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Research Infrastructure for Solid Earth Sciences: The Case for International Collaboration

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Solid Earth science seeks to understand the complex chemical and physical processes shaping our planet. This knowledge is essential for addressing key societal challenges, from mitigating natural hazards to managing vital resources. Yet, the scale and nature of the data required for such research—spanning petabytes and crossing geographical, disciplinary, and temporal boundaries—necessitate a global response supported by robust, interoperable Research Infrastructures (RIs).

Research Infrastructures play a central role in enabling this science by providing high-quality, open, and standardized data and services. They foster scientific excellence, promote equitable access to resources, and underpin the collaborative frameworks necessary for large-scale, multidisciplinary research. In the field of solid Earth science, international collaboration among RIs is not just beneficial—it is essential.

Recognizing this, EPOS (Europe), AuScope (Australia), and EarthScope (United States)—the leading solid Earth RIs in their respective regions—have formally committed to working together through a Memorandum of Understanding signed in September 2024. Their collaboration is rooted in shared principles: advancing Open Science; upholding FAIR (Findable, Accessible, Interoperable, Reusable) data practices; and striving toward global equity in scientific research. Recently, this initiative has expanded with the participation of GNS Science, New Zealand's national RI for geoscience, which is in the process of joining the agreement.

The grand vision underpinning this collaboration is the creation of a globally federated research infrastructure—one that interlinks regional platforms into a cohesive, interoperable system. Such a federation would allow scientists worldwide to access and contribute to high-quality, multidisciplinary data and services, accelerating discovery and innovation in solid Earth sciences on a planetary scale.

To realise this vision, these organizations aim to federate and harmonize their platforms, enabling seamless access to multidisciplinary data and services across continents. This vision demands coordinated action to align technical standards, protocols, and vocabularies, and to overcome significant barriers—legal, political, economic, and infrastructural.

Key challenges include:

Interoperability: Aligning technical frameworks and data standards across regions to enable seamless data sharing and integration. A key challenge lies in the varying levels of maturity across geoscience subdomains when it comes to data and metadata standards. While some scientific communities, such as seismology and geodesy, have a strong tradition of global collaboration and well-established protocols, others remain fragmented and operate with divergent standards or limited interoperability. This heterogeneous landscape complicates the integration of multidisciplinary datasets, which is essential for addressing complex solid Earth processes. Overcoming this hurdle requires fostering cross-domain dialogues, supporting the development and adoption of shared standards, and creating incentives for communities to converge around interoperable solutions that respect disciplinary specificities.

Legal and regulatory hurdles: Navigating diverse national policies governing data access and cross-border collaboration. While the European Union benefits from a common regulatory framework that generally facilitates alignment across member states, many other regions lack such harmonization. This disparity can hinder international cooperation and the free exchange of scientific data. Bridging this gap will require multilateral dialogues to develop shared legal principles, the adoption of interoperable data governance frameworks, and capacity-building efforts to support regions'more fragmented regulatory systems. International organizations and policy fora can play a vital role in fostering convergence while respecting national sovereignty and data rights.

Sustainability: While long-term funding remains a cornerstone, it represents only one facet of the broader sustainability challenge. Equally critical are open and accessible technical infrastructure, high-performance computing, data storage, and robust connectivity—resources still lacking in many regions. Disparities in expertise and limited training opportunities further constrain participation and innovation.

. Ensuring sustainability therefore demands a holistic approach that couples investment in digital infrastruc-

tures with the widespread development of skills and knowledge through inclusive education and training programs, workforce mobility and capacity building.
An integral part of the sustainability effort is also long-term data preservation—particularly for geospatial data, whose volume and multidimensionality pose significant challenges. Ensuring the longevity and usability of such data demands coordinated strategies that optimise storage, adapt to evolving formats, and support reproducibility and future reuse.

Inclusivity and equity: Promoting research autonomy in lower-resourced regions and avoiding scientific dominance by wealthier nations. This includes upholding the CARE (Collective benefit, Authority to control, Responsibility, and Ethics) principles, particularly in relation to Indigenous data governance. Research Infrastructures must recognize and support the rights, knowledge systems, and agency of Indigenous People by integrating Indigenous knowledge respectfully, ensuring community-led data stewardship, and enabling meaningful participation in research and infrastructure development.
Addressing these challenges requires not only scientific and technical coordination but also sustained policy support at national and international levels. Governments have a critical role to play in fostering an enabling environment for global scientific collaboration. This includes aligning national research infrastructure roadmaps, simplifying regulatory frameworks, supporting staff development and mobility, and committing to long-term investment in globally shared infrastructure.
Global RIs contribute directly to international policy goals, including the United Nations Sustainable Development Goals, by delivering the knowledge and capacity needed to sustain a resilient, habitable planet. Their role in supporting global scientific diplomacy and cooperation is vital in an era of growing geopolitical complexity and environmental urgency.
The partnership among EPOS, AuScope, EarthScope, and GNS-NZ exemplifies a growing global movement to build coordinated, inclusive, and impactful research infrastructures and underlines the need for policymakers to support global scientific collaboration not as a luxury but as a necessity to confront humanity's grand challenges.

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