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Spatio-temporal monitoring of suspended sediments in the Solimões River (2000–2014)

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ABSTRACT

The Amazon River sediment discharge has been estimated at between 600 and 1200 Mt/year, of which more than 50% comes from the Solimões River. Because of the area's inaccessibility, few studies have examined the sediment discharge spatial and temporal pattern in the upper Solimões region. In this study, we use MODIS satellite images to retrieve and understand the spatial and temporal behaviour of suspended sediments in the Solimões River from Peru to Brazil. Six virtual suspended sediment gauging stations were created along the Solimões River on a 2050-km-long transect. At each station, field-derived river discharge estimates were available and field-sampling trips were conducted for validation of remote-sensing estimates during different periods of the annual hydrological cycle between 2007 and 2014. At two stations, 10-day surface suspended sediment data were available from the SO-HYBAM monitoring program (881 field SSS samples). MODIS-derived sediment discharge closely matched the field observations, showing a relative RMSE value of 27.3% (0.48 Mtday) overall. Satellite-retrieved annual sediment discharge at the Tamshiyacu (Peru) and Manacapuru (Brazil) stations is estimated at 521 and 825 Mt/year, respectively. While upstream the river presents one main sediment discharge peak during the hydrological cycle, a secondary sediment discharge peak is detected downstream during the declining water levels, which is induced by sediment resuspension from the floodplain, causing a 72% increase on average from June to September.

1. Introduction

Amazon River sediment discharge is controlled by the slope, soil type, climate, geology and morphology of the catchment (Dunne et al., 1998; Mertes et al., 1996) and may now experience significant influence of anthropogenic activities, such as land-use change related to deforestation, industrial activity, gold mining, or dam constructions.

The Amazon River drains an area greater than 6.5×10^6 km^2; the mean discharge at the river mouth in the Atlantic Ocean is 209,000 m^3/s (Molinier et al., 1996). The Amazon River is formed in Peru, at the confluence of

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the Ucayali and Marañón rivers, and is renamed the Solimões River at the Peruvian–Brazilian border. It is only 2050 km downstream, at the confluence of the Solimões and Negro rivers, that the river is called the Amazon again. The Amazon River is the world's largest fluvial system in terms of drainage area and runoff. At the gauging station at the city of Óbidos, sediment discharge was estimated at 600–1200 Mt/year (Filizola, 2003; Filizola et al., 2011; Gibbs, 1967; Meade et al., 1979; Guyot et al., 2005; Martinez et al., 2009).

Amazon River sediment discharge is mainly supplied by the Madeira sub-catchment (48%) and Solimões sub-catchment (50%) (Filizola, 1999). Besides its dominance in terms of the liquid, solid and dissolved contribution to the Amazon basin's inputs to the Atlantic Ocean, the dynamic of suspended sediment along the Solimões River 1600-km long stretch is known little, apart from results provided by the HYBAM long-term monitoring program at Tamshiyacu, Tabatinga and Manacapuru stations and some field-sampling trips in the 1980s and 1990s (Dunne et al., 1998, Guyot et al., 1998; Richey et al., 1986).

The Tamshiyacu gauging station (TAM) is located at 85 km downstream from the confluence of the Ucayali and Marañón rivers in Peru (Fig. 1). River discharge at the TAM station represents 16% of the mean water discharge at the mouth of the Amazon River (Espinoza et al., 2009, 2011, 2012; Ronchail et al., 2006) and 400–550 Mt/year of sediments discharge (Armijos et al., 2013; Guyot et al., 2007).

Downstream, at the Manacapuru gauging station (MNA, Fig. 1), the last station before the Negro River confluence, the Solimões River discharge is 103,000 m^3/s, approximately three times the river discharge at TAM station, which denotes a significant contribution in terms of water balance of local tributaries such as the Napo, Japura, Jurua, Javari, and Purus Rivers. At the MNA station, river sediment discharge has been calculated at between 400 and 700 Mt/year (Dunne et al., 1998, Filizola, 1999, 2003; Filizola and Guyot, 2009; Laraque et al., 2005). Therefore, there appears to be little or no increase in sediment discharge along the Solimões River stretch, although many tributaries drain geomorphological areas that are subject to significant erosion processes, such as the northern Andes of Ecuador and Colombia (e.g., Napo, Iça, Japura Rivers) and the Fitzcarrald Arch (mainly Jurua and Purus Rivers). Important questions remain, including the role of the large Solimões River floodplain and the sediment discharge dynamics of the main tributaries. The use of alternative techniques for suspended sediment monitoring is important for filling gaps in our current understanding of the main tributary of the Amazon River.

