

MODIS DATA ACQUISITION, PROCESSING AND SCIENTIFIC UTILIZATION FRAMEWORK AT THE INSTITUTE OF INDUSTRIAL SCIENCE, UNIVERSITY OF TOKYO

Tran Hung, Shiro Ochi, Toshihiro Nemoto, Masaru Kitsuregawa, Yoshifumi Yasuoka

4-6-1 Komaba, Meguro-ku, Tokyo, Japan 153-8505

Tel: +81-3-5452-6410, Fax: +81-3-5452-6410

E-mail: tranhung@iis.u-tokyo.ac.jp, ochi@iis.u-tokyo.ac.jp, nemoto@tkl.iis.u-tokyo.ac.jp, kitsure@tkl.iis.u-tokyo.ac.jp, yasuoka@iis.u-tokyo.ac.jp

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ABSTRACT: In May 2001, the Institute of Industrial Science (IIS), University of Tokyo had installed a new X-band satellite reception facility to collect data from MODIS, an electro-optical sensor aboard the TERRA satellite. In addition to the existing satellite receiving systems of NOAA HRPT and GMS S-VISSR, the IIS's MODIS Direct Broadcast (DB) system produce real-time wide-spectrum geolocated and calibrated (level 1b) products for short-term applications, forecast and warning use in the region. All the data are archived in the archiving system with Satellite Image Database service through WWW. In collaboration with the Asian Center for Research on Remote Sensing (ACRoRS), AIT, the IIS receive and archive daily MODIS data acquired in Bangkok, Thailand since June 2001. As there is an increasing need for near real-time MODIS data for environment and disasters monitoring in South / East Asia, the Institute is in the process of expanding its MODIS receiving and processing system as well as collaboration with various regional MODIS receiving stations. Similar to the existing network of HRPT receiving stations (at IIS, AIT, Kuroshima and Ulaan Baator), which generates 10-day AVHRR composite for Asian region since 1998, the aim of the Asian MODIS receiving stations network is to exchange data and then to create a multi-temporal database of MODIS for whole Asian region in a shortest possible time lag. The expected products are Asian mosaics of MODIS 8-day cloud-free 1km-resolution composite and selected regional products for medium and long-term continental change researches. On the other hand, we are in the process of incorporating MODIS data as supplements to AVHRR data into our current research activities of terrestrial ecosystem changes researches.

BACKGROUND

The Institute of Industrial Science (IIS), University of Tokyo has been receiving GMS S-VISSR and NOAA/AVHRR data since 1980 within the framework of the global HRPT receiving stations network. The satellite data receiving and processing systems at the IIS are jointly managed by two research laboratories namely: Yasuoka and Kitsuregawa Labs with the former focuses on overall data receiving and scientific requirements and later focuses on data archiving management. The systems were purchased from Dundee Satellite Systems Ltd., UK which compose of: 2.4m parabolic reflector antenna, an antenna control PC and a SPARCstation 5 for HRPT data ingestion; and 3.7m parabolic reflector antenna and a SPARCstation 5 for S-VISSR data ingestion. The systems routinely acquire data from GMS and NOAA-12, NOAA-14 and NOAA-15 day and night passes. The data are archived in the D3 tape archiving system including Level 0, geo-corrected surface temperature, weekly NDVI, metadata and digital quick-look images and, then, distributed using Satellite Image Database service through WWW (<http://www.tkl.iis.u-tokyo.ac.jp/SatIAN/Welcome.html>). Since 1997, IIS has collaborated with the Asian Institute of Technology (AIT) to receive daily AVHRR data from Bangkok, Thailand through network transferring. In spite of the existing AVHRR data set for global and continental scale, there has been relatively little practical contribution to multi-temporal AVHRR database for Asian region. As there is an increasing need for quasi real-time NOAA data for environment and disasters monitoring in South / East Asia, the Institute has expanding its NOAA receiving and processing system as well as has increasing the collaboration with various regional HRPT receiving stations. The aim of this collaboration study is to create a multi-temporal database of AVHRR for whole Asian region with much shorter time lag. Followed the data exchange agreement between HRPT receiving stations at IIS, AIT, Kuroshima and Ulaan Baator, the Laboratory of Remote Sensing Data Analysis (Iwate University, Japan) has started to develop an automatic processing system to generate 10-day composite 1km-resolution image of AVHRR data for Asian region with the first prototype image of 1-10 August 1998 period. The participants of this collaboration network are IIS, AIT, Chiba University, Iwate University, Science University of Tokyo and National Institute of Environmental Studies, Japan. It is expected that within 2-3 years the developed processing system will be installed at the Kitsuregawa Lab, IIS to automatically generate AVHRR composite for Asian region in shortest time lag (Yokoyama *et al.*, 1999). The combined area coverage for 4 HRPT stations ranges from 50°00'E to 180°00'E and from 20°00'S to 80°00'N as shown in Figure 1.

