Coupled atmosphere-wave-ocean simulation of Hurricane Dorian from August 29 to September 7, 2019

Website: https://www.bco-dmo.org/dataset/888783
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Project
» Collaborative Research: RAPID: Storm and tropical cyclone effects on the spawning activity, larval dispersal, and ecosystem impacts of an endangered marine predator (Storm effect on predator)

Contributors	Affiliation	Role
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Abstract
This dataset provides the output of the coupled atmosphere-wave-ocean simulation of Hurricane Dorian from August 29 to September 7, 2019. Hurricane Dorian was a major Atlantic hurricane that affected most of the southwest part of the North Atlantic Ocean. The simulation is a composite of two separate simulations: 1) from 00 UTC August 29 to 00 UTC September 1, 2019; and 2) from 00 UTC September 1 to 00 UTC September 7, 2019. The first simulation serves as a "spin-up" for the hurricane and its environment prior to landfall. The second simulation is initialized from the output of the first simulation, while relocating the Dorian vortex to its correct position on September 1. Due to the size of the dataset, only the surface fields are made available. The coupled model used to produce the simulation consists of the Weather Resarch and Forecasting (WRF) model for the atmosphere, the Univesity of Miami Wave Model (UMWM) for the ocean surface waves, and the HYbrid Coordinate Ocean Model (HYCOM) for the ocean circulation. The purpose of the simulation is to improve our understanding of hurricane impacts on ocean surface waves, circulation, and surge near landfall, and consequent impacts on the spawning and dispersal of goliath grouper. The simulation was produced and analyzed by Claire Paris-Limouzy, Milan Curcic, and Ana Vaz at the University of Miami.

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Coverage

Spatial Extent: **N**:34 **E**:-65 **S**:18 **W**:-82
Temporal Extent: 2019-08-29 - 2019-09-07

Methods & Sampling

Model description
Atmosphere: Weather Research and Forecasting (WRF, https://github.com/wrf-model/WRF) model v4.2.2, with the Advanced Research WRF (ARW) dynamical core. The model has a 3-km resolution grid over the parent domain and a 1-km resolution nest over the Bahamas region (September 1-7 only), both with 45 vertical

layers. Initial and boundary conditions are based on 6-hourly ERA-5 dataset.

Ocean Waves: University of Miami Wave Model (UMWM, https://umwm.org). The model is configured at the same 3-km as the atmosphere model, and has 36 directional bins and 37 frequency bins that are logarithmically spaced from 0.0313 to 2 Hz.

Ocean Circulation: HYbrid Coordinate Ocean Model (HYCOM, https://github.com/HYCOM) v2.3.01, configured at 0.01-degree resolution and 41 vertical layers. Initial and boundary conditions are based on daily GOFS 3.1 41-layer HYCOM + NCODA Global 1/12° Analysis, daily. K-Profile Parameterization for vertical mixing.

Coupling: Earth System Modeling Framework (ESMF, https://github.com/esmf-org/esmf) v8.0.1

Coupling interface: Earth System Modeling Framework (ESMF, v8.0.0, https://github.com/esmf-org/esmf) is a software framework that facilitates data exchange and regridding between model components.

Coupled model implementation: The coupling of the atmosphere, ocean waves, and ocean circulation model components is done by implementing model component-specific interfaces using ESMF (the coupling framework). The implementation is largely based on the set of equations described in Curcic (2015). In a nutshell, the coupled model advances each model component by one or more time steps. Each model component may have different time steps. In the case of this simulation, WRF and UMWM were configured with 15-s time steps, while HYCOM was configured with a 5-s time step. Thus, for each of the WRF and UMWM time steps, HYCOM advances for three time steps. Once all three model components are co-located in time, the coupling interface performs the exchange of fields between the model components. WRF passes the horizontal components of 10-m wind vector and air density to UMWM, and radiative and enthalpy fluxes and precipitation to HYCOM. UMWM passes wave growth stress vector to WRF and wave-dissipative stress to HYCOM. Finally, HYCOM passes sea surface temperature and surface current to WRF, and surface current and water density to UMWM. Each model component then updates its model state with the coupling fields that it received from other components. The interpolation of fields between model grids is conservative and performed in parallel by ESMF using a sparse matrix multiplication-based algorithm.

