1. Introduction

Typical forest fires or wild fires are natural phenomena. However, over 90% of all wild fires in forests or savannas today are due to human action and cause significant loss of forest lands causing various environmental problems including haze. On average, fires burn between 6-14 million hectares of forest per year worldwide leading to enormous economic losses, damage to environmental, recreational and amenity values, and even loss of life. Occurrence of fires in Asia is increasing annually due to changes in the global whether patterns. Fires in Indonesia are increasing causing sever haze problems in neighboring countries. More forest fires are happening in Thailand and in Vietnam than past. Forest fire problem which was previously limited to forest management activities receiving the attention of various other agencies such as environment, land management, air traffic, weather bureaus as consequences of fires are becoming a treat to normal life than before.

High resolution satellite data such as Landsat Thematic Mapper, SPOT and ALOS combined with moderate resolution satellite images such as NOAA-AVHRR or MODIS offer new possibilities to monitor forest fires. They have a number of advantages over conventional means of observation: Using satellite images, it is possible to view vast expanses of land, continuous and near real-time observation. This can be performed regularly for the same area and recorded in different wavelengths, thus providing information on the state of forest resources.

Terra and Aqua satellites of the Earth Observation System (EOS) program, which data is acquired and distributed by the Geoinformatics Center (GIC) of Asian Institute of Technology, are equipped with a MODIS sensor (Moderate-resolution Imaging Spectroradiometer). Thirty-six spectral channels cover the wave-length range from 0.4 to 14.4 μm. Fire sites can be interpreted both visually and automatically, using radiance temperatures of thermal channels. Algorithms of detecting fires in automatic mode are based on a considerable difference in temperatures between the ground surface (usually, not exceeding 10-250C) and the fire spot (300-9000C). Almost a hundredfold difference in thermal radiance of the objects is registered on the images, whereas the information received from the other spectral channels helps to discriminate the clouds.

Using MODIS data receives at GIC, potential forest fire locations based on MODIS spectral values are estimated using Active Fire Product (MOD14) Production Code version 4.3.2 of NASA. The algorithm generated outputs are not validated globally and the product generated by MOD14 is not sufficient for effective forest fire monitoring activities in the region. Therefore, the AIT MODIS Fire system has been developed based on the algorithm as mentioned and upgraded to Fire Information System, which includes the generation, data statistical analysis, database archiving, visualization, and validation modules to serve the research activities on forest fire disaster as well as for forest fire protection activities in the countries of the region.

2. Objectives

The main goal of this Mini-Project is to develop potential forest fire locations in the region in near-real time to share the information among interested user for better forest fire monitoring and management. The objectives of this project can be enumerated as below;

1. Develop a system to automatically generate hotspot (potential forest fire areas) using MOD14 algorithm

2. Develop a Web system to distribute the generated hotspot information to interested users through Internet
3. Provide information on the distribution of hotspot in the region
4. Provide hotspot visualization module through Internet
5. Develop a Internet based system to interact with users to collect ground based information for validation.

3. Methodology

The MODIS fire algorithm used in this study is the ATBD-MOD14 developed by NASA. This algorithm was used to develop a free software "MODIS Active Fire Product (MOD14) Production Code, version 4.3.2" (Giglio and al, 2003) by NASA which is freely available at NASA website. This algorithm uses brightness temperatures derived from MODIS Level1B spectral bands in 4 μm and 11 μm spectral regions, denoted by T_{22} and T_{31}, respectively. The MODIS sensor has two 4-μm bands, named as 21 and 22 uses in the fire detection algorithm. Band 21 saturates at nearly 500 K; Band 22 saturates at 331 K. As the low-saturation band 22 is less noisy and has a smaller quantization error, T_{22} derives from band 22 is used whenever possible. However, when band 22 saturates or has missing data, it is replaced with the high saturation band to derive T_{22}. T_{31} is computed from the 11-μm band (band 31), which saturates at approximately 400K for the Terra MODIS and 340K for the Aqua MODIS. The 12-μm band (band 32) is used for cloud masking; brightness temperatures for this band are denoted by T_{12}.

The 250 meter resolution red and near-infrared bands are aggregated to 1km and used to reject false estimates (false alarms) and for masking clouds. The 500 meter 2.1-μm band are also aggregated to 1km and used to reject water-induced false alarms. A summary of all MODIS bands used in the algorithm is shown in Table 1.

Table 1. MODIS bands used in detection algorithm

Band number	Central wavelength (μm)	Purpose
1	0.65	Sun glint and coastal false alarm detection; cloud masking
2	0.86	Bright surface, sun glint, and coastal false alarm rejection; clouds masking
7	2.1	Sun glint and coastal false alarm rejection
21	4.0	High-range band 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 system developed in this project includes following components:

1. MODIS Fire Product generation
2. MODIS Fire statistical analysis
3. MODIS fire visualization
4. MODIS fire archiving database
5. MODIS fire validation systems.

The flowchart of the system development is illustrated in Figure 1.

