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Hydrology and Earth System Sciences Discussions

Interactive comment on "Applying PUB to the real world: rapid data assessment" *by* C. Jackisch et al.

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As we find repeating arguments from all reviewers we address these first in the majors section. This is the same reply to all reviewers. It is followed by additional replies to the specific comments of the reviewers. This reply contains some supplementary material briefly drafting the model verification and DSS application.

Thank you very much for your challenging comments. We clearly see the shortcomings of our study and that we too could not resolve the PUB questions. However, we regard the study as valuable contribution to the discussion about them, which we hope to have shown in the major replies. The revised MS will highly reduce the discussion space within the study presentation and condense it to an appropriate section. We will

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Interactive Discussion

Discussion Paper

include many of your valuable specific comments there.

MAJOR 1 :: The presented data and strategy cannot be evaluated without the model results

We agree with the reviewers. Our objective to present the data assessment alone has clearly failed and will be entirely revised and integrated with the model part, which we have done already. The results will show that the gathered data are applicable to parameterize the model without calibration and allow the setup of the decision support system (DSS).

This implies a complete re-organisation of the MS. We will consider all the reviewers' comments and re-structure the data presentation addressing the shortcomings and condensing the information. In opposition to reviewer 3 we think this can be achieved within major revisions. Moreover, we will carefully revise the title to better reflect how and why this study contributes to the PUB discussion.

MAJOR 2 :: The presented sampling strategy is ad hoc and poorly justified

In opposition to other approaches we present a clearly model- and hypothesis-driven sampling strategy. As we failed to show this in the MS it shall be drafted here. It comprises the three central objectives of the study: 1) validating the assessment strategy through the setup of a hydrological model; 2) assess hydro-meteorological input data and a suitable approach to estimate potential evaporation; 3) extension towards a hydrology based land use DSS.

Objective 1: Derivation of a functional soil map for model setup

We hypothesize that Horton overland flow is the dominant process for the catchment under study. Hence we bias the measurement campaign to address a) infiltration capacity and b) characteristic catena topologies. Simultaneously, the model WASA is found most applicable for the given landscape and purpose. This pre-defines data needs to considerable degree.

To assess the catchment's soil hydraulic parameters and their variability we seek to combine a bottom-up approach aiming at representative samples and hill-slopes/catenas with top-down remote sensing connecting the singular samples to the entire catchment. Parallel, WASA needs definitions of specific soil columns, which are referenced in the catena and subbasin expressions.

The bottom-up sampling strategy reduces the number of samples with increasing complexity of the analytical method. We implicitly hypothesize that first-order (with respect to assessability) characteristics (e.g. soil texture and colour), local observations of infiltration capacity and second-order characteristics (grain size distribution) are sufficient to cover hillslope scale heterogeneity. This is further linked back to third-order characteristics (van Genuchten parameters α, n, Θ_r; Cation exchange capacity, C_{org}), which are treated as homogeneous within a given soil class. We admit that this is a strong assumption, which needs to be discussed and will be verified by presenting hydrological model results in the revised MS.

The top-down analysis (remote sensing) yields spatial distribution and spectral classification information. The supervised classification of Landsat data was trained with ground truths (large, quasi-homogeneous representatives of a certain class identified on site) of the soil classes. It was further validated with the field sample sites (which have been independently classified based on their soil properties). The validation will be presented in the revised MS. We finally obtain a functional soil map that is suitable to parameterise the WASA model by assigning the second and third order characteristics from the bottom-up approach to spatial distribution of soil classes in the catchment. We again agree, that the feasibility of this regionalisation approach has to be tested by presenting and discussing hydrological model results in the revised MS.

We preferred to rely all parameterization on real measurements in opposition to approximations through transfer functions (e.g. Rosetta) or standard values from literature (e.g. van Genuchten parameters defined by soil class). The feasibility of this approach will be verified by presenting the hydrological model results (compare supplementary material). Additionally, we will compare directly measured van Genuchten-Mualem parameters from soil samples with estimates from pedo-transfer functions to underpin the value of local observation.

Objective 2: Meteorological input data for the model and a suitable approach to estimate potential evaporation

Concerning meteorological data we admit that using data from a station that is located 140 km west from our catchment is a potential error-source concerning timing and amount of precipitation events; which should be reflected in systematic timing errors of simulated discharge events.

