

Forest Parameters Inversion Based on Airborne P-Band SAR Tomography: A Case Study of the Saihanba Forest

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Abstract

Forest parameters inversion is crucial for global ecological balance and carbon cycle monitoring. The Synthetic Aperture Radar (SAR) Tomography (TomoSAR) technique, which provides large-scale, penetrative, high-resolution three-dimensional (3D) observations under all-time and all-weather conditions, is of great significance for forest parameter inversion. Based on 12-track P-band airborne SAR data acquired over the Saihanba Forest in China, we performed TomoSAR 3D imaging of the forest following the procedures of co-registration, phase flattening, and phase calibration. We first compared the performance of different tomographic imaging algorithms, including Fourier transform, Capon, Multiple Signal Classification (MUSIC), and Compressive Sensing, in forested areas, highlighting their respective advantages and limitations. The underlying topography and forest height of the Saihanba Forest are retrieved based on the reconstructed tomograms. The root mean square error (RMSE) between the underlying topography derived from airborne TomoSAR and that from airborne LiDAR data is approximately 4.17 meters. The forest height estimated by airborne TomoSAR is between 0~25m, which is generally consistent with the SAR reference image in Pauli false color.

Study area

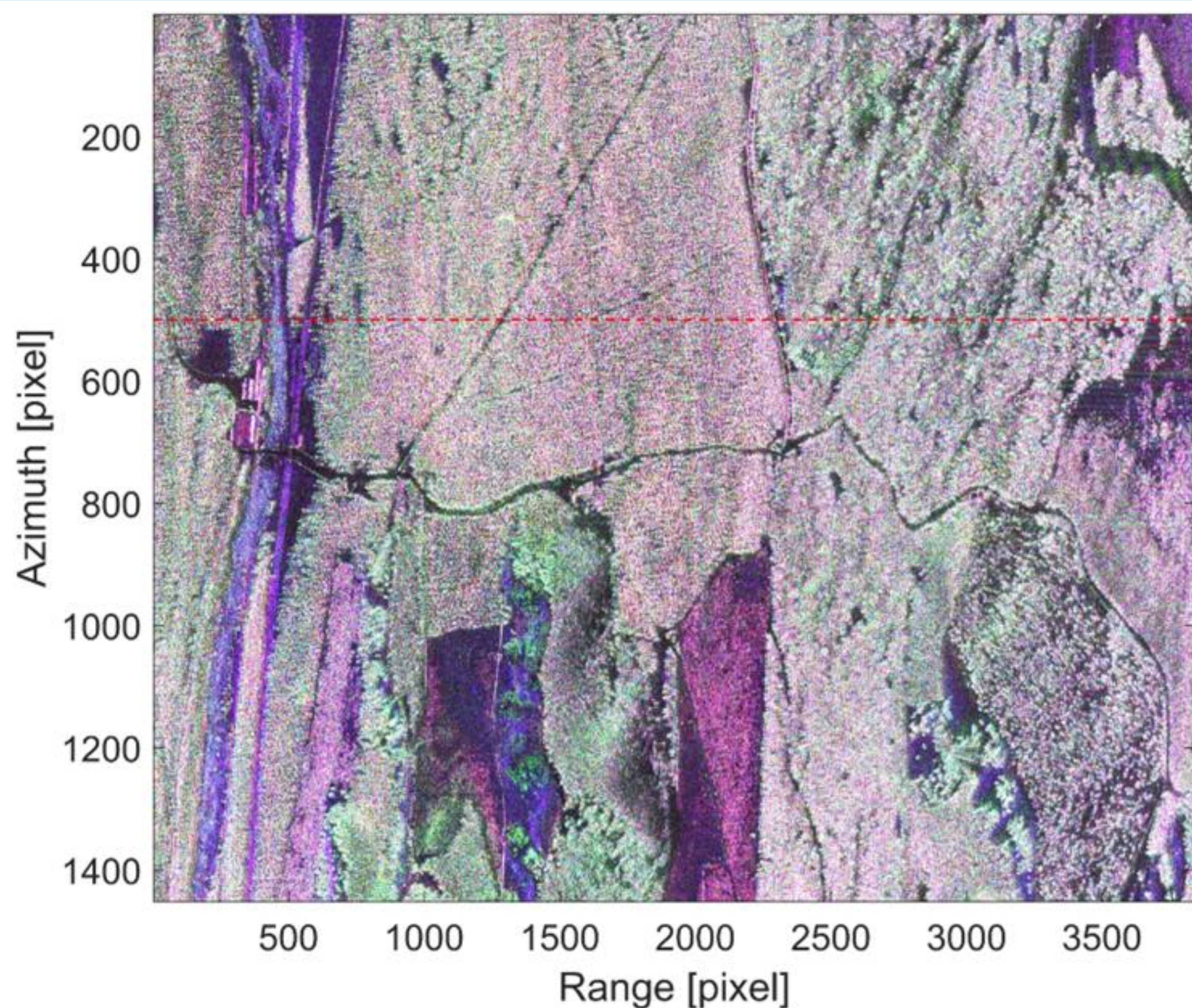


Fig. 1. SAR image in Pauli false color

- Saihanba is the largest man-made forest in Hebei Province, China.
- 12-track P-band airborne fully polarimetric SAR data are acquired over the Saihanba Forest on 2 October 2023.
- The azimuth, range, and elevation resolutions are approximately 0.97 m, 0.57 m, and 5 m, respectively

Data Processing

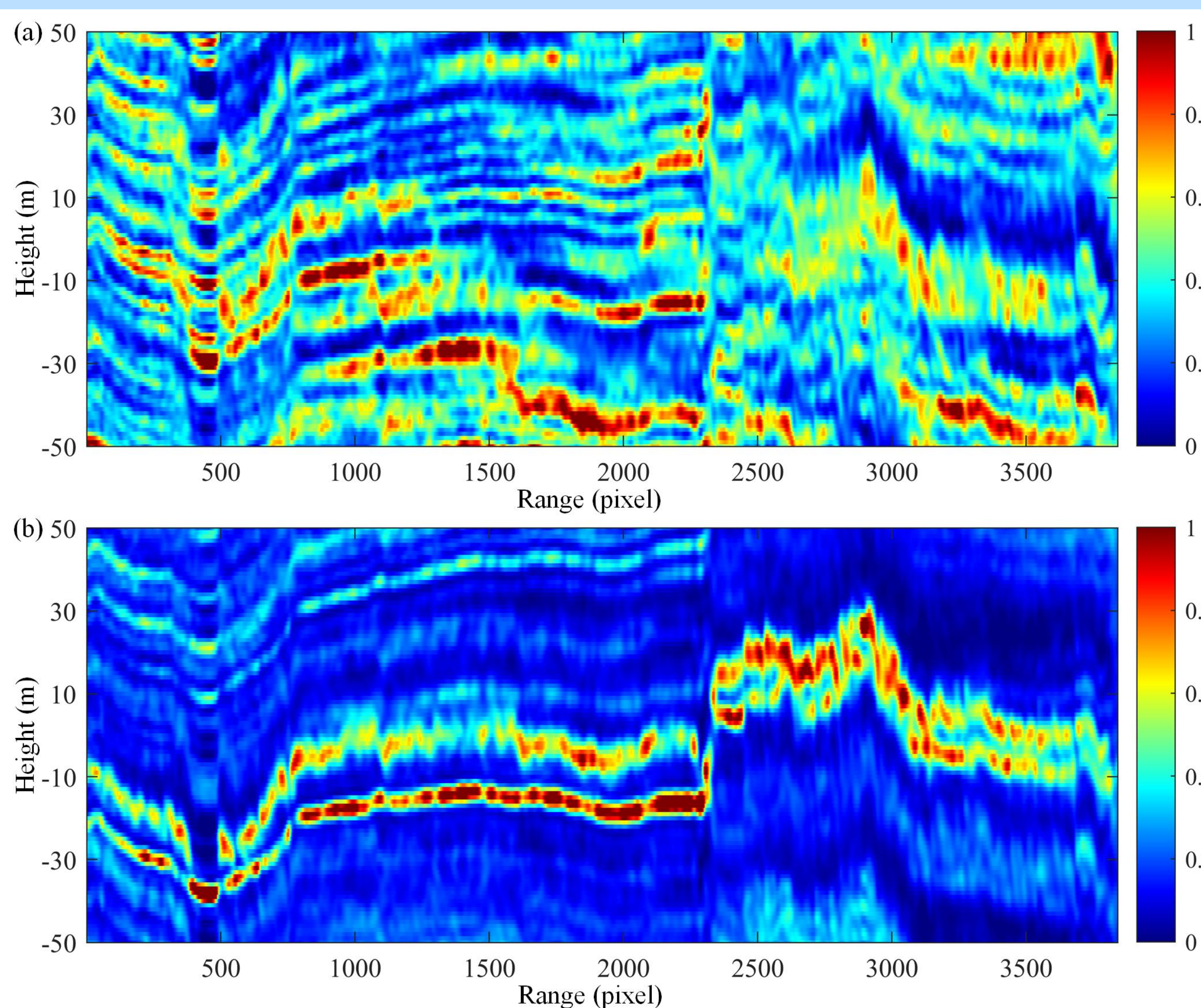


Fig. 2. TomoSAR vertical profile of the read dashed line in Fig. 1 using the Fourier transform (a) without phase calibration and (b) with phase calibration by PCDL.

