5. Doppler Wind Lidar (DWL) Boundary-layer Module

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Links to IFEX:

This experiment supports the following NOAA IFEX goals:

Goal 1: Collect observations that span the TC lifecycle in a variety of environments;

Goal 2: Development and refinement of measurement technologies;

Goal 3: Improve our understanding of the physical processes important in intensity change for a TC at all stages of its lifecycle;

Program Significance:

The boundary layer has been identified in prior studies to be of critical importance to hurricane intensification (e.g., Emanuel 1997; Smith et al. 2009). Despite the critical nature of this environment, routine collection of kinematic and thermodynamic observations in the boundary layer remains elusive (Black et al. 2007). Currently, boundary layer observations are very limited since the primary source of data is from point-source GPS dropsonde measurements (Zhang et al. 2013). The lack of data coverage at low levels is a primary reason why hurricane boundary layer structure and associated physical processes remain poorly represented in today's operational hurricane models (Zhang et al. 2012).

The DWL on NOAA P3 (N42) aircraft measures three-dimensional wind velocities with ~50 m vertical resolution and ~2 km horizontal resolution (Pu et al, 2010). In the stare mode, the horizontal resolution in the marine boundary layer is on the order of a few meters. This is a new tool for boundary layer observations in addition to the existing GPS dropsonde and Doppler radar. Airborne Doppler radars provide three-dimensional wind estimates only where there is precipitation, whereas a DWL can provide wind estimates wherever there are aerosols and broken cloudiness. The DWL will be evaluated as an additional observing system that can increase the spatial coverage of wind estimates to improve the initial state of the HWRF model, and to reduce model biases through improved representation of the boundary layer physical processes.

Objectives:

The main objectives of the DWL Boundary-layer Module are to:

- Characterize the distribution and variations of kinematic boundary layer heights in hurricanes;
- Identify and document the characteristics of organized eddy such as boundary-layer rolls;
- Quantify the capabilities of the operational hurricane models to accurately capture and represent boundary layer rolls.

Model Evaluation Component: Boundary layer rolls are quasi-two dimensional features that can affect the surface flux transport and modulate the mean boundary layer structure. Observations that are collected during this experiment module will be used to evaluate the robustness of the operational coupled model forecast system (e.g. HWRF) to represent boundary layer rolls.

Mission Description:

This module can be included in any of the following HRD research missions or experiments: TC Genesis Experiment, Shear Experiment, Saharan Air Layer Experiment, Arc Cloud Module or TC Landfall and Inland Decay Experiment or as part of operational NHC-EMC-HRD Tail Doppler Radar (TDR) missions.

This module will target sampling of the kinematic structure of the boundary layer with focus on investigating the characteristics of the boundary layer height and coherent structures. The module can be combined with other experiments or modules, as it does not necessarily require a specific flight track. During P3 missions with standard figure-4 or butterfly flight pattern, the DWL will stay full-scan mode in downward-looking direction. Although the DWL measurements could be affected by clouds, data can still be collected in broken cloud conditions.

If the DWL boundary-layer module is given the priority, a box module with duration of 20-25 minutes (**Fig. 5-1**) would be the preferred experimental setup. GPS dropsonde and flight-level data will be used to quantitatively evaluate the quality of the DWL measurements. The DWL will scan in the following modes with downward looking direction. The first is a full scan mode. The second mode follows a sector scanning strategy that allows an increase in the horizontal resolution of the wind retrieval. The optimal flight altitude is ~ 500 m when possible (or as low as safety permits). Cloud avoidance is crucial for the module, which may require adjusting the horizontal flight track or flight altitude when heavy cloud is encountered, as safety permits.

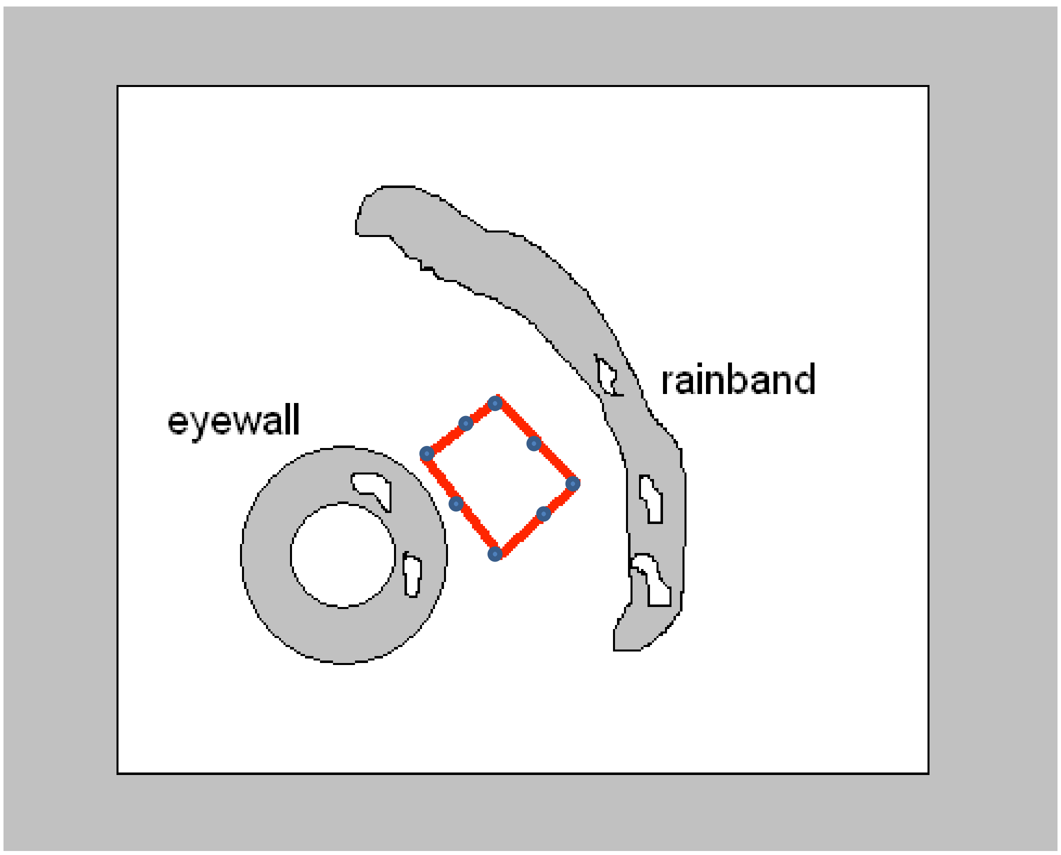

Figure 5-1: Box module (20-25 minutes) for DWL observations at altitudes between 500 m and 1500 m as low as safety permits. The blue dots show the locations for releasing dropsondes.

References:

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