North Atlantic Hurricanes Contributed By African Easterly Waves North and South of the African Easterly Jet

Joshua Alland[1] and Tsing-Chang (Mike) Chen[2]

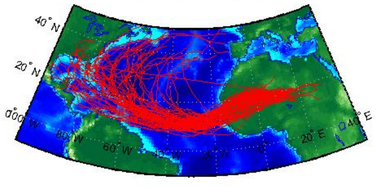
[1]Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York

[2]Department of Geological and Atmospheric Sciences, Iowa State University

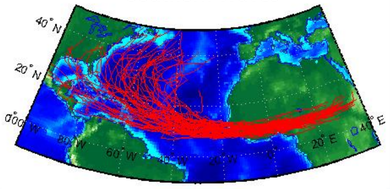
Introduction and Motivation

- African easterly waves (AEWs) are weather disturbances that travel westward from the western coast of Africa.
- Some of these waves dissipate quickly, but others develop into TCs and in some cases, powerful hurricanes.
- Northern waves (AEW_Ns) are AEWs that develop north of the African easterly jet (AEJ), while southern waves (AEW_Ss) are AEWs that develop south of the AEJ (Chen et al. 2008).
- ***Hypotheses:***
  1. AEW_Ns generally do not strengthen due to the negative impacts of the Saharan Air Layer (SAL).
  2. AEW_Ss have a greater likelihood of development and eventual intensification due to ample moisture in this region.
  3. *If AEW_Ns can penetrate and cross the AEJ, these waves have a greater chance to develop and intensify.*
- Hurricanes Andrew (1992) and Katrina (2005) were both AEW_Ns that crossed the AEJ, which later developed into powerful hurricanes that caused significant loss of property and life. Thus, understanding this crossing mechanism *is vital* to the meteorological community and operational forecasters to better predict intensification.

Northern Waves

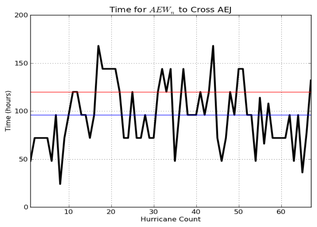


Southern Waves



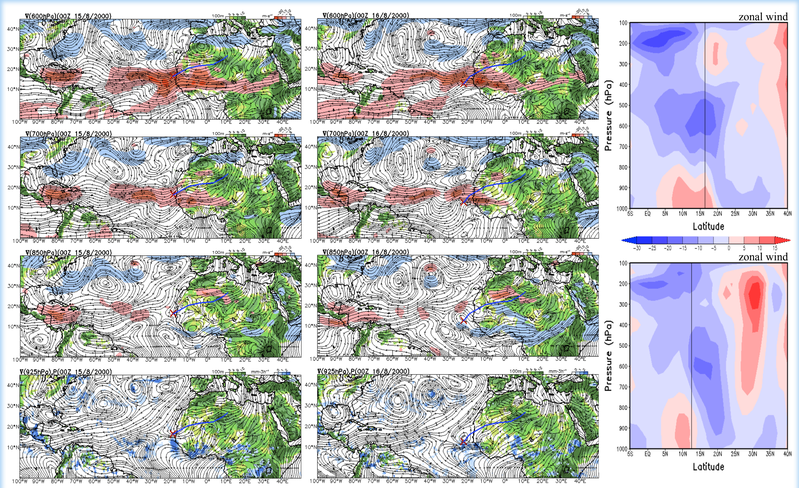
Methodology

- 138 northern and southern waves were analyzed from 1990–2010 that eventually developed into tropical depressions or stronger.
- Streamline charts were created for the 71 total AEW_Ns at 600, 700, 850, and 925 hPa using the National Centers for Environmental Protection (NCEP) Reanalysis and the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA-Interim Reanalysis.
- Precipitation was plotted using the Tropical Rainfall Measuring Mission (TRMM) dataset, and outgoing longwave radiation (OLR) was plotted using the ECMWF ERA-Interim Reanalysis.
- AEW_Ns were split into fast-crossing waves (less than 96 hours), moderate-crossing waves (96-120 hours), and slow-crossing waves (120 hours or greater).
- Vertical-latitudinal cross sections of zonal wind were analyzed to determine the height of the AEJ during the crossing period.
- 32 non-crossing northern waves were also analyzed to determine why these waves did not cross the AEJ.



