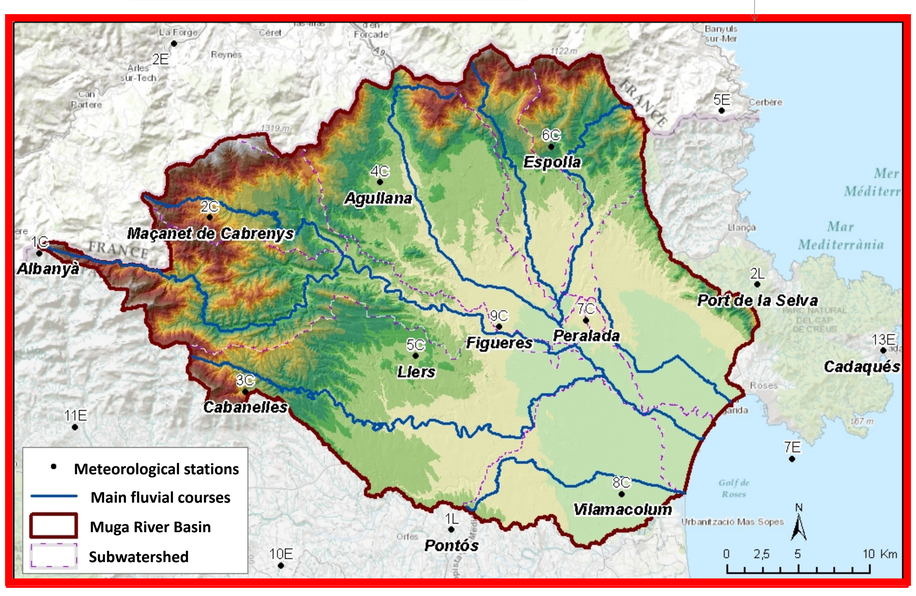
Trend Analysis of Precipitation and Synoptic patterns of torrential rainfall in the Muga River Basin (NE Spain) in the Western Mediterranean area

M.J. Cordobilla-Cascales
Climatology Group, Institut de Recerca de l'Aigua (IdRA), University of Barcelona

The effects of climate change are first felt through water – through droughts, floods or storms. When these disasters hit, they can wipe out entire water supplies or leave them contaminated, risking the human lives or the economics activities, especially agriculture production.
Global warming will also change our relationship with water, both fresh and salty, and the question is, are we prepared to face the change? And adapt to new patterns and recorded meteorological data.

