An Integrated Ocean Platform for Extreme Wave and Weather Early Warning Systems in The Bahamas

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Abstract: Extreme waves along the eastern coastlines of the eastern-most Bahamian islands with direct exposure to the Atlantic Ocean pose serious risks to coastal populations and infrastructure. This is also a problem for other islands throughout the Caribbean Sea. To enhance the predictability of extreme wave (and other weather) events, it is proposed to develop an early warning system that comprises of overlapping in situ and remote sensing observational platforms, numerical models, and artificial intelligence/machine learning methods. Specifically, a network of oceanographic buoys will be deployed in the coastal zone and tuned for the detection of waves with significant wave heights lower than ~ 3 m as the average regional significant wave height is ~2 m. However, buoys cannot be placed at every point of interest, necessitating the usage of high-frequency coastal radar for the observation of waves higher than 3 m, with periods ranging from 5 - 20 seconds, and wavelengths of 50 - 300 m. Despite these platforms allowing for direct measurements, they cannot allow for an examination of wave states before they were deployed, nor peer into the future. To overcome this challenge, a high-resolution wave model ran with the highest resolution bathymetric product available is considered and validated using buoy, coastal radar, and satellite data. However, it is inevitable that vast computational resources will be required not only to run numerical models, but to store and process the data they produce. To reduce this computation cost, artificial and machine learning methodologies are employed. In addition to the forecasting capabilities they provide, additional benefit can be garnered as these make it possible to make more full use of observational and model data to generate physics-informed neural networks (PINNs). It is envisioned that through this project, the basis for a comprehensive atmosphere and ocean monitoring system can be developed alongside the construction of a digital ocean twin for The Bahamas and the Caribbean Sea.