Flash floods evolution in Catalonia: from precipitation to societal aspects

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Photo: Calonge, October 2005 (Jordi Oriol)
OUTLINE

• The FLOODHymex database

• Floods and flash floods in Catalonia

• Trends detected in floods and flash floods

• Trends detected in heavy rainfall and convective rainfall

• Two cases of study: the Maresme and Empordà regions
<table>
<thead>
<tr>
<th>Region</th>
<th>$N_e$</th>
<th>$N_e$ Ext</th>
<th>$N_e$ Cat</th>
<th>Number of deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE France</td>
<td>29 (17)</td>
<td>0 (0)</td>
<td>29 (17)</td>
<td>186</td>
</tr>
<tr>
<td>Calabria</td>
<td>107 (7)</td>
<td>40 (0)</td>
<td>36 (7)</td>
<td>26</td>
</tr>
<tr>
<td>Catalonia</td>
<td>213 (42)</td>
<td>114 (18)</td>
<td>22 (15)</td>
<td>110</td>
</tr>
<tr>
<td>Balearic I.</td>
<td>36 (6)</td>
<td>28 (1)</td>
<td>8 (5)</td>
<td>11</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>385 (72)</td>
<td>182 (19)</td>
<td>95 (44)</td>
<td>333</td>
</tr>
</tbody>
</table>

Table 6. Number of events that produced floods ($N_e$) identified in the FLOODHYMEX database; $N_e$ Ext: number of extraordinary flood events; $N_e$ Cat: number of catastrophic flood events; Total number of deaths. The period analysed is 1981-2010. Between brackets is the number of events which caused casualties.

**Figure 1.** Comparison between the number of floods identified for the four selected regions in the HYMEX, EM-DAT and NATHAN databases for the period 1981-2010.

Only 23 cases from 385 flood events have been recorded in the EMDAT database and this figure decreases to 8 cases when we refer to the NATHAN.
<table>
<thead>
<tr>
<th>Category</th>
<th>Total valuation of damages</th>
<th>The less expensive event</th>
<th>Dates of the event</th>
<th>The more expensive event</th>
<th>Dates of the event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 0</td>
<td>4 457 668</td>
<td>25 587.61</td>
<td>17/09/1996</td>
<td>1 569 606.29</td>
<td>05/08/2000</td>
</tr>
<tr>
<td>Category 1</td>
<td>196 774 166</td>
<td>75 839.34</td>
<td>10/07/2000</td>
<td>83 450 923.1</td>
<td>17/08/2003</td>
</tr>
<tr>
<td>Category 2</td>
<td>267 479 907</td>
<td>1 971 053.63</td>
<td>01/11/2005</td>
<td>141 140 543</td>
<td>10/06/2000</td>
</tr>
<tr>
<td>TOTAL</td>
<td>468 711 740</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Insured loses by floods payed by the Consorcio de Compensación de Seguros (CCS) 1996-2005
Relevant role of vulnerability and exposure factors

Percentage area of residential land (2011) (IET)

Percentage area with systems (Source: Institut d’Estudis Territorials)

Percentage area or urban surface with economic activity (Source: Institut d’Estudis Territorials)

Population density by ‘comarcas’ in 2011 (GAMA, from information of idescat)
213 flash floods and flood events have been identified for the period of 30 years (365 starting in 1900), that have produced 42 casualties. The major part of them are produced between the months of August and November.
• **Ordinary flood**: It takes place when the river flow increases in such a way that it can affect the day-to-day of local population, temporary infrastructures around the river (e.g. walkways) or flood river crossings. However there’s no major damage.

• **Extraordinary flood**: It takes place when the river overflows and even though it does affect the day-to-day of local population and it does cause some damage it does not completely destroy infrastructure. These floods can be local or extensive.

• **Catastrophic flood**: It takes place when serious material losses happen such as total or partial destruction of bridges, mills or any other infrastructure, as well as cattle and crop loss.
MONTHLY DISTRIBUTION OF FLASH FLOODS AND NO FLASH FLOODS EVENTS (1982-2007)

- Flash Floods
- No Flash Floods

25 September 1995: 80 mm 21:30 - 22:30

MONTHLY DISTRIBUTION OF FLOODS IN CATALONIA TAKING INTO ACCOUNT THEIR IMPACT

Convective precipitation versus stratiform precipitation by using raingauge data

Distribution of flash flood events and non flash-flood events. Flash floods are associated to heavy convective precipitation.
Between 1981-2010 there is no significant trend in the total number. The period 1981-2007 the trend of increase 0.16 floods/year is significant at 95% (according to Turco and Llasat method, NHESS, 2011).

- The extraordinary floods show a tendency to an increase of 0.15 flood/year with a 95% flood until 2007.
- In the ordinary and catastrophic floods there are no significative trend.
Trend of annual precipitation a) 1950-2011; b) 1981-2010. Significance at 95%, E-OBS data at 25 km resolution. The great dependence with the considered period to calculate the trend is signaled. For the last period a general negative trend is observed in all Catalonia.
No general trends at a regional scale have been observed in ECCTI related with heavy rainfalls, considering the annual and the seasonal regional values of all the indices and considering all the different time windows.

