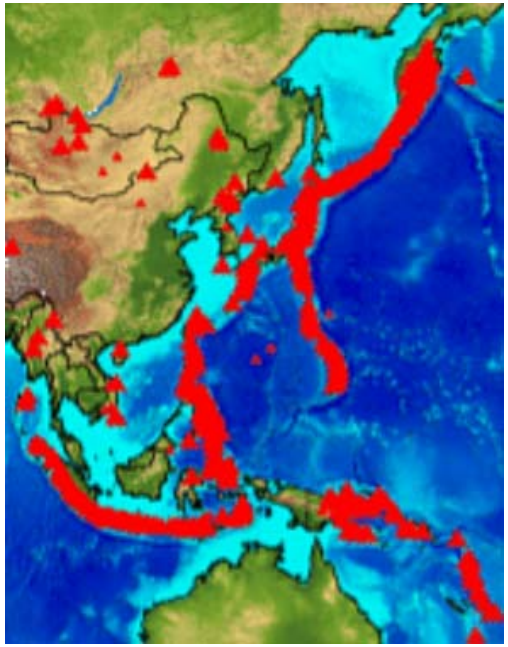
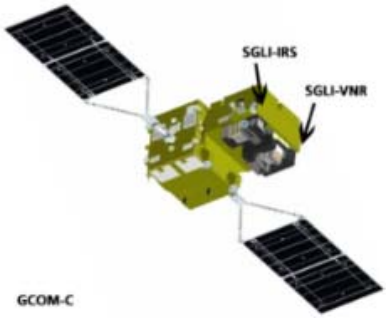
Improvement of active volcano monitoring system in east Asia by using SGLI : preparation for realtime high spatial-resolution observation





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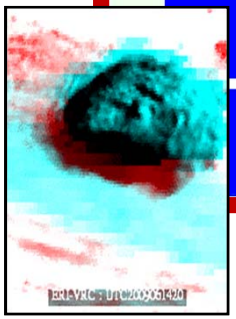
* CeRES Chiba University

Background

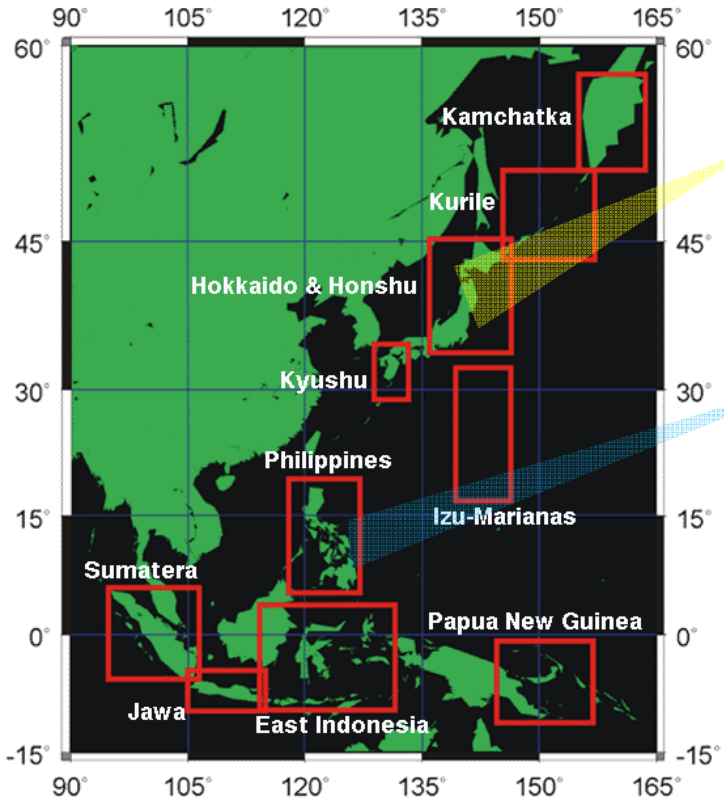
Web site
http://vrsserv.eri.u-tokyo.ac.jp/REALVOLC

observation results

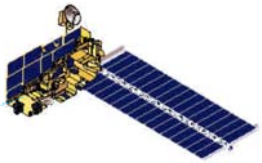


occurrence of eruption clouds

We developed a realtime monitoring system based on infrared images from MODIS and MTSAT and are monitoring active volcanoes in east Asia.

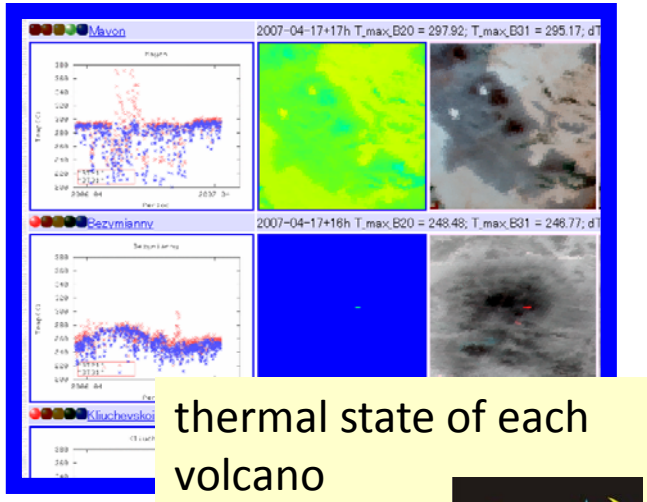


MTSAT



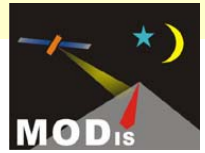
MODIS

147 volcanoes



thermal state of each volcano

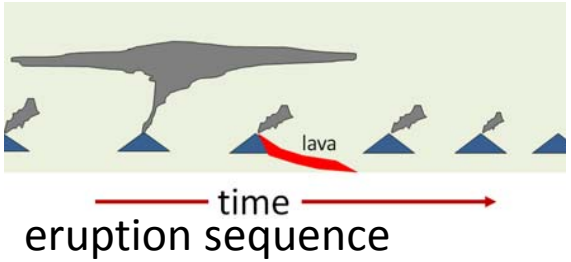
Nighttime

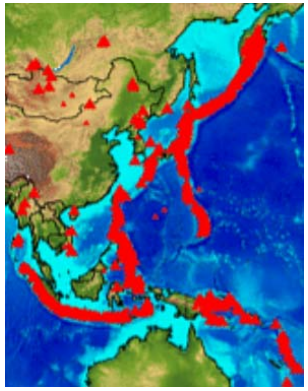


Background

■ Objectives of this project

(1) Studies on eruption sequences
(2) Provision of information on volcanic activities





In east Asia, ground-based observation network is very limited. Realtime information on activities is useful for disaster mitigation.

