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# Does the Budyko curve reflect a maximum power state of hydrological systems? A backward analysis

M. Westhoff[1], E. Zehe[2], P. Archambeau[1], and B. Dewals[1]

[1]Hydraulics in Environmental and Civil Engineering (HECE), University of Liege (ULg), Liege, Belgium
[2]Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

*Correspondence to:* M. Westhoff (martijn.westhoff@ulg.ac.be)

**Abstract.**

## S1 Sensitivity of relation between $h$ and $G_r$ and $G_e$

In the manuscript we used a linear relation between $h$ and $G_r$, scaled between zero and unity. Here we test different the sensitivities of the assumed relation between $h$ and one of the gradients.

### S1.1 Quadratic relation $h = f(G_{\mathrm{r}}^2)$

$h$ is a function of $G_{\mathrm{r}}^2(k_{\mathrm{e}})$ scaled between zero and unity:

$$G_{\mathrm{r}}(h) = \min\left[G_{\mathrm{r}}^2(k_{\mathrm{e}})\right] + \left(\max\left[G_{\mathrm{r}}^2(k_{\mathrm{e}})\right] - \min\left[G_{\mathrm{r}}^2(k_{\mathrm{e}})\right]\right) h \tag{1}$$

To test the sensitivity of this relations, we constructed the Budyko curve for a dry spell of six months. Comparison with the Budyko curve obtained with the original relation were $h$ is assumed to be linear with $G_{\mathrm{r}}(k_{\mathrm{e}})$ shows that the sensitivity is very small (S1)

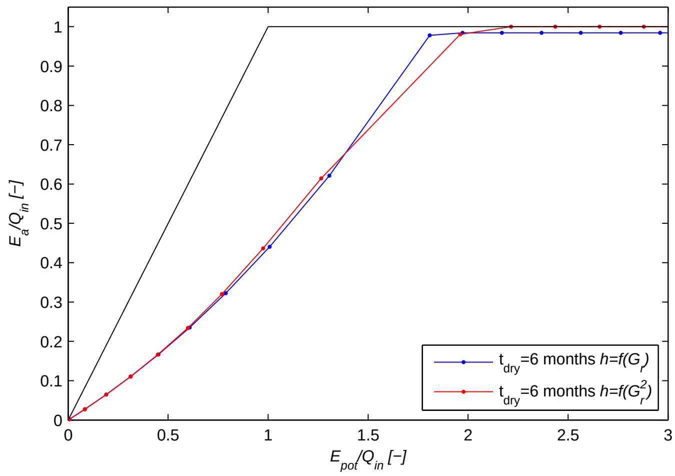


**Figure S1.** Sensitivity of a quadratic relation between $h$ and $G_{\mathrm{r}}(k_{\mathrm{e}})$.

### S1.2 Linear relation between $h$ and $G_\mathrm{e}(k_\mathrm{e})$: $h = f(G_\mathrm{e})$

Another option is to assume that $h$ is a linear function of $G_\mathrm{e}(k_\mathrm{e})$, scaled between zero and unity. To applying this assumption, we had to adapt the gradients in such a way that i) at $h = 0$, $G_\mathrm{r} = 0$ and ii) $G_\mathrm{r}$ is a monotonously increasing with $h$. These two requirements resulted in two different choices for adapting the gradients: the first is to let $G_\mathrm{r}$ at the its minimum between $h > 0$ and $h$ at the minimum of $G_\mathrm{r}$, while at $h = 0$, $G_\mathrm{r} = 0$; the second is to set $G_\mathrm{r}$ to zero between $h = 0$ and $h$ at the minimum of $G_\mathrm{r}$ (Fig. S2a and b). The resulting Budyko curves are completely different from the original one (Fig. S2c). The main reason for this is that, to fulfil the requirements mention above at small absolute values of $\mu_\mathrm{atm}$, the gradients have to be adapted over a too large range of relative wetness.

