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Challenges in Understanding Sediment Flow in Lago Grande de Curuai in Central Amazon: A 2D Numerical Modeling Approach

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ABSTRACT

This study investigates sediment dynamics in the Amazon River floodplain, using Delf3D simulations. The average flow was 5,000 m³/s through Lago Grande de Curuai, surpassing observed values by over 2%, with peak flows potentially exceeding 20,000 m³/s. Seasonal sediment concentration patterns (Feb to Sep) were identified. While simulations exhibited peak lags compared to observations, they provided crucial information about sediment transport dynamics in the region, vital for informed decision-making and environmental protection.

KEYWORDS: Floodplains; Computational Modeling; Sediment Transport.

Desafios na Compreensão do Fluxo de Sedimentos do Lago Grande de Curuai na Amazônia Central: Abordagem via Modelagem Numérica em 2D

RESUMO

Este estudo investigou a dinâmica sedimentar na planície de inundação do Rio Amazonas por meio de simulações com Delf3D. A vazão média pelo Lago Grande de Curuai foi de 5.000 m³/s, ultrapassando os valores observados em mais de 2%, com picos podendo exceder 20.000 m³/s. Padrões sazonais de concentração de sedimentos (fev a set) foram identificados. Apesar de defasagens nos picos simulados em relação às observações, as simulações ofereceram informações cruciais sobre a dinâmica de transporte de sedimentos na região, fundamentais para tomadas de decisões informadas e proteção ambiental.

Palavras-chave: Planícies de Inundação; Modelagem Computacional; Transporte de Sedimentos.

1 INTRODUCTION

Due to its vast dimensions, the Amazon Basin has been affected by global climatic variations. Along the Amazon River and most of its tributaries, there are high annual precipitation rates, divided between rainy and dry seasons, leading to significant and periodic fluctuations in water levels and flows (NEILL *et al*., 2006; MOLINIER *et al*., 1997; 1996; JUNK *et al*., 2011). In this region, flood pulses are the primary ecological driving force in floodplain areas, controlling the occurrence and distribution of plants and animals, primary and secondary production processes, decomposition, and nutrient cycles in water and soil. Suspended sediments transported during flood events play a crucial role in this kind of ecosystem, as particles can constitute a source of contaminants and/or nutrients for adjacent waters (CAVALVANTI et al., 2012; CRISPIM et al., 2015). Associated with geomorphological characteristics, floods are also directly related to erosion, sediment transport, and deposition processes (BONNET *et al*., 2008; JUNK, 1997; DUNNE *et al*., 1998; IRION *et al*., 1997).

Floodplains play a crucial role in sediments' production, transport, and deposition, but understanding these processes in the Amazon region has been challenging. Through numerical simulation, this study aims to enhance the understanding of sediment transport and deposition in the floodplain of Lago Grande de Curuai.

The use of computational models is essential for analyzing sediment dynamics in complex systems, such as floodplain areas. This approach will provide valuable insights into hydrosedimentological processes in this region and will contribute to the management and conservation of Amazonian floodplain ecosystems.

This study presents unprecedented 2D sediment simulations in the floodplain of Lago Grande de Curuai, conducted using the Deflt3D hydro-morphodynamic model. The choice of Deflt3D is justified by its proven ability to capture intricate complexities of riverine systems, especially in floodplain areas. Moreover, current literature underscores the growing importance of accurate representation of these areas through software to better comprehend similar ecosystems, emphasizing the relevance of this research. This study highlights the challenges faced in understanding sediment flow in the Amazon and underscores the significance of computational modeling to advance this field. By exploring the specific characteristics of the floodplain in Lago Grande de Curuai, it is anticipated not only to enhance understanding of sediment dynamics in this unique region but also to contribute to the necessary theoretical and practical foundation for the sustainable management of floodplain ecosystems in the Amazon. This aligns with the region's current needs for conservation and sustainable development.

2 FLOODPLAIN OF LAGO GRANDE DE CURUAI

In the Amazon River region, the Floodplain of Lago Grande de Curuai (Figure 1) covers an area of 3,660 km² and comprises 30 interconnected lakes through channels. It is considered a significant sediment storage area (MOREIRA-TURCQ *et al*., 2004; BOURGOIN *et al*., 2007; BONNET *et al*., 2008). The hydrological dynamics are influenced by the Amazon River's annual fluctuations, with flood levels ranging from 575 to 2,090 km². During the flood season, water from the river and regional rainfall contribute to surface water storage in the lakes, reaching depths of up to 10 meters (MOREIRA-TURCQ *et al*., 2004).

Sedimentation in the floodplain occurs variably, decreasing as it moves away from the main river channel. Sediment deposition is related to flood cycles, where water flow allows the transport of coarser materials during the flood season, while the receding waters lead to the settling of finer sediments (IRION *et al*., 1997). Studies indicate a high deposition rate, up to 1 cm/year in certain areas (MOREIRA-TURCQ *et al*., 2004). The floodplain of Lago Grande de Curuai plays a significant role in the context of the Amazon basin, retaining sediments and contributing to the region's sediment balance (MOREIRA-TURCQ *et al*., 2003; 2013; BOURGOIN *et al*., 2007).

In summary, the Floodplain of Lago Grande de Curuai presents complex hydrological dynamics, influenced by the Amazon River's fluctuations. The area serves as an important sediment storage, with high deposition rates.

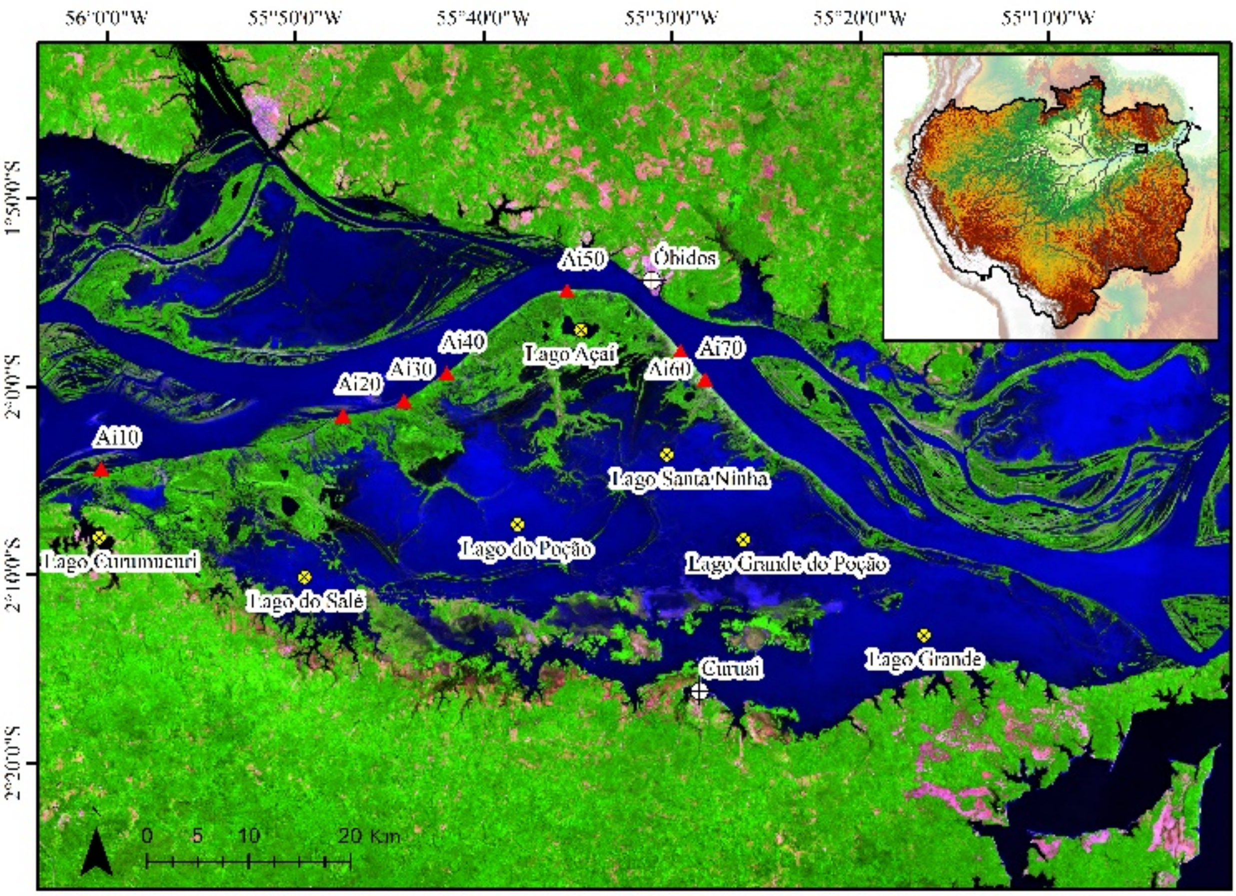

Figure 1 - Location of the floodplain area of Lago Grande de Curuai

3 PREVIOUS STUDIES

Over the years, hundreds of studies have been conducted, encompassing the theme of sediments in the Amazon Basin. The initial efforts began between the 1950s and 1970s, involving field and laboratory data analysis studies to understand the sediment dynamics of the Amazon

HOLOS
ISSN 1807 - 1600

River, its main tributaries, floodplains, and the Amazonian continental shelf (e.g., SIOLI, 1951; GIBBS 1967).