■ Limitations in the current system

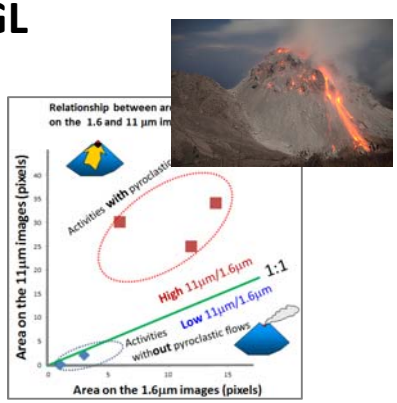
(1) Low resolution
(2) Low realtime performance

SGLI data --- high resolution and high realtime performance
If we integrate SGLI into the system, we can improve these limitations.

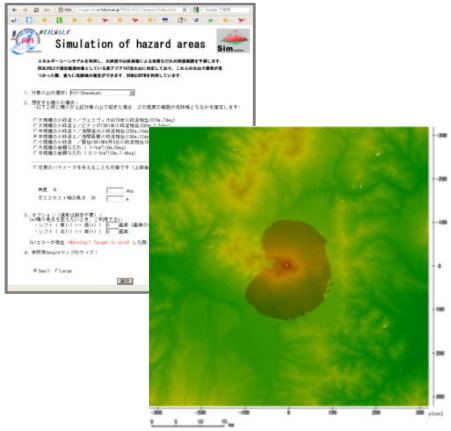
■ Previous studies on SGL

We discussed

(1) a method to monitor generation of pyroclastic flows associated with growth of a lava dome



(2) realtime monitoring & realtime simulation system using the advantages of SGLI

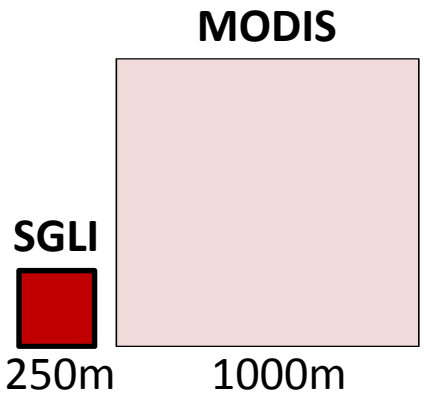


Objectives of 2013

■ **Observation of lava flows using SGIL**

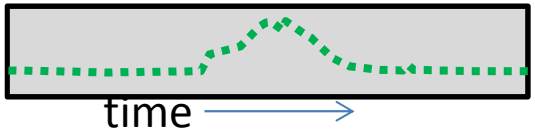
Lava flows --- most common volcanic products

Key --- use of the 250m resolution channels **1.6um, 11um**



(1) Recognition capability of distribution of lava flows - **using these two channels**

(2) Monitoring time-series variation of activity level

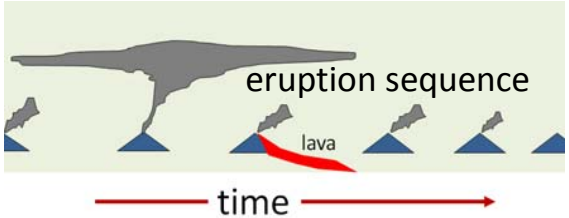


Methods

In this study, we adopted an unusual method

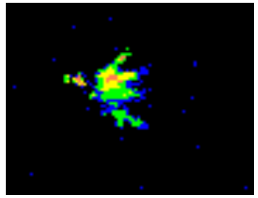
Producing SGLI images using a numerical model of lava flows

Because...



time-series images are necessary

But…



highly-frequent high resolution images are not available

Advantage

We can examine **relationship** between **initial conditions** and **resulted "SGLI images"**.

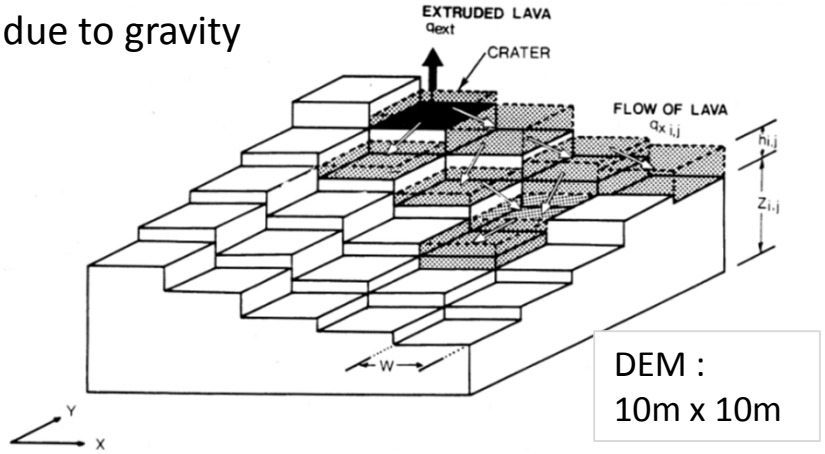
Methods

■ Numerical model of lava flows

Ishihara et al. (1990)

