GLOBAL LAND COVER MAPPING BY UPSCALING FROM GPS PHOTOS DATABASE THROUGH ALOS AVNIR2

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ABSTRACT: Global land covers are generated from global MOD13A3 monthly 1-kilometer for 10 years (2001 - 2010) based on the IGBP definition. The auto-generated land covers are validated with a few validation sites in global. JAXA provided AVNIR2 images to the SAFE prototypes initiating countries. AVNIR2 image has advantage with better spatial resolution than MODIS. This advantage could be applied to validate the MODIS global land cover. The training forest covers are generated from the AVNIR2 images in the ASEAN region with the same algorithm. On the other hand, field works are done in Laos, Vietnam, Myanmar and Cambodia. The photographs with positioning information are collected in the field works. Those existing national land covers are used to validate in global land cover mapping as upscaling process.

1. INTRODUCTION

Vegetation is a key biophysical parameter of terrestrial surfaces due to its specific role in geosphere-biosphere interactions and is therefore a sensitive indicator for global environment changes (Qi *et al.*, 2000). Multi temporal data set gives reliable and appropriate information of land cover by recording the changes in phenology throughout the growing season and thus enabling distinction among vegetated and non-vegetated surfaces as well as within the vegetated areas (DeFries and Townshend, 1995). The phonological differences among vegetation types when recorded through the earth observation satellite gives precise and accurate discrimination for vegetation types based on the seasonal dynamics (Justice *et al.*, 1985; Tucker *et al.*, 1985; Duchemin *et al.*, 1999). These differences among vegetation types, reflected in temporal variations derived from satellite data, have been used to classify land cover at continental scales (DeFries and Townshend, 1994; Sellers et al., 1994).

The national land covers are generated from MODIS monthly composites for 10 years since 2001 to 2010 (Takeuchi W. and et al. 2010) using the IGBP definition (Belward A. S., 1996). Auto-generated national land covers are published in the SAFE prototype website for Asia countries (www.safe.iis.u-tokyo.ac.jp). Though available land covers are in research level prototype, the validation and verification are require to promote to usable products for the end users. In parallel, GPS photograph database is developing (An, V. N., et al. 2010) for the land cover monitoring. The database has photographs together with geographic latitude, longitude and IGBP code. The IGBP codes are defined together with local forestry experts in the field. In this validation process, the scientific legend which auto-generated from the satellite images with IGBP 17 classes would be validated based on the GPS photographs information which collected in Asian region.

2. LOCAL AND GLOBAL LEGENDS

The study focus on global land cover mapping from the upscaling process of local legend which collected from local agency. Thus, the both legends are compared in the section

Since 1956, there are 8 standard forest types, namely: 1) tidal forests, 2) beach and dune forests, 3) swamp forests, 4) evergreen forests, 5) mixed deciduous forests, 6) dry forest, 7) deciduous dipterocarp or indaing forest and 8) hill forest (Shien Hoe, T., 1956). Similar forest types are appeared in the status report on the forestry sector of Myanmar (Tint, K. 1995) as tidal forest or mangrove forest, beach and dune forest, swamp forest, tropical evergreen forest, mixed deciduous forest, dry forest, deciduous dipterocarp forest, hill and temperate evergreen forest. Moreover, four nations' forest local legends are compared; although the sources are in different nature; it could be used to understand the diversity of regional forest cover. As the global legend IGBP definition is used in the study. The local legends are needed to assign to the IGBP code. Moreover, the aggregation of the local land cover to IGBP definition is required. The possible aggregation result is listed (table 1).

Table 1. The allocation of local land covers to IGBP definition.

Code	IGBP class	Local Land Cover
001	Evergreen Needleleaf Forests	Coniferous forest (Laos, Vietnam)
		Beach and dune forest (*asuarina equisetifolia -tinyu*) (Myanmar)
		Plantation (Vietnam)
002	Evergreen Broadleaf Forests	Evergreen forest (Cambodia)
		Semi-evergreen forest (Cambodia)
		Bamboo forest (Cambodia, Myanmar and Vietnam)
		Lower dry evergreen forest (Laos)
		Upper dry evergreen forest (Laos)
		Gallery forest (Laos)
		Tidal or Mangrove forest (Myanmar, Vietnam)
		Tropical evergreen forest (Myanmar)
		Hill forest (Myanmar)
		Evergreen broadleaf forest: rich/medium/low/regrowth (Vietnam)
		Limestone forest (Vietnam)
003	Deciduous Needleleaf Forests	
004	Deciduous Broadleaf Forests	Deciduous forest (Cambodia)
		Dry dipterocarp forest (Laos)
		Dipterocarp or indaing forest (Myanmar)
		Deciduous forest (Vietnam)
005	Mixed Forests	Lower mixed deciduous forest (Laos)
		Upper mixed deciduous forest (Laos)
		Mixed coniferous/broadleaf forest (Laos, Vietnam)
		Mixed deciduous forest (Myanmar)
		Dry forest (Myanmar)
		Mixed evergreen and deciduous forest (Vietnam)
		Mixed wood and bamboo forest (Vietnam)
006	Closed Shrublands	Wood shrubland evergreen forest (Cambodia)
007	Open Shrublands	Wood shrubland dry forest (Cambodia)
008	Woody Savannahs	Swamp Forest (Myanmar)
009	Savannahs	
010	Grasslands	
011	Permanent Wetlands	
012	Croplands	Other land (Agricultural, transport, …) (Vietnam)
013	Urban and Built-Up	Residential area (Vietnam)
014	Cropland/Natural Vegetation Mosaic	
015	Snow and Ice	
016	Barren	Limestone area (Vietnam)
		Bare land planned for forestry (Vietnam)
017	Water Bodies	Water area (lake, big river, …) (Vietnam)

