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Recommendations on Dynamic Water Resources Assessment Tool (DWAT) applications

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Introduction

The Dynamic Water Resources Assessment Tool (DWAT) has been developed by the Republic of Korea as a contribution to the WMO Regional Association II (RA II) Working Group on Hydrological Services. The Sixteenth Session of RA II (February 2016), through its Decision 4.6(3), invited the WMO Commission for Hydrology (CHy) to undertake an assessment of DWAT and to provide guidance to the RA II Working Group on Hydrological Services to further its development for the benefit of Members. During the Fifteenth Session of the CHy, held in Rome in December 2016, it was agreed that further testing of the DWAT approach would be beneficial.

The CHy undertook an independent peer review of DWAT which was led by a team of experts from its Advisory Working Group. The team consisted of Dr Yuri Simonov (Hydrometeorological Research Centre of the Russian Federation), Mr Tom Kanyike (Ministry of Water and Environment, Uganda), and Mr Marcelo Uriburu Quirno (National Commission on Space Activities of Argentina). The reviewers have extensive experience in operational hydrology, ranging from the operation of measurement instruments and the monitoring of hydrometeorological data, as well as data management to computational forecasting of hydrological phenomena, such as extreme floods and low flows. Their experience proved helpful during the review process particularly in the areas of input data management, the modelling process and the generation of the final products.

The main results of the independent peer review have been described in the assessment report, which was submitted to WMO in December 2018 (see Annex). The independent peer review included results from the implementation of the tool in three river basins – in Argentina, Uganda and the Russian Federation, as well as recommendations on the way forward for the different components of DWAT. The results of the assessment highlighted that a number of recommendations needed immediate attention, specifically regarding the user manual, the model, the software and the graphical user interface (GUI).

The Second DWAT Global Workshop and the 2019 Symposium on DWAT were held from 7 to 10 May 2019, in Seoul, Republic of Korea. During the workshop, DWAT developers presented the status of the changes made to the latest version (version 1.1) of the DWAT software as well as its user manual, including the progress made with respect to addressing and incorporating the reviewers' findings and recommendations from the first assessment report. The report of these meetings can be accessed through the WMO DWAT web page.

The scope of the present report "CHy recommendations on DWAT applications" is to describe and assess progress achieved with respect to the findings and recommendations arising from the independent peer review, and to make an assessment of the tool in terms of its potential applicability in different WMO Regional Associations by the Members. This also takes into account a variety of runoff generation conditions across the globe, differences in NHS capacity (National Hydrological Services), including, but not limited to differences in data availability, computational ability and staffing levels. It was also planned to include recommendations for further development and improvements for advancing the capabilities of DWAT based on the first assessment. However, most of them have already been incorporated in view of the DWAT Symposium and those yet to be incorporated do not preclude the immediate distribution of the tool for users of the Regional Associations.

Progress achieved since the independent review report

This section describes the progress achieved with respect to different components of DWAT since the independent peer review report. All findings and recommendations are described in detail in the report (see Annex). Described below are the main generic conclusions on the achievements of the latest version of the tool (version 1.1) with respect to an evaluation of the recommendations issued previously.

User Manual

The user manual (available on the WMO DWAT webpage) has improved significantly since the first review process. In summary, the initial findings mainly covered different aspects for improvement, focusing on the need for better formats, the lack of completeness and clarity, and the occurrence of some inaccuracies. In the current version of the tool (version 1.1), the following improvements can be observed:

(a) A reorganization of the sections has increased the manual's readability;

(b) The manual's format has improved and typos have been corrected;

(c) Conceptual explanations are clearer and more precise;

(d) Equations included in the manual have been corrected or rewritten, where necessary, with a better and more complete description of the variables and units. Unit inconsistencies have been resolved and the equation numbering is now correct;

(e) Figure resolution has improved.

Having mentioned this, it is possible to conclude that the user manual of DWAT is now very helpful in terms of guiding a user on how to set up the tool, apply it on a watershed and interpret the output results.