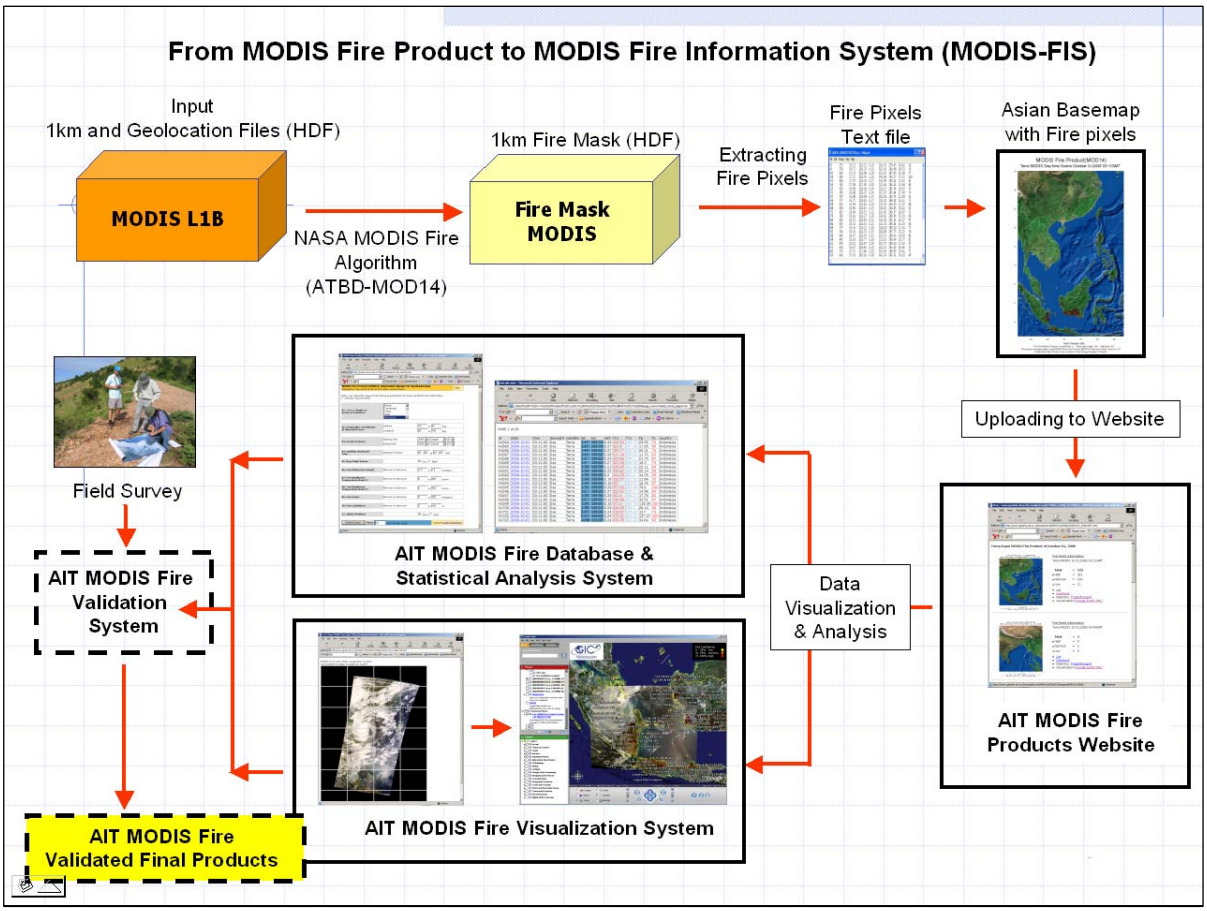


Figure 1 Flowchart of the System

MODIS data are received at GIC for all day and night passes over the horizon of the receiving station of GIC. Received data are pre-processed to Level 1B, and send to MODIS Fire Product generation module for generating the MODIS Fire Product known as MOD14. Number of parameters are extracted from this product for further processing including geographical location of the hotspot pixels, brightness temperature, fire power, confidence level with respect to surrounding pixel and stored in a table. In the next step, locations of hotspot pixel are mapped with three different confidence levels; high, nominal low. The hotspot pixels information can also be used to overlay with MODIS true color of 250 meter and view on the Google Earth 3D viewer to further investigate the active time occurrence in near real-time with high resolution satellite image available on Google Earth. Next, the hotspot pixels information are sent to generate statistical information of the distribution of possible active fire pixels by country. The same hotspot pixels information are sent to store in a database for multi-temporal data analysis of potential fire occurrence. MODIS Fire Product generated by this system are not verified with actual fire occurrence in the field. Therefore, to interact with potential collaborators for field validation, another module was developed for fire pixels validation to make the Fire Product generated by the system to be more meaningful and value-added.

4. MODIS Fire Information Access

The fire information can be accessed through the internet by the address www.geoinfo.ait.ac.th/mod14. In this website all of the MODIS Fire Information System modules are shown. Users can download hotspot data, visualize the fire occurrences with Google Earth, retrieve past hotspot data from the database. Users can use the MODIS Fire Product generated by this system freely with the acknowledgement to the Geoinformatics Center of Asian Institute of Technology.

During the development of the system, it was presented at the Meeting of the Wildfire Subgroup of Sentinel Asia, organized in LAPAN, Jakarta, Indonesia (Sep 19-21, 2006). After the development of system was completed in October 2006, the system was demonstrated at the 27th Asian Conference on Remote Sensing which was held on October 09-13, 2006 in Ulaanbaatar, Mongolia to the participants of the conference.

The fire information generated by the system is currently used in Forest Fire Working Group of Sentinel Asia. The research team from the Institute of Low Temperature Science, Environmental Informatics at Graduate School of Agriculture of the Hokkaido University has acquired the fire information from the system over the Palangkaraya area of Southern part of Kalimantan for wildfire verification works.

Further, the system was presented to the participants of 3rd MODIS Workshop which was organized in Bangkok on 15-16 January 2007 by University of Tokyo and GISTDA. During the forest fire disaster occurred in Northern part of Thailand in March 2007, the fire information was used by GISTDA for monitoring the fire phenomenon. Also, a presentation was done at the 1st Global Earth Observation Grid Workshop, which was organized in NECTEC, Bangkok Thailand on March 20, 2007 with the collaboration of AIST Japan. The research activity on the development of the system was also reported as in the AIT part of the Solution Oriented Research for Science and Technology (SORST) project report for Fiscal Year of 2006 under the sponsorship of the Japanese Science and Technology Agency (JST).

In April 2007, researchers from the Joint Graduate School of Energy and Environment (JGSEE at the King Mongkut's University of Technology Thonburi of Thailand) used the fire information data for the research on air pollution modeling due to forest fire in the Northern part of Thailand.

