NON STATIONARY POT MODEL FOR EXTREME TEMPERATURE AND PRECIPITATION ANALYSIS IN BURKINA FASO

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MIA-Paris/LANIBIO

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Extreme Climate Events, Climate Change

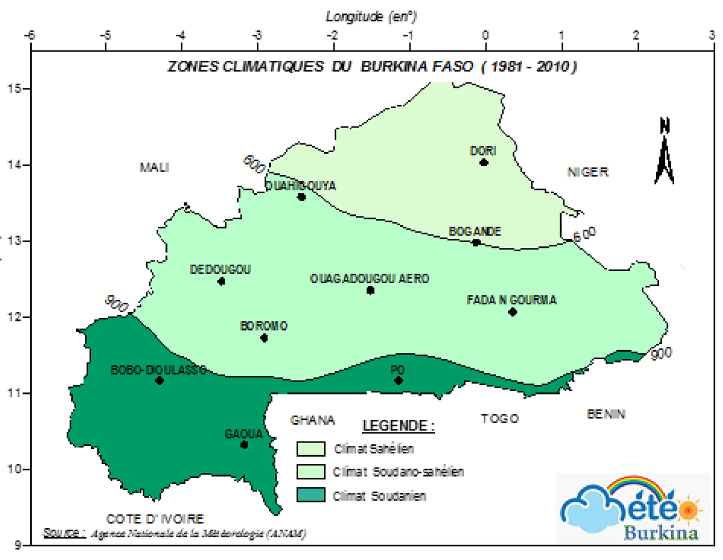
Objectives

- detect trends of extreme weather, in a non-stationary context;
- calculate the extreme quantiles, from the extrapolation of identified trends;
- study the spatial dependence structures of extremes of temperature and precipitation.

Ouaga, 2009

Datasets

Stations

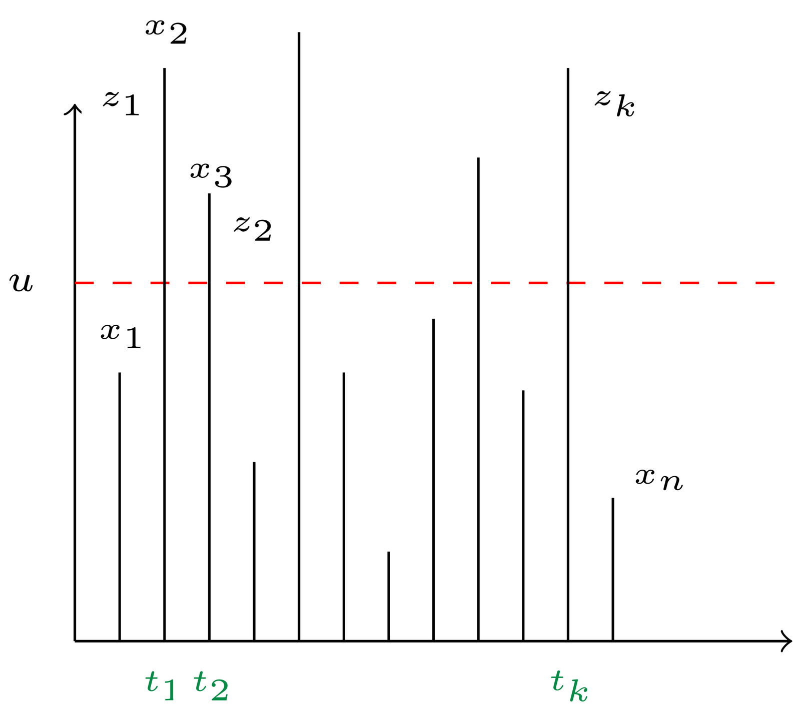


Series

- Spatial uniformity, representativeness of the different climatic regimes;
- the quality of the data;
- Hot days: from March 15th to June 15th (temperatures);
- Rainy days: from June to October (precipitation).

