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Trend analysis of the climate database used in agricultural climate risk zoning

Abstract – The objective of this work was to identify trends in the series of historical rainfall, temperature, and evapotranspiration, considering the meteorological database used in studies on agricultural climate risk zoning (ZARC). The daily meteorological databases used in ZARC were compiled from about 4,000 station points over a continuous period from 1984 to 2022. The trend analysis was performed using Mann-Kendall's test and Sen's slope estimator for the entire Brazilian territory. The results highlighted the emergence of marked spatial and temporal climate trends in Brazil, with a potential impact on agricultural risks. Although more than 79% sites have shown no significant rainfall trends, a decreasing pattern was observed mainly at the beginning of the rainy season in August-September over the central region of Brazil, as well as a decrease in rainfall in April and an increase in October, in the South of the coutry. This decline in the central region coincides with a significant rise of minimum/maximum temperatures and evapotranspiration, leading to an extension of the dry season. The spatial-temporal change in rainfall associated with an annual increase in temperature (5%) and evapotranspiration (10%), could significantly affect agricultural production across many grain-producing regions in Brazil, particularly in areas where more than one crop is grown per season.

Index terms: climate variables, historical series, Mann-Kendall's test, Sen's slope estimator.

Análise de tendências em banco de dados climáticos utilizado em zoneamento agrícola de risco climático

Resumo – O objetivo deste trabalho foi identificar tendências nas séries históricas de chuva, temperatura e evapotranspiração, por meio do banco de dados meteorológicos utilizado nos estudos de zoneamento de risco climático agrícola (ZARC). As bases de dados meteorológicos diários, utilizadas no ZARC, foram compiladas de cerca de 4.000 pontos de estação em um período contínuo de 1984 a 2022. A análise de tendências foi realizada por meio do teste de Mann-Kendall e do estimador de declive de Sen, para todo o território brasileiro. Os resultados evidenciam o surgimento de tendências climáticas espaciais e temporais marcantes no Brasil, com potencial impacto sobre os riscos agrícolas. Embora mais de 79% dos locais não tenham mostrado tendências significativas de chuva, observou-se um padrão de diminuição, principalmente no início da estação chuvosa, em agosto-setembro, na região central do Brasil, bem como uma diminuição das chuvas em abril e um aumento em outubro, no Sul do país. Este declínio na região central

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coincide com um aumento significativo das temperaturas mínimas/máximas e da evapotranspiração que leva a um prolongamento da estação seca. A alteração espaço-temporal da chuva, associada ao aumento anual de temperatura (5%) e evapotranspiração (10%), pode afetar significativamente a produção agrícola em muitas das regiões produtoras de grãos do Brasil, especialmente em áreas onde mais de uma safra é cultivada por estação.

Termos para indexação: variáveis climáticas, série histórica, teste de Mann-Kendall, estimador de declive de Sen.

Introduction

Brazil is a world leader in the production and export of agricultural products such as soybean, coffee, sugar, beef, and chicken (FAO, 2025). However, just over 7% of the country's agricultural area uses irrigation (ANA, 2021; IBGE, 2025), and less than 20% is covered by rural insurance (Brasil, 2020), which indicates that most of the productive sector remains exposed to considerable climate risks. These facts reinforce the importance of policies and technologies to improve climate risk management in agriculture.

Agriculture is inherently influenced by weather variability, and assessing long-term meteorological trends is crucial for understanding potential risks to agricultural production. In Brazil, the agricultural climate risk zoning (*zoneamento agrícola de risco climático* – ZARC) is key in determining the climate risk for crop suitability across regions, by integrating crop-related information with local limitations of soil and weather conditions (Brasil, 2019). Since the 1990s, ZARC assessments have been used by the Brazilian Ministry of Agriculture and Livestock (Ministério da Agricultura e Pecuária, MAPA), as a criterion for reducing claims in risk transfer programs − such as the agricultural activity guarantee program (Programa de Garantia da Atividade Agropecuária – Proagro) and the rural insurance subsidy (Programa de Subvenção ao Prêmio de Seguro Rural (PSR) (Brasil, 2022). However, the increasing impacts of climate change and interannual variability on crop productivity (Ray et al., 2015; Hu et al., 2024) pose significant challenges in updating the climatic database, to ensure that risk assessments remain accurate.

Reliable agrometeorological assessments require high-quality, long-term weather data, ideally averaged over 30 years (WMO, 2017). In regions with limited ground-based measurements, data gaps can be addressed using Earth observation systems such as the National Aeronautics and Space Administration Prediction of Worldwide Energy Resources (NASA POWER) and Climate Hazard Group InfraRed Precipitation with Station data (CHIRPS), widely used in agrometeorological assessments across Brazil (Duarte & Sentelhas, 2020; Battisti et al., 2024). Additionally, potential evapotranspiration, closely related to productivity, is often estimated using the Penman-Monteith method recommended by the Food and Agriculture Organization (FAO) (Allen et al., 1998).

