Indicators of extreme events in the Central Andes

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1. Introduction

Different extreme climatic events have several impacts in society and the ecosystem over a short or extended period (Alexander et al., 2016; Choi et al., 2008).

The objectives of the project "Data on climate and Extreme weather for the Central AnDEs" (DECADE) was to generate an database and based on this an Atlas of Climatology and Extreme Events.We adapted some indices suggested by the joint CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection to our database.

2. Data The region of study is on the Central Andes (14º-22ºS) (Figure 1a). This region covers the southeastern part of Peru and western Bolivia.

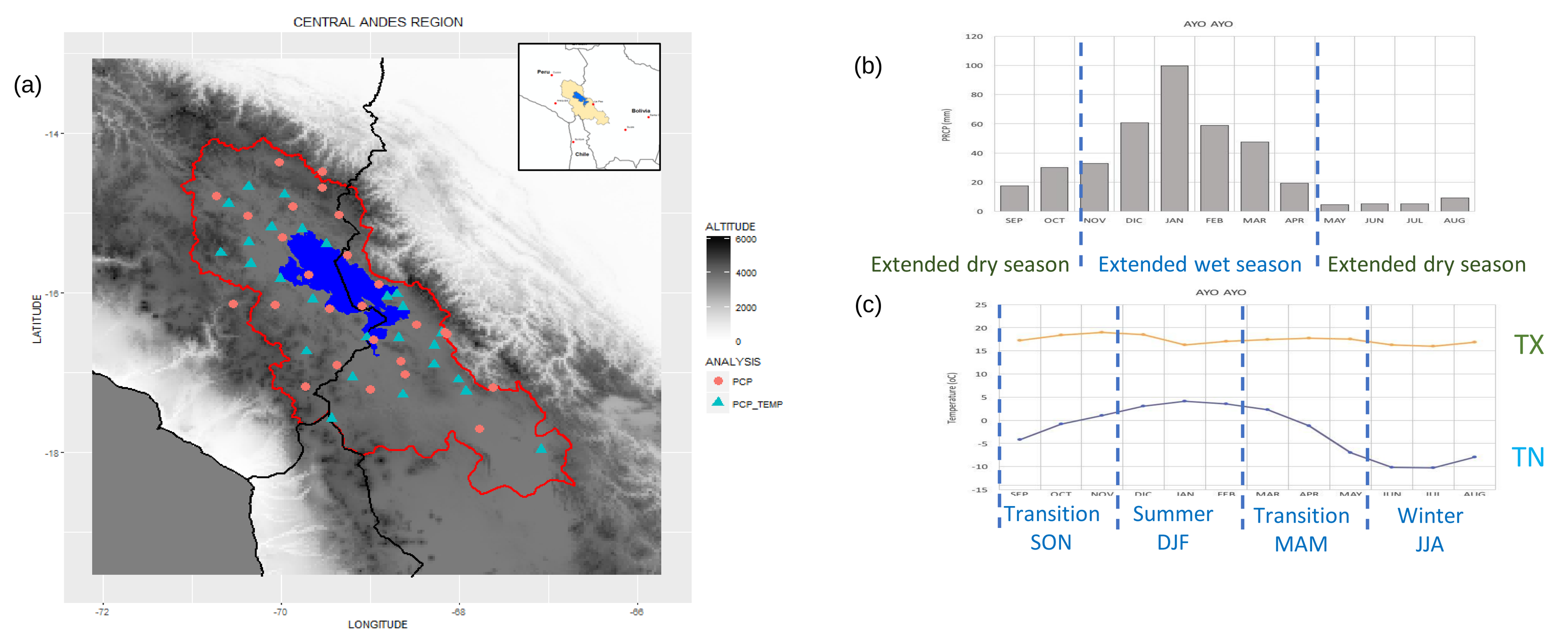

Figure 1 (a) Red line define the region of interest for our analysis. Green triangles represent stations whit precipitation and temperature data and the red circles, stations with only precipitation data. (b) The extended period is seasonal for precipitation and (c) trimestral for temperature.