Trend evolution of SDII 1973-2003 (this trend is not sustained for different time windows of 30 years, 1950-2003, SPAIN-02, 20 km resolution) shows a negative value at the NE and SE parts (Turco and Llasat, NHESS, 2011)

Trend evolution of annual days with convective precipitation (5-min intensity>35 mm/h), 1996-2011 (15 years). SAIH network of Catalan Water Agency had initially 126 raingauge stations; after a quality control only 43 stations have been selected.
Trend of annual convective days

No significative trend in the ratio of convective precipitation, at annual scale, 1996-2011. However, trends point to an increase. Increase of days with moderate convective events (0.3<β<0.8). A generalised increase (although not significative) is found in the number of days with very high convective events (0.8<β). This

Pluviometric regionalization of Catalonia taking into account the convective precipitation. The Northern part has de major convective contribution (Llasat et al, Atmospheric Research, 2007).
Population density trend by regions (1981-2010). Barcelona has a negative trend and also is the region with more population density by far.

Changes in population density (1981-2010) in some regions of Catalonia and number of floods in the period of 1981-2010 by regions.

Where there is more density population is where there are more floods. Density population is an important factor of exposure and vulnerability.
A decrease of convective precipitation contribution has been found in Alt Empordà and an increase has been found near Maresme Region.

April 2002, Alt Empordà more than 350 mm/24 h

September 2006, Catalan coast, near 250 mm/24 h
Number of floods in the period of 1981-2010 in Maresme by municipalities.

47 events in Arenys de Mar
36 events in Mataró

Other factors different to precipitation have to be considered

Percentage area of economical sector (1), systems (2) and residential land (3) for Maresme municipalities.
Number of floods in the period of 1981-2010 in Costa Brava by municipalities.

- 13 events in Peralada
- 11 events in Figueres municipality
- 13 events in Roses

Percentage area of economical sector (1), systems (2) and residential land (3) for Maresme municipalities.
Conclusions

Mediterranean coast experiences every year important flash floods with damages that frequently are not included in the «official» databases.

Catalunya has experienced 213 f/ff in 30 years, being concentrated in areas with great exposure and vulnerability. The major part of them are extraordinary ones, concentrated between July and November. Major exposure in summer.

A positive trend has been found in extraordinary floods (1981-2010).

A negative trend of annual rainfall has been found.

A positive trend in the number of days with convective precipitation has been found and a significative negative trend in the North Eastern part. Both trends are mainly due to the increase/decrease of days with moderate convective events.

Changes in use of soil and a positive trend in population density have been observed.

Both factors have contributed positively to the increase of floods in central area. On the contrary, the disminution of convective contribution in the NE part can justify the lack of trend in floods.

The NE part has an anomalous behaviour in comparison with the rest of the region.
THANK YOU VERY MUCH FOR YOUR ATTENTION!

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Impacts of the case of 11/10/2005 in Alt Empordà i Maresme

L’Escala
(Dwellings: 79%)

Roses
(Dwellings: 75%)

Palafolls
(Dwellings: 63%)

Malgrat de Mar
(44% in commerces, industries, offices,... Dwellings: 26%, Vehicles: 25%)

Total precipitation

Convective/total precipitation

Cost (€)

- 0
- 500 - 11572
- 11572 - 29256
- 29256 - 84619
- 84619 - 737304
And hydrological and hydraulic conditions have also changed...

Example of an ephemeral stream flow channeled in Maresme
<table>
<thead>
<tr>
<th>Database</th>
<th>Coverage</th>
<th>Kind of events</th>
<th>Criteria</th>
<th>Start date</th>
<th>Owner</th>
<th>Public access?</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM-DAT - Emergency Events Database -</td>
<td>Global</td>
<td>Natural and technological disasters</td>
<td>At least one of the following criteria: a) 10 or more people killed; b) 100 or more people affected/injured/homeless; c) declaration of state of emergency; d) appeal for international assistance.</td>
<td>1900</td>
<td>Univ. Catholique de Louvain, Belgium</td>
<td>Yes</td>
</tr>
<tr>
<td>NATHAN - Natural Hazards Assessment Network</td>
<td>Global</td>
<td>Natural hazard-based disasters</td>
<td>Great natural catastrophes: supra-regional or international assistance is required: thousands of fatalities; hundreds of thousands of people homeless; or when the overall losses and/or insured losses reach exceptional orders of magnitude.</td>
<td>1974</td>
<td>Munich Re Germany</td>
<td>Partially</td>
</tr>
<tr>
<td>ESWD - European Severe Weather Database</td>
<td>European</td>
<td>Severe convective storms</td>
<td>No common criteria. Information is reported by the sources</td>
<td>2006</td>
<td>European Severe Storms Laboratory Germany</td>
<td>Yes</td>
</tr>
<tr>
<td>Global Active Archive of Large Flood Events</td>
<td>Global</td>
<td>Floods</td>
<td>At least one of the following criteria: a) significant damage to structures or agriculture, b) long intervals since the last similar event or fatalities</td>
<td>1985</td>
<td>Dartmouth Colorado: Darmouth Flood Observatory Colorado</td>
<td>Yes</td>
</tr>
<tr>
<td>Swiss Re (Sigma)</td>
<td>Global</td>
<td>Natural and man-made disasters</td>
<td>Losses of US $86.6 M and/or insured losses of US $43.3 M (both in 2010 values) and/or 20 fatalities/ people missing</td>
<td>2003</td>
<td>Swiss Re</td>
<td>Partially</td>
</tr>
</tbody>
</table>