Assessing vegetation drought for Tropical Dry Forests(TDFs) using Vegetation Condition Index(VCI) and Temperature Condition Index(TCI)

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Introduction

Drought, resulting from lower than normal precipitation, is a temporal aberration unlike aridity, which is a permanent feature of climate.

Droughts themselves are usually classified into three types: (1) Meteorological droughts, (2) Hydrological droughts, and (3) Vegetation droughts(Y. Zhang et al., 2013).

The standardized Precipitation Index (SPI) is the most broadly accepted meteorological drought index due to low data requirement and flexibility of being calculated for different time scales.

During recent years, many remote sensing vegetation drought indices have been proposed, such as the vegetation condition index (VCI; Kogan, 1995) and the Temperature Condition Index(TCI; Kogan, 1995).

Droughts may have serious effects on forest ecosystem, such as improving the dead rate and changing the structure of the forest ecosystem (Aragao,2007). Tropical Dry Forests(TDFs) comprising 42% of tropical forests(Kalacska,2004). Therefore, drought may potentially affect the TDFs ecosystem.

Objects

- To explore vegetation drought conditions in the TDF regions related to the VCI and TCI in 17 years.
- To determine whether differences exist in reflecting vegetation drought conditions in the TDFs regions based on the VCI and TCI.

Study Area

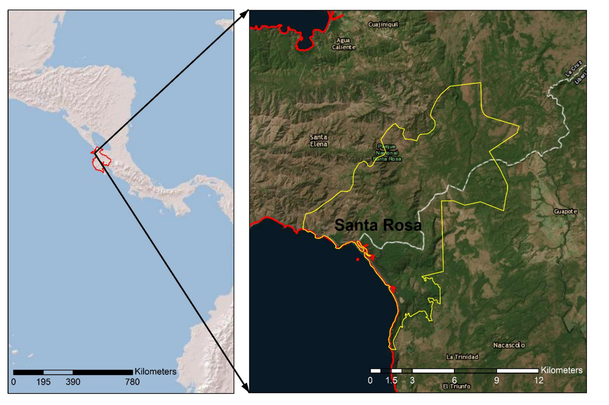

Figure 1. Santa Rosa National Park

Santa Rosa National Park(SRNP) is a sector of the Área de Conservación Guanacaste in Northwest of Costa Rica (10° 48'N, 85°36'W). The dry season is from December to April and the wet season is from May to December. The mean annual precipitation is 1390.8 mm a^{-1} and mean annual temperature is 26.6 °C(Sánchez-Azofeifa, 2005).

Methods

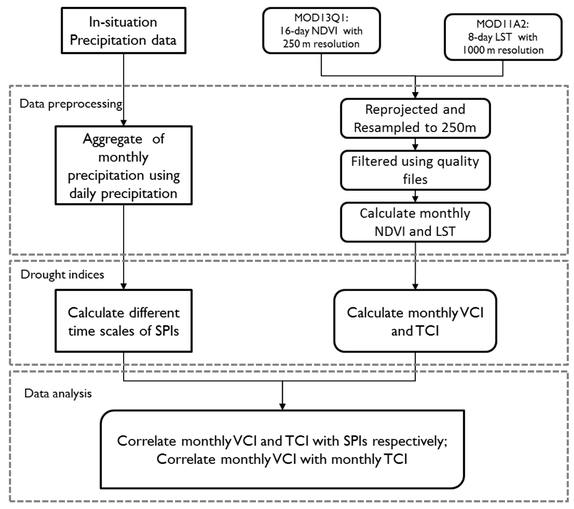

Figure 2. The flowchart of the processes used in the study

$$VCI = (NDVI_j - NDVI_{j\,\min})/(NDVI_{j\,max} - NDVI_{j\,\min})$$
$$TCI = (LST_{j\,max} - LST_j)/(LST_{j\,max} - LST_{j\,\min})$$