6. Results

The results of the system development are presented below under different headings explaining each of the targeted product modules.

6.1 Fire Product Generation Module

Figure 2 shows the front page of the AIT MODIS Fire Information System which users can access by the address http://www.geoinfo.ait.ac.th/mod14/ .

Figure 3 shows the web-based daily MODIS Fire product. In this web, the users can access the daily-updated information of the active fire occurrences. This figure is an example of the active fire detected on March 11, 2007 with various information related to the location of fire pixels or hotspots in text, statistical table and graph and KML format for viewing in Google Earth 3D viewer. Figure 4 shows an example of active fire detected within one MODIS scene.

6.2 Fire Statistical Analysis Module

This module calculates the distribution of active fire occurrence by different countries in the region in term of statistical table and graph. Figure 5 is a sample output that shows the fire pixels are grouped in three groups of fire confidence based on countries. Figure 6 shows active fire pixels of the same MODIS scene in bar-chart.

6.3 MODIS Fire Visualization Module

In order to easy understanding of the active fire occurrences and recognize their spatial locations, Google Earth 3D viewer is used to visualize the fire pixels, by overlaying them on the real time true color MODIS image of 250m resolution or the high resolution satellite images available on Google Earth which are free to use. Figure 7 is a sample image of the visualization module. Figure 8 shows the use of the MODIS active fire pixels on MODIS true color image of 250 meter resolution in Google Earth 3D viewer of a specific area with Zoom-in mode. Figure 9 is another example selected from the database and integrated on the Google Earth 3D viewer of a specific area with Zoom-in mode. In this Figure, the strong smoke and its fire location is shown. Figure 10 shows an example of MODIS active fire pixels information with the high-resolution satellite image on Google Earth 3D viewer of a specific area with Zoom-in mode. Figure 11 is a MODIS active fire detected in the northern part of Laos, Thailand and Myanmar on March 11, 2007 at 06:59 GMT

6.4 MODIS Fire Database Module

Figure 12 is the front page of the MODIS Fire Database. The system can be accessed through the internet. As shown in this figure, users can query areas, dates, times, bands etc. in extracting MODIS hotspot data from the database. The query results will display as shown in Figure 13.

6.5 MODIS Fire Validation Module

This module has been developed to support the field survey for the validation of the fire product generated by the system. The user can access to this system on-line and upload the ground truth information from the field survey for further analysis and validation of the fire occurrence.

