Study Project

Brandenburgische Technische Universität Cottbus - Senftenberg

Assessment of Climate Indices in the Mediterranean island Corsica

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Objective

- To observe the climate change using temporal Analysis of extreme climate indices by evaluating Trends and Variabilities.

Study Area

- Corsica - ‘Beauty island’ and ‘The mountain in the sea’.
- Mediterranean climate with hot summers and mild, sunny winters.

Table 1: Station data for the study region

Station	Longitude	Latitude	Elevation
Ajaccio	8.793	41.918	5m
Solenzara	9.401	41.922	12m

Figure 1: Study region

Study Area

- The pleasant winter and spring weather is often interrupted, however, by cold and blustery weather brought by a northerly wind called the Mistral.
- Cyclones passing over Corsica transporting moisture from the Atlantic cause precipitation events in Ajaccio.
- In contrast the eastern part of the island often experiences a rainshadow effect due to the north-south oriented terrain.

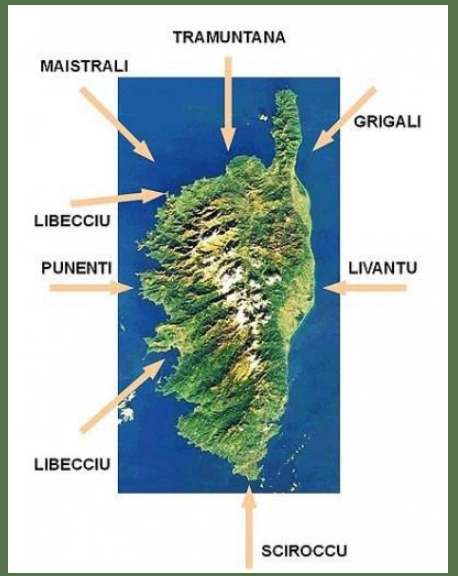

Figure 2: Types and direction of winds

Source: Mattei, F. (2016)

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Data

- Period: 1981-2018
- Format: netCDF
- Nature of data: RR, Tmax, Tmin

Methodology

- Mann-Kendall Tau test
- Linear Regression
  - Ordinary Least Squares method
  - Theil-Sen regression method
- A differenced first order auto regressive method (ARIMA)

Tools

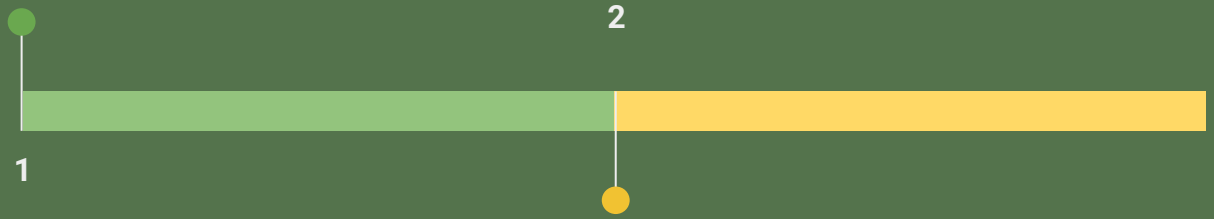
- Python (numpy, xarray, xclim, pandas, seaborn, matplotlib, statsmodels, sklearn, scipy)

- Microsoft Excel

- Tableau

Process

Selection and calculation of suitable temperature and precipitation indices



Trends and variabilities using Regression analysis and statistical techniques

Climate indices

- 8 indices:
  - 4 indices related to temperature
  - 4 indices related to precipitation
- Indices are driven from:
  - Maximum temperature
  - Minimum temperature
  - Precipitation

Table 1: Selected climate indices and their definitions for the study

Climatic parameter	Type of index	ID	Name	Definition	Units
Temperature	Percentile	tx90p	Warm days	Percentage of days when TX>90th percentile	days
	Duration	WSDI	Warm spell duration indicator	Annual count of days with at least 6 consecutive days when TX > 90th percentile	days
	Absolute	TXx	Max TXx	Monthly maximum value of daily maximum temp	°C
		TNn	Min TNn	Monthly minimum value of daily minimum temp	°C
Precipitation	Threshold	R10	Number of heavy precipitation days	Annual count of days when PRCP>=10mm	days
		R20	Number of very heavy precipitation days	Annual count of days when PRCP>=20mm	days
	Duration	CWD	Consecutive Wet Days	Maximum number of consecutive days with RR<1mm	days
		CDD	Consecutive Dry Days	Maximum number of consecutive days with RR>=1mm	days

