

Groundwater recharge at the Nučice catchment

Study groundwater recharge at the Nučice catchment.

- Use measured volumetric water content and soil water potential to better predict effective soil hydraulic parameters.
- Compare the modeled water content with the measured data to do so.
- Use inverse modeling to obtain the best parameter set.
- Calculate recharge to groundwater level for each month of the modeled season.

Procedure

1 - Have a look at the data. **Make graphs of rainfall, evaporation, and transpiration.** Partition ET in evaporation and transpiration using NDVI and empirical formula from presentation. **Plot also the SWC and SWP data.**

2 - Prepare the H1D model. Use meteorological data as the upper boundary condition and free drainage as the lower boundary condition. Include root water uptake in the model. RUN THE MODEL. Put the modeled volumetric water content and soil water potential data into graph with the measured data.

3 - Change soil hydraulic characteristics “by hand” and try to model the measured data. **Plot the modeled volumetric water content and soil water potential data into graph with the measured data. Also include the parameters you found.**

4 - Prepare inverse solution problem in H1D and run it. Use the soil water content and soil water potential in two depths.

5 - Explore the results in *Inverse Solution Information* and *Observation Points*. Change the parameter margins or the initial value of parameters, if the results are not sufficient (in *Water Flow – Soil Hydraulic Parameters*). **Put the modeled volumetric water content and soil water potential data into graph with the measured data. Include also the final (possibly best) parameter set.**

5 - **Show how much water recharge to GW and got in the soil profile for each month.**

Instructions in red are mandatory hand-in.

Detail procedure

Ad1

P.csv:

DOY - Days Of Year
mm_day - Daily precipitation in mm

ET_0.csv:

DOY - Days Of Year
mm_day - Daily reference crop evapotranspiration mm
NDVI - normalized vegetation index
CC_perc - use formula from presentation
 E_mm - Evaporation in mm = $(1-CC/100) * ET$
 T_mm - Transpiration in m = $(CC/100) * ET$

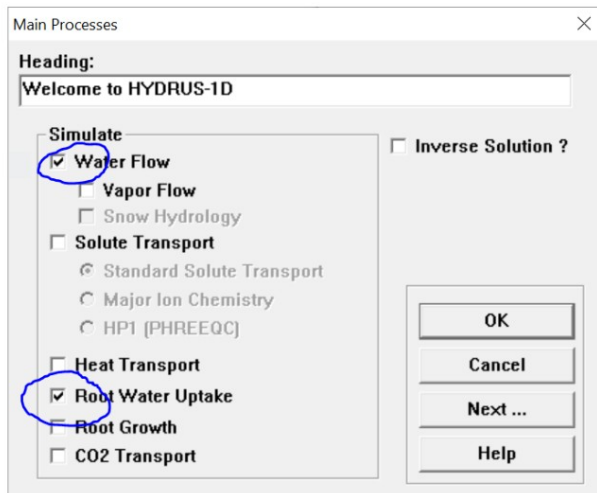
swc_swp.csv:

DOY - Days Of Year
Swc_30_ - soil water content in 30 cm
Swc_60_ - soil water content in 60 cm
Swp_30_kPa - soil water potential in 30 cm
Swp_60_kPa - soil water potential in 60 cm

Convert all to same units (including the model).

Ad2

Main processes:

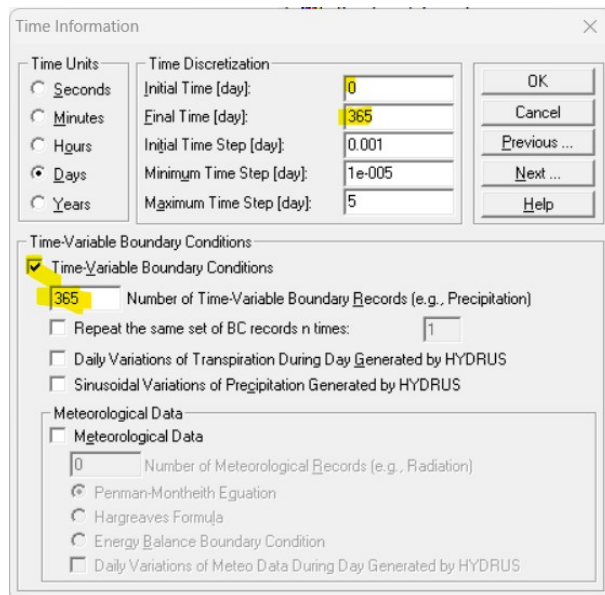


The 'Main Processes' dialog box in HYDRUS-1D shows the following settings:

- Heading:** Welcome to HYDRUS-1D
- Simulate:**
 - ☒ Water Flow
 - ☐ Vapor Flow
 - ☐ Snow Hydrology
 - ☐ Solute Transport
 - ☒ Standard Solute Transport
 - ☐ Major Ion Chemistry
 - ☐ HP1 (PHREEQC)
 - ☐ Heat Transport
 - ☒ Root Water Uptake
 - ☐ Root Growth
 - ☐ CO2 Transport
- ☐ Inverse Solution ?
- Buttons:** OK, Cancel, Next ..., Help

Geometry information: Soil profile of 65 cm.

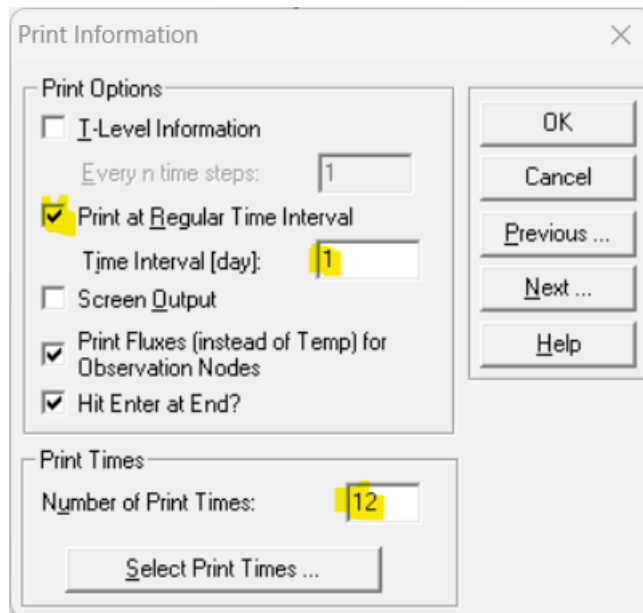
Time information: Set the variable boundary condition. The number of Time-Variable Boundary condition is number of records of your meteorological data.



The 'Time Information' dialog box in HYDRUS-1D shows the following settings:

- Time Units:**
 - ☐ Seconds
 - ☐ Minutes
 - ☐ Hours
 - ☒ Days
 - ☐ Years
- Time Discretization:**
 - Initial Time [day]: 0
 - Final Time [day]: 365
 - Initial Time Step [day]: 0.001
 - Minimum Time Step [day]: 1e-005
 - Maximum Time Step [day]: 5
- Time-Variable Boundary Conditions:**
 - ☒ Time-Variable Boundary Conditions
 - 365 Number of Time-Variable Boundary Records (e.g., Precipitation)
 - ☐ Repeat the same set of BC records n times: 1
 - ☐ Daily Variations of Transpiration During Day Generated by HYDRUS
 - ☐ Sinusoidal Variations of Precipitation Generated by HYDRUS
- Meteorological Data:**
 - ☐ Meteorological Data
 - 0 Number of Meteorological Records (e.g., Radiation)
 - ☒ Penman-Monteith Equation
 - ☐ Hargreaves Formula
 - ☐ Energy Balance Boundary Condition
 - ☐ Daily Variations of Meteo Data During Day Generated by HYDRUS
- Buttons:** OK, Cancel, Previous ..., Next ..., Help

Print information: Print several times. You can use the default times.



