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Estimation of the wave power resource in the Caribbean Sea in areas with scarce instrumentation. Case study: Isla Fuerte, Colombia

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ABSTRACT

There are great difficulties in properly evaluating the power present in waves in the Caribbean Sea due to of the scarcity of marine instrumentation and the reduced length of the existing records. This research aimed to design a new methodology for estimating wave power potential in places lacking instrumentation by using reanalysis wind and wave generation models to generate hourly synthetic wave information (maps and wave series), which was later compared and corrected with nearby buoy measurements. Nested runs of the models allowed the results to be downscaled and detailed wave power maps to be created. The best sites for a possible wave farm could then be identified. These maps were built from the propagation of characteristic sea-states of the synthetic series, and were chosen using joint probability, power percentiles and the k-means clustering algorithms. New series were generated in the chosen locations and processed to determine the wave power potential in different time scales. Isla Fuerte, a small non grid-connected island in the Colombian Caribbean, served as a case study for the implementation of the methodology.

1. Introduction

Wave power presents itself as a clean, reliable source of energy and as a promising alternative for the supply of electricity. Wave power can be especially useful for coastal or island communities, which can take advantage of the fact that this renewable resource is nearby, and avoid the transportation and burning of fossil fuels. There have been a large number of studies to assess wave potential in different parts of the world [1,2], but very few have been conducted in the Caribbean Sea [3]. This is mainly because marine instrumentation in the Caribbean is scarce, and if existent, wave records are only usually available for a very short period of time, insufficient for long term assessment. Furthermore, the existing information is very site-specific, and so there is no wave information for very large extensions of the coastal areas of the Caribbean countries.

Motivated by the possibility of harnessing a clean and renewable resource for power production, this research strives to develop a methodology to assess the wave resource in places with scarce instrumentation in the Caribbean Sea. The methodology encompasses the creation of artificial long term wave records using wave propagation numerical models and local database reanalysis winds, which are later calibrated using the existing instrumentation and finally processed to assess wave power. It also tries to take into account environmental, social and economical variables to identify the best places for potential wave farms, in accordance with the specific requirements that need to be fulfilled in order to harness waves for power generation.

The methodology was applied to evaluate the wave power resource in an area of sea around a small island located in the Colombian Caribbean, Isla Fuerte (Fig. 1). This island has a population of about 2000 habitants, and it is not part of the Colombian National Electric Grid because of its location 11 km from the mainland. As a result of this situation, the habitants are forced to use very expensive fossil fuels for their energy needs, or to use wood from the mangrove forests of the island. As a consequence, both the ecosystems and the economic conditions of the Island are negatively affected. In January 2009 two gas-powered electric generators were installed on the island, and a local grid was set up to provide energy at subsidized prices (90% discount) to the population. As natural gas is costly (prices are about 1UDS/kWh) and transportation to the island is not easy, interest has been expressed

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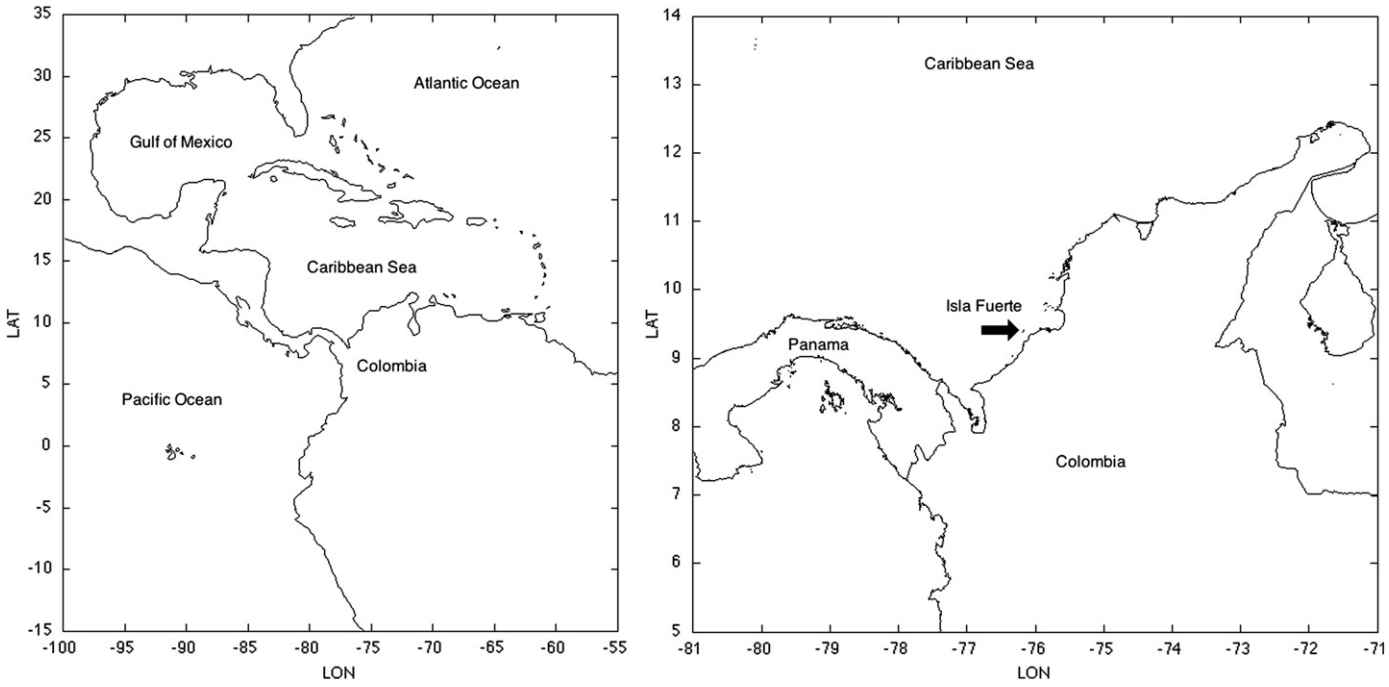

