ALOS-Indonesia POL-InSAR Experiment (AIPEX): Progress Update

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Acknowledgement

POLSARPRO
Overview

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2. Objective
3. Test Site
4. SAR-Calibration
5. POL-InSAR Analysis
6. Validation
7. Conclusions
Introduction

- Forest is an important issue for 2012 (Post-Kyoto Protocol)
- Required quantitative approach i.e. Tree Height (THE)
- Tree Height (THE) is important element for Biomass and REDD (Reducing Emissions from Deforestation and Degradation)
- THE + Allometry (Boreal/Temporal/Tropical) = Biomass
Introduction

- First attempt of THE measurement by space-borne SAR made locally in Indonesia = JAXA supported Second Research Announcement (RA2-402): “ALOS-Indonesia POL-InSAR Experiment (AIPEX)”
- Jointly implemented by Indonesia (IPB and Bakosurtanal) and Russian (IRE/RAS) team
- Envisat-Indonesia Radar Biomass Experiment (EIRBEX), ESA AOE-869, 2002
- Airborne SAR: Indonesia Radar Experiment II (INDREX-II), Nov 2004, ESA Campaign (POL-InSAR Tropical Forest)
- AIPEX test-site not the same with EIRBEX/INDREX-II test-sites
Objective

- To study the application of POL-InSAR analysis of ALOS/PSR FP image (PLR-215) for tree height measurement of tropical natural forest in Indonesia:
  1. What is L-Band repeat pass interferometry (tree) height accuracy?
  2. What is the performance of POL-InSAR tree height for 21 classes of the existing Indonesian operational forest categories?
Test Site
TEST SITE
Test Site
SAR-Calibration

- SAR-CAL process was completed and reported in 2nd ALOS Joint PI Symposium in Rhodes Island, GREECE, 2008
- Calibration test of Faraday rotation angle, cross talk and range distribution of sigma nought for ALOS/PSR PLR-215 in Indonesia was OK for vegetation study
- POL-InSAR analysis, therefore, could be implemented for THE measurement
POL-InSAR Analysis

• THE Measurement Options:

- LIDAR (Airborne)
- DB-InSAR = DualBand-InSAR (Airborne)
- POL-InSAR = Polarimetric-InSAR (Spaceborne)
The GeoSAR System

- GeoSAR is mounted on a Gulfstream GII jet aircraft.
- Flies around 12000m altitude, with a top speed of Mach 0.85 and a range of over 1600 nautical miles.
- X-band between 9.63GHz and 9.79GHz, wavelength at centre frequency of 3.1cm.
- P-band between 0.27GHz and 0.43GHz, wavelength at centre frequency of 0.86m.
- High bandwidth of 0.16GHz (at both bands): best slant-range resolution of 0.94m (unweighted aperture).
- Single-pass interferometry with horizontal baselines of 2.6m at X-band and 22m at P-band.
- Used for wide-area mapping: collects data for 288sqkm per minute.

<table>
<thead>
<tr>
<th></th>
<th>X-band</th>
<th>P-band</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mosaic DEM height accuracy</td>
<td>1-3m (Absolute)</td>
<td>2-5m (Absolute)</td>
</tr>
<tr>
<td>Mosaic planimetric accuracy (GPS/Lidar Control)</td>
<td>2.5m (Absolute)</td>
<td>4m (Absolute @ 10km Altitude)</td>
</tr>
<tr>
<td>Ground swath width</td>
<td>10-12km, Each Side</td>
<td>10-12km, Each Side</td>
</tr>
<tr>
<td>Incidence angles</td>
<td>25-60 deg.</td>
<td>25-60 deg.</td>
</tr>
<tr>
<td>Polarization</td>
<td>VV</td>
<td>HH (interferometric) + HV</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>160MHz</td>
<td>160MHz</td>
</tr>
<tr>
<td>Wavelength at centre frequency</td>
<td>0.03m</td>
<td>0.85m</td>
</tr>
<tr>
<td>Baseline length</td>
<td>2.6m</td>
<td>22m</td>
</tr>
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(www.fugroearthdata.com)
How GeoSAR Works

Collection Height:
31,000 to 39,000 ft MSL

X-Band (3 cm wavelength)
P-Band (85 cm wavelength)
Profiling LIDAR

(www.fugroearthdata.com)
GeoSAR X-band InSAR

• X-band: frequency 9.7GHz, wavelength 3.1cm.

• The short wavelength radiation is strongly (but not completely) attenuated by woody material and foliage.

• The interferometric phase centre lies below the tree crown surface in the upper canopy.

• The interferogram yields a canopy surface map (DSM).

