Synoptic situations and occurrence of extreme temperatures in the Iberian Peninsula

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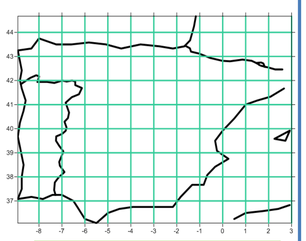
A-Introduction

Hot waves and cold spell events have a special attention in the last years due to their influence on human activities, health, agriculture, power supply, infrastructures and ecosystems (Bieli et al., 2015). In the context of climate change, there are evidences that extreme temperature episodes, and not only the mean temperature, are changing in response to the anthropogenic radiative forcing. This work is focused in the determination of the synoptic situations associated with the production of episodes of extreme temperature in Iberian Peninsula . A Lagrangian approach is used in order to provide information about the pathways of the air masses causing the 0.1% most extreme hot and cold events for the 20-year period 1994-2013. The relationship between the synoptic situations and extreme events has been studied at the mean sea level pressure and at 850 and 700 hPA geopotential by using different methodologies: 1) the averaged data of the extreme days ; 2) by applying principal component analysis (PCA) in direct and inverse (T-mode) mode; 3) by using the Hess-Brezowsky (GWL) catalogue and, 4) by using a subjective method based on the visual analysis of the synoptic charts from the Plymouth State Weather Center.

B-Material & methods

1- Data

12-hourly max/min temperatures at 2 m height from the ERA-Interim reanalysis data (ECMWF) PERIOD: 1994-2013



Domain:
Grid of 10º×13º lat/lon
Resolution: 1ºx1º

2- Extreme definition:

HOT extreme: T (2m) Max > 99.9 th percentile
COLD extreme: T (2m) Min < 0.1 th percentile

3-Backward trajectories for the extreme events:

- 10-day isosigma back-trajectories using HYSPLIT-4 (NOAA) (Draxler, 1998)
- NCEP/NCAR Reanalysis data
- Vertical levels: 100, 500 and 1500 m.a.s.l.

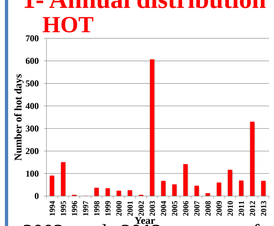
4-Synoptic situations

- Studying the mean air pressure for all extreme events in 20years in three vertical levels
- Using principle component analyses (PCA) for air pressure value in Direct Mode data and T-mode matrix.
- Studying the synoptic situations for all extreme events visional **(Plymouth Weather Center)**
- Using the Hess-Brezowsky (HB) catalogue also known as Grosswetterlangen or GWL catalogue to study synoptic pattern for all extreme events in Europe.

C- Results

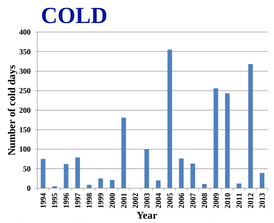
1- Annual distribution

HOT



2003 and **2012** account for **40%** of the total hot events

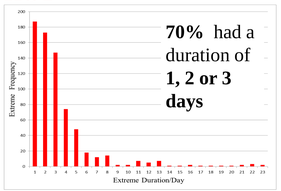
COLD



2005, 2009, 2010 and **2012** account for **60%** of the total cold events

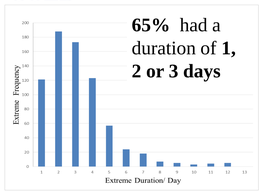
2- Time duration

HOT



70% had a duration of **1, 2 or 3 days**

COLD



65% had a duration of **1, 2 or 3 days**

3-Trajectory distance 4 days before the extreme arrivals

Median (Km)		
Hot 100 m	**Hot 500 m**	**Hot 1500 m**
717	781	1119
Cold 100 m	**Cold 500 m**	**Cold 1500 m**
2135	2051	2015

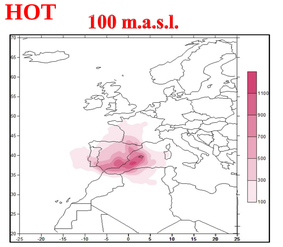
The median travel distance for hot events is substantially lower than the corresponding one for cold events.

4- Trajectory densities

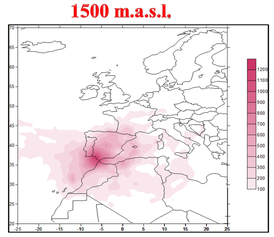
4-days trajectory densities for H/C extremes at 100 and 1500 m.a.s.l.

HOT

100 m.a.s.l.



1500 m.a.s.l.

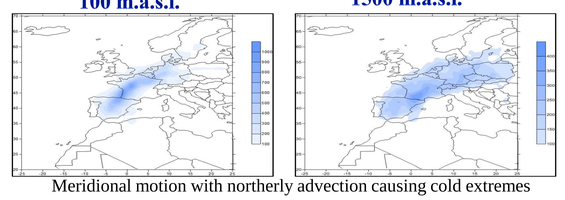


Prevalence of atmospheric blocking and regional recirculations in hot events

COLD

100 m.a.s.l.

1500 m.a.s.l.



