Hydrol. Earth Syst. Sci. Discuss., 4, S1413–S1424, 2007
www.hydrol-earth-syst-sci-discuss.net/4/S1413/2007/

Hydrology and Earth System Sciences Discussions

HESSD

4, S1413–S1424, 2007

Interactive Comment

Interactive comment on "Parameter extrapolation to ungauged basins with a hydrological distributed model in a regional framework" *by* J. J. Vélez et al.

J. J. Vélez et al.

Received and published: 17 November 2007

COMMENTS TO REFEREE 4

The paper aims to present a parameterization strategy of a conceptual distributed model or regional water resources applications on ungauged basins. The model TETIS was used, and an original approach was developed for the model parameterization, calibration and validation. The Basque region (8500 km2) located northern Spain was used as application case, and all long-term discharge gauge stations were used : calibration on 20 gauged catchments, validation on 62 gauged catchments and prediction on more than 500 points. This topic is of international interest for both research and engineering applications. The data are of good quality (and quantity). My major comments concern : 1. The paper mixes a research approach and an engineering *approach. The authors needs to focus more the paper on the research approach.*

The introduction, the discussion and conclusion need to be restructured and rewritten in order to show clearly the state of the art on the topic, the originality and the genericity of the approach: i) indicate clearly the objective of the paper (not only as an application on the Basque region)

Right, it is not only an application. The research objective of the paper is to show a successful approach to transfer parameters of calibrated distributed models to ungauged basins, which was clearly stated in the title, but not in the abstract and introduction. The application actually was the initial technical objective, but in the paper it is the applicability demonstration of the presented methodology. It will be fixed in the final version.

ii) justify the choice of TETIS in comparison to other models (particularly to physically based spatially distributed grid models);

There was in the 90's a great debate between physically based and conceptual models. From our point of view, it is difficult to delineate the boundary between conceptual and physically based models because it depends on the scale: nowadays any model is working at the point scale which means all the models are conceptual at the usual grid size scale. Which is important is that the model parameters would maintain their physical meaning, and this is stressed in several parts of the paper, including the abstract.

In this context, we just choose TETIS because the parameters are physically based, it performed well in several cases (P912, L25), it is free software, it is our model and, therefore, we could change/improve the code during the research in order to incorporate the specific parameter structure that can permit the automatic calibration and the transfer of the calibrated parameters (actually, the correction factors) to ungauged basin.

iii) discuss the specificities of the study case in comparison to other cases;

HESSD

4, S1413–S1424, 2007

The number of flow gauge stations and the hydrological differences between the basins (especially between the northern and southern basins) makes the case study much more general than the usual one single experimental basin case study. It will be stressed in the conclusions.

iv) discuss if the parameterization strategy proposed in the paper can be applied for other models on other catchments; what are the domain of application and limitations of the approach?

The parameterization strategy proposed in this paper can be applied to any distributed model, as it is stated in page 932 line 23 (see also Frances et al, 2007) and it is obvious that can be applied at any basin.

2. The state of the art must refer to the various approaches developed the last decade on research projects on Prediction on Ungauged Basins (PUB).

Of course, we recognize that PUB as research topic has been very active during last decade in different publications, congress and workshops. PUB have been studied from different point of views, which can vary from empirical, probabilistic to physically based approaches and focused in different processes as runoff, peak flows, extreme floods, water table, etc. PUB also have discussed topics as uncertainty, calibration strategies and model conceptualizations. But in this way, PUB is too wide and too sparse and most references supplied in this work are indirectly related to PUB. And, as far as we know, we are not following any of the PUB approaches to solve the problem of model calibration and calibration extrapolation to ungauged basin. For this reason, there are few references to PUB publications, but, because the common objective, they must be properly referenced in the introduction. For example, we must add some ideas from McDonnell et al. (2007), Sivapalan et al. (2003, 2006), Wagener et al. (2004), Vélez et al. (2007).

Sivapalan et al. (eds) Predictions in Ungauged basins: promises and progress. IAHS Publication 303, May 2006, 520 pp

McDonnell, J. J., Sivapalan, M., Vaché, K., Dunn, S., Grant, G., Haggerty, R., Hinz, C., Hooper, R., Kirchner, J., Roderick, M.L., Selker, J., Weiler, M. (2007), Moving beyond heterogeneity and process complexity: A new vision for watershed hydrology, Water Resour. Res., 43, W07301, doi:10.1029/2006WR005467.