From the 1990s onwards, remote sensing data have started being used to assist in understanding the hydrodynamics and suspended sediment transport in the Amazon River and its floodplains. The use of Landsat remote sensing images, coupled with point measurements of sediments throughout the Amazon Basin, allowed a greater understanding of these dynamics. Satellite data became more abundant than field measurements, enabling better spatialization of the data and providing a deeper insight into sediment exchange within the river-floodplain system (e.g., MERTES *et al*., 1993; MELACK *et al*., 1994).

In Bourgoin *et al*. (2005; 2007), the influence of floodplains on the hydrology and sediment dynamics in the floodplain system of Lago Grande de Curuai has been thoroughly investigated. Using data collected by a monitoring network operated between 1999 and 2003, including seven field campaigns between 2001 and 2003, remote sensing images from different temporal periods, and a hydrodynamic model applied to the Curuai floodplain, the study revealed crucial findings. The results highlighted that sediment accumulation predominates during the five months of rising floods, from December to April. This was supported by water level data, suspended solids concentrations, and spatial patterns observed in satellite images, providing a detailed insight into the hydrological and sedimentary dynamics in the region. The integrated study of these data, satellite images, and numerical modeling allowed a profound understanding of water and sediment behavior in the Curuai floodplain.

The authors highlighted several key considerations for improving data analysis. In addition to developing a 2D or 3D hydrodynamic model to simulate the diffuse sediment flow in this system, they emphasized the importance of paying more attention to modeling resuspension processes, associated with wind effects that affect bottom sediments in connecting channels during the falling water stage when the highest sediment fluxes are observed.

The MGB-SED model (BUARQUE, 2015; FÖEGER, 2019) is a sediment production and transport model coupled with the MGB AS hydrodynamic model (SIQUEIRA *et al*., 2018). In Fagundes *et al*. (2020), the model was applied at the continental scale of South America (MGB-SED AS), involving simulation, calibration, and validation of daily suspended sediment concentration data through 595 sediment metric stations.

In Fassoni-Andrade & Paiva (2020), Villar *et al*. (2013; 2018), and Yepez *et al*. (2018), mapping of major rivers in the Amazon was performed using MODIS satellite image data with a regression approach for Suspended Sediment Concentration (CSS), measured throughout the Amazon Basin. These studies have provided interesting approaches to overcome the scarcity of measured sediment data in the region, offering spatial and temporal approximations of sediment data.

4 OBJECTIVE AND METHODOLOGICAL SYNTHESIS

This work aims to comprehend the spatiotemporal dynamics of sediments in the floodplain region of Lago Grande de Curuai in central Amazonia through 2D simulations, supported by large-scale hydrodynamic and sediment modeling, measured data, and various remote sensing products and climate reanalysis.

In general terms, the employed method has been designed to conduct hydrodynamic simulations and study sediment transport and deposition in the floodplain areas of Lago Grande de Curuai in central Amazonia, using the Delft3D hydro-morphodynamic model (DELTARES, 2021). To achieve this, measured flow and water level data have been used as boundary conditions for the hydrodynamic model (Delft3D-FLOW), and simulated data from the continental sediment production and transport model (MGB-SED AS), coupled with the South American hydrodynamic model MGB-IPH, have been used as inputs for the sediment transport and deposition model (Delft3D-SED). In addition, field-measured data and remote-sensing products have been utilized for model calibration and validation. Figure 2 provides a comprehensive flowchart of the methodology employed in the study.

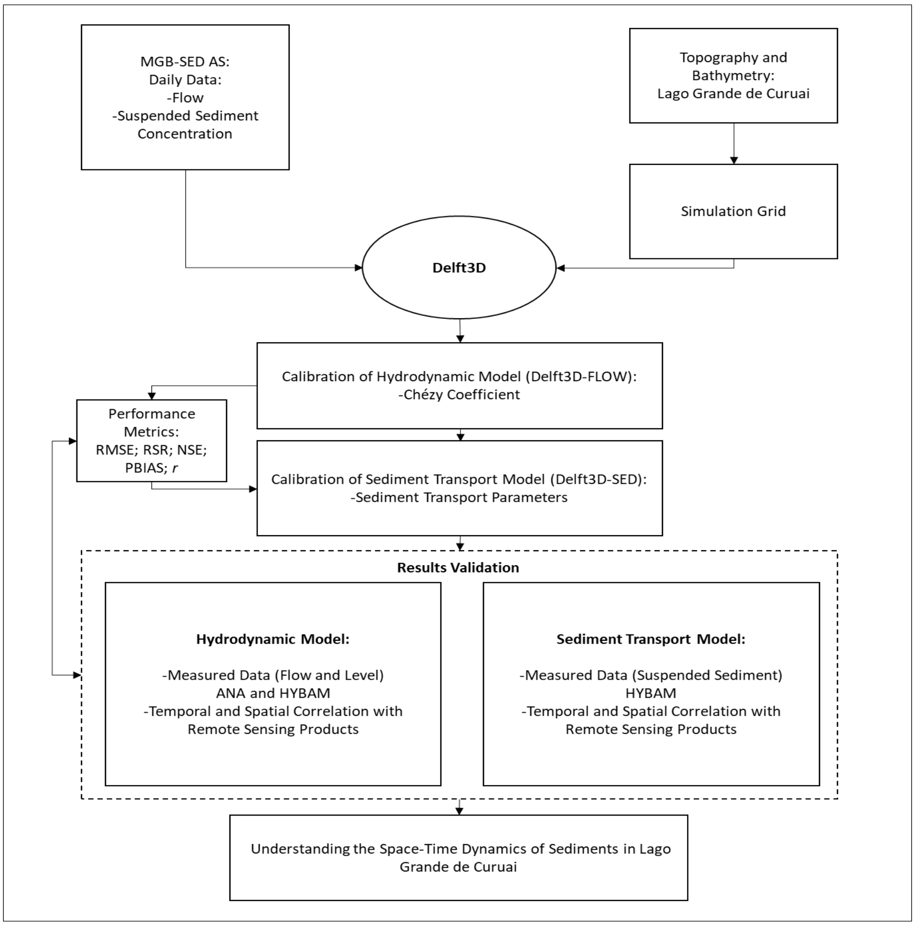

Figure 2 - General Flowchart of the Study's Methodology.

5 DELFT3D MODEL

The Delft3D hydro-morphodynamic model is a widely used computational model for simulating hydrodynamic and morphodynamic processes in aquatic environments. It integrates equations, describing the behavior of water and sediment and enabling the analysis of numerous phenomena such as waves, currents, sediment transport, and bed changes.

The Delft3D model is based on mass conservation and momentum conservation equations for water and sediment. These equations are solved numerically, considering interactions between different variables and physical processes.

Delft3D is widely applied in studies related to coastal engineering, water resources management, port and estuary planning, river processes modeling, and environmental impact assessments. It allows for simulating currents, waves, and sediment transport at local or regional scales, aiding in the prediction of extreme events, risk assessment, and decision-making, related to coastal projects and interventions. It also enjoys broad acceptance for applications in riverine environments (*e.g.*, DIJKSTRA *et al.*, 2019; WEI *et al.*, 2018; FLORES *et al.*, 2017; RAHBANI, 2014; DURÓ *et al.*, 2016; JAVERNICK *et al.*, 2018; KASPRAK *et al.*, 2015; PAARLBERG *et al.*, 2015; WILLIAMS *et al.*, 2013, 2016a; 2016b; YOSSEF, 2016).

Furthermore, Delft3D is used to study bed evolution and sediment dynamics, aiding in water resources management, coastal erosion prevention, and identification of sediment deposition areas. In addition to the hydrodynamic module, the Delft3D-FLOW module integrates the sediment transport module (Delft3D-SED) and the morphology module (Delft3D-MOR). The FLOW module alternately communicates with the sediment transport and morphology modules at each time step, accounting for suspended sediment transport. Due to the different characteristics associated with cohesive and non-cohesive sediment dynamics, various formulations are necessary to simulate sediment flow at the water-sediment interface, including bed erosion and deposition. The sediment transport modeling and morphological alteration account for bed load and suspended sediments, which can be cohesive or non-cohesive.

The implementation in Delft3D uses Van Rijn's formulation (1993), which distinguishes between bed load and suspended sediment transport (Ss). This method also considers erosion and deposition rates to implement sediment exchange with the bed and to calculate both the input and output of suspended particles in the flow (DELTARES, 2021).

6 IMPLEMENTATION, CALIBRATION, AND VALIDATION OF SIMULATIONS

For the simulations in the Delft3D-FLOW hydrodynamic module, data from river gauging stations from the Hidroweb system (https://www.snirh.gov.br/hidroweb), maintained by the National Water Agency (ANA), have been used. In the region of study, there is a station (17050001), near the city of Óbidos, with water levels and flow measurements available from 1968 to 2014, and a station with water level measurements in Lago Grande de Curuai (17060000) from 1982 to 2021. The flow data used in the simulations had exaggerated peaks by 10%, by data consistent with other studies that evaluated water flow among the Amazon River and its floodplains (ALSDORF, 2010; RICHEY, 1989; FASSONI-ANDRADE; 2022).

