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Natural Hazards and Earth System Sciences

An analysis of the evolution of hydrometeorological extremes in newspapers: the case of Catalonia, 1982–2006

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Abstract. This contribution analyzes the evolution of perception of certain natural hazards over the past 25 years in a Mediterranean region. Articles from newspapers have been used as indicator. To this end a specific Spanish journal has been considered and an ACCESS database has been created with the summarized information from each news item. The database includes data such as the location of each specific article in the newspaper, its length, the number of pictures and figures, the headlines and a summary of the published information, including all the instrumental data. The study focused on hydrometeorological extremes, mainly floods and droughts, in the northeast of the Iberian Peninsula. The number of headlines per event, trends and other data have been analyzed and compared with "measured" information, in order to identify any bias that could lead to an erroneous perception of the phenomenon. The SPI index (a drought index based on standardized accumulated precipitation) has been calculated for the entire region, and has been used for the drought analysis, while a geodatabase implemented on a GIS built for all the floods recorded in Catalonia since 1900 (INUNGAMA) has been used to analyze flood evolution. Results from a questionnaire about the impact of natural hazards in two specific places have been also used to discuss the various perceptions between rural and urban settings. Results show a better correlation between the news about drought or water scarcity and SPI than between news on floods in Catalonia and the INUNGAMA database. A positive trend has been found for non-catastrophic floods, which is explained by decrease of the perception thresholds, the increase of population density in the most flood-prone areas and changes in land use.

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1 Introduction

In the past few years there has been a growing interest in climate change and its consequences in the form of natural hazards. Until now, not enough evidence had been gathered to confirm a general and significant increase in the frequency and intensity of natural hazards. However, it seems that the societal impact of natural disasters is indeed higher now. This fact has been linked to a higher vulnerability, a lower acceptable risk threshold and a higher social perception. Apart from this fact, the last IPCC (2007) points to an increase in extreme values which, in conjunction with the previous considerations, would imply an increase in the natural risks occurrence, like as floods or droughts.

When public perception about natural risks and its evolution are analyzed it is necessary to distinguish between the different factors that could be involved in it (Brilly and Polic, 2005). A factor analysis allows a distinction to be drawn between two main factors: those related to the perception as such (Slovic, 1992, 1997; Slovic and Weber, 2002), and those related to the own natural risk occurrence. Here in turn, risk has to be broken down into hazard and vulnerability (Varnes, 1984; Renn, 1992; Crozier, 1993; Slovic, 2000; Cardona, 2004; Smith, 2004). Following the UNISDR (United Nations, International Strategy for Disaster Reduction) terminology (2009) the term "hazard" refers to a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage", while the term "vulnerability" refers to "the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard". Depending on the nature of the hazard, people can react to a greater or lesser extent. The vulnerability is proportional to the potential damage that could be caused in a specific zone when

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Table 1. Different factors related to hail, floods and droughts, their risk and perception.

	Hail	Flood	Drought
Hazard	Deep convection, strong instability at low levels, organized convective systems (supercells, MCS), etc.	High rainfall, sea storm, ice melting,... Geomorphological features of the basin, hydraulic infrastructures, etc.	Water scarcity (low precipitation, high temperatures, negative water balance, etc.
Vulnerability	Crops, exposed objects and structures, etc.	Occupation of flood-prone areas, imprudent activities, warning systems, low educational level of the population, poverty, etc.	Water resources planning, increase in individual use, new uses (private swimming-pools), etc.
Risk	Damages to agriculture, cars and houses, injured people, economic losses, etc.	Casualties, damages to infrastructures and cars, injured people, agricultural and economic losses, etc.	Restrictions in water supply, environmental and agricultural losses, impact in tourism, economic losses,etc.
Perception	Mass-media information Rural or urban areas Local impact of weather modification activities Direct surveys	Mass-media information Previous experiences with floods, interest for protection measures, education and awareness, identification of risk zones	Mass-media information Participation of the population (campaigns on environmental education), orientation of the articles in mass media, confidence in authorities (in the context of political discussions)

the potential risk was triggered, giving rise to a catastrophe. Vulnerability includes exposure, knowledge and risk management. The term "exposure" refers to "People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses" (UNISDR, 2009). Some disciplines (i.e. geology) consider the risk consisting of hazard, vulnerability and exposure, independently of each other (Lastoria et al., 2006; Blaikie et al., 1994). In their turn, the individual and social perception are essential in defining the term "risk", because this term acquires full meaning only in relation with a number of cultural considerations (Burton et al., 1978; García Codrón and Silió Cervera, 2000). From the 1980s, a large number of studies have focused on the fact that the perception of risks is built socially (Beck, 1996; Hoffman and Oliver-Smith, 2002; Peretti-Watel, 2001). Several authors claim that the social perception of risks and the levels of acceptance of these risks are constructed collectively, in much the same way as language or aesthetic judgments (Douglas and Wildavsky, 1982). In consequence, this perception will depend on the dominant patterns and beliefs in a particular society, i.e., on its culture. This explains why the perception thresholds with respect to certain risks vary so much from one society to another (Ouarda et al., 1998). When values of a resource (i.e. water) are above the upper perception threshold (i.e. flood) or below the lower perception threshold (i.e. water scarcity) they have negative consequences for the population. These situations are usually recorded in newspapers, in people's memory or in archives.

On the other hand, risks that are constructed socially are experienced differently by different individuals or group of individuals within one particular society, thereby leading to multiple individual perceptions of one and the same event (Oliver-Smith, 2002). Therefore, it is important to consider the scale of normative and subjective values of each individual. This scale defines, in last term, how the relationship person-risk will be. Surveys application is one of the more used methods to obtain such information (Brilly and Polic, 2005). It is interesting to compare this information with "measured information" like that provided by the meteorological records (Delitala, 2005).