lava flows -- Bingham fluid

flowing down on a slope
due to gravity

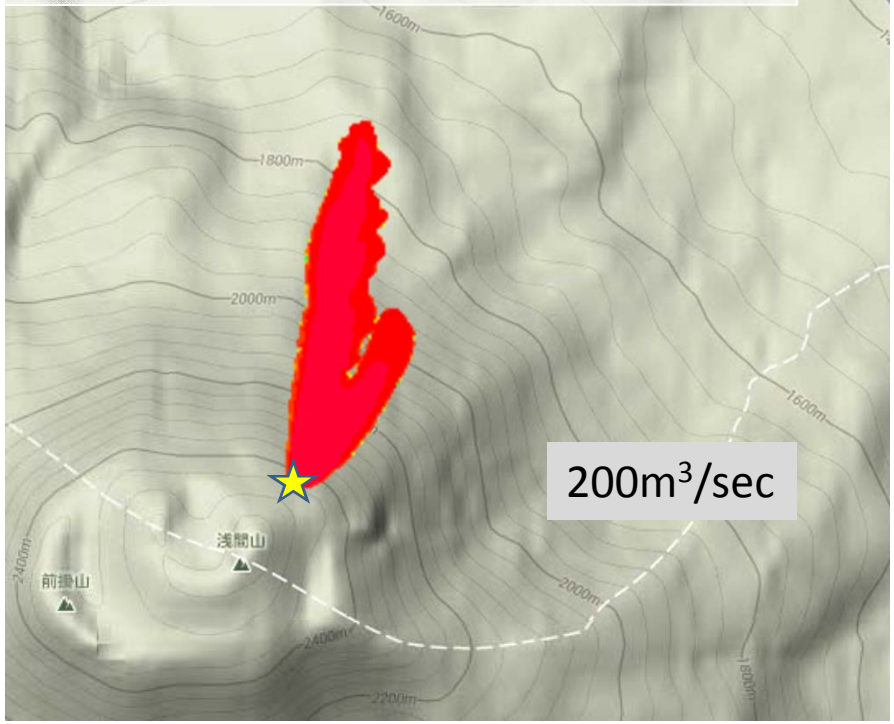


DEM :
10m x 10m

As time elapsed, lava flow spread, and is **cooled by radiation** at the surface

■ Conditions for simulation

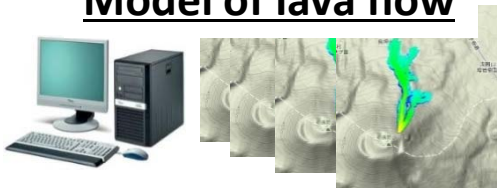
Test site: Asama volcano
DEM: 10mx10m
Effusing vent: northern side of the summit
Viscosity : eq. andesite ($\eta=3\times10^6$ poise)
Temperature of magma: 1000°C
Background temperature: 27°C
Duration: 10days
Effusion rate : constant
100, 200, 300m^3/sec



Methods

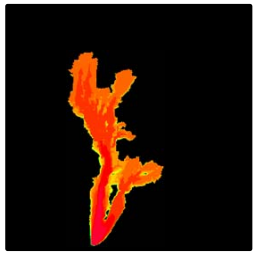
■ Procedures for producing simulated SGLI and MODIS images

Model of lava flow

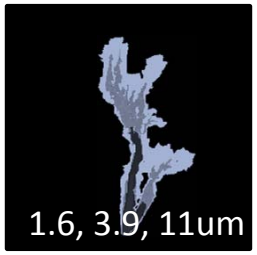


flowing process of lava flow is calculated for a period of 10 days.

every six hours



Plank (λ,T)



Temperature map

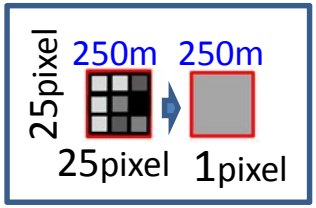
10mx10m

Temperature maps showing temperature of the lava flow are produced every six hours

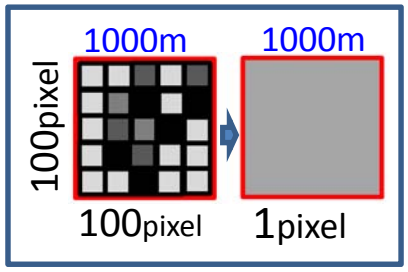
Radiance map

10mx10m

From temperature maps , **Radiance maps** are produced using plank equation

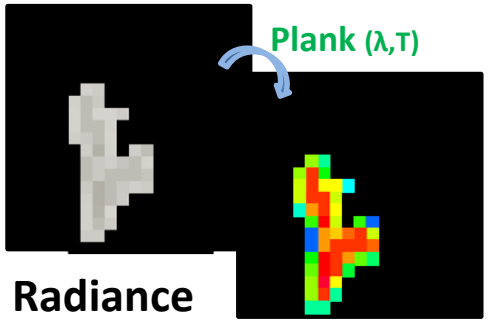


averaging



To produce **simulated SGLI** and **MODIS images**, averaged radiances are calculated from the radiance map for each pixel

