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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Contrasting seasonal changes in total and intense precipitation in the European Alps from 1903 to 2010" *by* Martin Ménégoz et al.

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The manuscript by Ménégoz et al. investigates precipitation trends in the Alpine region through the aid of regional climate model MAR applied over the period 1903-2010. The model is forced by boundary condition from ERA-20C. Details of climate change over the Alps, especially for precipitations, need to be clarified further. Local feedbacks respect to air mass temperature increase, soil conditions, moisture availability also in relation with altitude in addition to changes in the dynamics of weather pattern are all factors potentially affecting precipitation distribution.

In that respect, regional climate models (RCM) are useful to enrich trends analysis and

overcome some limitations posed by availability, coverage and representativity of observational network. One aspect emphasized in this work is the estimate of the vertical gradient of precipitation, hardly quantifiable over a region from sparse observations.

However, it is necessary to be very careful when comparing these results with observations due to inevitable systematic errors introduced by modelling. Biases may be different for different precipitation types. For example, I would tend to believe that the variations of the winter stratiform precipitation are more solid than the trends deduced for warm seasons precipitation, due to the well-known difficulties in representing local convection, starting from the diurnal cycle up to the poor ability to simulate well convective organization, especially when running at such intermediate resolution (7km). I think these limitations should be stated more clearly, especially in the introduction where a very optimistic idea is given about model ability to reproduce precipitation processes in such a complex geographical area.

Nevertheless, I found this valuable work and now I will focus on some specific issues to improve the manuscript.

1) In the introduction, where primary observational datasets are introduced, perhaps it worth to consider also the recent ARCIS dataset (https://www.arcis.it/wp/) which consists of a high-resolution climate precipitation analysis for north-central Italy (1961-2015). See also Pavan et al. 2019 for a description of the dataset which covers the entire south-alpine area at high-resolution.

2) At line 306 you state that the annual mean of your reconstructed climatology 1971-2008 is higher in the northern part of the Alps than in the south, and assume that is consistent with observations. This sounds like a wrong assumption since the annual precipitation maxima are recorded in the southern side of the Alps. Isotta et al. 2014 and Crespi et al. 2018, for example, is showing that annual maxima (EURO4M) are larger on the southern-side compared to the moist northern rim, where it rains more frequently but with less intensity. Piedmont-Ticino-Lombardy and Julian/Carnic Alps

and some part of the northern Apennine are well known to be hot spots of heavy precipitation in the Alpine area.

3) Your study area leaves out the eastern alpine region, which, as mentioned above, shows the annual maxima (the Carnic Alps). I found this choice a bit weird. Maybe justify this or reconsider in consideration of the title of the work from which one assumes all the Alpine range is considered

4) A precipitation bias on the northern side is evident in the MAR experiment, and this should be considered more trough the text.

5) The mean seasonal trends are not in total agreement with other works, especially over cold seasons. MAR positive trends are to be found in winter and Norther-Western Alps while in other seasons and regions the trend in the mean is mostly negative or neutral. From observational datasets (namely Isotta et al.2014, Pavan et al. 2019) we see a positive and significant trend in Autumn more than winter, mostly affecting regions with higher annual rainfall (south-side of eastern Alps and northern Apennine). This is also consistent with the findings of Brönnimann et al., 2018.

6) It would be interesting to discuss more the Autumn season in which precipitation in the Alpine area is more intense and often produced by an “optimal” synergy of synoptic-scale systems, which convey towards the region the necessary moist convergence, and mesoscale convective systems (Grazzini et al. 2019). In this respect, a RCM output may be useful to investigate the changes in the relative contributions of large-scale vs mesoscale systems to precipitations.

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