Models

To test DWAT, during the first review, the stream flow of the Oka river basin (European part of the Russian Federation) was simulated. The results revealed that the snowmelt process was not modelled in an appropriate manner by the snow dynamic routine of DWAT. Thus it was recommended that the snow dynamic routine be checked for its suitability to model snow accumulation and snow melt processes in river basins with moderate climate conditions. As stated in the final report of the 2nd Global Workshop on DWAT (2019), in the latest version of the tool, the model is capable of successfully simulating the runoff of the river catchments with moderate climate (with seasonal snowpack formation and its significant influence on the river flow). Application of the output adjustment technique, described in the report, helped significantly improve the quality of simulation of daily, as well as monthly streamflow, generated from both rainfall and snowmelt.

Regarding the Horton infiltration capacity formula, currently no correction is included in DWAT to factor that in. In reality, infiltration capacity is not an explicit function of time, which is what Horton proposes, but rather a function of the current soil moisture content. So in the usual case where precipitation intensity is less than infiltration capacity (*fp*) up to a given time, the decrease of *fp* for the following time step is not the one corresponding to the Horton equation evaluated at that given time, but at an equivalent (shorter) time, which is the one required for the Horton capacity formula to accumulate the actual infiltration volume. Although the reviewers have not assessed the impact of not considering this fact, the correction is rather simple and, as such, it is recommended to incorporate it in future versions of the tool. Standard hydrology textbooks such as Viessman and Lewis (2003) or Bras (1990) can be consulted for this.

Software

The independent peer review report included proposals on possible improvements to the DWAT software section. Many of them referred to the DWAT software functionalities, which were identified as requiring improvement. Most of the recommendations were devoted to functionalities, which (if addressed) would make the software easier and more convenient to use. For example, in the previous version of the software, background maps could be downloaded only in one specific format (graphical format) but, in the latest version, different formats of graphical files became available while adding the background layer. Other recommendations were also addressed, such as: an easier generation of data series within the DWAT software (both climatological and streamflow), the organization of data files in text format (so that it is possible to correct it in text editors), the editing of data series within the software, allowing the operation of different routing schemes (as only the Muskingum model worked among the three proposed routing models). Most of the software issues reported were successfully addressed by the DWAT development team, allowing for an easy and user friendly application of the tool using its original software package.

Graphical User Interface

The graphical user interface (GUI) of DWAT is user friendly, which makes it possible for a new user to navigate it with little or no assistance. The interface is intuitive, i.e., a user can start setting up the project quite easily with the help of the user manual. Significant improvements have been achieved in the latest version of the tool (version 1.1) with reference to the main recommendations of the independent reviewers (see Annex 1). Few minor issues identified during the initial testing still remain, however they do not influence significantly the process of GUI usage.

Recommendations

Regarding the user manual, the following modifications are recommended:

- Addition of a list of specific examples on the use of the tool in the real world, as the DWAT might have other applications than water resources assessment, e.g. applications for water resources management, or flood forecasting.
- DWAT has proven its ability to simulate flows for small time steps, thus, there is a high potential for DWAT application in operational hydrological forecasting. Additional functionalities of the DWAT software (e.g. ability to easily ingest NWP data) will allow application of the tool in operational flood forecasting.
- The manual should recommend the modeller to use the option of editing the dpr file with a text editor. Since the file structure is very simple, it can be convenient to define the model topology and model options by editing this file instead of using the GUI, particularly, in the case of complex topologies with many nodes, links and other options.
- It would be useful to have a chapter devoted to a step-by-step application of the tool, i.e. a quick start tutorial. A link to an online video can also be an attractive alternative.
- In order to help generalize the use of DWAT, it would be convenient to add to the user manual a few annexes containing operational examples of DWAT usage for water resources management, including cases addressing the various component (nodes) functionalities, with a focus on the use of the tool for making more informed decisions on water management, which is its primary purpose.
- Introduction of output correction (adjustment) technique will be of significant benefit, as shown in the report for streamflow simulation of the Oka River (see 2nd Global Workshop on DWAT. Final report, Seoul, Republic of Korea, 7-9 May 2019) due to the quality of simulations, which may be substantially increased for different time steps (daily and monthly time steps were used). The results of the suggested method for output correction are determined by parameters of DWAT and by statistical estimations based on the training sample. Such output correction will also allow climate change simulation study using DWAT with new probable variants for the meteorological elements, but with the same parameters of models.
- It should be possible to apply the calibration capability to all the nodes and links simultaneously. It is not an uncommon that there are no discharge observations at internal subcatchment outlets but only at the most downstream outlet of the whole modelled system (as reported for the Burrumayo River Basin test case).
- Embedded GIS functionality of the tool could be further developed to be able to process spatial data, projected in different coordinate systems, as many potential users may have spatial data in different projections. As a first step, guidance should be provided to the users on how to process spatial data using freely available GIS software (e.g. QGIS), if initial datasets are not projected in Geographical Coordinate system. This initial step seems to be vital as all other watershed characteristics are calculated based on the spatial data.
- It would be helpful if functionality for data pre-processing such as filling of gaps in hydrometeorological data, can be included in DWAT.
- Future applications of the tool may be reinforced by creation of a community of practice on DWAT, where NHS experts could successfully implement and run DWAT without the need to consult with the developers in-person. Developing a CoP specifically for DWAT to address any specific questions or issues and share results was one of the approaches considered.
- As the tool will potentially be used by developing countries, which may lack the data required to run the tool, e.g. historical hydrometeorological data, as well as surface information (relief, land use, land cover), it is recommended that case studies highlighting the application of DWAT with freely available datasets are introduced, and recommendations on which datasets to use should be proposed.

