ARTIFICIAL INTELLIGENCE

DM630/MESPAC S.r.l. - Advanced methods for processing and improving metocean variables from remote, in-situ and numerical sources

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Context of the research activity	This research focuses on developing advanced bias correction techniques and algorithms for metocean variables, (e.g. wave and wind), obtained from earth observation satellites, reanalysis numerical models, and in-situ instruments. The aim is to enhance the accuracy of these data to improve the performance assessment of offshore energy converters and the design of mooring systems under various operational and survivability conditions. The study includes correlating the accuracy of remote sensing data with environmental conditions and conducting co-location analysis for cross-calibration and accuracy quantification. Progetto finanziato dal PNRR a valere sul DM 630/2024 - CUP: E14D24002330004

	The increasing global demand for sustainable energy sources has spurred the development of offshore renewable energy technologies, such as floating offshore wind turbines and wave energy converters. These technologies are critical for meeting ambitious decarbonization targets set by various international bodies, including the European Union. The performance and reliability of these offshore energy systems are highly dependent on accurate metocean data, which describe the meteorological and oceanographic conditions at a given location. Metocean data are typically obtained from three primary sources: - Earth Observation Satellites: These provide extensive spatial coverage and are instrumental in monitoring large areas of the ocean surface. However, satellite data can be affected by factors such as distance from shore,

Objectives	orography, and varying sea and wind states, impacting their accuracy. - Reanalysis Numerical Models: These models integrate past observations with physical principles to provide continuous datasets of historical weather and ocean conditions. Despite their comprehensive nature, they often require calibration to correct inherent biases and inaccuracies. - In-Situ Instruments: These are deployed directly in the ocean and provide high-fidelity data at specific locations. Instruments such as buoys, Acoustic Doppler Current Profilers (ADCPs), and wave radars are examples. While highly accurate, their spatial coverage is limited. Combining data from these sources can significantly enhance the understanding and prediction of metocean conditions, thereby improving the design and operational strategies for offshore renewable energy systems. However, discrepancies and biases among these data sources must be addressed to achieve reliable and accurate datasets. The primary objective of this research is to develop and implement advanced methods for processing and improving metocean variables obtained from remote, in-situ, and numerical sources. This involves several key goals: Bias Correction Techniques: - Develop and implement novel bias correction methods to enhance the accuracy of metocean data from satellites, reanalysis models, and in-situ measurements. - Apply these techniques to wave and wind data, crucial for assessing the performance and reliability of offshore energy converters. Performance Assessment of Offshore Energy Converters: - Use the improved metocean datasets to conduct detailed performance assessments of floating offshore wind turbines and wave energy converters. - Evaluate how corrected data influence the accuracy of performance metrics and operational strategies under various sea and wind conditions. Design of Mooring Systems: - Utilize the enhanced data to improve the design of mooring systems for offshore structures, ensuring they can withstand operational and survivability conditions. - Focus on determining more reliable Design Load Cases (DLCs), which are critical for the structural integrity and longevity of offshore installations. Accuracy Correlation and Co-Location Analysis: - Investigate the correlation between the accuracy of satellite data and environmental conditions, such as distance from shore, orography, and sea/wind states. - Perform co-location analysis, which involves comparing data from different sources at the same time and location to cross-calibrate and quantify the accuracy of each source. Development of Integrated Datasets: - Create integrated datasets that combine corrected data from satellites, reanalysis models, and in-situ measurements. - Ensure these datasets are robust, reliable, and suitable for various applications in offshore renewable energy.

	Implementation of Machine Learning Algorithms: - Employ advanced machine learning algorithms to enhance the interpolation and prediction of metocean variables, especially where data gaps exist. - Apply novel algorithms to reconstruct the full column of wind profile, starting from measurements close to sea level. By achieving these objectives, the research aims to provide a significant contribution to the field of offshore renewable energy. The improved accuracy and reliability of metocean data will: - Enhance the performance and safety of offshore energy systems. - Reduce the risks and uncertainties associated with the design and operation of these systems. - Contribute to the overall goal of increasing the deployment and efficiency of renewable energy sources, thereby supporting global efforts towards a more sustainable energy future. Moreover, the methodologies developed in this research can be applied to other areas of ocean engineering and environmental monitoring, showcasing the broader impact and utility of the work beyond the immediate focus on renewable energy. This research is performed in collaboration with the company MESPAC s.r.l., which is a start-up working on developing innovative gap-filling artificial intelligence algorithms applied to metocean variables for offshore renewable energy. Moreover, international collaboration with European Universities, most likely with Mondragón University and/or Aaborg University.

Skills and competencies for the development of the activity	The ideal candidate should have a background in renewable energy systems and/or oceanography. Proficiency in data analysis and numerical modeling is beneficial. Experience with satellite data processing and/or in-situ instrumentation and/or bias correction methods is desirable. The candidate should possess strong analytical skills, attention to detail, and the ability to work independently and collaboratively in an interdisciplinary and international research environment.