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

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Model-based decomposition receives more attentions recently (2009-)!

[1] W. T. An, Y. Cui, and J. Yang, "Three-component model-based decomposition for polarimetric SAR data," *TGRS*, vol. 48, pp. 2732-2739, Jun 2010.

[2] Y. Yamaguchi, A. Sato, W. M. Boerner, R. Sato, and H. Yamada, "Four-component scattering power decomposition with rotation of coherency matrix," *TGRS*, vol. 49, pp. 2251-2258, Jun 2011.

[3] J. S. Lee and T. L. Ainsworth, "The effect of orientation angle compensation on coherency matrix and polarimetric target decompositions, " *TGRS*, vol. 49, pp. 53-64, 2011.

[4] J. J. Van Zyl, M. Arii, and Y. Kim, "Model-based decomposition of polarimetric SAR covariance matrices constrained for nonnegative eigenvalues," *TGRS*, vol. 49, no. 9, pp. 3452-3459, Sep 2011.

[5] M. Arii, J. J. van Zyl, and Y. Kim, "A general characterization for polarimetric scattering from vegetation canopies," *TGRS*, 48(9) 3349-3357, Sep 2010.

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[7] M. Arii, J. J. van Zyl, and Y. J. Kim, "Adaptive model-based decomposition of polarimetric SAR covariance matrices," *TGRS*, 49(3) 1104 – 1113, Mar. 2011.

[8] S.W. Chen and M. Sato, "Model-Based Polarimetric Decomposition Using PolInSAR Coherence," *IEEE Int. Geosci. Remote Sens. Symp.*, Vancouver, Canada, Jul 2011.

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[10] A. Sato, Y. Yamaguchi, G. Singh, and S.-E. Park, "Four-component scattering power decomposition with extended volume scattering model," *GRSL*, (in press)

[11] J. S. Lee, T. L. Ainsworth and Y. Wang, "Recent advances in scattering model-based decompositions: an overview," IEEE Int. Geosci. Remote Sens. Symp., Vancouver, Canada, Jul 2011.

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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

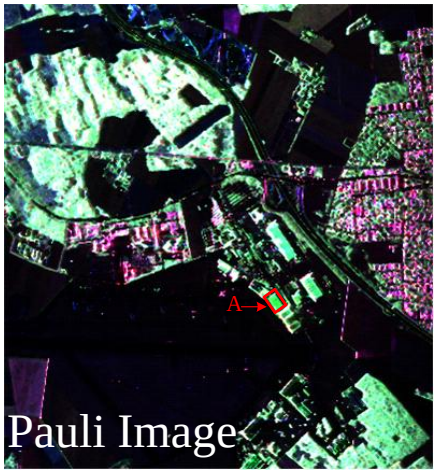
- Basic models for covariance matrix

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

Double Bounce | **Volume Scattering** | **Odd Bounce**

Decomposed volume scattering power

$$P_v = (a+b+c)\, f_v = \left(1+\frac{a+c}{b}\right) C_{22} \Rightarrow P_v > 3C_{22}$$



Oriented building

	SPAN	$P_v = 3\langle C_{22} \rangle$
Before Deorientation	19.48	19.47
After Deorientation	19.48	17.56

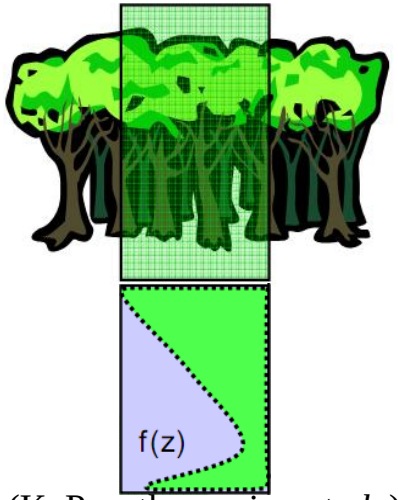
PolInSAR coherence

- PolInSAR covariance matrix and coherence

$$C_6 = \begin{bmatrix} C_{11} & \Omega_{12} \\ \Omega_{12}^H & C_{22} \end{bmatrix} \Rightarrow \hat{\gamma}(\omega_1, \omega_2) = \frac{\left| \left\langle \omega_1^H \Omega_{12} \omega_2 \right\rangle \right|}{\sqrt{\left\langle \omega_1^H C_{11} \omega_1 \right\rangle \left\langle \omega_2^H C_{22} \omega_2 \right\rangle}}, \quad 0 \le \gamma \le 1$$

