



## COMMENTARY

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### Special Section:

The Power of Many: Opportunities and Challenges of Integrated, Coordinated, Open, and Networked (ICON) Science to Advance Geosciences

### Key Points:

- We address challenges and opportunities to advance equity in GeoHealth using the ICON (integrated, coordinated, open science, networked) framework
- There is a need to develop, improve, and scale coordinated and networked efforts that address collaboration and open science
- Scaling ICON in GeoHealth includes intentional actions that shift power and follow community expertise to drive equity in science

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## GeoHealth Perspectives on Integrated, Coordinated, Open, Networked (ICON) Science

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**Abstract** GeoHealth research both characterizes and predicts problems at the nexus of earth and human systems like climate change, pollution, and natural hazards. While GeoHealth excels in the area of integrated science, there is a need to improve coordinated and networked efforts to produce open science to enable environmental justice. There is a need to resource and empower frontline populations that are disproportionately marginalized by environmental injustice (i.e., the unequal protection from environmental harms and lack of access and meaningful engagement in decision making for a healthy environment; EPA, 2022, <https://www.epa.gov/environmentaljustice>). GeoHealth practice has the opportunity to advance environmental justice or the “fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income” with respect to how research and collaboration of GeoHealth professionals supports the “development, implementation, and enforcement of environmental laws, regulations, and policies” that produce equal protection from environmental and health hazards and access to the decision making for a health environment (EPA, 2022, <https://www.epa.gov/environmentaljustice>). Here we highlight barriers and opportunities to apply an equity-centered ICON framework to the field of GeoHealth to advance environmental justice and health equity.

**Plain Language Summary** Technical, structural, and cultural hurdles are roadblocks towards advancement of open science by design in the field of GeoHealth. To shift the GeoHealth paradigm, we present a commentary about the strengths, limitations, and provide recommendations for centering equity in the development and implementation of ICON in GeoHealth.

## 1. Introduction

Integrated, Coordinated, Open, Networked (ICON) + Findable, Accessible, Interoperable, and Reusable (FAIR), science aims to enhance synthesis, increase resource efficiency, and create transferable knowledge (Goldman et al., 2021). Equitable and just implementation of ICON-FAIR follows Collective Benefit, Authority to Control, Responsibility, and Ethics (CARE) principles that respect and follow Indigenous data sovereignty and data governance (Carroll et al., 2020). This article belongs to a collection of commentaries (Goldman et al., 2021) spanning geoscience on the state and future of ICON science.

GeoHealth is an emerging research field that strives to build an integrated earth-human systems understanding that is necessary to characterize, quantify, and predict and prevent health challenges (Almada et al., 2017). Human disruption, especially settler colonization of Earth's natural systems, causes and amplifies health inequities (Whyte, 2018). The abuse of power and profit for few drives inequities felt through extreme events, food and water insecurity, and infectious disease at neighborhood to international scales (Ebi & Hess, 2020). When GeoHealth research is centered on equity, it produces the intersectional research, education, and capacity building and policy engagement needed to produce health equity. Designs for health equity must engage collaboration across human diversity, spatial scales, disciplines, and expertise.

Here, we convey how the approaches of ICON practices and equity principles may be centered and applied together to advance equity in GeoHealth (Figure 1). Race Forward, a national organization that helps institutions

