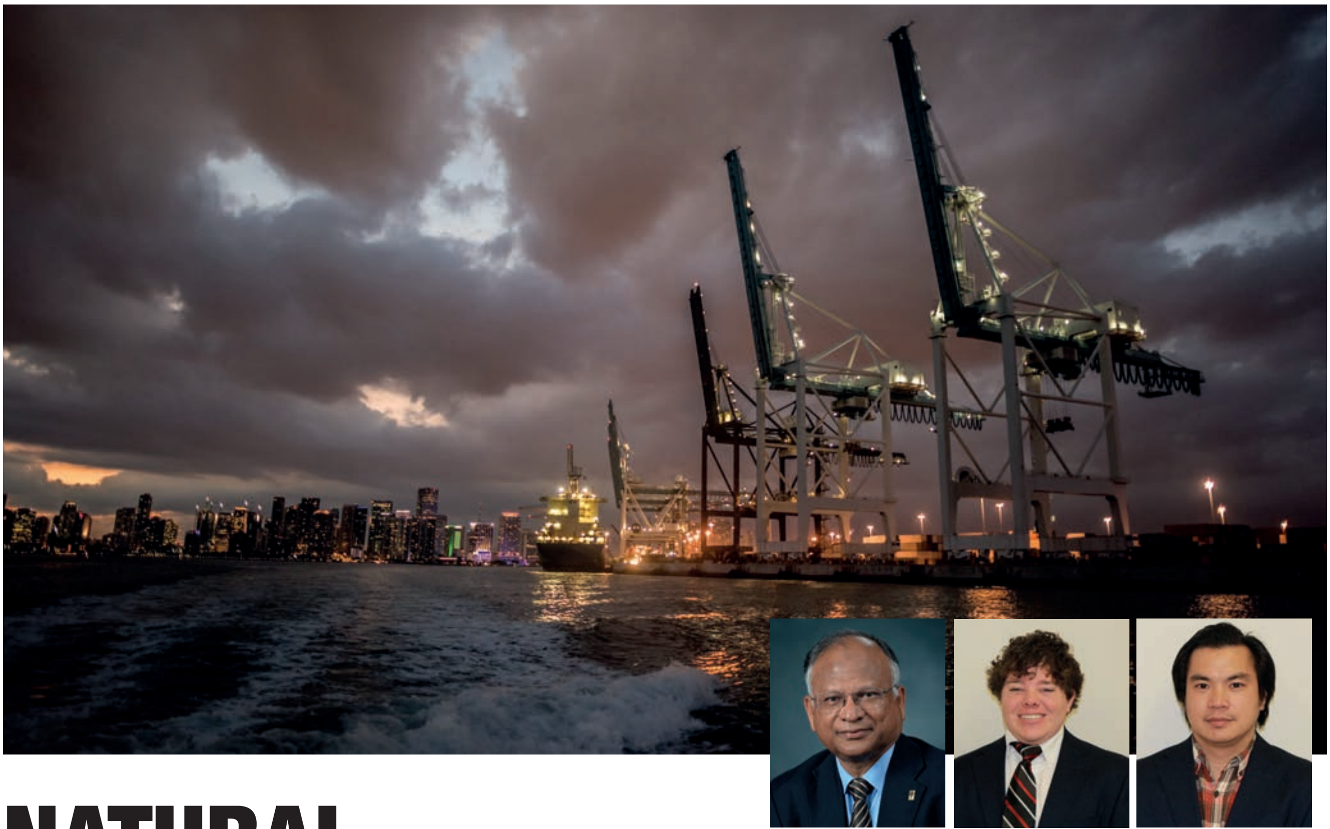

NATURAL DISASTER RISK

GEOSPATIAL ASSESSMENTS FOR RESILIENT PORT INFRASTRUCTURE

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Natural disasters, such as coastal hurricanes and rainfall flooding, can create major impacts on marine transportation. Ports and port cities will also be increasingly threatened by tsunami and climate-related sea level rise (SLR) by year 2100. This paper presents computer modeling and geospatial analysis of these natural disaster risks and resilience management strategy using a case study of Port city of Miami.