The integration of these datasets to updated bases is crucial, as several studies have identified notable trends in key climatic variables across Brazil, including rising temperatures and shifts in rainfall patterns (Salviano et al., 2016; Penereiro, 2020; Regoto et al., 2021). In this context, trend analysis techniques including the Mann-Kendall´s test and Sen's slope estimator have been widely used to provide valuable insights into the direction and magnitude of climatic changes over time (Marengo et al., 2022a; Tomasella et al., 2023).

The objective of this work was to identify trends in the series of historical rainfall, temperature, and evapotranspiration, considering the meteorological database used in studies on ZARC.

Materials and Methods

The preparation of the database followed the same criteria used in ZARC that prioritizes the selection of long-term and continuous series, without gaps, and with erroneous data flagged and replaced (Monteiro, 2024). Rainfall data were primarily sourced from rainfall stations operated or distributed through the National Water Resources Information System (Sistema Nacional de Informações sobre Recursos Hídricos − SNIRH), from the Agência Nacional de Águas e Saneamento Básico (ANA, 2024). These rainfall information were complemented by additional stations from other national or state networks, such as the Instituto Nacional de Meteorologia (INMET), Comitê de Monitoramento do Setor Elétrico (CMRHSE), Empresa de Pesquisa Agropecuária do Rio Grande do Norte (EMPARN), and Instituto de Tecnologia de Pernambuco (ITEP), by applying the same end date criteria. Only stations with at least 31 years of records between 1984 and 2022 were considered. Stations with more than 30% missing data were excluded. Remaining data were subjected to a quality control procedure, through comparisons with those from CHIRPS (Funk et al., 2015), and flagged as error in cases of monthly rainy days, or total rainfall outside long-term median +/- 3 standard deviations and also annual extreme values with less than 50 mm, or greater than 5000 mm. Any rain data removed during the quality check, along with remaining gaps were filled using CHIRPS data.

For the selected stations, the daily meteorological variables global solar radiation, Tmin, Tmax, wind speed, and relative humidity were obtained from NASA POWER and used to calculate the reference evapotranspiration (ETo), following the FAO-56 Penman-Monteith method (Allen et al., 1998). Furthermore, daily Tmin and Tmax data were obtained from the Brazilian Daily Weather Gridded Data (BR-DWGD) database (Xavier et al., 2022). These two datasets for temperature and ETo estimation are the current options being used in ZARC. The BR-DWGD provides a better representation of temperature extremes, which are crucial for ZARC's thermal risk evaluation. NASA POWER provides consistent spatial and temporal coverage for weather variables essential for reliable ETo estimations, addressing the limitations present in the Brazilian weather station records.

The Mann-Kendall's test (Kendall, 1938; Mann, 1945) assesses trends in time series data by comparing each value with all preceding values, using the function ($x_j - x_i$). This function outputs either 1, 0, -1, depending on whether the difference between the data points at times i and j is positive, zero, or negative, respectively. The statistic Z-score (Zs) is then calculated, based on the mean (S) and variance (Var(S)) of these differences, as expressed by:

$$Zs = \begin{cases} \frac{S-1}{\sqrt{Var(s)}} \text{ if } S > 0 \\ 0 \text{ if } S = 0 \\ \frac{S+1}{\sqrt{Var(S)}} \text{ if } S < 0 \end{cases}$$

Positive Zs values indicate an increasing trend, while negative values suggest a decreasing one. A trend is considered statistically significant at a given significance level (α), if |Zs| exceeds the corresponding critical value ($Z1-\alpha/2$), leading to the rejection of the null hypothesis of no trend. In the present study, significance levels of $\alpha = 0.10$, $\alpha = 0.05$, and $\alpha = 0.01$ were applied, and the null hypothesis was rejected when |Zs| surpassed 1.65, 1.96, and 2.58, respectively. The term $Z1-\alpha/2$ represents the critical value from the standard normal distribution (for instance, for $\alpha = 0.05$, $Z1-\alpha/2 = 1.96$).

To quantify the magnitude of detected trends, the Sen's slope estimator (Sen, 1968) was applied together with the Mann-Kendall's test. Both tests were individually applied for each study site using monthly and annual time series data (1984-2022) on rainfall, Tmax, Tmin, and ETo. Trend significance was assessed at 90%, 95%, and 99%.confidence levels of

Results and Discussion

Rainfall exhibited a heterogeneous spatial distribution across Brazil, varying by month, with no significant trends in over 79% of the evaluated locations (Table 1 and Figure 1). Few scattered points with an upward, or downward trend occurred more isolated in all months. In contrast, in just a few months, there was a greater concentration of points with the same defined trend in a more dispersed and broad manner, or in a grouped manner. Significant decreases were observed in the central region of Brazil, mostly in August and September, with mean negative trends of -0.239 mm and -0.893 mm per year, respectively (Tables 1 and 2; Figure 1). Rainfall reaches 52% reduction in September, which represents a critical increase in climatic risk, with the potential to destabilize the planting window, compromising the viability of the second crop and increasing cost and pressure on the regional water sources. A negative trend was also pronounced in April (-1.510 mm per year), and it was more concentrated in the country's Southern region, and in its Southeast region (São Paulo state), being scattered in the Center-West region. These results indicate an earlier onset and later end of the dry season in the central region of Brazil, particularly in the transitional months April and September. In contrast, October and November exhibit 11.7% and 12.1% of the locations, with significantly increasing rainfall trends (at 10%), mostly in parts of the South and Southeast regions, at a rate of 1.364 mm per year and 1.353 mm per year, respectively.

