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Effect of High-Resolution Topography in Simulations of Hurricane Maria's Landfall in Puerto Rico

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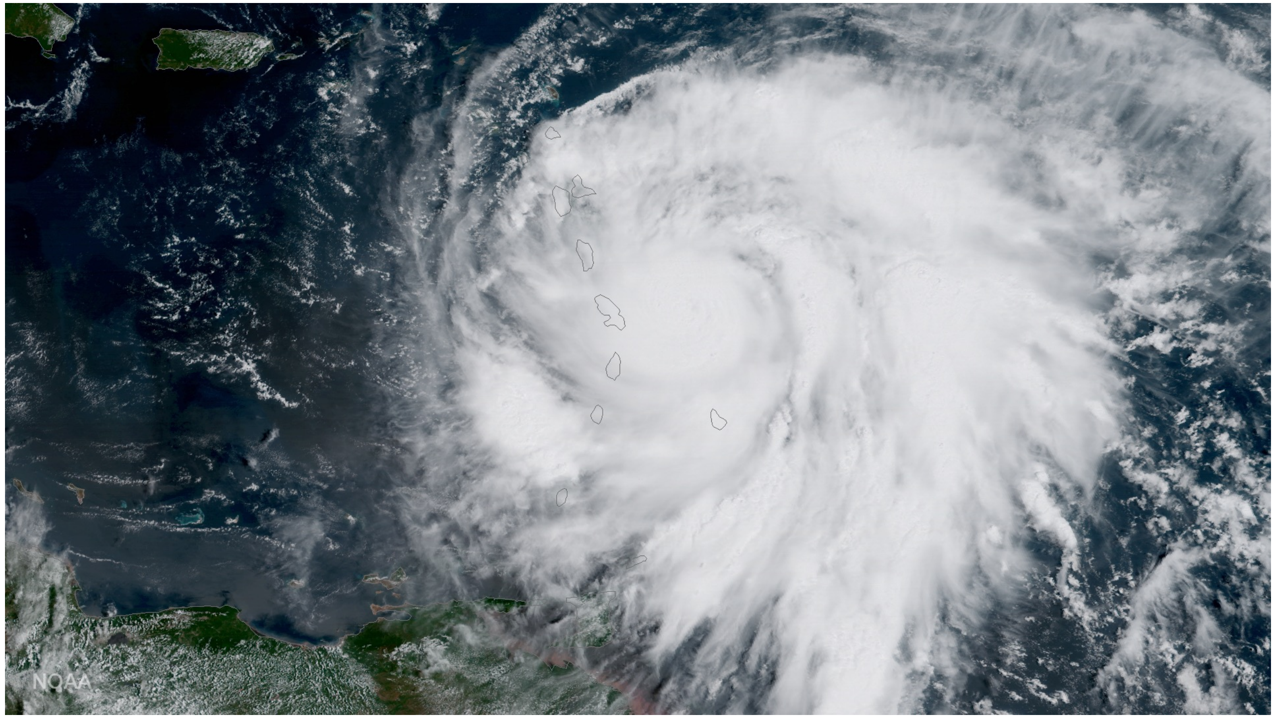
Background: NASA Earth Observatory images by Joshua Stevens, using data from the NASA-NOAA GOES project

Topography affects the behavior of Tropical Cyclones

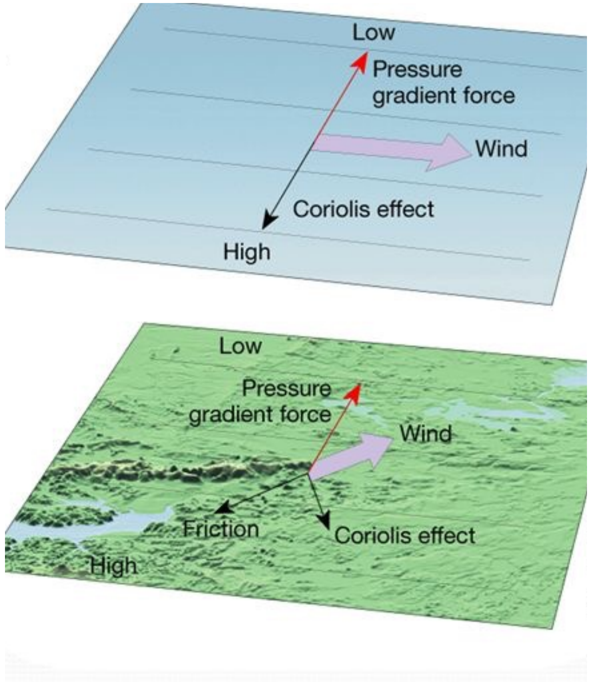
- Atmospheric variables are influenced by the topography
- Numerical weather prediction models cannot resolve many of the topographical factors that influence surface weather



NOAA's GOES-16 satellite – Hurricane María

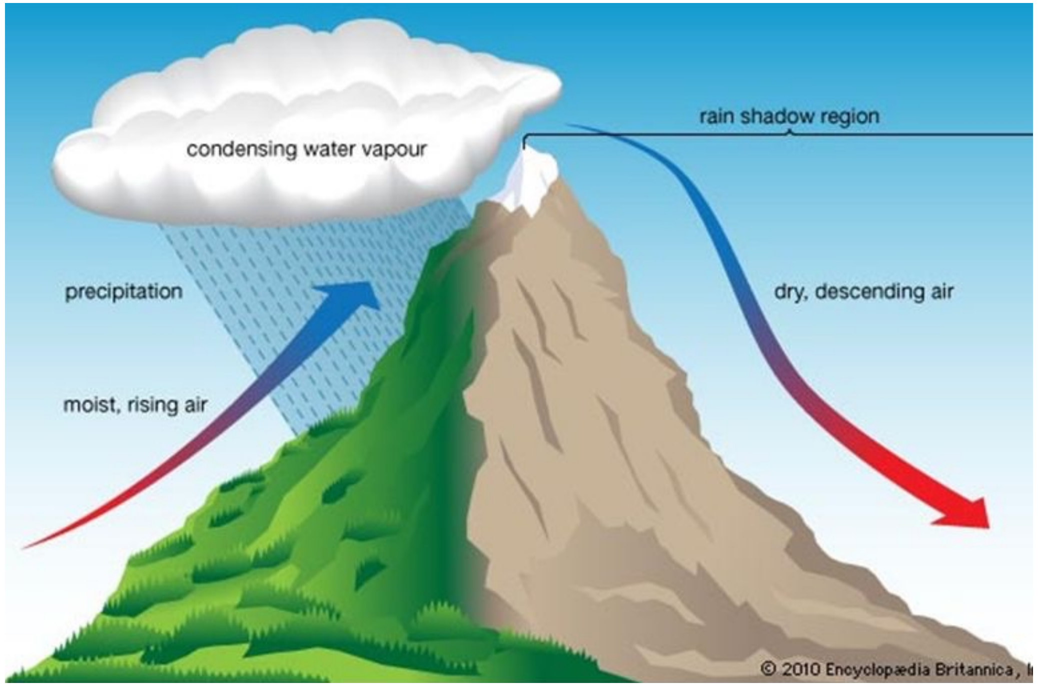
Atmospheric processes change with the interaction between the system and landmass

- Winds near the surface are affected by friction



The Atmosphere, 8th edition, Lutgens and Tarbuck, 8th edition, 2001

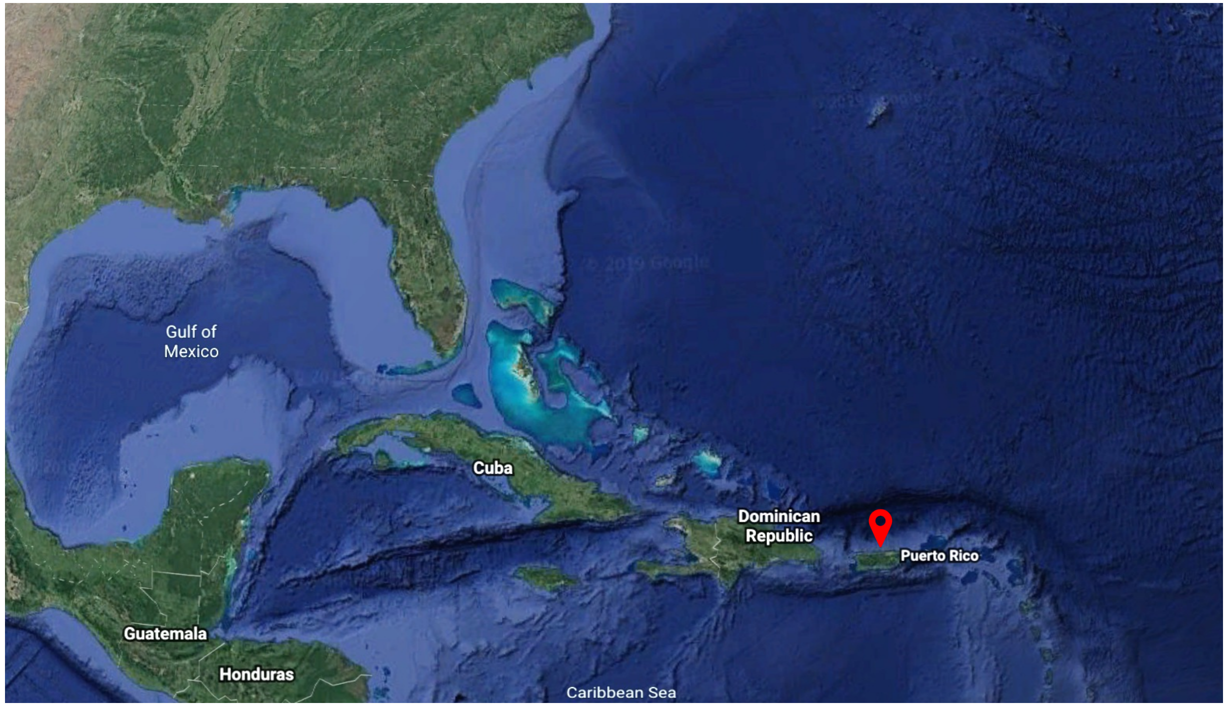
- Additional lifting of moist air produces more precipitation



