



Faculté des Sciences de Rabat



HydroSciences Montpellier



École Hassania des Travaux Publics

Characterization of weather types in Morocco for extreme situations of temperature

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IV International WORKSHOP on HYDROLOGICAL EXTREMES

Cosenza

15–17/09/2011

Framework and aims

Climate change impact on the climate and water resources of the Bouregreg and Tensift watersheds

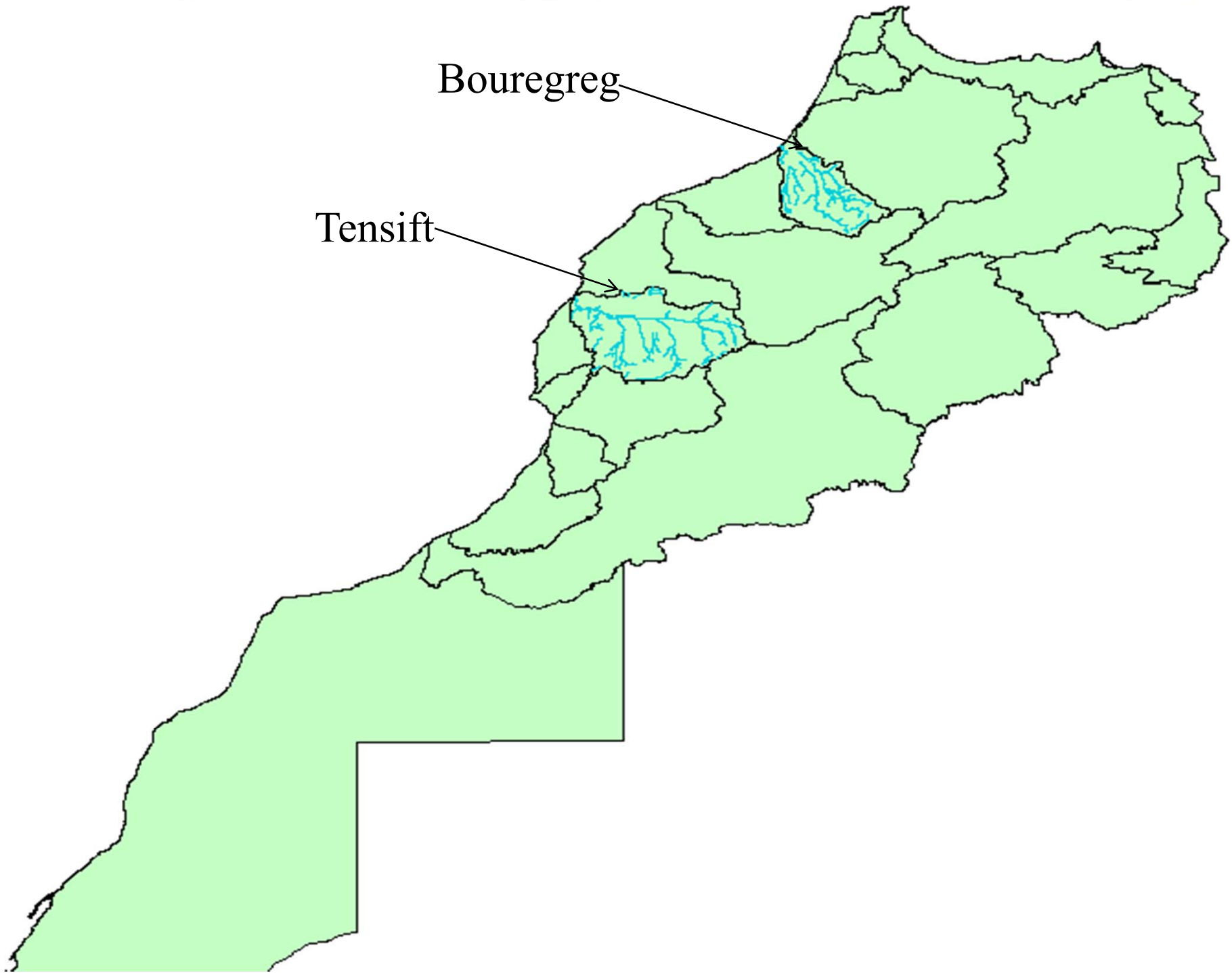


SIGMED project: Spatial approach of the impact of agricultural activities in the Maghreb on sediment transport and water resources in major watersheds

Framework & aims ►

Data & Methodology

Results



Bouregreg

Tensift



- Name: Bouregreg Basin
- Area: 9770 Km²
- Place: Rabat-Salé totally & Khemisset and Khenifra partly
- Topography: Mountains, Hills & Plateaus
- Climate: semi-arid

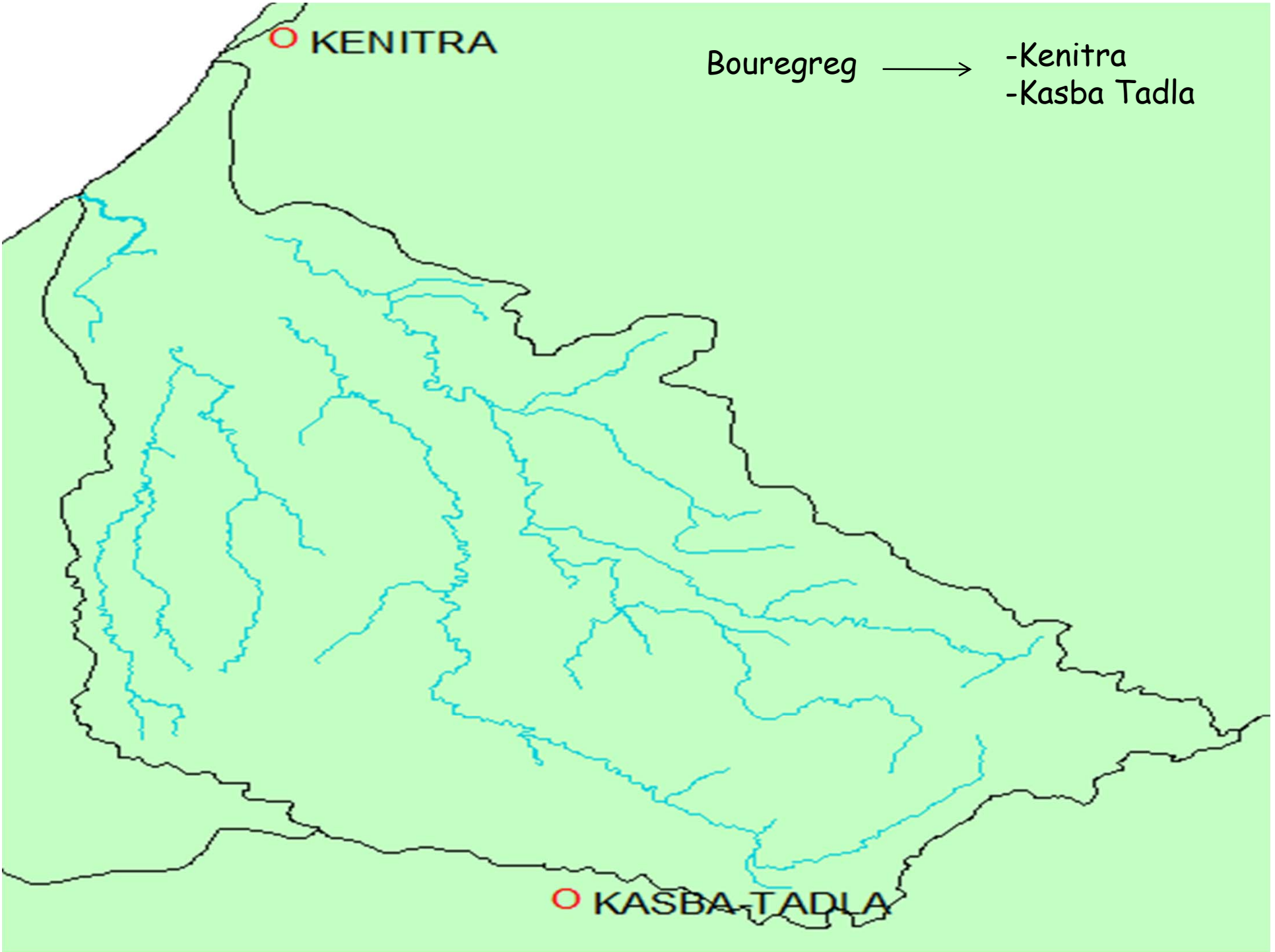


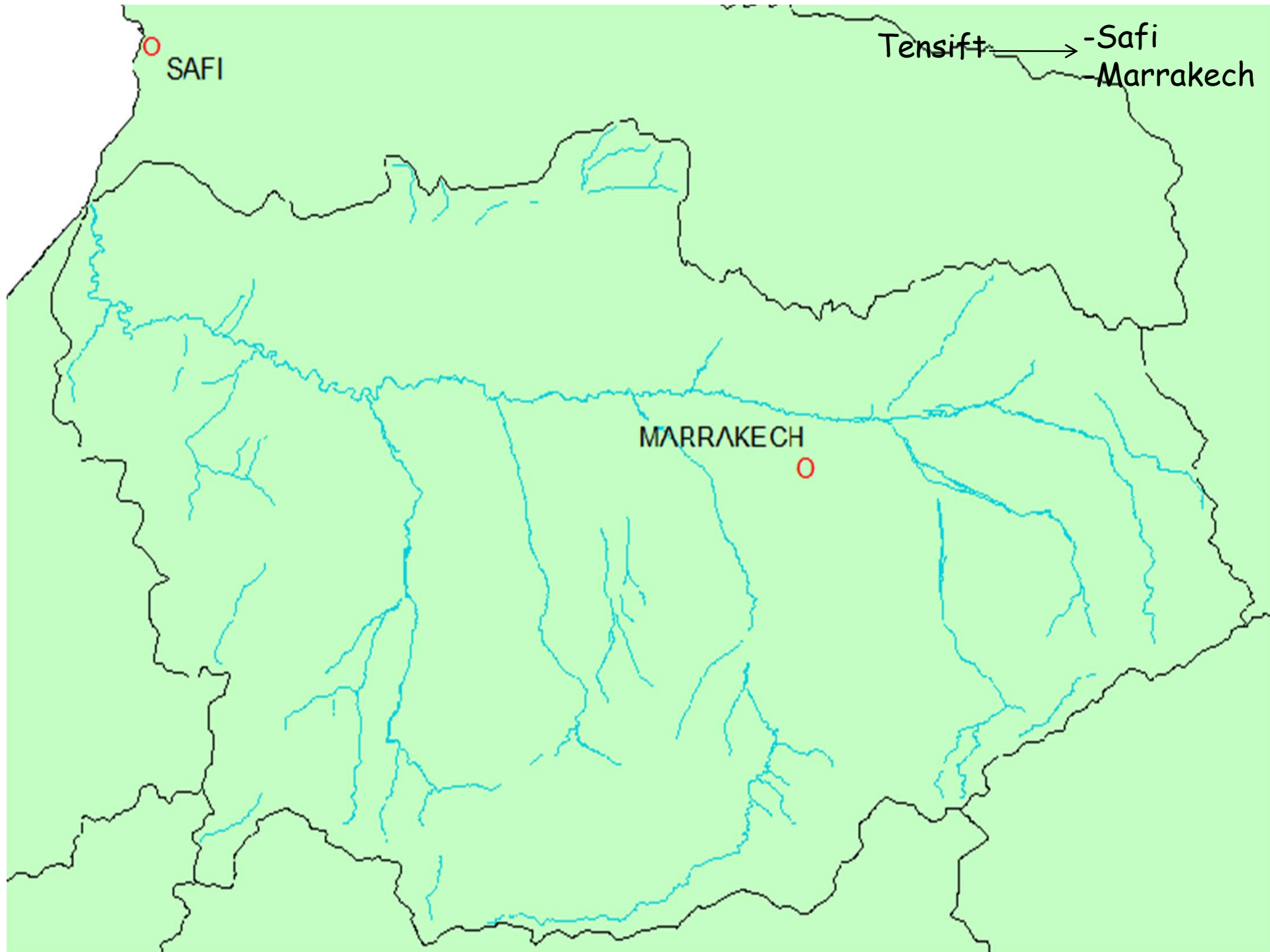
- Name: Tensift Basin
- Area: 19 800 Km²
- Place: Marrakech totally & Safi and Essaouira partly
- Topography: High Atlas, Houz plain & Jbilet (small mountains)
- Climate: arid

○ KENITRA

Bouregreg → -Kenitra
-Kasba Tadla

○ KASBA-TADLA





Data

- Daily Maximum Temperature
- Daily Mean Temperature
- Daily Minimum Temperature

- Kenitra (1951-2010)
- Kasba Tadla (1983-2010)
- Safi (1956-2010)
- Marrakech (1941-2010)

- Weather type maps

Framework & aims

Data & Methodology ►

Results

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Methodology

1. The study of daily series evolution : annual scale
2. The study of daily series evolution : seasonal scale
3. The study of extreme events of temperature: daily maximum temperature of each 5 years
4. The study of extreme events of temperature each year during the 5 last years
5. The study of temperature extreme situation weather types in 2009

