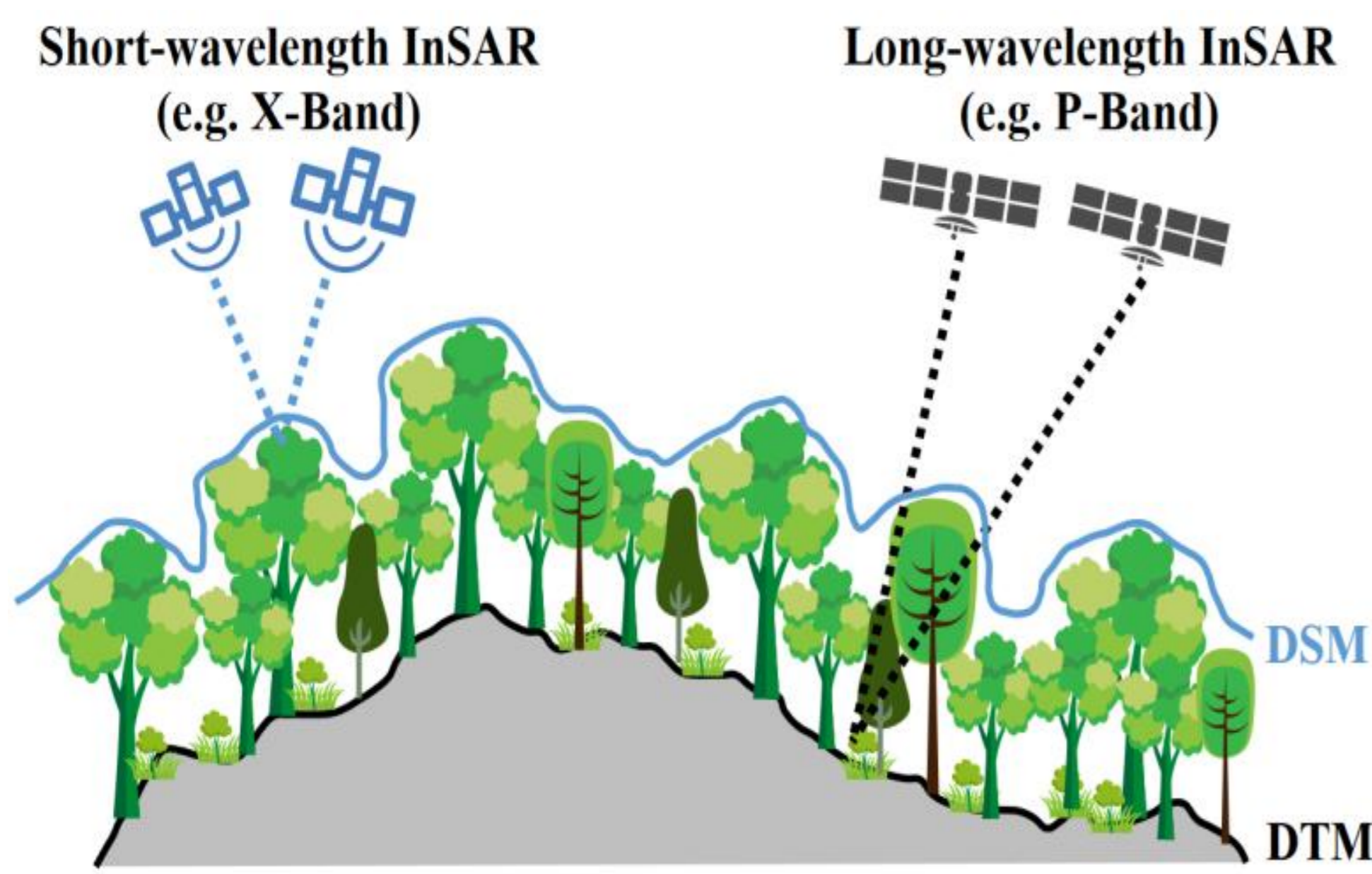


Research On Forest Height Extraction Method Based On Multi-band InSAR Data



