DROUGHT EVOLUTION IN NORTH AMERICAN RIVER BASINS: ATTRIBUTION ANALYSIS THROUGH A LAGRANGIAN APPROACH

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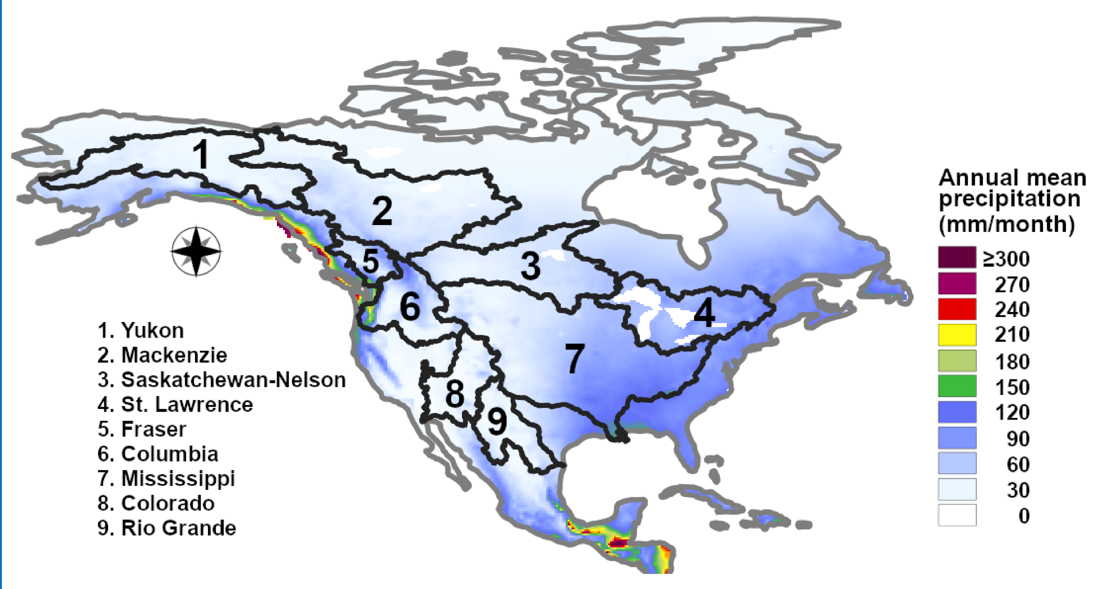
1. INTRODUCTION

Drought events have become more frequent and severe across North America, threatening water availability in watersheds and thus ecosystem and socio-economic development. Therefore, in this study we investigate the occurrence, evolution and attribution of drought conditions in nine major river basins of North America over the period 1980-2018. The assessment of drought conditions through the Standardised Precipitation Index (SPI) at a time scale of 1 and 3 months revealed the number of drought episodes that affected each river basin. A direct relationship was also found between the severity of drought events and the respective severity calculated in the oceanic and terrestrial SPI series for most of the basins. This highlights the influence of oceanic origin SPI severity for most of the North American basins, confirming the attribution of drought due to a deficit in moisture transport from the ocean.

1.1. STUDY AREA



2. DATA AND METHODOLOGY

2.1 Data

- Precipitation data from MSWEP (P_{MSWEP}). Period: 1980-2018.
- Oceanic (PLO) and terrestrial (PLT) origin precipitation [1].

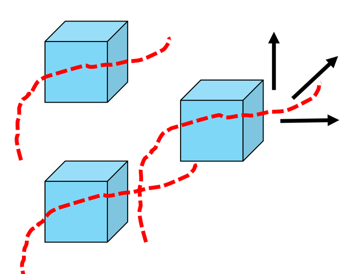
2.2 Methodology

- Standardized Precipitation Index (SPI).
- Standardized Precipitation-Evapotranspiration Index (SPEI). Both for 1 and 3 temporal scales.
- Copula Analysis (Regarding the pair (SPIMSWEP, SPIPLO, PLT), the selected copula model C with estimated parameter is used to estimate the desired probabilities for each threshold (thres) as follows:

$$P(SPI_{MSWEP} < thres \text{ I } SPI_{PLO} < thres) = \frac{C(F(thres), G(thres) \text{ I } \theta)}{G(thres)}$$

FLEXPART v9.0 model [2] + Meteorological reanalysis data from ERA-Interim Project. Period 1980-2018,