- Potential training workshops, as well as a DWAT web-based helpdesk will complement the available training materials and the user manual. The organization of such training workshops and the helpdesk will substantially help WMO Members, as well as other users to successfully use and apply the tool all over the world.

Conclusions

Application of the latest version of DWAT (version 1.1) in river basins with different runoff generation processes showed reliable and sustainable results in simulating runoff and related fluxes, such as snow cover dynamics, soil water exchange, etc. This freely available tool allows a user to set up a modelling system on a particular basin by using the GIS Preprocessor, which is available within the tool, for processing the initial long-term data series, computation of basin cover characteristics, model calibration, and presentation of the final products in an effective manner. It can be said that all significant findings and recommendations from the CHy Independent Peer Review (see the annex) were taken into account by developers of the tool. Recommendations for the sake of potential future development of the DWAT are listed in the Recommendations section of this document.

The DWAT package includes the latest version of the software, a user manual with an extensive description of the tool and examples on how to apply the tool on a watershed(s). It would also be beneficial for the potential users to have a look at the outcomes of the Global DWAT Workshops for additional examples and case studies and the described features of DWAT. It was shown that models are capable of simulation of flow values in different time steps – from daily flows to monthly flows, which is more acceptable for water resources assessment of the big river systems, making DWAT a universal tool for water resources assessment applications. The potential for application of DWAT hydrological forecasting was also explored.

DWAT is a freely available tool, covering the request from WMO Members to provide a tool for NMHSs to meet their needs in the assessment of water resources and other aspects of operational hydrology.

Based on the Independent Peer Review that was carried out, it can be concluded that DWAT has the required capabilities and modelling characteristics to become a widely used tool for water resources assessment catering to a wide variety of users, including NMHSs, academia, the private sector and other governmental and non-governmental organizations with respect to water-related goals.

References

- WMO DWAT webpage: https://public.wmo.int/en/water/dynamic-water-resources-assessment-tool
- 2nd Global Workshop on DWAT. Final report, Seoul, Republic of Korea, 7-9 May, 2019 available at the WMO DWAT webpage
- Bras, R.L. (1990). Hydrology. An introduction to hydrologic science, Addison-Wesley, Reading, Mass, 643 pp.
- Viessman, Warren Jr. and Lewis, Gary L. (2003). Introduction to Hydrology. Fifth edition. Pearson Education Inc. ISBN: 0-67-399337-X