Methodology ([1], [2], [3])

Stationary POT



- the law of excesses is given by:

$$S-GP(z \mid \sigma_u, \xi_u) = 1 - \left(1 + \xi_u \frac{z}{\sigma_u}\right)_+^{-\frac{1}{\xi_u}}.$$

- The law of occurrences is given by :

$$P\left(N\left[t_2 - t_1\right] = k\right) = \frac{\left[\lambda\left(t_2 - t_1\right)\right]^k}{k!} e^{\left[-\lambda\left(t_2 - t_1\right)\right]}.$$

Non-stationary POT

- In this new statistical framework $Z \sim NS-GP\left(\sigma_u(s,t), \xi_u(s,t)\right)$ whose distribution given by:

$$\text{NS-GP(z)=}\begin{cases} 1\text{-}\left(1+\xi_u(s,t)\dfrac{z}{\sigma_u(s,t)}\right)^{-\frac{1}{\xi_u(s,t)}}, & \xi_u(s,t) \neq 0 \\ 1\text{-exp}\left(-\dfrac{z}{\sigma_u(s,t)}\right), & \xi_u(s,t) = 0 \end{cases}$$

- In this case, for $B = [t_1, t_2]$, the law of occurrences of the excesses

$$P\left(N\left[B\right] = k\right) = \exp\left(-\Lambda(B)\right)\frac{\Lambda(B)^k}{k!}, \qquad \Lambda(B) = \int_{t_1}^{t_2} \lambda(s,t)ds,$$

- the non-stationary Return Level (RL) z_m, is solution of the equation:

$$\sum_{t=t_0}^{t_0+mn_z}\left(1 + \frac{\xi}{\sigma_u(s,t)}\left(z_m(s) - u\right)\right)^{-\frac{1}{\xi}} \lambda(s,t) = 1.$$

Likelihood, Ratio Test

$$\begin{cases} \sigma_u(s,t) = & \exp\left(\sigma_0 + \sigma_1 t + \sigma_2 t^2\right) \\ \lambda(s,t) = & \alpha_0 + \alpha_1 t + \alpha_2 t^2 \\ \xi_u(t) = & \xi_0 \end{cases}, s \in \mathcal{S} \subset \mathbb{R}^2.$$

- Estimation of the parameters of $\lambda(s,t)$:

$$\ell\left(\mathbf{t} \mid \Theta\right) = -An_z\left(\alpha_0 + \frac{1}{2}\alpha_1 A n_z + \frac{1}{3}\alpha_2 A^2 n_z^2\right) + \sum_{i=1}^{k}\log\left(\alpha_0 + \alpha_1 t_i + \alpha_2 t_i^2\right)$$

- Estimation of the parameters of $\sigma_u(s,t)$:

$$\ell\left(\mathbf{z} \mid \Theta\right) = \begin{cases} \sum_{i=1}^{k}\left(\sigma_0 + \sigma_1 t_i\right) - \left(1 + \frac{1}{\xi}\right)\sum_{i=1}^{k} \log\left(1 + \xi_0 z_i \exp\left(-(\sigma_0 + \sigma_1 t_i)\right)\right), & \xi_u \neq 0. \\ -\sum_{i=1}^{k}\left(\sigma_0 + \sigma_1 t_i\right) - \sum_{i=1}^{k} z_i \exp\left(-(\sigma_0 + \sigma_1 t_i)\right), & \xi = 0 \end{cases}$$

