INTRODUCTION OF FOREST COVER AND CARBON MAPPING IN THE GREATER MEKONG SUBREGION AND MALAYSIA PROJECT

Li Zengyuan[1], Pang Yong[1], Huang Chengquan[2], Sun Guoqing[2], John Townshend[2], VivaradPhonekeo[3], Li Chungan[5], Khali Aziz Hamzah[6], YueCairong[4],Sukan Pungkul[7], Sithong Thongmanivong[8], Nguyen Phu Hung[9], Kao Dana[10], Tan Bingxiang[1], Chen Erxue[1],Qin Xianlin[1], Li Shiming[1], Li Jie[1], Zhang Lianhua[1,4], ZhaoKairui[1,4]

1. Institute of Forest Resource Information Technique, Chinese Academy of Forestry, Beijing 100091, China
2. Department of Geography, University of Maryland, College Park, MD 20742, USA
3. Geoinformatics Center, Asian Institute of Technology, Thailand
4. Forestry Institute, Southwest Forestry University, Kunming 650224, China
5. Guangxi Forest Inventory and Planning Institute, 14 Zhonghua Road, Nanning 530011,Guangxi, China
6. Forest Research Institute Malaysia, Kepong 52109 Kuala Lumpur, Malaysia
7. Forest Land Management Office, Royal Forest Department, BKK, Thailand 10900
8. Research Division, Faculty of Forestry, National University of Laos, Vientiane, Lao PDR.
9. Forest Inventory and Planning Institute, Viet Nam
10. Department of Forest and Forestry Community Management, Forestry Administration of Cambodia

KEY WORDS: Forest cover, carbon, mapping, the Greater Mekong Subregion (GMS), Malaysia

Abstract: Forests play a vital role in sustainable development and provide a range of economic, social and environmental benefits, including essential ecosystem services such as climate change mitigation and adaptation. For the purposes of the project, the Greater Mekong Subregion (GMS) and Malaysia comprises of Cambodia, the People's Republic of China (Yunnan province and Guangxi province), Lao People's Democratic Republic, Malaysia, Myanmar, Thailand, and Viet Nam. This region is rich in forest resources, but the forests have been undergoing rapid changes due to human activities. The project will be achieved by making intensive use of recent satellite remote sensing technology, establishing regional forest cover maps, documenting forest change processes and estimating carbon storage in the GMS and Malaysia. The project structure and some results from 1st phase were introduced.

INTRODUCTION

Forest monitoring is important for the estimation and evaluation of the state of forest resources, carbon sequestration, and the results of forest program implementation. It provides a key source of information used to for the crackdown on illegal logging, forest fire monitoring and early warning for forest degradation, the reduction of deforestation, and the improvement of forest quality. Also, forest monitoring to support sustainable forest resources management can provide the earth observation data and technical support needed by countries to effectively fulfill their obligations arising from international environmental agreements (e.g., United Nations Framework Convention on Climate Change (UNFCC)).

The area of the GMS and Malaysia project ranges from 92.2° to 119.3° east longitude and 0.8° to 29.2° north latitude, with total land area of 317,242,000 ha and total population of 348 million. It includes Cambodia, the People's Republic of China (Yunnan province and Guangxi province), Lao People's Democratic Republic, Malaysia, Myanmar, Thailand, and Viet Nam. The total forest area is 148,128,000 ha reported by Forest Resources Assessment 2010 (Yunnan & Guangxi data were from the 7th national forest inventory of China).Study area of the GMS and Malaysiaproject is shown in Figure 1.

