Use of Fully Polarimetric PALSAR Data for the Cartography of Tropical Vegetation

Context:

- Assessment for radar polarimetry for tropical vegetation classification
- Follow on study with AIRSAR data over a French Polynesian Island

Goal:

Evaluation of spaceborne PALSAR polarimetric data for tropical vegetation cartography by comparison to AIRSAR airborne data
Outline:

- Study site: Tubuai Island
- Classification method: SVM
- Results with AIRSAR data
- Results with ALOS/PALSAR data
STUDY SITE

French Polynesian Island: Tubuai

Quickbird Image (Google Earth)
French Polynesian Island: TUBUAI

KONA

TUBUAI
STUDY SITE

French Polynesian Island: Tubuai

Tropical vegetation

- **Landscape:**
  - Forests $\approx 60\%$
  - Low vegetation $\approx 30\%$
  - Agricultural fields
  - Residential areas
STUDY SITE: Tubuai Island

4 forest species

Purau  Pinus  Falcata  Guava (invasive)

2 low vegetation classes

Fern lands  Swamps

bare soils (agricultural fields + roads)
Classification Method: Support Vector Machine (SVM)

- **Supervised** classification method
- **Principle**: find a geometrical surface (*Hyperplane*) separating the training classes vectors.
- **Non linear case**:

  *kernel* method (*RBF*, polynomial,...) = *projection* of input data space to *higher space* where data are linearly separable

- **Noisy data**: *relaxation* (*Cost*) parameter

Example of non linear case:

☞ **SVM**: combination of *many* and *heterogeneous* indices
Fully Radar Polarimetric Data

Coherency Matrix $<T_3>$  ➔ 49 polarimetric indices

➔ SVM algorithm: 2 vectors

$V_{T3}$

\[
\begin{pmatrix}
T_{11} \\
T_{22} \\
T_{33} \\
\Re(T_{12}) \\
\Im(T_{12}) \\
\Re(T_{13}) \\
\Im(T_{13}) \\
\Re(T_{23}) \\
\Im(T_{23})
\end{pmatrix}
\]

Coherency matrix

Intensities and ratios

$T_{ij}(i, j = 1, 2, 3)$

$I_{hh}, I_{vv}, I_{ll}, I_{rr}$

$I_{hh}^2 + 2I_{hh} + I_{hh}^2$

$I_{hh} / I_{vv}, I_{hv} / I_{hh}, I_{hv} / I_{vv}$

$I_{ll} / I_{rr}, I_{ll} / I_{lr}, I_{rr} / I_{lr}$

Variation coefficient

$C_{V, hh}, C_{V, hv}, C_{V, vv}$

$C_{V, ll}, C_{V, lr}, C_{V, rr}$

Degree of coherency

$\rho_{hh-vv}, \rho_{hh-hv}, \rho_{vv-hv}$

$\rho_{ll-rr}, \rho_{ll-lr}, \rho_{rr-lr}$

Free space backsc. power

$\rho_{ll-lr}, \rho_{ll-lr}, \rho_{rr-lr}$

Degree of polarisation

$I_{min}, I_{max}/I_{min}$

Cloude/Pottier parameters

$dP_{min}, dP_{max}, \Delta dP$

Frequency

$H / A / \alpha$

Freeman parameters

$P_s, P_d, P_v$
AIRSAR acquisition over Tubuai Island

Sensor **AIRSAR** (JPL/NASA) August 2000

- **L** ($\lambda=23\text{cm}$) and **P** ($\lambda=67\text{cm}$) fully polarimetric (**POLSAR**):
- **C** band ($\lambda=5.7\text{cm}$): VV (**TOPSAR**)
- Incidence angle: 20-60°
- Spatial resolution: 13.5 x 5 m² – 4 looks
- Pixel size: 5 x 5 m²

**Double bounce**

- Volume
- Single bounce

L Band: Pauli Decomposition
AIRSAR Classification: Main Results

Coherency matrix elements ($V_{T3}$):

- SVM $>>$ Wishart classification \textit{(reflection symmetry not observed)}

  - $\text{MPA} = 87\%$
  - $\text{MPA} = 66\%$

Improvement with additional polarimetric indices

  - $\text{MPA} = 91\% (+4\%)$ with optimal set

Classification accuracy:

$\text{MPA} = \text{Mean Producer Accuracy}$
AIRSAR CLASSIFICATION RESULTS (P+L+C bands)

Satisfactory results according to the local concerned people
ALOS/PALSAR acquisition

- Acquisition date 9th April 2009
- Fully polarimetric (PLR)
- Incidence angle: 26°
- Spatial resolution: 10 x 70 m
- Pixel size: 3m x 20 m

500 x 250 pixels!

Double bounce
Volume
Single bounce

L Band: Pauli Decomposition
### ROI derived from AIRSAR classification

<table>
<thead>
<tr>
<th>Vegetation Type</th>
<th>Training samples</th>
<th>Control samples</th>
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<tbody>
<tr>
<td><strong>Forest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>1000</td>
<td>11,254</td>
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PALSAR CLASSIFICATION RESULTS

$\text{SVM(T3): MPA} = 57\%$

$\Rightarrow \text{Reflexion symmetry still not observed}$

$\text{Wishart: MPA} = 53\%$

$\text{Addition of polarimetric indices: } 60\%$
PALSAR CLASSIFICATION RESULTS

SVM(T3): MPA = 57%

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➡️ Reflexion symmetry still not observed

Addition of polarimetric indices: 60%

Comparison with AIRSAR

AIRSAR (4 looks)  66 %

➡️ Spatial resolution

PALSAR (3 looks)  57 %
**PALSAR CLASSIFICATION RESULTS**

SVM(T3): MPA = 57%

Wishart: MPA = 53%

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**Comparison with AIRSAR**

| AIRSAR (4 looks) | 66 % |
| AIRSAR (boxcar 4x4) | |
| PALSAR (3 looks) | 57 % |

*Similar spatial resolution*
**PALSAR CLASSIFICATION RESULTS**

SVM(T3): MPA = 57%

Wishart: MPA = 53%

⇒ Reflexion symmetry still not observed

*Addition of polarimetric indices: 60%*

Comparison with AIRSAR

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<th>66 %</th>
<th>Radiometric resolution + texture</th>
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<td>AIRSAR (boxcar 4x4)</td>
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*Similar spatial resolution*
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With ROI adapted to PALSAR-PLR spatial resolution
With ROI adapted to PALSAR-PLR spatial resolution:

- MPA = 90%

**PALSAR-PLR data are able to discriminate the different forest types for area compatible with its spatial resolution**
CONCLUSION

A study case not *a priori* favorable to PALSAR data

PALSAR: same observations made with AIRSAR

- Discrepancies with Wishart distribution ➔ SVM > Wishart
- Good results with T3 elements
- MPA +3% with additional polarimetric indices

Results illustrate that PALSAR polarimetric mode is well suited for tropical vegetation cartography for areas compatible with its spatial resolution

*Many thanks to JAXA for the PALSAR Acquisition*