Application Studies for Active Fire Monitoring over Korea Using MODIS Direct Broadcast Data

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Abstract: The MODIS Land Rapid Response System (RRS) has been developed to provide rapid access to MODIS data globally, with initial emphasis on 250 m color composite imagery and active fire data. Fire detection is based on a contextual algorithm that exploits the strong emission of mid-infrared radiation from fires. This algorithm examines each pixel of the MODIS swath, and ultimately assigns to each one of the following classes: missing data, cloud, water, non-fire, fire, or unknown.

In this paper, we introduce the MODIS Rapid Response System established at the Korea Aerospace Research Institute (KARI) and present some application results for Korea using the direct broadcast data acquired at KARI ground station.

Keywords: MODIS, RRS, Fire Detection

1. Introduction

Moderate Resolution Imaging Spectroradiometer (MODIS) is a key instrument aboard the Terra and Aqua satellites, which was launched as part of NASA's Earth Observing System (EOS). MODIS are viewing the Earth surface every 1 to 2 days, acquiring data in 36 spectral bands, or groups of wavelengths. These data will improve our understanding of global dynamics and processes occurring on the land, in the oceans, and in the lower atmosphere.

The MODIS Fire Products are designed to provide information for both global change science and practi-cal applications. The MODIS Fire Products has two types: an active fire product which give the location of burning fires and a burned area product which gives the extent of burn scars over a specified time period.

The MODIS Rapid Response system has been developed to provide rapid access to MODIS data globally, with initial emphasis on 250m color composite imagery and active fire data. Imagery and data are now being provided to a number of users e.g. the USFS Remote Sensing Applications Center (RSAC), the National Interagency Fire Center (NIFC), the U.N. Global Fire Monitoring Center, and NASA's Earth Observatory. The data delivery system is also being developed as a contribution to the implementation of the international Global Observation of Forest Cover/Global Observation of Landcover Dynamics (GOFC-GOLD).

2. Fire Detection Algorithm Description

Active fire detection for MODIS is based on heritage algorithms developed for the AVHRR and TRMM VIRS. The algorithm mainly uses brightness temperatures derived from the MODIS 4 ㎛ and 11 ㎛ channels.
The purpose of the detection algorithm is to identify pixels in which one or more fires are actively burning at the time of the satellite overpass; such pixels are generally referred to as 'fire pixels'.

Table 1. MODIS channels used in detection algorithm [2]

No. of Channel	Wavelength (㎛)	Purpose
1	0.65	Sun glint and coastal false alarm rejection; cloud masking
2	0.86	Bright surface, sun glint and coastal
7	2.1	Sun glint and coastal false alarm rejection
21	4.0	High-range channel for active fire detection
22	4.0	Low-range channel for active fire detection
31	11.0	Active fire detection, cloud masking
32	12.0	Cloud masking

The fire detection algorithm is based on the absolute detection and relative detection. The absolute method is for the strong enough fire and the relative method is for the weaker fire. The relative method identifies pixels with values elevated above a background thermal emission obtained from the surrounding pixels.

1) Absolute Fire Detection

For the absolute method, the algorithm requires that at least one of two conditions be satisfied.

① T4 > 360 K (at daytime), 330 K (at night)
② T4 > 330 K (at daytime), 315 K (at night) and T4 –

T11 > 25 K (at daytime), 10 K (at night)

where, T4, T11 are the brightness temperatures derived from 4 ㎛ and 11 ㎛channels, respectively.

If either of these absolute conditions is not met, the algorithm pursues a relative method [1].

2) Relative Fire Detection

In a relative method, the fire is distinguished from the followed conditions.

T4 > mean(T4) + 3stddev(T4) and T4 – T11 > median(T4 – T11) + 3stddev(T4 – T11)

The fire is distinguished from the mean background values by three standard deviations in T4 and T4 – T11. The relative detection process are computed for pixels within an expanding grid centered on the candidate fire pixel until a sufficient number of cloud, water and fire-free pixels are identified. Especially fire-free background pixels are identified as those pixels for [1]:

T4 < 325 K (at daytime), 315 K (at night) and T4 – T11 < 20 K (at daytime), 10 K (at night)

3. MODIS Rapid Response Fire Product

1) MODIS Active Fire Products

The current MODIS fire products are listed in Table 1.

