An analysis of intense convectively-generated wind gusts in the Brazilian Amazon

Vanessa Ferreira[1], Letícia de Oliveira dos Santos[2], Ernani de L. Nascimento[2] and Anja Rammig[1]

[1]Technical University of Munich, Germany - vanessa.ferreira@tum.de, [2] Federal University of Santa Maria, Brazil

Background

- The documentation and understanding of storms reaching severe thresholds remain limited in the Amazon.
- Severe wind can reshape forest structure, increase tree mortality, and pose risks to ecosystems and communities
- Investigating severe wind gusts and their environments is therefore essential to better understand the drivers and impacts of severe convection in the Amazon.
- This study presents an assessment of severe convective wind gusts (≥20 m s^{-1}) across the entire Brazilian Amazon from 2000 to 2024.

Data and methods

- We use hourly observations from a network of automated weather stations (AWS) from the Brazilian National Meteorological Institute (INMET).
- A threshold of **20 m s^{-1}** was adopted to define intense wind gusts in the Amazon, as higher mid-latitude thresholds (≥25 m s^{-1}) are too rare to capture locally significant events.
- To analyze the atmospheric environments we used hourly ERA5 reanalysis data with hybrid-sigma vertical coordinates.
- Atmospheric profiles were generated from ERA5 at the grid points nearest to the AWS and for the hours of the reported wind gusts.
- The analysis period was divided into:
  - wet season: December to April;
  - dry season: June to September;
  - transition season: May, October, and November.
- **337** severe wind gusts were identified for 2000-2024 in the Brazilian Amazon:
  - 32.6% in the wet season;
  - 33.5% in the dry season;
  - 33.8% in the transition season.

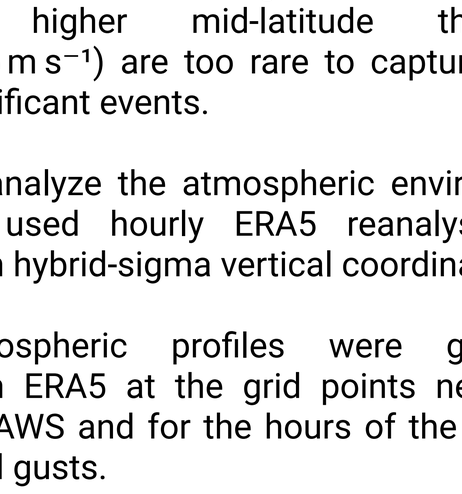

Fig 1 - Map of South America highlighting the Brazilian Amazon region.

Wind gusts characteristics

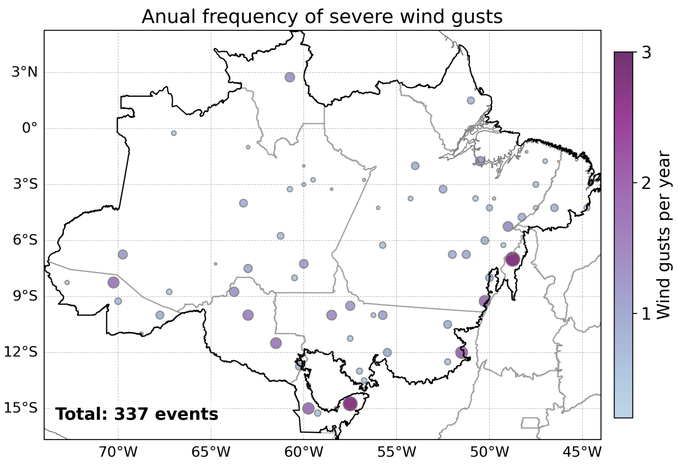

Fig. 2 - Spatial distribution of severe (≥20 m s^{-1}) wind gusts (gusts per year) from 2000 to 2024 in the Brazilian Amazon.

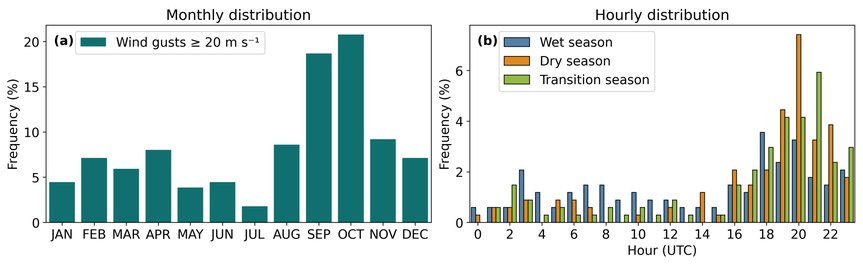

Fig. 3 - (a) Monthly and (b) hourly frequency of severe wind gusts detected by INMET's AWS network in the Brazilian Amazon from 2000 to 2024.

