

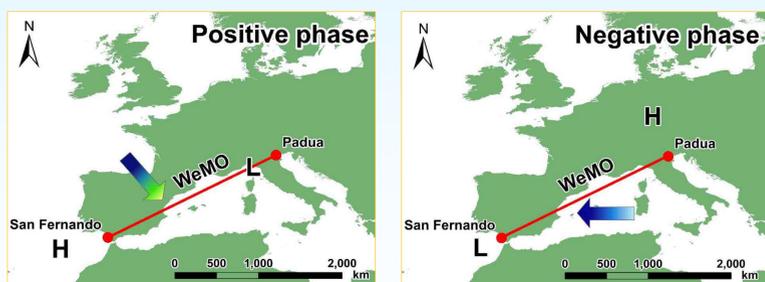
Intraannual variability of the Western Mediterranean Oscillation (WeMO) and occurrence of extreme torrential rainfall in Catalonia (NE Iberia)

Joan A. Lopez-Bustins⁽¹⁾, Javier Martin-Vide⁽¹⁾, Laia Arbiol-Roca⁽¹⁾ and Marc Prohom⁽²⁾

⁽¹⁾ Climatology Group, University of Barcelona (UB), Spain (jlopezbustins@ub.edu)

⁽²⁾ Meteorological Service of Catalonia (SMC), Barcelona, Spain

Phases of the Western Mediterranean Oscillation index (WeMOi)



The WeMOi is a regional teleconnection index defined within the western Mediterranean basin. WeMOi values are computed using surface pressure data from San Fernando (SW Spain) and Padua (NE Italy) weather stations. The reference period considered is 1961-1990.

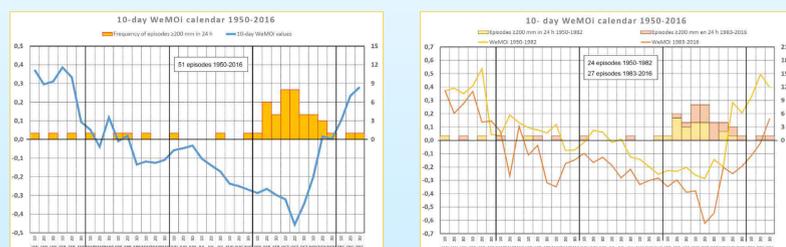
WeMOi calendars

We computed daily WeMOi values for the 1950-2016 study period and constructed a WeMOi calendar (intraannual variability) based upon the mean values obtained for 10-day periods.

The lowest (most negative) WeMOi values are detected in autumn, during the second 10-day period of October (from the 11th to the 20th of October).

We also constructed WeMOi calendars for two subperiods: 1950-1982 (33 years) and 1983-2016 (34 years), observing an overall decrease in WeMOi values, particularly as from the second 10-day period of November to the second 10-day period of December.

We added the frequency of the torrential episodes to the WeMOi calendars in order to detect intraannual changes in these events.



Selection of the extreme torrential episodes in Catalonia (NE Iberia)

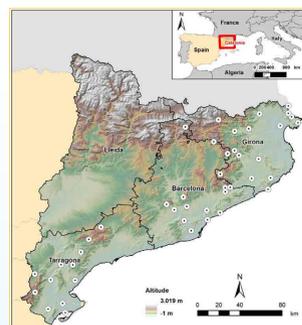
We selected the extreme torrential episodes (≥ 200 mm in 24 hours) that had taken place over the coastal provinces of Catalonia (Girona, Barcelona and Tarragona) (NE Spain) during the 1950-2016 study period (67 years).

Data are from several sources (SMC, AEMet, ACA and CHE) and from both automatic and manual weather stations. The pluviometric 7-7 UTC period is considered along the whole study period.

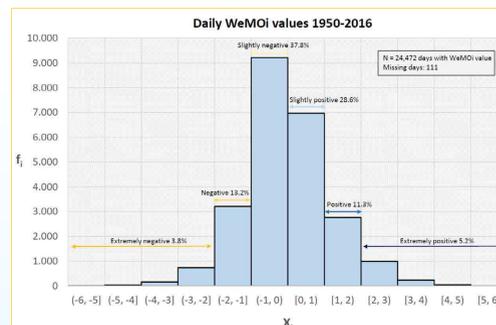
During the 1950-2016 period, 51 episodes were detected (0,8 cases per year); these were mainly concentrated in the Eastern Pyrenees (Girona) and southern Catalonia (Tarragona). The table on the right-hand side displays the list of episodes including date, maximum precipitation, location, province and daily WeMOi value.

The highest rainfall amount in 24 hours ever recorded in Catalonia is 430 mm. This occurred in Cadaqués (on the coast of Girona province) on 13th October 1986.

Daily WeMOi values follow a Gaussian distribution. Most days (66.5%) of the 1950-2016 study period showed a neutral (-1, 1) WeMOi value. We considered the threshold of $WeMOi \leq -1$ (13.2% of the days) and $WeMOi \leq -2$ (3.8% of the days) to detect a negative and extreme negative WeMO phase, respectively, at daily resolution.



Study area. 43 different weather stations registered at least once the highest rainfall amount during an extreme torrential event.



