Relationships between discharge in the Amazon basin and SST: time and space variability

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One of the objectives of **Hybam (Hydrogeodynamics of the Amazon basin)** is to describe the discharge variability within the Amazon basin and determine where and at what time scale discharge is predictable.

CONCLUSION: An El Niño/dry signal is observed in a large domain of the Amazon basin during the 1981-2002 period. However, the wavelet analysis of the 1903-2001 Óbidos runoff data shows that this signal, when considering mean and maximum annual discharge, is not stationary during the XX th century,

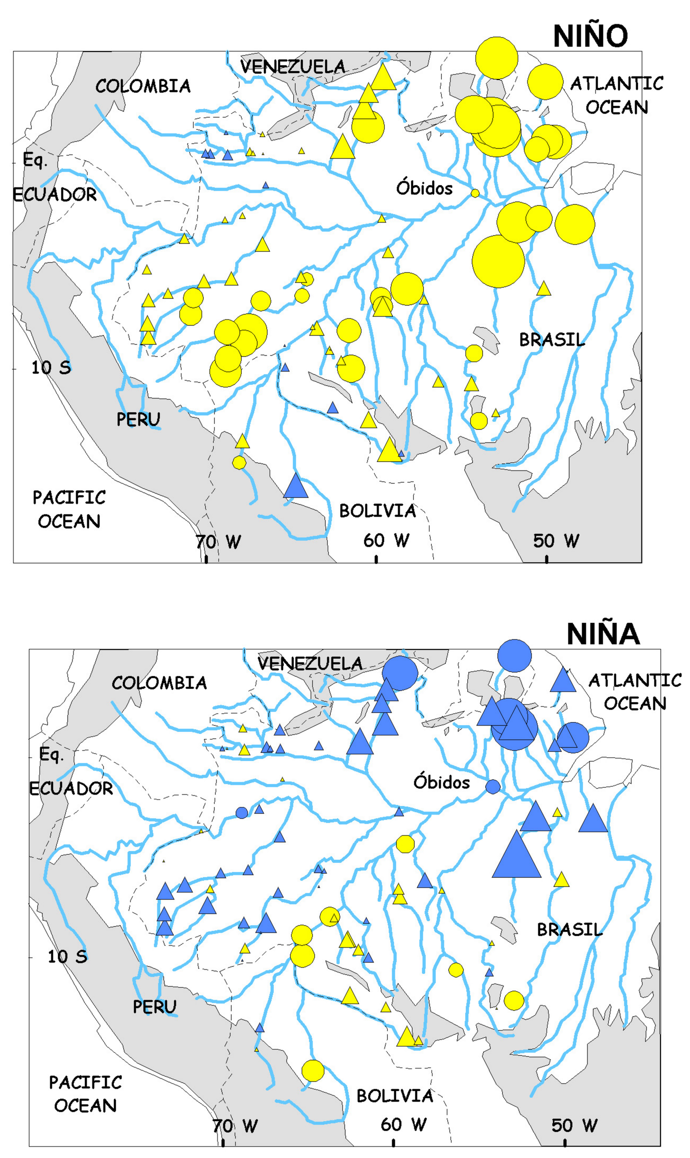
High discharge in the southwestern and northeastern affluent of the Amazon River are associated with cold SSTs over the northern tropical Atlantic (NATL), especially during the low flow season (1981-2002). More, a common, though not permanent, near decadal signal is observed in Óbidos low flow and in NATL SSTs. The 1970's shift in Óbidos discharge corresponds to interdecadal oscillations coinciding with major changes in Atlantic and Pacific climate.

The discharge of the southernmost Amazon rivers are related to the south Atlantic SSTs; however the signals are space and time dependant.

Data and methods:
- Daily discharge in 80 stations (1967-2002 for the longest series, 1981-2002 for the shortest) - Monthly discharge in Óbidos (1903-2001) - HYBAM
- SST data from NOAA-NCEP
- EOF analysis to define hydrological regions in the Amazon basin. Correlation (results not shown here), composites and wavelet analysis to analyse SST-discharge relationships.

