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Evaluating the temporal transferability of statistical downscaling models for climate change impact studies.

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A large number of statistical downscaling models (SDMs) have been used in the last decade for the generation of meteorological scenarios at scales relevant for impact studies. The validation of SDMs forced by reanalysis large scale fields usually focus on their ability to reproduce the main statistical characteristics of the climatology (e.g. distribution and seasonality of reconstructed variables). This is a necessary but unsufficient condition for their temporal transferability, particularly in a changing climate context. We present here an evaluation methodology to illustrate the possibilities and/or the difficulties to transfer in time these algorithms.

Due to the large uncertainty in the downscaling relationships, the generation of times series with SDMs usually rely on some stochastic processes. In such a case, we first demonstrate that the validation should not be performed on single scenarios. It has to be probabilistic, based on scenario ensemble obtained from different runs of the downscaling algorithm.

Next, the time transferability of SDMs should consider their ability to simulate the low-frequency variations of paste climate as a sort of "natural" climate change. For this, the chronology of generated scenarios, aggregated on several months or years, should explain a large part of the observed chronology and especially of observed trends if any. Similarly, the capacity of the model to give similar performance for a validation period with quite different atmospheric conditions than that observed for the calibration one should be tested. This thus calls for an evaluation framework similar to that usually applied by hydrologists.

A poor time transferability could suggest a poor model performance. It could also result from time heterogeneities in both large scale fields and local meteorological data. As data heterogeneities would however lead to similar results for different SDMs, a multi-model evaluation can be useful to isolate the respective effects of model and data. The same may be achieved with different parametrizations of a same SDM (e.g. different large scale predictors).

The ability of SDMs to generate relevant correlations between the reconstructed meteorological variables required as input of the behavioural model of the studied hydrosystem is a last important feature to test. The non-linearity between precipitation and discharge can emphazise or lessen some weaknesses of SDMs. A hydrological evaluation of the SDMs, where reconstructed and observed hydrological series are compared at different aggregation time steps, should be additionally required.

Our methodology has been applied on a mesoscale alpine basin in Southern French Alps (the Upper Durance basin, 3580 km2) with three different SDMs : "dsclim", based on a weather regimes classification and regional precipitation indices (Boé et al. 2006), "analog", a k-nearest neighbours resampling model for selecting an analog day from large scale predictors fields (Obled et al, 2002), "ddwgen" based on generalized linear models for simulating mean areal precipitation and temperature from atmospheric circulation indices (Mezghani and Hingray, 2009). Meteorological reconstructed scenarios are used as input of the physical-based hydrological model ISBA-Durance to simulate discharges.

In this context, the proposed methodology is more severe than classical climatological validations and allows better highlighting the strengths and weaknesses of the considered SDMs.

References

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