Hydrol. Earth Syst. Sci. Discuss., 8, C4649–C4659, 2011
www.hydrol-earth-syst-sci-discuss.net/8/C4649/2011/

Hydrology and Earth System Sciences Discussions

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

C. Jackisch et al.

gg54@iwk.uni-karlsruhe.de

Received and published: 26 October 2011

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 or your very detailed reflections. As restructuring and highly condensing the MS will take into account many of your suggestions already, we will limit the specific replies to the specifics concerning the scientific content of the MS.

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. 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 hillslopes/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 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 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 2

7504, 9-17: In order to simulate the effect of land use on the water cycle we need to represent bidirectional feedbacks between the two. WASA is our model of choice handling the hydrology of the catchment. Although it is structured as a lumped approach it can be used fully distributed. Moreover, the smallest calculation entity is again a soil column and already has a subroutine for vegetation feedbacks. This subroutine is a look-up table as it was designed for bushland. We used the crop routine from SWAP/Wofost and substituted this look-up table with the dynamic crop representations of SWAP/Wofost. Thus we omit any incompatibilities coming with different representations of the soil-water-plant system and numerical setups and are able to use the two models simultaneously with feedbacks. A detailed description will be given in the revised MS.

7505, 22 - 7506, 10: This is an important discussion point we will adapt.

7506, 13-18: The reason why we refer to these studies (at least to Weiherbach and Malacahuello) is that they support our idea that understanding the catena is key to understand hydrological functioning of the catchment. We agree that these studies are however in humid climates and at smaller scale. As suggested, we will re-research in the literature to refer to studies at similar scale and in similar climate.

7506, 24: The uncertainty of vague singular ground observations vs. integrated remotely sensed data is for sure a very important discussion. Exactly this is regarded as the dilemma of the mesoscale. While long integration distances allow for more generalisation; smaller footprints and more specific process representation will not simply sum up in the system's dynamic because processes are scale dependent. A proposal for connection of information from different sources at the respective scales is exactly what we aim to present in the revised MS.

7507, 21-25: Most of the soft data results in the foundations of the cropping agent. This will be part of the revised MS.

7509, 12 - 7510, 11: What we obviously fail to convey is how we hypothesize to be able to project few singular samples to classes which are identified on the one hand based on the analytical properties and on the other hand based on e.g. spectral properties of the landscape. We will carefully work out a revised presentation of the combination of data sources at different stages what was intended by figure 4. (see also Major 2)

7511, 26: The idea to use a representative hillslope/catena is the common binder to the Weiherbach project. Although the Weiherbach is a humid catchment, Hortonian

overland flow is the dominant process and the catena is the key to understand and model rainfall-runoff behaviour there. We will refer to additional studies that corroborate this idea.

7512, 1-3: Our sampling strategy and the selection of the WASA model is by the fundamental assumption that the catena and Horton overland flow are the dominant structure and process. See major 2 and 3 for more details.

7514, 7-9: This is specified in Major 2 and will be addressed in the revised MS.

7515, 4-16: The meteorological data from the stations within and close to the catchment are, as presented, rather vague references. On the one hand data quality and frequency of measurement is too low for the model application. On the other hand they simply lack necessary parameters (e.g. relative humidity or pan evaporation). Using satellite products (TRMM) would require downscaling (especially temporal as at least daily observations are needed) and add uncertainty to the setup. Moreover, TRMM has no overlap to the existing discharge time series (1992-1996). We will restructure the presentation of the meteorological data to discuss this and to give some comparison of data from the different stations. (see also Major 2)

7516, 21: We will revise the presented figures carefully. During the condensation process we expect most figures and tables to be substantially adapted. As mentioned, also the identification process of the transects will be pointed out. The reason for having no transect in the south east part is that we had limited time and expected to address these entities through the finding from the other transects.

7518, 11: The double ring data will be presented. Units will be converted to SI. At clay sites high infiltration capacity is due to cracks that close during the wetting process. We agree that the average infiltration capacity is with 2.7e-5 m/s rather high. However, the threshold to initialise Horton overland flow is not the saturated but the unsaturated conductivity, which is determined how fast unsaturated hydraulic conductivity (ku) decreases soil moisture. At highly eroded sites the soil layer is very shallow and saturation access overland flow gets important. The respective role of infiltration access and saturation access will be included in the discussion in the revised MS.