As an example, Table 1 shows some features related to the factors that can act in this risk perception for three hydrometeorological risks: hail, floods and droughts. Floods, droughts and hail are the most important hydrometeorological risks in the analyzed region (Llasat-Botija et al., 2006). Floods affected mainly the coastal zone, while hail events can produce strong damages in the western and southern part, where the most important culture areas are placed. However, the impact of these hail events in newspapers is very heterogeneous and, for this reason, it has not been analyzed in this paper. On the contrary, in order to show the different perception between rural and urban areas, hail has been considered in the perception survey.

Suppose, for instance, an increase in hail risk perception. This increase could be due only to an increase of perception, but not to the actual risk. There are already some previous studies that argue the case for use of the press to estimate the social perception of natural risks or climate change (Delitala, 2005; Lacey and Longman, 1997; Rowe et al., 2000; Fischer, 1998; Llasat-Botija et al., 2007; Tàbara, 2008). On the basis of this relationship, this increase in hail risk perception could be caused by an increase of the press coverage of each event. In its turn, press coverage could be influenced by external events such as political declarations, elections, the economic situation or other events (Llasat-Botija et al., 2007). But it could also be related to changes in the sensitivity of the population to certain natural hazards, for instance, as a consequence of a strong campaign related to weather modification by cloud seeding. Both cases would lead the population to think that there was an increase of such natural risk, without taking into consideration the actual change it has undergone. Another possibility could be related to a vulnerability increase. Changes in the kind of crops or in the size of the cultivated area pertaining to a hail-prone region may have brought about a change in the vulnerability factor. Finally, a substantial increase of meteorological situations favorable to hail storms could also have altered the hazard and, consequently, the hail risk and perception.

The objective of this paper is to assess the evolution of the societal perception of floods and droughts through the press in Catalonia (NE Spain), and to relate this information with meteorological/climatic data. A second objective is to evaluate the appropriateness of using the press as indicator of hydrometeorological risk evolution. In order to achieve these objectives, the paper presents the databases used for analysing the evolution of droughts and floods as well as the questionnaire distributed among two different types of population in order to assess the urban and rural components. After this, the news evolution on floods and droughts is analyzed and compared with the evolution estimated from the flood geodatabase and the Standard Precipitation Index (SPI), respectively, for the period 1982–2006. An in-depth analysis of some flood events and droughts is also undertaken in order to discuss the main factors that can be involved in press coverage.

2 Data and methodology

The region of study includes Catalonia and the Ebro Valley (the northeast part of the Iberian Peninsula). To the east, it borders on the Mediterranean Sea, to the north on the Pyrenees, and to the west on Aragon (Fig. 1). The most significant topographic features are the Pyrenees, which rise to over 3000 m, the Littoral range and the Pre-littoral system, both running parallel to the coast and rising to higher than 700 m and 1700 m, respectively. The hydrographical network includes small torrential catchments that cause frequent local floods in the towns/cities of the coast, and in major basins such as those of the Llobregat, Ter and Ebro rivers. Some dams built on these rivers act as reservoirs for water management as well being able to act on flood lamination. The proximity to the Mediterranean Sea and its complex orography plays an important role in rainfall and flood production in this region (Llasat, 2009). The climate is characterized on average by two wet seasons (autumn and spring) and two dry seasons (winter and summer). Usually, water scarcity is caused by precipitation deficiency during spring and autumn, although the summer can play a secondary role due to its precipitation contribution to the Pyrenean region.

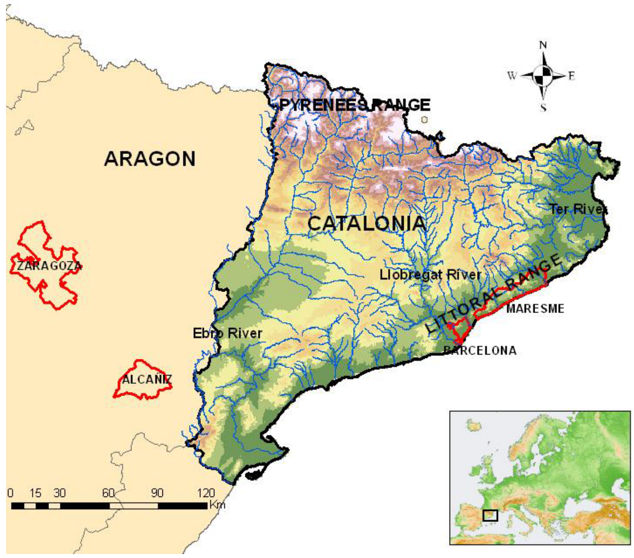

Fig. 1. Map of Catalonia and the Ebro Valley Region, showing the location of the places cited in the text (red) as well as the main catchments (black).

2.1 News database

A preliminary description of the news database can be found in Llasat-Botija et al. (2007), and the complete one will be published in Llasat et al. (2009). It is an ACCESS database that includes all the news related to natural risks and climate change, starting in 1982 and continuing down to today. These news items are classified following the criteria shown in Table 2. More than 14 000 news items for the period 1982–2007 have been analyzed and entered into this ACCESS database. From this study, and data from insurance companies, it is concluded that floods are the most important natural hazard in the region. However, factors such as the season of the year, the proximity of the affected region to the capital, topical issues at the time and the presence of other important news must be considered when the impact in the press is analyzed. Added to which the average number of headlines per event can be different depending on the kind of risk. For instance, the rate number of headlines/event for topics 1 and 4 is, respectively, 5.7 and 6.4 (Llasat-Botija et al., 2007). This fact can be related to the major duration of drought periods and will be discussed in the Conclusions. For this paper, all the

Table 2. Codes used to group the news.

