Susceptibility of macrophyte productivity to variations in flood intensity in the Amazon floodplain

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INTRODUCTION

The mainstem Amazon River floodplain contributes actively to carbon biogeochemistry in the Amazon system (Richey et al. 2002; Melack et al. 2004), and its role as a potential converter of atmospheric CO_2 into atmospheric CH_4 is well established, with significant implications to global warming (Bastviken et al. 2011).

Net primary productivity (NPP) in the floodplain is driven mostly by woody and herbaceous (macrophytes) plants, and controlled by the annual "flood pulse" (Figure 3) (Melack et al. 2009). Amazonian macrophytes have very high NPP rates, and can thrive on both dry and flooded conditions, responding almost immediately to flooding patterns (Silva et al., 2009).

The last decade has seen two extreme drought events for the Amazon, in 2005 and 2010, and one extremely high flood in 2009 (ANA 2012). More importantly, increased frequency and intensity of droughts have been predicted for the Amazon under current climate change scenarios (Hutyra et al. 2005; Malhi et al. 2008), but little attention has been given to their potential effects on the aquatic ecosystems of the Amazon floodplain.

The interplay between macrophyte growth and flooding in the Amazon floodplain is the result of two seemingly opposite processes; macrophyte cover ("horizontal growth") has been shown to increase during dry periods (Silva et al. 2010, Figures 6 and 8), while stem elongation ("vertical growth") is mostly driven by the increase in flood levels (Junk & Piedade 1997, Figures 7 and 9). Therefore, determining how these mechanisms can interact to determine annual macrophyte NPP is key to better comprehend the effects of changes in flooding patterns on the carbon biogeochemistry in the Amazon floodplain.

The present study thus addresses the question of "how does variability in the flood pulse affects the contribution of macrophytes to the carbon budget of the Amazon floodplain ?", by combining remote sensing estimates of macrophyte cover, *in situ* macrophyte biomass measurements, historical water level records, and statistical simulation.

METHODS

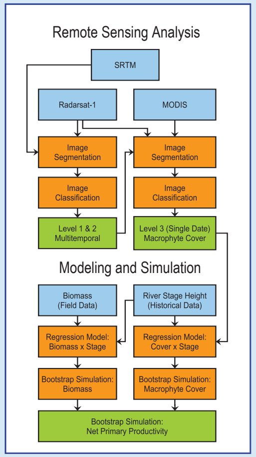

Figure 1. Image processing and modeling workflow.

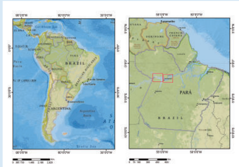

Figure 2. Location of the study sites, in the Eastern Amazon Floodplain.

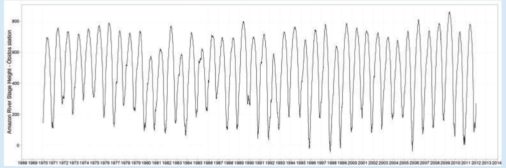

Figure 3. Daily Amazon river stage height at Óbidos station, for the 1970 - 2011 period

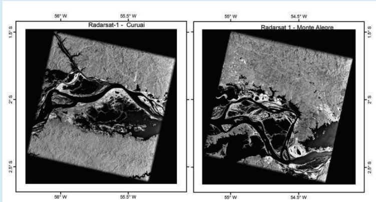

Figure 4. Radarsat-1 images for Curuai and Monte Alegre lakes.

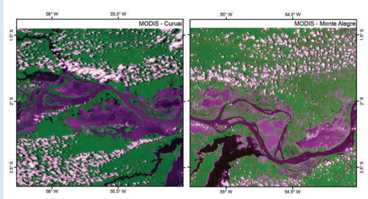

Figure 5. MODIS MOD09 images for Curuai and Monte Alegre lakes.

CONCLUSIONS

1) Macrophyte distribution is controlled by inundation levels and lake topography, forming two disticnt groups: year-round communities and short-lived communities;

2) Short-lived communities are more suscpetible to variations in minimum annual water levels, due to changes in available exposed substrata for colonization;

3) Yearly communities are more susceptible to variations in maximum annual water levels, due to the necessity to maintain continuous elongation throughout the season;

4) Maximum annual water level had a stronger influence in the total NPP for both lakes (*i.e.* ¨vertical¨ growth had the largest contribution).

5) However, there is no indication of correlation between maximum and minimum water levels during each growing season, for the 1970-2011 period. For this reason, the sucession of extreme droughts and extreme floods can lead to higher NPP (*e.g.* the year 2006).

