



Tropical Cyclone Rapid Intensification Using Bootstrapping Extreme Threshold Estimation

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Introduction

- Rapid Intensification (RI), or Rapid Deepening (RD), can be characterized as a process in which a tropical cyclone (TC) undergoes an unusual strengthening in a certain period of time.
- Thompson & Holiday (1979): TCs during 1956-1976 in the western North Pacific. Pressure fall greater or equal to 42 mb in 24 hours which represented the 75th percentile.
- Kaplan & DeMaria (2003): Atlantic TCs from 1989-2000 with a positive change of 30 knots in 24 hours as delimited by the 95th percentile.
- Kaplan et al. (2010): Atlantic and eastern North Pacific basins. Study period 1989-2006. The 30 knots threshold corresponded to the 94th percentile for the Atlantic and 92nd percentile for the Pacific.

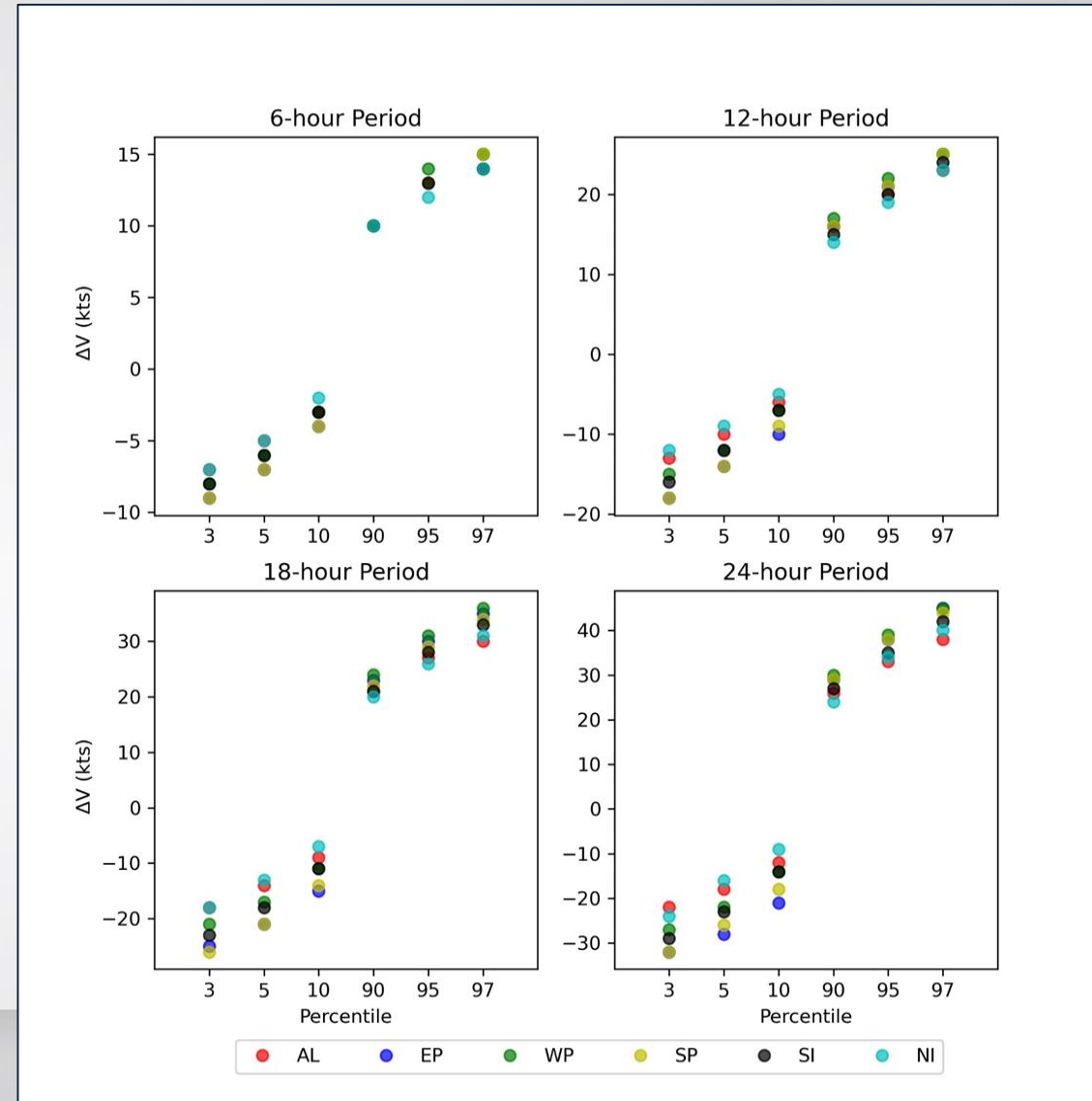
Background

- The “Fixed Percentile” approach is a rule-of-thumb technique in Extreme Value Analysis. The theoretical basis is presented by DuMouchel (1983) who essentially proposed to fit a Generalized Pareto Distribution (GPD) to the upper ten percentile.