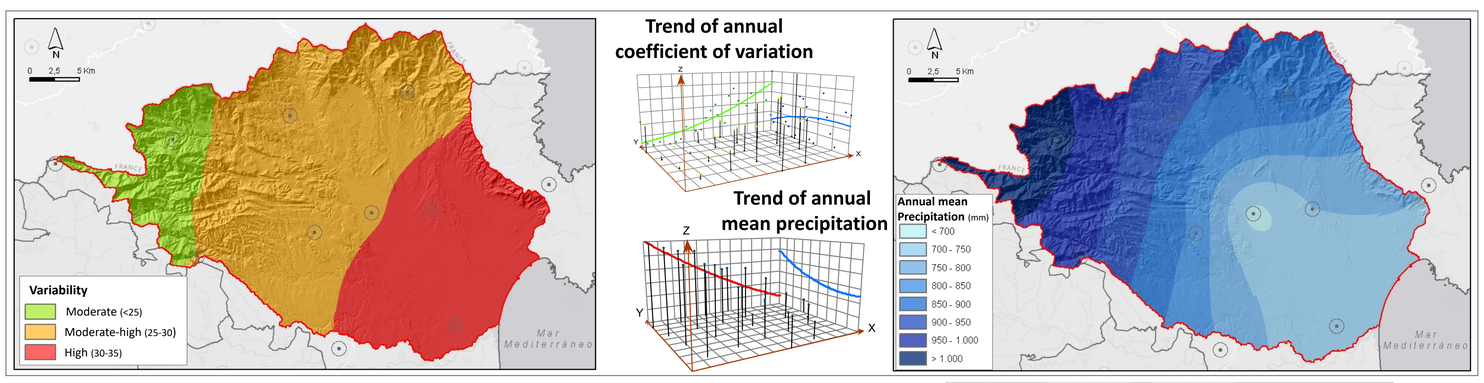


OBJECTIVE, DATA AND METHODS

- The present study attempts to determine the long-term trends (annual, monthly and seasonal precipitation) and frequency of rainy days, adding the synoptic patterns of torrential rainfall (equal or over 100mm/24h) in the Muga River Basin and avaluated the relation with the mean monthly value of the Western Mediterranean Oscillation Index (WeMOi) with the synoptic patterns obtained in this area in the Western Mediterranean area.
- Meteorological stations make use of the database Spain 02 v4, for the 1971-2010 period. Precipitation data from 24 meteorological stations within and around the study area were selected to analyze.
- The annual mean precipitation (P annual), annual coefficient of variation (CV annual), the Standard deviation annual (SD annual) with spatial variables (latitude, longitude and altitude (Z)). Kriging interpolation method was used to determine the spatial variation.
- Pearson's correlation coefficients and P-value between the different precipitation indices and spatial variables were calculated to determine if there is any statistical relationship between them.
- Application of The Mann-Kendall test and Sen´s slope estimator, statistical test, for trend detection in meteorological variables.
- Circulation patterns were obtained by the use of objective method applying the rules of Jenkinson and Collison (J&C). This method allows 27 different classification weather types to be defined. These types are characterized through the use of a set of indices associated to the direction and vorticity of geostrophic flow. The grid consisting of 9 grid points was used.
- The study analysis also considers two subperiods of 20 years (1971-1990 and 1991-2010) in order to detect variations in the synoptic patterns, WeMOi values and in the frequency of heavy rainfall episodes.

RESULTS

Regionalization according to different variables and results statistical tests.



Pearson's correlation coefficient

	Latitude	Longitude	Altitude (Z)	P annual	SD annual	CV annual	
Latitude	X	-0.189	0.406	0.482	0.120	-0.498	Latitude
Longitude	0.578	X	**-0.818**	**-0.833**	-0.168	**0.847**	Longitude
Altitude	0.216	**0.002**	X	**0.869**	0.441	**-0.704**	Altitude
P annual	0.133	**0.001**	**0.001**	X	0.523	**-0.821**	P annual
SD annual	0.726	0.622	0.174	0.099	X	0.053	SD annual
CV annual	0.119	**0.001**	**0.016**	**0.002**	0.876	X	CV annual