Result

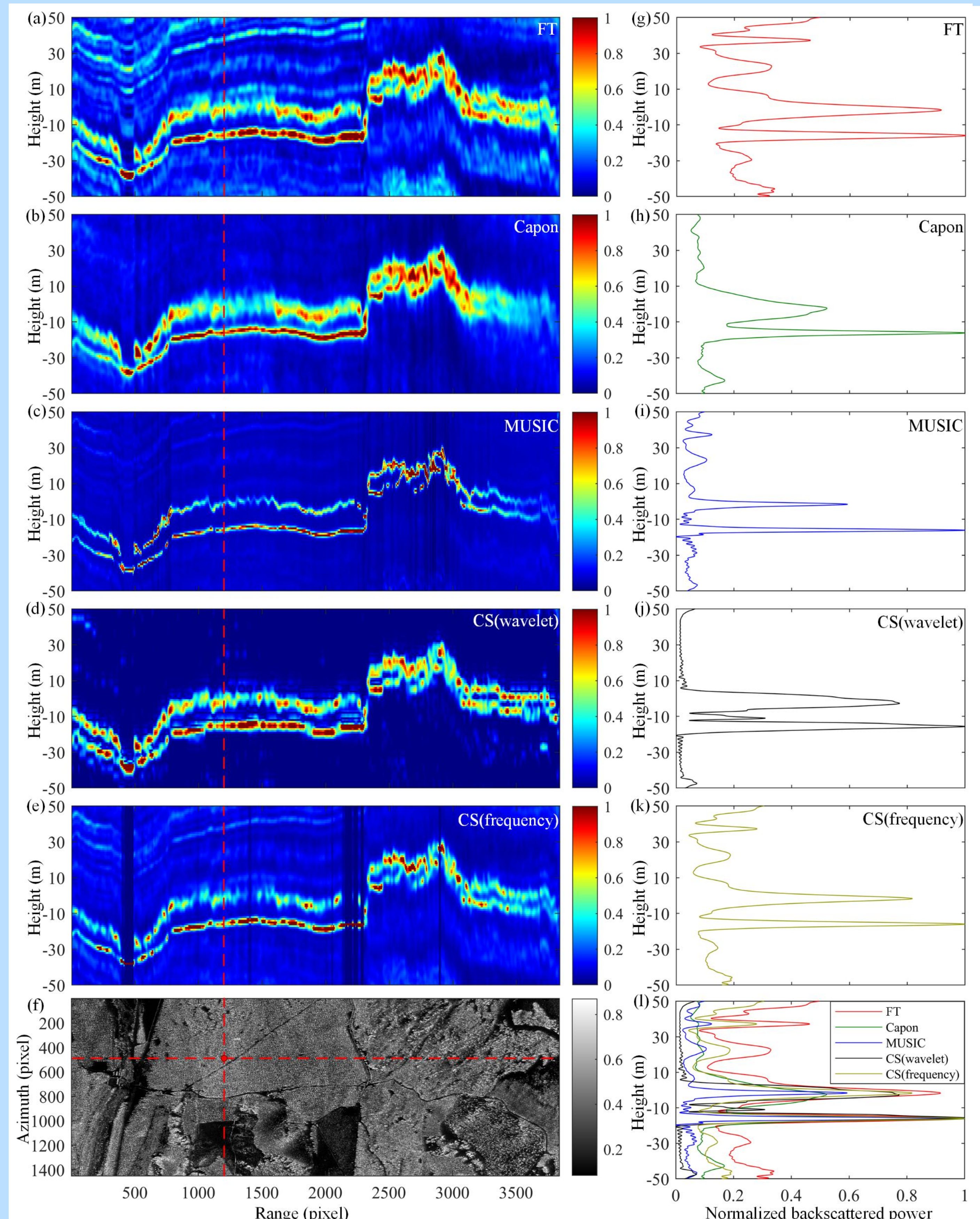


Fig. 3. Comparison of TomoSAR 3D imaging algorithms in the forest scenario

- Fourier transform, Capon, MUSIC and Compressive Sensing each have their own advantages and disadvantages in terms of radiometric accuracy, super-resolution capability, sidelobe suppression, and robustness.