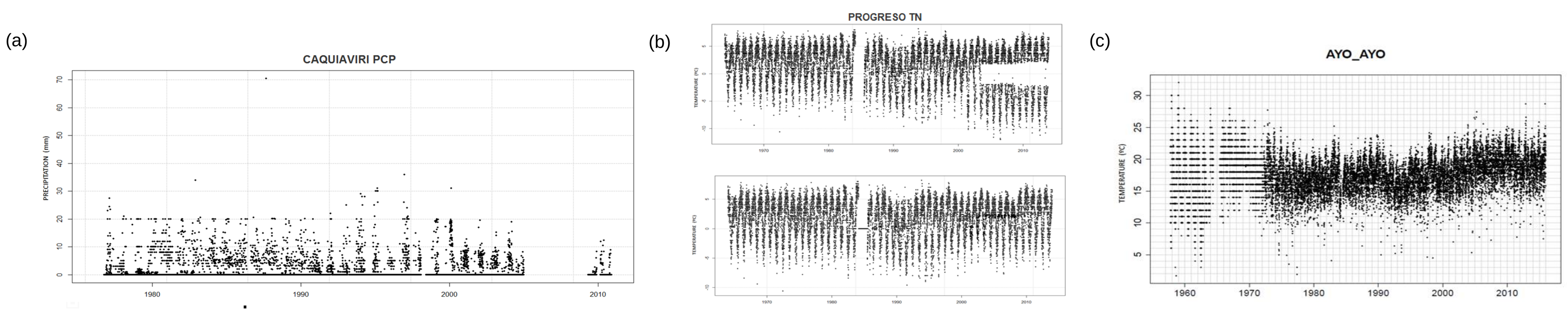

Figure 2 (a) Caquiaviri station with problem of truncation. (b) Progreso station with missing temperature data interval and (c) Ayo Ayo station with rounding data in the beginning od the period.

We used the time series data from 52 precipitation stations and 26 for minimum and maximum temperature stations and our period of study: 1981-2010. The indices were adapted existing problems in some time series (Figure 2).

3. Method

We worked with 25 indices of extreme events. Of which 11 were adapted from ETCCDI indices and 14 were developed by us (Table 1). The value we reported is the magnitude of the index as an climatology average and the value of the 95th percentile.

