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Hydrology and Earth System Sciences Discussions

Interactive comment on "The Hydrological response to climate change of the Lesse and the Vesdre catchments (Wallonia, Belgium)" *by* A. Bauwens et al.

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Dear referee,

First of all we would like to thank you for your review.

Please see our comments for the main issues you raise.

It must be clearly stated that this article is centered on the hydrological modeling and wants to contribute to a more physically based understanding of climate change effect on the water soil plant system. Your comments will of course help us to improve the

quality of this paper and highlight its purpose.

1) Concerning the CCI-HYDR Perturbation Tool.

It can be indeed surprising how different modeling hypothesis and a broad range of climate model can lead to exactly similar results on precipitation changes in summer (high and low CCI HYDR scenarios). The authors of this perturbation algorithm yield similar results (Baguis P. et al., 2009) and a simple explanation can be found in their report quoted below:

"A possible confusion that is worth noting is to assume that the high impact scenario means high precipitations for all seasons and that the low impact scenario means low precipitations for all seasons. The scenarios are constructed for hydrologic impacts and are thus based on range of impacts. During winter, the high, mean, and low scenarios are clear while for the other seasons summer, spring, and autumn the scenarios assume either high, mean, and low conditions based on the climate predictions. "

The impact scenarios are defined in the table below and explain why we have the same rainfalls values in spring and summer.

[table1]

The three scenarios have been obtained by a method of statistical reduction which implies a transfer of the changes forecasted by the climate models to an observed set. Based upon the models presented in the table below, The three scenarios have been calculated in order to represent the width of the expected climate change hydrological impact. The set of the 28 model results implied that there were 28 possible scenarios (A2 and B2) which required close examination as all were equally plausible.

[table 2]

The perturbations series have been developed based on the control period 1961-1990 and the scenario period 2071-2100 of the PRUDENCE database. For the other periods, interpolation is made to account for potential differences between the period covered and the control period, prediction of changes are less certain due to interpolation and extrapolation procedures.

In our study, we have worked with a reference period slightly different: 1967-2000. The reason is simply a lack of observed data before 1967. The most important point raised by the authors is to use at least 30 years of recorded data as input in the perturbation tool, in order to take a whole climatic cycle into account.

Again, our purpose was to focus on the hydrological part of the rainfall runoff modeling. Building up a new climate model was not in the scope of this paper. Nevertheless, it is of importance to notice that this perturbation algorithm is dedicated to the region in which we used it. That is the reason why we focused a little on this algorithm in the paper. We could remove some details to make clear we did not work on the tool development itself.

2) Novelty of the paper:

The choice of a model is sometimes dependent of data availability but is also related to the objectives of the study. Here, we put the emphasis on the modeling of water-soil-plant continuum face to climate change. Our physically-based model includes a crop module which represents crop growth, water uptake, actual evapotranspiration, etc... All these intermediate variables show how crops are affected by climate change. This is particularly important in local, more detailed modeling where conceptual models fail to predict detailed aspects of the phenomena involved (Bittelli et al., 2010; Grizzetti et al, 2005).

As an example, Figure 1 shows the actual evapotranspiration modeled at daily time step during the reference period in the VESDRE Catchment. Each of the colored lines is related to a year of modeling. The black bold line shows the daily mean value. Figure 2 shows the actual evapotranspiration modeled at daily time step during the 2070-2100 time slice using high scenario.

[Figure 1]

[Figure 2]

We can see how actual evapotranspiration is affected by climate change. It is far from a linear change. Vegetation begins to evapotranspirate earlier in the very beginning or the year. Actual evapotranspiration reaches its maximum value more or less at the same time than during the reference period but is then severely reduced due to water scarcity in summer. During fall, actual evapotrapiration restarts and reaches the same value than during the reference period.

Figure 3 shows the actual evapotranspiration calculated using the low scenario. In comparison with the previous one, we can notice that the vegetation evapotranspirates less water in spring with this scenario. The water scarcity in summer is also noticeable but in a slightly less extent than with the high scenario. One can imagine than the maturity (and water need) of crops under high scenario reaches higher level when water availability decreases in summer.

Actual evapotranspiration presents a high variability from year to year but the climate change signal clearly impacts its value through year. Actual evapotranspiration is reduced by 11% between the reference period and the 2070-2100 high scenario. (This value is presented in table 5 of the paper). The reduction is of 17% in the 2070-2100 low scenario.

