ADVANCES IN THE UNSTRUCTURED WAVEWATCH III AND APPLICATION TO HURRICANE DORIAN

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WAVEWATCH III ADVANCEMENTS

The spectral wave generation and propagation model WAVEWATCH III (WW3) (WW3DG 2019) is undergoing rapid development to extend capability and 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 involves 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. Block-Jacobi and Block-Gauss-Seidel solvers are applied with improved convergence. 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 the application of WW3 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. The new numerical scheme shows better accuracy with respect to the statistics in contrast to the explicit scheme. This study extends the WW3 validation to Hurricane Dorian (2019), including deepwater buoys on the US south Atlantic coast and nearshore gauges at the US Army Corps of Engineers, Coastal and Hydraulics Laboratory, Field Research Facility (FRF) in Duck, North Carolina, USA.

HURRICANE DORIAN

Hurricane Dorian impacted the Bahamas as a Category 5 storm, with maximum one-minute sustained winds of 295 km/h and minimum central pressure of 910 millibars on 1 September 2019. Dorian threatened landfall in Florida prior to turning north, parallel to the US east coast, reducing in intensity, and making landfall at Cape Hatteras, NC, as a Category 1 storm on 6 September. Dorian transitioned to an extratropical storm before making landfall in Nova Scotia and then Newfoundland, Canada, with hurricane force winds on 8 September. Dorian is tied with the 1935 Labor Day Hurricane as the strongest land-falling hurricane in the Atlantic. The Bahamas were devastated by Dorian, receiving approximately $7 bill (USD) in damages.

The progression of the storm along the US coastline is reflected in buoy measurements with peak water heights exceeding 8 m off Cape Canaveral, FL. Offshore of the FRF, wave height peaked at 6.8 m (26-m water depth). The wave transformation and decay was captured by the FRF cross-shore arrays of wave gauges (buoys, ADCPs, and pressure gauges) at depths of 17, 11, 8, 4.5, 3.5, 2 m).

CONCLUSIONS

The unstructured grid and nesting capabilities of WW3 allow combined basin wave generation and nearshore transformation for large regions. Present plans are to integrate WW3 into the Coastal STORM modeling system with linkages to Corps of Engineers circulation and sediment transport models.

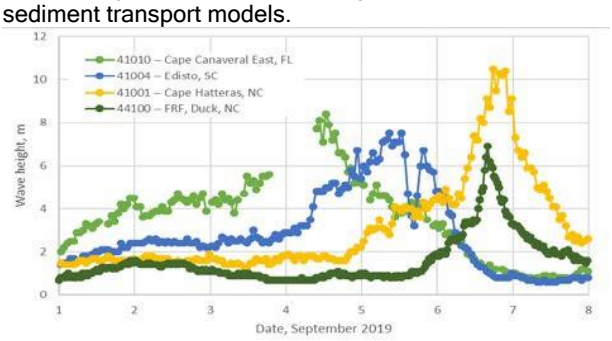

Figure 1 - Buoy measurements along the south Atlantic coast during Hurricane Dorian.

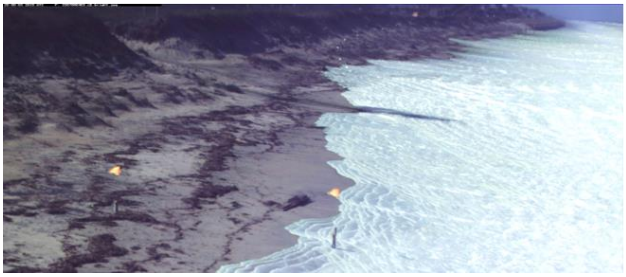

Figure 2 - Runup at the FRF during Hurricane Dorian.

REFERENCES

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