Table 1Description of the extreme indices

EXTREME INDICES					
CCL/CLIVAR Working Group on Climate Change Detection			DECADE		
Abbreviation	Name	Definition	Abbreviation	Name	Definition
PRECIPITATION					
Rnnmm or W	*Annual count of days*	*When PRCP≥ nnmm, nn is a user defined threshold*	NRD*	Number of rainy days	For any given season, mean number of the count of rainy days (PCP>0mm) over N years of data.
$RR_{wn}95$	---	RRwn95 be the 95[th] percentile of precipitation on wet days in the 1961-1990 period.	R95p*	Extremely rainy days	For any given season, mean number of days that exceed the 95[th] percentile of the distribution of wet days (PCP > 95p). The 95th percentile is calculated for each season (for N years).
R95pTOT	*Annual total PRCP when RR > 95*	Let RR_{wj} be the daily precipitation amount on a wet day *w (RR ≥ 1.0mm)* in period *i* and let $RR_{wn}95$ be the 95[th] percentile of precipitation on wet days in the 1961-1990 period. If *W* represents the number of wet days in the period, then:	R95pTOT*	Total precipitation for the extremely rainy days	Sum of PCP when PCP > 95p, for a given season
CWD (CDD)	*Maximum length of wet (dry) spell*	*Maximum number of consecutive days with RR ≥ 1mm (RR < 1mm)* : Let RR_{ij} be the daily precipitation amount on day *i* in period *j*.	CRD*(CDD*)	Consecutive rainy (dry) days	For any given season, mean value of the distribution of rainy (dry) days PCP>0 mm (PCP=0 mm)
---	---	---	CRD-95p (CDD-95p)	Extreme consecutive wet (dry) days	The value of the 95th percentile of the distribution of CRD (CDD). This defines the threshold for an extremely long rainy (dry) period.
---	---	---	C(R95p)*	Consecutive extremely rainy days	
MINIMUM TEMPERATURE					
FD	Number of frost days (absolute threshold)	Annual count of days when TN (daily minimum temperature) < 0°C	FD*	Number of frost days	(TN<0ºC), for any given season.
TN10p (TN90p)	Cold (warm) nights	Percentage of days when TN < 10th (TN>90th) percentile	TN10p* (TN90p*)	Number of cold (warm) nights	Mean count of the number of cold (warm) nights, TN<TN10p ((TN>TN90p) for a given season. The10th(90th) percentile is calculated for each season (for N years)
CSDI	Cold speel duration index	Annual count of days with at least 6 consecutive days when TN < 10th percentile	CCN (CWN*)	Consecutive cold (warm) nights	For any given season, mean value of the distribution of consecutive cold (warm) nights TN<TN10p (TN>TN90p). This represents the mean duration of a cold spell in the region.
---	---	---	CCN-95p (CWN-95p)	Extreme consecutive cold (warm)nights	The value of the 95[th] percentile of the distribution of CCN (CWN).
---	---	---	C(TN10p)95p [C(TN90p)95p]	Consecutive extremely cold (warm) nights	Count of consecutive days that exceed the 95[th] percentile of number of cold (warm) nights TN10p (TN90p)
MAXIMUM TEMPERATURE					
TX90p (TX10p)	Warm (cold) days	*Percentage of days when TX > 90th (TX < 10th) percentil*	TX90p* (TX10p*)	Number of warm (cold) days	Mean number of warm (cold) days TN>TN90p (TX<TX10p) for a given season. The 90th percentile is calculated for each season (for N years).
WSDI	*Warm speel duration index*	Annual count of days with at least 6 consecutive days when TX > 90[th] percentile	CWD* (CCD*)	Consecutive warm (cold) days	For any given season, mean value of the distribution of consecutive warm (cold) days TX>TX90p (TX<TX10p). This represents the mean duration of a heat wave in the region.
---	---	---	CWD-95p (CCD-95p)	Extreme consecutive warm (cold) days	The value of the 95[th] percentile of the distribution of CWD (CCD)
---	---	---	C(TX90p)95p [C(TX10p)95p]	Consecutive extremely warm (cold) days	Count of consecutive days that exceed the 95[th] percentile of number warm (cold) days TX90p (TX10p)