For the annual scale that is consistent with 83.3% of sites without significant trend, early studies by Salviano et al. (2016) and Penereiro (2020) also reported no significant trend in over 70% of Brazil's territory. When significant trends are detected (at 10% level), reductions of annual rainfall (9.1% of the series) are more frequent than increases (7.6% of the sites). However, an average

Table 1. Monthly and annual percentage of weather stations, across Brazil, showing negative, nonsignificant (NS), and positive rainfall, minimum temperature (Tmin), maximum temperature (Tmax), and evapotranspiration (ETo) trends at 99%, 95%, and 90% confidence intervals (CI), based on the Zs values of the Mann-Kendall's test over the historical period (1984-2022). For the NS level, CI of 90% was considered.

Variable	CI	Month												Annual
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Rainfall	-99%	0.3	0.5	0.9	2.2	1.0	0.7	1.1	2.1	2.9	0.9	0.5	0.5	2.0
	-95%	1.0	2.0	3.6	10.6	3.9	2.3	5.4	7.3	11.1	2.5	1.9	2.3	5.5
	-90%	2.4	4.0	6.7	18.1	7.7	4.3	9.3	12.4	18.1	4.4	3.2	4.2	9.1
	NS	94.0	90.3	88.1	79.0	89.7	89.7	87.8	85.9	79.8	83.9	84.7	90.4	83.3
	90%	3.6	5.7	5.2	2.9	2.6	6.0	2.9	1.7	2.1	11.7	12.1	5.4	7.6
	95%	1.7	3.2	2.8	1.7	1.2	3.2	1.5	0.8	1.4	6.5	8.0	3.1	4.8
	99%	0.4	1.0	0.6	0.6	0.3	0.5	0.6	0.1	0.3	1.3	2.9	0.9	2.2
Tmin	-99%	0.6	0.8	1.6	5.6	5.4	0.2	1.3	2.7	0.6	0.1	1.3	0.8	3.0
	-95%	1.8	3.1	4.2	9.6	10.3	0.6	3.6	5.9	1.8	0.5	3.8	2.9	6.2
	-90%	3.0	5.2	5.7	12.3	13.1	1.2	5.6	8.1	2.4	1.1	6.1	4.5	7.8
	NS	50.4	50.4	50.1	56.1	57.3	38.8	44.6	48.6	35.4	31.6	54.3	44.2	29.1
	90%	46.6	44.4	44.2	31.6	29.6	60.0	49.8	43.3	62.2	67.3	39.6	51.3	63.1
	95%	38.6	37.4	38.8	28.0	24.4	53.6	43.2	36.8	54.9	60.8	35.4	44.4	58.5
	99%	24.9	25.1	25.6	21.5	18.2	40.9	29.7	23.2	40.9	48.9	27.2	30.8	50.7
Tmax	-99%	0.3	0.6	0.9	1.3	3.0	0.4	0.6	0.4	0.0	0.5	2.9	1.0	1.7
	-95%	0.7	1.8	1.8	2.8	5.4	0.9	1.0	0.9	0.2	1.1	4.5	1.4	2.6
	-90%	1.2	3.0	2.3	3.8	7.0	1.4	1.3	1.6	0.4	1.7	5.7	1.7	3.2
	NS	62.9	51.6	40.3	44.6	58.9	42.7	29.0	35.7	10.0	40.1	58.7	46.4	16.1
	90%	35.9	45.4	57.4	51.6	34.1	55.9	69.7	62.7	89.6	58.2	35.6	51.9	80.7
	95%	26.0	33.9	50.0	43.4	28.9	47.9	60.8	55.8	87.5	51.8	30.5	42.5	76.2
	99%	11.7	17.5	31.0	29.8	18.6	35.1	41.4	44.3	76.7	39.6	23.4	25.2	67.0
ETo	-99%	0.1	0.7	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	10.7	0.6	0.1
	-95%	3.1	1.5	0.7	0.4	0.1	0.0	0.0	0.1	0.0	2.0	18.9	4.6	0.8
	-90%	7.8	2.9	1.3	0.5	0.4	0.2	0.1	0.1	0.0	5.8	24.6	8.7	1.9
	NS	82.7	87.5	73.0	58.5	71.0	68.2	52.8	46.5	41.8	77.8	70.9	82.0	64.2
	90%	9.5	9.6	25.7	41.0	28.6	31.6	47.1	53.4	58.2	16.4	4.5	9.3	33.9
	95%	5.0	6.0	16.4	29.1	21.9	22.8	37.8	42.9	46.6	11.9	2.3	4.9	28.0
	99%	1.1	1.2	6.1	12.0	12.3	14.4	25.6	24.6	28.2	5.3	0.5	0.8	18.6

Table 2. Monthly and annual Sen's slope rate of the linear trends of rainfall, minimum temperature (Tmin), maximum temperature (Tmax), and evapotranspiration (ETo) over the historical period (1984-2022), for sites that show significant changes at 10% level. In parentheses, percentage variation in relation to the national climatological average over 1984–2022.

