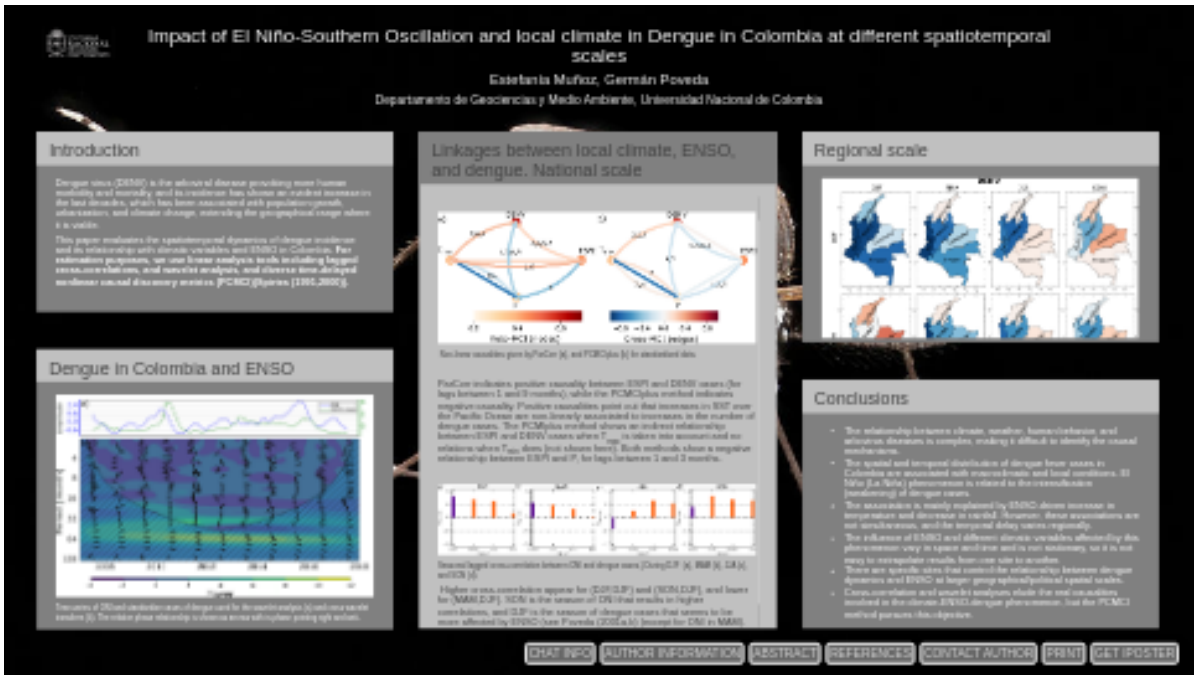
Impact of El Niño-Southern Oscillation and local climate in Dengue in Colombia at different spatiotemporal scales



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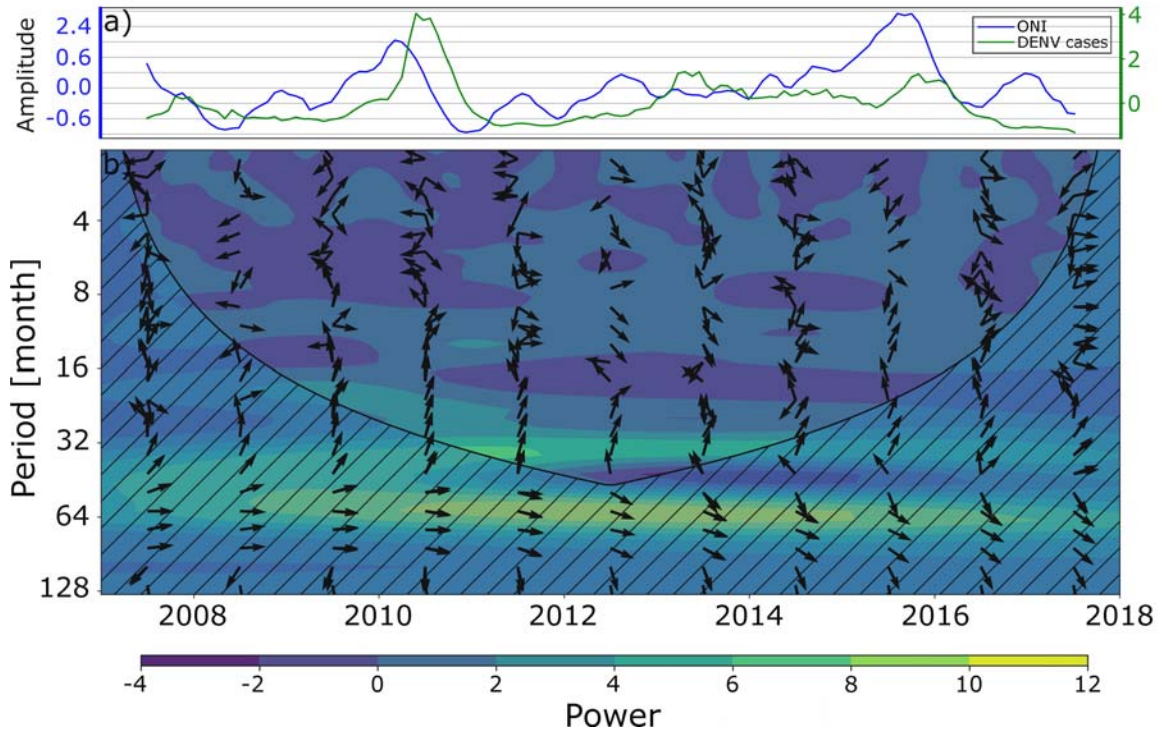
PRESENTED AT:

INTRODUCTION

Dengue virus (DENV) is the arboviral disease provoking more human morbidity and mortality, and its incidence has shown an evident increase in the last decades, which has been associated with population growth, urbanization, and climate change, extending the geographical range where it is viable.

This paper evaluates the spatiotemporal dynamics of dengue incidence and its relationship with climatic variables and ENSO in Colombia. **For estimation purposes, we use linear analysis tools including lagged cross-correlations, and wavelet analysis, and diverse time-delayed nonlinear causal discovery metrics (PCMCI)(Spirtes (1991,2000)).**

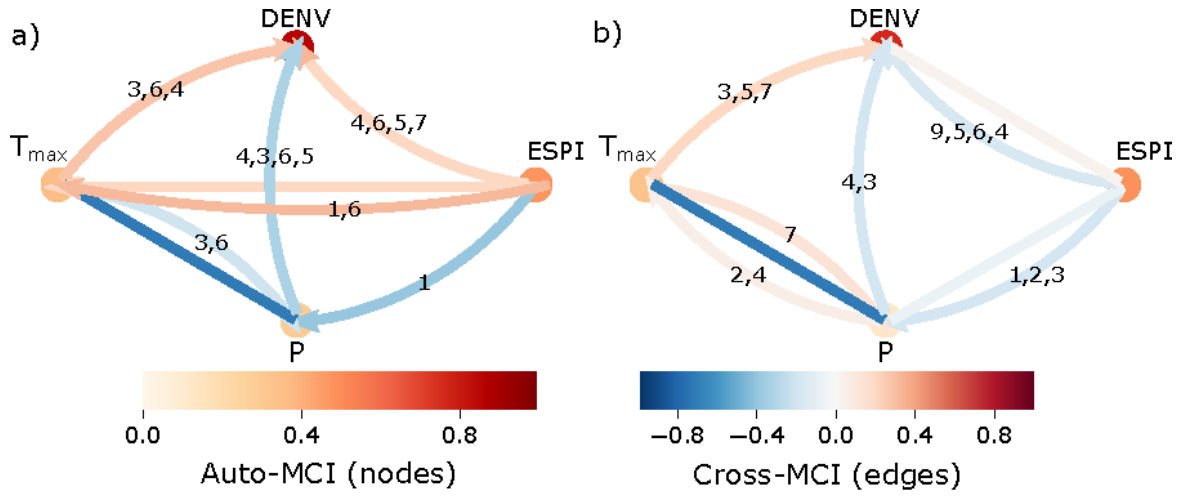
DENGUE IN COLOMBIA AND ENSO



Time-series of ONI and standardize cases of dengue used for the wavelet analysis (a) and cross wavelet transform (b). The relative phase relationship is shown as arrows with in-phase pointing right and anti-phase pointing left.

