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## **Advances in Remote Data Communication from Seismograph Stations: Development and Application of Tools Using 4G Radio Systems**

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## Advances in Remote Data Communication from Seismograph Stations: Development and Application of Tools Using 4G Radio Systems

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Real-time data transmission is essential for efficient seismological monitoring. However, multiple challenges hinder reliable data recovery, including proprietary hardware and software with complex, unstable communication protocols and limited internet connectivity in remote locations. In this context, 4G radio systems emerge as a promising solution for collecting and transmitting data from seismic stations, particularly in hard-to-access areas. This study presents the development of innovative tools to facilitate seismological data communication, highlighting the advantages of 4G technology. We propose a long-distance communication system that demonstrates operational and economic benefits through hardware and software solutions designed for seamless integration with existing seismic monitoring infrastructure. Our results confirm the viability of 4G communication for remote and emergency scenarios, showing significant reductions in operational costs and data transmission complexity.

We selected 4G communication modules adaptable to monitoring station requirements for system development. Concurrently, we developed optimised communication protocols and compression and encryption algorithms to ensure stable, secure, and efficient data transmission. The system was designed for easy deployment across multiple seismic stations without requiring complex instrumental modifications or risking equipment damage. Our solution is compatible with existing infrastructure and features low energy consumption and compact dimensions for flexible installation in constrained spaces. Field testing will validate the system's stability, transmission speed, security, and overall communication reliability under real-world conditions.

This innovation provides a practical and efficient remote seismic activity monitoring solution, significantly improving emergency response times through faster, more reliable communication. By leveraging global 4G coverage and simplified integration with existing infrastructure, our accessible solution serves seismic monitoring stations and supports various scientific and industrial applications in Brazil and abroad. The implementation of 4G radio systems for remote data communication represents a significant advancement in seismology, aiming to enhance operational efficiency and democratise access to seismic monitoring technologies, ultimately contributing to global disaster preparedness.