3. AUTO-GENERATED LAND COVER MAP

The land cover auto-generation algorithm from MODIS monthly composite (Takeuchi, W., et al., 2010) uses IGBP 17 classes definition. The image is classified into 100 maximum likelihood classes and matched with the Boston University global land cover data.

Although, IGBP legend has 17 classes; the auto-generated classes might be fewer. For the year 2001 to 2010, the auto-generated land cover matched up to 12 classes from IGBP 17 definition. Although 12 IGBP classes are automatically mapped by the algorithm of MODIS monthly composite; the class appearance is unstable in year by year (table 2).

Year	Matched IGBP Codes
2001	001, 002, 003, 005, 007, 008, 009, 010, 012, 015, 016
2002	000, 001, 005, 007, 010, 012, 015, 016
2003	000, 001, 002, 005, 007, 008, 009, 010, 012, 015, 016
2004	000, 001, 002, 005, 007, 008, 009, 010, 012, 015, 016
2005	001, 002, 005, 007, 008, 009, 010, 012, 015, 016
2006	000, 001, 002, 005, 007, 008, 009, 010, 012, 015, 016
2007	000, 001, 002, 005, 007, 008, 009, 010, 012, 015, 016
2008	000, 001, 002, 005, 007, 008, 009, 010, 012, 015, 016
2009	000, 001, 002, 005, 007, 008, 009, 010, 012, 015, 016
2010	000, 001, 002, 003, 005, 007, 008, 009, 010, 012, 015, 016

Table 2. Matched IGBP codes by auto-generation algorithm.

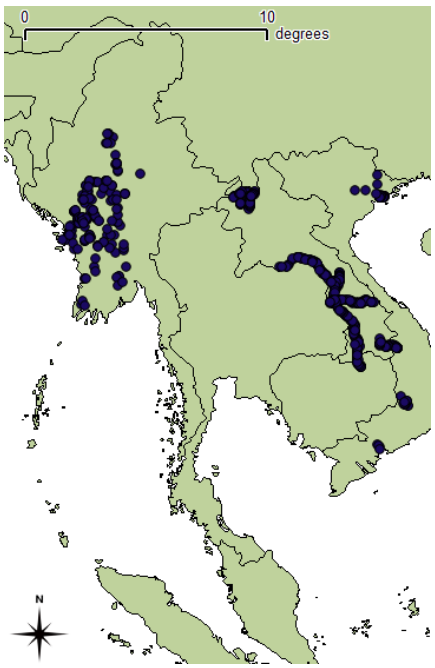

Figure 1. GPS Photos points distribution

4. LAND COVER VALIDATION USING GPS PHOTOGRAPHS DATABASE

The GPS photographs database development is performing in parallel (An, V. N., et al., 2010). There are more that 5000 GPS photographs are collected in the database together with IGBP definition in each photographs. The most of the GPS photographs are collected using GPS tracking technique. Thus, many GPS photographs could be accumulated in one pixel location of satellite image. In the case of MODIS image for the national level the study used 250 meters by 250 meters pixel size. Thus, it is required to remove redundance points for each pixel. Moreover, some track route has several points thus the grid filtering methodology is introduce to fix this problem (figure 2). After the processes are performed unusable GPS points are reduced (table 3).

GPS Photos	Original Amount	Simplified Amount
Cambodia	Not concern	Not concern
Lao PDR	4508	460
Myanmar	355	173
Vietnam	154	91
Total	5017	724

Table 3. Simplified GPS photographs.

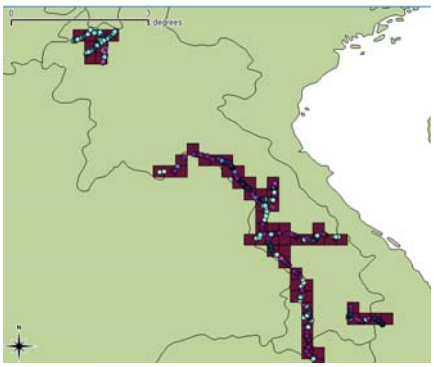

Figure 2. 0.25° grid to remove accumulated points.