Sediment data, which referred to the concentration of suspended solids, used as boundary conditions in the Delft3D-SED model, have been obtained from the MGB-SED model (BUARQUE, 2015; FÖEGER, 2019), applied to South America (FAGUNDES *et al.*, 2020), based on the MGB AS hydrodynamic model. Figure 3 illustrates the boundary conditions inserted in the simulations.

For the calibration and validation stages of sediment spatiotemporal dynamics, suspended sediment data have been used from the Environmental Research Observatory for Geodynamic, Hydrological, and Biogeochemical Control, and Erosion and Matter Transport Alteration in the Amazon (ORE-HYBAM). These data were available at the same location as the ANA river gauge station in Óbidos, collected through field surveys conducted between 1994 and 2017.

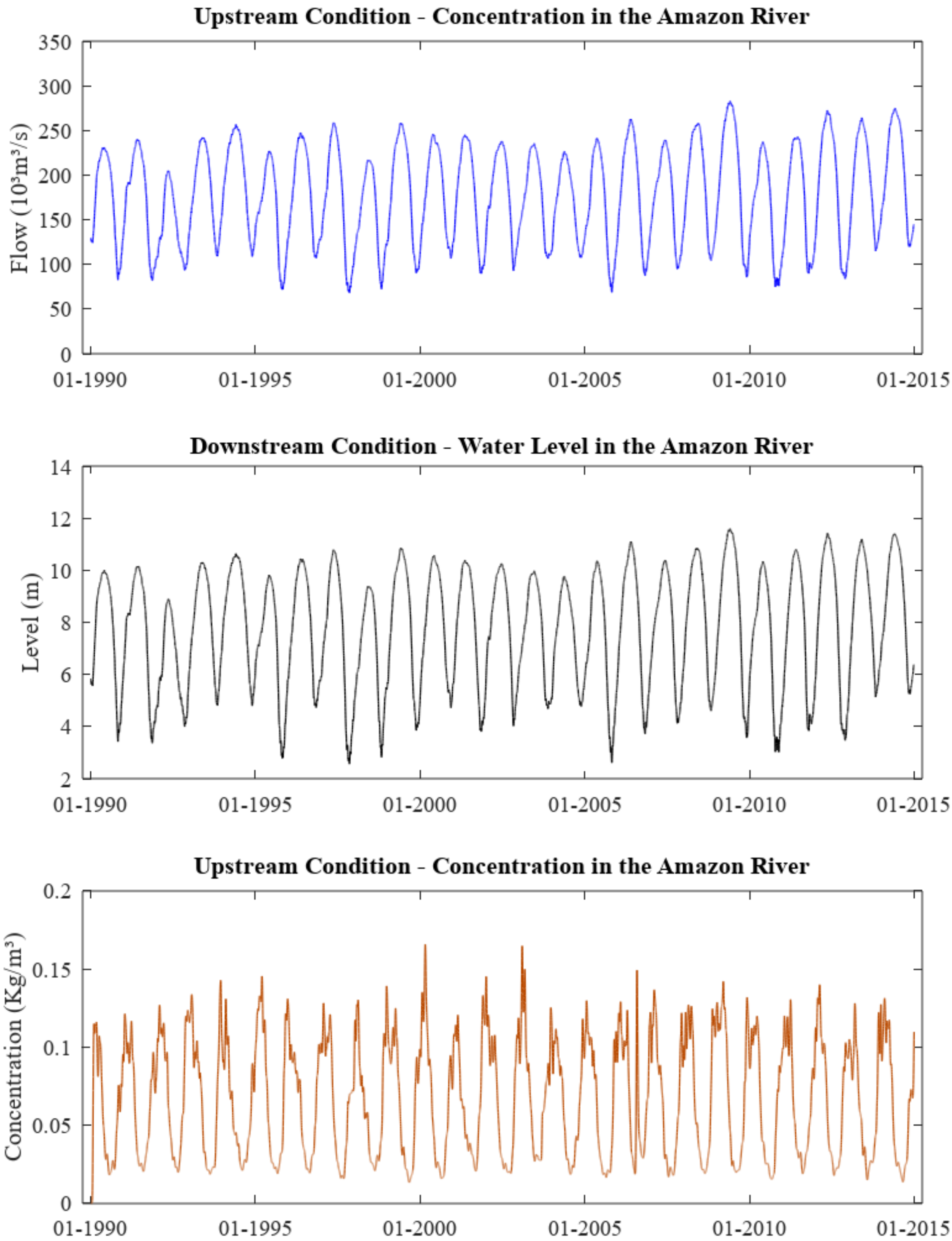

Figure 3 - Boundary conditions inserted in the Delft3D model.

Bathymetric data for the stretch of the Amazon River, running through the Lago Grande de Curuai floodplain were obtained from Rudorff *et al*. (2014). The river bathymetric data were generated by scanning nautical charts, published by the Brazilian Navy, whereas the lake bathymetric data were obtained through echo-soundings conducted during the 2004 flood, using an Acoustic Doppler Current Profiler (ADCP). This period aligns with the simulation timeframe used in this study. Both datasets were incorporated into the Shuttle Radar Topography Mission Digital

HOLOS
ISSN 1807 - 1600

Elevation Model (SRTM) (JARVIS *et al.*, 2008). For the Lago Grande de Curuai region, a Flexible Mesh was created, and refined in the region's characteristic areas (inflow channels into Lago Grande de Curuai, islands, Amazon River meanders, and permanently flooded regions of Lago Grande de Curuai). The mash design also considered the calculation time interval, constrained by the Courant-Friedrichs-Lewy (CFL) number, indicating numerical stability and accuracy. Guidelines for the Courant number were based on practical experience. In locations with significant variations in bottom geometry or coastline, the Courant number should not exceed a value of 10 (LUIJENDIJK, 2001). Figure 4 shows the bathymetry and the flexible grid used in the simulations.

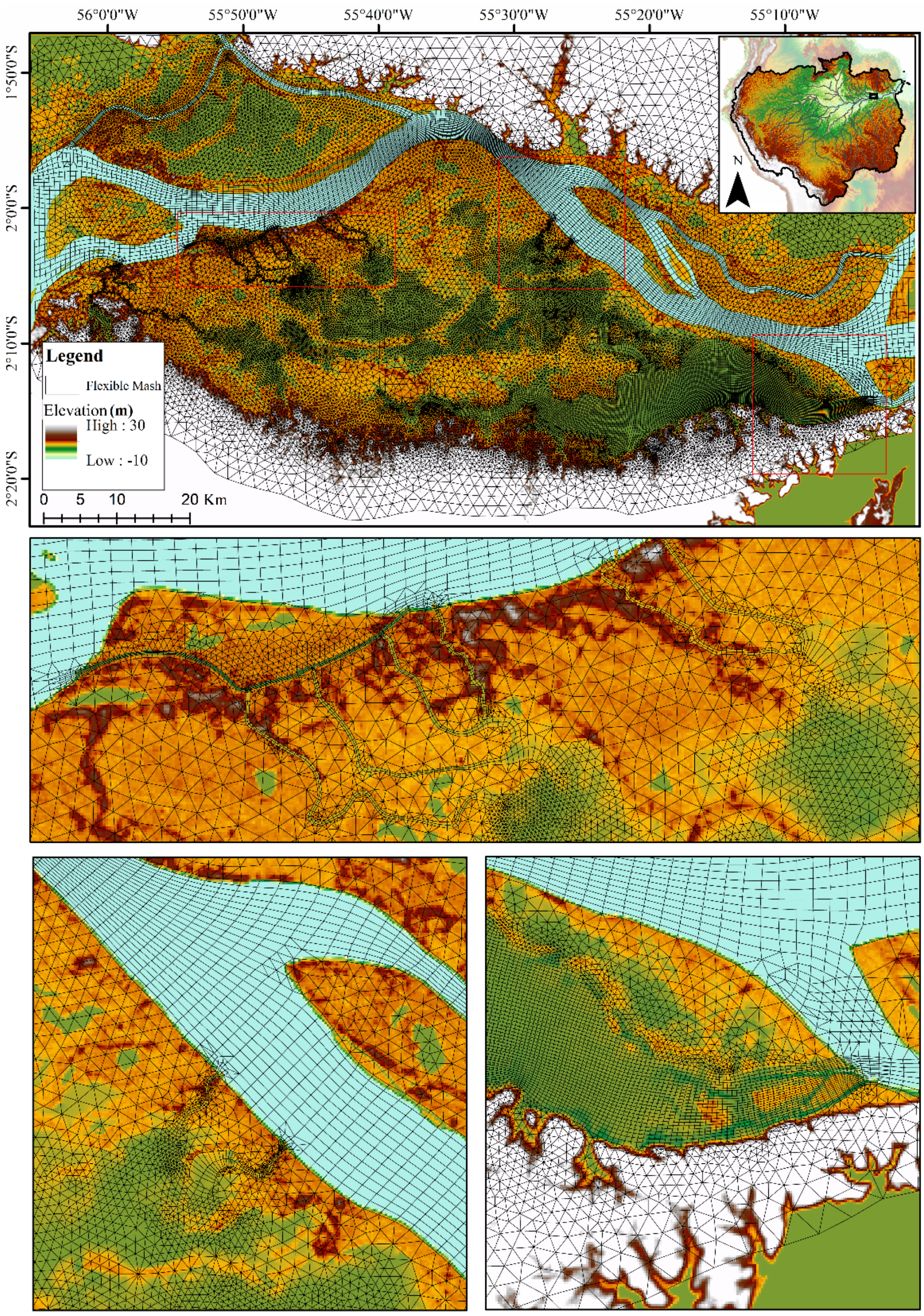

Figure 4 - Bathymetry and flexible grid of the simulation domain.