Our computer simulations show that tsunami and sea level rise create more inundated land area than extreme rainfall flooding. They also indicate that a population of 1.42 million is at risk in metropolitan Miami and surrounding areas. Hardening of port infrastructure assets in the area is recommended to enhance resilience against coastal disasters and minimize supply chain disruptions. About 90% of global imports and exports are facilitated through ports and over 70% of this travels aboard container ships.

The American Association of Port Authorities (AAPA) reported that the US seaports move more than 99% of the country’s import and export cargo by volume and 65% by value. Coastal storms, hurricanes, cyclones, and rainfall flood disasters can halt inland and marine transportation and supply chains, causing delays in processing cargo ships, destruction of port infrastructure, and adverse impacts on coastal communities. An average of 130 ports have been struck each year by tropical cyclones in recent decades.

SIMULATION OF COASTAL DISASTERS

Flood risk maps for port infrastructure in Miami and surrounding areas were created using geospatial analysis and computer modeling simulating one-dimensional rainfall flooding, possible SLR or land subsidence, and possible tsunami.

The port docks were not inundated by rainfall flooding in the simulation because the port is located at 2 meters elevation on a small island surrounded by ocean, and rainfall in the port area flows directly to ocean without flooding the port docks. However, the water depth ranged from 0.2 meters to 1 meters on two bridge roads connecting the mainland with the port in the simulation.

This caused disruptions in ship processing as well as intermodal facilities at the port serving supply chain traffic of freight trucks and freight trains.

Next, we conducted a computer simulation of SLR due to climate impacts using newly developed CAIT methodology. According to a study by National Oceanic and Atmospheric Administration (NOAA), the global mean sea level may rise from 0.2 to 2.0 meters by the year 2100. Therefore, the maximum value of 2 meters SLR was used for computer modeling and geospatial analysis of sea level rise using spatial map of several elevation ranges created from 2-feet (0.61-meters) digital elevation model (DEM). After that a shoreline was created and 2 meters height seawater polygons were created for the entire study area. All the land areas in the ranges of 0 to 2 meters below the SLR polygons were classified as submerged land.

The 2 meters SLR simulation indicates that 411.96 km2, or 57.08% of land area is submerged by seawater, putting 1.42 million people at risk because they live or work in the floodplain. Some parts of the port docks and the roads connected to the port were submerged. Other important pieces of infrastructure such as the Miami International Airport, Interstate 95, and Interstate 395 were also affected by both extreme rainfall flood and 2 meters SLR simulations.

The development of CAIT tsunami simulation methodology was based on the 9.2 meter tsunami wave peak height (WPH) that hit the Kesennuma Bay in Japan on March 11, 2011. The 2 meter-high tsunami WPH simulation results using the CAIT methodology, based on the 2011 Fukushima catastrophic tsunami data, are similar to the results of the 2 meters SLR for Maimi. Land is 0.32% more submerged by both the tsunami and SLR simulations than by extreme rainfall flood. Such a Fukushima-style tsunami could potentially occur and reach US shores any time there is a strong earthquake in the Atlantic Ocean along the Eastern and Southern Coasts of the US.

RESILIENCE MANAGEMENT OF PORTS

Our research proposes a disaster resilience rating scale for infrastructure assets including port infrastructures, where 100 is the best and 0 represents building failure or collapse. The rating scale can improve timely and efficient emergency management, as well as prioritize different infrastructure asset groups for appropriate hardening strategies based on the type of disaster and associated risks. Due to higher cargo shipping demand and coastal disasters (storms, hurricanes, tsunamis) in future years, the port level of service will be degraded, as explained in detail by Nguyen. Timely resilience management is imperative for the docks and other port assets, bridges, rail, and road infrastructure in the flood risk areas in order to minimize disruptions in loading or unloading cargo ships and supply chain.

