



OpenDinkel Tools – User's Guide

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2010

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Introduction

This document is an introduction to how to use OpenDinkel Tools in ILWIS Open. The document is supposed to provide users with the basic information needed to run the programs in the application. In order to understand the original file format systems of the applications FEQ and OTIS, the user is advised to read (Franz and Melching, 1997; Runkel, 1998).

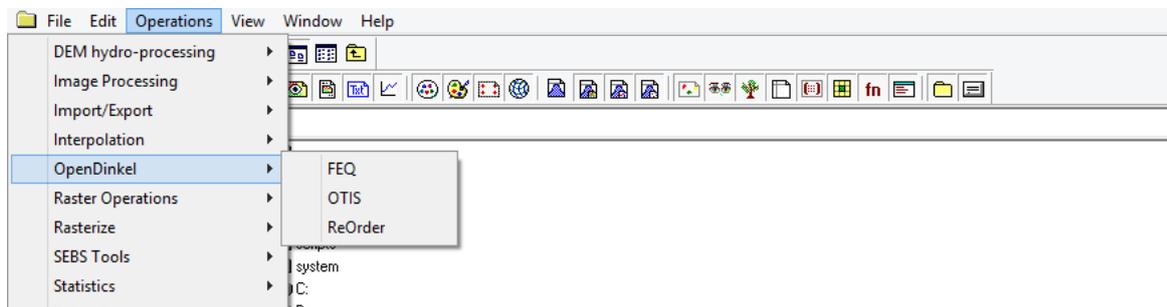
The original file formats for both models – FEQ and OTIS have been substantially modified into the format accepting within the ILWIS Open environment. What in real sense, the original codes of these models have not been modified in any form. The system adapted to achieve this, is reprogramming the file formats for the models “on the fly” for representation in ILWIS, then in the final run of these models, the these files are re-converted into the original formats, and run in subroutine mode to produce the outputs for the models.

A very important step which has been left out of this user guide is the hydro-processing in ILWIS. This is because there exists a comprehensive guide on how to do this in ILWIS, reader can refer to (Maathuis and Wang, 2006). The main products were the hydro-processing are the Digital Elevation Model (DEM) and drainage network for the study area. These maps together with other maps (to be discussed in detail later) are then used in the “reorder” process under OpenDinkel Tools. All other procedures following this are detailed out in this user guide.

Apart from showing the details, the document also uses information from the Dinkel River as a show case in explaining the how to use the OpenDinkel Tools.

Installation

The OpenDinkel tools is already available under ILWIS Open 3.7. Currently, users are not required to do any prior installation. All users have to do is to download the ILWIS Open 3.7 from www.52north.org and install it. Also, download the “exefile.rar” file from the same website and unzip it. Now, copy all files from the “exefile” into “ILWIS\debug\ilwis3\Extensions”. You are now ready to run OpenDinkel Tools. Launch ILWIS Open 3.7, click on “Operation Tree”, or click on “Operations” and you see OpenDinkel Tools as:



Features of OpenDinkel Tools

-  OpenDinkel
-  FEQ
-  OTIS
-  ReOrder

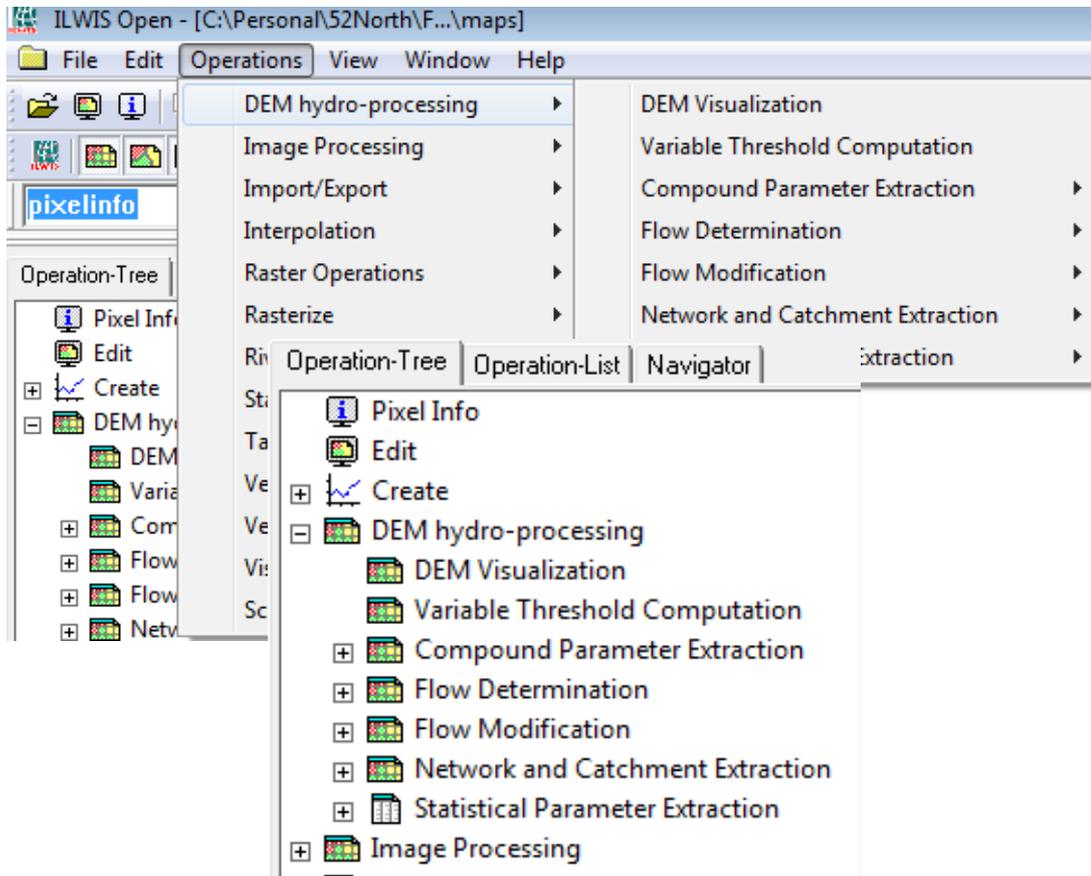
The OpenDinkel Tools as indicated here has three basic applications – FEQ, OTIS and ReOrder functionalities.