Code	Type and description
1	Flood: Heavy rainfalls, floods and landslides caused by rainfalls
2	Wind storms: Wind storm, gale, tornado, hurricane, dust storm
3	Snow and cold: Snowfalls, cold waves, snow avalanches
4	Agrometeorological risks: Forest fires, drought, hail, heat waves, frost
5	Sustainable development: Climate change, pollution
6	Alert chain: Prevention, statistics, alerts, forecasts, training
7	Others: Earthquake, volcanoes

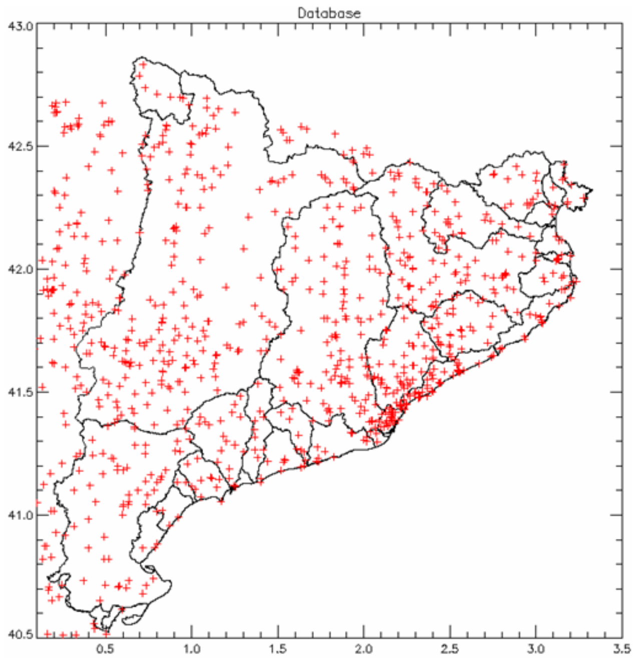

Fig. 2. Map of Catalonia and its surrounding regions showing the total number of pluviometric stations with monthly data partially or totally available for the period 1948–2007.

news items of types 1 and 4 published by the *La Vanguardia* daily newspaper for the period 1982–2006 (25 years) were considered. To focus this analysis more closely, floods and droughts were extracted from groups 1 and 4. Other studies that deal with the utilization of Spanish newspapers to evaluate climatic factors can be found in Duce Díaz (1995), Anillo and Gutiérrez (2006), Hernández Varela et al. (2003) and Tàbara et al. (2004).

2.2 Flood database

A complete description of the INUNGAMA flood database spanning the 20th century for the whole of Catalonia (NE Spain) can be seen in Barnolas and Llasat (2007a). In synthesis, this database, which has been updated, includes documentary information (affected areas and damage) and instrumental information (meteorological and hydrological records) for all floods recorded since 1901, from the minor but most frequent ones to the most catastrophic but less frequent floods. These data have been organized into a relational database in ACCESS normalized to the third normal form with the aim of being implemented on a Geographical Information System (GIS). A total of 260 flood events were identified for the period 1900–2006. Flash floods are the most frequent cases; they are produced by very convective events of short duration but high intensity, usually associated with mesoscale convective systems and multicell systems (Rigo and Llasat, 2004) that affect the coastal region, where short but torrential rivers drain the Littoral Mountains. Autumn is the season that concentrates the highest flood event occurrence in all Catalan regions.

Regarding spatial distribution, the most severely affected areas are located in the northeast of Catalonia and in coastal regions with high population density. The trend analysis has shown a smooth increase in the frequency of floods in the Littoral Region, with a positive slope of two floods per century at the end of the series. This positive trend is mainly associated with increased vulnerability (greater exposure) as well as changes in land use as a consequence of urbanization and new roads and highways. This increase is not observed in the Pyrenees and inland regions, where no such changes have taken place. These results are consistent with those obtained for the longest periods, which show a positive trend for extraordinary floods for the last two centuries but no trend in the case of catastrophic floods (Llasat et al., 2003, 2005). In fact, the population of Catalonia has risen from 5 956 414 inhabitants in 1981 to 7 134 697 inhabitants in 2006. Besides this, a movement of population towards the coast and outside the capital, Barcelona, has increased the population density in some flood-prone regions (Llasat et al., 2008). This fact will have a strong influence in the press coverage of natural risks that affect the region.

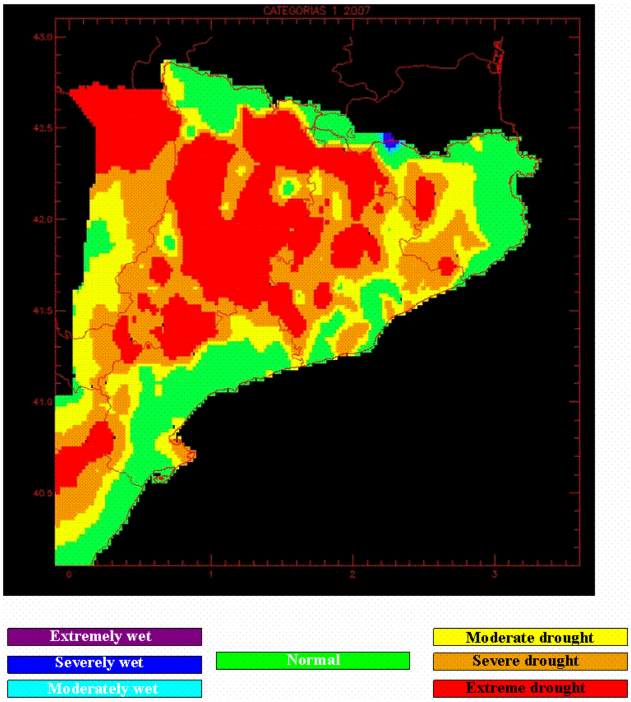

Fig. 3. Map of Catalonia and its surrounding regions showing the SPI distribution for the month of January 2007.

2.3 Drought database

There is a wide variety of definitions associated with the concept "drought" that may or may not take account of all the factors involved in water management. In this study, the concept of "drought" will be related to water scarcity due to a negative anomaly of precipitation, and the Standard Precipitation Index (SPI) will be used as indicator.