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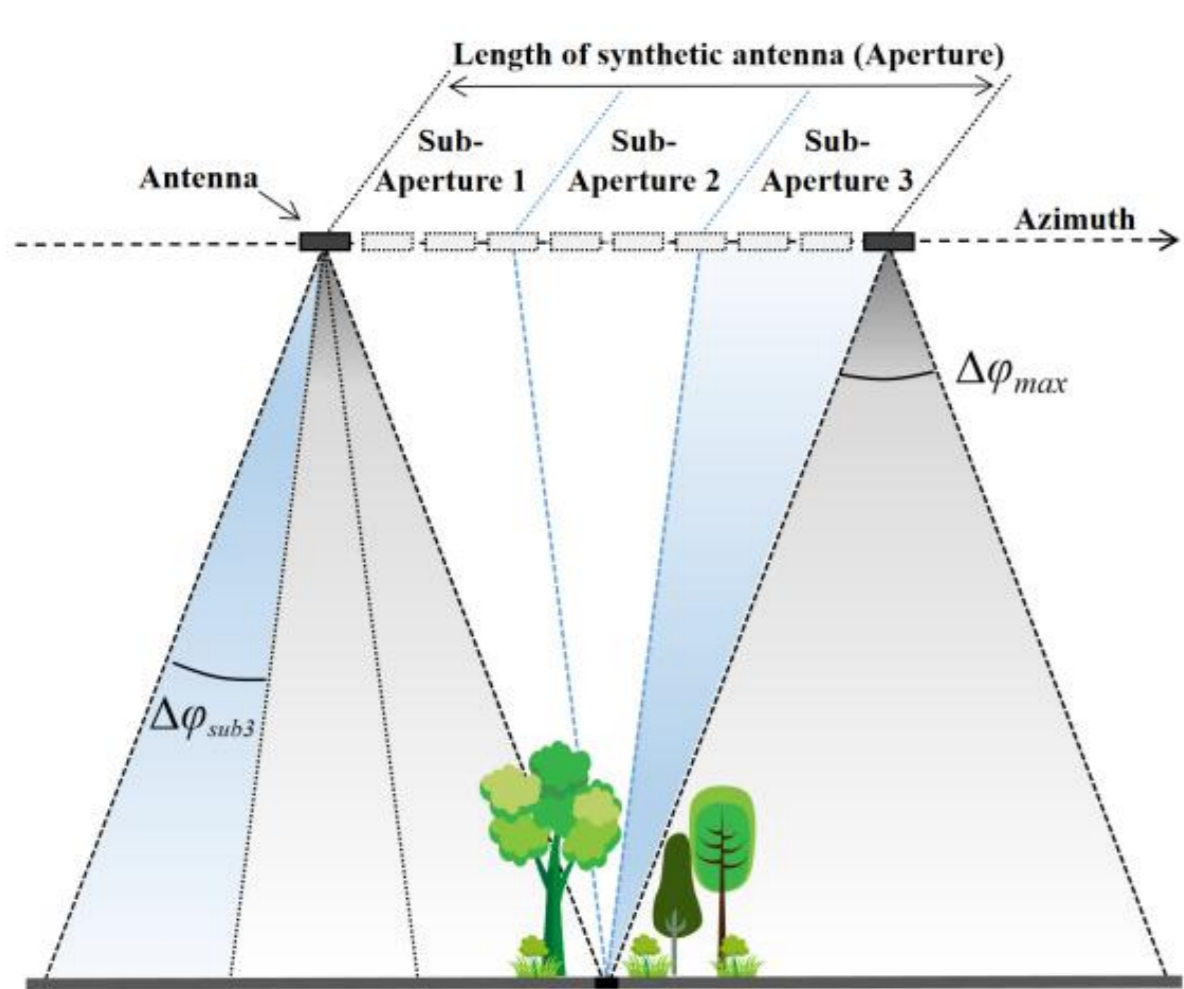
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Abstract