El Niño-Southern Oscillation

During the 1981-2002 period, an El Niño/low discharge signal is observed in many Amazonian rivers, except in the western streams (Solimões, Japura, Negro) and in the upper Madeira basin (Mamoré) (Figure 1). The strongest signal is observed in the north-eastern rivers where a La Niña/high discharge signal is also noticeable. In the Madeira and upper Tapajós basins, low discharges are associated with La Niña events, as in the SESA region (Southern Brazil, Uruguay, NE Argentina).



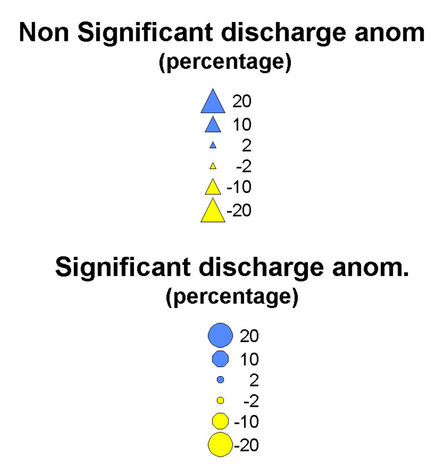


Figure 1: Composite mean annual discharge anomalies, significant at the 90% level (circles) or not significant (triangles) during El Niño and La Niña episodes in the equatorial Pacific (1981-2002).

Tropical north Atlantic

Cold (warm) conditions over the northern tropical Atlantic are associated with higher (lower) than usual discharges (Figure 2). This signal is observed in the NE Amazon and in the south western affluents (Madeira, Solimões, Purus, Jurua) and when considering mean and low flow runoff. On the contrary, low discharges are noticeable in the northern Amazon (Branco, Demeni) during cold events.

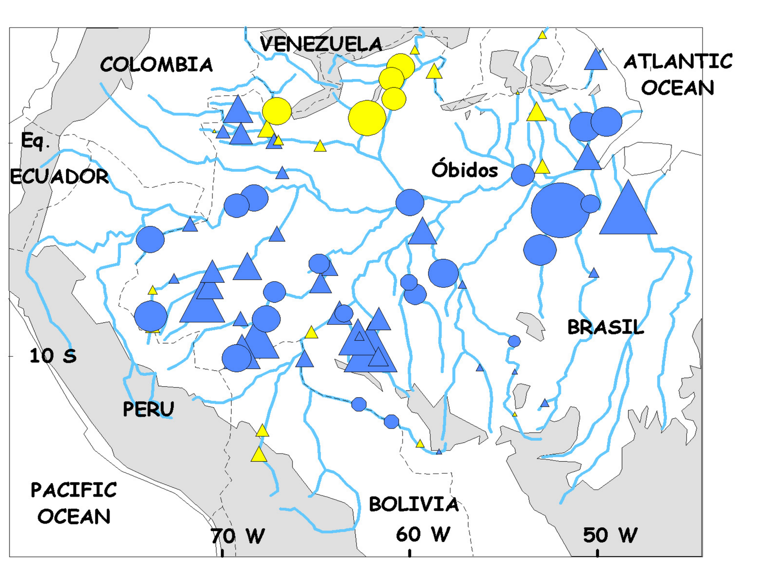
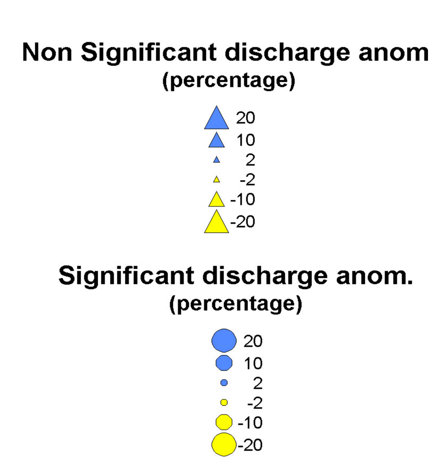
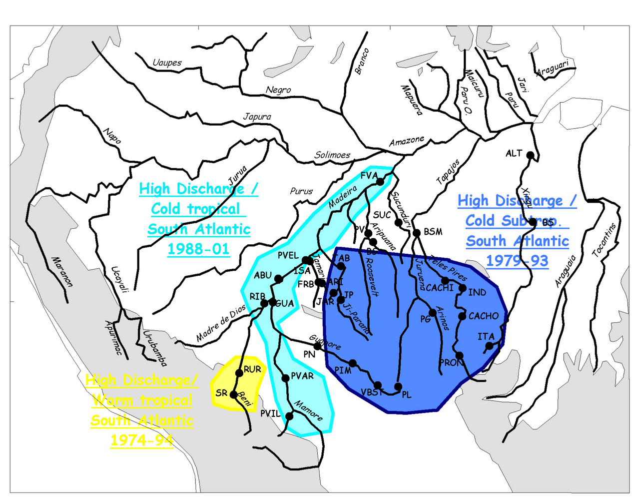


