Mapping and monitoring tropical rain forest areas
Results Insular SE Asia
Final Science team meeting – Phase 1

Dirk Hoekman
Tsukuba, 14 January 2009
ALOS Kyoto & Carbon Initiative
11th Science Team Meeting, JAXA TKSC
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Persistent cloud cover requires radar monitoring

Persistent cloud cover prevents optical remote sensing monitoring of the world’s tropical rain forest areas. The colour code shows the estimated number of months per year LANDSAT fails to deliver useful images (Source: Friedl, 2006).
Forest land in different global land cover data sets

Forest definitions:
IGBP: tree cover >60% / tree height >2m
GLC2000: tree cover >15% / tree height >3m

(Source: Herold, 2004)
International standards

- **GOFC GOLD** (Global Observation of Forest and Land Cover Dynamics)
  Expert group working towards standardisation and harmonisation of forest monitoring

- **FAO Land Cover Classification System (LCCS)**
  Internationally recognized accepted translation mechanism to compare and harmonize land cover classifications
Example partnership network local end users - Indonesia:

**National**: Ministry of Forestry, World Resources Institute, SDSU

**Papua**: Provincial government, Conservation International, Sekala

**Borneo**: Governments, Nunukan + Malinau districts, WWF Heart of Borneo

**Central Kalimantan**: Provincial government, EMRP MP, Wetlands International, BOSF

**Sumatra**: Provincial government NAD Aceh, Leuser International Foundation

**Riau**: APRIL, Leicester University-WL Delft Hydraulics, WWF

**Jambi**: Wetlands International, National Park Service Berbak-Sembilan

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2. Main prototype area Central Kalimantan, early results
Data used:
2 PALSAR images: FB HH-HV & WB1 HH

Land use/cover map of the EMRP project area and Sebangau in Central Kalimantan, Indonesia. This information is applied, among others, for peat swamp forest protection, hydrological restoration (such as canal blocking), reforestation, and development of REDD projects. On the basis of extensive groundtruth the accuracy is estimated to be over 84%.
Comparison with current practice

Local end users (government, national park and NGO’s) prefer this PALSAR map over existing maps, which were based on Landsat visual interpretation.
Data used:
9 PALSAR images: WB1 HH & LULC map (poster 1)

Proper flood frequency mapping requires knowledge on land cover. Therefore this map may be considered as a second map layer.
3. Continental wide, high resolution mapping (Example Borneo)
First test results using standard FBD mosaics: Borneo

Data used:
PALSAR Borneo FBD mosaic (HH-HV)
SRTM
MODIS

Weaknesses:
• Mountains
• Wet season missing
• Far less forest classes and other land cover classes can be differentiated (as compared to Central Kalimantan LULC map).
First test results using standard FBD mosaics: Papua

Data used:
PALSAR New Guinea mosaic (HH-HV)
GRFM JERS-1 mosaic

Weaknesses:
Mountains
GRFM mosaic not orthorectified

Conclusions: The first test results for Borneo and Papua show high consistency with existing maps (like TREES/JRC, based on optical data, 250-1000m), show additional details and show recent land cover change.

➢ It is important to add a wet season observation (FBS)
➢ Slope corrections are needed
**Data desired:**
22 FBD strips, cycle 13
22 FBS strips, cycle 9

**Data used:**
4 FBD strips replaced, cycles 12 & 14
3 FBS strips replaced, from 2008(!)

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Slope correction/mitigation (1)

Data correction:

Using slope & aspect angle derived from SRTM

Assuming isotropic opaque volume scattering
Slope correction (2)

FBS/FBD composite before and after slope correction
(same backscatter scale)
Mosaicing result: slope corrected FBS+FBD

After radiometric balancing, orthorectification and slope correction, strips are ready for classification (two classified areas are already shown).
Mixture modelling followed by Markov Random Field classification of a small part of a polarimetric image over Central Kalimantan. Models of increasing complexity reveal a hierarchy of classes. Re-generating forests can be distinguished in model 10 (black arrow). The model number equals the number of clusters ($g$).

