Monitoring Paraná River wetland dynamics using MODIS NDVI time series

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Framework

The largest wetlands in South America are associated with the floodplains of the big rivers like the Paraná. These wetlands have subregional extension mostly covered by herbaceous vegetation and showing a high spatial and temporal variability of the water table that constrains biogeochemical cycles and fluxes. These wetlands are important habitats sustaining commercial fisheries, cattle ranching and agriculture providing also roughness surfaces for flood regulation. There is a vast history of using NDVI for the study of vegetation characteristics, including biomass, type and condition of vegetation (Lauer y Whittaker, 1991, Jensen, 1996). However, the examples on wetlands are few and recent. Zoffoli (2006) analyzing a 20 years AVHRR-NDVI series of the Paraná River Delta Region, could identify the annual and interannual variations of landscape units and their relation with flood pulses. Unfortunately, the few spatial resolution of the sensor did not allow the author to differentiate the productivity patterns of the distinct vegetation types present on the region.

Objective, data and methodology

The objectives of this work were:

- to identify spatial and temporal change patterns based on the hydrologic and plant phenology behavior
- to gain insight on the impact of extreme hydrological events (EHE) on the river floodplain.

Methodology

We modeled NDVI temporal evolution as (de Burs & Henneyxy 2005):

$$NDVI = \alpha + \beta \cdot JD + \gamma \cdot JD^2$$

This is a quadratic model of NDVI change along the year, starting in winter, so it coincides with the growing cycle.

The advantage of this model is that it’s complex enough to provide a good fit, and simple enough so that each parameter have an immediate ecological interpretation.

Parameter Definition Biological meaning Comment
\(\alpha\) Intercept NDVI
Amount of green biomass at the beginning of the observation period (winter) Always a positive value
\(\beta\) Initial slope of NDVI pattern
Initial vegetation growing rate or green biomass uptake rate Always a positive value
\(\gamma\) Concurrency of NDVI pattern
Larger absolute values imply shorter growing seasons

Results

Implanted Forest - no EHE

1) NDVI patterns show seasonal variations with maximum over summer. Low interannual variability.
2) Parabolic model fits data - very low residues.
3) Model parameters \(\alpha, \beta, \gamma\) values do not show significant variations.

Forest - drought:

1) NDVI patterns show seasonal variations with more interannual variability than implanted forests.
2) In years when parabolic model fits data, this interannual variability is seen in the values of model parameters \(\alpha, \beta, \gamma\).
3) Model does not fit in 2001 (due to sensor failure that produced bad data) and 2008 (due to a regional drought).

Marsh - no EHE

1) NDVI patterns show seasonal variations with maximums over summer. Interannual variability is larger than the one of implanted forest, but of the same order than native forests.
2) Parabolic model fits data with very low residues, except for 2001 (sensor failure produced bad data).
3) Model parameters \(\alpha, \beta, \gamma\) values show variation, but these variations are not significant.

Marsh - flooding and fire:

1) NDVI patterns show seasonal variations with maximums over summer. Interannual variability is larger than the one of implanted forest, but of the same order than native forests.
2) Parabolic model fits data with very low residues from 2001 to 2006. In 2007 this sample was affected by a flooding related to an ENSO event, and in 2008 by a fire. In the first case, there is a progressive and rapid descent of NDVE value at the site get flooded, and a rapid recovery as the water receded. In the second case, there is a rapid descent as the vegetation get burned, but no recovery at least until the end of that winter.
3) From 2003 to 2006, \(\alpha, \beta, \gamma\) decrease and \(\beta\) increases. This lead to a more extreme seasonality.

Rush - flooding and drought

1) NDVI patterns show seasonal variations with maxima over summer. Interannual variability is larger than the one of forests (implanted and native) and marshes.
2) Parabolic model fits data with very low residues, except for 2007 (flooding) and 2008 (drought). In the first case we see an abrupt descent of NDVE and a rapid recovery of previos values when the water start receding (1 month). In the second case there’s a gradual descent of NDVI as plants wither.
3) From 2003 to 2006, \(\alpha, \beta, \gamma\) decrease and \(\beta\) increases. This leads to a more extreme seasonality.

Future work

We are currently working in mapping and classifying the parameters of the model used for the sample analysis, in order to compose a map that considers both the land cover type and its annual and interannual dynamics.