Simulated SGLI images

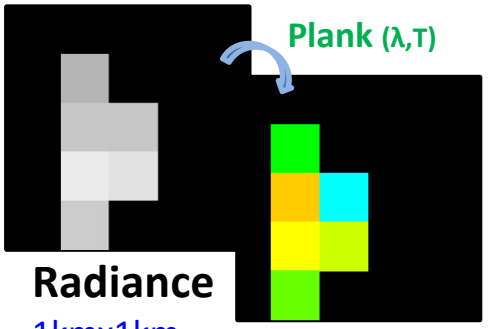


Radiance

250mx250m

Brightness T

Simulated MODIS images



Radiance

1kmx1km

Brightness T

■ Produced images

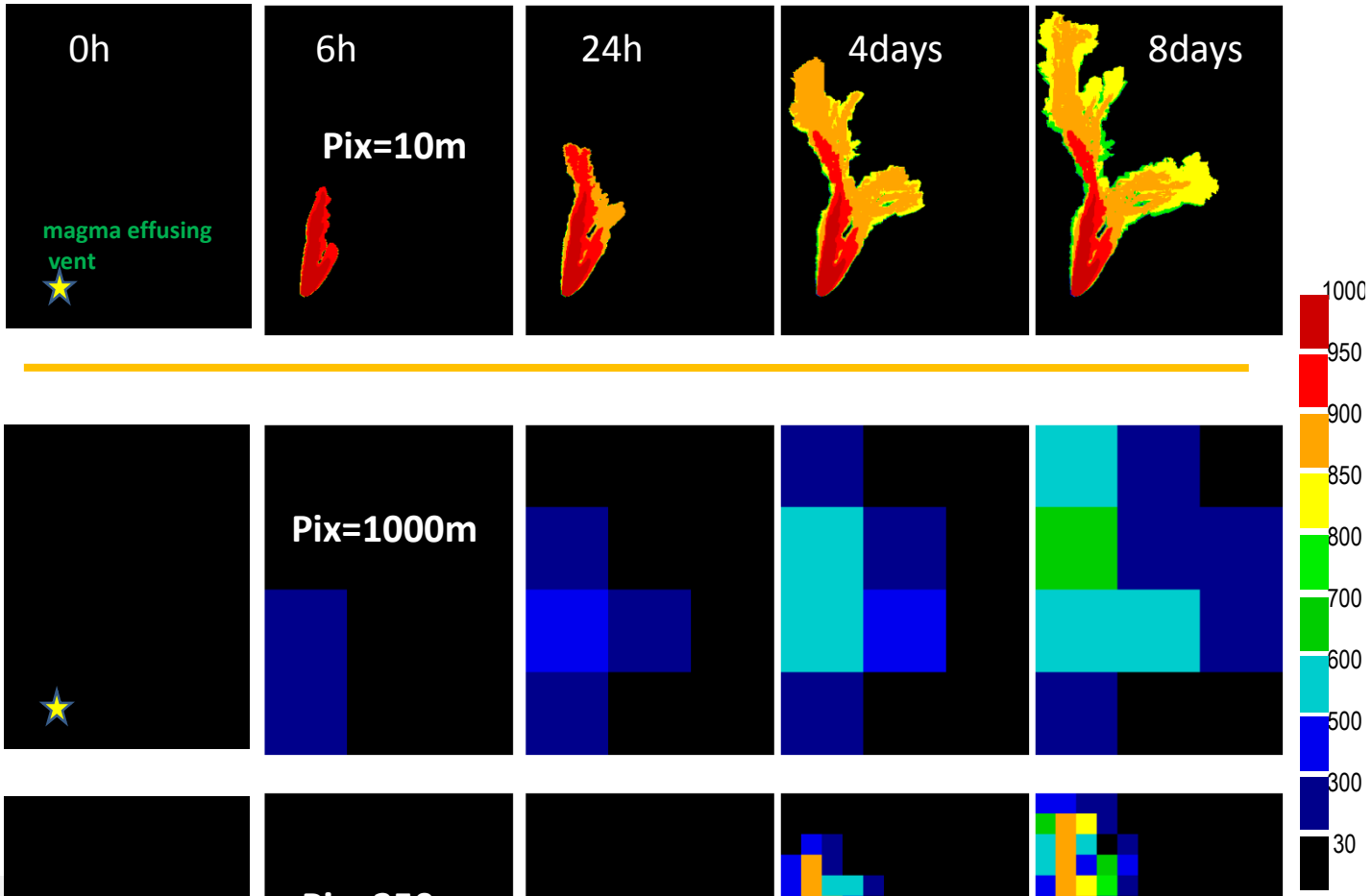
		wavelength		
SGLI	(250m x 250m)	**1.6um**	-	**11um**
MODIS	(1km x 1km)	-	**3.9um**	**11um**

Recognition capability of distribution of lava flows

■ Comparison between 250m and 1km resolutions

Temperature maps
generated by the model

Rate=200m^3/S
Andesite

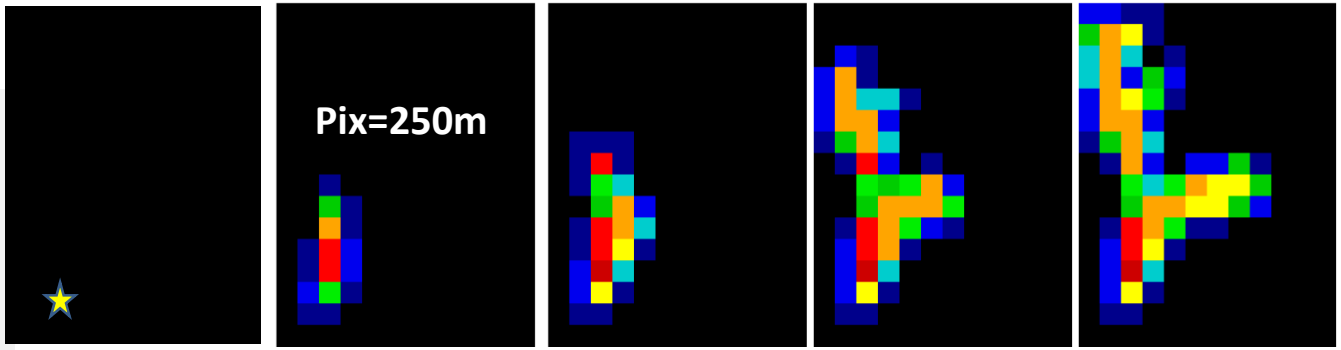


MODIS 11um BT

we can recognize enlargement of depositional area of the lava flow, but it is difficult to know the exact distribution.

SGLI 11um BT

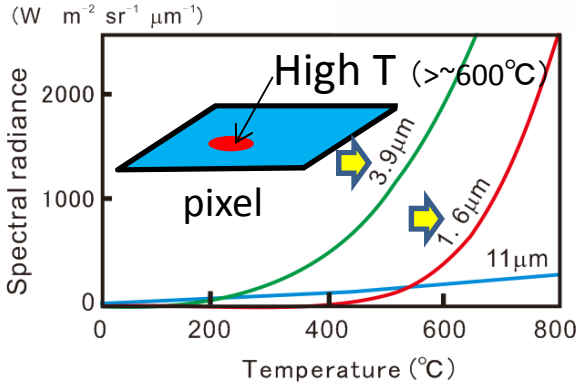
we can recognize the broad outline. Based on the time-series images, we can estimate the location of the magma effusing vent, and the moving direction of the lava flow.



Recognition capability of outline of lava flows

■ Simulated MODIS 3.9um and SGLI 1.6um BT images

Basic features are the same as those in the 11um images.