The image shows a 'Print Information' dialog box with a close button (X) in the top right corner. It is divided into two main sections: 'Print Options' and 'Print Times'. The 'Print Options' section contains five checkboxes: 'I-Level Information' (unchecked), 'Print at Regular Time Interval' (checked), 'Screen Output' (unchecked), 'Print Fluxes (instead of Temp) for Observation Nodes' (checked), and 'Hit Enter at End?' (checked). There are two text input fields in this section: 'Every n time steps:' with the value '1' and 'Time Interval [day]:' with the value '1'. The 'Print Times' section contains a text input field 'Number of Print Times:' with the value '12' and a button labeled 'Select Print Times ...'. To the right of the input fields are five buttons: 'OK', 'Cancel', 'Previous ...', 'Next ...', and 'Help'.

Print Information

Print Options

☐ I-Level Information

Every n time steps: 1

☒ Print at Regular Time Interval

Time Interval [day]: 1

☐ Screen Output

☒ Print Fluxes (instead of Temp) for Observation Nodes

☒ Hit Enter at End?

Print Times

Number of Print Times: 12

Select Print Times ...

OK

Cancel

Previous ...

Next ...

Help

Water Flow Parameters:

$\theta_r = 0.043 \text{ [cm}^3/\text{cm}^3\text{]}$, $\theta_s = 0.509 \text{ [cm}^3/\text{cm}^3\text{]}$, $\alpha = 0.02485 \text{ [1/cm]}$, $n = 1.189[-]$, $K_s = 127 \text{ [cm/den]}$

Water Flow Boundary Conditions:

Upper BC: Atmospheric BC with surface runoff

Lower BC: Free drainage

Root water and Solute uptake model

Use uptake reduction model of Feddes and parameters for Wheat in the Database

Root Water and Solute Uptake Model

Root Water Uptake Model

Water Uptake Reduction Model

☒ Feddes

☐ S-Shape

Solute Stress Model

☒ No Solute Stress

☐ Additive Model

☐ Multiplicative Model

☐ Threshold Model

☐ S-Shape

1 Critical Stress Index for Water Uptake

Root Solute Uptake Model

☐ Active Solute Uptake

1 Solute with Active Uptake

0 Potential Solute Uptake Rate

0.5 Michaelis-Menten Constant

0 Minimum Concentration for Uptake

1 Critical Stress Index for Active Solute Uptake

☐ Reduced Potential Solute Uptake due to Reduced Water Uptake

OK

Cancel

Previous

Next

Help

Root Water Uptake Parameters

Feddes' Parameters

P0 [cm] 0

P0pt [cm] -1

P2H [cm] -500

P2L [cm] -900

P3 [cm] -16000

r2H [cm/day] 0.5

r2L [cm/day] 0.1

OK

Cancel

Previous ...

Next ...

Help

Database: Wheat [Wesseling, 1991]

Time variable Boundary Condition: Copy + paste from input data.

Time Variable Boundary Conditions

	Time [day]	Precip. [mm/day]	Evap. [mm/day]	hCritA [mm]	Transp. [mm/day]
1	1	0	0.241375	1000000	0.358625
2	2	0	0.28842	1000000	0.41158
3	3	1.5	0.453231	1000000	0.646769
4	4	9.9	0.337412	1000000	0.462588
5	5	3	0.258901	1000000	0.341099
6	6	0	0.176495	1000000	0.223505
7	7	0	0.0450975	1000000	0.0549025
8	8	0.2	0.138214	1000000	0.161786
9	9	1.7	0.18818	1000000	0.21182
10	10	2.5	0.0940898	1000000	0.10591
11	11	0	0.0480186	1000000	0.0519814
12	12	0	0.0979845	1000000	0.102016
13	13	0	0.199864	1000000	0.200136
14	14	0.1	0.509396	1000000	0.490604

OK

Cancel

Previous ...

Next ...

Help ...

