Co-developing Visualizations for Dialogue, Deliberation, and Decision

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Co-development of coastal hazard visualizations can make complex ideas accessible to anyone and enable dialogue, deliberation, and decision. Coastlines' ecosystems and communities are rich, spatially and temporally dynamic, heterogeneous systems that are not only complex to study, but complex to discuss. While new models and high resolution data will allow researchers to better understand these systems and to explore scenarios for perturbation, catastrophe, and intervention, they do not automatically translate into local or well-timed discussions and actions. Our recommendation is for the NSF CoPe Hubs to promote research focused on creation and use of hazard visualizations that support early involvement with stakeholders in the synthesis of data and systems analysis to enable decisions that promote resilience.

Evidence suggests that visualizations can orient community stakeholders around complex hazards by helping them identify and relate to local, contextualized issues, rather than around general fears (Lane et al. 2011). Furthermore, the use of visualizations can draw out and capture local knowledge from community observations to identify what people value and care about (Luke et al. 2018). This allows for specific discussions of information needs and impacts, allowing for broader participation through an iterative process that makes visualizations relevant and accessible, and enables informed decision making.

Visualizations challenge researchers to simplify complexity and communicate concepts and potential impacts into locally meaningful scales. However, the science behind the process of creating and using visualizations for different datasets and applications requires further development. In particular, within the built environment, where the impacts of coastal hazards are concentrated, visualization demands access to high resolution datasets and presents opportunities for innovative modeling to link natural and built environments. Furthermore, the process to meaningfully engage stakeholders in the co-development of visualizations requires additional study to identify and disseminate generalizable practices that are cost-effective to implement. There are, however, several prototype frameworks for integrating local knowledge

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and developing visualization platforms to inform decisions that promote resilience to extreme events. These have mainly been tested in Europe in the context of flooding (Steinfuhrer et al. 2008, Pasche et al. 2009, Dawson et al. 2011, Meyer et al. 2011, Evers et al. 2014), but there has also been work in North America addressing flooding and erosion (Luke et al. 2018).

These early efforts demonstrate that the co-development of visualizations can serve as a means to answer important research questions and uncover new ones while taking practical steps within communities to build resilience. Example research questions include:

- What are the best paradigms for integrating data and models to communicate hazards within urban spaces?
- How can we capture and simplify system dynamics to meet end user needs for understanding and decision-making?
- How can we use visualizations to align interests and prioritize decisions?
- What is the most effective process of iterating between researchers and stakeholders to co-develop useful visualizations?
- How can the process of co-development best support each phase of the disaster management cycle including preparedness, planning, mitigation, early warning, emergency response and recovery?

One powerful aspect of our recommendation is that it can broaden participation through several mechanisms. First, it creates many opportunities for meaningful engagement through iteration (Dilling and Lemos 2011). It provides a flexible and inclusive process for user experience, interaction and iteration to foster accessibility and use of scientific data in decisions for coastal resiliency. Secondly, the lessons learned while identifying effective visualizations and their utilization can lead to best practices. These best practices can be applied to accelerate the impact and integration of CoPe and other NSF Hubs activities and research initiatives. The process and visualizations can be applicable to multiple systems (built/natural/human systems) and adapted to multiple hazards. Furthermore, best practices can help create intuitive platforms for education and outreach.

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