ARTICLE AWASH RIVER WFLOW

How to make a representative model with Wflow

Boaz Elias-Pour	0922267	
Michiel Kappetein	0869913	
Troy Vlieger	0997410	
Rick van Bragt	0998412	IGODLT
Djurre Schouten	0925603	Group B

Abstract

The Awash river in Ethiopia is the most utilized basin. Due to the every-increasing population and economic development more stress is stacked upon the water resources. The extra stress lead to water scarcity. Water scarcity is mainly caused by population growth, pollution and the increasing demand for economic development. Since the Awash river has its most consumers upstream, downstream the river dries out. Especially since climate change leads to longer periods of drought. Due to the long drought periods the Awash river often changes its path. This paper is aimed to develop a working Wflow model that Is representative for the reality. With data from local weather stations and meteorological data. Wflow is a hydrological modelling platform and targeted to preform hydrological simulations using raster data. Wflow is a distributed modelling platform which maximizes the use of satellite data. With the data of the weather stations the results of Wflow will be checked. This is to find out whether the Wflow is a program that is suitable for the Awash river. For this study Melka Kuntire and Melka Sedi. These were chosen because there is the central point of the catchment area. With Melka Kuntire being upstream and Melka Sedi downstream. The results of both weather stations were compared to each other. Also, the results of the parameter changes of Wflow were compared to the data of the weather stations. The results of the Wflow model shows that Wflow for now is not representative for reality. Wflow does not take all inflows and outflows accountable and therefore is not representative. More parameters and more data are needed for the program to function properly.

Introduction

Keeping sustainable utilization of water resources gets harder every year due to the increasing demand of water resources. In Ethiopia the Awash River Basin is the most utilized basin. Due to the ever-increasing population and economic development more stress is stacked upon the water resources. This leads to water scarcity. Water scarcity is mainly caused by population growth, pollution and the increasing demand for economic development. These factors are the cause of the decline of available water resources in the basin. Another factor that comes into play is climate change. This also affects the hydrological cycles a water resource. Due to the population growth and climate change the basin is pushed to their natural limits. The problem becomes worse with increasing water demand and economic growth. The river basin water is becoming scarce due to the increasing demands and poor water resource management. Whenever it will dry out due to the poor management and increasing demands thousands of Ethiopians will suffer. Due to long drought periods the Awash river changes its path often. With an economic growth Ethiopia wants to use the river for water supply. With the river changing its path and basins a location needs to be found for the industrial growth. Nowadays water resource is modelled with various models. Wflow is a promising technology for modelling a water resource but there are very few implementations so far.

Therefore, this paper aimed to develop a water resource model for the Awash river in Wflow to make representative model outputs.

- What is the current problem with Ethiopia and the Awash river?
- How can Wflow record the Awash catchment?
- What are the results of the changing parameters upstream compared to downstream?

Current situation Awash river

The Awash River basin is like mentioned above the most utilized basin in Ethiopia, it covers a total area of 114,123km^2. The annual rainfall of the basin ranges from 100 to 1700 mm which has spatiotemporal variation. The rain season is from June to October and dry season from November to

May. The Awash river basin has been the most utilized basin in Ethiopia since modern agriculture. The basin is home to roughly 15 million inhabitants. Like many African countries' parts of Ethiopia face water shortages, poor sanitation and lack access to clean water resources.

In the past twenty years, droughts have affected several areas in the country (The Water Project, 2019). Lakes, rivers and streams dried up or became extremely shallow. During these drought periods the river receives a lot less water. The precipitation density is much higher in the drought periods what leads to problems. Due to the drought the groundwater level declines, during downpours a low percentage of the water can infiltrate the ground. The water that doesn't infiltrate the ground creates flash floods in the country, which causes economical damage. During the drought seasons, as said before, has a lower water supply than during the rain seasons. Since the river has less water it searches for another path to flow to the basin. This makes it difficult for Ethiopia to grow economically as industrially. If the river changes its path the basins in the river also change. This makes it hard to find a location for economic growth. Climate change adds on to the drought seasons and rain seasons. Longer drought periods will occur, and precipitation comes in a higher density. More and bigger problems will come with climate change.