Table 2. MODIS current fire products

MODIS Fire Product	Data Type
Level 2 Fire Product	MOD14
Rapid Response Fire Product	-
Level 2G Daily Daytime Fire Product	MOD14GD
Level 2D Daily Nighttime Fire Product	MOD14GN
Level 3 Daily Fire Product	MOD14A1
Level 3 8-Day Summary Fire Product	MOD14A2
Global Daily Fire QA Browse Imagery	-

The Level 2 fire product is the most basic fire product in which active fires and other thermal anomalies, such as volcanoes, are identified.

Global browse images of the MODIS active fire product are generated on a daily basis at 5 km and 20 km spatial resolution.

2) MODIS Rapid Response System

The MODIS Rapid Response System (RRS) was developed in response to the need, articulated in particular by the fire community, for MODIS fire data shortly after acquisition.

The MODIS fire algorithm is applied to the data and then generates images superimposing the 1 km active fires on the 250 m corrected reflectance product for the same acquisition and made available over the World Wide Web. Combining the two products provides a geographic context to the fire locations.

The MODIS Rapid Response System (RRS) products are as follows:

① Near-Real-Time Production

Daily MODIS RGB imagery products are available as produced.

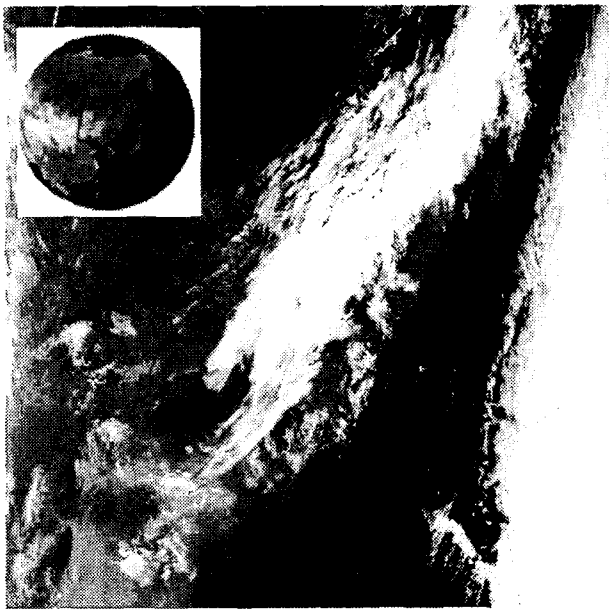

Figure 1. An Example of Near-Real-Time Production (Terra, 09/29/2004, 02:35 UTC)

② Image Gallery

A number of images are handpicked each day and posted on Image Gallery page by the MODIS Rapid Response System as soon as possible after data acquisition.

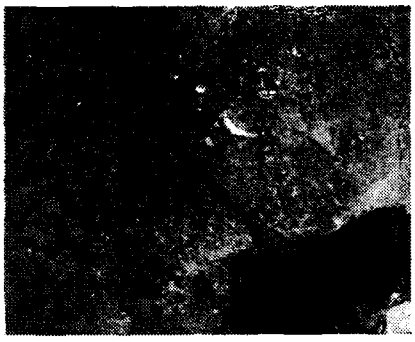

Figure 2. An Example of Image Gallery (The Volga River Delta, Russia, 09/29/2004)

③ Web Fire Maps

Web fire maps views an interactive map incorporating

active fire detection point data from MODIS with physical features and the University of Maryland's land cover product. It displays for fire detections in a given date range, and query a particular detection for more information (time, brightness temp, latitude and longitude).

④ USFS Remote Sensing Applications Center Regional Fire Maps

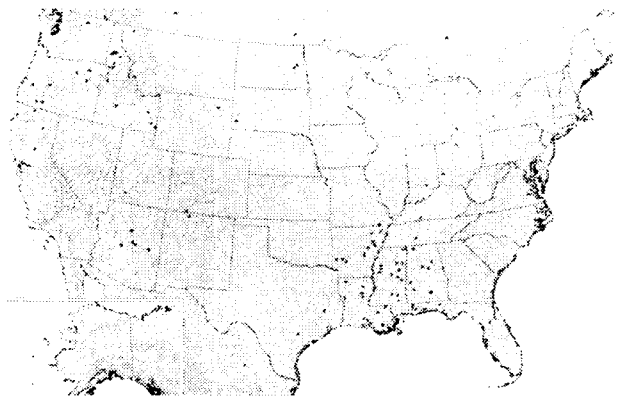

Figure 3. An Example of USFS RS Applications Center Regional Fire Maps (Current MODIS Fire Detections From 09/28/2004, 2 AM MDT to 09/29/2004, 2 AM MDT)

These cumulative fire extent maps show actively burning area and previously burned area from the MODIS Rapid Response system. This product contains fire detection data and summary information that includes fire location for the 24-hour period previous to the specified time. Fire locations are geolocated using thermal data collected at a spatial resolution of 1 km and represent the centroid of a MODIS pixel.

