

**COMMENT ON “TEMPORAL GEOMORPHIC
MODIFICATIONS AND CLIMATE CHANGE IMPACTS
ON THE LOWER COURSE OF THE SÃO FRANCISCO
RIVER, BRAZIL” BY TORRES ET AL. (2023)**

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**COMENTARIO SOBRE "MODIFICACIONES
GEOMÓRFICAS TEMPORALES E IMPACTOS DEL
CAMBIO CLIMÁTICO EN EL CURSO INFERIOR DEL
RÍO SÃO FRANCISCO, BRASIL" DE TORRES ET AL.
(2023)**

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ABSTRACT

Torres et al. (2023) argued that the Lower São Francisco River (LSFR) has undergone a significant morpho-sedimentary process in recent decades. The work applied remote sensing techniques in a multi-temporal analysis (1986–2020) to quantify sedimentation and erosion processes. Moreover, the Modified Normalized Difference Water Index (MNDWI) was used to indicate the narrowing of the channel. The authors examine how precipitation, runoff, MNDWI, and sedimentation are interrelated. They found that lower precipitation, reduced runoff, and increased sedimentation are correlated. However, the investigation strategy and analysis of the results present several limitations in the study of large tropical rivers. We argue here why the observation of increased sedimentation in the investigated area may not be considered valid for other areas of the LSFR. We also explain why the applied statistical relationship (precipitation, flow, and sedimentation) is inadequate. Our concern is that the use of results from an area that exhibits a transitional channel-pattern zone may be used as knowledge base for future interventions to repair a fluvial system as sensitive and complex as the São Francisco River.

Keywords: fluvial geomorphology, São Francisco River, anthropogenic impact, climate change, Northeast Brazil

1. INTRODUCTION

Torres et al. (2023) argued that recent sedimentation in the Lower São Francisco River (LSFR) is a response of the fluvial system to anthropogenic interference and climate change. They also suggested that the deposition of fine sediments in the channel has altered the longitudinal profile. To support their argument, the authors presented data that indicated an increase in sedimentation (+22%) in a restricted area of the fluvial system during the period 1985–2020. It was estimated that approximately 80% of the left bank remained stable or increased, while erosion occurred in a smaller proportion (20%). The findings were also supported by a statistical analysis



that considered the relationship between sedimentary areas (SED), MNDWI, precipitation, and flow.

We understand that the paper is important because it contributes to the documentation of morpho-sedimentary data for the LSFR, which is historically very limited. However, the investigation strategy and the discussion of the results present several aspects that are far from convincing.

Particularly, the São Francisco River is of major geomorphological and societal importance. It drains one of the largest basins in South America (Santos and Latrubesse, 2022a), serve as the main drainage system of the world's most populous dryland region (Marengo et al., 2016), and represents an emblematic case of Brazil's hydro-social-political tension (Brito and Magalhães, 2017). Given this significance, conclusions about recent morphological changes in the river should be supported by robust evidence and careful analysis. Therefore, we discuss several limitations in the approach adopted by Torres et al. and examine whether the available evidence adequately support their conclusions.

2. ARGUMENTS

2.1. Channel narrowing, increased island sizes, and the proliferation of sandbanks: A record limited to a transitional zone

LSFR is characterized by distinct geomorphological compartments, precipitation regimes, and vegetation types. The main channel along its course contains various geomorphological features. In general, in its upstream reach, the river is characterized by being embedded in a canyon of crystalline rocks (igneous and metamorphic) or by presenting a limited alluvial plain development. Downstream of Propriá, it drains less resistant sedimentary rocks from the Sergipe-Alagoas sedimentary basin and exhibits a significant alluvial plain. A brief look at the high-resolution Google Earth imagery shows that there are clear differences in the floodplains. These range from a floodplain formed by the accretion of banks (bars and islands) to a floodplain marked by the abandonment of meandering channels (Santos et al., 2025). Even more pronounced are the differences found in the channel. Therefore, there is clear evidence indicating variations in the pattern of sedimentation and erosion along the LSFR.