Framework & aims

Data & Methodology ►

Results

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Results

Temperature evolution

Temperature evolution ►

Extreme events

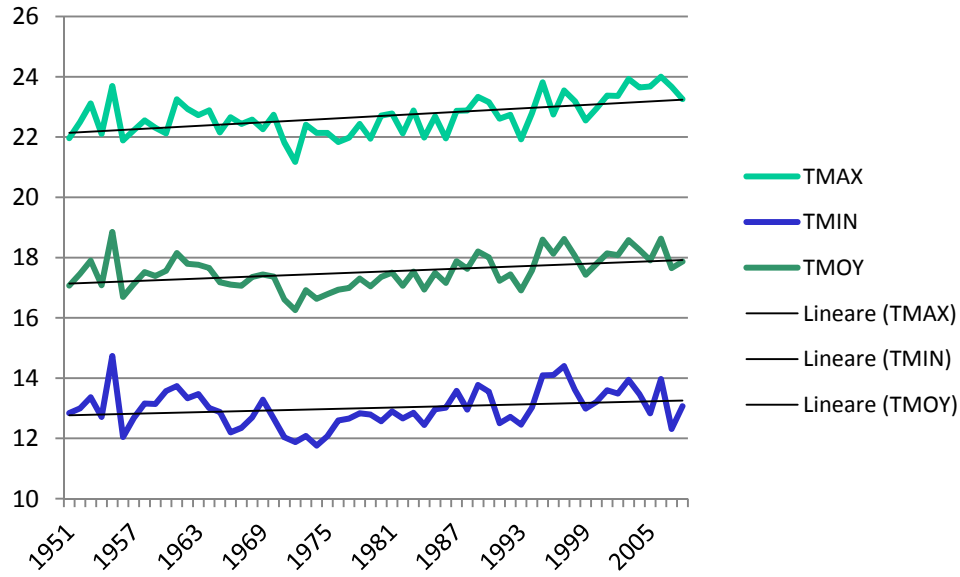
Weather types

Annual scale

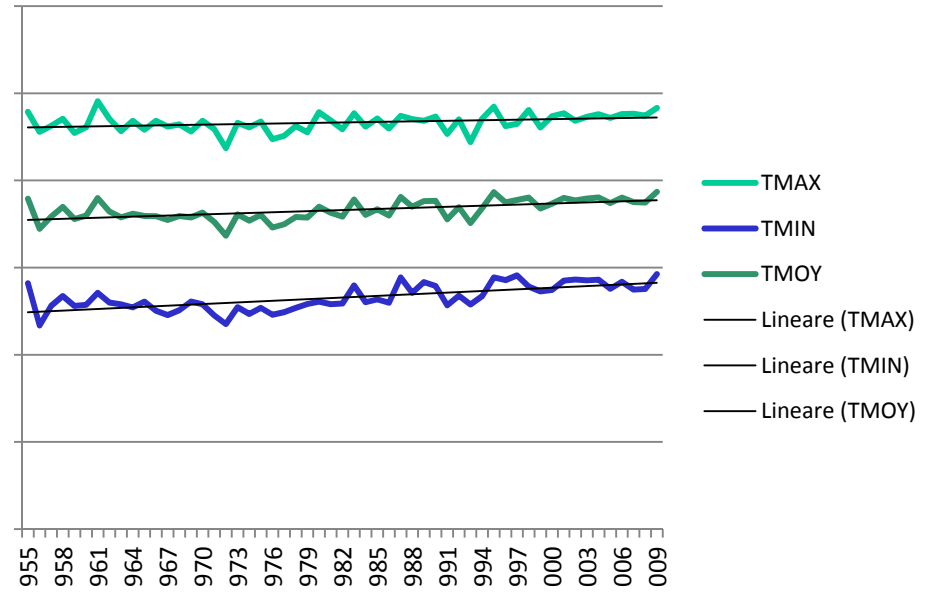
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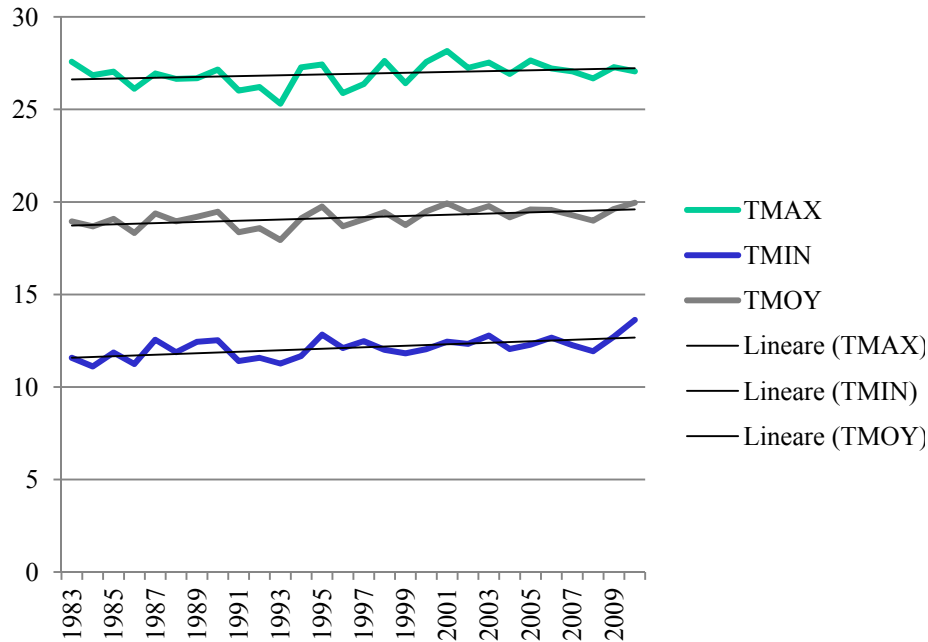
Température Kenitra



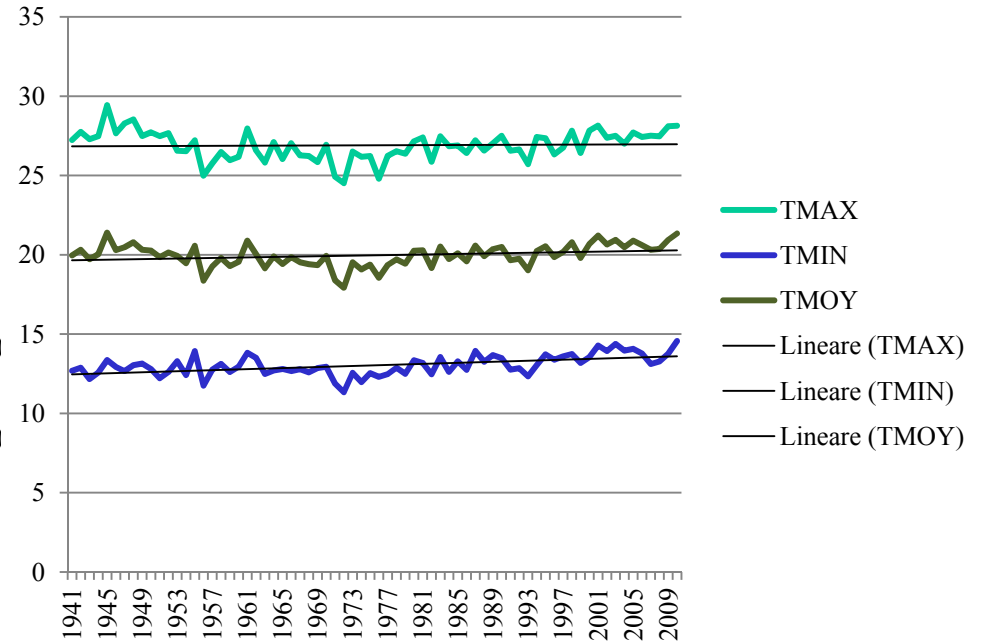
Température Safi



Température de Kasba Tadla



Température Marrakech



Results

Temperature evolution

Annual scale

Temperature evolution ►

Extreme events

Weather types

	Tmax	Tmin	Tmean
Kenitra	↗	↗	↗
Safi	↗	↗	↗
Kasba Tadla	—	↗	↗
Marrakech	—	↗	—

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Seasonal scale

A dry month is a month that has an average rainfall in millimeters equal or less than twice its average temperature ($P \leq 2T$). Bagnouls & Gausson (1953,1957).



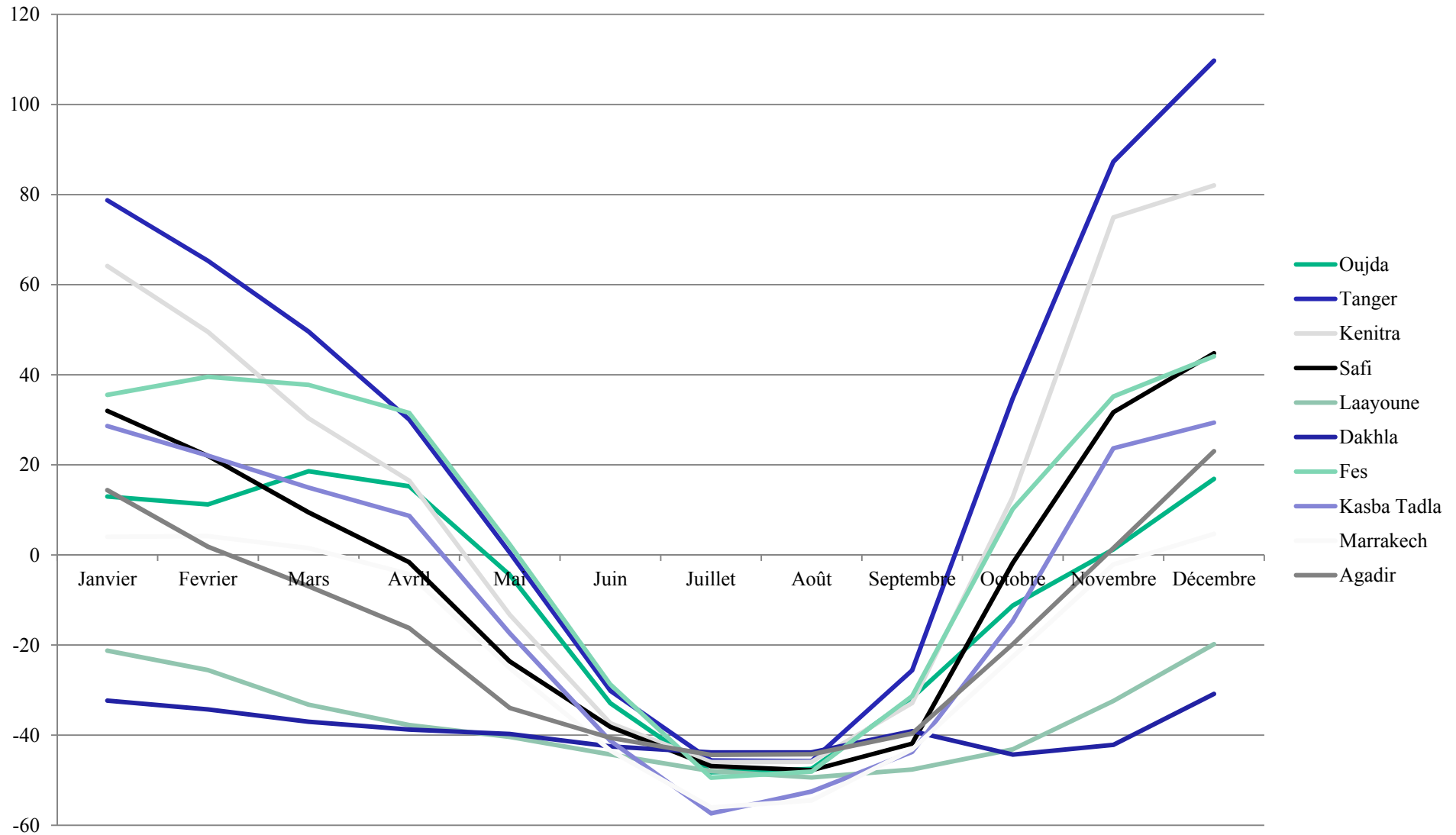
Climograph of 10 meteorological stations

Temperature evolution ▶

Extreme events

Weather types

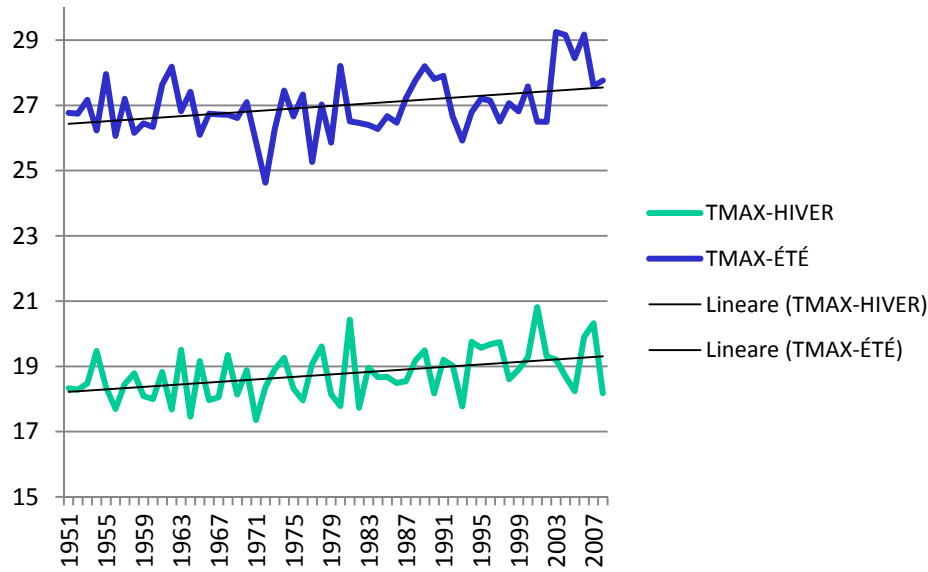
Diagramme ombrothermique



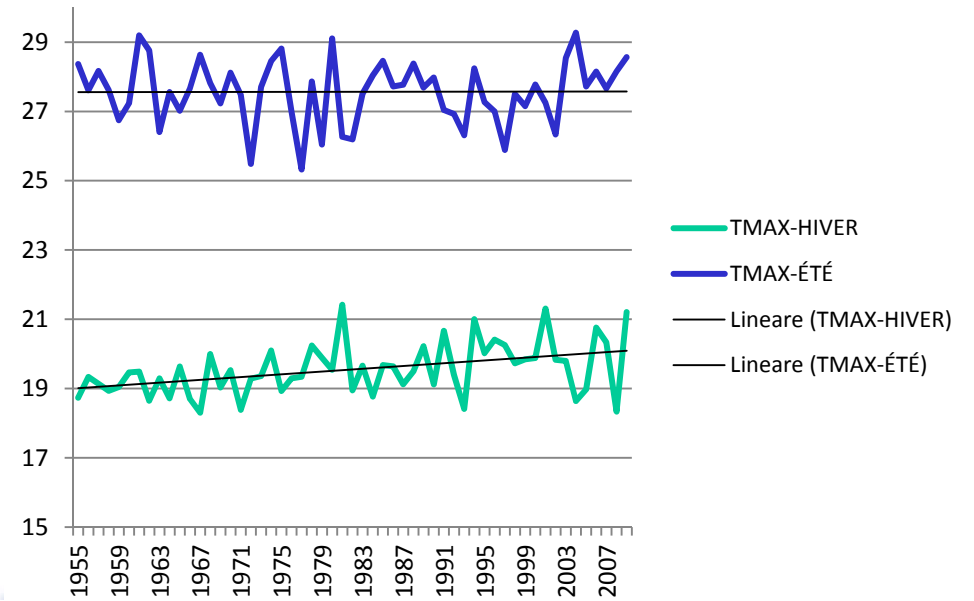
- Cold season: November, December, January, february

