Tropical Cyclogenesis via Convectively Coupled Kelvin Wave (CCKW) – African Easterly Wave (AEW) interactions. Part II: AEW Behavior during the 2020 Atlantic Hurricane Season

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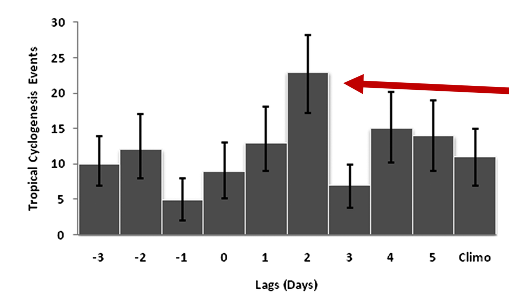
1) Background

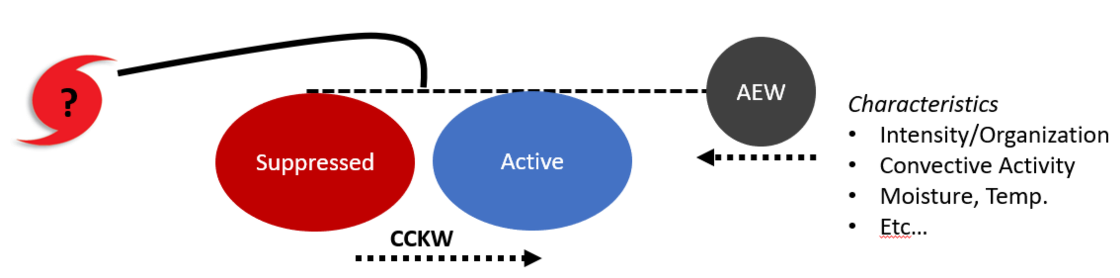
- It has been shown that the genesis of tropical cyclones (TCs) in the Atlantic is favored or suppressed in various phases of CCKWs[1,2].



- Various hypotheses have been proposed for this, including: CCKW modification of environmental factors like moisture or wind shear[1], direct CCKW interactions with AEWs and their dynamics[2], and indirect effects on the AEW recirculation and outflow[3]
- **However, there has not been a comprehensive study directly connecting these hypotheses to the evolution of AEW characteristics and structure throughout their lifetimes**

We are building a framework to study AEW-CCKW interactions in three steps: **1) Tracking AEWs**, **2) Isolating the CCKW impacts** on AEWs, and **3) differentiating favorable interactions**

Here, we implement step 1) in the context of climatology and 2020



2) AEW Tracking Method

Dataset: ECMWF ERA5 reanalysis at 1° x 1° resolution.
Time period: Tracker run for July-September from 1979-2020.

- Built a AEW database by tracking AEWs via the radially averaged (600km) non-divergent **curvature vorticity** field at 700hPa[4] (henceforth, CV) similar to Elless and Torn (2018)[5]
- Track local maxima in the 5-20°N band of CV forward in time, remapping to latitude/longitude and adding self-extrapolation[6]
- AEWs are connected to TC genesis events if a track is within 500km of TC formation; remove waves that last less than 2 days

We specifically designed this tracker to be more conservative by restricting latitudinal movement over Africa (limiting "jumps"), limiting forward motion to 25 m/s, and tracking differently by region

4) Summary

- To fully understand AEW-CCKW interactions, **need a comprehensive framework to isolate CCKW impacts on AEW behavior/structure**
- **Improved upon previous wave trackers[4,5] to develop a 42-year AEW database**, with tracked AEW behavior in line with established studies[4,7,8]
- 2020 matched previous studies[1,2], **with a majority of TC genesis events lagging active CCKW phase**
- Preliminary analysis of AEW-relative fields highlight why an **established climatology of AEW characteristics is needed to isolate CCKW impacts**