Monthly rainfall data was provided by the Spanish National Meteorological Institute (INM, currently the Spanish Meteorology Agency, AEMET) as well as the Catalan Meteorological Service (SMC). On the basis of both sources, it is possible to find more than 850 stations that totally or partially cover the period 1948–2007 (Fig. 2). From their monthly data a pluviometric grid of $0.02^{\circ}\times0.02^{\circ}$ has been built for this period, using the kriging methodology. In order to undertake the present work, the series corresponding to the period 1982–2006 was extracted.

Once the monthly precipitation has been built for each pixel it is possible to calculate the SPI for each one of them. The SPI was developed by McKee et al. (1993) and is a drought index based only on standardized precipitation. In this paper a monthly precipitation data set was drawn up for a period of 60 years (1948–2007), and monthly values were aggregated for periods of 12 months using a mobile window of one month. The aggregated series was standardized and fitted to the Gamma function to define the relationship of probability to precipitation. Once the relationship of probability to precipitation has been established from the historic records, the probability of any observed precipitation data point for the period 1982–2006 is calculated and used along with an estimate of the inverse normal to calculate the precipitation deviation for a Gaussian probability distribution function. Once a time series of SPI (1982–2006) had been obtained for each pixel, the average value was calculated for the entire region, in order to compare it with the press database.

Table 3. Hydric regimes resulting from different SPI values.

SPI value	Hydric regime
$\geq$2.00	Extremely wet (H3)
1.50 to 1.99	Severely wet (H2)
1.00 to 1.49	Moderately wet (H1)
−0.99 to 0.99	Normal (N)
−1.00 to −1.49	Moderate drought (S1)
−1.50 to −1.99	Severe drought (S2)
$\leq$−2.00	Extreme drought (S3)

On the basis of the SPI values it is possible to distinguish seven kinds of situations (Lloyd-Hughes and Saunders, 2002), from wettest to driest (Table 3). Figure 3 shows an example of SPI spatial distribution, corresponding to the last severe drought to have affected Catalonia and that ended in May 2008. Although the coastal region lies within the normal range, most of the river basins that serve most of the population as well as agriculture show extremely dry conditions.

2.4 Perception test

In order to have a preliminary estimation of the different perception of droughts between rural and urban areas, a questionnaire has been built in the framework of the National Project SEVERUS, devoted to the analysis of heavy rainfalls and hail storms in Catalonia and Aragon. The questionnaire was distributed between the populations of one town and one village, located to the west of Catalonia: Zaragoza (urban area) and Alcañiz (rural area). Both places are located in the Ebro Valley, and have a similar climate and orography features to the west of Catalonia (see Fig. 1). The questionnaire included questions about the following items:

– **Personal information:**
  Age range; education; sex; town.

– **General ideas about storms:**
  Kinds and effects of storms; meteorological hazards affecting their home town; media reliability with respect to weather forecasts; weather forecasts utility; resilience measures and insurance responsibilities; confidence in the scientific knowledge about the physical mechanisms

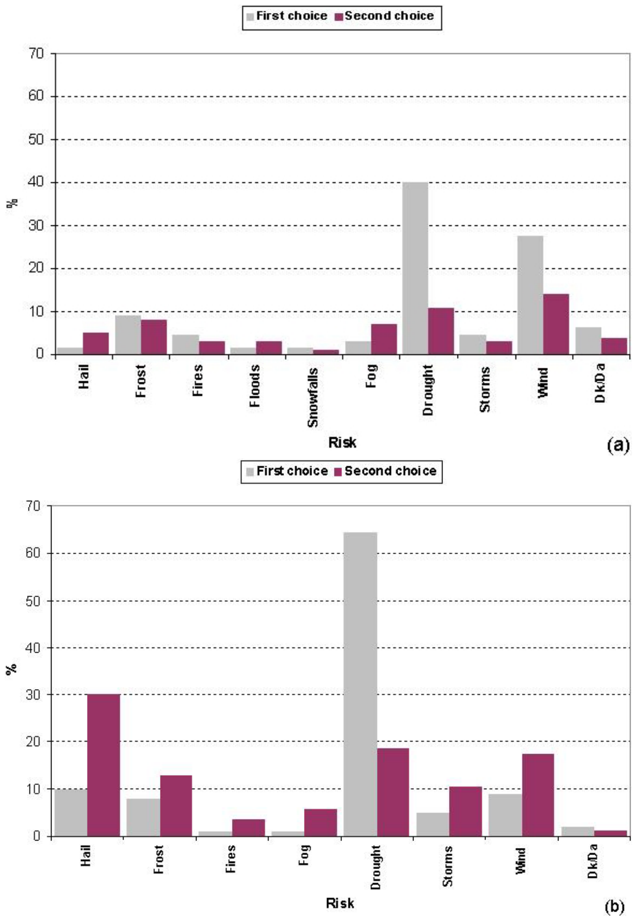

Fig. 4. Importance of meteorological risks as perceived by the population (1st and 2nd), evaluated by conducting questionnaires in **(a)** Zaragoza, **(b)** Alcañiz.

that cause a storm; degree of potential intervention vis-à-vis a storm.

– **Attitude to risks:**
Listening to the weather forecast; source of information (TV, radio, internet and so on); required time to be warned before the start of a severe storm; personal safety measures that they would adopt if a severe storm was approaching their home; fearful attitude to severe storms.

– **Knowledge of their region:**
Number and kind of events that have affected their village/town and its hinterland; perception of damage produced by storms in their village/town; potential climate change impact in their region; zones most affected by natural hazards in their region; preparedness of their region for natural hazards.