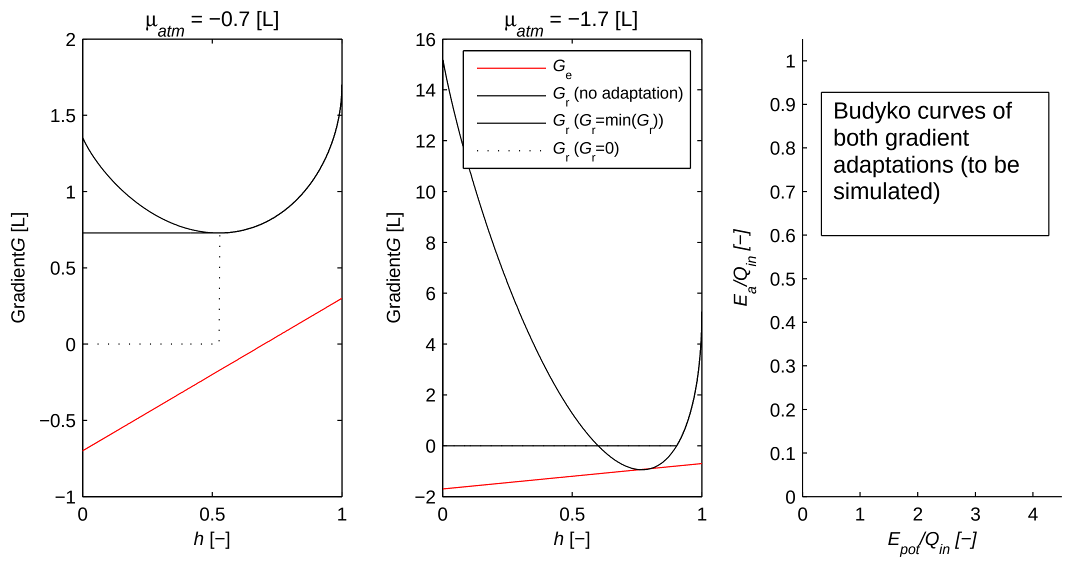


**Figure S2.** Gradients $G_\mathrm{e}$ and $G_\mathrm{r}$ for a) $\mu_\mathrm{atm} = 0.7$ and b) $\mu_\mathrm{atm} = 1.7$, and c) Budyko curves for the two different choices of adaptation of the gradients.

### S1.3 Linear relation between $h$ and $-k_{\mathrm{e}}$: $h = f(-k_{\mathrm{e}})$

The last option we tested is the assumption of $h$ being a linear function of $-k_{\mathrm{e}}$, scaled between zero and unity. Both gradients have been derived as a function of $k_{\mathrm{e}}$ (Eq. 13 and 15). However, only the $k_{\mathrm{e}}$ values representing the falling limb of the Gaussian function of Eq. (13) are used. This is because $k_{\mathrm{e}}^{*}$ is in that section. Because we use the falling limb, we use $h$ as a function of minus $k_{\mathrm{e}}$ in order to get monotonous increasing gradients.

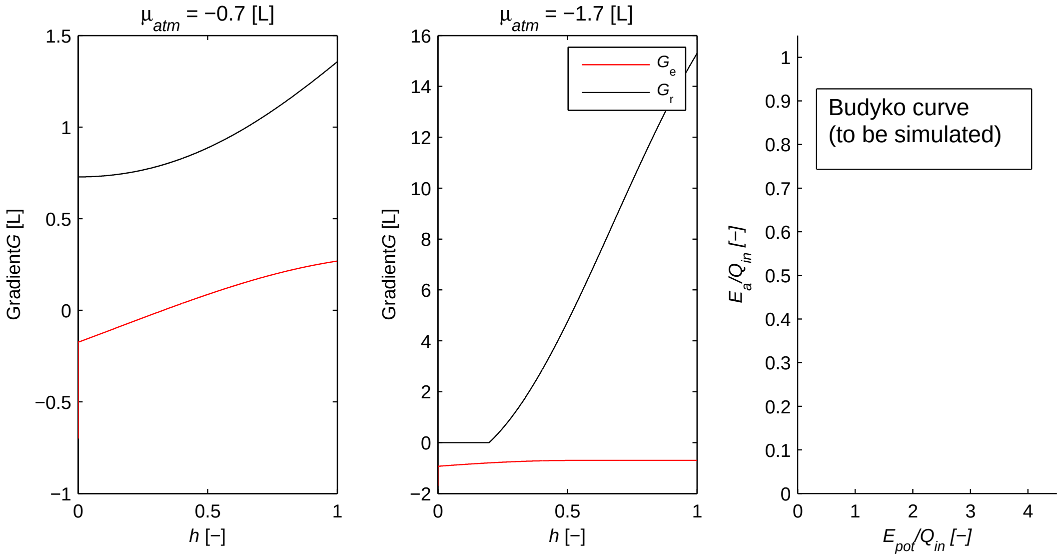


**Figure S3.** Gradients $G_{\mathrm{e}}$ and $G_{\mathrm{r}}$ for a) $\mu_{\mathrm{atm}} = 0.7$ and b) $\mu_{\mathrm{atm}} = 1.7$, and c) Budyko curve.