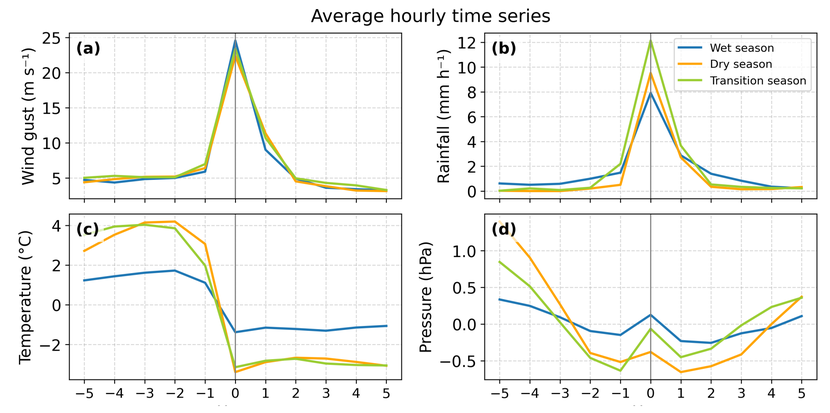

Fig. 4 - Hourly time series of atmospheric variables, averaged for all events of each season over a 5 h window around the gust report (hour 0).

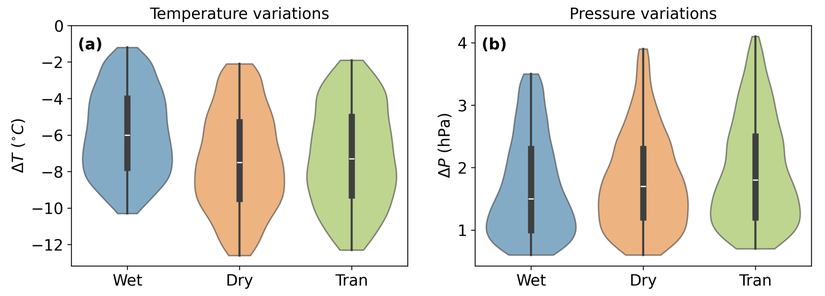

Fig. 5 - Violin-plot distribution of (a) temperature and (b) pressure variations. Violin-plot extremes are the 5th and 95th percentiles of the distributions.

Atmospheric environments

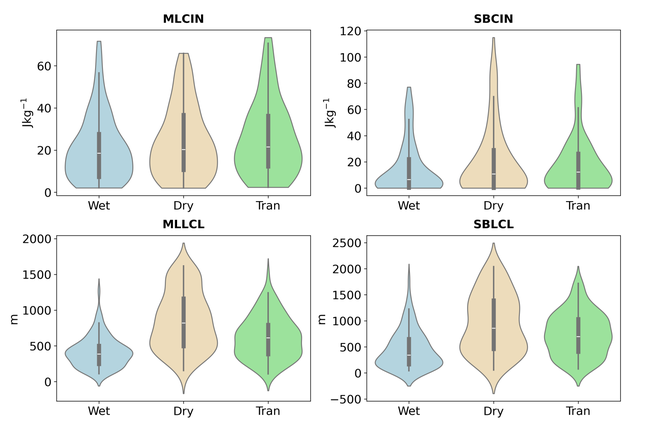

Fig. 6 - Violin plots showing CIN and LCL distribution by season.

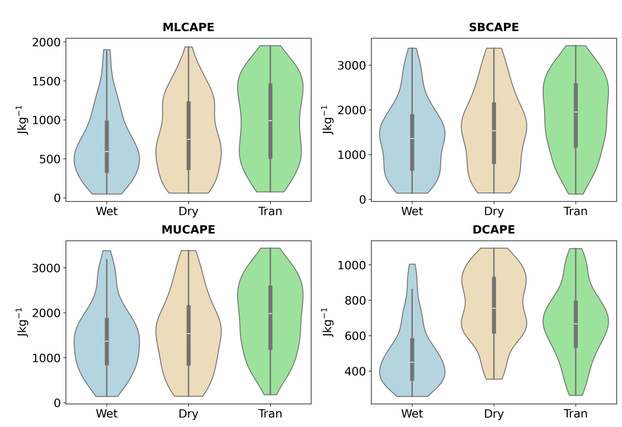

Fig. 7 - Violin plots showing CAPE distribution by season.