Backward analysis: For each tracked parcel (~2 million, with the same mass *m*) are calculated changes of Specific humidity (*q*) through differences of evaporation (*e*) and precipitation (*p*) every 6 hours.



$$e - p = m\frac{dq}{dt}$$

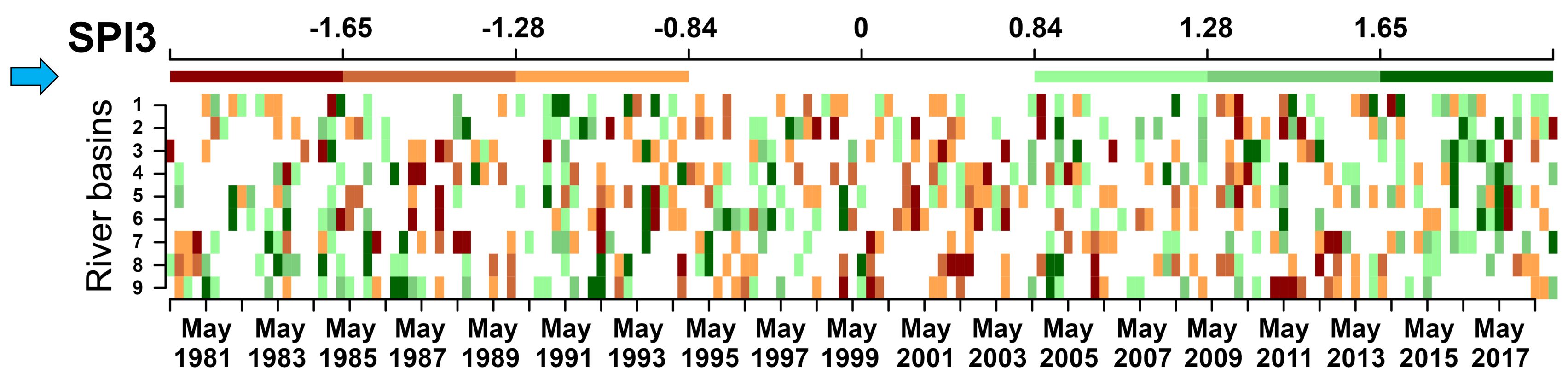
Calculating for all parcel residing in the atmospheric column over a target area, we obtain (E-P). Integration in 't optimum' days.

$$E - P \approx \frac{\sum_{k=1}^{K}(e-p)}{A}$$

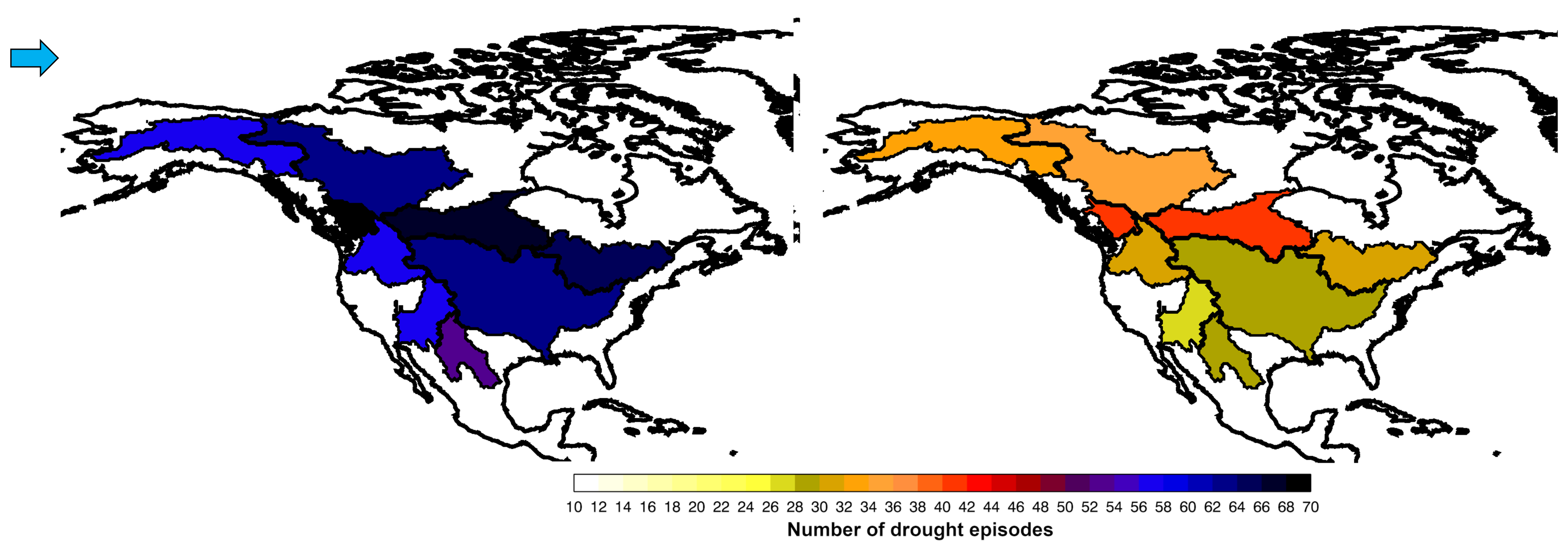
E → evaporation P → precipitation
K → No parcels
PLO → precipitation of oceanic origin
PLT → precipitation of terrestrial origin