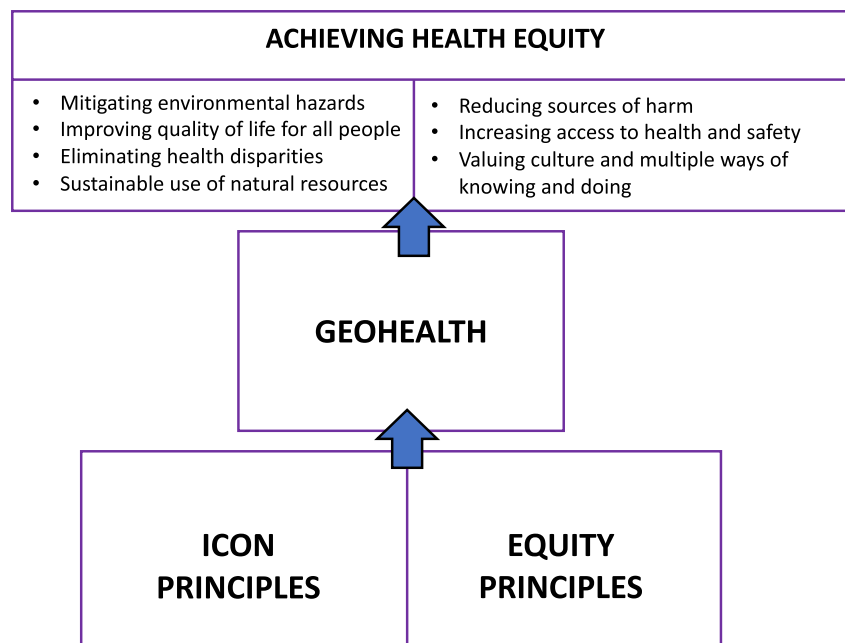
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take actions toward racial equity defines equity as both an outcome and process. Everyone should have what they need to thrive and those most impacted by inequities must be “meaningfully involved in the creation and implementation of policies and practices” (Race Forward, 2021). In GeoHealth, this means centering and resourcing the priorities and leadership of those marginalized by harm at the nexus of the earth-human system. This results in health equity outcomes such as mitigating hazards, improving quality of life, eliminating disparities, sustainable resources, reducing sources of harm, increasing access to health and safety, and valuing culture and multiple ways of knowing and doing. Our model draws from the EPA definition of environmental justice, Jemez Principles of Self Organizing, and consideration of GeoHealth inequities (EPA, 2022; SNEEJ, 1996).

## 2. ICON in GeoHealth

### 2.1. Equitable Practices Enhance ICON in GeoHealth

The integration of health data, environmental data, demographic, and social data is embedded into GeoHealth research and practice. However, community decision making based on data integration – such as reducing urban heat islands, mitigating flooding, and improving air quality with green landscapes must be planned with consideration of how they design factors impact other socioeconomic conditions like gentrification to ensure they are reducing and not producing harm (Eckerd, 2011). Integrated science must span social and environmental systems. Coordination of methods and protocols across geopolitical boundaries at all scales advances our real time and predictive understanding of environmental pollution and injustice. Recent work modeling spatial reductions in emissions (e.g., NOx) associated with lockdowns during COVID-19 using international data, highlights the value of coordinating science for more pollutants at the right resolution for scales of action (Sun, 2020). Politics, resource inequities, cost efficiency, funding, data sharing infrastructure, privacy concerns, and even data validity hinder coordination and Open Science (Bakker & Ritts, 2018; Beniston et al., 2012). In order to increase the openness of GeoHealth research, research articles and findings should be translated and communicated to the public through both traditional and social media outlets (Dwivedi et al., 2022) and we especially need participatory engagement for reciprocal literacy (Hayhow et al., 2021). Networking between communities, organizations, and decision makers is also critically important to employ. Collaboration across different expertise and centering frontline community leadership improves predictive and problem-solving capabilities and confronts systemic factors like structural racism, colonialism, capitalism, rural isolation, and political polarization that set up and sustain health inequities. There is a need to move toward community collaboration and employ strategies such as activist-scholar, scholar-activist models that foster community relationships (Reynolds et al., 2020).



**Figure 1.** The ongoing application of ICON practices and equity principles to GeoHealth leads to achieving health equity.

## 2.2. Promising Examples of Applying ICON to Advance Equity

At all scales there are exciting examples of collaboration between scientists, community members, community organizations, and decision makers, which demonstrated the potential of ICON principles and practices to support more inclusive and intentional work for equitable and just solutions. Many successful efforts for open science are led and organized by frontline and NGO leadership. For example, Freshwater Future and Earth Economics created and expanded use of the Stormwater Tracking App to empower residents to map stormwater challenges (e.g., upload images of flooding and puddles in their community to inform planning) through coordination. Their study engaged North Detroit residents and will expand to empower marginalized communities and protect the Great Lakes. During the COVID-19 pandemic, the team also adapted the app to identify and support families living without water in cities like Chicago, Detroit, Toledo, Flint, and Benton Harbor. This is an example of equity driving science for health. The National Academies have published additional examples and models in their reports on open data and citizen science (NAS, 2018a, 2018b).