The Awash river has many consumers up streams. The river upstream is surrounded by big cities and therefor needs a bigger water supply. The water consumption upstream leads to water shortage downstream. Especially during droughts, the river dries out downstream. Downstream a lot of farmers use the Awash river as water supply. During dry periods farmers cannot make use of this water supply if this dries out or it could lead to problems further down the river for the inhabitants/farmers. The precipitation downstream is close to nothing compared to the precipitation upstream. The precipitation downstream is 10% of the precipitation upstream. Hence why the inhabitants downstream depend on the water supply from the Awash river.

Wflow

Wflow is a hydrological modelling platform and targeted to preform hydrological simulations using raster data. Wflow is a distributed modelling platform which maximizes the use of satellite data. The data is based on physical parameters and meteorological input data.

Sources of data

The datasets that were used to establish the Wflow model were meteorological data and data from local weather stations. It contained hydrological data for the Awash river. The data was obtained by Deltares. It contained information of several weather stations nearby the Awash catchment.

Methods

This study aims to develop a Wflow model that shows a time lapse of the flow of the Awash river. Wflow has been successfully applied worldwide for evaluating the impacts of climate change or management alternatives and inundation modelling (Deltares, 2018). The Wflow platform consists of several modelling concepts. These concepts share the same structure. To route the water downstream the program uses wflow_sbm model. The wflow_sbm is about the soil processes of a specific area. A schematization is given below of the soil processes.

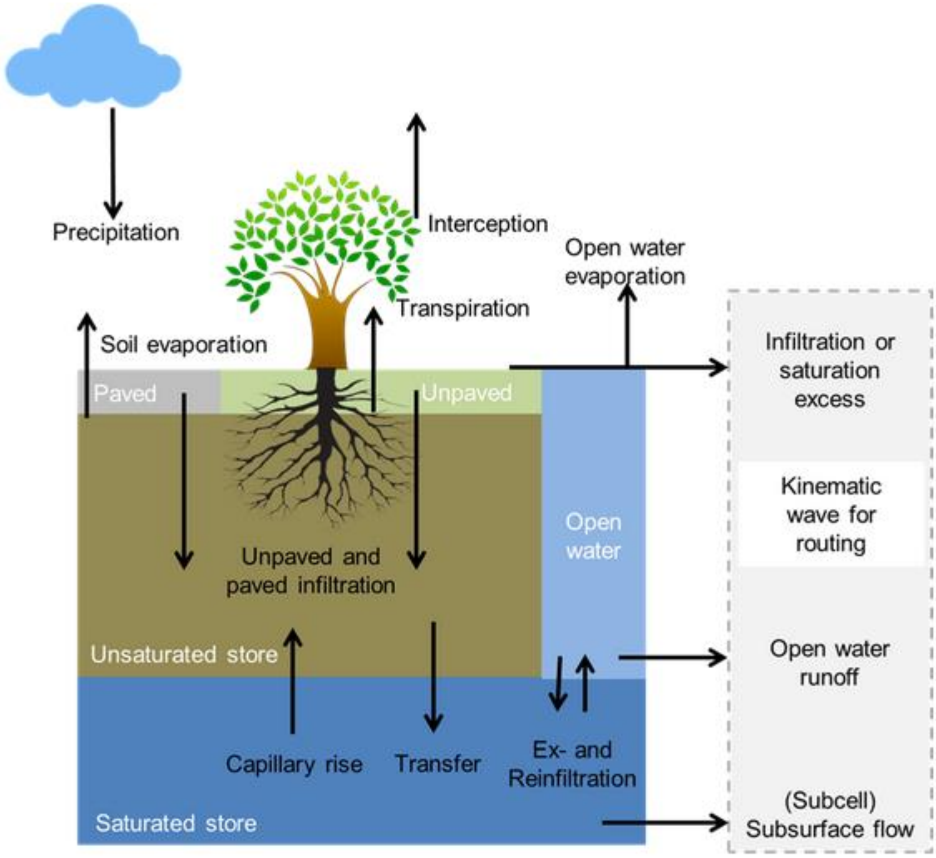


Figure 1 Soil processes

Approach

The data that is received was about the weather stations in Ethiopia. These weather stations showed exactly how much precipitation fell throughout the years. The data was put together in Excel. The outcome was compared to the results of Wflow. In Wflow the parameters have also been changed. This is to an as much realistic model as possible compared to the weather station data.