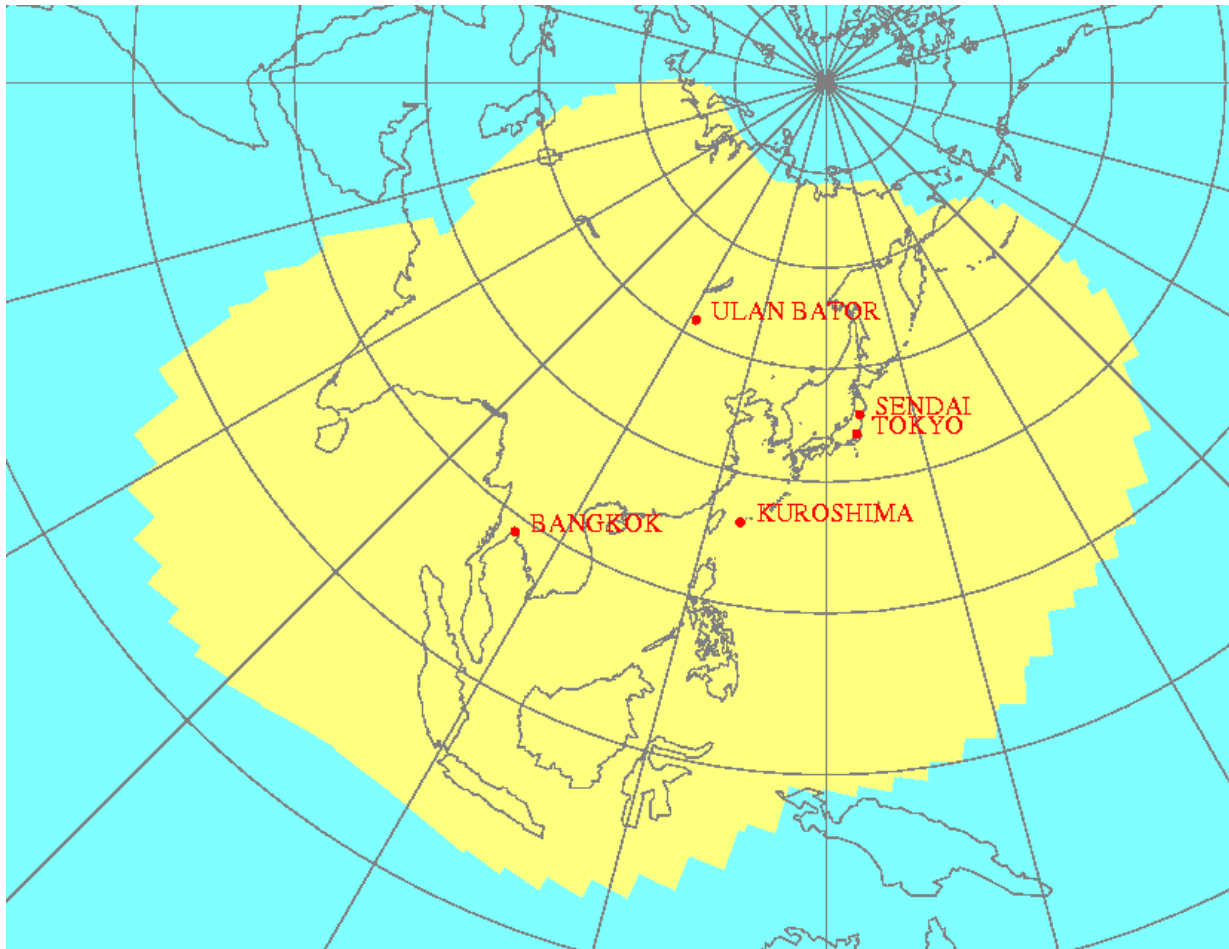


Figure 1 The coverage of Asian AVHRR data composite (IIS, 1998)

Alongside with NOAA data acquisition and processing, the IIS's research laboratories have been intensively utilizing AVHRR data during the last 2 decades for environmental research at global and continental scale. Examples of our recent scientific activities include: land cover/vegetation classification, monitoring of biosphere, atmospheric CO₂ concentration, thermal characteristics of human-induced land use change, water distribution mapping, and estimation of NPP based agricultural production.

The MODerate resolution Imaging Spectroradiometer (MODIS) was launched in December 18, 1999 onboard of the Earth Observing System TERRA satellite. The design for land imaging combines and improves upon the strengths of the AVHRR and the Landsat TM, adding spectral bands in the middle and long-wave infrared and providing a spatial resolution between 250m and 1km. In order to improve our research capability in terrestrial ecosystem change research as well as to provide near real-time products for short-term applications, disaster forecast and warning in the region, the IIS received research budget from the Ministry of Education, Japan to purchase and install MODIS Direct Broadcast facilities at the IIS campus (Tokyo) and AIT campus (Thailand).

MODIS DATA ACQUISITION, PROCESSING AND ARCHIVING SYSTEMS

Data Acquisition and Processing

