

## Introduction

### Motivation:

- Accurately predicting near-surface winds during hurricane landfalls is crucial to improving situational awareness and post-storm recovery.
- Previous studies have used coastal radar Velocity Azimuth Display (VAD) winds to estimate 10-m winds (V10) during hurricane landfalls (Krupar et al. 2016) by applying a log-law fit to the VAD wind profile in the lowest few hundred meters. **Significant weak bias was noted!**
- Can improved estimation of surface winds be achieved over land during hurricane landfalls using radar observations?

### Preview:

- This study (Leffler et al. 2025) demonstrates that the pronounced weak bias arises from neglecting the wind structure within a shallow internal boundary layer (IBL), which forms in response to rapid surface roughness transitions from water to land (Hirth et al. 2012; Chen and Rozoff 2025).
- Leveraging the IBL winds is a key for more accurate V10 estimates.**

## Data and Methods

**Data:** KLIX WSR-88D radar data and KASD [5-min (Ida) or 1-min (Zeta)] ASOS data. DOW7 radar and tower (1 Hz) data for Laura.  
**Analysis Periods:** 1800 UTC 29 August – 0400 UTC 30 August 2021 for Ida & 1900–2344 UTC 28 October 2020 for Zeta. 0300–1100 UTC for Laura.

### Three Methods for Estimating 10-m Winds:

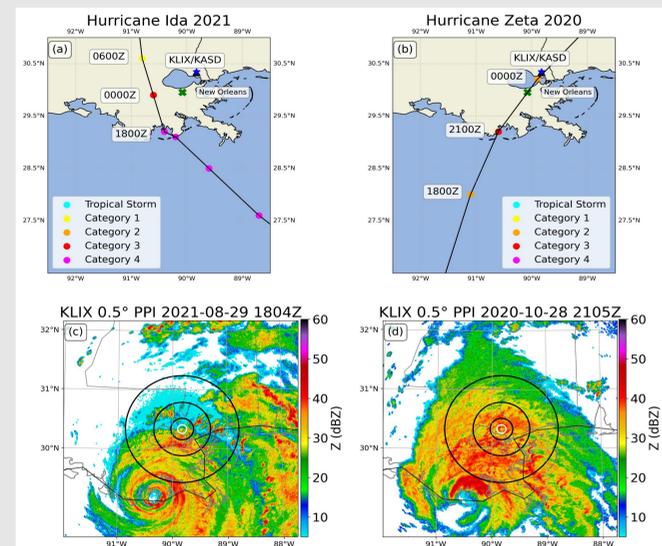
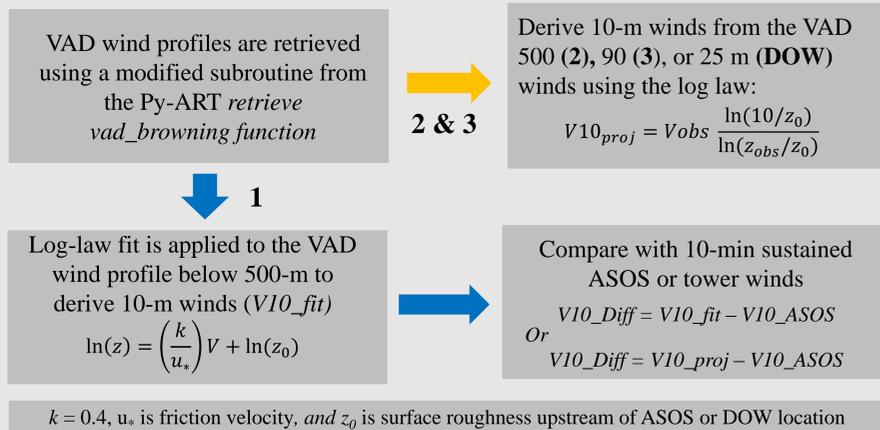


Figure 1: NHC best tracks and KLIX radar-reflectivity for Ida and Zeta.

