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OMEGA-K ALGORITHM WITH AN IMPROVED STOLT INTERPOLATION STRATEGY FOR SHARAD DATA

Abstract

Accurate subsurface imaging of Mars holds significant scientific and exploratory value. By employing synthetic aperture radar (SAR) imaging technology, it is possible to analyze layered structures precisely, providing critical insights into the geological evolution of Mars, the potential presence of liquid water, and future resource exploration. However, conventional imaging methods assume that the subsurface medium is a simple, homogeneous, single-layer structure. This assumption is inadequate for the complex geological conditions of Mars, often resulting in blurred layer interfaces, reduced imaging accuracy, and limited capability for detailed geological analysis. To address these challenges, this study applies the omega-k algorithm to high-precision imaging of layered deposits in the Martian polar region using the SHARAD (Shallow Radar) data. The proposed algorithm first applies a two-dimensional fast Fourier transform to convert the radar data into the two-dimensional frequency-wavenumber domain, followed by matched filtering and phase compensation. Subsequently, Stolt interpolation is utilized to correct for range migration errors, and finally, an inverse two-dimensional fast Fourier transform is performed to generate the focused radar image. Given the complex stratification, large number of layers, and significant variations in dielectric permittivity in Martian layered deposits, conventional interpolation methods often introduce errors, leading to imaging artifacts and reduced clarity in subsurface structures. To overcome these limitations, this study optimizes the interpolation approach by introducing adaptive correction mechanisms based on variations in layer thickness and electromagnetic wave propagation velocity. This strategy enhances the compensation for range variations across different layers, effectively reducing blurring and artifacts caused by interpolation errors. The results are compared with existing SHARAD products, demonstrating that the proposed algorithm significantly enhances the accuracy of geological structure analysis. In particular, it improves the clarity of layer boundaries and the resolution of interlayer thickness, offering superior imaging performance for Martian subsurface exploration.