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Hydrology and Earth System Sciences Discussions

Interactive comment on "Optimal operation of a multipurpose multireservoir system in the Eastern Nile River Basin" *by* Q. Goor et al.

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We would like to thank the reviewer for his/her constructive comments. Hereby, we separately replied to all points raised.

1. a) Indeed, we make the assumption that historical weather patterns are representative of possible future conditions. Taking climate change into account was beyond the scope of this study due to data, models and time constraints. However, interested readers can refer to recently published papers on the issue of climate change in the Blue Nile basin (Block & Strzepek, 2009, Journal of Water Res Plann & Mgmt). This assumption is now clearly mentioned in the manuscript (in section 3-6 Model parameters and assumptions).

b) According to several experts that we interviewed while collecting data, the volumetric allocation of water in the Nile basin is by far the most contentious issue. This does not mean that environmental impacts due, for example to change in sediment loads, are negligible and should be ignored. But in such a large river basin, we could not explicitly consider every aspects associated with infrastructural development in the basin and the growing water demands. However, we have added the following paragraph on the impacts of sediments:

"Soil erosion of the intensively farmed highlands in the Ethiopian Plateau is a major source of sedimentation in downstream reservoirs. The annual sediment load of the basin is estimated around 140 Mt/y at Roseires [1]. However, construction of the four mega dams on the Blue Nile within Ethiopia will significantly trap sediment which currently discharges down the Blue Nile in Sudan particularly in the flood season months of July to September.". Secondly, the regulated flow will substantially reduce the flood plain area along the rivers in Sudan.

Cited references: [1] Norplan,Norconsult & Lahmeyer International. Karadobi Multipurpose Projet pre-feasibility study (Final Report) - Volume 5, Initial Environmental Assessment. The Federal Democratic Republic of Ethiopia, Ministry of Water Resources, 2006

c) To avoid confusion, we would like to clarify that the algorithm used in this study is Stochastic Dual Dynamic Programming (SDDP) and not SSDP (mentioned by the reviewer) which usually refers to Sampling Stochastic Dynamic Programming (Kelman & Stedinger, 1990, WRR). The comparison of the analysis described in this paper with the current operation is difficult since: (1) the SDDP model assumes a coordinated management of all the infrastructures while the existing infrastructures are currently operated independently, and (2) we do not know yet how future infrastructures will be operated (independently or conjunctively?)

The authors believe that a comparison between SDDP and SDP would not be very informative because (1) we know that SDP will perform better on small systems (up to 3 reservoirs) for the reasons mentioned by the reviewer, and (2) on large systems, such as the one analyzed here, the comparison is impossible due to the curse of dimensionality associated with SDP.

2. a) We have corrected the mathematical formulation and improved the description of the various variables and parameters. Bold vectors have been adopted for vectors and matrices.

b) The purpose of this paper is not to provide a detailed description of the SDDP algorithm but to focus on an application (here, the Eastern Nile river basin). Due to space constraints, we are left with no choice but to give a rather brief description of the optimization model. Readers should refer to the references given in the manuscript for further information on the SDDP model, especially how cut's parameters at a given stage t are derived from the primal and dual information available at the solution of the many each one-stage optimization problems at stage t+1. We have added the following sentence after eq (15): "Where phiˆl, etha, gamma, beta are expected values of the parameters defining the lth hyperplane. See Tilmant & Kelman, 2007 and Goor et al. 2010 for a detailed explanation on how those parameters are derived from the primal and dual information available at the solution of the one-stage optimization problem (7)-(15)."

c) As suggested by the reviewer, the paragraph has been removed and the reader is invited to refer to a reference (Goor et al., 2010, Journal of Water Res Plann & Mgmt) for further information.

d) Previous modelling runs have shown that the time horizon considered in the present analysis is long enough. The use of a terminal value function did not change the allocation decision for the sampled year, which is year #4, in this study.

3. a) A subsection entitled "Short-run net benefits" has been added to the section "Results and analysis". This new subsection discusses the annual short-run net benefits

for both the energy and the agricultural sectors in each country and for each scenario (as shown on the new Fig. 12).

b) The allocation problem is coupled in time, i.e. allocation decisions taken today will affect future decisions and vice-versa. Irrigation benefits, which are only observed at the end of the irrigation season, depend of the allocation decisions taken throughout the irrigation season. In a backward moving optimization algorithm like SDDP, the optimal allocation decisions are first determined for the end of the irrigation season. Previous allocations decisions are not yet known, and will be determined in the following stages as the algorithm progresses to the first stage. To establish a link between the current decisions and decisions that have not yet been determined by the model but that influence the benefits from the irrigation sector, we consider reservoirs of accumulated water diverted to the crops. For several volumes of water available in each reservoir, the model gives us the optimal volume of water that must be diverted to the various irrigation areas throughout the irrigation season. The net benefits are assumed to be proportional to these accumulated volumes. In systems with large storage (over-year) capacity, deficits, when they occur, are evenly distributed over the irrigation season due the system's memory. In systems with limited storage capacity, however, temporally local deficits can indeed be observed (but then the use of SDDP becomes less attractive as it essentially manage storages).

Typos and minor errors have been corrected.

- line 16, page 4337: vector -> vectors

- line 27, page 4344: project -> projects

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 4331, 2010.

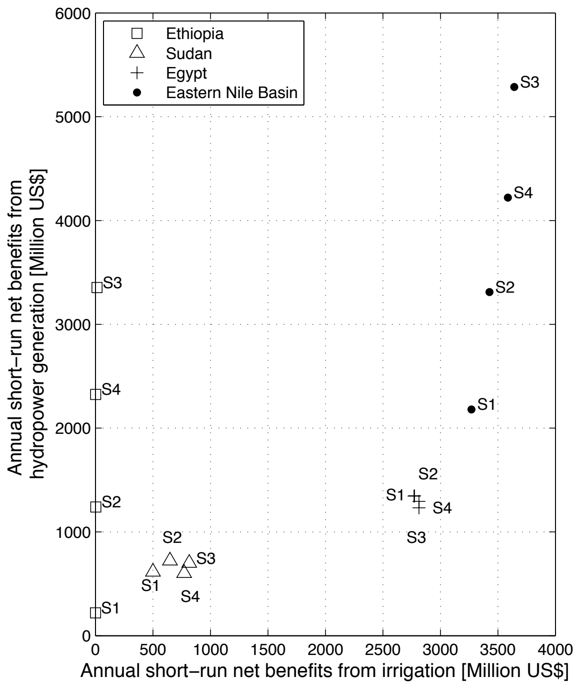

Fig. 1. Average annual short-run net benefits from hydropower generation and irrigation.