- Hot season: June, July, August, September

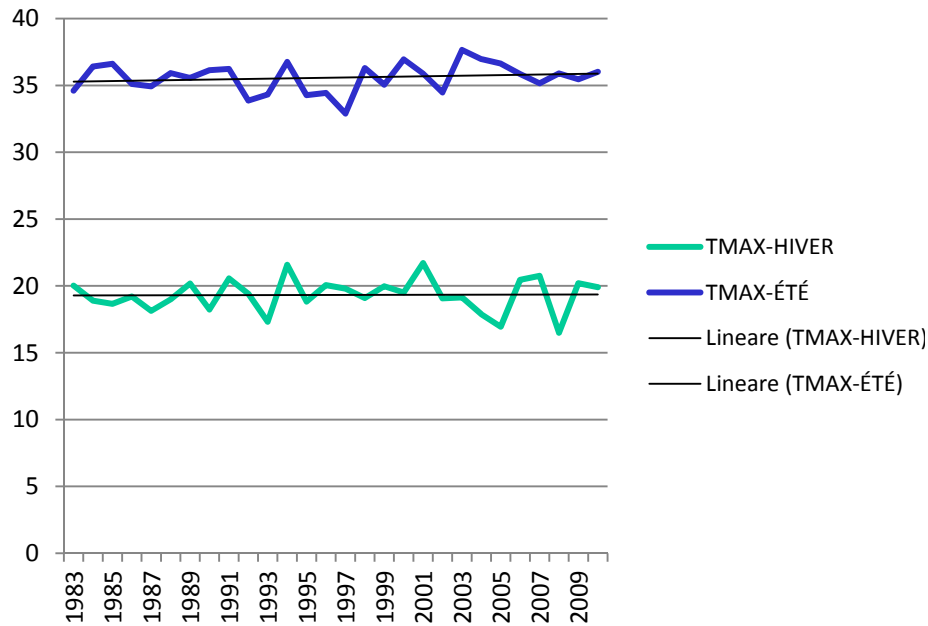
Température maximale Safi



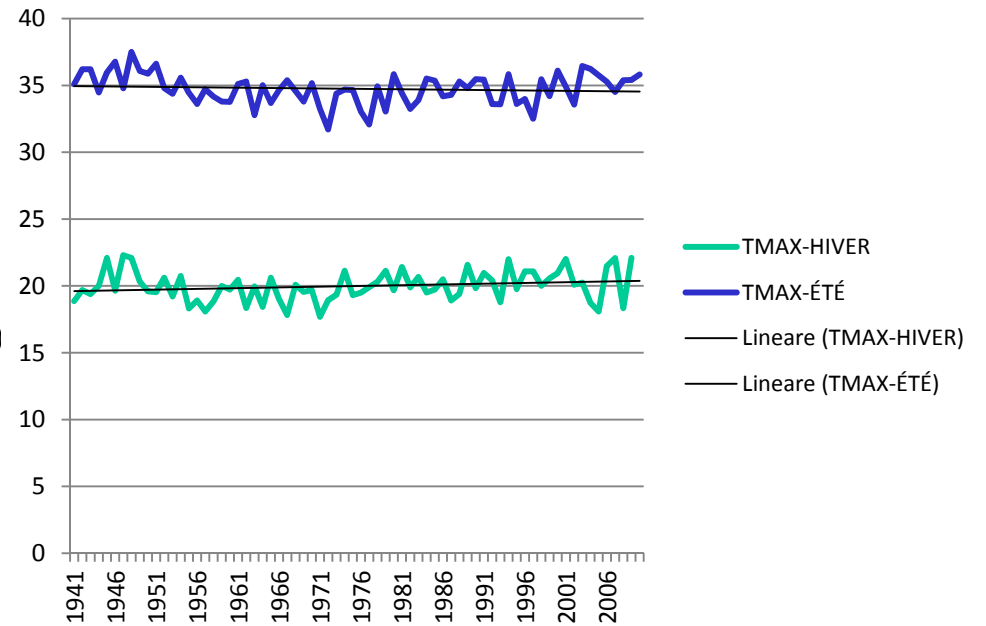
Température maximale Safi



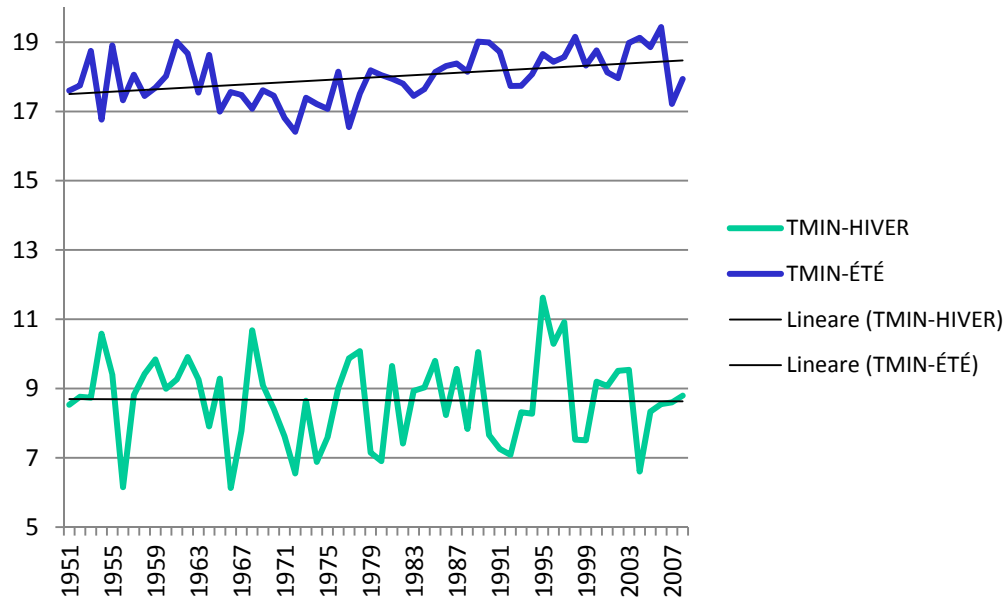
Température maximale Kasba Tadla



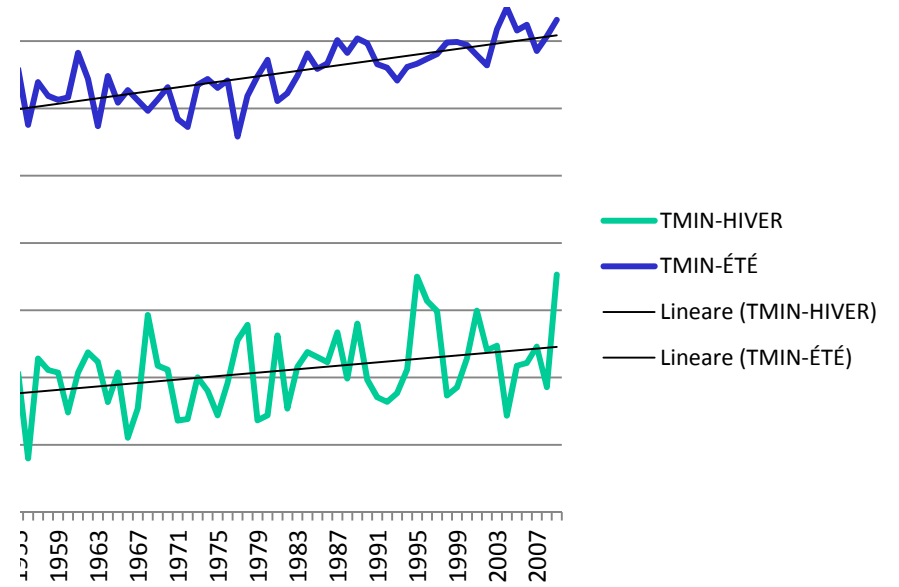
Température maximale Marrakech



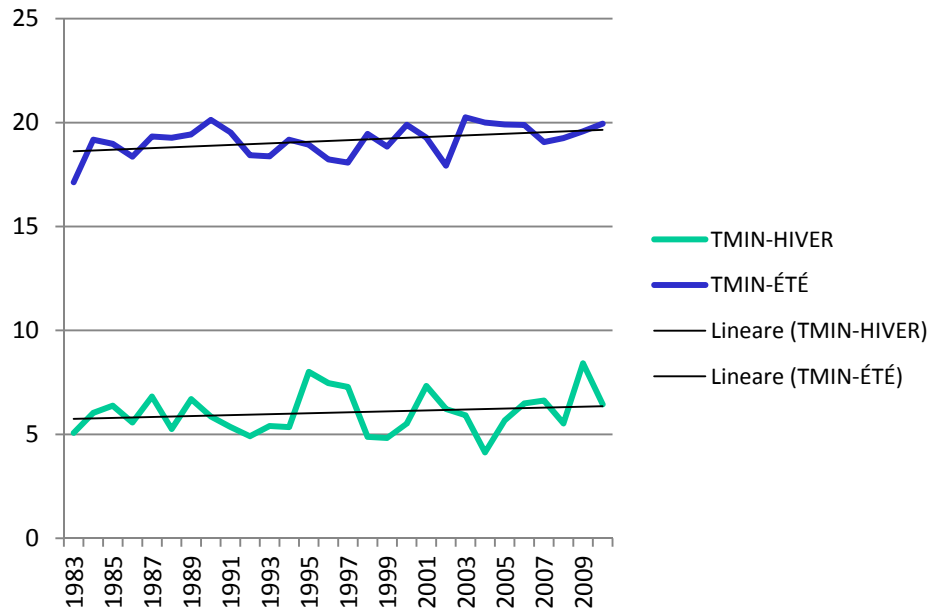
Température minimale Kenitra



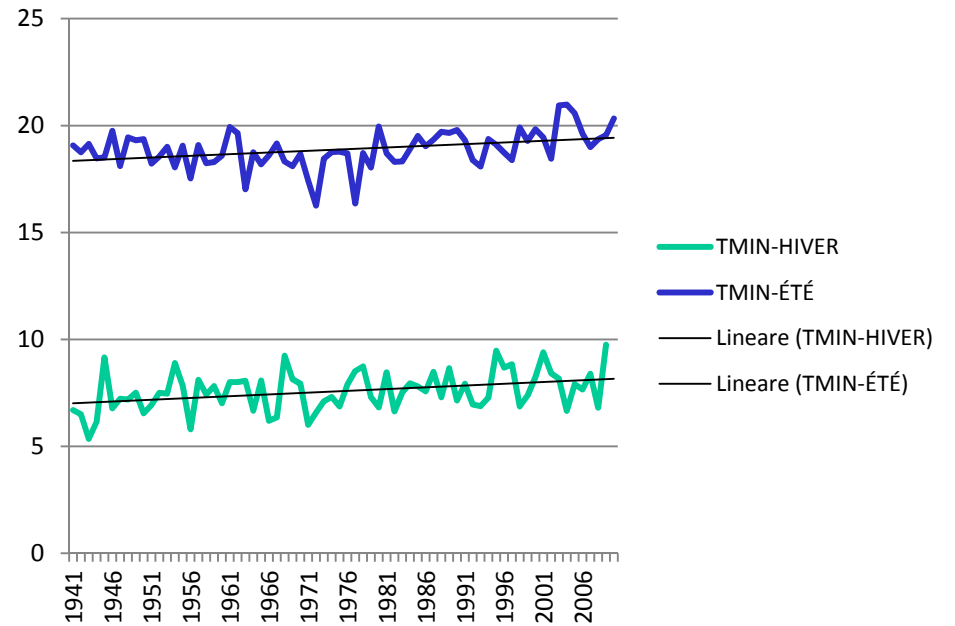
Température minimale Safi



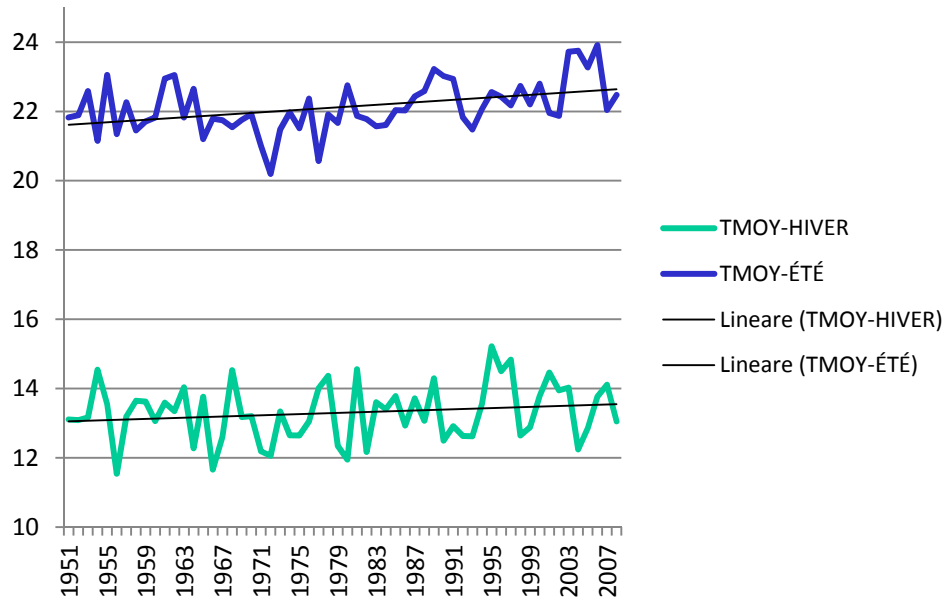
Température minimale Kasba Tadla



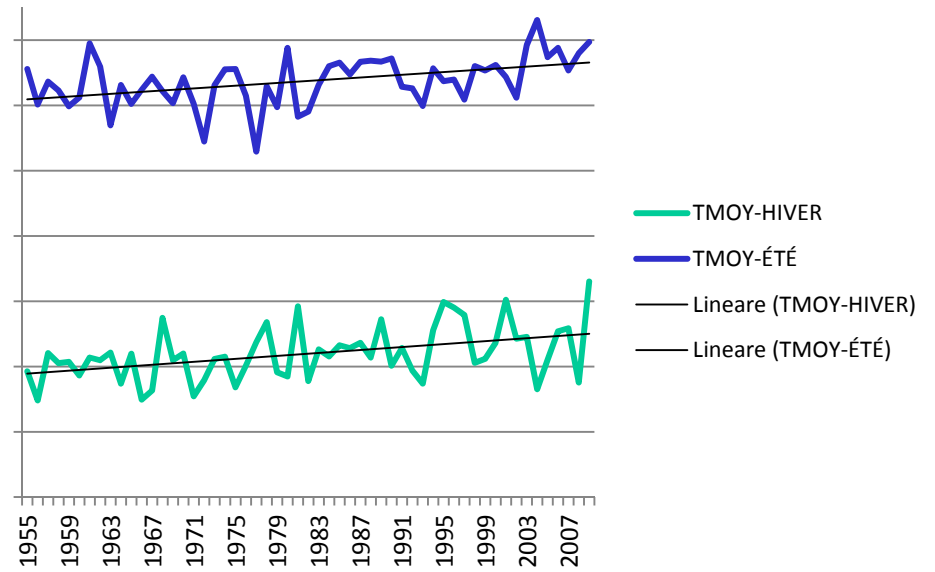
Température minimale Marrakech



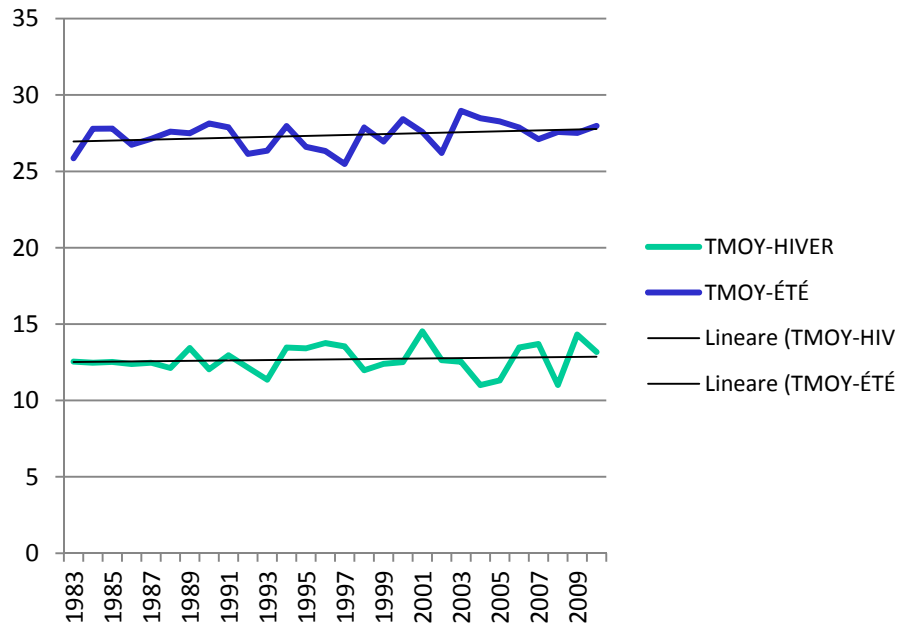
Température moyenne Kenitra



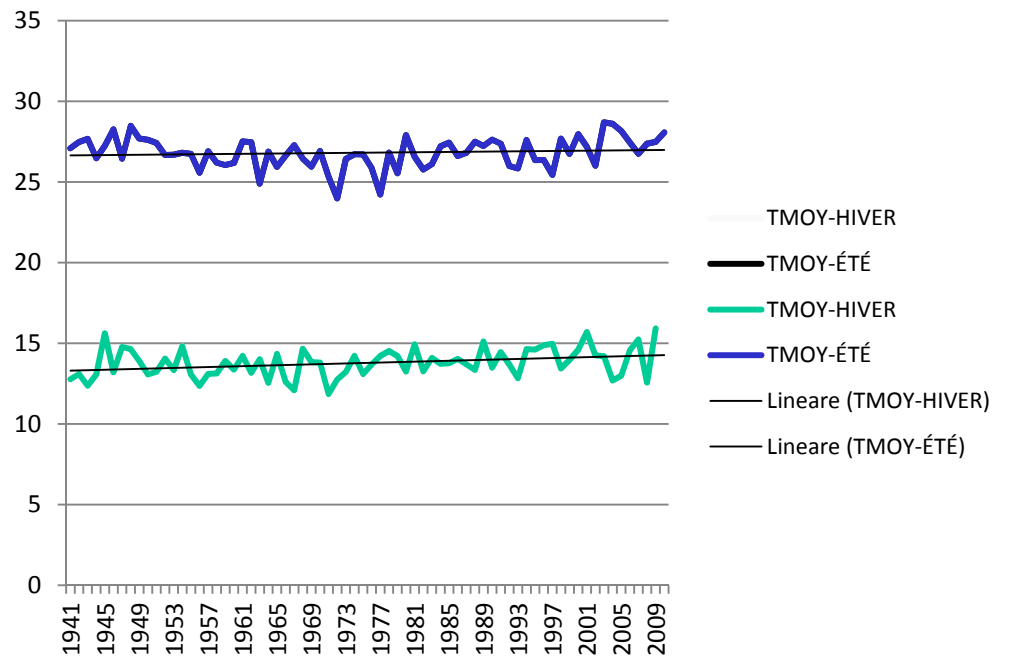
Température moyenne Safi



Température moyenne Kasba Tadla



