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Unraveling the Climate Vulnerability Web: Integration of Physical, Biological, Social, and Economic Models in Time and Space

Big Idea. We recommend a community-focused research effort to develop and integrate high resolution models of climate, social, ecological, and economic systems to identify vulnerabilities in human and ecological systems — and use that information to manage and reduce climate risks and increase resiliency. The effort will be carried out by teams who work in concert with community stakeholders, so decision makers and stakeholders can develop recommendations and policies to adapt to and mitigate climate change vulnerabilities in their affected communities.

Reasoning and Justification. Today, communities worldwide are struggling with the complex interaction of environmental threats, economic development, and societal inequity. These threats also impact the ecosystems on which these communities rely. Both human and ecological communities face interconnected risks that necessitate the use of data collection and an approach that can assess these impacts through a holistic lens. Existing integrated models are at a coarse scale, and frequently neglect important aspects of social and natural systems—such as social and ecological feedback and ecosystem responses—in the model development and analysis in favor of focusing on aggregated economic outcomes. NSF is uniquely positioned to bring together interdisciplinary teams due to its broad funding scope. Further, NSF has a successful history of programs that transcend the standard funding mechanisms of PI-driven funding, with the GLOBEC program a particular example. This type of funding structure is uniquely possible at NSF and is needed to leverage the expertise of STEM and social science researchers and community stakeholders. When these diverse teams co-produce the research questions, analysis and output, they will build the foundations of a new transdisciplinary approach to identify climate risks and mitigate vulnerabilities.

Requirements. Expertise from multiple mathematical sub-disciplines (dynamical systems, numerical analysis, simulation, machine learning, statistics, uncertainty quantification), and other STEM (computer science, environmental science and ecology, atmospheric, land, sea ice and ocean science, agricultural science) and social science disciplines (economics, behavioral science, and political science) is required, as well as input from stakeholders (local and regional government officials, community educators, policymakers, NGOs, and entities in the private sector). Typical funding structures break grants up, passing the pieces on to individual teams that pursue parts of the project and will not lead to the required interconnections among the different teams. This will inhibit the kind of integrated multi-disciplinarity required for the projects recommended. We recommend the development of an innovative and appropriate funding and governance mechanism for the overall research effort.

Value and Impact. In closing the distance between models and metrics for vulnerability assessment, we form a (far more) complete picture of attribution pathways from computational and mathematical modeling decisions, ecosystem services, social vulnerabilities, and human consequences. From this, comprehensive quantified uncertainty in forecasts (that can be attributed to processes covered by modeling) may be captured. Knowledge of uncertainty can lead to targeting resources to key aspects of model development, and targeted data acquisition, which leads to quantifiable uncertainty reduction for assessments. Such developments build greater scientific understanding on climate change vulnerability.

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