Source: Brown, P. J(2010)

Results

Bar plots: Temperature indices

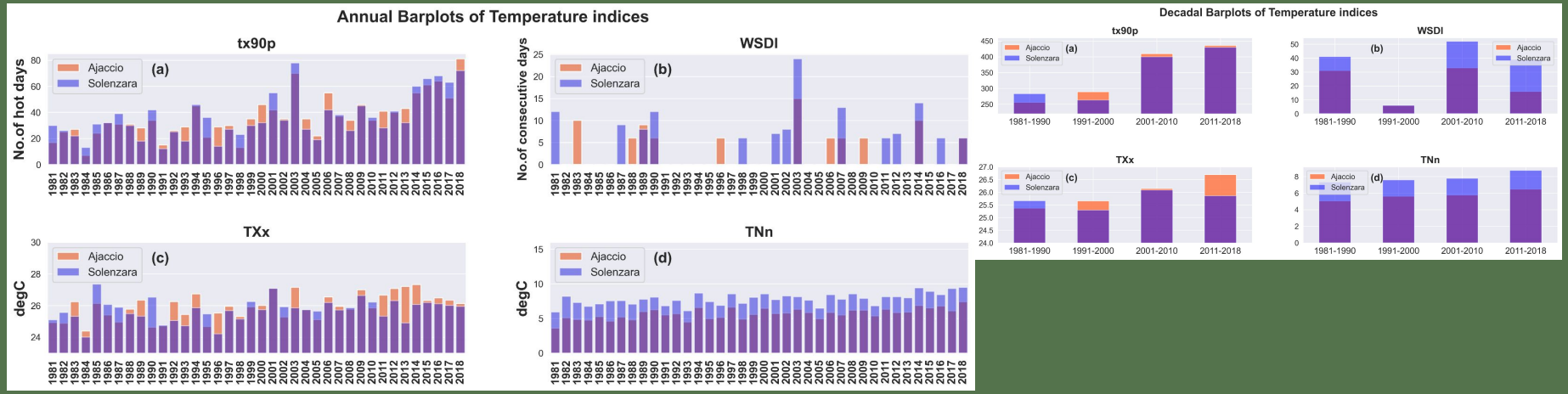


Figure 3: Annual and Decadal bar plots of temperature indices a) tx90p, b) WSDI, c) TXx and d) TNn.

- The hottest years in the last 15 years were 2003, 2006, 2014, 2015, 2016, 2017 and 2018.