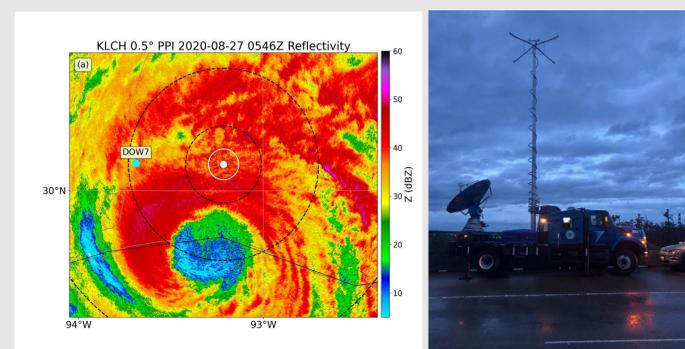


Figure 2: KLCH radar-reflectivity for Laura near landfall and DOW7 deployed for Laura courtesy of Kosiba et al. (2025).

## KLIX VAD Analysis for Ida (2021) and Zeta (2020)

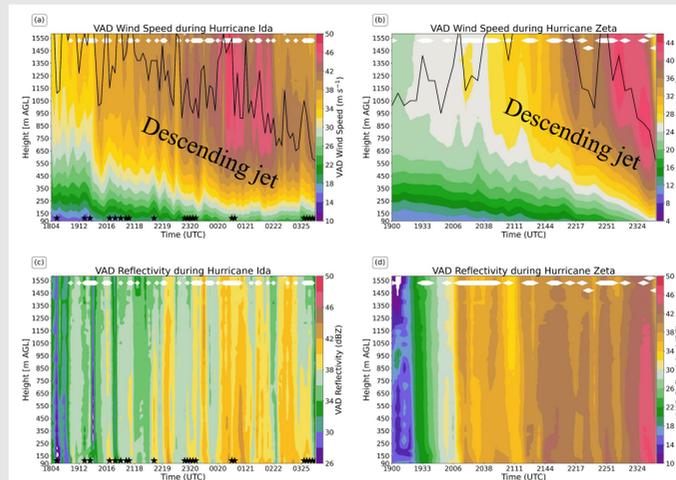


Figure 3: (a)-(b) Hovmöller diagram of the KLIX VAD wind speed, the black line marks the jet level. (c)-(d) similar to (a)-(b), but for mean reflectivity in the VAD domain. Black stars in (a)-(d) represent the times when  $|V10_{Diff}| > 2 \text{ m s}^{-1}$  for the third method of V10 estimation.

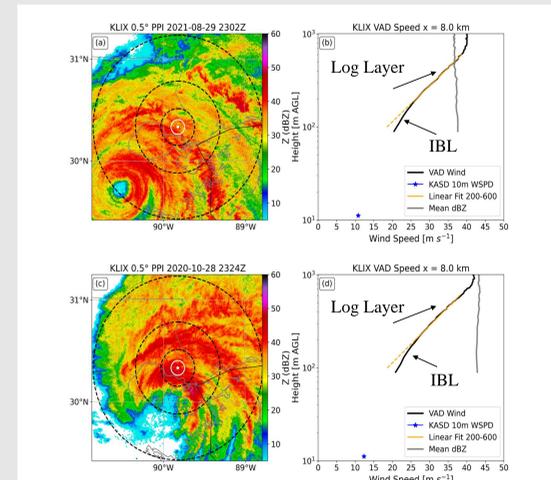


Figure 4: (a) KLIX radar reflectivity at 2302Z 29 Aug. 2021 for Ida. (b) Retrieved VAD wind and reflectivity profiles along with the log-law fit lines between 200-600 m AGL. Blue star at  $z = 10 \text{ m}$  denotes the  $V10_{ASOS}$ . (c)-(d) same to (a)-(b) but for 2324Z for Zeta.

## DOW7 VAD Analysis for Laura (2020)

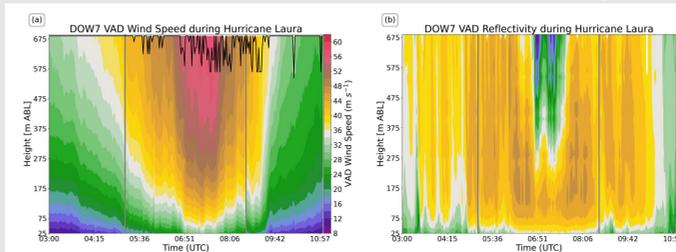


Figure 5: (a) Hovmöller diagram of the DOW7 VAD wind speed, the black line marks the jet level. (b) similar to (a), but for mean reflectivity in the VAD domain.