[Figure 3]

I feel that it was not clear in the paper what was hidden behind this simple table 5. I shall propose to discuss more on the basis of this kind of graphs. It shows better the hydrological part of variability during the runoff rainfall modelling and the interest of a physically-based hydrological model.

Lets remind that the calibration of the model (using transfer functions) only aims at calculate discharges value at watershed outlet in order to validate de model. There are no actual evapotrapiration measurements available. But the hydrological partition between rainfall, runoff, water uptake and deep infiltration is only based on physical soil descriptors extracted from the Belgian soil data base. Of course a range of uncertainty exists in this database. Previous publications discussed it ((Masereel P., Dautrebande S. (1995), Cocu et al (1999), Dautrebande et al (1999), Sohier et al (2009)). We will present a summary of these and discuss Nah coefficient through years in both catchment. Let just notice that a kartic geology in the Lesse catchment might explain the differences in modelling performances.

We will do our best to address your comments and concerns above in the revised manuscript. Thank you again for your comments.

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Table 9: CCI-HYDR impact scenarios and the related changes in precipitation, temperature, ETo and wind.

Season	ETo/Temperature	Precipitation/Wind	Scenario
Winter	high	high	High/Wet
Spring	mean	mean	
Summer	high	low	
Autumn	mean	mean	
Winter	mean	mean	Mean/Mild
Spring	mean	mean	
Summer	mean	mean	
Autumn	mean	mean	
Winter	Low	Low	Low/Dry
Spring	Low	Mean	
Summer	Low	Low	
Autumn	Low	Mean	

Fig. 1. Table 1: CCI-HYDR impact scenarios and the related changes in precipitation, temperature, ET0 and wind

Table 25: Selected models and their respective GCMs and RCMs.

CONTROL	SCENARIO	SCENARIO	GCM	RCM
SMHI	SMHI-MPI-A2	A2	ECHAM4/OPYC	RCAO
	SMHI-MPI-B2	B2	ECHAM4/OPYC	
	SMHI-HC-22	A2	HadAM3H	
	SMHI-A2	A2	HadAM3H	
	SMHI-B2	B2	HadAM3H	
KNMI	KNMI	A2	HadAM3H	RACMO
METNO	METNO-A2	A2	HadAM3H	HIRHAM
	METNO-B2	B2	HadAM3H	
DMI	DMI-S25	A2	HadAM3H	HIRHAM
	DMI-ecsc-A2	A2	ECHAM4/OPYC	
	DMI-ecsc-B2	B2	ECHAM4/OPYC	
	DMI-HS1	A2	HadAM3H	
	DMI-HS2	A2	HadAM3H	
	DMI-HS3	A2	HadAM3H	
ETH	ETH	A2	HadAM3H	CHRM
HC	HC-adhfa	A2	HadAM3P	HadRM3P
	HC-adhfe	A2	HadAM3P	
	HC-adhff	A2	HadAM3P	
	HC-adhfd-B2	B2	HadAM3P	
MPI	MPI-3005	A2	HadAM3H	REMO
	MPI-3006	A2	HadAM3H	
CNRM	CNRM-DC9	A2	ARPEGE	ARPEGE
	CNRM-DE5	A2	ARPEGE	
	CNRM-DE6	A2	ARPEGE	
	CNRM-DE7	A2	ARPEGE	
GKSS	GKSS-SN	A2	HadAM3H	CLM
UCM	UCM-A2	A2	HadAM3H	PROMES
	UCM-B2	B2	HadAM3H	