Month	Rainfall (mm/year)	Tmin (ºC/year)	Tmax (ºC/year)	ETo (mm/day/year)
Jan.	0.648 (13%)	0.024 (5%)	0.036 (5%)	0.004 (4%)
Feb.	0.932 (21%)	0.022 (4%)	0.034 (4%)	0.006 (6%)
Mar.	-0.075 (-2%)	0.020 (4%)	0.036 (5%)	0.011 (11%)
Apr.	-1.510 (-43%)	0.009 (2%)	0.035 (5%)	0.011 (13%)
May	-0.327 (-13%)	0.007 (2%)	0.027 (4%)	0.012 (16%)
June	0.089 (5%)	0.048 (12%)	0.042 (6%)	0.015 (21%)
July	-0.199 (-15%)	0.036 (9%)	0.048 (7%)	0.013 (17%)
Aug.	-0.239 (-22%)	0.029 (7%)	0.049 (7%)	0.016 (15%)
Sept.	-0.893 (-52%)	0.044 (10%)	0.077 (10%)	0.021 (18%)
Oct.	1.364 (52%)	0.037 (8%)	0.051 (7%)	0.012 (10%)
Nov.	1.353 (41%)	0.022 (4%)	0.030 (4%)	-0.012 (-9%)
Dec.	0.485 (11%)	0.023 (4%)	0.036 (5%)	0.001 (1%)
Annual	1.598 (4%)	0.023 (5%)	0.034 (5%)	0.010 (10%)

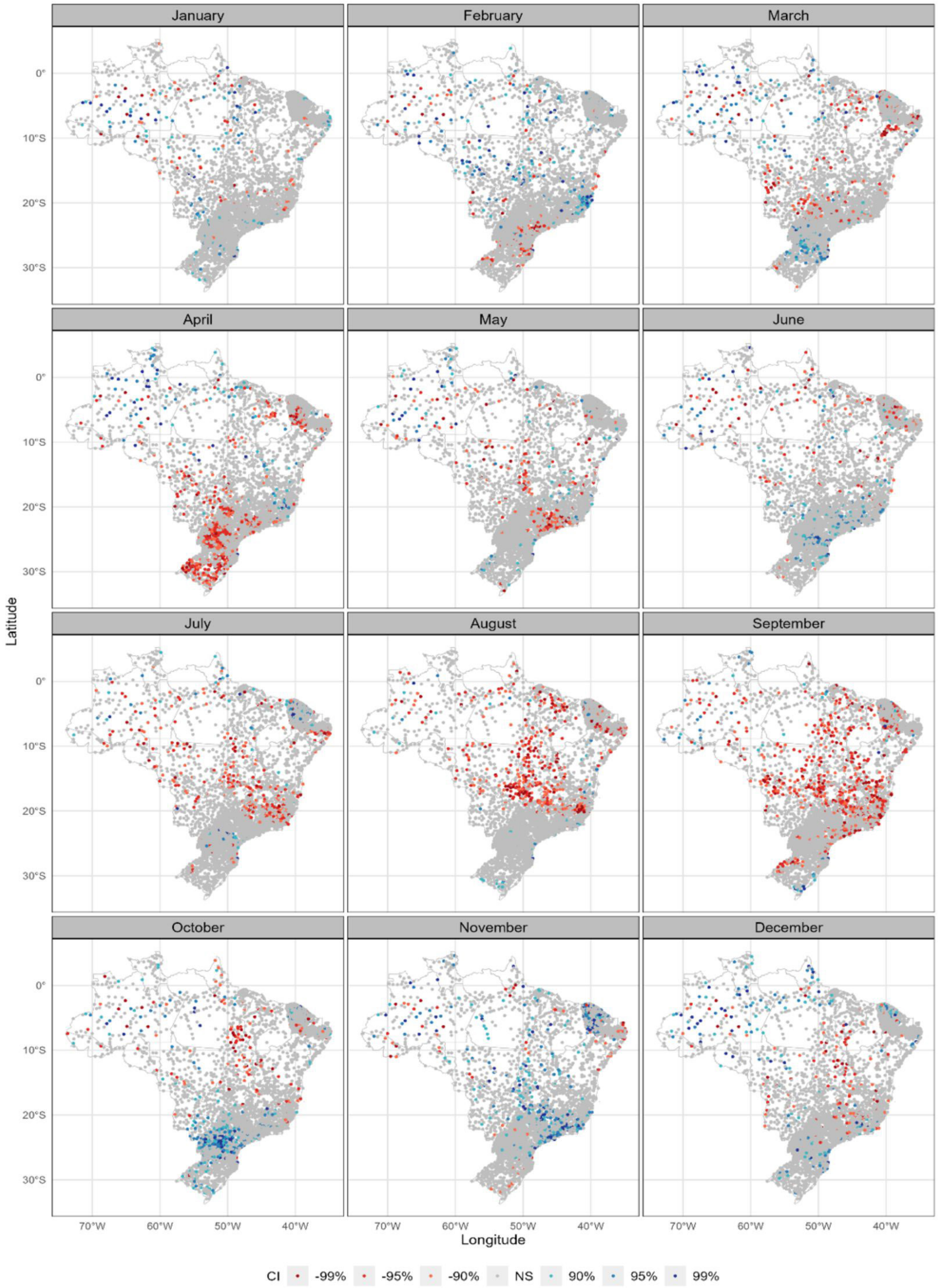

Figure 1. Monthly confidence intervals (CI) for rainfall trend across Brazil. Stations are categorized by trend direction, and significance is based on the Zs values of the Mann-Kendall's test, with negative (red), nonsignificant (NS, gray), and positive (blue) trends at 99%, 95%, and 90% CI. Higher color intensity represents a greater statistical significance over the historical period (1984-2022).