3. RESULTS

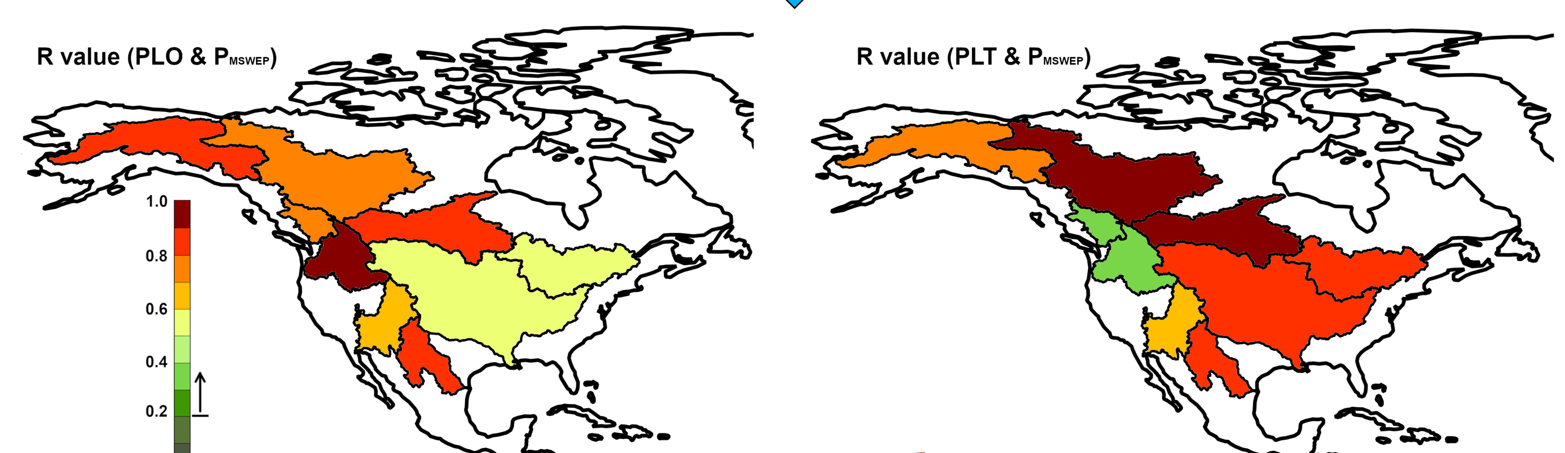
Drought analysis: In this figure we show the temporal evolution of dry and wet conditions that affected each of the NA river basins according to the SPI3. Highlights the period from 1999 to 2003. However, it does not provide an overview of the most affected basins. Therefore, a frequency analysis was carried out.



The identification of drought episodes showed a higher number on the 1-month temporal scale of the SPIMSWEP for all basins compared to those obtained on the 3-month temporal scale. This is because variability decreases as the time scale increases.