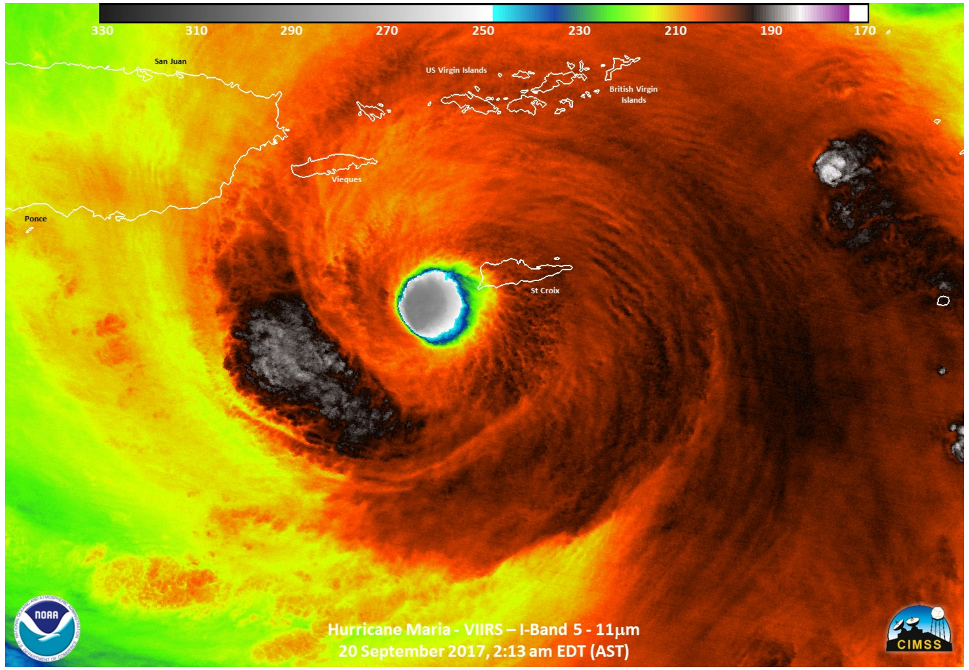
Encyclopedia Britannica, 2010

Hurricane Maria and Puerto Rico

- Puerto Rico is located in the Caribbean



- Hurricane María made landfall in Puerto Rico on September 20, 2017 as a category 4 hurricane



Imaged captured by The Visible Infrared Imaging Radiometer Suite (VIIRS) aboard the NOAA-NASA Suomi NPP satellite

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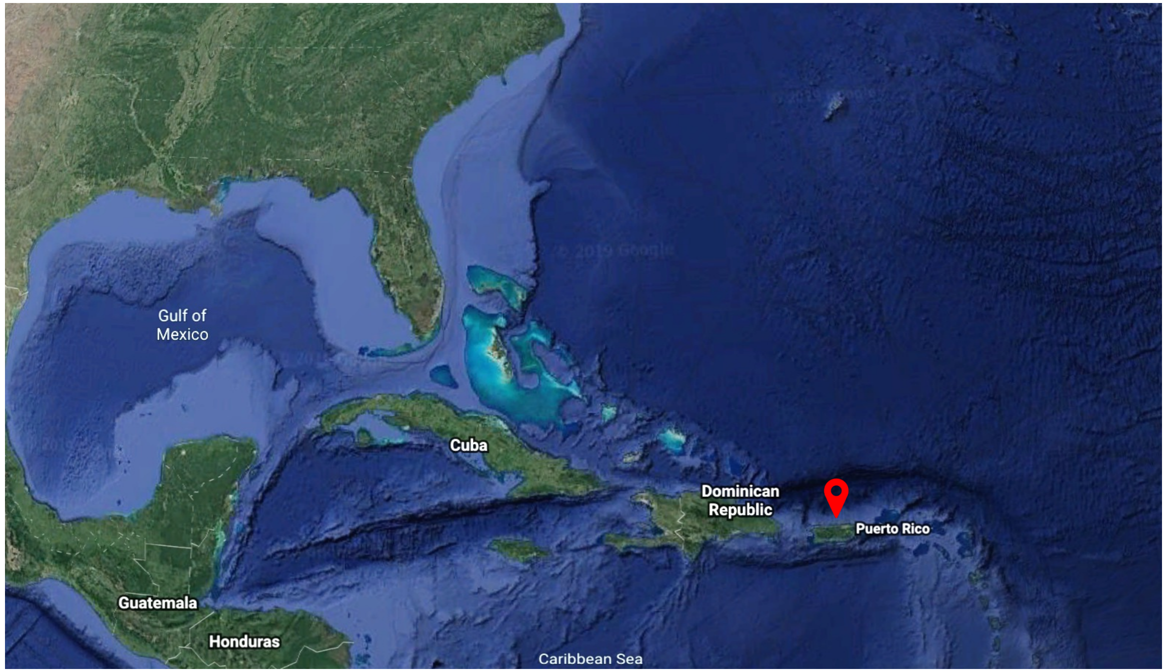
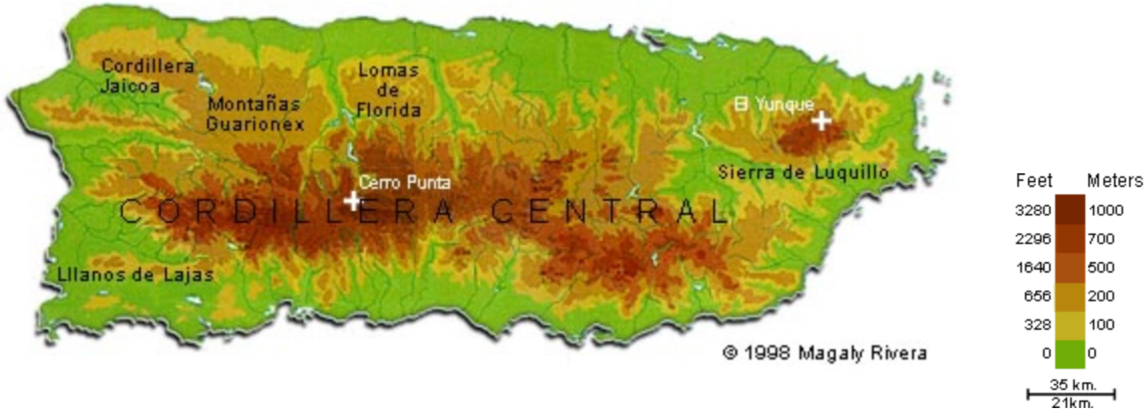
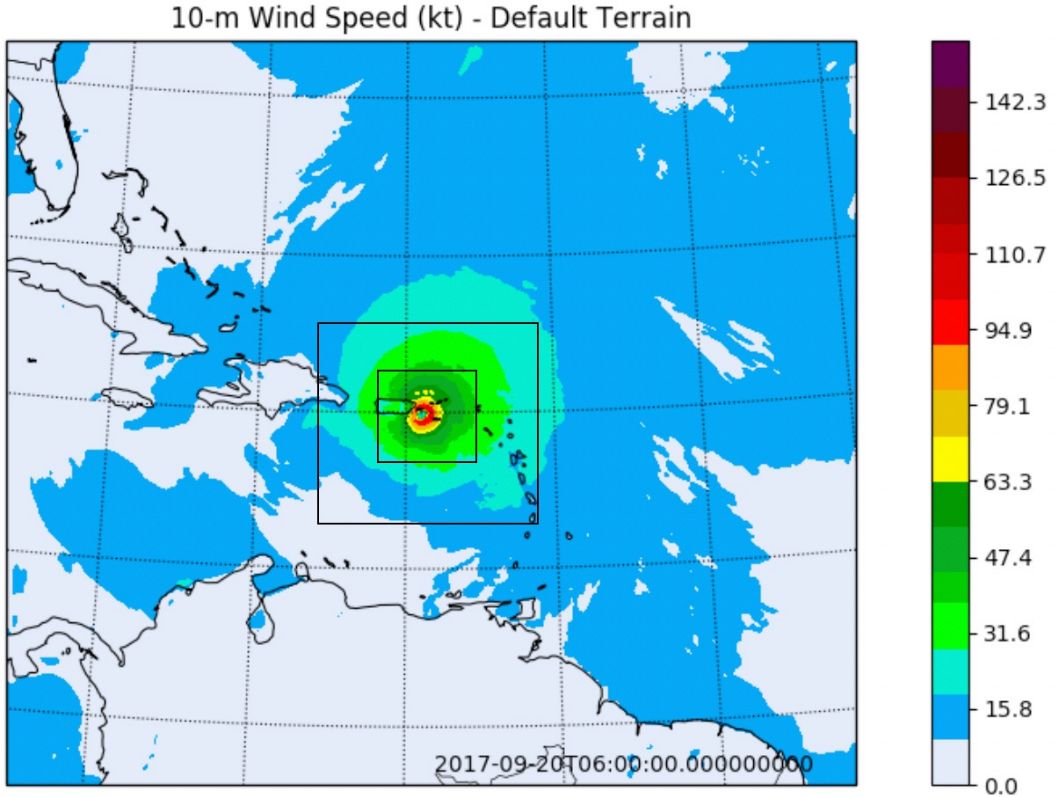