6) The present analysis offers a first insight on how macrophyte productivity may respond to changes in flooding dynamics due to climatic change. However, local variability due to topographical and environmental conditions remains unadressed.

RESULTS

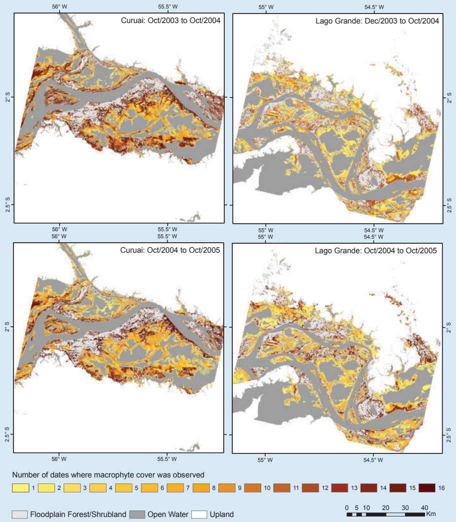

Figure 6. Macrophyte recurrence maps, showing the different groth strategies in the floodplain.

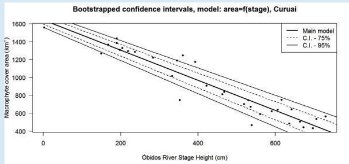

Figure 7. Modeled relationship between macrophyte cover and river stage height, Curuai Lake

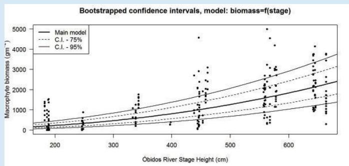

Figure 8. Modeled relationship between macrophyte biomass and river stage height.

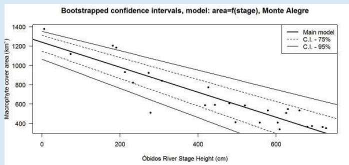

Figure 9. Modeled relationship between macrophyte cover and river stage height, Monte Alegre Lake

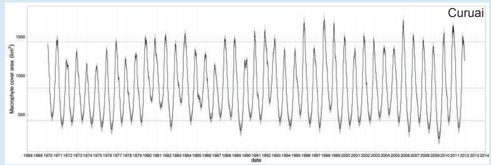

Figure 10. Simulated macrophyte cover for the 1970-2011 period, Curuai Lake. Gray bands indicate the 95% confidence interval.

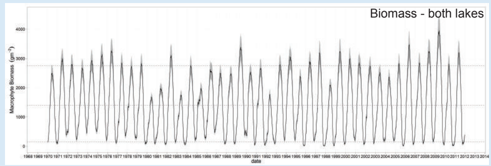

Figure 11. Simulated macrophyte biomass for the 1970-2011 period. Gray bands indicate the 95% confidence interval.

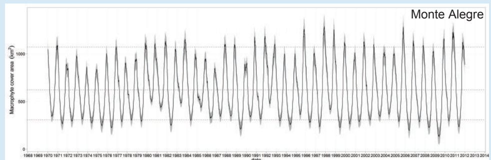

Figure 12. Simulated macrophyte cover for the 1970-2011 period, Monte Alegre Lake. Gray bands indicate the 95% confidence interval.

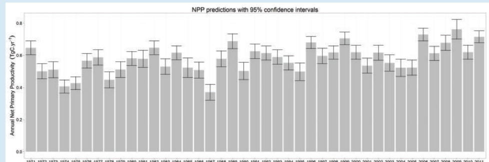

Figure 13. Simulated macrophyte NPP for the 1971-2011 period, Curuai Lake. Lines indicate the 95% confidence interval.

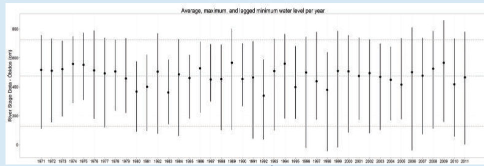

Figure 14. Average, maximum and 1-year lagged minimum river stage at Óbidos station for the 1971-2011 period .

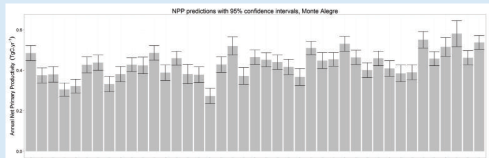

Figure 15. Simulated macrophyte NPP for the 1971-2011 period, Monte Alegre Lake. Lines indicate the 95% confidence interval.

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