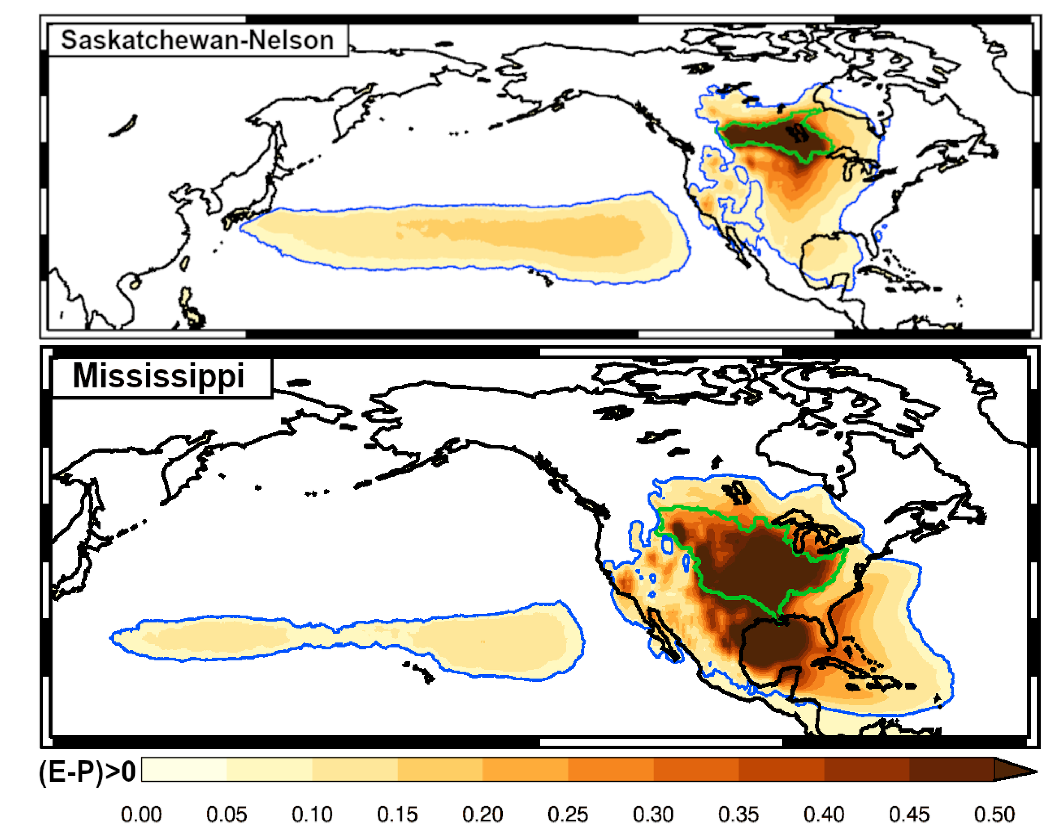


Moisture transport analysis: More than 50% is of oceanic origin in catchments 1, 5, 6, 7. In basin 8 the amount of precipitation of terrestrial and oceanic origin is similar. Higher correlations with PLO (PLT) were obtained for the western (eastern) basins Conversely, the lowest correlations between P_{MSWEP} and PLO were obtained for the Mississippi and St. Lawrence River basins, although, these were statistically significant.

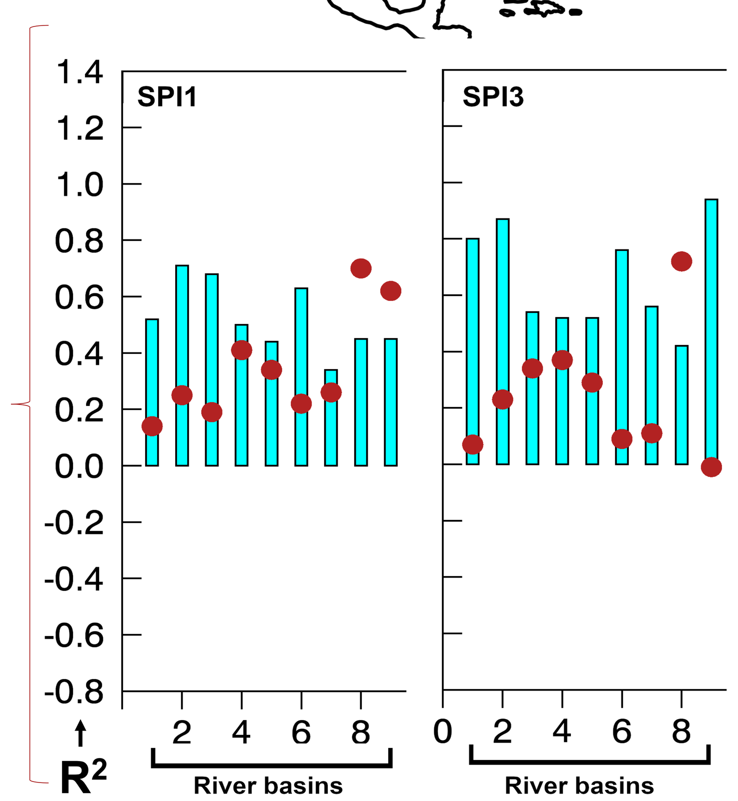


The analysis backwards in time with FLEXPART made it possible to investigate the **most important oceanic and terrestrial moisture sources.**

