Rapid Intensification of North Atlantic Tropical Cyclones in a Changing Climate

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Background

- Rapid Intensification (RI) refers to an increase of at least 30 knots within a 24-hour period of a tropical cyclone (TC).
- **Climate change** is contributing to warmer sea surface temperatures (SST), which provide more energy for tropical cyclones, potentially **increasing the frequency and intensity of RI events**.
- RI presents a significant challenge for meteorologists due to its sudden and rapid nature, making it **difficult to predict with high accuracy.**
- RI can lead to unexpectedly severe TCs, giving communities and emergency services **less time to prepare and respond.**
- This could result in more significant damages to infrastructure, higher risks to human life, and greater economic losses.

Objectives

- Analyze historical data to assess changes in the frequency and severity of RI events over the past decades.
- Investigate the specific atmospheric and oceanic conditions that contribute to RI, including SST, relative humidity (RH), vorticity, and wind shear.
- Hypothesize how RI may change under different climatic conditions and what dangers may arise from it as well.

Methodology Overview

RI Trend Analysis

Obtain NHC's HURDAT2 dataset over the NATL basin

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Run RI mapping code for 1980-2000 and 2001-2021 periods

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RI comparison analysis between periods

Environmental Conditions

Develop RI data frame

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Obtain historical environmental data (ERA5)

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Run SST, RH, vorticity, wind shear, and their climatology with respect to RI points

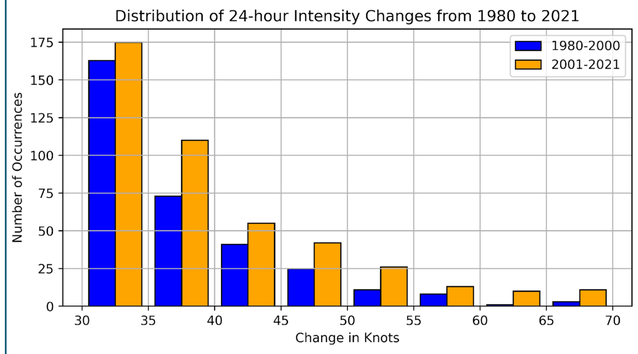
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Calculate difference in environment between RI and climatology

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Hypothesize RI behaviors in future climatic conditions

RI Frequency and Intensity is Increasing



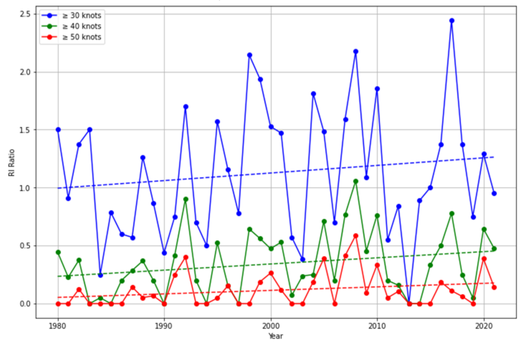
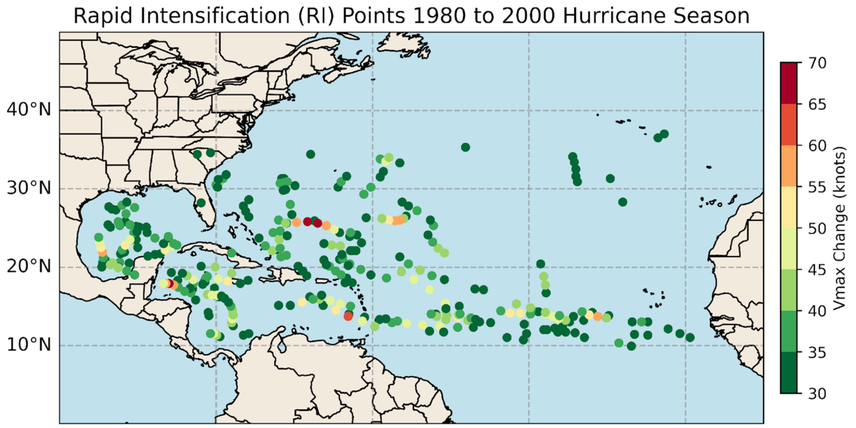
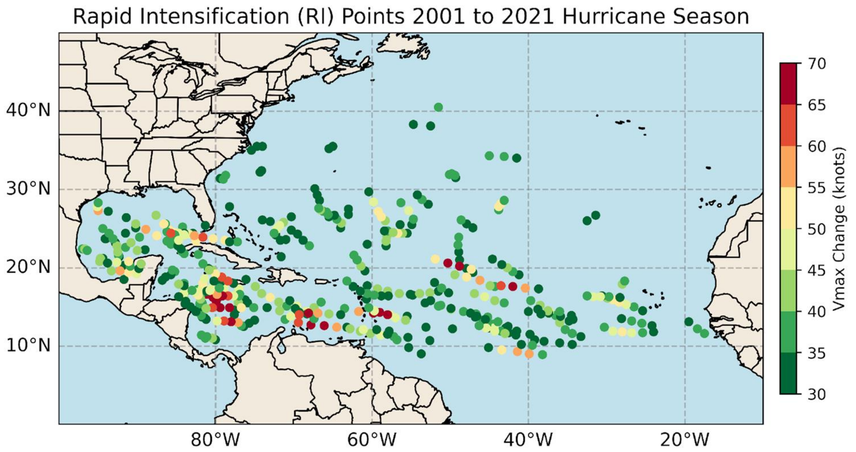


