EUROPEAN UNION
MINISTRY OF FORESTRY AND ESTATE CROPS

FOREST FIRE PREVENTION AND CONTROL PROJECT

VEGETATION FIRES IN INDONESIA: OPERATING PROCEDURES FOR THE NOAA-GIS STATION IN PALEMBANG, SUMATRA

Ivan P. Anderson, Ifran D. Imanda and Muhnandar

Balai Inventarisasi dan Perpetaan Hutan Wilayah II
and
Kanwil Kehutanan dan Perkebunan, Palembang

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Cover: NOAA 14 image composite of Sumatra derived from twelve day-time images captured during July 1996. Image processed to show relative vegetation greenness (NDVI). Dense, actively photosynthesising vegetation appears green; fire-damaged or sparsely vegetated areas show yellow.

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This is one of a series of reports prepared during 1999 by the Forest Fire Prevention and Control Project. Together they cover the field-level prevention, detection and control of vegetation fires in Sumatra. Titles are:

Vegetation fires in Indonesia: operating procedures for the NOAA-GIS station in Palembang, Sumatra. I.P. Anderson, I.D. Imanda and Muhnandar.

Vegetation fires in Indonesia: the interpretation of NOAA-derived hot-spot data. I.P. Anderson, I.D. Imanda and Muhnandar.

Vegetation fires in Sumatra,Indonesia: the presentation and distribution of NOAA-derived data. I.P. Anderson, I.D. Imanda and Muhnandar.

Vegetation fires in Indonesia: the fire history of the Sumatra provinces 1996-1998 as a predictor of future areas at risk. I.P. Anderson, M.R. Bowen, I.D. Imanda and Muhnadar.

Vegetation fires in Sumatra, Indonesia: a first look at vegetation indices and fire danger in relation to fire occurrence. I.P. Anderson, I.D. Imanda and Muhnandar.

The training of forest firefighters in Indonesia. M.V.J. Nicolas and G.S. Beebe (Joint publication with GTZ).

The management of forest fires in the timber concessions of Indonesia. M.V.J. Nicolas and G.S. Beebe (Joint publication with GTZ).

A field-level approach to coastal peat and coal-seam fires in South Sumatra province, Indonesia. M.V.J. Nicolas and M.R. Bowen.

A fire danger rating system for South Sumatra province, Indonesia. M.V.J. Nicolas, I.P. Anderson and H. Pansah.

FFPCP will also publish reports on;

- the policy, planning and implementation aspects of natural resource management in the province of South Sumatra,
- the role of local communities in fire prevention, and
- environmental education in primary schools.

Copies of these reports are also available in Bahasa Indonesia, and can be obtained from;

The Project Leader, FFPCP, PO Box 1229, Palembang 30000, Indonesia
Fax number: +62 711 417 137 – Homepage: http://www.mdp.co.id/ffpcp.htm
or
Counsellor (Development), Representation of the European Commission, PO. Box 6465 JKPDS, Jakarta 10220, Indonesia
Fax number: +62 21 570 6075

FOREWORD

European Commission

Tropical rain forests cover less than six percent of the surface of the earth, but contain more than 50 percent of the world's biodiversity. Indonesia's forests are considered to be one of the biodiversity centres of the world. However, these vital areas are under threat from over-exploitation, encroachment and destruction because of fire.

The seriousness of the threat to Indonesia's forests has prompted the European Commission to reorient its development co-operation with Indonesia to focus on the sustainable management of forest resources. Based on the Agreed Minutes of a meeting between the Government of Indonesia and the Commission, which were signed in May 1993, the Commission supports a range of projects in the field of conservation and sustainable forest management. The funds for this support have been donated in the form of grants.

The importance of the fire issue cannot be over-emphasised. Estimates have set the economic loss caused by the haze that blanketed the region in 1997 at around Euro 1.4 billion. The loss of wildlife habitat, which will take decades to regenerate or the soil erosion, which is the inevitable result of heavy burning, is too great to be expressed in financial terms.

Because fire prevention and control is such an important issue, the Commission has been willing to support the Forest Fire Prevention and Control Project, which started in April 1995, with a grant of Euro 4.05 million. The long-term objective of the project was to, *"Furnish support, guidance and technical capability at provincial level for the rational and sustainable management of Indonesia's forest resources."* Its immediate purposes were to evaluate the occurrences of fire and its means of control, to ensure that a NOAA-based fire early warning system would be operational in South Sumatra, and that a forest fire protection, prevention and control system would be operational in five Districts within the province.

In co-operation with local government, representatives of the Ministry of Forestry and Estate Crops and the private sector, the project set out to implement a series of activities that would support the achievement of these purposes. The results of these activities are now made available in a series of technical reports of which this is one. We believe that these professional publications will be of considerable value to those concerned in the forestry, agriculture and land-use planning sectors.

Klauspeter Schmallenbach
Head of the Representation of the European Commission in Indonesia

Kanwil Kehutanan dan Perkebunan

Vegetation fires have undoubtedly become a more urgent focus of concern to the regional office of the Ministry of Forestry and Estate Crops in South Sumatra after the widespread smoke haze pollution of 1997. As part of our commitment to sustainable forest management, considerable efforts have been made to prevent fires happening again on such a scale. We hope that in the new spirit of reform the people of South Sumatra will play a greater role in protecting and managing the forests and their resources.

I warmly welcome the FFPCP series of reports on their work from 1995 to 1999. These reports examine in detail the underlying causes of vegetation fires in the province, and this understanding allows us to suggest how numbers may be reduced. The reports also set out methods of prevention, NOAA satellite detection, and control of fires. These are based on methods that have been shown to work under field conditions and when fully introduced will bring practical benefits to us all.

I also hope that the work will serve as a reminder that we need to keep improving our capability to deal with future fires. While good progress has been made, much work still remains to be done before damaging vegetation fires are a thing of the past.

Ir. Engkos Kosasih
Head of the Provincial Forestry and Estate Crops Office, South Sumatra

SUMMARY

A NOAA receiver system linked to a GIS was installed in Palembang, South Sumatra, by the European Commission funded Forest Fire Prevention and Control Project in January 1996. The receiver is used to obtain real-time data to detect vegetation fires and for vegetation dryness monitoring.

This technical manual is written for operators of the Palembang system but could without undue difficulty, be adapted to cover the use of similar equipment installed in other locations. A basic understanding of MS-DOS commands is assumed.

Actions prior to data capture, capture, and post-capture processing of the NOAA data, are described step-by-step. Also covered are the processes which lead to the production of the hot-spot co-ordinates required to prepare fire-maps and vegetation index images. Methods to allow these vegetation indices to be used to assess relative vegetation dryness and fire-risk at a regional scale are described.

