Dear Editor,

The first version of our manuscript (9th September 2013) received substantially good reviews and you recommended moderate corrections. We responded to these recommendations – modifying especially the introduction and supplementing the manuscript when needed. We also answered to the reviewer's comments as fully as possible, explaining our choices and clarifying a number of points raised by their comments. After the second review, we realized that we probably misunderstood your initial assessment and we understood that further efforts are needed to improve the presentation of our analysis.

We carefully assessed how we could improve our manuscript based on your last comments and before resubmitting a modified version, we would like to clarify with you different points in order to identify whether the proposed overhaul of the paper can fit your expectations and those of the reviewers. It is the subject of this mail.

The main objective of our manuscript.

Let us first recall what is our goal, and perhaps first what it is not:

- Our manuscript was perhaps unclear in this regard, but the aim of our study is not to show the limits or to complete the developments currently carried out on the dynamic programming technique. The numerous developments associated with dynamic programming are mainly dedicated to the important issue of the real-time and operational management of dynamic systems and a lot of outstanding works are regularly published on this topic. As we will precise it below, our work does not fit to this operational management context.

- **The aim of our study is to present a metric which allows characterizing the optimal equilibrium between resource and demand for a given socio-climatic context.** The availability of such metric is important in a context of global change where society needs simple but informative indicators, for anticipating required adaptations. At a given time, the available resource is usually not equal to the demand. The temporal deviations between the resource and the demand can be balanced with storage and release operations to transfer the resource in excess at a given time to times with insufficient resource. The storage temporal fluctuations required to reach the best resource/demand equilibrium over the considered period directly results from and thus fully describes the natural asynchronisation between resource and demand (the optimal equilibrium sought can be simply defined in terms of water quantities, but it can be also socioeconomic, taking into account the marginal values of water for different demands/uses). These storage temporal fluctuations define what we will further call **the storage requirement scheme that is needed to reach the best equilibrium**. This storage requirement scheme **can be actually described by the temporal fluctuations of the marginal values of storage water,** which can be obtained as a by-product of the dynamic programming optimisation algorithm. The aim of our manuscript is thus 1) to show the strong temporal structure of the SWV fluctuations, as a signature of the storage requirement scheme, and 2) to show how it depends on the socio-hydroclimatic context.

- For clarification, **we propose to improve the introduction, including those arguments.**

- As you notice, **we only use the dynamic programming method as a tool** to produce a signature characterizing the optimal resource/demand equilibrium. We understand that, in the present version of our manuscript, we give too much weight to the algorithm itself. We also understand that the full description of the algorithm in the heart of the article is counterproductive for understanding our main objective.

- **We therefore propose to move the description of the optimization algorithm to an Appendix.** We believe that this will prevent the reader from a misunderstanding of the real subject of the discussion, which is the analysis of the optimal demand/resource equilibrium, through the analysis of SWV signatures.

Deterministic Dynamic Programming versus Stochastic Dynamic Programming

- **We are aware that the dynamic programming technique is usually used for the real-time and day to day optimization of operational management systems**. In this context, the optimization process aims to identify the optimal storage strategy for the near future. This strategy can also be described with the marginal values of storage water. In this context, we fully agree that a key requirement for an efficient operational management of water resource system is to account for uncertain nature of the near-future inflows and demands. That is why, to our knowledge, a number of systems are optimized using stochastic optimization methods such as SSDP (sample stochastic dynamic programming).

- **As explained previously, we do not want to stick to the operational context of the water resource manager.** We are interested in the optimal resource/demand equilibrium, independently from the uncertain nature of the near-future and from its forecastability. We therefore estimate SWV in a deterministic way from the known sequences of inflow and demand. **To reach this optimal equilibrium,** which is to our mind an important feature to be described for any global change analysis, **it is not relevant to mimic the operational management context** and the difficulty of the manager to anticipate future inflow and demand has to be voluntarily disregarded. The SWV obtained with deterministic dynamic programming is perfectly suited for our question. It only focuses on the balance between the resource and the demand, independently of any forecastability issue.

- Considering this point, **we understand the term of storage strategy is clumsy**, as 'strategy' automatically refers to the operational context of system management. That is why, as presented above, **we propose to use the term 'storage requirement scheme' instead of 'storage strategy**". We believe this term will discard any possible confusion with operational oriented analyses.

Accounting for uncertainty in future projections

- As you noticed it, we do not account - in the elaboration of the storage requirement scheme - for uncertainties in future demand and or resource projections. Uncertainty in future projections that arise from scenario uncertainty, model uncertainty and also internal variability of model can of course be very large as highlighted by a number of recent studies (e.g. Hawkins and

Sutton, 2011). From the manager point of view, and at least **from our point of view, this makes no sense to characterize the optimal resource/demand equilibrium from all possible future projections of the future climate. Only one climate will actually realize.** We are convinced that it is therefore much more relevant to estimate the modification of the optimal resource/demand equilibrium and of the storage requirement scheme conditional on one future possible realization. The question to which we answer is: what would be the optimal storage requirement scheme if the future climate would present those future characteristics (in terms of temperature and precipitation). This is **the reason why we presented the modifications of the SWV conditional on different future possible climates.**

- We do not think this is necessary to clarify it in a revised version of the manuscript. Just let us know if you think it is indeed.