Important for next phase of this AEW-CCKW framework

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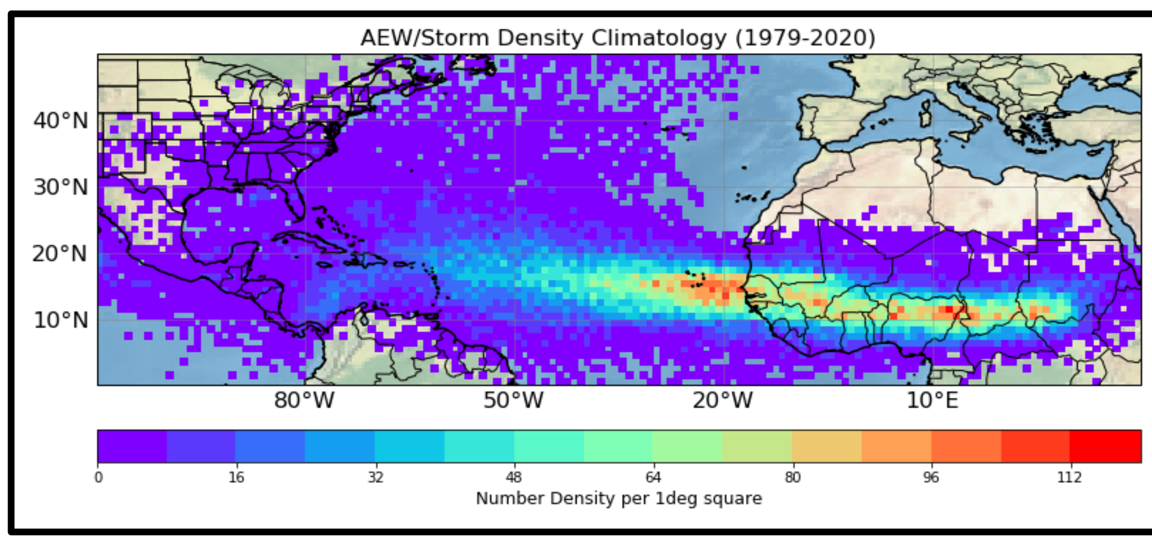
3) Results

1979-2020 Climatology of Tracked AEWs

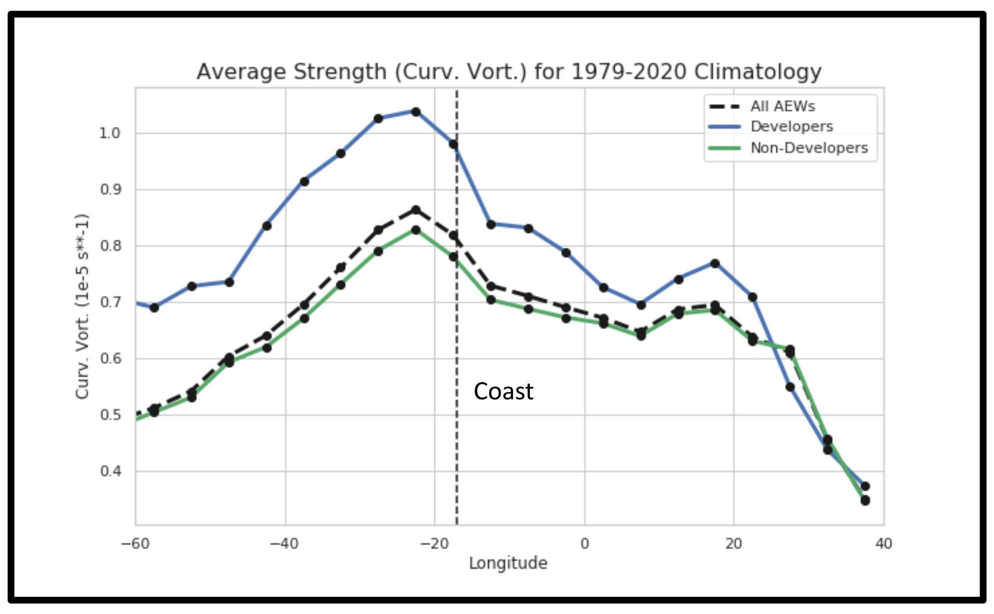
Results below compare well to established observational studies (Reed et al. 1997; Laing et al. 2008)[7,8]

- Over 1500 AEWs tracked (~35 each year July-Sept), with 220+ waves linked to a TC genesis event
- Average wave speed ~8 m/s, with a drop off in speed from 8.5 to 7.5 m/s crossing African coast