Procedures needed to integrate the GIS with NOAA-derived hot-spot data, and thus the production of fire-maps, are similarly detailed.

Batch-files used during the processing of NOAA data are given in an appendix to the main manual.

DEFINITIONS

Vegetation Fires, Hot-spots, Wildfires and Smoke Haze

The term '**forest fire**' is widely used - it occurs in the title of FFPCP - but, when referring to Indonesia, is often misleading. Fires on land within the natural forest estate - in legal terms 'forest' - often burn little except grassland and scrub. In areas outside forest-land, it is again agricultural waste, land-clearance and low-value vegetation, which are most vulnerable to fire. Fires in these non-forested areas are sometimes referred to as land fires. This term can also be misleading if confused with ground fires that burn organic material (e.g. peat) beneath surface fires. NOAA satellite imagery is incapable of distinguishing fires that burn trees from those which do not. The term **vegetation fire** is thus preferred, and is used throughout the five reports which cover the capture, processing, interpretation and presentation of NOAA-derived fire data.

Wildfire is used for a vegetation fire that is out of control. It does not suggest that the fire was ignited by lightning or other natural means - only a fraction of a percent is.

Hot-spots indicate the location of vegetation fires as seen on a computer monitor or printed map, or when referred to by their co-ordinates. It is a populist term introduced early in the use of NOAA imagery to detect vegetation fires, and is now well understood by all. Acceptance of the more obvious term 'fire-spot' has been resisted, as its introduction has inevitably been proposed by interests wishing to suggest that many hot-spots do not indicate fires. In this they are mistaken. For all practical purposes a **hot-spot** is **synonymous** with a **fire-spot**. Hot-spot is thus used throughout all FFPCP reports.

Smoke is defined by the Deutsches Institut fur Normung (DIN) as, 'A visible aerosol resulting from combustion'; **haze**, by the World Meteorological Organisation, as 'Where the visibility is reduced owing to dry particles'. Neither term is used uniformly in the literature on vegetation fires in Indonesia and FFPCP has thus chosen to use the general phrase '**smoke haze**' throughout its reports.

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1. INTRODUCTION

The EU-funded Forest Fire Prevention and Control Project (FFPCP) is based in Palembang, South Sumatra, and has captured and processed NOAA data since January 1996. This manual provides a detailed description of the procedures used by FFPCP to plan, capture, process and archive NOAA satellite data. These data can also be integrated into a Geographic Information System (GIS) to allow the generation of fire-maps, vegetation assessments and other bio-physical statistics. The integration procedures are also described.

The NOAA receiver was installed by FFPCP to obtain real-time data for fire detection and vegetation monitoring. The latter is of value in the assessment of fire risk on a regional scale. Monitoring of fire locations over the three year period 1996-1998, two 'normal' years and an exceptionally dry 1997, has allowed FFPCP to gain a considerable understanding of the dynamics of fire-events in relation to agricultural and forest land management in south-central Sumatra (Anderson *et al*. 1999, 1999a and 1999b).

The principal recipients of the fire location data are Dinas Kehutanan and Kanwil Kehutanan dan Perkebunan, the Provincial and Regional offices of the Ministry of Forestry and Estate Crops. Together they are responsible for vegetation fire prevention and suppression through organisational structures that operate at provincial, district and sub-district levels. Information on fires is e-mailed to the provincial (head) offices of these organisations in seven provinces within Sumatra - South Sumatra, Bengkulu, Lampung, Jambi, Riau, West Sumatra and North Sumatra.

FFPCP provides direct assistance to five fire-prone Districts in South Sumatra Province to help upgrade their fire-fighting capability. Fire information is sent directly to the Dinas controlled District Fire Centres in Muara Enim, Lahat, Bangka, OKI and MUBA as part of this support,

Organisations that have received fire information regularly or on request include:

- BAPEDAL, Jakarta
- BAPEDAL, Pekanbaru, Riau Province
- FLB, Jakarta
- ICRAF, Bogor
- Indonesia Forest Fire Management Project (GTZ), Samarinda
- INTAG, Jakarta
- Kanwil Kehutanan dan Perkebunan, Palangkaraya, Kalimantan
- KODAM, Palembang
- LAPAN, Jakarta
- Leuser Development Programme, Aceh (EU)
- Ministry of Environment, Jakarta (Hot-spot Collator)
- PHPA, Bogor
- POSKO, Jakarta

There are seven other stations in Indonesia which receive NOAA imagery:

- Indonesia Forest Fire Management Project (GTZ), Samarinda East Kalimantan - which covers Kalimantan
- ITFMP, Palangkaraya, Central Kalimantan, non-operational
- JICA FFPMP, Bogor - covers Sumatra and West Kalimantan
- LAPAN, Jakarta - covers western Indonesia
- LAPAN, Biak, Irian Jaya - covers eastern Indonesia
- BPPT, Jakarta - marine and land-use studies in eastern Indonesia
- BMG, Jakarta - used for meteorological applications

A number of stations outside Indonesia also monitor vegetation fires in the country using a variety of remote-sensed data. A list of these stations together with more information on in-country stations is given by CIFOR (1998). A new project, Fire in Global Resources and Environmental Monitoring (FIRE), is due to open in 1999 under the Joint Research Centre of the European Commission. The objective is to document biomass burning patterns in the tropics and analyse the pattern in relation to the dynamics of land-use and land-cover.

The NOAA Satellites

The American NOAA series of satellites has evolved from numerous experimental and operational launches, which began with TIROS 1 on 1 April 1960. NOAA refers to the US government department responsible for the control of the programme, the **N**ational **O**ceanic and **A**tmospheric **A**dministration. The TIROS N/NOAA series was introduced in 1978 and evolved into an advanced generation that began with NOAA 8. The current status of these satellites is shown in Table 1.

Table 1. Launch dates and current status of the NOAA series of satellites

SATELLITE	LAUNCH DATE	STATUS
NOAA 8	28 March 1983	Deactivated 29 December 1985
NOAA 9	12 December 1984	Deactivated 13 February 1998
NOAA 10	17 September 1986	Infrared channels degraded since 1994
NOAA 11	24 September 1988	Failed on 13 September 1994
NOAA 12	14 May 1991	Operational
NOAA 13	9 August 1993	Failed 21 August 1993
NOAA 14	30 December 1994	Operational
NOAA 15	13 May 1998	Undergoing check-out procedures

The NOAA programme aims to provide continuous coverage of the earth to assist in weather prediction and monitoring. However, organisations around the world have made use of the primary data for many other natural resources applications. These include snow-cover mapping, flood monitoring, vegetation mapping, regional soil moisture analysis, wildfire fuel mapping, fire detection, sandstorm monitoring and various geological applications such as the detection of volcanic eruptions.