Température moyenne Marrakech



Results

Temperature evolution

Seasonal scale

Temperature evolution ►

Extreme events

Weather types

	Tmax		Tmin		Tmean	
	Cold	Warm	Cold	Warm	Cold	Warm
Kenitra	↗	↗	—	↗	↗	↗
Safi	↗	—	↗	↗	↗	↗
Kasba Tadla	—	—	—	↗	—	↗
Marrakech	—	—	↗	↗	↗	—

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Extreme events

The study of seasonal events of maximal temperature using percentile calculation during each 5 years.

The percentiles used are: the 95th and the 99th.

Rare extreme events

Very rare extreme events

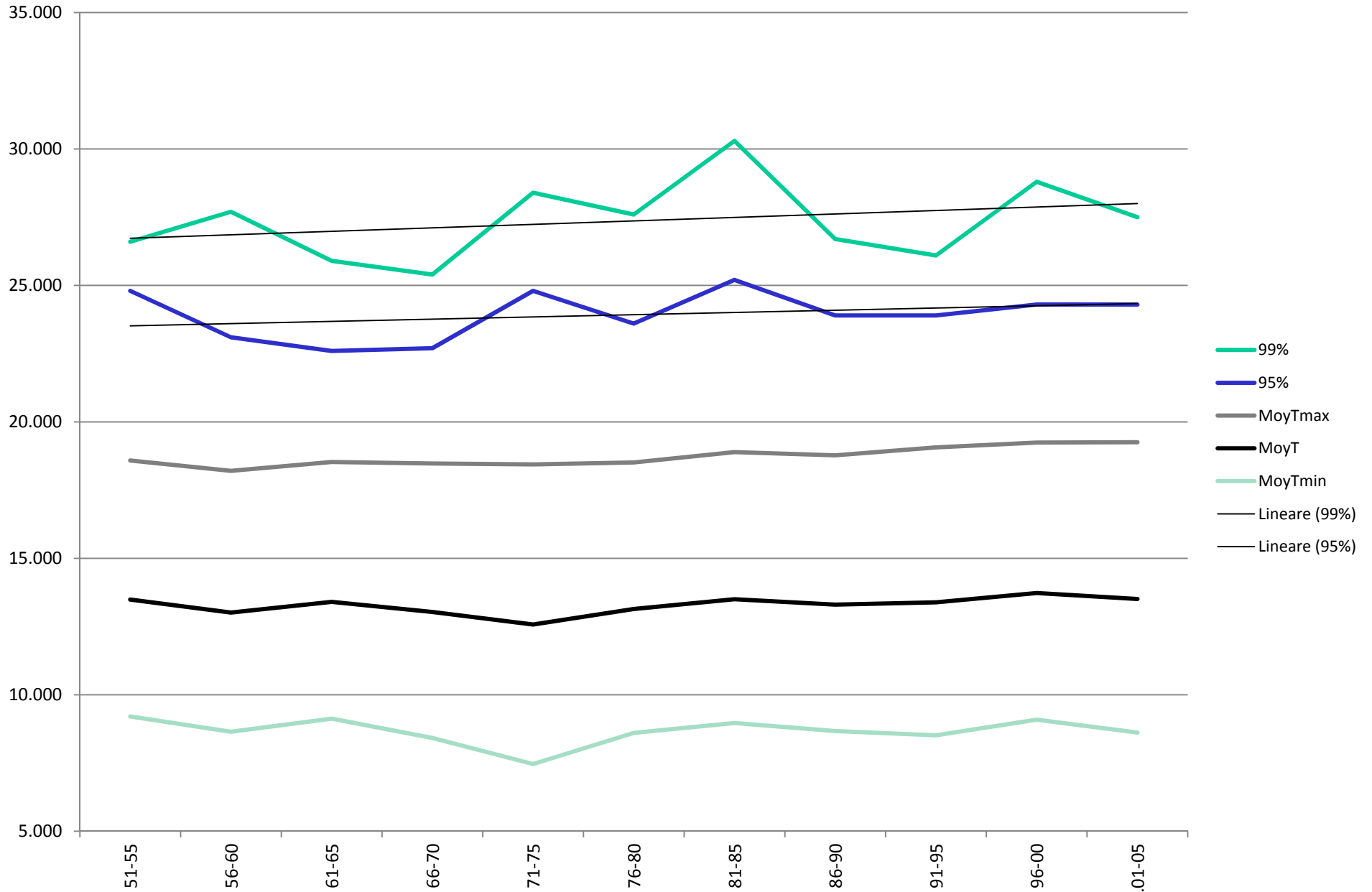
$95^{\text{th}} \leq \text{Days Tmax} < 99^{\text{th}}$

$99^{\text{th}} \leq \text{Days Tmax}$

A rare (very rare) extreme event of 2, 3, 4, ... days is a sequence of 2, 3, 4, ... rare (very rare) events of one day.

