

## ***Interactive comment on “Modifying a dynamic global vegetation model for simulating large spatial scale land surface water balance” by G. Tang and P. J. Bartlein***

### **Anonymous Referee #3**

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### **General comments**

This article describes the application of a modified dynamic global vegetation model to simulate the hydrology on a large scale. The hydrology component of such a model is used and, to avoid long model run times, the vegetation cover is derived from satellite data instead of being calculated by the model itself. To assess the validity of this approach, important hydrological quantities, such as soil moisture, evapotranspiration and surface runoff, are compared to existing measured and simulated data. The results obtained are promising and show the ability of the presented model to accurately simulate ET, soil moisture and discharge.

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The article in its present form does not address important issues, which should be examined in greater detail. Proof reading by a native english speaker could improve the quality of the language. Long sentences with additional information given in parentheses often hamper the readability of the article. Some parts of the article should be rewritten into shorter sentences. This would allow the reader to understand the article more easily.

In the introduction the advantages of using such a model should be stated more precisely. Despite the reduced complexity of the model it is not clear what the advantages of such a model are, compared to the original model, but also compared to other global hydrological models, such as WaterGAP by Döll et al. (2003) or similar models.

At the end of the introduction you should provide a short overview over the structure of the article, including section numbers.

The description of the methodology should be more precise. Most of the readers of this article will be hydrologists, thus the most important parts of the model need a better explanation. Especially the processes modelled in the vegetation water balance / photosynthesis module and soil water balance model should be described in more detail. This would help the reader to better understand which parameters are used for which process.

I also suggest to rearrange the contents of Section 2 to improve clarity. The layout of the sections could be organized as follows or similar:

## 2. Methodology

### 2.1 The LH model

### 2.2 Vegetation water balance

### 2.3 Soil water balance

### 2.4 Reference methods and data

## 3. Data

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### 3.1 Land cover and soil properties

### 3.2 Meteorological data

According to this structure Page 1211, lines 3 – 12 would belong to section 2.1. Lines 13 – 23 belong to section 3.1 and Page 1211, lines 24 – 28 belong to section 3.2. The other sections can be divided accordingly.

Additionally, specific contributions of the author and the improvements made to the model are not distinguished clearly from the work done by others. A concise description of the original model and a more detailed description of the improvements made to the model would foster the readers insight.

It is also not clearly visible from the model description that the model runs on a monthly time step.

Results: It is hard to keep track of the different parameters, with which the simulated data ET and soil moisture are compared to the observed data. I would recommend you to collect the parameters calculated in a table. This would help the reader to understand your comparison.

The structure of the discussion (Section 4) should strictly follow the one in Section 3, followed by more general observations and insights.

You state on Page 1226, line 23 that the LH model incorporates static land cover but no dynamic simulation. A static landcover could still be used in a dynamic model, which simulates the seasonal changes of the vegetation cycle. It is not clear to me if such dynamics are part of the original DGVM or not. If they are simulated in the DGVM, why are they not used in LH?

According to Page 1227, line 19 you observe that the simulation in the Sacramento river basin is not particularly successful due to the intensive use of water. It is well known

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that global hydrological models have difficulties to cope with river basins featuring large reservoirs. Why was the Sacramento river still included in the comparison? A few lines later, on line 23, you state based on the poor fit between simulation and observation in same river basin, that the discretisation of the soil layer is not sufficient. I think this statement is not valid, considering the main reasons for the poor fit.

Also you state that the vegetation distribution of the LPJ-DGVM is not necessarily the same as the one derived from the GLC data. How does this influence the model results?

On Page 1228, line 8, you write that some improvements need to be done to the model. Which of the simulated processes or model parameters need special attention and why?

You were running simulations using a different atmospheric CO<sub>2</sub> concentration. These simulations should also be described in the methodology section.

On Page 1229, line 24 you draw the conclusion that the model presented in this article is useful to assess the effects of land cover changes. The same statement can be found in the first few sentences of the abstract and at the end of the introduction. However, this model is only capable of incorporating static land cover. How exactly could it be applied to assess natural or antropogenic land cover changes?

## Specific comments

**Page 1210, line 14** The sentence "(...) because satellite-based land covers are often thought of high accuracy in representing the land characteristics." is too general. The accuracy of such data depends on the raw data, which are uses as well as on the sophistication of the processing. I agree that the GLC dataset used in this article is considered to be of high quality.

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**Page 1212, line 12** The "minimum water scalar value" should be defined properly. Is it equivalent to  $W_{min}$ ?

