EVIDENCES OF INCREASING ARIDITY IN THE SÃO FRANCISCO WATERSHED, NORTHEAST BRAZIL

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Évidences de l'intensification de l'aridité dans le bassin du fleuve São Francisco, nord-est du Brésil

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Introduction

Aridity, despite a complex concept to define, is usually used as a term to characterize dry and barren lands which struggle to bear life or that are populated with highly-specialized and resilient ecosystems (Greve *et al.,* 2019). Aridity is often observed in drought-prone areas and is used as an indicator of susceptibility for desertification. In a climate change scenario, drought events are becoming more frequent, leading to increasing aridity and therefore increasing risk for desertification (Greve *et al.,* 2019). This poses an important threat to dryland ecosystems and populations, which will need to further adapt to face the challenges of an increasingly drier climate over these regions. Despite its complexity, aridity is usually assessed through the simple Aridity Index (AI), based on the early Thornthwaite's water balance studies, which is the ratio between water input (precipitation – P) and output (potential evapotranspiration – PET) over a region (Tsiros *et al.,* 2020). Depending on the AI value, a region's dryness can be classified as hyperarid, arid, semiarid, dry subhumid or humid. Assessing climatological changes in the AI is important to monitor the effects of climate change over drylands, and it should be conducted not only on 30-years average terms but also observing the annual frequency of aridity types. For example, Dubreuil *et al.* (2019) assessed Koppen's climate types changes over Brazil through a climatological and annual perspective, finding increasing occurrence of climate types that are not captured by the 30-year climatology.

Therefore, the objective of this work is to highlight changes in aridity over the São Francisco watershed (SFW), Northeast Brazil, which is a key basin in Brazil providing water to most of the semiarid areas of the country. The study is conducted comparing two periods: 1961-1990 and 1991-2020, while also accounting for annual changes in the frequency of AI classes. The idea is to complement previous studies conducted in the SFW which already found increasing PET and meteorological water deficit in the last decades (Mutti *et al.,* 2020, 2022).

1. Data and methods

The AI was calculated using P and PET data from the Brazilian Daily Weather Gridded Dataset (BR-DWGD) by Xavier *et al.* (2022), which provides ground-measured interpolated meteorological data in a 0,1º x 0,1º grid for the 1961-2020 period. We compared mean AI values over the SFW for the 1961-1990 and 1991-2020 periods (linear correlation between each period). We also analyzed the annual frequency of each aridity class defined by the AI in the entire period: AI < 0.03: hyperarid; 0.03 < AI < 0.20: arid; 0.20 < AI < 0.50: semiarid; 0.50 < AI < 0.65: dry subhumid; and AI > 0.65: humid.

2. Results and discussion

The Figure 1 shows the spatial result for the arid classification (0.03 < AI < 0.20), which features up to 90% more occurrences in the 1991-2020 if compared to 1961-1990 in most of the low-middle SFW (LMSF) and portions of the middle SFW (MSF). These results agree with Dubreuil *et al.* (2019), which found increasing frequencies of Koppen's dry climate types over these regions. Mutti *et al.* (2022) also found an expansion of drought occurrence towards the MSF and low SFW (LSF) in the last decades. It is noteworthy that large unprecedent arid areas were registered at least once in the 1991-2020 period, even in the more humid upper SFW (USF). These areas do not appear in the climatological map for the 1991-2020 period (figure not shown).

Regarding the average AI in 1961-1990 and 1991-2020, one can notice that it decreased in magnitude over the entire SFW (right panel of the figure 1). Mean overall reductions from 3% (LSF) to 16% (LMSF) in the AI were

observed. The Figure 1 also shows that the most remarkable change was from dry subhumid classes to semiarid, mostly in the MSF and USF.