- Optimization

$$\max_{\omega_1, \omega_2} |\gamma| \quad s.t.: \ \|\omega_1\| = \|\omega_2\| = 1 \Rightarrow \gamma_{Opt\_1} \ge \gamma_{Opt\_2} \ge \gamma_{Opt\_3}$$



(K. Papathanassiou *et al.*)

PolInSAR coherence:

- ✓ **Sensitive to diverse terrains**
- ✓ **Close relationship to forest structures**

Potentially, the volume scattering can be modeled from it!

ALOS/PALSAR datasets

Range

Azimuth

ALOS AVNIR-2
Optical Image

Ibaraki and Chiba prefecture

2007-12-31

Pauli

2007-04-02

Image

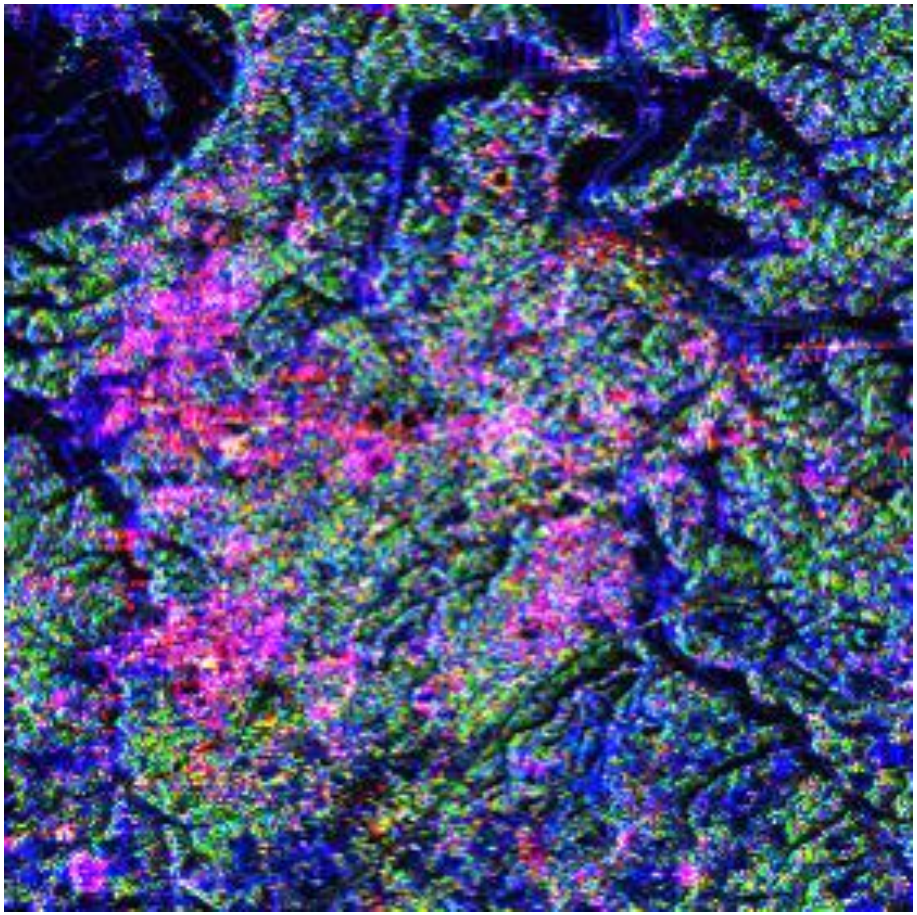
Spatial baseline: 299m

2007-05-18