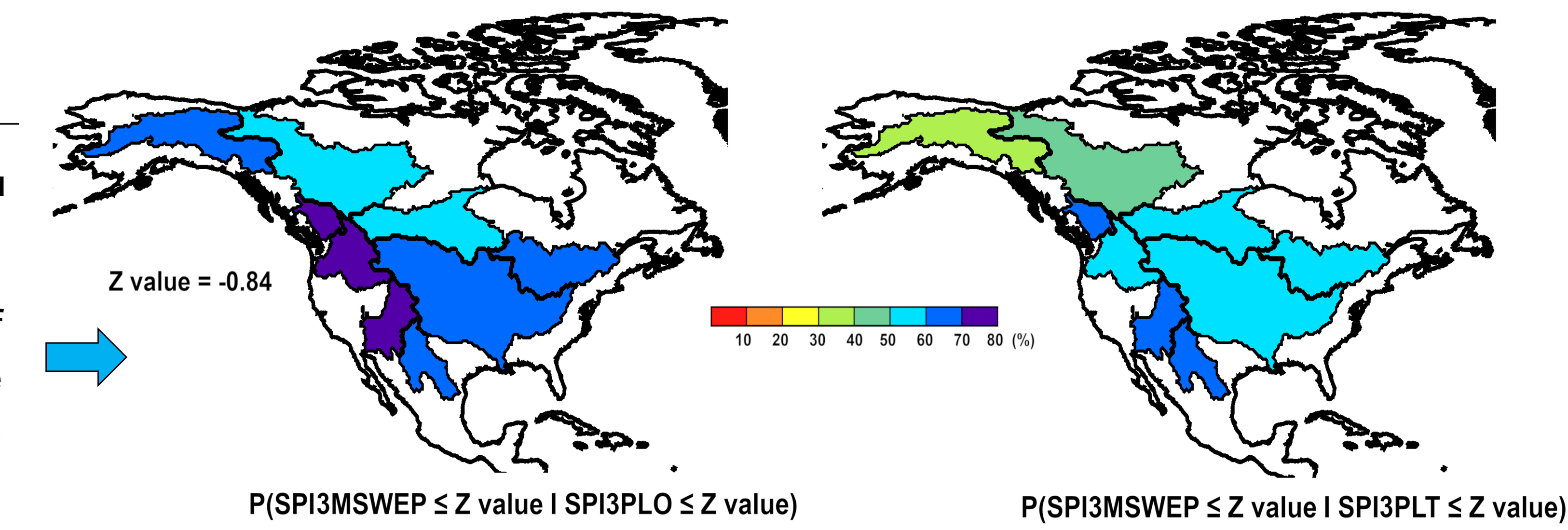
In this case we show those for the Mississippi and Saskatchewan and Nelson.



Drought and moisture transport: A multiple regression analysis was performed between the severity of each drought episode at 1 and 3 months of the SPIMSWEP for every basin, and the corresponding severity was calculated using the SPI1-3PLT and SPI1-3PLO series. The sizes of the coefficients in the equation are represented as light blue bars for SPI1-3PLO and as brown filled circles for the SPI1-3PL. Both components, but particularly the oceanic, have a positive effect on the estimation of the severity of drought episodes.



The copula analysis revealed major conditional probabilities of drought of oceanic origin in most of the basins of North America, particularly in those located in the west. For these basins the moisture transported from the North Pacific Ocean is crucial.



4. CONCLUSIONS

In this study we initially investigated the temporal evolution of dry conditions in the major North American watersheds, as well as the occurrence of drought events. The results show that the basins located further north have experienced more affected by dry conditions in the study period. In a second analysis, the oceanic and terrestrial origin of precipitation over the basins was determined, revealing the coherence of the percentages obtained with the role of regional moisture transport mechanisms. The usefulness of using both precipitation components to attribute drought occurrence and severity in North American watersheds was also demonstrated.

REFERENCES

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