STOCHASTIC MODELING OF THE EXTREME MINIMUM AIR TEMPERATURE SERIES OF CAMPINAS, STATE OF SÃO PAULO, BRAZIL: A NON-STATIONARY APPROACH

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INTRODUCTION

Parametric distributions, such as the general extreme value distribution (GEV), have been used to assess the probability of occurrence of extreme minimum air temperature values (Tminabs) that may cause death of plant tissues.

The GEV is a three parameter function in which the probability of occurrence of an extreme event, observed in any time (t), can be described as $Pr\{X \leq z_t\}=GEV(z_t; \mu, \sigma, \xi)$; where μ, σ, ξ are, respectively, the parameters of location, scale and, shape.

Since the parameters of this distribution are time-independent, the use of the $GEV(\mu, \sigma, \xi)$ model is frequently called "the stationary approach".

HOWEVER...

According to COLES (2001), PUJOL et al. (2007), FELICI et al. (2007) and, FURIÓ & MENEU (2010), if a significant trend is detected in a meteorological data sample (composed by extreme values), the assumption that the probabilistic structure of this series does not change over the time may no longer be supported.

Consequently, under non-stationary climate conditions, the use of a stationary GEV model may underestimate or overestimate the probability of occurrence associated with an extreme (agro)meteorological event, such as frosts.

IN ADDITION...

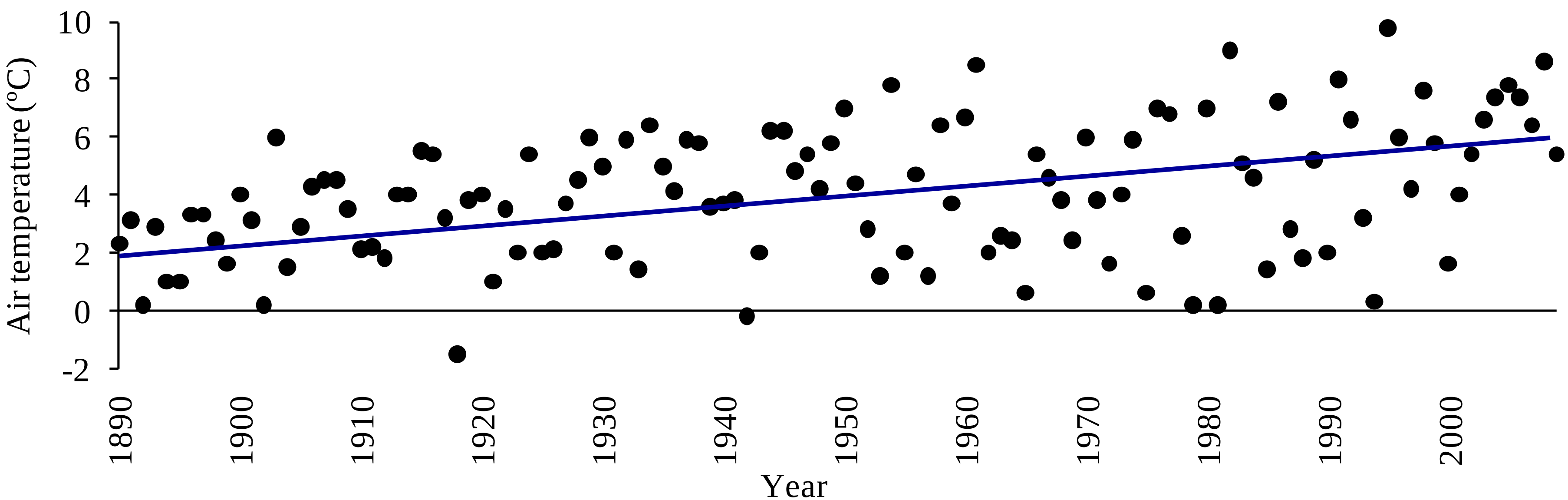

Figure 1. Annual extreme minimum air temperature series. Weather station of Campinas, State of São Paulo, Brazil.

The use of a GEV model, in which the presence of climate trends is neglected, may no longer be valid (in the location of Campinas).

Thus…It seems that we need to develop a non-stationary model!

The non-stationary model

As described in Coles (2001), El Adlouni et al., (2007), Méndez et al., 2007; Pujol et al. (2007) and, Furió and Meneu (2010), a non-stationary GEV model may be described by the following probability density function:

$$f(x)=\frac{1}{\sigma_t}\left[1+\frac{\xi_t\left(x-\mu_t\right)}{\sigma_t}\right]^{-1-\frac{1}{\xi}}\exp\left\{-\left[1+\frac{\xi_t\left(x-\mu_t\right)}{\sigma_t}\right]^{-\frac{1}{\xi_t}}\right\}$$

Under the framework of this equation, we have proposed four GEV models with increasing numbers of parameters to be estimated.

Model 1: GEV($\mu_t=\mu$, $\sigma_t=\sigma$, $\xi_t=\xi$) – The stationary model. The parameters are constant.