A forest height estimation method utilizing the penetration capability of multi-band InSAR is introduced and investigated using P-band and X-band InSAR data. In this method, a time-frequency (TF) analysis method was used to obtain the DTM based on P-band data. Furthermore, a novel compensation algorithm based on multi-layer model (MLM) was proposed to remove the penetration bias of X-band InSAR to obtain the true DSM for the forest area. And then the forest height is obtained by the difference between the X-band DSM and P-band DTM.

P-band DTM extraction using TF analysis



Sub-aperture with pure ground contribution

$$S = FFT_{az}^{-1}[\omega(n) \times FFT_{az}(SLC)]$$

S : sub-aperture image; FFT : fast Fourier transform
 SLC : full-aperture data; $\omega(n)$: band-pass filter

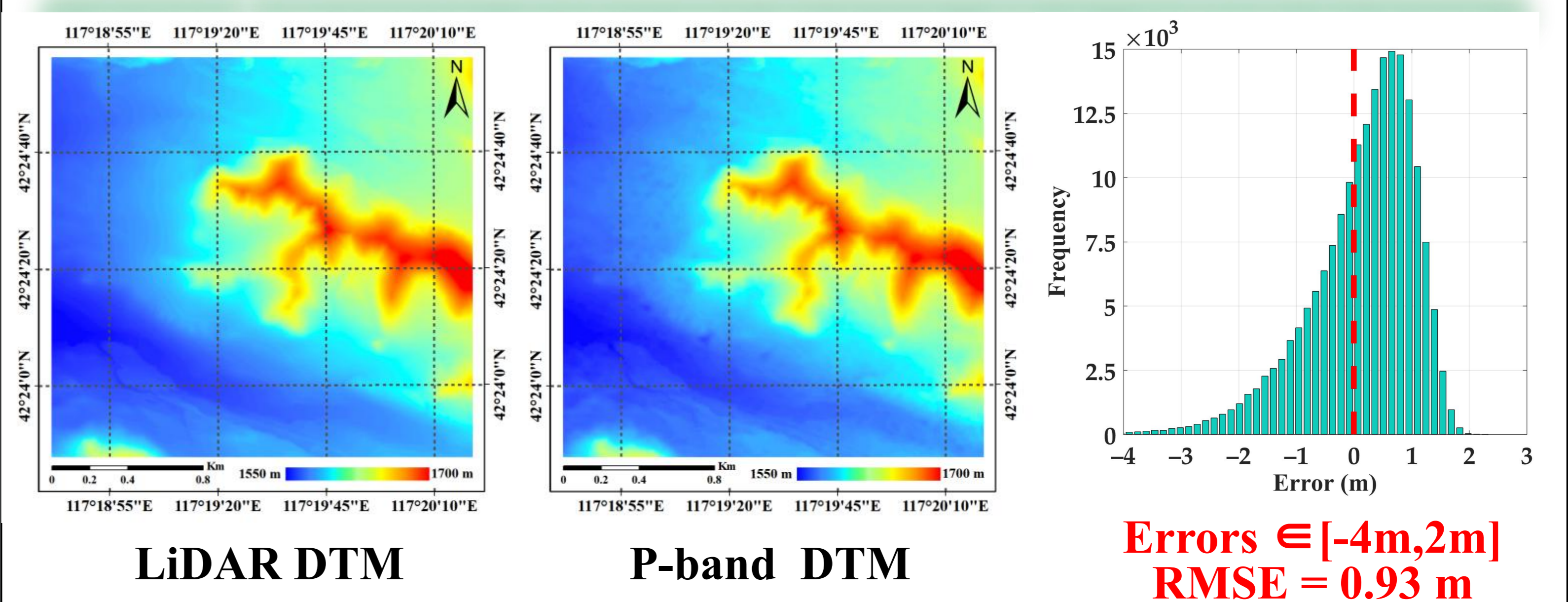
TF analysis method obtains the sub-aperture images