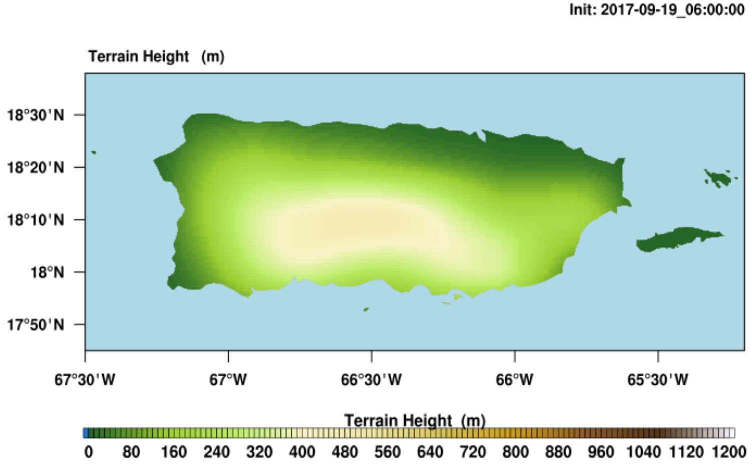
- The main island has multiple mountain ranges and the topography is characterized by:
  - 40% mountains
  - 35% is hills
  - 25% plains

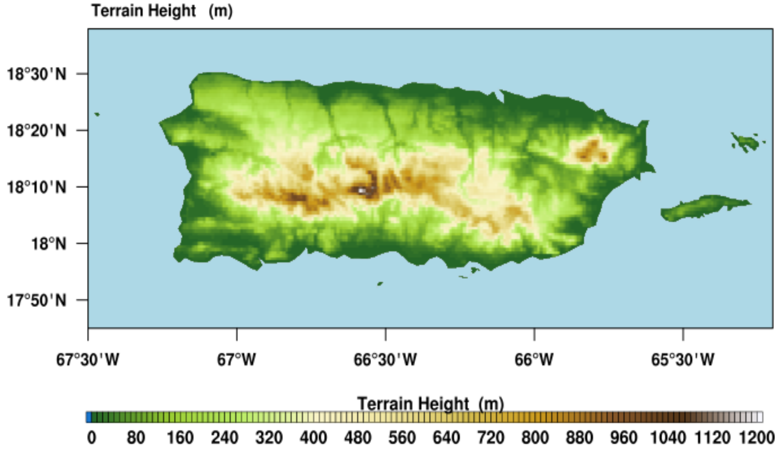


Data & Methodology

The basis for the study is the WRF- ARW 4.1 Model

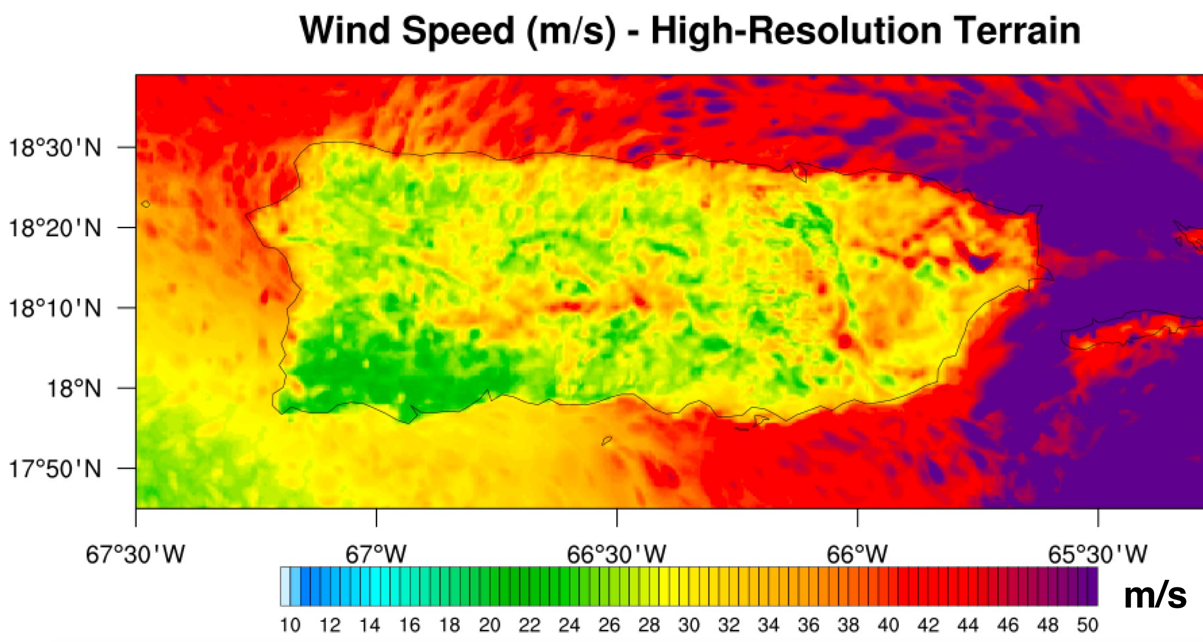




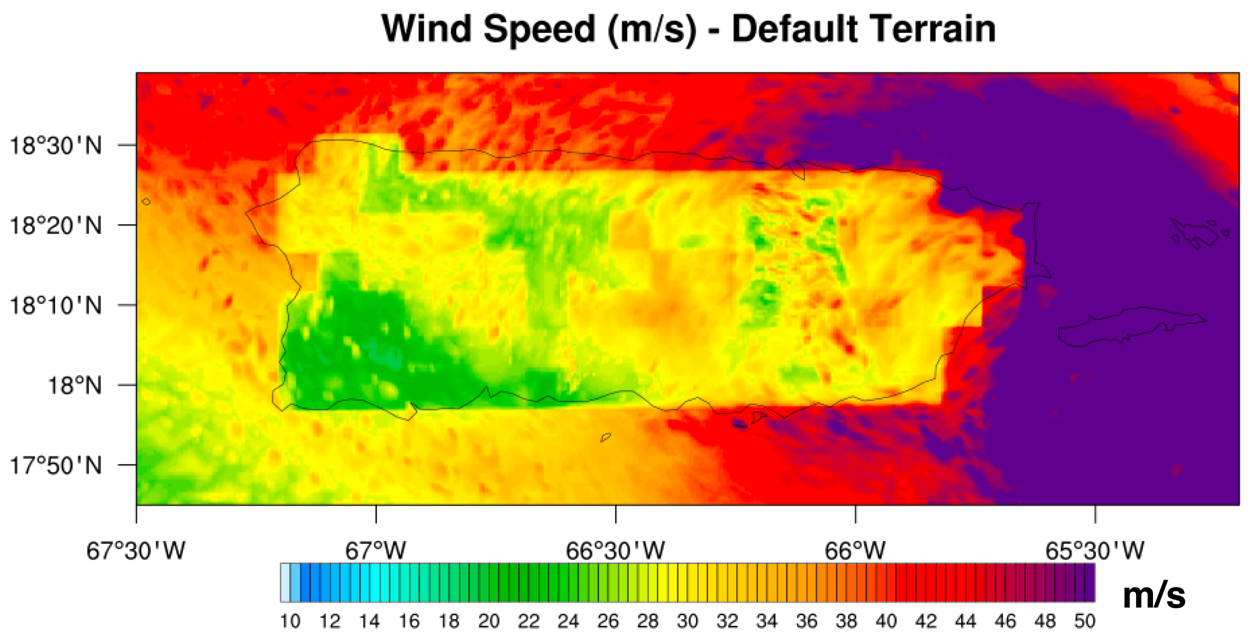


Strongest winds were located in the mountainous interior of the island using high-resolution terrain data

High-Resolution Terrain



Default Terrain



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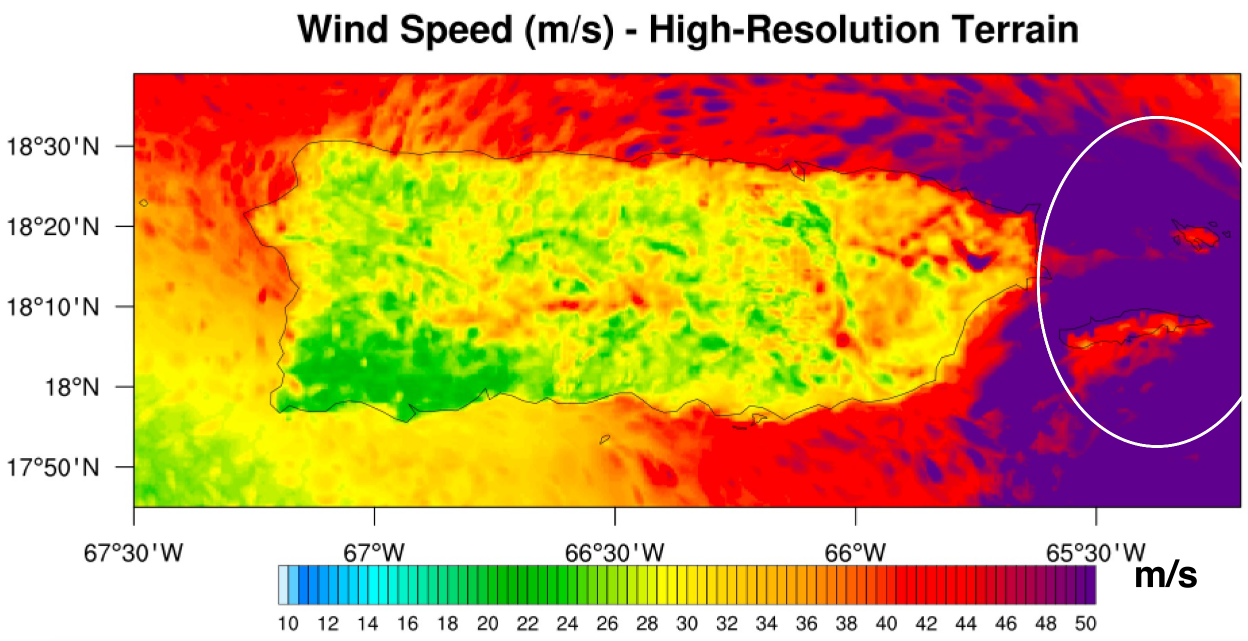