Weather station data

The data that was received from Deltares was put in Excel. These files were changed from .txt to .csv. Since Wflow works with Qgis the data was prepared to be used for Qgis. Of the weather stations shapefiles were created in Qgis. The shapefiles were created with the latitudes and longitudes coordinates. These were also given in the Excel.

Meteorological data

The data is received by desk study. This data contained weather data from 1990 to 2008. The data was processed with Wflow. From this process an SBM map was created. For this process in the ini.file ,from Wflow, the runtime was changed. For these files a time lapse of five years was chosen. This was between 2003 and 2008. The reason behind this was because the first five years of the data was unreliable. The first few years of the run the model is not representative due to the lack of water in the soil and in the river. Therefore, the first few years weren't used for calculations. With this being done the normal run of the Wflow can be started with the use of the .Bat files. The .Bat file has the specific catchment area. After this process multiple files came with the SBM map in which the run.csv was the most interesting. With the run.csv the data from the meteorological data could be compared to the weather station data.

Changing the parameters

The results from the Wflow run were compared to the weather station data. The difference between these results showed that the Wflow model run was unrealistic. Therefore, the parameters had to be changed. The parameters were Soil thickness, KsatVer, KsatHorFrac, Rooting Depth and N_River. These parameters were added to the .Bat file. Multiple runs were made with different input data. After every run an SBM map was created. With each run the results were compared to the weather data.

In each SBM map a wflow_outmaps.nc is located. With the use of a plugin named Crayfish the file can be plotted in Qgis. From here on out Qgis can visualize the results of the run. This is shown in the figure below.

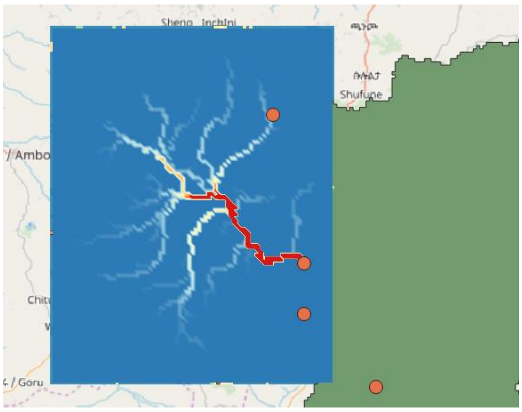


Figure 2 Results of model run in Qgis

Results

With the simulated data that was received from the SBM map. The run file is compared to the weather station data. The data that is shown in the figure below is the weather station data and the simulated data of Wflow that is made in the SBM map. The blue line is the data from the weather stations. The black line is the non-parameter changes line from Wflow. The discharge is roughly 400m^3/s.

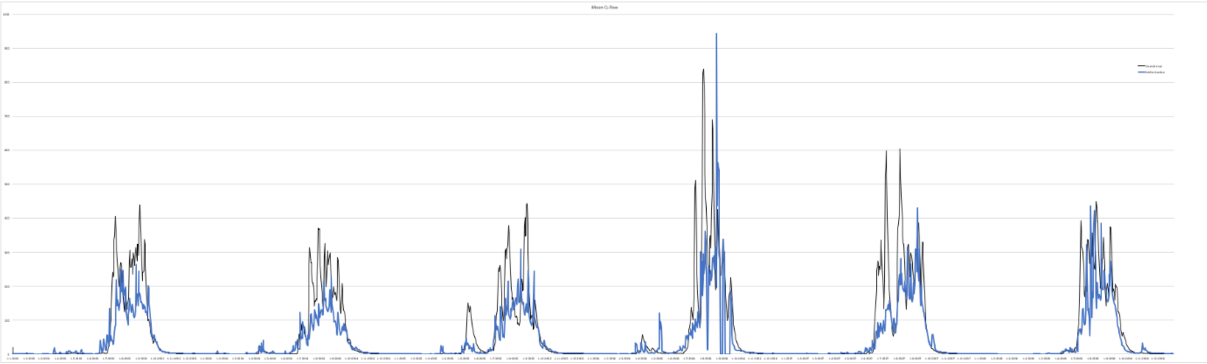


Figure 3 Comparison between the weather stations and the non-parameter Wflow

To get a realistic working Wflow model the difference between the results must be minimize possible. Over the five years the weather station and the data of the run model do not match. To get a realistic Wflow model changes were with the parameters. By changing the parameters, the difference in the results should minimize. These results were to be expected since the specific data of the weather stations is per area. The meteorological data is measured over the area.