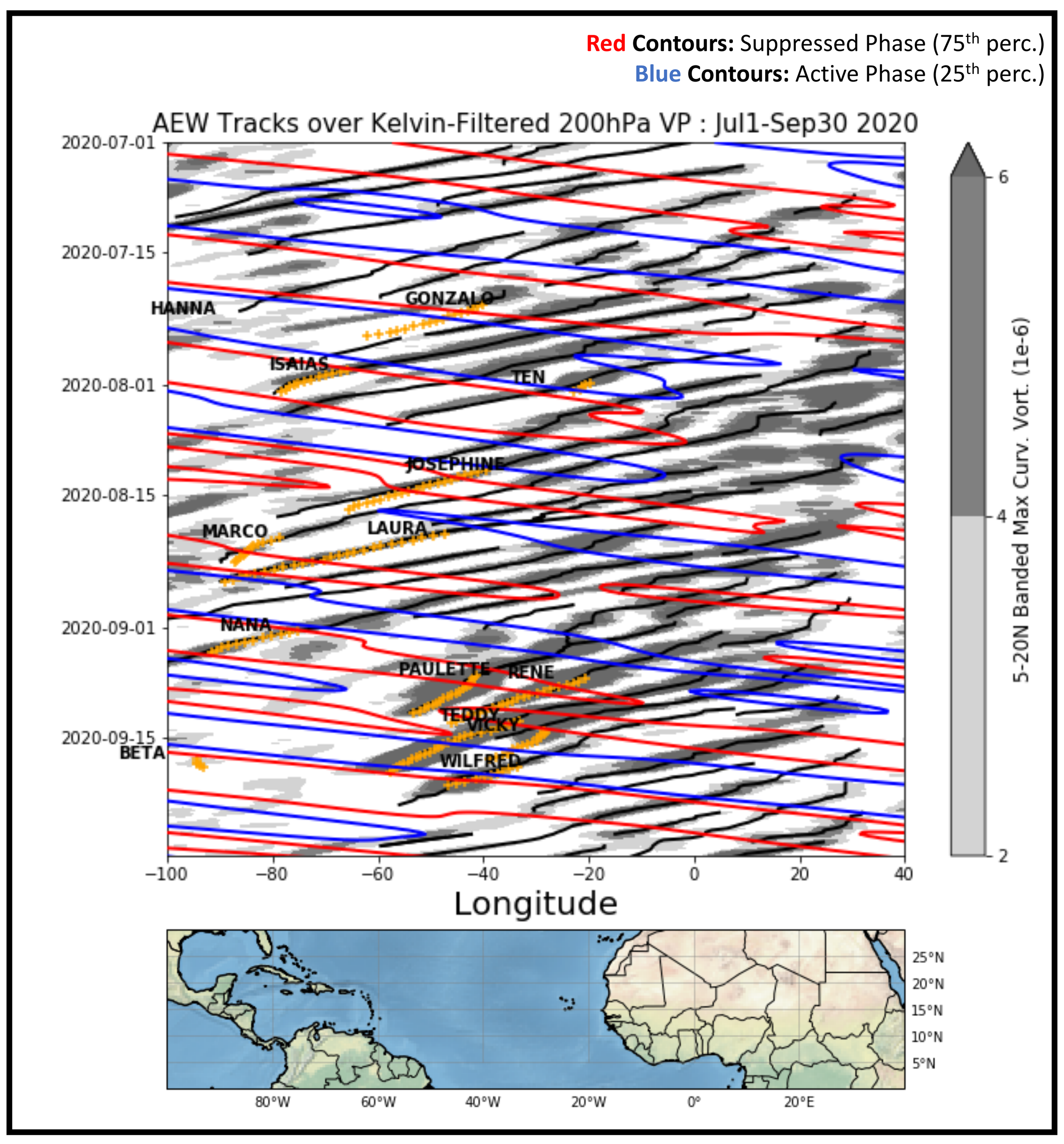


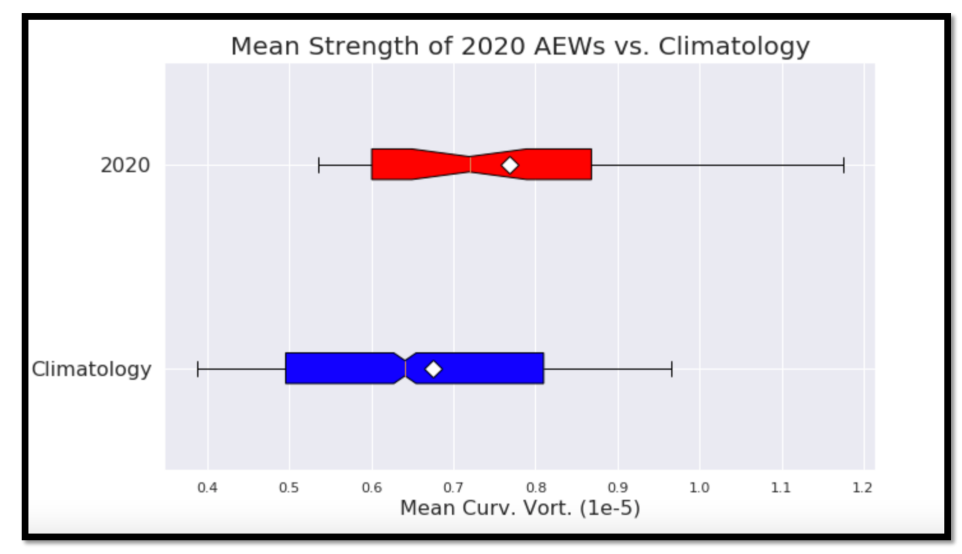
- AEW number density (left) compares well with that of Brammer and Thorncroft (2015)[6]
- Waves most prominent in tropical eastern Atlantic, but some are tracked into Pacific
- Tracks were also validated using manual inspection of 2D Hovmöller diagrams and 3D animations (not shown)

