A global analysis of the asymmetric effect of ENSO on extreme precipitation

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1 Introduction

The global and regional influence of the El Niño Southern Oscillation (ENSO) phenomenon on the design-relevant extreme precipitation (e.g. the 1 in 10 year event) was analyzed using a global database comprising over 7000 high quality observation sites.

The key findings are:

1.Regions found to be influenced by ENSO include parts of North and South America, southern and eastern Asia, South Africa, Australia and Europe.

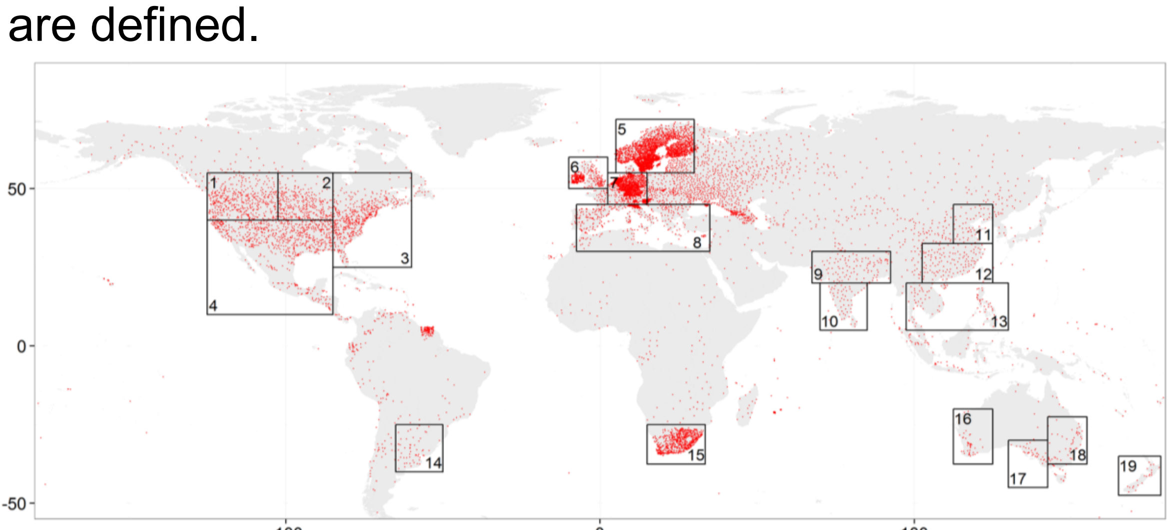
2.The season experiencing the greatest ENSO effect varies regionally, but in most of the ENSO-affected regions the strongest effect happens in boreal winter.

3.The 1 in 10 year precipitation during a strong El Niño/La Niña episode can be 50% higher or lower than that during a neutral phase.

4.The effect of ENSO on extreme precipitation is asymmetric, with most parts of the world experiencing a significant effect only for a single ENSO phase.

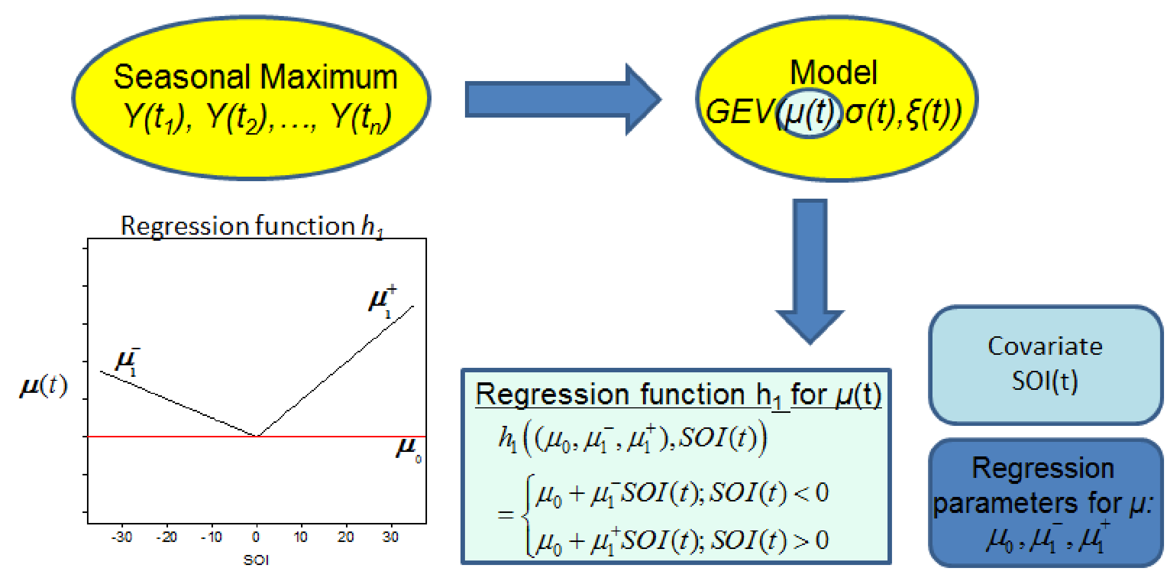
2 Data

The Hadley Center Global Climate Extremes Index 2 (HadEX2) dataset (Donat et al., 2013) comprises the monthly maxima of daily precipitation from 11,588 high quality observation sites. The 7037 sites with records longer than 40 years were used, with a median record length of 60 years. According to the spatial pattern of the ENSO effect and the availability of data, 19 areas are defined.