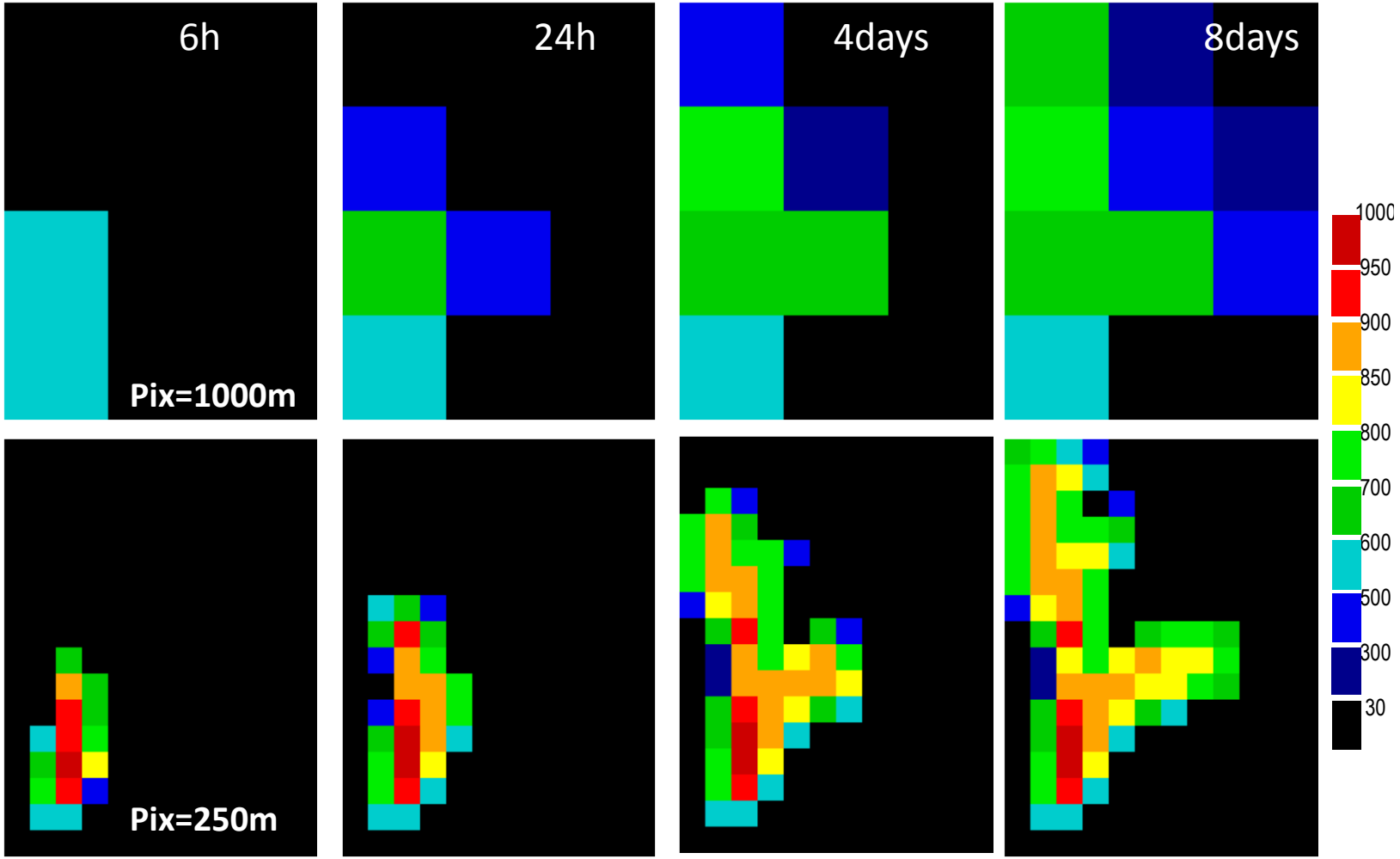
(eruption rate: 200m³/S)

MODIS 3.9um BT

current system monitoring activity level

SGLI 1.6um BT

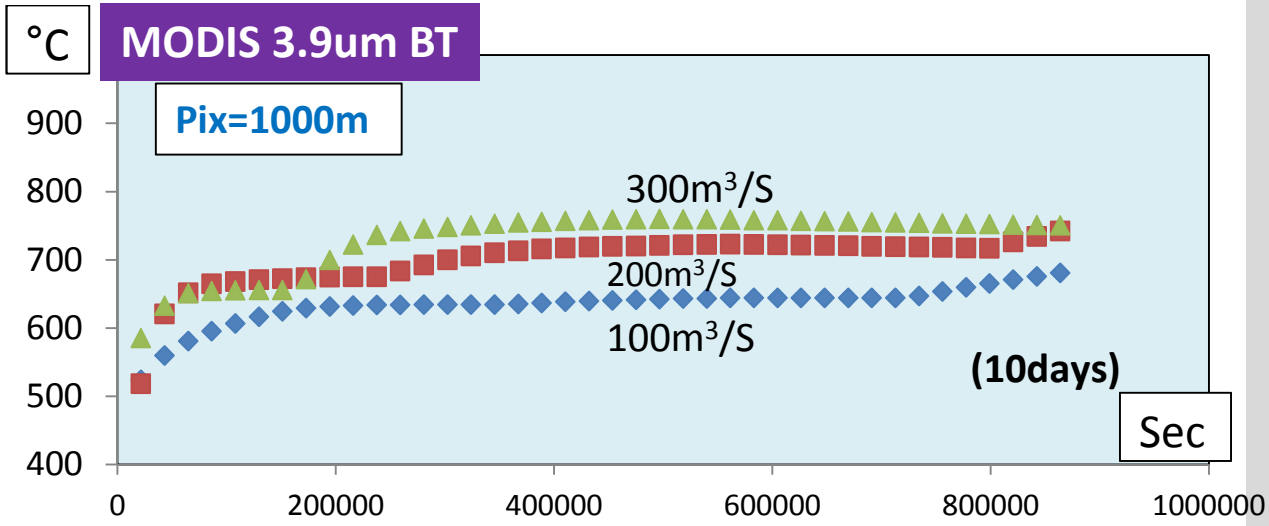
SGLI system monitoring activity level



These channels are sensitive to existence of high temperature objects within a pixel → higher BT than 11um images

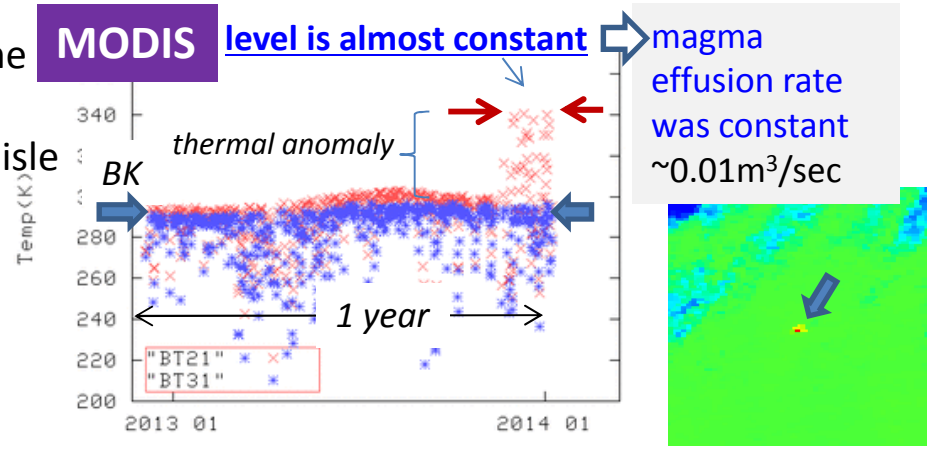
Monitoring time-series variation of activity level