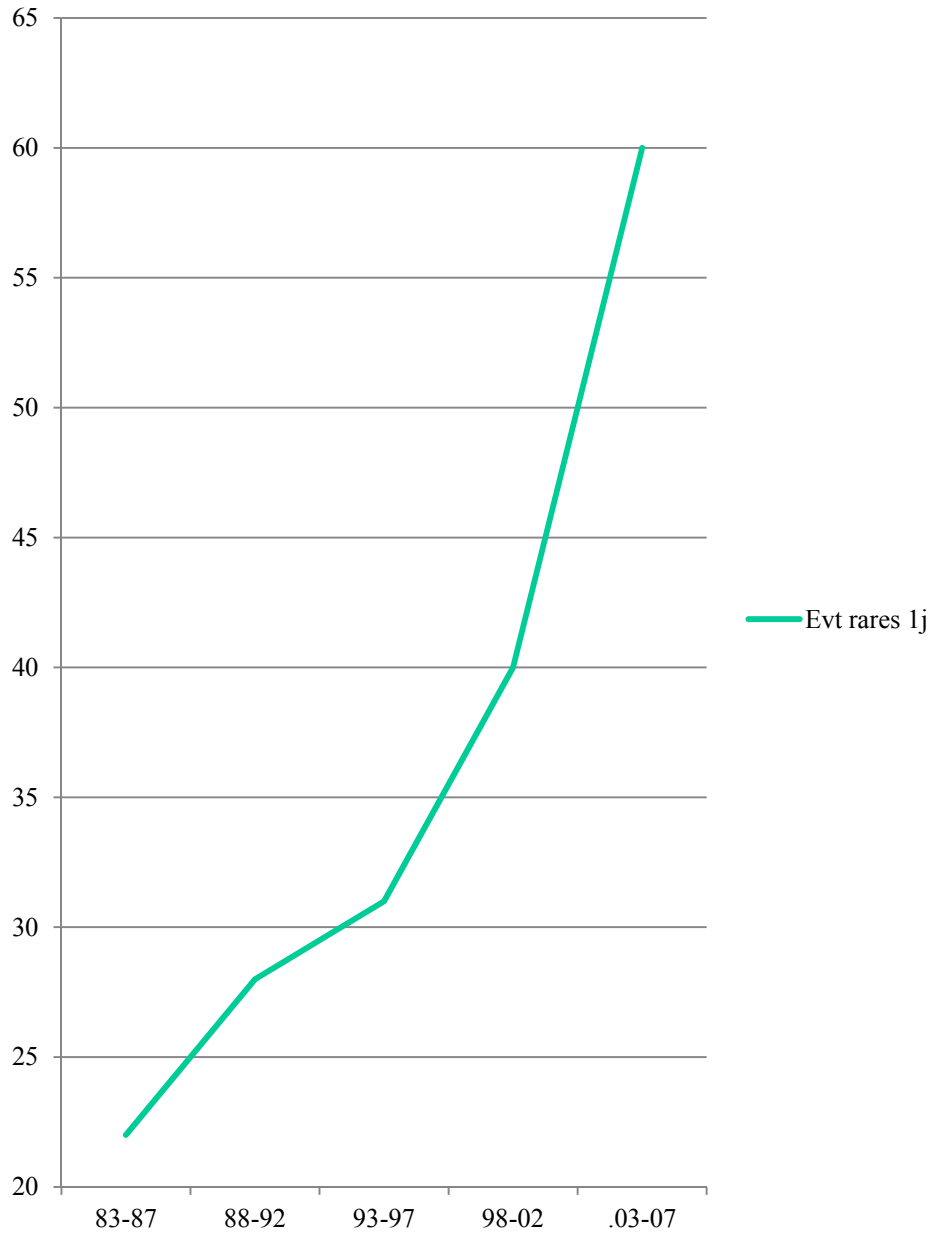
Evolution of percentiles : Cold season

Percentile Kenitra - Froide

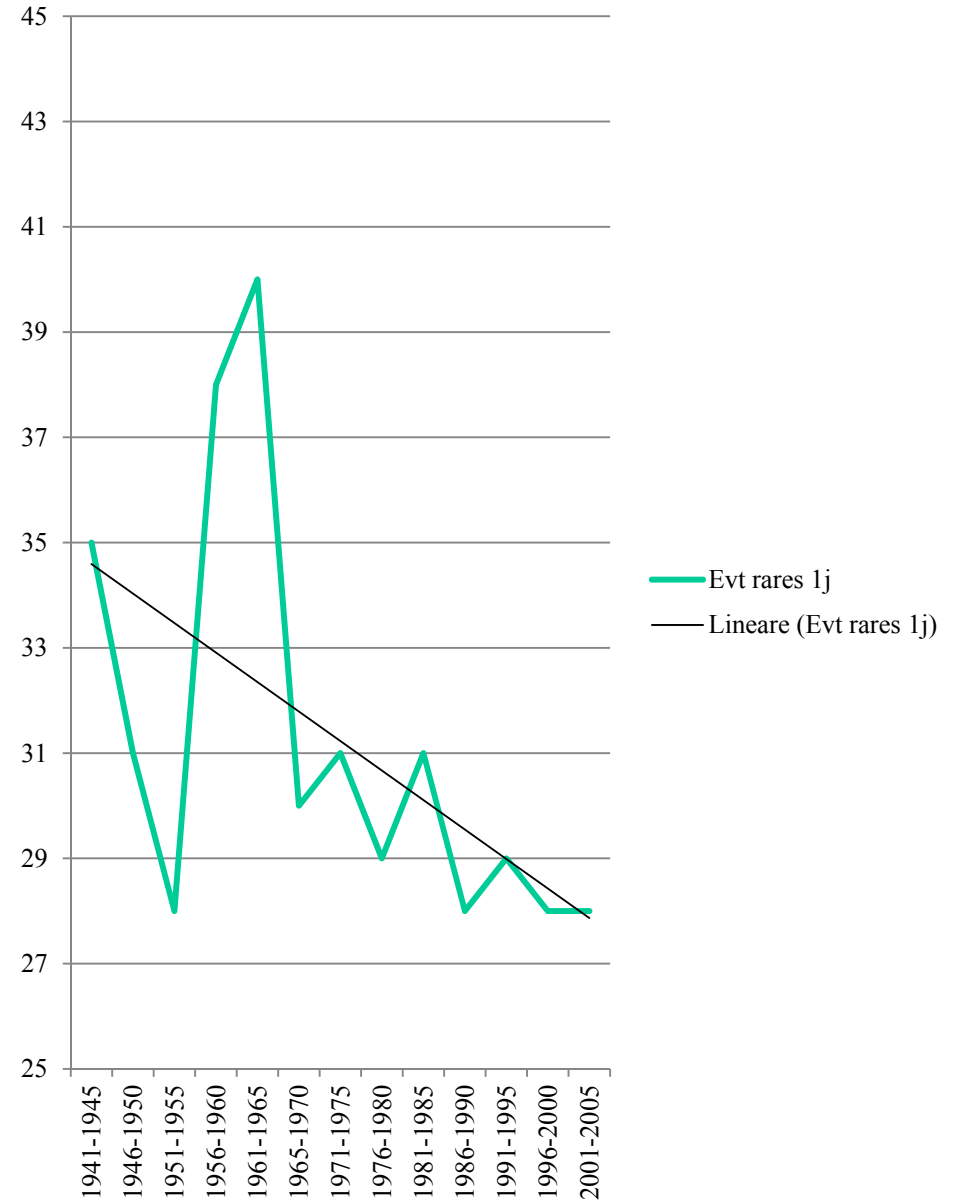


Evolution of 1 day rare extreme events : cold season

Evt rares 1j Kasba Tadla - Froide

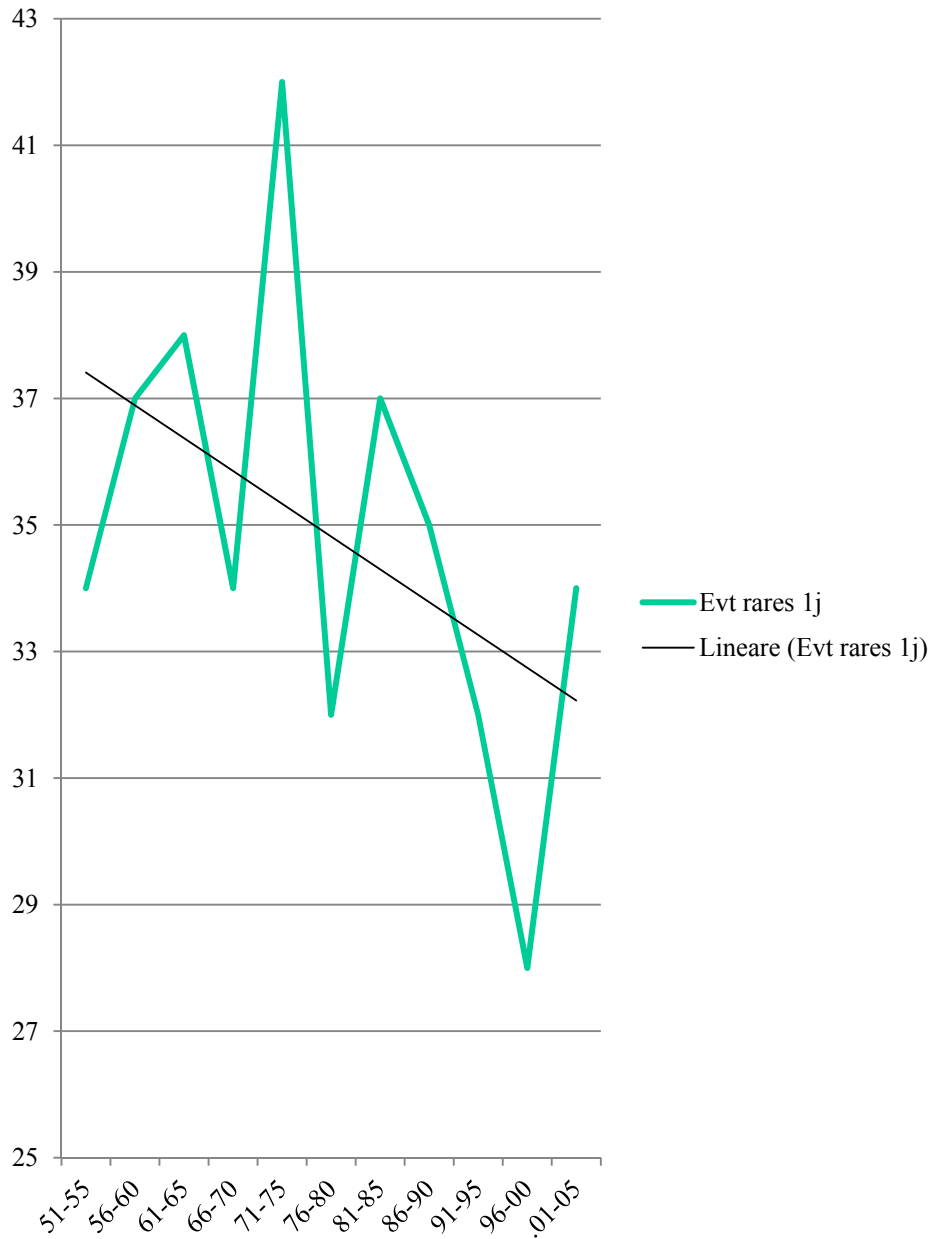


Evt rares 1j Marrakech - Froide

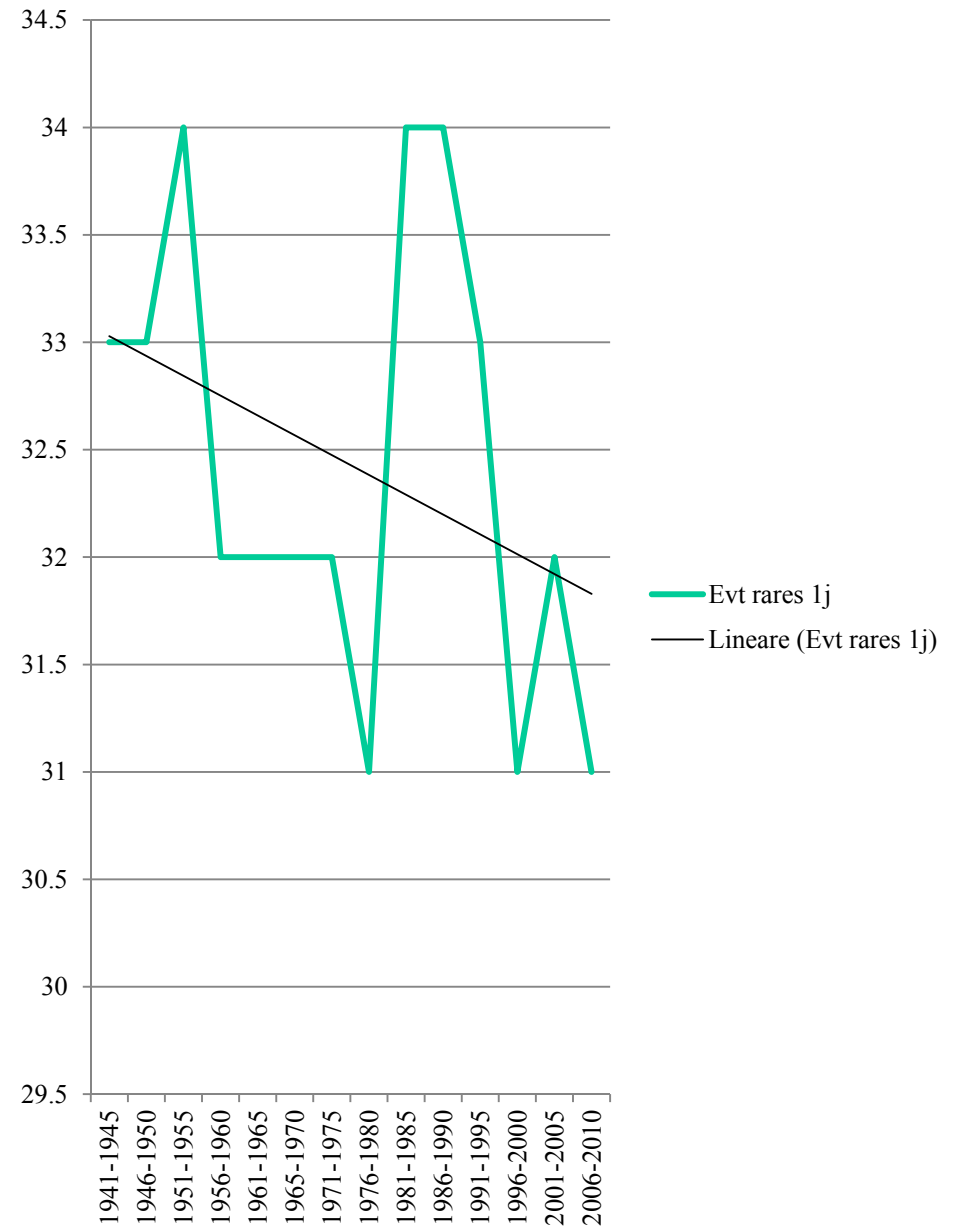


Evolution of 1 day rare extreme events : Hot season

Evt rares 1j kenitra - Chaude



Evt rares 1j Marrakech - Chaude

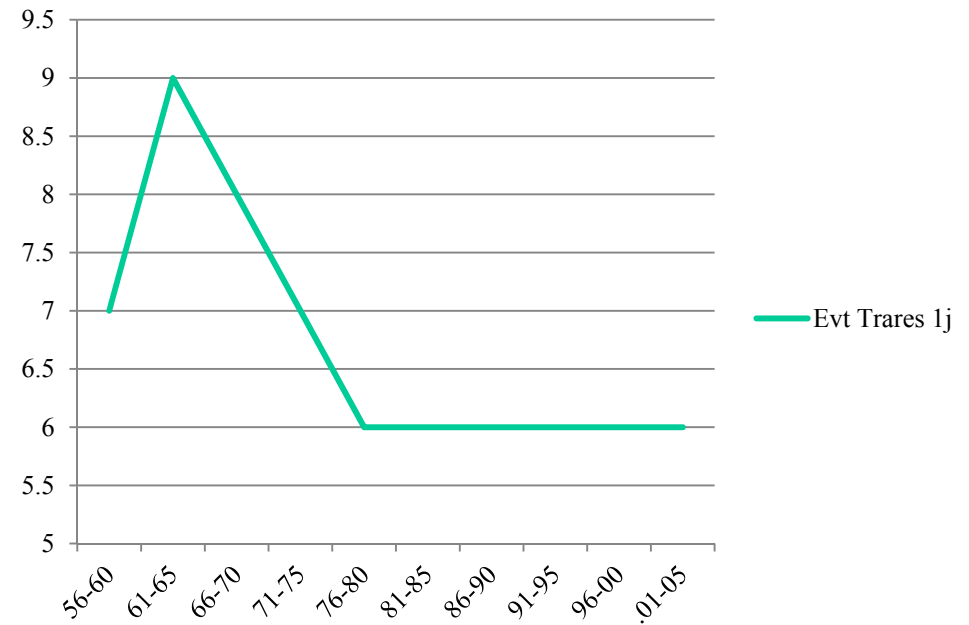


Evolution of 1 day very rare extreme events : cold season

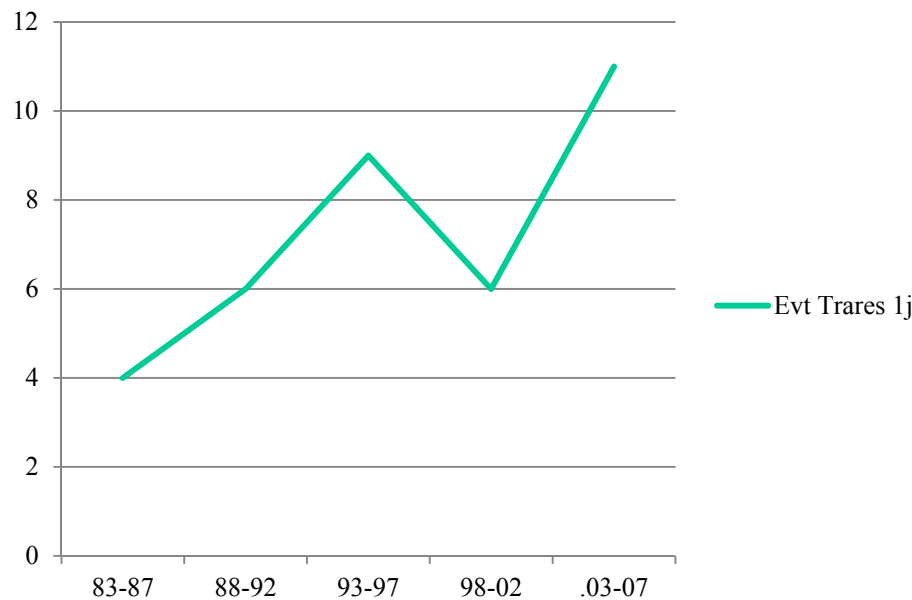
Evt Trares 1j Kenitra - froide



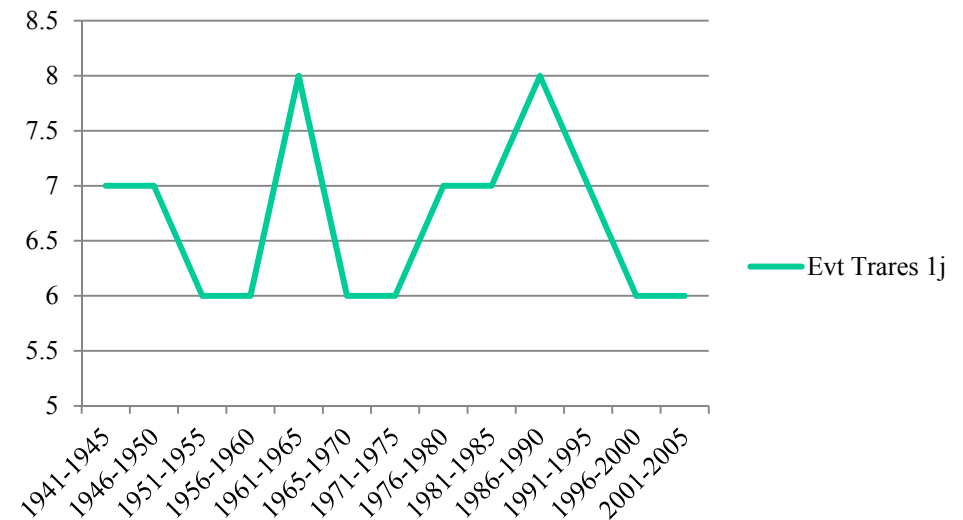
Evt Trares 1j Safi - Froide



Evt Trares 1j Kasba Tadla - Froide

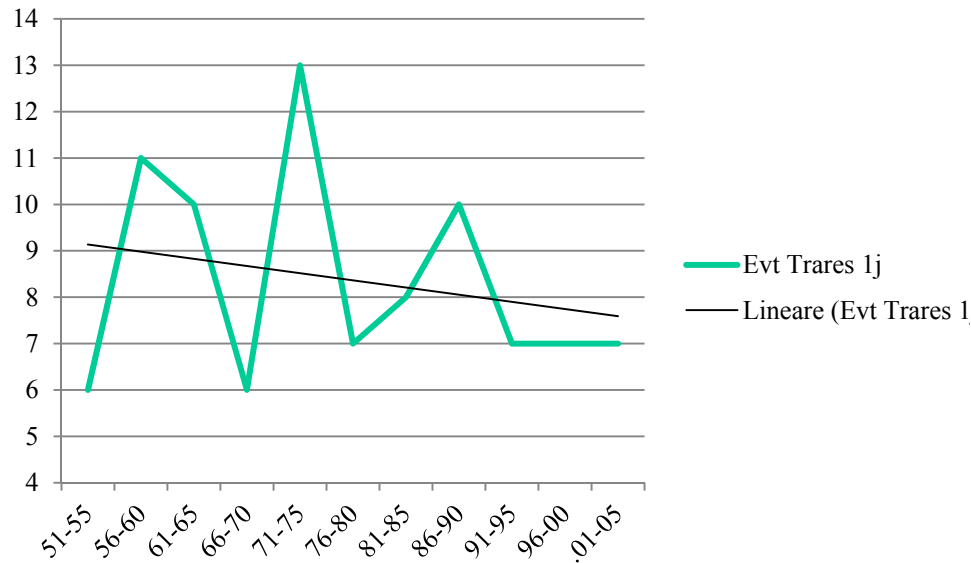


