Spatio-temporal stability of the variability signal in long term annual rainfall times series homogenized by the regional vector method, in Morocco

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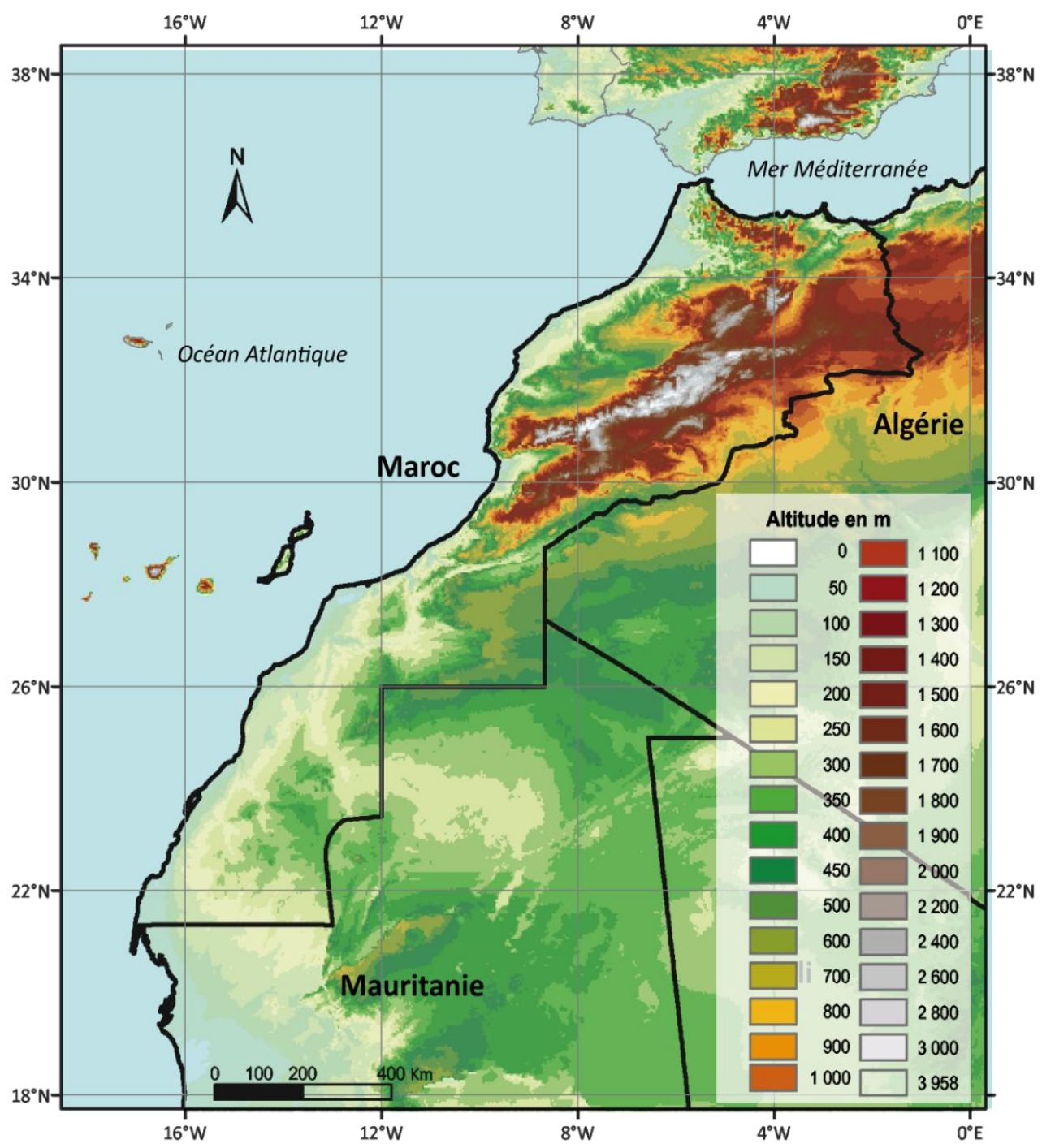
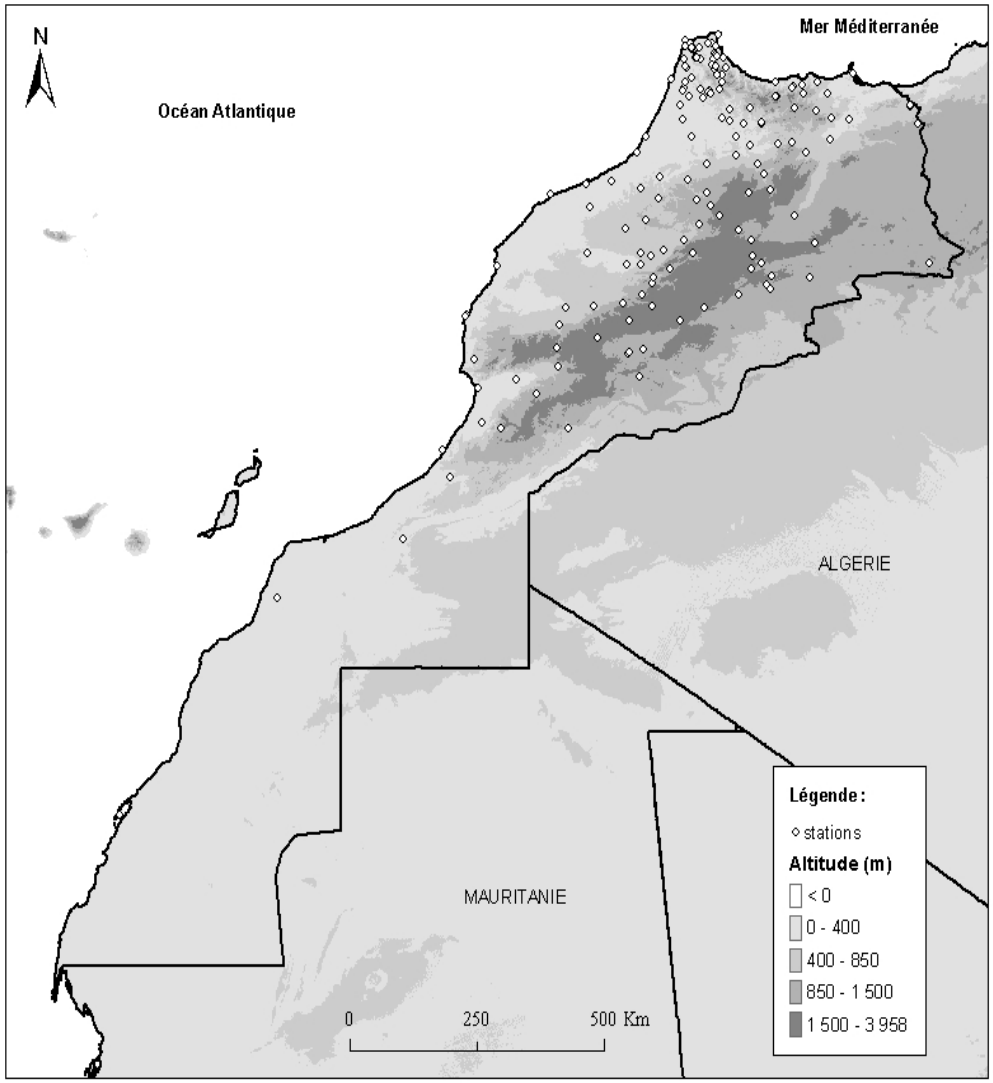
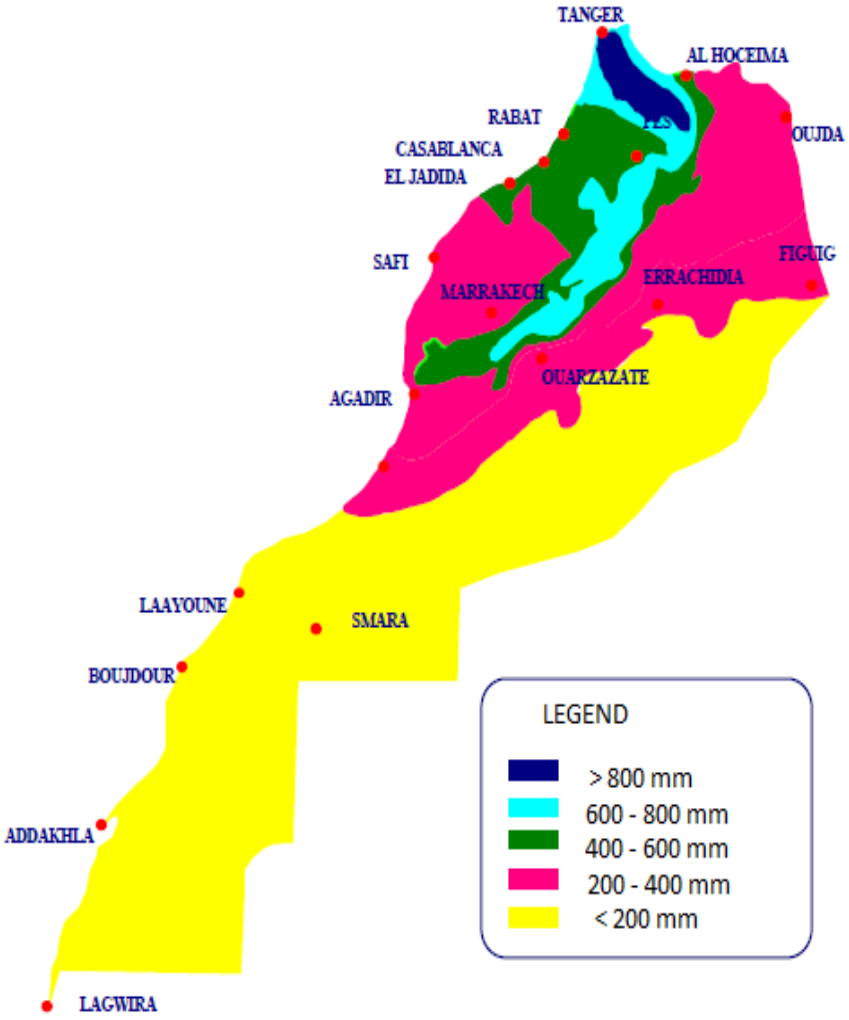
Kindly presented by ***Yves TRAMBLAY***



