Deep Learning-Generated Energy Spectra streamlining Downscaled Coastal Wave Modeling

In coastal wave modeling, the accurate representation of wave spectral energy at the lateral open boundaries is crucial for simulating realistic wave conditions within downscaled limited-area coastal and nearshore domains. However, obtaining full energy spectra from parent models often poses computational and storage challenges due to their demanding nature. For these reasons, most of the state-of-the-art data provider services for operational forecasting (e.g., CMEMS) do not provide such data but only statistical wave parameters (e.g., significant wave height and mean wave period and mean wave direction). Additionally, the timing of generating these spectra is critical as the parent model must be run beforehand, leading to potential delays in the modeling forecasting chains. In this paper, we propose a novel approach utilizing AI techniques to produce spectral energy data for open boundary forcing in downscaled coastal wave models. By employing deep learning, our method reduces computational and storage requirements, ensuring timely availability of spectral data, without dependency on parent model runs. The method avoids the need for empirical spectral reconstruction at the boundary, thereby enhancing the quality of boundary-driven areas, particularly significant for small domains ad coastal applications. Through numerical experiments and validation in Mediterranean Sea, we demonstrate the effectiveness and efficiency of our proposed AI-based approach in improving the accuracy and reliability of downscaled coastal wave modeling for forecasting purpose.

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