ADVANCES IN UNSTRUCTURED WAVEWATCH III AND APPLICATIONS TO NEARSHORE WAVES

Jane McKee Smith, US Army Engineer Research and Development Center (ERDC), jane.m.smith@usace.army.mil
Tyler J. Hesser, US Army ERDC, tyler.j.hesser@usace.army.mil
Ali Abdolali, NOAA, NCEP, Environmental Modeling Center, ali.abdolali@noaa.gov
Mary Anderson Bryant, US Army ERDC, mary.a.bryant@usace.army.mil
Aron Roland, BGS IT&E GmbH, aaronroland@gmx.de

ADVANCES IN WAVEWATCH III

The spectral wave generation and propagation model WAVEWATCH III (WW3) (WW3DG 2019) is undergoing rapid community development to extend capability and nearshore modeling applicability. An option for unstructured grids and implicit solution provides WW3 with the flexibility and efficiency to resolve complex shorelines and high-gradient wave zones to drive nearshore circulation, wave setup, and wave-driven sediment transport with multi-scale spatial coverage over approximately three orders of magnitude. A hybrid approach to parallelization uses spectral partitioning for advection in geographical space and domain decomposition for spectral advection and the source term integration. The advection part of wave action equation is integrated fully implicitly, and a new convergent action limiter derived from Komen et al. (1994) and Hersbach and Janssen (1999) is applied. The model is compatible with community-based coupling infrastructure to facilitate two-way coupling with circulation models for simulating hurricane storm surge and waves. Abdolali et al. (2020) evaluated WW3 enhancements on a large-scale numerical domain employing the new parallelization algorithm and implicit solver for unstructured grids and compared to the existing parallelization algorithm, domain decomposition, and robust explicit numerical solver of WW3 on both structured and unstructured grids. These new capabilities in the wave model push the limitations of the model, including minimum resolution (10s of meters), maximum number of model grid points (~2 million), and computational scalability, as well as better accuracy in contrast to the explicit scheme. This paper describes model enhancements and validation.

NATURAL AND NATURE-BASED FEATURES (NNBF)

Modeling wave transformation and attenuation afforded by NNBF structures requires flexible gridding for complex coastal and estuarine shorelines, dissipation source terms for complex structures (reefs) and vegetation, and regional or system-scale coverage. Unstructured WW3 is modified for wave dissipations due to vegetation and applied to investigate wave dissipation in wetlands systems. Comparisons with field data in a Chesapeake Bay wetland are used to evaluate model performance (Fig. 1). Changes in wave energy reduction due to elevated water levels resulting from storm surge are evaluated.

COASTAL MODEL TESTBED (CMTB)

The Coastal Model Test Bed is a framework established at the ERDC Field Research Facility (FRF) on the coast of North Carolina, USA, to assess model errors and uncertainty over a wide range of forcing conditions over long duration. The CMTB applies a cross-shore array of wind, wave, current, and water level measurements along with monthly bathymetry surveys to set up and evaluate coastal models. WW3 is implemented in the CMTB and evaluated for conditions spanning intense extratropic storms, hurricanes, swell conditions, and mixed sea-swell conditions. Fig. 2 shows example results from the CMTB for H. Sandy and Irene and a March 2018 storm for water depths from 17 to 2 m.

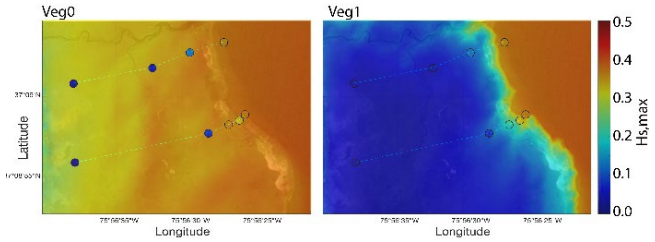

Figure 1 - Wave model sensitivity to wave-vegetation interaction: spatial distribution of significant wave height without (left) and with (right) wave-vegetation interaction (observed maximum values at wave gauge locations shown in circles).

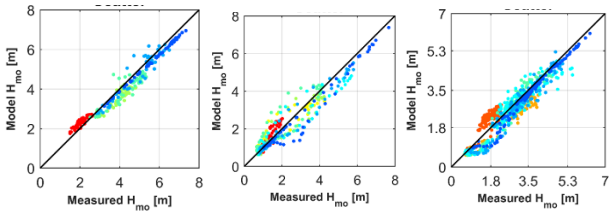

Figure 2 - WW3 evaluation for Hurricanes Sandy and Irene and a March 2018 extratropical storm (shallow (red) to intermediate (blue) depth gauges).

CONCLUSIONS

The enhanced unstructured/implicit WW3 allows combined large-scale wave generation and nearshore transformation for basin to regional to local application. WW3 is being integrated into the Coastal STORM Modeling System with linkages to Corps of Engineers circulation and sediment transport models.

REFERENCES

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