increase of 1.598 mm per year is observed (Tables 1 and 2). Despite this slight increase of rainfall in Brazil, this pattern is not uniform across the country, as some sites also exhibited declining trends.

The spatial variability observed in the present study corroborates the results of broader studies, which have reported declining rainfall trends across some parts of Brazil, particularly in the Northeast, Center-West, and Southeast regions (Regoto et al., 2021; Marengo et al., 2022b; Hofmann et al., 2023; Tomasella et al., 2023). Rainfall reductions have been attributed to distinct drivers such as El Niño Southern Oscillation (ENSO), Atlantic Ocean Sea Surface Temperature (SST), atmospheric circulation patterns and deforestation (Hofmann et al., 2023; Smith et al., 2023; Tomasella et al., 2023). Latest drought events reinforce these findings. Marengo et al. (2022a) reported a delayed onset of the 2019–2020 rainy season in the Pantanal biome region (Center-West region), contributing to one of the most extreme droughts in recent decades. Similarly, Hofmann et al. (2023), identified reductions of rainfall of up to 50% across the Cerrado biome (Center-West Brazil), especially during the dry season and at onset of the wet season.

There is a consistent increase of temperature across Brazil, with a predominant warming trend in locations where significant changes were detected at 10% level (Figures 2 and 3). For Tmin, from January to May and November recorded the highest percentages of sites without a significant trend, ranging from 50.4% to 57.3% (Table 1). Overall, the South region shows no clear trend. A significant increase was observed in June, September, October, and December across more than 60% of the sites analyzed (Table 1; Figure 2). The greatest monthly average increase is observed from June to October (>0.029ºC year^{-1}, warming of 1.12°C from 1984 to 2022). This increase peaks at 0.048°C per year in June, with warming of 1.87°C over the historical period assessed (60% of the sites), followed by 0.044°C per year in September (62.2% of the sites). These results represent 12% and 10% increases, respectively, mostly in areas of the Center-West, Southeast, and South. However, localized significant decreases of Tmin are observed in certain months, particularly in the South and in the Southeast regions.

The analysis of Tmax trends indicates that May, November, January, and February concentrated mostly nonsignificant changes, covering more than 51.6% of locations (Table 1, Figure 3). More than 50% of the sites exhibited increasing trends in March (57.4%), April (51.6%), from June to October (55.9% to 89.6%), and December (51.9%), with the most pronounced warming occurring from June to October (>0.042°C per year, warming of 1.63°C) (Tables 1 and 2). September stands out with the highest number of sites experiencing significant increases (89.6% and 10% increase), particularly in the Center-South region, where the warming average rate reaches 0.075°C per year (Figure 3, Tables 1 and 2), which is potentially connected with the observed rainfall decrease in this region. Although warming trends dominate, some locations exhibit significant decreasing trends of Tmax (South and Southeast coast). Across the country, Tmax exhibits a higher rate of increase than Tmin, with annual rises of 0.034°C per year and 0.023ºC per year, observed in 80.7% and 63.1% of the sites, respectively (Tables 1 and 2).

Temperature data show consistent and widespread warming trends across most of Brazil, which corroborates the findings by Penereiro (2020), Curado et al. (2023), and Tomasella et al. (2023), who reported statistically significant and positive trends for both Tmin and Tmax throughout the country, except for some of the South and Southeast. Salviano et al. (2016) also identified increasing trends of mean temperature, at 10% significance level, from 49.6% to 82.5% of the Brazilian territory. Souza et al. (2025) further quantified this warming, indicating an annual increase of Tmax of up to 0.027°C per year. These patterns reflect broader global trends, including the warmest decade on record worldwide, and Brazil experiencing 2024 as its hottest year since 1961, likely amplified by the recent El Niño events (INMET, 2025).

The observed temperature increase (for instance, over 1°C in 39 years) implies not only average warming, but a significant increase of the frequency of days with extreme temperatures, which intensifies the risk of plant heat stress.