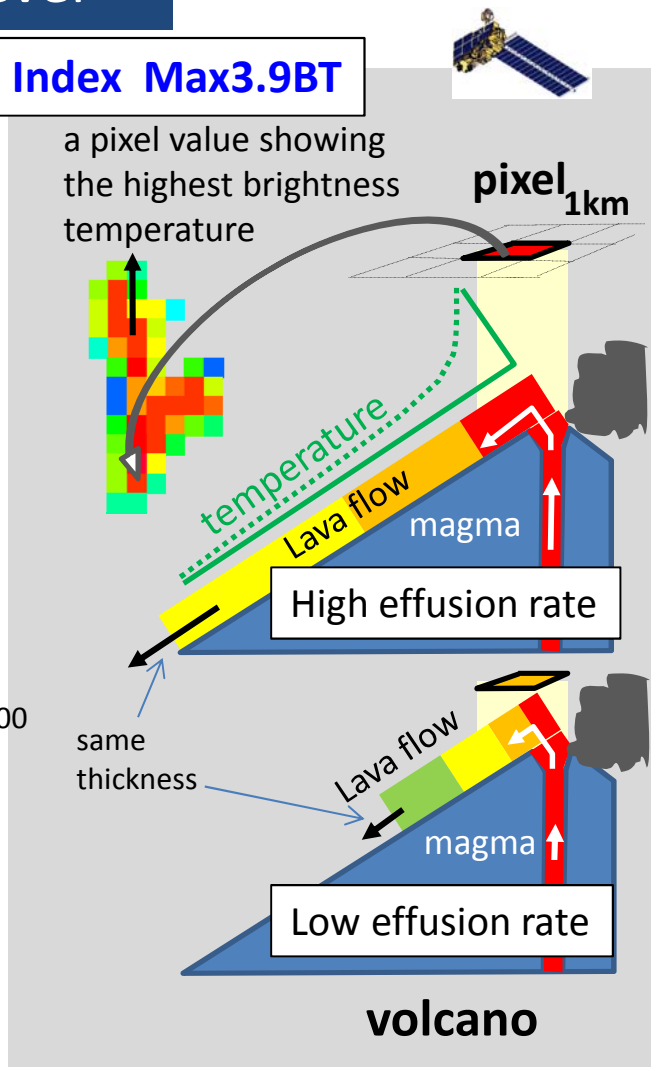
■ Time-series variations of the same index -Max3.9BT-
as that of the current MODIS system



Higher effusion rate shows higher level. Each of them shows a constant level, corresponding to the constant magma effusion rates.

e.g.,
Variation of the same index in Nishinoshima isle
(Nov 2013-)





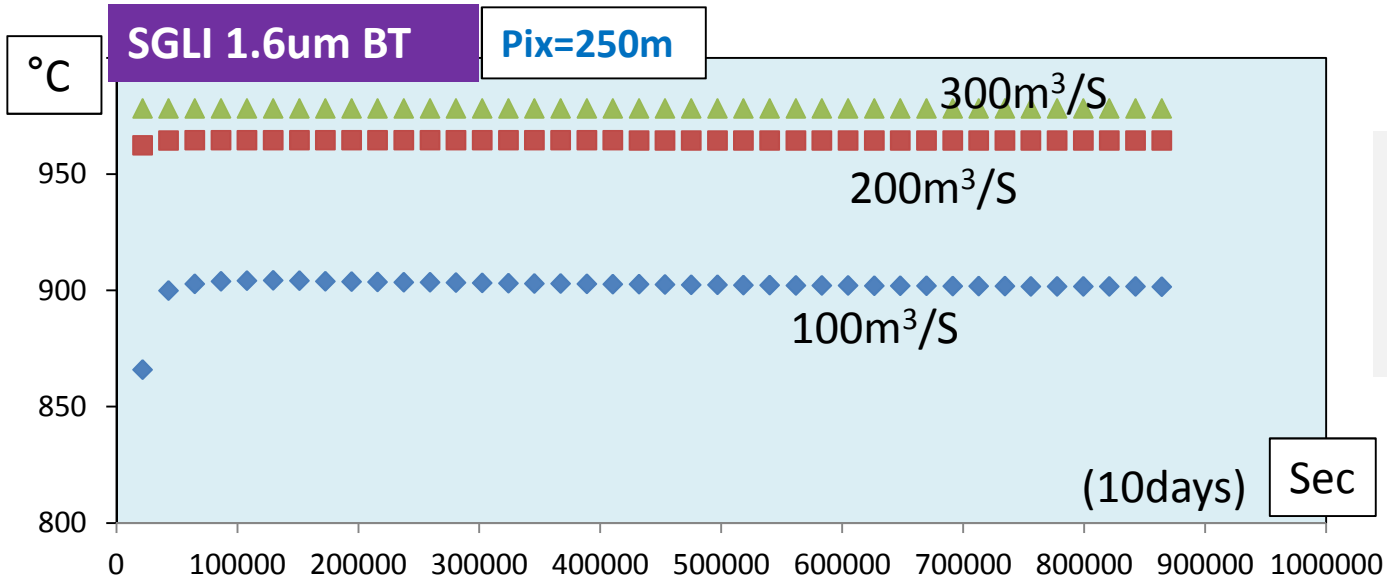
With increase of **magma effusion rate**, the **brightness temperature** of this pixel increases, corresponding to expansion of the **high temperature area** on the lava flow.

Monitoring time-series variation of activity level

■ Adopting the same type of index as MODIS in the SGLI system (Max1.6BT)

Time-series variations of the same index as MODIS (Max1.6BT)

pixel value showing the highest brightness temperature



Higher effusion rate shows higher level

Each of them shows a constant level

→ we may use this index for monitoring in the SGLI system.

very high temperature levels...