The FEQ is a 1-D full equation for performing unsteady flow conditions in rivers. The OTIS is also a 1-D transport with inflow and storage model. The details of each of these models have been described properly in the

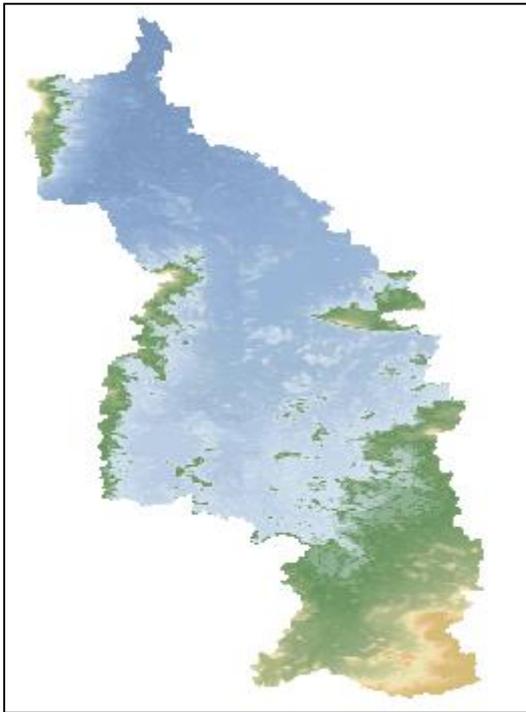
application guide for the application. The “Reorder” is a pre-processing tool for providing the required input for FEQ and OTIS.

Input Files & Formats

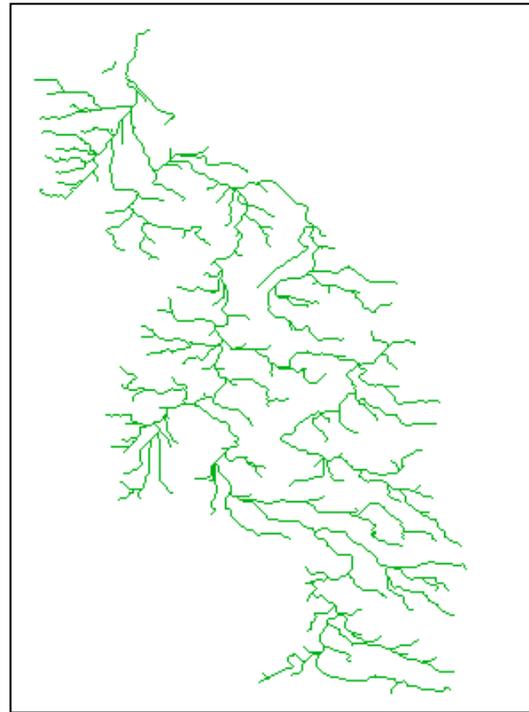
Before OpenDinkel tools can be used, there is one crucial step – the use of the DEM hydro-processing tools to extract the drainage network for the study area. This tool is located under the “Operation Tree” or “Operations” in ILWIS Open as shown below:



The details on how to use this tool, the user can refer to the ILWIS user guide for more details or refer to (Maathuis and Wang, 2006). For this particular user guide, use is made of information from the Dinkel River system in the Netherlands. Therefore, the SRTM 90m resolution DEM for the Dinkel River and the drainage network derived from using the DEM hydro-processing tools under ILWIS Open are shown below:



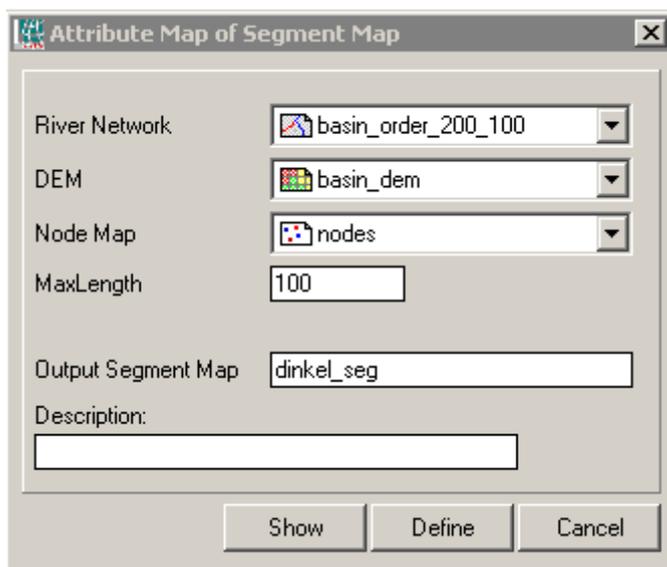
DEM of Dinkel River



Drainage Network of Dinkel River

In this particular show case, it was considered advisable to use a low resolution DEM for the extraction. The user is encouraged to test the suitability of higher resolution DEM for the same exercise. Therefore, the derived two files (DEM and Drainage Network) are major input for running the “**ReOrder**” application. It must be emphasised the extraction of the drainage network is just not a click of the bottom, the user must ensure that the derived drainage network of the area of interest practically represent reality.

The run of the “**ReOrder**” application shows the following:

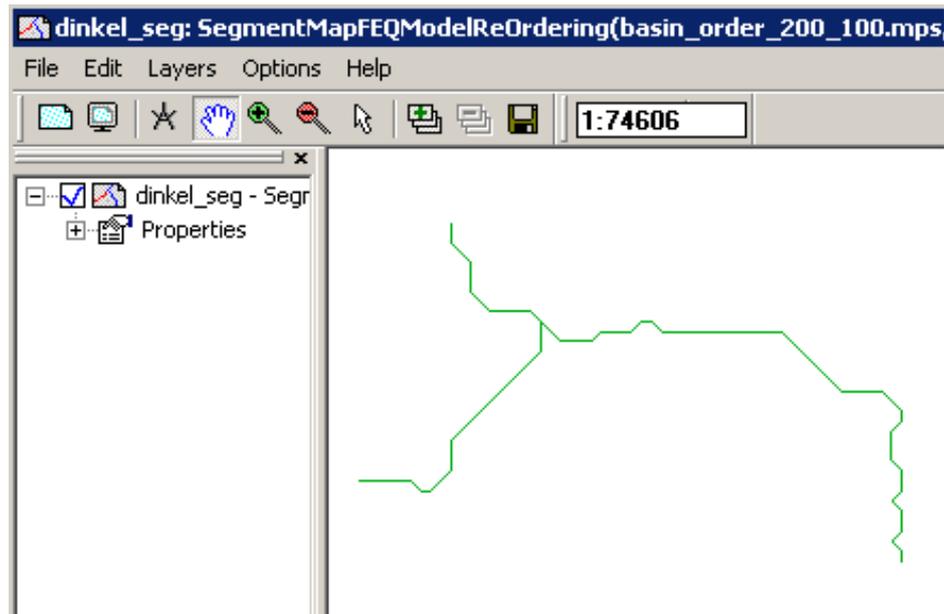


The **River Network** is the derived extracted drainage network described above. In this instance, choose “basin_order_200_100” file provided in your demo folder. Under the DEM, choose “basin_dem”. The Node Map is the map indicating the location at which measurements of hydrologic parameters were done. Since the node map is created for you, choose “nodes”.

MaxLength: When ReOrder runs, the operation will search the nearest point on segments for each node. If the distance between the found point and the node is larger than MaxLength, the operation will neglect this node as an

outlet. You could try other lengths in your own instance. Give a name to the output segment map that is familiar to you. In this case we use “Dinkel_seg”. You can then press “Show” to execute results.

After this, open the created reordered network “Dinkel_seg” file, and you will see this map:



This map will now further be used for both OTIS and FEQ computations. Therefore, it is important that the steps to arrive at this should be done more carefully.