Barplots: Precipitation indices

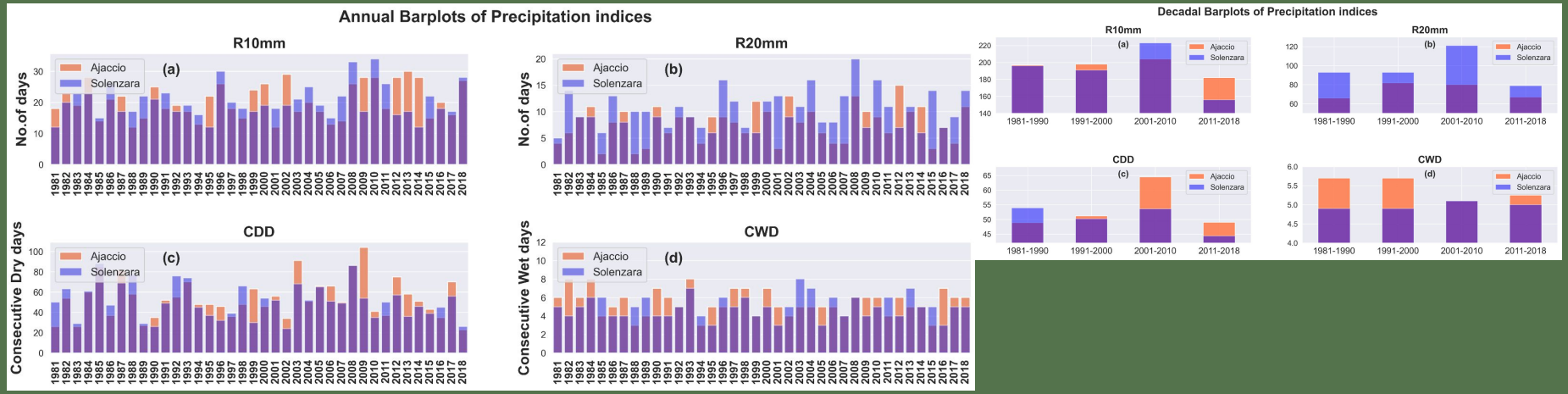
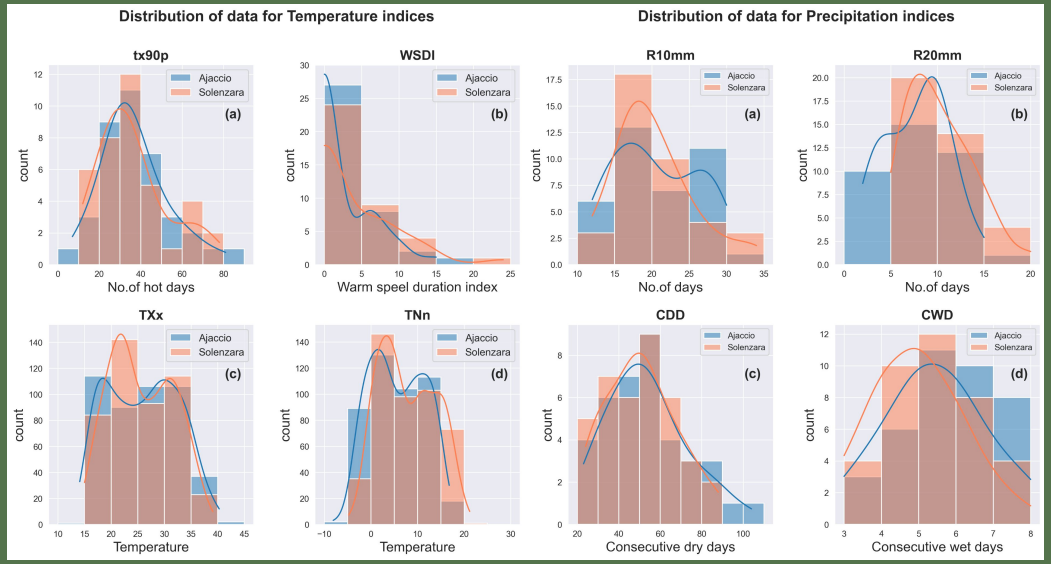


Figure 4: Annual and Decadal bar plots of precipitation indices a) R10mm, b) R20mm, c) CDD and d) CWD.

- The decade 1981-1990 is characterized as "very dry."
- The decade 1991-2000 is characterized by a series of significant surpluses and deficits.
- The decade 2001-2010 is characterized by a dry period followed by wetter period.

Source: Mattei, F. (2016)

Distribution plots: Climate indices



- Shape
- Center
- Spread
- Outliers

Figure 5: Distribution plots of temperature indices a) tx90p, b) WSDI, c) TXx and d) TNn and Distribution plots of precipitation indices a) R10mm, b) R20mm, c) CDD and d) CWD.

