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**SINKHOLES AND THE ENGINEERING AND
ENVIRONMENTAL IMPACTS OF KARST**

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View of the Rio Grande de Arecibo and mogote karst from Cueva Ventana, Puerto Rico. NCKRI photo by George Veni.

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FOREWORD

As all of us are aware, the global COVID-19 pandemic has forced the postponement or cancellation of dozens of conferences and cultural events worldwide. This is unfortunately also true of the sixteenth Sinkhole Conference, originally scheduled for late April of 2020 in San Juan, Puerto Rico. Rather than completely cancelling this event, the organizing committee has chosen to reschedule the conference for the following year. The Sixteenth Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst will now meet on April 12 through 16, 2021, at the same venue in San Juan, Puerto Rico. We have issued a call for additional papers to appear in a second edition of these Proceedings along with the manuscripts that have already been submitted. This second edition will be available to attendees at next year's rescheduled Sinkhole Conference.

In spite of the delay, we anticipate a successful and productive meeting. This will be the first Sinkhole Conference to be held outside the coterminous United States since the conference series began in 1984. Several of the papers in this first edition focus on karst phenomena specific to the island of Puerto Rico and the Caribbean region.

In 2011 the National Cave and Karst Research Institute (NCKRI) assumed responsibility for hosting the Sinkhole Conference series. NCKRI is a congressionally-created organization dedicated to pure and applied research on caves, karst phenomena, and karst hydrology. Several of the staff of NCKRI have a long history of participation in past Sinkhole Conferences, and we look forward to supporting and hosting future meetings in other areas of the United States and abroad.

As senior editor of the Proceedings Volume, I would like to thank all of those on the Organizing Committee who have contributed to making this event happen under these particularly challenging circumstances. In the past three years the residents of Puerto Rico have endured a remarkable number of natural disasters, discouraging tourism and business investment. The most important assistance we can provide the people of Puerto Rico at this time is to continue visiting this geologically and ecologically unique island, and investing in the economy by, frankly, spending our money. Thank you in advance for your attendance at next year's conference and enjoy your stay.

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KEYNOTE SPEAKER

MUCH TO WIN, EVEN MORE TO LOSE: ASSESSING KARST WATER AVAILABILITY IN TIMES OF ENVIRONMENTAL CHANGE

Dr. Andreas Hartmann

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Many regions across the world are dependent on drinking water from karst aquifers. Globally, around a quarter of the world population completely or partially depends on karst water resources. Karst develops due to the dissolution of carbonate rock and creates pronounced surface and subsurface heterogeneity in their hydrological flow and storage behaviour. Consequently, water resources management faces significant challenges in karst regions, in particular at times of environmental change.

My lecture will provide an overview of established approaches that can be used to assess the impact of environmental change on karst water resources. A walk across scales from the scale of individual caves to the scale of entire continents will elaborate on (1) how understanding of their processes can be obtained, (2) how dominant processes can be identified and (3) how this understanding can be incorporated into karst-specific modeling approaches. Using two recent large-scale studies, I will contrast the opportunities and challenges of managing karst aquifers across different climatic regions. The former will demonstrate that, presently and in the future, disproportionately large amounts of drinking water are available in karst regions compared to non-karstic areas. The latter will quantify the contamination risk of karst water resources that can go along with inadequate management and how this risk may be altered through environmental change. These findings will be linked to the Puerto Rican karst and climate. Finally, I will propose some possible directions for future research in karst hydrology.

Biography

Climate variability and land use changes affect karst water resources and their water quality. Andreas Hartmann's research focuses on the assessment of water resources in karst regions at various scales using

novel simulation approaches and model evaluation schemes. Nontypically for a modeler, he also performs experimental field research and incorporates hydrological and hydrochemical information into his modeling approaches to achieve a high degree of process representation to increase their reliability for future projections of climate and land use changes. Andreas did his PhD in 2013 at Freiburg University before he moved to the United Kingdom (University of Bristol) and Canada (McGill University) for his postdoc. His work as an early career scientist has been awarded the Young Karst Researcher Prize of the International Association of Hydrogeologists, the Jim Dooge Award for the best publication in 2012 in the *Journal of Hydrology*, and the Earth System Sciences and the Groundwater Research Prize of the City of Dresden. Since 2017, Andreas has been an Assistant Professor and head of his own lab "Hydrological Modeling and Water Resources." As the principal investigator of a €1.5M. research project founded by the German Research Foundation, he and a team of four researchers are estimating the risk of water stress in karst regions around the globe under changing environmental conditions. Apart from developing improved modeling approaches that can be applied on larger scales, the project includes a global karst monitoring program with study sites in Australia, Germany, the UK, Spain and Puerto Rico.

BANQUET SPEAKER

PUERTO RICO KARST WATER RESOURCES AND CLIMATE CHANGE: WHAT'S AT STAKE?

Abel Vale

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Regardless of any personal opinion and any doubts, all serious research has confirmed that the climate is changing to become warmer with higher temperatures, higher sea levels due to the melting of glaciers and polar ice shields, changes in rainfall either with extreme rainfall with floods or more frequent droughts, which are already affecting all lifeforms.

The Earth's climate has changed throughout history. The current warming trend is of particular significance because most of it is extremely likely (greater than 95 percent probability) to be the result of human activity since the mid-20th century and proceeding at a rate that is unprecedented over decades to millennia.

How does this affect Puerto Rico's water availability; in particular its effect on karst aquifers is of vital importance. What's at stake?

Biography

Abel Vale-Nieves received his B.A. from the University of Puerto Rico at Mayaguez and his M.A. from SUNY Binghamton. Abel, with his wife Evelyn, has owned a small business that provides equipment for the utility market. An encounter with the karst and caves of Mona Island, more than 35 years ago ignited his passion for carbonate rocks and set him to visit and learn about karst in Europe, Asia, Russia, the Middle East, North, Central and South America and the Caribbean. He was one of the founders of Ciudadanos Del Karso CDK a nonprofit NGO with the mission to protect and conserve the karst of Puerto Rico through education, scientific studies, and land acquisition. Abel has been CDK's president for the last 25 years and CDK has received numerous recognitions, locally and internationally, for its work to protect Puerto Rico's karst. One of its main achievements was working with Puerto Rico's legislature that passed a law to protect the karst landscape and that gave special

protection to over 232,000 acres. Looking toward the future, CDK is now in the process of creating the Puerto Rico and Caribbean Karst Research Institute, in a structure in the city of Arecibo that formerly housed a school.