Morocco is a country of the northwest of Africa, north of the Saharan desert.

The Atlas mountains reach 4000 m and are an important feature for the rainfall distribution over the country.





The rainfall stations in Morocco used for this study

Well distributed over the country. Except in the South (Saharan desert) and in the north-east (near the Algerian border)

Objectives:

Study if the same climatic signals are detected at all spatial scales,
And
Study if the reconstruction of missing values in time series modifies the climatic signals detected.

The climatic signals are detected according to statistical tests for ruptures in times series:

- non parametric test of Pettit,
- Bayesian method of Lee et Heghinian,
- Hubert's segmentation.

Lubès-Niel H., Masson J.M., Paturel J. E., Servat E. (1998). Variabilité climatique et statistique. Etude par simulation de la puissance et de la robustesse de quelques tests utilisés pour vérifier l'homogénéïté de chroniques. *Revue des Sciences de l'Eau*, **11**(3), 383–408.

Khronostat (1998) Logiciel d'analyse statistique de séries chronologiques. ORSTOM Ed. Paris. http://www.hydrosciences.org/spip.php?article239

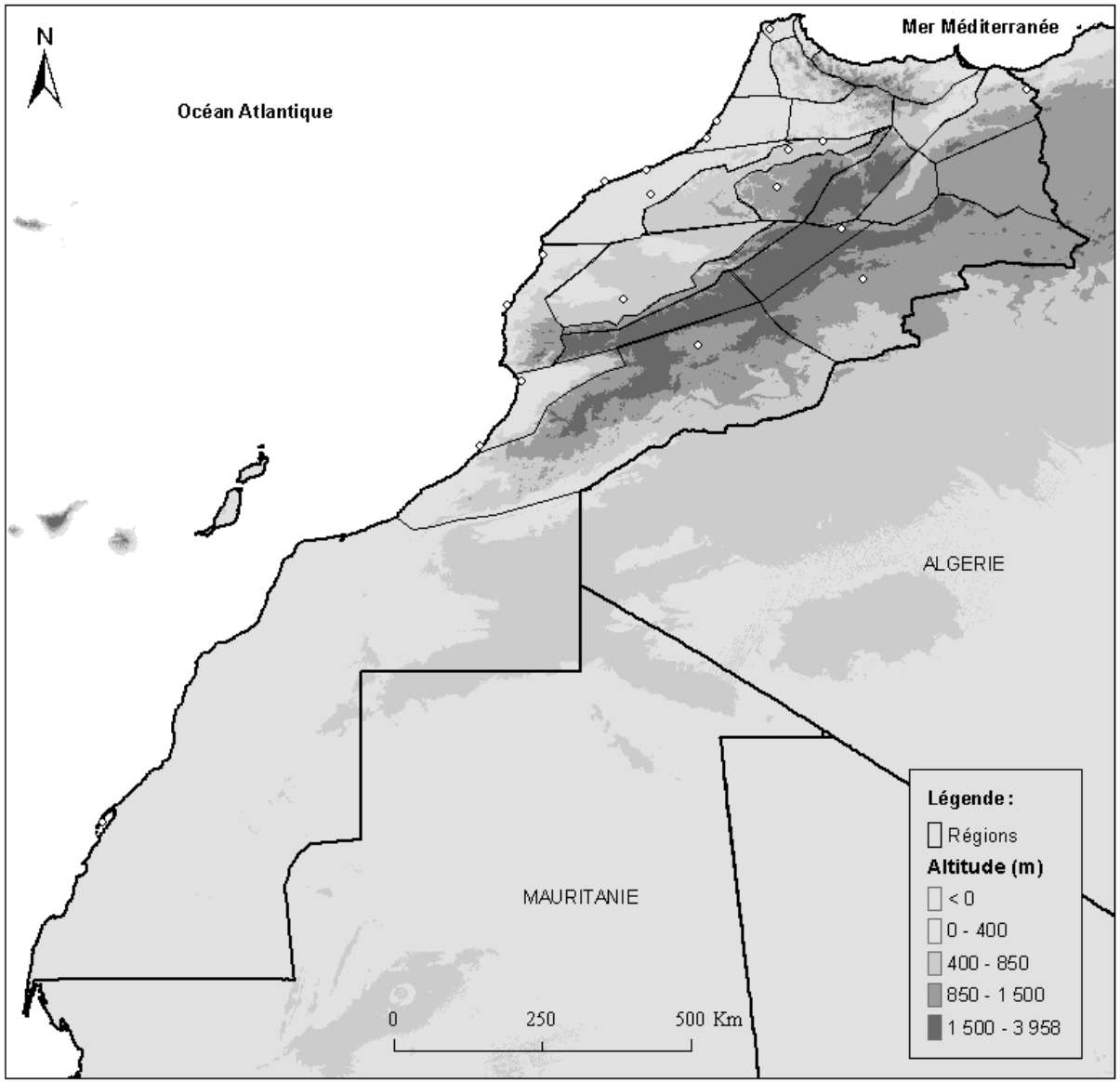
A climatic unit is defined as an area where rainfall are homogeneous and where rainfall stations within the area follow the same interannual variability.

The method used to delineate the regions in this study is called the « regional vector »

Hiez G., 1977. L'homogénéité des données pluviométriques. *Cahiers ORSTOM. Série Hydrologie,* **14** (2) : 129-172.

The regional vector is a chronological rainfall index, representative of the evolution of rainfall within a region where climatic fluctuations are homogeneous between stations.
The time series of rainfall of each station vary colinearly to the regional vector within the climatic unit.

This method allows to reconstruct missing values in times series by combining the vector anomaly and the station's average



Origin of data:

- SIEREM database
http://www.hydrosciences.fr/sierem

- Global Historical Climate Network (GHCN) US

- Climatic Research Unit (CRU), Norwich UK

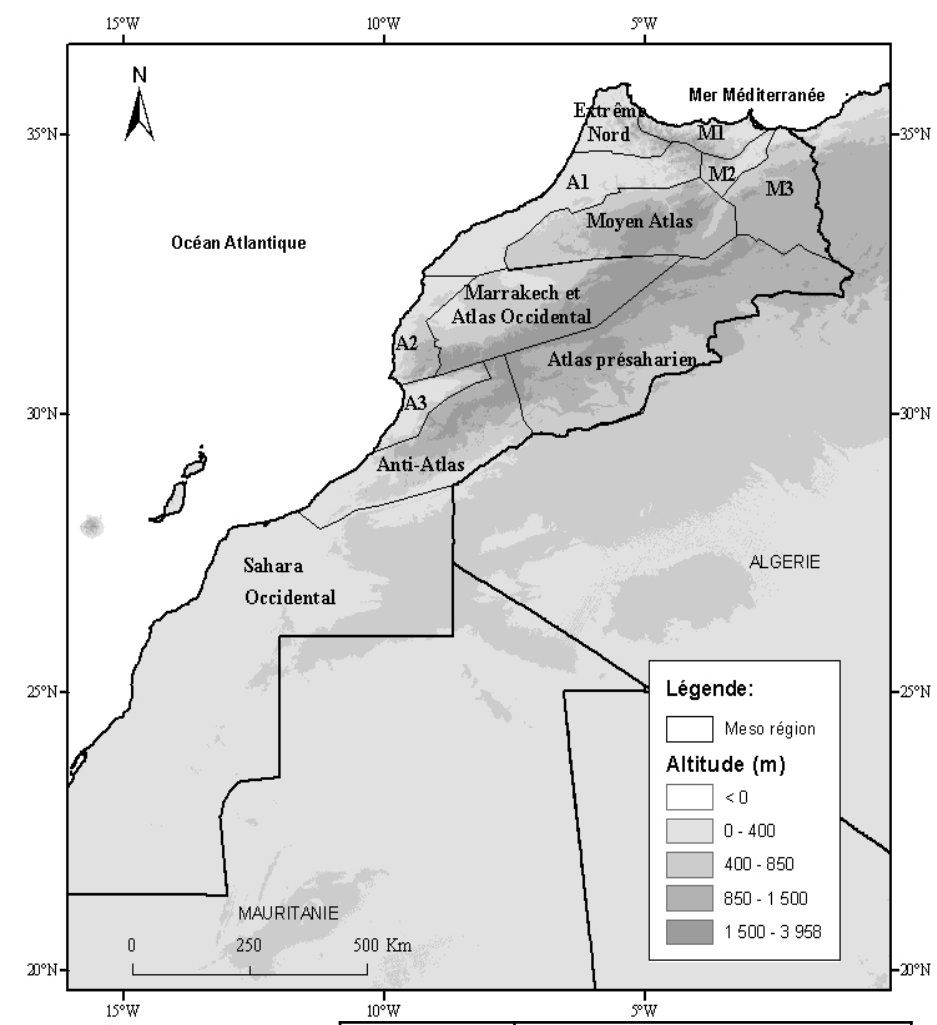
- National Meteorology of Morocco