Delft3D allows the spatialization of the Chezy coefficient, which integrates formulations of bed roughness in the boundary conditions and is described through the Manning formulation. This spatialization was performed using Manning values, defined, and mapped in the work of Rudorff *et al*. (2014), and established according to information found in the literature for natural channel types and floodplains (ARCEMENT & SCHNEIDER, 1989).

For the calibration of the Delft3D-SED sediment module, modifications were made to some of the parameters in the sediment erosion and deposition formulations that affect the sediment transport equation, altering the term representative sources and sinks between exchanges in the bed of resuspension and sediment deposition.

The modified parameters include the critical shear stress for deposition (τ cr,d), the critical shear stress for erosion (τ cr,e), and the parameter M, defining erosion. Simulations were conducted with different parameter sets according to ranges of values indicated by various authors (as shown in Table 1). The results were compared with data measured at the HYBAM sediment station in Óbidos (17050001), using performance metrics to identify the parameter set that best represents the sediment dynamics of Lago Grande de Curuai. The comparisons between measured and model-simulated series were verified through the calculation of the following statistical parameters: root mean square error (RMSE); root mean square error applied to the standard deviation of observed data (RSR), Nash-Sutcliffe efficiency coefficient (NSE), percent bias (PBIAS), and Pearson correlation coefficient (r).

Table 1 - Ranges of values for the parameters of sediment transport module calibration.

Parameter	Description	Range Values
$\tau_{cr,d}$	Critical deposition stress	0,01 a 0,5 N/m²
$\tau_{cr,e}$	Critical erosion stress	0,01 a 0,6 N/m²
M	Erosion definition	1x10^-6 a 5x10^-4 kg/m².s

Sources: Widdows *et al*. (2007); Hu *et al*. (2009); Van Maren *et al*. (2015) and Van Rijn (1993).

7 RESULTS

7.1 Hydrodynamic Model

A long-term simulation was conducted, from which data were derived to comprehend the overall hydrodynamics pattern in the river-floodplain system of Lago Grande de Curuai. This extended simulation was assessed, using performance metrics by Moriasi *et al*. (2007), both for the simulated and observed flows and levels at the Óbidos station (17050001) as well as for the levels at the Vila Curuai station (17060000). These results are depicted in Figure 5.

From the simulations, it was possible to infer the magnitude of Amazonas River flows, which pass through Lago Grande de Curuai from February to September when the Amazon River presents sufficient levels for water ingress into the floodplain of Lago Grande de Curuai. The results indicate an average flow passing through the lake of approximately 5,000 m³/s, with a maximum value of 27,456 m³/s in 2009. From 2000 to 2014, the simulated outflow in the Delf3D model demonstrated an average of 185,724 m³/s, with a peak of 288,561 m³/s, both values exceeded the simulated average and maximum flows at the section, corresponding to the Óbidos station (4,447 and 22,934 m³/s, respectively). Moreover, the simulation outlet displayed an error of volume percentage (PBIAS) 2.39% higher, throughout the entire period, than the flows simulated at the Óbidos section, the most distant location from the Amazon basin headwaters, with river measurements. Having considered the aforementioned performance metrics as ideal, these results indicate that the actual Amazon River flow that passes through the Lago Grande de Curuai floodplain is over 2% higher on average than the observed flow, potentially reaching peak values over 20,000 m³/s. Figure 6 illustrates the graphical results for the long-term simulation, highlighting the differences among the simulated flow at the Óbidos station, the simulated flow at the Delft3D-FLOW hydrodynamic module's outlet, and the magnitudes of the flows, which traverse Lago Grande de Curuai, according to the results obtained.

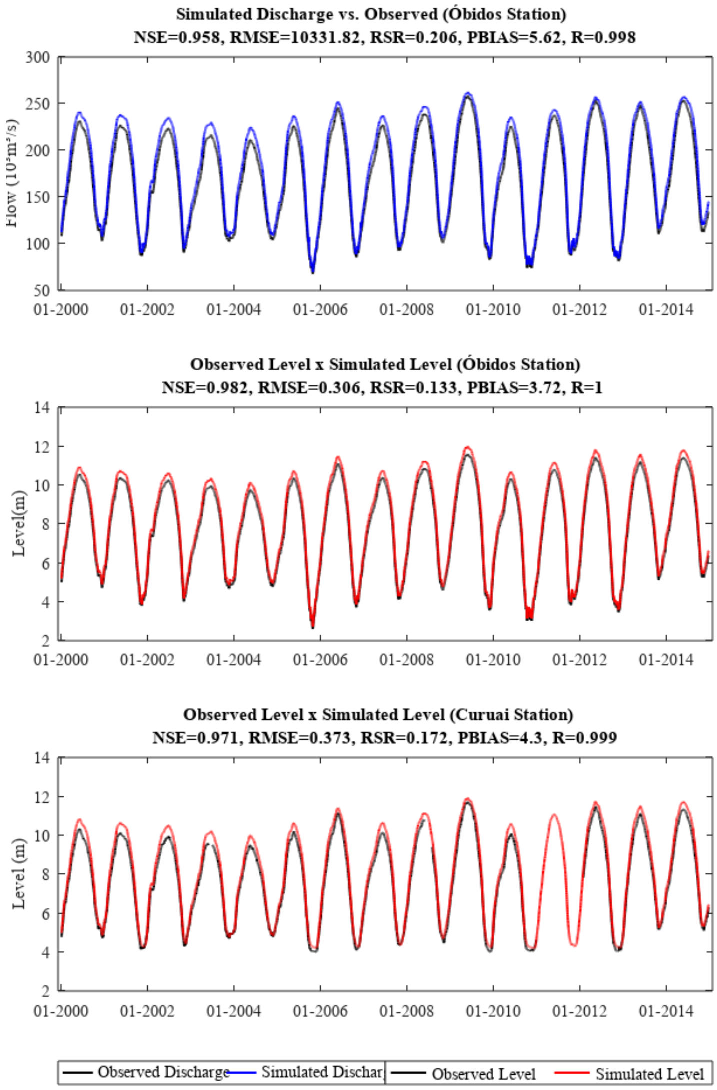

Figure 5 - Performance metrics obtained for the hydrodynamic model in long-term simulations, concerning the water levels and flows observed at the Óbidos station (17050001) and the water levels observed at the Vila Curuai station (17060000).