**Page 1212, line 16** How is the leaf area calculated from the leaf longevity. Is the leaf area equivalent to the leaf area index (LAI) which is used later?

**Page 1212, line 19** Equation (1): The parameters used in the formula calculating the relative soil moisture are not well described.  $w_1$  and  $w_2$  are the fraction of available water in each layer (i.e. the volume of available water divided by the volume of drainable pores of the soil). In my understanding, roots usually diminish the drainable porosity. Thus, the relative soil moisture in soil, excluding the roots, would be  $\frac{w}{n-f}$ , where  $n$  is the drainable porosity. If the meaning of  $w_r$  is different, please add a proper definition.

Additionally, I suspect that you add two intensive properties of the soil. Please clarify the meaning of the single variables and explain why you simply add the relative water content of two layers. As the equation presents itself now,  $w_r$  could take a value greater than 1 under certain circumstances. This contradicts the definition in the text (line 18).

It is also not clear to me which values are used for  $f_2$ . In Table 1 only the values for  $f_1$  are indicated.

**Page 1218, line 8 and 9** According to this, the discharges simulated by the LH model are converted into  $\text{m}^3 \text{s}^{-1}$ . In the results section most of the data is still indicated in mm.

**Page 1218, line 13** Equation (11): Add the corresponding indices to the variable  $\text{srf}_{i,j}$ .

**Page 1218, line 21 to 25** This sentence is too long and should be split in one describing the combination of the two river basins to the "Alabama River" and one on the

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Nash-Sutcliffe coefficient. Generally, the latter is well known among hydrologists and does not necessarily need to be indicated here.

**Page 1222, line 9 – 11** "Nevertheless. . .": This sentence is not very clear and needs re-formulation. "The simulated soil moisture in this region shows a higher variability compared to the observed data."

**Page 1222, line 12** Units are missing: 29 mm.

**Page 1226, line 9** Replace "aerodynamic" by "meteorological".

**Page 1226, line 12 – 16** "Actual ET is considered. . .": This sentence is too long and not clear. Split it into smaller parts. "Actual ET increases with an increasing water vapour pressure deficit. This explains the differences between ET simulated with the LH model and the values found by Vörösmarty et al. (1998) in the ( . . . ) river basins. While the latter considered the influence of the water vapor pressure on the land surface hydrology, this is not done with the LH model."

**Figure 4** The sudden phase shift of the simulated to the observed ET in April 98 should also be mentioned in the text (Section 3.1).

## Technical corrections

- The original model used (LPJ-DGVM) should always be identified by the same name. It often is referred to as "the predecessor". Thus, it is not always very clear which model is meant. I would also suggest to omit the short form of it, as it is defined in section 2.6.
- The typesetting of the formulas could be enhanced to improve the readability:

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- Equation (2) could be written as a fraction to omit the parentheses.
- Equation (5): Omit the brackets.
- Use the variable names with the proper indices in the same manner throughout the document.
  - Use  $E_{\max}$  instead of  $E_{\max}$ , as it refers to the same quantity as  $E_p$  and  $E_{eq}$
  - Also use indices instead of long variable names, if possible. Use long variable names only for well known expressions, such as LAI (leaf area index).
  - The foliar vegetative cover is identified as FVC in Figure 1 and as fvc in Equation (3).
  - The variables  $w_1$  and  $w_2$  are used in Equation (1) and in Equation (9), but do not have the same meaning nor units.
- Table 1: Add  $f_2$  for the second soil layer.
- Table 5: Add the Nash-Sutcliffe efficiency, the RMSE and  $R^2$  to the table. In contrary the standard deviations can be removed.
- Figure 2, 5 and 7: The indicated coordinates of the x and y-axis should be rounded to whole numbers and positioned accordingly.
- Figure 4 and 6: Set the ticks of the x axis to the first of January of each year. Use the same font throughout the image.
- Figure 3, 4, 6, 8 and 9: Set the ticks of the y axis to more "regular" values (e.g. 100, 120, 140, ... instead of 102, 119, 135, ...).
- Figure 4, 6 and 9: The gray used for the observation is too light. Use a black dashed line instead.

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- Figure 8 and 9: The single plots are too small. Please select the most important ones for plotting and use a table to indicate the performance parameters calculated in all river basins.

## References

Döll, P.; Kaspar, F.; Lehner, B.: A Global Hydrological Model for Deriving Water Availability Indicators: Model Tuning and Validation Journal of Hydrology, 270 (1-2) 105-134, 2003

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