In order to run FEQ and OTIS models, some additional files are needed, branch and node information. The formats for the branch and node are different for the models. For instance, for the FEQ model, the branch information is denoted as “branch_a” and the node as “node_a”. The “branch_a” file is shown below. The table has been split into two for display purposes. This table has 12 columns, the first 9 columns are the key requirements for FEQ. The “Branchstream” denotes the upstream branch, “branchdstream” denotes the downstream branch, “nodeustream” denotes the upstream node, “nodedstream” denotes the downstream node, “uele” denotes upstream elevation, “dele” denotes downstream elevation, “length” denotes the length of a branch, “intp” denotes an interpolation technique, “numsub” denotes number of divisions within a branch, “dispersion” denotes longitudinal dispersion in small rivers, “storage” denotes the cross sectional area of storage zone and “alpha” denotes the coefficient of transient storage exchange. It should be noted that, this branch information is very similar to the one for OTIS model. It happens that in the case of the branch information for FEQ model, dispersion, storage and alpha columns are given the value (-1), this means that they are not used in the computation of the FEQ model and this applies to all other sections of the this guide.

ID	BRANCHSTREAM	BRANCHDSTREAM	NODEUSTREAM	NODEDSTREAM	UELE
1	-1	2	1	2	34.20
2	1	3	3	4	33.20
3	2	6	5	6	31.20
4	-1	5	7	8	31.00
5	4	6	9	10	30.50
6	3,5	-1	11	12	30.00

DELE	LENGTH	INTP	NUMSUB	DISPERSION	STORAGE	ALPHA
33.20	0.50	1	10	-1.00	-1.00	-1.00
31.20	3.43	1	10	-1.00	-1.00	-1.00
30.00	0.27	1	10	-1.00	-1.00	-1.00
30.50	0.45	1	10	-1.00	-1.00	-1.00
30.00	1.75	1	10	-1.00	-1.00	-1.00
29.00	1.23	1	10	-1.00	-1.00	-1.00

If one however looks at the branch information for the OTIS model, all column headings are the same compared to the FEQ model, just that the headings “dispersion”, “storage” and “alpha” have been given some values at node 2 as shown below:

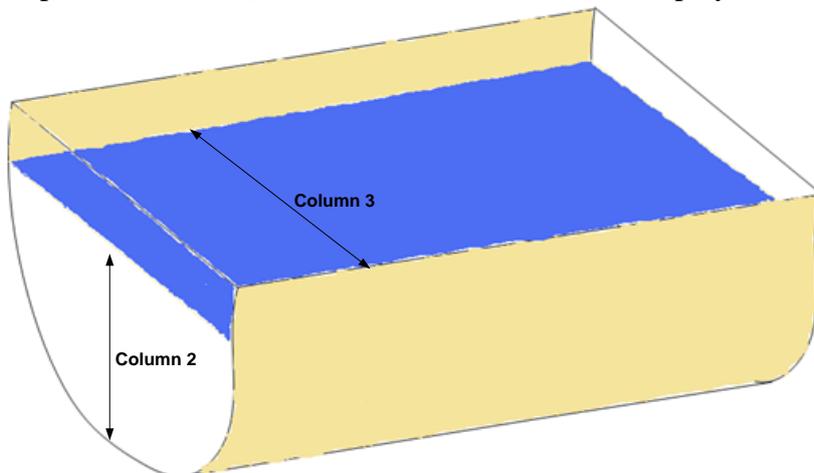
BRANCHUSTREAM	BRANCHDSTREAM	PHA
-1		2 -1.00
1		3 -1.00
2		6 48.41
-1		5 -1.00
4		6 -1.00
3,5		-1 -1.00

Another look at the node file information for both FEQ and OTIS follows a similar explanation as above. However the node file can be divided into four sections: “node” identification columns (column1 – column 4), “cross” (cross section at a given node), “boundary” (prevailing upstream flow

conditions) and “OTIS” (prevailing quality upstream conditions).

Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9
NODE	?	?	?	?	?	?	?	?
1	0	2	2.00	0	0	0	35.75	1.50
2	0	2	0.00	0	0	0	-1.00	-1.00
3	0	2	0.00	0	0	2	-1.00	1.50
4	0	2	0.00	0	0	0	-1.00	-1.00
5	0	2	0.00	0	0	0	-1.00	1.50
6	0	4	0.00	0	0	0	-1.00	-1.00
7	0	1	1.00	0	0	0	33.57	7.50
8	0	1	0.00	0	0	3	-1.00	-1.00
9	0	1	0.00	0	0	0	-1.00	7.50
10	0	3	0.00	0	0	0	-1.00	-1.00
11	0	3	0.00	0	0	0	30.99	8.00
12	0	3	0.00	0	0	1	30.99	8.00

In the above table, kindly ignore columns (5-9), they are irrelevant for the time being. As you scroll down the node file, you will reach another section called the “cross”. This part of the node file specifies the cross section dimensions of the river at a particular section (node). The diagram below explains how this (ie column 2 and column 3) is displayed in the table below:



As shown in the above figure therefore, column 2 indicates measurement of depths or elevations of river at each specified length across the width (column 3). Column 3 depicts the width of the river and represents all measurements across the width of the river at a specified node. In this case, two nodes are used.