Evt Trares 1j Marrakech - Froide

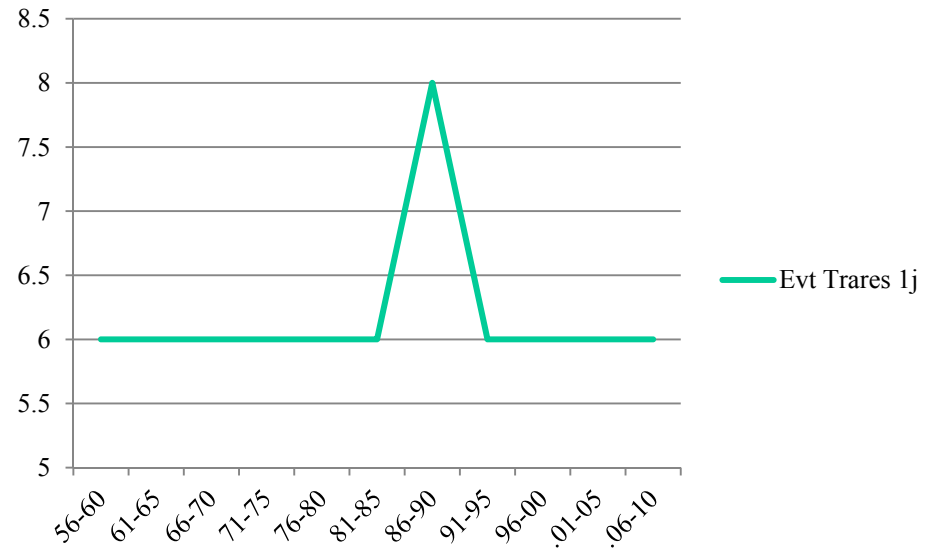


Evolution of 1 day very rare extreme events : Hot season

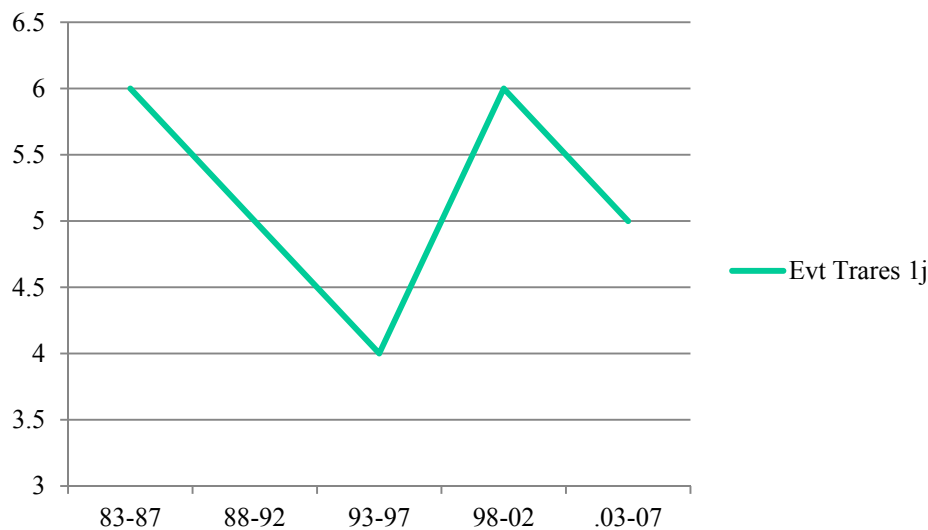
Evt Trares 1j Kenitra - Chaude



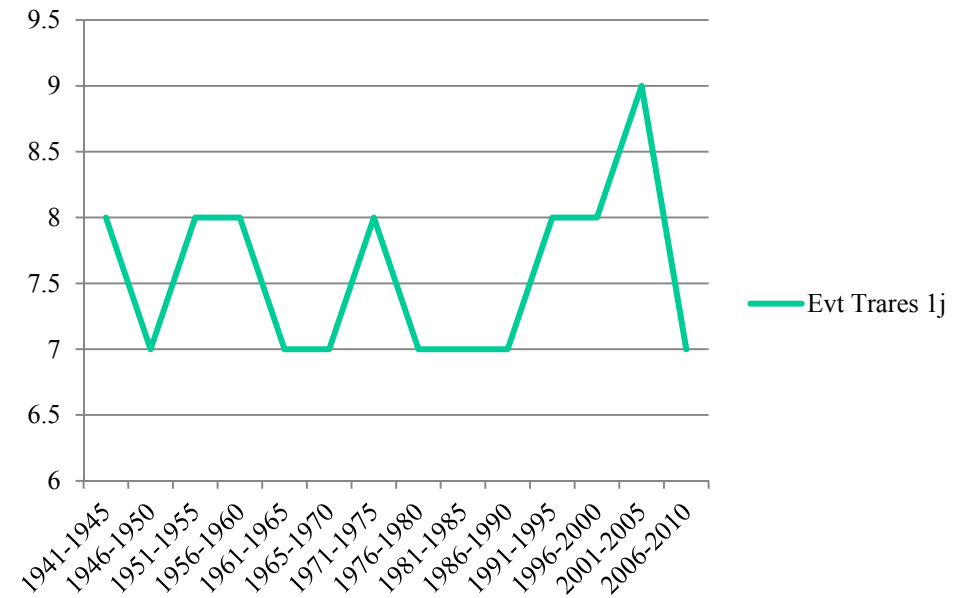
Evt Trares 1j Safi - Chaude



Evt Trares 1j Kasba Tadla - Chaude



Evt Trares 1j Marrakech - Chaude



Results

Extreme events

Temperature evolution

Extreme events ▶

Weather types

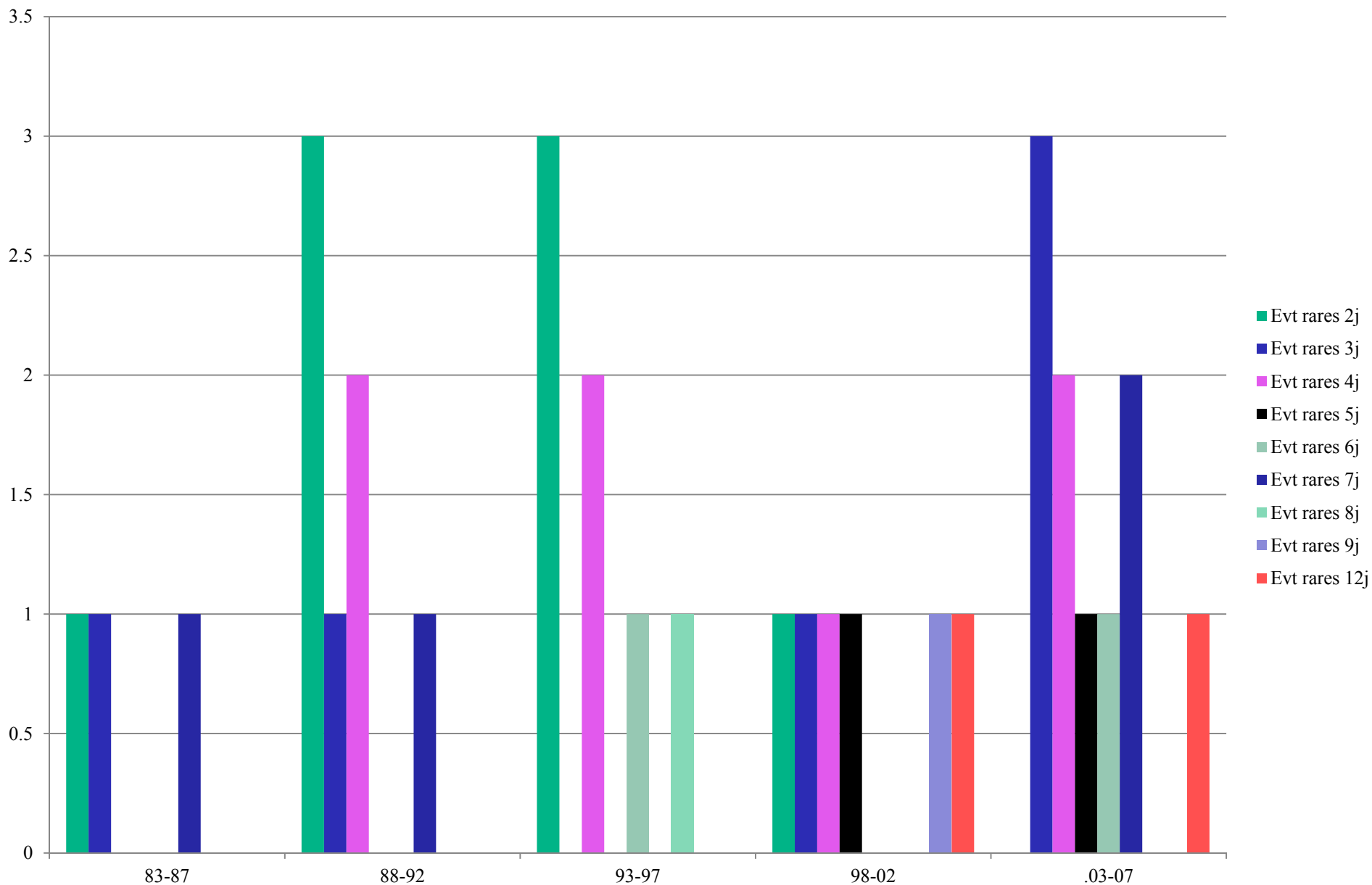
	1day rare extreme event		1day very rare extreme event	
	Cold	Warm	Cold	Warm
Kenitra	—	—	—	↘
Safi	↘	—	—	—
Kasba Tadla	↗	—	—	—
Marrakech	↘	—	↘	—

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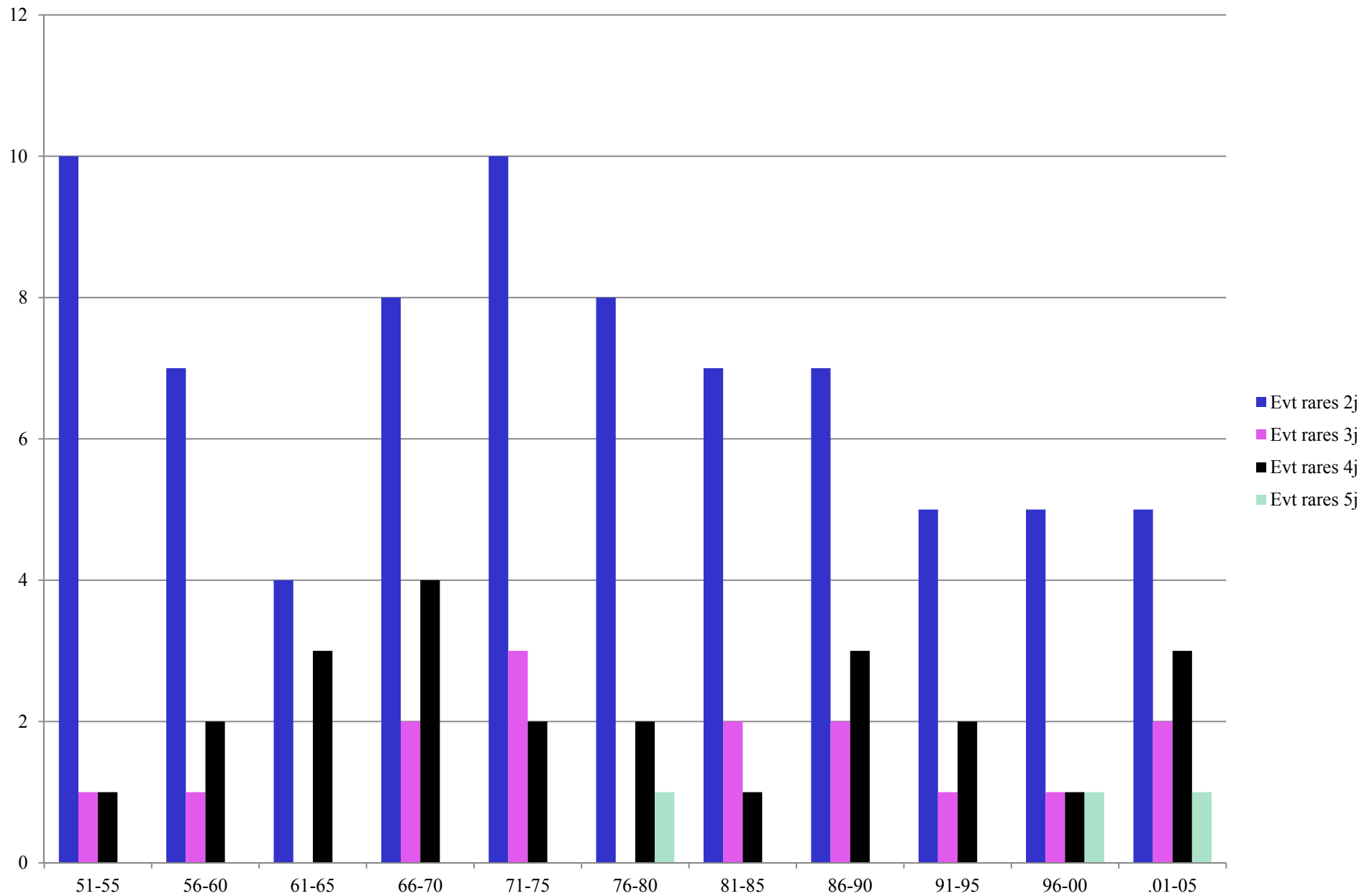
Evolution of more than 1 day rare extreme events : cold season

