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Predictability of Hurricane Hilary (2023) in 33-day Simulation using the WRF Model

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Abstract Text:
Following Tropical Storm Noa's landfall on the Baja California Peninsula in 1997, Hurricane Hilary (2023) marked the second storm to make landfall in the same region, leading to significant impacts. Given the storm's considerable economic and societal consequences and the distinctive characteristics of its origin and trajectory, a series of simulations spanning 33 days were conducted using the NCAR WRF model. These simulations aimed to assess the predictability of various aspects of the storm, including its formation and projected path and its potential precursor, likely an African easterly wave. The simulations demonstrated a reasonable degree of accuracy in replicating key movement patterns of both the storm and the African easterly wave compared to the NCEP reanalysis data.

Analysis indicates that within the span of 33 days since 0000UTC 20 July, several African easterly waves (AEWs) emerged within the Atlantic Ocean and proceeded in a westward direction. After its passage through Central America, the 4th AEW experienced a strengthening process, culminating in its development into a tropical storm that ultimately transformed into the hurricane named Hilary off the south coast of Mexico on 17 August.

The occurrence of an upper-level trough moving in an eastward direction positioned west-northwest of Hurricane Hilary, coupled with its interplay with the westward-propagating arm of the high-pressure system situated in mid-latitudes, east-northeast of Hurricane Hilary, gave rise to an exceptional steering flow resembling a saddle point. This steering flow was responsible for propelling Hurricane Hilary on a northward trajectory. The impact of this large-scale atmospheric flow played a pivotal role in facilitating a reasonably accurate simulation of Hurricane Hilary's movement.

This study presents three significant discoveries: (1) The 33-day WRF simulation effectively captures the unique characteristics of Hurricane

Hilary, encompassing its genesis location and trajectory. (2) The observed predictability extending beyond the traditional two-week limit aligns with Shen et al.'s (2010) findings, which showcased credible 30-day simulations involving multiple African easterly waves (AEWs) and Hurricane Helene (2006). This finding also supports Lorenz's view on the predictability limit, as discussed in Shen et al. (2023a, 2023b) and Shen (2023). (3) The distinctive steering flow reminiscent of a saddle point mechanism was responsible for the unique northward movement of Hurricane Hilary, setting it apart from other storms encountered within the region during 2023.

References:

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3. Shen, B.-W., R. A. Pielke Sr. and X. Zeng, 2023a: The 50th Anniversary of the Metaphorical Butterfly Effect since Lorenz (1972): Special Issue on Multistability, Multiscale Predictability, and Sensitivity in Numerical Models. [Editorial] Atmosphere 2023, 14(8), 1279; https://doi.org/10.3390/atmos14081279 (22 journal pages)
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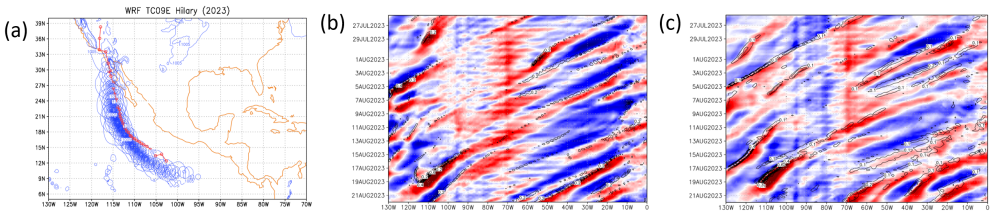

Figure 1. (a) WRF simulated SLP(contour, blue), best track(line, red) (b) 700mb vorticity, 850mb V windspeed time-longitude plot from 33-days WRF (c) same as (b), but for the GFS analysis

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