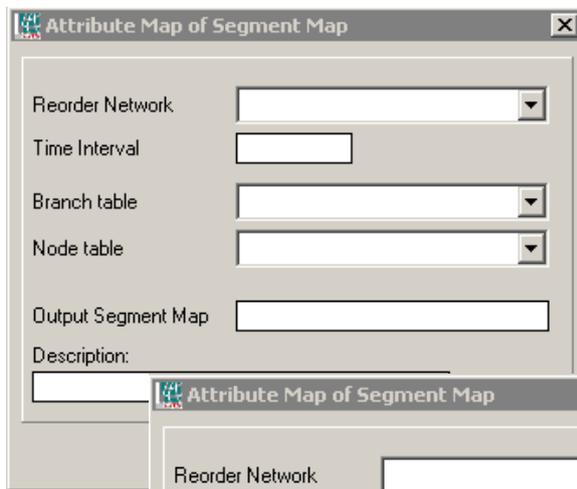
CROSS	?	?	?
1	3	0.034	?
	0.000	35.300	1.00
	4.500	35.100	1.00
	9.500	35.050	1.00
	13.000	31.200	1.00
	22.500	31.300	1.00
	22.800	31.600	1.00
	24.500	33.200	1.00
	24.700	33.900	1.00
	32.500	34.100	1.00
2	3	0.034	?
	0.000	36.430	1.00
	6.700	36.430	1.00
	7.300	36.010	1.00
	7.900	35.050	1.00
	8.600	34.630	1.00
	10.000	34.630	1.00
	11.500	34.750	1.00
	12.200	35.050	1.00

The next section below this section is called “boundary”. This is found by scrolling down the node file information. The boundary represents boundary conditions specified at a particular node. Both FEQ and OTIS require some boundary conditions to function. In the table below, the first conditions indicated here are those for FEQ model.

BOUNDARY	?	?	?
1	2	2	?
	2009/3/1	0:0:0	32.60
	2009/3/1	1:0:0	32.61
	2009/3/1	2:0:0	32.61
	2009/3/1	3:0:0	32.60
	2009/3/1	4:0:0	32.60
	2009/3/1	5:0:0	32.59
	2009/3/1	6:0:0	32.58
	2009/3/1	7:0:0	32.57
	2009/3/1	8:0:0	32.55
	2009/3/1	9:0:0	32.55
	2009/3/1	10:0:0	32.53
	2009/3/1	11:0:0	32.52
	2009/3/1	12:0:0	32.51

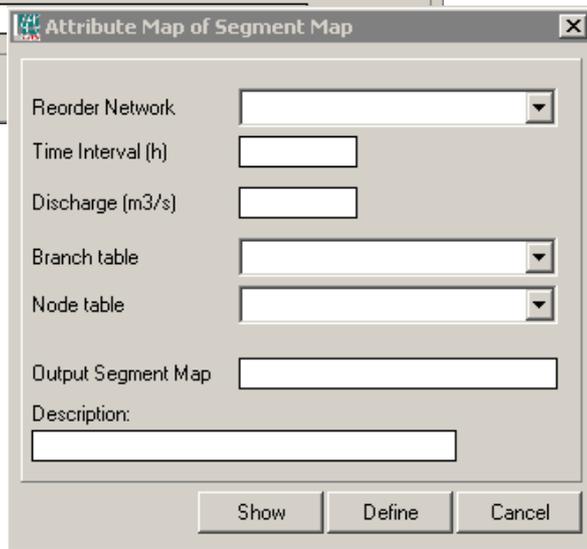
The next boundary condition is that of OTIS; as one scroll down one will find the name “OTIS” in the node file, this section represents the boundary conditions for the OTIS model.

OTIS	?	?	?
1	1	?	?
	2000/1/1	0:0:0	9.00
	2000/1/1	1:0:0	32.00
	2000/1/1	2:0:0	100.00
	2000/1/1	3:0:0	151.00
	2000/1/1	4:0:0	94.00
	2000/1/1	5:0:0	145.00
	2000/1/1	6:0:0	220.00
	2000/1/1	7:0:0	178.00



Once the input files have been prepared, the FEQ model which is given by the dialog box (shown to the left) can then be used to perform the operation.

If it running OTIS



happens that, you are interested in the OTIS model instead, use the dialog as shown here.

Demo

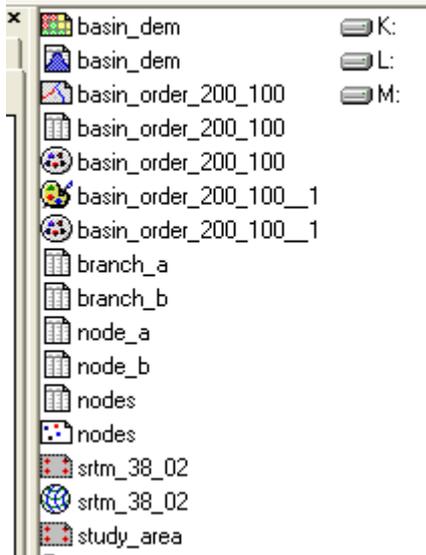
Introduction: These are introductory exercises for both FEQ and OTIS models. This is meant to guide the user to quick basic understanding of the operation of the FEQ and OTIS models incorporated in ILWIS Open and also to further explain the output file formats and what further information can be derived from these files.