Evt rares > 1j Kasba Tadla - Froide



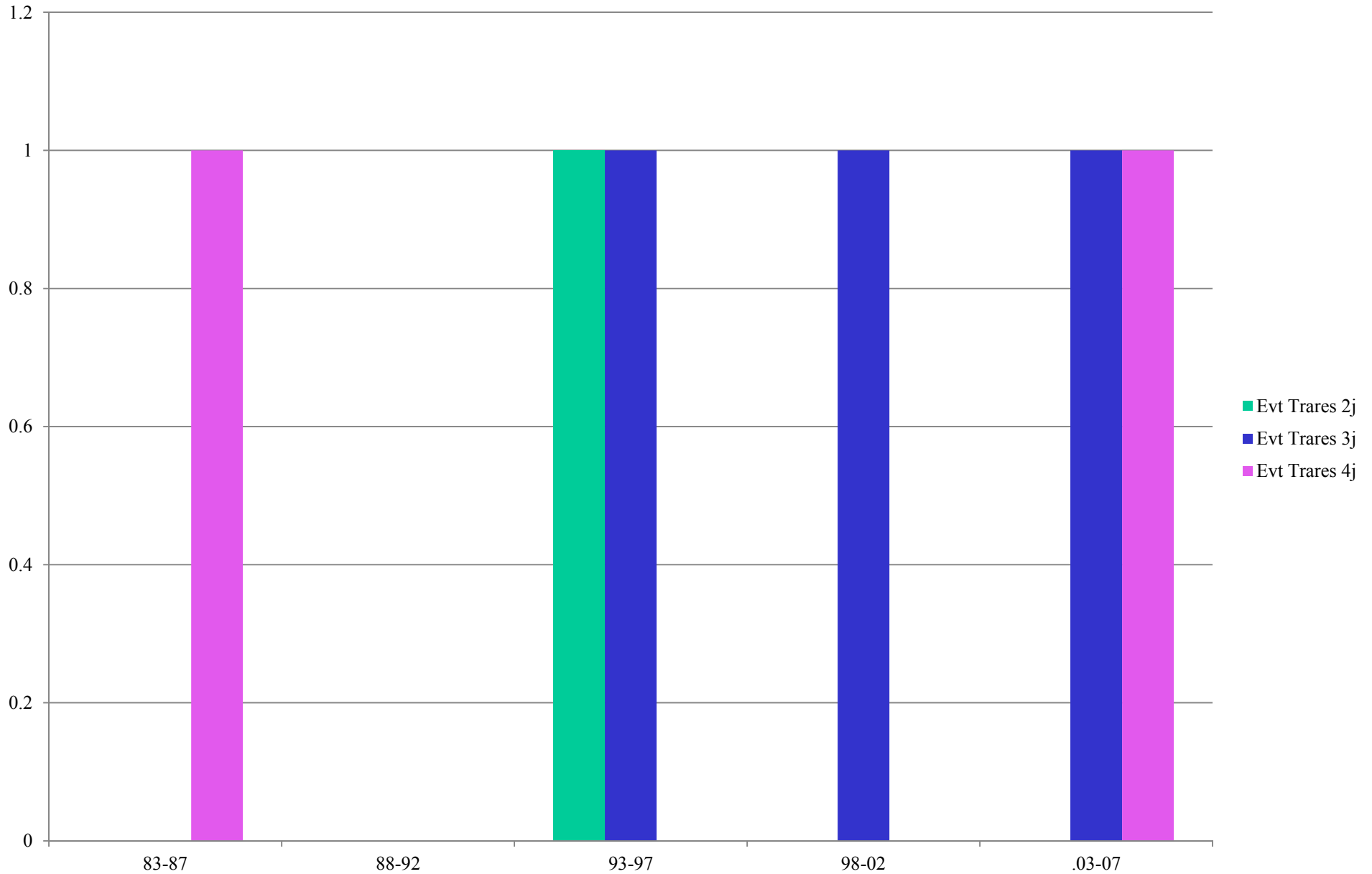
Evolution of more than 1day rare extreme events : Hot season

Evt rares > 1j Kenitra - Chaude



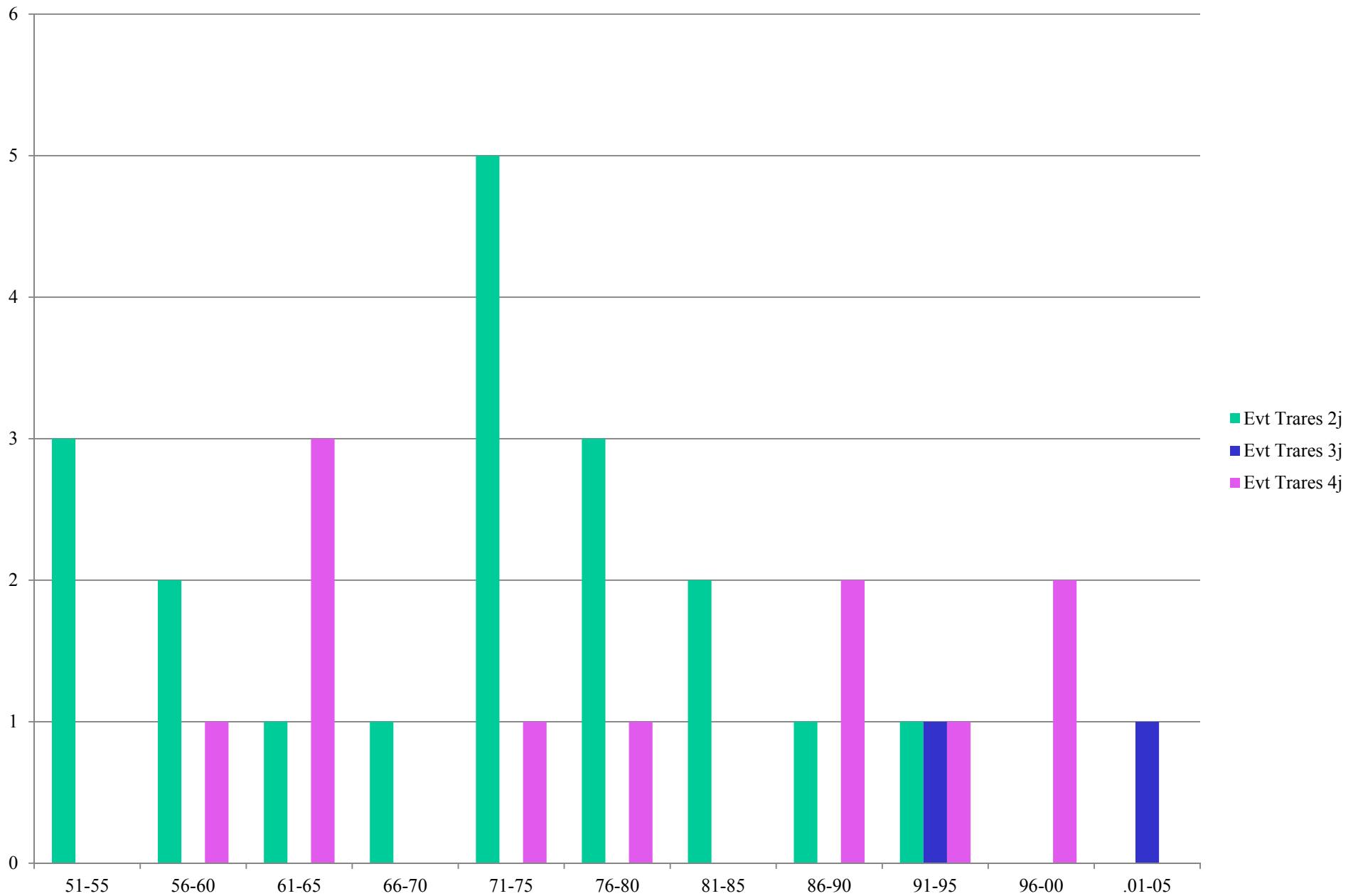
Evolution of more than 1 day very rare extreme events : cold season

Evt Trares > 1j Kasba Tadla - Froide



Evolution of more than 1 day very rare extreme events : Hot season

Evt Trares > 1j kenitra - Chaude



Extreme events

More than 1 day rare events evolution:

- Decrease of 2 Days extreme events in both seasons
- Increase of 3 & 4 Days extreme events in both seasons
- Apparition of longer rare events: 11D (Safi) & 12D (Kasba Tadla)

Temperature evolution

Extreme events ▶

Weather types

Extreme events

The study of seasonal events of maximal temperature using percentile calculation during each year between 2005 and 2010.

The percentiles used are: the 95th and the 99th.

Rare extreme events

Very rare extreme events

$95^{\text{th}} \leq \text{Days Tmax} < 99^{\text{th}}$

$99^{\text{th}} \leq \text{Days Tmax}$

A rare (very rare) extreme event of 2, 3, 4, ... days is a sequence of 2, 3, 4, ... rare (very rare) events of one day.

Results

Temperature evolution

Extreme events

Weather types ►

Weather types

**16 weather types
in Morocco**



Summer Circulation

Winter Circulation

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Results

Weather types

Summer Circulation

Regime of East :
Chergui

Ridge axis
on
Morocco

Summer
Circulation
and close
periodes

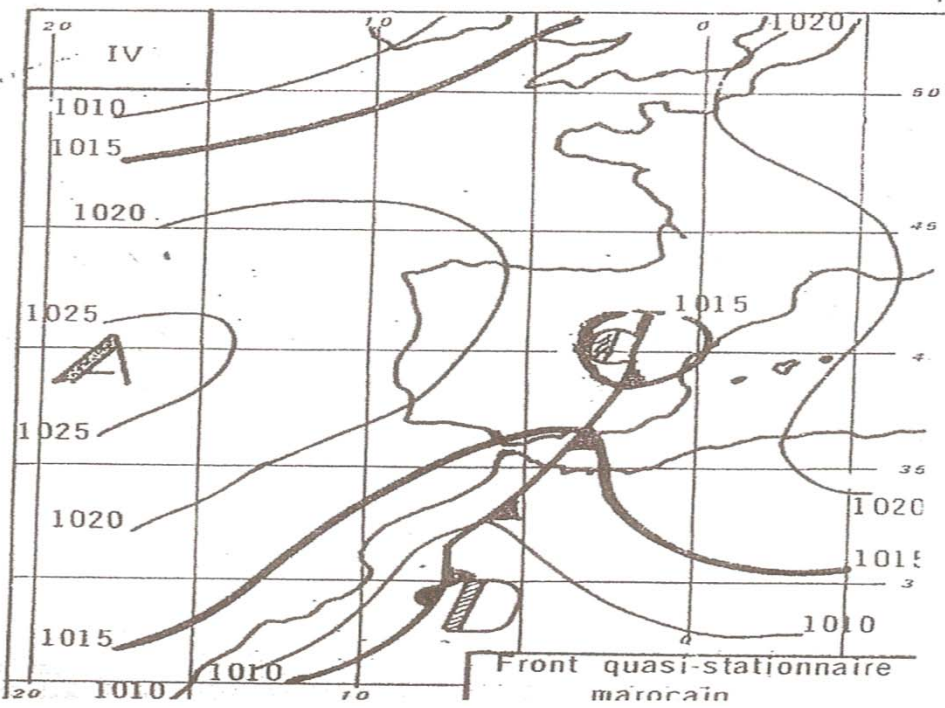
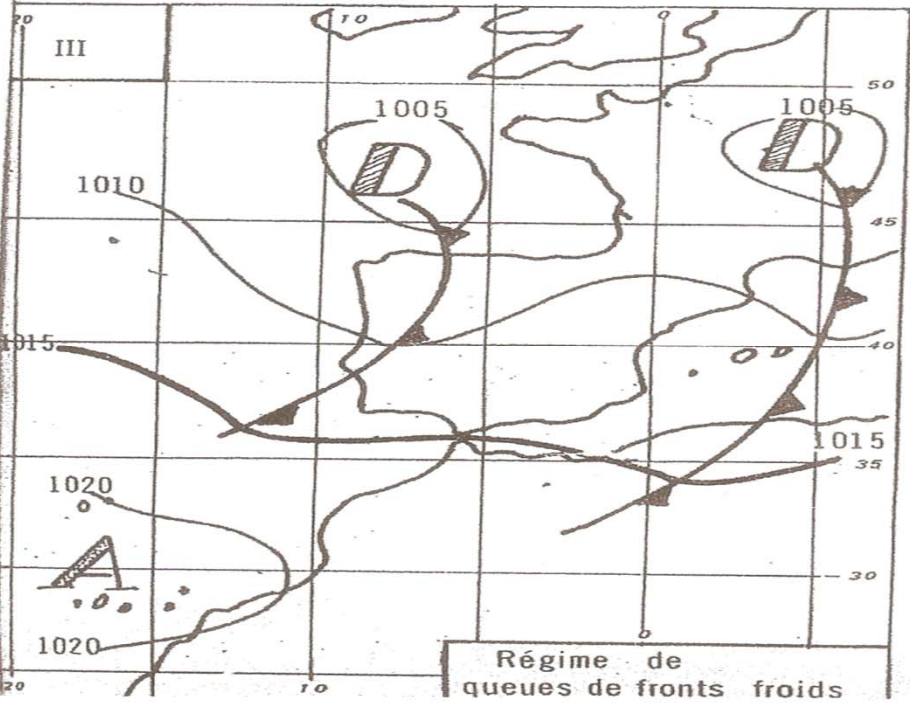
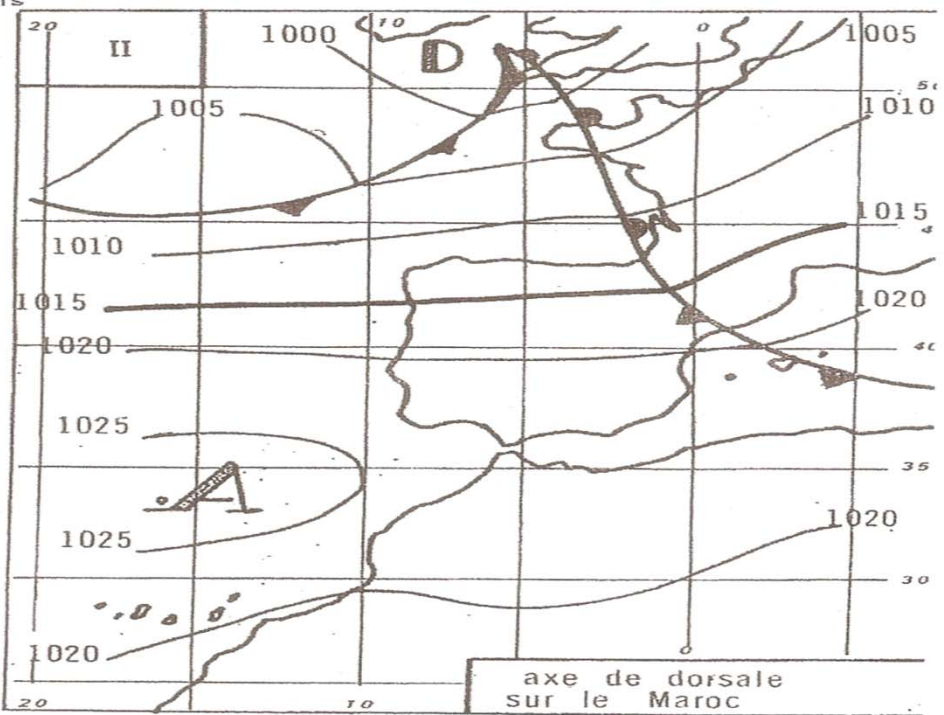
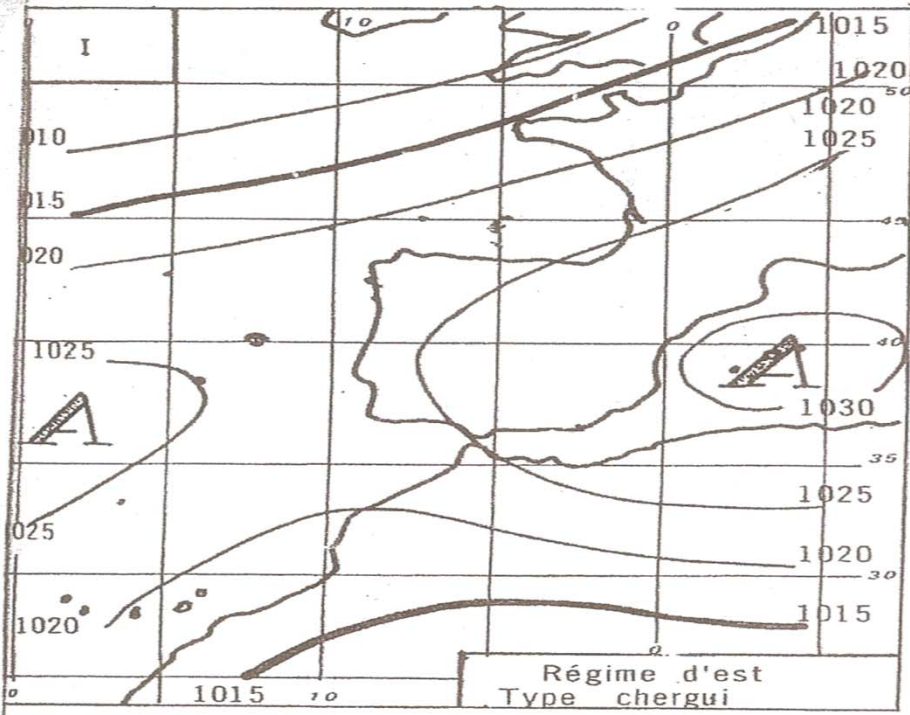
Mauritania
n slow
perturbatio
n

