Looking From Above:
Towards an integrative view of macrophyte growth and productivity at the Amazon Floodplain

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The Amazon Floodplain – A big wetland, with big concerns!

- A very dynamic and heterogeneous system
- Not as well studied as its terrestrial counterpart
- Over 800,000 km$^2$ in area for the lowland Amazon floodplain (Melack & Hess, in press)
- May be responsible for exporting over 0.5 Pg C.yr$^{-1}$ to the atmosphere (Richey et. al, 2002)
- Important given the uncertainties regarding the whole Amazon C budget
Productivity in the Amazon Floodplain

- Variable across different environmental conditions:

  - Forests: 800 - 1250 Mg C km\(^{-2}\) y\(^{-1}\) (Worbes, 2007)

  - **Macrophytes**: < 900 Mg C km\(^{-2}\) y\(^{-1}\) to >5000 Mg C km\(^{-2}\) y\(^{-1}\) (Costa, 2005)

  - Phytoplankton: 200 Mg C km\(^{-2}\) y\(^{-1}\) (Melack and Forsberg, 2001)

  - Periphyton: 210 Mg C km\(^{-2}\) y\(^{-1}\) (Melack and Forsberg 2001)

- *Aquatic vegetation can represent the major percentage of NPP at some areas.*
Amazon Macrophytes

- Mostly emergent, grass-like vegetation
- C3 and C4 species
- Fast growth rates
- Seed dispersal plus vegetative growth
- Annual growth cycles tied to the flood pulse

Studies on Productivity of Amazon Macrophytes

- Reported values in the range of $<900 \text{ Mg C km}^{-2} \text{ y}^{-1}$ to $>5000 \text{ Mg C km}^{-2} \text{ y}^{-1}$ (Engle et al, 2008, Costa 2005, Junk and Piedade 1993, Piedade et al, 1991 and others)
- Mostly local studies, concentrated on specific portions of the floodplain
- Different productivity rates due to environmental variability (Silva et al, submitted)
- Large areas demand a comprehensive estimation methodology
Remote Sensing

- Synoptic, continuous and regular acquisition of data
- Radiometric information related to plant biophysical characteristics
- Problem - Cloud Cover
  - Radar – only slightly affected by clouds
  - Fast imaging rates – increase the probability of acquiring a clear image
Previous Remote Sensing Approaches

- **Central Amazon habitat mapping** (Hess et al., 2003)
  - JERS-1, 100m resolution, two dates (high/low water)
  - No data about productivity
- **Comparison of mapping performance from coarse resolution data** (Silva et al, 2007)
  - MODIS / Landsat TM5, 2 dates
  - Indicated that MODIS was capable of acquiring reasonable results despite the lower resolution
- **Macrophyte mapping and NPP estimation at Monte Alegre lake** (Costa, 2005)
  - JERS-1/RADARSAT-1, 4 dates,
  - Imagery acquired over different years
- Using remote sensing for measurements of cover and NPP is feasible
- Spatially/Temporally consistent measures of cover and production over a seasonal period are still lacking.
Can we improve it? Our current goals:

- Produce a robust mapping methodology to deliver accurate results on a local to regional scale;

- Develop a modeling approach to estimate macrophyte biomass and NPP over the floodplain;

- Measure the evolution in macrophyte cover throughout the annual hydrological cycle;

- Provide an estimate of macrophyte NPP through the combination of monthly cover maps and monthly biomass data.
Figure 4: Graphical representation of average NPP values (dots) and confidence intervals (bars) calculated for the present study. G1 – G7 represent different locations of Monte Alegre lake. Notice that confidence intervals are noticeably larger for smaller sample sizes. (Silva et. al, submitted to Wetlands).
Remote Sensing Analysis – Multiple Image Sources

- Synthetic Aperture Radar (C-Band, 5.6 cm wavelength)
  - Radarsat ST2 – 14 images (HH)
  - Radarsat ST4 – 5 images (HH)
  - ENVISAT ASAR – 8 images (HH + HV)
Remote Sensing Analysis – Multiple Image Sources

- Optical
  - MODIS 09 - 12 scenes (1 scene per month is reasonable)
  - Landsat TM – 5 scenes
  - CBERS 2 – 5 scenes
  - Videography data: for interpretation and validation

MODIS
(R:B1,G:B2,B:B1)

Landsat TM
(R:B5,G:B4,B:B3)

CBERS CCD
(R:B5,G:B3,B:B4)
Remote Sensing Analysis – Multiple Image Sources

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Remote Sensing Analysis – Preliminary Results

- Radarsat C-HH
  - Circumvents the cloud cover limitation
  - Most extensive temporal coverage
  - Not able to provide good discrimination between cover types in single date imagery.
Remote Sensing Analysis – Preliminary Results

- The use of a time series, however, highlights the seasonal behavior of different cover types:

Radarsat ST2 - (R:Dec03,G:Jul04,B:Dec04)
Remote Sensing Analysis – Preliminary Results

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![Image of radar satellite data with a graph showing seasonal variations in backscatter intensity for different land cover types.](image)

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Remote Sensing Analysis – Preliminary Results

- Definiens Developer 8.0 (www.definiens.com)
  - Object-oriented classification approach
  - Multi-Level Image Segmentation and Classification
  - Capable of dealing seamlessly with multiple sensors, resolutions, and ancillary data
  - Fuzzy, rule based classification rule system

Classification Approach - Multilevel Classification

- First Level – based on the temporal signature of each cover type (multidate)
- Second Level – based on the radiometric signature, constrained by the temporal information
- Each level composed itself by sub-levels to increase accuracy
Original Radarsat ST2 Image Series
(R:Dec03,G:Jul04,B:Dec04)
First Classification Level:

- Upland
- Floodable
- High Change (Submergible)
- Water
First Classification Level:

- Upland
- Floodable
- Macrophytes
- High Change (Submergible)
- Water
Second Classification Level:

Once probable macrophyte area is mapped on the image time series, analysis of single-date imagery is restricted to those areas.
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Once probable macrophyte area is mapped on the image time series, analysis of single-date imagery is restricted to those areas.
Macrophyte at this date

Not macrophyte at this date
Remote Sensing Analysis – Primary Productivity

- Relationship between reflectance/backscatter and vegetation biomass
- C – Band: captures the low biomass variability
- MODIS: captures the high biomass variability
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Summary

- A methodology for estimating plant biomass and productivity over large areas and consistently through time is needed

- Remote sensing can provide the tools for these measurements, but no methodology has been developed so far for continuous mapping

- The use of multitemporal and multisensor data can provide complementary information which may help discriminating macrophyte cover and estimating macrophyte productivity

- The use of the temporal signature and a hierarchical classification approach can help to obtain improved classifications for single-date images.
Thank You – Obrigado!

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http://www.geog.uvic.ca/dept2/SPECT/index.html