# *Interactive comment on* "High-resolution Med-CORDEX regional climate model simulations for hydrological impact studies: a first evaluation in Morocco" *by* Y. Tramblay et al.

**Anonymous Referee #3**

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Summary of the manuscript

The manuscript deals with the impact of precipitation and air temperature on the discharge at the dam Makhazine in North Morocco. The catchment drains an area of 1808 km$^2$. Precipitation and air temperature from observations and regional climate model (RCM) simulations on 50 km and 12 km resolution with the French ALADIN-Climate model, which is applied in the frame of Med-CORDEX are evaluated for the study catchment and applied as forcing for a parsimonious model for streamflow simulation (GR4J) for the hydrological impact study. Since precipitation data from RCM simulations are biased, the authors study the stationarity hypothesis of bias correc-

tion methods for the study region prior to their application for climate projection studies. Studied are the past decades (1984-2010 (forced with observational data and ERA-interim forced RCM simulation) and 1984-2005(CMIP5 forced RCM simulations) respectively) and results from projection simulations of CMIP5 under the RCP4.5 and RCP8.5 scenarios (study period 2041-2062). Prior to application of the RCM data as forcing of GR4J, the precipitation data is bias corrected testing a quantile-mapping method and a quantile perturbation method. Simulations are run with uncorrected and bias corrected (quantile perturbation) data. The temperature bias is not corrected itself. For the projections only the change of monthly mean temperature between the observation and projection runs is used for the impact study instead of bias correcting the absolute RCM temperatures.

General comments

The study is of interest to the earth system science community, namely the hydrological regional climate modeling community. It is one of the first impact studies based on the latest regional climate model simulations within CORDEX, a regional downscaling experiment of the CMIP5 global climate model simulations for the next IPCC report. It evaluates the precipitation and temperature data in a semi-arid catchment which is of agricultural importance and supposed to suffer from water shortage in the near future. The results can be regarded as a pre-study for the use of the ensemble simulations from MED-CORDEX in the future. The quantile perturbation method needs evaluation on historical data prior to its application to projections though. In case the quantile perturbation method cannot be verified, this is also an important result, but in that case the study should not consider bias correcting the projections. Further more details need to be described. I am looking forward to seeing this study published after a major revision.

Specific comments

1) Title: The title suggests a focus on the climate model simulations from Med-

CORDEX but the manuscript deals with precipitation and temperature only, the impact is only studied with respect to discharge and in a small catchment (i.e. smaller than 1 grid cell in the 50 km resolution RCM simulations). The manuscript rather deals with bias correction methods and their applicability to a semi-arid catchment in Morocco. Further Med-CORDEX is an initiative where a lot of RCMs are applied and also forced with different GCMs from the CMIP5 GCM simulations. In this study only one RCM from the Ensemble is used and only forced with data from one GCM. So the title is misleading and needs to be changed accordingly.

2) Abstract, line 4/5: this sentence should be deleted. It suggests that here data from ensemble runs from Med-CORDEX are used, which is not the case.

3) Abstract, lines 9-15: It should become clear that this study is only carried out for a small catchment covering 1 and 9 grid cells from one RCM respectively. With such a small catchment these high goals cannot be reached. Namely if one keeps in mind, that climate data from RCMs needs to be averaged in space over some grid cells (see e.g. Maraun, 2012). RCMs output – and therefore their impact – should not be evaluated on single grid cells.

4) Page 5690, lines 7/8: Why is only this catchment used, if the goals are to evaluate an RCM and study its hydrological impact? Why are not the other 5 larger dams used as well?

5) Line 24 on page 5690: "...model bias is stationary in time (Maraun et al., 2010)...": First of all the term "bias" has to be defined. Bias of a climate model is the systematic mean difference between the simulated and observed mean climate (by definition the mean over 30 years). So to show that a model bias is stationary in time, a long time series is needed. Then for 30 year periods (running mean) the monthly precipitation and temperatures biases need to be calculated.

6) Page 5690, line 27: this cannot be done in the same way as for parameter calibration in a hydrological model. An RCM not necessarily simulates the same years or months

as dry/wet months as observed. One needs to evaluate the statistics and mean values over a long term period (in your study 1984-2010), as it is done for example within CORDEX and has been done e.g. in ENSEMBLES.

