Water restrictions under climate change: a Rhone-Mediterranean perspective combining 'bottom up' and 'top-down' approaches

Les restrictions en eau soumises au changement climatique : une perspective Rhône-Méditerranéenne conjuguant les approches 'bottom up' et 'top-down'

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RÉSUMÉ

Les plans de gestion « sécheresse » requièrent une vue d'ensemble des conditions climatiques futures pour assurer la pertinence de leurs processus de décision. A cette fin, des approches 'bottom up' ont été développées pour mieux répondre à des besoins décisionnels comme la sensibilité intrinsèque des bassins versants au changement climatique. Du fait d'étiages sévères et d'importantes diminutions du manteau neigeux, les ressources en eau des bassins au climat méditerranéen sont sujettes à des altérations conséquentes. En réponse, les Préfectures du district Rhône-Méditerranée ont adopté des plans d'action « sécheresse » comportant des restrictions en eau. L'objectif de cette étude est de fournir une perspective des réponses des bassins à travers les restrictions de prélèvements en eau potentielles sous climats futurs. Nous avons mis en place une approche 'bottom up', c'est-à-dire soumis 105 bassins à une vaste gamme de 1350 scénarios climatiques puis analysé les résultats présentés sous la forme de surfaces de réponse. Un ensemble de projections 'top-down' est superposé pour visualiser des perspectives à des temps différents, et pour mesurer le degré d'exposition des bassins à des situations critiques. Les résultats obtenus après une première classification mettent en lumière des besoins d'adaptation des modes de gestion pour les bassins sujets à des hausses conséquentes de restrictions en eau.

ABSTRACT

Drought management plans require an overview of future climate conditions for ensuring long term relevance of existing decision-making processes. To that end, 'bottom up' approaches have been developed to best match decision-making needs as catchment intrinsic sensitivity to climate change. Due to severe low-flow and drastic snowpack decrease, Mediterranean-climate catchments are subject to substantial alterations of water availability in France. In order to adapt to these concerns, drought action plans including water restrictions have been set up by Prefecture in the Rhône-Méditerranée district. The objective of this study is to provide a perspective in catchment responses through potential water restrictions under climate scenarios. We have implement over 1958-2013 a 'bottom up' framework for analyzing responses of 105 catchments to a wide range of 1350 climate scenarios using response surfaces. In addition, a set of 'top-down' projections have been superimposed to visualize perspective at various time scales. Results from a first cluster analysis highlight potential needs to adapt water restrictions, mainly for temperature sensitive catchments more subject to consequent water restriction increase.

MOTS CLES

Bottom up, drought management, surface responses, water restrictions

1 CONTEXT & OBJECTIVES

The objective of this study is to provide a perspective in catchment responses through potential water restrictions (WR) under climate scenarios by identifying sensitive catchments and their main climatic drivers. This study will not assume accurate predictions in water restrictions, but a first overview of potential responses. First, WR simulations are implemented over 1958-2013 by identifying main low-flow monitoring and thresholds variables that supported WR decisions adopted in the Rhône-Méditerranée (RM) district. Second, climate-WR response surfaces are built to sweep up a large range of 1350 possible climate scenarios and by superimposing projections from Regional Climate Models (RCMs) at time scales 2021-2050, 2051-2070 and 2071-2100. A preliminary cluster analysis at the RM scale is suggested discussing catchment responses with respect to the 2011 low-flow event.

2 SIMULATING WATER RESTRICTIONS

In a first step, the rainfall-runoff model GR6J with snow module was used to simulate daily flow using Safran reanalysis as baseline climatology over 1958-2013 for 105 selected catchments of the Rhone-Méditerranée (RM) district. Secondly, WR processes were analyzed based on drought management plans, to identify key modalities of low-flow monitoring and thresholds variables that led to restriction decisions in the RM district. Decisions for adopting, revoking or upgrading WR prefectural decisions rely on various low-flow monitoring and threshold variables documented in each department drought management plan. The analysis of the 28 department plans indicates four prevalent modalities to implement forthcoming WR simulations.

3 APPLICATION TO CLIMATE CHANGE RESPONSES

Response surfaces are helpful to represent in a two-dimensional space decision variable as WR* delta change associated with both the climate sensitivity from 'bottom up' framework and the projections from 'top-down' RCMs. A 'bottom up' framework is first implemented to encompass a large range of climate change conditions through 1350 scenarios. Climate scenarios are time series of precipitation (P), temperature (T) and potential evapotranspiration (PE) obtained by the so-called delta change approach from a baseline climatology established on the period 1958-2013. These 1350 scenarios combine 45 and 30 sets of P and T/PE mean monthly changes, respectively. For each climate scenario, GR6J outputs were post-processed to simulate legally-binding water restriction (WR*) for 105 catchments of the RM district. WR* delta changes are calculated in terms of number of ten-day periods under each climate scenario with respect to the baseline climatology.

Then response surfaces are built following **Prudhomme *et al.* (2015)**. X- and y-axes represent the key climate drivers, giving priority to output variables available from RCMs, *i.e.* P and T, with changes in PET being implicit from changes in T. Responses surfaces are then constructed by plotting the color gradient to visualize WR* delta changes in term of ten-day periods. Each WR* delta change derived from a given climate scenario is defined by its (x, y) climatic coordinates. After a preliminary cluster analysis **Fig. 1** shows that ∆WR* are differently driven by the P and T gradients in the four classes identified. The first class is driven by the P gradient whereas the fourth is mainly driven by the T gradient. Classes 2 and 3 are partly influenced by both P/T gradients. Notice that the part of climate scenarios associated with a decrease in ∆WR* (blue colors) is gradually lower from class 1 to class 4. For all exposures almost all projections (grey dots) of class 4 point out an increase in WR*, and are mostly higher than ∆WR*(2011) for exposures 2051-2070 and 2071-2100.