Box plots: Temperature indices

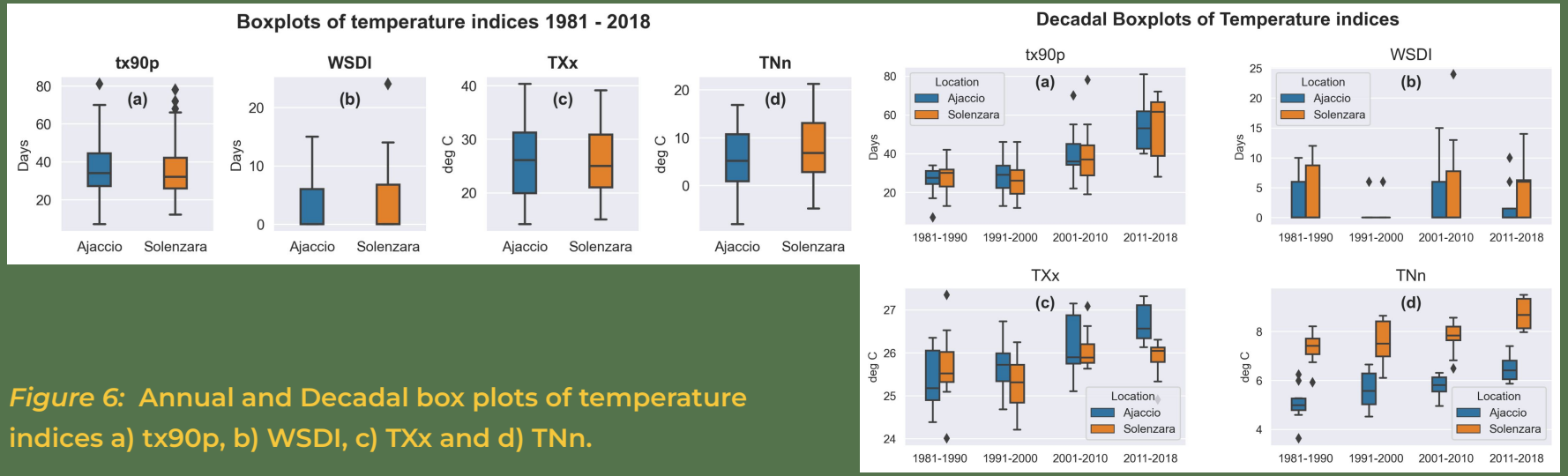


Figure 6: Annual and Decadal box plots of temperature indices a) tx90p, b) WSDI, c) TXx and d) TNn.

Box plots: Precipitation indices

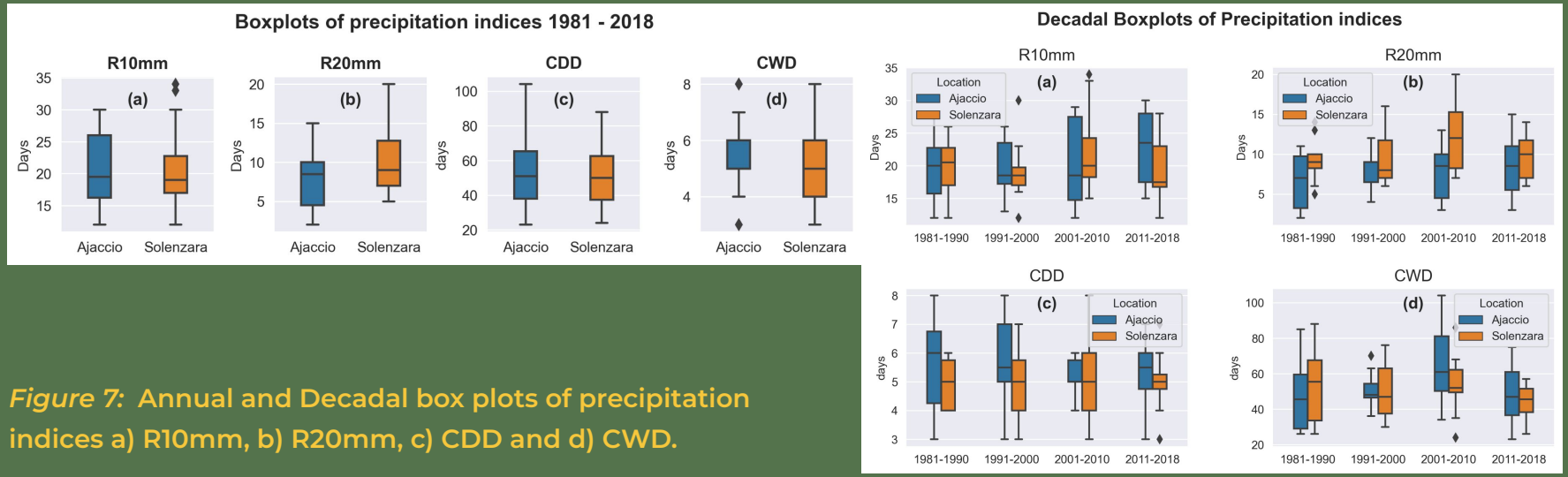


Figure 7: Annual and Decadal box plots of precipitation indices a) R10mm, b) R20mm, c) CDD and d) CWD.

Accuracy Metric

- R-squared statistic provides a measure of fit.
- Always takes on a value between 0 and 1.
- Represents how much of our data is being explained by our model.