Fig. 2. Table 2: Selected models and their respective GCMs and RCMs

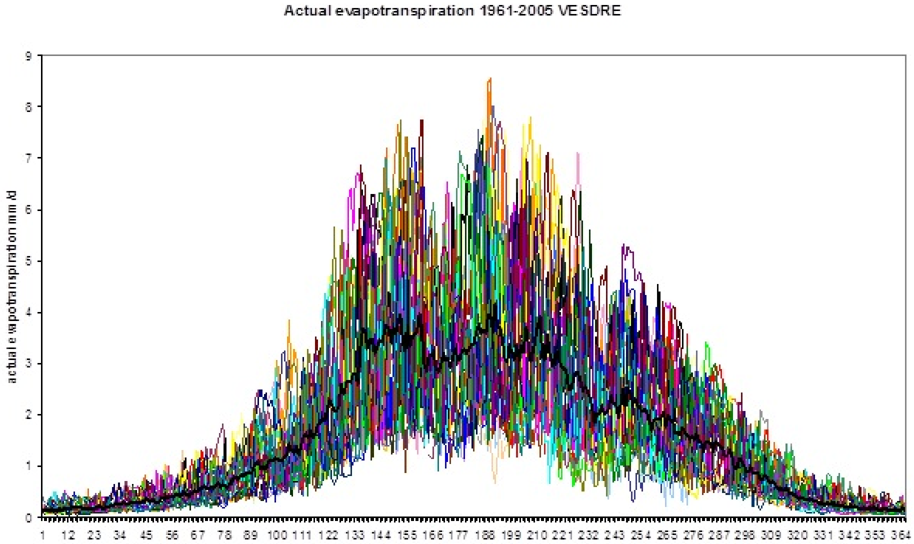

Fig. 3. Figure 1: Actual evapotranspiration in the Vesdre catchment: reference period

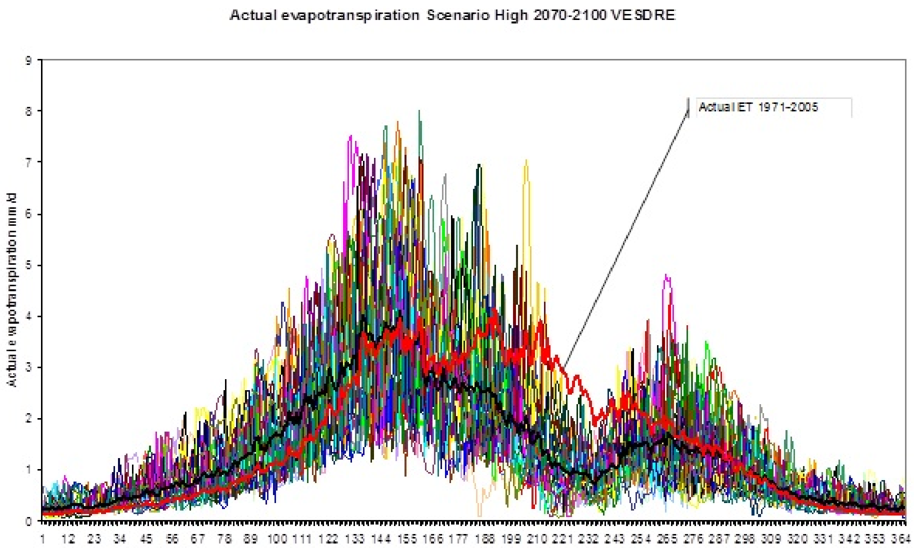

Fig. 4. Figure 2: actual evapotranspiration Vesdre 2070-2100 scenario HIGH

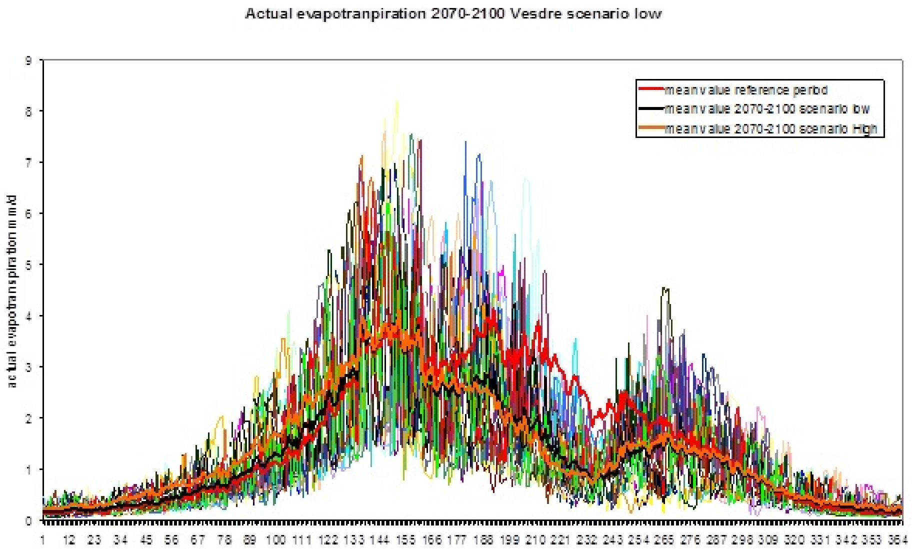

Fig. 5. Figure 3: actual evapotranspiration Vesdre 2070-2100 scenario LOW