Vélez J.J., López, F., Francés, F., Calibration Strategy For Hydrological Distributed Conceptual Models. IUGG XXIV General Assembly. "Earth: our changing planet", IAHS-PUB session HW2005: From Measurements and Calibration to Understanding and Predictions. Perugia, Italy, July 2-13, 2007. http://www.iugg2007perugia.it/abstracttype.asp

Wagener, T., Wheater, H.S., Gupta, H.V.: Rainfall-runoff modelling in gauged and ungauged catchments. London : Imperial College Press ; 2004. 306p.

Sivapalan, M., Takeuchi, K., Franks, S.W., Gupta, V.K., Karambiri, H., Lakshmi, V., Liang, X.,. McDonnell, J., Mendiondo, E.M., O'Connell, P.E., Oki, T., Pomeroy J.W., Schertzer, D., Uhlenbrook, S., Zehe, E. IAHS Decade on Predictions in Ungauged Basins (PUB), 2003 - 2012: Shaping an exciting future for the hydrological sciences. Hydrological Sciences, Journal des Sciences Hydrologiques, 48(6), 857-880, 2003.

3. Discuss also the scale effect : i) parameterization strategy and estimation of parameter values : from the grid size on a map to the grid size of the model (P925, L15-18); see also P926, L17-20 when moving from a DTM 25x25m to 500x500m; please discuss the uncertainty on parameters; ii) The problem of space and time steps needs to be addressed more clearly and in detail for the TETIS model. What are the domain and limitations of the model. What time and space steps can be used. Is there any link between the grid size (space step) and the time step of the model (P917, L18-23); iii) the problem of scale effects : what domain of application of the model in space (what catchment size) and in time (what data time steps).

The scale (spatial and temporal) effect is managed with the correction factors, as it is mention in P918 L15-18, and it is not the subject of this paper. More explanations about the problems of the scale effects were done in Francés et al (2007). We can add once more this reference in the text.

The change of the scale in the DTM described in P926 is a usual step in distributed modeling. The main spatial scale effect is the slope smoothing, which must be corrected by the corresponding correction factors (affecting the velocities of the overland flow and the river channels). The changes on the river network topology is corrected in the scale change process within the GIS (in our case ArcGIS), mainly forcing the 25 m network in the 500 m map.

In P925 L15-18 there is not any reference to scale. In L20- is just indicated that the time scale is the day and the problems when mixing daily data (starting in the morning) and 24h data (starting at 0:00)

The uncertainty is an important topic and was already discussed in the comments to referee 1 at pages S690 and S691.

In P917 L18-23 only it is stated that the temporal scale is the day. The day and 500 m is a usual combination for continuous simulations in distributed hydrology.

The TETIS model doesn't have any limitation in space and time discretization or size: only the computing time and the scale of the basic information. In fact, it has been applied from experimental basins with 12 km^2 to the Tagus River with a basin of 51,000 km^2; from cell sizes of 10 m to 500 m (never more in order to not be much bigger than the slope size). From 5 min to 1 day temporal discretization (never more, in order to not increase too much the time scale effect); and finally, TETIS is a global model, in the sense that can be used for event (some hours or days) and continuous (years) simulations.

TETIS limitations must be look for in its hydrological conceptualization. For example, the kinematic wave approach for the river flow propagation or the no computation of the water table for the saturated storages.

HESSD

4, S1413–S1424, 2007

Interactive Comment

4. The paper lacks of uncertainty analysis. This point is very important as one objective of the paper is water resources management. The authors have to discuss the uncertainty on the results given during the calibration, validation and prediction (Tables 2, 3, 4 and 5). The uncertainty depends on input variables (uncertainty on rainfall, temperature), on parameters (how parameters are estimated from maps), on output variables used for calibration (uncertainty on discharge), and on model structure and calibration strategies.

See the comments to referee 1 at pages S690 and S691.

Specific comments: P 910, L 3-5. In the abstract, the objective focus on the application case on the Basque region. Please give a more general and generic objective. The Basque region becomes an application case.

Already explained and commented above.

P 910, L13 : Please correct (at the cell scale).

Corrected.