This questionnaire was completed by 100 subjects in Alcañiz and 85 in Zaragoza. Out of the whole population of subjects, 70% were women. This is due partly to the high percentage of women living in rural areas, and partly to the type of survey (telephone interviews). As far as the age range of the informants is concerned, the following distribution was found: between 18 and 25 (5.5%), between 25 and 45 (35.3%), between 45 and 70 (43.2%) and over 70 (14.3%). With respect to the educational level, the results are the following: no education (8.8%), primary education (33.5%), secondary education (30.6%) and university education (25.8%).

3 Drought perception in rural and urban environments

The results of the preliminary perception test show important differences in the perception of meteorological risks between rural and urban environments (Fig. 4). In Zaragoza (urban environment) 40% of the population considers droughts to be the main meteorological hazard, followed by strong winds (28%), and frost (9%). Hailstorms are considered to be an important hazard by only 5%. The interviews conducted in the rural show that droughts are also the hazard most widely perceived as such, with 60% of the total. Next score hailstorms with 10%, and strong winds come next with 9%. In this area storms were mentioned as the second most important meteorological hazard (30% of the population).

The effects of droughts vary in accordance with the vulnerability of the population. In rural areas most of the population work in jobs related to agriculture and have closer contact with the real need of water for crops, thus being more concerned by the state of rivers and lakes. Small villages in rural areas have relatively small freshwater tanks, and limited supplies from wells and reservoirs for irrigation. As a result, small villages are more vulnerable to meteorological droughts. In contrast, in the cities there is not such a close contact with nature, and as a consequence droughts are only perceived as important after a number of everyday activities are restricted, such as the filling of private swimming-pools, or the irrigation of private gardens, or even restrictions in household water supplies. In despite of this different vulnerability, droughts are perceived as the more important risk in both towns, while the other risks do not follow a similar distribution. Although it is only a preliminary result, this fact could show a homogeneous perception of droughts in both environments, that probably will lead to a specific impact in the drought coverage given by the newspapers.

4 Flood evolution versus news about floods

Figure 5 shows a comparison between the number of news items about floods recorded in the press and the number of floods recorded in the INUNGAMA database. The number of news items includes all the headlines about floods recorded in each year; the newspaper for a specific day may have more than one headline for the same event. A flood event is usually reported immediately after the event, but

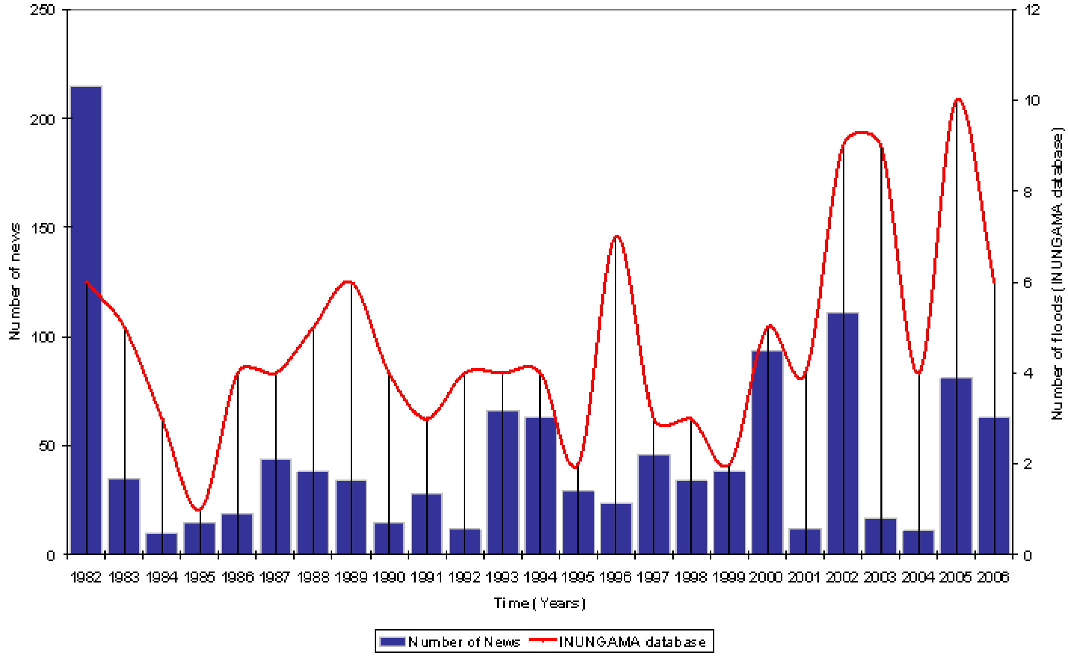

Fig. 5. Flood evolution estimated from the number of news items and from hydrometeorological and impact information, for the period 1982–2006.

there may be subsequent news about the same event. However, a flood event is characterized by the day (or period of days) on which the flood or heavy rain took place; accordingly, two floods affecting two rivers on the same day are considered as the same event. There is not any threshold to select flood events: all those cases that produce a rise in water level that affects the population are included. Following the classification proposed in Barriendos et al. (2003) and applied to analyse the floods in Catalonia since the 14th century (Llasat et al., 2005; Barnolas and Llasat, 2007b), the considered floods can be ordinary, extraordinary or catastrophic, depending on the damage caused. No systematic flow data can be used due to the specific features of some rivers where no gauges are in place.

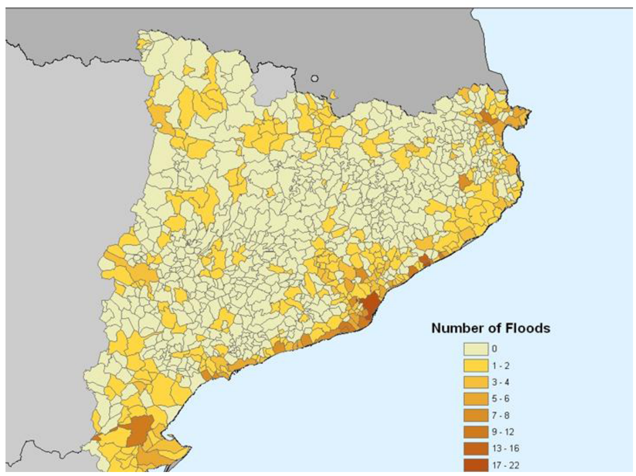

Fig. 6. Municipalities affected by floods during the period 1982–2006.

