A Southeast Asia Environmental Information Web Portal

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Abstract: In this paper, we describe the development of a Southeast Asia environmental information web portal based on near real time MODIS Level 2 and higher level products generated from the direct broadcast data received at the Centre for Remote Imaging, Sensing and Processing (CRISP). This web portal aims to deliver timely environmental information to interested users in the region. Interpreted data will be provided instead of raw satellite data to reduce operational requirements on our system, and to enable users with limited bandwidths to have access to the system.

Keywords: MODIS, direct broadcast, environmental monitoring, internet, fire detection, algal blooms

1. Introduction

We are developing a Southeast Asia environmental information web portal with an aim to provide near real time environmental information of the region. Currently, the system is based on higher level products generated from the Moderate Resolution Imaging Spectrometer (MODIS) direct-broadcast data received by the ground station at the Centre for Remote Imaging, Sensing and Processing (CRISP), National University of Singapore. MODIS on-board the TERRA and AQUA satellites is a valuable instrument for environmental monitoring. It has 36 spectral bands spanning from the visible blue to the thermal infrared spectral regions, and three spatial resolution modes (250 m, 500 m and 1 km). The accurate calibration of the sensors enables the retrieval of land, atmosphere and ocean parameters from the data. One of the unique features of the MODIS instrument is its ability to broadcast data from the satellite to anyone within its line-of-sight. Any ground stations equipped with a 3m or larger X-band reception system and the necessary hardware and software can receive the data. It is particularly useful for regional ground stations to perform near-real-time environmental monitoring.

The ground station at CRISP has been routinely receiving MODIS direct-broadcast data since early 2001. Initially the data were processed up to Level 1B. Currently, operational software adapted from NASA's Institutional Algorithms is used to generate higher level products.

Space agencies such as NASA, NASDA and ESA routinely provide satellite data and standard products for scientific research. Due to the high work loads on the data provider and limited internet bandwidths available to most users in this region, there is a time-lag between data request and data delivery to the scientists requiring the data. This arrangement is tolerable for studying the general behavior and for monitoring the evolution of the environmental situation in the past. In order to perform near-real time monitoring and to provide early warning of impending environmental disasters, data has to be acquired, analyzed, interpreted and delivered to the users in as short a time as possible. Our web-based system will provide timely delivery of derived environmental information to interested users.

The target users of the web portal are expected to be those related to the national environmental protection and enforcement agencies, non-governmental organizations, international organizations, commercial and industrial companies, researchers, and interested public.

2. MODIS Direct Broadcast Data Reception at CRISP

In early 2001, CRISP established the MODIS Direct Broadcast Reception and Processing system to receive MODIS data and process the data to Level 1B [1]. This is a fully automated system that acquires direct broadcast MODIS data by a 6-m X-band antenna. The raw data is fed into a demodulator and recorded on a direct ingest system. A reformatting software program was developed to convert the recorded signal into MODIS level-0 data in Production Data Sets (PDS) format.

An in-house developed software generates browse images directly from the Level-0 files and incorporates a procedure to remove the "bowtie" effect. A web-based catalogue system for MODIS data received at CRISP has been developed and integrated into CRISP's existing catalogue system. Level 1B products are subsequently generated using the University of Wisconsin International MODIS/AIRS Processing Package (IMAPP) software. All process-

ing has been integrated to run on a Linux system. The acquisition, archival, browse image generation, catalogue updating and Level 1B processing are all performed automatically.

3. MODIS Higher Level Products

Since the beginning of the year 2003, NASA has progressively made available the MODIS Level 2 science algorithm software code developed by various NASA science teams to the direct broadcast user community [2]. This software code is considered Institutional since it is part of a large, integrated MODIS Operations Data Processing System (MODAPS) operating at NASA's data processsing facility used to operationally generate Level-2 and 3 MODIS data products, in a chained production mode. The Institutional Algorithms are grouped by the Product Generation Executables (PGE). Each PGE comes with the algorithm codes for generating a specific group of science products, together with an overview of the source code, required inputs, output files, build and run guidelines.

To make the Institutional Algorithms run in a standalone mode, some changes to the codes and environment set-ups are necessary. Most PGEs include static files which need to be staged for a proper run. In addition, the PGE may require ancillary data input such as the 6-hour Global Data Assimilation System (GDAS) meteorological data from the National Centre for Environmental Prediction (NCEP) and daily total column ozone data (also available at NCEP). The necessary libraries also need to be installed properly before the PGEs can be compiled. Table 1 shows the list of libraries currently installed at our system. Each PGE has a Process Control File (PCF) which needs to be updated with the correct location of the static, input, output and ancillary data files, if required before each run. The runtime environmental variables also need to reflect the location of the SDP Toolkit as well as this PCF file.