Identify the sub-aperture with pure ground contribution

Extract the DTM based on the ground phase center

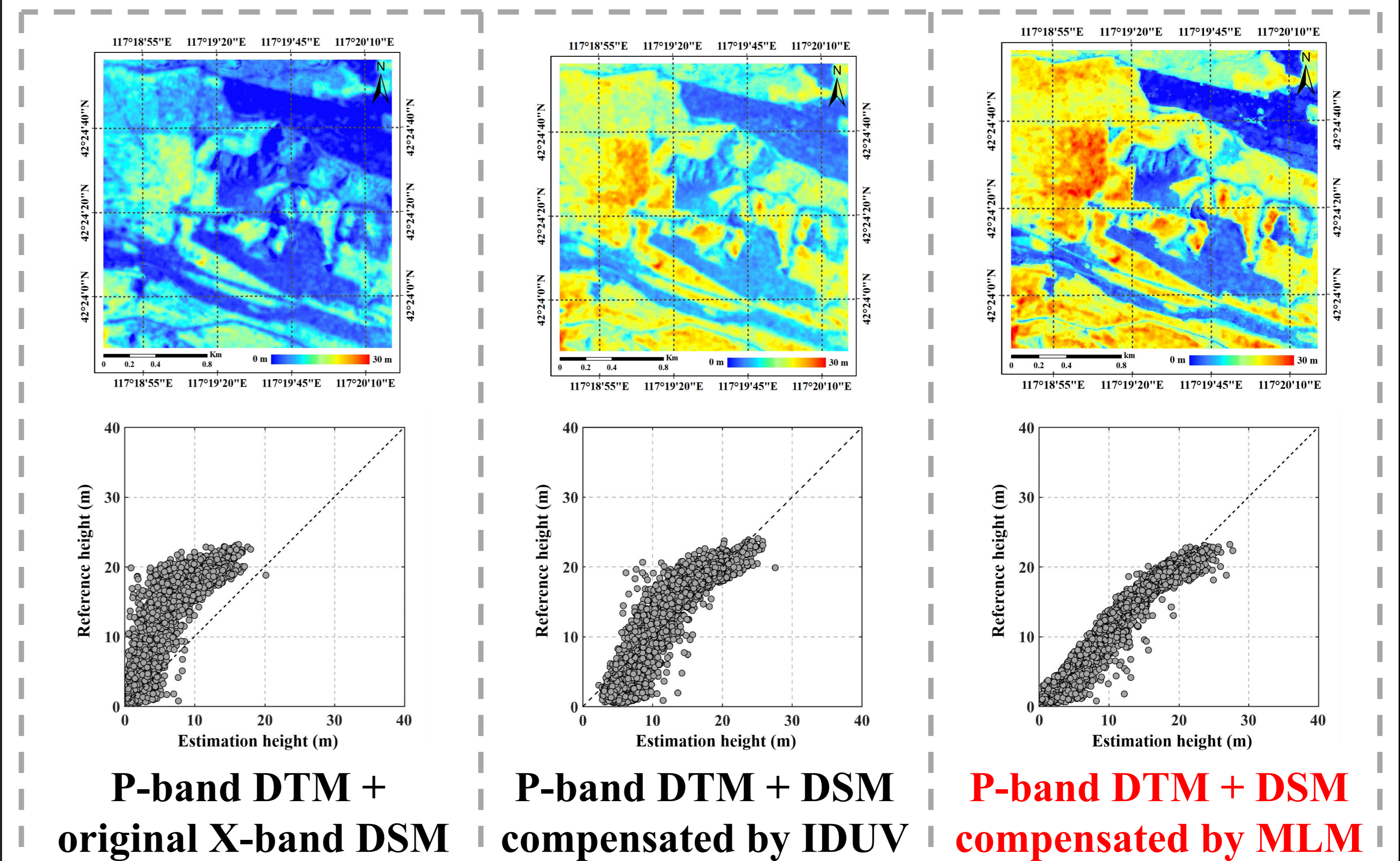
- Obtain the sub-aperture image with the pure ground contribution by changing the observation angle.