In addition to the existing satellite receiving systems of NOAA HRPT and GMS S-VISSR, a new X-band satellite reception facility was installed in the Komaba Research Campus (University of Tokyo), which started operation since 18 May 2001. The dish is placed on the roof of the 8-story IIS building (35.66° N, 139.68° E & 87 m above MSL) in between of the existing HRPT and GMS antennas. In order to acquire EOS data for expanded continental-scale change researches into the Southeast Asian sub-region, the Institute of Industrial Science has provided Asian Center for Research on Remote Sensing, Asian Institute of Technology one identical MODIS receiving facility. That station was set up in late of May 2001, on top of the Geoinformatics building (14°05' N and 100°37' E), Asian Institute of Technology, Thailand and managed by the Joint Management Committee composing of ACRoRS (AIT), Geo-Informatics and Space Technology Development Agency (Thailand) and the Institute of Industrial

Science (University of Tokyo). The MODIS raw data from AIT receiving facility is sending to the IIS archiving system in DLT tapes as well.

The receiving systems (for both IIS's and AIT's sites) supplied by the Sumitomo Electric Co., Japan (main contractor) includes antenna, related processing hardware and software:

- The Dundee Satellite Systems XY antenna dish with 2.8 m in diameter has a full X/Y mount, allowing it to tilt and pan in any direction (except down!) without interruption.
- The tracking X/Y antenna software from Crawford Space Communications Ltd. is used to calibrate and automate the tracking path.
- Motor Control Unit, Receiver, Antenna Interface Unit and Antenna Control PC (Windows 98).
- Data Ingest PC (Linux Red Hat 7.0), which could also process data to level 1B using Wisconsin University IMAPP processing package.

