GUEST EDITORS' INTRODUCTION

Visualization of Climate Change

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The *Oxford Dictionary* defines climate as *the weather conditions prevailing in an area in general or over a long period.* In that frame of reference, *climate change* can ring non-sensical or invasive. As a species we have begun to master the prediction of weather, facilitated by more and more environmental sensors that provide inputs to mathematical models, and provide outputs useful for ground-truth data with which to evaluate prediction accuracy. As existing sensors continue to function, and new sensors are deployed, visualization shows promise in helping make sense of the onslaught of data sensors avail.

Sensors are deployed from the seafloor to orbiting satellites, monitoring land, air, and sea from icy to hot and dry locations. Many of the sensors we use to predict weather are also useful for understanding climate. The atmospheric understanding that helps inform weather models provides perspective on climate. The Coupled Model Intercomparison Project (CMIP), currently in iteration six, has expanded to include forty-six modeling groups that share coupled modeling components and develop improvements within individual models associated with other components that drive climate.

As scientific and data visualization professionals, we hypothesize that graphics and other outputs from a visualization pipeline should facilitate insight, verification, and communication within and between teams. We wonder how visualization might help us with understanding all the relevant phenomena that contribute to climate anywhere on Earth. Many scientific papers inform us as to where the CMIP community thinks resources need to be deployed and modelers need to model. The conclusions from many of those papers convince us that the iterations on the coupling process are driving climate prediction services along the trajectory of the weather modeling trajectory of many years ago. Our instincts suggest not enough visualization professionals are choosing climate domain in which to apply their skills and tools. We asked to coordinate a CG&A special issue on climate change in order to investigate our instincts and expand our insight on current climate-related visualization work. We surveyed sixty-two seasoned, published, climate modeling experts working on at least one of the CMIP teams, and had eight respondents.

According to that limited sample size, the mean percentage of time that respondents consider visualization-related within their CMIP team effort is 11.375% (ranging from 3 to 20%), but not a single respondent includes visualization as a distinct line item in their team work time budgets (some do for related outsourced publication). Various Python libraries dominate the list of technologies they use for model inputs visualization, investigating running models, and modeling output visualization. None of the respondents suggested uses of visualization that surprised us beyond our expectations. Most suggested the tried and true data visualization methods used for decades in collaboration continue to meet the necessary functional needs of the CMIP enterprise, and how geospatial awareness via a globe or map mattered most. We appreciated reading those who suggested visualization lets them see something unexpected when visualizing results from a statistical model.

We received only four submissions to our special issues papers call, the deadline for which came during a global pandemic. Through the formal

IEEE *Computer Graphics and Applications* review process of the four submissions, work identified in two of the papers had neither advanced enough, nor demonstrated a clear enough connection to computer graphics and applications, to warrant publication. We appreciate their efforts for the advancement of climate issues awareness and communications and hope their hypotheses regarding human collaboration test true. Both of the papers we accepted consider climate-related communications, but include visualization tools and methods we think you will find engaging as you think through the significance climate may have on your life.

In "Dynamic 3D Visualization of Climate Model Development and Results," Walton and coauthors describe how visualization improves their CMIP6 modeling process, share the tools and methods they use, and provide examples of communicating with broader audiences through images. We appreciate the well-written introduction to CMIP6 Climate Experiments that motivates the work as well as the clear case study of applying methods to a domain that readers from other domains may find useful.

In "Mapping the Hazard: Visual Analysis of Flood Impact on Urban Mobility", Kuang-Ting Huang shares his approach to visualizing flood scenarios that climate change models suggest are likely to become more common in the years ahead. His metrics resonate with thoughts on built infrastructure, urban mobility planning, and resilience design while connecting to the greater climate modeling community when considering his methods in conjunction with scenarios RCP 4.5, RCP 8.5, given in the IPCC report.

We wish to thank Pak Chung Wong and Torsten Möller for their guidance in producing this special issue. We owe thanks to the department editors, particularly Francesca Samsel and Theresa-Marie Rhymes who pursued related content in parallel with our call. We wish to thank the authors and reviewers for their hard work in helping us learn through our guest editor role. Without all their work, there would have been no Special Issue, which we hope you will find useful as pleasurable reading through which you learn more about climate-related visualization while considering the theme of potential climate change ramifications to any or all bounds of our shared biota.

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NICK HEDLEY is the founding director of the Spatial Interface Research Lab at Simon Fraser University (SFU), Burnaby, BC, Canada, and an Assistant Professor in the Department of Geography, also at SFU. He received his PhD in Geography from the University of Washington. Nick has been researching geovisualization interfaces, virtual environments and mixed reality for 15 years. He works in the areas of 3D interface technology design, empirical human interface evaluation, and how humans engage information and each other through these technologies.

CHRIS WEAVER is an associate professor in the School of Computer Science, University of Oklahoma, Norman, OK, USA. Dr. Weaver was a research associate at the GeoVISTA Center in the Department of Geography at Penn State University, where he was also a founding member of the North-East Visualization and Analytics Center (NEVAC), one of the first academic centers for the study of the new field of visual analytics. While there, he led the development of numerous visual analysis tools that culminated in both a first place in the InfoVis 2007 Contest and two awards in the VAST 2008 Challenge. Dr. Weaver's research focuses on developing interactive techniques and systems that integrate methods from information visualization, human- computer interaction, databases, and data mining to support visual exploration and analysis of complex geospatial, temporal, and social information. He received his PhD in Computer Science from the University of Wisconsin, Madison, WI, USA, in 2006.