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Hydrology and Earth System Sciences Discussions

Interactive comment on "Water balance estimation in high Alpine terrain by combining distributed modeling and a neural network approach (Berchtesgaden Alps, Germany)" *by* G. Kraller et al.

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The authors describe the application of an artificial neural network (ANN) to improve the quality of the results (i.e. modelled vs. observed water balances and discharge curves) of a distributed hydrologic model in a high Alpine catchment characterized by a karstic environment. The problems arising from unknown flow paths and flow patterns in karstic systems are comprehensively described (and they are apparent in many other model applications, too). The proposed approach to consider unknown subsurface flows by defining boundary conditions to the groundwater flow as results

of an ANN instead of "simply" correcting the total runoff is new and very promising, since it allows in principle to correct for external impacts at the places of origin of these impacts and thus allowing the model to run under more realistic (subsurface) conditions – which is essential for physically based models.

On the other hand, there are two major points of criticism: 1) It was, in my opinion, not sufficiently tried to exclude effects of interpolation and precipitation correction. At least for the Königsee-subbasin, the missing runoff could have been easily created by increasing precipitation by either a larger precipitation correction (especially for snow) and/or using other interpolation methods (like a combination of Thiessen polygons with a fix "lapse rate" or gradient, as is available in the used model WaSiM-ETH since May 2010 (version 8.07). In essence, this means, that the proposed correction of subsurface storages by ANN results could simply be a correction of missing precipitation – only more sophisticated and transferred to a later stage in the model chain. To be sure about the reason for the mismatch in observed vs. modelled storage balance and runoff, the water balances of the surrounding catchments to the south and south-east must be taken into account in order to estimate the potential inflow from these sources. Is it realistic that the required amounts of water can originate from the relative small areas of sufficient elevation (to ensure a sufficient gradient) outside the Königsee catchment? This becomes even more critical when looking at the Wimbach catchment: The two neighboring catchments, the Klausbachtal and the Königsee catchment, are contained in the model domain already, so subsurface water exchanges between these subcatchments wouldn't show up in the balance of the entire basin. The Königsee catchment may loose some water to the Wimbachtal, but this effect should partly cancel out the mismatch between modelled and observed runoff in that catchment (i.e. Königsee) as well. The required additional water for the Wimbachtal catchment equals approx. 63% of the modelled runoff (table 3, last row), which is around 800mm/a. So where does this water come from? I would strongly suggest to do some model runs with larger precipitation correction in order to show if and under which circumstances the runoff balance could be modelled without considering external inflows. If this correction would be unrealistic huge, then this would support the theory of the authors.

2) The effect of the ANN application seems to be quite limited. Although there is an improvement in the modelled storages for the months May to September 2007 (fig. 12), there are no or only minor improvements or even worse results in other years (April 2007, May/June 2008, April and July 2009, May, July, August 2010) not to speak about the large deviations in November 2007. Consequently, the discussion and the results shown in figs. 14 and 16 are focussing on 2007, the only year for which the approach works really nice.

I'm missing a comparison of the observed hydrograph against the modelled hydrographs with and without ANN-corrections (similar to fig. 5, but for several years, not only one year). This could demonstrate the effectiveness of the approach much better than the total balance, since it will show the changes in the dynamic of the hydrograph.

I think the reason for the large underestimation of modelled runoff is rather a combination of precipitation underestimation and karst effects (unknown groundwater inflows/outflows). So, the ANN correction is a promising approach but must be justified by better evidence of the real value of the mean areal precipitation.

One thought about the method: Applying constant fluxes to the boundary cells (by the way: which cells where selected by which criteria?) will work for underestimated storages only (so the storage change applied by the ANN is positive), because then the applied flux is positive and the additional groundwater will flow through the subsurface system to the rivers. But what if the storage change is negative? A negative boundary condition (negative constant flux) at the higher elevation rim of the catchment will have almost no effect (except on the cells the boundary condition was applied to). Wouldn't it be better to apply negative boundary fluxes to all cells of a catchment or at least to cells at the lower end of the aquifer? Since the ANN results may well give positive and negative corrections, this must be implemented somehow in the model in order to apply the model+ANN corrections in karst environments where larger portions of the

groundwater flow out of the basin.

My recommendation is to publish the paper after the suggested additional checks and analysis are done (try to model the runoff with higher precipitation corrections or larger precip.-gradients and estimate the possible inflow from the surrounding areas as well as showing the results for several years (not only 2007), also as compared hydrographs).

Please check the attached PDf for much more (also technical) details!

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/9/C19/2012/hessd-9-C19-2012-supplement.pdf

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