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Cutting-Edge Statistical Approaches, Resources Yield New Insight into Detecting, Attributing, Projecting Future Climate Change

Special Issue of CHANCE explores complexities of global climate change models that prove existence of climate change, project future events and impact on mortality, economy

ALEXANDRIA, Va. (December 21, 2017) – Projecting the future of extreme weather events and their impact on human life, the environment and vulnerable ecosystems locally and across the globe remains a complex task in climate research—and one in which statisticians are increasingly playing key roles, particularly through the development of new models. The December issue of *CHANCE* examines complexities of intense, massive data collection and statistical analysis techniques in climate research and features new proposed statistical methodology that could be a "game changer" in understanding our climate system and in the attribution of extreme climatic events.

Changes in events related to atmospheric circulation, such as storms, cannot be characterized robustly due to their underlying chaotic nature. In contrast, changes in thermodynamic state variables, such as global temperature, can be relatively well characterized. "Rather than trying to assess the probability of an extreme event occurring, a group of researchers suggest viewing the event as a given and assessing to which degree changes in the thermodynamic state (which we know has been influenced by climate change) altered the severity of the impact of the event," notes Dorit Hammerling, section leader for statistics and data science at the Institute for Mathematics Applied to Geosciences, National Center for Atmospheric Research.

Climate models are complex numerical models based on physics that amount to hundreds of thousands, if not millions, of lines of computer code to model the Earth's past, present and future. Statisticians can analyze these climate models along with direct observations to learn about the Earth's climate.

"This new way of viewing the problem could be a game changer in the attribution of extreme events by providing a framework to quantify the portion of the damage that can be attributed to climate change—even for events that themselves cannot be directly attributed to climate change using traditional methods," continues Hammerling.

Another promising approach involves combining physics, statistical modeling and computing to derive sound projections for the future of ice sheets. Considering that the Greenland and Antarctic ice sheets span more than 1.7 million and 14 million square kilometers, respectively, while containing 90% of the world's freshwater ice supply, melting of ice shelves could be catastrophic for low-lying coastal areas.

Murali Haran, a professor in the department of statistics at Penn State University; Won Chang, an assistant professor in the department of mathematical sciences at the University of Cincinnati; Klaus Keller, a professor in the department of geosciences and director of sustainable climate risk management at Penn State University; Rob Nicholas, a research associate at the Earth and Environmental Systems Institute at Penn State University; and David Pollard, a senior scientist at the Earth and Environmental Systems Institute at Penn State University detail how parameters and initial values drive an ice sheet model, whose output describes the behavior of the ice sheet through time. Noise and biases are accounted for in the model that ultimately produces ice sheet data.

"Incorporating all of these uncertainties is daunting, largely because of the computational challenges involved," and to an extent, "whatever we say about the behavior of ice sheets in the future is necessarily imperfect," note the authors. "However, through such cutting-edge physics and multiple observation data sets that piece the information together in a principled manner, we have made progress."

Specific articles in this special issue of *CHANCE* include the following:

- "The Role of Statistics in Climate Research" by Peter F. Craigmile, professor in the department of statistics at The Ohio State University
- "How We Know the Earth Is Warming" by Peter Guttorp, professor at the Norwegian Computing Center and professor emeritus in the department of statistics at the University of Washington
- "Instruments, Proxies, and Simulations: Exploring the Imperfect Measures of Climate" by Craigmile and Bo Li, associate professor in the department of statistics at the University of Illinois at Urbana-Champaign
- "Climate Model Intercomparison" by Mikyoung Jun, associate professor in the department of statistics at Texas A&M University
- "Climate Change Detection and Attribution: Letting Go of the Null?" by Hammerling
- "Quantifying the Risk of Extreme Events Under Climate Change" by Eric Gilleland, project scientist at the Research Applications Laboratory at the National Center for Atmospheric Research; Richard W. Katz, senior scientist at the Institute for Mathematics Applied to Geosciences at the National Center for Atmospheric Research; and Philippe Naveau, senior scientist at the Laboratoire des Sciences du Climat et de l'Environnement (LSCE) at the Centre National de la Recherche Scientifique
- "Statistics and the Future of the Antarctic Ice Sheet" by Haran, Chang, Keller, Nicholas, and Pollard
- "Ecological Impacts of Climate Change: The Importance of Temporal and Spatial Synchrony" by Christopher K. Wilke, Curators' Distinguished Professor of Statistics at the University of Missouri
- "Projecting Health Impacts of Climate Change: Embracing an Uncertain Future" by Howard H. Chang, associate professor in the department of biostatistics and bioinformatics at Emory University; Stefanie Ebelt Sarnat, associate professor in the

department of environmental health at Emory University; and Yang Liu, associate professor in the department of environmental health at Emory University.

Members of the media can obtain a complimentary copy of *CHANCE* by emailing jill@amstat.org.

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About the American Statistical Association

The ASA is the world's largest community of statisticians and the oldest continuously operating professional science society in the United States. Its members serve in industry, government and academia in more than 90 countries, advancing research and promoting sound statistical practice to inform public policy and improve human welfare. For additional information, please visit the ASA website at www.amstat.org.

About CHANCE

CHANCE is a publication of the ASA designed for anyone with an interest in using data to advance science, education and society, highlighting sound statistical science. *CHANCE* is a nontechnical magazine, representing a cultural record of an evolving field, intended to entertain as well as inform.

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