Figure 2 Front page of AIT MODIS Fire Information System

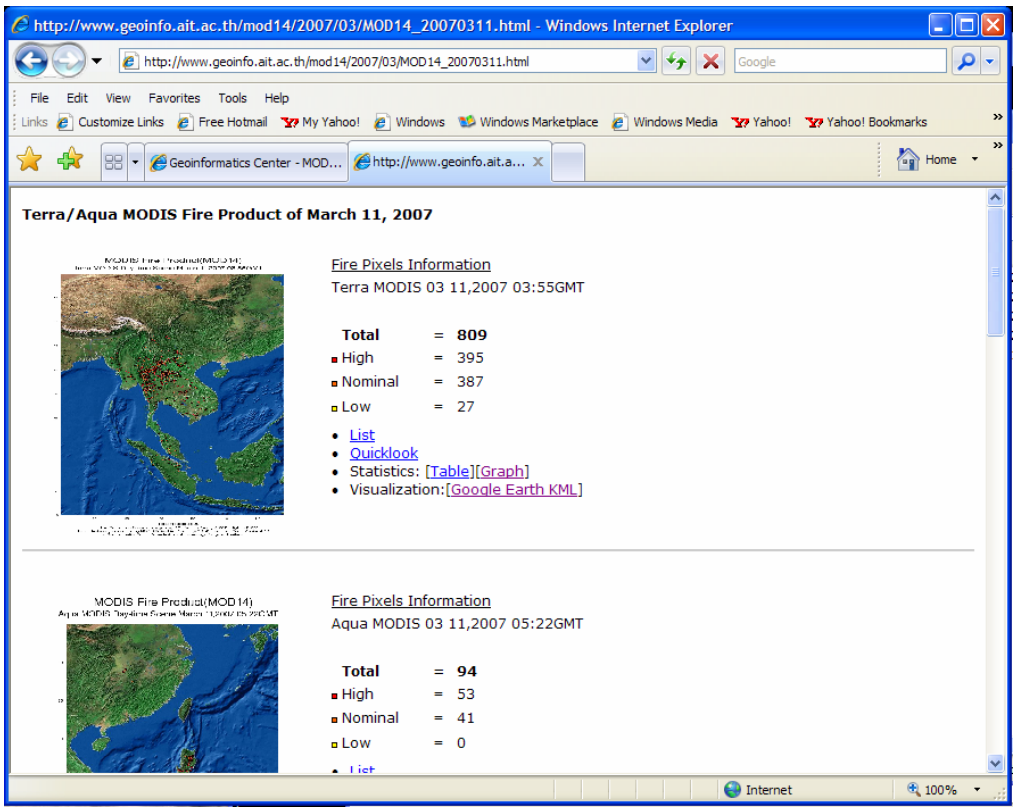


Figure 3 Web-based daily MODIS Fire product

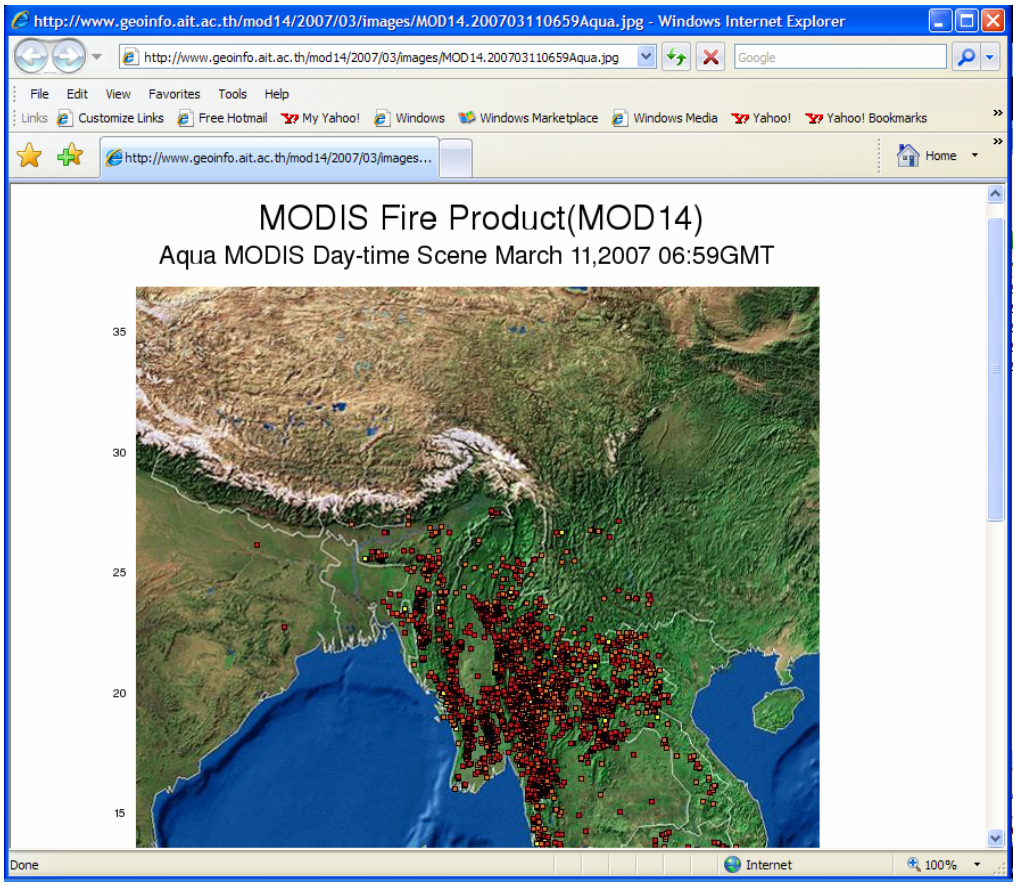


Figure 4 Active fire detection within one MODIS scene

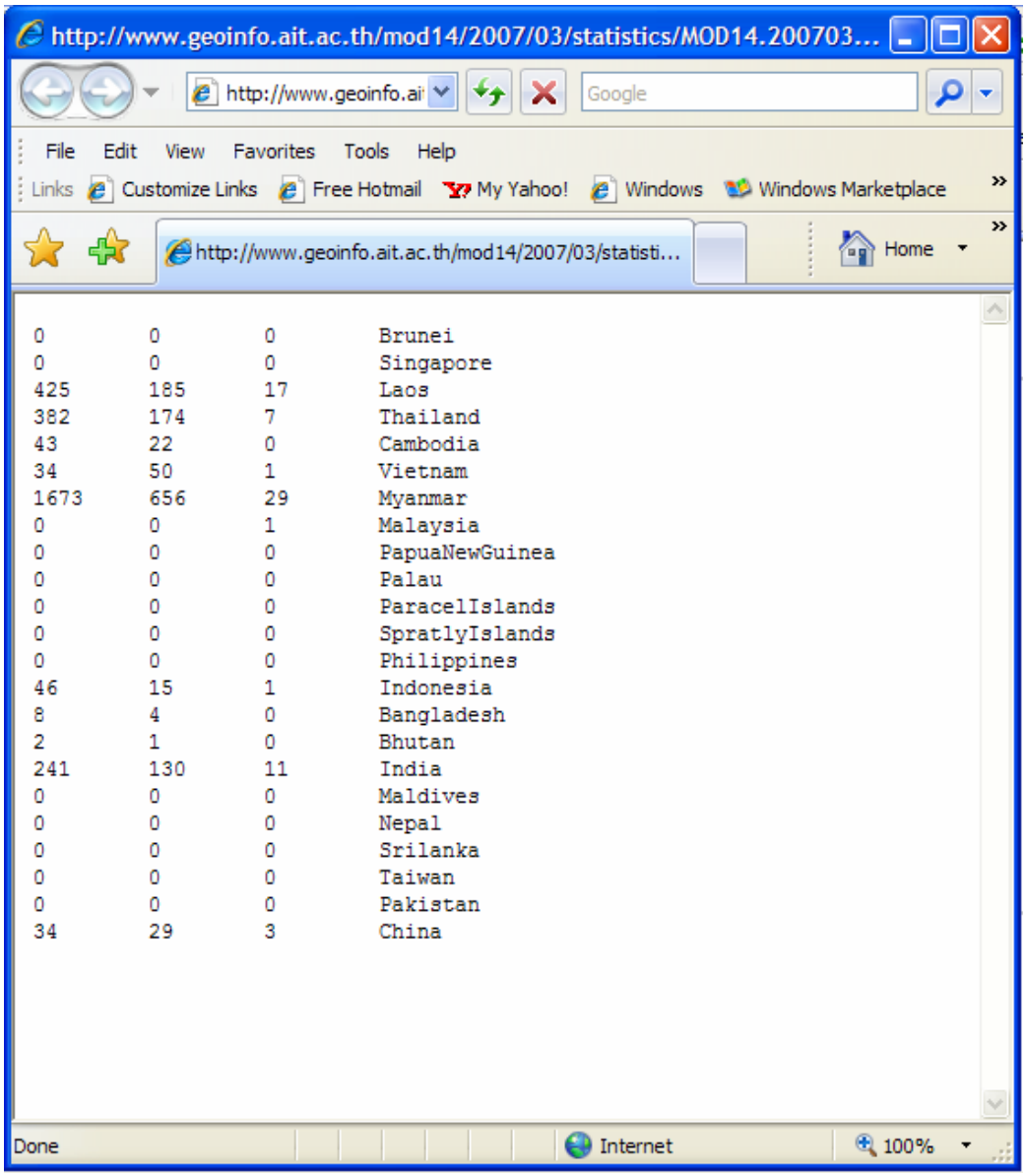


Figure 5 Statistical table of active fire detected within one MODIS scene

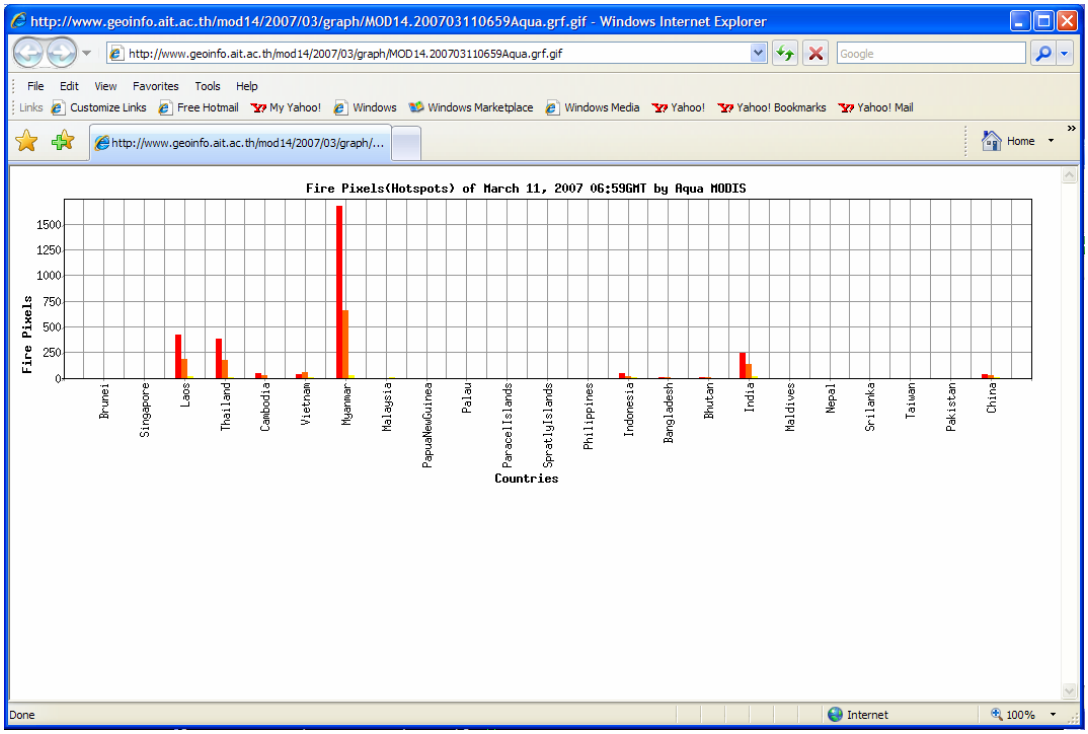