In this sense, a clear positive trend of 0.12 flood/year has been found in the flood evolution, mainly conditioned by the last five years and by the increase of ordinary and extraordinary floods at the coast (Fig. 6). Indeed, immigrations of population to flood-prone areas located near the coast, as well as the increase of total population and tourism, have led to increased pressure on the territory and higher vulnerability (Llasat et al., 2008). Tingsanchali and Karim (2005) suggest that the vulnerability factor is proportional to population density. Besides the temporary or permanent occupation of the soil near the non-permanent rivers (“wadis”), changes in the landscape have occurred that have affected the geomorphological and hydraulic characteristics of the region. Floods have increased mainly during the late summer season (August and September) when the maximum concentration of population at the coast occurs and short and local heavy rainfalls occur. This positive trend found for extraordinary and ordinary floods is consistent with this other one obtained for Barcelona city as well as the nearby coastal region over recent centuries and it is explained by changes in the uses of soil and infrastructural preventive measures as well as the decrease of the perception threshold (Berga, 1995; Coeur and Lang, 2000; EEA, 2001; Plate, 2002; Barriendos et al., 2003; Llasat et al., 2005; Barrera et al., 2006).

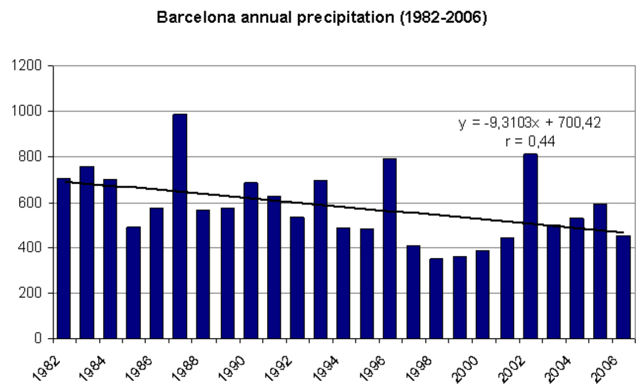

Fig. 7. Annual rainfall evolution in Barcelona for the period 1982–2006.

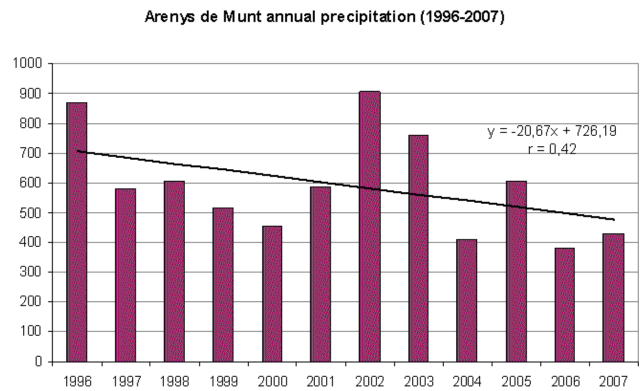

Fig. 8. Annual rainfall evolution in Arenys de Munt (Maresme region) for the period 1996–2007.

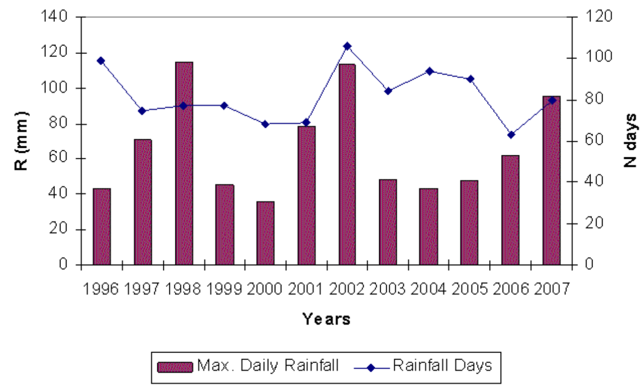

Fig. 9. Annual maximum daily rainfall evolution (bars) and number of rainfall days evolution (continuous line) in Arenys de Munt (Maresme region) for the period 1996–2007.

The comparison with rainfall evolution corroborates this conclusion. Figure 7 shows the annual rainfall evolution for Barcelona city between 1982 and 2006; it can be discerned that neither annual precipitation nor autumn precipitation have undergone any increase. On the contrary, a negative trend has been found as a consequence of the last dry period, although with a very low correlation ($r<0.4$). This negative trend is also found when the evolution of annual rainfall is analysed for other cities located in the Maresme region (Fig. 8). Although in this case only data for the period 1996–2007 were available, the two anomalous rainy years 1996 and 2002 are clearly identified in Fig. 7. The year 1996 was extraordinarily wet throughout Catalonia, and being the first year of the series it leads to a negative trend that cannot be attributed currently to climate change. However, analysis of the maximum daily rainfall as well as the number of rainfall days for the Maresme region does not show any trend (Fig. 9), which fact points to the existence of factors other than precipitation as a cause of this flood increase. This lack of positive trend in the annual rainfall in this region has been also found for longer periods than analysed here (Barrera et al., 2006; Barrera and Llasat, 2004; Gonzalez-Hidalgo et al., 2008).