During model verification spatial rainfall distribution was estimated by means of inverse distance interpolation of local rain gauge data, if available. The other necessary data to calculate potential evaporation (we tested Shuttleworth-Wallace and Hargreaves) were taken from the Indore climate station. In the revised MS this procedure will be explained. We had objections to use remote sensing data for estimating precipitation inputs, because to our experience these data a) are strongly biased and b) do not provide all data needed to run the model. Again we agree, that this approach has to be justified by presenting and discussing the related hydrological model results.

Objective 3: Data on land use and land use potentials to set up the DSS

As land use is of concern for our study we analysed soil samples for organic carbon and cation exchange capacity as proxy for soil fertility. Unfortunately we were not able to establish a reference to data on agricultural productivity because this data lacks geographical reference. However, this data is used in the DSS. The top-down step to characterise the spatial distribution of land use relied on remote sensing (post-monsoon Landsat images) and on site mapping. Rules for cropping practice were inferred from interviews with farmers, NGOs and GOs and contributed to the DSS setup by means

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of a cropping agent. This will be further explained in the revised MS.

MAJOR 3 :: Justify the selection of models that are not totally compatible and get specific about the DSS

To test land use strategies under certain constraints (e.g. maximum yield, minimal risk, water use concerns) we developed a DSS for the lower mesoscale, which consists of a model representing the catchment hydrology (WASA) including crop dynamics (SWAP/Wofost subroutine) to be able to account for feedbacks (water demand/use, productivity). It is driven by a cropping agent (single actor, deciding on given optimality rules on land use and cropping for each element) and a simple weather generator (to test different cropping strategies on longer time scales and to avoid any bias from a singular realisation). This will be further explained in the revised MS.

Since we aim on model parameterization with non-exhaustive measurements a fully physically based hydrological model is out of scope (not to mention the numerical problems at this scale). We thus selected a semi conceptual model that a) resolves the dominant structures and processes of the study catchment (catena and spatially explicit treatment of Hortonian overland flow) and b) already provided a link to vegetation dynamics (WASA). To account for bidirectional feedbacks between land use and the water cycle we fully integrated the SWAP/WOFOST crop routines into WASA, replacing the original look-up tables which have been used at the level of "soil vegetation components" (quasi soil columns). The revised MS will underpin that the model performs reasonably well without parameter calibration, at least in cases of not too wet kharif seasons. Presenting cropping agent and weather generator will further clarify the DSS and concerns of especially non-physical data.

MAJOR 4 :: Selection of catchment – too data scarce but still not PUB

We fully agree with the reviewers that we indeed have to point out a) how we consider the catchment being a PUB example and b) how to show the feasibility of the presented

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rapid data assessment strategy. Concerning a) we agree that the catchment is not totally ungauged. However, with respect to the DSS, we consider this site as very data scarce. Moreover, the existing gauge time series was not used for any model calibration but validation of the hydrological model, which implies testing the feasibility of the presented approach to derive a functional soil map (with a strongly limited project budget). Furthermore, available maps (from the 70s and 80s) where used as priors for the transect selection and had to be discarded during the process, because they were out-dated. The fact that 2/3 of the world's catchments are indeed ungauged is for us justification to look for cheap and rapid data assessment approaches.

We agree that there are different approaches to derive the minimal amount of data that is necessary to setup such kind of model and DSS: For instance working at a very well investigated site and successively reducing the amount of information for the DSS setup. However, in contrary to the reviewers' statements we are not aware of such a study in NW India. The fact that one of the co-authors (Dr. Singh) has excellent contact to local NGOs und farmers in the study area and the fact that such a DSS is urgently needed in this area justifies the site selection.

MAJOR 5 :: The MS is chaotic and uninformative and lacks an overview of existing knowledge in semi arid hydrology.

Through the reviews we clearly see that major points of our study have not been conveyed in the MS. We will adapt the proposals and restructure the paper to crisply present the complete study condensing the discussion in an appropriate section.