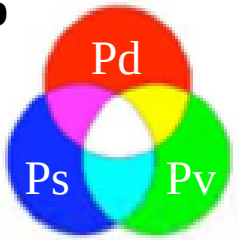
Built-up region I

Flight direction

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
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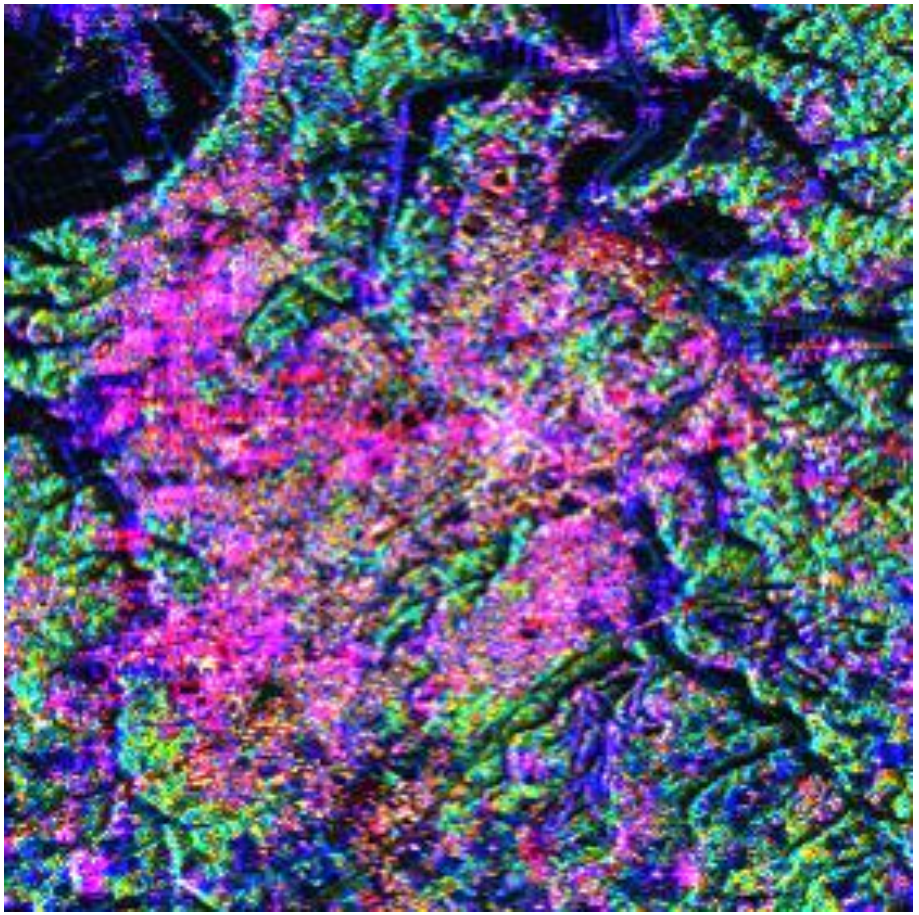
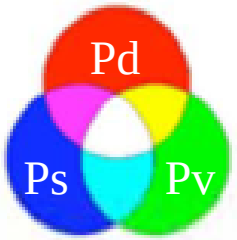
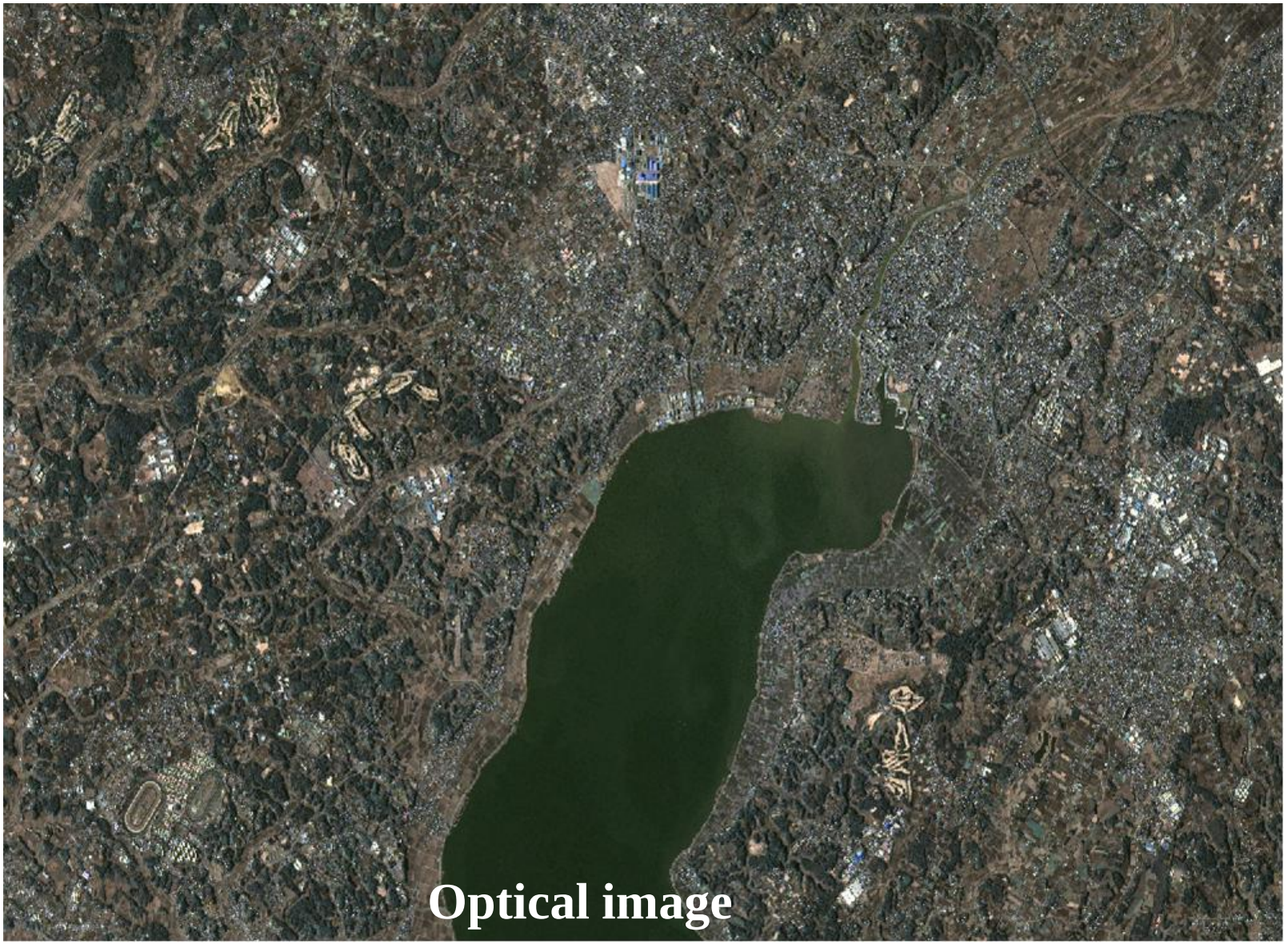