*DECADE indices+A10

4Results

PRECIPITATION

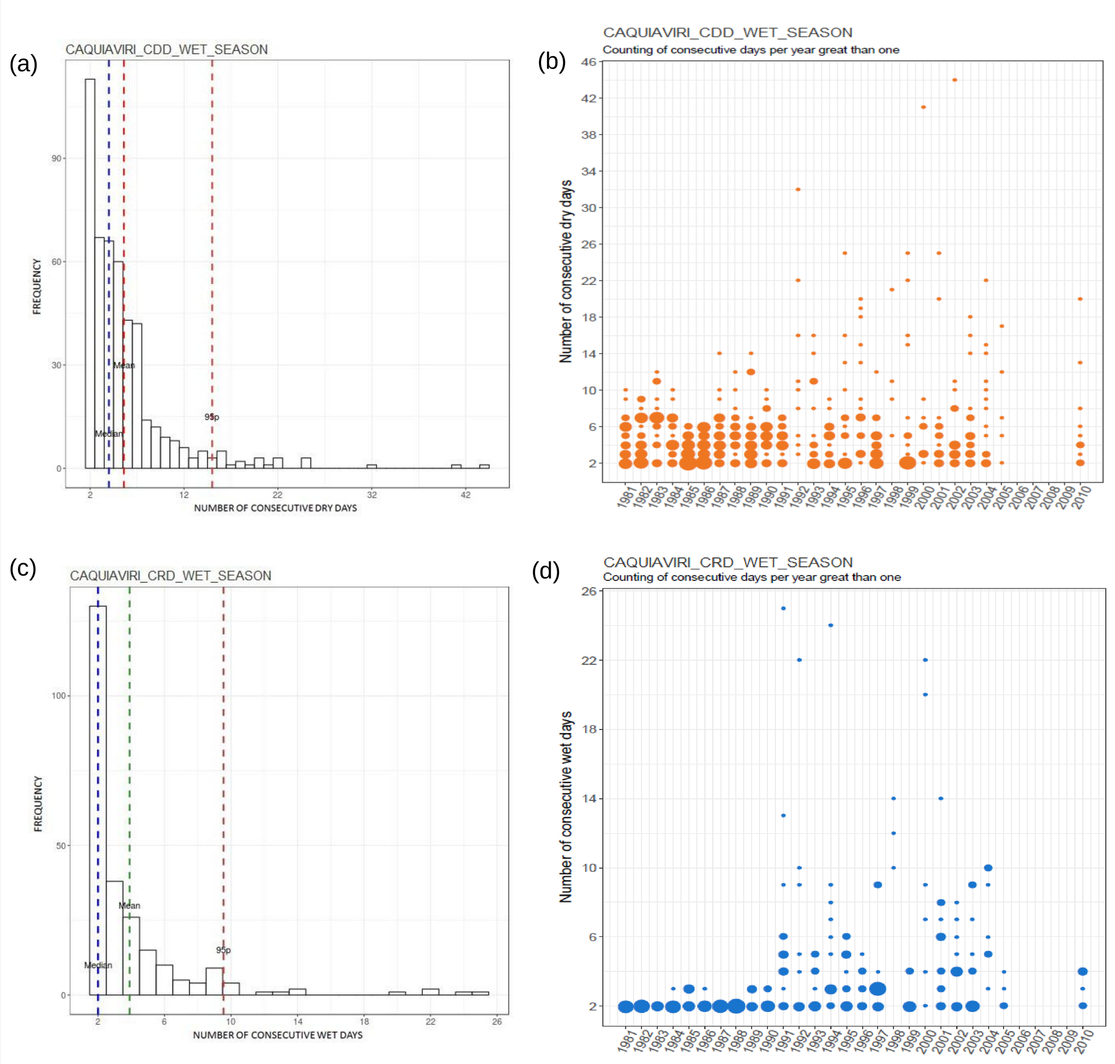

Figure 3 Caquiaviri station we can calculate: Consecutive Dry Days (CDD) and the Consecutive Rainy Days (CRD) indices on wet season NOV-APR (a),(c) are histograms, (b) and (d) are the series of consecutive days respectively.

We can calculate the absolute extreme indices even with truncation problems in precipitation (Figure 2a).