P 910, L15-18 : The term (correction factor) is not defined in the abstract, and it is not clear how it is defined and used. Also there is a confusion between (correction factor) and (correction function). Please define clearly the terms.

Correction function can be eliminated from the abstract. The definition for the correction factor is in L15 (relationship between them), which is enough for the abstract. More details are explained in Section 3.

P 911, L8-26 : The introduction starts with details of the study site. The introduction must be strengthen as stated above.

Ok, already discussed above.

P912, L11 : Give details for (temporal fluctuations); what variables or processes?

HESSD

4, S1413–S1424, 2007

Interactive Comment

In hydrological modelling, all the model inputs have temporal fluctuations or variations. This sentence tries to stress the time scaling effect on the state variables (describing the processes) by temporal aggregation of the inputs. The sentence will be improved in the final version.

P912, L23 : Define the term (effective parameters), and indicate clearly what hydrological processes will be studied.

The term effective parameter was defined previously in the abstract (P910 L12). The processes in P912 L20-21 is any one which is non-linear: in hydrology all of them are non linear in some degree, but especially those with a threshold as the infiltration and percolation processes. All these aspects were discussed in our previous paper Frances et al. (2007) and we want to concentrate this paper in its objective.

P912, L25-30 : Justify the choice of TETIS in comparison to other distributed models.

Already discussed above.

P914, L15 and L28 : Refsgaard instead of Refsgaars. Check also the references (P936, L25).

Corrected.

P916, L20-30: The term (correction factor) is not defined. Please define clearly this term when it is defined for the first time in the text.

Already discussed above. The reference to the correction factors in section 2 can be eliminated in order to first mention in section 3, where they are explained.

P916, P917 : Please give a complete list (in a Table for example) indicating what are the model parameter, and how they are estimated. For each parameter indicate the source (soil map, land use, tables of hydrodynamic properties, topography, etc.).

The list is already in P918-919. The explanations for the initial estimation of the parameter maps are given in section 3.1, but it can be more detailed using the case study in the revised paper. In particular, the next table can be added:

Cell parameter	Decomposition in TETIS model	Source maps
Maximum static storage	$H_u^* = CF_1 \cdot H_u$	DEM, tectonics, stratigraphy, lithology, land use, soil maps (texture, permeability, field capacity, wilting point), hydrogeological units, hillslope orientation, hypsometry and slope
Vegetation cover index for months $i = 1, \ldots, 12$	$\lambda_i^* = CF_2 \cdot \lambda_i$	Land use and vegetation cover
Infiltration capacity	$k_s^* = CF_3 \cdot k_s$	DEM, landscape curvature, FAO conductivity, slope, tectonics, stratigraphy, lithology, land use, permeability, drainage network, hydrogeological units, hillslope orientation and hypsometry
Surface runoff velocity	$u^* = CF_4 \cdot u$	Slope
Percolation capacity	$k_p^* = CF_5 \cdot k_p$	DEM, landscape curvature, slope, tectonics, stratigraphy, lithology, land use, permeability, drainage network, hydrogeological units, hillslope orientation, topographic index and hypsometry
Interflow velocity	$k_{ss}^* = CF_6 \cdot k_s$	Same as infiltration capacity
Groundwater outflow capacity	$k_{pp}^* = CF_7 \cdot k_p$	Same as percolation capacity
Base flow velocity	$k_b^* = CF_8 \cdot k_p$	Same as percolation capacity

Table X. Parameters structure and information used for the initial estimation of them at cell scale.

Interflow velocity uses the same initial estimation than infiltration capacity, which means that CF_6 must take into account also the anisotropy between the vertical and horizontal hydraulic conductivities. Similar for the base flow velocity. With respect groundwater outflow capacity, CF_7 depends on the basin water balance. See also our answer to E. Pasche pages S858 and S859.

For the GKW geomorphological parameters, see our answer to E. Pasche in page S859.

P917, L1-3 : The unit is given for beta (mm/m in the text and I think m/m in Table 2; I am not sure please check), however it is not mentioned that the correction factors are

HESSD

4, S1413–S1424, 2007

non-dimensionalized.

Correction factors are dimensionless. β has dimensions of mm/m. The caption of Table 2 must include this and, in order to be clearer, β can be defined as a "precipitation interpolation coefficient with altitude".

P917, L4-6 : Give details concerning the nine geomorphologic parameters.