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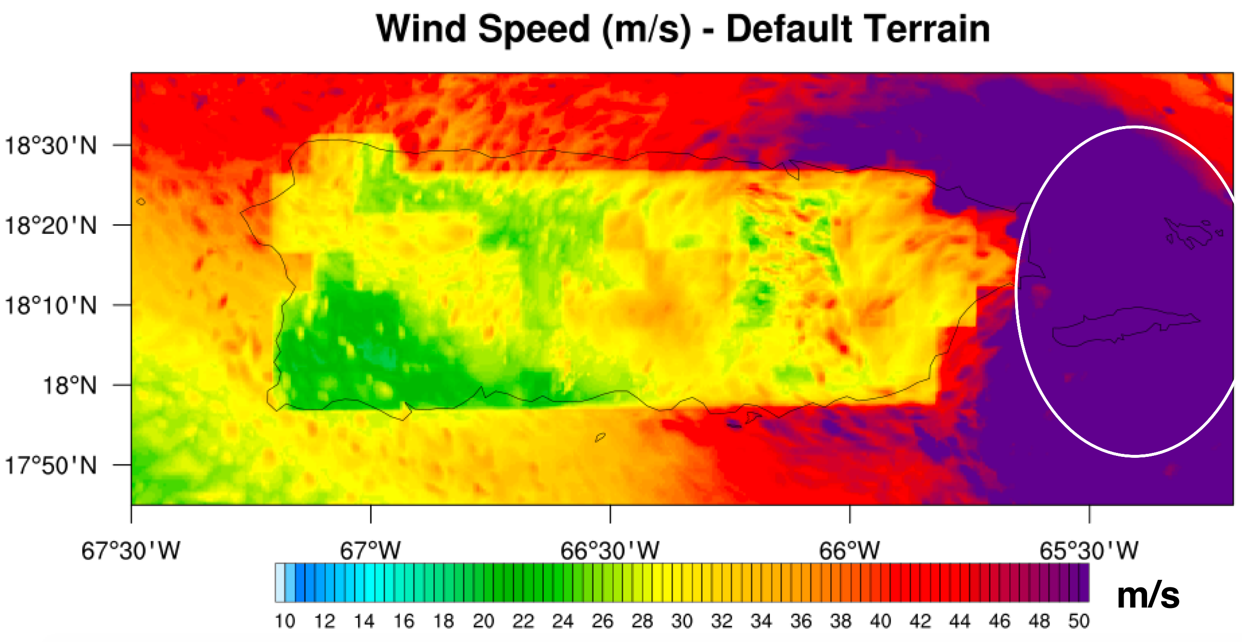

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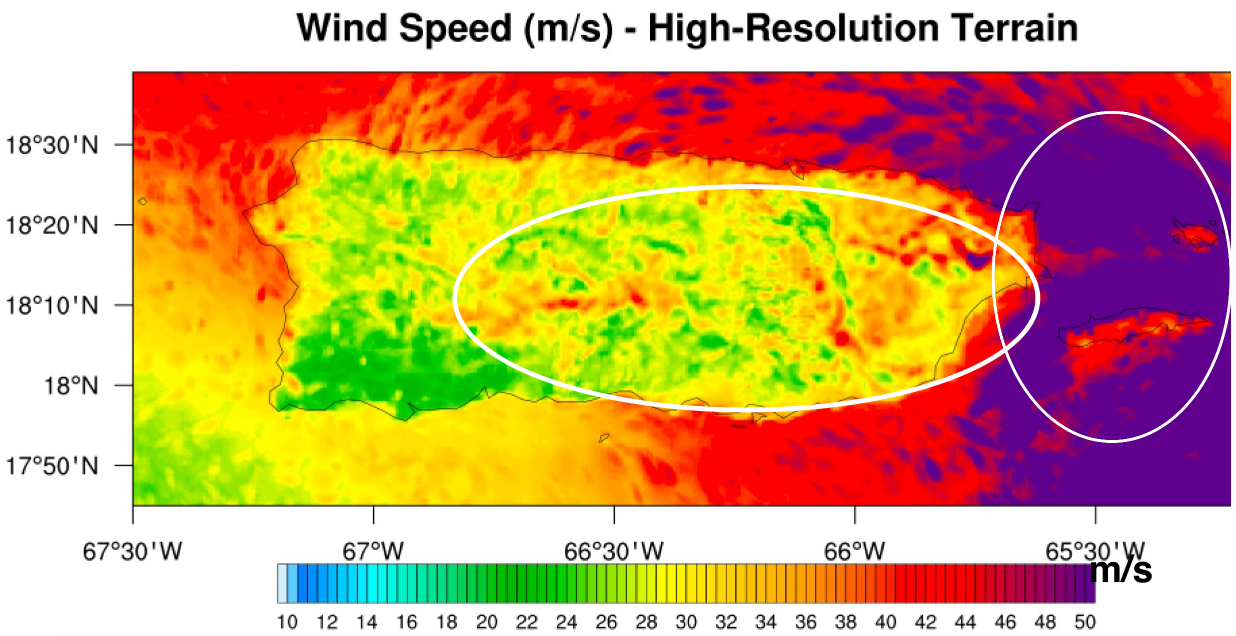

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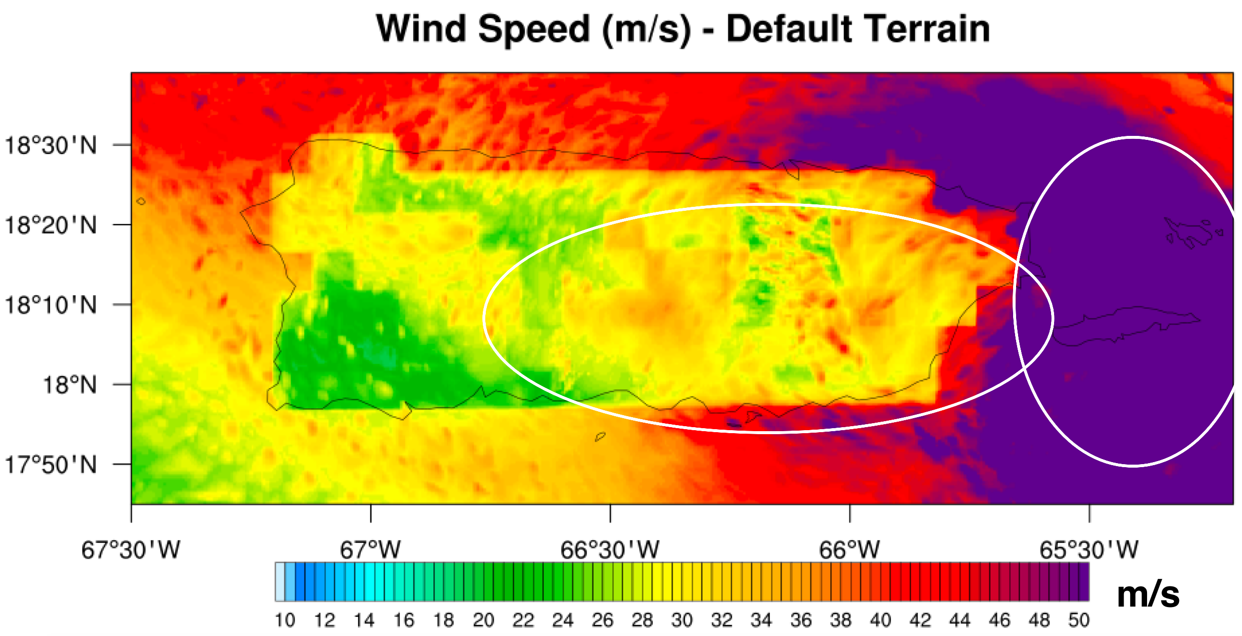

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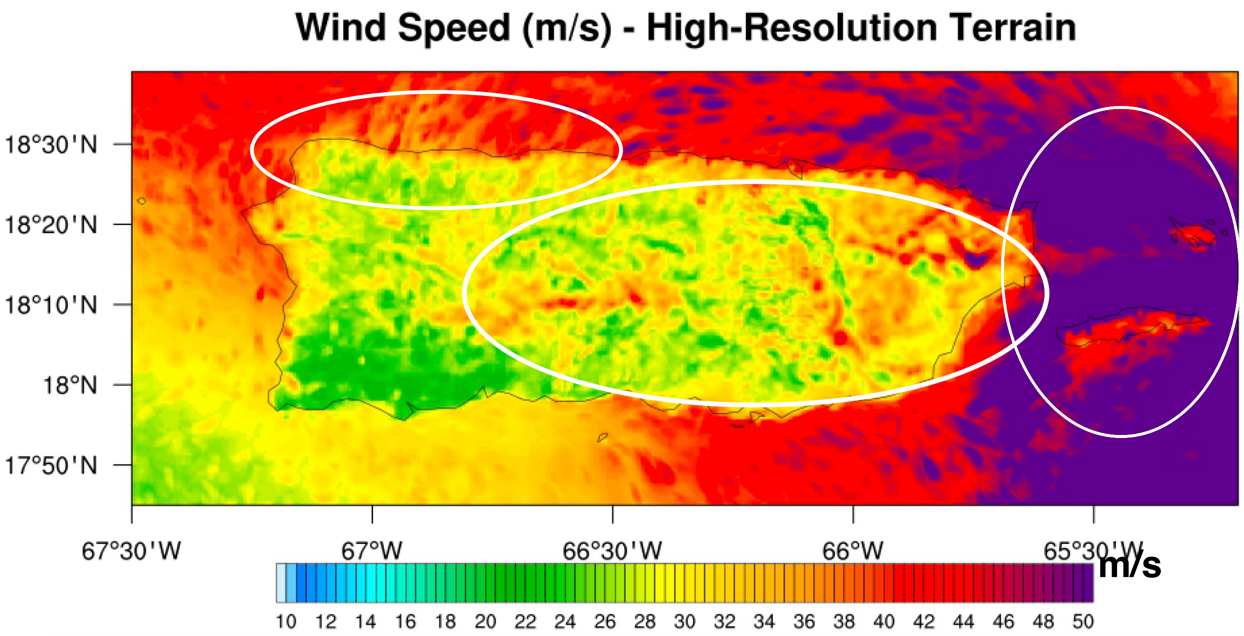