The press news evolution shown in Fig. 5 does not show any clear trend. The large number of news items corresponding to the year 1982 is significant. This major coverage is consistent with the facts: between 6 and 9 November 1982, the most catastrophic flood event recorded in the last 50 years had occurred (although in terms of casualties the worst was the September 1962 event). This event affected the entire Northeastern part of Spain, Andorra and the Southeast of France. More than 500 mm were recorded in 24 h in the Pyrenees region and rivers such as the Llobregat and the Segre, in Spain, or the Têt and the Tech in France overflowed (Llasat, 2009). Severe landslides as well as wind storms also characterized this event. A total of 184 news items were collected for it (from a total of 215 news items corresponding to 10 events recorded in 1982), a figure that is far from the 94 news and 111 flood news items recorded for the years 2000 and 2002, respectively. The year 2000 produced two catastrophic flood events in Catalonia: the June flash-flood that mainly affected the Llobregat basin, with a maximum rainfall of 220 mm in less than 6 h (Llasat et al., 2003), and the October flood event that affected the south of Catalonia and the eastern side of Spain, with more than 319.2 mm/h. The case of the year 2002 is a clear example of an extraordinary flood event with considerable social impact (Llasat, 2004). Between 8 and 10 October 2002, flooding occurred in a very densely populated area near the mouth of the Llobregat River. The rainfalls reached a maximum of 196.5 mm/24 h and also affected the highway and the airport. A total of 60 news items were published by *La Vanguardia* newspaper in relation to this event, a figure very close to the 59 news items published about the catastrophic flood of June 2000. Again, between 9 and 12 April 2002 an extraordinary flood event affected the Northeastern part of Catalonia, with a maximum of 321.7 mm in 24 h, though in this case the same newspaper carried only 13 headlines. These three cases serve to illustrate the discussion about hazard, vulnerability, risk and perception initiated in the introduction:

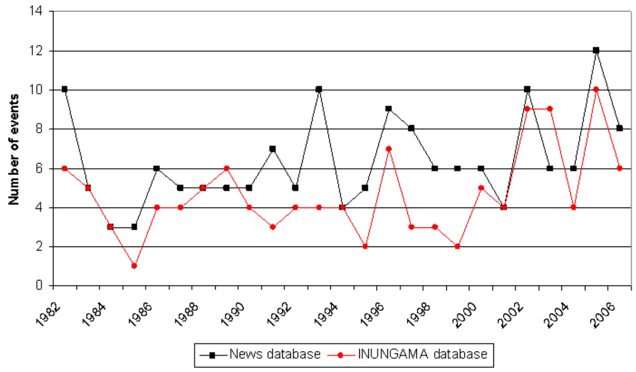

Fig. 10. Comparison between the flood events identified in the INUNGAMA database and the number of events obtained following the printed news media.

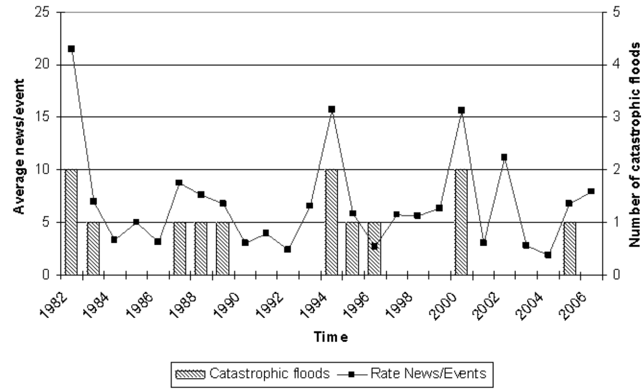

Fig. 11. Comparison between the average number of news items per event and catastrophic floods for the period 1982–2006.

– The November 1982 flood event affected a broad region and was provoked by a very exceptional meteorological situation due to its extension, though the floods that occurred had return periods of less than 50 years in some places (high hazard level). Unlike in the case of Andorra where it affected the most important cities, in the case of Catalonia it mainly affected a lightly populated region (low social vulnerability). It arose in the framework of an economic depression, a month after a catastrophic flood that had affected the east of Spain (mainly the Valencia region) and on the same date as, one year later (6–8 November 1983), another flood event affected Catalonia; these factors favoured the number of news items and raised its social perception.

– The April 2002 flood event affected the region that has the highest frequency of rainfall events above 200 mm (high heavy rainfall hazard), where tourism, services and agriculture are the most important economic sources, but with a low density of population (moderate vulnerability). In contrast with the damage produced, press coverage was low (low social perception), probably as a consequence of the high frequency of this kind of events in this region and the adaptation of the population to them.

– The October 2002 flood event was produced by a typical situation associated with local heavy rainfalls in autumn in Catalonia (moderate hazard), but in one of the most vulnerable zones of Catalonia due to the high density of population, industries and agriculture (great vulnerability). At the same time, a political confrontation about the new airport in the affected region favoured the high press coverage (high perception). The events of the year 2002 did not leave any casualties, whereas more than 25 people died as a consequence of the floods recorded in November 1982. The existence of casualties is another fact that triggers the number of news items.

Bearing in mind the above comments, it is possible to explain the low correlation found between the number of headlines and the number of flood events shown in Fig. 5 (ρ=0.396, significant at the 95% confidence level using the Spearman test). Figure 10 shows the correlation between the flood events mentioned in the newspapers in comparison with those recorded in the INUNGAMA database. A correlation of ρ=0.462 (significant at the 99% confidence level) has been found, as well as an overestimation of the number of events by the press (the mass-media frequently identify high rainfalls with floods). Finally, a comparison between the yearly average number of news items/event and catastrophic floods has been made (Fig. 11). All the years with catastrophic floods have recorded an average of above five news items/event. The years 1982, 1994 and 2000 have the most catastrophic events recorded; this fact is in accordance with the yearly press coverage.

5 Drought evolution versus news evolution

In order to obtain a representative drought index to compare with the news coverage, an averaged SPI value for all Catalonia and for each month has been calculated. Figure 12 shows the correlation between the number of news items and the SPI index for the last four years, characterized by some months with very dry conditions. The figure also includes the first months of 2008, to show the extraordinary rise of news as a consequence of two facts: the changing political decisions about the water supply to the Barcelona city had the drought persisted, and the general elections in Catalonia. When only the period January 2004–December 2007 is considered, a good correlation of −0.60 (significant at the 99.9% confidence level) is obtained between the monthly series. This correlation further improves when only dry years are considered. For instance, the correlation for the year 2005 is −0.877 (99.9% confidence level).