P-value

In bold type , Statistically significant at 0.05 level

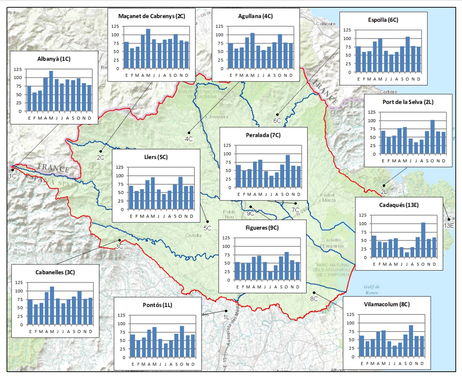
Trend of summer precipitation

Series temporales	Test Mann-Kendall		Sen's slope estimate				
	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95
Albanyà (1C)	-2.903	**	-3.469	-6.813	-0.314	-5.664	-1.550
Maçanet de Cabrenys (2C)	-3.169	**	-2.998	-6.030	-0.735	-5.206	-1.335
Cabanelles (3C)	-3.484	***	-3.071	-5.590	-1.020	-5.274	-1.399
Agullana (4C)	-2.831	**	-2.751	-4.840	-0.292	-4.338	-0.877
Llers (5C)	-2.686	**	-2.279	-4.079	-0.052	-3.662	-0.609
Espolla (6C)	-2.589	**	-2.334	-4.159	-0.035	-3.681	-0.719
Peralada (7C)	-2.274	*	-1.642	-3.231	0.335	-2.829	-0.221
Vilamacolum (8C)	-2.177	*	-1.483	-3.008	0.392	-2.647	-0.110
Figueres (9C)	-1.935	+	-1.659	-4.007	0.553	-3.335	0.054
Pontós (1L)	-2.468	*	-1.880	-3.596	0.174	-3.249	-0.398
Port de la Selva (2L)	-2.008	*	-1.425	-3.206	0.445	-2.758	-0.023
Cadaqués (13E)	-3.508	***	-1.600	-3.028	-0.375	-2.579	-0.662

Trend of maximum precipitation registered P24-hour

Series temporales	Test Mann-Kendall		Sen's slope estimate				
	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95
Albanyà (1C)	0.315		0.093	-0.684	0.976	-0.472	0.765
Maçanet de Cabrenys (2C)	1.084		0.298	-0.499	1.193	-0.272	1.002
Cabanelles (3C)	0.641		0.251	-0.734	1.301	-0.490	0.999
Agullana (4C)	1.363		0.601	-0.497	1.714	-0.243	1.513
Llers (5C)	1.247		0.505	-0.490	1.696	-0.220	1.439
Espolla (6C)	2.388	*	1.016	-0.106	2.025	0.138	1.761
Peralada (7C)	1.293		0.632	-0.633	1.598	-0.306	1.408
Vilamacolum (8C)	1.247		0.492	-0.514	1.345	-0.317	1.128
Pontós (1L)	0.757		0.277	-0.623	1.079	-0.337	0.893
Port de la Selva (2L)	1.293		0.529	-0.670	1.626	-0.298	1.397
Cadaqués (13E)	0.315		0.093	-0.684	0.976	-0.472	0.765

Distribution of monthly precipitation annual (1971-2010)