Proposed Decomp



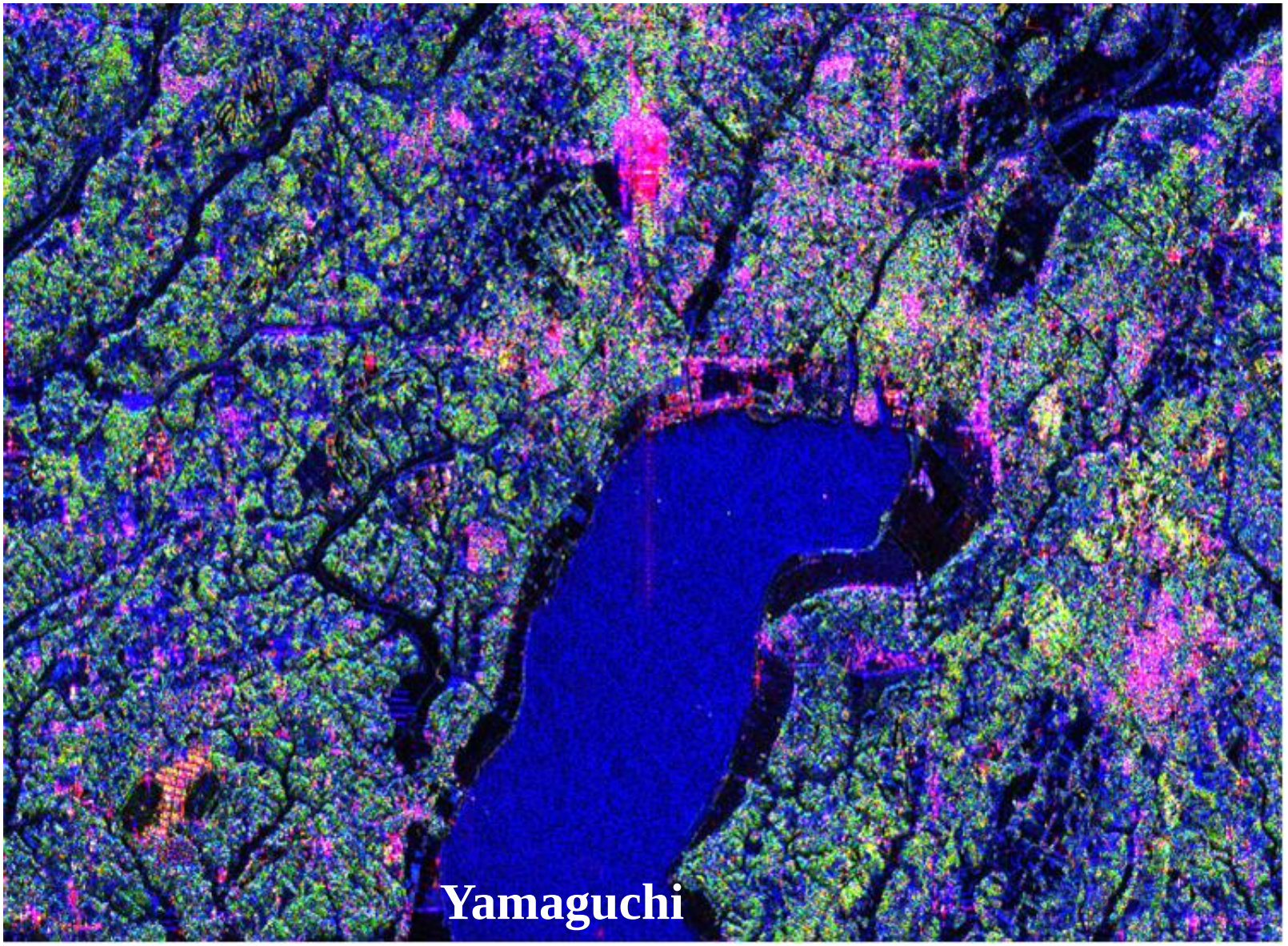
Built-up region II

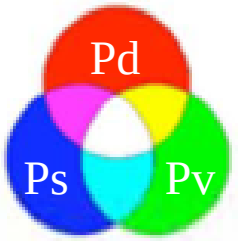
Flight direction



Built-up region II

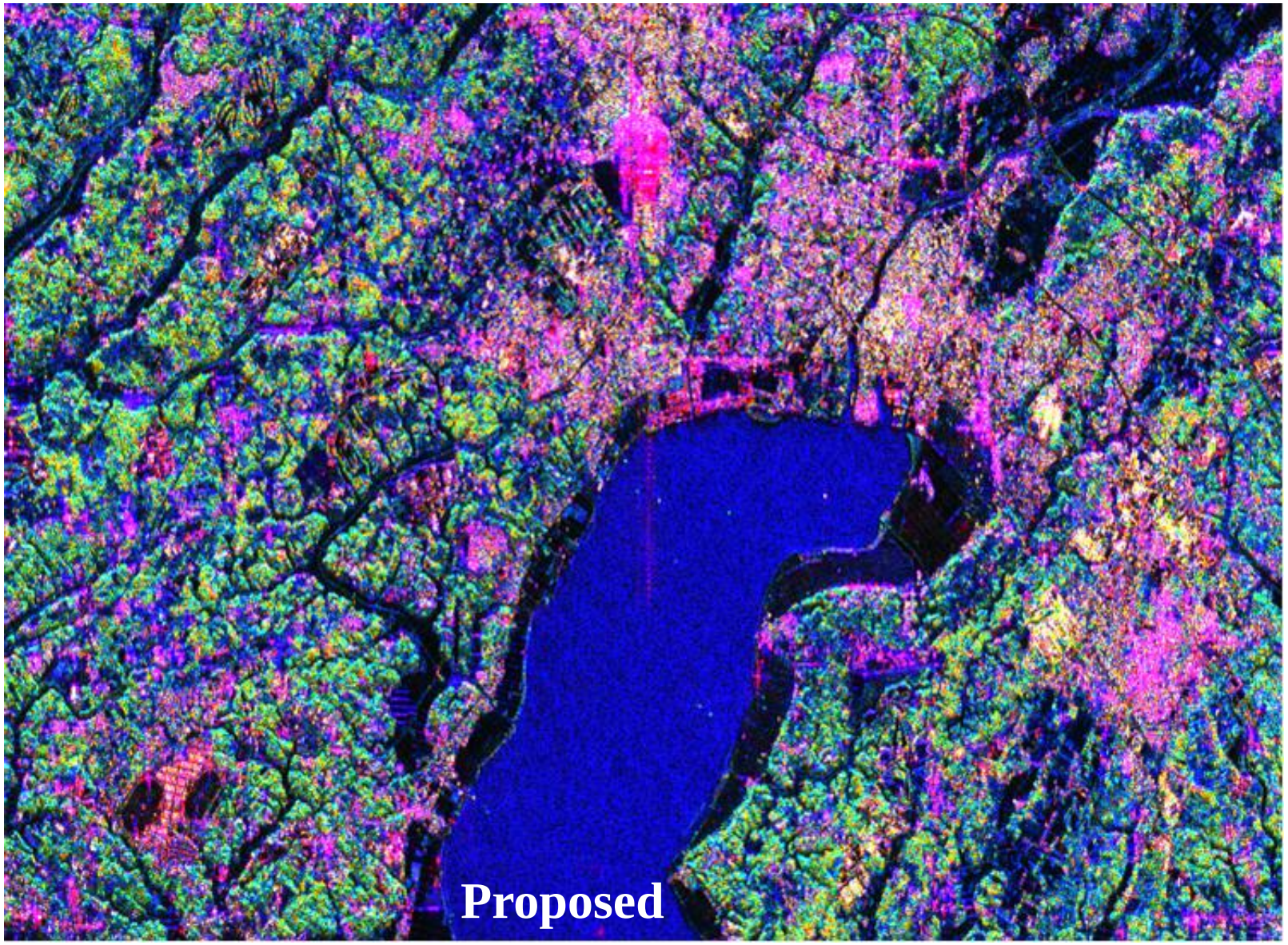