Trends

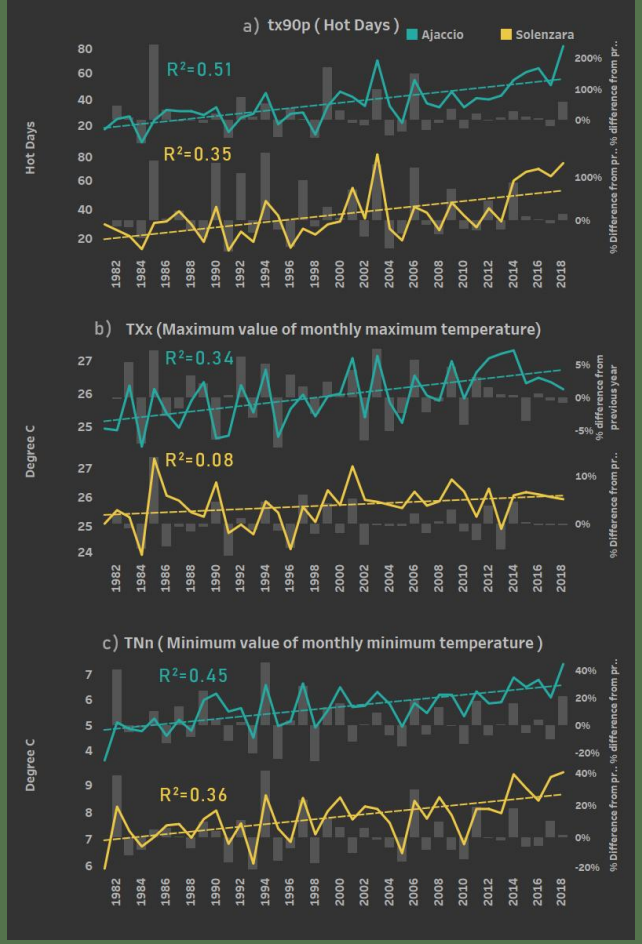


Figure 8: Climate indices with increasing trends a)tx90p b)TXx and c)TNn.

Index	Location	p-value	Trend	R^2
tx90p	Ajaccio	0	1.01	0.51
	Solenzara	0	.90	0.35
WSDI	Ajaccio	.887	0	0
	Solenzara	.456	0	0.01
TXx	Ajaccio	.004	.042	0.34
	Solenzara	.001	.018	0.08
TNn	Ajaccio	0	.047	0.45
	Solenzara	.001	.045	0.36
R10mm	Ajaccio	.221	.115	0.05
	Solenzara	.742	0	0.02
R20mm	Ajaccio	.238	.057	0.04
	Solenzara	.323	.047	0.04
CWD	Ajaccio	.543	0	0.02
	Solenzara	.896	0	0
CDD	Ajaccio	.624	.157	0.01
	Solenzara	.279	.363	0.04

Table 2: p-value Trend and R-squared of extreme climate indices.