Required data

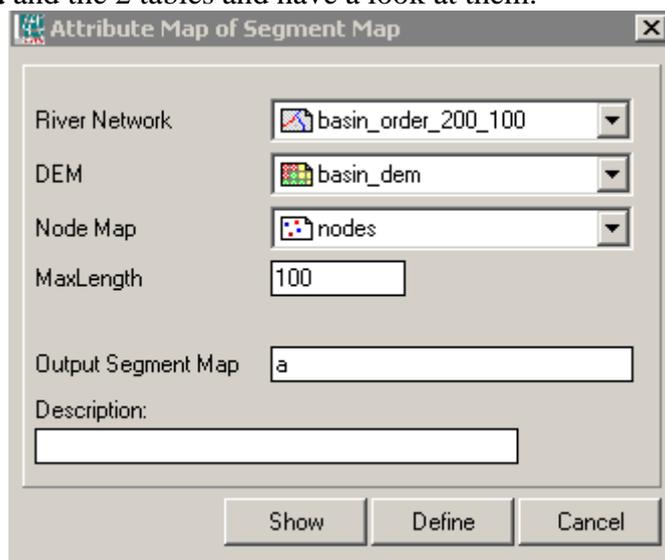
1. DEM image that covers the whole river basin. Here we use SRTM image named “study_area” with about 90m resolution. *(user is encouraged to try other resolutions other than this)*
2. The basin drainage network as indicated earlier, is obtained from DEM hydro-processing, in this example, the extracted drainage network is dubbed here “basin_order_200_100”.
3. Hydraulic parameters. Cross sections and elevation of the channel are measured in some points.
4. Discharge and water quality data. These data are monitored by a long time series. For unsteady flow, there are 2 options. One is using discharge data, the other is using water level data. Here we use water level data.

Exercise 1: FEQ model

1. After ILWIS is opened, go to the **exercise1** folder. You can see the files showed as below. “**basin_dem**” is the DEM image for dinkel basin. “**basin_order_200_100**” is the segment map and table for Dinkel River networks. “**nodes**” contains all control points where we measured cross section, etc.

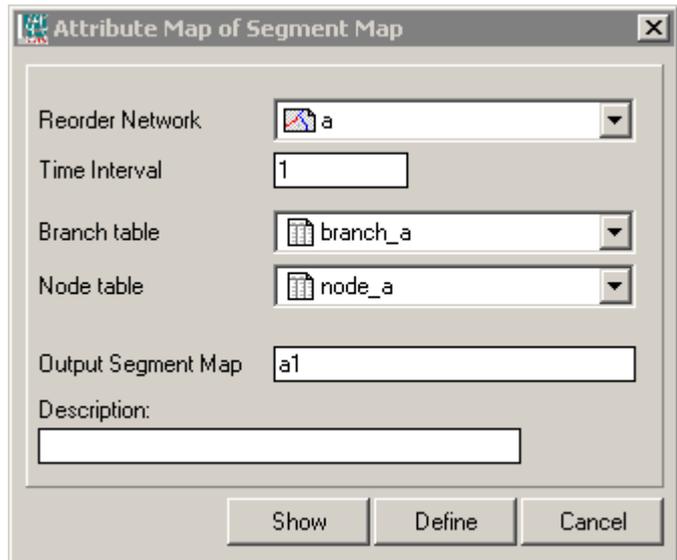


2. In ILWIS Open, find **Operations->OpenDinkel tools->reorder**, open it. Set the input as the figure showed below. Run it. You will find a new segment map **a** and 2 tables (**branch** and **node**). Open **a** and the 2 tables and have a look at them.