To prevent future hurricane, tsunami, and SLR disasters as well as to protect infrastructures and communities in Miami, seawalls around port infrastructures should

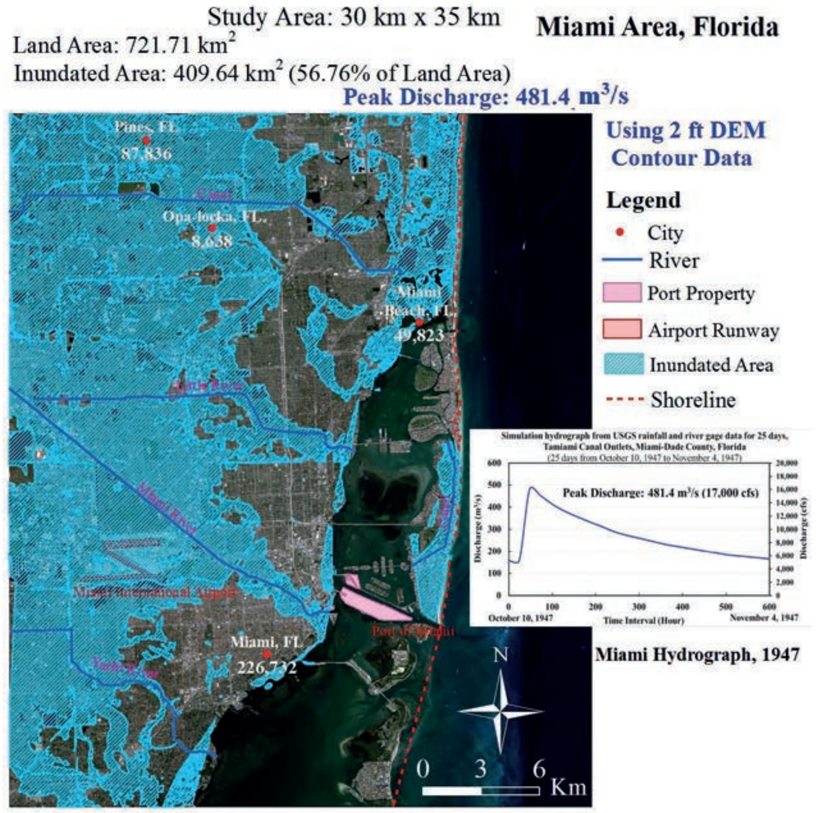

Figure 1 Extreme hydrograph from 1947 on right and flood simulation results on left. The flood simulation results indicate that 409.64 km2, or 56.76% of the land area, are inundated, and 1.42 million people are at risk because they live or work in the floodplain