Figure 2: Composite low flow discharge anomalies, significant at the 90% level (circles) or not significant (triangles) during cold events in the tropical northern Atlantic (period: 1981-2001, events: 1984-85, 1985-86 and 1993-94).



Southern Atlantic

Figure 3: Relationships between discharge and SSTs in the southern Atlantic, tropical (0-20 S ; 30W-10E) and subtropical (20-30S ; 30-50W). Light blue (yellow) shading indicates negative (positive) relationships between discharge in the Mamoré-Madeira (Beni) basin and the southern tropical Atlantic SSTs. Dark blue shading (Upper Xingu , Tapajós and Guaporé) indicates a negative relationships between discharge and subtropical SSTs (read details on the map, Ronchail et al. 2004).



Amazon discharge variability in Óbidos 1903- 2001

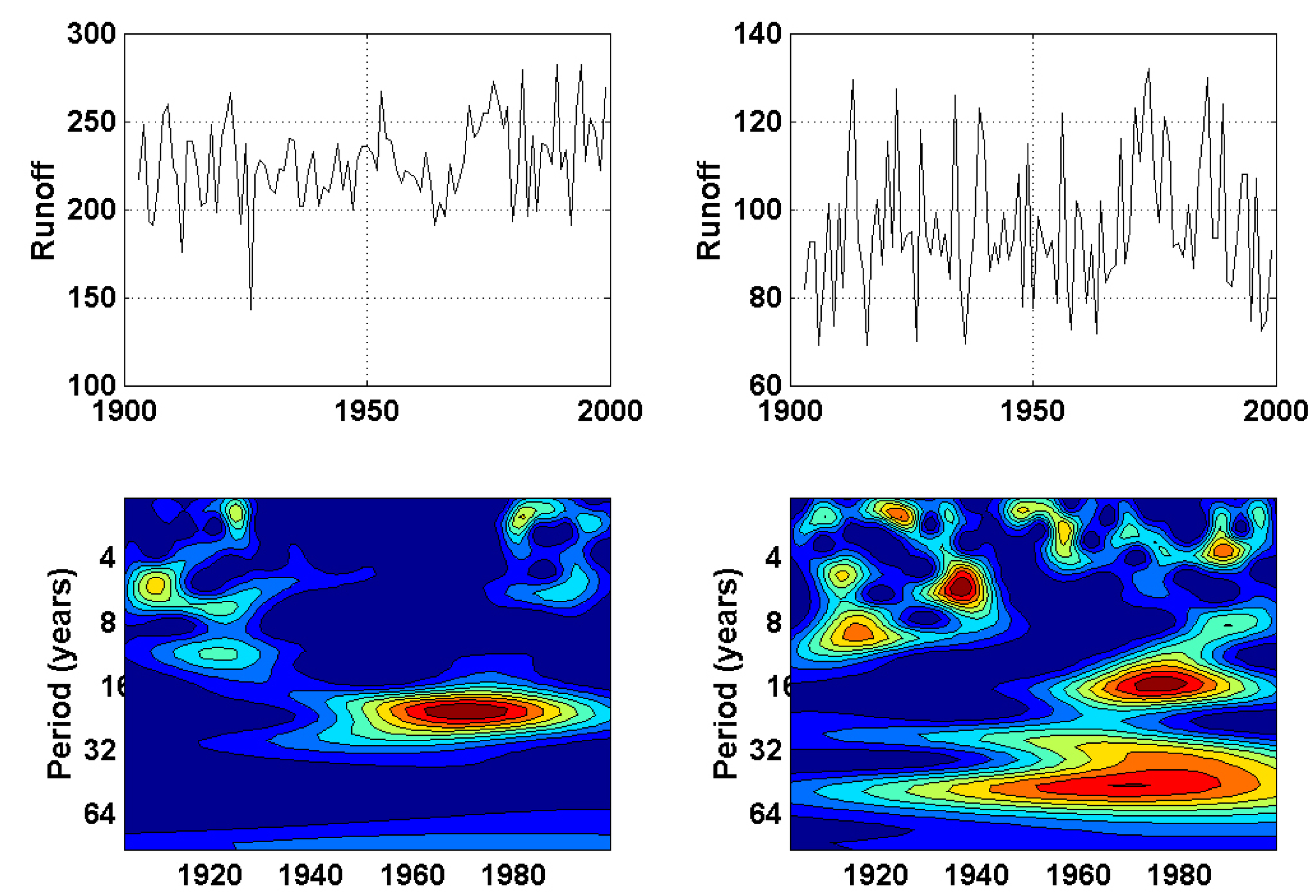
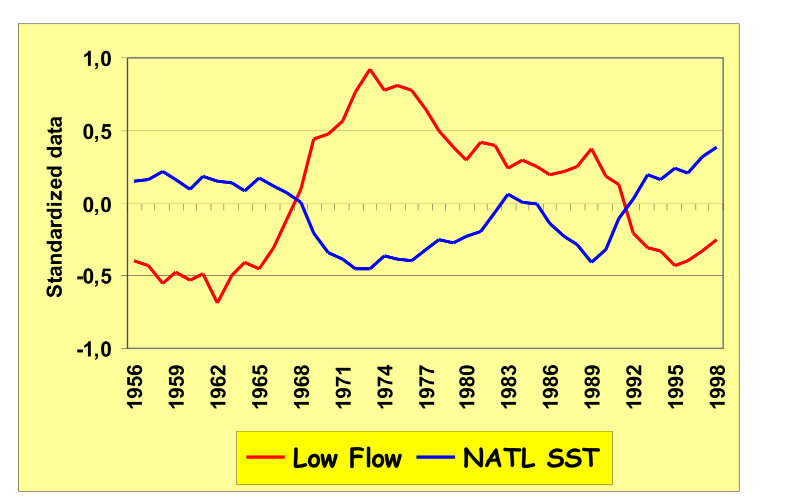