MINIMUM TEMPERATURE

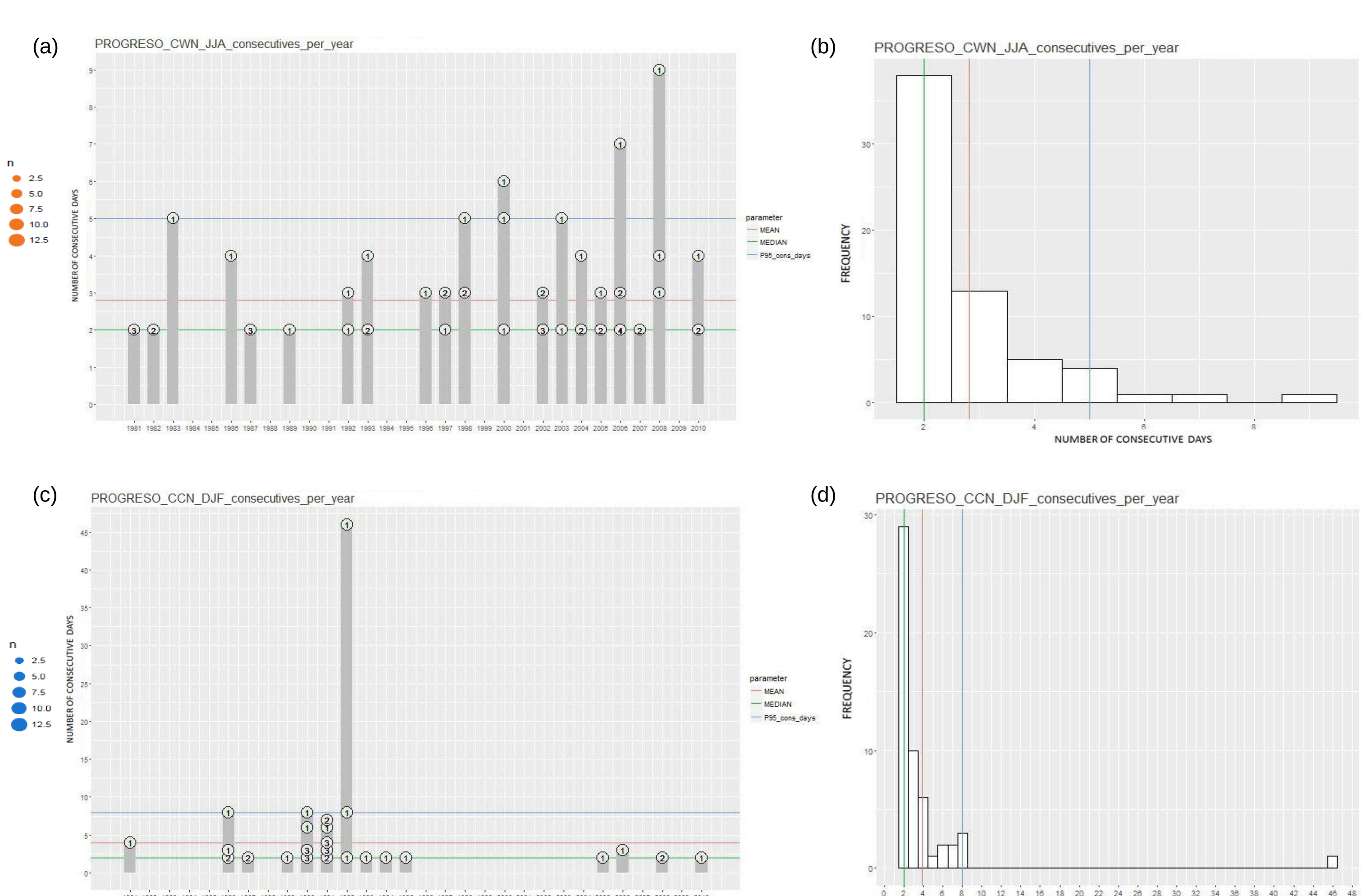

Figure 4 Progreso station, we can calculate all indices, such as Consecutive Warm Nights (CWN) in the trimester JJA and Consecutive Cold Nights (CCN) in DJF. (a) y (c) are their respective histograms, and (b) and (d) their time series of consecutives days. There are 46 consecutives cold night in 1992 on our summer.