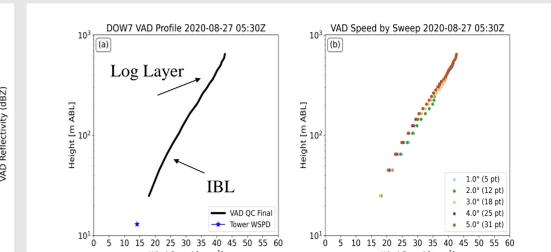


Figure 6: (a) DOW7 VAD wind profile at 0530Z on 27 Aug. 2020. Blue star at  $z = 10 \text{ m}$  denotes the  $V10_{Tower}$  wind. (b) VAD wind profiles for each sweep.

## 10-m Wind Estimation using Radar VAD Retrievals

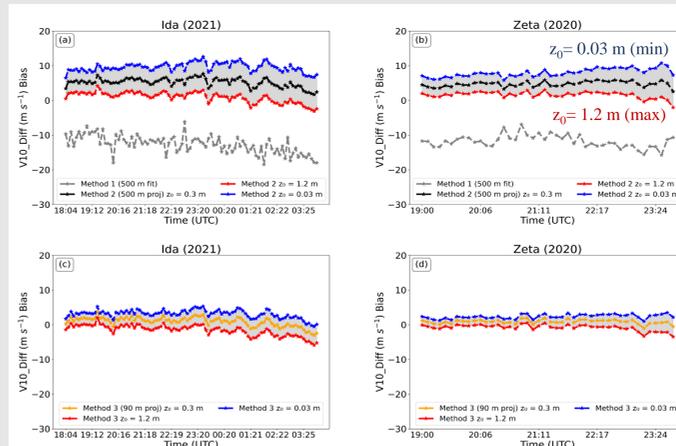


Figure 7: (a)-(b) Time series of V10 bias for methods 1 and 2 of estimating 10-m winds. (c)-(d) V10 bias for method 3.

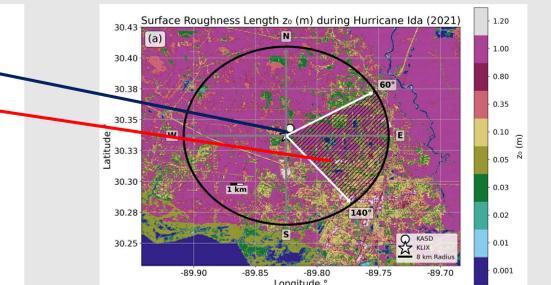


Figure 8: NOAA C-CAP-derived surface roughness ( $z_0$ ) centered on KLIX.

- 500 m log-law projection (**method 2**) has a mean (median) error of  $\sim 5.0 \text{ m s}^{-1}$ .
- 90 m log-law projection (**method 3**) contains the smallest mean (median) error of  $\sim 1.0 \text{ m s}^{-1}$ .

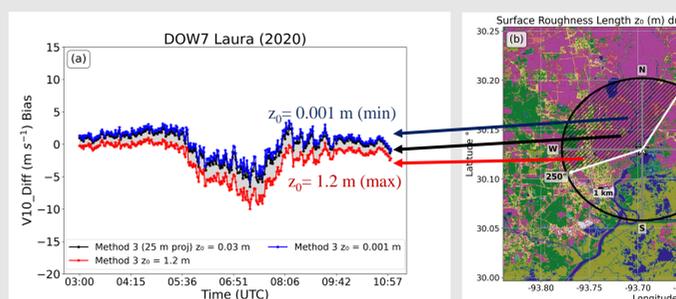


Figure 9: (a) Time series of V10 bias for methods 3 of estimating 10-m winds during Laura (2020). (b) NOAA C-CAP derived  $z_0$  near DOW7.

- 25 m log-law projection contains the smallest mean (median) error of  $\sim 1.0 \text{ m s}^{-1}$ .
- Weak bias  $\sim 10 \text{ m s}^{-1}$  occurs with the passage of Laura's western eyewall.

## Conclusions & Future Work

- Estimating 10-m winds by applying a log-law fit to the VAD profile in the lowest 500 meters leads to a notable **weak bias** of  $\sim 20 \text{ m s}^{-1}$ , consistent with Krupar et al. (2016)'s finding.
- Among the three methods, projecting the VAD wind within the **IBL** to 10-m AGL produced the **smallest error (and spread)** compared to other methods.
- Extend the VAD analysis and new method that leverages IBL winds to estimate 10-m winds for all U.S. landfall cases between 2000-2025.

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