Approaching the wave energy potential in a coastline section of the Nicoya peninsula

Henry Alfaro Chavarría [1], Georges Govaere Vicarioli[2], Javier Zumbado González[3]

henry.alfaro@ucr.ac.cr [1], georges.govaere@ucr.ac.cr [2], javier.zumbado@ucr.ac.cr [3]
Unidad de Ingeniería Marítima de Ríos y de Estuarios- iMARES,
Instituto de Investigaciones en Ingeniería, Universidad de Costa Rica

Keywords: *Wave energy, Pacific coast, swell downscaling*

INTRODUCTION

Costa Rica is a country that generates about 99% of its energy from renewable sources such as hydroelectric, wind, geothermal, solar power and biomass [6]. In addition, its privileged location provides two additional resources in front of its coastlines: the Caribbean Sea and the Pacific Ocean; being the last one an important source for the generation of wave energy [2].

Figure 1 shows, according to preliminary studies, [2] that the zone with the most theoretical potential available for the generation of wave energy is in the northwest of Nicoya peninsula, in the Pacific Ocean. In this zone, the preliminary study identified subzones, where the wave potential (kW/m), seabed geology, nearby power grid infrastructure, marine protected areas, among others, were taken into account.

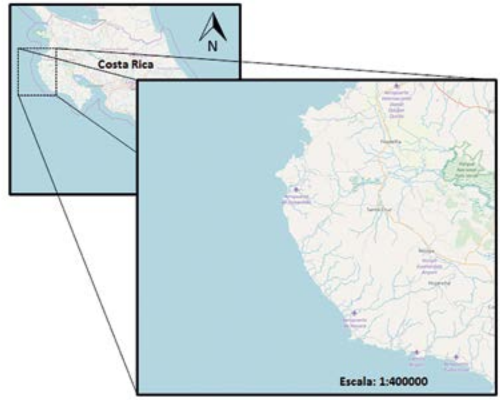

Figure 1. Research zone for the determination of the wave energy potential

The present work aims to generate an additional input to previous studies as well as deepens into the wave energy potential available. To reach this objective, it is projected to apply hybrid downscaling methods which combine numerical and statistics tools, to increase the spatial and temporal resolution in the research zone.

INITIAL DATA

This study, in particular, use different sources of information, such as reanalysis data (wind and wave), satellite measured data (wave), astronomical tide data, and global and local bathymetric surveys.

The wave reanalysis is obtained from the NOAA database, which was generated for the third generation Wavewatch III model [10]. In the study zone, this model uses a grid with a spatial resolution of 0.5° x 0.5°, where relevant wave climate information is obtained for each point of the grid, allowing the characterization of wave climate parameters such as the significant wave height (Hs), wave periods (Tp) and wave direction (Dp). The model has a temporal resolution of 3 hours; besides, and it also has data since 2005 that are constantly updating. The wind information used is magnitude (V) and direction (Dv), which comes from the high-resolution wind reanalysis CFSv2 (Climate Forecast System Version 2) [9]. This reanalysis is generated by the NCEP (National Center for Enviroment Prediction).

Data measured by satellites equipped with altimeter radars issued to calibrate the wave reanalysis. From these satellites the significant wave height can be obtained. The databases for Hs are available from 1991 to 2017. They were generated by several satellites like ESR 1, ESR 2, Envisat, Topex, Poseidon, Jason 1 and Jason 2. The altimetric data were obtained from the “Laboratoire d’Océanographie Physyque et Spatiale” of the French Research Institute IFREMER.

The program TOGA provides the astronomical tide [7] and the General Bathy-metric Chart of the Oceans” (GEBCO) facilitates the global bathymetric information with a 1° spatial resolution, in combination, in available sites, with detailed bathymetric surveys to define shallow areas.

WORK METHODOLOGY

Camus’s methodology [5] is followed quasi-similar way to estimate the wave energy potential in the study zone. The methodology followed is presented in Figure 2.