The IIS DB facility is capable of receiving 4-5 passes overhead of approximately 10 minutes duration (with maximum elevation not lower than 5°) per day, resulting in around 4GB of raw ingested data in packet format for archiving. Raw data are then frame-synchronized to produce time-ordered level 0 data. In near real-time, IMAPP software from Wisconsin University (for the time being) is used to process the level 0 data producing calibrated and geolocated radiances (level 1b). These radiances are available in spatial resolutions of 250 m (for bands 1, 2), 500 m (for bands 3-7 and aggregated bands 1,2), and 1 km (for bands 8-36 and aggregated bands 1-7). Then, using SIMAP (a IDL-based script from DAAC), quicklooks are generated as a “true color” composite (1km-aggregated bands 1/2/1 as R/G/B) for day scenes and a B-W 1km-resolution radiance image (band 31) for night scenes (Tran, Ochi & Yasuoka, 2001). High-level land products for scientific research are produced selectively using our customized IDL-based processing code. The details of the MODIS data processing flow used at the Institute of Industrial Science are shown in Figure 2.

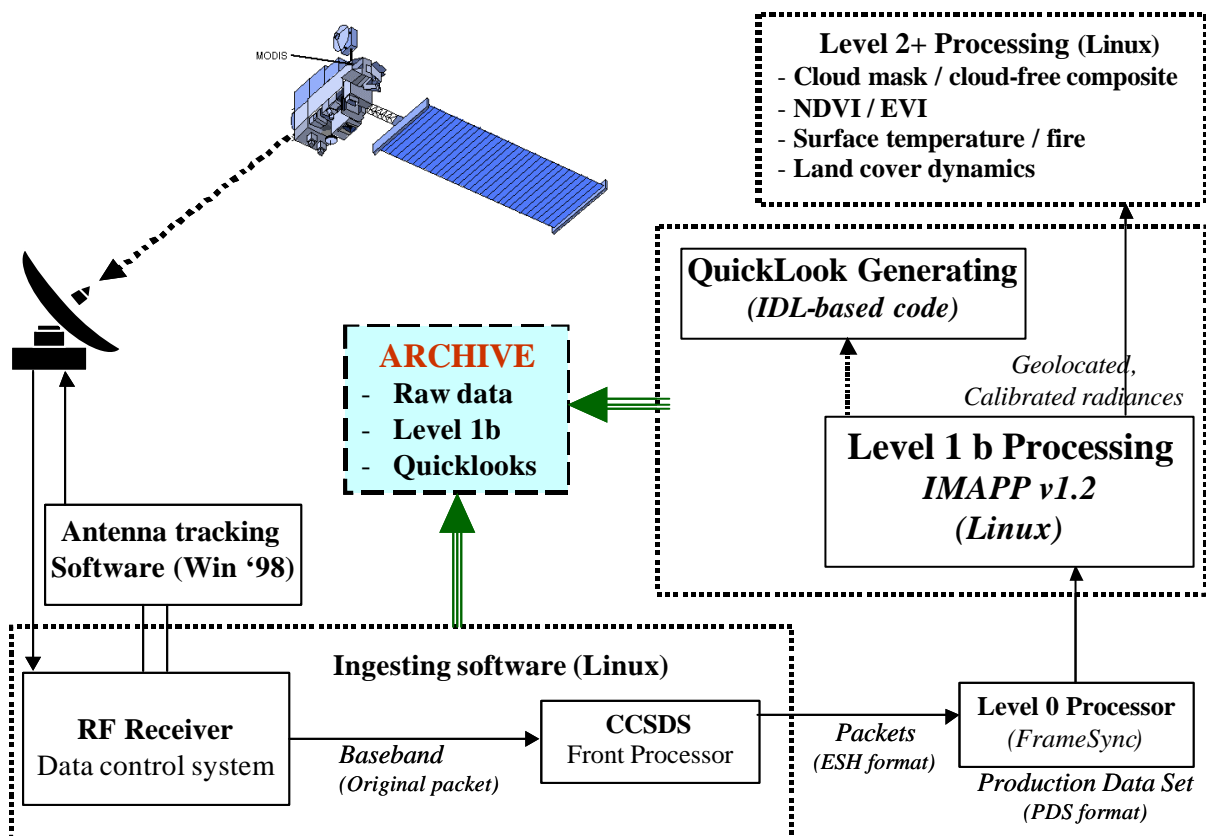


Figure 2. MODIS data processing flow adopted at the Institute of Industrial Science (UT)