Figure 6 Statistical graph of active fire detected within one MODIS scene

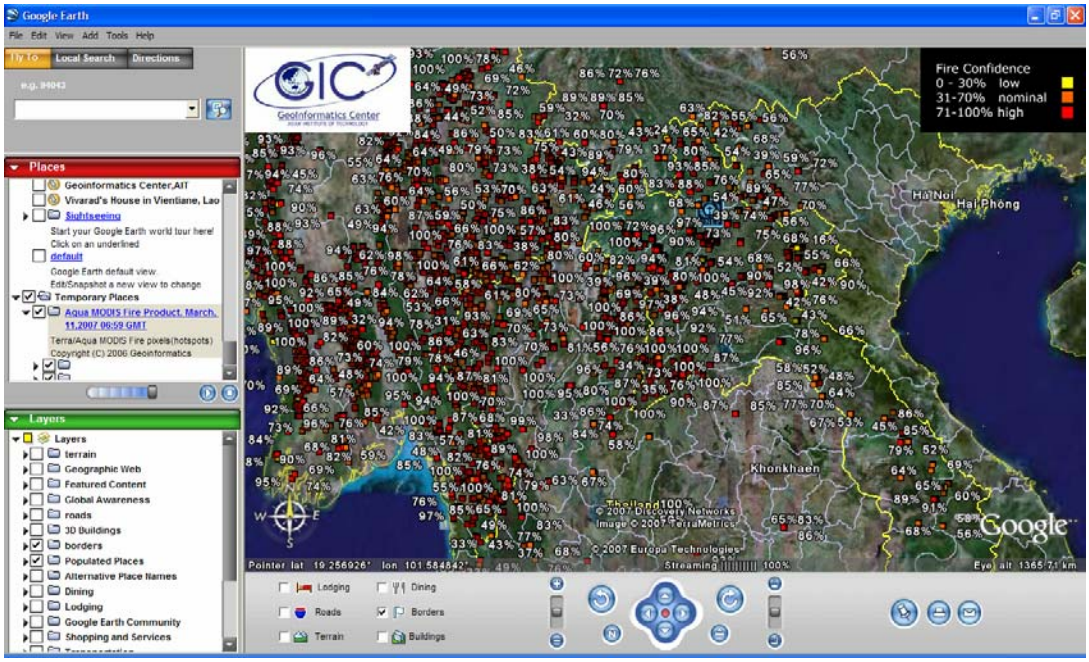


Figure 7 Visualization of the MODIS active fire pixels on Google Earth 3D viewer

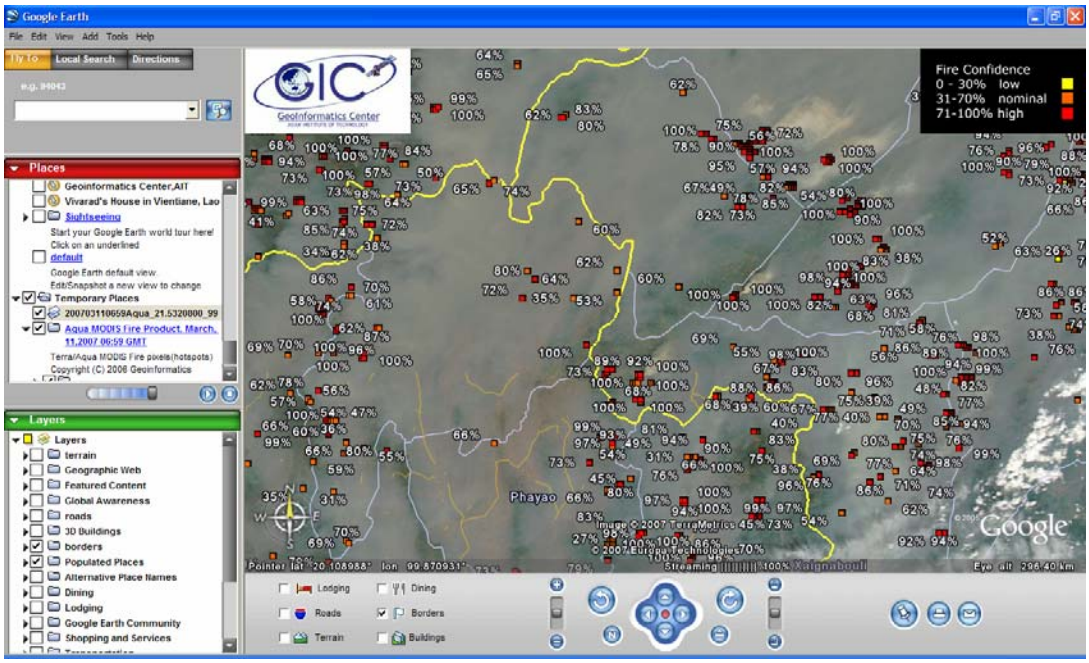


Figure 8 Visualization of the MODIS active fire pixels on MODIS true color image of 250m resolution in Google Earth 3D viewer of a specific area with Zoom-in mode.