Linear Regression: Climate indices

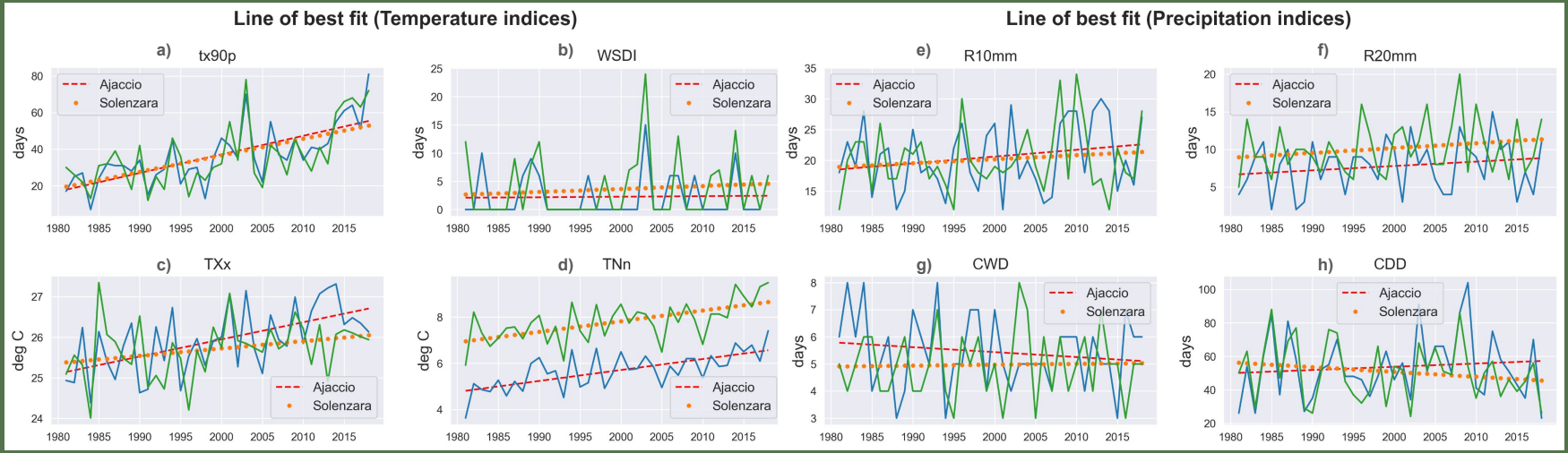


Figure 9: Line of best fit for Temperature indices a) tx90p b) WSDI c) TXx d) TNn and Precipitation indices e)R10mm f) R20mm g) CWD h) CDD.

Linear Regression: Climatic parameters

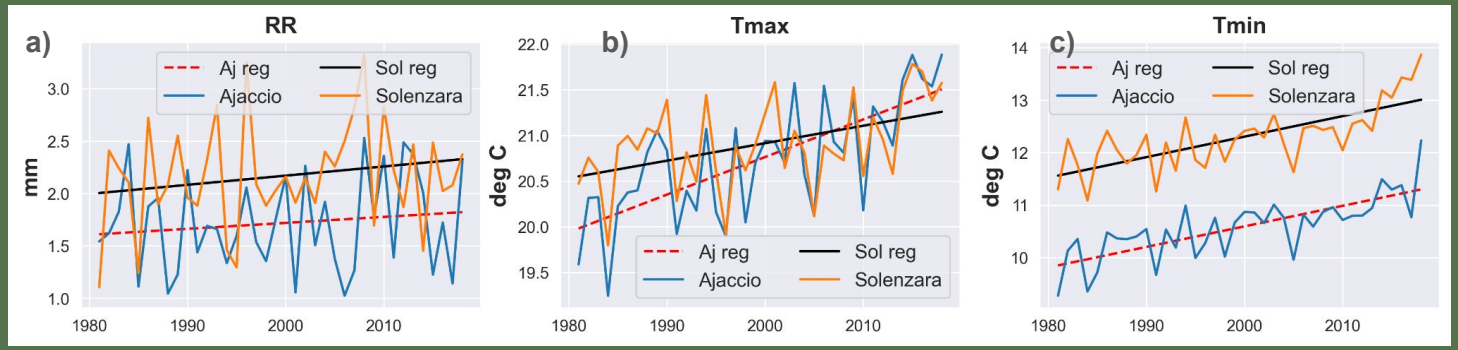


Figure 10: Line of best fit for the climatic parameters a) RR, b) Tmax, and c) Tmin

Table 3: p-value and Trend value of RR, Tmax, and Tmin for Ajaccio and Solenzara

Region	RR		T_{max}		T_{min}	
	p-value	Trend	p-value	Trend	p-value	Trend
Ajaccio	0.49	0	0	+0.04°C/yr	0	+0.03°C/yr
Solenzara	0.35	0	0	+0.01°C/yr	0	+0.03°C/yr

Global readings

- Global surface temperature has increased ≈0.2°C per decade in the past 30 year.

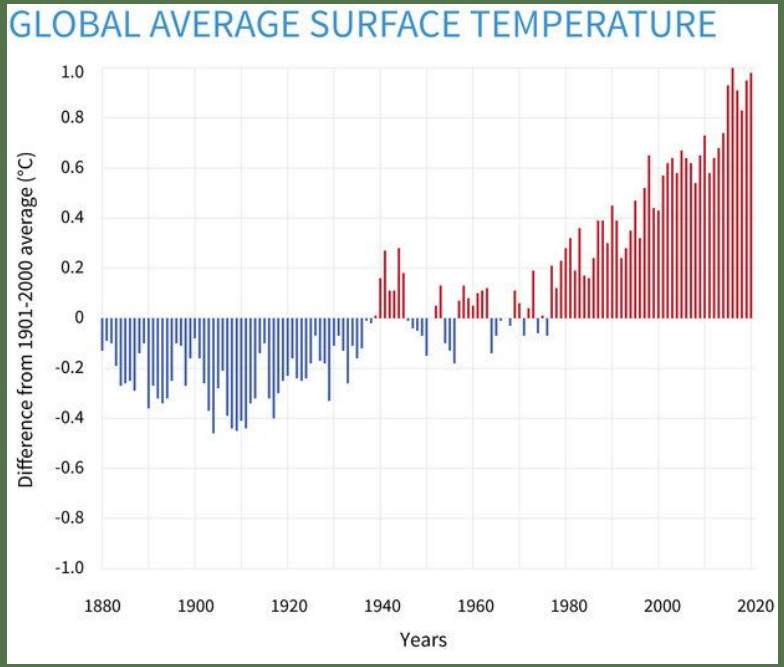


Figure 11: Yearly surface temperature compared to the 20th-century average from 1880–2020.