The data of interest to FFPCP derive from the AVHRR sensor (**A**dvanced **V**ery **H**igh **R**esolution **R**adiometer) carried aboard the NOAA series since NOAA 6. Only NOAA 12 and 14 provide data that can be used to monitor vegetation and detect fires. Data from NOAA 15 will be added, probably in late 1999 when processing software for fire detection and vegetation monitoring becomes available.

Several authors have discussed the benefits and limitations of using NOAA data to detect vegetation fires, e.g. Malingreau (1990) and Siegert and Hoffmann (1998). The FFPCP experience in the interpretation of hot-spot data is given by Anderson *et al*. (1999), while ways to present and distribute these data are given by Anderson *et al*. (1999c).

The Manual

Extensive use has been made of the manual, "NOAA AVHRR receiving and processing system", written by Bradford University Research Limited (BURL), UK, in August 1993. However FFPCP field-based experience showed that the Bradford manual contains several small errors and inconsistencies that make it difficult for the user to follow. It does, however, contain more information on technical details and should be referred to in conjunction with the operating procedures described here. Operators need a basic understanding of MS-DOS commands and this has been assumed.

The manual is intended primarily as a training aid for system users at Palembang but will be of interest to other stations using the BURL equipment. The manual is structured to take the user step-by-step from initial selection of the ground area to be captured as an image, through the capture and image processing procedures, to the final products in a GIS format. Other useful guides to NOAA-GIS system applications are Schneider (1995 and 1995a) and Perryman (1996).

2. PRE-CAPTURE OF NOAA DATA

Before starting the capture programme, the operator must ensure that;

- the orbit calibration files (TLEs) are up-to-date,
- an area of interest for image capture has been selected, and
- the 'CURRENT' directory is empty, as any image files in that directory will be over-written as the new data are received.

Up-dating of TLE Data

The TLEs need to be up-dated regularly. If they are not, operators will experience difficulty in capturing images owing to misalignment of the antenna.

Two Line Element data (TLE) are held as a digital file that contains information used by the software to predict the position of the NOAA satellites. It is essential that this information be updated at least once a month. The data can be obtained via the INTERNET at website: *http://celestrak.com/NORAD/elements/noaa.txt*

Once obtained, these data are saved in the directory C:\NOAA\TWO_LINE as an ASCII text file. The file containing the old TLE data (C:\NOAA\TWO_LINE\NEW.TLE) should be renamed (e.g. C:\NOAA\TWO_LINE\OLD3.TLE) and the new data copied to the two-line directory, using the name NEW.TLE. The program TLUPDATE.EXE is then run to update the software so that it uses the new information held under the file names NOAA12.TWL and NOAA14.TWL.

The update program appends the new data to provide users with an historical record. Backup copies of these previous files are made for safety and are given names with .TBK extensions (i.e. NOAA14.TBK). These backup copies are used should there be an error in the new data. If an error occurs the user can delete the new .TWL file and copy the .TBK file to a .TWL file.

Planning to Capture Orbits

The NOAA image dimensions restrict the capture area within Sumatra to Lake Toba southwards; most of Peninsular Malaysia is covered incidentally. Alternative areas for capture are Aceh Province or Kalimantan. The planning procedure described immediately below outlines the method to select areas of interest.

The orbit prediction programme should be run and orbit selection made at least 30 minutes ahead of the satellite overpass. Orbits can be planned and stored for up to two

weeks in advance. Within NOAA\SETUP is a file SATLIST.LST that contains a list of satellites of interest (currently NOAA 12 and 14). When new NOAA satellites come into operation, SATLIST.LST will need to be updated. Within NOAA\TWO_LINE are files of two-line data for NOAA satellites 9 to 15 inclusive.

When ORBIT.EXE is run, called in by PLAN.BAT, the future orbits for NOAA 12 and 14 satellites are displayed in turn, overlaid on a map called RGNMAP.OLL in NOAA\SETUP and centred on Palembang at 2.9°S 104.7°E, the approximate location of the NOAA system aerial. When ORBIT.EXE is first entered, the age of the TLE data-sets is displayed. Press any key to remove the overlaid panel.

Now select Alt P (for Plan) and observe, by pressing Alt F, the First available orbit. Similarly, press Alt N (for Next) to view the next orbit in time sequence. Pressing Alt P (for Previous) will allow a step back to the First available orbit.

The region of image capture is displayed as a box outlined in red. It is possible to:

- change the size of the capture region by pressing Alt X and/or Alt Y;
- change the position by use of the arrow keys either along (track) or across (swath). [Use of the Shift and an arrow key together causes large steps in position to be made.]

Pressing Alt S will Save this specification which is then listed in the display window. Each specification is saved as a .NCD (NOAA Capture Details) file in the directory NOAA\NCD. A number of specifications can be saved in turn until the window is full. When planning is complete press <Esc> to return to the higher level menu. From this, either exit by Alt Q (for Quit) or select Alt N to review New planned captures. At this stage, capture specifications can be Deleted selectively by typing Alt D. After captures, use Alt O to review Old captures (and delete them).

In DOS, users may check in NOAA\NCD for any failed captures as such NCD files are given .XXX extensions. Failed capture NCD files can be renamed as .OLD if the user wishes to review the intended capture region and other details.

3. CAPTURE OF NOAA DATA

The antenna moves into the appropriate start position for each capture after the computer is pre-programmed. A motor automatically controls the direction and tilt of the antenna as the capture proceeds. Each image is saved in turn until all planned orbits are captured.

Capture Procedure

Image capture takes place using NOAA_CAP.EXE, by typing NOAA_CAP. Once this program is started, the system waits for the first scheduled overpass and the aerial moves into position to receive data from the satellite. No further activity is possible with the computer (unless reset) until the block file is captured. When NOAA_CAP is run, the first (in time) NCD capture specification is loaded and displayed on a map screen which shows the capture region, orbit details and a 'Waiting for satellite transmission' warning. If the capture is initiated well in advance of the overpass time, it is advisable to switch off the monitor to protect the screen. The BURL NOAA receiver unit should be set for 'Auto frequency selection'.