*Algorithm described in:* Hoekman *et al*., 2007; Tran *et al*., 2005
How many clusters? The Bayesian Information Criterion (BIC) is used to determine how many clusters (or classes/sub-classes) are present in a certain area (such as a peat swamp area, a mangrove area, or a dryland forest area. This technique is used to support the development of a legend for (the entire) Borneo.
Selection and aggregation of clusters: In this theoretical one-dimensional example there are 3 clusters in area A and 3 in area B. Together they have 4 clusters. In practice we may select between 50-100 relevant clusters for the entire Borneo. Subsequently, clusters can be aggregated to form a (compound) thematic class.
Deforestation time-series based on SPOT-VEGETATION are updated (by SarVision) every 3 months. This information is useful since it provides knowledge on the age of secondary re-growth or tree plantations.
MODIS is better than MERIS in areas with persistent cloud cover.
Extended classification approach: synergy optical data (3)

Legend: forest land / non-forest land / water / deforestation or severe forest degradation in 2007 / forest re-growth

Forest land 2007
Deforestation 2007

Deforestation maps based on MODIS are made annually by SarVision. For Borneo this is done in cooperation with WWF.
Note: The classification of PALSAR data can be done in several ways, such as:

1. Using PALSAR data only.

2. Using PALSAR data, in combination with MODIS data.

3. Using PALSAR data, with MODIS data or thematic data derived from MODIS and/or SPOT-VEGETATION as prior information.

We use PALSAR data only. In case the validation study reveals certain weaknesses (for example, with secondary forests), then approaches 2 and 3 will be further investigated.
Results: Central Borneo (1)

Forest - Lower biomass and/or degraded
Deforestation types
Riverine-riperian and swamp forest
Shrub land
Results: Central Borneo (2)
Results: Central Borneo (3)

- Forest - Lower biomass and/or degraded
- Forest - Higher Biomass
- Deforestation types
- No data (radar shadow and layover)
Results: Peat swamps

- Forest and forest on peat/heath
- Peat swamp less dense
- Peat swamp low pole
- Riverine-riperian and swamp forest
- Burnt shrubs and bare
- Shrub land
Results: Disturbed peat swamps

- Forest and forest on peat/heath
- Peat swamp less dense
- Riverine-riperian and swamp forest
- Burnt (peat) forest and bare
- Burnt shrubs and bare
- Shrub land
- Sawah
Results: Sabah

Mangrove 1
Tree plantations and Palm oil
Results: Mangroves Tarakan

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Results: Overview

With a single protocol and a single set of statistics all strips can be classified directly.

Several types of forest, shrubs, deforestation can be differentiated, i.e. more than in the tentative legend given here.

A validation study is ongoing, revealing a proper legend (i.e. what the radar can differentiate well) and associated accuracies.
4. Validation

Study Netherlands Ministry of Environment
Netherlands contribution to GEO task on Forest Carbon Tracking
Validation: Example areas

426. Oil palm development area

414. Mangrove area

Comparison PALSAR results with:
• Landsat
• MODIS 2007
• Ministry of Forestry classification, 2005
• NRM classification, 1997
• GlobCover, 2006

• Selected validation data set

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Landsat 2004
Landsat 2008 January
PALSAR 2007 JAXA (HH – HV – HH-HV)
PALSAR 2007 FBS-FBD
Classification PALSAR 2007
Classification 2005 Ministry of Forestry (Landsat)

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MODIS 2007
Landsat 2007 March
PALSAR 2007 JAXA
(HH – HV – HH-HV)
Classification 2007
PALSAR
Classification 2005-06
GlobCover
5. Conclusions
Conclusions

1. The quality of the LULC map of the main K&C prototype area in Central Kalimantan based on PALSAR exceeds the quality of maps previously made based on Landsat.

2. A standard methodology for automated mapping of continental wide forest and land cover map at high resolution is available.

3. To improve classification of secondary forest, the optional use of auxiliary data sets derived from MODIS is considered. These data are made routinely available by SarVision.

4. The tentative legend already contains six forest types which have typical biomass ranges, and which can be mapped fairly accurate.

5. Likely, more types of deforestation, tree plantations and shrubs be differentiated.

6. Since more classes can be differentiated (on the continental scale) than initially foreseen, more validation effort is required.

7. It is expected that more characteristics of agricultural and peat forest areas can be obtained when the ScanSAR cycles are included in the classification (or parameter retrieval) procedures. These features are mainly related to cropping cycles, hydrological/seasonal cycles and flooding events.

8. The data set is large. It is proposed to deliver final products in sheets of 2x3 degrees.

9. Methodology is generally applicable. After the Borneo validation, other areas, namely Papua and Sumatra, should follow soon.

Thank you