Figure 9 Visualization of the MODIS active fire pixels information on Google Earth 3D viewer of a specific area with Zoom-in mode. In this Figure, the strong smoke and its fire location is shown

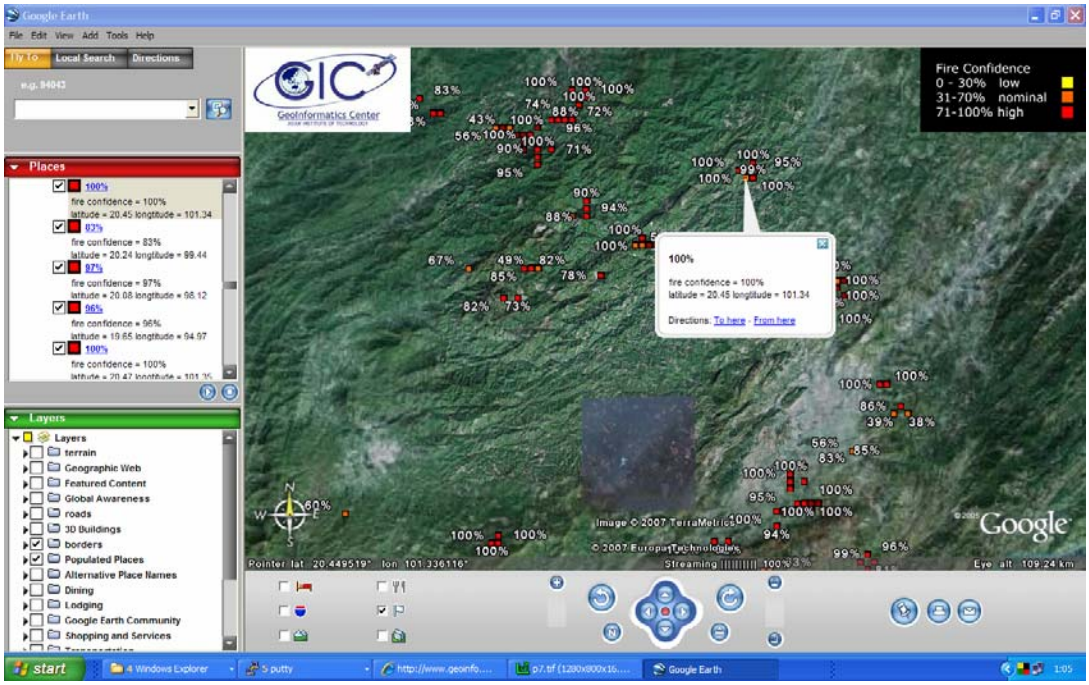


Figure 10 Visualization of the MODIS active fire pixels information with the high-resolution satellite image on Google Earth 3D viewer of a specific area with Zoom-in mode.

