Previous studies about heavy rainfall events have examined the scaling properties between extreme precipitation depths and their temporal duration at a global scale (Jennings 1950, Galmarini et al. 2004, Zhang et al. 2013) similarly as other approaches as those described by Monjo and Martin-Vide (2016) to study the global precipitation concentration at daily scale.

In this presentation, we report recent related results obtained by Gonzalez and Bech (2017) and provide further discussion in terms of possible associated atmospheric processes. Spanish precipitation extremes were obtained processing the Agencia Estatal de Meteorología (AEMET) precipitation databases containing more than 11,000 rain gauge stations, some of which exceeded 200 years length, by computing temporal moving windows from 10 minutes to 2 years of selected durations, similarly as described in Galmarini et al. (2004) or Zhang et al. (2013) where updated world rainfall extremes were considered. The resulting list of all-time rainfall records is shown in Table 1 and also is plotted in a log-log diagram in Figure 1 which allows to compare the scale-dependence of both data sets. Last column of Table 1 lists additionally the ratio between the Spanish precipitation record compared to the corresponding World record, indicating that maximum ratios (~30%) are achieved for periods between 20 minutes to 2 days while the others are around 20%. An absolute maximum of 44.8% is found for the 24h period, corresponding to the amount recorded on the 3rd November 1987 in Oliva (Valencia) in the eastern Mediterranean coast, largely influenced by deep moist convection, large moisture availability from the sea and enhancing orographic effects.

