On the importance of downscaling methods to study the impact of climate change on Mediterranean basins

P. Quintana Seguí[1,2], A. Ribes[2], E. Martin[2], F. Habets[3] and J. Boé[4]

1: Observatori de l'Ebre (Universitat Ramon Llull – CSIC)
2: CNRM-GAME (Météo-France - CNRS)
3: UMR Sisyphe 3 (Université Pierre et Marie Curie – CNRS)
4: Atmospheric and Oceanic Sciences Department, University of California Los Angeles

Introduction

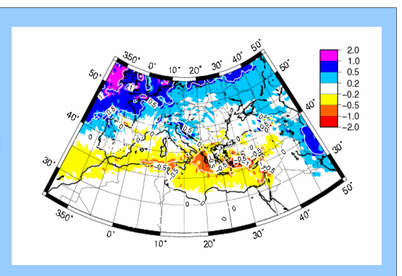
Studies of the **impact of climate change on water resources** usually follow a top to bottom approach: a scenario of emissions is used to run a GCM simulation, which is downscaled and bias-corrected. Then, this data is used to force a hydrological model. Seldom, impact studies take into account all relevant **uncertainties**. In fact, many published studies only use one climate model and one downscaling technique. In this study, the outputs of an atmosphere-ocean regional climate model are downscaled and bias-corrected using **three different techniques**: a statistical method based on weather regimes, a quantile-mapping method and the method of the anomaly. These data are used to force a distributed hydrological model to simulate the **French Mediterranean basins**, which are characterized by water scarcity and an increasing human pressure, which cause a demand in assessments on the impact of climate change hydrological systems.

The **purpose** of the study is mainly methodological: the **evaluation of the uncertainty related to the downscaling and bias-correction step**. The periods chosen to compare the changes are the end of the 20th century (1970-2000) and the middle of the 21st century (2035-2065).

Method

Climate

- Atmosphere-Ocean Regional Climate Model for the mediterranean: SAMM
- Resolution: ~ 50 km for the atmosphere and ~10 km for the Mediterranean sea.
- Emissions: SRES A2

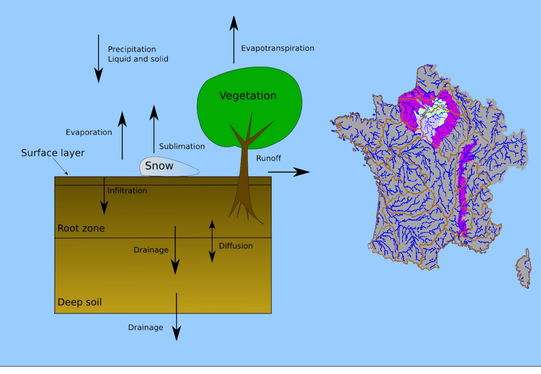


Downscaling

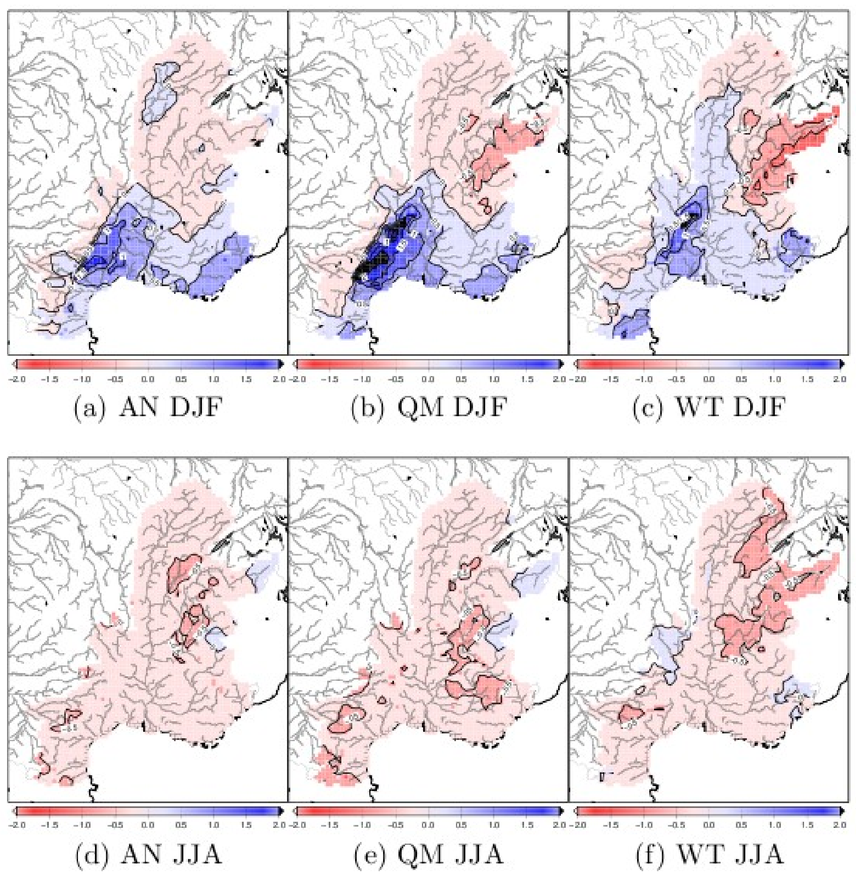
- Three methods:
  - Anomaly (**AN**) : The mode'ls anomaly is added to observed series.
  - Quantile Mapping (**QM**): A correction is found for each quantile for each variable separately
  - Weather typing (**WT**): Multivariate and conditional resampling.
- All the three methods use the SAFRAN database as pseudo-observations.