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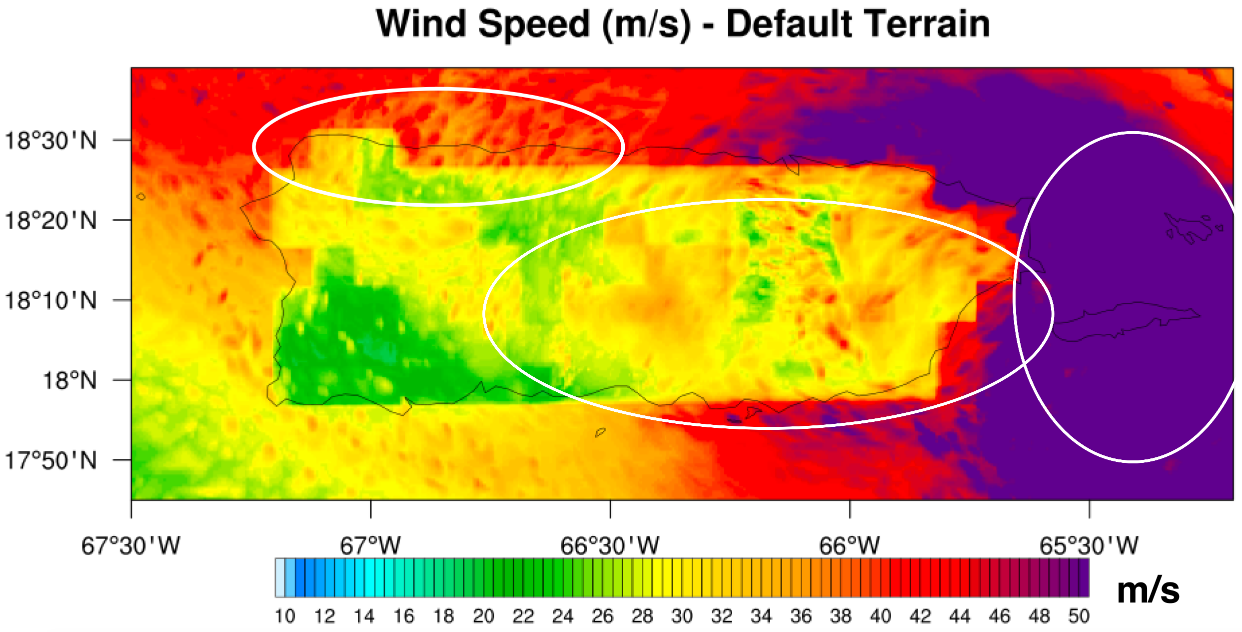
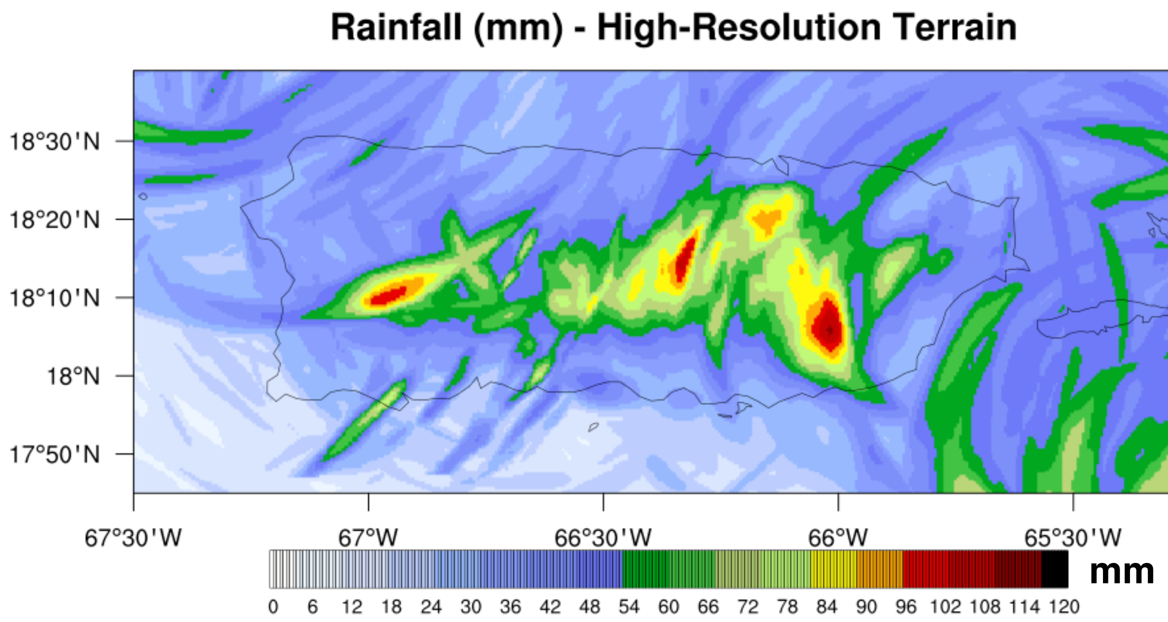


Distribution of Rain

- Changes when incorporating high-resolution terrain data

High-Resolution Terrain



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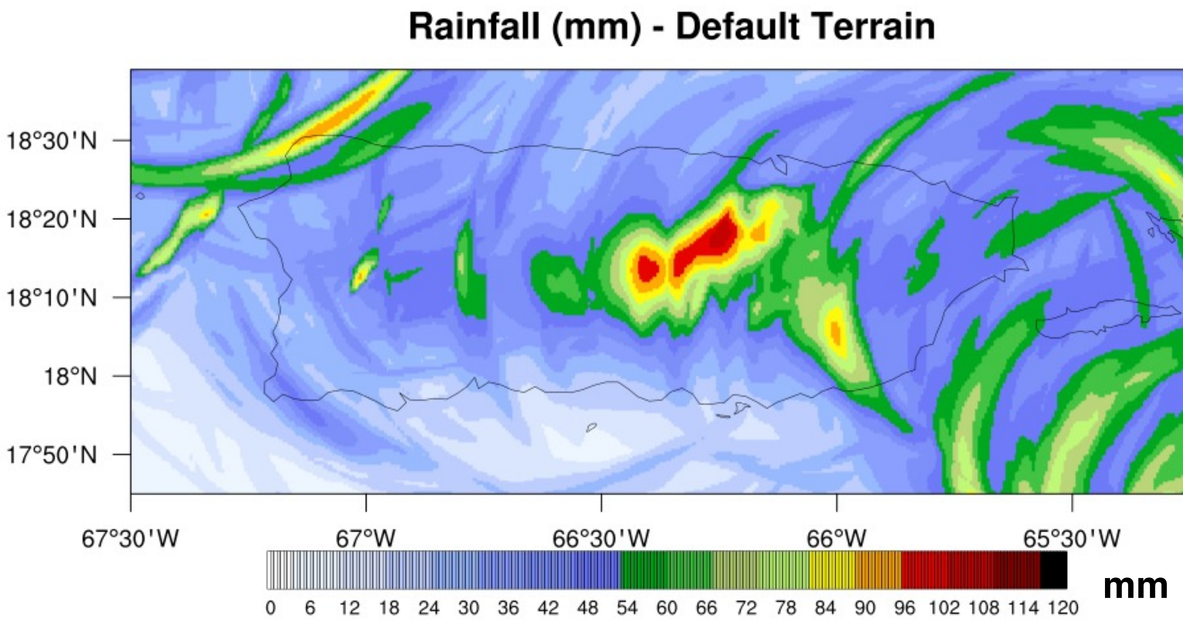