Data Archiving and Distribution Management

The MODIS raw ingested data, processed level 1b radiances and quicklooks are transferred to archiving system at the Kitsuregawa Lab, which is in charge of data archiving and distribution management. The archiving system

composes of a file server (SUN Enterprise 6500 with 8 CPUs, 2GB Memory), hard-disk arrays and tape jukeboxes. The disk arrays totaled of 822 GB are used for temporal archive of recently acquired data (for about last 20 days). The unique feature of the IIS archiving system is 3 D3 tape jukeboxes, which used for distributing data through the network (intranet or WWW) from permanently archived D3 tapes (100 TB capacity). Data then exchange internally and transfer through network using ATM (156Mbps), CDDI (100Mbps), ISDN (1.5Mbps) and Ethernet (100Mbps, 10Mbps). The Kitsugerawa Lab also has developed a Web-based searchable database for metadata to facilitate the data distributing process. The system keeps users' downloading records and dynamically manages the D3 jukeboxes (and re-write back to hard-disks if needed) to the most-frequently-needed data to speed-up the downloading process for users (Nemoto & Kitsuregawa, 1998).

As the IIS receives the main portion of its research budget from the Ministry of Education, Japan, the satellite data products of IIS are available free to the scientific community. Due to the network transferring limitation, currently the data distribution through network is limited to only quick-look images for public and allowed to download full data files only for registered users. The potential users could also order data in DLT tapes with the cost of storage media.