Add Line

Delete Line

Default Time

Soil Profile - Graphical Editor



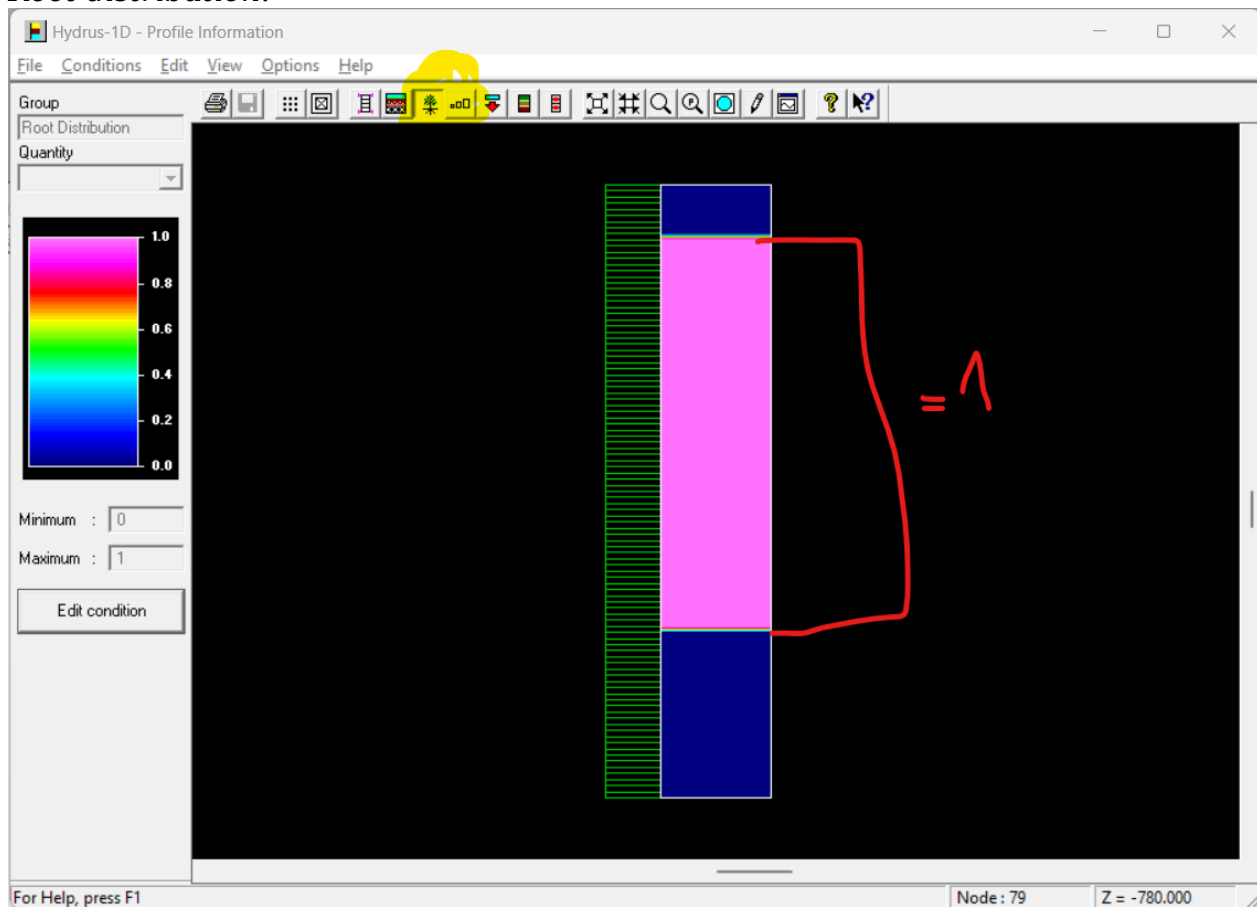
Initial condition: Set the initial pressure head based on the first monitored data.



Observation points: Put is one observation point to the depth of the -30 cm and -60 cm where the water content and soil water potential probes are, so you can compare the model results with the measured dat.



Root distribution:



NOW YOU CAN RUN THE MODEL. Have a look at the results when the calculation is successful.

Modeled data can be found in the directory: [directory with the project]/[project directory]/Obs_Node.out

Ad3

Change the soil hydraulic parameters and try to visually fit the model results with the measured data.

Modeled data are in the output: *observation points -> vertical variable: water content*

Copy the modeled water content into the excel sheet when you are satisfied with your results for comparison with the first run and observed data.

Modeled data can be found in the directory: [directory with the project]/[project directory]/Obs_Node.out

Ad4

The image displays two screenshots of the HYDRUS-1D software interface.