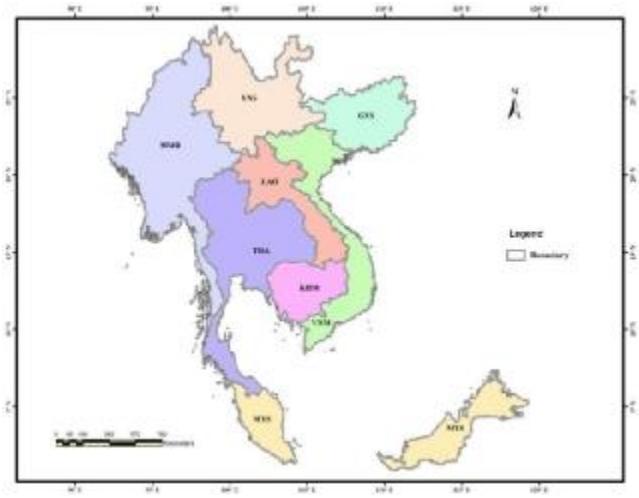

Figure 1: Study Area of the GMS and Malaysia Project

The project area has a diverse geographic landscape including massifs, plateaus and limestone karsts, lowlands, fertile floodplains and deltas, forests
(evergreen andsemi-evergreen, deciduous, dipterocarp, mangroves,and swamp), and grasslands. The region's geographic variety and consequent variety of climatic zones supports significant biodiversity, with more than 1068 new species discovered during the last ten years. The geographic region encapsulates 16 of the World Wild Fund for Nature (WWF) Global 200 Eco regions. The region's biodiversity is ranked as a top-five most threatened hotspot by Conservation International. High forest coverage and rich forest resource result in large amounts of wood export from this region. The WWF states that the region is particularly vulnerable to global climate change.

The primary goal of the project is to estimate forest coverage and above-ground carbon stock in the GMS and Malaysia. The approach will integrate multi-sources remote sensing data, ground measurements and other thematic geographic data. The outcomes of this project will help to clarify how, when and where the forests changes in the GMS and Malaysia. The approach will determine forest coverage and biomass estimates through the following specific objectives:

i). Develop pan-GMS and Malaysia forest cover mapping techniques to monitor forest cover type changes in the region, using both optical and radar remote sensing techniques.
ii). Develop a framework for forest carbon estimation using ground measurements, spacebornelidar sampling data and imaged remote sensing data.
iii). Produce forest cover maps of 2005, and 2010 at 30-50m spatial resolution and forest cover maps annually from 2005 to 2010 at 300-500m spatial resolution.
iv). Produce a forest carbon storage map for 2005 in the GMS and Malaysia at 300-500m spatial resolution.

PROJECT STRUCTURE

A project steering committee comprised of national representatives and international experts will be established. This committee will communicate and make top-level design for the whole project. One recommended national representative was recommended. Milestones and main deliverables will be discussed by this steering committee.

Institutes with intensive remote sensing technologies and forest resources will be organized as an algorithm development and training group. The common data processing and forest information extraction methods will be explored and developed. Technical progress and innovative methodologies will be regularly synthesized and feed to support operational data processing through training workshops and progress meetings.

The reference database and middle resolution forest mapping activities will be carried out by each country's organizations. Annual forest map of coarse resolution and forest carbon storage map will be done by the methods development team. After each forest coverage and carbon storage map generated, they will be evaluated by a validation team. Then the steering committee will do analysis with other related information.

The working packages are as

WP1: Project design and management (including training)
WP2: Methods development (including Algorithms)
WP3: Remote sensing data acquisition and pre-processing
WP4: Ground truth database development (compiling existing data)
WP5: Mid-resolution forest mapping product
WP6: Coarse-resolution forest mapping product
WP7: Forest carbon storage mapping product
WP8: Reporting and dissemination

WP1, WP2, WP7 and WP8 will lead by the Chinese Academy of Forestry, GOFC-GOLD and the University of Maryland with inputs from involved countries. The data of WP4 will be distributed in each country but serve for this project. WP4, WP5, WP6 and WP7 will be carried out by the national forest institute or university of each country in the GMS and Malaysia. Relevant forest mapping techniques and software tools will be developed into a streamlined production system in WP1 and WP2. And the production system will be distributed to the team of each country through training courses/workshops. The data will be distributed to each team, who will do the mapping and validation by themselves. Classification and mapping activities are proposed to be done by each county's team for their country task.