GPS photos' redundancy and area filtering processes reduced 87 % of overall points. The filtered 13 % is used to validate the global land cover.

Table 4. Validated IGBP codes by year.

Year	Validated IGBP Codes
2001	002, 004, 007, 010, 012, 014, 015, 016
2002	000, 001, 002, 004, 005, 007, 010, 012, 014, 015, 016
2003	000, 001, 002, 004, 005, 007, 010, 012, 014, 015, 016
2004	000, 002, 004, 005, 007, 008, 012, 014, 015, 016
2005	000, 002, 004, 005, 007, 008, 010, 012, 014, 015, 016
2006	000, 001, 002, 004, 005, 007, 010, 012, 014, 015, 016
2007	000, 001, 002, 004, 005, 007, 010, 012, 014, 015, 016
2008	000, 001, 002, 004, 005, 006, 007, 012, 014, 015, 016
2009	002, 004, 007, 009, 012, 014, 015, 016
2010	000, 002, 004, 005, 007, 009, 010, 012, 014, 015, 016

The auto-generated land cover had 12 definitions of IGBP such as water, evergreen needleleaf forest, evergreen broadleaf forest, deciduous broadleaf forest, mixed forest, open shrublands, woody savannas, savannas, grasslands, croplands, snow and ice and barren or sparsely vegetation. The validated result has one 14 classes. Although the classes count are not so difference with auto-generation, the class categories are broader to deciduous broadleaf forest, close shrublands and cropland/natural vegetation mosaic. Thus, the validation process could increase the land cover classes (table 4) and the local vegetation could be validated to global land cover.

5. RESULT AND DISCUSSION

The validation results are shown in the figures (figure 4 and figure 5). The Tonle Sap lake of Cambodia is illustrated for both of auto-generated land cover and validated land cover for 10 years. The comparison shows that the validated land covers are more diverse around the Tonle Sap Lake (figure 3 and figure 4).
As the future work, verification with inland waterbody in other region (Oo, K. S., et al., 2010) could be done.

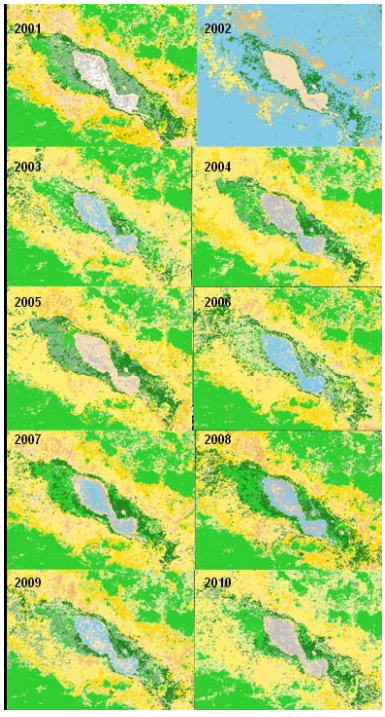

Figure 3. Auto-generated land cover.

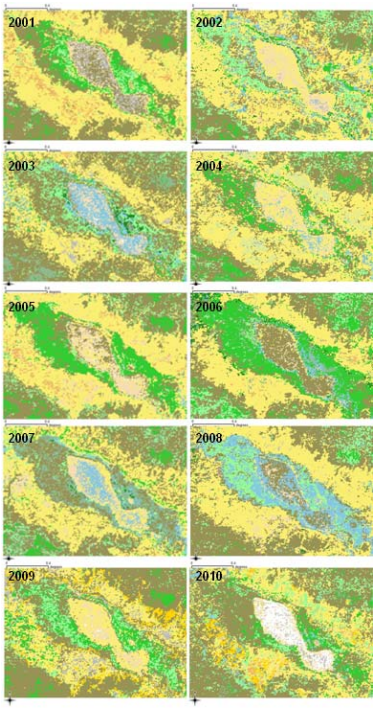

Figure 4. Validated land cover.

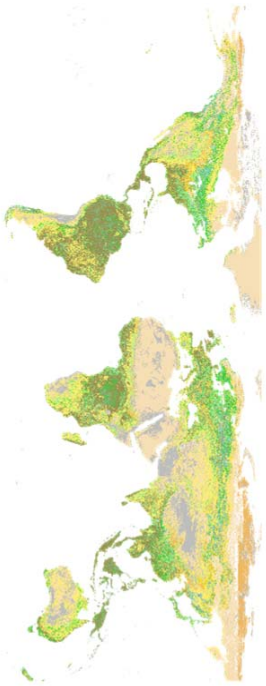

Figure 5. Validated 2010 land cover.

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