire (T>360K)	31	20	23
Both Giglio et al. (2003) and this study: fire	470	622	630
Giglio et al. (2003): non-fire, this study: fire	58	96	197
Giglio et al. (2003): fire, this study: non-fire	49	65	13
Both Giglio et al. (2003) and this study: cloud/water	768,728	151,517	436,934

MODIS (2006.10.03) v.s. ground fire observation (2006.10.01) (+)
red: hot spot (T>360),magenta: fire* and fire**
yellow: non-fire* and fire**, blue: fire* and non-fire**
white: cloud or water, gray: non-fire
*Giglio et al.(2003) , **this study




MODIS (2006.10.05) v.s. ground fire observation (2006.10.05) (+)
red: hot spot (T>360),magenta: fire* and fire**
yellow: non-fire* and fire**, blue: fire* and non-fire**
white: cloud or water, gray: non-fire
*Giglio et al.(2003) , **this study
113°E
115°E
-2
-2.5
-3
-3.5
Latitude (°S)
N
W
E
S
Palangkaraya
Banjarmasin
50 km

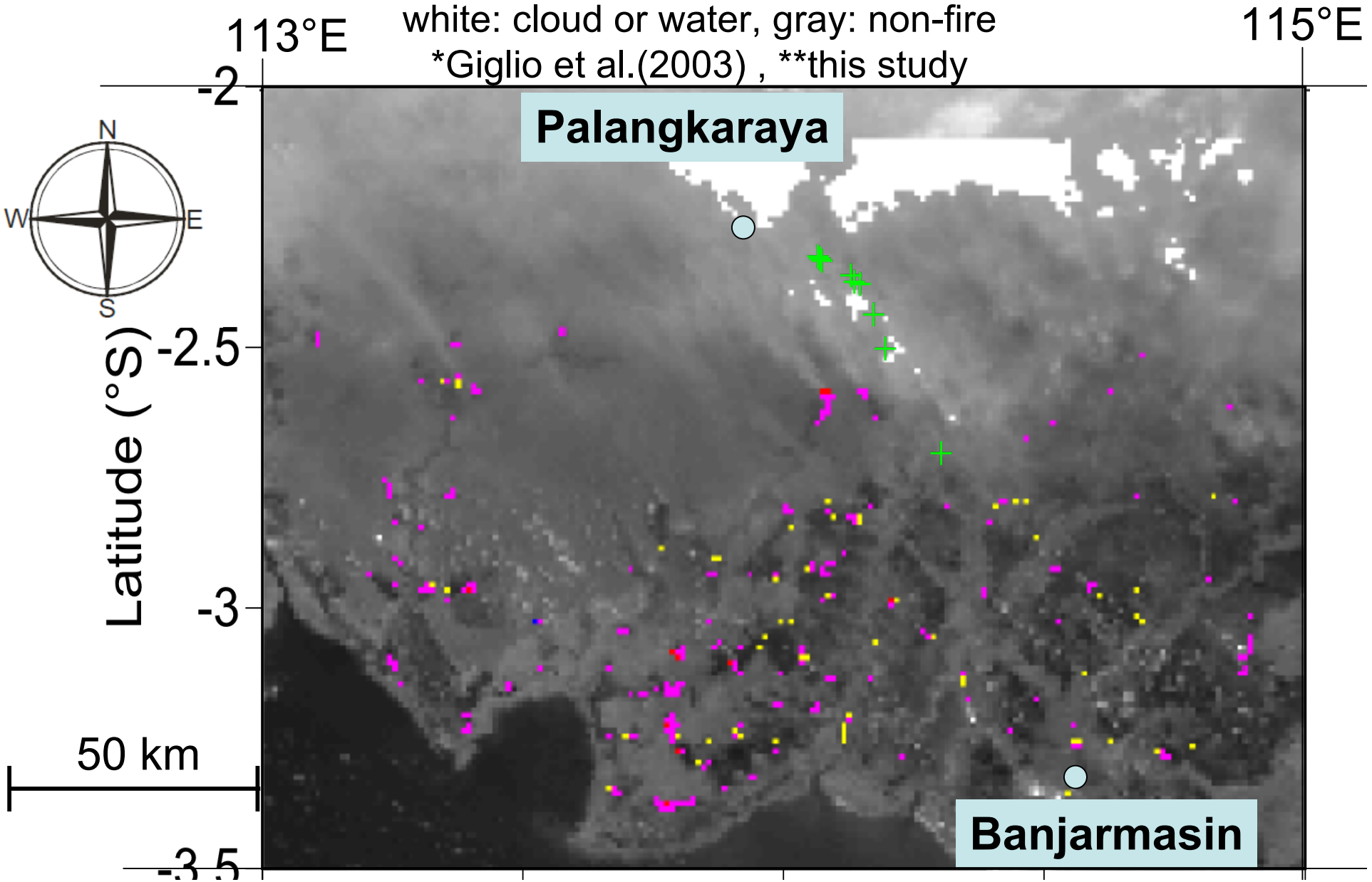
MODIS (2006.10.12) v.s. ground fire observation (2006.10.08) (+)

red: hot spot (T>360),magenta: fire* and fire**

yellow: non-fire* and fire**, blue: fire* and non-fire**

white: cloud or water, gray: non-fire

*Giglio et al.(2003) , **this study



Conclusions

- Radiance temperatures in 4μm for background pixels in Kalimantan island were estimated by using MODIS visible to near infrared 7 bands.
- As a result of the comparison between the new and NASA algorithms, the new algorithm added small hot spots near other hot spots, and eliminated small hot spots far from other hot spots.
- As a result of the comparison with field-observed fire situations, smoke along the road caused omission errors for the two algorithms.
- The new algorithm needs further inspections and evaluations using ALOS, SPOT, Landsat, and etc.