- Likelihood ratio test

Results

Trends of Extremes

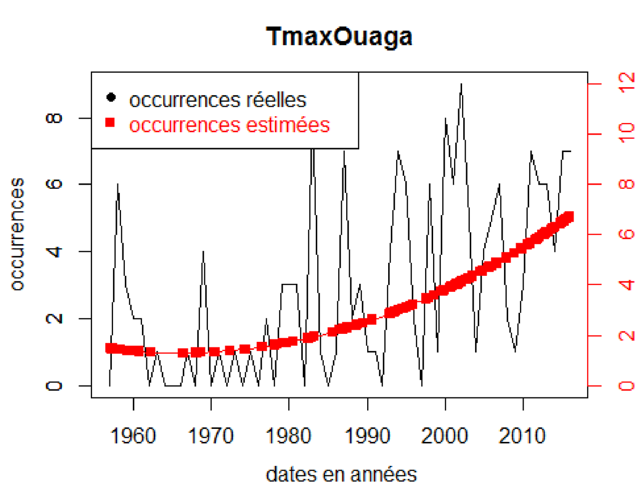
Likelihood Ratio Test Results

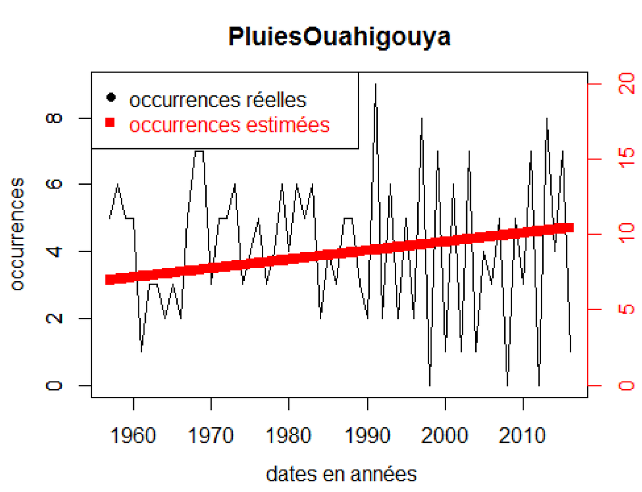
		Oua	Dor	Ohg	Déd	Bog
Tmin	σ	1	0	0	0	0
	λ	2	2	1	1	2
Tmax	σ	1	1	0	1	0
	λ	2	1	0	2	0
Pluies	σ	0	0	0	0	0
	λ	0	0	1	0	0

		Fad	Bob	Bor	Pô	Gaou
Tmin	σ	1	0	1	0	1
	λ	2	1	1	0	2
Tmax	σ	0	1	0	0	0
	λ	2	2	2	0	1
Pluies	σ	0	0	0	0	0
	λ	0	0	0	1	0

- An upward trend in extreme temperatures (Tmin and Tmax);
- The scale parameter remains constant in more than half of the stations;
- we have not detect a trend for extreme precipitation.

Some graphs

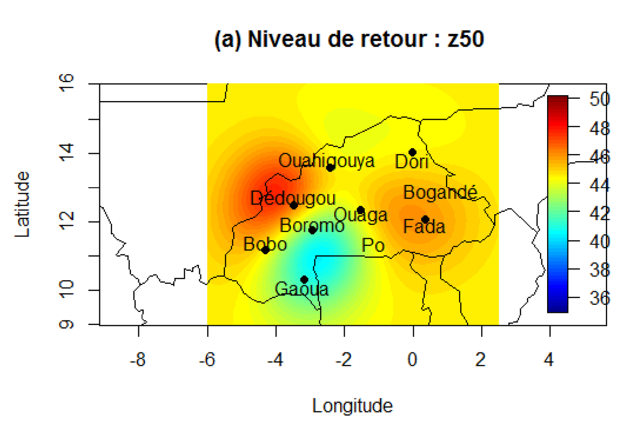




50RL[95% CI] .

Stations	Tmin	Tmax	Precipitation
Oua	31.8 [30.8, 33.8]	44.4 [43.1, 48.2]	275.2 [179.3, 477.6]
Dor	35.1 [34.1, 36.9]	46.2 [45.6, 46.7]	158.1 [135.1, 283.5]
Ohg	35.3 [33.5, 37.7]	45.8 [45.0, 46.8]	219.4 [149.6, 326.3]
Déd	35.5 [35.2, 38.0]	44.4 [43.5, 45.7]	172.2 [139, 328.6]
Bog	33.7 [32.4, 36.5]	39.9 [39.4, 40.6]	220.2 [154.7, 377.3]
Fad	31.0 [30.1, 31.9]	44.7 [44.0, 46.0]	200.9 [151.3, 437.2]
Bob	30.1 [29.4, 30.5]	41.1 [40.6, 41.4]	196.5 [149.4, 500]
Bor	33.3 [31.9, 35.4]	44.4 [43.8, 45.8]	224.5 [152.4, 377.2]
Pô	30.8 [30.1, 31.8]	44.4 [43.0, 47.9]	231.9 [156.7, 384.5]
Gao	29.8 [28.7, 31.3]	42.1 [41.7, 42.5]	249.6 [164.3, 418.7]

Spatial structure of RL50



- A slight spatial structure for extreme temperatures.
- for precipitation, no spatial structure could be exhibited on these estimates.

Conclusion and perspectives

- This study has described recent changes in temperature and extreme precipitation in Burkina Faso in a non-stationary setting;
- Over the period 1957-2016, the intensity of occurrences of extreme temperatures shows a slight (polynomial) upward trend with a slight spatial structure;
- No trend has been detected for extreme precipitation nor spatial structure;
- In perspective, we plan to better integrate the spatial aspect using the ℓ-Pareto processes (Ferreira and de Haan (2014) Dombry and Ribatet (2015)).

References

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