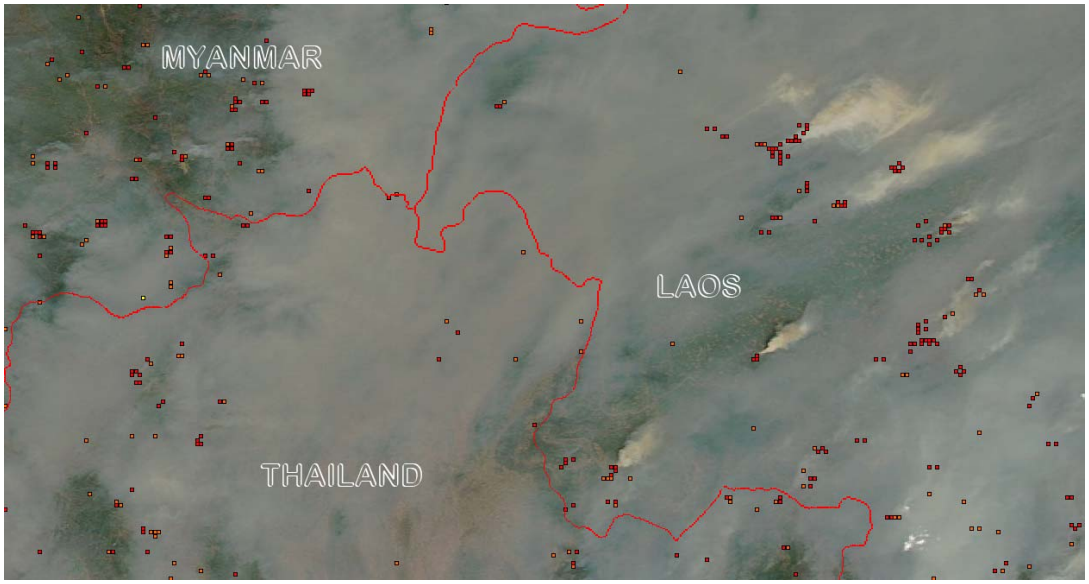


Figure 11 Visualization of the MODIS active fire detected in the northern part of Laos, Thailand and Myanmar on March 11, 2007 at 06:59 GMT

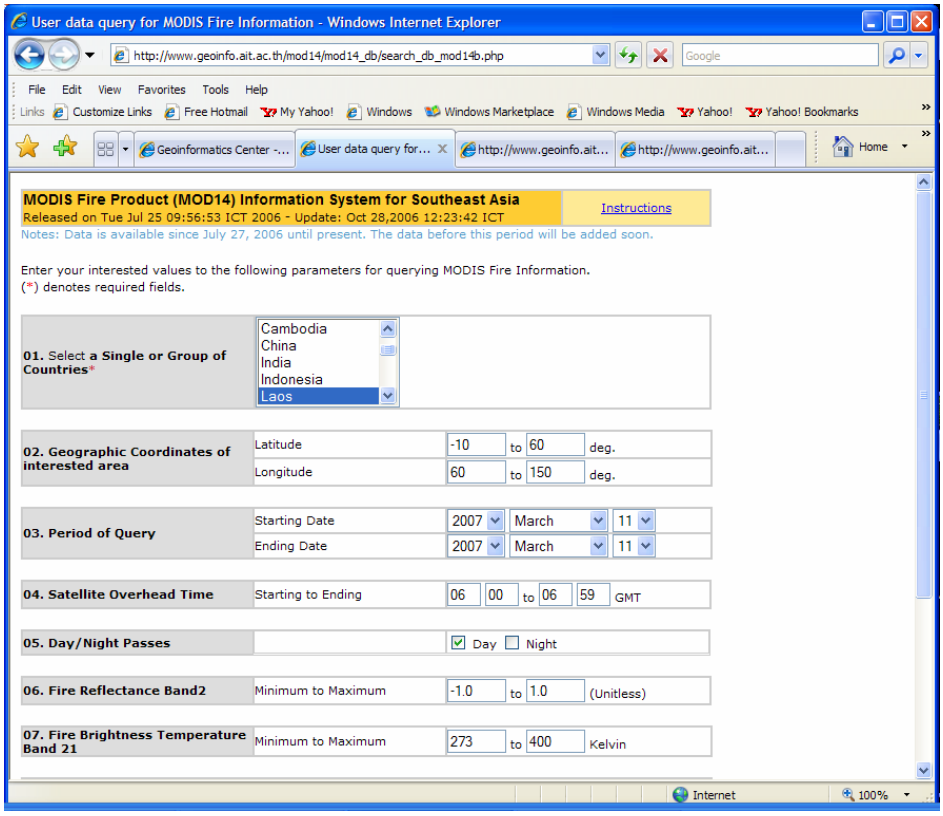
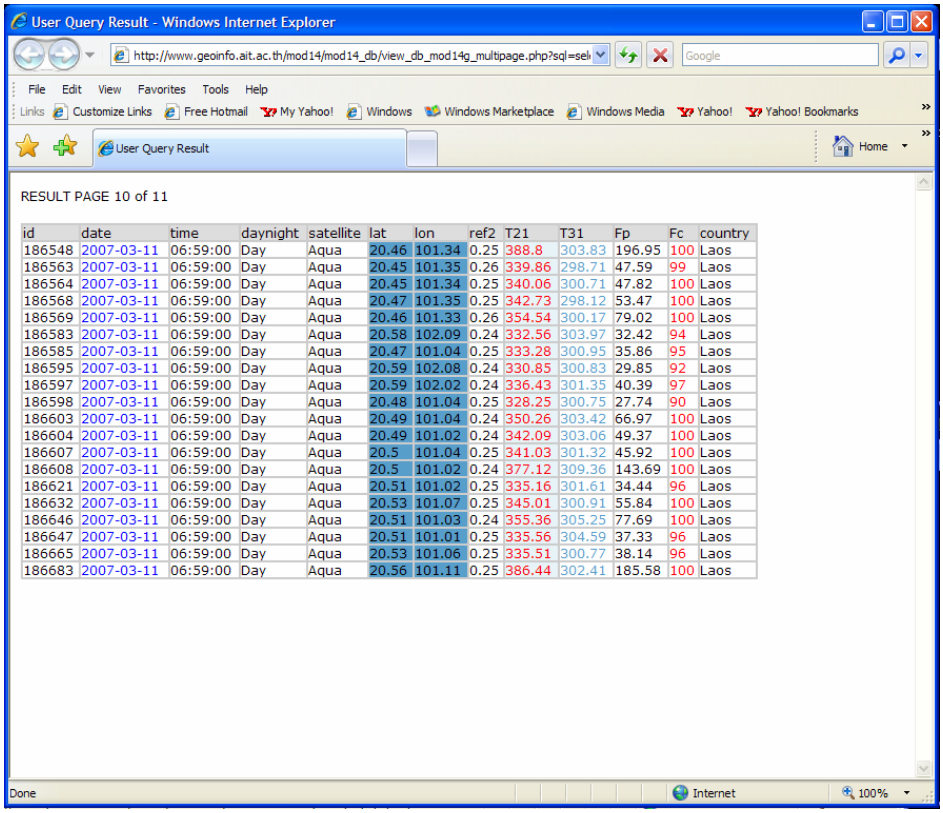