Meridional motion with northerly advection causing cold extremes

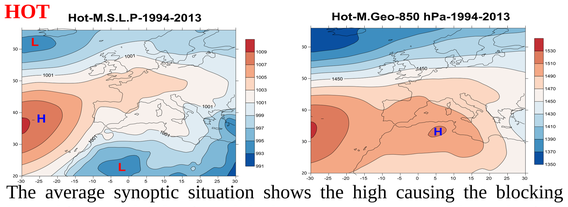
5- Synoptic situation

5-1 Mean synoptic situation for H/C extremes.

HOT

Hot-M.S.L.P-1994-2013

Hot-M.Geo-850 hPa-1994-2013

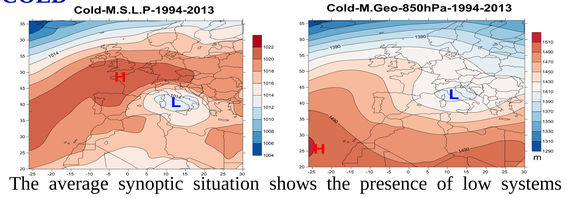


The average synoptic situation shows the high causing the blocking located in central Atlantic and the low pressure system of thermal origin over North Africa caused by intense heating.

COLD

Cold-M.S.L.P-1994-2013

Cold-M.Geo-850hPa-1994-2013



The average synoptic situation shows the presence of low systems in South Europe and high pressures over North Europe advecting cold air from the northeastern Europe regions to the Iberian Peninsula.

5-2 Subjective analysis of the synoptic situations

Plymouth Weather Center- See level Pressure

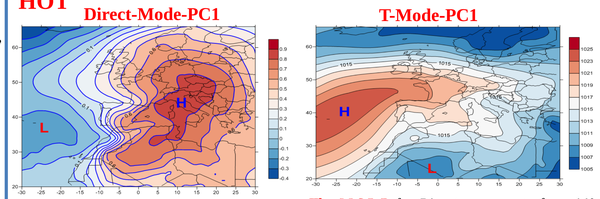
Extreme Hot events	LOW	High	Low-High	
142	58%	8%	34%	Low→ Cyclone in Iberian Peninsula High → Anti Cyclone in Iberian Peninsula
Extreme cold events	**LOW**	**High**	**Low-High**	**Low -High→ Cyclone and Anticyclone in Iberian Peninsula**
88	13%	45%	42%	

5-3 Principal Component Analysis (PCA)

HOT

Direct-Mode-PC1

T-Mode-PC1



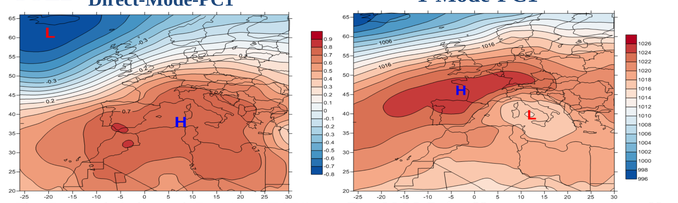
The Empirical Orthogonal Functions (EOF1) that explains **25%** of total variance had shown a strong positive correlations p<0.9-0.6 between Air pressure and a Longitude-Latitude in center of Europe ,The Mediterranean Sea and Algeria desert and weaker negative correlations p<-0.2 in the Atlantic Ocean.

The M.S.L.P for **54 extreme** events from **140** which had a maximum variance in the Empirical Orthogonal Functions (EOF1) that explains 40% of total variance. There are two air pressure systems , the first, Anticyclone center in the Atlantic Ocean extending to IP and second, Cyclone centered in North Africa extending to IP.

COLD

Direct-Mode-PC1

T-Mode-PC1



The Empirical Orthogonal Functions (EOF1) that explains **32%** of total variance had shown a strong positive correlations p<0.9-0.6 between Air pressure and a Longitude-Latitude in The Mediterranean Sea and Algeria desert and weaker negative correlations p<-0.2 in the Atlantic Ocean

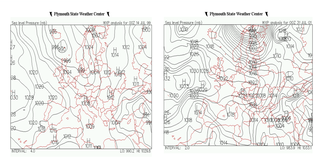
The M.S.L.P for **32 extreme** events from **88** which had a maximum variance in the Empirical Orthogonal Functions (EOF1) that explains 40% of total variance. There are two air pressure systems ,the first, Anticyclone in the Atlantic Ocean extending to IP and second, Cyclone centered in North Africa extending to IP

5-4 Synoptic pattern for H/C events

The Hess-Brezowsky (HB) catalogue (1881-2009)

HOT

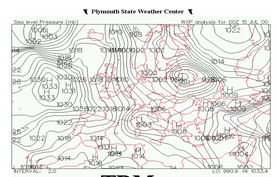
WZ (Cyclonic westerly)	**19**	**17%**
BM (Zonal ridge across central Europe)	**27**	**25%**



WZ BM

Cold

BM	**9**	**14%**
TRM (Trough over central Europe)	**14**	**22%**



TRM

D- Conclusions

- The warm air mass advection from Northern Africa regions(The Thermal low pressure) are a relevant factor for hot extremes in the Iberian Peninsula.
- For hot extreme events ,there are a high correlation between Air pressure system and Longitude-Latitude in center of Europe .
- The presence of low systems in South Europe and high pressures over East and Central Europe are the main features during cold extreme events in the Iberian Peninsula.

Acknowledgments

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References

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R. Draxler, An Overview of the HYSPLIT4 Modelling System for Trajectories, Dispersion, and Deposition, Roland NOAA Air Resources LaboratorySilver Spring, Maryland, U.S.A, Australian Meteorological Magazine, 47 (295-308), 1998.