Climatology and trends of environments favorable to severe convectively-induced winds in tropical Brazil

Letícia de Oliveira dos Santos[1], Ernani L. Nascimento[2], Vanessa Ferreira[3], Nathalie T. Boiaski[1], Christiane Machado Osório[4], Beatriz da Silva Bernardino[4]

[1] Universidade Federal de Santa Maria - deoliveiraaicitel@gmail.com, [2] Instituto Nacional de Pesquisas Espaciais, [3] Technical University of Munich, [4] Operador Nacional do Sistema Elétrico

BACKGROUND & AIM

- The understanding of severe convective storms and their environments is still poor in the tropics.
- Despite their potential to produce damaging winds in tropical South America, long-term climatologies and historical trend analyses of environments conducive to such events remain limited.
- This study investigates the climatology and long-term trends of environments favorable to severe convectively induced winds across four broad regions in north-central Brazil, using ERA5 reanalysis data from 1980 to 2021.

DATA AND METHODS

- Favorable environments were identified by applying thresholds to convective parameters derived from ERA5 profiles.
- The skill of the parameters in highlighting conditions during intense wind gusts was assessed using hourly measurements of gusts from 2000 to 2019 from the surface network by Brazil´s National Meteorological Institute (INMET) and from 1996 to 2019 using METAR reports.
- The set of ERA5-based minimum thresholds parameters that best reproduced the general observed climatology of intense gusts in tropical Brazil consisted of:
  - 100 J kg^{-1} for MLCAPE;
  - 500 m for MLLCL;
  - 5.7 °C km for 2–4 km environmental lapse rate;
  - 1 mm for precipitation as a confirmation of convective initiation.
- These thresholds were applied to hourly ERA5 data across four major Brazilian regions: Southeast, West-Central, North, and Northeast.

ACKNOWLEDGEMENTS

The authors thank the Operador Nacional do Sistema Elétrico (ONS) for supporting this work.

RESULTS

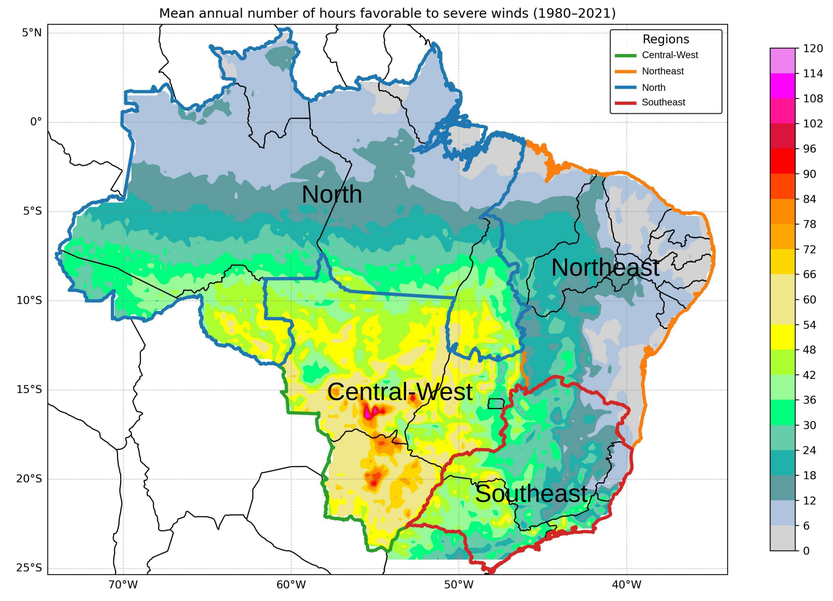

Fig. 1 - Mean annual number of hours favorable to severe winds in the Central-North Brazil (1980-2021).