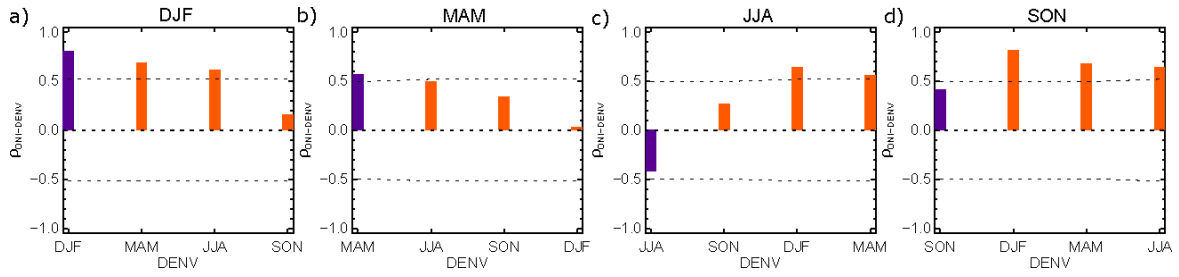
DENV and ONI phenomena show an almost completely in-phase behavior until around 2011, and it goes losing this as time goes on, although this period is out of the statistically significant (non-hatched) cone of influence. Also, there is a high power near 32 months (approx. 2.5 years), although the variables are not fully in-phase. Both periods of 32 and 64 months are associated with the occurrence of the extreme phases of ENSO.

LINKAGES BETWEEN LOCAL CLIMATE, ENSO, AND DENGUE. NATIONAL SCALE



Non-linear causalities given by ParCorr (a), and PCMCIplus (b) for standardized data.

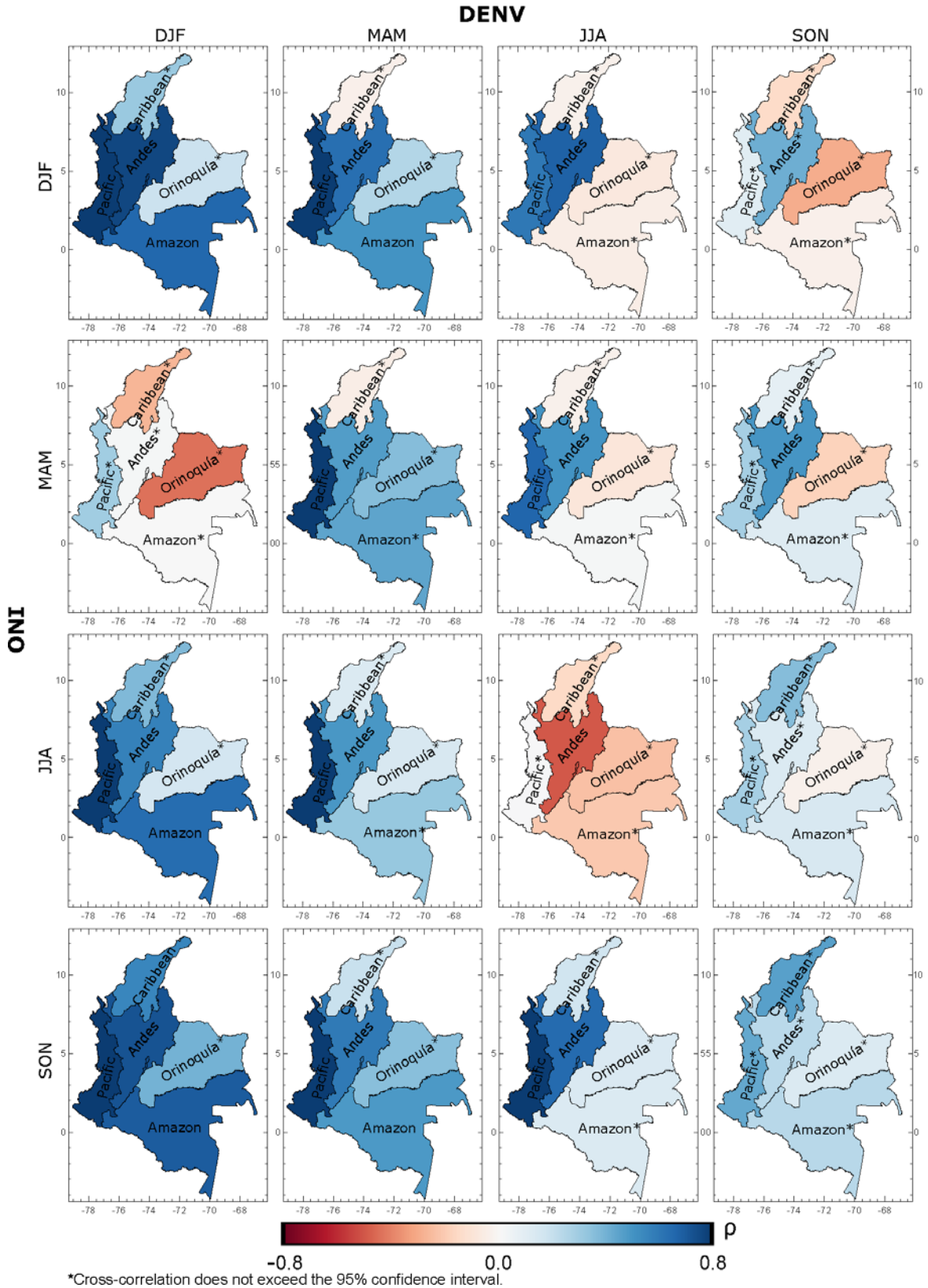
ParCorr indicates positive causality between ESPI and DENV cases (for lags between 1 and 9 months), while the PCMCIplus method indicates negative causality. Positive causalities point out that increases in SST over the Pacific Ocean are non-linearly associated to increases in the number of dengue cases. The PCMIplus method shows an indirect relationship between ESPI and DENV cases when T_{max} is taken into account and no relations when T_{min} does (not shown here). Both methods show a negative relationship between ESPI and P, for lags between 1 and 3 months.