Government agencies, organizations also offer exciting models for ICON across the scientist-community boundary. The European Commission within the EU Science Hub provides a community-science database developed by or with support from the European Commission. Tools are easily accessible and include a summary of each app or web-based tool. In the United States, there is a similar database found in CitizenScience.gov, where federal crowdsourced and citizen science projects are listed, including their status, project summary, and link to the project webpage. Both databases are user friendly, both in finding data and projects to become involved. Similarly, the EPA's How's My Waterway (HMW) website, provides integrated water data from eight databases within the EPA building networking with community stakeholders to address questions about how communities use and enjoy their waterways. HMW allows users to find information about drinking water, stream conditions, and whether water systems of interest are suitable for fish consumption. Using HMW, the Choctaw Nation monitors surface water in southeast Oklahoma and submits their data for open use and public reporting by the state. The honoring of Indigenous data sovereignty demonstrated here builds relationships needed for trust (Larson et al., 2021). Similar to the aforementioned examples, The World Health Organization's Urban Health Initiative (UHI) actively supports community building needed for improving health engaging frontline urban leaders in mapping the current decision landscape, then applying environmental and economic tools to their place to educate, mobilize, and sustain efforts to advance change (WHOI, 2021).

Professional societies, nonprofits, and academic centers also support the capacity for science in and with communities or with policy makers, are also important to directing the energy and resources of scientists to the advancement of equity. AGU supports capacity building through the Thriving Earth Exchange which connects community leaders and planners to scientists who help them monitor and evaluate environmental conditions important to community planning. Likewise, Scholars Strategy Network and the Union of Concerned Scientists help scientists find pathways for taking decision relevant science into policy and planning spheres. Similarly, the Environmental Justice Branch of the NAACP coordinates across regions to provide resources and science education to leaders of community environmental justice efforts. Collaboration across organizational and cultural boundaries co-creates knowledge and is needed for positive change and scale-up efforts. Working with NOAA, climate scientists and communities impacted by extreme heat and urban flooding, Groundwork USA launched the Climate Safe Neighborhoods Partnership (CSN). By digitizing and combining historical redlining maps, heat-island locations, and flood vulnerability data, Groundwork Trusts and its partners created shared language for understanding challenges and help move forward equitable policy solutions in the Richmond 300 Master Planning Process, RVA Green 2050 Sustainability Plan, and a Climate Equity Index (White-Newsome & Slay, 2022).

## 2.3. Recommendations

The advancement of health equity and environmental justice through the practices of GeoHealth calls not only for improving monitoring and forecasting challenges, but intentionally designing education and network building into professional work. We recommend strengthening community education informed by frontline priorities, providing opportunities to K-16 students and early career scientists to build skills and support for scientists and marginalized communities as part of their education and research mentoring (e.g., Fortner et al., 2021). We also recommend expanding research on the professional development and program designs that develop, improve, and scale collaboration that produces equitable outcomes. Efforts like those of Groundwork USA highlight the value and need to follow the leadership of frontline communities to form science-action partnerships between

community organizations, agencies, and academics. Scaling-up means active work to shift the value systems and resource distribution in higher education, agencies and organizations as ICON approaches are developed and applied. This includes exploring the outcomes of different levels of sharing and collaboration between scientists and community to enable change. Internationally, there is a need to hold high income countries accountable for network building, monitoring, prediction and solutions technology transfer to under-resourced countries. As noted by Suk et al. (2016), the international development agenda has motivated commitments and accountability for resources to combat infectious disease, but no such model exists for environmental health as has been done for infectious diseases like HIV/AIDS, malaria, and TB.

GeoHealth hazards like flooding, air pollution, and extreme heat are widely studied, so international agreements should establish and maintain open data protocols, such as on <https://www.protocols.io/> to increase opportunities for integrated and coordinated efforts. Furthermore, issues like climate change, hazards, and environmental pollution are often tied to who holds political or organizational power, yet impacts are felt most, not by the biggest emitters, but by those least able to respond to increasing floods, heat, infectious disease and more (Ebi and Hess, 2020). Therefore, ICON strategies must be designed for scientific understanding and shifting power, policies, practice across scales and scientist, community, and decision maker boundaries. As we work toward equitable collaboration, there are opportunities to get started or to improve. Informed by the above, we recommend people and organizations begin this journey by first reflecting on key questions as they plan and execute science:

1. What opportunities are there for you to develop a more **integrated** understanding of the GeoHealth issues and implications.
2. How will you **coordinate** methods and approaches to advance equity? How will you coordinate across the science-community boundary?
3. How will you build or strengthen **networks** and community participation that support communities most marginalized by GeoHealth Inequities?
4. How will you contribute to equitable **open science** by thinking intentionally about who decides what it is, who contributes it, and how it is made available (FAIR)?
5. How will you advocate, educate, and build community capacity to advance environmental equity and justice?

### Conflict of Interest

The authors declare no conflicts of interest relevant to this study.

### Data Availability Statement

Our commentary contains no original data.

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