Scattering Mechanism Analysis And Deorientation Effect Investigation For Oriented Built-up Areas Using ALOS/PALSAR PolInSAR Data Sets

Si-Wei Chen, Motoyuki Sato

Tohoku University, Japan

chensw@cneas.tohoku.ac.jp
sato@cneas.tohoku.ac.jp
Model-based decomposition receives more attentions recently (2009- )!


...
Recent main advancements

✓ Negative power control
✓ General volume scattering model
✓ Deorientation
✓ Complete information utilization discussion
✓ Adaptive and general decomposition development
✓ PolInSAR coherence utilization
Decomposition + Deorientation

➢ Basic models for covariance matrix

\[
C_{dbl} = f_d \begin{bmatrix} 1 & 0 & \alpha \\ 0 & 0 & 0 \\ \alpha^* & 0 & |\alpha|^2 \end{bmatrix} \quad C_{vol} = f_v \begin{bmatrix} a & e & d \\ e^* & b & f \\ d^* & f^* & c \end{bmatrix} \quad C_{odd} = f_s \begin{bmatrix} 1 & 0 & \beta \\ 0 & 0 & 0 \\ \beta^* & 0 & |\beta|^2 \end{bmatrix}
\]

**Double Bounce**

**Volume Scattering**

**Odd Bounce**

Decomposed volume scattering power

\[
P_v = (a + b + c) f_v = \left(1 + \frac{a + c}{b}\right) C_{22} \quad P_v > 3C_{22}
\]

<table>
<thead>
<tr>
<th>SPAN</th>
<th>(P_v = 3\langle C_{22}\rangle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Deorientation</td>
<td>19.48</td>
</tr>
<tr>
<td>After Deorientation</td>
<td>19.48</td>
</tr>
</tbody>
</table>

Oriented building

Pauli Image
PolInSAR coherence

- PolInSAR covariance matrix and coherence

\[ C_6 = \begin{bmatrix} C_{11} & \Omega_{12} \\ \Omega_{12}^H & C_{22} \end{bmatrix} \]

\[ \hat{\gamma}(\omega_1, \omega_2) = \frac{\langle \omega_1^H \Omega_{12} \omega_2 \rangle}{\sqrt{\langle \omega_1^H C_{11} \omega_1 \rangle \langle \omega_2^H C_{22} \omega_2 \rangle}}, \quad 0 \leq \gamma \leq 1 \]

- Optimization

\[
\max_{\omega_1, \omega_2} |\gamma| \\
\text{s.t.: } \|\omega_1\| = \|\omega_2\| = 1
\]

\[ \gamma_{opt\_1} \geq \gamma_{opt\_2} \geq \gamma_{opt\_3} \]

PolInSAR coherence:

- Sensitive to diverse terrains
- Close relationship to forest structures

Potentially, the volume scattering can be modeled from it!
ALOS/PALSAR datasets

ALOS AVNIR-2
Optical Image

Ibaraki and Chiba prefecture
2007-12-31

Range

Azimuth

Pauli Image

Spatial baseline: 299m

2007-04-02

2007-05-18
Built-up region I

2.5m resolution pan-sharpened true-color image generated from PRISM and AVNIR-2 data sets

Yamaguchi Decomp
Built-up region I

Flight direction

2.5m resolution pan-sharpened true-color image generated from PRISM and AVNIR-2 data sets

Proposed Decom
Built-up region II

Flight direction

Optical image
Built-up region II

Flight direction

Yamaguchi
Built-up region II

Flight direction

Proposed
Optical images for oriented built-up patches

- Pure buildings
- Similar size
- Different orientations
Built-up region II _ Scattering power contributions

- Double bounce
- Volume scattering
- Odd bounce
Conclusions

- Investigation the scattering mechanisms for built-up patches with different orientation angles using ALOS/PALSAR PolInSAR data sets
  - Decomposition+deorientation works well for small orientation angle case
  - The proposed decomposition works effectively for both small and large orientation angles cases

- PolInSAR mode shows more application potentials even the temporal baseline is 46 days
  - Classification
  - Scattering mechanism understanding
  - Biophysical parameters retrieval
  - … …
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Thank you for your attention!