Model 2: GEV($\mu_t=\mu_o+\beta t$, $\sigma_t=\sigma$, $\xi_t=\xi$) - The homoscedastic model

Model 3: GEV($\mu_t=\mu'_o+\beta' t$, $\sigma_t=\exp(\sigma_o+\alpha t)$, $\xi_t=\xi$) (The adopted one)

Model 4: GEV($\mu_t=\mu''_o+\beta'' t$, $\sigma'_t=\exp(\sigma'_o+\alpha' t)$, $\xi_t=\xi_o+\delta t$)

The small displacement of the Cartesian points in both percentil-percentil and quantil-quantil plots supports our decision in using **model 3** to represent the probabilistic structure of the Tminabs dataset.

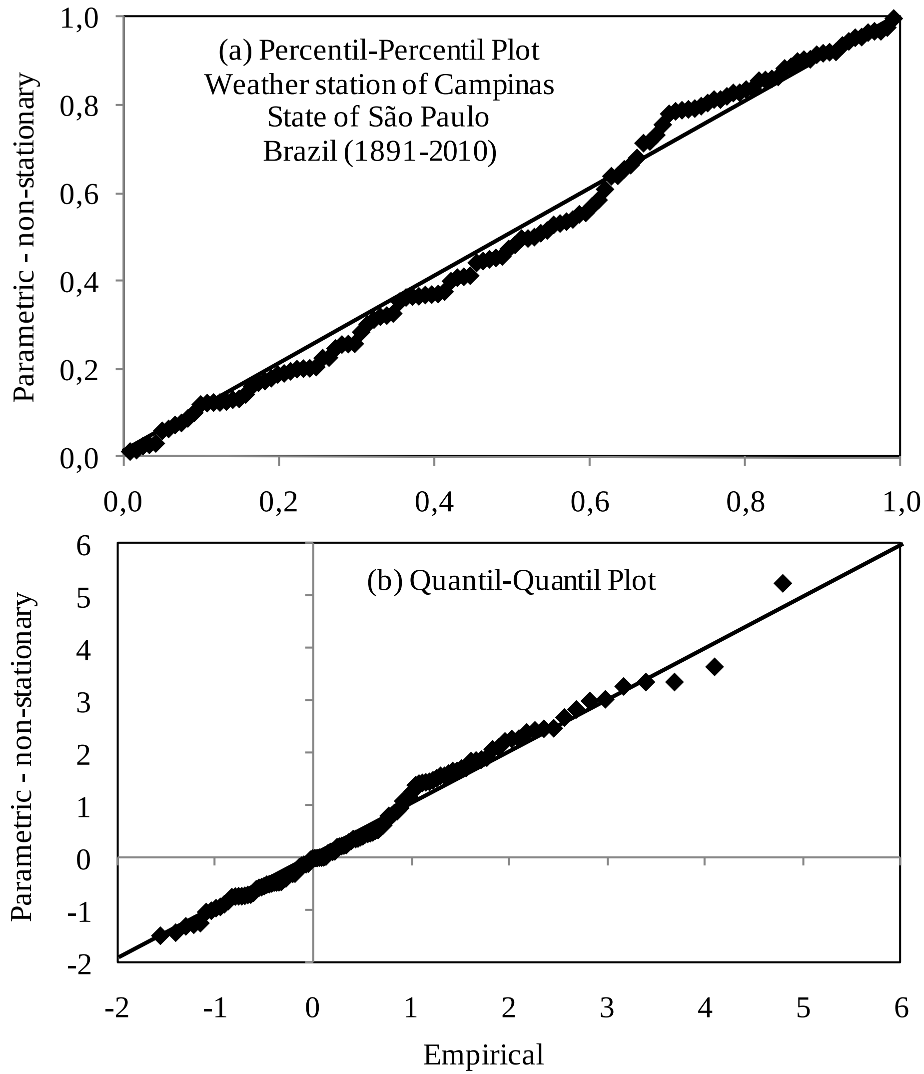

Figure 2. Supporting the use of the non-stationary model GEV(x_t; μ_t, σ_t, ξ_t) [μ_t=3.095 + 0.0301t, σ_t= exp(0.316 + 0.0053t), ξ_t= -0.177; t→year]. Percentil-Percentil (a) and Quantil-Quantil (b) plots applied to annual extreme minimum air temperature series.

CONCLUSIONS

1. A non-stationary GEV model in which the parameters of location and scale are expressed as time-dependent functions is recommended to describe the probabilistic structure of the annual extreme minimum air temperature series available from the weather station of Campinas, State of São Paulo, Brazil. In addition, since two of the three parameters of this probabilistic model are significantly conditioned on time, the presence of climate trends in the analyzed time series becomes evident.

2. Although this non-stationary model has indicated an average increase in the values of the analyzed data (represented by the time variability of μ), it does not allow us to conclude that the region of Campinas is now free from frost occurrence. The increasing temporal trend in the scale parameter reveals an increasing trend in the dispersions of the data sample. This greater dispersion may be linked with future values of this variable that still may cause the death of plant tissues. Further studies will focus this last statement.

Scientific investigations related with maximum air temperature series are also being carried out.

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Thank you