The parameters that were changed as the same as mentioned before. These were the Soil thickness, KsatVer, KsatHorFrac, Rooting Depth and N_River. For every change in parameters a full run for the model was needed. The changes vary between 0,5 to 3. A combination of changes to the parameters also were made. The following parameter changes have been created.

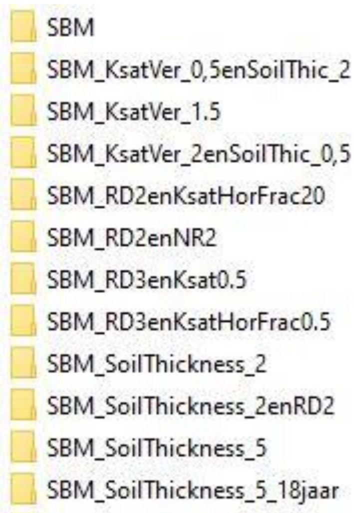


Figure 4 Changes to the parameters

Upstream

The results with the changed parameters are shown in the figure below. The blue line is the line of the weather station named Melka Kuntire, which is located upstream of the Awash river. Black is the normal run. The red line shows the change in the Rooting depth. It changed to 3. The green line shows a combination of changes in the parameter. It contains changes in the KsatHor 20 and Rooting Depth 2. These changes showed the most interesting results. Since these changes caused horizontal saturated conductivity and the rooting depth causes evaporation in plants.

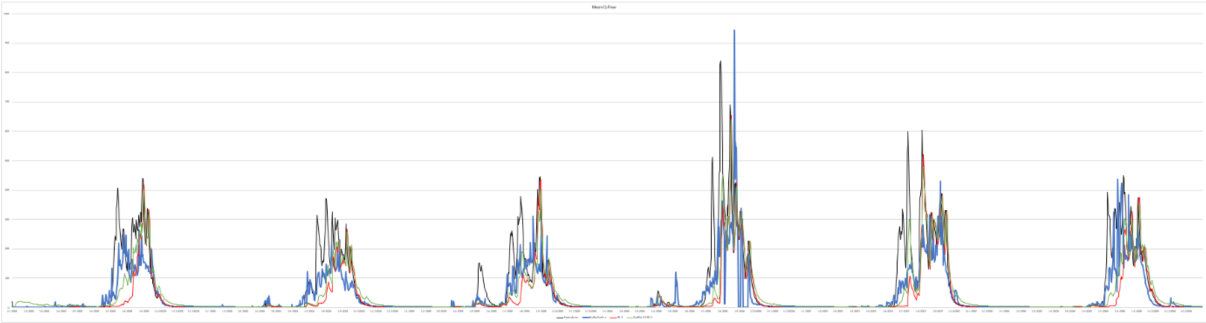
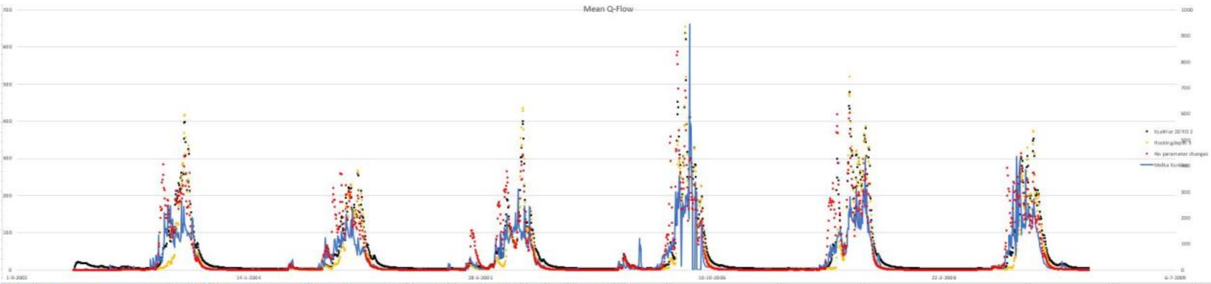