Flight direction

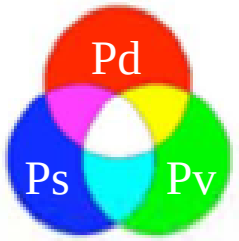




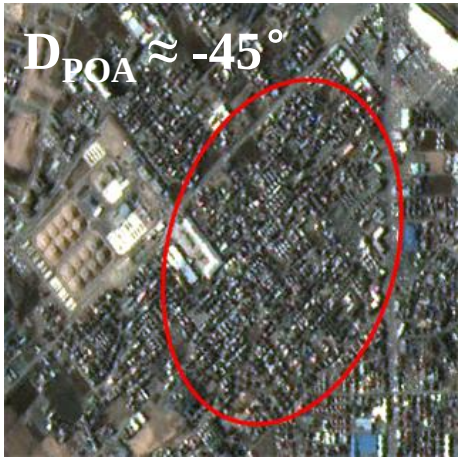
Built-up region II

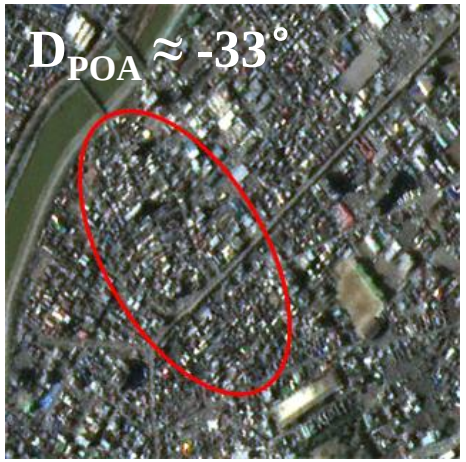