Prior to capture, 'Satellite due within 10 minutes' followed by, 'Locked on to satellite transmission' warnings appear. The progress of the satellite is displayed in blue along the track path up to the instant when data capture starts. A warning, 'Capturing satellite data' is then shown. This is followed by processing details and ends with a return to the DOS C:\> prompt. At this point, the aerial moves to the park position; details are contained in the aerial calibration file HORNCAL.CAL in NOAA\SETUP. Calibration of the position of the aerial is normally required only at the time of installation.

Capture Automation

To acquire satellite data outside working hours, batch files are run to allow the capture and saving of data from a specified number of passes. For example, two planned orbits can be captured by running 2CAP.BAT (the prefixed numeral indicating the number of planned captures).

```
cur_arc
cd \noaa\programs
noaa_cap.exe
cd \noaa\images\current
dir
cur_arc
cd \noaa\programs
```

```
noaa_cap.exe
cd \noaa\images\current
dir
```

Batch files of this type can capture any number of planned orbits.

To avoid loss of data in the event of a power cut, the DOS AUTOEXEC.BAT file is edited to include a final line, e.g. 36CAP.BAT, that allows resumption of data capture status when power returns. If the operator wishes to leave the capture screen before the batch file has run its course, the computer should be rebooted while holding down the F5 key. The AUTOEXEC.BAT file can then be edited in Norton Commander to rem the 36CAP.BAT line before booting the computer again.

4. PROCESSING OF NOAA DATA

Background

Captured images have to be processed using PROCESS.BAT (see Annex 1) before they can be viewed. The programme IP_NOAA.EXE is then used to view block files (e.g. *.2B2) in the 'CURRENT' or 'ARCHIVE' directories.

Running the Programme

Make sure the *unprocessed* block file - the file to be processed - is in the CURRENT directory, and run the batch file from the C prompt, not from inside NORTON or any other program.

When the standard batch file method is used - for example 2CAP.BAT - the newly captured files are automatically saved to the C:\NOAA\IMAGES\ARCHIVE directory after they are acquired. Since PROCESS will only operate on the image stored in CURRENT, copy the file to be processed from the ARCHIVE directory to the CURRENT directory using the command ARC_CUR.EXE as follows:

Example: C:\ NOAA\IMAGES\ARCHIVE>*ARC_CUR NE5AAJ14.2B1*

If NORTON COMMANDER is being run, make sure you quit NORTON before running the programme, or memory will be insufficient.

Run PROCESS (from the 'CURRENT' directory) as follows:

C:\NOAA\IMAGES\CURRENT>*PROCESS NE5AAJ14.2B1*

If the program does not run, check that the image filename has been typed correctly.

While 'Process' is running, the words 'calibrating' (filename) 'navigating' (filename) and 'mapping' (filename) are displayed.

The PROCESS program stops at MAP_MOVE.EXE. After exiting MAP_MOVE.EXE the image processing program IP_NOAA.EXE starts automatically.

Map Correction / Alignment Using MAP_MOVE.EXE

The NOAA software includes a digital map of Indonesia's coastlines that can be over-laid on NOAA screen images. However, as the position of NOAA satellites vary with time owing to orbital drift, it is necessary to move the digital map in relation to the image. MAP_MOVE.EXE allows the digital map to be 'nudged' until a best fit with the image is obtained. For day images any channel may be selected for this operation; an infrared channel, preferably Channel 3, must be selected for night images.

Map_move displays the image being processed, with the digital boundaries overlaid in red. At this stage the percentage cloud cover should be assessed and a decision taken whether to proceed with processing or to delete the image. It is usually not worth keeping the image if there is more than 80 percent cloud cover. What is required are cloud free areas of southern Sumatra, particularly South Sumatra Province, in order to accumulate an archive of Vegetation Index Images.

Step 1. Select a sub-area. Move the box to an area where ground features can be identified. The most used feature is the coastline, particularly Selat Bangka, as it is a distinctive reference area. Press <ENTER>.

Step 2. MAPMOVE displays the selected sub-area, overlaid with the digital map boundary drawn in red. Using the arrow keys, move the digital map until it fits as closely as possible with the coastline on the image. Press <ENTER>.

Step 3. Repeats Step 2 after selecting another sub-area.

If no further map adjustment is necessary, press <ESC>.

The program asks 'SAVE MAP POSITION?'
If you are satisfied that the map has been correctly aligned, type 'Y'.
The program returns to 'Channel Menu'.
Press <ESC> again.
MAPMOVE terminates.

The main part of Processing is now over. If you wish to look at the image in more detail, the batch file now starts IP_NOAA. If you do not want to use IP_NOAA, press <ESC>.

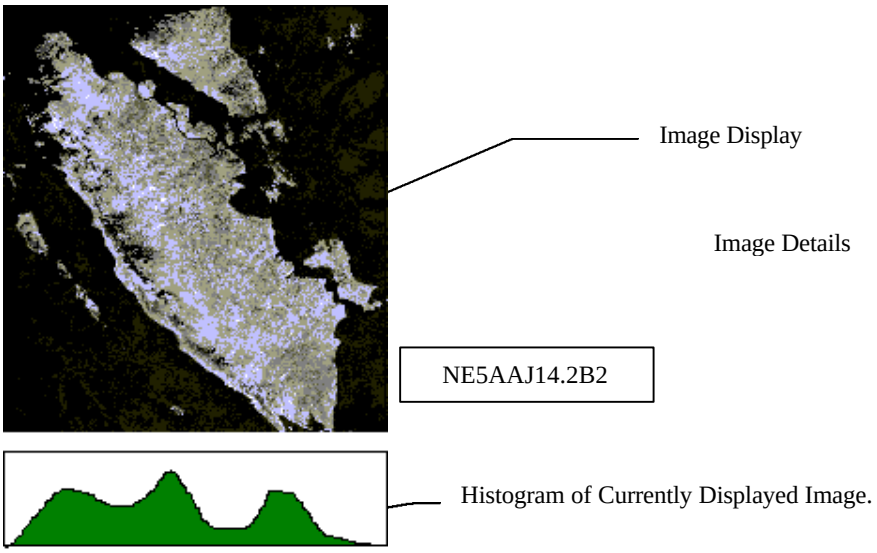
Image Processing Using IP_NOAA.EXE

IP_NOAA is a simple image-processing program that is used to examine BLOCK FILES. The program is used to estimate what information can be derived from the image by further processing. It is usually used first to estimate the amount of cloud cover on an image, and second to assess whether there are any hot-spots present.

IP_NOAA can display BLOCK FILE images, which are either in the CURRENT directory or in the ARCHIVE directory. If IP_NOAA is run and the message “FILE READ ERROR CANNOT READ BLOCK FILE” appears, it means that the file you wish to read has not yet been processed. Copy the file to CURRENT directory using ARC_CUR (filename), run PROCESS (filename) and then try to read the file again.

