Review of "Opinion paper: How to make our models more physically-based", submitted to HESS by Hubert H.G. Savenije and Markus Hrachowitz

- This opinion paper addresses the relevant issue of how much physics (and ecology) is represented in so-called physically-based models vs. conceptual models and proposes that wisely conceived conceptual models may reflect more of the relevant physics than physically-based models.
- The paper's topic and style are well-suited for a HESS Opinion paper. The style is relatively informal – actually I can vividly imagine the first author addressing an audience at a scientific conference (or a lecture hall full of students) with more or less the same words.
- It becomes clear from the Introduction that the paper deals with "catchment-scale hydrological" models. This is an important focus of the paper. Hence, I suggest this should be reflected in the paper's title.
- The abstract does capture the reader's attention, but actually reads more like (part of) an introductory section. I propose to shorten (and thereby strengthen) it significantly.
- Introduction, first paragraph: I would have expected a reference to James ("Daisyworld") Lovelock's Gaia hypothesis. Perhaps the authors omitted it deliberately?
- Section 1.1: In discussing drainage patterns, a reference to a book such as Rinaldo and Rodriguez-Iturbe's "Fractal river basins" would have been appropriate. Complexity in the subsurface was for instance addressed in Marc Bierkens' PhD thesis "Complex confining layers" and subsequent papers.
- Section 1.2: "This is Darwinian thinking, alien to the purely mechanistic, Newtonian philosophy on which much of our state-of-the-art modelling concepts are based." – there are of course (mechanistic) crop growth models (pioneered in the early 1970's by C.T de Wit and colleagues in Wageningen). Do the authors also consider such models to be "Newtonian" rather than "Darwinian"?
- Section 1.2: "Hydrological systems at all spatial scales, from the plot to the catchment scale, rather need to be understood as meta-organisms" – this again points towards Lovelock's work I think. In this section, the authors are critical about the "current generation models [...] mostly built on the foundations of time-invariant system boundary conditions". Although such models may indeed "deprive us of developing a better understanding of what drives the change and thus of the systems' future trajectories", they may still serve a (practical) purpose, such as flood (or drought) forecasting. Of course, not all models (have to) serve the "higher" objective of advancing the science of hydrology. On the other hand, also "physically-based" models based on (coupled) partial differential equations may play a useful role in tackling specific questions in scientific hydrology.
- Section 2.1: The authors take the catchment as their spatial model domain. However, the horizontal and vertical extents of these domains my differ largely from one (sub)catchment to the next. How do the authors deal with the aspect of (spatial) scale in their modelling approach? How can model parameters identified at one particular scale (catchment size) be transferred to another (even if the general conditions of climate, soils and vegetation are comparable)? Another aspect the authors pay relatively little attention to is the human influence on catchment behaviour. Catchments, in particular in lowland areas, do not only (or necessarily) reflect the (natural) co-evolution of climate, landscape and vegetation. How is the modelling framework advocated by the authors able to deal with such human influences as polders, dams, irrigation, drainage, etc.?
- P.11, l.18-19: "the these" --> "these".
- Section 2.2: When the authors discuss the "co-evolution between climate, ecosystem, substrate and hydrological functioning", what aspects of climate do they have in mind – only precipitation and temperature (or solar energy), or also atmospheric composition (e.g. CO_2)? The latter, although often disregarded in hydrological models, is known to affect plant transpiration. Regarding the "emergence of patterns", have the authors read Per Baks' "How nature works"? I am sure they have. The late Per Bak also claimed that the complex behaviour we often observe in physical (including living) systems does not necessarily require complex models to be mimicked.
- Section 3: Do the authors consider the VIC model, which they refer to (P.13, l.8), to be a physically-based or a conceptual model?
- Section 4: "At the present level of technology there is still considerable uncertainty in the estimation of E, P and W time series" [determined from satellite information] – but don't most

satellite retrieval algorithms for E employ conceptualizations of the (eco)hydrological functioning of the land surface, which are not necessarily consistent with the modelling framework proposed by the authors? In other words, are the methods currently employed to estimate E from remotely sensed radiances fully physically based?

Remko Uijlenhoet