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Extreme hydrometeorological events and climate change predictions in Europe

Millán M. Millán *

Fundación CEAM, Valencia, Spain

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SUMMARY

Field meteorological data collected in several European Commission projects (from 1974 to 2011) were re-analysed in the context of a perceived reduction in summer storms around the Western Mediterranean Basin (WMB). The findings reveal some hitherto overlooked processes that raise questions about direct impacts on European hydrological cycles, e.g., extreme hydrometeorological events, and about the role of feedbacks on climate models and climate predictions. For instance, the summer storms are affected by land-use changes along the coasts and mountain slopes. Their loss triggers a chain of events that leads to an **Accumulation Mode** (AM) where water vapour and air pollutants (ozone) become stacked in layers, up to 4000(+) m, over the WMB. The AM cycle can last 3–5 consecutive days, and recur several times each month from mid May to late August. At the end of each cycle the accumulated water vapour can feed V_b track events and generate intense rainfall and summer floods in Central Europe. Venting out of the water vapour that should have precipitated within the WMB increases the salinity of the sea and affects the Atlantic-Mediterranean Salinity valve at Gibraltar. This, in turn, can alter the tracks of Atlantic Depressions and their frontal systems over Atlantic Europe. Another effect is the greenhouse heating by water vapour and photo-oxidants (e.g., O_3) when layered over the Basin during the AM cycle. This increases the Sea Surface Temperature (SST), and the higher SST intensifies torrential rain events over the Mediterranean coasts in autumn. All these processes raise research questions that must be addressed to improve the meteorological forecasting of extreme events, as well as climate model predictions.

1. Introduction

After the 1972 UN Stockholm Conference on the Environment, a number of actions were initiated worldwide following the recommendations of the Conference (MIT, 1970, 1971). The European Commission initiated its programme in Environment and Climate in 1973, by launching several large projects, with intensive field campaigns in the areas of Atmospheric Chemistry, i.e., Air Pollution (Guillot, 1985) and Desertification (Mairota et al., 1998). While searching for measurement sites, and during instrumental deployments, scientists were alerted by locals regarding a decrease in the number of summer storms. An oddity at the time was that the comments came mainly from areas surrounding the Western Mediterranean Basin (WMB), except from Central Italy.

In December 1991, the EC's Unit Head for Environment and Climate (Dr. Heinrich Ott) and I met to review data from the MECAPIP and RECAPMA projects (Appendix A). The subject of the summer storms came up, and he inquired about using the field information and meso-meteorological data collected in the EC projects to find an answer to 18 years of comments about storm loss around the Mediterranean. Moreover, the query of the storms, as in this Special Issue, offered a chance to challenge conventional wisdom, raise questions, and postulate mechanisms that could be used to select topics for EC research programmes. This paper, following the initial objective, describes the analysis sequence, including a review of the available field data, the interpretations, the questions arising, and the likely answers and hypotheses derived at each stage.

2. The precipitation types

In 1992 we talked again about initiating the precipitation study in areas where large field campaigns had taken place, and the comments about the storms had arisen (Appendix A). For example, in Marseille-Fos Berre (France), in the Po Valley (Italy), in the Mijares Valley, Valencia-Teruel (Spain). We also considered the availability of the data and, above all, its spatial extent. In the MECAPIP the measurements covered the north-eastern quadrant of the Iberian Peninsula. They included meteorological towers, tethered balloons and instrumented aircraft measurements, all the way from the

* Address: CEAM, C/Charles Darwin 14, Parque Tecnológico, 46980 Paterna, Valencia, Spain. Tel.: +34 96 131 8227, mobile: +34 699 433 276; fax: +34 96 131 8190.
E-mail address: millan@ceam.es

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Mediterranean coast to the headwaters of the Mijares Valley, and beyond, i.e., to Madrid, and Bilbao in North-Atlantic Spain, and along the Ebro Valley (Millán et al., 1991, 1992). The RECAPMA project had further extended the experimental coverage from the Atlantic coast of Portugal, to southern France and Italy. It included instrumented flights over the WMB in July 1991. In fact, we were reviewing those results when the query about the storms came up.

