Modelling of atmospheric hazards and severe weather phenomena related to floods in Western Mediterranean basin coastal of Iberian Peninsula since 1960

David Pino, Juan Carlos Peña, Salvador Gil-Girado, Alfredo Pérez-Morales, Francisco López-Martínez
1. OBJECTIVE

The main goal of this study is to present a methodological approach to improve synoptic classifications associated to basin coastal floods. A further step is done towards an objective reclassification of new events to improve and facilitate the task of flooding weather forecast.

2. DATA

• The Twentieth Century Reanalysis (20CR) at 2.5° resolution (Compo et al., 2011) was used to classify the synoptic configuration for each day. The gridded area covered was 30°N to 70°N and 30°W to 30°E.

• Variables chosen in this study were:
  - Sea level pressure (SLP)
  - Temperature at 850 hPa (T850)
  - Geopotential at 700 hPa (Z700)
  - Geopotential at 500 hPa (Z500)

• We used the normalized anomalies of variables corrected by the square root of the cosine of latitude (in radians) required to account for the convergence of the meridians (area weighting), which lessens the impact of high-latitude grid points that represent a small area of the globe.
3. METHODOLOGY

- A Principal Sequence Pattern Analysis (PSPA) was applied to sea level pressure, temperature at 850 hPa, geopotential at 700 hPa and 500 hPa.

- The methodology used is based on three steps:
  - Principal Sequence Component Analysis in S-mode, the scree-test to determine the number of components involved and Orthogonal Varimax rotation to minimise the number of variables with high factorial loadings;
  - Cluster Analysis to determine the main synoptic patterns associated with flooding activity in the study area using the non-hierarchical K-means and the hierarchical Ward clusters; and,
  - Discriminant Analysis for validating the model.

4. RESULTS

- The results showed twelve PSPA related to atmospheric convection associated with a trough in the middle levels of the troposphere, and to thermal forcing. Regional differences are modulated by a triggering effect due to local convergences.
Pino et al. (2019): Modelling of atmospheric hazards and severe weather phenomena related to floods in Western Mediterranean basin coastal of Iberian Peninsula since 1960

**Monthly distribution**

**Geographic distribution**

**Description**

- **PSPA 7**: Atlantic low-pressure with south flux in surface.  
  Cold pattern: December - April

- **PSPA 8**: Similar to PSP 1 but with a more well developed low pressure system.  
  Warm pattern: All year but more frequently in August and September

- **PSPA 9**: Similar to PSP 3 but with a more well developed low pressure system.  
  Cold pattern: more frequently in January, March and December

- **PSPA 10**: Similar to PSP 4 but east surface is stronger.  
  More frequently in Autumn.

- **PSPA 11**: Low-pressure over south–east of Iberian Peninsula with east flux in surface.  
  Equinoctial pattern: March, September and October

- **PSPA 12**: Atlantic low with south flux in surface.  
  Cold pattern: November to January.
<table>
<thead>
<tr>
<th>PSPA</th>
<th>Cases</th>
<th>Low-pressure</th>
<th>High-pressure</th>
<th>500-mb through</th>
<th>500-mb ridge</th>
<th>Surface flux</th>
<th>Seasonality</th>
<th>Affected areas</th>
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</thead>
<tbody>
<tr>
<td>PSPA 1</td>
<td>424</td>
<td>Iceland</td>
<td>Central Atlantic</td>
<td>North Africa/Iceland</td>
<td>North Sea/Central Atlantic</td>
<td>W</td>
<td>End of the Summer/Autumn</td>
<td>NE &amp; central</td>
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<td>PSPA 2</td>
<td>104</td>
<td>Spanish Atlantic coast</td>
<td>Spanish Atlantic coast</td>
<td>Iceland</td>
<td></td>
<td>S</td>
<td>Autumn</td>
<td>NE &amp; S</td>
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<tr>
<td>PSPA 3</td>
<td>49</td>
<td>Iberian Peninsula</td>
<td>North Atlantic</td>
<td>Iberian Peninsula</td>
<td>North Atlantic</td>
<td>NE</td>
<td>Winter</td>
<td>SE &amp; S</td>
</tr>
<tr>
<td>PSPA 4</td>
<td>14</td>
<td>Iceland</td>
<td>Western Europe</td>
<td>North Africa/Iceland</td>
<td>Western Europe</td>
<td>E</td>
<td>Winter</td>
<td>Central</td>
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<td>PSPA 5</td>
<td>32</td>
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<td>Iceland</td>
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<td>Iceland</td>
<td>NE</td>
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<td>53</td>
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<td>North Atlantic</td>
<td></td>
<td></td>
<td>SE</td>
<td>Winter</td>
<td>S</td>
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<td>North Atlantic to central Europe</td>
<td>Azores isles</td>
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<td>Winter</td>
<td>S &amp; NE</td>
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<td>Azores isles</td>
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<td>N British Islands</td>
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<td>N British Islands</td>
<td>SE</td>
<td>Winter</td>
<td>All</td>
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<td>42</td>
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<td>N Atlantic</td>
<td>N Africa/Norwegian Sea</td>
<td>N Atlantic</td>
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<td>S</td>
<td>Winter</td>
<td>Central &amp; S</td>
</tr>
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</table>
4. OBJECTIVE RECLASSIFICATION OF NEW EVENTS

Once the synoptic patterns were identified, the new flood time-series recollected for 2014 and 2015 have been reclassified from the component score coefficients matrix and Discriminant Fisher Functions of the reference period (1960-2013). The component scores were calculated from the following equation:

\[ A_{ij} = \sum_{k=1}^{K} B_{ik} C_{kj} \]

Where \( A_{ij} \) is the score value at time \( i \) for the PCA component \( j \); \( B_{ik} \) is the variable at time \( i \) at the grid point \( k \); and \( C_{kj} \) is the component score coefficient at the grid point \( k \) and PCA component \( j \).

\[ SP = \max_t \left\{ Z_t + \sum_{j=1}^{J} A_{jt} X_{jt} \right\} \]

Where \( SP \) is the predicted synoptic pattern; \( Z_t \) is the constant coefficient of the Fisher discriminant function for the synoptic pattern \( t \); \( A_{jt} \) is the score value of the PCA component \( j \) for the synoptic pattern \( t \); and \( X_{jt} \) is the Fisher function coefficient for the PCA component \( j \) and the synoptic pattern \( t \).
4. OBJECTIVE RECLASSIFICATION OF NEW EVENTS

- In comparison to other techniques, the method applied in this study obtains the discriminant functions that can be applied to reclassify a classification, as we did in this study, or to classify flood events in the future.

- Consequently, in a Meteorological Service, this tool could be an operational system for classifying any flood synoptic pattern for a period of 6-hours and delimiting the more likely flooding areas for the studied region.

...thanks!!