In this context, we argue that the study area investigated by Torres et al. is located in what has been described as a transitional zone between channel patterns (Fontes et al., 2002; Santos et al., 2025). Specifically, it marks the transition from braided multichannel system (the stretch between Propriá and Penedo/Neópolis) to anastomosed multichannel (the stretch between Penedo/Neópolis and the mouth of the river). It is a region where rocky outcrops and more resistant sediment deposits occur in several places along the riverbanks, especially at the bottom of the channel. Another specific geomorphological characteristic of the investigated area is that the left bank, where erosive



processes were identified, is dominated by alluvial sedimentary deposits. The left bank is composed of bank accretion, dominated by sand, and is therefore less resistant to erosion. In contrast, the right bank is predominantly comprised of older rocks and sedimentary deposits with greater resistance, which explains its greater stability.

We also argue that the choice to analyze the erosive processes of the LSFR at this site is inadequate for a larger-scale evaluation. In sinuous channels, shear stress is generally higher on the outer margin of the curves (such as the analyzed margin), which tends to favor erosion relative to the inner margin (Dunne and Alto, 2013).

Regarding morpho-sedimentary processes and controls, a rather ambiguous conclusion is drawn from the statement that the accumulation of vertically suspended sediment within the channel altered the longitudinal profile. We emphasize this conclusion, as one of the distinctive features of large multichannel rivers (anabranching patterns) is their remarkably low gradients (Latrubesse, 2008). There is also substantial literature addressing the equilibrium of fluvial systems (Schumm and Kahn, 1971; Blum et al., 2013; Santos et al. 2022b and others). Nonetheless, the work provides neither nor arguments to substantiate their conclusion.

Therefore, we urge caution when evaluating the results regarding sedimentation and erosion in the LSFR. The fluvial responses in reaches dominated by multichannel braided (upstream of the studied area) and anastomosed tend to exhibit distinct morpho-sedimentary dynamics. One issue that should not be overlooked is the conclusion regarding adjustments to the longitudinal profile fit based on the deposition of fine sediments (mud and clay), as the authors failed to provide any evidence to support this assertion.

2.2. An inappropriate relationship between sedimentation, precipitation, flow, and MNDWI variables

The statistical analysis of sedimentation, precipitation, flow, and MNDWI variables presented by Torres et al. is inadequate. One of the typical regional characteristics of large rivers is that these systems, along their course, drain different geological-geomorphological terrains and climatic zones (Latrubesse et al., 2005). Therefore, we consider that the relationship between the flow and the precipitation in the LSFR region is insufficient to discuss the reported increase in sedimentation in the channel.

We disagree with the statistical analysis adopted because it assumes a direct relationship between local precipitation and channel sedimentation. However, the hydrological behavior of the São Francisco River is controlled by processes operating across a large and environmentally diverse drainage basin. Periods of lower precipitation in the LSFR region generally occur between October and February, when river discharge remains relatively high. Moreover, the basin spans distinct



geological-geomorphological settings and climatic zones, with annual precipitation ranging from ~1400mm in the Upper São Francisco to ~600mm in the Middle São Francisco River. In addition, the LSFR contributes only about 1% of the river’s average natural discharge (Fontes, 2015). Taken together, these characteristics indicate that local precipitation alone cannot adequately explain variations in channel sedimentation.

Therefore, this correlation alone cannot be used to explain changes in the main channel. Furthermore, despite the scientific consensus regarding the impacts of climate change in Northeast Brazil (IPCC, 2014), Torres et al. provide no evidence to support the notion that climate change is responsible for the observed increase rise in sedimentation in the investigated region.

3. FINAL THOUGHT

Remote sensing has transformed the study of fluvial systems by enabling the analysis of large datasets and the monitoring of remote regions that are otherwise difficult to investigate. However, in complex sedimentary environments such as large tropical rivers, remote-sensing products alone are insufficient to explain morpho-sedimentary dynamics. Their interpretation must be guided by a sound understanding of geomorphological processes and the spatial variability of river systems.

We therefore encourage the continued expansion of erosion and sedimentation assessments based on satellite imagery and other geospatial datasets. At the same time, such analyses should be integrated with geomorphological theory and field-based knowledge to avoid overgeneralizations and unsupported inferences. This integrated approach will provide a more reliable knowledge base for sustainable management of environments that are as sensitive and heavily impacted as the LSFR.

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