The numerical model
--- indicating higher temperature
than that of the actual surface

Saturation level of the 1.6um channel of SGLI
--- around 450°C in BT

⇨ In the case of **low effusion rate**,
we can possibly observe lava flows without saturation with the 1.6 um channel

⇨

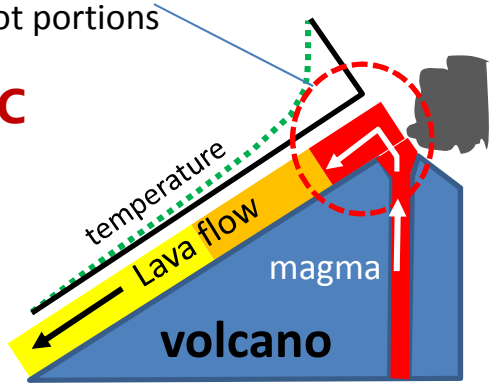
Monitoring time-series variation of activity level

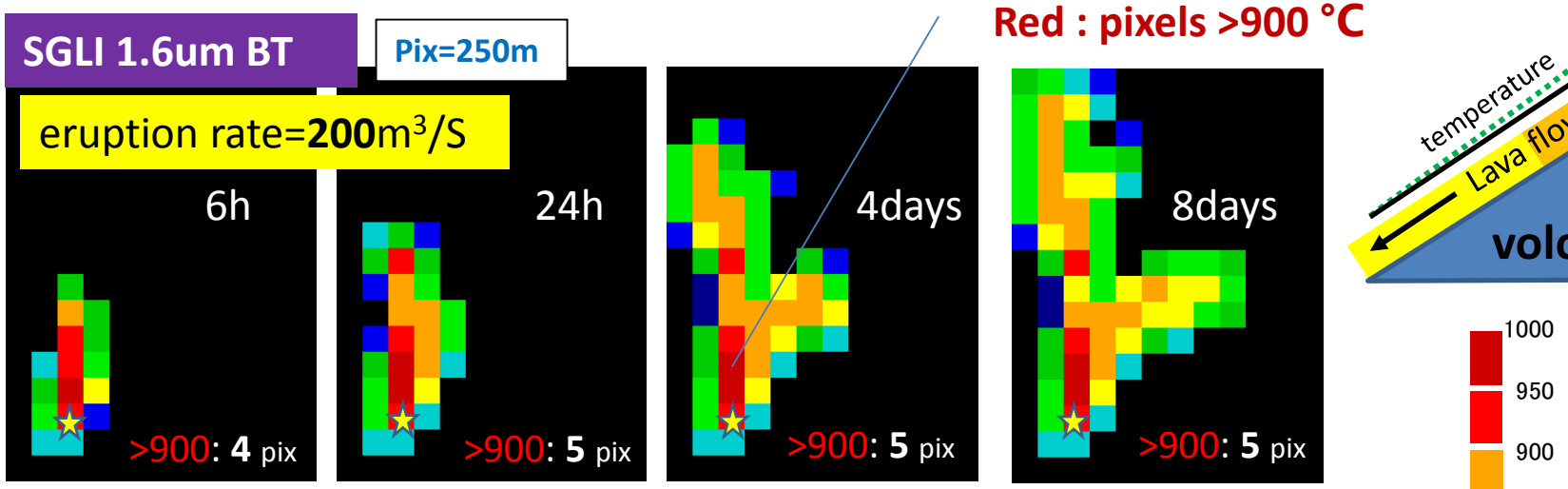
■ Use of a multi-pixel type index for monitoring

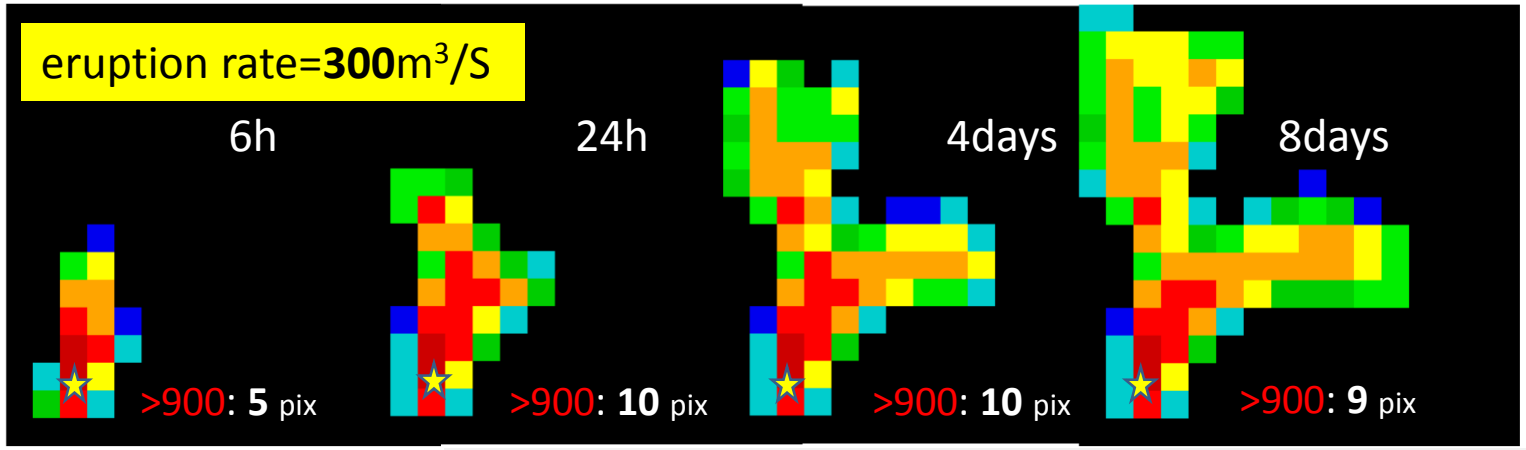
Simulated SGLI images of the 1.6um channel

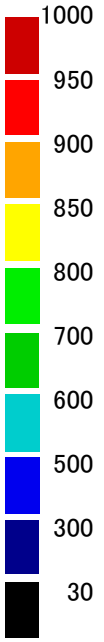
extending from the effusing vent, and corresponding to the very hot portions just after effusion