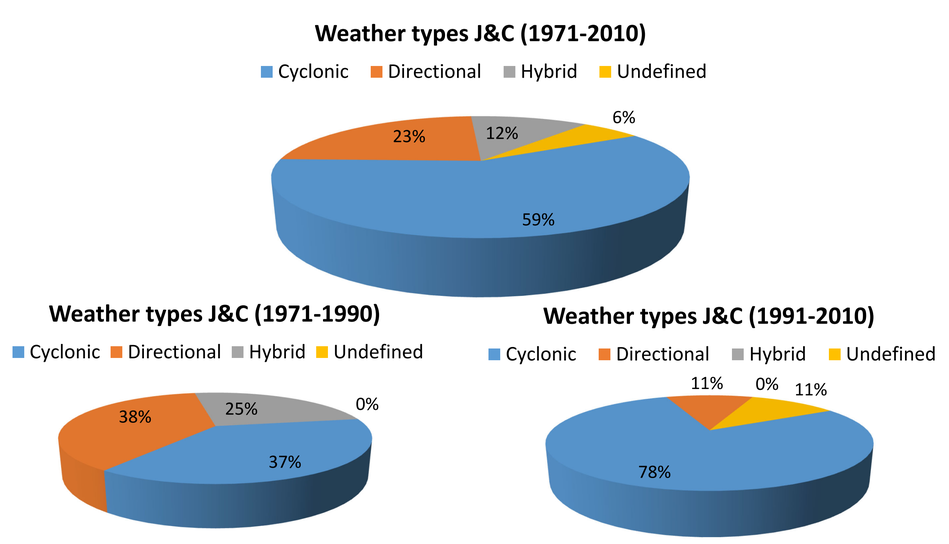
Trend of monthly precipitation in June

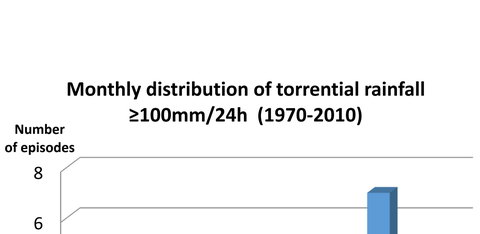
Series temporales	Test Mann-Kendall		Sen's slope estimate				
	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95
Albanyà (1C)	-3.018	**	-1.819	-3.385	-0.369	-2.889	-0.704
Maçanet de Cabrenys (2C)	-3.321	***	-1.796	-3.199	-0.497	-2.981	-0.794
Cabanelles (3C)	-3.390	***	-1.795	-3.136	-0.477	-2.702	-0.834
Agullana (4C)	-3.647	***	-1.492	-2.747	-0.510	-2.334	-0.762
Llers (5C)	-3.064	**	-1.277	-2.305	-0.343	-2.079	-0.664
Espolla (6C)	-3.623	***	-1.279	-2.461	-0.532	-2.127	-0.740
Peralada (7C)	-2.948	**	-1.050	-1.790	-0.158	-1.577	-0.426
Vilamacolum (8C)	-2.715	**	-0.916	-1.641	-0.062	-1.389	-0.323
Figueres (9C)	-2.202	*	-1.075	-2.403	0.258	-2.091	-0.061
Pontós (1L)	-2.552	*	-1.021	-2.057	0.006	-1.831	-0.360
Port de la Selva (2L)	-3.018	**	-0.967	-1.636	-0.206	-1.436	-0.475
Cadaqués (13E)	-3.157	**	-0.688	-1.216	-0.108	-1.084	-0.269

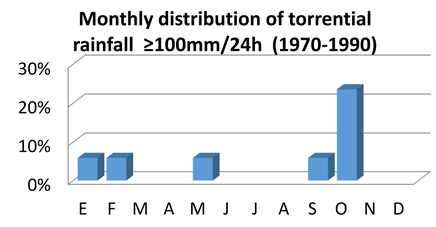
Trend of number of days of annual precipitation

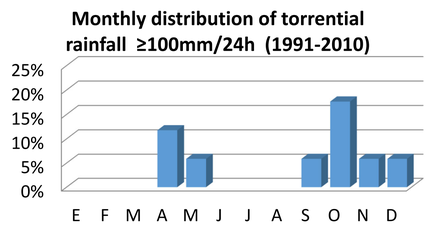
Series temporales	Test Mann-Kendall		Sen's slope estimate				
	Test Z	Signific.	Q	Qmin99	Qmax99	Qmin95	Qmax95
Albanyà (1C)	1.843	+	0.559	-0.276	1.600	0.000	1.316
Maçanet de Cabrenys (2C)	1.924	+	0.584	-0.250	1.657	0.000	1.369
Cabanelles (3C)	-0.572		-0.167	-0.885	0.773	-0.700	0.500
Agullana (4C)	0.898		0.286	-0.550	1.362	-0.333	1.003
Llers (5C)	0.000		0.000	-0.700	0.924	-0.539	0.680
Espolla (6C)	1.713	+	0.596	-0.323	1.604	-0.119	1.360
Peralada (7C)	1.248		0.369	-0.379	1.150	-0.251	0.923
Vilamacolum (8C)	0.991		0.231	-0.426	1.133	-0.300	0.909
Pontós (1L)	-0.828		-0.260	-0.857	0.763	-0.650	0.500
Port de la Selva (2L)	1.609		0.429	-0.358	1.351	-0.118	1.046

