UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL of MARINE & ATMOSPHERIC SCIENCE

The Influence of El Niño - Southern Oscillation (ENSO) on African Easterly Waves and Tropical Cyclogenesis

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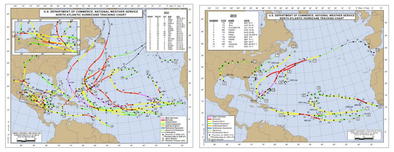
Background

- Shifts in Walker circulation during El Niño (La Niña) episodes cause stronger (weaker) vertical wind shear in the Caribbean.
- This results in **suppressed** Atlantic tropical cyclone activity during El Niño years and **enhanced** activity during La Niña years (Klotzbach 2011).
- These are known effects in the Caribbean only on **developed** tropical cyclones.

2010 La Niña: Active Season | **2015 El Niño: Inactive Season**



Goals of This Study:

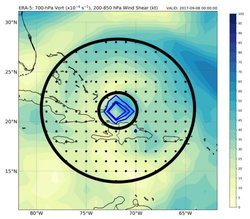
- We seek to discover if ENSO influences African easterly waves (AEWs) and their eventual genesis into tropical cyclones.
- ENSO's effect on wind shear is known in the Caribbean, but how far into the main development region (MDR) does this reach?
- Investigate vertical wind shear and relative humidity during El Niño and La Niña years:
  - Average values during the peak of the Atlantic hurricane season
  - In the immediate environment of AEWs

Methods

- **Dataset:** ECMWF ERA5 reanalysis, 1° x 1° resolution.
  - https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5
- Initially test for 2010 and 2015, and later extend to multiple hurricane seasons with strong El Niño and La Niña episodes.
- Key variables from the Statistical Hurricane Intensity Prediction Scheme (SHIPS, DeMaria et al. 2005) are tested, and extended for AEW cases.

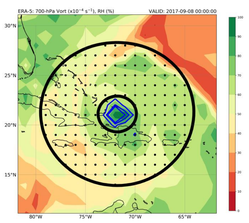
SHIPS Wind Shear

Shading: 200-850 hPa wind shear
Averaged in 200-800 km annulus
Blue Contours: 700 hPa vorticity
Dots show each 1° grid point

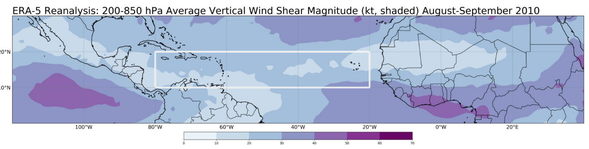


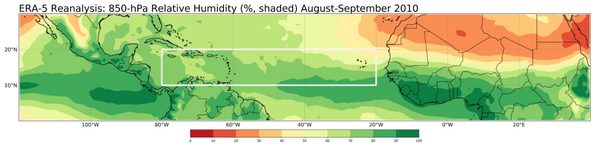
SHIPS Relative Humidity (RH)

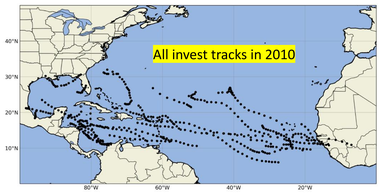
Shading: 700 hPa humidity
Averaged in 200-800 km annulus
Blue Contours: 700 hPa vorticity
Dots show each 1° grid point