Seasonal lagged cross-correlation between ONI and dengue cases.} During DJF (a), MAM (b), JJA (c), and SON (d).

Higher cross-correlation appear for (DJF,DJF) and (SON,DJF), and lower for (MAM,DJF). SON is the season of ONI that results in higher correlations, and DJF is the season of dengue cases that seems to be more affected by ENSO (see Poveda (2001a,b) (except for ONI in MAM). Remarkably, the only negative cross-correlation occurs in (JJA,JJA), but it does not exceed the confidence interval of statistical significance.

REGIONAL SCALE



Regional seasonal cross-correlation maps between ONI and DENV cases.

The effects of ENSO vary in space and time. Higher cross-correlations between (ONI, Dengue) occur during (DJF, DJF), (DJF, MAM), (MAM, MAM), (JJA, DJF), (JJA, MAM), (SON, DJF), (SON, MAM), and (SON,JJA), especially in the Pacific and Andes regions.

CONCLUSIONS

- The relationship between climate, weather, human behavior, and arbovirus diseases is complex, making it difficult to identify the causal mechanisms.
- The spatial and temporal distribution of dengue fever cases in Colombia are associated with macroclimatic and local conditions. El Niño (La Niña) phenomenon is related to the intensification (weakening) of dengue cases.
- The association is mainly explained by ENSO-driven increase in temperature and decrease in rainfall. However, these associations are not simultaneous, and the temporal delay varies regionally.
- The influence of ENSO and different climatic variables affected by this phenomenon vary in space and time and is not stationary, so it is not easy to extrapolate results from one site to another.
- There are specific sites that control the relationship between dengue dynamics and ENSO at larger geographical/political spatial scales.
- Cross-correlation and wavelet analyses elude the real causalities involved in the climate-ENSO-dengue phenomenon, but the PCMCI method pursues this objective.