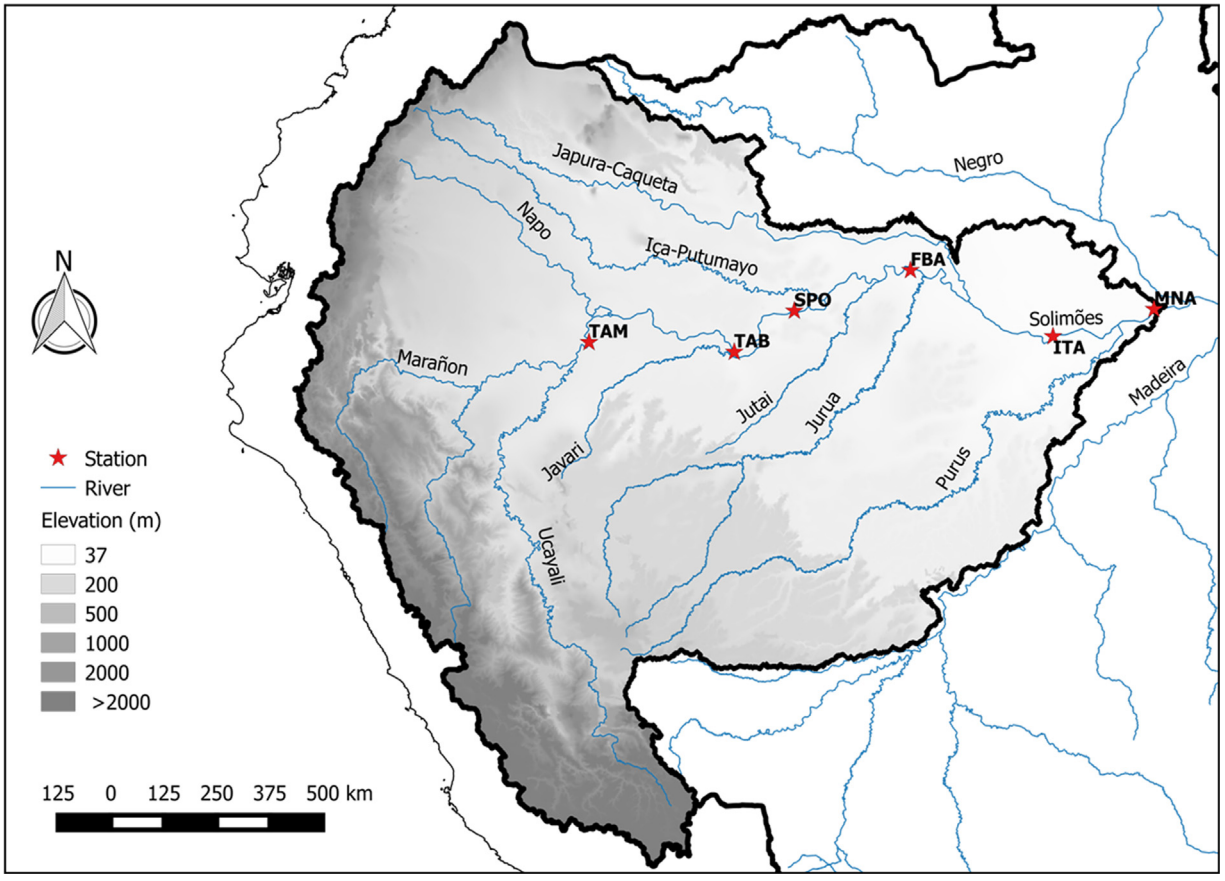

Fig. 1. Location of the Solimões Basin up to Manacapuru (MNA), in the Amazon Basin. The red stars indicate sampling stations.

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