The top screenshot shows the "Main Processes" dialog box. The "Heading:" field contains "Welcome to HYDRUS-1D". Under the "Simulate" section, the "Inverse Solution ?" checkbox is checked and circled in red. Other options include "Water Flow", "Vapor Flow", "Snow Hydrology", "Solute Transport", "Standard Solute Transport", "Major Ion Chemistry", "HP1 (PHREEQC)", "Heat Transport", "Root Water Uptake", "Root Growth", and "CO2 Transport". Buttons for "OK", "Cancel", "Next ...", and "Help" are visible.

The bottom screenshot shows the "Inverse Solution" dialog box. The "Estimate ..." section has "Soil Hydraulic Parameters" checked and circled in red. Below it, "Solute Transport Parameters" are listed with options: "Resident Concentrations", "Log. Resident Concentrations", "Flux Concentrations", "Total Concentrations (liquid+solid)", and "Resident Concentrations (MIM)". The "Weighting of Inversion Data" section has "Weighting by Mean Ratio" selected and circled in red. The "Max Number of Iterations" is set to 20. The "Number of Data Points in Objective Function" field is empty. Handwritten red text "DATA POINTS IN EXCEL" with an arrow points to this field.

Number of data points are provided in the CSVs. The number is a number of rows.

Water Flow Parameters - Inverse Solution - Material 1

	Qr	Qs	Alpha	n	Ks	I
Initial Estimate	0.043	0.45	0.036	1.56	24.96	0.5
Minimum Value	0	0	0.001	1.2	1	0
Maximum Value	0	0	0.1	1.7	100	0
Fitted ?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Soil Catalog for Initial Estimate:

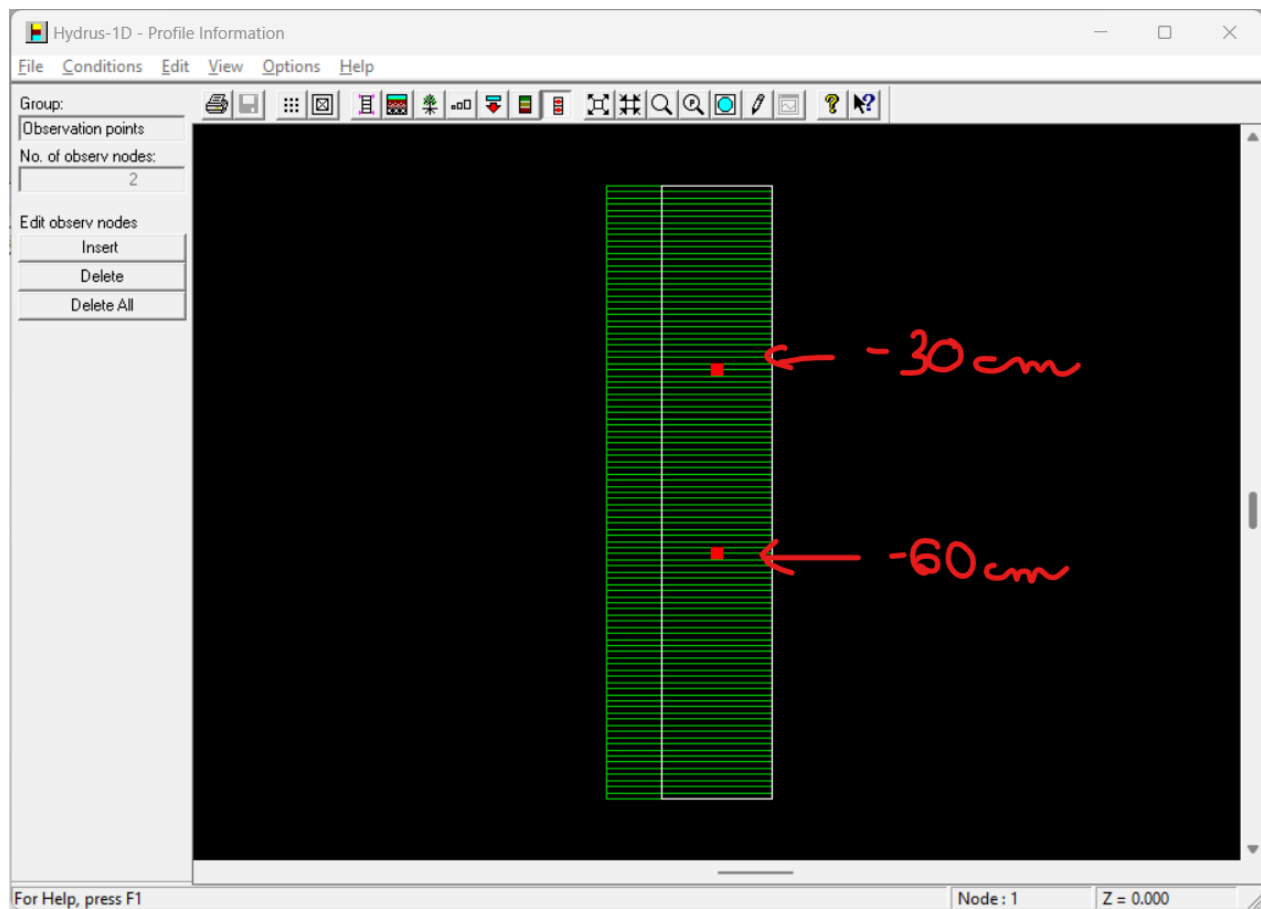
Use saturated and residual water content from the „by hand“ optimization from previous step the ,by hand‘ calibration. Fit only alpha, n, and Ks. Choose reasonable minimal and maximum values and the initial estimation.