Data Processing Description

Each model component outputs a NetCDF file for each output snapshot. We read the individual component output files and combined them into a post-processed summary output file.

BCO-DMO Processing Description:
- Adjusted field/parameter names to comply with BCO-DMO naming conventions
- Missing data identifier 'NaN' replaced with 'blank' (BCO-DMO's default missing data identifier)

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Related Publications

Chassignet, E. P., Hurlburt, H. E., Smedstad, O. M., Halliwell, G. R., Hogan, P. J., Wallcraft, A. J., Baraille, R., & Bleck, R. (2007). The HYCOM (HYbrid Coordinate Ocean Model) data assimilative system. Journal of Marine Systems, 65(1–4), 60–83. https://doi.org/10.1016/j.jmarsys.2005.09.016
Methods

Curcic, M., 2015. Explicit air-sea momentum exchange in coupled atmosphere-wave-ocean modeling of tropical cyclones. University of Miami.
Methods

Donelan, M. A., Curcic, M., Chen, S. S., & Magnusson, A. K. (2012). Modeling waves and wind stress. Journal of Geophysical Research: Oceans, 117(C11), n/a-n/a. Portico. https://doi.org/10.1029/2011jc007787
https://doi.org/10.1029/2011JC007787
Methods

Hill, C., DeLuca, C., Balaji, Suarez, M., & Da Silva, A. (2004). The architecture of the earth system modeling framework. Computing in Science & Engineering, 6(1), 18–28. https://doi.org/10.1109/mcise.2004.1255817
https://doi.org/10.1109/MCISE.2004.1255817
Methods

Powers, J. G., Klemp, J. B., Skamarock, W. C., Davis, C. A., Dudhia, J., Gill, D. O., Coen, J. L., Gochis, D. J., Ahmadov, R., Peckham, S. E., Grell, G. A., Michalakes, J., Trahan, S., Benjamin, S. G., Alexander, C. R., Dimego, G. J., Wang, W., Schwartz, C. S., Romine, G. S., … Duda, M. G. (2017). The Weather Research and Forecasting Model: Overview, System Efforts, and Future Directions. Bulletin of the American Meteorological Society, 98(8), 1717–1737. https://doi.org/10.1175/bams-d-15-00308.1 https://doi.org/10.1175/BAMS-D-15-00308.1
Methods

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Parameters

Parameters for this dataset have not yet been identified

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Project Information

Collaborative Research: RAPID: Storm and tropical cyclone effects on the spawning activity, larval dispersal, and ecosystem impacts of an endangered marine predator (Storm effect on predator)

Coverage: Jupiter, Florida; and Bahamas

NSF Award Abstract:

Many species of reef fish form large seasonal gatherings at specific locations to spawn. Such aggregations may lead to population overfishing if not well managed. Additionally, spawning aggregations in shallow coastal areas may also be susceptible to prolonged surge, high volumes of freshwater run-off and potentially changes in salinity associated with large storms and tropical cyclones. Yet, the impact from such events, which are becoming increasingly prevalent, has not been studied. This study investigates the impacts of hurricane Dorian on spawning activity of the endangered goliath grouper (Epinephelus itajara) fish species off the southeast coast of Florida. The broader impacts of the project relate to its value to inform fisheries management plans for goliath grouper. The project supports two early career faculty members and training of a postdoctoral researcher, a graduate student, and several undergraduate students at Florida International University.

Hurricane Dorian occurred at the peak of goliath grouper's spawning aggregation in Florida's shallow waters. This project takes advantage of ongoing acoustic surveys since 2017, telemetry, biophysical modelling, and behavioral studies of goliath grouper at spawning sites to assess how hurricane Dorian: 1) influenced the duration of spawning events and the size of aggregations, 2) affected individual residency to spawning sites and spawning behavior, 3) changed the dispersal patterns of goliath grouper larvae and identify nursery habitats with/without storm or hurricane events, and 4) influenced trophic cascades at the reef ecosystem level due to goliath grouper spawning aggregations as determined by changes on lower trophic level foraging rates and the subsequent changes to the benthos. The combination of methods provide insight into how storms affects spawning behavior from the individual to the group level, and how subsequent larval recruitment may be influenced. Finally, this project tests the utility of acceleration sensors for identifying spawning behavior in free ranging fishes, which will be of major significance to spawning studies across taxa.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2006295

Funding Source	Award

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