

11C.2 - Improving Hurricane-induced Flood Forecasts using Coupled Hydro-Meteorological Models



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2:00 PM - 2:15 PM



339 (The Baltimore Convention Center)

Abstract

Title: Improving Hurricane-induced Flood Forecasts using Coupled Hydro-Meteorological Models

Authors: Md Murad Hossain Khondaker and Mostafa Momen

Department of Civil and Environmental Engineering, University of Houston

Abstract:

Hurricanes have been the most expensive natural catastrophe in the United States causing significant damages and disastrous floods. Considering the increased projected destructiveness of future hurricanes due to global warming, a reliable hurricane forecasting model is a national priority. Despite significant enhancement in weather prediction models, hurricane-induced flood forecasts are not sufficiently accurate yet. This inadequacy could be attributed to inaccurate hurricane intensity and track forecasts which can be due to improper physical parameterizations of unique hurricane dynamics. Previous studies have shown that remarkable differences exist in the dynamics of hurricanes compared to regular atmospheric boundary layers (Momen et al. 2021; Li et al. 2023; Matak and Momen 2023). These differences are due to strong rotational effects in hurricanes that are not represented in current turbulence and planetary boundary layer (PBL) parameterization schemes (Romdhani et al. 2022). These discrepancies in different physical schemes can cause improper hurricane structure, trajectory, intensity, and precipitation; ultimately leading to inaccurate hurricane-induced flood forecasts. It is not well known how adjusting PBL dynamics can influence hydro-meteorological forecasts in hurricanes.

In this talk, we seek to bridge this knowledge gap by coupling Advanced Weather Research and Forecasting (WRF-ARW) with the hydrological model WRF-Hydro to simulate multiple hurricanes in the US. We will first show the impacts of various PBL, microphysics, and cumulus parameterizations on the accuracy of real hurricane intensity, track, and flood forecasts. All these runs will be conducted coupled with the WRF-Hydro model, which is extensively calibrated for three coastal regions in the US using multiple USGS gauges. The best-performing parameterizations will then be determined through a comprehensive sensitivity test.

We will next present new adjustments to the default PBL schemes of WRF that enhance hurricane intensity forecasts. Following (Matak and Momen 2023), the default vertical diffusion of WRF is reduced to enhance hurricane intensification. Then, the impacts of these adjustments and hurricane dynamics improvements on hurricane-induced flood forecasts are quantified. For example, the attached figure shows an example of our simulations. By reducing the default diffusion, the intensity of hurricanes increases, and their size decreases compared to the default model. This remarkably influences hurricane precipitation rate and aerial distribution. Intensified hurricanes were shown to generate more intense and localized precipitation. This improved representation of hurricane dynamics led to better flood forecasts for the considered hurricanes. In total, we found that by reducing the vertical diffusion, hurricane intensity forecasts were enhanced by ~40% on average compared to the default models. This led to ~16% and 34% improvements in streamflow bias and correlation forecasts, respectively. This research provides new insights into the effects of PBL dynamics on hurricane streamflow forecasts. These new adjustments play a vital role in improving the hurricane and streamflow forecasts in coupled hydro-meteorological models.

References

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- Momen, M., M. B. Parlange, and M. G. Giometto, 2021: Scrambling and Reorientation of Classical Atmospheric Boundary Layer Turbulence in Hurricane Winds. *Geophys Res Lett*, **48**, <https://doi.org/10.1029/2020GL091695>.
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Hurricane Katrina: Precipitation and intensity
on 12:00 UTC 29 Aug 2005

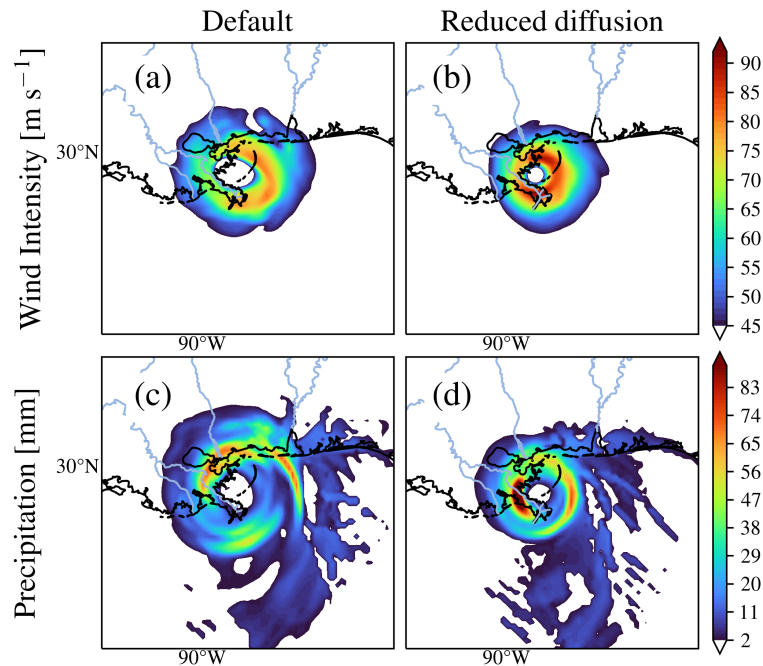


Figure 1: (a-b) Wind intensity at 500 m altitude and (c-d) induced precipitation for Hurricane Katrina on 1200 UTC 29 August 2005 with (left) default and (right) reduced diffusion WRF configuration.

Co-Authors



Md Murad Hossain Khondaker (Presenter)

University of Houston
Houston, TX
USA



Mostafa Momen
Univ. of Houston
Houston, TX
USA