7) Page 5690, lines 28/29: No, Maraun (2012) did not do a split-sample test.

8) Page 5691, lines 1-6: Why then do you assume that the model bias is stationary in time in your study area and that it is enough to study 27 years in Morocco?

9) Page 5692, lines 20-27: It is mentioned before that this study is only carried out for a small catchment in North Morocco. So these issues will only be addressed for 1 and 9 grid cells respectively. This should become more clear in the 3 topics themselves then being hidden in the sentences before.

10) Page 5693, Section 2.1: Here the climate of the study area should be described more detailed, i.e. it should be described in the connection with the past climate and its relation to large scale circulation patterns. Knippertz et al. (2003) found a relationship of monthly precipitation and the storm tracks (NAO related) over the Atlantic. It is also supported by Esper et al. (2007), that the droughts are related to the NAO and Atlantic sea surface temperatures. Looking at the annual precipitation data of the catchment from 1984 to 2010 one cannot see a significant trend due to the strong variability, but the first 10 years are drier than the last 10 years, interrupted only by a few wet years in the mid-nineties. The observed precipitation and temperature timeseries should be discussed.

11) Page 5693, line 25: How much runoff is generated in mm/yr? Is this the pan evaporation measured at the dam or the evapotranspiration of the catchment?

12) Page 5694, line 1: When did the precipitation records start?

13) Page 5694, line 3: Did the temperature records stop in 1996? Which observed temperatures did you then use between 1996 and 2010?

14) Page 5694, lines 7-10: For temperature this is in contradiction to IPCC 2007, fig.

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3.10. For precipitation there is no trend, but a tendency towards extremes (see figure 2). Please show the graphs of the records to show there is no trend. Please show this not only for the study period but for the full record lengths.

15) Page 5694, Line 1: Did you apply the model yourself for this study or did you use the data from the model runs?

16) Page 5695, lines 14-18: These lines can be deleted, since they are of no interest for this study.

17) Page 5696, line 13: Citation for ERA-Interim (e.g. Dee et al., 2011)

18) Page 5697, line 21: It does not make sense to "interpolate" a 2500 km$^2$ grid cell to a 1800 km$^2$ catchment, so please describe more specifically what you did.

19) Page 5698, section 3.1: Please provide the equations and/or a graphical description of the model. Is irrigation included?

20) Page 5699, lines 10-20: Temperature data is only available until 1996. It does not become clear here how with this temperature data the potential evapotranspiration is calculated from 1984-2010.

21) Page 5699, line 22: Please give the formula used for the calculation of PE and show the graphs.

22) Page 5699, line 24: see above, contradiction to IPCC 2007.

23) Page 5700, line 1: This section is about bias correction, not about downscaling methods.

24) Page 5700, section 3.2.1: This method assumes that the quantile distribution does not change under climate changed conditions. Further this method might enhance uncertainty about climate projection, namely if only one model is used. The method shall be evaluated for the catchment, e.g. verifying it on precipitation data from 1961-1990.

25) Page 5702: This perturbation method assumes that the quantile distribution is independent of an increased temperature of 1.8°C. So this should be discussed. Further the method should be verified for 1961-1990 for the Med-HIST runs prior to applying them to projections.

26) Page 5703: It should be discussed that the seasonal cycle is shifted in winter towards maximum precipitation in February in the simulations instead of December. Which effect does this have on the bias correction? Further the observed local minimum in March is not met by MED_HIST. Does MED_HIST show the same large scale circulation patterns from 1984-2010 as MED_EVAL? Are 27 years enough to overcome the strong variability in the study area?

27) Section 4.1: Please add Fig. 4 for the projections and discuss it.

28) Page 5704, line11: But there is a strong cold bias (up to 5 K) in winter in the simulations.

29) Page 5708, section 4.4: The method should be verified for 1961-1990 for MED-HIST.

30) Page 5709, section 4.4: Please add the figure 14 without bias correction and discuss it.

31) Considering the large variability, additional plots of the standard deviation on the monthly mean precipitation in fig. 3 and 4 would be useful.

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