Change detection analysis for under-cover detection in L and UHF band

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Outline

- Presentation of the experiment
- Change detection methodology
- UHF data analysis
- L band data analysis
- Conclusion
**Context**

**TROPISAR project:**
- ONERA project: polarimetric UHF measurements on tropical forest
- financed by ESA and CNES
- part of the BIOMASS project

**TROPISAR dataset**
- Data acquired in the same geometry at different dates: interferometric dataset
- UHF + L polarimetric data
- Azimut resolution: 1.5 m
- Range resolution: 1.2 m
- Incidence angle: from 24° to 60°
- Images made available by ESA
FALCON 20 Aircraft
(AVDEF Company)
Adjustable incidence angle

<table>
<thead>
<tr>
<th>RF Band</th>
<th>UHF</th>
<th>L</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>220-460 MHz</td>
<td>1.3 GHz</td>
<td>9.5 GHz</td>
</tr>
<tr>
<td>Polarisation</td>
<td>Full polar</td>
<td>Full Polar</td>
<td>Full Polar</td>
</tr>
<tr>
<td>Resolution</td>
<td>65 cm</td>
<td>75 cm</td>
<td>10 cm</td>
</tr>
</tbody>
</table>
TROPISAR, the sites

The ECOFOG Sites
- Nouragques
- Paracou
- Arbocel

Calibration site
- Rochambeau

Other sites
- Marais de Kaw Mangroves
## Dataset used in this experiment

<table>
<thead>
<tr>
<th>Image</th>
<th>Date</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image 208</td>
<td>14/08</td>
<td>ZB</td>
</tr>
<tr>
<td>Image 305</td>
<td>17/08</td>
<td>ZB</td>
</tr>
<tr>
<td>Image 402</td>
<td>24/08</td>
<td>ZB</td>
</tr>
</tbody>
</table>
| Image 403 | 24/08  | Delta h= 15 m  
          |         | Ha=100m  |
| Image 405 | 24/08  | Delta h= 45 m  
          |         | Ha=33m   |
| Image 407 | 24/08  | Delta h= 75 m  
          |         | Ha=20m   |
| Image 506 | 30/08  | ZB       |
Target deployment on the 24th of August

Isuzu: under cover but the wave is going through half of the forest height

Laguna: completely under cover

Master: may be not under cover (located in a small open area)

Corner reflector: under cover
Change detection algorithm (from Leslie Novak)

Mono polarisation criterion

\[ Z_{0}\cdot j_0 = \frac{\sum_{i=j_0-N}^{j_0+N} \sum_{j=i_0-N}^{i_0+N} |S_2(i,j)|^2}{\sum_{i=j_0-N}^{j_0+N} \sum_{j=i_0-N}^{i_0+N} |S_1(i,j)|^2} \]

Polarimetric criterion

\[ Z^p_{0}\cdot j_0 = \frac{\sum_{i=j_0-N}^{j_0+N} \sum_{j=i_0-N}^{i_0+N} Cov_2(i,j)}{\sum_{i=j_0-N}^{j_0+N} \sum_{j=i_0-N}^{i_0+N} Cov_1(i,j)} \quad \text{with} \quad Cov(i,j) = \begin{bmatrix} S_{HH}(i,j).S^*_{HH}(i,j) & S_{HV}(i,j).S^*_{HV}(i,j) & S_{VH}(i,j).S^*_{VH}(i,j) \\ S_{HV}(i,j).S^*_{HV}(i,j) & S_{VV}(i,j).S^*_{VV}(i,j) & S_{VH}(i,j).S^*_{VH}(i,j) \\ S_{HH}(i,j).S^*_{HH}(i,j) & S_{HV}(i,j).S^*_{HV}(i,j) & S_{VH}(i,j).S^*_{VH}(i,j) \end{bmatrix} \]
UHF – Hh – no target
UHF – Hh – targets
UHF – Hv – no target
UHF – Vv – no target
UHF polarimetric composition - targets
Hh Change Detection

Corner reflector

master

Isuzu
Corner reflector

master

Other target

Isuzu
Polarimetric change detection

Corner reflector

master

Other target

Isuzu
UHF - Hh – no target

Corner reflector

master

Other target

Isuzu
UHF – Hh - targets

Corner reflector

master

Other target

Isuzu
UHF – Hv – no target

Corner reflector

master

Other target

Isuzu
UHF – Hv - targets

Corner reflector

master

Other target

Isuzu
UHF – Vv – no target

Corner reflector

master

Other target

Isuzu
UHF – Vv - targets

Corner reflector

master

Other target

Isuzu
Band P - Polarimetric change detection: performances analysis

Polarimetric Change detection statistics

<table>
<thead>
<tr>
<th>Target</th>
<th>mean</th>
<th>std</th>
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<tr>
<td>Isuzu</td>
<td>16 dB</td>
<td>+/-0.75 dB</td>
</tr>
<tr>
<td>Master</td>
<td>16.5 dB</td>
<td>+/-0.7 dB</td>
</tr>
<tr>
<td>Other target</td>
<td>10 dB</td>
<td>+/-0.5 dB</td>
</tr>
<tr>
<td>Corner reflector</td>
<td>6 dB</td>
<td>+/-1.4 dB</td>
</tr>
<tr>
<td>Clutter</td>
<td>0 dB</td>
<td>+/-1.4 dB</td>
</tr>
</tbody>
</table>
Polarimetric change detection analysis: clutter analysis / Baseline
Measured forest attenuation

From change detection => Precise location of the corner reflector

Tropical forest attenuation measurements
P band, tropical forest -35m high, 30° incidence

RCS measurements

Average on 4 measurements
- 2 ways attenuation Hh: -14dB +/- 0.5 dB
- 2 ways attenuation Vv: -17.6dB +/- 0.8 dB
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L band Hh no target
L band Hh with targets
L band Hv no target
L band Hv with targets
L band Vv no target
L band Vv with targets
Bande L – Polarimetric change detection : 402 - 506

Master : 15 dB

Isuzu : 26 dB
Conclusion

Application of Novak’s polarimetric change detection to the TROPISAR dataset

- 3/4 detected target in P band with no false alarms
- 2/3 detected target in L band
- Under cover detection
- Robustness versus volumic and temporal decorrelation

Measurement of attenuation in P band