⑤ Monthly Active Fire Distributions

This maps show the global distribution of fire detections produced by the MODIS Rapid Response System. These active fire detections are produced using the same algorithm as the standard MODIS MOD14 Fire and Thermal Anomalies Product. Each detection represents the center of a 1 km pixel flagged by the algorithm as containing a fire within that pixel.

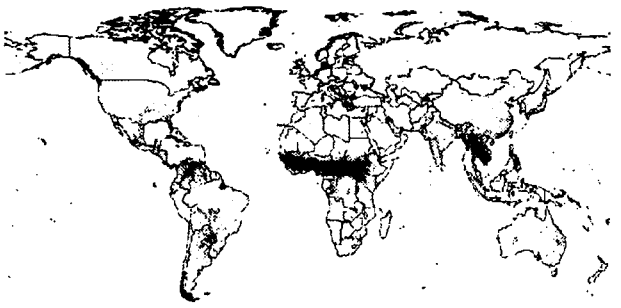

Figure 4. An Example of Monthly Active Fire Distributions (February 2004, Terra data only)

4. The MODIS Rapid Response System at KARI

The Korea Aerospace Research Institute (KARI) established the MODIS Rapid Response System in September, 2003 and have been applied the MODIS Rapid Response System for the Korea Peninsula including neighboring areas using the direct broadcast data acquired at KARI ground station.

1) Importing and Installation the MODIS Rapid Response System

The KARI has been received the Terra and Aqua MODIS data from the direct broadcast system at KARI ground station since July, 2002. Especially the KARI introduces the MODIS Rapid Response System from NASA for the purpose of monitoring natural disaster particularly forest fires and verify the fire detection algorithm.

Figure 5. MODIS Rapid Response System at KARI

2) Studying the Fire Detection Algorithms related with Satellite Data

We studied the MODIS fire detection algorithms comparing with BIRD[1] to understand the specific character of detection algorithms. And we collected the paper related with forest fires and information of various kinds for applying the MODIS Rapid Response System.

3) Monitoring the Natural Disaster

KARI periodically receives the MODIS observational data and monitors various natural disasters as like forest fires, Asian dusts, typhoons, floods for Korea Peninsula.

[1] The micro-satellite on Bi-spectral Infrared Detection (BIRD) is a demonstrator of innovative remote sensing technology dedicated to fire recognition by small satellites. BIRD was developed, manufactured, and tested by the German Aerospace Center (DLR). It was piggy back launched together with the Indian satellite TES and the ESA micro-satellite PROBA on 22 October 2001.

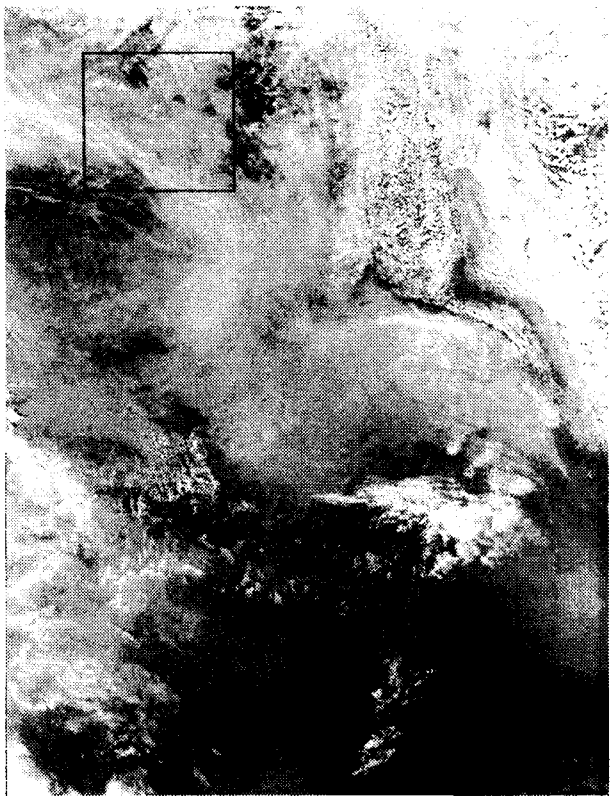

Figure 6. Fire and Smoke in Siberia (In the forests and tundra of eastern Russia, fires have been burning off and on for weeks. This smoky image of the region was captured by the MODIS on the Aqua satellite on May 20, 2002)

Figure 7. Fires in the Korea Peninsula (Fires were burning in North Korea on April 16, 2004. To the west, ripples of smoky air flow over East Sea. This MODIS image is from the Aqua satellite.)