Synoptic patterns of torrential rainfall (≥100 mm/24h) in the Muga River Basin

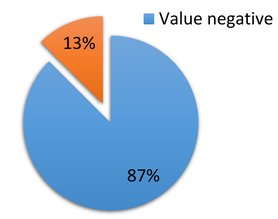








WeMOi and torrential rainfall (≥100 mm/24h) in the Muga River Basin



CONCLUSIONS

- The maps show a types of regionalization of the study area, with a zoned spatial patterns.
-The variable longitude has a high and significant negative correlation with mean annual precipitation (r=-0.833, p-value=0.002), and a positive correlation with the annual coefficient of variation (r=0.847, p-value=0.001), both with a probability value above 95%. Altitude and coefficient of variation are also closely related to annual mean precipitation.
-The most noteworthy result involves a downward precipitation trend in summer and concentrated in the month of June.
- The significance level of the decreasing precipitation trends is higher in the headwaters and the middle reaches than in the lower reaches.
- The weather types J&C more representative of torrential rainfall are Cyclonic, we observed an increase in the frequency of this synoptic pattern to produce heavy rainfall episodes during the second subperiod (78%, 1991-2010) compared with the first subperiod (37%, 1971-1990).
- The WeMOi monthly values and the occurrence of heavy rainfall, the results showed a clear association between the negative values (87%) of this teleconnection index and the torrential rainfall in the Muga River Basin (NE Spain) in the Western Mediterranean area.
- The most negative WeMOi values are observed in autumn, especially during October.
- Several previous studies and this study have demonstrated that the Western Mediterranean Oscillation index (WeMOi) has a statistically significant correlation with total rainfall amount over eastern Iberia. Becoming the WeMO in an essential tool for forecasting heavy rainfall in the study area in northeast of Spain and the Western Mediterranean area.

REFERENCES

-Herrera et. al. (2016) Update of the Spain02 Gridded Observational Dataset for Euro-CORDEX evaluation: Assessing the Effect of the Interpolation Methodology. International Journal of Climatology, 36:900–908. DOI: 10.1002/joc.4391.
- Herrera et. al. (2012) Development and Analysis of a 50 year high-resolution daily gridded precipitation dataset over Spain (Spain02). International Journal of Climatology, 32:74-85 DOI: 10.1002/joc.2256.
-Jenkinson, A.F. y Collison, F.P. (1977). An Initial Climatology of Gales over the North Sea. Synoptic Climatology Branch Memorandum, número 62, Bracknell. Meteorological Office, London.
-Lopez-Bustins, J.A.; Pascual, D.; Pla, E., Retana, J. (2013): Future variability of droughts in three Mediterranean catchments. Natural Hazards, 69, pp. 1405-1421.
-Martín-Vide, J. y López-Bustins, J.A. (2006). The Western Mediterranean Oscillation and rainfall in the Iberian Peninsula. International Journal of Climatology, volumen (26), 1455-1475. doi: http://dx.doi.org/10.1002/joc.1388
-Martín-Vide, J.; Sanchez-Lorenzo, A.; Lopez-Bustins, JA.; Cordobilla, MJ.; García-Manuel, A.; Raso, JM. (2008). Torrential Rainfall in Northeast of the Iberian Peninsula: Synoptic patterns and WeMO influence. Advances in Science and Research 2: pp. 99-105.
-López-Bustins, J.A., Martín Vide, J., Prohom, M., Cordobilla, M.J. (2016). Variabilidad intraanual de la Oscilación del Mediterráneo Occidental (WeMO) y ocurrencia de episodios torrenciales en Cataluña. En J. Olcina Cantos, A.M. Rico Amorós y E. Moltó Mantero (eds.), Clima, sociedad, riesgos y ordenación del territorio (pp. 171-181). doi: http://hdl.handle.net/10045/57984

ACKNOWLEDGEMENTS

Thank AEMET and UC for the data provided for this work (Spain02 v4 EURO-CORDEX dataset, http://www.meteo.unican.es/datasets/spain02) and the Servei Meteorologic de Catalunya (SMC). This work has been funded by the WEMOTOR project (CSO2014-55799-C2-1-R, 2015-2017) of the Ministry of Economy and Competitiveness, and by the Climatology Group of the Universitat de Barcelona (UB) (2014 SGR 300, Catalan Government). I am grateful to my supervisor, Dr. J. Martín-Vide for their invaluable advice, continuous support, and patience during my PhD study.