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Spatiotemporal variability of marine renewable energy resources in Norway

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Abstract

Marine Renewable Energy (MRE) resources such as wind and wave energy depend on the complex behaviour of weather and climatic conditions which determine the development of MRE technologies, energy grid, supply and prices. This study investigates the spatiotemporal variability of MRE resources along the Norwegian coast employing NORA10 (NOrwegian ReAnalysis 10 km) data for the period 1957-2016. The results indicate high local mean wind and wave energy resources exceeding 1 kW m^{-2} and 40 kW m^{-1}, respectively. We find that MRE resources undergo a positive trend over time which is attributed to climatic variations of cyclonic distribution, frequency and intensity.

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Keywords: Renewable energy resources; marine energy variability; wind power; wave power; Norway; North Sea; Norwegian Sea; NORA10

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1. Introduction

Rising energy demands worldwide require efficient exploitation of renewable energy resources. It is expected that by 2020, 20% of the European electricity demand will be met by renewable power generation while, by 2030, a substantial proportion of the electricity generation would become largely decarbonised [1]. Notably, based on

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European Union (EU) targets for 2030, the energy consumption from renewable energy resources as a proportion of the total energy consumption is expected to reach 24% [2].

Marine Renewable Energy (MRE) resources such as wind and wave energy could play a key role to achieve this aim. More specifically, offshore areas are characterized by increased energy supply, due to the high intensity of wind and wave conditions [3]. Offshore wind is more intense and steady in time compared to onshore [4]. Additionally, there are available wide-open offshore areas in contrast with the satiated onshore areas for large-scale wind projects [4].

Nevertheless, MRE resources are largely dependent on the weather and climatic conditions. The complex physical processes and dynamical interactions in Earth system make the successful spatiotemporal analysis and prediction of MRE resources a challenging issue. Moreover, it is essential to improve the understanding of MRE resources variability since this can determine the development of MRE technologies as well as energy grid infrastructure, energy supply and energy prices [5,6].

This study envisages characterizing the spatiotemporal variability of MRE resources along the Norwegian coastline focusing on wind and wave energy. Norwegian coastline has been selected as study area due to high MRE resources [7]. This study supports the exploitation of both wind and wave energy plants providing a statistical energy analysis. High resolution wind and wave reanalysis data are employed to quantitatively assess the spatiotemporal variations and the interrelationships between the two MRE resources. As proposed by [8], long-term reanalysis data are usually preferred over data produced by numerical models or satellite retrievals to limit various degrees of uncertainties.

2. Methodology

2.1. Dataset

In this study, wind and wave energy resources are estimated based on 10 offshore points covering a widespread area of Norwegian coast (Fig. 1). Wind and wave data are retrieved by NORA10 (NOrwegian ReAnalysis 10 km) data in horizontal resolution of 10 km every 3 hours for the period from September 1957 to September 2016 [9]. NORA10 is a combined high-resolution atmospheric downscaling and wave hindcast over the northern Atlantic Ocean implemented by the Norwegian Meteorological Institute. This is a downscaling of ERA-40 reanalysis data (until 2002) and ECMWF IFS operational analyses (after 2002) with HIRLAM model [9,10]. The wave component is based on WAM model forced by HIRLAM surface wind fields. Wind and wave data of NORA10 have been evaluated against observations presenting a good agreement [9,10].

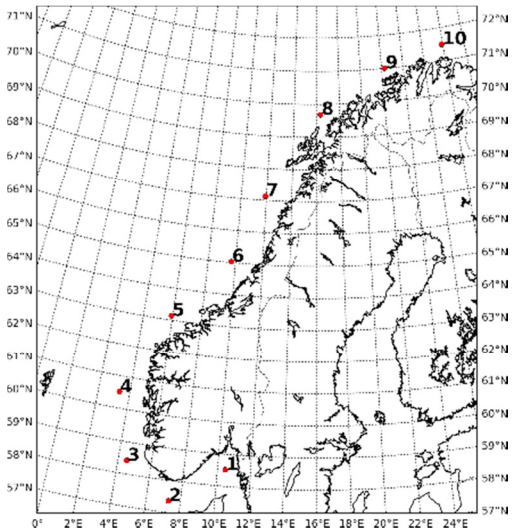

Fig. 1. Selected offshore points (1-10) along the Norwegian coastline