RC1#1: This is a comprehensive dynamical downscaling study of regional climate change in Europe. They applied a statistical approach called QUALYPSO to a very large ensemble of regional climate model simulations to partition uncertainties due to internal variability, model, scenario, etc..

We thank the reviewer for its interest in this work.

RC1#2: But the method to partition uncertainty has limitations (Hawkins and Sutton 2009), uncertainty here only means ensemble spread and it has nothing to do with errors. No observational constraints are taken into consideration.

We agree with the reviewer that our approach provides an estimation of the model ensemble spread, which is only one of the components of the error of the future projections.

Concerning the use of past observations to improve the final regional climate information provided, many things are implicitly done or could be done to complement QUALYPSO-like approaches:

1. Observations have been used in the development phase of the GCMs and RCMs and to select GCMs used as driving models in EURO-CORDEX (McSweeney et al. 2015). QUALYPSO already benefits from this kind of observational constraints applied to obtain the EURO-CORDEX ensemble.
2. Observational constraints can also be applied to weight or to select GCM or RCM in the initial ensemble. Those constraints are not applied in the current study but it could be considered in future works, as a complementary approach.
3. Regional observations can also be used to correct a posteriori the regional climate simulations (Vrac and Friederichs, 2014) through statistical correction technique. In the current study, QUALYPSO is not applied to postprocessed MMEs using such techniques but this could be easily done in a future work by applying QUALYPSO after a correction step.

These points will be added in the Section “Discussion”.

RC1#3: It’s unclear whether the GCMs can represent internal decadal variability and its regional climate impacts reasonably well.

We agree with the reviewer that GCMs are known to produce very different internal variability from one GCM to the other (Deser et al. 2020), which tends to show that some GCMs overestimate/underestimate this characteristic of future possible climates. In this study, we acknowledge that QUALYPSO relies on the runs available in the MMEs with their limitations / drawbacks, including this possible misrepresentation of the internal decadal variability. This will be added to the discussion.

RC1#4: Although the uncertainty partitioning method has been quite popular in literature, it will be helpful to add some discussions on this method.

There is already an extended paragraph at lines 58-71 of the current manuscript. We believe that this discussion is sufficient, and more details can be found in the previous study (Evin et al., 2019). Compared to existing uncertainty partitioning methods, QUALYPSO 1/ use the “time series approach” to disentangle internal variability and the climate response, 2/ balance the estimates, 3/ has been applied to RCP / GCM / RCM MMEs on the contrary to many related studies.

RC1#5: Particularly, if the uncertainty here has nothing to do with error, how should we use the results to help provide robust estimates of future regional climate change.

First, it is important to remind here that the study assesses changes between a future and a reference period, as most of the studies on this subject. The evolution of the climate from this reference period only is trusted and assessed, and not absolute values. Second, as indicated above (comment RC1#2), QUALYPSO already applies observational constraints by assuming that the MME has been correctly built, and can be applied on bias-corrected projections (which was for example the case in Evin et al., 2019). Third, many papers question the model democracy" approach and aim at estimating future mean changes and associated uncertainties by proposing different way to combine the runs of the MME, mostly using weights (see Brunner et al., 2020 for a recent comparison).This study provides many insights about the different uncertainty components, models diversity in terms of climate change response. As such, this work should be considered as complementary to the aforementioned methods. In QUALYPSO, contrary to most existing approaches, our estimates are "robust" to the subsampling of the complete MME (i.e. possible combinations of RCP / GCM / RCM). In future works, we could also consider using the weights provided by other methods either to select the most relevant runs of the MMEs or to propose weighted estimates of future mean changes and associated uncertainties.

Modifications will be made to the manuscript to discuss these aspects, and to the points discussed above (i.e. "observational constraints" discussed in comment RC1#2).