Impacts on hydrology

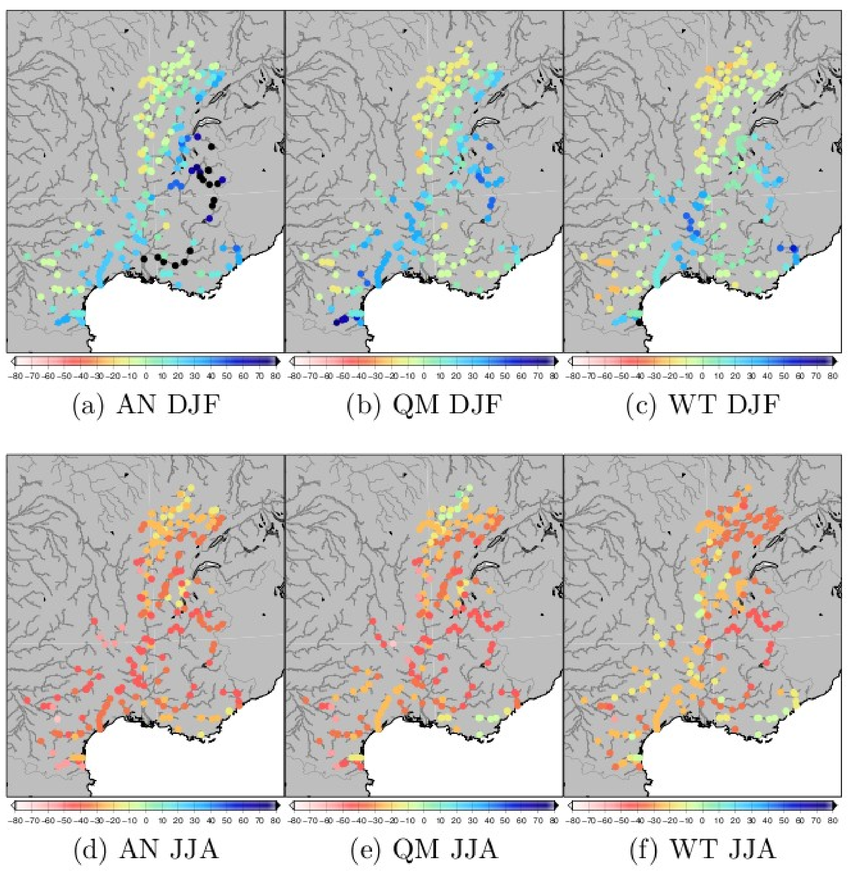
SAFRAN-ISBA-MODCOU hydrological model
•Distributed.
•Based on the **ISBA** surface model and the **MODCOU** hydrogeological model.
•Resolution: 8 km for ISBA.
•The system calculates evaporation, soil wetness, runoff, river discharge (~ 900 gage stations in France), ...



Results



Anomaly of precipitation (mm/day)



Anomaly of Discharge (%)

Study

- 2035 – 2065 vs 1070 – 2000
- The signifiance of the results was studied (not shown).

Impacts

According to the RCM simulation used and to the periods studied, there might be:

- Significant increases of winter precipitation on the Cévennes region of the Massif Central
- Significant decreases of summer precipitation in most of the region.

This will cause a decrease in the average discharge in the middle of the 21st in most of the gauging stations studied, specially in summer. Winter and, maybe spring, in some areas, are the exception, as discharge may increase in some basins.

Conclusion

The study shows that:

- The three methods qualitatively produce similar anomalies of the mean annual precipitation,
- but, quantitatively, there are important differences, mainly in terms of spatial patterns.
- There are important differences in the anomalies of temperature.
- These uncertainties are amplified by the hydrological model.
  - In some basins, the simulations do not agree in the sign of the anomalies
  - in many others, the differences in amplitude of the anomaly are very important.

Therefore, **the uncertainty related to the downscaling and bias-correction of the climate simulation must be taken into account in order to better estimate the impact of climate change, with its uncertainty, on a specific basin**.

3rd HyMeX Workshop. 1-4 June 2009, Heraklion (Greece)
Contact: Pere Quintana Seguí (pquintana@obsebre.es, http://pere.quintanasegui.com, http://www.obsebre.es)
Download the poster: http://pere.quintanasegui.com/coses/quintana-hymex-2009.pdf

1 . Boé, J., J. et al. **Statistical and dynamical downscaling of the Seine basin climate for hydro-meteorological studies**. International Journal of Climatology 27, 1643-1655 (2007).

2 . Habets, F. et al. **The SAFRAN-ISBA-MODCOU hydrometeorological model applied over France**. Journal of Geophysical Research 113, D06113 (2008).

3 . Quintana-Seguí, P. et al. **Analysis of Near-Surface Atmospheric Variables: Validation of the SAFRAN Analysis over France**. Journal of Applied Meteorology and Climatology 47, 92-107 (2008).

4 . Somot, S. et al. **21st Century climate change scenario for the Mediterranean using a coupled Atmosphere-Ocean Regional Climate Model.** Global and Planetary Change 63, Issues 2-3, 112-126 (2008).

5. Quintana-Seguí P. **Simulation hydrologique en région méditerranéenne avec SAFRAN-ISBA-MODCOU. Amélioration de la physique et évaluation des risques dans le cadre du changement climatique.** PhD Thesis. Université de Toulouse III Paul Sabatier (2008).