REVOLUTION IN GNSS-IR AS A REMOTE SENSING TECHNIQUE FOR MONITORING SURFACE CHANGES

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Global Navigation Satellite System Interferometric Reflectometry (GNSS-IR) is a powerful remote sensing technique that utilizes reflected GNSS signals to analyze environmental and anthropogenic parameters. Traditionally considered an error source in GNSS applications, multipath signals are now harnessed to extract crucial surface properties such as soil moisture, snow depth, water levels, and many other applications. This study introduces a comprehensive review of existing methodologies of GNSS-IR and its applications, discussing its role in environmental monitoring.

The methodology of GNSS-IR involves analyzing the interference patterns generated by the combination of direct and reflected GNSS signals received by ground-based antennas. This approach enables the retrieval of crucial environmental parameters by utilizing the signal-to-noise ratio (SNR) variations observed in GNSS data [1]. Research has demonstrated that extracting multipath effects from these signals provides valuable insights into surface characteristics such as soil moisture [2], water level measurements [3], detecting sea ice [4] and snow depth [5]. By leveraging geodetic GNSS receivers and specialized software tools, researchers can process these signals to estimate reflector height and other geophysical metrics with high precision.

Key applications of GNSS-IR include snow depth monitoring, where geodetic receivers and smartphones demonstrate high accuracy in measuring snow accumulation [6]. The technique is also employed in water level estimation, leveraging signal-to-noise ratio (SNR) oscillations to determine reflector height. Studies validate the effectiveness of GNSS-IR for tide gauge monitoring, achieving centimeter-level precision comparable to traditional in situ methods [7]. Recent advancements in GNSS-IR software tools have expanded its usability, integrating machine learning and cloud computing for real-time environmental monitoring [8]. Despite these advancements, challenges remain in refining GNSS-IR methodologies to account for vegetation interference, terrain variations, and atmospheric effects. Future research should focus on integrating multi-GNSS signals, improving phase center correction models, and developing adaptive algorithms to optimize reflectometry-based remote sensing. The continued expansion of GNSS constellations offers new opportunities to enhance GNSS-IR applications, ensuring its role as a cost-effective and scalable solution for environmental monitoring.

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