Figure 12 MODIS Fire Database System



id	date	time	daynight	satellite	lat	lon	ref2	T21	T31	Fp	Fc	country
186548	2007-03-11	06:59:00	Day	Aqua	20.46	101.34	0.25	388.8	303.83	196.95	100	Laos
186563	2007-03-11	06:59:00	Day	Aqua	20.45	101.35	0.26	339.86	298.71	47.59	99	Laos
186564	2007-03-11	06:59:00	Day	Aqua	20.45	101.34	0.25	340.06	300.71	47.82	100	Laos
186568	2007-03-11	06:59:00	Day	Aqua	20.47	101.35	0.25	342.73	298.12	53.47	100	Laos
186569	2007-03-11	06:59:00	Day	Aqua	20.46	101.33	0.26	354.54	300.17	79.02	100	Laos
186583	2007-03-11	06:59:00	Day	Aqua	20.58	102.09	0.24	332.56	303.97	32.42	94	Laos
186585	2007-03-11	06:59:00	Day	Aqua	20.47	101.04	0.25	333.28	300.95	35.86	95	Laos
186595	2007-03-11	06:59:00	Day	Aqua	20.59	102.08	0.24	330.85	300.83	29.85	92	Laos
186597	2007-03-11	06:59:00	Day	Aqua	20.59	102.02	0.24	336.43	301.35	40.39	97	Laos
186598	2007-03-11	06:59:00	Day	Aqua	20.48	101.04	0.25	328.25	300.75	27.74	90	Laos
186603	2007-03-11	06:59:00	Day	Aqua	20.49	101.04	0.24	350.26	303.42	66.97	100	Laos
186604	2007-03-11	06:59:00	Day	Aqua	20.49	101.02	0.24	342.09	303.06	49.37	100	Laos
186607	2007-03-11	06:59:00	Day	Aqua	20.5	101.04	0.25	341.03	301.32	45.92	100	Laos
186608	2007-03-11	06:59:00	Day	Aqua	20.5	101.02	0.24	377.12	309.36	143.69	100	Laos
186621	2007-03-11	06:59:00	Day	Aqua	20.51	101.02	0.25	335.16	301.61	34.44	96	Laos
186632	2007-03-11	06:59:00	Day	Aqua	20.53	101.07	0.25	345.01	300.91	55.84	100	Laos
186646	2007-03-11	06:59:00	Day	Aqua	20.51	101.03	0.24	355.36	305.25	77.69	100	Laos
186647	2007-03-11	06:59:00	Day	Aqua	20.51	101.01	0.25	335.56	304.59	37.33	96	Laos
186665	2007-03-11	06:59:00	Day	Aqua	20.53	101.06	0.25	335.51	300.77	38.14	96	Laos
186683	2007-03-11	06:59:00	Day	Aqua	20.56	101.11	0.25	386.44	302.41	185.58	100	Laos

Figure 13 Result of data retrieving from MODIS Fire Database System

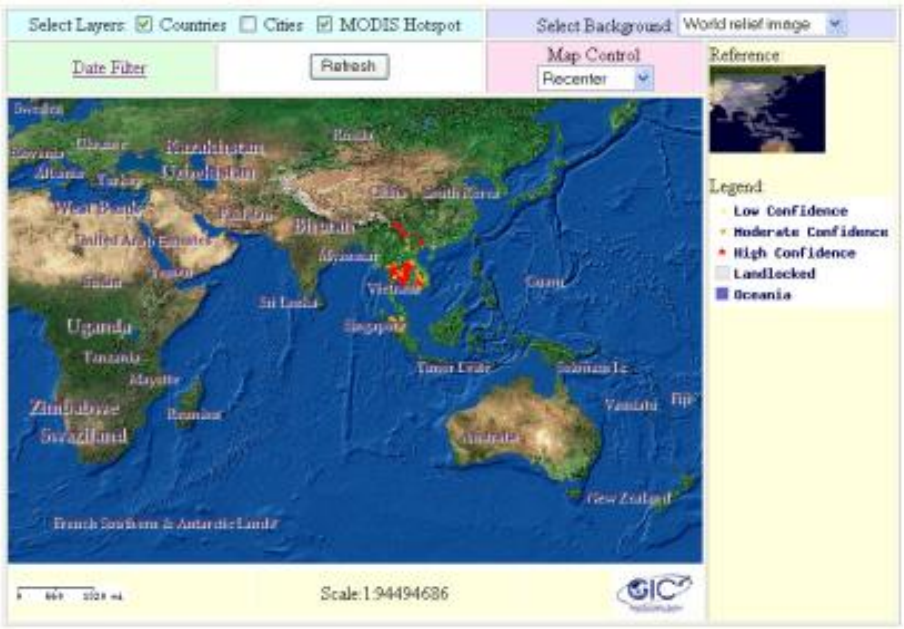


Figure 14 MODIS Fire Validation Module