See our coments to E. Pasche page S859.

P918, L23 : Please explain what represents i = 1 to 12 (months?)

Yes, months. Corrected.

P920, L10 : Explain what are the three main variables.

Additional information can be added to clarify this point in L6: "available water and saturated hydraulic conductivities of soil and subsoil, respectively)"

P924, L11-15 : The two criteria RMSE and E are linked. We obtain the same optimal parameters when calibrating a model using one of these two criteria. Please justify this choice. What about other criteria.

In fact, TETIS model can handle other criteria as HMLE and AMLE (but they need additional parameters) and temporal aggregation for the objective function evaluation. And the referee is correct: when we have good information (inputs and spatial information for the parameter estimation as it is the case in this paper) we also can not find significant differences between different objective functions. With no specific reason we usually use RMSE for the calibration process and the all statistics (in the paper RMSE, E and %ErrVol) for the posterior performance evaluation during calibration and validation periods.

P926, L27 : The word (maps) is repeated three times. Indicate on a map the location of the stations (for calibration in Table 2, validation in Table 4, and prediction in Table 5). Also indicate on a map the location the (lower basin zone) and (upper basin *zone) (P927, L18-25). Also indicate on the map the location of (northern basins) and (southern basins) (P930, L11-13).*

The paragraph on P926, L26- can be lightly modified: ”In addition, based on available information as topology, land use, lithology and geology the needed by TETIS four parameter maps have been obtained: the three main soil characteristics (available water and saturated hydraulic conductivities) and the vegetation index cover map as mentioned in previous section.”

We can add without names the location of the calibration and validation points in Figure 1.

The Oria basin location is indicated in Fig. 1. We think it is clear the lower basin zone correspond to the area close to the Bay of Biscay and the upper basin zone is in the middle of the Basque Country region. Lower and upper refers to altitude.

The separation between of northern and southern basins is indicated in Fig. 1 with the red line.

P928, L1-5 : The paragraph is not clear.

See our comments to referee 1 pages S687 and S688.

P929, L12-19 : Define the notations DR, BF, RET, etc.

Corrected.

P930, L1 and in other parts of the text : Define clearly how to rate a model as good, very good, excellent, etc. What criteria (or combination or criteria) id used? What about uncertainty on data? The same remark for P933-L29 and P931 L1-4.

In the text was defined the model performance according to the Nash and Sutcliffe Efficiency Index (E) and the criteria was for calibration was previously defined in P929, L23 to L26. For validation at P930,L25 to L28. Why these values? They are from our

HESSD

4, S1413–S1424, 2007

Interactive Comment

personal experience, but you must agree that a calibration with E bigger than 0.8 or a validation with E > 0.7 must be considered excellent.

About uncertainty, again see the comments to referee 1 at pages S690 and S691.

P930, L22 : How many negative indexes? and what was the total number?

Two negative indexes from 62 as shown in Table 4. Corrected.

P931, L8 : The title (4.6 Simulation) needs to be modified in order to focus on what kind of simulations? The conclusion needs to discuss more the generalization of the results and the methodology for applications with other models, or on other catchments.

OK, ”long term simulations” have been adopted for the title of section 4.6.

P939, Table 2. Indicate the unit of beta (is this mm/m or m/m herein).

Already discussed above.

Give a criteria in order to compare the variability of the CF-i between catchments. Is the criteria is the mean value and the standard error for example?

Very important point (actually it is in the core of the extrapolation of the correction factors), but you must see our response to E. Pasche pages S859-860.

P941, Table 4: The first basin Bidasoa does not figure in tables 2 and 3. How the parameters were calibrated for this basin?

The following paragraph can be included in section 4.1: ”In those basins with short length data where calibration was not carried out the validation process was performed using the correction factors of the closest and similar basin, as it is the case of Bidasoa basin, where the correction factors from Oiartzun basin were used.”

The text must be checked to correct English errors (i.e. the term dramatically is used in various places probably instead of drastically please check (P910, L19 ; P916, L22 ; P918, L13).

HESSD

4, S1413–S1424, 2007

The term ”dramatically” has been changed to ”drastically”.

We are worried about these comments because the English in the original manuscript was checked by HESS office with the corresponding invoice increment! In any case, we will review more carefully the English of the next version.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 909, 2007.