Several sites (over 41.8%) exhibited no significant trends in ETo throughout the months (Table 1 and Figure 4). At 10% significance level, a predominant pattern of increasing water demand is evident in most of the country. From October to January, at least 5% of sites showed a decline of ETo, with a particularly notable reduction in November (24.6%), when the number of sites with decreasing trends exceeds those with increasing ones. These areas are primarily

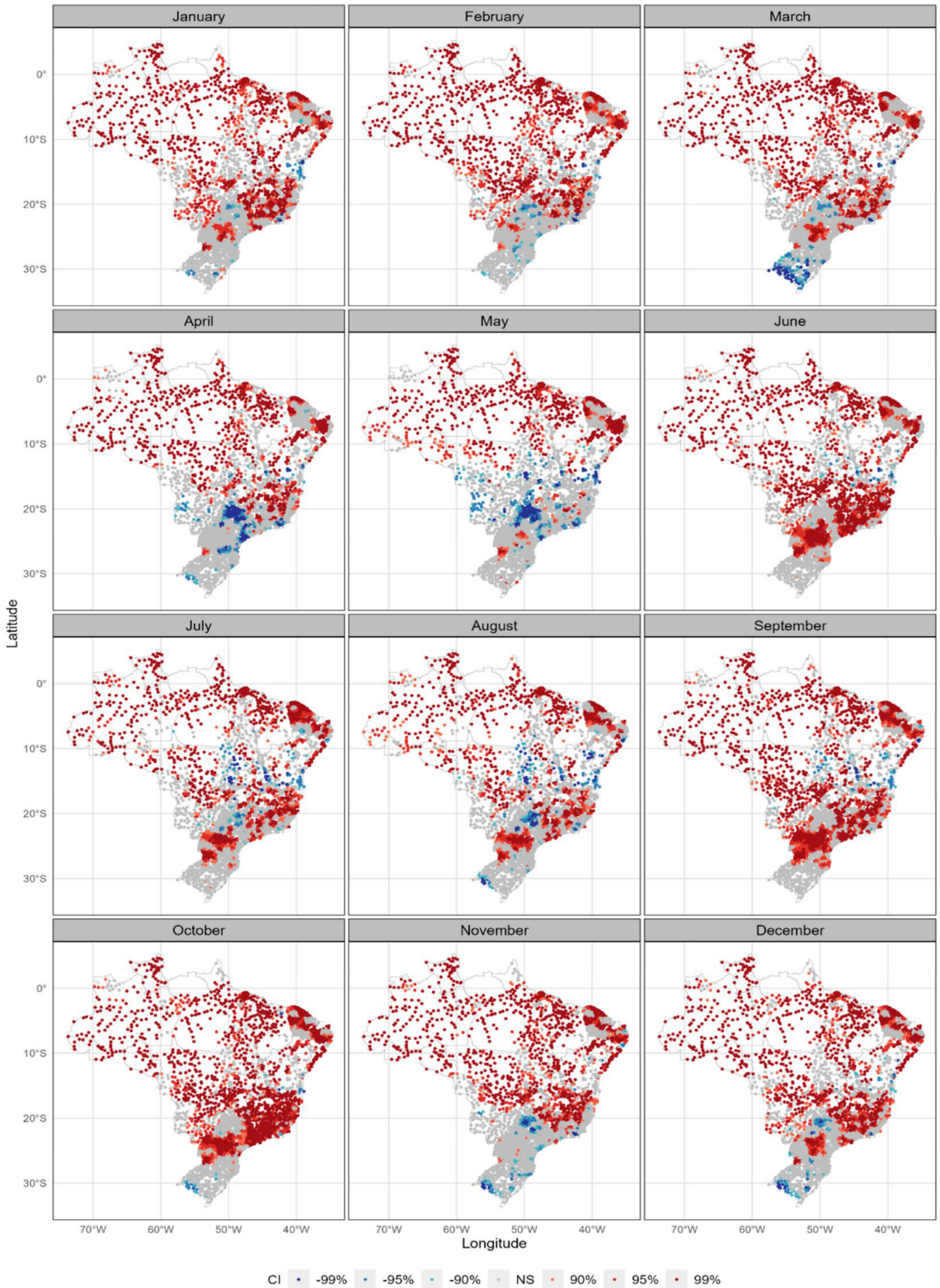

Figure 2. Monthly confidence intervals (CI) for minimum temperature trend across Brazil. Stations are categorized by trend direction, and the significance is based on the Zs values of the Mann-Kendall´s test, with negative (blue), nonsignificant (NS, gray), and positive (red) trends at 99%, 95% and 90% CI. Higher color intensity represents a greater statistical significance over the historical period (1984-2022).