j represent the j th month

Results

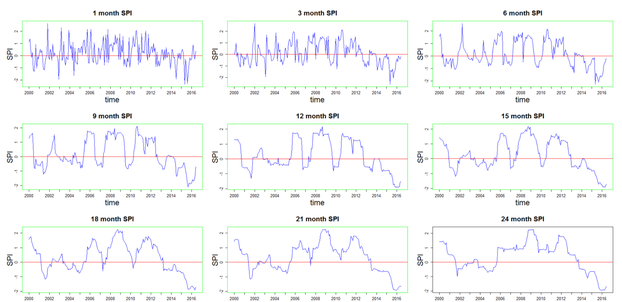

Figure 3. The meteorological drought in SRNP using SPI

Extremely dry -2 SPI 2 Extremely wet

2015 is the most serious meteorological drought year

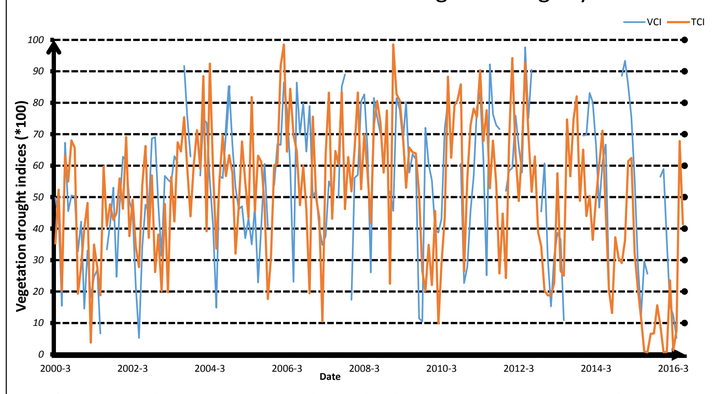

Figure 4. The vegetation drought in SRNP using VCI and TCI

Below 35: Extreme drought ; Between 35 and 50: Moderate drought; Between 35 and 100: Normal and humid

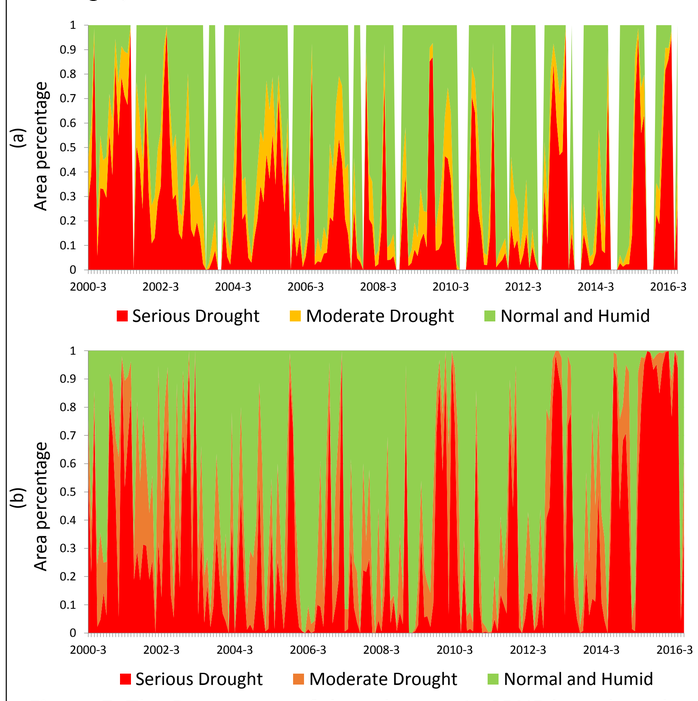

Figure 5. The Percentage of drought area in SRNP based on the (a) VCI and (b) TCI