Source: Lindsey, R. (2021)

Projected Climate Change at the horizon of 2050

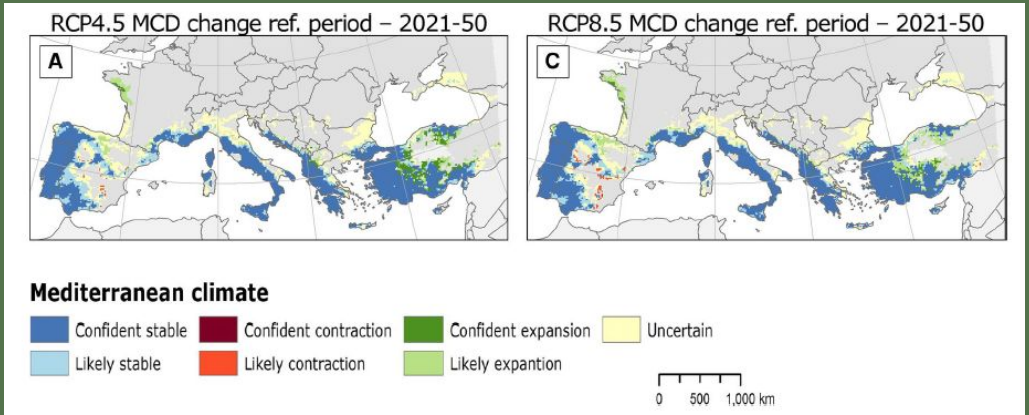


Figure 12: Projected changes of the Mediterranean climate domain (MCD) under scenario RCP4.5 and RCP8.5 in two future periods in relation to the reference period (1981–2010)

Source: Barredo, J. I.(2018)

- The climate of Corsica will remain Mediterranean and won't convert into arid even in RCP 8.5 scenario.
- However, a small decrease of precipitation could result in a transition from Mediterranean to arid climate type.

RCP 8.5 refers to the concentration of carbon that delivers global warming at an average of 8.5 watts per square meter across the planet. The RCP 8.5 pathway delivers a temperature increase of about 4.3 ˚C by 2100, relative to pre-industrial temperatures.

A differenced first order auto regressive method (ARIMA)