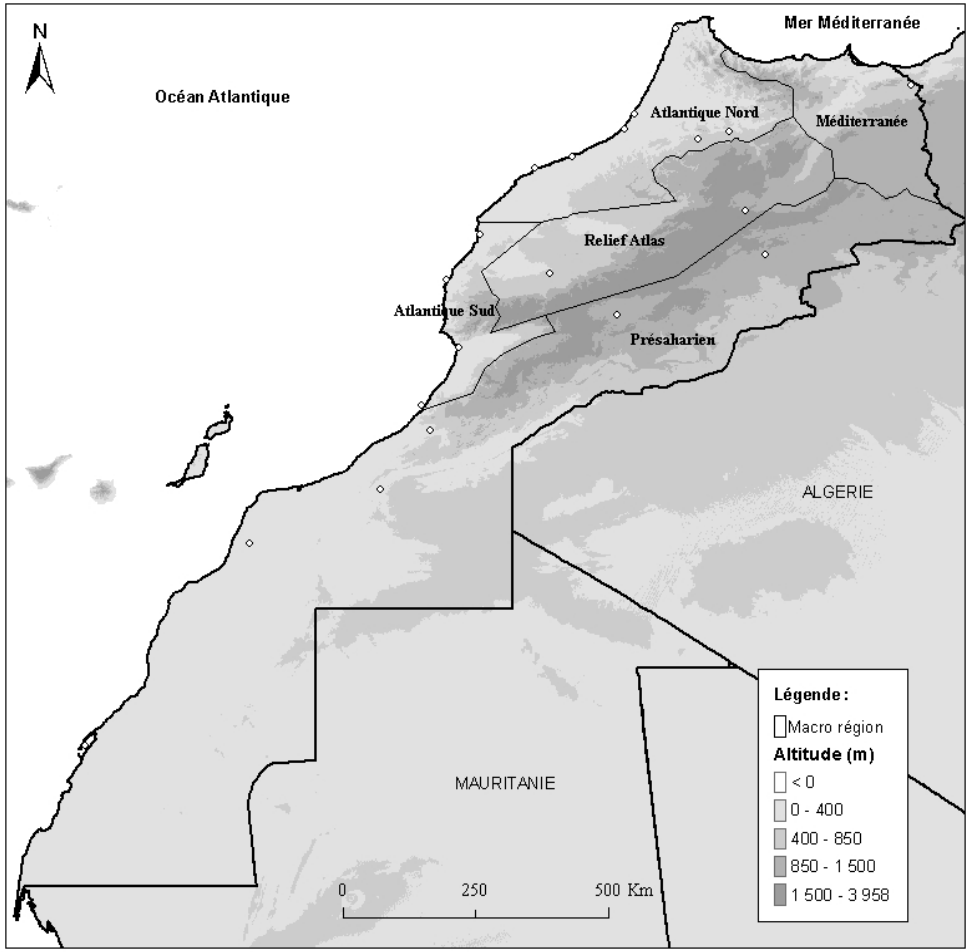
MICRO regions

The 23 climatic regions of Morocco (adapted from previous studies)

The number of regions delimited depends on the number of stations used.