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Annex

DWAT Peer-Review Report

No	Item	Peer-Review	Review Results	Manual Page
1	**User Manual**	The manual should be centred on the DWAT software; the model description should be placed in an annex (or below the software description).	Modified	p. 96
2		The manual addresses issues on how to run the tool, but there is lack of information on how to fine tune the model in order to get more qualitative results.	Modified everywhere in the user guide Reflected in the Quick Start Tutorial with sample data (Video)	-
3		It should be noted in the manual that only a geographic coordinate system is currently supported by GIS Preprocessor.	Modified	p. 10
4		The manual should better describe what meteorological input data are needed for the different approaches that could be selected (there are several options, and they have to be better described).There are many possible approaches for estimating PET and AET, so the manual should provide guidance on which approach would be preferred based on the available data types (e.g., what to do if wind, RH, and sunshine hour data are not available).	Providing Hargreaves method	p. 38 p. 109
5		A more detailed description on how to best approach model calibration (initial parameters value sets) is needed.	Reflected in the Quick Start Tutorial with sample data (Video)	-
6		In some instances, the explanation does not match the graphic being used. Some examples are used in the middle of an explanation rather than starting from the beginning of application of a tool. It is recommended to have a step-by-step manual that consistently uses an example to build a case. The same example can be used to illustrate application on other tools.	Modified everywhere in the user guide Reflected in the Quick Start Tutorial with sample data (Video)	-

No	Item	Peer-Review	Review Results	Manual Page
7		It would be good if different examples of model use are explicitly listed, more specifically than just saying that the model is for water resources management. The manual is too concise. More examples of use would be useful.	Reflected in the Quick Start Tutorial with sample data (Video)	-
8		As it is found in user manuals of other models (e.g. EPA SWMM), it is very useful to have a chapter devoted to showing a step-by-step simple application, i.e. a quick start tutorial. In this way, the user can quickly run the model successfully, even if it is in a very simple case.	Reflected in the Quick Start Tutorial with sample data (Video)	-
9		The manual should recommend the modeller to make use of the option of editing the dpr file with a text editor. Since the file structure is very simple, it can be convenient to define the model topology and model options through editing this file instead of using the GUI, particularly in the case of complex topologies with many nodes, links and other options.	Future work	(System Improvement)
10		section 1.1 Hydrological cycle concept (section 1.1) should be reviewed in terms of the model. In fact, DWAT, as most hydrologic models, deals with just a portion of the hydrologic cycle, occurring on the continent, more precisely within a basin. As found in the textbook by Chow et al. (1988), for most practical problems, only a few processes of the hydrologic cycle are considered at a time, and then only considering a small portion of Earth's surface. A more restricted system definition than the global hydrologic system is appropriate for such treatment, and is developed from a concept of the control volume.	Modified	p. 96
11		"It also enables to compare the impacts of infiltration, evaporation and groundwater flows with climate change" (section 1.1). This is not exactly correct. The model simulates the system output for a given input, irrespective of its nature. It is up to the modeller to force the model with inputs that are either observed, forecasted, long-term predicted, synthesized (e.g. storms from IDF curves) or the result of climate-change models.	Modified	p. 96

No	Item	Peer-Review	Review Results	Manual Page
12		"The model was designed so that all input/output data are linked with Microsoft Excel or text file formats to facilitate parameter management by project" (section 1.1). This statement invites the reader to believe that DWAT is able to read Excel files, which is not exactly true. Time series data can be copied from an Excel (or text) file and pasted in DWAT time series window.	Modified	p. 31
13		Figure 1.1 The labels in Figure 1.1 should be corrected, they are permuted.	Modified	p. 97
14		Section 1.3.2 Theta: volumetric soil moisture. Theta sat and residual are also volumetric soil moistures. Better call Theta as Available or Actual or Current volumetric soil moisture (section 1.3.2 Infiltration)	Modified	p. 102
15		Equation 1.8 In section 1.3.2 Infiltration: Eq 1.8 kr(theta(t)) should be clarified	Modified everywhere in the user guide	p. 102 p. 103
16		Equation 1.9 Slope degree of downslope (eq. 1.9) is dimensionless and it should be indicated.	Modified	p. 104
17		Figure 1.7 Different shape for Conditional blocks in flow chart (figure 1.7) should be used.	Modified	p. 105
18		Horton method Horton: no correction seems to be included with respect to the fact that if precipitation intensity is less than infiltration capacity (*fp*) at a given time, the decrease of *fp* is not the corresponding to Horton equation for the following dt. At least, the User Guide is not explicit in how DWAT solves the issue. See textbooks as Viessman and Lewis (1977) or Bras (1990).	Modified	p. 106

