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Wave energy resource assessment for eastern Bay of Bengal and Malacca Strait

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ABSTRACT

Maritime countries are benefited by wave energy resources. There has been some initiatives for assessing the wave resources along the South East Asia (SEA) countries, however among the SEA the coastal regions facing the Indian Ocean are least studied. This study focuses on the estimation of wave energy in the eastern Bay of Bengal and Malacca Strait. Major part of these regions are exposed to swells from the South Indian Ocean and affected by the predominant monsoons, especially the SW monsoon. A third generation wave model has been used to simulate the wind-waves over a domain covering the Indian Ocean, South China Sea and part of the Western Pacific Ocean (20° - 140°E, 60°S - 35°N) during a ten year period (1997–2006). The wave model has been forced with ECMWF re-analysis winds available for every 6 h in 0.75° × 0.75° spatial resolution. The model results have been used to estimate the wave power. Monthly, seasonal and annual mean wave powers are assessed. In addition, inter-annual variability has been analysed and discussed.

1. Introduction

Wind-wave is one of the potential sources of renewable energy in maritime countries; however, the wave energy conversion still remains to be explored in many countries. Ocean wave energy has large potential compared to other renewable energies [1]. Some of the crude estimations show that the wave energy around the world is about 2 TW [2]. Recently, there have been initiatives to assess the wave energy resources at some of the world coasts, and specifically along the South East Asia (SEA) countries. For instance, the wave energy potential in the seas of China was derived based on multi-satellite merged radar altimeter data, and found that wave energy resources are abundant in both offshore and coastal areas of China's seas [3]. The wave energy potential along the east coast of Malaysia facing the South China Sea (SCS), were assessed based on measurements [4] and modelling [5]. Although the available wave power is low (based on measurements), the wave power off the east coast of Peninsular Malaysia is still a potential source of energy [4]. The wave energy off Korea has strong seasonal variabilities [6].

Among the SEA the regions facing the Indian Ocean are yet to be assessed for its wave energy resources. This region covers eastern Bay of Bengal (BoB) and Malacca Strait (MS), and the associated coastal regions are: south and north coasts of Sumatra, west coasts of Malaysia, Thailand and Myanmar and the coasts of Andaman and Nicobar Islands (ANI). Ocean wave energy has not been significantly exploited in these coastal countries/regions. A proper assessment of the wave energy resources along these coasts will contribute to overcome the demand in the energy sector. The present study aims to assess the wave energy resources along the coastal regions of the SEA facing the Indian Ocean.

Long-term wave data is necessary for a proper assessment of wave energy potential desirable areas. In the past, the wave energy assessments were based on *in situ* measurements, which are usually covers short-terms and do not have large-scale information [7]. For site specific studies point measurements are adequate if long-term data is available. Third generation spectral wave models are likely the best tool to predict the long-term waves, with fine temporal and spatial resolutions, in absence of long-term *in situ* and satellite measurements. Earlier studies have assessed the wave energy resources at few locations in the world using parametric and numerical wave models [8–12]. In recent decades, the wave energy potential assessment advanced using third generation spectral wave models. For example, the wave climate at Taiwan were investigated using SWAN model [13], the East China Sea and South China Sea [14] and the east coast of Peninsular Malaysia [5] were studied using WAVEWATCH III model, and the Australian coasts [15] and in the Mediterranean [16] were studied using WAM model. For relatively

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longer periods, a reasonable agreement of the model results compared with measurements could be sufficient for the estimation wave energy, even though extensive calibrations and validations can significantly improve the accuracy of the model results.

IEC TS 62600-101:2015(E) establishes a system for analyzing and estimating the wave energy resource at sites potentially suitable for the installation of Wave Energy Converters (WECs). It recommends a minimum of 10 years of data for the wave energy resource assessment, to avoid the year-to-year variations that heavily influence the estimated results. In this perspective, we have considered a 10 year period (1997–2006) for the estimation of wave energy potential for the eastern BoB and MS. Fig. 1 shows the domain covered in this study and the area of focus. The BoB is in the north Indian Ocean bordering by India and Sri Lanka at the west, Bangladesh at the north, and Myanmar, Thailand, and Sumatra on the east. The Andaman and Nicobar Islands lies in the eastern BoB along with the coastal regions of SEA countries mentioned. The major part of the eastern BoB is also known as Andaman Sea. This region is exposed to the monsoons and swells from the South Indian Ocean. The BoB connects the Malacca Strait at the east. The MS is a narrow, 805 km stretch of the ocean water between the Peninsular Malaysia and the Indonesian island of Sumatra. The MS is bounded by the coastal regions of west peninsular Malaysia, north Sumatra and part of Thailand. The Singapore Strait is at the east of MS, which connects to the South China Sea. Even though relatively sheltered, the MS is exposed to monsoon waves. The prevailing seasons over the study region are classified as: northeast (NE) monsoon (Dec–Mar); pre-monsoon (Apr–May); southwest (SW) monsoon (Jun–Sep) and post-monsoon (Oct–Nov). The terms pre- and post-mentioned here is connected to the SW monsoon.