For this study we could use a great number of stations thanks to the Moroccan Meteorology.

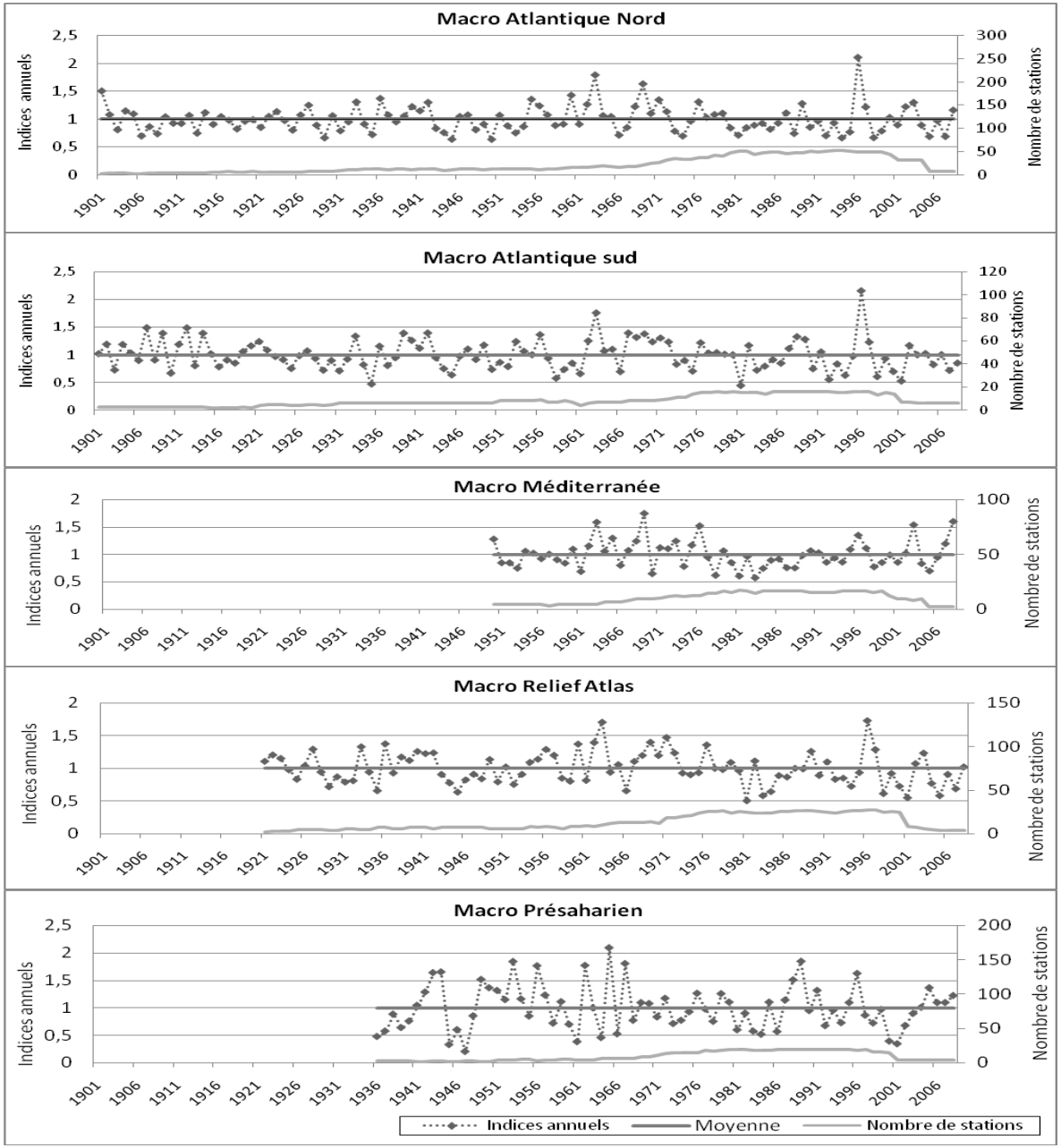




Abréviation	Nom de la région
M1	Méditerranée Rif
M2	Méditerranée Basse Moulouya
M3	Méditerranée Est
A1	Atlantique Nord
A2	Atlantique Sud
A3	Atlantique/Anti-Atlas

MESO regions

MACRO regions



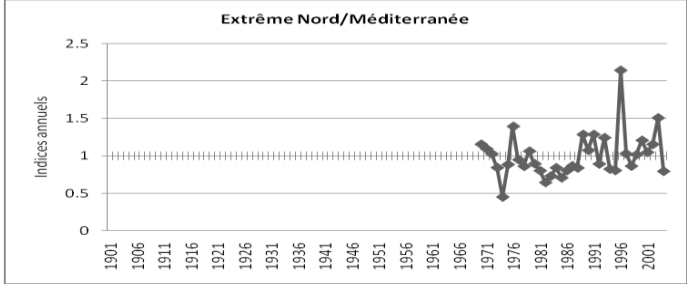
- Annual fluctuations for each of the 5 MACRO regions (dots),
- Interannual average (horizontal line),
-Number of stations per year (line).

