Detection and mitigation of radio frequency interference in ISRO's P-band airborne synthetic aperture radar

Vetal Akshay Pandit*, Prantik Chakraborty, Yogendra Sahu, Pankaj Kanti Nath and Ch. V. Narasimha Rao

Space Applications Centre, Indian Space Research Organisation, Ahmedabad 380 015, India

Radio frequency interference (RFI) significantly degrades the quality of synthetic aperture radar (SAR) signals, particularly in lower-frequency bands. The present study presents an algorithm designed to suppress RFI in P-band SAR (450 MHz) signals, thereby improving image quality. The algorithm for RFI mitigation is not band-specific. The proposed method identifies RFI signatures in the frequency domain by analysing the magnitude of the complex fast Fourier transform (FFT) for each radar pulse. RFI detection relies on statistical analysis of mean and standard deviation within defined spectral regions, flagging anomalies that exceed a dynamic threshold. Mitigation is achieved through the targeted replacement of spectral components for narrowband interference (NBI) and masking for wideband interference (WBI), while strictly preserving phase information. Additionally, a calibrated noise signal, with its own RFI components removed, is coherently subtracted in the FFT domain to enhance the signal-to-noise ratio (SNR). The algorithm was rigorously tested using data collected by the Indian Space Research Organisation's (ISRO) first P-band airborne SAR during flight campaigns near Bengaluru and Hyderabad. Results demonstrate the algorithm's effectiveness in suppressing RFI, leading to a notable 8 dB improvement in noise equivalent sigma zero (NESZ) and significant visual enhancements in SAR imagery.

Keywords: P-band, RFI, SAR, spectrum, standard deviation, threshold.

obscured by dense forest canopies – a capability far exceeding that of higher-frequency synthetic aperture radar (SAR) systems operating in L, S, C and X bands. P-band's long wavelength primarily interacts with the woody parts of trees, like trunks and large branches, rather than leaves. This makes it exceptionally effective for assessing biomass and carbon stock, as it directly measures the structural core of the vegetation. Beyond forestry, P-band's superior penetration is also highly advantageous for applications such as soil moisture mapping, geological surveys and urban infrastructure monitoring, where other sensors face obstructions[1–8].

The Indian Space Research Organisation (ISRO), through its Space Application Centre (SAC) in the microwave remote sensing area (MRSA), has successfully developed a P-band airborne SAR as part of a dedicated technology demonstration project. This radar system operates with a center frequency of 450 MHz and a bandwidth of 50 MHz. Its antenna dimensions are 1.5 m in azimuth and 0.5 m in elevation. The system is designed to achieve a peak transmit power of 100 W with a maximum duty cycle of 5%. Notably, P-band SAR is designed to achieve full polarimetric imaging capability, which is considered the gold standard in SAR technology.

Extensive flight campaigns have been conducted in regions surrounding Bengaluru and Hyderabad, acquiring data over diverse landscapes, including dense forests and urban environments. Figure 1 shows the P-band SAR system mounted within the belly of the airborne platform during these operations.

The broad bandwidth utilised by P-band radar systems to achieve high spatial resolution often results in their operational frequencies overlapping with the