- Can define strength of each wave by the value of CV at tracked AEW center – recall, CV is radially averaged (600km)
- Averaging this strength across 5° longitude bins across the whole climatology (right):
  - AEW have intensification trend when exiting African coast
  - AEWs that develop into TCs are more intense over Africa



AEWs and CCKWs during the 2020 Season





- Distribution of mean AEW intensity appears slightly higher in 2020 compared to previous climatology (above graphs)

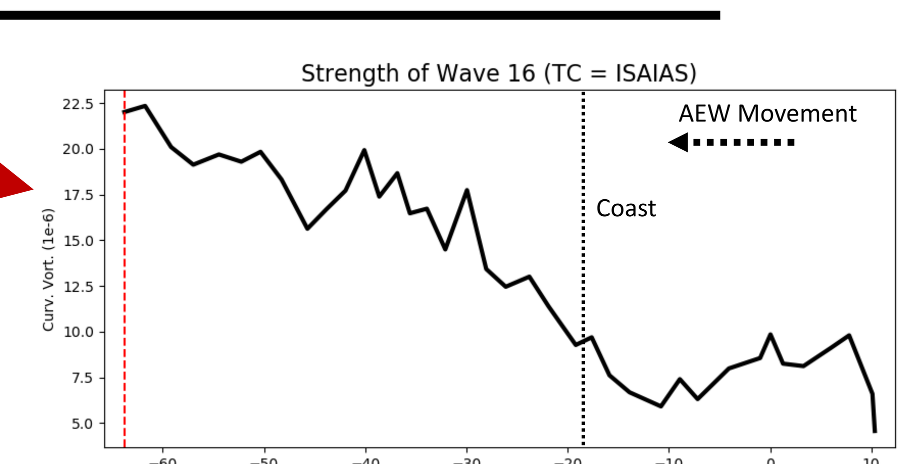
Does 2020 fit into our conceptual model of CCKWs and TC genesis (left)? **Yes!**

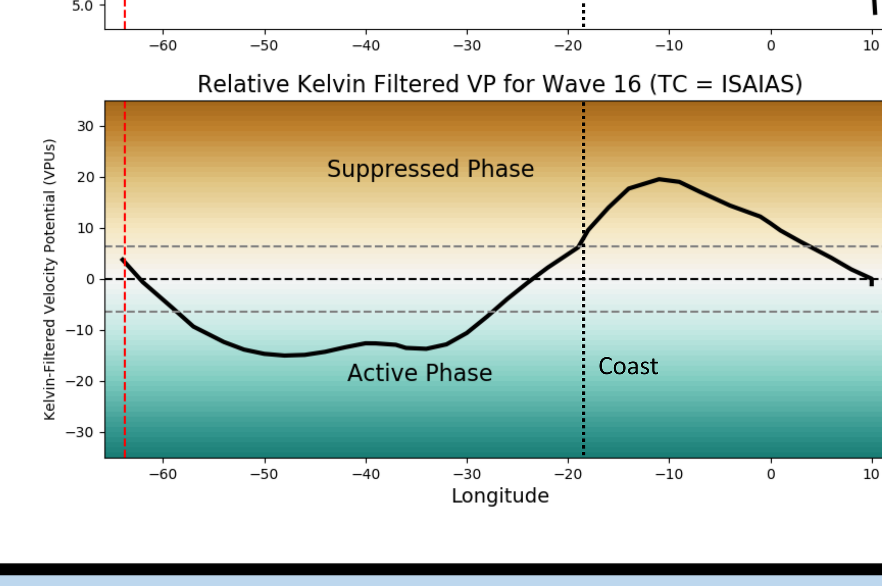
- Overlay of CV (grey shading), objective AEW tracks (black lines), a proxy for CCKW phasing (red and blue contours), and TCs
- *The 200hPa Kelvin-filtered velocity potential is used as a proxy for CCKW phasing*
- **TC genesis occurs after passing CCKW active peak majority of time (9 out of 12)**

Implications for AEW-CCKW Framework

The next step in the framework– how do we isolate the influence of CCKWs on AEWs?

- One way to study interactions is to take the radial average of parameters surrounding AEWs as they pass through CCKWs
- One example (right) – the AEW that eventually spawned Isaias (2020) as it passes through a CCKW
- **It is important to recognize how the raw values and trends are deceiving here – even though these graphs appear related**
- The AEW moves off the African coastline (~18W) around the same time it enters the active CCKW phase – climatologically, most AEWs strengthen in this region regardless of CCKW phase





Thus, must consider climatology of AEW behavior at given date and longitude to isolate CCKW influence

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