The screen messages displayed when IP_NOAA is run are:

Screen Message	**Explanation/Action required**
1. Select Image Region	Press <ENTER>
2. Current or Archive	Where is the file you want to display - in CURRENT or in ARCHIVE ?
3. Select File	A list of files is displayed on the right side of the screen in green text. Select a file from the list. Explanation: The file names are displayed, along with the satellite number, the time, and the date the image was captured.
4. Select Channel	Select which channel you wish to display. For a daytime image use Channel 1 or 2; for a night-time image use Channel 3. The image is then displayed on the screen. You will now see the full image displayed:



5. Select sub area The screen displays the full image and a small box, which represents the area, covered by 512 x 512 pixels.

Explanation: The IP_NOAA program is not able to display images larger than 512 x 512 at *full resolution.* This means that images larger than this size are 'sampled', and not all the data are displayed on the screen. If the image you have chosen to look at is greater in size than 512 x 512, (*.1B1) you will now be able to select a sub-area for detailed examination, where every pixel on every line is displayed.

Move the small box until it covers the area you wish to look at, then press <ENTER>. The area is now displayed at full resolution.

6. *Select Image Region / Process Image Region:* Select 'Process Image Region'

This command is asking if you wish to process the image currently being displayed or to select a new image.

7. *Multi Channel System / Single Channel System* Select 'Single Channel'

Here, you can either view all five Channels at the same time, or view just one channel, and display all the digital numbers of channels.

8. View Channel Select Channel 3. Channel 3 is used to detect hot-spots. You may be able to see dark spots on the image. They are considered to be potential fire points if the dark spots have a temperature value substantially higher than the surrounding background temperature. Check the temperature value of a sample of spots using the X hair cursor.

9. Choose 'X hair cursor'

Use the keypad keys and the arrow keys to point the cursor at the dark spots on the image. The arrow keys move one pixel at a time, while the keypad keys move 20 pixels at a time. At the right of the screen is displayed:

If this value is substantially greater than the background temperature and Ch3-Ch4 difference is greater than 10° then this is a potential fire pixel

Sensor	Raw	Radiance	Alb / Btemp
Channel 1	169	71.71	13.84
Channel 2	194	54.01	16.68
Channel 3	5	1.61	321.88
Channel 4	442	86.10	283.37
Channel 5	467	92.46	277.43

If there are a number of fire pixels, go on to generate the fire-map using the batch file API.BAT (Annex 1). If, on NOAA 14 afternoon images, there are no fire points but the image is relatively cloud free, continue to run a batch file to generate a vegetation index image.

5. PROCESSED NOAA PRODUCTS

Two NOAA products are of interest to FFPCP. These are the hot-spots co-ordinates required to prepare fire-maps and the vegetation index images. The vegetation index images can, in turn, be used to assess relative vegetation dryness and fire-risk at a regional scale. (see Anderson *et al.* 1999a and 1999b).

Background

API.BAT is a batch file which executes a number of other programs. All the results of processing are written to the C:\TEKCOR\EXT_DATA directory. API runs the NDVI and FIRES programs to process the NOAA block file in the CURRENT directory, then corrects a defined geographic area using PRODS_LL.EXE. This results in four new calibrated files called EXTENDED image files. All these EXTENDED files have the file extension 'E' - (for extended) instead of 'B' - (for block). Users can build batch files to control product generation: examples are described in Annex 1.

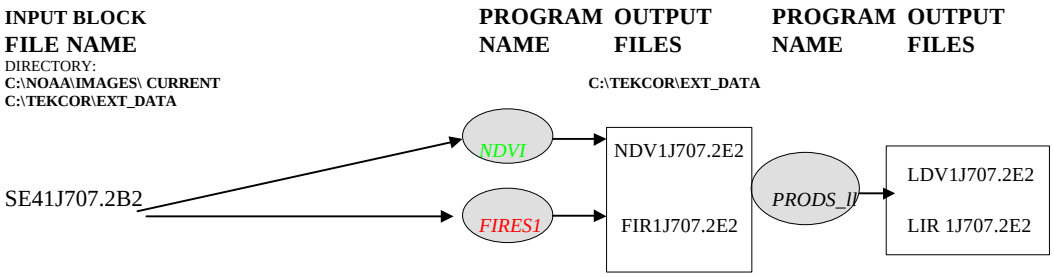
Running the Batch File API.BAT

Run API from the CURRENT directory,
C:\NOAA\IMAGES\CURRENT>API NE5AAJ14.2B2

API.BAT, in the directory C:\BATCH, comprises the following (with explanation shown in black text):

```
@echo off
rem Give name of image as batch file argument
if "%1" == "" goto help
:sumatra
cd \noaa\images\current
ndvi %1   [The batch file runs the program NDVI, on Channels 1 and 2, to produce
          the vegetation index image]
fires1  %1  T3=320  T5=273.15   [The batch file runs the program FIRES1 on
                                 Channels 3, 4 and 5 to produce the fire image]
prods_ll  4.23  96.88  -6.00  107.11  0.01  0.01   [The batch file runs the program
                                                     PRODS_LL on all the files
                                                     produced by the above programs
                                                     to geometrically correct the
                                                     images]
```

At each stage of processing, the output image files are given a standard suffix that enables them to be identified.
Using, for example, a block file called SE41J707.2B2 processing proceeds as follows:



The name of the re-projected image starts with an L to indicate re-projection to Latitude / Longitude form.

It is important to remember that the input file must be in the C:\NOAA\IMAGES\CURRENT directory and all output from API.BAT is written to the sub-directory C:\TEKCOR\EXT_DATA.

Normalised Difference Vegetation Index

The Normalised Difference Vegetation Index (NDVI) is used as an empirical approach to assess the amount and photosynthetic activity of natural and cultivated vegetation. The index formula is given by:

NDVI = (Channel 2 minus Channel 1) / (Channel 2 plus Channel 1) where Channels 1 and 2 are the red and near-infrared reflectance respectively. This equation produces values in the range of -1.0 to 1.0.

Typically, small index values of –0.3 to 0.2 correspond to bare soils, and larger values of 0.2 to 0.65 indicate an increasing presence of green vegetation. Index values outside this range are much less sensitive to change in these environmental variables. NDVI data are often composited over 10-day periods to minimise cloud cover in the area of interest.

