Relationship Between NDVI and ENSO/ARID Indices in the Pampa Grasslands of Southern Brazil and Uruguay

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Introduction

The occurrence of annual climate cycles such as the El Niño - Southern Oscillation (ENSO), which is a main driver of climate variability around the world, has intensified water use and the occurrence of droughts in several regions with grasslands like the Pampa in Southern Brazil and Uruguay. Besides recent land use change, climate variability has been a key factor in the modification of vegetation patterns. Agricultural Reference Index for Drought (ARID) has been found to be a good indicator of the effects of climatic conditions in the vegetation. In addition, the Normalized Difference Vegetation Index (NDVI) shows significant variability in annual phenological response and could be used to characterize grasslands patterns.

Purpose

This study aims at describing the spatial variability of the correlation between NDVI time series images and climatic indices in the Pampa region.

Methods

ENSO was characterized by the Multivariate ENSO Index (MEI) (Wolter et al., 1998), and ARID (Woli et al., 2012) was calculated using daily spatial weather data from 20 meteorological stations in Rio Grande do Sul/Brazil and Uruguay. The NDVI was acquired from MODIS (Rouse et al., 1973), 16 days composited 250 m resolution, for 2000 to 2011, and from Global Inventory Modeling and Mapping Studies (GIMMS), biweekly composited 8-km resolution, for 1981 to 2006. The analyses conducted were based on monthly periods in grasslands areas. NDVI was correlated with ARID in 20 samples (where the weather stations are) while with MEI, NDVI was correlated by pixel.

Results

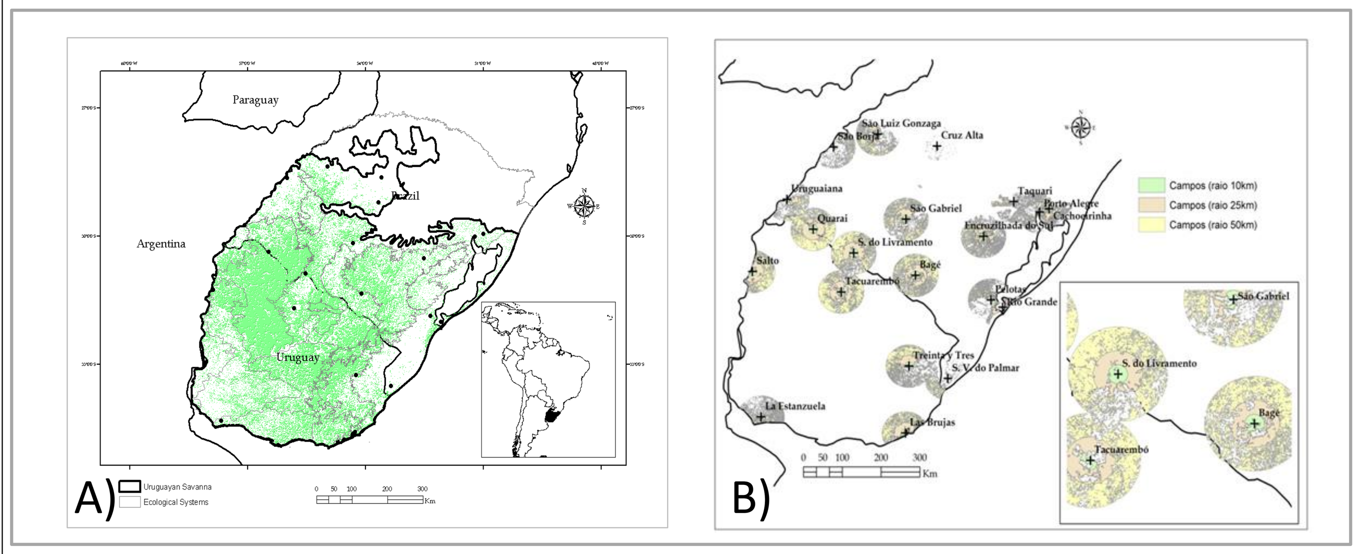

Fig. A) grasslands in study area (green), B) 10km, 25km and 50km radius for NDVI/MODIS samples extracted. In this region during summer and fall, the warm phase of ENSO (El Niño) is associate with increase of rainfall and decrease of temperature; while the cold phase (La Niña) is associated with the opposite effects.