No	Item	Peer-Review	Review Results	Manual Page
19		Section 1.3.3 It is unclear if it is k0 or K0 in Eq. 1.16 and 1.17. Inconsistency with posterior definition of riverbed material hydraulic conductivity and with Eq. 1.18	Modified	p. 106
20		Section 1.3.4 The equation numbering should be corrected (eq. 1.21).	Modified	p. 109
21		Section 1.3.5 In section 1.3.5 Channel Routing: unless the Discretely Coincident Form of the Muskingum parameters is used in DWAT, the usual form of the parameters (as found in most Hydrology textbooks) requires the following condition to be satisfied: $$\frac{\Delta t}{K(1-x)} < 0.5$$ This may be indicated in the manual.	Modified	p. 111
22		Equation 1.23 The parameter C2 is repeated in eq. 1.23 $$C_3 = \frac{K - Kx - 0.5\Delta t}{K - Kx + 0.5\Delta t}$$	Modified	p. 111
23		Kinematic Wave Method In section 1.3.5 Channel Routing, Eq. 1.24: in Kinematic Wave section, the hydraulic radius can be approximated by water depth only in the case where the channel width is much larger than water depth. This should be noted in the manual.	Modified	p. 112
24		Section 1.3.6 There is a unit’s inconsistency in eq. 1.26. With the equation as it is shown, Qs does not result in cubic meters per second. There is a unit’s inconsistency in Eq. 1.27. With the equation as it is shown, Qsd does not result in cubic meters per second.	Unit changed Internally	p. 113

No	Item	Peer-Review	Review Results	Manual Page
25		It could be useful to add a section for wetlands, before or after 1.3.6 Paddy.	Modified	p. 113, p. 114 p. 115
26		Section 4.1 "Catchment information is required and information on water level stations is needed to compare simulation results to observed data" (section 4.1). A time series of "observed" discharge is required, rather than water levels.	Modified	p. 30
27		Section 5.1 The purpose of this menu Model setup (section 5.1) should be clarified? Is it intended for selecting a simulation period shorter than the input time series length? Runs can be performed without visiting this menu. The purpose of the option to set the time interval in the Model setup menu (section 5.1) should be clarified. The time step is imposed by the time series. Or is it possible to ask for a different time step than the time series interval? In this case, does the model interpolate the input series in order to become consistent with this time interval?	Modified	p. 66 p. 67
28		CHAPTER 5: ANALYSIS OF RESULTS Name of the 6th chapter should be changed. Now it says CHAPTER 5: ANALYSIS OF RESULTS	Modified	p. 68
29	**Model**	During stream flow simulation of the Oka River watersheds it was noticed that spring flood (induced by the seasonal snow cover melt) was not modelled in appropriate manner. It is recommended that snow dynamic routine is checked, and then tested on a basin with significant snowmelt influence. It will be also beneficial to introduce calibration of snow routine parameters against measured data (e.g. SWE, snow depth).	To be verified	-
30	**Software**	Download background layers Download background layers - more formats could be added: to open very popular .png formatted file it was necessary to choose "all formats"	Modified	p. 6

No	Item	Peer-Review	Review Results	Manual Page
31		It appeared to be more difficult to make observed streamflow time series, than making climate time series. There is no explanation on how to create a time series file for observed data. It was disturbing as some issues with date and time formats were different. A common style of time series generation should be introduced.	Modified	p. 83
32		It would be beneficial to have data files in text format (rather than in binary), to make it possible to make it (or edit) in popular text editors.	Future work	(System Improvement)
33		A procedure of editing a data series is not provided within the tool, thus it should be introduced (so far it is necessary to make data file from scratch).	Modified	p. 36
34		In series view, if one accidentally clicks on the load button before browsing for the time series file through the "…" button, the software simply crashes without any warning. This is not good for the user. They need to know why the operation is not going to work.	Modified	(System Improvement)
35		In general, the GIS pre-processor is a great idea however it still has some faults, which need to be addressed such that the modeller does not have to look for other software while using DWAT.	Modified	p. 10
36		The GIS pre-processor was used to automatically create a flow accumulation raster by providing a DEM. However, it was observed that for a large DEM covering a small country like Uganda, the automation became too slow before finally failing. However, when the pre-processor was tested on smaller DEM's, it worked well.	Modified	p. 10
37		The capability of the pre-processor appears to be limited. For instance, it may not be able to define projections, trim inputs for the area of interest, etc., therefore as it stands, one has to use other GIS software to prepare the required inputs.	Modified	p. 10
38		The process of defining the outlet point is time consuming if the coordinates of the outlet shapefile do not fall exactly on a pixel of the populated flow accumulation raster. This means that one has to select another point on a pixel that is closest to the outlet point and unfortunately this introduces some error in catchment area and volume.	Modified	p. 12

