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Interactive comment on "Hydroclimatology of the Nile: results from a regional climate model" *by* Y. A. Mohamed et al.

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Hydroclimatology of the Nile: results from a regional climate model

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The comments and questions raised by Referee#1 are very much acknowledged, and we have accordingly amended the manuscript. A polemical question asked by Referee#1 is about the merit of using data derived from the RCM to estimate the hydrological metrics over the Nile Basin. We have clarified the reasons, and added that to the manuscript. Below, we give our clarification to the points raised by the referee, and indicate the corresponding sections where they have been inserted in the manuscript. All modifications will be presented in the final paper.

Ref#1 This is a very interesting paper and I would like it to be published eventually. It is generally well-written although there are numerous grammatical and spelling mistakes, mainly typographical, which the authors should screen and eliminate. However,

I have a number of somewhat more serious concerns about the results and unless the authors satisfactorily address these concerns I will have trouble accepting the paper for publication in HESS. In particular, since the paper does not include details of the coupled limited area climate model, I take it that this paper is a regional water balance and water recycling paper, and I am reviewing it from this perspective. It cannot be seen as a test of the climate model! 1) An obvious question that comes to mind when reading the abstract and the conclusions. The authors compare the strength of recycling between the Nile, Mississippi and the Amazon - this is very interesting indeed. First of all, how did they come up with these numbers for the Amazon and the Mississippi? However, clearly they did not apply their coupled model to the Amazon and the Mississippi. Secondly, why couldn't they use the same method on the Nile, or did they? I find it troubling that this comparison is a major conclusion of the paper, taking up 50% of the abstract surely it cannot be a validation of the coupled model?

Reply# The paper has been re-edited, and corrected as much as possible for grammatical and spelling mistakes. The paper intentionally aimed at presenting the validation results of the Nile regional climate model. It presents the model results, which describe the regional water cycle in the Nile basin, and compares these results to two other large basins (Amazon and Mississippi). However, the RCM has been built basically to assess impact of land use change on the Nile regional hydroclimatology (results presented in a different paper). Why we are presenting the RCM results? To our knowledge this is the first RCM to be applied over the Nile Basin (which is now stated in the manuscript), and it would be worthy to share the experience with a wider group of readers. So, the objective of the paper has been clearly reformulated in the abstract. Further information on the RCM is added (section 3.1 and 3.2). However, detailed description of model parameterization schemes may not be possible, because of the large number of parameters involved in those schemes (convection, radiation, orographic drag, turbulence, land surface). The validation procedure focused on the final model outcome - in particular the hydrological budget terms - rather than detailed tracking of model sensitivity to a given alteration. E.g., adjusting the amount of aerosols in the atmosphere

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affects the incoming short and long wave radiation, outgoing long wave radiation, energy portioning at surface, evaporation and sensible heat, subsequently that affects the remaining components of the water budget terms. Additional (brief) explanation is added wherever possible. Different sources of data (section 5.5) have been used to compute moisture recycling over the 3 basins. For the Amazon it is based on ECMWF 15-year reanalysis reported in Eltahir and Brass (1994), the Mississippi it is based on atmospheric observations reported in Benton et al. (1950), the Nile it is based on the results from the RCM. It is believed that the Nile (validated) RCM provides better data on the regional hydrological budget than the reanalysis, because of the increased spatial resolution of the resolved processes, and the lack of data assimilation increments in the hydrological budget equations in the model interior.

Ref#1 2) I also have concerns about the coupled climate model. The authors took an existing model, the details of which are not presented in the paper, made modifications to it, and then applied it to the Nile. I am not convinced, given the evidence presented, that the model has been validated. I am novice in this kind of coupled model, the authors downplay the complexity of the model by not including any details of the input requirements and model assumptions - how does one validate such a model? The authors should go over, at least briefly, the fundamentals and the assumptions behind the model, and demonstrate how these are tested with the data at their disposal?

Reply# A brief elaboration on the RCM is given in section (3.1). Extensive validation of the model has been carried out over Europe (and Antarctica) (to which references are given), but never to the Nile area. Further (brief) details on the validation process have been added (section 3.2). The model has been validated against observations of: runoff (4 sub-basins), precipitation (4 sub-basins), evaporation (Sudd sub-basin), change of soil moisture (Sudd sub-basin), short wave radiation (2 stations), and long wave radiation (1 station). We believe that the spatial and temporal variability of the validation datasets, allows a satisfactory judgement of the model quality.

Ref#1 3) The recycling percentage over the Nile is about 11%. This seems very small

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to me - how is one confident that this is statistically significant, given the fact that main transverse fluxes are quite large - the 11% is just the difference between two large numbers!

Reply# The result of moisture recycling over the Nile (11%) is realistic, and it is relatively larger than the values derived for the Mississippi (8%). The monthly value varies between 9 and 14%. The results are compatible with the annual regional water budget depicted in Fig. 16, and on monthly time step presented in Table 3, i.e., the annual convergence = net loss from the atmosphere = runoff from the basin. However, if a different recycling formula is applied to the same dataset, e.g. Schär et al. (1999), then β becomes 29%, 14% and 19%, for the Amazon, Mississippi and the Nile, respectively. It is to be stressed here that the numerical value of the recycling ratio and the other metrics given in the paper should not be adopted literally. That is because the assumptions embedded to the formulae are hard to satisfy in reality (well mixing atmosphere, and linear variability of fluxes; Brubaker et al., 1993; Trenbert, 1999). These indices represent average basin characteristics, and have no prognostic values. The advantages of using them that they are easy to apply, and allow comparison between different basins.

Ref#1 4) I have a very polemical question. While congratulating the authors on implementing a coupled climatic-hydrological model on the Nile basin, I suggest that the fundamental limitation of the work is the availability of precipitation data and runoff data. Therefore, I suggest that the authors could have come up with similar conclusions by analyzing just the available precipitation, runoff and reanalysis data. Is this correct? If this is correct, what good did the application of the limited area climate model do to the whole analysis? What is the essential role of the coupled climate model here? I would like the authors to discuss these points in their rebuttal, and clarify these points in their revision of the paper. I would also like the paper to be reviewed by people working on the recycling question in any of these three major river basins, to seek their perspective

Reply# It is correct that it is possible to compute the regional hydrological metrics from

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the reanalysis data, as done e.g., for the Amazon case. However the RCM, although driven by reanalysis data at the lateral boundary has advantages because it encounters all regional climate process, including the regional water transfer within the Nile domain. The Nile domain itself is much smaller than the RCM to be influenced by the lateral boundary conditions. On the other hand, the reanalysis data actually based on GCM simulations assimilated with observation. The resolution of the GCM might be too coarse to account for local (regional) processes, which could be reasonably captured by the RCM with much finer resolution. This point is added to the paper (section 5.5). A second advantage of using a RCM is that experiments with changed land use characteristics can be carried out, to explore the possible effects of these changes. That cannot be done with observations alone with the same amount of detail. This model has been applied to study the impact of land use change (draining of the Sudd wetlands) on the Nile hydroclimatology, however, results we presented in a different paper (WRR).

Interactive comment on Hydrology and Earth System Sciences Discussions, 2, 319, 2005.