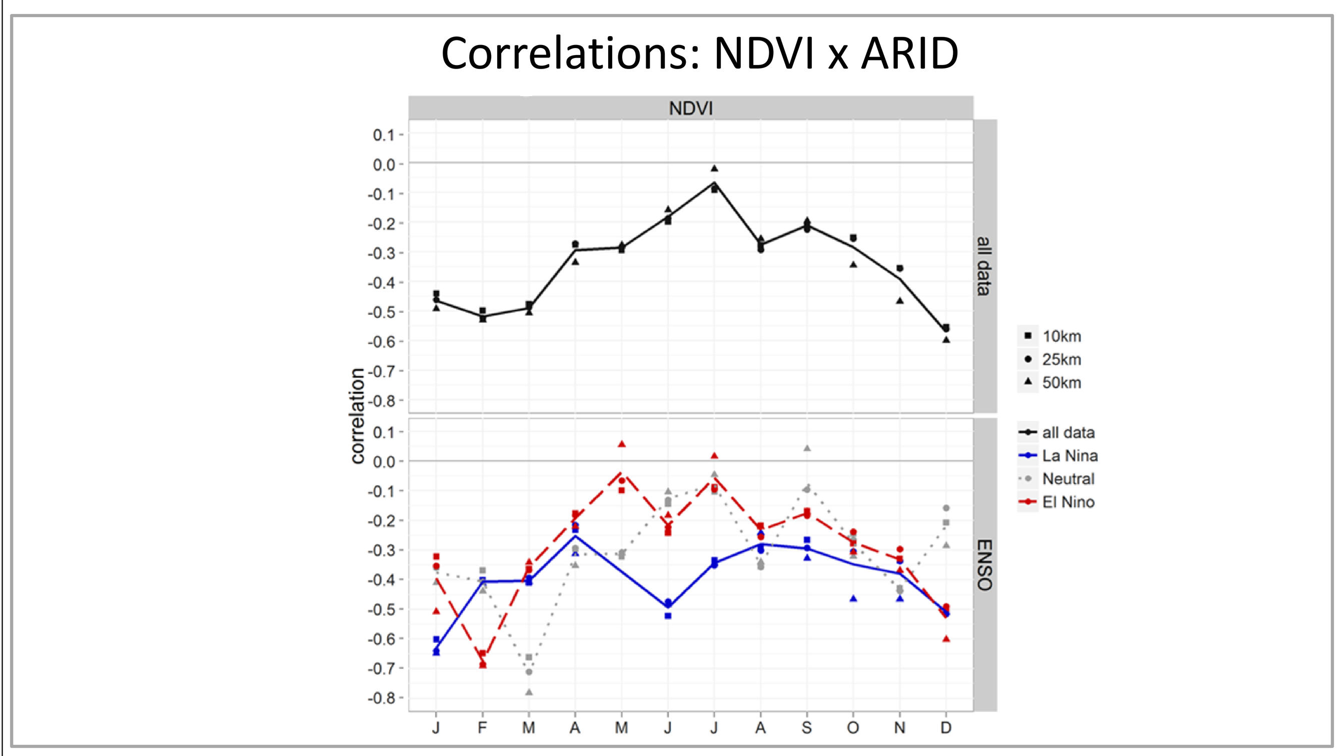

Fig. 2. Monthly correlations between NDVI/MODIS and ARID ($p < 0.05$, lag0) for all data set and ENSO phases in the three circles (10km, 25 km, and 50 km) samples around weather stations.