Table 1. Some libraries required by the PGEs

Library	*Version*	*Remarks*
Science Data Processing (SDP) Toolkit	5.2.7.3	Required by all PGEs
HDF	4.1r5	Required by all PGEs
HDFEOS	2.4	Required by all PGEs
Modis Application Programming Interface (MAPI)	2.3.3	Required by some PGEs

CRISP's Level 1B HDF files are generated from the IMAPP software which produces HDF files whose format differs slightly from that of the NASA's software. The differences lie in the way some of the metadata are stored in the HDF files [3]. Furthermore, NASA's PGEs expect each HDF data granule to be up to 5 minutes in length, whereas IMAPP processes each direct broadcast pass into a single HDF file which can last as long as 13 minutes. Thus, the PGE codes need to be modified to accommodate these differences.

We have successfully integrated the PGEs to run on a Linux PC with RedHat 8.0 operating system. There are a whole suite of PGEs available to generate higher level products [4]. Table 2 shows a list of PGEs successfully built and currently in production mode at CRISP.

The order of execution of the PGEs is important when scheduling run jobs. The cloud mask product (MOD35) generated from PGE03 is required as an input to atmospheric profile (MOD07) run. It is also required as input to the water vapour (MOD05) run and cloudtop (MOD06) run. In addition to the cloud mask, the water vapour run will also require the atmospheric profile (MOD07) output of MOD07 from PGE03. For the best results, the cloud mask and atmospheric profile runs require GDAS meteorological data. This can be downloaded by FTP from the site in [5]. Due to the data dependencies and availability, we currently generate Level 2 products once a day for Terra day passes only. The only exception being PGE30 (fire product) which does not require any ancillary data, it is run as soon as Level 1B data is available to generate near-real time fire products.

Table 2. Operational PGEs installed at CRISP

PGE	*Version*	*Description*
PGE03	4.1.2	Cloud mask (MOD35) Atmospheric Profile (MOD07)
PGE04	3.1.0	Water Vapour (MOD05)
PGE06	4.2.5	Cloudtop (MOD06)
PGE09	4.2.2	Ocean Colour
PGE10	4.2.2	SST (MOD28)
PGE30	4.3.2	Fire detection (MOD14)

Once the Level 2 products are available, gridded data of selected geophysical parameters are produced using the MODIS Swath-to-Grid Toolbox (MS2GT) [6]. The gridded data are then converted to JPEG images or tabular information showing the distribution and statistics of the specific parameters in the region and made available on the web portal.

4. Near-Real Time Products

The main objective of this project is to disseminate timely information for near-real time monitoring of the environment and to provide early warning of impending environmental disasters. In order to achieve this objective, data has to be acquired, analyzed, interpreted and delivered to the users in as short a time as possible. Thus, the web portal will provide interpreted data instead of the raw satellite data or the standard products in chunky HDF files to reduce operational requirements on our system, and to enable users with limited bandwidths to have fast access to the system. An email-alert service will also be implemented. The near real time products would enables users to monitor and track the evolution of significant environmental events such as vegetation fire, haze, drought, floods, algal blooms etc in the region.

Two initial applications of the near-real time products have been identified: forest fire and algal bloom monitoring. Even before the NASA PGEs were available, CRISP has implemented an in-house fire detection algorithm to detect active fires using MODIS data [7]. Currently, NASA's PGE30 runs concurrently with CRISP-developed hotspot detection algorithm. The fire near-real time products include the hot spot locations and the characteristics of the detected fires. They are used internally for the routine monitoring of the regional fires, for planning the acquisition of high resolution SPOT images of the fire affected areas. Efforts are also being made to validate the near-real time fire products using high resolution SPOT images, and to fine tune the fire detection algorithm to optimize its performance for the local conditions.

The algal-bloom near real time product consist of daily sea water chlorophyll charts derived from PGE10 (ocean colour products) and chlorophyll anomaly produced by comparing the near-real time chlorophyll product with the seasonal chlorophyll composite of the region. Chlorophyll anomaly is possibly an indication of impending algal bloom event. A chlorophyll anomaly alert is issued when the chlorophyll concentration of a given area is significantly higher than the seasonal average.

Near real time products for other environmental applications will be developed to meet specific user requirements.

4. Conclusions

The regional environmental information web portal under development aims to deliver timely information for near-real time monitoring of the environment. Currently, the system is based on Level 2 and higher level products derived from the MODIS direct broadcast data received at CRISP's ground station. Near-real time geophysical parameters are generated and delivered in the form of interpreted images, graphical and tabular information. Basic information is expected to be available to the general public while specific customized services will be made available on subscription basis. At present, near-real time products have been developed for applications in the detection and monitoring of fires and algal blooms. It is anticipated that other applications will be developed in consultation with potential users.

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