The influence of environmental vertical wind shear on hurricane eye formation

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Understanding the structural changes in tropical cyclones as they intensify is essential for improving hurricane forecasting skill. Previous studies recognize eye formation as an important indicator for a tropical storm to intensify into a mature cyclone. However, the question of why some tropical storms form eyes while others do not is still not well understood. We expect to provide more insight by identifying large-scale environmental conditions that favor or inhibit hurricane eye formation.

Introduction

The eye is the tropical cyclone's central area (**Figure 1**) which is governed by subsidence, comparatively light winds, and lessened precipitation.

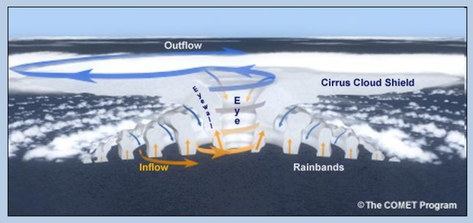


Figure 1. Tropical cyclone structure

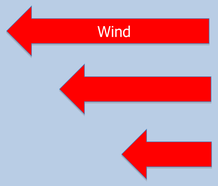


Figure 2. Vertical wind shear

Although a variety of factors were considered as possibly influential to eye formation, we focused on the influence of vertical wind shear (**Figure 2**) because it is often considered the most disruptive to storms. Environmental vertical wind shear (EVWS) greater than 20 knots is usually considered unfavorable for hurricane development.

Methods

A. Case selection

We compared nine North Atlantic basin storms from 2000-2008 for a 48-hour period centered on the time of eye formation or the time of peak intensity (if no eye formed). Aircraft data and best track data were used to select cases for detailed study and to sort them into three categories. These include storms that:

1. Successfully formed an eye	2. Did not form an eye at all	3. Had a transient eye formation
2001 Michelle	2000 Chris	2002 Gustav
2002 Isidore	2002 Edouard	2005 Ophelia
2005 Rita	2005 Gamma	2008 Fay

B. Data sources and treatment

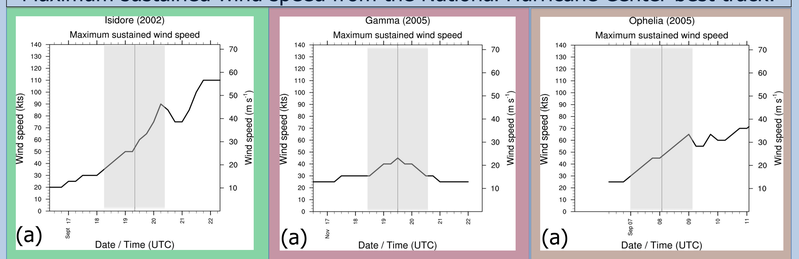
- EVWS predictors analyzed by the Global Forecasting System for the Statistical Hurricane Intensity Prediction Scheme (SHIPS) model were examined
- Data collected with Global Positioning System (GPS) dropsondes (**Figure 3**) from NOAA G-IV reconnaissance aircraft were used to calculate the 200-850 hPa wind shear at each launch location
- The cases were further characterized using infrared and microwave satellite imagery

Figure 3. GPS dropsonde

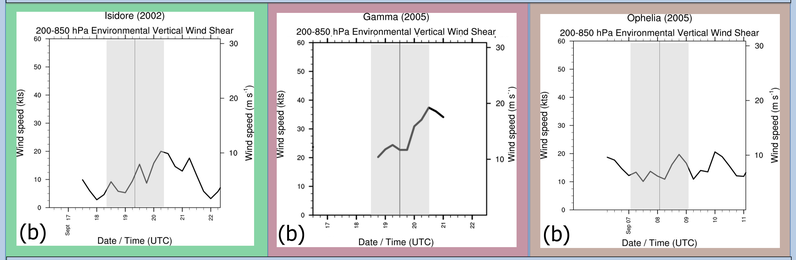
Results and Discussion

1. 2002 Isidore	2. 2005 Gamma	3. 2005 Ophelia

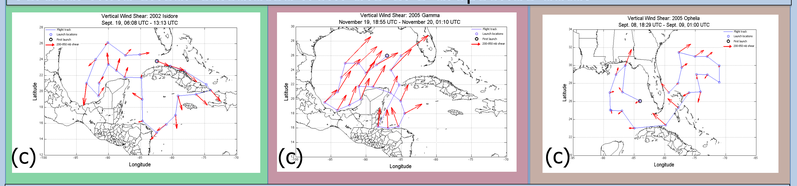
Maximum sustained wind speed from the National Hurricane Center best track:



Time evolution of EVWS from SHIPS data:



Vertical wind shear calculated from the GPS dropsonde data:



Infrared satellite images of the storms:

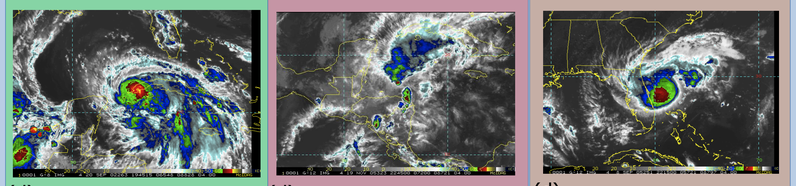


Figure 4. **Figure 5.** **Figure 6.**

- Plots on **Figures 4a-6a** support the idea that the appearance of the eye is an indicator of intensification, as both Isidore and Ophelia intensified around the time of eye formation.
- Cases that did not form an eye at all, such as Gamma (**Figure 5**), were affected by EVWS higher than 20 knots.
- Cases that did form an eye, such as Isidore and Ophelia (**Figure 4** and **6**), were affected by EVWS lower than 20 knots.
- Certain features might be observed by examining the spatial distribution of the wind shear (**Figures 4c-6c**) and comparing it to the flow observed in satellite imagery (**Figures 4d-6d**).
- Cases that had a transient eye formation showed a more complex EVWS influence than cases from the other categories.

Conclusions

- Storms that formed an eye had lower EVWS than storms that did not form an eye at all
  - Certain features, such as upper-level lows, could be enhancing the storm's outflow and allowing for the storm to form an eye
- Storms that had a transient eye formation had a more complex environment than the other two groups
- Results suggest that high EVWS has a detrimental effect on eye formation

Future Work

Future work will include investigating the vertical structure of the EVWS, and examining additional variables, such as instability, relative humidity, and sea surface temperature. We also expect to include more cases and compare them in terms of their inner structure.

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References

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Satellite images: Cooperative Institute for Research in the Atmosphere