Improving Efficiency and Accuracy of WAVEWATCH III on Unstructured Grids

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The ocean wave model WAVEWATCH III has been known for its capabilities in large scale applications both in operation and academia. The model robustness and stability has been proved by many studies as a result of the implemented explicit schemes for the equation solvers. Moreover, the conventional card-deck parallel decomposition for single grid and mosaic grid decomposition algorithm for multi-grids, embedded in the model makes it scalable on HPC environments within operational forecast systems. The model offers a variety of options from grid types and physical packages to coupling compatibility with atmospheric and ocean circulation models.

However, this mode is comparably expensive compared to hydrodynamic models due to the nature of spectral wave models, requiring improvement in the performance to catch the counterparts and resolve nearshore physics, where most of wave actions are taking place. Moreover, there are a couple of limitations for the unstructured meshes including minimum grid resolution (~200 m), maximum number of model grid (~2M) and computational scalability (720 computational cores).

To tackle the aforementioned issues, a new domain decomposition algorithm, based on parallel graph partitioning algorithm [1] has been implemented equipped with an implicit Residual Distribution (RD) schemes in geographical space in combination with simple 1st order upwind schemes in spectral space and linearized source terms solved implicit in time. The implicit scheme solves all propagation dimensions without any splitting between the various dimensions using block Gauss-Seidel solver for source term, avoiding splitting errors in fractional step method. These options empower us to increase nearshore resolution and the number of grid nodes, leading to better representation of such complicated geometry, without loosing computational efficiency [2].

In these regards, the new developments are first tested for Boers 1996 laboratory experiment [3] considering depth breaking and triad interactions on structured and unstructured grids with different decomposition and solver options. Then, the model is used to reconstruct a major hurricanes (i.e. Ike 2008 [2], Irma 2011 [4], Sandy 2012 [5]) on large scale numerical domains, covering the east coast of the US from generation zone to landfall locations. The validation is done against satellite altimeter data and in-situ measurements at offshore NDBC buoy and nearshore USACE gauges at Duck, NC.

The validation results for the laboratory cases show identical results between implicit and explicit methods on unstructured grids and structured grid. For the realistic case, different configurations result in identical performance in deep water and superior results from implicit scheme in nearshore region where structured grid is not able to resolve the coastline and geographical features properly.

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