Data for Inverse Solution

	X	Y	Type	Position	Weight
1	1	0.39	2	1	1
2	2	0.39	2	1	1
3	3	0.39	2	1	1
4	4	0.39	2	1	1
5	5	0.4	2	1	1
6	6	0.39	2	1	1
7	7	0.39	2	1	1
8	8	0.38	2	1	1
9	9	0.38	2	1	1
10	10	0.39	2	1	1
11	11	0.39	2	1	1
12	12	0.39	2	1	1
13	13	0.38	2	1	1
14	14	0.38	2	1	1
15	15	0.38	2	1	1

☐ Show list boxes (not recommended for large data files)

Fill the data for inverse solution table. Use help ... to find out the meaning of the column X and Y and what should be in the column Type.



Check the soil profile – graphical editor. You need to have one observation point in the depth of -30 cm and -60 cm. This should have been done in the previous step.

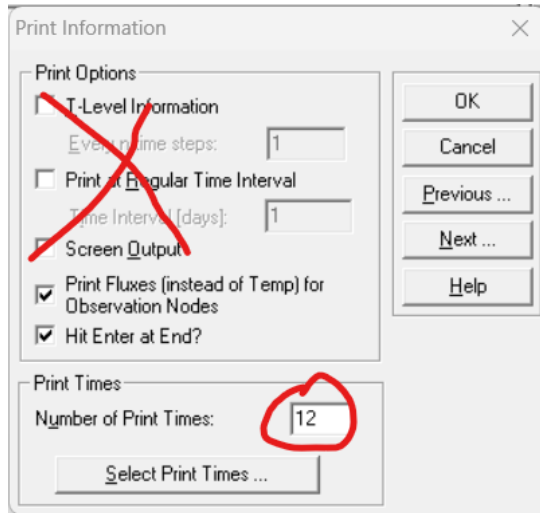
RUN THE MODEL!

Ad 5

Modeled data can be found in the directory: [directory with the project]/[project directory]/Obs_Node.out or in the file storing the inverse solution information [directory with the project]/[project directory]/Fit.out.

Ad6

To obtain results only in the end of each month try:



Modeled variables at boundaries can be found in the file: [directory with the project]/[project directory]/T_levels.out

In the file, you need to have a look at the columns:

sum(vTop): cumulative flow through the top boundary condition

sum(vBot): cumulative flow through the bottom boundary condition

Get the monthly inflows/outflows from the data and fill with them the table similar to a table below. Include only months in which you have data for all days in the month.

Month	Top [L]	Bottom [L]
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Make bar plot from the data in the table.