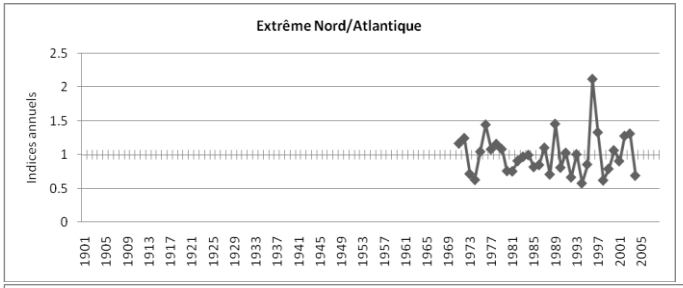
1901 to 2008

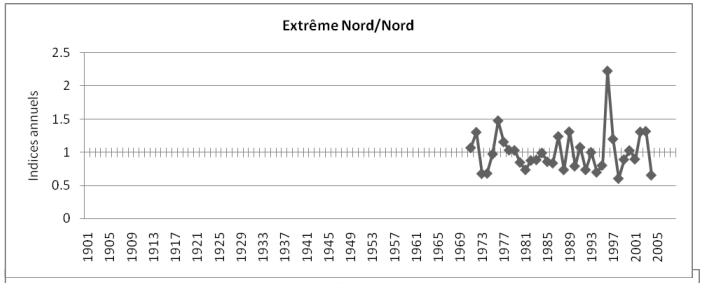
The interannual fluctuations at the larger spatial scale are not important.
Nonetheless, three regions show a sustainable decrease of rainfall from 1980 onward : Atlantique Nord, Atlantique Sud and Relief Atlas.

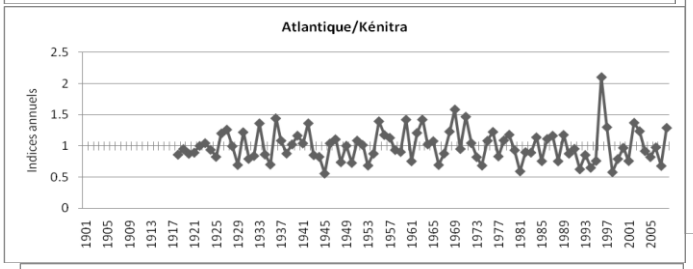
Hereafter is presented the example of the MACRO region Atlantique Nord, and what are the fluctuations of each of the 7 MICRO regions which are averaged within.

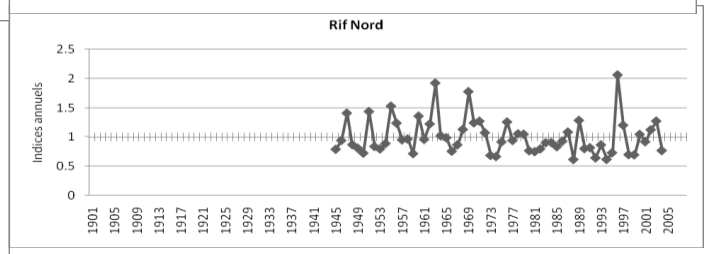
Annual fluctuations for each of the 7 MICRO regions of the MACRO region Atlantique Nord