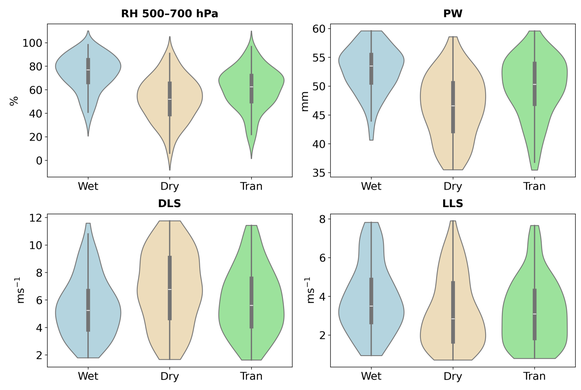

Fig. 8 - Violin plots with RH, PW, DLS and LLS distribution by season.

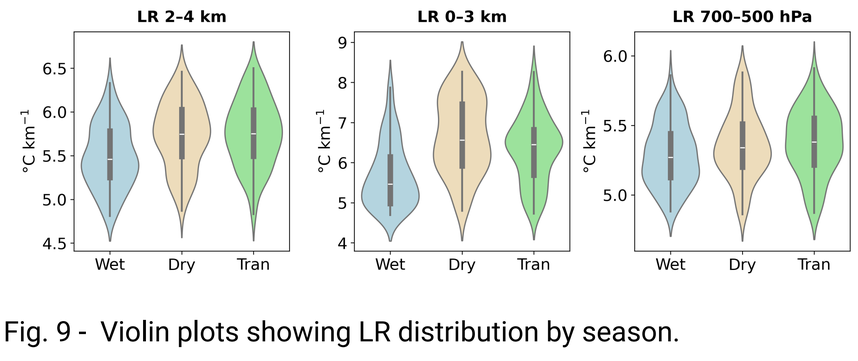

Fig. 9 - Violin plots showing LR distribution by season.

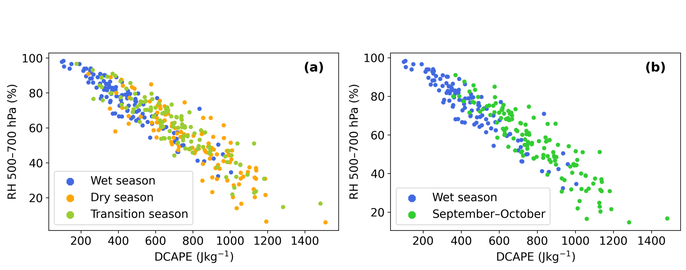

Fig 10 - Mid-level RH (500–700 hPa) and DCAPE space: (a) wet, dry , and transition seasons; (b) wet season versus September–October gusts.

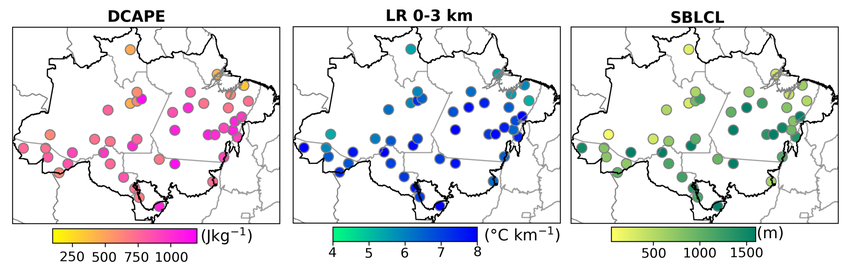

Fig 11 - Spatial distribution of mean DCAPE, LR 0-3 km and SBLCL associated with severe wind in the dry season.

Conclusions

- Severe wind gusts are widespread across the region and are more frequent during the dry-to-wet transition months of September and October, with a peak in the mid- to late afternoon.
- Wind gusts were accompanied by temperature drops, which were sharper in the dry and transition seasons (reaching −12.6°C), and pressure rises that were similar in magnitude across seasons.
- From an ingredients-based perspective, our results indicate that the thermodynamic environment in the Brazilian Amazon during the dry and transition seasons is more conducive to severe wind gusts, owing to the combination of higher DCAPE, steeper lapse rates, and more elevated LCLs.

Acknowledgements

The first author thanks the Alexander von Humboldt Foundation for supporting this work through a postdoctoral fellowship. We also thank the Operador Nacional do Sistema Elétrico (ONS) for supporting this work.