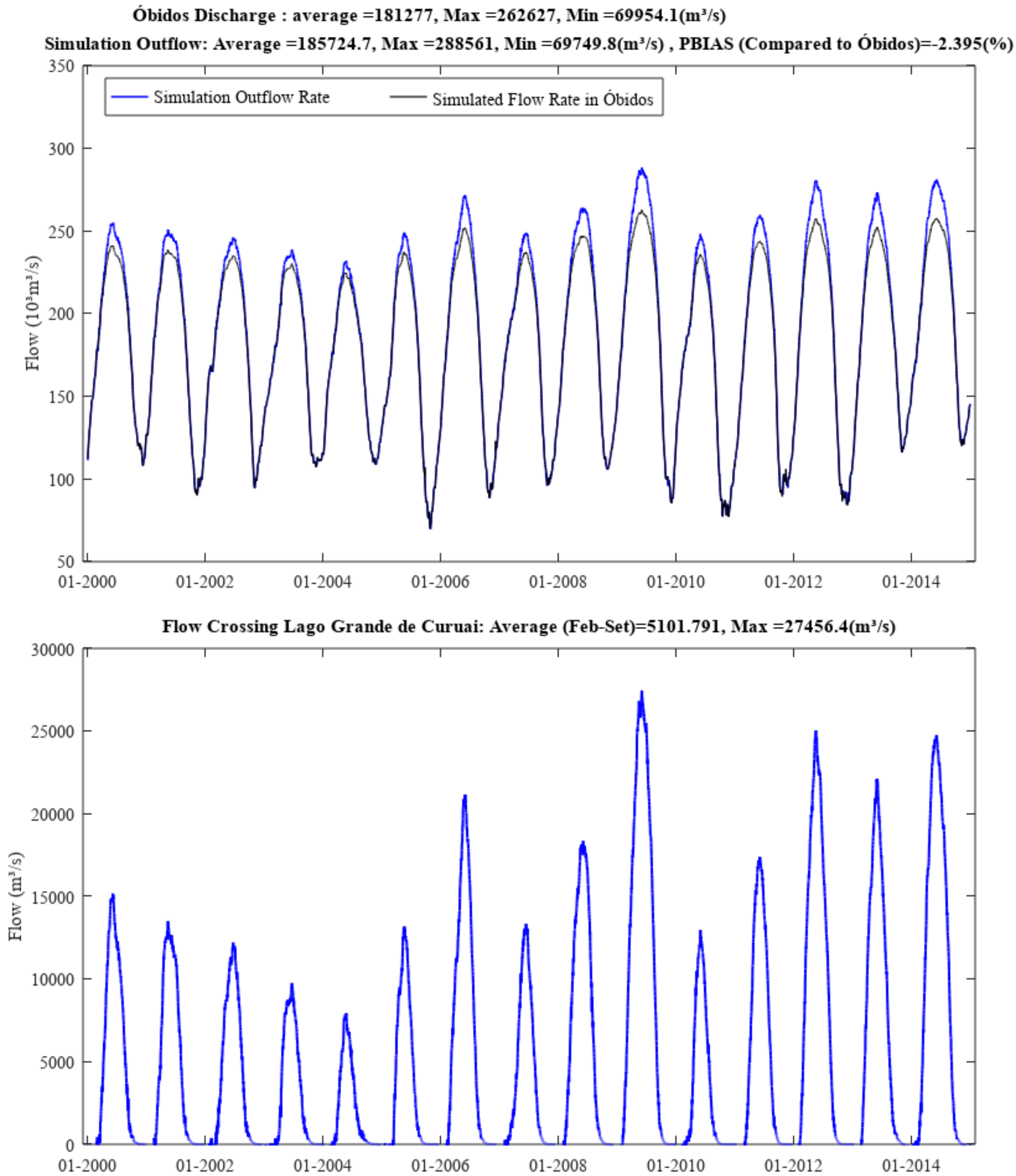

Figure 6 - Flow rates obtained through the long-term hydrodynamic model: Simulation outflow, Óbidos Station (17050001), and Flow passing through the Lago Grande de Curuai.

In order to assess whether the spatial extent of flood patches, generated by 2D simulations in the Delft3D-FLOW module, accurately represented water extents observed in the floodplain, Landsat 5 satellite images were used. These images were processed using Google Earth Engine's cloud-based platform. The Augmented Normalized Difference Water Index (ANDWI), proposed by Rad *et al*. (2021), was applied to enhance the contrast between water and non-water pixels in satellite images.

For the floodplain area of Lago Grande, this index showed a strong visual correlation with the observed water extensions in the images. Spectral water response extensions were defined by setting ANDWI values above zero as masks. To enable comparisons with simulated data, images with minimal cloud cover in the study area were selected, representing various periods and flow rates of the Amazon River.

Figure 7 compares simulated flood extensions described, based on simulated water depth, with vectorized water masks from two selected satellite images. Upon analysis of these figures, it can be inferred that the simulations closely correspond to the water extensions observed in the satellite images, spatially. This demonstrates that the simulated water depths align closely with the outlines of the spectral water response masks obtained from the satellite images.

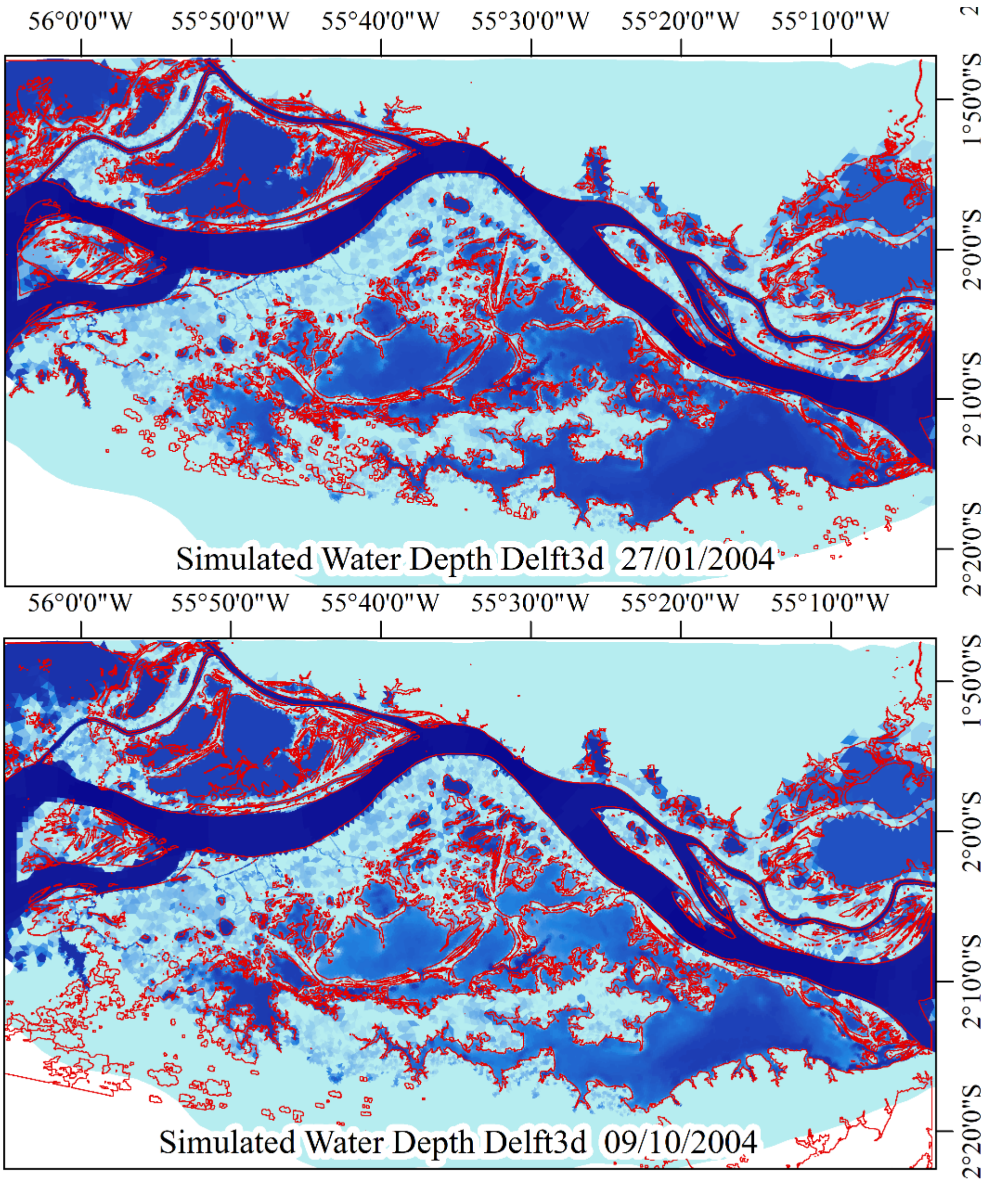

Figure 7 - Comparison of simulated water depth by the Delft3D hydrodynamic model and spectral water response masks obtained through Landsat 5 satellite image processing.

7.2 Sediment Model

From various calibration tests conducted for the Delft3D-SED sediment transport and deposition model, the final sediment simulation was performed, covering the period from January 2000 to December 2002, encompassing a total of three hydro-sedimentological years of the

Amazon River. This simulation yielded data related to the overall pattern of sediment transport and deposition in Lago Grande de Curuai.

In terms of performance metrics compared to the suspended sediment concentration data observed at the Óbidos station of Hybam (17050001), the final simulation showed satisfactory values in terms of Nash-Sutcliffe efficiency (NSE = 0.51), Root Mean Square Error (RMSE = 0.039 kg/m³), and Root Mean Square Error, applied to the Standard Deviation of observed data (RSR = 0.7). The results were considered highly satisfactory in terms of Volume Errors (PBIAS = 3.4%), following the criteria of Moriasi *et al*. (2007).

Figure 8 compares the simulated and observed suspended sediment concentrations at the Óbidos station of Hybam (17050001). A significant agreement between simulated and observed values is visible in the first year of simulation. This is due to the fact that the observed peaks at the Óbidos station in 2000 had less significant values compared to the peaks observed in other simulation years, where the simulation could not capture peaks of sediment concentration exceeding 0.2 kg/m³.