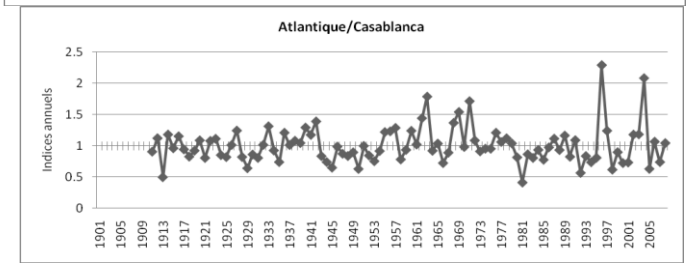


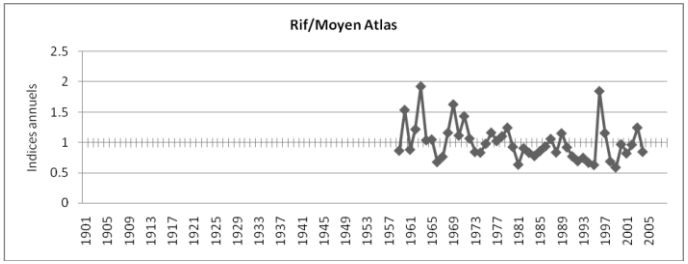












Most of the MICRO regions show a decrease of rainfall,
except the MICRO region “Extrême Nord/Méditerranée”, where the rainfall have increased since the end of the 1980s.

The rupture tests are applied to the reconstructed time series for all MACRO, MESO and MICRO regions, and for the “reference stations”, i.e. the time series of synoptic stations within the MACRO region.

- Reconstructed means that the missing values are completed according to the vector anomaly of each region.

The rupture test are applied also to the observed time series for MACRO, MESO and MICRO regions, but not for reference stations, which often present some lack of data which prevent from applying the rupture test.

A weak rupture means that 1 out of the 3 rupture tests is positive
A strong rupture means that 2 or 3 of the rupture tests are positive

Results are presented on the following tables

Année	Macro	Méso	Micro	Stat.	Année	Macro	Méso	Micro	Ref.	Stat.
25				14	25					14
26				15	26					15
…	…	…	…	…	…	…	…	…	…	…
47				25	47					28
48				28	48					28
49				28	49					25
50				23	50					30
51				28	51					35
52				35	52					35
53				35	53					35
54				38	54					38
55				36	55					36
56				35	56					35
57				34	57					34
58				34	58					33
59				40	59					39
60				39	60					39
61				36	61					36
62				38	62					38
63				43	63					43
64				50	64					51
65				50	65					50
66				48	66					48
67				53	67					53
68				54	68					54
69				61	69					61
70				58	70					62
71				71	71					75
72				79	72					83
73				88	73					92
74				86	74					90
75				92	75					96

Rupture years for observed time series (left), and reconstructed time series (right).

-White : no rupture

- Light Grey: 2 regions or stations (ref stations) show a weak rupture

- Dark Grey: 2 regions or stations (ref stations) show a strong rupture

- Black: At least 3 regions or stations (ref stations) show a strong rupture)

-The last column is the total number of stations studied.

Rupture years from 1925 to 1975

Année	Macro	Méso	Micro	Stat.	Année	Macro	Méso	Micro	Ref.	Stat.
76				100	76					104
77				105	77					109
78				111	78					115
79				108	79					112
80				117	80					121
81				121	81					125
82				118	82					123
83				110	83					114
84				113	84					117
85				119	85					123
86				120	86					125
87				118	87					122
88				120	88					124
89				120	89					124
90				120	90					125
91				118	91					122
92				118	92					123
93				120	93					126
94				122	94					128
95				122	95					128
96				121	96					126
97				121	97					126
98				112	98					116
99				116	99					120
00				105	00					109
01				56	01					59
02				56	02					58
03				53	03					55
04				52	04					55
05				22	05					24
06				22	06					24

Rupture years for observed time series (left), and reconstructed time series (right).

-White : no rupture

- Light Grey: 2 regions or stations (ref stations) show a weak rupture

- Dark Grey: 2 regions or stations (ref stations) show a strong rupture

- Black: At least 3 regions or stations (ref stations) show a strong rupture)

Rupture years from 1976 to 2006

Analysis

- Most of the ruptures are negative ones (no positive ruptures after 1970)
- A lot of time series show a rupture between 1979 and 1980, which has been already described as the beginning of a drought in the country
-The number of ruptures is weaker for reconstructed time series than for observed time series: this is probably due to the fact than more time series are averaged after reconstruction. Thus the remaining signal shows a more representative phenomenom at the regional scale than that issued from observed time series
- Most of the ruptures detected for MACRO and MESO regions for observed time series do not appear in recontructed time series
- It is only for 1947 and 1976 that ruptures are detected for MACRO and MESO regions for reconstructed time series, but paradoxically no ruptures are detected for observed time series

Conclusion

-The reconstruction of time series have an important impact on the detection of ruptures in times series (assimilated to climatic signals)

- Most of the ruptures detected for MACRO and MESO regions for observed time series are not detected for reconstructed time series

- But the main years of ruptures are well depicted by both times series reconstructed and observed, at the level of MICRO regions and reference stations : 1979 and 1980

Thanks for attention