Using time-series PALSAR data for deforestation detection in Indonesia

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Project objectives

The study aims to investigate time-series ALOS PALSAR data for more accurate/effective forest change mapping

1. Backscattering coefficient (gamma-zero, $\gamma^0$)
2. Interferometric coherence

Study area:
Riau province, Sumatra Island, Indonesia
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Gamma-naught before/after deforestation

Red: Deforested land
Green: Natural forest
Blue: Acacia plantation

Threshold
Spatial pattern of $\gamma^0$ changes

(a) HH  
(b) HV

HV polarization shows clear changes and patterns
Accuracy of the deforestation detection using gamma-zero changes
Riau province, Indonesia
Comparison to the interpretation of optical images

Sample = 5000 pixels

Max. 95%
Min. 70%
Gamma-zero HV vs. TRMM 10-day precipitation

Detection accuracy vs. TRMM 10-day precipitation
Annual deforestation map of Riau, Indonesia

Natural forest map is provided by WWF

- Threshold = -1dB
- Stacking several scenes in each year for reducing errors

Validation result:
  Accuracy = 92%
  Kappa = 0.89
### Forest loss trends in Indonesia by PALSAR (1000 ha)

<table>
<thead>
<tr>
<th>Region</th>
<th>Loss, 2008</th>
<th>Loss, 2009</th>
<th>Loss, 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sumatra</td>
<td>661</td>
<td>898</td>
<td>452</td>
</tr>
<tr>
<td>Kalimantan</td>
<td>467</td>
<td>845</td>
<td>363</td>
</tr>
<tr>
<td>Indonesia Total</td>
<td>1,634</td>
<td>2,342</td>
<td>1,041</td>
</tr>
</tbody>
</table>

### Forest fires in Indonesia by Aqua MODIS

- **El Nino (hot, little rain)**
- **La Nina (cool, much rain)**
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Forest change detection using coherence change

No change (natural forest)  \rightarrow  Low coherence

Deforested  \rightarrow  Low coherence

No change (cleared land)  \rightarrow  High coherence
PALSAR coherence and temporal baseline

**HH**

**HV**

![Graphs showing InSAR coherence for HH and HV polarizations](image)
Characteristics of PALSAR 46-days coherence

- Natural forest
- Deforested in 2010

Year 2010
Land cover (WWF map)

- Natural forests
- Acacia
- Oil palm
- Rubber
- Open land
- Others

Time-series average coherence (2010)

0.2  0.4  0.6
Coherence of each land cover type

- **Natural forests**
- **Acacia**
- **Oil palm**
- **Rubber**
- **Open land**
- **Water**

Graph showing the coherence of each land cover type with different markers for each type.
Low coherence at acacia plantations <- rapid growth?

Fig. 2 Forest plantation of Acacia mangium in the targeted area: (a) 1st year, (b) 3rd year, (c) 4th year, (d) 5th year and (e) 6th year. A permanent sample point (PSP) pole can be seen in the foreground of images (a) and (d).

Kobayashi et al., 2012
Detection accuracy of the coherence change method (ROC curve)

Coherence based

95% @ 10% FAR

Gamma-zero based

80% @ 10% FAR
Coherence based

Gamma-zero based

16 looks, averaging filter for 5 x 5 pixels
Summary

- **Gamma-zero based forest change detection**
  - Polarization: HV
  - Automatic, low computation cost
  - Accuracy: > 70%
  - Application: early warning (illegal deforestation, forest fires, etc.)

- **Coherence based forest change detection**
  - Polarization: HH (many FBS mode data can be used)
  - Automatic, high computation cost (InSAR process)
  - Low latency: more than two acquisitions after deforestation are required.
  - Accuracy: > 90%
  - Application: inventory