The NOAA NDVI.EXE program is designed to produce values of -0.3 to +0.65, the range of greatest sensitivity to environmental variables. These are stretched over the available pixel intensity range, i.e. 5 to 250. The display system uses 8 bits or 256 (2 to the power 8) brightness levels. However, only 246 of the possible 256 pixel intensity levels are used for the grey-level satellite image. Values 0 to 3 are reserved for fixed colours (black, red, blue, green), value 4 is reserved for special features (e.g. fires, see below), values 251 to 254 are used for maps, and level 255 is white.

Program usage: NDVI <Block filename> </M> where /M is the control to produce an overlay map.

Fires

The fire image is derived from Channels 3, 4 and 5. Channel 4 is used to act as the general temperature scaled background, Channel 3 for hot-spot detection and Channel 5 for cloud detection. The threshold temperatures, in degrees Kelvin, for both Channels 3 and 5 may be set as parameters:

Program name	Image name	Ch3 temp	Ch5 temp	Map control
FIRES1	SE5BC70E.2B2	317.15°K	273.15°K	/M

Program usage: FIRES1 <Block filename> <T3=?(°K)> <T5=?(°K)> </M>

The FIRES1 program produces a temperature image with hot-spots above 44°C marked as level 4 and with any pixels which have a Channel 5 temperature less than 0°C (273°K) classified as cloud. A Lookup Table (LUT) called FIRES is used to display these images with fire pixels shown in red. LUTs allow users to specify a product-appropriate colour or grey-scale palette for image viewing, for example a green scale display for NDVI.

API.BAT must be edited to set threshold temperatures for Channel 3 (fire detection) and Channel 5 (cloud detection). The digital values associated with hot-spots are used as a guide to set threshold temperatures. These digital values are determined using IP_NOAA.EXE and the 'X' hair cursor.

NOAA 14 afternoon image fire pixels are frequently saturated, (brightness temperature approximately 323°K), and an appropriate T3 threshold is 320°K. Different thresholds for Channel 3 need to be used for night images and day images within the same ecosystem. This makes full automation of fire detection difficult. For night images, lower temperature thresholds within the range 303° to 317°K are required. Hot-spots can often be detected visually through thin cloud cover. In these cases, the T5 temperature is adjusted to a figure less than the measured cloud temperature. If it is not, the hot-spot will fail to be detected when API.BAT is run.

The presence of non-fire 'hot-spots' caused by sun-glint from water bodies, clouds or hot, bare soil is a frequent complication in the visual assessment and subsequent processing of day images for fire pixels. The effect may be obvious - reflection from the sea or rivers - and the offending hot-spots can be edited out. The NRI developed contextual algorithm FIREINDO (Flasse and Ceccato, 1996) is used if the effect is less amenable to editing. Use of the algorithm is a two-stage process. The first stage selects candidate pixels that are potential fires and the second confirms or rejects these pixels by comparison with their immediate neighbours. The programme works only with daytime images and occasionally fails with *.1B2 images.

To use the FIREINDO programme, process the image file in the 'CURRENT' directory by using the PROC_IDL batch file. An example for a 20 November image illustrates the process.

C:\NOAA\IMAGES\CURRENT>*PROC_IDL SE6BK70E.2B2 20NOVCA*

This batch file pre-processes the image and creates a 16 bit ERDAS *.LAN file with the five NOAA channels calibrated and two additional channels for the latitude and longitude. FIREINDO is then run from within Windows;

- Double click the FIREINDO icon and from the resulting window select IMPORT IMAGE.
- Select the *.LAN file of interest. A Channel 3 image is displayed.
- Press the DETECT FIRES button. The image is processed for fires, which appear in red.
- Press the EXPORT LAT/LONG button. The fire co-ordinates in decimal degrees are written to a file (20novca.lld in the example) in the same directory as the *.LAN image file. The *.lld file should later be renamed *.txt
- MAP LAT/LONG is pressed to display a map of Indonesia with fires plotted in red and clouds in grey.

Product Re-Projection

PRODS_LL.EXE re-projects the image as seen by the NOAA satellite into latitude / longitude form. All products in the C:\TEKCOR\EXT_DATA directory with names that correspond to the BLOCK filename in the current working directory, i.e. in C:\NOAA\IMAGES\CURRENT, will be re-projected. The format is:

PRODS_LL <LatNW> <LongNW> <LatSE> <LongSE> <LatScale> <LongScale>

E.g. PRODS_LL 4.23 96.88 -6.00 107.11 0.01 0.01 , where the latitude and longitude, in decimal degrees, refer to the region of interest. A value of 0.01 is normally used for scaling. API identifies a region of interest as:

Lat.NW	Long.NW	Lat.SE	Long.SE
4.23°N	96.88°E	6.00°S	107.11°E

This region of interest corresponds to a rectangle with its northwest co-ordinates near Takengon in Aceh Province, and southwest co-ordinates on the north coast of Java near Jakarta. Latitudinal co-ordinates south of the equator are entered as negative numbers.

After running API.BAT, the products, as E image files, can be viewed using the TEKCOR image processing system. The system is activated by running EXTENDED.EXE from the TEKCOR directory. This will display the fire-map.

6. GIS PRODUCTS

The GIS is used to analyse hot-spot data and produce fire-maps.

The Creation of Hot-Spot Co-ordinates

The re-projected fire-image can be processed to provide a list of hot-spot co-ordinates that can be integrated with the FFPCP GIS. With the use of Norton Commander to manage the files, the fire image (e.g. LIR15716.2E2) is moved to C:\EXERCISE and, while highlighting the filename, NOAA2IDR.EXE is run. This produces an IDRISI file from the processed product E file that includes essential header / trailer information. The format is the program name followed by image name followed by the name you wish to give the IDRISI file e.g. NOAA2IDR LIR15716.2E2 5APR

NOAA2IDR.EXE produces four files e.g. 5APR.DOC, 5APR.DVC, 5APR.IMG and 5APR.VAL. All four files should be moved to C:\TEKCOR\EXT_DATA.