1st PHASE RESULTS

1) Remote Sensing Database

We have built remote sensing database including coarse resolution remote sensing data for the whole region, mid-resolution data of 2005 and 2010 for whole region, fine resolution data for 16 test sites of 2010 circaand space borne Lidar data for whole region.

For coarse resolution remote sensing data, the MOD09A1 and MOD13Q1 data products were acquired.For mid-resolution data, we collected Landsat TM/ETM+ data and HJ CCD data of 2005 and 2010 with contributions from USGS, UMD, and some remote sensing agencies in China.RapidEyedata with 5 m resolution is used as high resolution in this project for detail mapping and validation purpose.

GLAS Level-1A altimetry data (GLA01), level-1B waveform parameterization data (GLA05) and level-2 land altimetry product (GLA14) were used to estimate forest height and biomass. The GLA01 data include the transmitted and received waveform from the altimeter. The GLA05 data contain waveform-based range corrections and surface characteristics. The GLA14 data contain the land elevation and land elevation distribution data.

2)Coarse-resolution forest mapping

In this research, time series MODIS NDVI data from 2005 wereusedfor forestcover mapping of the Greater Mekong Subregion and Malaysia. In order to reduce cloud and other noise effects, Harmonic Analysis of Time Series (HANTS) was performedon the time series MODIS NDVI image. To distinguish ambiguous landcover classes, hierarchical mapping and decision tree classification were performed for land cover classification with the support of phenological features of vegetation. The preliminary mapping result is shown in Fig. 2.

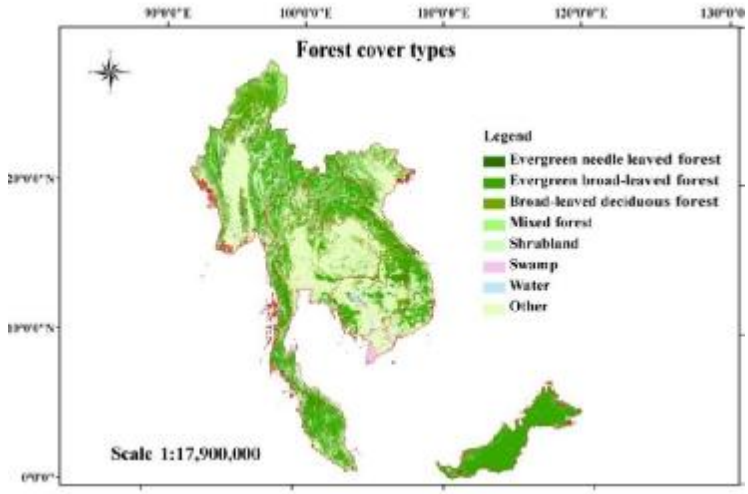

Figure2: Coarse-resolution Forest Mapping

3)Mid-resolution forest mapping

Using TM orthorectification images to make geometric correction, HJ-1 CCD satellite optical remote sensing data over Mengla, China and Phongsail, Lao PDR is acquired with the date of this image is January 4, 2010.

