An analysis of ENSO impact on global extreme rainfall using a Bayesian regional model

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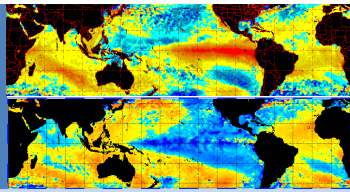


1 Introduction

El Niño Southern Oscillation (ENSO) effects on global rainfall and streamflow have been extensively reported. In this study, we apply a non-stationary regional model to ~7000 observation sites worldwide to describe the global relationship between ENSO and extreme rainfall. This research will:

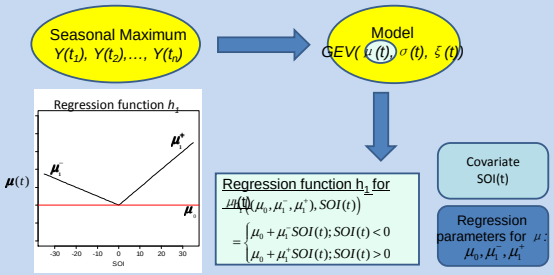
(1) Identify regions where extreme rainfall is significantly influenced by ENSO.

(2) Evaluate the extent to which ENSO exhibits asymmetric impacts between the El Niño and La Niña phases.

(3) Describe the spatial pattern of the impact intensity.

2 Non-stationary models

In each gauged station, the seasonal 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.



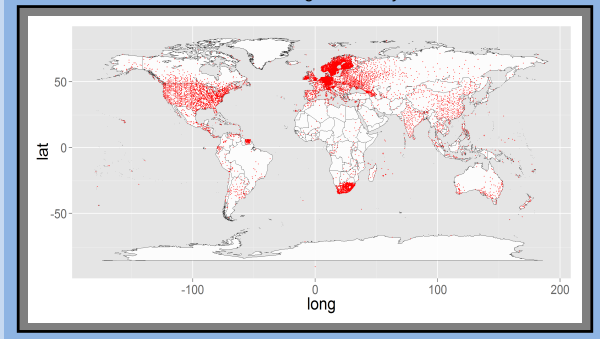
Each grid of 5 * 5 (degree*degree) is considered as a 'region'. We assume that the ENSO impact is the same for all sites in the region. Regression models for $\mu(s,t)$, $\sigma(s,t)$ and $\xi(s,t)$ are shown as below:

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 same for all sites, and with subscripts "*loc*" are site specified.

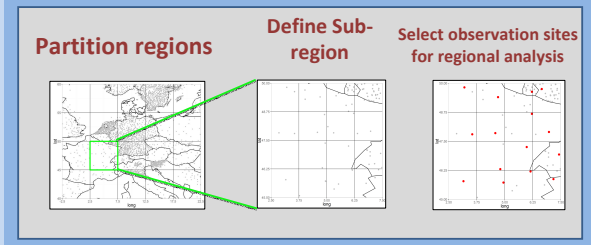
3 Data

In this new database of 11,588 high quality observation sites, data are available at monthly intervals. Our study is focused on approximately 7000 observation sites which have series longer than 40 years.



4 Regions settings

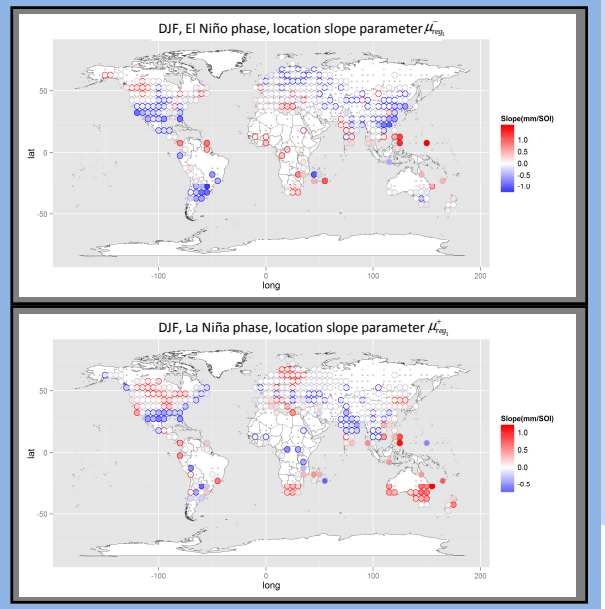
The world is gridded into 2592 regions with grid size of 5 * 5 (degree*degree). Due to computation time, in each region we select a subset of 16 observation sites, based on selecting the longest record in each of 16 equally spaced sub-regions.



In several regions, both selected sites and whole sites are used in the analysis to compare the differences. We find that there is not a significant difference between the result from the selected sites and the whole sites.

5 Results

The impact of ENSO is illustrated though slope parameters: $\mu_{reg_1}^-, \sigma_{reg_1}^-$ for El Niño phase and $\mu_{reg_1}^+, \sigma_{reg_1}^+$ for La Niña phase. The following figures show the intensity and the significance of the ENSO effect on location slope parameters for the maximum precipitation of December, January and February.



Red (blue) circle means the slope parameter $(\mu_{reg_1}^-, \mu_{reg_1}^+)$ is significantly positive (negative). Thus during El Niño phase, blue means stronger El Niño, stronger precipitation; red means stronger El Niño, less precipitation. During La Niña phase, red means stronger La Niña, stronger precipitation; blue means stronger La Niña , less precipitation. Grey circle means not significant. Color inside the circle shows the average of the slope parameter at that region. Grey dot means insufficient data.

6 Conclusions

In the season of Dec, Jan and Feb, El Niño increases the intensity of extreme precipitation in South U.S., Mexico, South part of the South America and Southeast Coast of China. And El Niño also decreases the intensity of extreme precipitation in Africa and west coast of India.

During La Niña phase, the intensity is increased in the Northern part of North America, South Africa and Australia. And in the southern part of North America and India, the intensity is decreased.

In North Europe, during both El Niño and La Niña phases, a significant increase is found. However, the value of the slope is relatively small.

From this study, the asymmetric impact of ENSO is clearly outlined.

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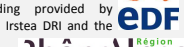

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