Then, still in Norton Commander, run the Idrisi RECLASS module (image classification) and respond as follows, using 5APR as the example:

1. Enter name of the image file to be classified - 5APR Press <ENTER>

2. Enter a new name for the output image file - 5APRR Press <ENTER>

3. Choose option (2) *User-defined classification*

4. Assign a new value of - 0 to the old values ranging from - 5 to those just less than – 255

5. Then press <ENTER> four times

Next, run the Idrisi POINTVEC module (raster to vector point file conversion) and respond as follows:

1. Enter name of image to be processed - 5APRR Press <ENTER>

2. Enter a name for the vector file to be created - 5APRV Press <ENTER>

Finally, run the Idrisi ARCIDRISI module (ArcInfo to or from Idrisi conversion) and respond as follows:

1. Choose option (2) *Idrisi to ArcInfo*

2. Enter name of the Idrisi vector file to be converted - 5APRV Press <ENTER>

3. Enter a name for the ArcInfo GENERATE file to be created - 5APR.TXT Press <ENTER>
4. Enter field width - enter for default Press <ENTER>

5. Enter the number of decimal places - 2 Press <ENTER>

Exit Norton Commander for Windows and navigate to File Manager. Then:

1. Move 5APR.TXT to C:\TEXTFILE

2. Copy the text file from the PC Dell 2 to the PC Acer either via the network or by diskette

3. Delete all the files in \TEKCOR\EXT_DATA as well as the LIR1 file in \EXERCISE.

The latitude / longitude co-ordinates for all the hot-spots detected for the 5 April NOAA pass have now been saved in 5APR.TXT

The Creation of Maps with Hot-Spot Themes

1. In Excel, import the NOAA hot-spot text file, e.g. 5APR.TXT

2. Insert column headings - X in column A (Longitude), Y in column B (Latitude), Date in column C, Time in column D (using local date and time - WIB) and Temperature in column E. In the Temperature column, the algorithm used should be shown, e.g. CA for contextual algorithm.

3. Save this edited file in C:\NOAA\<month><year>\ e.g. JAN97.

4. Exit Excel.

5. Open ArcView. Navigate to the directory containing the project files (*.apr) and select the project of interest e.g. lampung.apr.

6. Load the data as a table by making the Project window active, and choosing *Add Table* from the Project menu.

7. In the dialogue box that appears, choose *Delimited Text (*.txt)* and navigate to the directory that contains the wanted file, e.g. C:\NOAA\JAN97\

8. Click on the wanted file or, if more than one file is wanted, hold down SHIFT and click on them in turn. Press OK. The file is opened in the project and its name listed in the Tables list in the Project window.

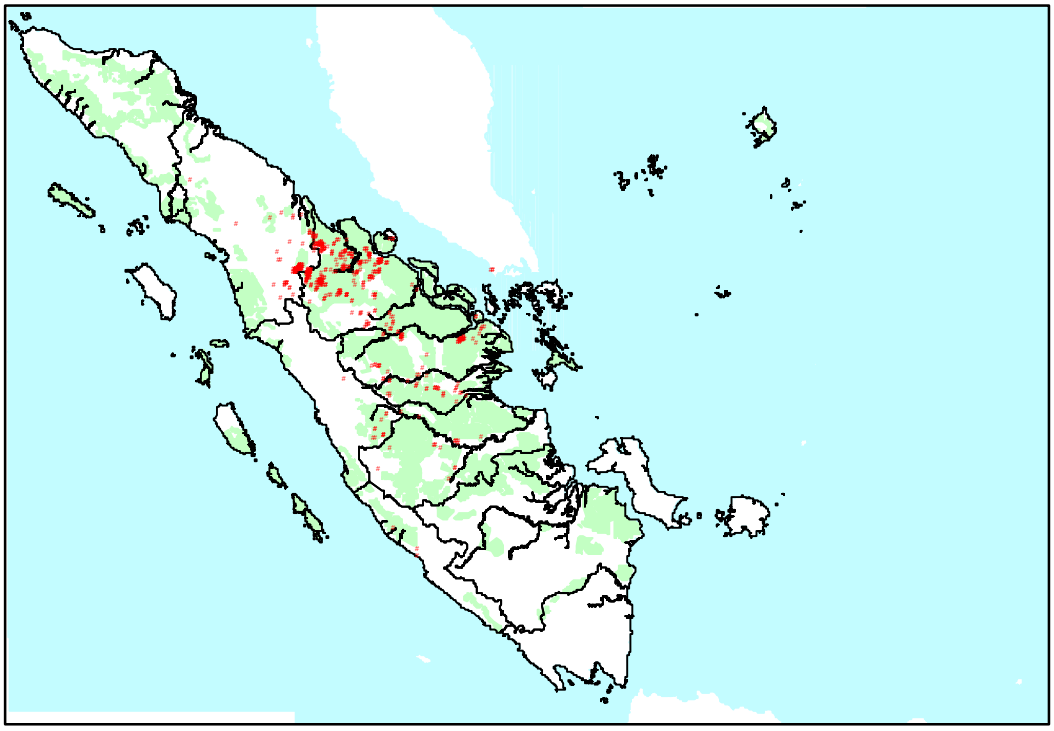
9. Open the view of the project of interest. From the View menu, choose *Add Event Theme*.

10. In the dialogue that appears, choose the name of the table from the Table dropdown list. ArcView reads the field names for Longitude (X) and Latitude (Y). Press OK and a new theme is added to the view.

11. The Font and Colour palettes can be used to change the appearance of the hot-spot symbol.

12. Finally, a simple fire map can be printed as shown below (Map 1). Examples of other map formats are given in Anderson *et al.* (1999c).

Map 1. Fire map of Sumatra derived from NOAA 14 image captured on 14 June 1998 at 15:13 hrs WIB



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ABBREVIATIONS AND ACRONYMS

AVHRR	Advanced Very High Resolution Radiometer
BAPEDAL	Badan Pengendalian Dampak Lingkungan (Environment Impact Assessment Agency, Ministry of Environment)
BMG	Badan Meteorologi dan Giofisika (Agency for Meteorology and Geophysics)
BPPT	Badan Pengkajian dan Penerapan Technologi (Agency for the Assessment and Application of Technology)
BURL	Bradford University Research Limited
CIFOR	Center for International Forestry Research
EC	European Commission (EU)
EU	European Union
EUFREG	European Union Fire Responses Group
FFPCP	Forest Fire Prevention and Control Project (EU)
FFPMP	Forest Fire Prevention Management Project (JICA)
FLB	Forest Liaison Bureau
GIS	Geographic Information System
GTZ	Gesellschaft fur Technische Zusammenarbeit (German Agency for Technical Coorperation)
ICRAF	International Center for Research in Agro-forestry
IFFM	Indonesia Forestry Action Programme
INTAG	Inventarisasi dan Tata Guna Hutan (Directorate General of Forest Inventory and Land-Use, Ministry of Forestry and Estate Crops)
ITFMP	Indonesia Tropical Forest Management Programme (UK Overseas Development Administration)
JICA	Japanese International Co-operation Agency
KODAM	Komandom Daerah Militer (Military District Command)
LAPAN	Lembaga Penerbangan dan Antariksa Nasional (Indonesian National Institute for Aeronautics and Space)
MUBA	Musi Banyu Asin (name of a District in South Sumatra)
NDVI	Normalised Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
OKI	Ogan Komring Ilir (name of a District in South Sumatra)
PHPA	Perlindungan Hutan dan Pelestarian Alam (Forest Protection and Nature Conservation, Ministry of Forestry and Estate Crops)
POSKO	Pos Komando (Command post)
TLE	Two line element
WIB	Waktu Indonesia Barat (West Indonesia time)