2010 La Niña

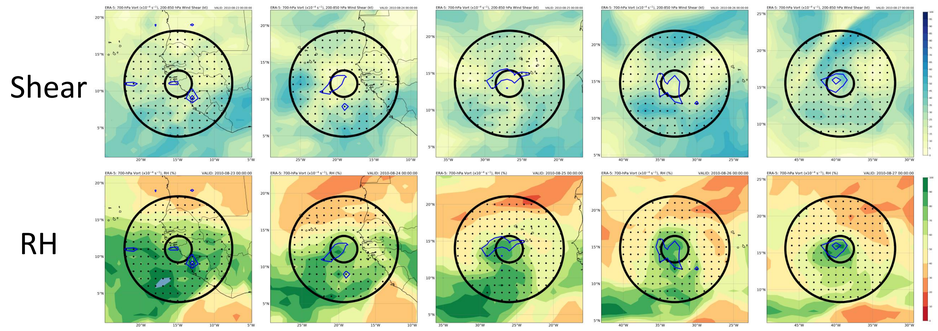




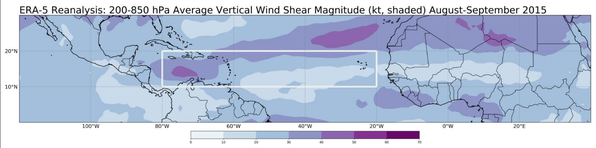


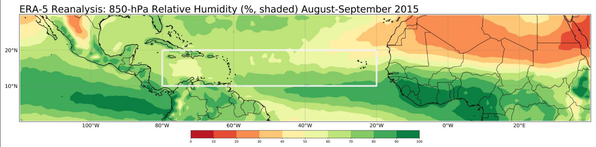
Invest	Invest Dates	Cyclone Dates	AEW?	Developer?	Classification	Peak Intensity	Name
BALB12010	Jul 31-Aug 2	Aug 2-8	Yes	Yes	Tropical Storm		Colin
BALC32010	Aug 5-12	*Non-Developer*	Yes	No			
BALB42010	Aug 8-10	Aug 10-11	Yes	Yes	Tropical Depression		Five
BALB52010	Aug 19-21	Aug 21-30	Yes	Yes	Hurricane	4	Danielle
BALB62010	Aug 22-25	Aug 25-Sept 4	Yes	Yes	Hurricane	4	Earl
BALB72010	Aug 25-30	Aug 30-Sept 3	Yes	Yes	Tropical Storm		Fiona
BALB82010	Aug 30-Sept 1	Sept 1-2	Yes	Yes	Tropical Storm		Gaston
BALB92010	Sept 2-4	Sept 5-9	No	Yes	Tropical Storm		Hermine
BALC02010	Sept 4-6	*Non-Developer*	Yes	No			
BALD12010	Sept 7-8	Sept 9-21	Yes	Yes	Hurricane	4	Igor
BALD32010	Sept 10-12	Sept 12-20	Yes	Yes	Hurricane	4	Julia
BALB22010	Sept 9-14	Sept 14-18	Yes	Yes	Hurricane	3	Karl
BALC42010	Sept 17-21	Sept 20-26	Yes	Yes	Hurricane	1	Lisa
BALC52010	Sept 20-23	Sept 23-26	Yes	Yes	Tropical Storm		Matthew
BALC62010	Sept 27-28	Sept 28-28	No	Yes	Tropical Storm		Nicole
BALC72010	Sept 29-Oct 6	Oct 6-10	Yes	Yes	Hurricane	1	Otto