- Critique: Scarrott & MacDonald (2012) stated that pre-fixing a threshold is theoretically inappropriate probably because there is no intention to find the best tail index, but to fit the GPD to the chosen index without taking into account bias or variance.
- Trade-off when fitting the GPD to describe the upper tail of the distribution:

If the tail index (threshold) is too low, the estimation will be biased. On the other hand, if the tail index is too high, the estimation will have a large variance.

Motivation

- Use an objective and more sophisticated methodology.
- Based on the plot shown, what's the most accurate limit to designate as 24-hr RI (90, 95, 97, or other).
- Apply the same methodology to other intervals.
- As more years are considered, the values seem to converge. Then, a 'unified' index seems reasonable.

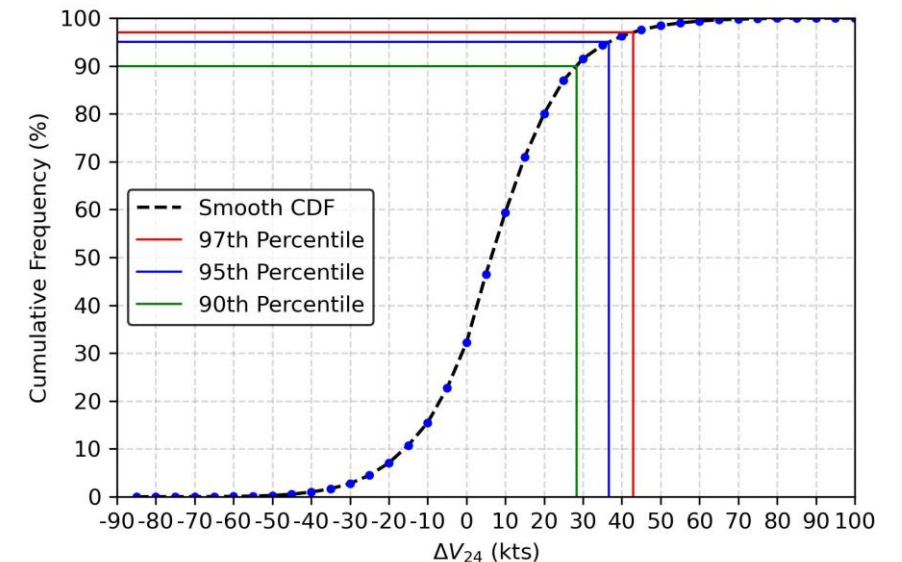
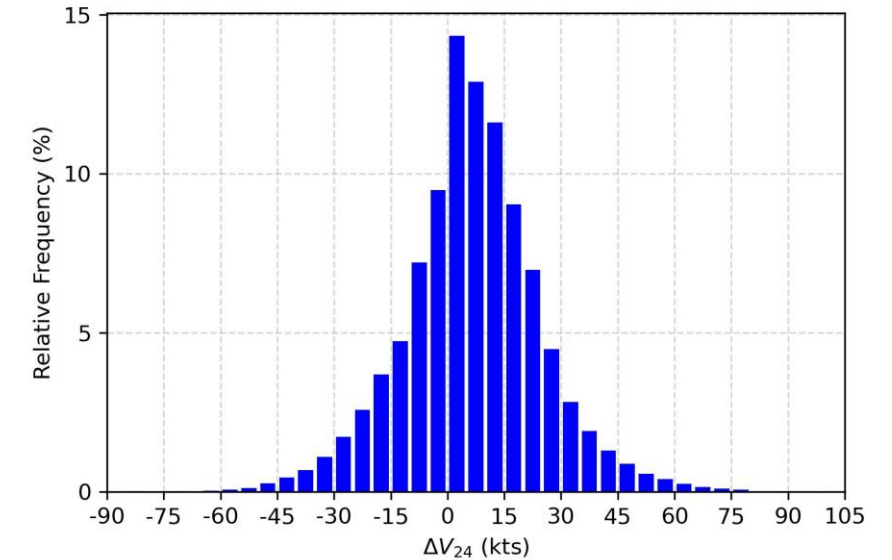