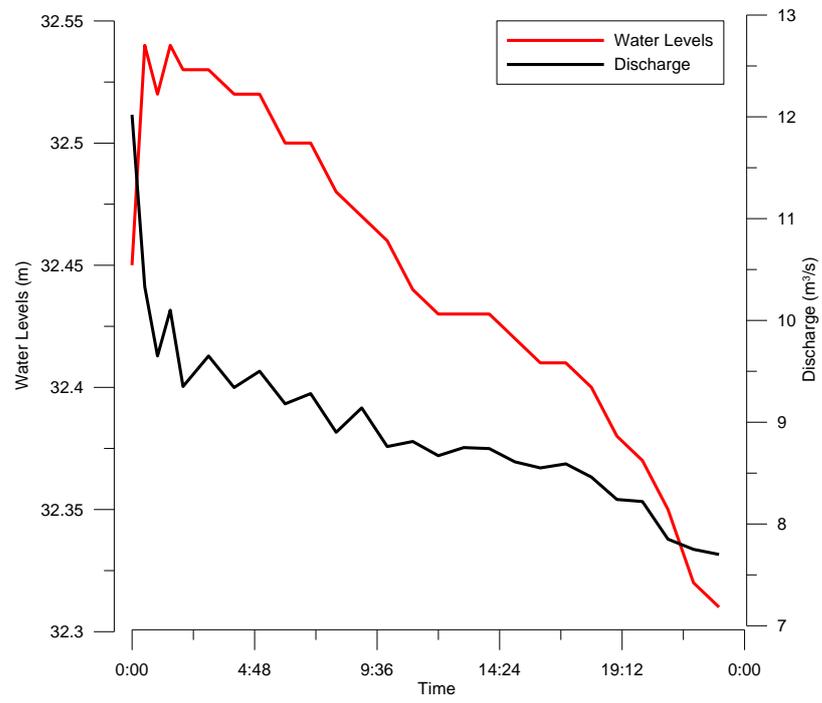


3. Here we should change some data in table **branch** and add some data in table **node**. The explanation of formats of table **branch** and **node** has been given in earlier sections of this user guide. These tables can be modified to fit the exact flow information of your user. In this example, the two new tables represent the adapted tables for running the FEQ stimulation into this example. Open and have a look at table "**branch_a**" and "**node_a**".

4. Open **FEQ** dialogue and set input as shown below. Then click **show**. A new segment map **a1** and its attached table will be generated. The segment map a1 is an empty map. This is normal and is not needed presently. The table **a1** is what is needed, open it and have a look at it. This is the time series for discharge or water level at these chosen points. As seen below in the output table a1, date and time indicated in the table represent the same meaning as in ordinary day to day activities. U2_LVL denotes upstream water level at node 2. D4_LVL represents upstream water level at node 4 and so on. On the other hand, D4_DIS denotes discharge at node 4 and so on. Information from table a1 can further be expressed as graphs using auxiliary graphing software. In this case, a plot of D4_LVL and D4_DIS against a 24-hour period gives the graph shown here. Further, this data could further be compared to field measurements collected for the same period.

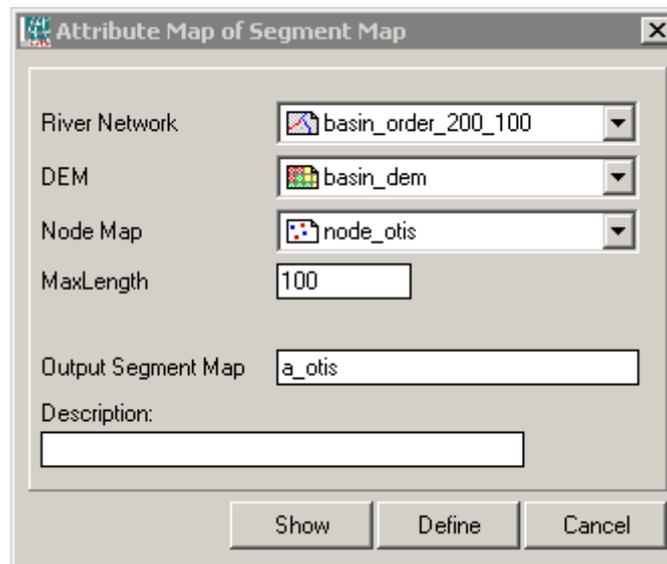


DATE	TIME	U2_LVL	D4_DIS	D4_LVL	D6_DIS
2009/03/01	0:0:0	34.20	12.02	32.45	8.73
2009/03/01	0:30:0	34.37	10.33	32.54	10.55
2009/03/01	1:0:0	34.36	9.65	32.52	11.92
2009/03/01	1:30:0	34.37	10.10	32.54	12.25
2009/03/01	2:0:0	34.36	9.35	32.53	12.56
2009/03/01	3:0:0	34.35	9.65	32.53	12.65
2009/03/01	4:0:0	34.34	9.34	32.52	12.52
2009/03/01	5:0:0	34.34	9.50	32.52	12.48
2009/03/01	6:0:0	34.33	9.18	32.50	12.33
2009/03/01	7:0:0	34.32	9.28	32.50	12.22