Comparison: LiDAR DTM & P-band DTM

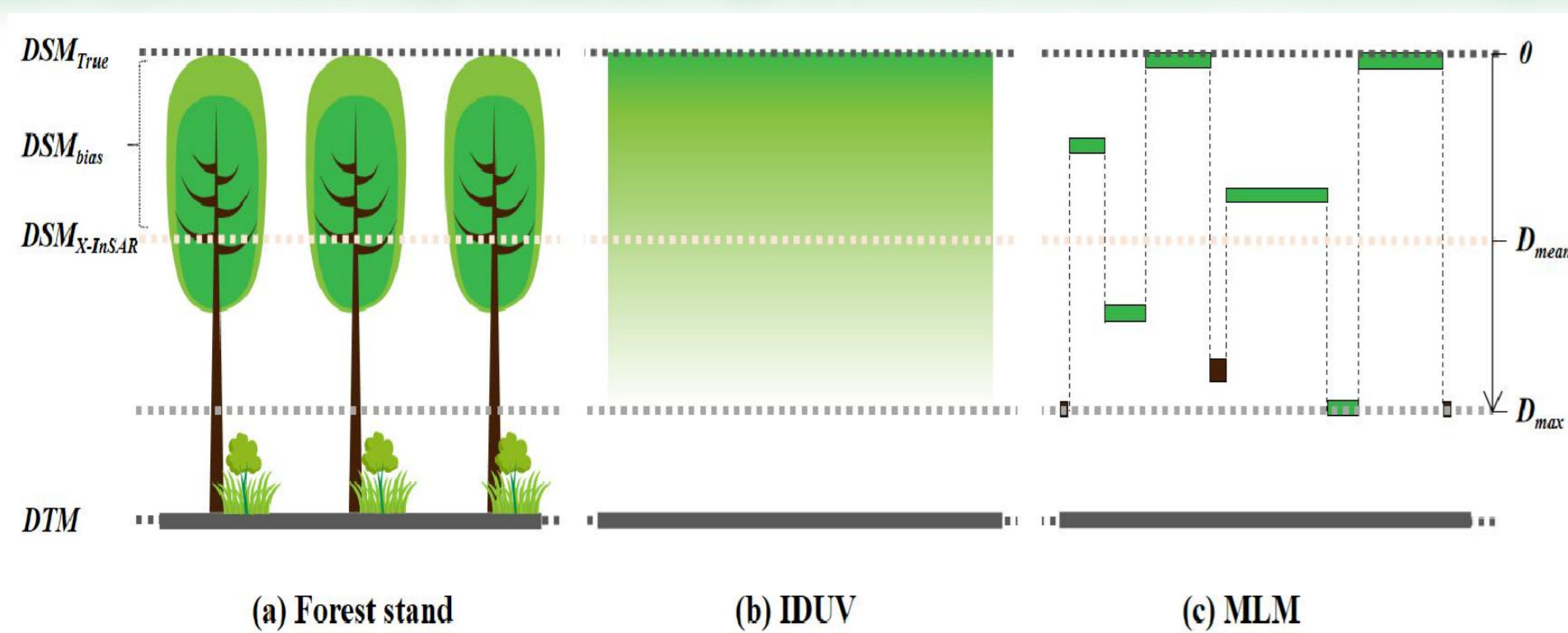


Comparison: Forest height estimation results

- Forest height results of Multi-band InSAR based on the X-band DSM before and after compensation.