No	Item	Peer-Review	Review Results	Manual Page
39		The GIS pre-processor is fond of crashing a lot and without warning. Therefore, it was not possible to setup the model using the pre-processor.	Modified	(System Improvement)
40		Model setup and Run Setting up the model was done by connecting various nodes in the working area using a background image. During this process, the model crashed sometimes due to wrong entries. There was no warning or error message reported before the crash	Modified	(System Improvement)
41		Difficulty in assigning weights for Theisen polygon areas to the different weather stations; a calculation has to be done outside of DWAT to define the Theisen polygon areas associated with each station before defining it in the parameters window.	Modified	p. 48
42		Although the units would easily be seen by clicking at each parameter input, for some inputs, the units are either not clear or missing.	Modified	p. 28
43		Only Muskingum model worked among three proposed routing models within the Oka river basin project (see Oka river project folder). The Muskingum – Cunge routing option is available (and was used for the Burrumayo basin). However, the method is run by DWAT exclusively with default parameters, even if they had been changed to non-default values, which is a bug to be fixed.	Modified	p. 61 (System Improvement)
44		The Horton infiltration model is not working properly	Modified	(System Improvement)
45		Although one defines a name for the model run/setup, it is not saved. Therefore, it is necessary to redefine the model setup at each crash. And again, there is no error reporting or warning about a potential failure and crash.	Modified	(System Improvement)
46		The computation of the Nash – Sutcliffe efficiency (NSE) metric between the observed and simulated streamflow time series does not seem to be right. The NSE has been computed outside the model, from first principles, with the same sample of concurrent observations and simulated flow rates, obtaining a substantially different result compared to that of DWAT (differences of around 50%).	Modified	(System Improvement)

No	Item	Peer-Review	Review Results	Manual Page
47	**Graphical User Interface (GUI)**	DWAT software should be capable of error catching and reporting to the users.	Modified	(System Improvement)
48		Every time a project is reopened a background picture is absent and needs to be reopened - it is a minor issue, but still takes time and should be fixed	Modified	(System Improvement)
49		Error messages pop up and there is no description as to the source of an error - it makes using the software much more difficult.	Modified	(System Improvement)
50		Background layers are represented (shown) as "background", and if there is more than just one background layer uploaded, it is impossible to understand which layer to remove - it is better to name background layers according to their file names.	Modified	p. 9 (System Improvement)
51		Soil moisture depth units were indicated as "m", but in reality it should be in "mm"	Unit changed internally	p. 43
52		When doing manual calibration of parameters, it would be beneficial to visualize the efficiency of the new model run (within the scatter chart) at the same time as the parameters that are being calibrated, without having to re-open every time the efficiency scatter chart. Instead, the software currently makes the user close the scatter chart before modifying the parameters, necessitating another run.	Future work Graphic results of the current project and other projects are displayed when other projects are opened and selected in “Chart view”.	p. 72 (System Improvement)
53		When exporting graphs to files (bitmap format), the extension has to be provided when writing the file name, it is not inserted automatically. It would be more convenient to have the extension (.bmp) automatically added to the file name, without the need of typing it.	Modified	-
54		The water balance graphical result shows the word Evapotranslation instead of Evapotranspiration, a typo to be resolved	Modified	p. 71