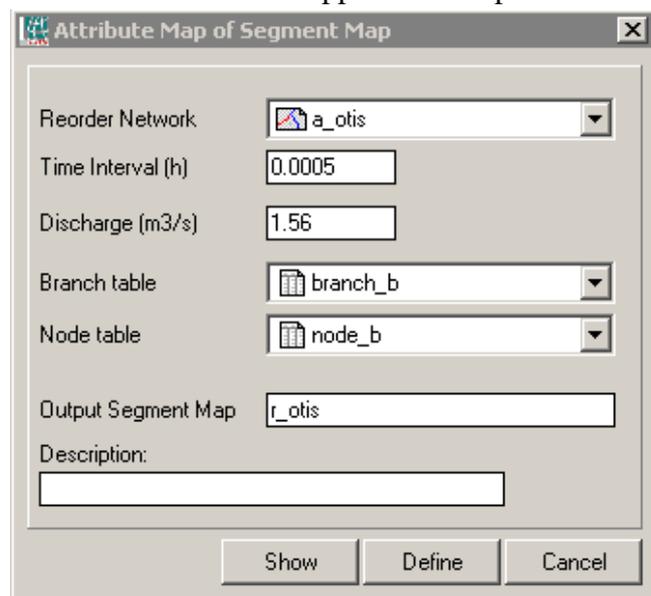


Exercise 2: OTIS model

1. Open folder **exercise2**, and do **reorder** once again by using **node_otis** instead of **nodes** as shown below. Give the new segment map a name, for example **a_otis**. Then 1 segment map and 2 tables will be created.



2. Edit table **branch** and **node** for data input. These have already prepared for you i.e tables **branch_b** and **node_b**. These will be used for the for OTIS application. Open **OTIS** dialogue. Set inputs as shown below and run it. Two files are created out of this stimulation, a segment map **r_otis** and a new table **r_otis**.



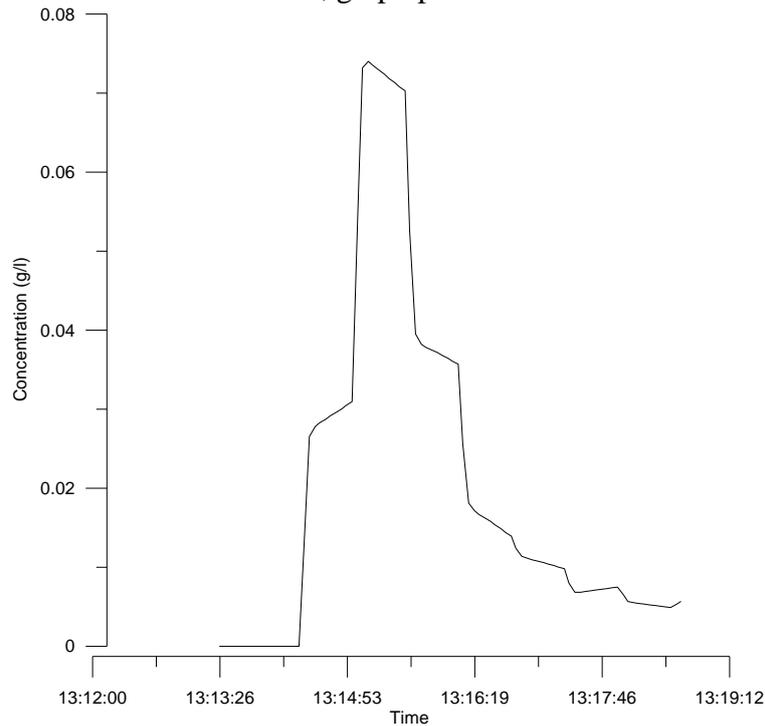
3. The segment map **r_otis** is an empty map and irrelevant and should be seen as a inbuilt support function for ILWIS Open.

4. Therefore, open the table **r_otis** and you will realise that the output format for OTIS is different from FEQ model. As show to the left, the output gives the various concentrations at a specified point measurement along the river. The ordinary OTIS stand alone program requests the user to specify the particular point to display information but in this program, the program automatically prints at every 1/10 distance along the river. There are two output concentrations eg MC12m means that main concentration plug at 12m and TSC12m means transient storage concentration plug at 12m and so on.

TIME	MC12m	TSC12m	MC24m
13:15:14	0.072075	0.072003	0.072130
13:15:18	0.071654	0.071617	0.071752
13:15:21	0.071222	0.071214	0.071352
13:15:25	0.070782	0.070797	0.070936
13:15:28	0.070335	0.070368	0.070507
13:15:32	0.069884	0.069931	0.070067
13:15:35	0.041523	0.043944	0.046099
13:15:39	0.039188	0.039619	0.039902
13:15:43	0.038596	0.038827	0.038939
13:15:46	0.038154	0.038339	0.038421
13:15:50	0.037733	0.037890	0.037957
13:15:54	0.037319	0.037454	0.037511
13:15:57	0.036910	0.037029	0.037078
13:16:1	0.036505	0.036611	0.036653

After this you can decide to visualise your results

at any of the sections. In this exercise, graph plotted for MC120m has been shown.



References

- Franz, D.D. and Melching, C.S., 1997. Full equations (feq) model for the solution of the full, dynamic equations of motion for one-dimensional unsteady flow in open channels and through control structures. , U.S. Geological Survey.
- Maathuis, B. and Wang, L., 2006. Digital elevation model based hydro-processing. *Geocarto International*, 21(1): 21-26.
- Runkel, R., 1998. One-dimensional transport with inflow and storage (OTIS): A solute transport model for streams and rivers. *US Geological Survey Water-Resources Investigation Report*, 98: 4018.