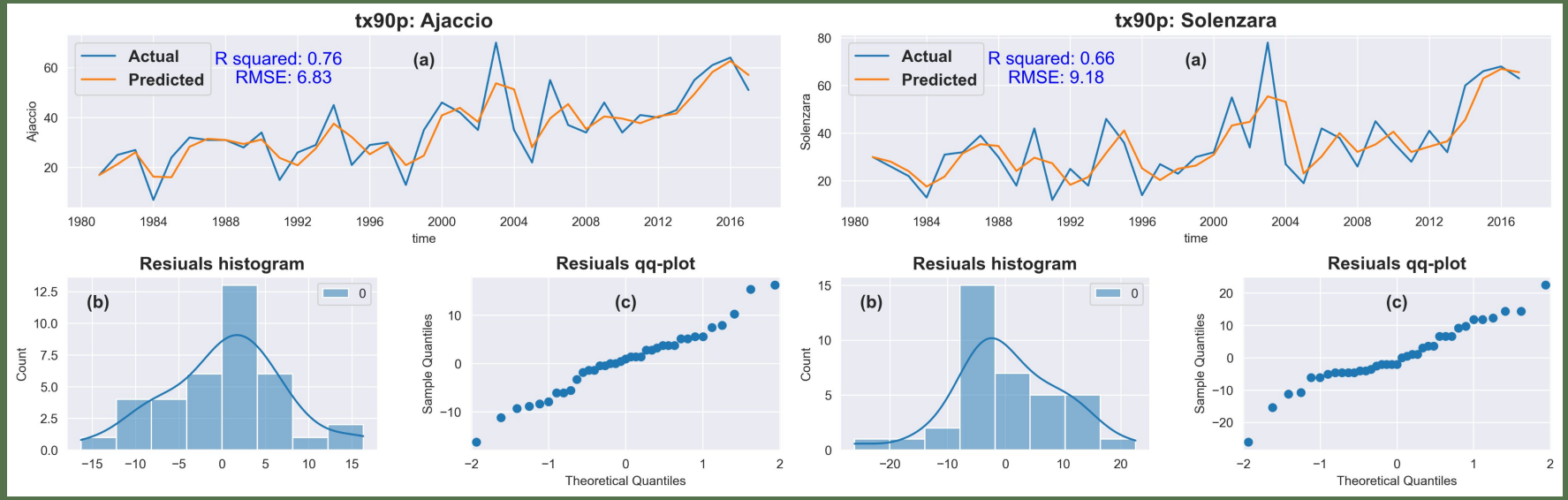


Figure 13: A differenced first order auto regressive method for tx90p of Ajaccio and Solenzara a)Actual Vs Predicted values b) Residuals c) QQ-plot

A differenced first order auto regressive method (ARIMA)

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Table 4(a): R^2 and RMSE of Temperature indices

Index	Station	R^2	RMSE
tx90p	Ajaccio	.80	6.28
	Solenzara	.66	9.18
WSDI	Ajaccio	.46	4.14
	Solenzara	.46	4.14
TXx	Ajaccio	.36	.64
	Solenzara	.32	.57
TNn	Ajaccio	.48	.52
	Solenzara	.44	.60

Table 4(b): R^2 and RMSE of Precipitation indices

Index	Station	R^2	RMSE
R10	Ajaccio	.56	3.6
	Solenzara	.48	3.65
R20	Ajaccio	.47	2.44
	Solenzara	.34	2.8
CDD	Ajaccio	.50	13.21
	Solenzara	.73	8.58
CWD	Ajaccio	.28	1.15
	Solenzara	.55	.82

Correlation: Climate indices

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a)

	Aj tx90p	Aj WSDI	Aj TXx	Aj TNn	So tx90p	So WSDI	So TXx	So TNn
Aj tx90p		0.37	0.67	0.76	0.87	0.32	0.44	0.75
Aj WSDI	0.37		0.34	0.21	0.30	0.55	0.02	0.18
Aj TXx	0.67	0.34		0.58	0.54	0.19	0.40	0.52
Aj TNn	0.76	0.21	0.58		0.61	0.17	0.38	0.86
So tx90p	0.87	0.30	0.54	0.61		0.47	0.57	0.67
So WSDI	0.32	0.55	0.19	0.17	0.47		0.15	0.14
So TXx	0.44	0.02	0.40	0.38	0.57	0.15		0.43
So TNn	0.75	0.18	0.52	0.86	0.67	0.14	0.43	

Correlation Coefficient: 0.02 – 0.87

b)

	Aj CDD	Aj CWD	Aj R10	Aj R20	So CDD	So CWD	So R10	So R20
Aj CDD		0.03	0.02	0.11	0.68	0.15	-0.19	-0.10
Aj CWD	0.03		0.36	0.37	0.13	0.01	0.09	0.01
Aj R10	0.02	0.36		0.86	-0.31	0.01	0.24	0.15
Aj R20	0.11	0.37	0.86		-0.19	0.05	0.21	0.11
So CDD	0.68	0.13	-0.31	-0.19		0.20	-0.15	0.00
So CWD	0.15	0.01	0.01	0.05	0.20		0.25	0.27
So R10	-0.19	0.09	0.24	0.21	-0.15	0.25		0.80
So R20	-0.10	0.01	0.15	0.11	0.00	0.27	0.80	

Correlation Coefficient: -0.31 – 0.86

Figure 14: Correlation coefficients of a)Temperature indices and b)Precipitation indices

Key Takeaways and Conclusion

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- Climate extremes are a sign of the climate change.
- Temperature and Warm days increased in magnitude and intensity.
- No significant trend pattern was observed in Precipitation and related indices.
- There is an increase in extreme events. 38 were recorded from 1958 to 2017, versus 4 in the previous 120 years.
- Plantation areas, forest fires risk and Surface water availability.
- Drought issues.
- Higher water demands and lower water availability.

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Thank you for your time!