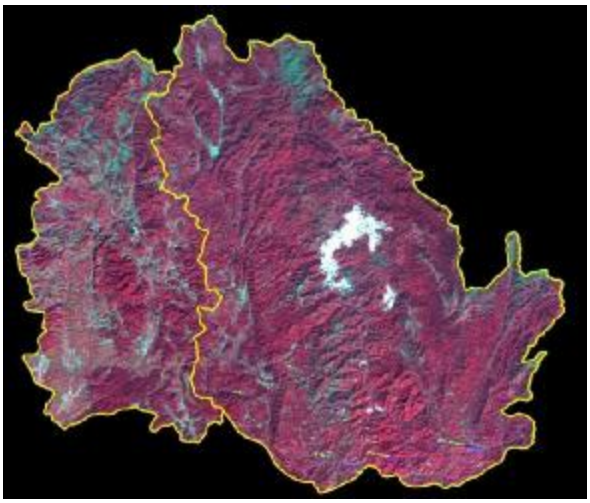

Figure3: HJ-1 CCD Image over Mengla, China and Phongsail, Lao PDR

Using band 3 and 4 of the image, we generated NDVI diagram to distinguish between vegetation and non-vegetation. Mask non-vegetation and produce vegetation image,the classification of supervised result is shown in Figure 4. Using the ground truth data, this image classification results are tested, the overall accuracy is 87.6%. Mixed forests and broad-leaved forest, shrub and forest occurs the higher proportion of errors.

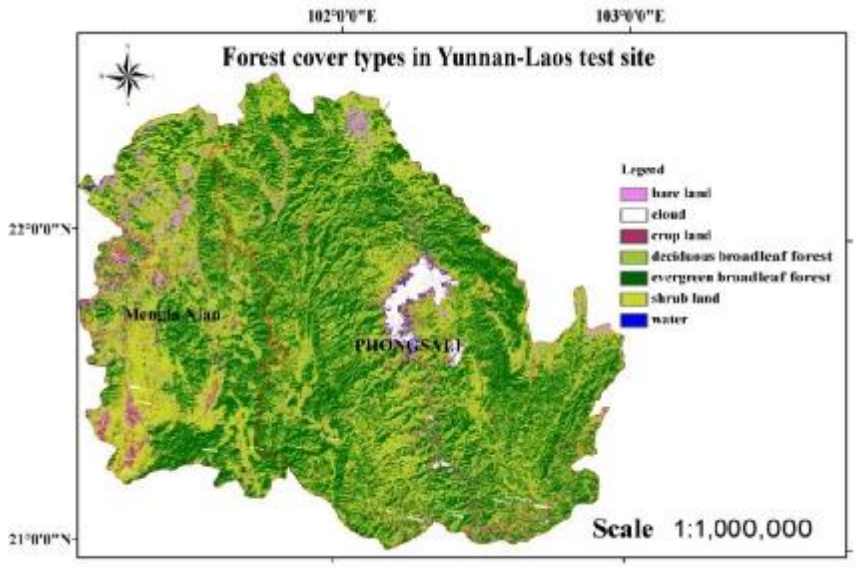

Figure4: Mid-resolution Forest Mapping

4)Forest disturbance mapping

Landsat data has 30m spatial resolution and its historical images can be free acquired from the United States Geological Survey (USGS) website. Forest disturbance in Landsat image has a series of spectra-time attributes which are different from non-forest and not disturbed forest (Huang et al., 2008 & 2010). Based on these assumptions, we adapted Vegetation Change Tracker (VCT)developed by Huang et al. (2010) to this area. The forest training samples can be detected automatically. Then the integrated forest index (IFI) was calculated. Themulti-temporal IFI images were investigated using time series analysis. The forest disturbance history was re-built. Figure 5 showed the test result in Jinghong, Yunnan province.