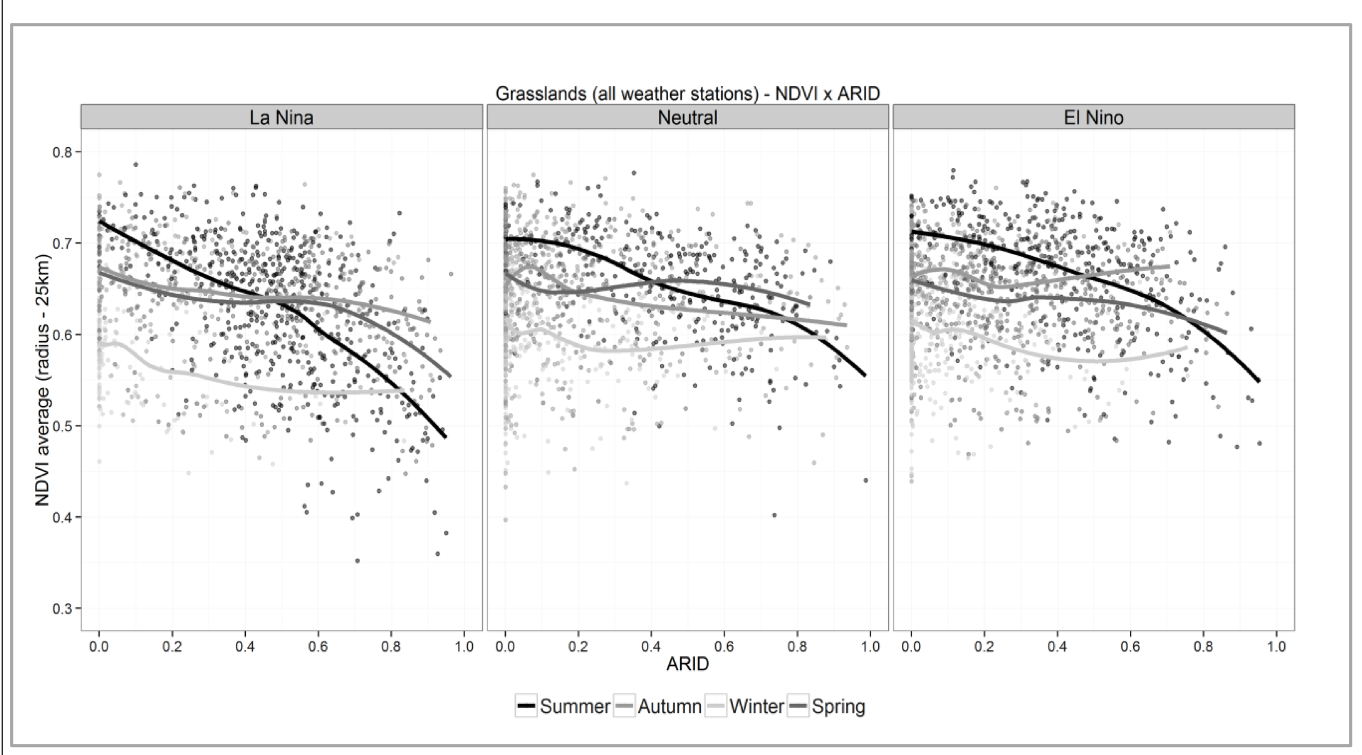

Fig. 3. Scatterplot between NDVI/MODIS and ARID for ENSO phases, example for 25km radius around the weather stations.