Flight direction

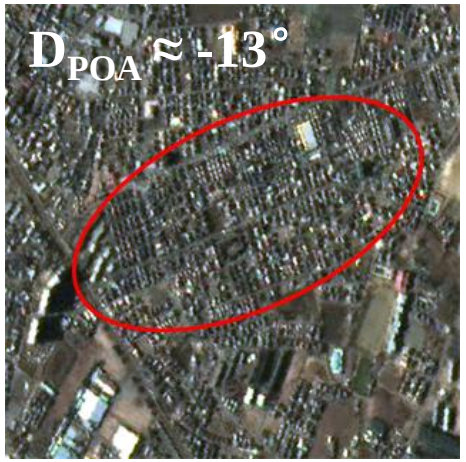


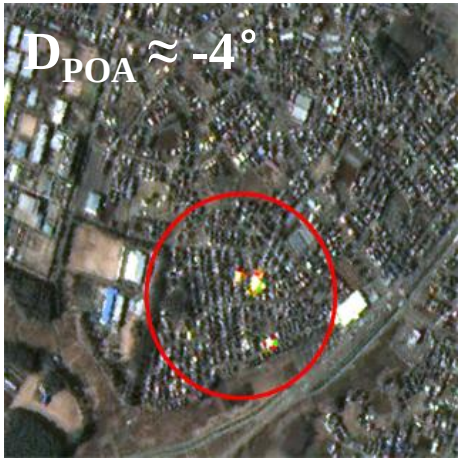


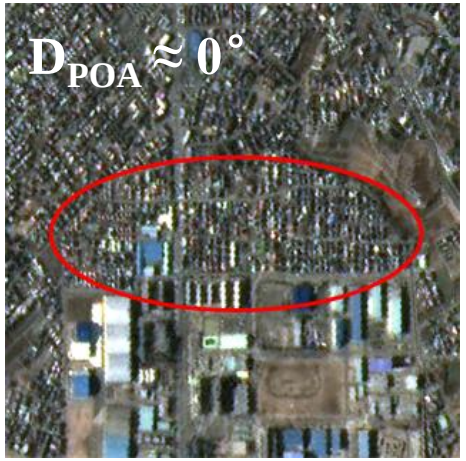
Optical images for oriented built-up patches