Cold tails
front
regimes

Moroccan
quasi-
stationary
front

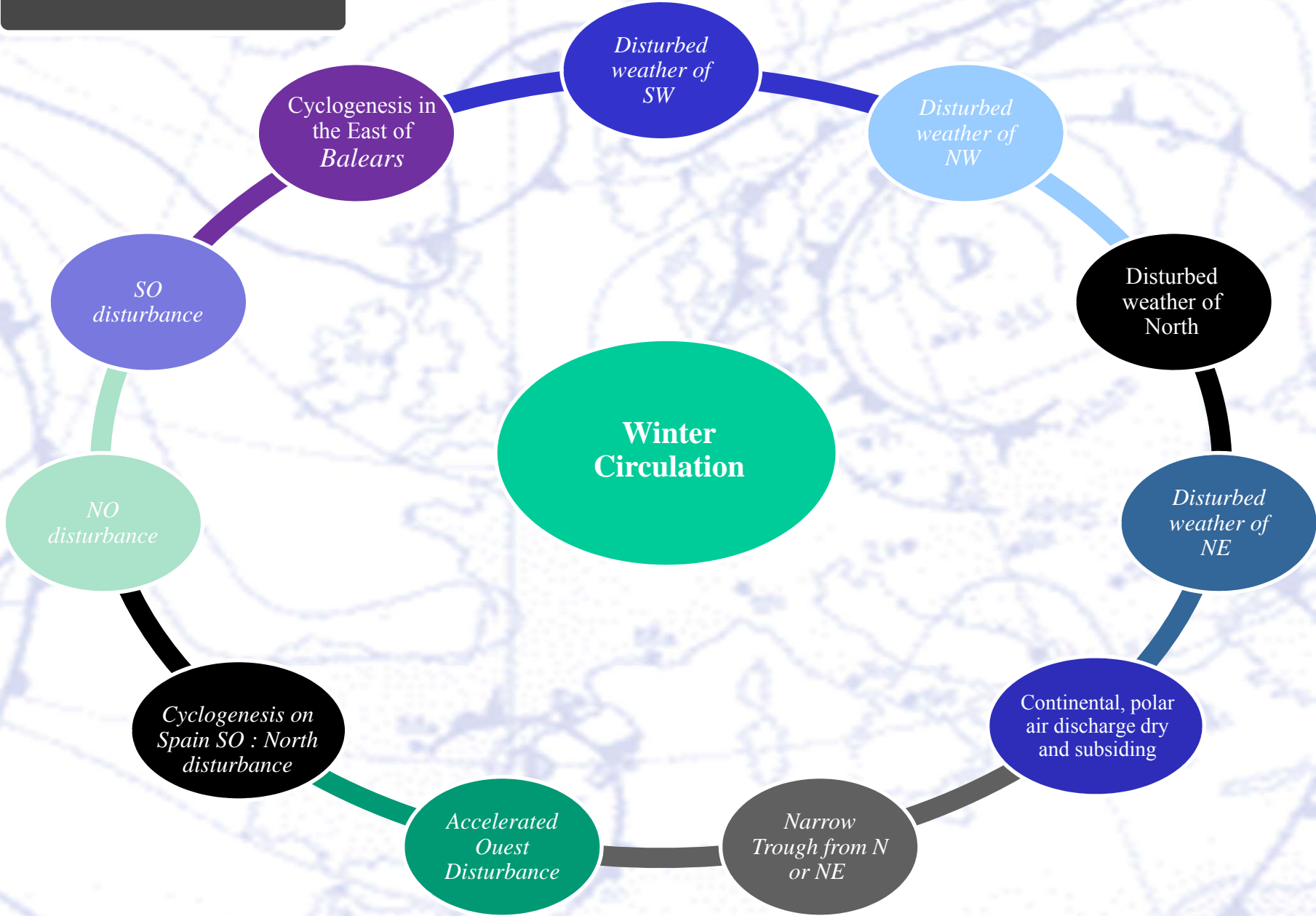
Cosenza

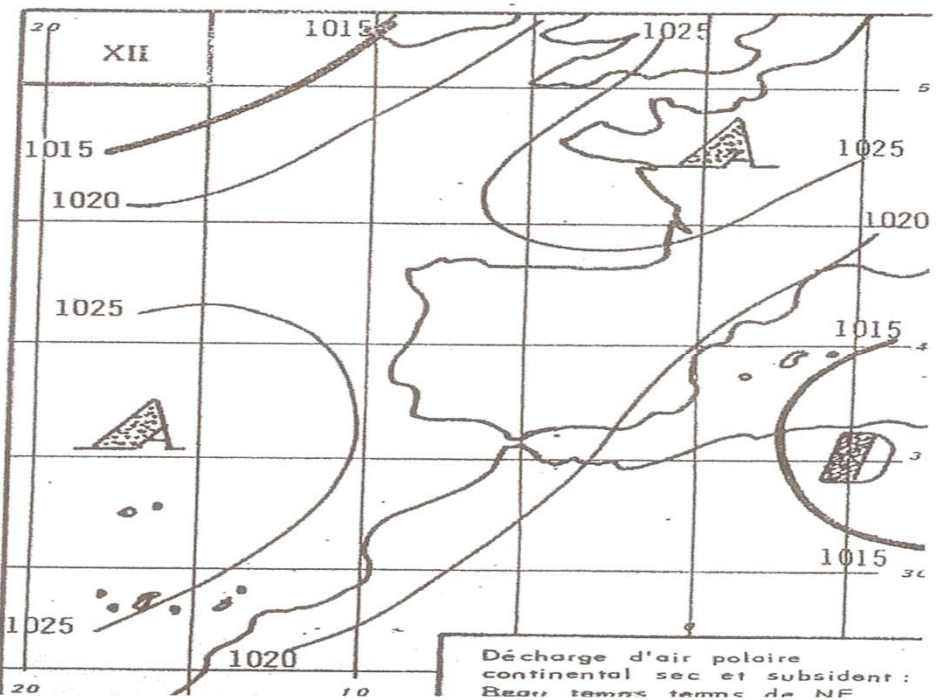
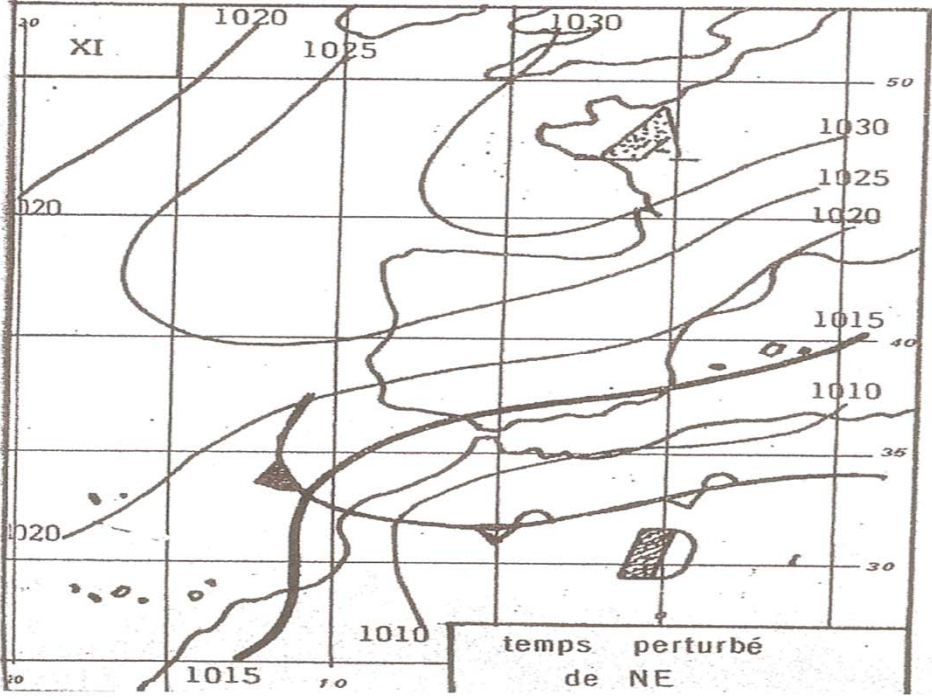
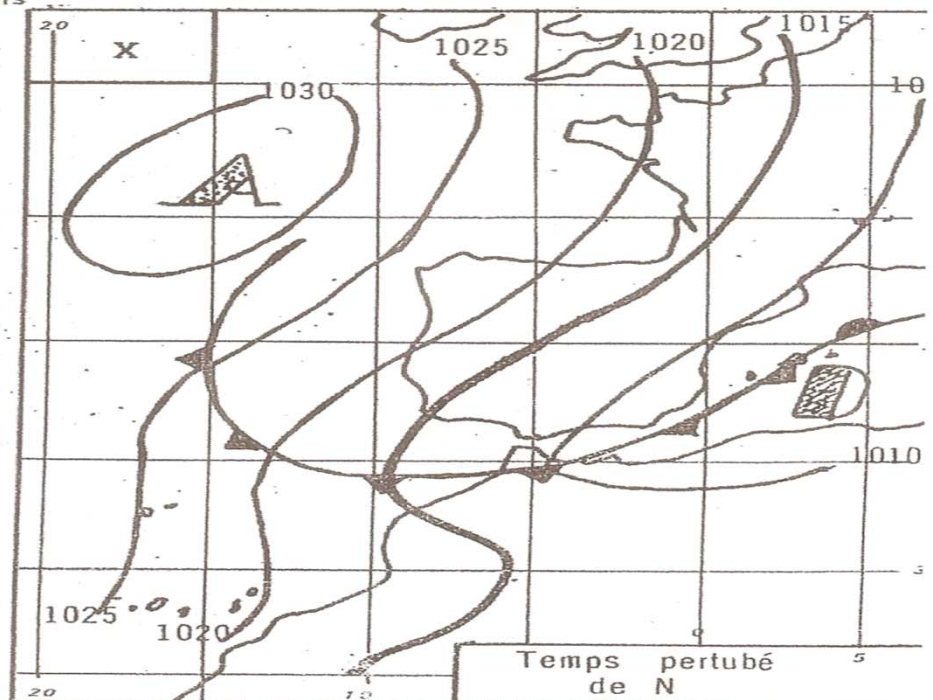
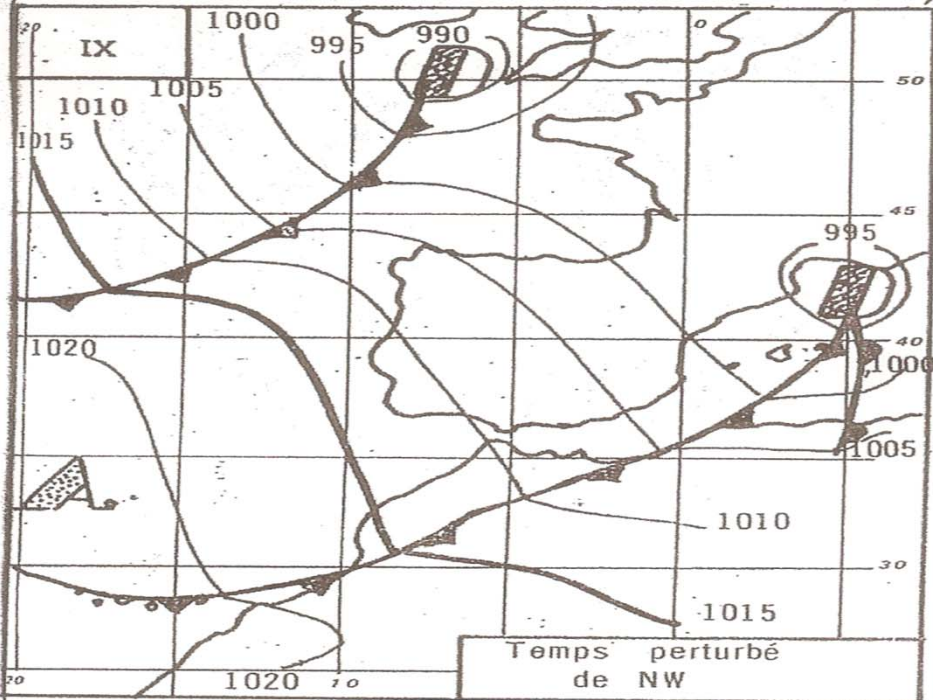
15-17/09/2011



Weather types

Winter Circulation





Temperature evolution

Extreme events

Weather types ►

Weather type	Frequency
Disturbed weather of SW	5
Dorsal axis on Morocco	4
Moroccan quasi-Stationary front	4
East regime: chergui	3
Cold front tails regime	3
NW disturbance	3
Slow mauritanian disturbance	2
Cyclogenesis on east Boreal	1

Frequency and weather types related to rare situations of maximum temperature in 2009



*Thank
you*