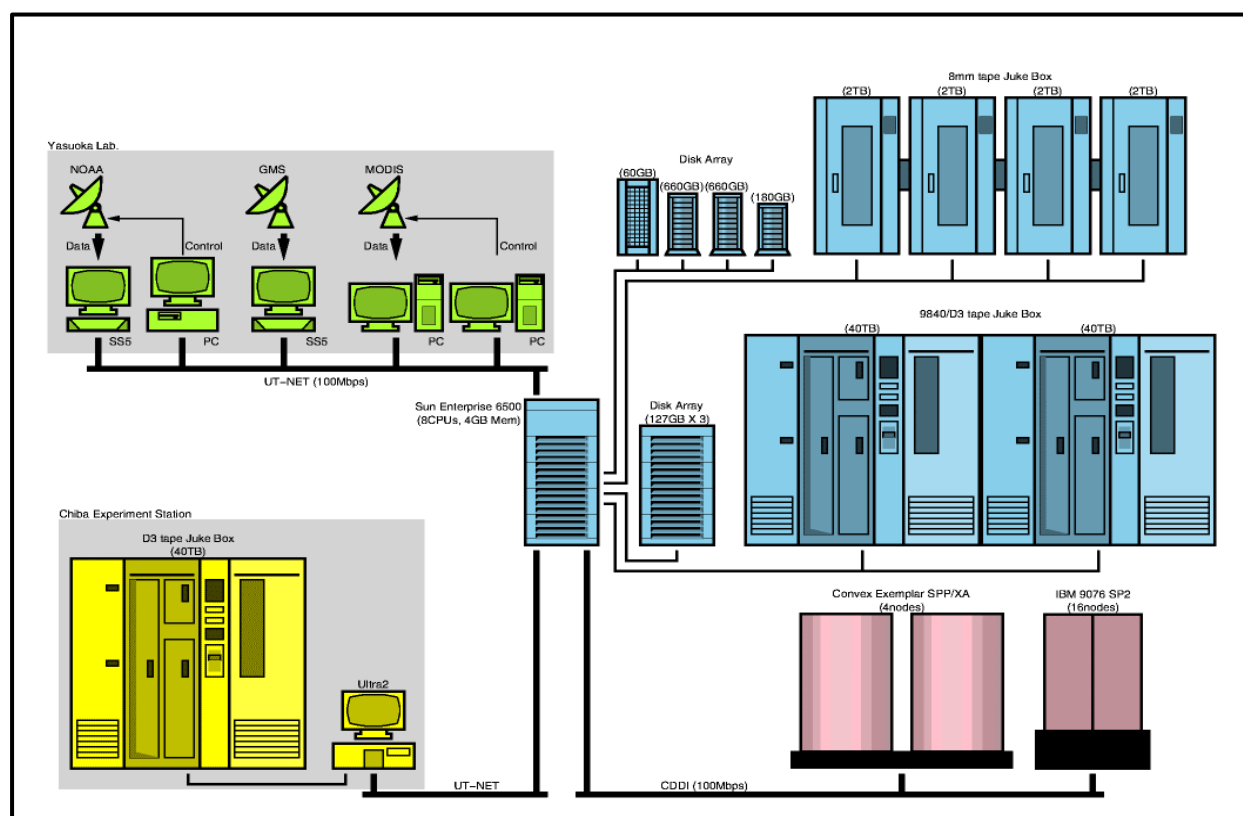


Figure 3 Details of the D3 type archiving system at the Institute of Industrial Science (UT)

SCIENTIFIC UTILIZATION FRAMEWORK

The MODIS receiving facility makes it possible to continue and expand our AVHRR-based terrestrial ecosystem change research as well as upgrade our capability for near-real-time data distribution for disaster warning and extreme weather events forecast. In addition to providing raw and level 1b data to research community, we started to produce operationally selective high-level products such as cloud mask, 500m-resolution VI, 1km-resolution LST and its 8-days, monthly composites (Figure 2). Scientifically, we are focusing on utilizing DB MODIS data in three areas: short-term applications, selective products for long-term change research in specified areas, and regional MODIS DB network cooperation.

Near Real-time and Short-term Applications

For near real-time forecast and warning of extreme events such as volcanoes, forest fire, surface flooding we are generating and distributing (over Internet) fire/burned area product and snow/ice cover.

Ecosystem change researches

As global MODIS products are systematically generated by DAACs and MODAPS data centers (Justice, 2001) and given voluminous ingested data, we are generating selected high-level land products with long-term variability interest only for specified regions for our own and collaborative researches. Currently, for comparative urban dynamics study we are developing time series database from acquired MODIS data for major East Asian urban sub-regions including Tokyo, Osaka, Seoul and Shanghai. The level 3 and 4 products include:

- 250m, 500m-resolution NDVI, 8-days/monthly composite of NDVI
- 1km-resolution day- and night- land surface temperature, 8-days/monthly LST composites
- 500m-resolution cloud-free 8-days corrected surface reflectance products
- Land cover / land cover change of urban footprint regions

We are also experimenting the combined use of high-temporal-resolution MODIS data with high-spatial-resolution satellite data: ETM, ASTER in monitoring urban land cover dynamics. As system is still ever evolving, some preliminary results will be presented at the conference.

MODIS DB Asian Regional Network

With current successful collaboration between Japanese universities and institutions in managing the acquired HRPT data, the IIS intends to continue expand the network of satellite receiving stations for Asian region. Based on an inventory by James Dodge (August, 2001), there is a number of operational MODIS-DB stations in East Asia such as Kumamoto (southern part of Japan) managed by Tokai University, Beijing and Urumqi (China) managed by the China Meteorology Administration and Yakutsk (Russia) managed by Sakhageoinform. Following the successful US network of MODIS DB ground stations, the IIS has started preliminary discussions with various regional receiving stations managing authorities in order to build up a regional DB network to exchange MODIS DB data. The aim is to jointly study jointly continental-scale natural hazards and extreme weather events and/or create MODIS Asian mosaic products with coverage similar to current HRPT mosaic coverage (Figure 1). The expected products are Asian mosaics of MODIS 8-day cloud-free 1km-resolution composite and selected regional products for medium and long-term continental change researches. The Institute of Industrial Science is looking forward to collaboration research utilizing MODIS-DB data with various governmental agencies, universities and scientific community in the region.

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