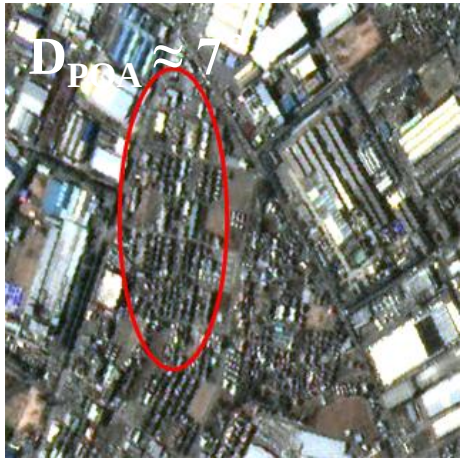


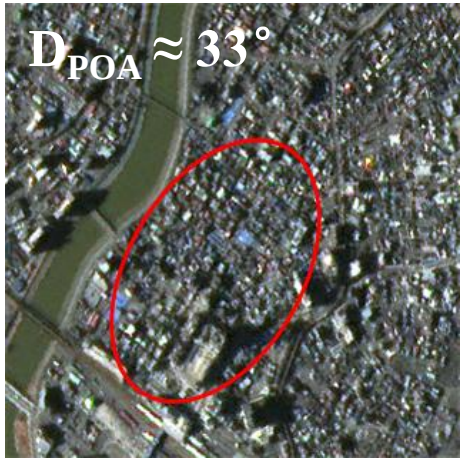






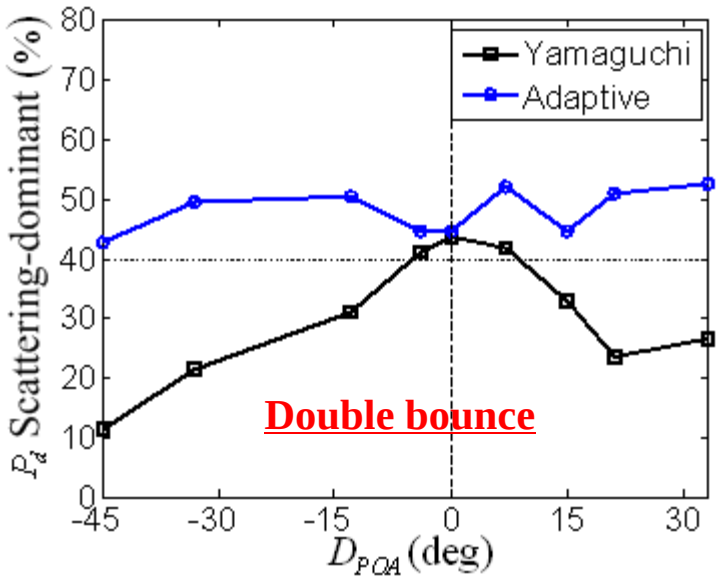


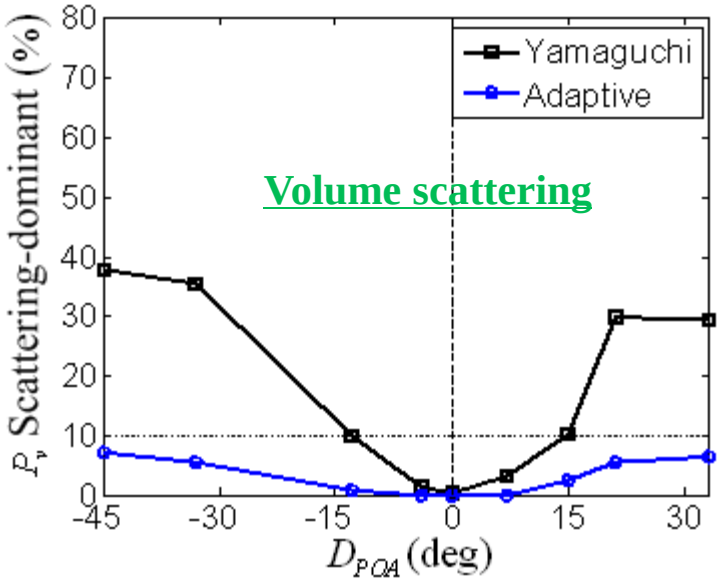


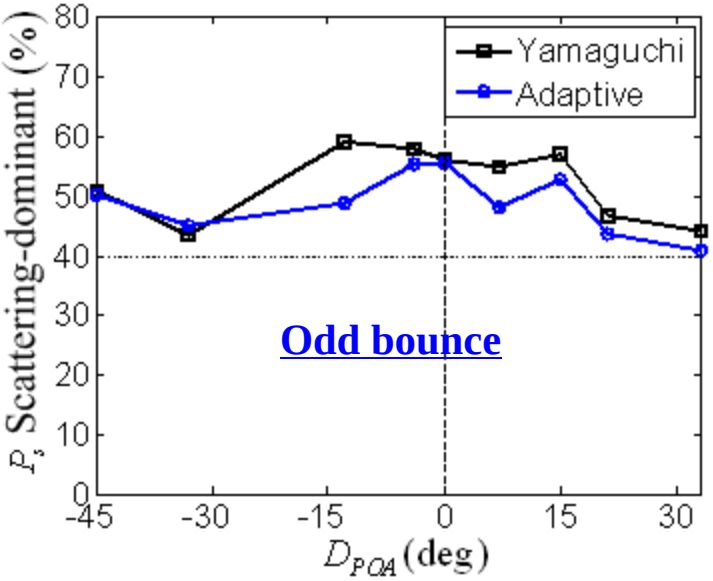


- ✓ Pure buildings
- ✓ Similar size
- ✓ Different orientations

Built-up region II _ Scattering power contributions







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**
  - **… …**

ALOS-1
2006~2011

ALOS-2
2013~

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Thank you for your attention !