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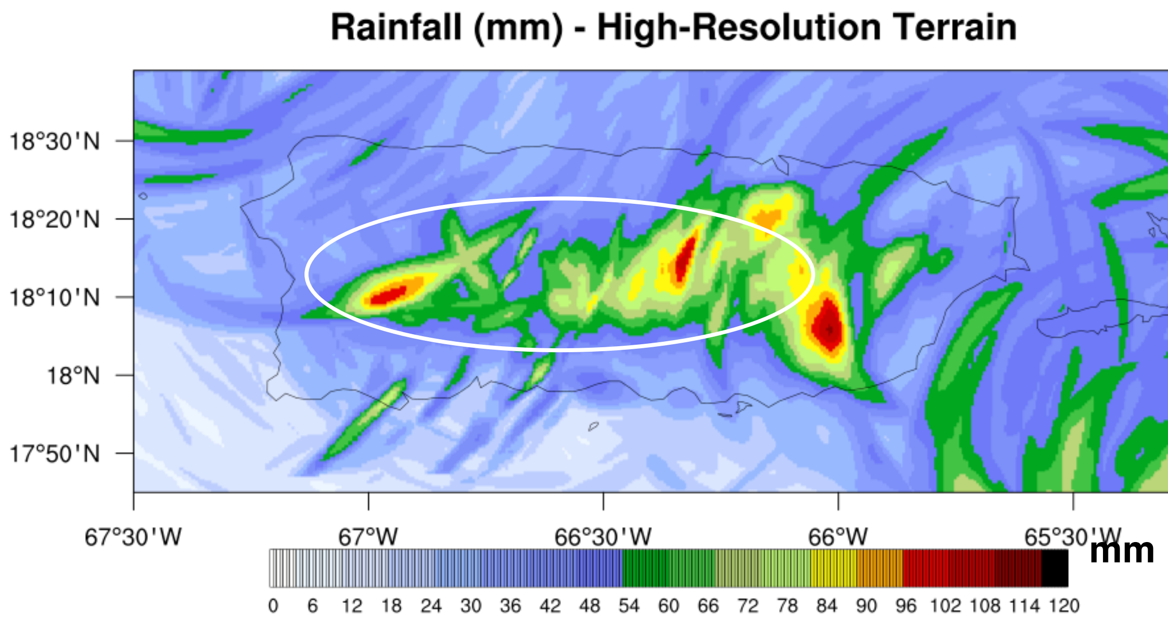

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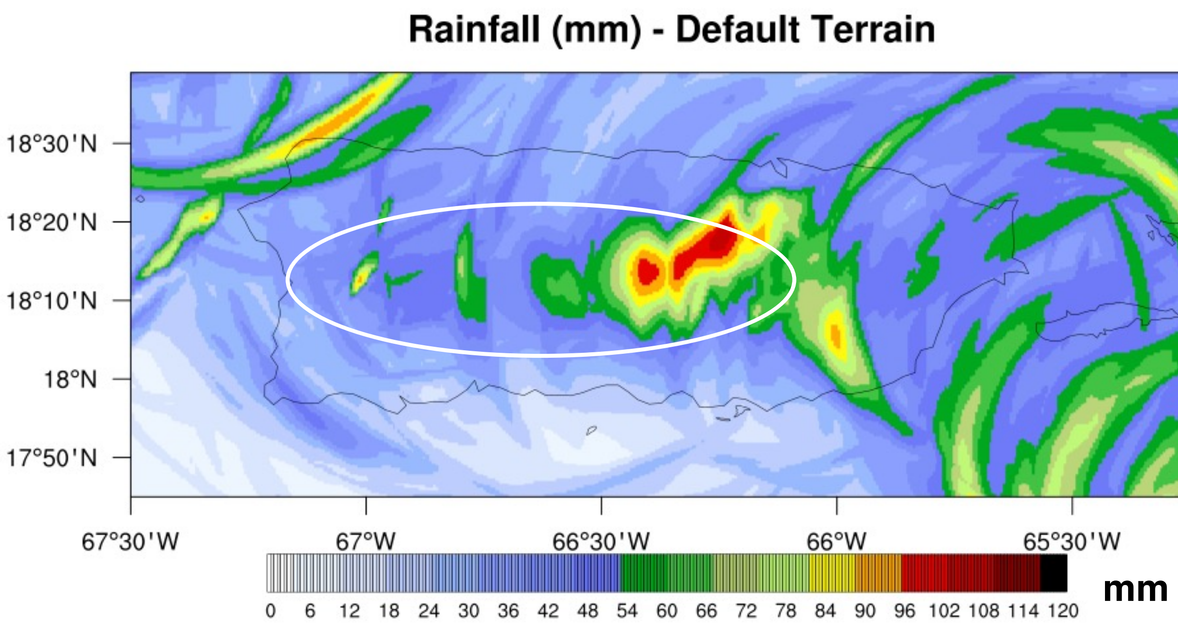
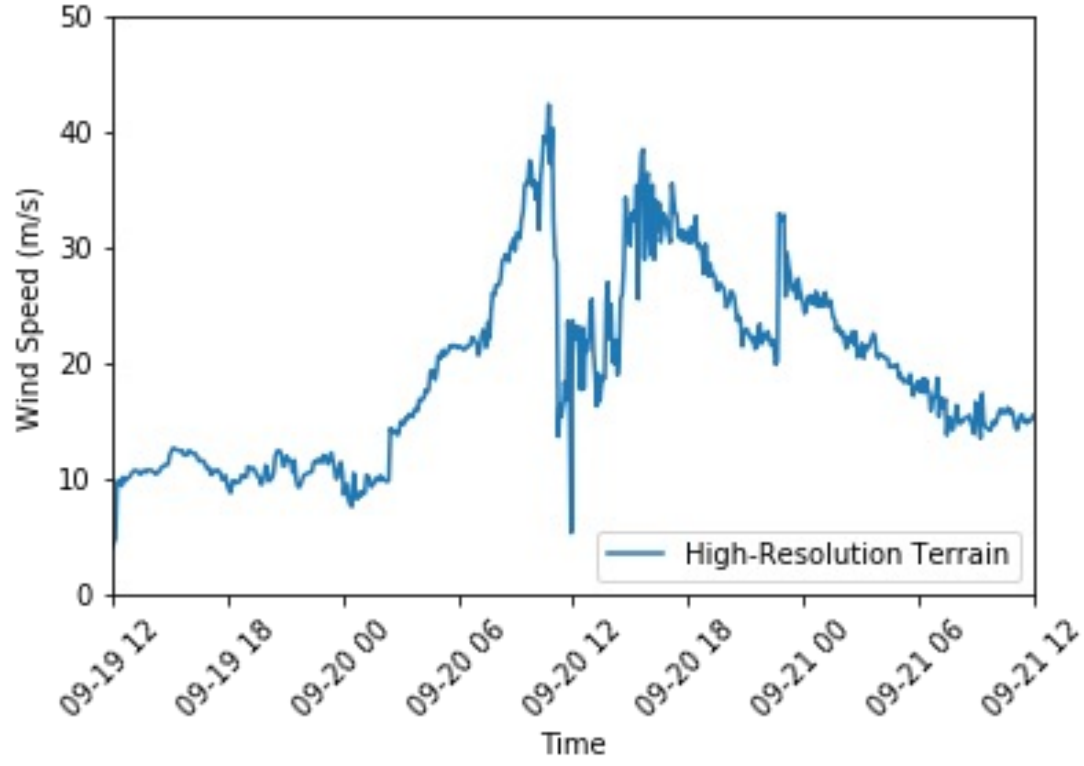


Wind Speed

- Time series plots show the magnitude of 10-m wind speed for one location of Puerto Rico

High-Resolution Terrain



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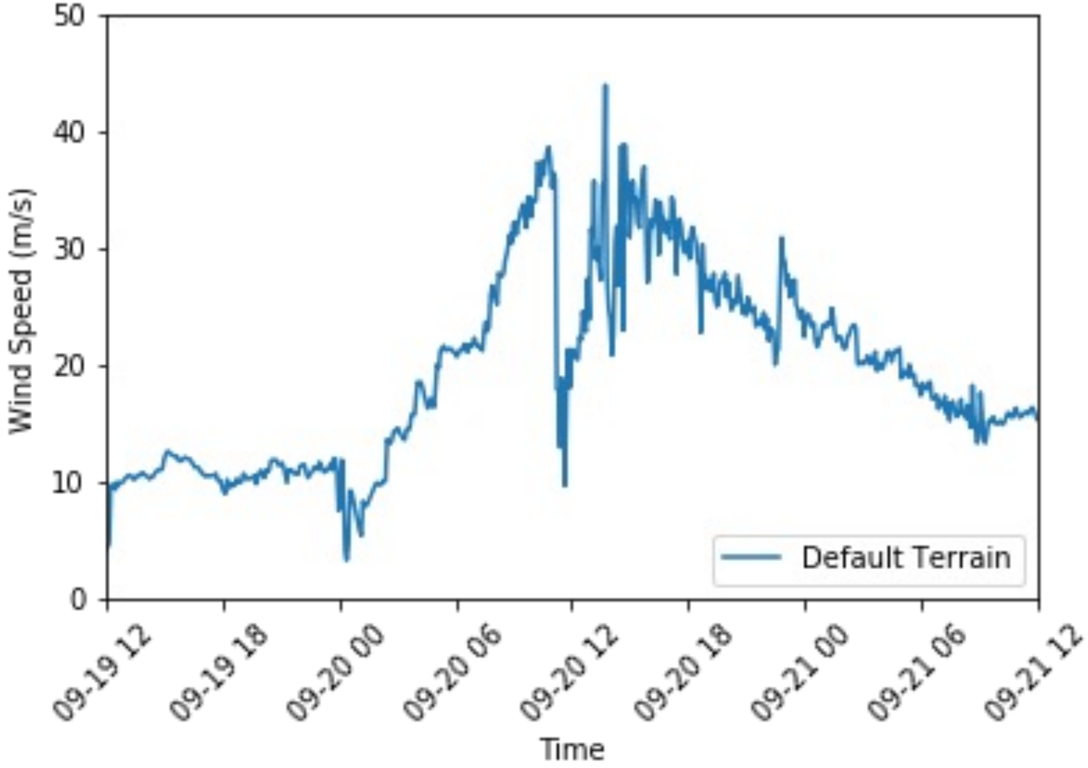
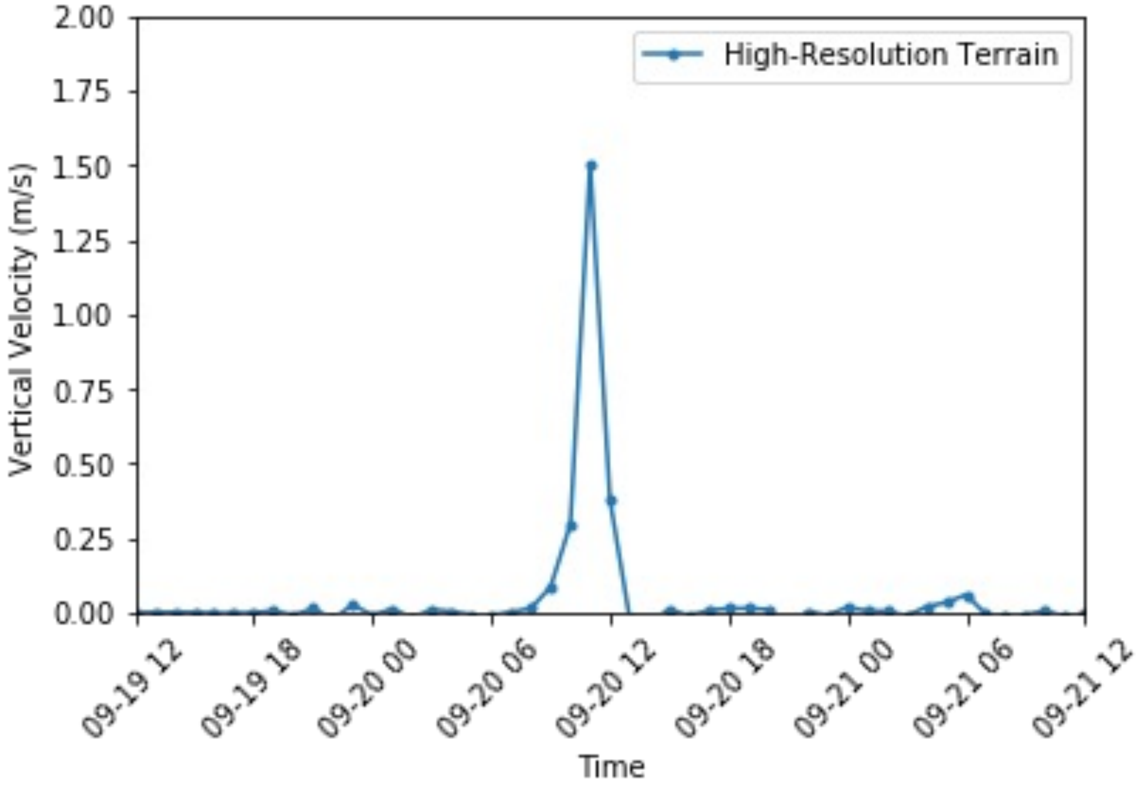