ANNEX 1

BATCH FILES USED TO PROCESS NOAA DATA

1. **a.bat** lists the contents of the archive directory:

```
cd \noaa\images\archive
cls
dir
```

2. **api.bat** produces reprojected fire and NDVI extended images of 1E1, 2E1 or 2E size:

```
@ echo off
rem Give name of image as batch file argument
if "%1" == "" go to help
:sumatra
cd \noaa\images\current
ndvi %1
fires1 %1 T3=317 T5=273.15 /M
rem prods_ll -1.30 102 -6.41 107.11 0.01 0.01
rem prods_ll -0.89 98.88 -6.00 109.11 0.01 0.01
prods_ll 4.23 96.88 -6.00 107.11 0.01 0.01
```

3. **arc.bat** lists the contents of archive by date and one screen at a time:

```
cd \noaa\images\archive
cls
dir/O:D/P
```

4. **bkf2erd.bat** converts block files to ERDAS *.LAN files:

```
echo Transforming image %1 into ERDAS format
bf_erd16 %1 c:\noaa\images\archive\%2.lan
cd\noaa\images\archive
dir *.lan
```

5. **buildtle.bat** updates the tle:

```
cd \noaa\two_line
\noaa\programs\tlupdate.exe new.tle list_tle.sat
```

6. **c.bat** lists the current directory:

```
cd \noaa\images\current
cls
dir
```

7. **capture.bat** deletes any BLOCK files in the current directory and captures a new BLOCK file. The inclusion of /E2 and /E3 produces E images for channels 2 and 3 i.e. a visible and an infra-red image to assist in the decision whether to process further:

```
rem cd\tekcor\ext_data
rem del *.?E?
rem cd\tekcor\comb
rem del *.?H?
cd\noaa\images\current
del *.?B?
cd\noaa\programs
noaa_cap.exe /E2 /E3
cd\noaa\images\current
dir
```

8. **e.bat** lists the contents of the exercise directory:

```
cd \exercise
cls
dir
```

9. **fire.bat** produces 2E2 reprojected fire and channels 3,4 and 5 images:

```
@echo off
rem Give name of image as batch file argument
if "%1" == "" goto help
:sumatra
cd \noaa\images\current
chxcal %1 chn=3 div=1 off=273
chxcal %1 chn=4 div=1 off=273
chxcal %1 chn=5 div=1 off=273
fires1 %1 T3=321 T5=273.15
prods_ll 4.23 96.88 -6.00 107.11 0.01 0.01
```

10. **fire_320.bat** is similar to 9 but with a lower fire threshold temperature (320°Kelvin):

```
@echo off
rem Give name of image as batch file argument
```

```
if "%1" == "" goto help
:sumatra
cd \noaa\images\current
chxcal %1 chn=3 div=1 off=273
chxcal %1 chn=4 div=1 off=273
chxcal %1 chn=5 div=1 off=273
fires1 %1 T3=320 T5=273.15
prods_ll  4.23 96.88 -6.00 107.11 0.01 0.01
```

11. **firejava.bat** produces a re-projected channel 3 E image for Java:

```
@echo off
rem Give name of image as batch file argument
if "%1" == "" goto help
:FIREJAVA
cd \noaa\images\current
echo Producing Scaled Channel 3
chxcal %1 chn=3 off=273 div=1 /M
PRODS_LL -5 105 -10.11 115.23 0.01 0.01
cd\TEKCOR
extended.exe
goto end
:help
echo The image filename form \NOAA\IMAGES\CURRENT directory must be given
echo as an argument to this batch file eg. PROCESS SB15OE10.2B1
goto end
:end
echo Now ending PRODUCT generation.
```

12. **geo_ria.bat** produces reprojected fire and NDVI images and copies the NDVI *.img and *.doc files to the idris directory:

```
@echo off
rem Give name of image as batch file argument
if “%1” == “” goto help
:sumatra
cd \noaa\images\current
ndvi %1
fires1 %1 T3=320 T5=273.15
prods_ll 4.23 96.88 -6.00 107.11 0.01 0.01
cd \tekcor\ext_data
ren ldvi%2.2e2 ldvi%2.img
copy ldvi%2.img \idris\*.*
copy \idris\document\2e2.doc \idris\ldvi%2.doc
```

13. **ie.bat** runs the extended program to produce E images:

```
cd\tekcor
extended.exe
```

14. **ip.bat** runs the general image processing program in tekcor:

```
cd\tekcor
ip.exe
```

15. **kalfire.bat** produces a reprojected calibrated channel 3 image for Kalimantan:

```
@echo off
rem Give name of image as batch file argument
if "%1" == "" goto help
:KALFIRE
cd \noaa\images\current
CHXCAL %1 CHN=3 DIV=1 OFF=273 /M
PRODS_LL 1 115 -4.11 120.11 0.01 0.01
```

16. **ndvi.bat** produces a re-projected ndvi image:

```
@echo off
rem Give name of image as batch file argument
if "%1" == "" goto help
:sumatra
cd \noaa\images\current
rem chxcal %1 chn=1 div=0.2 off=0
rem chxcal %1 chn=2 div=0.2 off=0
ndvi %1
prods_ll -0.89 98.88 -6.00 109.11 0.01 0.01
```

17. **noaa_cap** first deletes the previously captured image in the CURRENT directory and then captures the next data as specified in PLAN:

```
cd \noaa\images\current
del *.?B?
cd \noaa\programs
noaa_cap.exe
cd \noaa\images\current
dir
```

18. **plan.bat** runs the orbit program providing information on future satellite passes:

```
cd\noaa\programs
orbit.exe
```

19. **process.bat** executes programmes to calibrate, navigate the image and move on to the map "nudge" programme to allow the user to correct the map overlay. Process then runs the NOAA image processing program IP_NOAA:

```
@echo off
rem Give name of image as batch file argument
if "%1" == "" goto help
:process
cd \noaa\images\current
echo Calibrating Image %1
cal_img %1
echo Navigating Image %1
nav_img %1
echo Mapping Image %1
map_img %1
map_move
ip_noaa
goto end
:help
echo The image filename in \NOAA\IMAGES\CURRENT directory must
echo be given as an argument to this batch file
echo e.g. PROCESS SE6BK70E.2B2
:end
echo Now ending Process
```