Objective

- **Determine the 24-hr intensity change threshold using an established methodology.**
- **Define an RI index for shorter lead times: 6, and 12 hours.**

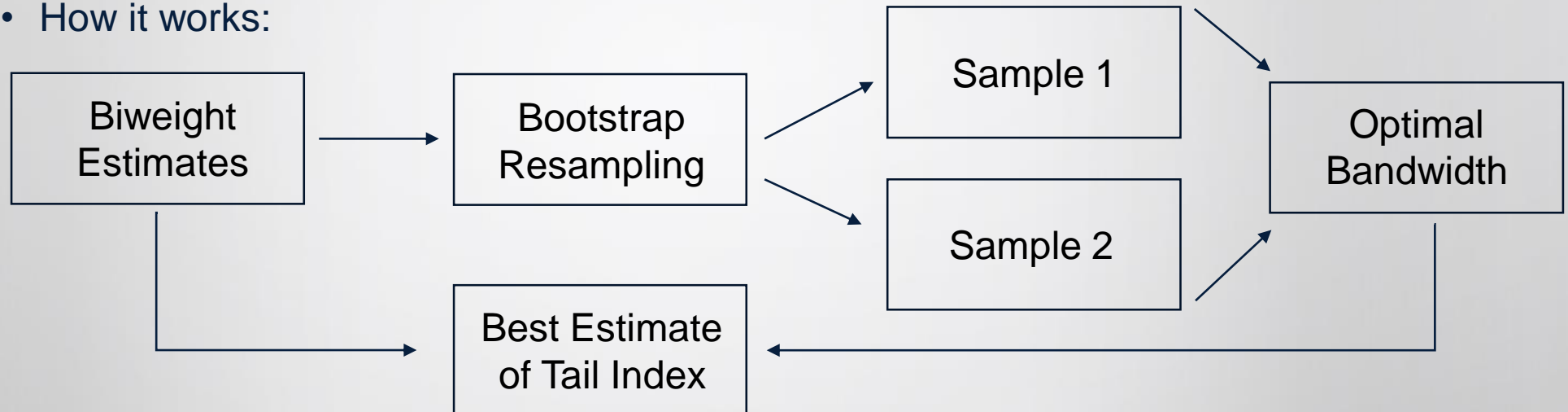
Data

- Study period: 1990-2020
- All Basins
- Categories: Tropical depressions, tropical storms, and hurricanes. Did not include Subtropical or Extratropical cyclones.
- TC center must remain over water (no landfalling cases).