Vertical Velocity

- Time series plots show the magnitude of 40-m vertical velocity for one location of Puerto Rico

High-Resolution Terrain



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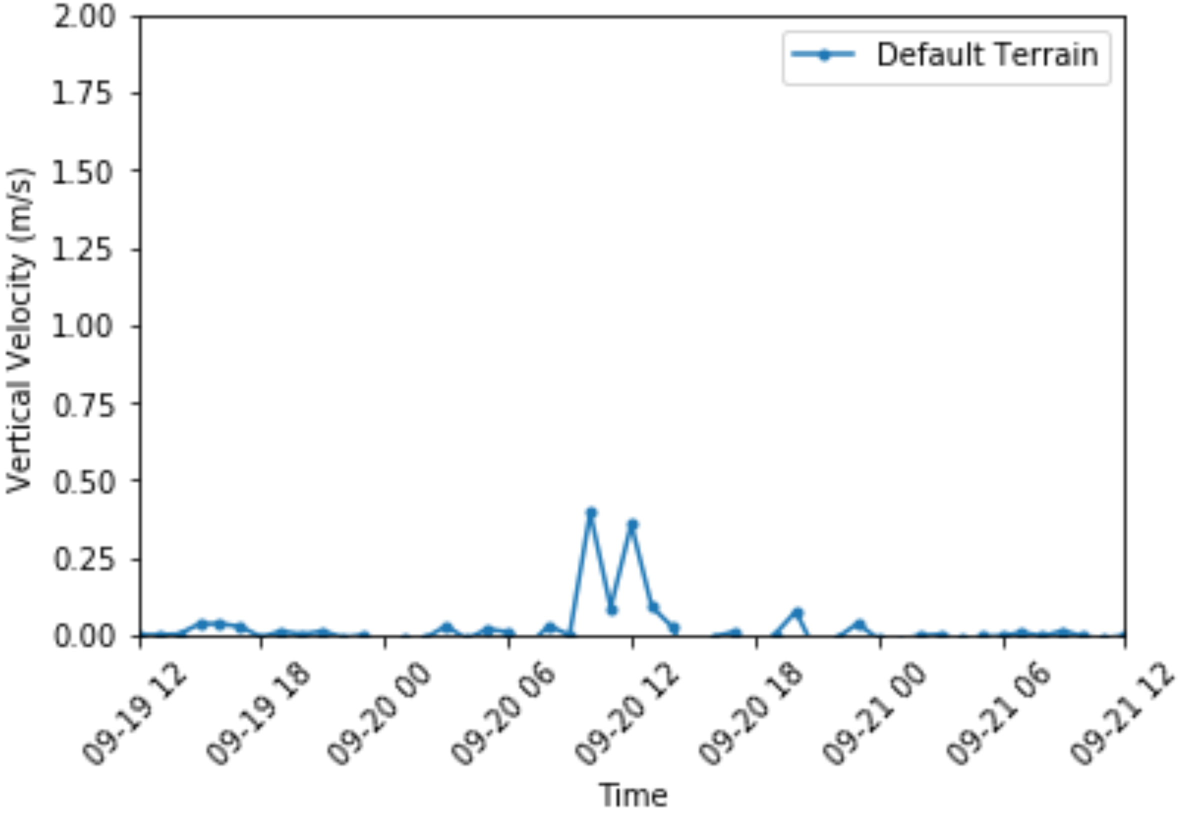
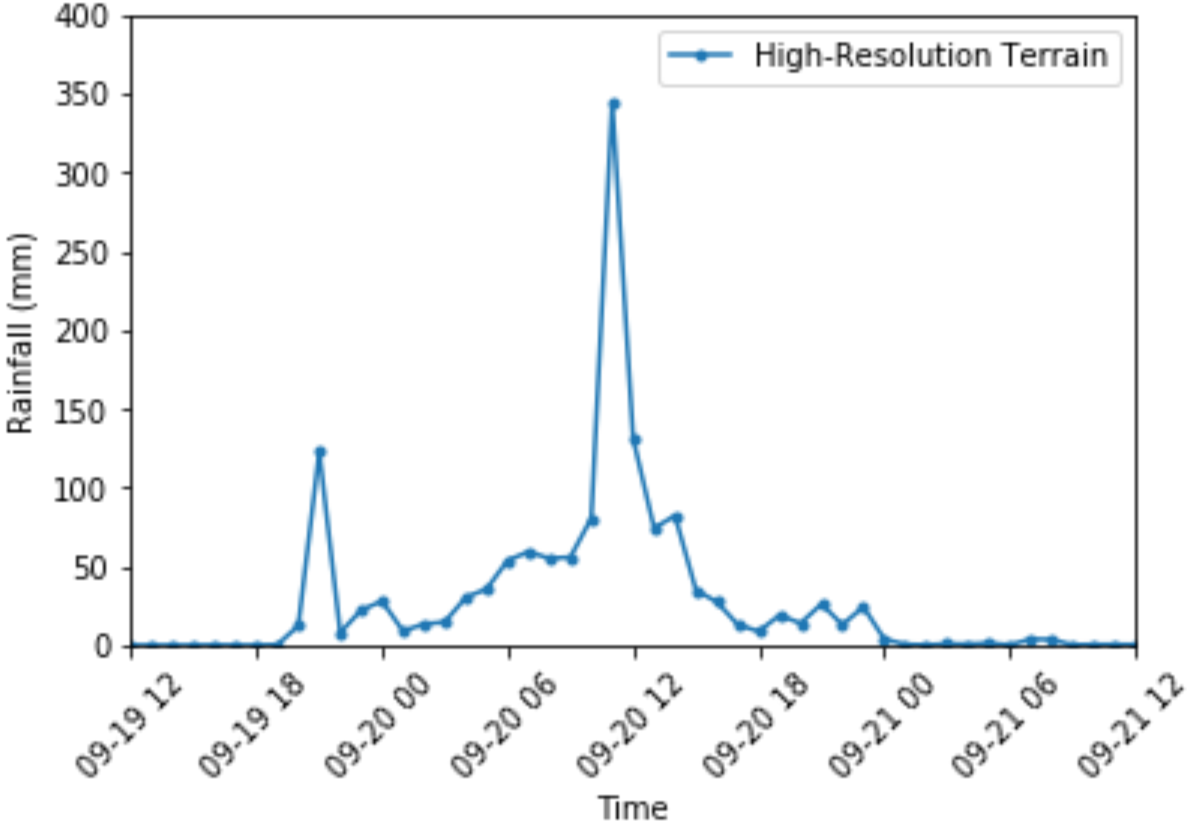


Rainfall

- Time series plots show the accumulated rainfall for one location of Puerto Rico