Figure 5 Graph upstream with parameters

RSME Upstream



Root-mean-square deviation: Comparing given data with calculated wflow data								
RMSE:	The closer to 0 the better the data						2192	Timesteps
Melka Kuntine - No Parameter changes			Melka Kuntine - KsatHor 20 RD2			Melka Kuntine - Rootingdepth 3		
5,48307	RMSE:	0,050014	3,680609	RMSE:	0,040976944	5,48307	RMSE:	0,050014
5,461737			2,019342		BEST RESULT	5,461737		

Figure 6 Results of RSME upstream

With the RSME calculation a comparison between the weather station and the results of the parameter changes. The calculation shows that the KsatHor 20 with Rooting Depth 2 has the best results.

In the beginning of 2006, the line of the weather station goes to zero. During these days the weather station did not register any rainfall.

Comparing to downstream

The location downstream is Melka Sedi. Without parameter changes the difference between the weather station and the Wflow run model is shown in the figure below. The discharge downstream is roughly 2000m^3/s. The discharge downstream is roughly five times higher. The graph shows gaps between the lines whereas in the graph upstream the gaps are hardly visible.

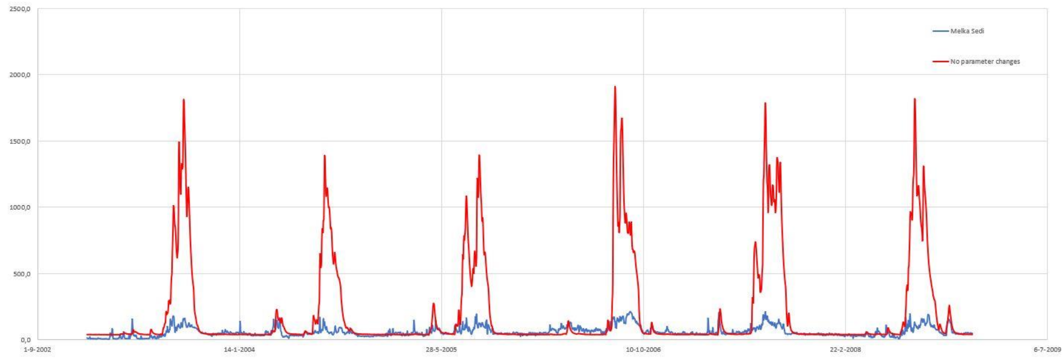


Figure 7 Graph downstream without parameter changes

The results with the changed parameters are shown in the figure below. The red line in the graph is he line without any changes with the parameters. The blue line shows the data of the weather station in Melka Sedi. The yellow line shows changes to the parameters with Rooting Depth to 3. The orange line shows the changes to the parameters with KsatHor 20 and Rooting Depth 2. These changes again, were the most interesting. Even though the lines in the graph don't come close to the data of the weather station. These were the results that came as close as possible.