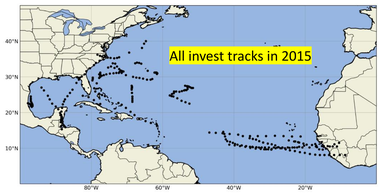
Case #1: Pre-Hurricane Earl



2015 El Niño

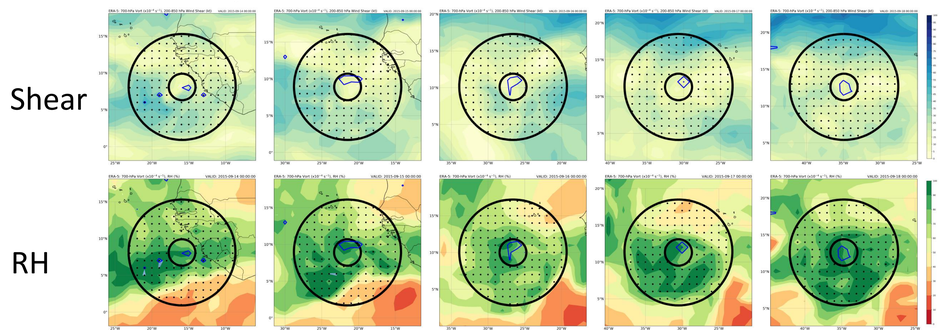






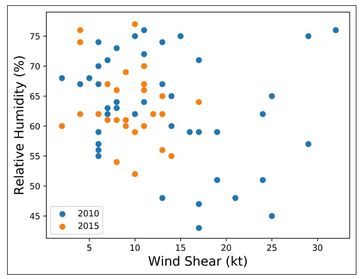
Invest	Invest Dates	Cyclone Dates	AEW?	Developer?	Classification	Peak Intensity	Name
BALA52015	Aug 2-5	*Non-Developer*	No	No			
BALA62015	Aug 15-18	Aug 18-24	Yes	Yes	Hurricane	3	Danny
BALA72015	Aug 19-24	*Non-Developer*	No	No			
BALA82015	Aug 22-25	Aug 24-28	Yes	Yes	Tropical Storm		Erika
BALA92015	Aug 28-30	Aug 30- Sept 6	Yes	Yes	Hurricane	1	Fred
BALB12015	Sept 3-5	Sept 5-9	Yes	Yes	Tropical Storm		Grace
BALB22015	Sept 7-9	Sept 8-11	No	Yes	Tropical Storm		Henri
BALB32015	Sept 9-16	Sept 16-19	Yes	Yes	Tropical Depression		Nine
BALA42015	Sept 10-15	*Non-Developer*	No	No			
BALB52015	Sept 12-18	Sept 18-27	Yes	Yes	Tropical Storm		Ida
BALB62015	Sept 17-21	*Non-Developer*	No	No			
BALB72015	Sept 21-23	*Non-Developer*	No	No			
BALC02015	Sept 28 - Oct 5	*Non-Developer*	No	No			
BALC82015	Sept 26-28	Sept 27-Oct 7	No	Yes	Hurricane	4	Joaquin
BALC92015	Sept 26-29	*Non-Developer*	No	No			

Case #2: Pre-Tropical Storm Ida



Summary of Results

- Scatterplot of RH versus Wind Shear for each Invest day during the **2010** and **2015** hurricane seasons.
- Surprisingly, many of the higher wind shear points are observed during the **La Niña** year.



- Differences in average wind shear are evident in the Caribbean (stronger in 2015) and East Pacific (stronger in 2010)
- These differences are less clear in the eastern half of the MDR: the average shear is very slightly stronger in 2010
- The average 700 hPa relative humidity in the western and central MDR is higher in 2010.
- In 2010, it is also very slightly (but perhaps not significantly) higher in the eastern MDR too.
- Individual cases can defy expectations: Pre-Earl 2010 (higher shear, lower RH) versus Pre-Ida 2015 (lower shear, higher RH)

Concluding Remarks

- The well-known effects of ENSO in the Caribbean are corroborated in the 2010 and 2015 Atlantic hurricane seasons, and are expected to be evident in other seasons.
- The effects of ENSO are less clear in the eastern part of the MDR, and more seasons will be tested for robustness.
- In 2015, several Invests developed into tropical cyclones, in spite of higher wind shear. This was surprising and requires further investigation.
- More detailed investigations of AEW structure, strength, and environments over multiple ENSO episodes are necessary.

References and Acknowledgments

DeMaria, M., M. Mainelli, L. K. Shay, J. A. Knaff and J. Kaplan, 2005: Further improvements to the statistical hurricane intensity prediction scheme (SHIPS). *Weather and Forecasting*, **20**, 531-543.

Klotzbach, P. J., 2011: El Niño–Southern Oscillation's impact on Atlantic basin hurricanes and US landfalls. *Journal of Climate*, **24**, 1252-1263.

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