X-band DSM compensation based on MLM



MLM model:

$$\gamma_v = \left| \int_0^H f(h) e^{jk_z h} dh \right|$$

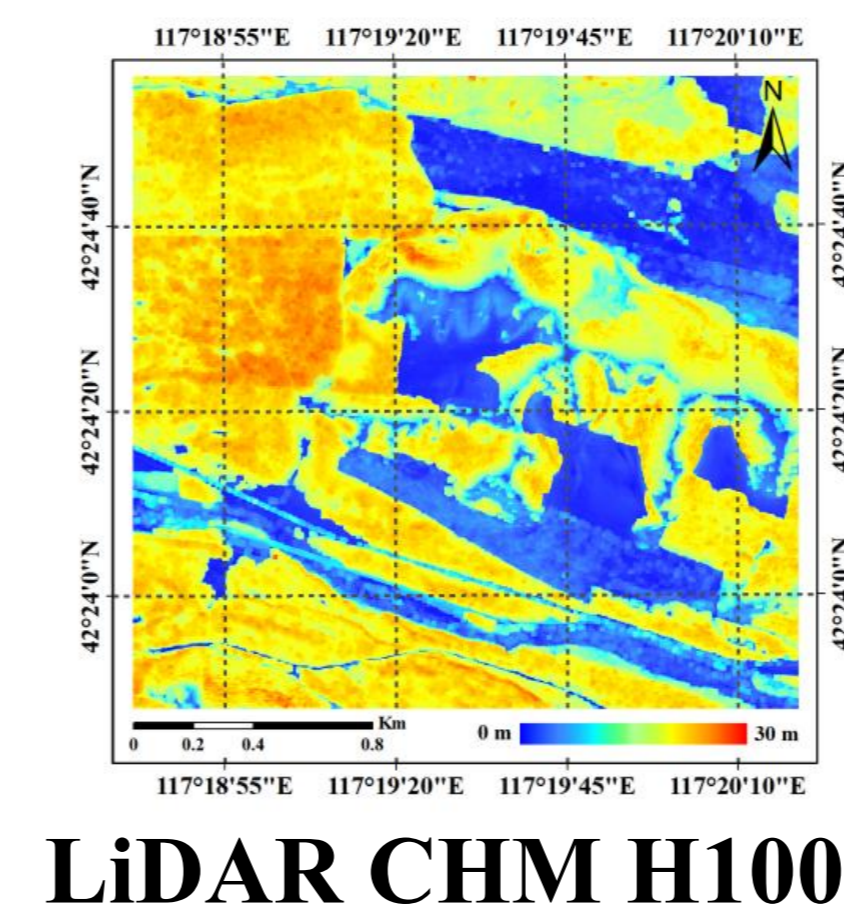
Special case of MLM

$$f(x) = \frac{1}{H} \quad x \in [0, H]$$

Penetration bias Δh :

$$\Delta h = \frac{\pi}{k_z} \left[1 - \frac{2}{\pi} \sin^{-1}(|\gamma|^{0.8}) \right]$$

- The proposed multi-layer model (MLM) emphasizes the gap penetration of the X-band InSAR, which is more in line with the characteristics of forest structure and the scattering mechanism of X-band than the existing model (such as IDUV).



DTM	P-band InSAR DTM based on TF analysis		
DSM	before compensation	compensated by IDUV	compensated by MLM
R ²	0.65	0.83	0.92
RMSE	7.72 m	2.98 m	1.81 m
Acc.	44.43%	78.09%	86.58%

Conclusion

The results showed that the TF analysis method can achieve high-precision P-band DTM extraction. Under the same DTM, the estimation accuracy of forest height based on the X-band DSM compensated by proposed MLM method is 86.58%, which is 8.49% higher than the result using X-band DSM compensated by IDUV method. Accuracy shows the effectiveness of the proposed approach.