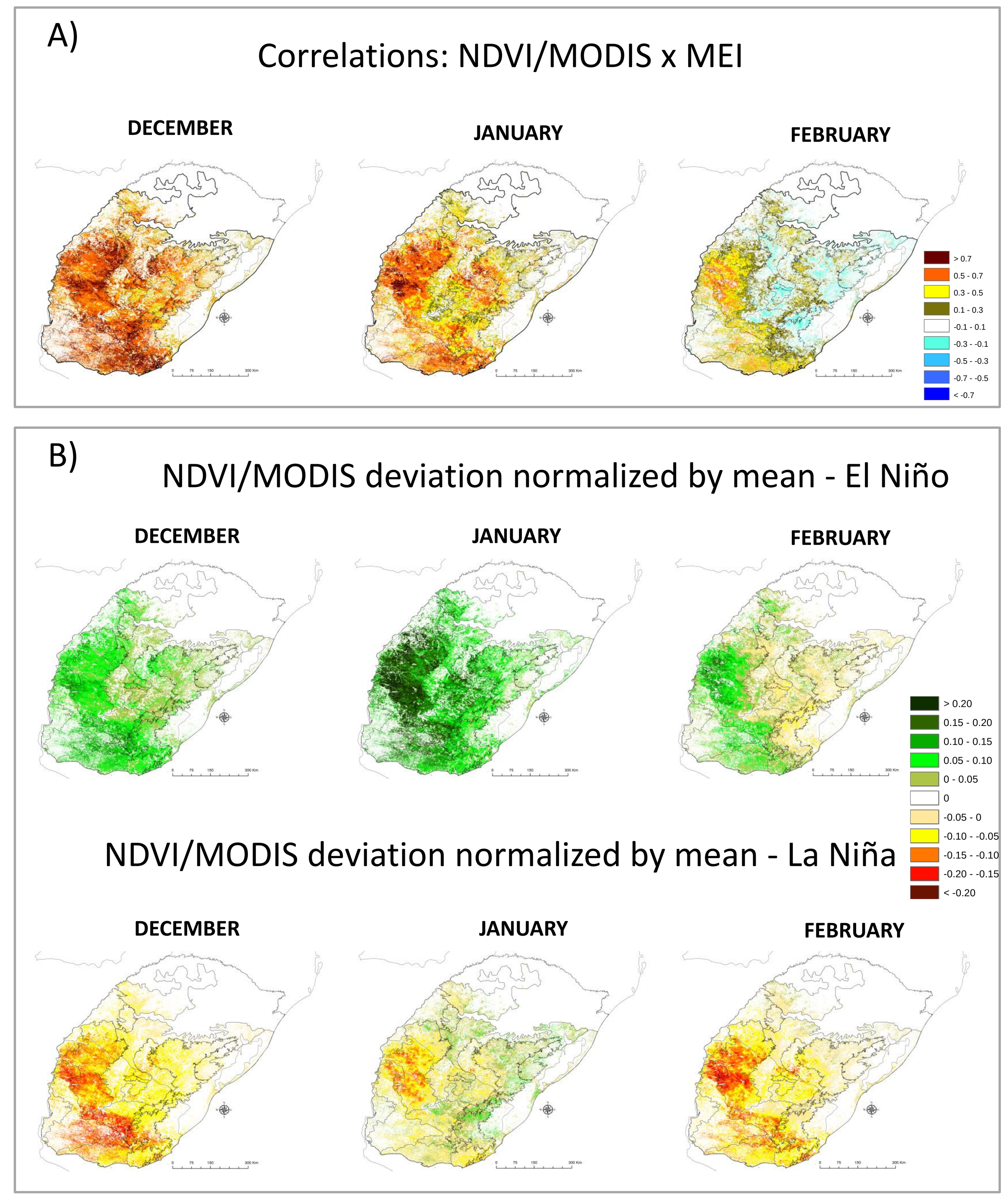

Fig. 4. A) correlations between NDVI/MODIS and MEI ($p<0.05$, lag0), and B) NDVI deviation normalized by mean in ENSO phases, at months December, January, and February. Period from Feb/2000 to Aug/2011.