Date	Max PRECIP (mm)	Location	Province	WeMOi value
13 October 1986	430.0	Cadaqués	Girona	-2.22
11 April 2002	367.5	Darnius	Girona	-3.85
20 September 1971	308.0	Esparreguera	Barcelona	-1.75
20 September 1972	307.0	Sant Carles de la Ràpita	Tarragona	-1.58
09 October 1994	293.0	Cornudella de Montsant	Tarragona	-2.88
03 October 1987	291.0	Castelló d'Empúries	Girona	-1.96
22 September 1971	285.0	Cadaqués	Girona	-2.19
19 October 1977	276.0	Cadaqués	Girona	-2.80
21 September 1971	275.0	Santa Maria de Palautordera	Barcelona	-2.21
18 October 1977	271.8	Camprodon	Girona	-2.21
21 October 2000	270.0	Faietà	Tarragona	-2.26
07 November 1982	266.0	la Pobla de Lillet	Barcelona	-5.56
12 October 2016	257.0	Vilassau de Mar	Barcelona	-1.86
29 November 2014	253.5	Parc Natural dels Ports	Tarragona	-4.54
16 February 1982	251.2	Amer	Girona	-2.41
25 September 1962	250.0	Martorelles	Barcelona	-1.52
04 November 1962	248.5	Sant Llorenç del Munt	Barcelona	-2.79
02 September 1959	246.5	Cadaqués	Girona	-0.84
10 October 1994	245.0	Beuda	Girona	-2.33
22 October 2000	240.0	Tivissa	Tarragona	-2.50
12 November 1999	233.5	Castellfollit de la Roca	Girona	-3.00
05 March 2013	233.3	Viladrau	Girona	-5.32
06 January 1977	233.0	Girona	Girona	-2.22
20 December 2007	230.2	Parc Natural dels Ports	Tarragona	-3.54
06 October 1959	230.1	Tossa de Mar	Girona	-1.36
03 October 1951	230.0	Cornellà de Llobregat	Barcelona	-1.02
20 September 1959	230.0	Gualba de Dalt	Barcelona	-1.49
11 October 1970	230.0	Riudabella	Girona	-1.61
04 October 1987	230.0	Sils	Girona	-2.79
23 October 2000	229.0	Horta de Sant Joan	Tarragona	-2.41
28 September 1992	226.4	Ampostà	Tarragona	-2.22
04 April 1969	226.0	Rupit	Barcelona	-2.21
12 November 1988	225.0	Corbera de Llobregat	Barcelona	-2.76
11 October 1962	223.0	Sils	Girona	-1.20
20 November 1956	221.0	Cornellà de Llobregat	Barcelona	-0.45
06 November 1983	220.0	Terrassa	Barcelona	-2.34
19 October 1994	220.0	el Port de Llançà	Girona	-2.36
31 July 2002	218.2	Badalona	Barcelona	-0.13
13 September 1963	217.5	l'Armetlla de Mar	Tarragona	-1.14
19 September 1971	217.0	Xerta	Tarragona	-0.97
17 September 2010	216.8	l'Armetlla de Mar	Tarragona	-0.60
17 October 2003	213.0	Vidrà	Girona	-2.48
09 June 2000	210.0	el Bruc	Barcelona	-0.23
31 August 1975	208.5	Santa Agnès de Solius	Girona	-0.15
29 January 1996	206.5	Fogars de Montolius	Barcelona	-2.37
09 October 1971	204.0	Miravet	Tarragona	-0.86
26 December 2008	202.5	Darnius	Girona	-2.84
07 May 2002	200.8	Godall	Tarragona	-2.47
07 October 1965	200.0	les Planes d'Hostoles	Girona	-2.12
27 October 1989	200.0	el Port de la Selva	Girona	-1.90
01 November 1993	200.0	Portbou	Girona	-2.57
Extremely negative WeMOi	Negative WeMOi	Slightly negative WeMOi		

Main results and discussion

Most of the episodes (61%) took place in an extreme (≤ -2) WeMOi value. 23% of the episodes occurred in a negative (≤ -1) WeMO phase. The remaining events (16%) took place in a slightly negative (-1, 0) WeMOi value. No extreme torrential episode presenting a positive WeMOi value occurred in Catalonia.

In Catalonia, the frequency of extreme torrential events is almost 1 case per year. The Catalan littoral is a territory characterised by a high temporal concentration of precipitation, but other parts of Iberia are even more torrential (the Valencia Region, eastern Spain, almost 2 cases per year and several episodes >500 mm).

The wettest month in most of the Catalan littoral and prelittoral is October, when the lowest WeMOi values of the year are recorded (humid easterly flows from the Mediterranean Sea are usually expected). In consequence, the highest accumulation of extreme torrential episodes is from 1st to 20th October.

Referring to the calendars by subperiods, we observed an overall decrease in WeMOi values throughout the year, but only an increase in 3 episodes. However, a sharp drop in the WeMOi is observed at the very end of autumn, which might indicate a shift in seasonality of the extreme torrential period from Sep-Oct to Oct-Nov.

The present research confirms these findings in previous studies, as well as the use of the WeMOi at daily resolution as an effective tool for analysing the occurrence of episodes of torrential rainfall over eastern Spain.

Acknowledgements

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