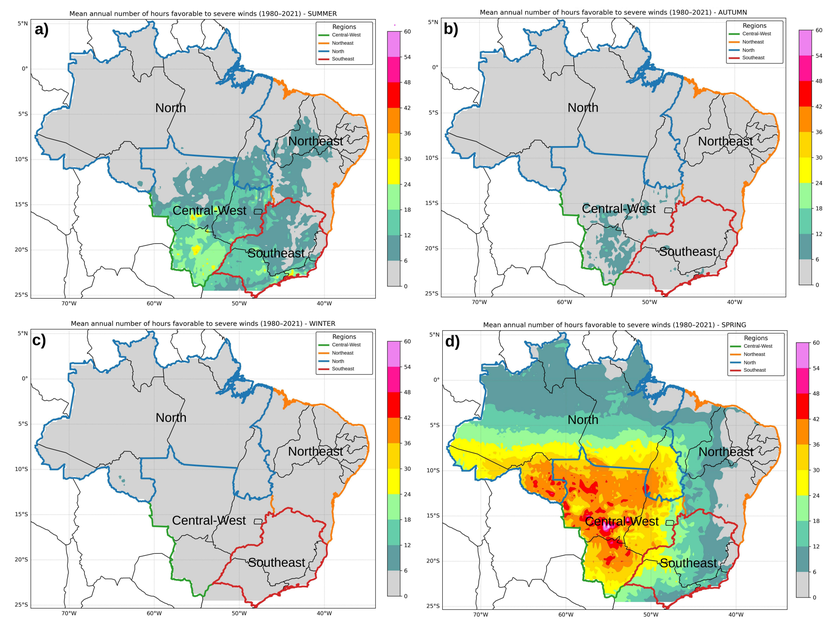

Fig. 2 - Mean seasonal number of hours favorable to severe winds in (a) Summer (b) Autumn (c) Winter (d) Spring in the Central-North Brazil (1980-2021).

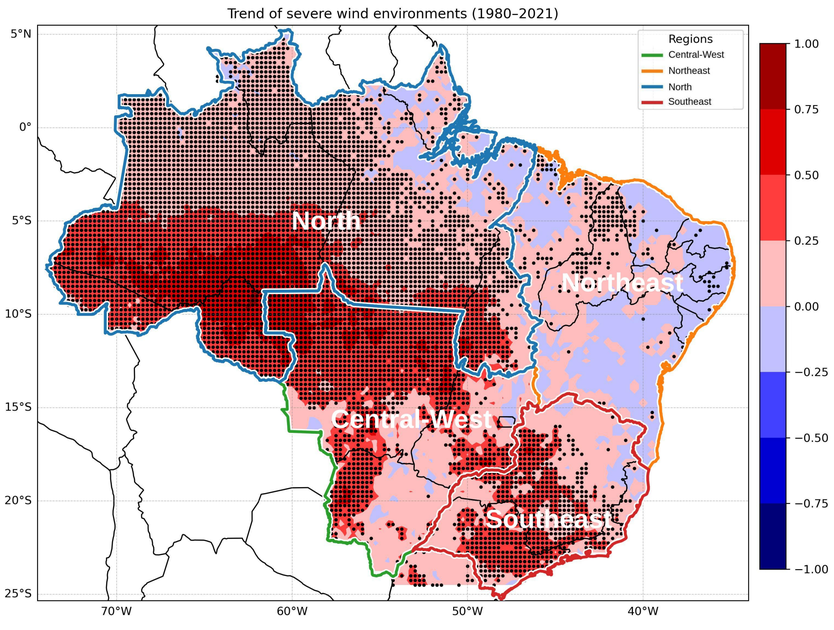

Fig. 3 - Trends for the mean annual number of hours with environments favorable to severe winds in the Central-North Brazil (1980-2021).

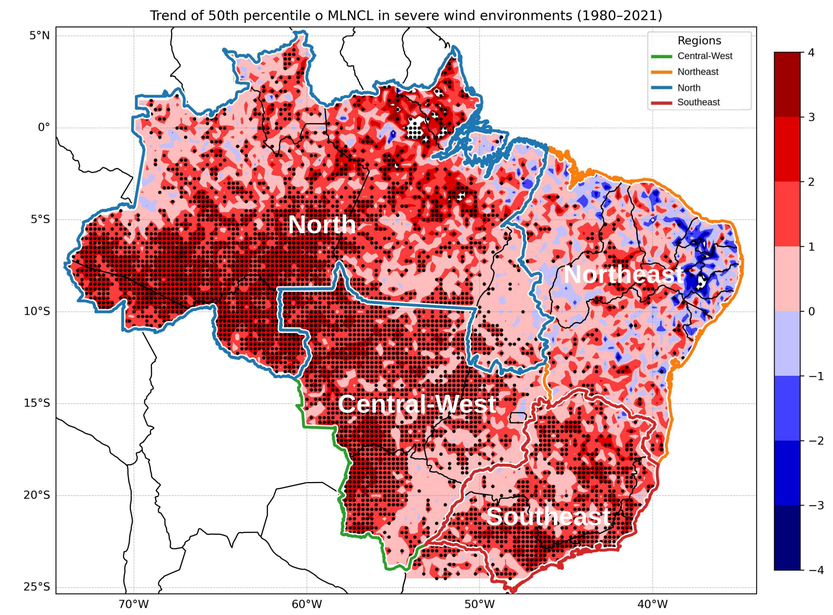

Fig. 4 - Trends for median MLLCL (m/season) under severe wind environments in the Central-North Brazil (1980-2021).