RC1#6: In addition, the study finds relatively small contribution from internal variability, this conclusion seems to contradict with many studies that emphasize the importance to run large initial-value ensembles. It would be useful to discuss whether this is caused by the analysis method here (e.g. whether this method tends to produce narrow internal variability uncertainty).

As indicated in Section 8.2.4 of the manuscript, the small contribution of internal variability is not caused by the method but by the temporal and spatial windows. The relationship between internal variability and the spatial aggregation scale is mentioned at l.223-232 of the current manuscript, based on the results obtained for the different countries and their respective capital cities. Concerning the temporal aggregation scale, in Evin et al. (2019), the same method, when applied to annual values of total precipitation in the French Alps (see their Fig. 7), shows contributions of internal variability between 40% and 70%. In the revised manuscript, this larger contribution of internal variability for smaller temporal aggregation scales will be illustrated with additional figures in the SM, using 1-year, 10-year and 30-year aggregation scales, for the 3 SREX regions, and for both seasons (see Figures 1 and 2 below for the winter season). At an annual time scale, the contribution of internal variability for relative changes of precipitation in winter is up to 80% of the total variance in the Mediterranean region in 2100 (Figure 2). For temperature, the contribution is smaller but reaches 40% in CEU at an annual time scale in 2100 (Figure 1).

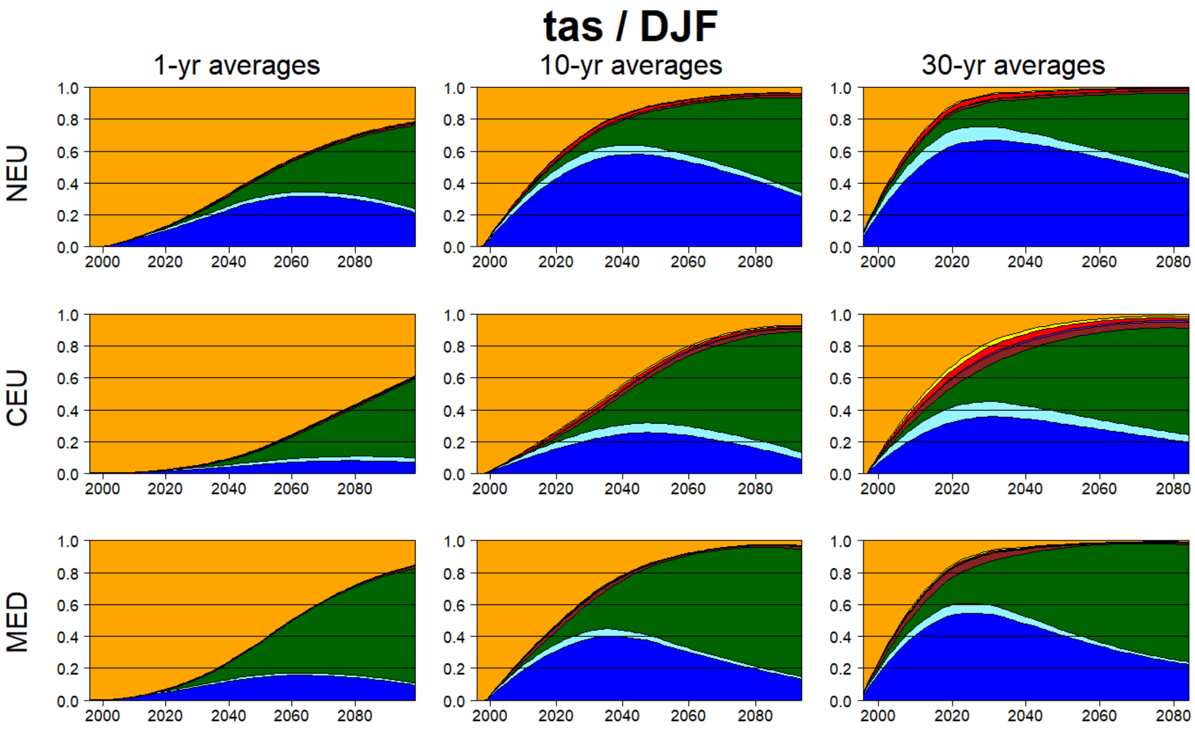

Figure 1: Fraction of total variance for absolute changes of mean temperature in winter (DJF), as a function of time, for different temporal aggregation scales: 1-year (left plots), 10-year (middle plots) and 30-year averages (right plots), for the 3 SREX regions.