7518, 13-18: Due to the limitation of logistics, facilities and budget the number of samples needed to be restricted. The general idea is that the more specific and laborious the analytics, the less samples will be processed. Common characteristics at a superior level of analysis (e.g. grain size distribution or soil type) are used as classifiers. The sample subset is then regarded as representative for the whole class. (see also Major 2)

7519, 19: Landsat was chosen as only freely available RS product at the time of the study setup with sufficient spatial resolution (30m). Moreover, it was regarded as global standard product at this time. The Scan Line Corrector failure is of cause a problematic draw back. However, the data is used as qualitative and relative classification basis, hence pre-2003 scenes are sufficient and atmospheric transmissivity corrections could be omitted.

The spectral properties of minerals, organic matter and silt content are the basis for the identification of the RS data subset. The composite from the bands with most sensitivity to these soil characterising aspects are used as basis for the supervised classification procedure (see major 2). Of cause we cannot be completely sure about plant remains. However, there is hardly any vegetation at the end of dry season, which could also be observed during the measurement campaign (Jan-Mar 2005). As we are not using the spectral values directly for property identification but as qualitative classification basis, the possible influence of plant remains appears rather low.

We will refer to more recent literature on using Landsat products in the revised MS.

7523-7525: The soil classification is presented in some detail as we consider this valuable information about the setting in the catchment. However, we obviously need to alter our presentation to really show the linkage of top-down and bottom-up approaches and the hierarchical sample treatment. Hence we will consider this to be condensed

as a table in the revised MS. (see Major 1 and 2)

7525: The cross-validation of the soil classification will be presented in the revised MS. (see Major 2)

7527-7528: This will be condensed to a table in the revised MS. (see 7523-7525 and Major 1 and 2)

7529-7531: As the data gathering aimed on the setup of a DSS for land use strategy assessment, information on land use praxis, decision building and social dependencies are of central concern. They are of core importance when setting up possible strategy scenarios under study, as these should be as realistic as possible. Moreover data on market value and production costs are used in the DSS for economic assessments. As the revised MS will embrace the whole study, and as we will revise the used figures to help understanding the study's structure, the "soft-data-topic" will be presented in close relation to the technical realisation.

Table 1: The topographic data basis for the field campaign was a 1:50,000 map of the Survey of India from 1976 and the SRTM DEM. A brief comparison of the two revealed quite some difference between them. Thus a simple GPS position tracking including the barometric elevation data and the observation of the transect topologies was used to gain "ground truth" references for the two data sources. Finally, the topographic map had to be rejected as basis for topographic GIS analysis. This is to some degree striking as we usually expect the SRTM information to be the less reliable data source.

The table will be carefully revised. In combination with other reviewers' comments the data presentation will most likely result in supplementary material to the study, which makes space for the more strategy, and model related aspects.

Table 4: The top-soil characteristics are presented here. The revised MS will contain the whole data set table. Thus support and uncertainties will be included. However, the study uses the presented hierarchical sample sub-setting scheme. To address the

uncertainty of this approach a much larger number of samples is needed. As specified in Major 2 we account for spatial heterogeneity/uncertainty of infiltration capacity, which we regard as the dominant source of uncertainty. Including our own studies we know no model study that accounts for uncertainty of alpha, n and residual water content. Please note, that In our case the validation is done through the uncalibrated model setup and the reference to the gauged discharge.

Figure 1: We agree that the figure needs revision. We will try to integrate as much information as possible about the samples.

Figure 2: The aim of this figure is to give some feeling about the data situation, which had to be assessed. We agree, that a condensed presentation will not include this.

Figure 4: This figure will be much more clear when the model part of the study is included in the revised MS. However, the figure will need revision and adjustments then. We will extend its explanation.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/8/C4649/2011/hessd-8-C4649-2011-supplement.pdf

---

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