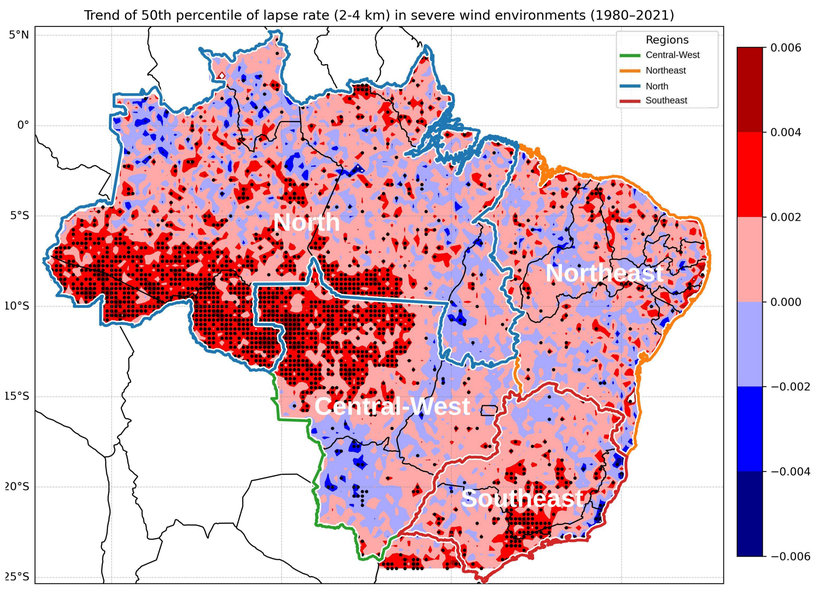

Fig. 5 -Trends for median LR2-4 (°C km/season) under severe wind environments in the Central-North Brazil (1980-2021).

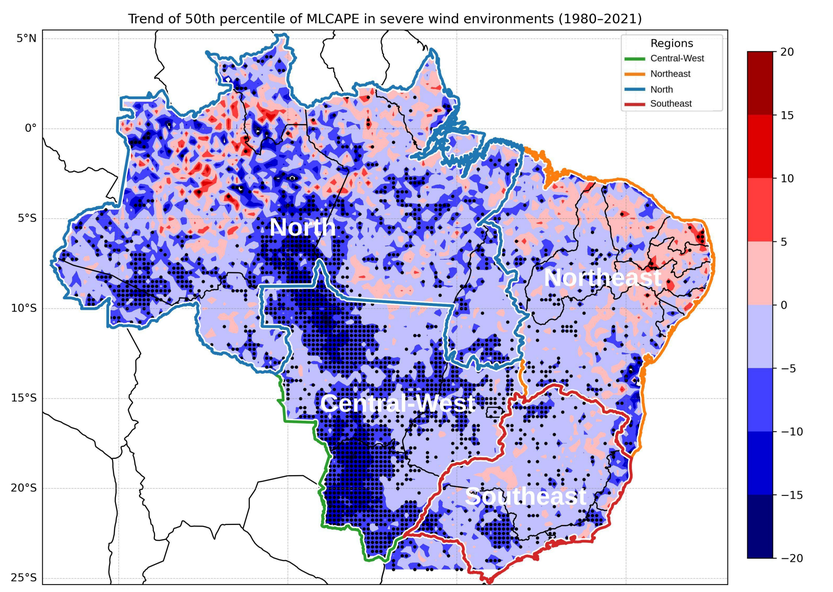

Fig 6 - Trends for median MLCAPE (J kg^{-1}/season) under severe wind environmentsin the Central-North Brazil (1980-2021).

CONCLUSIONS

- Central-West: the most active frequency of intense severe gust environments, surpassing 90 h/year in some regions.
- Southeast: maxima concentrated in the western MG and northern SP states, reaching ~ 60 h/year.
- North: well-defined latitudinal gradient, with frequencies decreasing toward the equator and increasing within the rainforest-cerrado transition.
- Northeast: the lowest frequency of favorable environments, with a longitudinal gradient with increased frequencies in western BA surpassing 30 h/year.
- Seasonally, severe convective gust environments peak from late austral winter to spring (dry-to-wet transition in tropical Brazil), with higher frequencies during the warm season, highlighting the strong role of thermodynamic instability.
- Over the past 40 years, most regions showed an increase in hours with environments favorable to severe gusts, except for the Northeast, where this trend was less evident.
- The positive trend is mainly linked to higher LCLs, which deepen the sub-cloud layer and potentially enhance evaporation of precipitating hydrometeors, favoring stronger downdrafts.