MAXIMUM TEMPERATURE

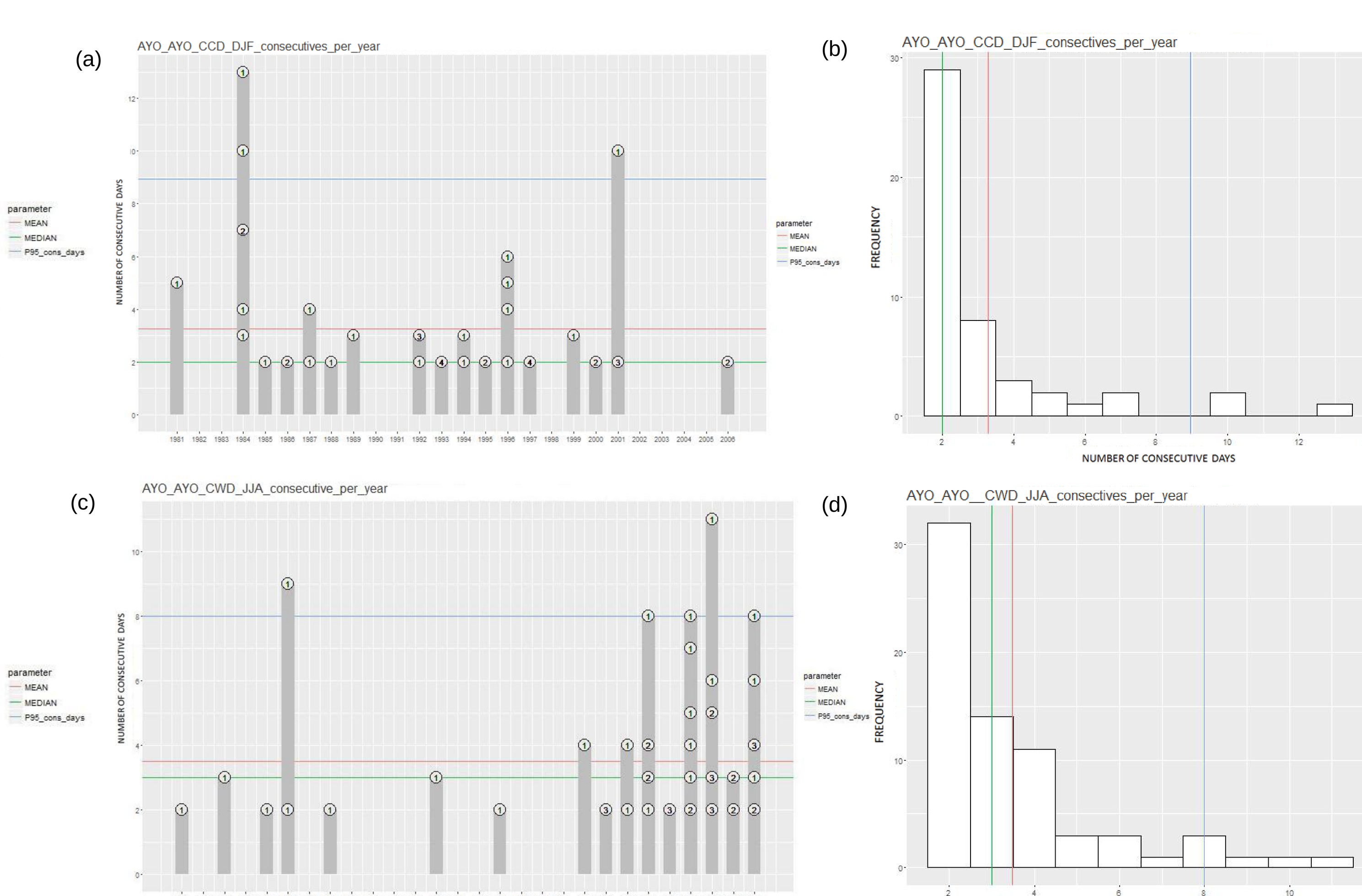

Figure 5 Ayo Ayo station, we can calculate all indices, such as Consecutive Cold Days (CCD) in the trimester DJF and Consecutive Warm Days(CWD) in JJA. (a) y (c) are their respective histograms, and (b) and (d) are their time series of consecutives days. There are 11consecutives warm days in 2008 in the trimester JJA

Those series where were identified some problems can be corrected and used in the calculation of the indices as the Progreso station. (Hunziker 2017)

5 Conclusion

We have adapted the calculation of the indices to the problems that can present some series of data. Even with problems in the series, these can be used in the calculation of some indices with absolute threshold. The magnitude of the indices as a climatological average is similar en several station in the region and the value of the 95th percentile can help us to detect problems in the series.

Reference

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