Red : pixels >900 °C







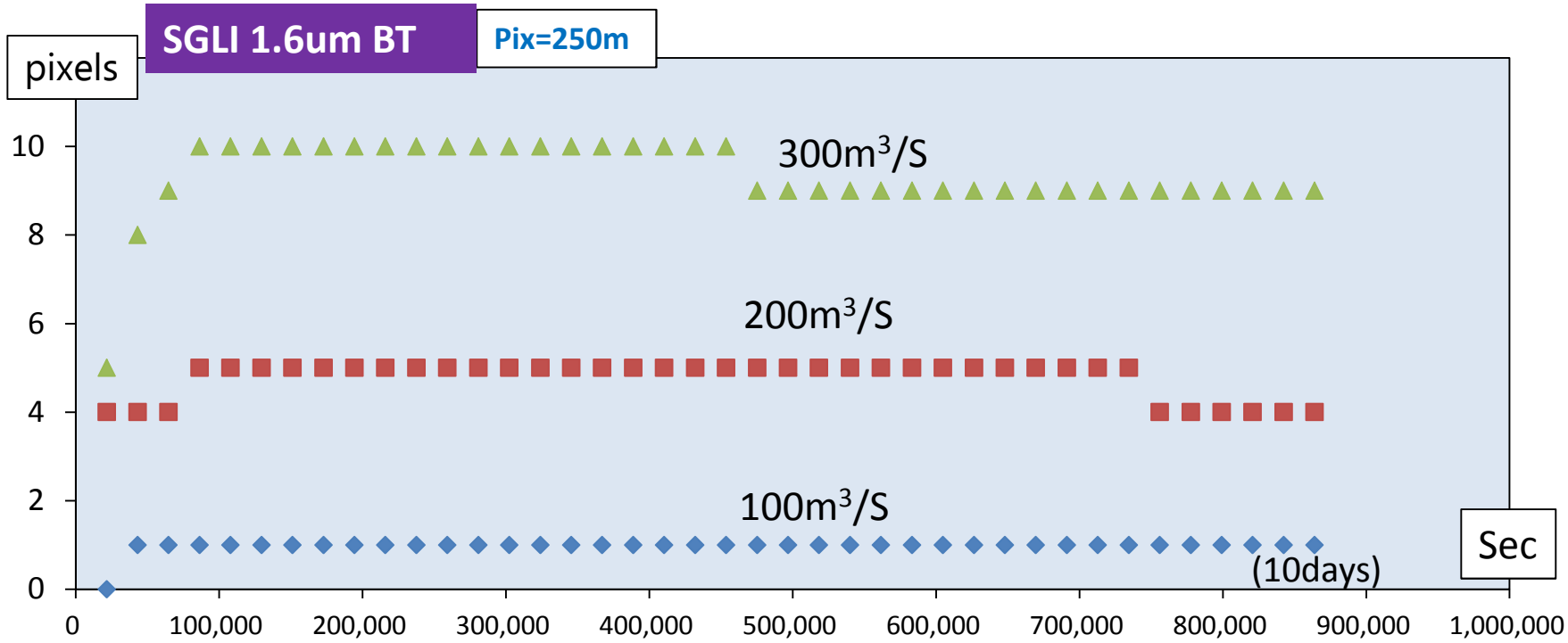


As time elapsed, distribution area of the lava flow enlarges

Number of "Red pixels" - constant at the same eruption rate
- increases with increase of effusion rate

Monitoring time-series variation of activity level

■ Time-series variations of the number of pixels > 900 °C



Higher effusion rate shows higher level
Each of them shows a constant level through the period
⇒ can be used for monitoring activity level

As to the threshold value, here we assumed to be 900 °C.,
we need to discuss more by using improved models, together with actual satellite images.

Provision of information

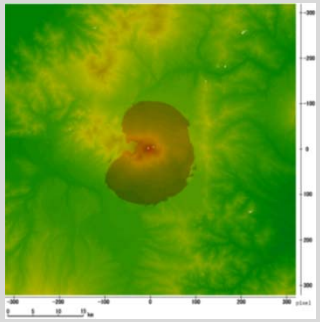
■ Web page

In the webpage of SGLI, we plan to show these types of real time information

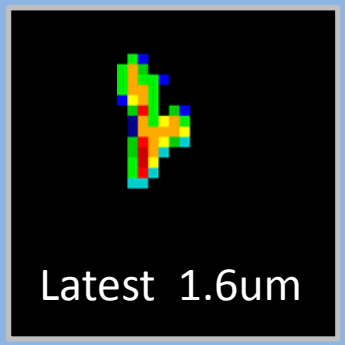
No.**
----- Volcano

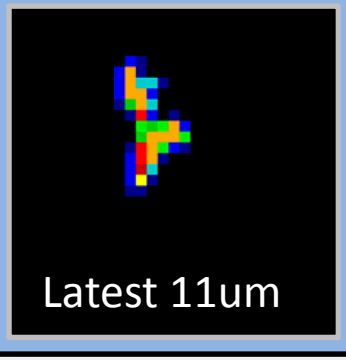
topography

simulations

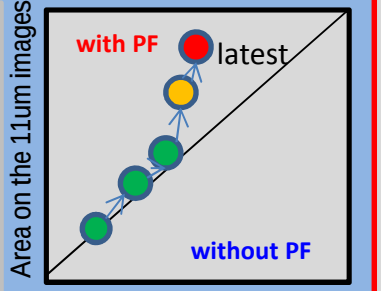


nighttime **SGLI**





Pyroclastic flow



Time series variations of 1.6um channel (>900°C)

Time series variations of 1.6um channel (Max1.6BT)

Time series variation of 11um channel（Total Area）

MODIS

Himawari

Application of the monitoring system of SGLI

Development of a realtime observation and realtime simulation system

Real-time monitoring

Real-time simulation

WWW

Eruption

SGLI 11um

Map

Using SGLI

eruption details
location of the eruption started or flow direction

Web-based simulation system

anyone can use

Time-series

a lava flow effused from the summit of a volcano

250m

comparing with a topographic map

estimation of **hazard areas**

lava flows

pyroclastic flows

realtime hazard maps

considering disaster-prevention measures

particularly useful in east Asia

Summary and future subjects

This year we have worked on observation of lava flows using simulated SGLI images produced by a numerical model of lava flows.

SGLI has higher recognition capability of distribution of lava flows compared to that of MODIS.

As to monitoring time-series variation of activity level (eruption rate of lava flow) , indexes based on single pixel or multi pixels of SGLI 1.6um channel are thought to be applicable .
However, we need to examine these indexes more by using improved models, together with actual satellite images.

Recognition capability of outline of lava flows