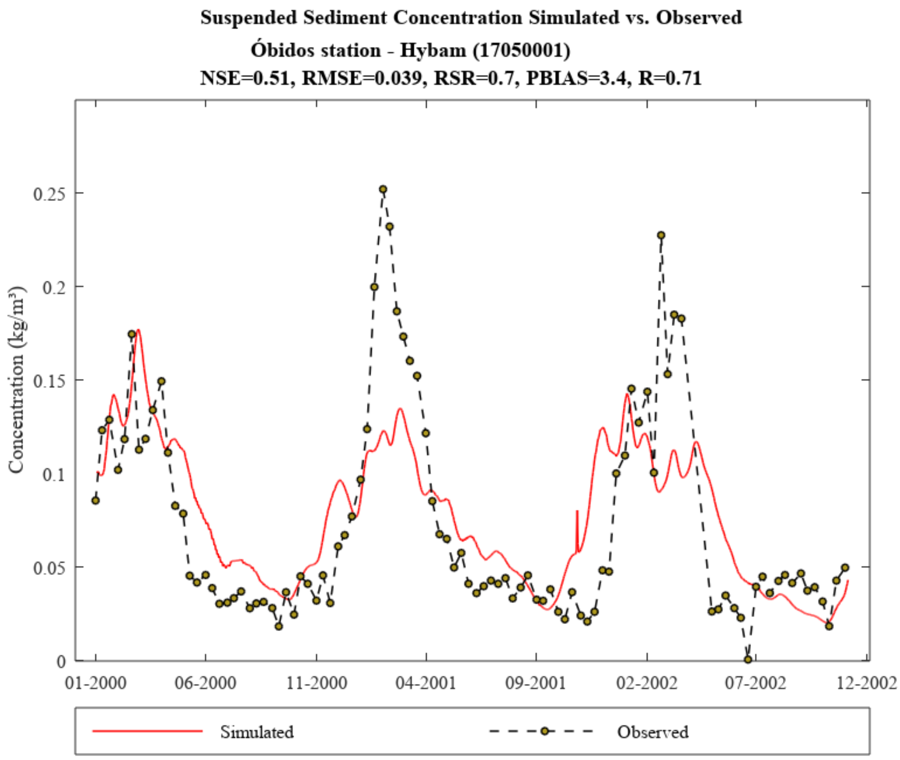

Figure 8 - Comparison between simulated and observed suspended sediment concentration at the Óbidos station (HYBAM - 17050001).

Figure 9 presents a comparison among suspended sediment concentration and simulated solid discharge for the Óbidos section, the entrance section of Lago Grande de Curuai, the exit section of Lago Grande de Curuai, the simulation drain section, and the simulation entrance section of the Delft3D-SED sediment model. From these analyses, it was possible to better understand the dynamics of erosion and suspended sediment propagation in the area of study. The results indicate solid sediment discharges entering Lago Grande de Curuai with average and maximum values of approximately 9.11x10^4 and 3.10x10^5 tons per day, resulting in an annual average value of 3.33x10^7 tons per year. At the lake's draining area, the results show average and maximum values of approximately 1.26x10^5 and 4.11x10^5 tons per day, resulting in an annual average value of

4.6x10^7 tons per year. The results indicated differences around 3.5x10^4 tons per day between the drain and entrance, with an annual solid discharge, leaving the lake 69% higher than the entrance to Lago Grande de Curuai.

As to the Amazon River, simulations indicated solid sediment discharges at the simulation drain, with average and maximum values of approximately 1.63x10^6 and 3.21x10^6 tons per day, respectively. These values were higher on average than the entrance data of the simulation, by approximately 7x10^5 tons per day, a difference even greater than the average solid discharges that crossed Lago Grande de Curuai, suggesting a considerable portion of sediments being transported due to the ongoing erosion of the Amazon River, presented in the simulations. Considering total values, the simulations presented a value of 5.96x10^8 tons per year transported by the Amazon River.

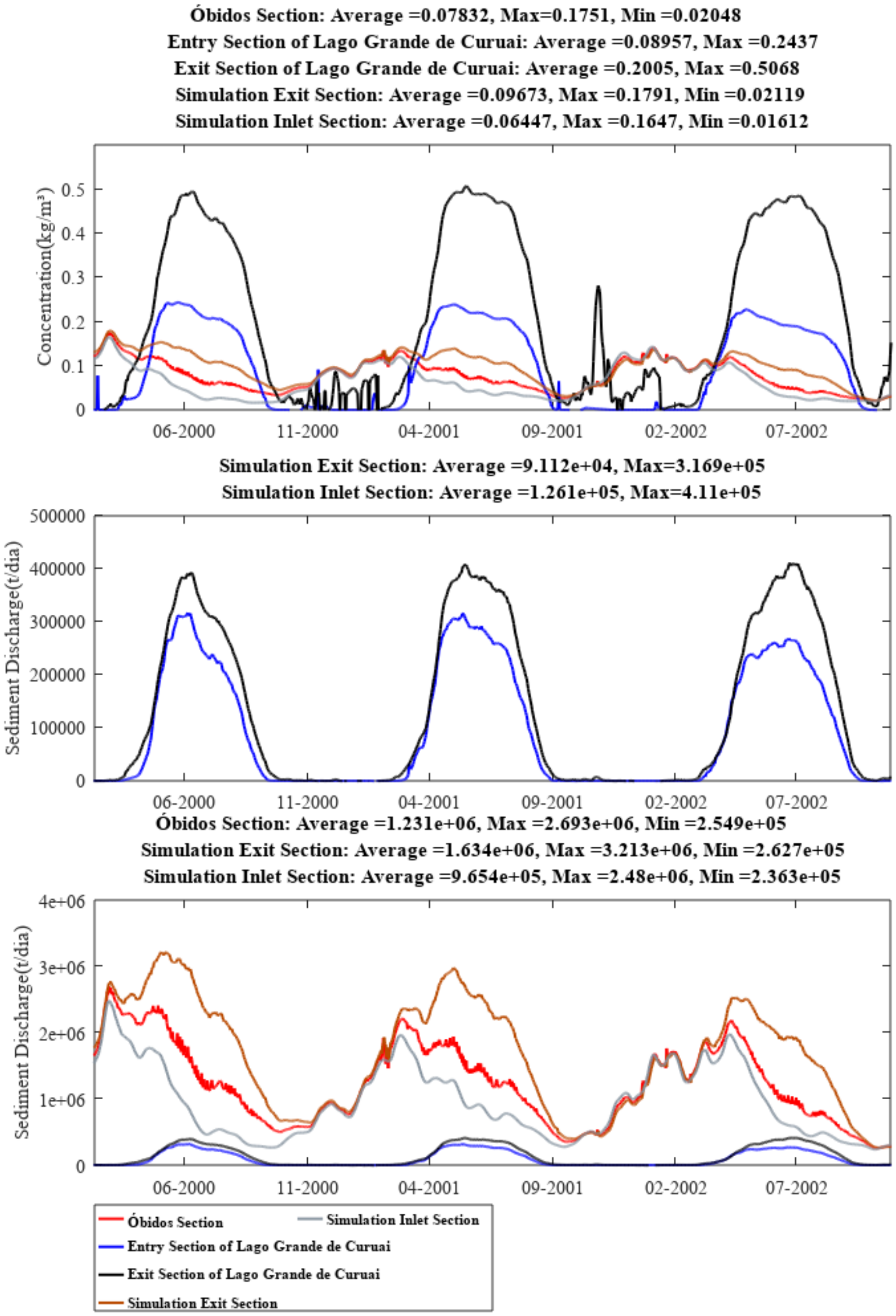

Figure 9 - Comparison among suspended sediment concentration and simulated solid discharge for the Óbidos section, entrance section of Lago Grande de Curuai, drain section of Lago Grande de Curuai, simulation drain section, and simulation entrance section of the Delft3D-SED sediment model.

Figure 10 shows the spatial evolution of suspended sediment concentration across Lago Grande de Curuai during a hydro-sedimentological year. year 2000 was taken as an example, because it corresponded to the period of acquisition of the SRTM digital elevation model. From the simulations, it was observed that around the end of March (when the average flow of the Amazon River starts to become significant, initiating the sediment transport process along the lake), peaks in concentration close to the beginning of July were reached, with concentrations exceeding 0.5

HOLOS ISSN 1807 - 1600

kg/m³, crossing the lake in accordance with the previously evidenced pattern. According to the simulations, around the beginning of September, the concentration in Lago Grande de Curuai started to decrease until it reached low values during periods of minimum Amazon River flow.