High-Resolution Terrain



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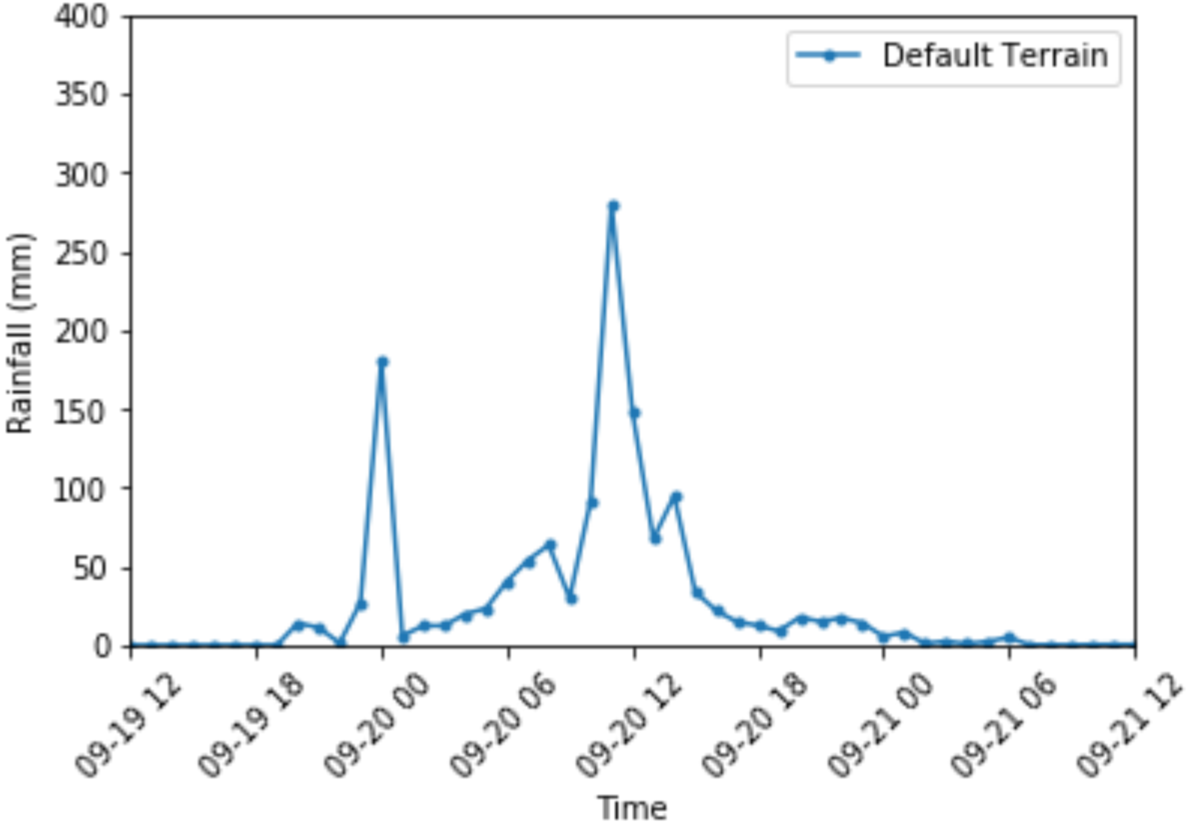
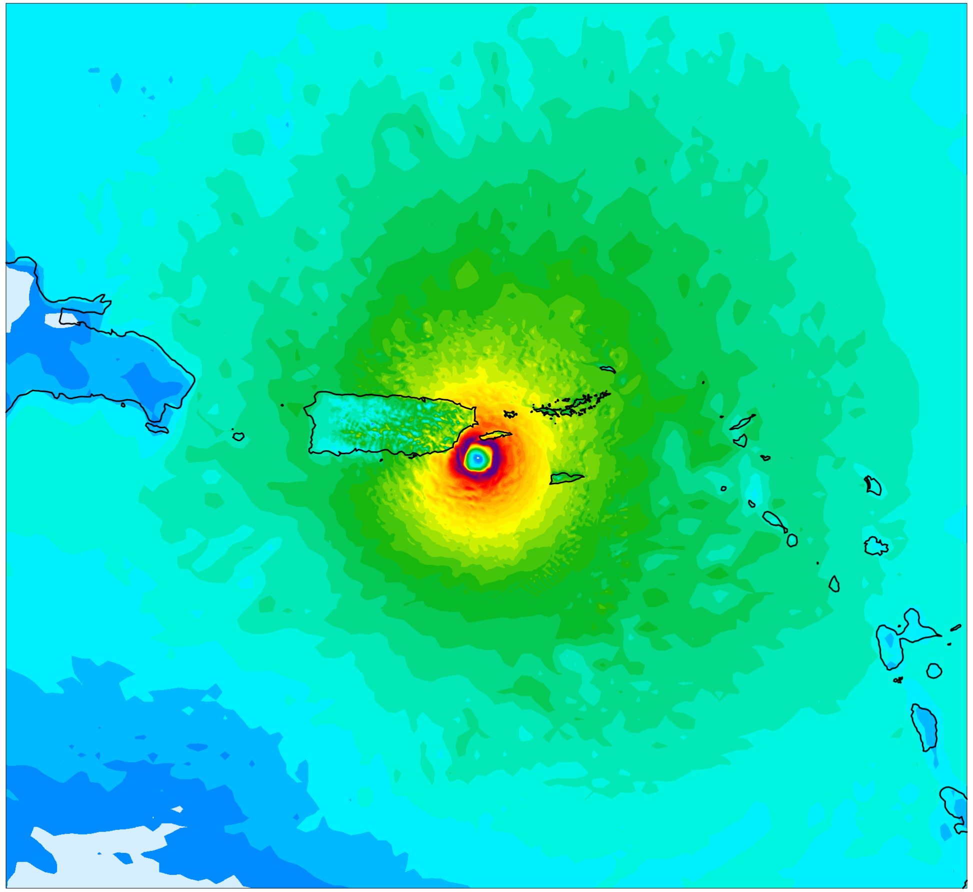


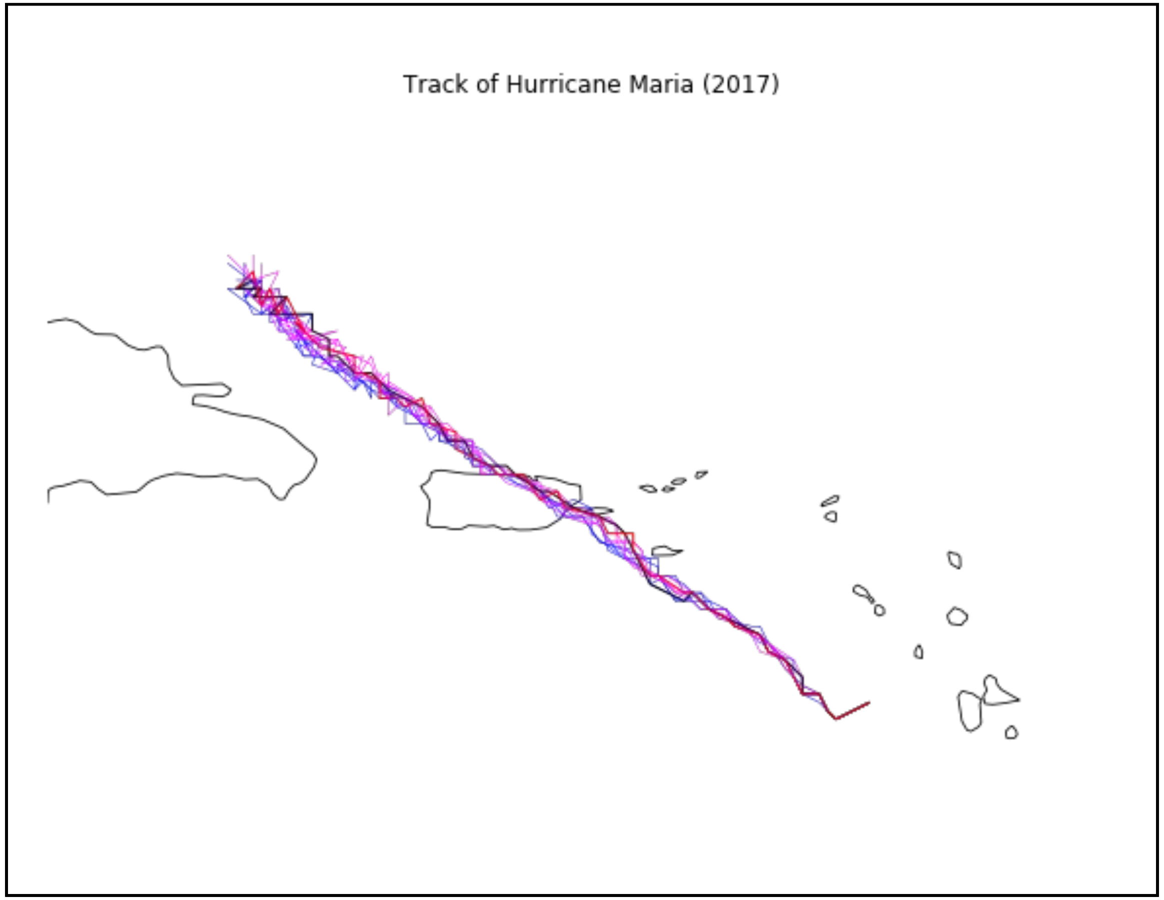
Key Results

When using the high-resolution terrain data we found ***stronger winds***, ***highest accumulation of rainfall***, ***vertical movement of the air*** in the mountainous interior of the island

High-resolution land data has the potential to lead to more accurate forecasts of wind and rain in cases when tropical cyclones interact with a landmass



What is next?



- Stochastic ensemble with for each topography setting
  - The ensemble was generated by stochastically perturbing the water vapor mixing ratio
  - The random perturbations were added only below 950hPa, within all domains

Acknowledgements

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