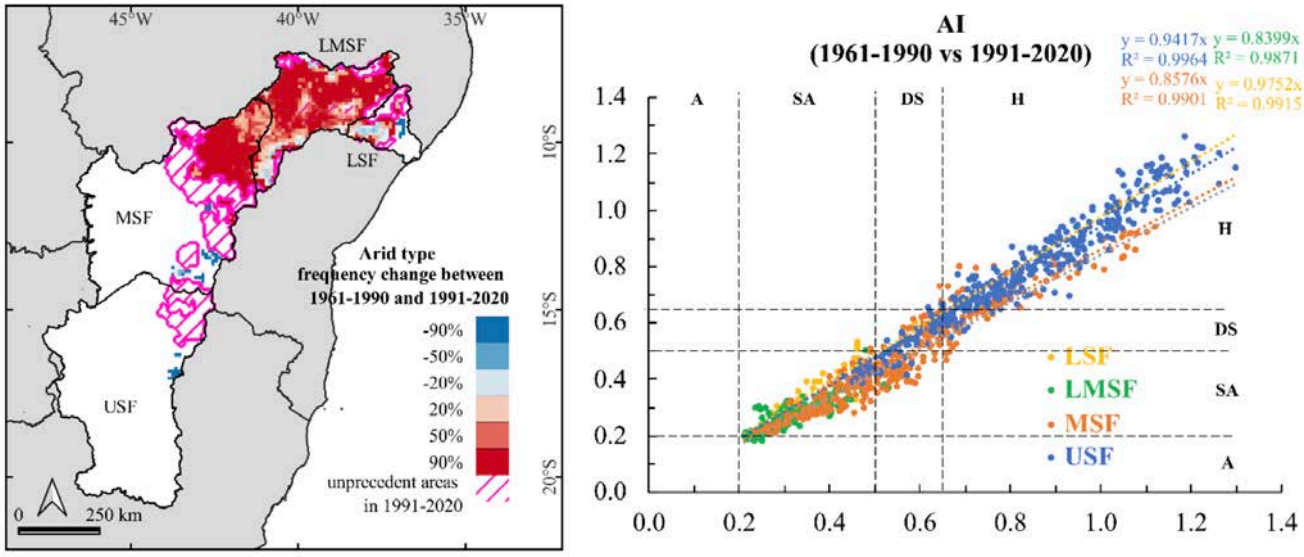

Figure 1. Left panel: arid type (0,03 < AI < 0,20) frequency change between 1961-1990 and 1991-2020, also showing areas classified as arid at least once in 1991-2020 but never in 1961-1990.
Right panel: scatter plot of the mean AI in sampled grid points of the study area in 1961-1990 (x-axis) versus 1991-2020 (y-axis). USF, MSF, LMSF and LSF refer to the upper, middle, low-middle and low portions of the São Francisco watershed. A: arid, SA: semiarid, DS: dry subhumid and H: humid.

Conclusion

Despite not all results being shown in the figure, our study revealed evidences of increasing aridity over the SFW, Northeast Brazil. We found that, in mean climatological terms, the region's overall dryness is increasing, with the expansion of semiarid lands and the diminishment of subhumid areas. Not only that, we also found that the annual occurrence of arid typologies is becoming more frequent, with unprecedent areas reaching high degrees of dryness.

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Bibliography

Dubreuil V., Fante K., Planchon O. et Sant'Anna Neto J. L., 2019 : Climate change evidence in Brazil from Köppen's climate annual types frequency. *International Journal of Climatology*, **39**, 3, 1446-1456.

Greve P., Roderick M. L., Ukkola A. M. et Wada Y., 2019 : The aridity index under global warming. *Environmental Research Letters*, **14**, 124006, 1-11.

Mutti P. R., Dubreuil V., Bezerra B. G., Arvor D., de Oliveira C. P. et Santos e Silva C. M., 2020 : Assessment of Gridded CRU TS Data for Long-Term Climatic Water Balance Monitoring over the São Francisco Watershed, Brazil. *Atmosphere*, **11**, 1207, 1-25.

Mutti P. R., Dubreuil V., Bezerra B. G., Arvor D., Funatsu B. M. et Santos e Silva C. M., 2022 : Long-term meteorological drought characterization in the São Francisco watershed, Brazil: A climatic water balance approach. *International Journal of Climatology*, **42**, 16, 8162-8183.

Tsiros I. X., Nastos P., Proutsos N. D. et Tsaousidis A, 2020 : Variability of the aridity index and related drought parameters in Greece using climatological data over the last century (1900-1997). *Atmospheric Research*, **240**, 104914, 1-9.

Xavier A. C., Scanlon B. R., King C. W. et Alves A. I., 2022 : New improved Brazilian daily weather gridded data (1961- 2020). *International Journal of Climatology*, **42**, 16, 8390-8404.