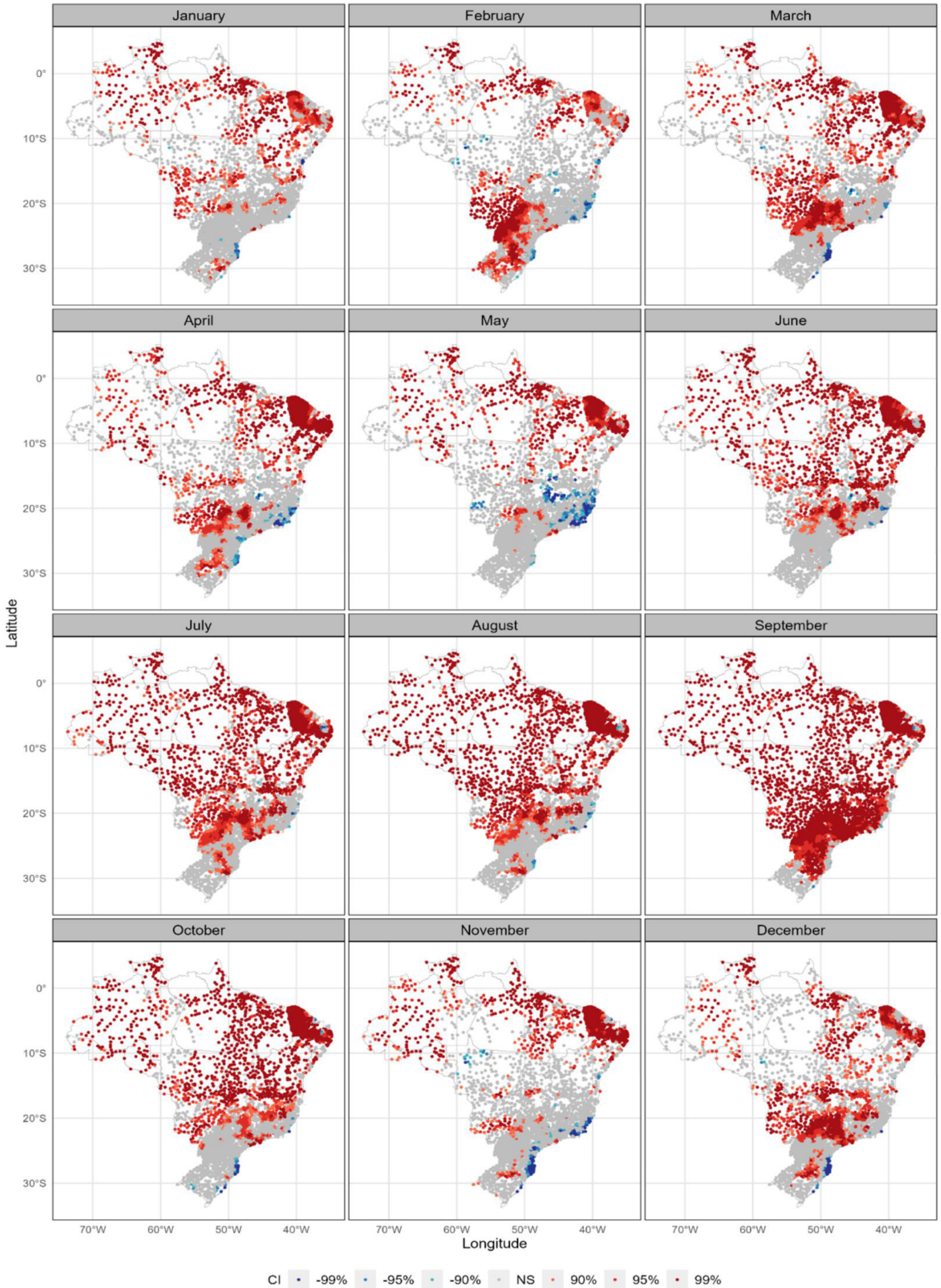

Figure 3. Monthly confidence intervals (CI) for maximum temperature trend across Brazil. Stations are categorized by trend direction, and the significance is based on the Zs values of the Mann-Kendall´s test, with negative (blue), nonsignificant (NS, gray), and positive (red) trends at 99%, 95%, and 90% CI. Higher color intensity represents a greater statistical significance over the historical period (1984-2022).