3 Regional models

The seasonal daily maximum precipitation is assumed to follow a time varying *GEV(μ(t),σ(t),ξ(t))* distribution, conditioned on temporally varying covariate *SOI (Southern Oscillation Index)*. The impact of ENSO is expressed through the parameters of regression functions.



Each grid with the size of 5° by 5° is considered as a 'region'. We assume that the ENSO impact for all sites in the region are the same . Regression models for *μ(s,t),σ(s,t)* and *ξ(s,t)* are shown as below:

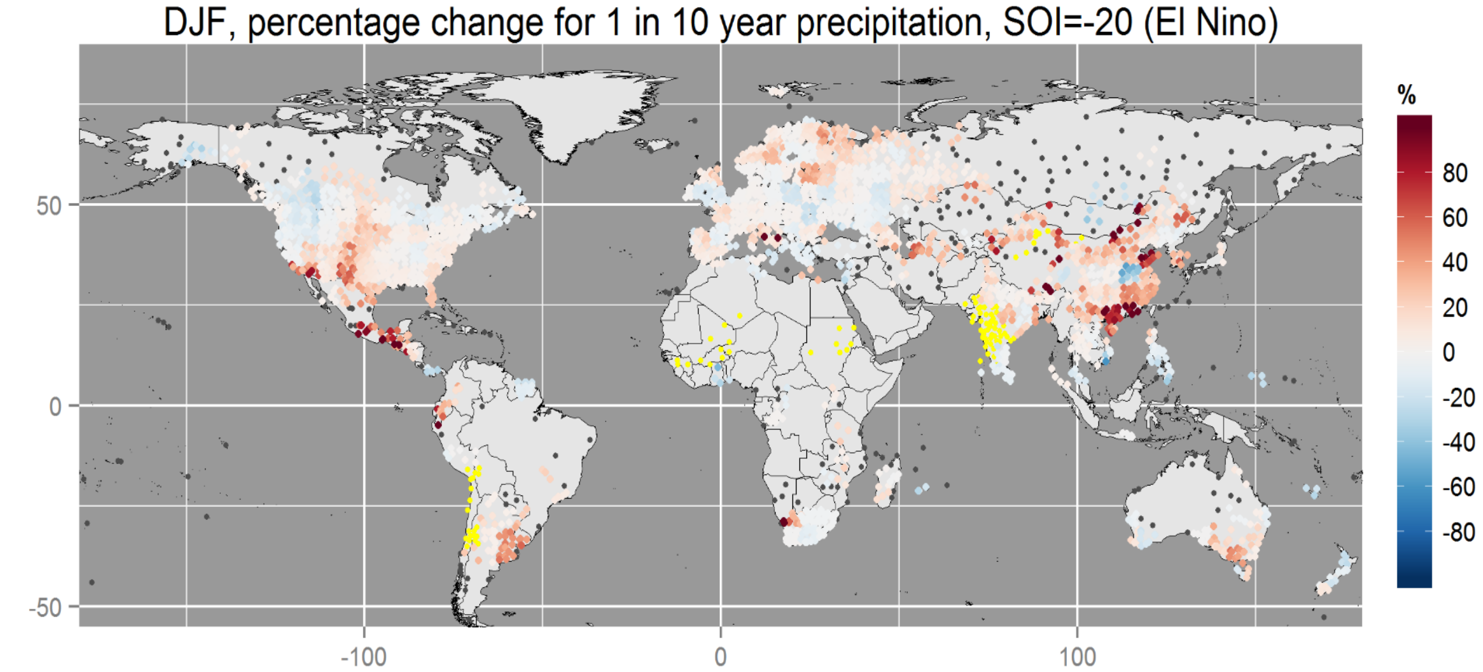
μ(s,t)	σ(s,t)	ξ(s,t)
$\begin{cases}\mu_{loc_0}^{(s)}+\mu_{reg_1}^{-} * SOI(t); SOI(t)<0\\ \mu_{loc_0}^{(s)}+\mu_{reg_1}^{+} * SOI(t); SOI(t)>0\end{cases}$	$\begin{cases}\sigma_{loc_0}^{(s)}+\sigma_{reg_1}^{-} * SOI(t); SOI(t)<0\\ \sigma_{loc_0}^{(s)}+\sigma_{reg_1}^{+} * SOI(t); SOI(t)>0\end{cases}$	ξ_{reg}

where *s* is for site and *t* is for time. The regression parameters with subscripts "*reg*" are identical for all sites, and with subscripts "*loc*" are site specific.