Fig 1: Shows absolute number of RI occurrences comparing 1980-2000 and 2001-2021. For both periods, the majority of RI occurrences represents increases of 30 - 35 knots. The 2001-2021 period has seen a higher frequency of RI occurrences at all intensities, especially from 60-70 knots.

Fig 2: Displays an upward trend of RI instances normalized by the number of storms.

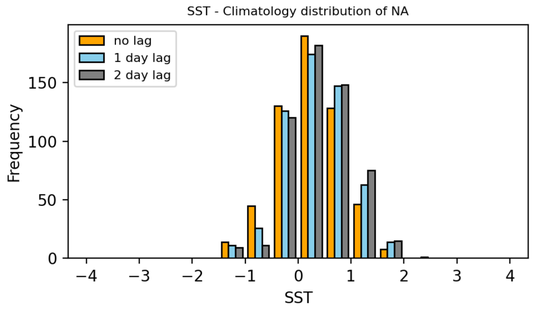
Fig 3 and Fig 4: Map showing RI locations from 1980 to 2000 and 2001 to 2021, respectively. Comparing the two periods, there is a higher density of strong (55-70 knots) RI cases in the 20° to 10° N, 80° to 60° W quadrant for the 2001-2021 period.



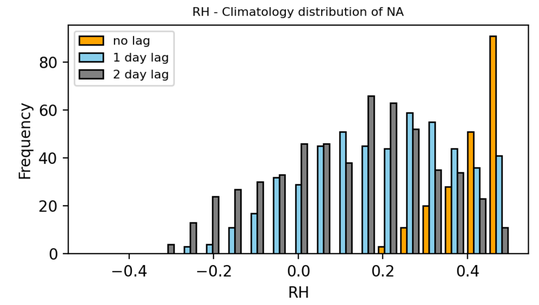


RI Occurs in More Favorable Environments

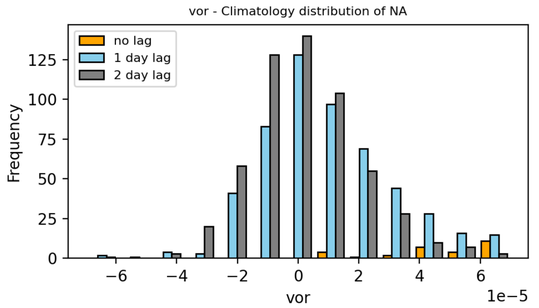
- Higher than average SSTs favors RI



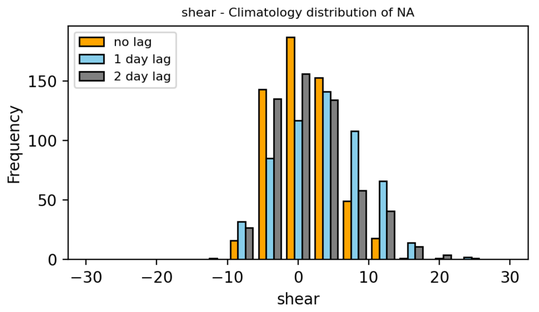
- RI occurs in more moist mid-level environments



- RI occurs in stronger low-level vorticity



- Unexpectedly, RI occurs in stronger wind shear. We are still investigating, but the strong winds aloft can ventilate TCs



Current Efforts and Future Work

- Validate RI trend analysis using multiple coded definitions of RI.
- Conduct deeper exploration of the significance of the environmental conditions.
- Obtain an understanding of RI behavior in future climatic conditions.
- Study the effects of RI on landfall precipitation.

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