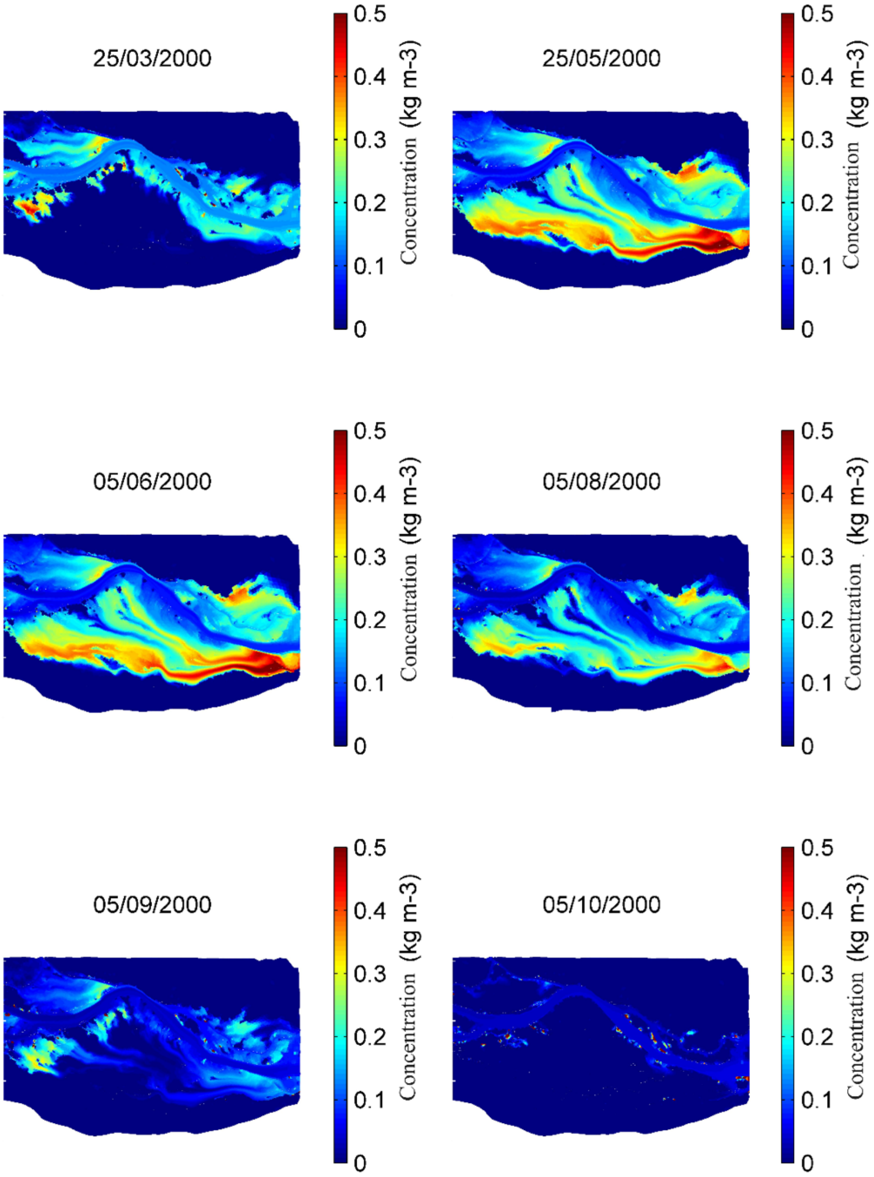

Figure 10 - Spatial differences in simulated suspended sediment concentration on different dates in the year 2000.

Figure 11 shows the spatial distribution of the maximum simulated suspended sediment concentration (on 06/05/2000), with a detailed view of the inlet and the outlet channels of Lago Grande de Curuai, including simulated water velocity vectors for the same day. Regarding the spatial analysis of suspended sediment concentration, which passes through Lago Grande de Curuai, a visual comparison was made using an image from the Landsat 8 satellite for a day of high observed discharge in the Amazon River (06/18/2015 - discharge of 262,673 m³/s). Although this date falls outside the simulation period, due to the satellite's temporal resolution (16 days) and the presence of extensive cloud cover during the Amazon River's flood periods, it was not possible to find a sufficiently representative image from Landsat 5 for the study's simulation period.

The Landsat 8 image was, then, compared (Figure 12) with the concentration observed on the date of the highest simulated discharge (05/24/2000 - simulated discharge of 239,800 m³/s). Upon comparison, a significant similarity in the pattern of suspended sediment plume propagated through Lago Grande de Curuai is evident between the observed image and the simulation results from the Delft3D model.

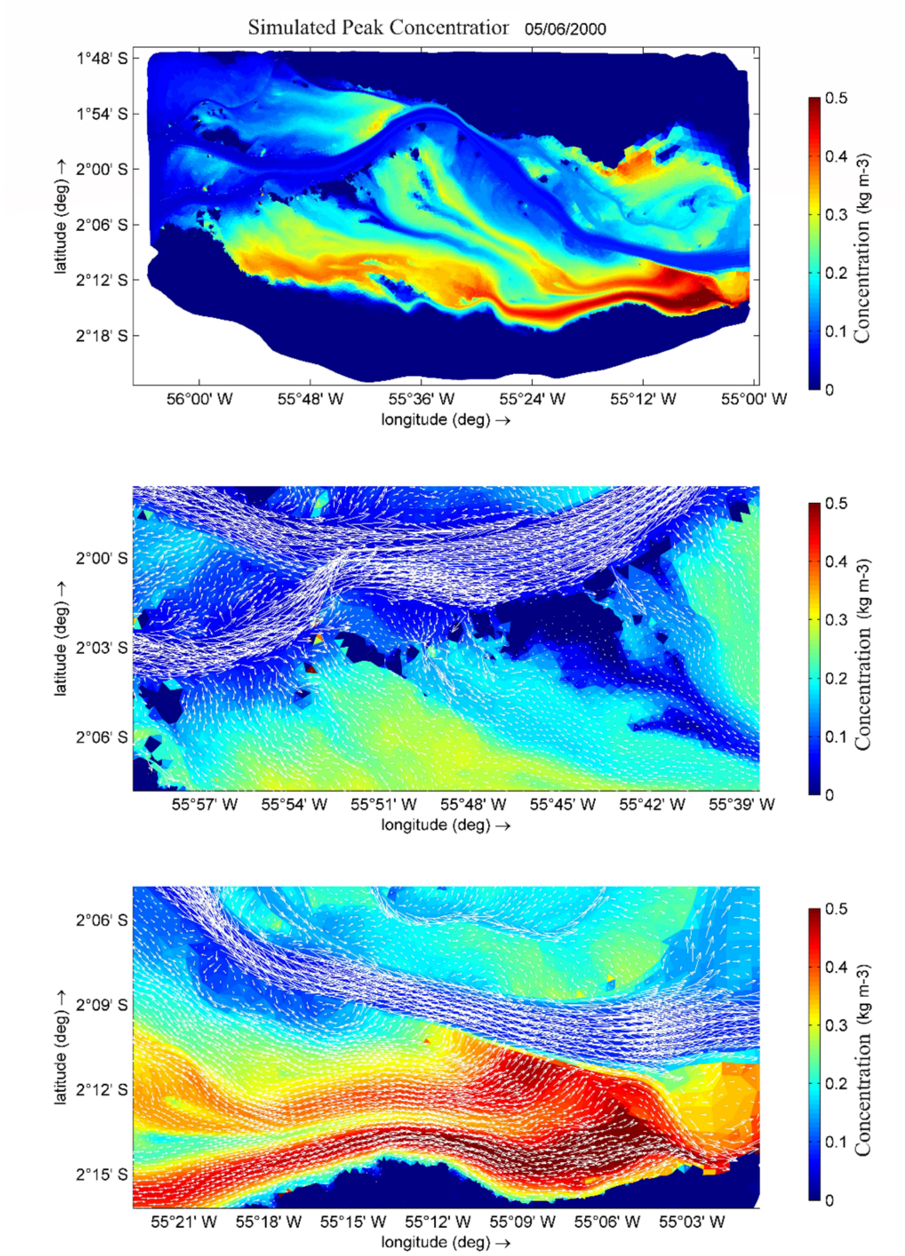

Figure 11 - Spatial distribution of simulated suspended sediment concentration on the day of the highest simulated concentration (white velocity vectors).