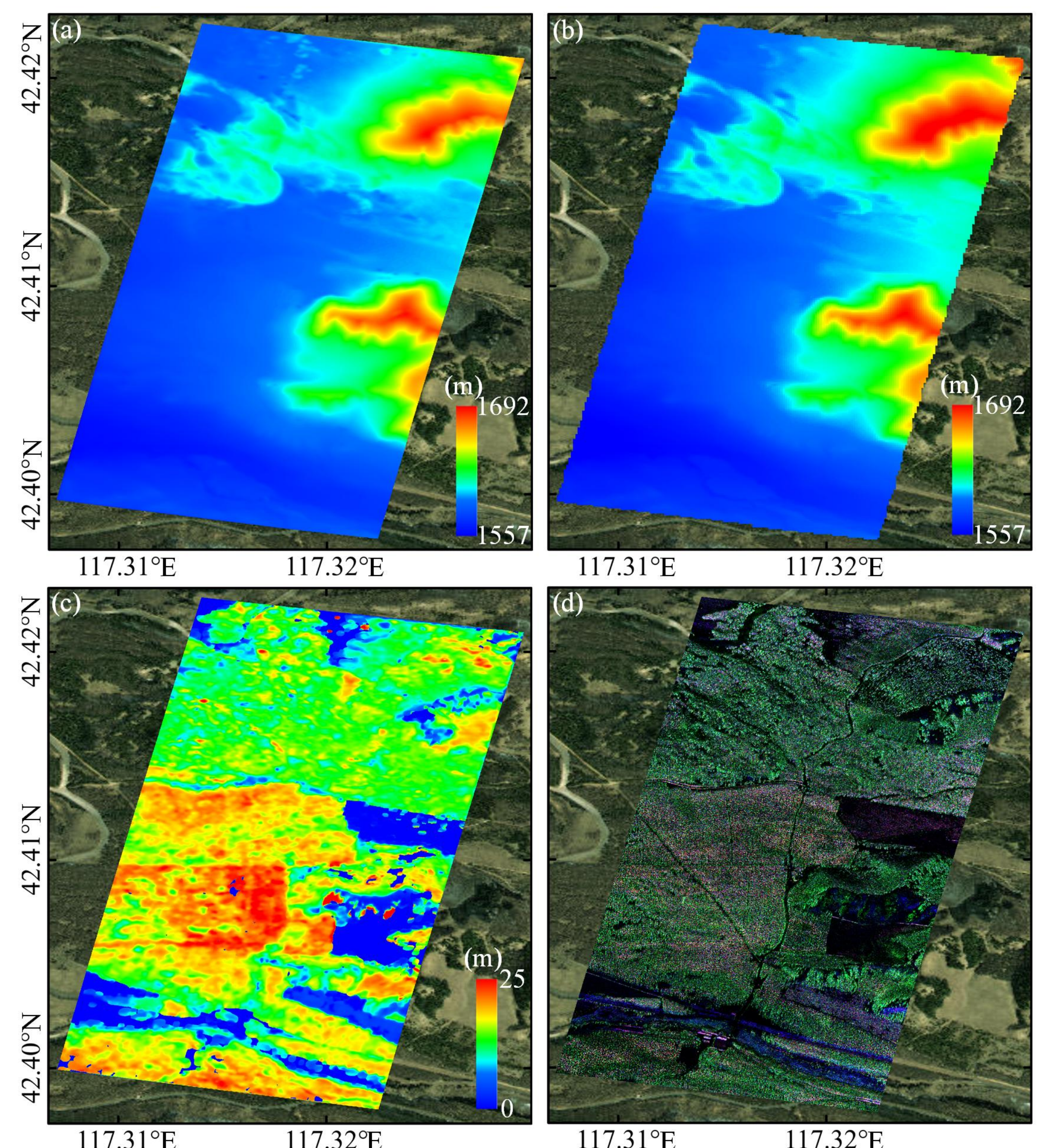


Fig. 4. The retrieved underlying topography and forest height by TomoSAR. (a) Underlying topography by TomoSAR (b) Underlying topography by LiDAR (c) Forest height by TomoSAR (d) SAR image in Pauli false color

- The (RMSE) between the underlying topography from TomoSAR and that from airborne LiDAR data is approximately 4.17m.
- The forest height estimated by airborne TomoSAR is between 0~25m, which is generally consistent with the SAR reference image in Pauli false color.

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