Unified Wave INterface - Coupled Model (UWIN-CM)

This document provides a brief description of the Unified Wave INterface - Coupled Model (UWIN-CM) and its components.

Description

UWIN-CM (Curcic et al., 2016; Chen and Curcic, 2016) is a fully coupled atmosphere-wave-ocean modeling system, originally developed at the University of Miami and currently maintained at the University of Washington. It consists of a unified coupler that is compatible with interchangeable atmosphere, wave, and ocean model components. The coupler includes the facilities for interpolation of fields between arbitrary grids, coupling physics, and parallel execution, and is based on the Earth System Modeling Framework (ESMF, Hill et al., 2004). The model has been used to study various applications, from air-sea interaction in hurricanes (Chen and Curcic, 2016; Zhu et al., 2016), winter storms (Judt et al., 2016), Stokes drift impacts on Lagrangian transport (Curcic et al., 2016), to storm surge prediction (Dietrich et al, 2017).

Components

In its current configuration, UWIN-CM consists of an atmosphere, ocean surface wave, and ocean circulation models.

Atmosphere model

The atmospheric model in UWIN-CM is the Weather Research and Forecasting (WRF) model v3.7.1 with Advanced Research WRF (ARW) dynamical core (Skamarock et al., 2008). WRF is a non-hydrostatic atmospheric model with a large number of model physics options and a storm-following, moving nest capability for hurricane forecasting. The outermost domain is from 55.0 to 103.0W in longitude and 7.0–45.0N in latitude with a 12 km horizontal grid spacing and 44 vertical levels. There is a nest at 4 km horizontal grid spacing centered over the Gulf of Mexico. The surface layer is based on the Monin–Obukhov theory and boundary layer parameterization is the Yonsei University scheme (YSU, Hong et al., 2006). The cloud microphysics is the single-moment five-species scheme WSM5 (Hong et al., 2004), which is used on the inner nested domain without cumulus parameterization. The Kain–Fritsch cumulus parameterization is used only on the 12 km domain (Kain and Fritsch, 1993) in addition to WSM5.

Ocean wave model

The ocean surface wave model in UWIN-CM is the University of Miami Wave Model (UMWM) v2 (Donelan et al., 2012). It is a spectral ocean wave model that predicts wave energy spectra and the atmosphere and ocean momentum fluxes based on winds and ocean currents. UMWM can be initialized either from existing wave states from a global wave model or a calm state. The wave model has the same domain as the WRF outer domain. It is configured with 4 km grid spacing in this study. The wave energy spectrum is represented by 36 directional bins and 37 frequency bins in the range from 0.0313 Hz to 2.0 Hz.

Ocean circulation model

The ocean circulation model in UWIN-CM is the HYbrid Coordinate Ocean Model (HYCOM) v2.2 (Wallcraft et al., 2009). It is a three-dimensional hydrostatic ocean model with a hybrid vertical coordinate: z-level in shallow waters, terrain-following coordinate in intermediate waters, and isopycnal (constant density) in deep waters. In this study, we use the non-local K -profile vertical mixing scheme by Large et al. (1994). HYCOM domain covers the region of the WRF outer domain. It is configured with 0.04° horizontal grid spacing (varying from ~3.8 to 4.4 km from north–south of the model domain) and 32 vertical levels.

Atmosphere-wave-ocean coupling

The UWIN handles the coupling between model components. It contains the coupling physics and a common exchange grid that is used for interpolation and calculation of air–sea exchange fields from the component models. WRF passes the wind profile and air density to the wave model, and radiative and heat fluxes and precipitation rate to the ocean circulation model. UMWM passes vectorial atmosphere stress to the atmosphere model, and vectorial ocean stress to the ocean circulation model. HYCOM passes sea surface temperature (SST) to the atmosphere model and surface current field and water density to the wave model. All fields are interpolated to the exchange grid and are co-located in discrete time. In the current model configuration, all fields from WRF, UMWM, and HYCOM are exchanged every 60 s.

Initial and lateral boundary conditions

The WRF model initial and lateral boundary conditions were from the National Center for Environmental Prediction (NCEP) Global Forecasting System (GFS) three-hourly forecasts at 0.25° horizontal resolution. The initial and boundary conditions for the ocean model are provided by the global, data assimilated, 0.08° horizontal resolution daily HYCOM fields. The wave model is restarted from the previos solution cycle and uses no lateral boundary conditions.

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