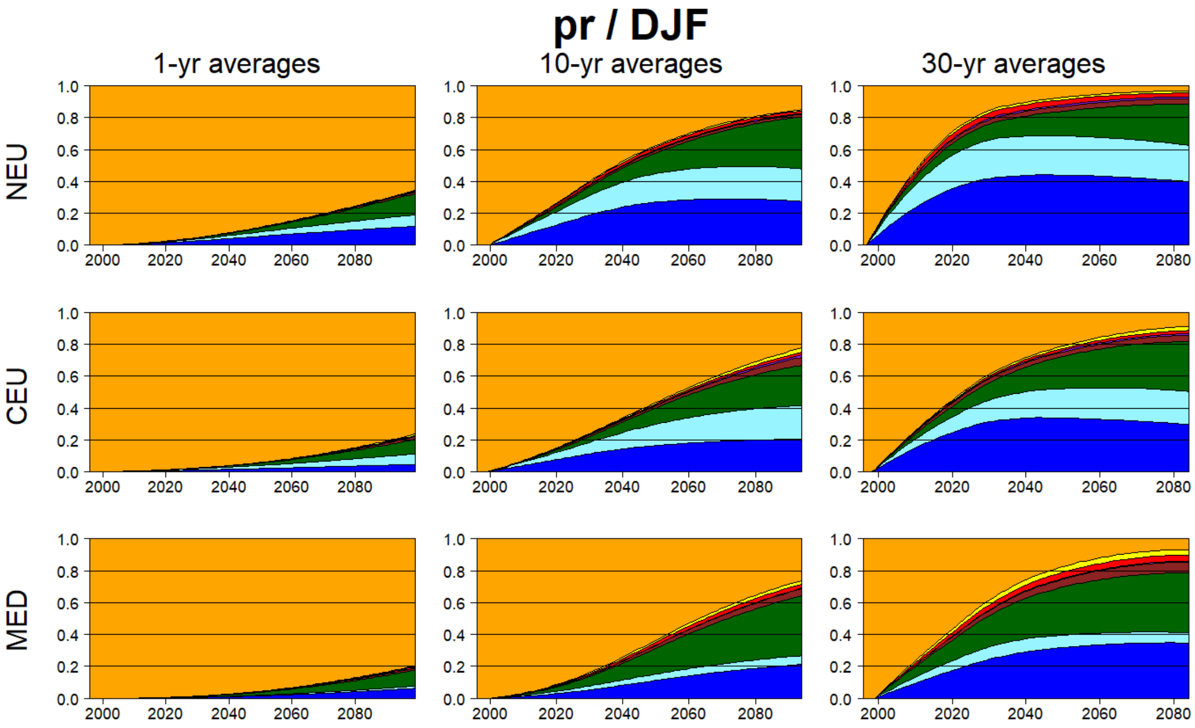

Figure 2: Fraction of total variance for relative changes of total precipitation in winter (DJF), as a function of time, for different temporal aggregation scales: 1-year (left plots), 10-year (middle plots) and 30-year averages (right plots), for the 3 SREX regions.

RC1#7: It will also be helpful to provide more introduction and discussions of QUALYPSO so that readers can understand how this method can provide a balanced estimate without reading the reference paper and the codes.

Thank you for this comment. The difficult understanding of the QUALYPSO method was also raised by the reviewer RC2 (comment RC2#3). The revised version of the manuscript will include a less technical description of the method, and will be illustrated with an additional figure including a global scheme of the approach.

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