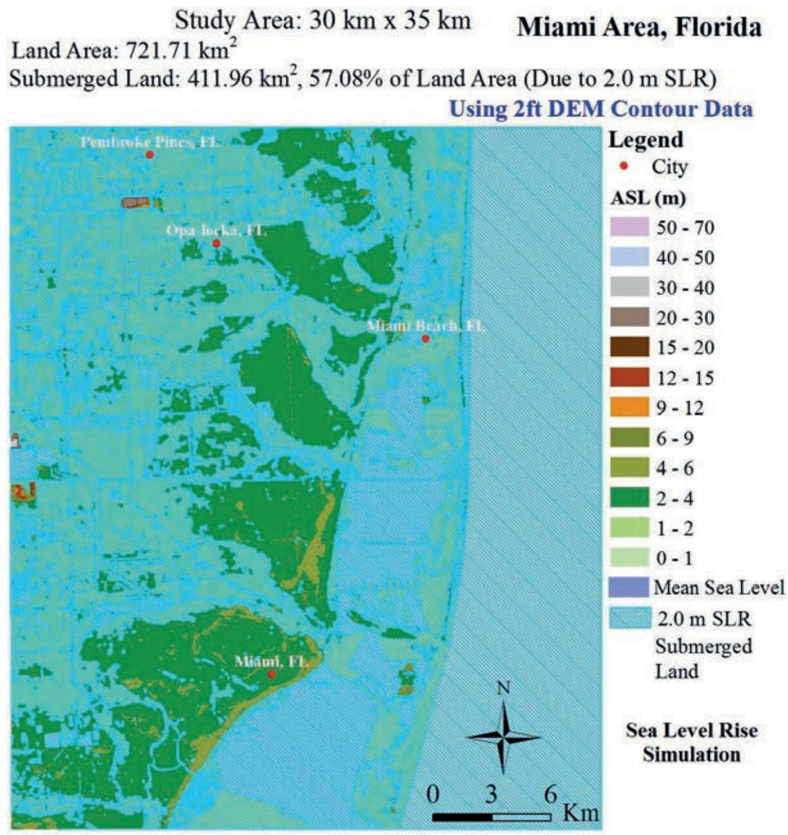

Figure 2. Spatial map of 2 meters SLR simulation overlay on DEM elevation map, Miami and surrounding areas, Florida

be raised to at least 2 meters high with flood gates. Innovative materials such as sheet piles made from fiber-reinforced plastic could be used for constructing seawalls, as shown in our value engineering study.

The results presented in this paper can be used by both Miami port authority and city authorities to assess coastal flooding risks. They may also use it to plan infrastructure hardening and safeguard against extreme weather events and other coastal disasters. Timely resilience management can help to minimize disruptions of port operations and maintain a sustainable supply chain.

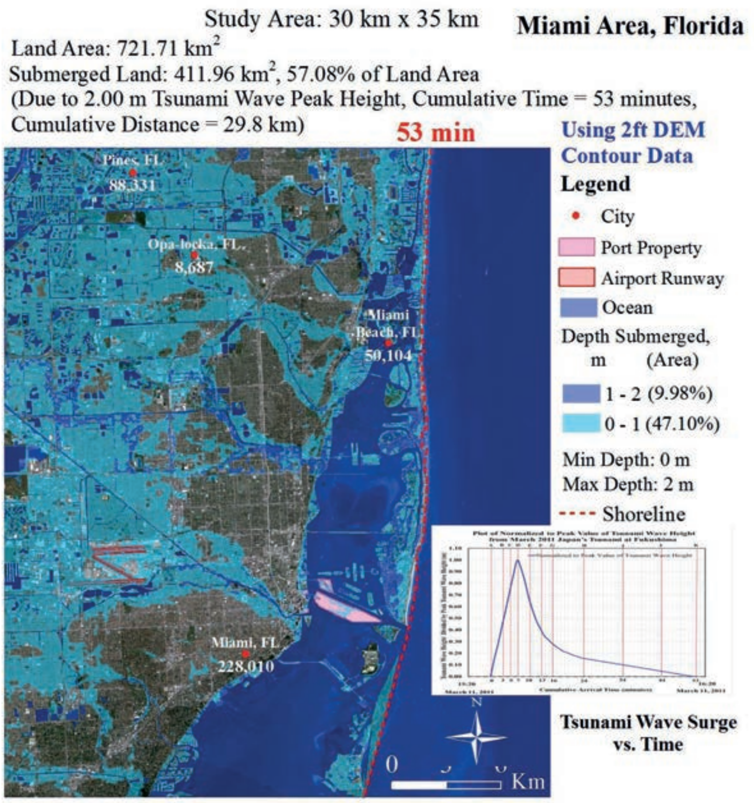

Figure 3. Spatial map of 2 meters tsunami WPH simulation overlay on Landsat-8 imagery, Miami and surrounding areas, Florida

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Dr. Waheed Uddin is Professor of Civil Engineering and Director, Center for Advanced Infrastructure Technology at the University of Mississippi. Previously a pavement expert for the United Nations, he has worked, lectured, and made presentations worldwide in 29 countries. In 2014 he was inducted in the University of Texas CAEE Academy of Distinguished Alumni.

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ABOUT THE ORGANISATION

University of Mississippi, is included in the elite group of R-1: Doctoral Universities - Highest Research Activity by the Carnegie Classification, it has a long history of producing leaders in public service, academics and business. Ole Miss is the state's largest university and is ranked among the nation's fastest-growing institutions, and its 15 academic divisions include a major medical school, schools of accountancy, engineering, law and pharmacy, and the Sally McDonnell Barksdale Honors College, renowned for a blend of academic rigor, experiential learning and opportunities for community action.

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