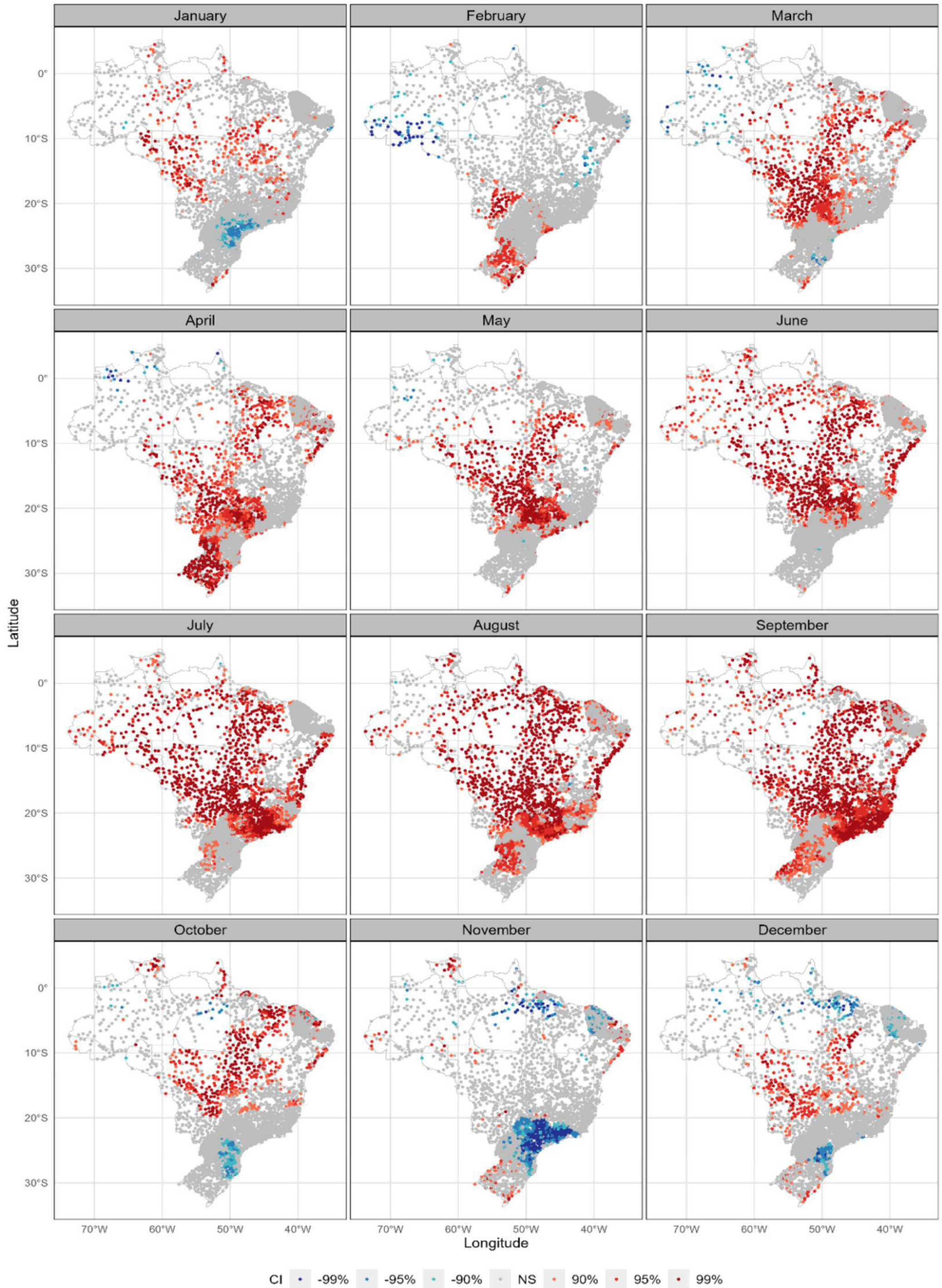

Figure 4. Monthly confidence intervals (CI) for reference evapotranspiration trend across Brazil. Stations are categorized by trend direction, and the significance is based on the Zs values of the Mann-Kendall´s test, with negative (blue), nonsignificant (NS, gray), and positive (red) trends at 99%, 95%, and 90% CI. Higher color intensity represents a greater statistical significance over the historical period (1984-2022).

concentrated in Southern Brazil and in the Southeast region only in November (Figure 4). Over the study period, annual water demand increased at 0.010 mm / day/year, which is 10% increase, at 33.9% of the sites, with a more pronounced rise (>0.011 mm/day/year) from March to October, peaking in September (0.021 mm/day/year, which is 18% increase, at 58.2% of the sites analyzed) in Center-Southeast areas (Tables 1 and 2, Figure 4). This rate of 0.021 mm/day/year, over 39 years, results in an ETo difference of 0.82 mm per day between the beginning and the end of the series. In contrast, in November, ETo exhibited a decline (-0.012 mm/day/year), mainly in parts of the South, Southeast, and Northeast regions, while the majority of the country remained neutral.

The observed increase of ETo across Brazil is closely aligned with significant rising trends in both Tmin and Tmax, especially during the dry season. This warming has been widely associated with higher atmospheric evaporative demand (Curado et al., 2023; Tomasella et al., 2023). These patterns suggest that Center-Southeast regions are increasingly vulnerable in terms of water scarcity.

The relationship between ETo and rainfall is complex. Reduced rainfall lowers soil moisture availability, which can increase evaporative demand by raising sensible heat and decreasing latent heat fluxes (Zhao et al., 2022). In regions experiencing both warming and declining rainfall, these effects can intensify the hydrological stress, resulting in more severe water deficits for agriculture (Marengo et al., 2022a; Tomasella et al., 2023). Conversely, reductions of ETo during certain months, or in specific regions, may be driven by other climatic or land-atmosphere interactions. For instance, increased cloud cover and rainfall, evidenced by positive rainfall trends in the same areas and periods (Figure 1), higher atmospheric humidity, or changes in surface albedo can reduce the energy available for evaporation (Caballero et al., 2022). These factors may limit ETo, even in the context of a broader climate warming.

Conclusions

1. There is a significant decreasing of rainfall trend in the central region of Brazil, during the dry-to-wet season transition (August-September), that potentially delays the onset of the rainy season.

2. Minimum temperature trends show a significant warming from June to October, particularly in the Center-Southeast region in Brazil, reinforcing the extension of the dry season

3. Maximum temperatures show a consistent and more intense warming trend than minimum temperatures, especially in September in the Center-South region of Brazil.

4. The increase of ETo, especially during the dry months, reflects higher atmospheric evaporative demand driven by warming.

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Data not available: research data are not available because they are subject to institutional restrictions. Requests for access may be directed to the corresponding author and will be considered upon approval.

Declaration of use of AI technologies

No generative artificial intelligence (AI) was used in this study.

Conflict of interest statement

The authors declare no conflicts of interest.

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