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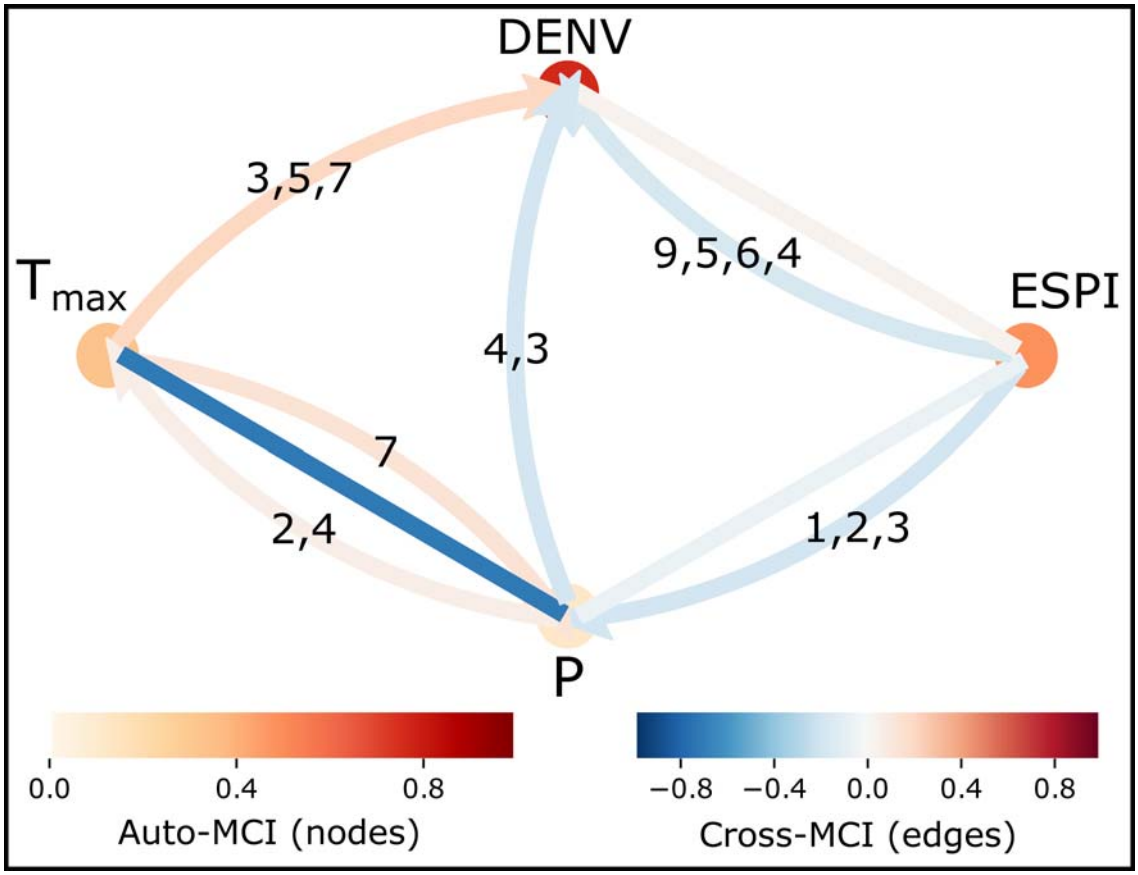
ABSTRACT

Dengue virus (DENV) is an endemic disease in the hot and humid low-lands of Colombia. We characterize diverse temporal and spatial patterns of monthly series of dengue incidence in diverse regions of Colombia during the period 2007-2017 at different spatial scales, and their association with indices of El Niño/Southern Oscillation (ENSO) and local climatic variables. For estimation purposes, we use linear analysis tools including lagged cross-correlations (Pearson test), cross wavelet analysis (wavelet cross spectrum, and wavelet coherence), as well as a novel nonlinear causality method, PCMCI, that allows identifying common causal drivers and links among high dimensional simultaneous and time-lagged variables. Our results evidence the strong association of DENV cases in Colombia with ENSO indices and with local temperature and rainfall data. El Niño (La Niña) phenomenon is related to the intensification (weakening) of dengue cases at the national level and in most regions and departments, with maximum correlations occurring at shorter time lags in the Pacific region, closer to the Pacific Ocean. This association is mainly explained by the ENSO-driven increase in temperature and decrease in rainfall, especially in the Andes and Pacific regions. The influence of ENSO is not stationary (there is a reduction of DENV cases since 2005) and local climate variables vary in space and time, and thus it is not easy to extrapolate results from one site to another. The association between DENV and ENSO varies at national and regional scales when data are disaggregated by seasons, being stronger in DJF and weaker in SON. Specific regions (Pacific and Andes) control the overall relationship between dengue dynamics and ENSO at national scale, and the departments of Antioquia and Valle del Cauca determine those of the Andes and Pacific regions, respectively. Cross wavelet analysis indicates that the ENSO-DENV relation in Colombia exhibits a strong coherence in the 12 to16-months frequency band, which denotes the frequency locking between the annual cycle and the interannual (ENSO) timescales. Results of nonlinear causality metrics reveal the complex concomitant effects of ENSO and local climate variables (Fig. 1), offering new insights to develop early warning systems for DENV in Colombia.



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