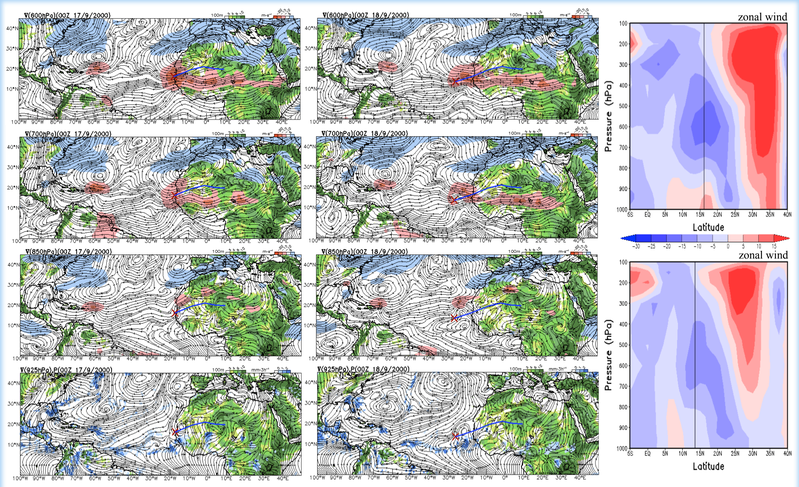
Strength	Northern Waves	Southern Waves
TD	4.23%	1.49%
TS	**40.85%**	29.85%
Category 1	18.31%	16.42%
Category 2	11.27%	4.48%
Category 3	16.90%	11.94%
Category 4	5.63%	**26.87%**
Category 5	2.82%	8.96%
Total Count	71	67

Fast-Crossing: Hurricane Debby (2000)



- Northerly flow at 700 hPa and a deep Harmattan steered the wave to the south.
- AEJ was positioned above the depth of the wave, allowing the wave to cross.
- *19 of the 28 waves* had both northerly 700 hPa flow and a deep Harmattan.

Moderate-Crossing: Hurricane Keith (2000)

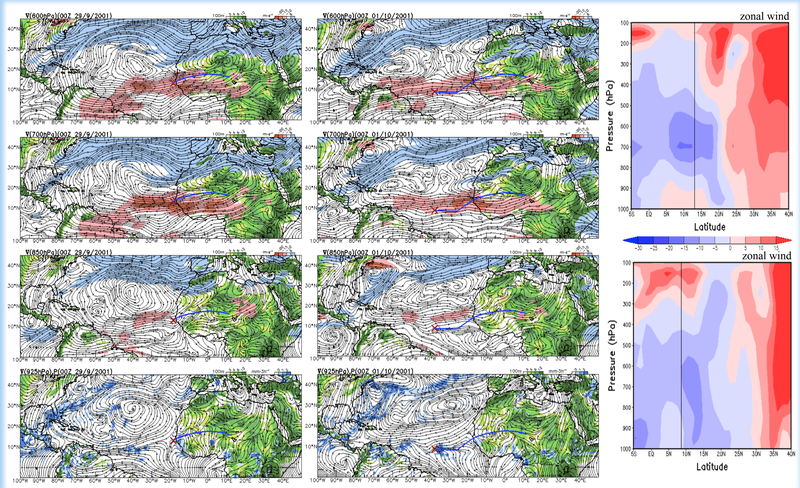


- Northerly flow at 700 hPa but a shallower Harmattan.
- AEJ was positioned above the depth of the wave, allowing the wave to cross.
- *8 of the 18 waves* had both northerly 700 hPa flow and a deep Harmattan.

Acknowledgements

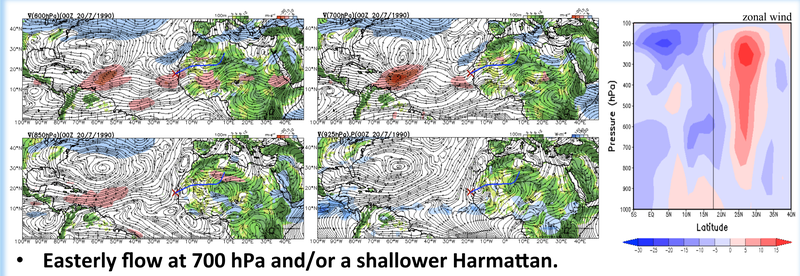
- Thank you to Dr. T.-C. Chen for his guidance, support, and suggestions throughout this project. Thank you to Dr. P. Tsay for supplying GrADS scripts and providing computer assistance whenever needed. Thank you to Jeremy Crocker for assistance in creating images.
- This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant No. 1060277.

Slow-Crossing: Hurricane Iris (2001)



- Easterly flow at 700 hPa and a shallower Harmattan.
- AEJ was positioned above the depth of the wave, allowing the wave to cross.
- *4 of the 21 waves* had both northerly 700 hPa flow and a deep Harmattan.

Non-Crossing Waves



- Easterly flow at 700 hPa and/or a shallower Harmattan.
- AEJ was positioned at or below the depth of the wave, hindering crossing.

Conclusions and Future Work

- Vertically integrated liquid water content was greatest south of the AEJ, meaning that northern waves likely had a greater potential to intensify after crossing to the south of the AEJ.
- The combination of northerly flow and a deep Harmattan allowed northern waves to penetrate and cross the AEJ.
- Crossing waves generally had a vertical depth below the AEJ, allowing these waves to slide underneath the jet. On the contrary, non-crossing waves generally had a shallower AEJ.
- If a northern wave did not cross the AEJ, it eventually dissipated due to the negative effects of the SAL.
- Future work should conduct a vorticity budget to determine the term(s) of the vorticity equation that most heavily contribute to the crossing process. Also, does the strength of the monsoon trough affect a wave's ability to cross the AEJ?