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Hydrology and Earth System Sciences Discussions

Interactive comment on "Comparing model performance of two rainfall-runoff models in the Rhine basin using different atmospheric forcing data sets" *by* A. H. te Linde et al.

E. Todini (Referee)

ezio.todini@unibo.it

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The paper is an interesting paper, which compares the performances of two hydrological models under different meteorological forcing: actually measured and estimated from ECMWF ERA15 reanalyses.

Unfortunately there is a misinterpretation in the paper that largely reduces its value.

The authors claim that they compare a "lumped conceptual model", the HBV (Bergström, 1976) to a "distributed physically based" model such as the VIC (Liang et al. 1996a,b). Unfortunately, this assumption is wrong. This reviewer entirely agrees

that the HBV is a "conceptual model". The problem is that the VIC is a "distributed conceptual model". It is true, as the authors claim, that the VIC incorporates a physically based SWAT model, but this does not change the nature of the hydrological model component. The SWAT model is part of the forcing.The problem lies in the runoff production and in the routing processes used in the VIC, which are conceptual (and coarse) representations of reality. The VIC model was developed by representing each pixel grid of a lattice with a model derived from the conceptual model ARNO (Todini, 1996), which was developed by modifying the original Xinanjiang model (Zhao, 1977). These two models were developed as "lumped conceptual models" at the catchment scale. The VIC (Liang et al. 1996a,b) only distributed in space this representation, similarly to what was done by Dümenil and Todini (1992) with the ARNO model in the ECHAM General Circulation Model. In their work, these two authors concluded (Todini and Dümenil, 1999) that although the ARNO model was better reproducing the hydrological component than the previous Manabe bucket (1969), the problem of estimating the parameter of the curve representing the saturated areas as a function of the soil moisture content did not allow for a physical interpretation, which prevented to use this approach globally in pixels where the model parameters (and in particular the saturated area-soil moisture content shape parameter) could not be related to some measurable quantity. This is why other more physically based approaches have been recently developed such as for instance LISFLOOD (De Roo et al., 1998; 2000), TOPKAPI (Todini, 1995; Liu and Todini, 2002), or tRIBS (Vivoni, 2003), which parameters are the local pixel slope, the hydraulic conductivity, the soil porosity and the soil thickness. Furthermore, in VIC only the drainage network routes runoff to the basin outlet, while there is no link, in terms of horizontal flow in soil and overland, between neighbour pixels, which may be acceptable if the pixels are large ($>$ 10 km). Not only the hydrological component of VIC is conceptual; also the routing component in VIC is the result of a high conceptualisation. Lohmans approach (1996), is nothing else than a linear kinematic wave routing, which is reasonable as a first approximation when dealing with 50x50 km pixels in the General Circulation Models, but is quite inadequate

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to physically represent the subsidence occurring in natural rivers at a finer mesh size, particularly when, as in the Rhine, the bed slope falls below 0.001.

Therefore, the paper has to be modified by eliminating any reference to "distributed physically based" models. The paper still holds a certain validity if the authors just comment on the fact that the VIC (a distributed conceptual model with a physically based SWAT) is not adequate to reproduce the rainfall-runoff process at the catchment scale. But they should not conclude that "physically based models" are not adequate, since they have not compared one of them.

There is another issue that the authors must acknowledge in their conclusions. They state: "The more realistic representation of evaporation processes by VIC than HBV did not result in better performance even in dry periods, when the evaporation volume is substantial in the water balance. The final advantage of HBV over VIC is that HBV has short computation times, which makes it suitable for simulating long time series of the many available different climate scenarios.". Which can only indicate that the "lumped conceptual" models have to be preferred to the "distributed conceptual models" (not the distributed or lumped physically based ones). Unfortunately they forget another essential issue. A model that can be used in climate studies should not require "calibration", because most of the pixels in the world will not have actual data for calibration. This is why the model parameters must be physically meaningful quantities to be estimated from maps (digital terrain, soil type map, land use map, etc.), in order extend the models to "ungauged catchments". Presnt research aims at deriving "lumped physically based" models by lumping the results of the "distributed physically based" models. This is the line of research that the authors should pursue in order to allow for a real quantum leap in hydrological modelling.

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