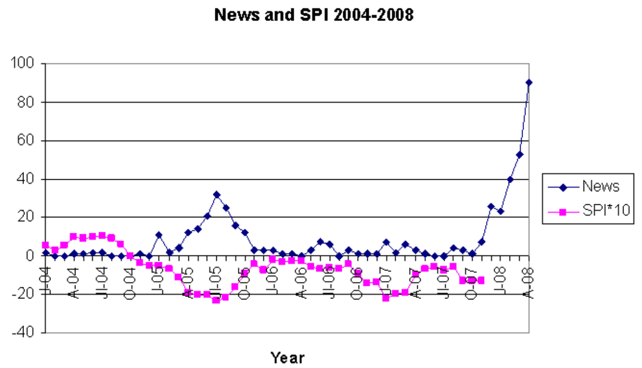

Fig. 12. Evolution of the monthly number of news items and SPI for the period January 2004–April 2008.

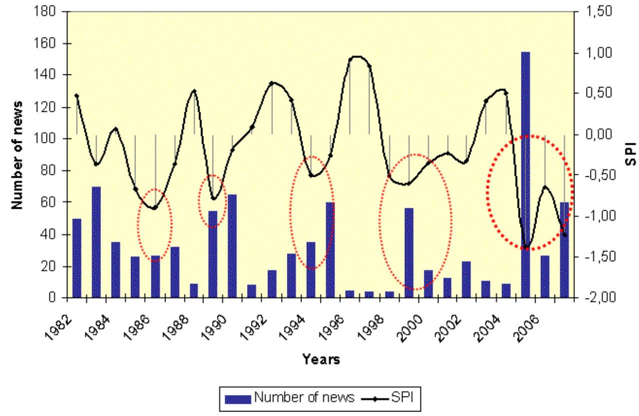

Fig. 13. Evolution of the annual number of news items and SPI in Catalonia for the period 1982–2007.

These good correlations slightly decrease to $\rho=-0.538$ (99.9% confidence level) when yearly values of SPI and news are compared for the period 1982–2007 (Fig. 13), characterized by both rainy and dry periods. A severe drought is identified by the two sources in the year 2005. The moderate droughts of 1998–1999 and 1989 are also well correlated. On the other hand, the moderate droughts of 1986 and 1994 are not so well identified by the press. Both years had a common factor: the catastrophic forest fires that burnt down more than 50 000 hectares, and particularly on Montserrat Mountain, the leading shrine of Catalonia. The drought story faded then, to be replaced by the forest-fire headlines.

6 Discussion and conclusions

Traditionally, press news has been used to build risk maps (Guzzetti and Tonelli, 2004; Petrucci and Polemio, 2003) or to analyse the evolution of certain natural hazards, mainly when not enough instrumental data were available. The present study has demonstrated that press news can be used as estimator of flood or drought evolution, though bearing in mind some factors that can generate a bias or an anomalous perception. The correlation between headlines and SPI and floods is close to -0.6 (period 1982–2007) and 0.4 (period 1982–2006) respectively with a level of confidence above 95%. The drought correlation improves during dry years (0.88), while the flood correlation is better when the number of events identified from news and those from the INUNGAMA database are compared (0.46). This correlation could be improved if the news published in specific periods of time after the event would be considered (i.e. only the news published one month after the flood event). This analysis will be taking into account in future work. This better correlation for droughts than for floods is due to the different temporal and spatial scales for the two risks. Floods are the most common natural hazard in the region of study; their economic and human impact, as well as their total press coverage are also the most significant (Llasat-Botija et al., 2006). This high frequency leads to less news coverage per event (Llasat-Botija et al., 2007). Besides this, the most frequent floods in Catalonia are local flash-floods and their impact in the news coverage is stronger or weaker depending on the accompanying socio-political context, the existence of associated casualties, the standard of living of the affected region or its strategic location (airport, etc.). On the other hand, droughts affected a wider region and lasted for a longer time. The results of a preliminary perception survey have shown that the drought perception is strong, independently of a rural or urban environment, a fact that might also explain the better press coverage. However, in order to assure this last conclusion, this perception test is going to be applied to other towns in Catalonia.

The use of press news is also a good indicator to assess the social perception of natural risk, and particularly floods and droughts. In turn, social factors can have an impact on the press coverage of any natural risk or disaster. In this sense, lack of water is a natural risk with increasing social implications. The ATLL (“Aguas del Ter y Llobregat”) with respect to the metropolitan area of Barcelona forecasts a deficit of water of around 350 hm^3/year in 2025. This deficit (65% of the current use) would be generated by the following causes:

1. population growth of 11%
2. increase in use per inhabitant of 17%
3. population displacement towards areas farther away from the city center
4. decrease of 35% of the water resources currently available due to pollution

Water shortage is conditioned by several factors such as droughts, changes in the organization and distribution of water usage and changes in the societal perception of droughts. The high number of articles in the regional press reflects a growing sensitivity to the lack of water, hydrological responses to changes in the basin, changes in the social interpretation of the uses of water resources, and the use of this issue as a factor in political confrontation. Impacts and the vulnerability when facing a drought vary greatly from one region to another. This variation is probably greater than the physical-spatial variation of rain patterns due to regional differences in the ways water uses are organized and the cultural perception. Usually droughts are more readily perceived in rural areas with economies strongly dependent on agriculture. The perception of the urban population, on the other hand, is mainly linked with the mass-media coverage, which in its turn usually increases when restrictive measures may be applied in urban areas. Finally, the rising awareness about climate change and its potential impacts is driving to a major press coverage on natural risks that could be involved in this climate change, a major sensibility about these problems and a positive trend in the total number of news about these topics (Llasat and Llasat-Botija, 2008).

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