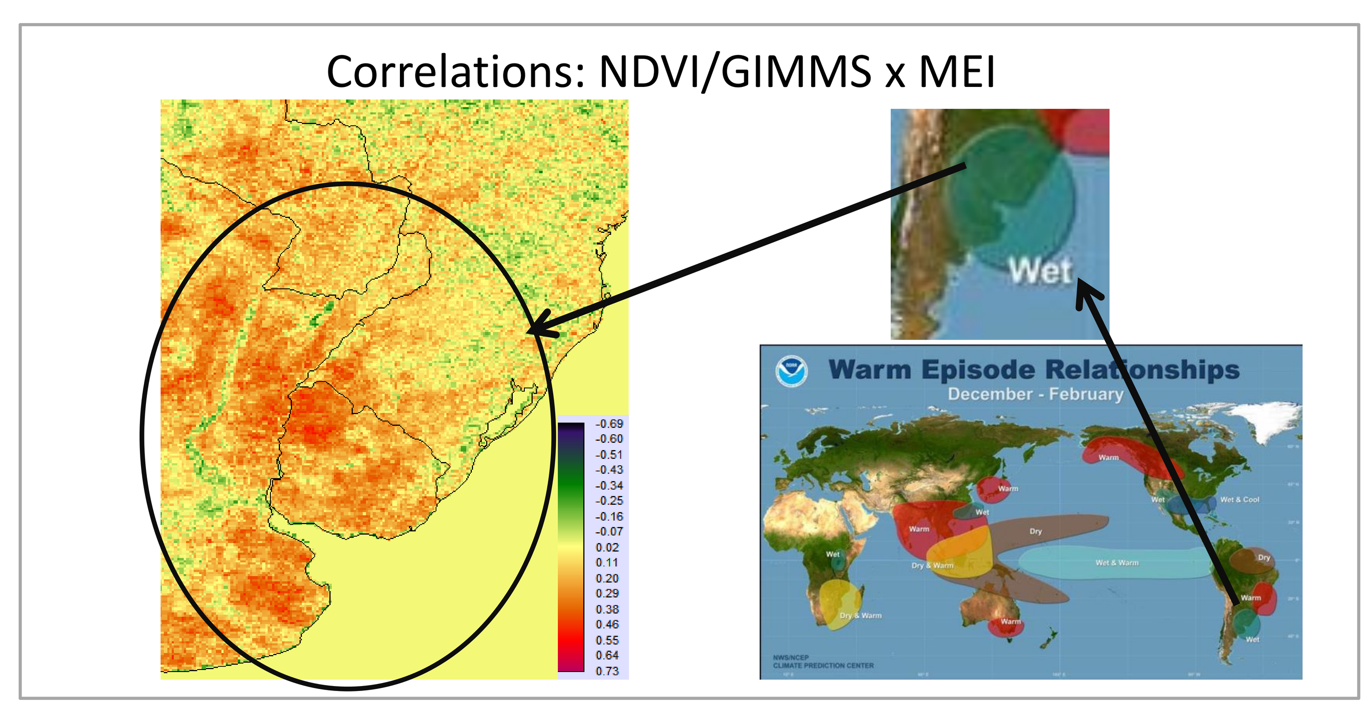

Fig. 5. Correlations between NDVI/GIMMS and MEI (lag0), to months DJF, during the period from 1981 to 2006, and relationship with warm ENSO episode (El Niño).

Vegetation Indices and ARID

➢ ***NDVI - Normalized Difference Vegetation Index***

$$NDVI = \frac{\rho_{IR} - \rho_R}{\rho_{IR} + \rho_R}$$

➢ ***ARID - Reference Index for Drought***

$$ARID = 1 - \frac{T}{ET_o}$$

ρ(IR) = near infrared reflectance;
ρ(R) = red reflectance;
ρ(B) = blue reflectance;
C1 = atmosferic correction coeficiente to red (C1= 6);
C2 = atmosferic correction coeficiente to blue (C2=7,5);
L = correction factor of the interference of the soil (L=1);
G = gain (G=2,5).
T= transpiration
Eto = potential evapotranspiration

Conclusions

Preliminary results indicate high positive correlations between NDVI and MEI on grasslands, mainly during the summer. The vegetation decrease during La Niña phases, and the opposite behavior occurs during El Niño phases corroborated by the observed trends and patterns. The positive correlation found during winter is being investigated, we speculate that it may be caused by an increase in freeze events during La Niña and warmer moist soils during El Niño. Results of correlations between NDVI and ARID indicated a threshold occurrence around 0.5 for ARID beyond which vegetation starts to be affected mainly during the summer. However the determination of this threshold requires further investigation.

Acknowledgement

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References

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