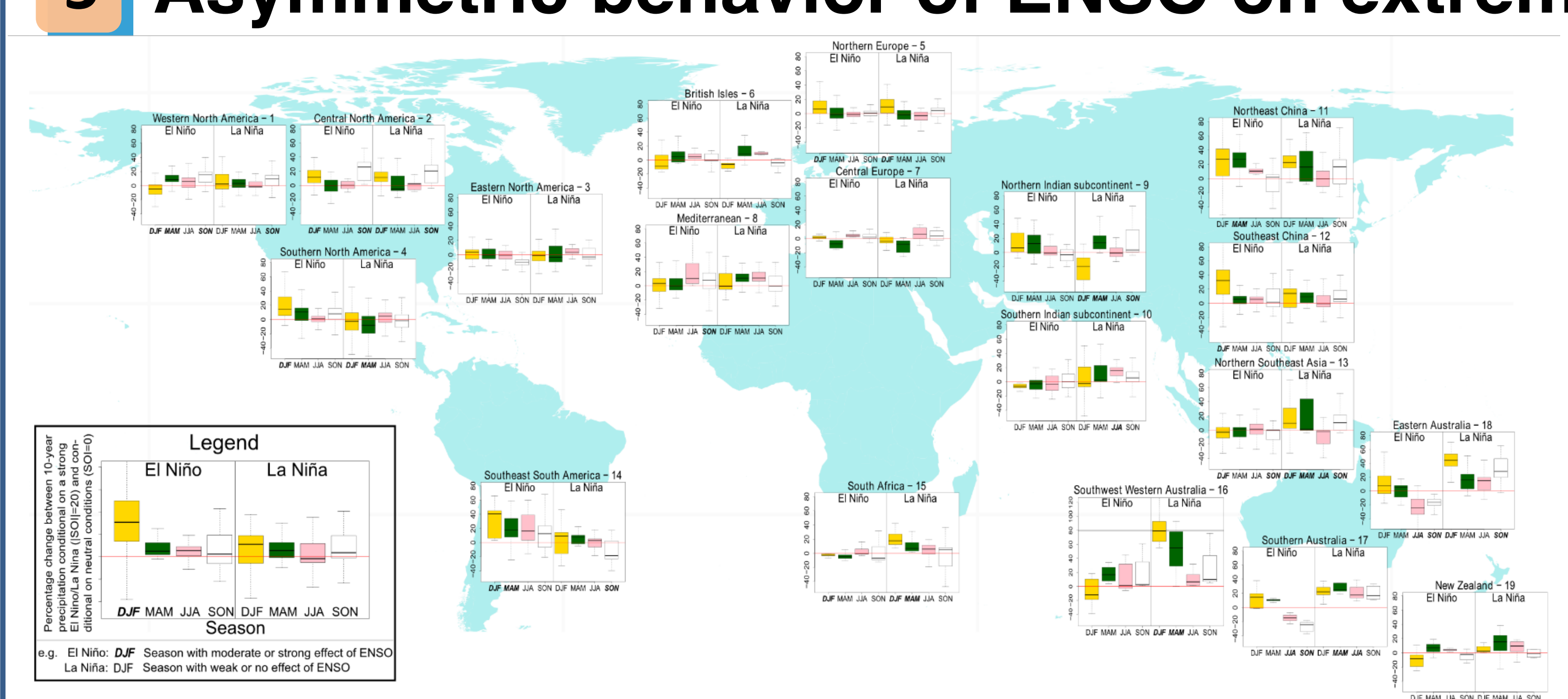
4 The effect of strong El Niño in boreal winter

Red and blue colors show the percentage change for 1 in 10 year precipitation during December-January-February between an extreme El Niño event (SOI = -20) and a neutral phase (SOI = 0). The 1 in 10 year precipitation can increase by 20% to 50% in southern North America and southeast China, about 40% in southeast South America, and 10% to 20% in central North America. A decrease of 10% can be observed in western North America and 10% to 20% in northern Southeast Asia.

DJF, percentage change for 1 in 10 year precipitation, SOI=-20 (El Nino)



5 Asymmetric behavior of ENSO on extreme precipitations



In most areas, precipitation is only affected during one phase of ENSO, which corresponds to an one-phase asymmetric behavior.
Two-phase asymmetric behavior (increasing during both strong El Niño and La Niña) is found in central and western North America, northeast China and northern Europe.
Symmetric behavior (opposite effect during El Niño and La Niña) is found in southern US during DJF, southern and eastern Australia during SON, and northern Southeast Asia during DJF and SON.

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