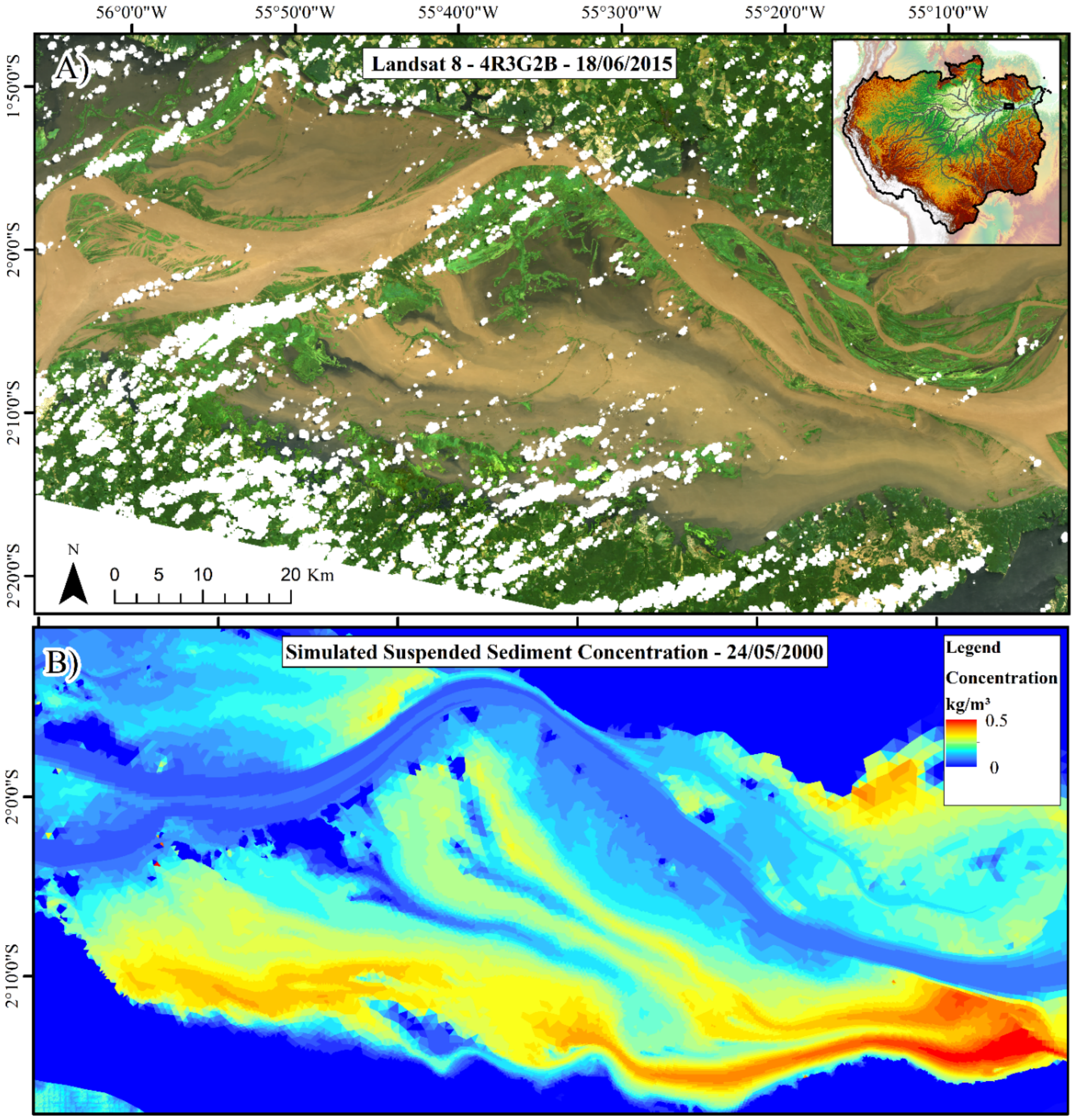

Figure 12 - Comparison between suspended sediment concentration simulated on the day of the highest simulated discharge (239,800 m³/s) and the Landsat 8 satellite image taken on a day of high discharge (262,673 m³/s) observed at the Óbidos station.

Figure 13 presents comparisons between the simulations performed and sediment approximations, based on the works of Fassoni *et al*. (2019), Villar *et al*. (2018; 2013), and Yepez *et al*. (2018), aiming to better understand the sedimentary dynamics in two specific regions: Lago Grande de Curuai and the Óbidos section, in the Amazon. MODIS images were used to analyze specific points in these areas. To improve data quality, cloud computing processing was applied. This process included temporal and spatial smoothing of the images, as well as the removal of spurious pixels that could compromise the analysis.

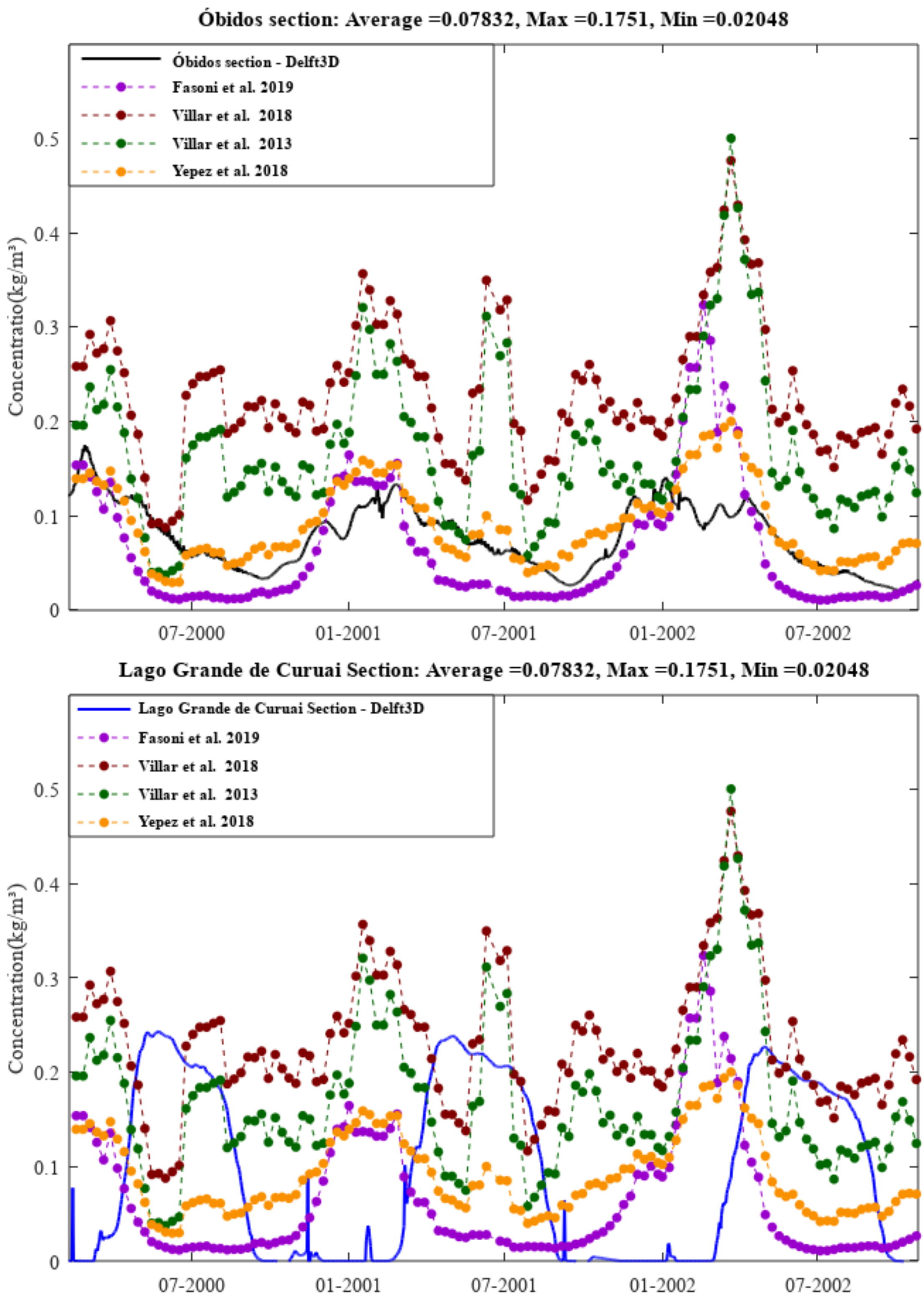

Figure 13 - Comparativo entre a concentração de sedimentos em suspensão simulada para a seção de Óbidos e do Lago Grande de Curuai com 4 trabalhos de aproximação por bandas de imagens de satélite MODIS.

Upon analyzing the data, a significant similarity was observed between the works of Fassoni *et al*. (2019) and Yepez *et al*. (2018) for the Óbidos section. This suggests that these approaches are effective in representing sediment dynamics in that region. However, for the Lago Grande de Curuai section, a lag in the peaks compared to remote sensing data was noticed. This highlights the challenges of representing sediment transport and deposition processes in extensive floodplain areas, such as the case of Lago Grande de Curuai.

The data also indicate that suspended sediment does not accumulate in the lake during periods of low Amazon River discharge. This phenomenon could be attributed to inadequate representations of the lake's outlet channels, the adopted Manning values, favoring higher flow velocities at the outlet of Lago Grande de Curuai, and even the sediment parameters used in the simulations, despite being consistent with the literature.

8 CONCLUSIONS

The present study aimed to investigate the interaction of sediments in the low Amazon river-floodplain system through numerical simulations using the Delf3D model. These simulations allowed the inference of the magnitude of flows from the Amazon River that pass through Lago Grande de Curuai. The results indicate an average flow, passing through the lake of approximately 5,000 m³/s, with maximum values of 27,456 m³/s. This suggests that the actual flow from the Amazon River, passing through the floodplain of Lago Grande de Curuai, is more than 2% higher on average than the flow observed, with possible peak values exceeding 20,000 m³/s.

A spatial-temporal understanding of sediment flow in the Lago Grande de Curuai floodplain region was achieved, revealing a seasonal concentration pattern only from February to September. The results indicated average and maximum concentrations of suspended sediments, crossing the lake at approximately 0.088 and 0.24 kg/m³, respectively, with sediment peak values reaching approximately 0.07 kg/m³ when compared to the Óbidos section.

The sediment simulations conducted in this study provide valuable insights into sediment transport and deposition dynamics in the Amazon region. Although they presented a lag about observed peaks, they allowed the identification of the general pattern of sediment dispersion in the Lago Grande de Curuai floodplain area. These results underscore the need for further research to investigate the cause of sediment peak lags and to enhance the understanding of sediment transport and deposition dynamics in large floodplains. In addition, conducting new simulations and studies is crucial to improving the accuracy of models and to deepening our comprehension of sedimentary processes in the Amazon region.

Understanding and monitoring sediment dynamics in the Amazon River are essential for the proper management of natural resources and the conservation of this valuable ecosystem. This information is vital for making informed decisions and implementing measures for the protection and mitigation of environmental impacts in the Amazon region.

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