Fig. 1. Location of Isla Fuerte, Colombia.

to complement this power delivery scheme using renewable power sources such as solar and wave power [4].

2. Methodology

The methodology is based on numerical simulations of a third generation wave propagation model that uses bathymetries and reanalysis winds in the Caribbean Sea. It aims to generate spatial and temporal wave information in areas with scarce instrumentation. A scheme of the methodology is presented in Fig. 2.The methodology involves 5 steps, enabling the wave power potential in a previously chosen location to be assessed. Step 1 of the methodology is to run the wave model on an oceanic scale in the Caribbean Sea, and then to downscale the results using nested runs until the desired detailed work scale is obtained. These nested runs provide wave information series near the chosen location. A similar procedure must be done in parallel, aimed at generating wave information at the nearest instrumented location, in order to compare the quality of the synthetic series and to make necessary corrections and calibrations of the model.

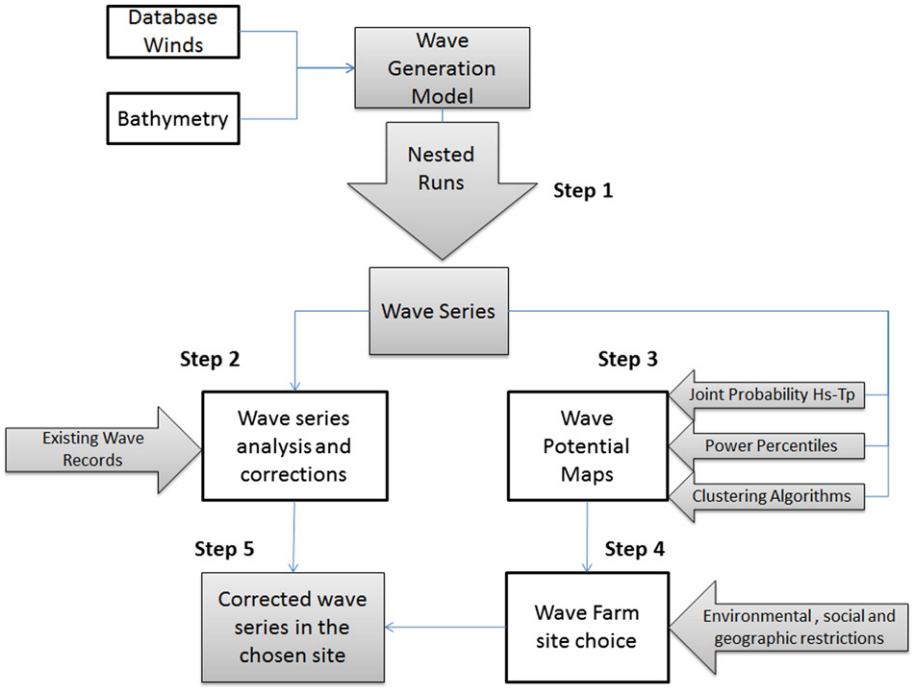

Fig. 2. Methodology.