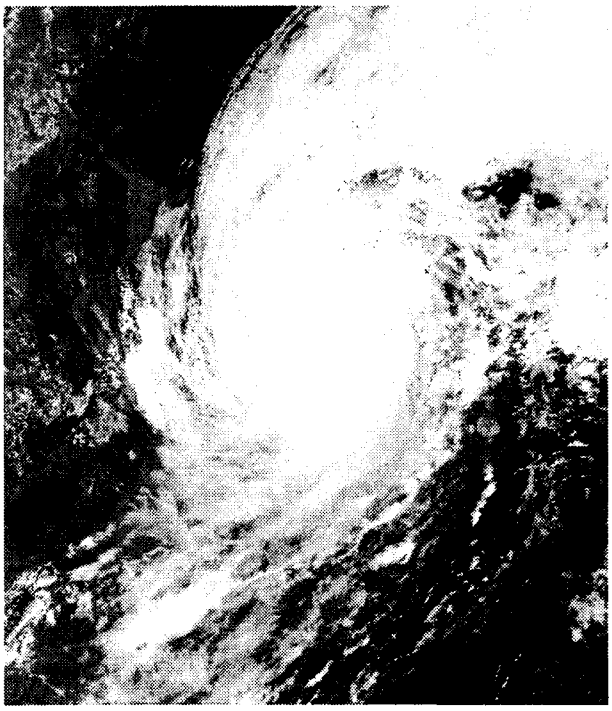

Figure 8. Typhoon 'Maemi' over Korea (Typhoon Maemi strikes a heavy blow on South Korea in this MODIS image captured by the Aqua satellite on 12 September 2003, at 1:55 pm, local time. With sustained winds of 135 miles per hour, the storm was the strongest to hit South Korea since records began. Media reports say that at least 104 people died in the storm.)

5. Summary

KARI has been receiving the Terra and Aqua MODIS data in directly from KARI ground station since July, 2002, and installed the MODIS Rapid Response System in September, 2003. We have been applying the MODIS data using the MODIS Rapid Response System for the purpose of monitoring natural disaster in particular forest fires.

The MODIS fire detection algorithm performs reasonably well. However there are some problems as follows: Firstly, persistent false detections occurred in some deserts and sparsely vegetated land surfaces. Secondly, relatively small fires were frequently not detected. In response to these limits, the established fire detection algorithm has to be improved in order to offers superior sensitivity into smaller fires and produce fewer false alarms.

Reference

[1] C.O. Justice, L. Giglio, S. Korontzi, J. Owens, J.T. Morisette, D. Roy, J. Descloitres, S. Alleaume, F. Petitcolin, and Y. Kaufman, 2002. The MODIS Fire Products, *Remote Sensing of Environment*, 83 (2002) 244-262

[2] Louis Giglio, Jacques Descloitres, Christopher O. Justice, and Yoram J. Kaufman, 2003. An Enhanced Contextual Fire Detection Algorithm for MODIS, *Remote Sensing of Environment*, 87 (2003) 273-282

[3] Yoram Kaufman and Chris Justice, 1998. Algorithm

Technical Background Document 'MODIS Fire Products' version 2.2, *MODIS ATBD*, MODIS Science Team

[4] K. Briess, E. Lorenz, D. Oertel, W. Skrbek, B. Zhukov, 2002. Fire Recognition Potential of the Bi-spectral Infrared Detection (BIRD) Satellite, *DLR*, Institute of Space Sensor Technology and Planetary Exploration

[5] E. Lorenz, K. Briess, W. Halle, H. Kayal, D. Oetel, W. Skrbek, B. Zhukov, W. Leibrandt, 2002, A Technology Demonstrator Dedicated to the Fire Hazard Detection and Monitoring, *DLR*, Institute of Space Sensor Technology and Planetary Exploration

[6] M. J. Wooster, B. Zhukov, D. Oertel, 2003, Fire Radiative Energy for Quantitative Study of Biomass Burning: Derivation from the BIRD Experimental Satellite and Comparison to MODIS Fire Products, *Remote Sensing of Environment*, 86 (2003) 83-107