Fig. 1.- Point-based rainfall depth extremes observed for different temporal durations for Spanish Extremes (green dots) and World Extremes (black crosses). Bold lines correspond to a power law fitting and dashed lines to the data envelope. Black dotted lines shows the percentage with respect to the WE fitting line. Green numbers show the episode Id which produced the extreme rainfall (see Table 1) - source: Gonzalez and Bech (2017).
<table>
<thead>
<tr>
<th>Duración</th>
<th>Id</th>
<th>Localización</th>
<th>Profundidad [mm]</th>
<th>Fecha</th>
<th>Proporción SR/WR [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 min</td>
<td>1</td>
<td>Cuevas de Nerja, Málaga</td>
<td>41.6</td>
<td>21 Set 2007</td>
<td>N/A</td>
</tr>
<tr>
<td>20 min</td>
<td>1</td>
<td>Cuevas de Nerja, Málaga</td>
<td>74.2</td>
<td>21 Set 2007</td>
<td>36.0</td>
</tr>
<tr>
<td>30 min</td>
<td>2</td>
<td>Sineu, Balearic Islands</td>
<td>87.8</td>
<td>12 Oct 2012</td>
<td>31.4</td>
</tr>
<tr>
<td>60 min</td>
<td>3</td>
<td>Santa Cruz de Tenerife</td>
<td>129.9</td>
<td>31 Mar 2002</td>
<td>32.4</td>
</tr>
<tr>
<td>2 horas</td>
<td>4</td>
<td>San Sebastián, Gipuzkoa</td>
<td>193.0</td>
<td>1 Jun 1997</td>
<td>39.5</td>
</tr>
<tr>
<td>3 horas</td>
<td>4</td>
<td>San Sebastián, Gipuzkoa</td>
<td>204.7</td>
<td>1 Jun 1997</td>
<td>28.3</td>
</tr>
<tr>
<td>4 horas</td>
<td>5</td>
<td>Huercal-Overa, Almería</td>
<td>216.3</td>
<td>28 Sep 2012</td>
<td>N/A</td>
</tr>
<tr>
<td>5 horas</td>
<td>5</td>
<td>Huercal-Overa, Almería</td>
<td>248.3</td>
<td>28 Sep 2012</td>
<td>N/A</td>
</tr>
<tr>
<td>6 horas</td>
<td>5</td>
<td>Huercal-Overa, Almería</td>
<td>275.0</td>
<td>28 Sep 2012</td>
<td>32.7</td>
</tr>
<tr>
<td>9 horas</td>
<td>6</td>
<td>Oliva, Valencia</td>
<td>306.4*</td>
<td>3 Nov 1987</td>
<td>28.2</td>
</tr>
<tr>
<td>12 horas</td>
<td>6</td>
<td>Oliva, Valencia</td>
<td>408.5*</td>
<td>3 Nov 1987</td>
<td>N/A</td>
</tr>
<tr>
<td>18 horas</td>
<td>6</td>
<td>Oliva, Valencia</td>
<td>612.8*</td>
<td>3 Nov 1987</td>
<td>38.6</td>
</tr>
<tr>
<td>1 día</td>
<td>6</td>
<td>Oliva, Valencia</td>
<td>817.0</td>
<td>3 Nov 1987</td>
<td>44.8</td>
</tr>
<tr>
<td>2 días</td>
<td>7</td>
<td>Javea, Alicante</td>
<td>878.0</td>
<td>1-2 Oct 1957</td>
<td>35.2</td>
</tr>
<tr>
<td>3 días</td>
<td>7</td>
<td>Javea, Alicante</td>
<td>978.0</td>
<td>1-3 Oct 1957</td>
<td>24.9</td>
</tr>
<tr>
<td>4 días</td>
<td>7</td>
<td>Javea, Alicante</td>
<td>978.0</td>
<td>1-3 Oct 1957</td>
<td>20.1</td>
</tr>
<tr>
<td>5 días</td>
<td>7</td>
<td>Javea, Alicante</td>
<td>978.0</td>
<td>1-3 Oct 1957</td>
<td>19.6</td>
</tr>
<tr>
<td>6 días</td>
<td>8</td>
<td>Saucos, Santa Cruz de Tenerife</td>
<td>984.8</td>
<td>24-29 Feb 1988</td>
<td>19.4</td>
</tr>
<tr>
<td>7 días</td>
<td>9</td>
<td>Grazalema, Cádiz</td>
<td>1023.2</td>
<td>14-20 Dec 1958</td>
<td>18.9</td>
</tr>
<tr>
<td>8 días</td>
<td>9</td>
<td>Grazalema, Cádiz</td>
<td>1099.2</td>
<td>14-21 Dec 1958</td>
<td>19.9</td>
</tr>
<tr>
<td>9 días</td>
<td>9</td>
<td>Grazalema, Cádiz</td>
<td>1226.2</td>
<td>14-22 Dec 1958</td>
<td>22.2</td>
</tr>
<tr>
<td>10 días</td>
<td>9</td>
<td>Grazalema, Cádiz</td>
<td>1273.6</td>
<td>13-22 Dec 1958</td>
<td>22.4</td>
</tr>
<tr>
<td>11 días</td>
<td>9</td>
<td>Grazalema, Cádiz</td>
<td>1277.2</td>
<td>12-22 Dec 1958</td>
<td>21.5</td>
</tr>
<tr>
<td>12 días</td>
<td>9</td>
<td>Grazalema, Cádiz</td>
<td>1280.0</td>
<td>12-23 Dec 1958</td>
<td>21.5</td>
</tr>
<tr>
<td>13 días</td>
<td>9</td>
<td>Grazalema, Cádiz</td>
<td>1282.2</td>
<td>11-23 Dec 1958</td>
<td>21.1</td>
</tr>
<tr>
<td>14 días</td>
<td>9</td>
<td>Grazalema, Cádiz</td>
<td>1282.2</td>
<td>11-23 Dec 1958</td>
<td>21.1</td>
</tr>
<tr>
<td>15 días</td>
<td>9</td>
<td>Grazalema, Cádiz</td>
<td>1284.8</td>
<td>9-23 Dec 1958</td>
<td>21.1</td>
</tr>
<tr>
<td>20 días</td>
<td>9</td>
<td>Grazalema, Cádiz</td>
<td>1454.1</td>
<td>3-23 Dec 1958</td>
<td>N/A</td>
</tr>
<tr>
<td>31 días</td>
<td>10</td>
<td>Cortes de la Frontera, Málaga</td>
<td>1674.0</td>
<td>18 Nov – 18 Dec 1989</td>
<td>17.5</td>
</tr>
<tr>
<td>2 meses</td>
<td>10</td>
<td>Cortes de la Frontera, Málaga</td>
<td>2420.0</td>
<td>Dec 1995 – Jan 96</td>
<td>19.0</td>
</tr>
<tr>
<td>3 meses</td>
<td>11</td>
<td>Casteloais, Ourense</td>
<td>2866.8</td>
<td>Nov 1959 – Jan 60</td>
<td>17.5</td>
</tr>
<tr>
<td>4 meses</td>
<td>11</td>
<td>Casteloais, Ourense</td>
<td>3269.9</td>
<td>Nov 1959 – Feb 60</td>
<td>17.5</td>
</tr>
<tr>
<td>5 meses</td>
<td>12</td>
<td>Casas do Porto, A Coruña</td>
<td>3835.8</td>
<td>Nov 2000 – Mar 01</td>
<td>18.8</td>
</tr>
<tr>
<td>6 meses</td>
<td>12</td>
<td>Casas do Porto, A Coruña</td>
<td>4176.1</td>
<td>Oct 2000 – Mar 01</td>
<td>18.6</td>
</tr>
<tr>
<td>9 meses</td>
<td>12</td>
<td>Casas do Porto, A Coruña</td>
<td>4680.1</td>
<td>Aug 2000 – Apr 01</td>
<td>N/A</td>
</tr>
<tr>
<td>12 meses</td>
<td>12</td>
<td>Casas do Porto, A Coruña</td>
<td>5503.4</td>
<td>Apr 2000 – Mar 01</td>
<td>20.8</td>
</tr>
<tr>
<td>18 meses</td>
<td>13</td>
<td>Dodro, A Coruña</td>
<td>7523.6</td>
<td>Oct 1984 – Mar 86</td>
<td>N/A</td>
</tr>
<tr>
<td>24 meses</td>
<td>11</td>
<td>Casteloais, Ourense</td>
<td>8991.5</td>
<td>Feb 1958 – Jan 60</td>
<td>22.1</td>
</tr>
</tbody>
</table>

Table 1.- Observed point-based rainfall depth extremes for different temporal durations in Spain and proportions of Spanish Record to World Record (SR/WR), expressed in % (adapted from Gonzalez and Bech, 2017).

*Rainfall amounts corresponding to 9, 12 and 18h were estimated from the 24h maximum events.
Further analysis of the results can be performed by examining the likely relevant atmospheric processes associated with each temporal scale, following the classical scale classifications provided by Orlanski (1975), Fujita (1981) or the recent work focused on a seven-day period simulation at mid-latitudes reported by Craig and Selz (2018), where several dynamical regimes were identified, including quasi-geostrophic flow, propagating gravity waves and stationary gravity waves related to orography.

This study was partly supported by the Water Research Institute of the University of Barcelona (UB/IdRA), and projects CGL2015-65627-C3-2-R (MINECO/FEDER) and CGL2016-81828-REDT (MINECO).

References