From 1992 to 1994, other projects (SECAP, BEMA I) were launched, extending the spatial scale from Portugal to Greece, Turkey and Israel (Millán et al., 1997). In all, the Mijares Valley had been used in five campaigns, which put this area at the head of the list for the precipitation study. The issue of the storms was finally addressed in 1993 – at first, riding piggy-back on the budget of on-going EC projects and funds from the Spanish National Research Programme (SNRP). It became a full project in 1995, after funding was procured from the SNRP to purchase high spatial resolution, daily precipitation data. The data series from 497 stations for the period (1950–1996) in the area outlined in Fig. 1, cost us

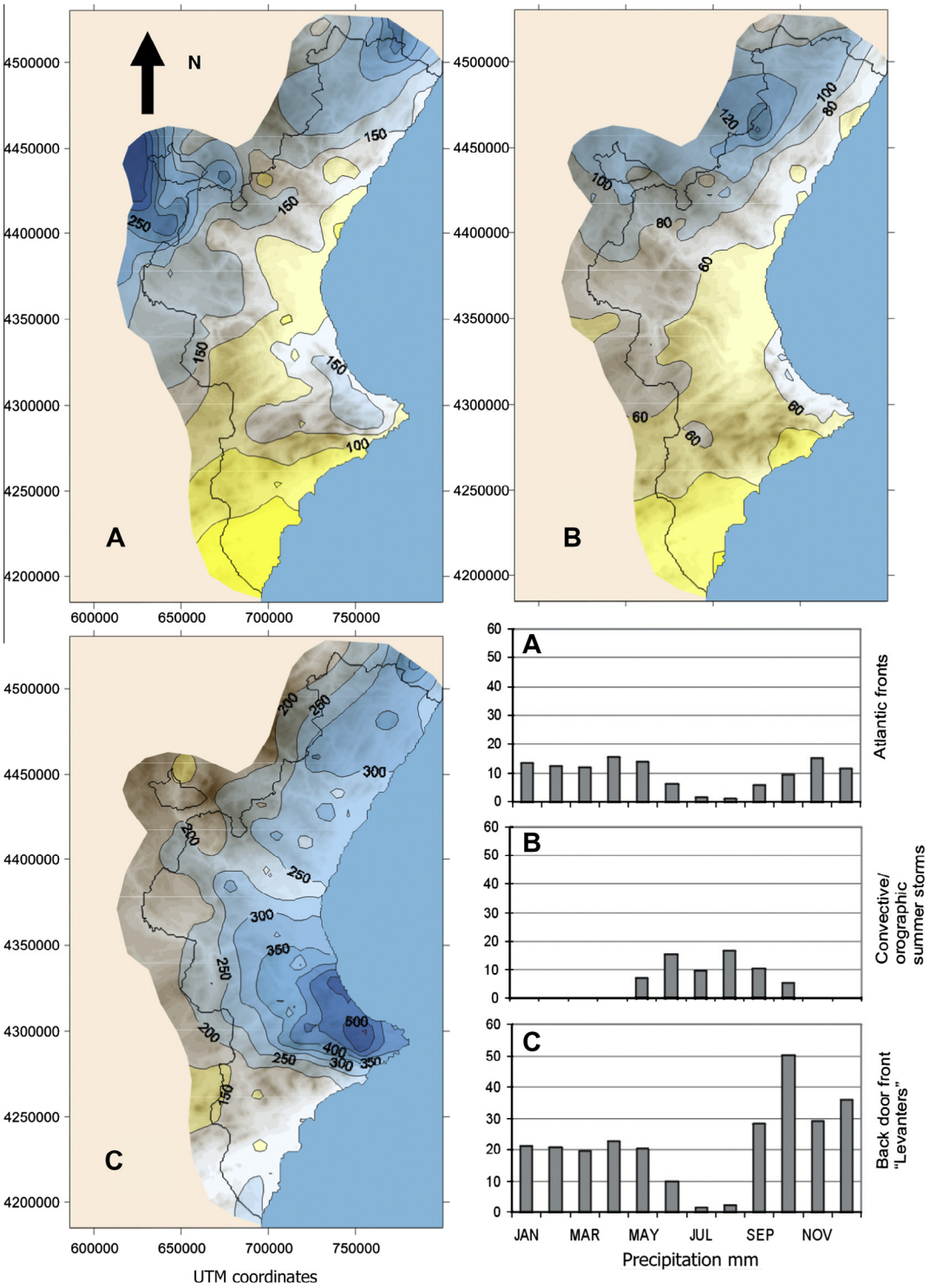

Fig. 1. Spatial and temporal disaggregation of the precipitation types for the Valencia Region and neighbouring areas in Spain (domain maps) for the period 1950–2000. Precipitation contours in mm. Yearly average series for the whole domain in mm.