Hurricane Maria Hindcast Using WRF-LES: A Preliminary Comparison of Topographic Wind Speed-Up

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EXTENDED ABSTRACT:
Hurricane Maria was a strong category 4 hurricane with sustained winds of 155 mph when it struck Puerto Rico in the morning of September 20, 2017, making landfall in the coastal municipality of Yabucoa with damage estimates of approximately $100 billion. Like other tropical island or Appalachians, Puerto Rico's complex terrain causes a considerable topographic speed-up effect resulting in stronger winds over hilly or mountainous terrain than flat terrain. The Federal Emergency Management Administration (FEMA), thru its Mitigation Assessment Team (MAT) Report FEMA P-2020 Hurricanes Irma and Maria in Puerto Rico, recommended the development of new design guidance for wind speed-up in Puerto Rico to produce guidance or wind maps similar to what was produced for Hawaii. Such maps were developed under the Strategic Alliance for Risk Reduction (STARR II), and Technical Services Architectural and Engineering contracted Applied Research Associates (ARA) to create a special wind region map for the mountainous areas in Puerto Rico, as defined by Section 26.5.2 in the ASCE 7-16 Standard *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (aka. Microzonation). The University of Florida (UF) supported this effort by experimentally characterizing speed-up on the main island of Puerto Rico and the municipal Island of Vieques and Culebra in the boundary layer wind tunnel (BLWT) using Cobra probes to collect data for ARA to validate wind speed-up predictions informed by studies of geographic regions outside of Puerto Rico. The outcome of such study is the new Wind Maps currently adopted in the 2018 Puerto Rico Building Code, which had been incorporated into the Applied Technology Council (ATC) *Hazard by Location* web tool and are currently under consideration for adoption in ASCE 7-22. The work that will be presented in this paper is part of an on-going investigation between UF and the University of Puerto Rico Mayagüez funded by the National Science Foundation (NSF) EAGER program. One of the EAGER project's main goals is to elucidate multiscale atmospheric simulations' capability using numerical weather prediction (NWP) framework to assess their potential for prediction wind speed-up in mountainous areas and other regions with steep slopes. Besides, speed-up under the EAGER project was under investigation using other numerical and experimental studies conducted using computational fluid dynamics (CFD) using OpenFOAM®, Machine Learning (ML), and collecting new wind tunnel data at UF's BLWT using stereoscopic PIV measurements under instrument control.

Furthermore, this paper will present the insight of the NWP framework configuration using the Weather Research and Forecasting (WRF) Model Advanced Research WRF (ARW) version 4.2.2 from the National Weather Service (NWS) Science and Training Resource Center's (STRC) Unified Environmental Modeling System (UEMS) version 21.1.2. The NWP simulation had been developed using UPRM in-house and the computational capabilities of the Texas Advanced Computing Center (TACC) of The University of Texas at Austin. A hindcast of Hurricane Maria over Puerto Rico had been conducted using WRF-ARW in LES mode for domains with a horizontal resolution less than 1 km. The WRF model configuration consists of six (6) one-way nesting domains ranging from a 12.15 km course horizontal resolution down to 50 m using a 1/3 ratio, with 61 vertical levels and a large time step of 40 seconds corresponding to the parent domain. The Timestep is also to scale down using a 1/3 ratio. The model boundary and initial conditions were obtained from the Global Forecast System Analysis (GFS-ANL) data set of 0.5° (~55.6 km), and Sea Surface Temperature (SST) data were obtained from 8.33 km Global data set. The speed-up comparison present will consist of ratios obtained from (i) FEMA-UF-BLWT-Cobra, (ii) ARA-model, (iii) EAGER-ML, (iv) EAGER-CFD-OpenFOAM®, (v) EAGER-UF-BLWT-PIV, and (vi) EAGER-NWP.

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