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

Thiago S. F. Silva*, Tarik S. Araújo**, Evlyn M. L. M. Novo*, John M. Melack***

Corresponding Author: thiago@dsr.inpe.br  * Remote Sensing Division, National Institute for Space Research (DSR/INPE), S. José dos Campos, SP, Brazil; ** Formerly at INPE/UCSB, now at the Brazilian Institute for Geography and Statistics (IBGE), Natal, RN, Brazil; *** Bren School of Environmental Science and Management, University of California Santa Barbara (UCSB), CA, USA.

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 CO₂ into atmospheric CH₄ is well established, with significant implications to global warming (Bazilek 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” (Richey et al. 2003). 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 rare 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 (Hyttel et al. 2005; Mafal 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.

RESULTS

CONCLUSIONS

1) Macrophyte distribution is controlled by inundation levels and lake topography, forming two distinct groups: a) horizontal growth has the largest contribution.

2) Short-lived communities are more susceptible 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 succession 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 unaddressed.

REFERENCES


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/MOS14 images for Curuai and Monte Alegre lakes.

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 cover and river stage height, Monte Alegre Lake.

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

Figure 10. Modeled relationship between macrophyte cover for the 1970-2011 period, Curuai Lake. Grey bands indicate the 95% confidence interval.

Figure 11. Modeled relationship between macrophyte cover for the 1970-2011 period, Monte Alegre Lake. Grey bands indicate the 95% confidence interval.

Figure 12. Modeled relationship between macrophyte biomass and river stage height, Curuai Lake.

Figure 13. Modeled relationship between macrophyte biomass and river stage height, Monte Alegre Lake.

Figure 14. Measured macrophyte biomass along the flood gradient, Curuai Lake.

Figure 15. Modeled macrophyte biomass along the flood gradient, Monte Alegre Lake.