(www.fugroearthdata.com)
GeoSAR P-band InSAR

- P-band: frequency 0.35GHz, wavelength 83cm.

- The long wavelength radiation penetrates the canopy.

- Scattering is dominated by the ground-volume return – with phase centre close to the ground.

- The interferogram yields a near-ground height map (DTM).

(www.fugroearthdata.com)
GeoSAR and DBInSAR

- Dual-frequency, single-pass SAR interferometry (DBInSAR).

- The difference in interferometric phase heights yields a surrogate vegetation height, $h_{XP}$.

- This height is strongly correlated with the true vegetation height (Sexton et al, 2009).

- Vegetation height statistics can be used to derive biomass.

- So GeoSAR multi-channel data could be used to estimate tropical forest biomass – without using PoInSAR …

(www.fugroearthdata.com)
POL-InSAR Analysis

- THE derived by POL-InSAR Analysis
- SLC image pair (ALPSRP060040030-P1.1__A of 2007/03/11 and ALPSRP066750030-P1.1__A of 2007/04/26) in PLR-215 mode
- **ALOS Systematic Observation Strategy**: PLR-215 is acquired only for one time per two years (2007/Cycles: 10-11 and 2009/Cycles: 26-27)
- Gap between adjacent track in equator area due to PLR-215 acquisition geometry
Ground Range – Slant Range
SLC Image Pair (PLR): Repeat Pass

20070311

20070426
Baseline Estimation

**POLinSAR Baseline Estimation**

- **Input Master Directory**: D:/00PLR11/A-00/M20070311
- **Input Slave Directory**: D:/00PLR11/A-00/S20070426
- **Output Slave Directory**: D:/00PLR11/A-00/S20070426
- **Init Row**: 1, **End Row**: 18432, **Init Col**: 1, **End Col**: 1248

**Baseline Estimation**

- **ALOS (JAXA)**
- **ALOS (ERSDAC)**
- **RADARSAT-2**
- **TerraSAR-X**

**Averaged Estimated Baseline Values**

- **Parallel**: -656.9
- **Perpendicular**: -1158
- **Horizontal**: -1318
- **Vertical**: 186.25

**Auxiliary Parameter Estimation**

- **Flat Earth**
- **kz**
- **Incidence Angle (deg)**

**Output Format**

- **real (deg)**
- **real (rad)**
- **complex (cos, sin)**

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*Raimadoya et. al, Page 23*
Incidence Angle (L) – Kz (R)
Flat Earth
Height Inversion

**Height Estimation from Inversion Procedures**

- **Input Master - Slave Directory**
  
  D:/00PLR11/A-00/M20070311_SUB_S20070426_SUB_COR_FER

- **Output Master - Slave Directory**
  
  D:/00PLR11/A-00/M20070311_SUB_S20070426_SUB_COR_FER

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<td>1</td>
<td>6001</td>
<td>1</td>
<td>1248</td>
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- **Update List**

- **Polarimetric Phase Centre Height Estimation**
  
  Polarimetric Channel: HV

- **DEM Differencing Algorithm**

- **Coherence Amplitude Inversion Procedure**

- **Ground Phase Estimation and RVQG Inversion Procedure**
  
  - Median Window Size: 11
  - Weighting Coherence Fraction Factor: 0.5

- **Top Phase Centre**: HV
- **Ground Phase Centre**: HH - WV

- **2D Kz File**
  
  D:/00PLR11/A-00/M20070426_SUB/kz.bin

- **Run**

- **Hist**

- **Exit**
Comparison: THE01-THE02
Comparison: THE03-THE04

![Graph 1](image1)

Max = 25.348576
Min = 0.006558

![Graph 2](image2)

Max = 27.215260
Min = 0.014611
Validation

• No validation was made yet
• Requires cooperation with other interested party in Indonesia (with good record of forest parameter) to apply POL-InSAR in their target site(s): 2010 validation exercise
• The target site(s) must be in PLR-215 repeat pass acquisition archive (2007 or 2009)
• Improvement of POLSARPRO is required prior to validation, to display the image and coordinate in UTM or Lat-Long
Conclusions

• The result of repeat pass (46-days) POL-InSAR analysis of ALOS/PSR PLR-215 in AIPEX test site (Indonesia) was successfully completed by local capacity.

• Further cooperation with other interested party(s) in Indonesia is required to validate the method in different natural tropical forest condition (21 classes).

• Improvement of POLSARPRO is required, prior to validation process, to allow the measurement in PLR-215 image could be done in “ground-range” SLC.

• Other option is MapReady could be used to import POL-InSAR final result from POLSARPRO, transform it from slant-range to ground-range and export it back to POLSARPRO.
MAHALO! THANK YOU