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Pioneering demonstration of large-baseline bistatic SAR in China: first experiment with SuperView Neo-2 satellites

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Large-baseline bistatic synthetic aperture radar (BiSAR) employing spatially separated transmitter and receiver platforms enhances target characterization through multi-angle scattering signatures and interferometric capabilities, enabling millimeter-level 3-D surface deformation surveys while providing inherent anti-jamming resilience due to receiver silent operation [1, 2]. This article presents China's first successful large-baseline (41 km) BiSAR experiment using the SuperView Neo-2 (SVN-2) satellites. We demonstrate high-resolution bistatic imaging over Sichuan Province, addressing synchronization challenges without inter-satellite links. Results reveal significant reflectivity variations even at a minimal bistatic angle of 3.4°, highlighting the potential for advanced Earth observation and target classification.

Brief introduction of SVN-2 SAR satellite. The SVN-2 is a commercial high-resolution interferometric mission in China with the main goal of providing a global and 1:25000-scale digital elevation model of the Earth surface by means of single-pass X-band synthetic aperture radar (SAR) interferometry [3]. The system further demonstrates advanced Earth observation capabilities by operating in repeat-pass differential InSAR (DInSAR) mode, enabling millimeter-level deformation monitoring through multi-temporal observations with precise orbital control. The SVN-2 03/04 satellites, developed by Shanghai Institute of Satellite Engineering, were successfully launched on November 25, 2024. In the commission phase, the two satellites of SVN-2 operated in the flight formation with 41-km separation, and the first successful large-baseline BiSAR imaging experiment were carried out.

Overview of bistatic imaging. The bistatic SAR imaging process based on the SVN-2 SAR satellites is introduced in this section.

(1) Bistatic imaging framework. For this 41-km baseline bistatic configuration, the SVN-2(03) satellite operated as a transmitter with a 1.7° squint angle, while the SVN-2(04) satellite functioned as a passive bistatic receiver with a −1.7° squint. This observation geometry yields a squinted monostatic SAR image and a bistatic image with minimal squint distortion. By comparison with traditional bistatic SAR missions (e.g., TerraSAR-X/TanDEM-X and LuTan-1), which operate with baselines typically less than 7 km, with the maximum experimental baseline reaching 20 km in the TanDEM-X mission [1, 4], the 41-km baseline in this experiment introduces unprecedented challenges for synchronization. Here, beam synchronization was achieved through an attitude steering approach. However, there was no phase and time synchronization link between the two satellites during the data acquisition. To solve this problem, the high-stability rubidium clocks are adopted in the satellite designation, thereby enabling the calibration of time and frequency synchronization errors via co-registration shifts between two SAR images. The echoes recorded by both satellites were further processed separately using the Chirp-Scaling algorithm [5].

(2) Experimental results. The first dataset acquisition was conducted on 4 December 2024 over Sichuan Province, China. By utilizing the above processing procedures for synchronization, the frequency synchronization error was approximately 2.16 Hz, while the time synchronization error was approximately 1925 ns. The first bistatic image acquired by SVN-2(03) is shown in Figure 1(a). For better comparison against the monostatic image, Figure 1(b) shows a zoom-in of the Dalongqu River super large bridge area with the monostatic and bistatic images overlaid in red and green, respectively.

In the bridge over the river area, the dominant scattering mechanism for single reflection, directly originating from the bridge road surface, appears to be bistatic. The dual-reflection observed between the bridge and river surfaces is nearly equal in magnitude, while monostatic scattering dom-

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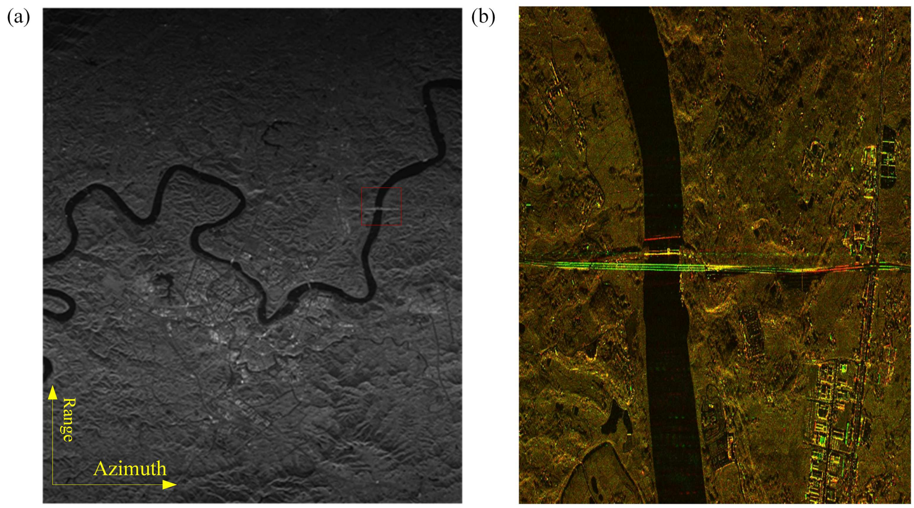

Figure 1 First SVN-2 large-baseline bistatic images. (a) The Guang'an city area in radar coordinates (horizontal azimuth time; vertical bistatic range). (b) Zoom over Dalongqu River super large bridge in Guang'an city ((green) SVN-2(03) bistatic over (red) SVN-2(04) monostatic).

inates higher-order reflections. These observations indicate that target reflectivity undergoes significant changes even at a small bistatic angle of approximately 3.4° during the experiment.

Conclusion. In this work, the first large-baseline bistatic SAR imaging using the SVN-2(03) and SVN-2(04) SAR satellite is introduced. The significant changes in target reflectivity have been observed in the experiment. Based on the current research, future work aims to further explore the identification or classification algorithms using bistatic SAR images.

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