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Editorial: Innovations in climate resilience

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Editorial on the Research Topic
Innovations in climate resilience

Introduction

At Battelle's second Annual Innovations in Climate Resilience Conference, we were inspired this year by the phrase "Bold Leaps and Action." Climate resilience is a goal and a field that requires boldness. Achieving a state in which societies, countries, continents, and even the globe is robust to changes in climate is often met with doubt, speculation, and indifference. Boldness is required to overcome the gap between an individual's personal experience and the sheer scale of climate interactions that span from microbes to planets and from nanoseconds to millennia. Moreover, individual scientists, government leaders, and industrialists might each make a small impact and never directly see a measurable effect in Earth's climate resilience. Is the scientific work in this area futile? Are we as a community on the right path or are we on the right track? Or are we collectively leveraging our potential and contributions toward scalable and more impactful climate resilience solutions that create compounding effects for cities, regions, countries?

That leads us to the second part of the phrase that inspired us. It is not just bold leaps but it is action too. The scientific community must put into effect the discoveries that come along with our work in climate resilience. This includes the processes or activities that translate foundational science into real products that society can use. Never before in the history of this country have we had such a commitment to the Research Topic of climate resilience. The White House has made it a major part of their platform. Congress has appropriated and authorized billions of dollars in support. The part we need next is real action. Through our efforts we can discover the interconnected scientific breakthroughs at many spatial scales from city/regional/state to global that were not possible without those government programs.

Summary of papers

Many state and local agencies want to take action by developing site-level resilience plans. Rabinowitz et al. point out that these organizations need location-specific climate projections to effectively assess their gaps and develop response plans. The authors found that local-level scenario planning and decision scaling insufficiently address the range of uncertainties in climate risk. They assert that decision frameworks that are technically robust, replicable, and include high-impact, low frequency (HILF) hazards are needed. The Department of Energy's (DOE) Vulnerability Assessment and Resilience Plan and the Federal Energy Management Program's (FEMP) Technical Resilience Navigator (TRN) tools each enable resilience planning, but require high resolution, site-specific climate data. In their paper, "Availability of state-level climate change projection resources for use in site-level risk assessment", Rabinowitz et al. provide a status of state-level resources. Thirty-five states and DC have state-level resources; 32 of those from high-resolution previously downscaled data from existing sources or modeling. Twenty-nine states host mesonets that collect weather data. They found that the type of information in the state-level climate projection resources was strongly driven by the stakeholders. Stakeholders from the emergency management community are critical for including HILF events; those from the agricultural community add precipitation and soil effects. Local organizations looking to complete site-level resilience planning will find this paper is a useful resource.

At the federal level, tools are needed to quantify the impact of potentially bolder moves to address climate change. Solar geoengineering, such as by stratospheric aerosol injection (SAI), has been proposed as an intervention that could rapidly reverse temperature and precipitation changes. However, it comes with large risks including technical, societal, regulatory, and geopolitical. The National Academy of Sciences, Engineering, and Medicine cautions that we must better understand SAI before we can make policy decisions. Wheeler et al. describe the efficacy of a tool developed for an equally challenging space, development of repository for radioactive waste disposal that must function thousands of years in the future. In their paper, "Performance assessment for climate intervention (PACI): preliminary application to a stratospheric aerosol injection scenario," they modify and apply the Performance Assessment (PA) from nuclear waste to climate change. They used the Geoengineering Large Ensemble (GLENS) scenario, which were simulated using the Whole Atmospheric Community Climate Model (WACCM). The inputs to the framework are the performance goals, e.g., specific monthly temperature, precipitation, drought index, soil water, solar flux, and surface run-off; the extent of the system; and the features, events, and processes (FEPs) relevant to calculating model output. The authors found that PACI provides a mechanism to compare how an SAI intervention relates to the stated goals *versus* how an alternative emissions pathway. This tool may be a useful starting point for informing decisions, though the authors propose that further work is needed to assess model credibility and extensive simulations to determine parametric uncertainty. We find it encouraging that other industries can empower action in climate change solutions.

To meet our climate resilience objectives, we will need a portfolio of advanced technologies and novel materials. In the paper Elmegreen et al., the authors describe a new toolkit for screening and simulating materials. They apply it to materials to improve capturing carbon and battery performance, including carbon capture amines and solid sorbents, and electrolytes for long-lasting batteries. Their method illustrates the use of artificial intelligence and advanced computing to rapidly screen for potential high-performance materials and prioritize their investigation in the laboratory. Such tools as described have the potential to accelerate discoveries and more rapidly enable competitiveness in the marketplace of new energy technologies.

Many of the advanced materials found through screening toolkits include more exotic metals and minerals, such as rare earth elements. When a technology reaches commercial scale, the extraction and use of raw and processed materials for mass manufacturing becomes a key feature in climate resilience. Mined materials are often concentrated in resource rich countries that may not have sufficient governance to avoid potential negative impact of their extraction. Gibson describes the challenges and potential benefits for the Democratic Republic of the Congo (DRC), a key country in the supply chain for the batteries and electronics essential to technologies for climate resilience. This mini-review of key literature makes the case for increased partnership and investment by the United States in the DRC to increase transparency and monitoring for environmental impact and worker safety. Strategic partnership for research in materials recovery, refinement, and providence tracking represent the first steps towards a more just global energy transition.

Climate change is known to disproportionally affect the most vulnerable populations. As resources are deployed in technology research, development, and deployment, it is essential that those resources are deployed in a way such that all populations can receive the benefits. While it is fairly straightforward to assess which populations receive the benefits of deployment investments, assessing the impacts of R&D before deployment is harder. And the earlier the stage of the research, the more difficult that assessment becomes. In their paper, Arkhurst et al. present the JUST-R metrics framework they developed to evaluate energy justice metrics in early stage (technology readiness level 1–3) science and technology research. This new framework provides an assessment method that could very well alter the way scientists and engineers approach basic science and technology research to ensure the energy transition is equitably rolled out.

Conclusion

Through these papers and the presentations at the conference, it is clear that we need a whole of society approach to continue advancing innovations in climate resilience. We are making progress translating climate science into plans, processes, and operations across many different dimensions of human security (i.e., energy, water, food, infrastructure, and health). However, to continue making bold leaps that translate into actions in climate resilience we must continue to gather multidisciplinary teams and public private partnerships to assess what the future climate holds (i.e., downscaled climate modeling), what intervention pathways are sustainable, and what technologies we must continue to create to enhance our global resilience. Accelerating discoveries in this complex, interconnected human-earth system requires leadership to promote a systems level of thinking. As the rate of climate change accelerates, those changes intensify the complexities of our interconnected human-earth systems and require our scientists, engineers, planners, and policymakers to adapt to a systems level of thinking.

Systems thinking refers to the practice of viewing policies, bodies, or decisions as part of a larger system of interrelated parts, rather than as individual concepts independent of other factors. Our bold action is employment of systems thinking to enable our society to view and understand how physical changes manifest as societal responses that go beyond the immediate needs (i.e., after a natural disaster). We must understand the interconnectedness of various elements such as geography, infrastructure, and socio-economic factors and how each contribute to our global resilience now and under future climate conditions.

Our bold action is to facilitate greater collaboration among diverse government, academic, and industry stakeholders to ensure a more holistic approach to prioritize resource utilization and translate innovations in climate resilience into actions. Through this action we will help translate immediate actions (i.e., in the wake of a natural disaster) to long-term recovery plans to naturally shifting the focus from tactical responses to rebuilding infrastructure and enhancing community resilience.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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