## S2 Boxplots of monthly precipitation and evaporation

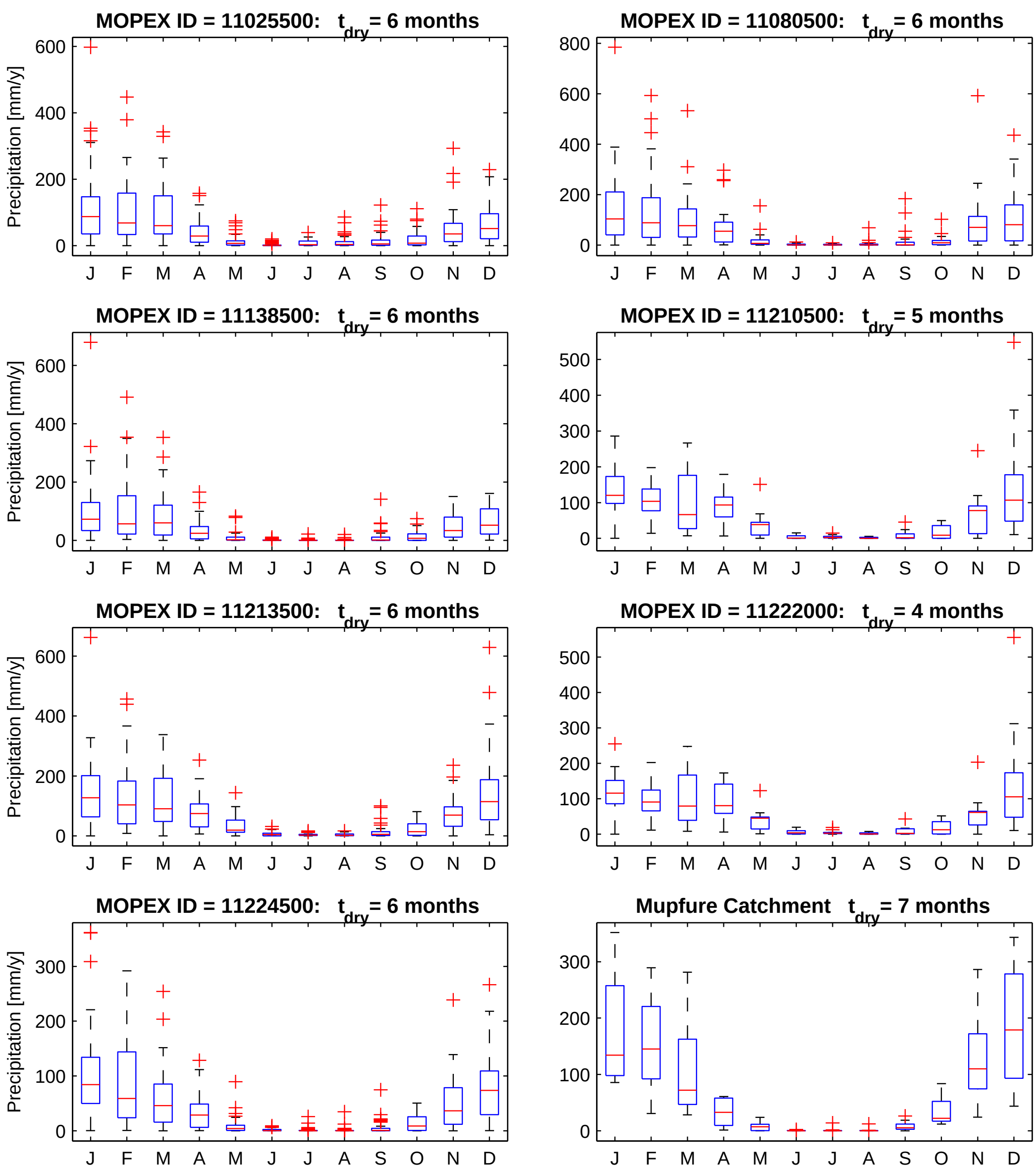


**Figure S4.** Boxplots of monthly rainfall of catchments with a clear distinct dry period.

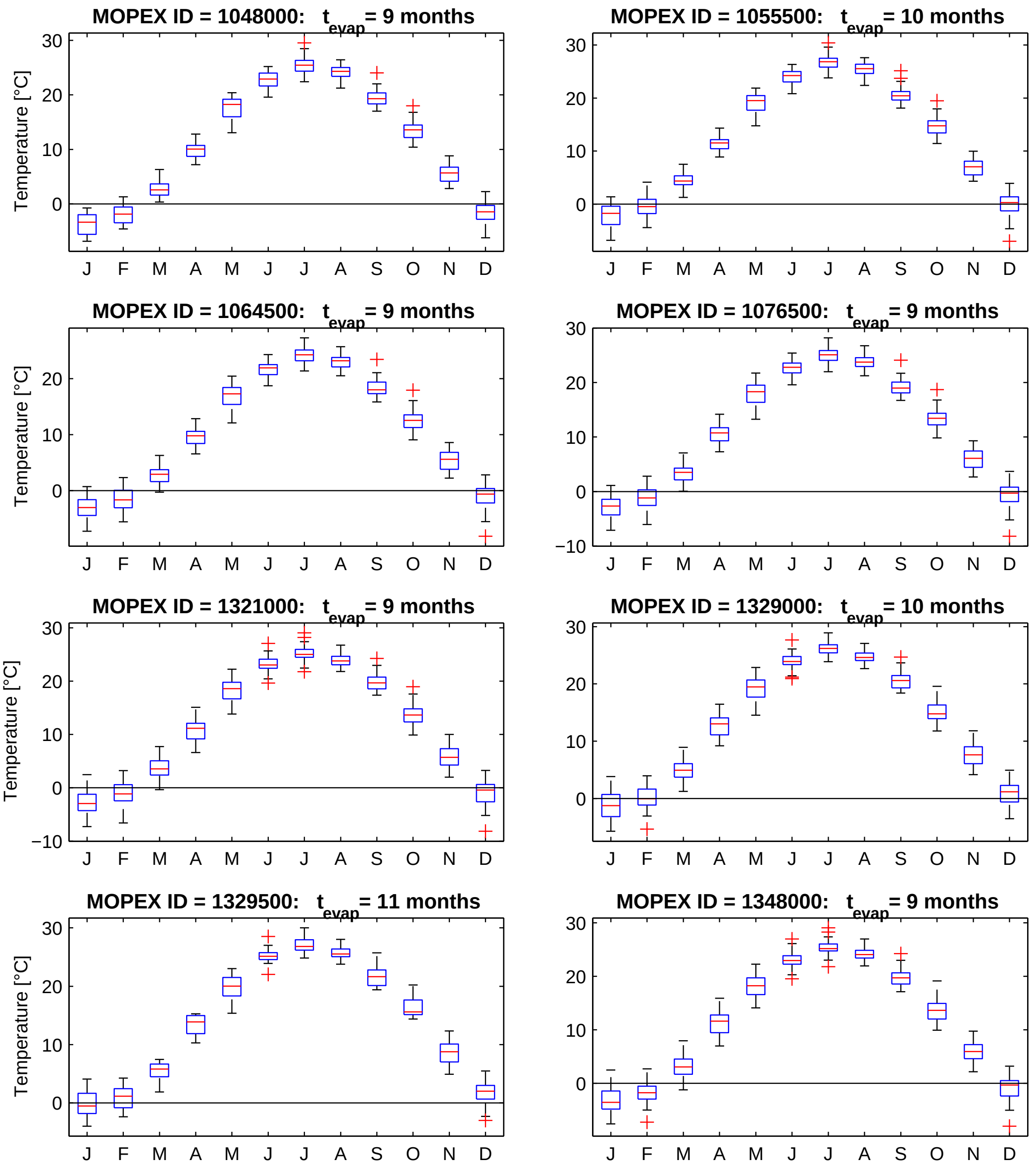


**Figure S5.** Boxplots of monthly temperature of catchment with at least one month of median monthly maximum temperatures below zero: these months are considered to have no actual evaporation.