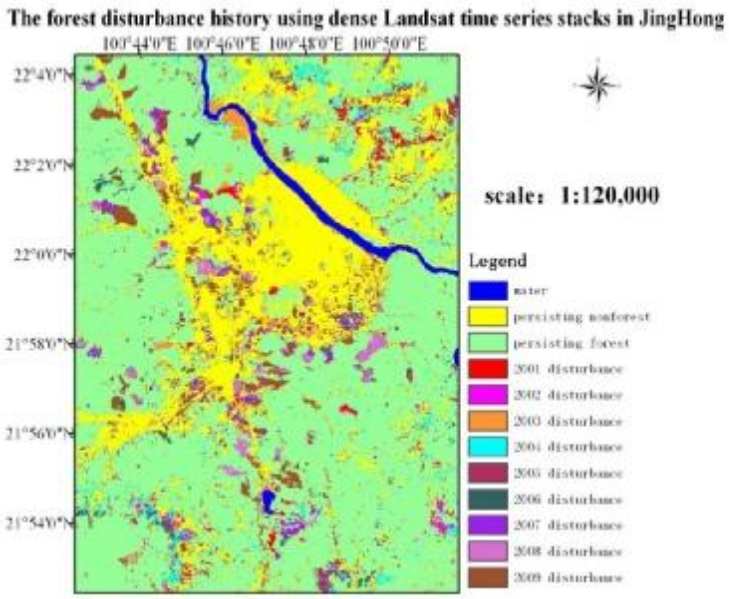

Figure5: Annual Forest Disturbance Mapping

5)Forest biomass mapping

Using maximum entropy method, combined with ICEsatGLAS data and ENVISAT MERIS, EOS MODIS optical data, we generate the distribution of forest biomass for the Greater Mekong Subregion as shown in Figure 6. This estimation is based on the ground reference data acquired in Yunnan province of China (Pang et al., 2011).

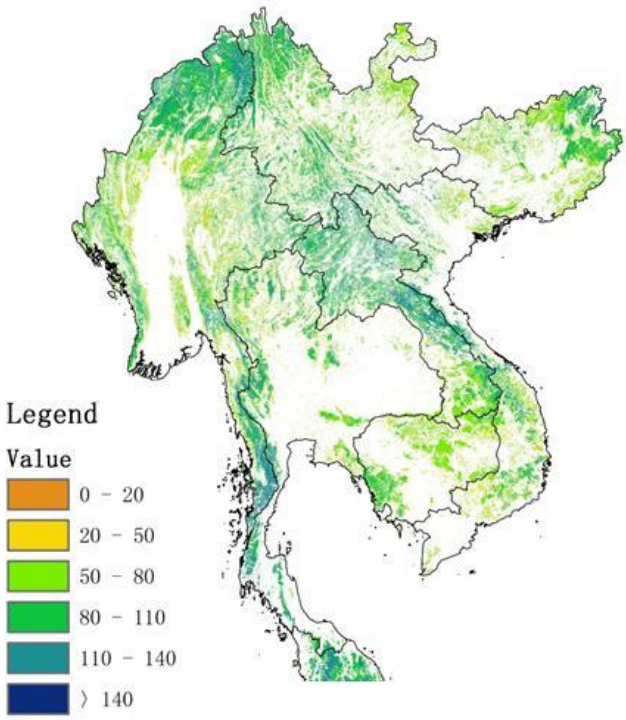

Figure6: Forest Biomass Mapping of Greater Mekong Subregion

SUMMERY &FUTURE WORK

To increase forest cover and improve forest quality are main objectives of the APFNet. The APFNet Project "Forest Cover and Carbon Mapping in the Greater Mekong Subregion and Malaysia" is under this umbrella. The forest coverage map from this project will reflect where and when the increased forests are. Since the inception in September of 2011, remote sensing database were built and some reference data were collected. From some first results from pilot test sites, the objectives of this project are feasible. With efforts of each organization and participant, the ground measurements and mapping activities are undergoing. More information about this project is available at http://www.apfrm.net.

ACKNOWLEDGEMENT

This work was supported by the Asia-Pacific Network for Sustainable Forest Management and Rehabilitation (Grant No. 2011PA004).

REFERENCES:

Huang C, Goward S N, Masek J G, Thomas N, Zhu Z and Vogelmann J E. 2010. An automated approach for reconstructing recent forest disturbance history using dense Landsat time series stacks. Remote Sensing of Environment, 114(1): 183-198.

Huang C, Song K, Kim S, Townshend J R G, Davis P, Masek J G and Goward S N. 2008.Use of a dark object concept and support vector machines to automate forest cover change analysis. Remote Sensing of Environment, 112(6): 970-985.

Pang Yong,Huang Kebiao, Li Zengyuan, et al., 2011. Forest Aboveground Biomass AnalysisusingRemote Sensing in the Greater Mekong Subregion, Resources Science, 33(10):1863-1869