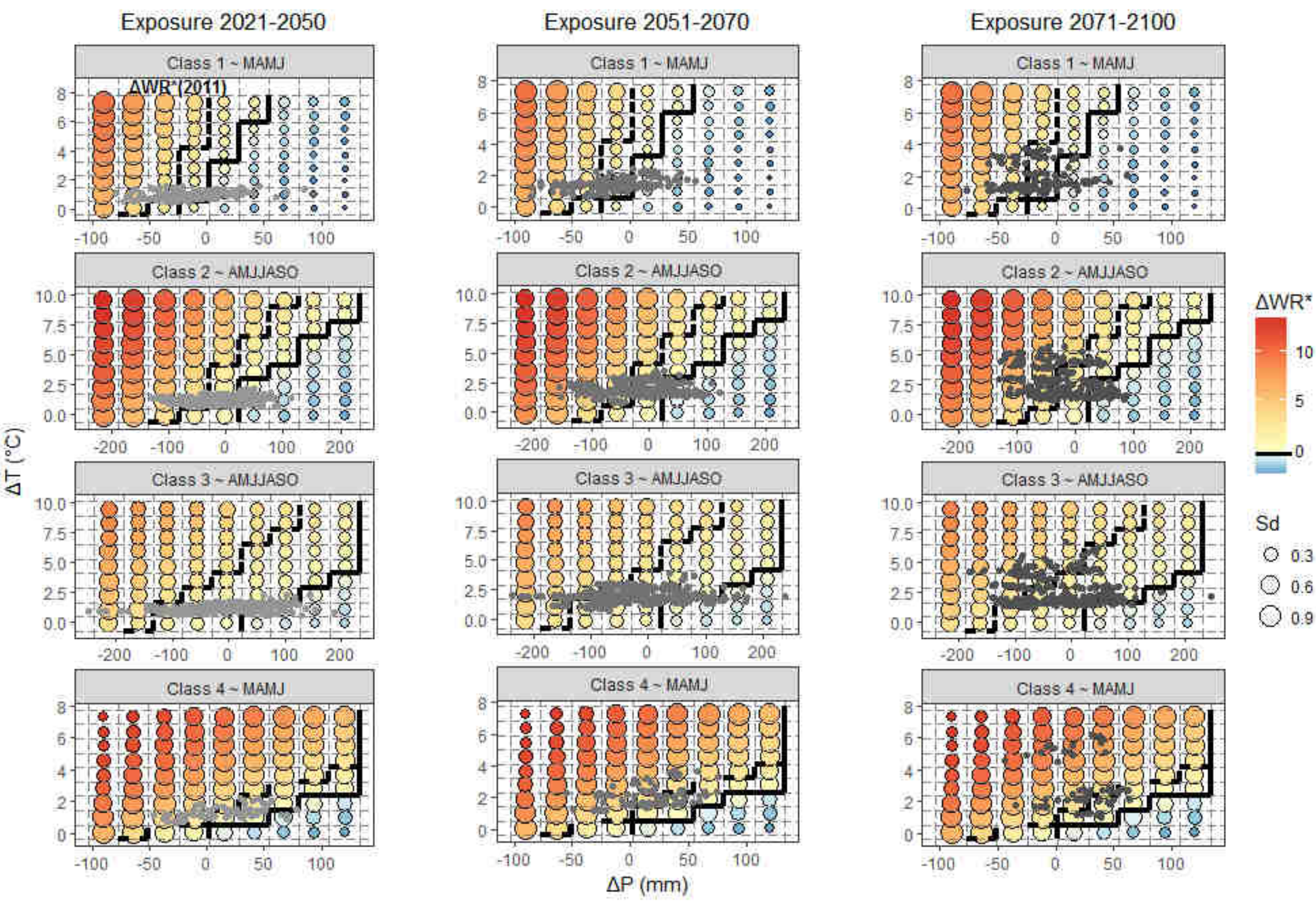

Fig.1 Mean response surfaces after cluster analysis (k=4) over 1958-2013. The black line points out the null ΔWR* and distinguishes the climate scenarios associated with positive ΔWR* on the left side, to the negative ones on the right side. The black dotted line points out the ΔWR* value calculated for the year 2011. Dot size is standard deviation.

4 CONCLUSIONS

ΔWR* gradients to P/T climatic drivers highlight catchment responses to climate changes. To summarize these responses at the scale of the RM district, a cluster analysis has been performed identifying temperature sensitive and rainfall sensitive catchments. Results show potential needs to adapt drought management plans, mainly in temperature sensitive catchments more subject to a consequent increase in legally-binding restriction. They demonstrate also that sustainability in drought action plans could differ significantly from one catchment to another. One of the limits of the study is the cumulative bias from hydrological and restriction simulations and the absence of other possible main drivers as lobbying actions from water users that may enter into the decision-making processes that lead to water restrictions.

BIBLIOGRAPHIE

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