Figure 4. Temporal fluctuations and corresponding Morlet wavelet analysis of the maximum (left) and the minimum (right) annual runoff (10m3 s-1) on the Amazon river at Óbidos over the 1903-2001 period.

The ENSO signal in Óbidos is intermittent during the XXth: 3-7 years variability in mean and high flow is observed at the beginning and the end of the century, during periods of high variability on the tropical Pacific (Figure 4-left, Labat et al. 2004). However, the ENSO signal is more permanent in the low flow discharge (Figure 4-right).

A common 15,5 years signal is observed in the low flow discharge in Óbidos and in the north tropical Atlantic SST since 1970 (Figure 4-right). It coincides with an abrupt elevation of discharge (Callede et al. 2004) and it is concomitant with a cooling of the northern tropical Atlantic (Figure 5). A bidecadal variability of mean and high flow discharge is also noticeable around 1970 (Figure 4-left).

Figure 5: Low flow discharge in Óbidos and annual SSTs in the tropical northern Atlantic (5-20N ; 60-30W). Data is standardized and an 11 years running mean is computed.



References:
- Callède J., Guyot J.L., Ronchail J., L'Hôte Y., Niel H., de Oliveira E. 2004. Evolution du débit de l'Amazone à Óbidos de 1902 à 1999. Hydrological Sciences, 49, 85-97
- Labat D., J. Ronchail, J. Callède, J. L. Guyot, E. de Oliveira, W. Guimarães 2004. Wavelet analysis of Amazon hydrological regime variability. Geophysical Research Letter, 31, L02501.
- Ronchail J., G. Cochonneau, L. Bourrel, L. Maurice Bourgoin, N. Filizola, P. Vauchel, J.L. Guyot, E. de Oliveira and V. Guimarães. Space-time variability of the SST-discharge relationships in the southern Amazon basin (Madeira , Tapajós, Xingu). Submitted to Hydrological Processes (February 2004).