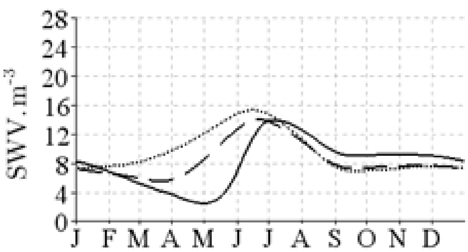
The Earth Mover's distance

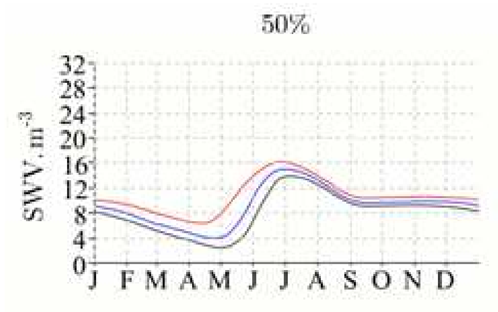
On the other hand, as suggested by the first reviewer (Ehret Uwe), we have explored the possibility to use the Earth Mover's Distance (Moeckel and Murray, 1997) to estimate in a more quantitative way how the signatures of our study are modified between the control period and any future scenario. **As you will see in the following, the Earth Mover's Distance (EMD) is not suited for this.** The table below shows the distance values obtained among the set of signatures presented within the present version of our manuscript (the unit is that of the SWV variable). The distance between two given signatures is estimated with an embedding dimension of 2 (see Moeckel and Murray, 1997, for details).

	Ctl	P10T0	P10T3	P10T5	P20T0	P20T3	P20T5	PctlT3	PctlT5
ctl	0,0	1,7	2,5	3,8	3,8	3,9	5,8	1,7	2,6
P10T0	1,7	0,0	1,6	2,3	2,1	2,4	4,1	1,7	1,7
P10T3	2,5	1,6	0,0	1,7	1,8	1,7	3,6	1,5	0,8
P10T5	3,8	2,3	1,7	0,0	1,1	0,6	1,9	3,2	1,6
P20T0	3,8	2,1	1,8	1,1	0,0	1,2	2,0	3,1	1,7
P20T3	3,9	2,4	1,7	0,6	1,2	0,0	1,9	3,2	1,6
P20T5	5,8	4,1	3,6	1,9	2,0	1,9	0,0	5,1	3,5
PctlT3	1,7	1,7	1,5	3,2	3,1	3,2	5,1	0,0	1,6
PctlT5	2,6	1,7	0,8	1,6	1,7	1,6	3,5	1,6	0,0

As you can notice, **the distance between the CTL signature** (control scenario) **and the scenario P10T0** (ΔP=-10% and ΔT=+0°C) **is the same than the distance between the CTL signature and the scenario PctlT3** (ΔP=0% and ΔT=+3°C). However when you look at the shape of the curves in the following graphs (extracted respectively from figure 7 and 8 of the revised version of the manuscript), **you can see that the blue curve (P10T0) is much more**

similar to the CTL curve (the dark continuous one in both graphs) **than the dashed one** (PctlT3 with the long discontinuous line segments).





The EMD is actually built to compare the distance of two signals in terms of fluctuations and not in terms of time evolution. Moeckel and Murray. 1997 built their distance based on the following requirement: the distance between two realisations of the same stochastic process should be small as these realisations often exhibit the same probability distributions. For this reason, the EMD distance compares the distributions of the signals and not the signals themselves. As the authors say : "*focusing on the way the points* [of the time series] *are distributed … without considering where in the time series individual points occur avoids the problem of sensitive or stochastic dependence on initial conditions*."

As a consequence, the distance between two identical signals that have just a delayed seasonality is for instance zero which is a major drawback for our analysis (this results was actually obtained in our case from a simple experiment where the 2 compared signatures are 1) the CTL one and 2) the same CTL one shifted in time by *n* days (e.g. 1 month, or 3 months, or 6 months)). This result is of course independent of the embedding dimension used to estimate the distance. We verified it empirically with different embedding dimensions (from 2 to 5 > the results are exactly the same).

As a consequence, the EMD distance is not a suited distance to quantify how our signatures are different one from the other. We do not really know other distances that allow a relevant and informative quantitative estimation. **A candidate distance could be the Nash Efficiency criteria but we would be very grateful if you would have better suggestion for this**. We otherwise think that the table we added in the revised manuscript version gives another valuable information on the way the signatures are modified.

If the above suggested modifications fit with your expectations, we could finalize a revised version of our manuscript accordingly. In this case, we would be also really grateful if you may allow us to provide this new version on mid-January.

Moeckel and Murray. 1997. Measuring the distance between time series. Physica D I02, pp.187-194