Comparison of past and future, high and low extremes of precipitation and river flow for the Mediterranean as projected using different statistical downscaling methods

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Area of study

- French Mediterranean basins.
- High variability.
- Densely populated.
- The Cévennes area is well known due to the intense events that take place in the region.
  - Sept. 2002: 700 mm in one day on the Gard basin.
- The southern part is also affected by long dry spells and occasional droughts.
Methodology

- Impact studies usually follow a top-to-bottom approach.
- There is a cascade of uncertainty.
  - The main uncertainties are the socio-economic scenarios and the GCM.
  - The uncertainties related to the final steps of downscaling are often neglected.
- We compare 3 different downscaling methods.
Downscaling techniques

- **Anomaly (delta-change)**
  - A monthly factor of change is obtained from the climate simulation and it is applied to observed series.
  - It is very simple and widely used.
  - It cannot take into account changes in climate variability.

- **Quantile mapping**
  - The model distribution is corrected using the observations, for each percentile.
  - It is considered that the model rightly simulates to which percentile each value of the corrected variable belongs, but it is not able to determine the value associated to each percentile.

- **Weather typing**
  - Boé et al. (2007, 2009).
  - Two large scale predictors: SLP and surface temperature.
Models

**RCM : SAMM**


**ARPEGE-Climat**

**SAFRAN**

Meteorological analysis 8 km

Habets et al. (2008) JGR

Quintana-Seguí et al. (2009) HESS

**ISBA 3-L**

Land-surface model 8 km

**MODCOU**

Routing and underground
Objectives

1. Evaluation of the impact of **downscaling methods** on the simulation of future **extremes** of both precipitation and river flow.

2. Analysis of the future extremes in this region, according to the climate simulation used.

- We focus on these two 30-yr periods:
  - Middle of the 21\textsuperscript{st} century: 2035-2064.

- Continuation of previous study:
  - Significant differences in the mean of river flows obtained using different downscaling methods.
Precipitation

Comparison between SAFRAN (obs) and the RCM and the downscaled data.

PQ95 1970-1999
Comparison between SAFRAN (obs) and the RCM and the downscaled data.

**PDJJA 1970-1999**

**PDJJA** = driest summer at each grid point (June, July, August).
Results

2035-2064 vs 1970-1999

Anomaly of PQ95

(a) SAMM
(b) AN
(c) QM
(d) WT
Results

2035-2064 vs 1970-1999

Anomaly of PDJJA

Important differences!
Precipitation: main results

- Compared to SAFRAN, both QM and WT are able, in general, to reproduce the extremes of precipitation.
- The differences in the anomalies of the indices are sometimes important.
- The main differences are found for low precipitation.
River flow

Comparison of the simulations to the observations

<table>
<thead>
<tr>
<th>High flows :</th>
<th>QJXA10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation</td>
<td>Bias (%)</td>
</tr>
<tr>
<td>SF</td>
<td>-18</td>
</tr>
<tr>
<td>QM</td>
<td>-26</td>
</tr>
<tr>
<td>WT</td>
<td>-44</td>
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<table>
<thead>
<tr>
<th>Low flows :</th>
<th>QMNA5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation</td>
<td>Bias (%)</td>
</tr>
<tr>
<td>SF</td>
<td>6</td>
</tr>
<tr>
<td>QM</td>
<td>-3</td>
</tr>
<tr>
<td>WT</td>
<td>-5</td>
</tr>
</tbody>
</table>

Daily high flow with 10-yr return period.
Monthly low flow with 5-yr return period.

Stations simulated well by the model according to NSE (> 0.5)
Stations simulated poorly by the model according to NSE (> 0.5)

$R^2$ Coefficient of determination.
Control run, model forced with obs
Model force with downscaled RCM data.
2035-2064: return period of the 1970-1999 QJXA10

Return period in years, calculated for 2035-2064, of the discharge corresponding to the QJXA10 of 1970-1999. Values smaller than 10 indicate a decrease of the return period.
2035-2064 : Return period of the 1970-1999 QMNA5

Return period in years, calculated for 2035-2064, of the discharge corresponding to the QMNA5 of 1970-1999. Values smaller than 5 indicate a decrease of the return period.
River flow: main results

• Compared to the observations:
  • The model is better for high flows than for low flows.
  • The scores obtained with WT were surprisingly poor.
  • The scores of future river flow obtained with AN were more comparable to the other variables than initially expected.

• Anomalies
  • There are important differences between methods when we compare the results station by station: uncertainty.
  • But if we look at the whole picture, the results are similar.
    − More floods on the region of the Cévennes.
    − The old QMNA5 will become more frequent.
Conclusions and future work

- The differences obtained using different statistical downscaling methods are important.
- Our study is limited, we did not assess all the uncertainties.
- Paper under review (NHESS).
- We are developing a model similar to SIM on the NE of the Iberian Peninsula (including the Ebro river) and working on downscaling methods to apply in this area.
  - Poster: EGU2011-11961 in session NP3.7 (yesterday).
    - Downscaling technique.
  - Poster: EGU2011-6700 in this same session (today, 17:30-19:00).
    - Hall A at board number A190.
    - Distributed model on the NE of the Iberian Peninsula.
Thank You!
Danke!

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River flow

1970-1999: downscaled data vs SAFRAN

QJXA10
Daily high flow 10-yr return period

QMNA5
Monthly low flow 5-yr return period

- Control run: SIM forced by SAFRAN (observations)
- We compare the runs forced with downscaled data vs the control run (%).
- The model simulates better the high extremes than the low ones (not shown).
- The results with WT are surprisingly bad.