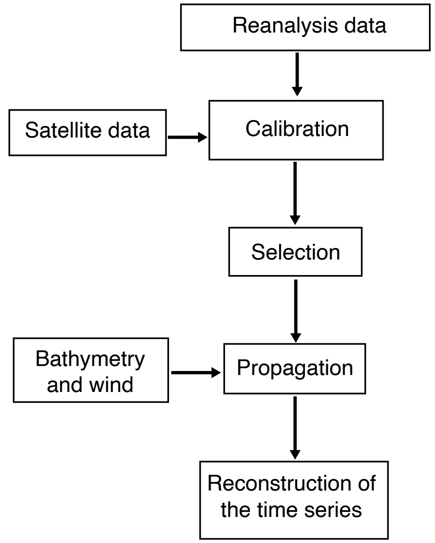

Figure 2. Methodology to estimate the theoretical wave energy potential available

From the wave reanalysis data and with the satellite data [8] the parameter Hs is calibrated. Then applying the maximum dissimilarity algorithm, [3] a selection of representative sea states in deep water is made, in order to spread them into the shallow waters using the waves generation and propagation numeric model SWAN [1]. The SWAN model is forced with the bathymetry, astronomical tide and data from the high-resolution wind reanalysis CFSv2 [9]. To rebuild the time series of Hs, a radial based functions (RBF) [4] interpolation is applied.

RESULTS

Once the wave database is reconstructed in the different points of the SWAN grid, it is possible to estimate the energy potential and the statistics that characterizes it; for example, the average annual energy or the seasonality of the energy throughout the year. Also, among the results, it is expected to produce a series of virtual buoys each kilometer along the 20 m and 50 m depths. Furthermore, by having an increase in the spatial resolution of the surge as a variable, it is possible to obtain climate information of the wave energy potential at different points of the study zone and for different temporal spaces.

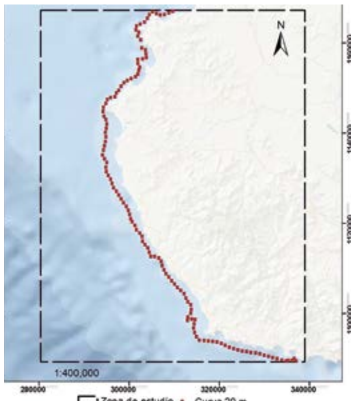

Figure 3. Methodology to estimate the wave energy potential

REFERENCES

[1] Booij, N., Ris, R. C., y Holthuijsen, L. H. (1999). A third generation wave model for coastal regions:1.Model description and validation. Journal of Geophysical Research: Oceans, 104(C4),7649–7666. https://doi.org/10.1029/98JC02622.

[2] Brito & Melo. (2013). Determinación del potencial de energía marina para generación eléctrica.

[3] Camus, P., Mendez, F.J., Medina, R., Cofiño, A.S. (2011a). Analysis of clustering and selection algorithms for the study of multivariate wave climate. Coastal Engineering, 58, 453-462. doi.org/10.1016/j.coastaleng.2011.02.003.

[4] Camus, P., Méndez, F.J., Medina, R., 2011b. A hybrid efficient method to down scale wave climate to coastal areas. Coastal Engineering 58 (9), 851–862. https://doi.org/10.1016/j.coastaleng.2011.05.007.

[5] Camus, P., Mendez, F. J., Medina, R., Tomas, A., & Izaguirre, C. (2013). High resolution downscaled ocean waves (DOW) reanalysis in coastal areas. Coastal Engineering, 72, 56–68. https://doi.org/10.1016/j.coastaleng.2012.09.002.

[6] Centro Nacional de Control de Energía, ICE. (2017). Generación y Demanda. Informe Anual. 2017.

[7] McPhaden M. J., Busalacchi A. J., Cheney R., Donguy J.-R., Gage K. S., Halpern D. y Takeuchi K. (1998). The Tropical Ocean-Global Atmosphere observing system: A decade of progress. Journal of Geophysical Research, 103(C7), 14169–14240. https://doi.org/10.1029/97JC02906.

[8] Mínguez, R., Espejo, A., Tomás, A., Méndez, F. J., y Losada, I. J. (2011). Directional calibration of wave reanalysis databases using instrumental data. Journal of Atmospheric and Oceanic Technology, 28(11), 1466–1485. https://doi.org/10.1175/JTECH-D-11-00008.1

[9] Saha, S., Moorthi, S., Wu, X., Wang, J., Nadiga, S., Tripp, P. y Becker, E. (2014). The NCEP climateforecast system version 2. Journal of Climate, 27(6), 2185–2208. https://doi.org/10.1175/JCLI-D-12-00823.1

[10] Tolman, H. (2002). User manual and system documentation of wavewatch-iii version 2.22. September NOAA/NWS/NCEP Technical Note .