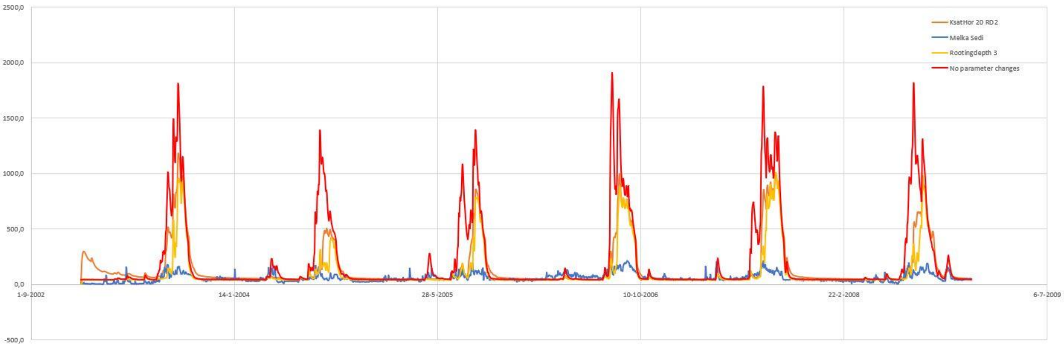
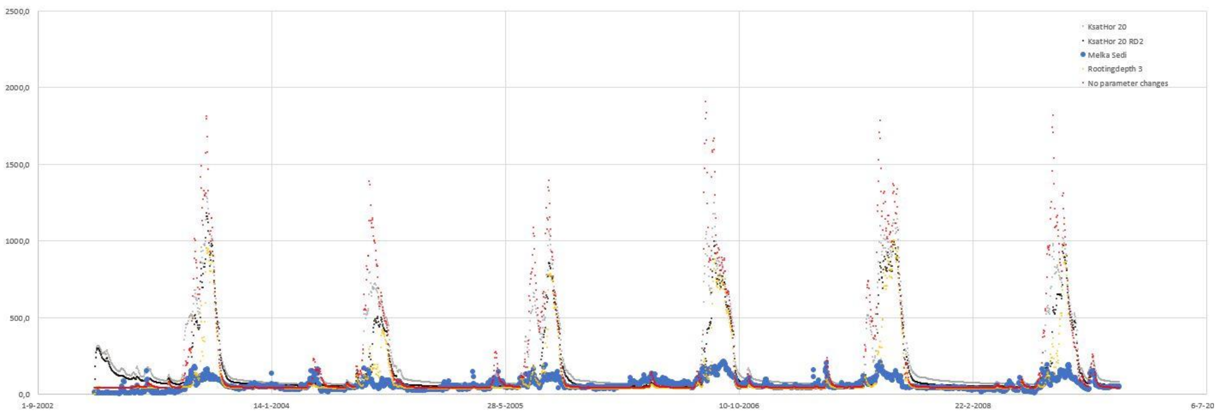


Figure 8 Graph downstream with changes in parameters

RSME



Root-mean-square deviation: Comparing given data with calculated wflow data														
RMSE:	**The closer to 0 the better the data**						2192	**Timesteps**						
Melka Sedi - No Parameter changes			**Melka Sedi - KsatHor 20**			**Melka Sedi - Rootingdepth 2**			**Melka Sedi - Rootingdepth 3**			**Melka Sedi - KsatHor 20 RD2**		
746,4	**RMSE:**	0,583521	13,6	**RMSE:**	0,07865641	197,3	**RMSE:**	0,300001	197,3	**RMSE:**	0,300003	14,6	**RMSE:**	0,081633
933,2			7314,6		BEST RESULT	114,9			115,0			7167,2		

Figure 9 Results RSME downstream

With the RSME calculation a comparison between the weather station and the results of the parameter changes. The calculation shows that the KsatHor 20 has the best results.

Discussion & Conclusion

The findings of this study showed that more local data is needed for a realistic model. The data that was worked with during this study was raw data. The results did not meet the expectations. There is a big differentiation between the parameter changes and the data of the weather stations. With the RMSE calculations the results are more fitting but still aren't the results that are needed for a working Wflow model.

The results, both upstream and downstream vary greatly, between the weather station data and the Wflow output. This shows that Wflow does not take all the inflows and outflows accountable. Therefore, Wflow for now is not representative for reality. This is since many data are missing in the calculations and more parameters are needed for better results. For example, with the graph upstream it shows that during a short period of time the weather station misses data.

The current problem of Ethiopia is that upstream there are too many water consumers which lead to water scarcity downstream. Besides that, the climate change causes to longer drought periods. Due to these drought periods the Awash river changes its path more often. Therefore, Ethiopia needs model the Awash river to understand the river and its path for the future.

Wflow makes a representative model of the river flow with the use of several parameters. Wflow works with meteorological data. With the meteorological data a model in Wflow can be run. This run shows results over a period over a certain area. The areas Melka Kuntire and Melka Sedi were chosen to represent the model. The results that were given with the meteorological data were compared to the local weather stations.

Without changing the parameters there is a big difference between upstream and downstream. This is shown with the comparison of meteorological data and the data of the weather stations. The difference between the meteorological data and the weather stations data had to be as minimum as possible. By changing the parameters, the gap between the meteorological data and the weather station data closed in on each other. By changing the parameters upstream, the gap between the meteorological data and the weather station data minimized. With this the model became more realistic. By changing the parameters downstream, the result was less accurate. The changes to the model were smaller.

In short, the Wflow program is not suitable yet. This is since data is still missing. Without the data a realistic model can't be made. Besides that, more parameters should be added so the model can be finetuned.