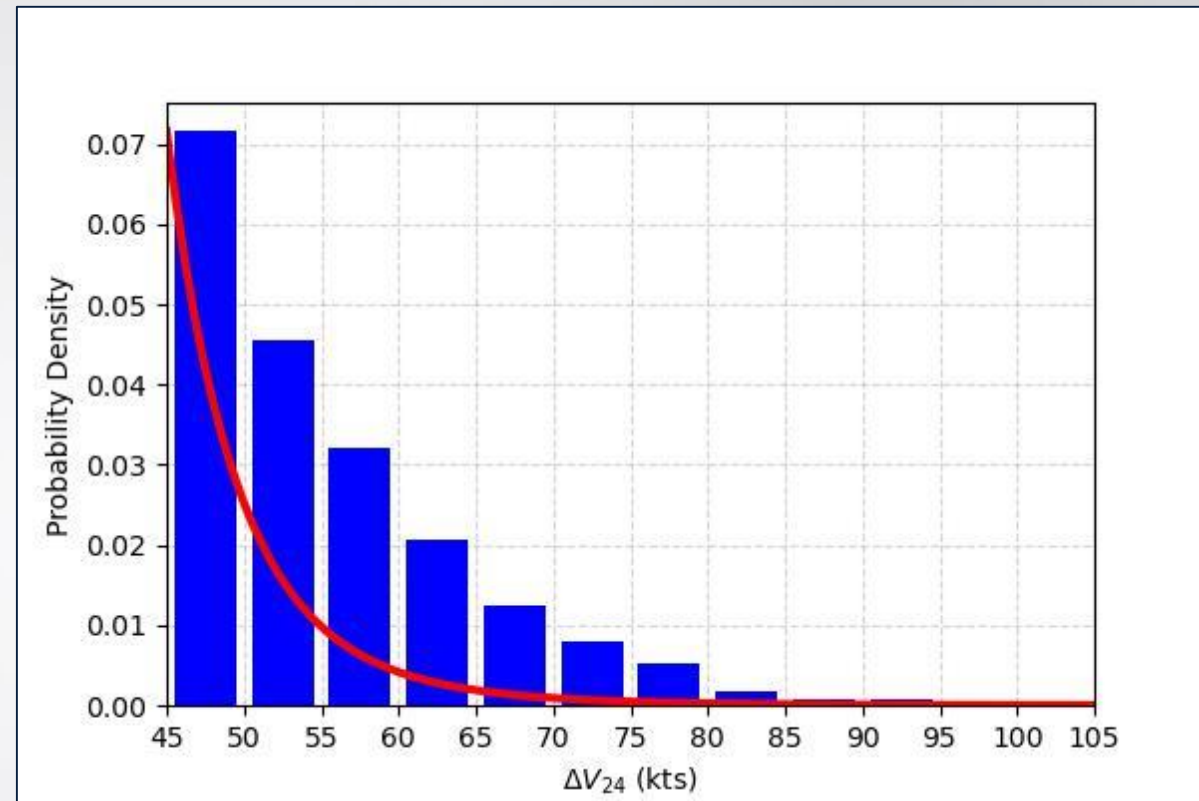
Methodology

- The kernel-type tail index estimator: A biweight kernel density estimates the tail of the distribution.
- Input Parameters: kernel bandwidth (~ 0.10), kernel smoothing factor (0.9), fraction of first bootstrap sample (0.45), and bootstrap iterations (10,000).
- How it works:



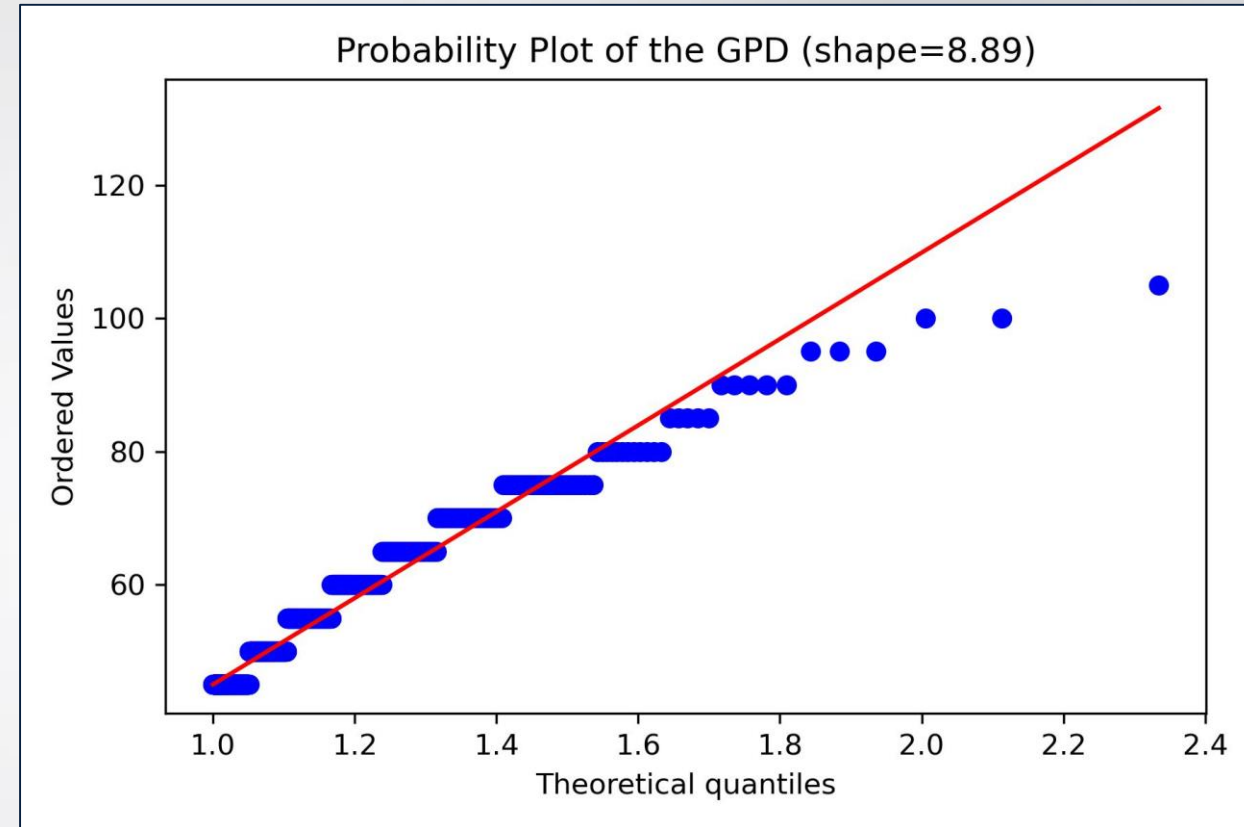
Preliminary Results

- Evaluated the Tail Index from the 95th percentile since this is where the extreme should be.
- Rapid Intensification is a synonym of extreme value.
- The bootstrap kernel-type estimator indicates that 45 knots is the cut-off threshold with the initial parameters.



Preliminary Results

- The Goodness of Fit test to the right reveals a very good correlation between the empirical and theoretical CDFs.
- Shorter Tail of the observed distribution hampers better fit due to 'outliers'.



Conclusions

- The 24-hr RI index was obtained using an objective technique adapted from Extreme Value Analysis.
- The resulting 45 knots/24-hr RI index falls slightly above the 97th percentile of the distribution of the global 24-hr TC intensity changes.
- A graphical Goodness-of-Fit analysis revealed how well the GPD describes the tail of the observed distribution which verifies the threshold selection.

Future Work

- **Perform sensitivity tests for the input function parameters: Try several combinations and decide the best by comparing bias and variance, or the mean square error.**
- **Test other estimators: Moments and Hill**
- **Extend results to longer lead times: 40 and 72 hours.**
- **Apply this methodology to individual basins.**



Thanks for your attention!

Questions?

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