The VCI and TCI represent not the same drought conditions in SRNP area

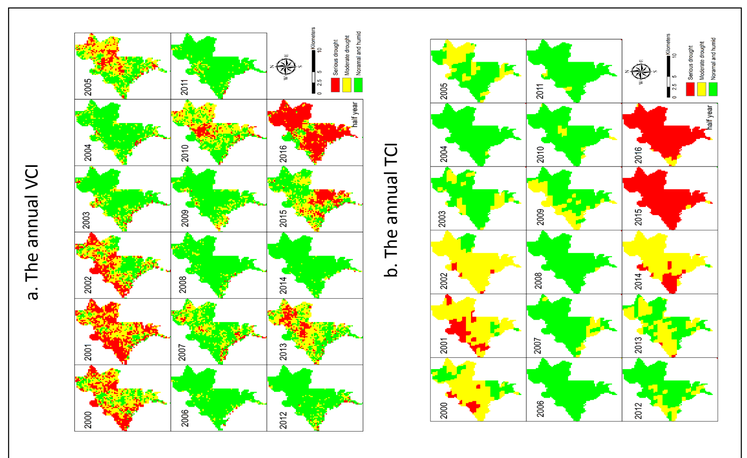

Figure 6. The annual drought mapping in SRNP based on the (a) VCI and (b)TCI

Vegetation need time to recover from extreme meteorological drought; The vegetation drought in 2014 and 2015 was significantly different for the VCI and TCI

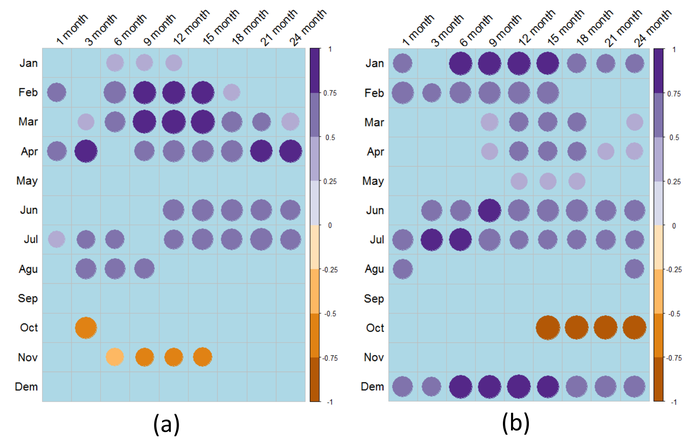

Figure 7. (a). Correlation between VCI and multi-scale SPIs
(b).Correlation between TCI and multi-scale SPIs

During dry seasons(January to April), VCI and TCI are mainly determined by last year meteorological drought condition.During late seasons(September to November), VCI and TCI are not affected by meteorological drought. During other seasons, the correlations between VCI/TCI and SPIs are not similar.

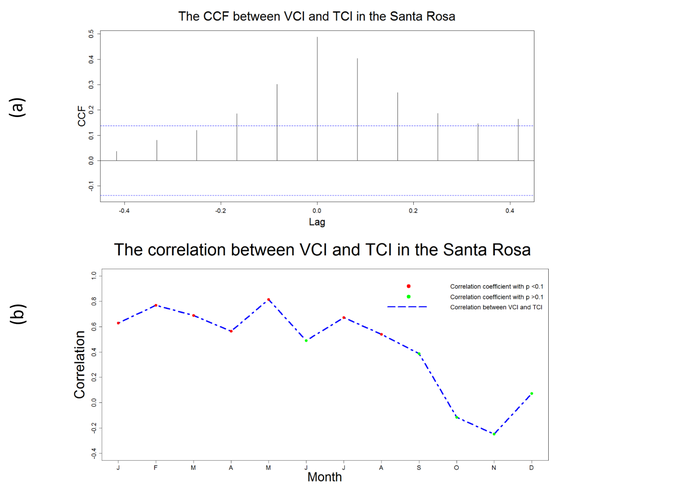

Figure 8.(a). The CCF between monthly VCI and TCI in SRNP
(b). The correlation between monthly VCI and TCI in SRNP

There are no lags between time series of VCI and TCI for TDFs; VCI and TCI are highly correlated during dry seasons and lowly correlated during wet seasons.

Conclusions

During dry seasons, VCIs and TCIs correlated significantly due to similar response of meteorological drought in the TDFs regions.

During the transition periods and early wet seasons, VCIs and TCIs have relative week correlations because VCIs are more resistant to lacking water, and TCIs are more sensitive to precipitation after long-time water deficit in the TDFs regions.

Meteorological drought is not main factor affecting either VCI or TCI in the late wet seasons(September to November) due to saturation in the TDFs regions.

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