No	Item	Peer-Review	Review Results	Manual Page
55		The user interface is not very friendly in various aspects: (a) it is difficult to manage the icons with the mouse, (b) the menus have to be expanded every time, which makes its use (unnecessarily) difficult and uncomfortable, (c) when a project is opened, it doesn't show the background, even if it had been previously saved with the background displayed, (d) it is not possible to close the background once opened, without closing the whole project, (e) it is not possible to change the background size (too rigid), (f) the information given at the bottom of the Properties window is too concise; such a good capability could be better exploited.	Modified	p. 9 (System Improvement)
56		Within the GUI, it is not possible to take advantage of the properties defined for one sub-catchment for using them for another sub-catchment to be further edited as necessary. One has to load the values one by one, even if they are the same as those for the previous sub-catchment. The possibility of copying and pasting the properties of one sub-catchment into a second one would be highly useful. However, it is noted that this drawback can be circumvented by editing the dpr file with a plain text editor. As it was mentioned above, the dpr file is very simply structured, and it can be conveniently edited, particularly in the case of complex topologies with many nodes, links and other options.	Modified	p. 41
57		DWAT run results cannot be saved. Whenever a project is reopened, a run must be done again in order to access the simulation results	Modified	(System Improvement)
58		Once a time series has been created, it is not possible to edit the values if required. The corrected time series has to be created from scratch	Modified	p. 36 (System Improvement)
59		When manual calibration is being done, it would be convenient to have the comparison chart (Qobs vs Qsim) open for visual inspection and, at the same time, to be able to modify parameters. For manual calibration, too many repetitive steps have to be done. It would be good if the software memorizes the last text/number insertions.	Future work Graphic results of the current project and other projects are displayed when other projects are opened and selected in "Chart view".	p. 72 (System Improvement)

No	Item	Peer-Review	Review Results	Manual Page
60		There are five menus provided in the Dynamic Water Assessment Tool (DWAT) that can all be accessed by a mouse click. The items at each menu are well connected to the expected functionalities except for a few items under the View/Toolbar menu like "??" which seem to be incomplete. In general, it may be necessary to rearrange the menu items in order to make DWAT more user friendly. For instance, creating time series would be well suited under the "model" menu. Furthermore, provision of a context menu at the level of a node through right clicking would be very handy. The tested icons of New, Open and Save function as expected.	Future work	-
61		- The nodes page consists of nodes represented by icons along with names at the top and names at the bottom. The nodes that have been tested include; Junction, Link, Outlet, Climate, Catchment and Select. These are straight forward and quite easy to apply. However, it's also very easy to make mistakes by creating several nodes at each click. Unfortunately, the nodes at the bottom of the page seem to be redundant	Modified	- (System Improvement)
62		- The model area enabled the model schematic to be set. The zooming functionality is not flexible to allow stepwise zooming.	Modified	- (System Improvement)
63	**Further Improvements**	- The calibration capability should be able to be applied to all the nodes and links simultaneously. It is not an uncommon case where there are no discharge observations at internal sub-catchment outlets but only at the most downstream outlet of the whole modelled system (as reported for the Burrumayo River Basin test case).	Modified	p. 90 (System Improvement)
64		- As the tool will potentially be widely used by developing countries, which may need data to run the tool, e.g. historical hydrometeorological data, as well as surface information (relief, land use, land cover) it is recommended that case studies with applying DWAT with freely available datasets are introduced, and recommendations on which datasets to better use are proposed.	Reflected in the Quick Start Tutorial with sample data (Video)	-

No	Item	Peer-Review	Review Results	Manual Page
65		- Embedded GIS functionality of the tool could be further developed to be able to process spatial data, projected in different coordinate systems, as many potential users may have spatial data in different projections. At the first step, guidance should be provided to the users on how process spatial data using freely available GIS software (e.g. QGIS), if initial datasets are not projected in Geographical Coordinate system. This initial step seems to be vital as all further watershed characteristics are calculated based on the spatial data	Modified	p. 10
66		- It would be helpful if functionality for data pre-processing such as gap filling of hydrometeorological data can be included in DWAT	Future work	-
67		- Further application of the tool may be reinforced by creation of the community of practice of DWAT, where NHS experts could successfully implement and run DWAT without the need to consult with the developers through, in particular, a face-to-face training session. One approach considered was to develop a CoP specifically for DWAT to address any specific questions or issues and share results.	Future work	-
68		- In order to help generalize the use of the DWAT tool, it would be convenient to add to the user manual a few annexes containing examples of use of DWAT for water resources management, including cases addressing the various component (nodes) functionalities, with the focus on the use of the tool for making more informed decisions on water management, which are its main purpose.	Reflected in the Quick Start Tutorial with sample data (Video)	-

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