2. Numerical modelling

Numerical modelling has been carried out to simulate the wind-waves during 1997–2006 over the Indo – Western Pacific domain (Fig. 1a). A third generation spectral wave model, MIKE 21 SW developed by DHI Water & Environment [17] has been used for the model computations. The model takes in to account of the growth, decay and transformation of wind seas and swells and their combined effect [18,19]. This model was utilized by some of the previous studies, e.g., for wind-wave predictions in the Indian Ocean and coastal regions of India [20–31].

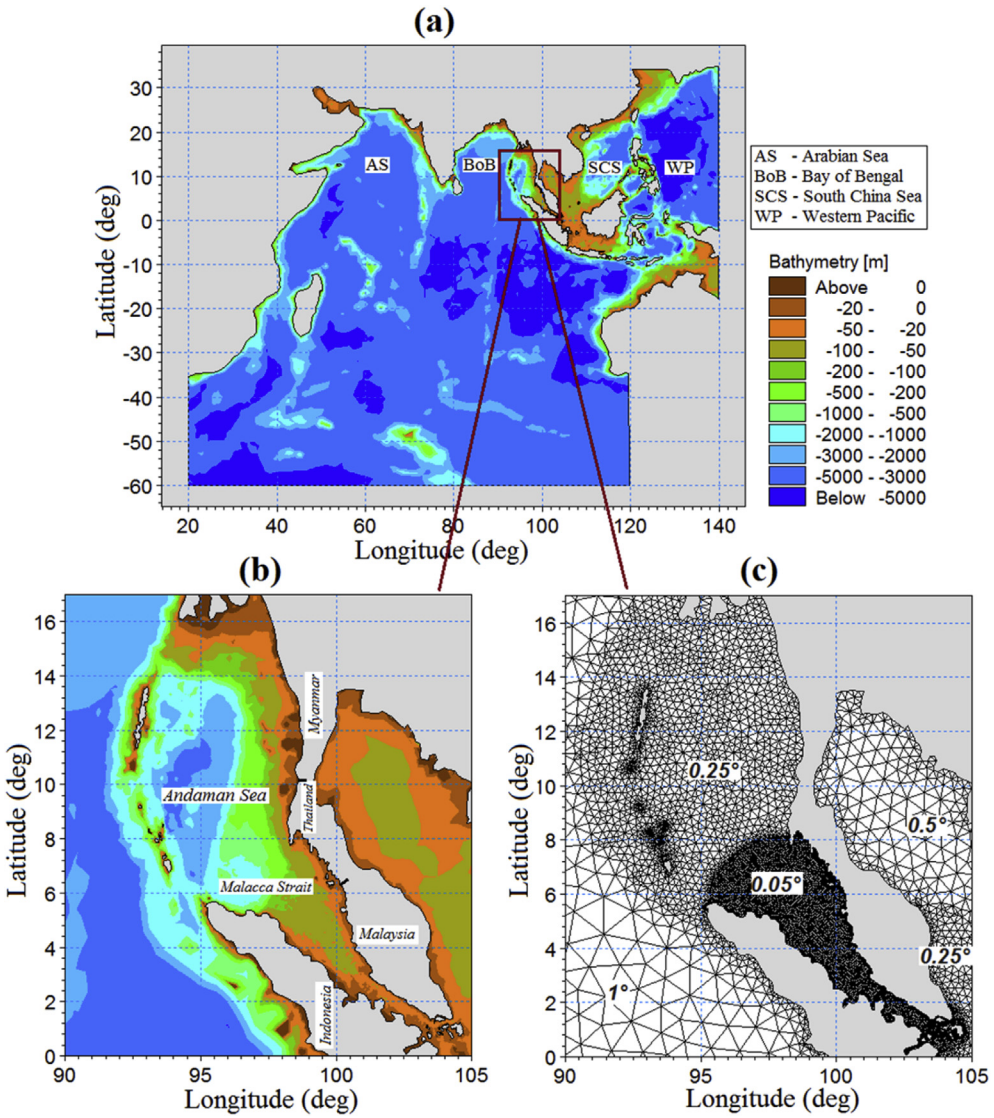

Fig. 1. (a) Domain and bathymetry covering Indian Ocean, South China Sea and part of Western Pacific, (b) Andaman Sea and Malacca Strait (west coasts of Malaysia and Thailand, and north coast of Sumatra region of Indonesia are marked by thin black lines), and (c) flexible mesh over the area of interest.

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