ADDITIONAL SPECIFIC REPLY TO REVIEWER 3

7501 3: The statement was meant to be offensive. We used "ad hoc assumptions" as overall description of conceptual suppositions in models, which cannot be directly used with observed data. We agree and will revise the formulation accordingly.

7501 8: We wanted to express, that implementation of PUB needs case studies in data scarce environments. We think that the structural revision of the MS will show that our study is such a case study and provides useful scientific information how to approach nearly ungauged catchments. (see also Major 4)

7501 11-24 (1.3): The inclusion of the model part of the study will alter the focus of the MS and include the DSS (see Major 3). It is definitely one aspect of the study to find out how far a strongly limited (in budget and manpower) study can reach (see Major 4).

7501 25 – 7502 20 (1.4): We agree that RS is of central importance to our study and that our formulation is confusing. We will revise the presentation of the top-down and bottom-up approaches (see Major 2).

Jim Dooge (WRR 1986) characterised systems of the lower mesoscale as systems of organised complexity. Meaning they are too large and too heterogeneous to be modelled with reductionist physically based models in a deterministic way. On the other hand they exhibit “some degree of organisation”, which hampers the application of conceptual models at that scale. In our case it is the catena that organises hillslope-scale overland flow response and we thus regard the selected model as appropriate for this scale and this particular catchment. This is what we meant with landscape entities controlling the dominant process.

7502 21 – 7503 8 (1.5): The scope of the study was not to quantify the uncertainty arising with the presented assessment strategy (see Major 2) but to present the feasibility of the model- and hypothesis-driven approach. As explained in Major 4 the hydrological model was applied without calibration, based on the functional soil map derived from the combined bottom-up and top-down approach and the available meteorological data. This will be better explained in the revised MS.

7503 9 – 7504 17 (1.6): We agree that the overall goal of the study cannot be answered with the data assessment part alone (see Major 1). The MS will be completely restructured and advises will be considered (see also Major 2).

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7505 15 – 7506 10 (2.1): We fully agree with the reviewer, that in any case an inter- or trans-disciplinary project will highly benefit from an integration of specialists from different fields. It might even be necessary. However, this was not possible for our study. Hence we could have opted not to do it or to reduce the problem to hydrology alone which will leave open virtually all integrating interfaces and thus cannot be validated. However, we did assess a rural human-eco-system with clear focus on hydrology and integration into a DSS. The revised MS will present the whole study and the validations.

7506 11 – 7507 6 (2.2): Unlike the reviewer we are not aware of this vast hydrological literature on comparable studies in regional setting, climate and scale. We will carefully re-research on this and give special attention to the mentioned programme. However, we are aware of the mesoscale discussions and did never claim any monopoly on the topic. We intended to highlight that the lower mesoscale is a key scale to this kind of problems, because this is the scale where decisions are made and implemented. We seek to contribute a new approach, which might help other studies to appropriately structure their measurement campaigns and model utilisation. This will become much more clear in the revised MS.

7507 7-28 (2.3): (see Major 1)

7510 12 ff. (4): (see Majors and especially Major 2) The 10 weeks at site are basically one season of pure field work in a remote area. The reviewer should be aware, that the full study (model development, analysis of soil samples, data analysis, DSS application, etc.) took much longer. This will be better explained in the revised MS.

7523 1 ff. (5): The revised MS will shorten the data assessment presentation, extend the presentation of the data in tabular form as supplementary material and re-draw the line from DSS requirements and data availability to the resulting data base and its application in the model and DSS. We do absolutely agree, that publishing all data is part of the scientific requirement. However, this is not suitable for all the data involved due to their non-tabular nature, large amount and possible copyrights. We will seek for

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some downloadable on-file solution.

7534 8 ff. (6): Including all the elements of the study (see Major 1) will present a) the connection of data requirement, data availability, model selection and its extension towards a DSS and its application, b) how this connection results in the proposed hypothesis-driven sampling strategy, c) that this strategy led to a successful uncalibrated setup of the model, d) that the DSS could also be set up, e) that even a full integration of the crop-subroutine could not capture the necessary feedbacks of the eco-hydrologic system at the mesoscale. We will reflect on the reviewer's comments in a fully restructured discussion section.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/8/C4660/2011/hessd-8-C4660-2011-supplement.pdf

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 7499, 2011.