HS10.5 High resolution modeling tool for prediction of waterflows through complex mires: Example of the Mukhrino bog complex in West Siberian middle Taiga Zone

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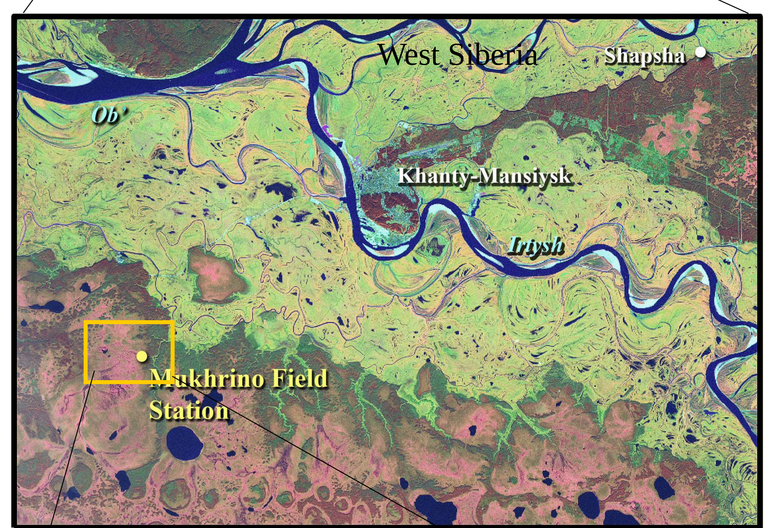
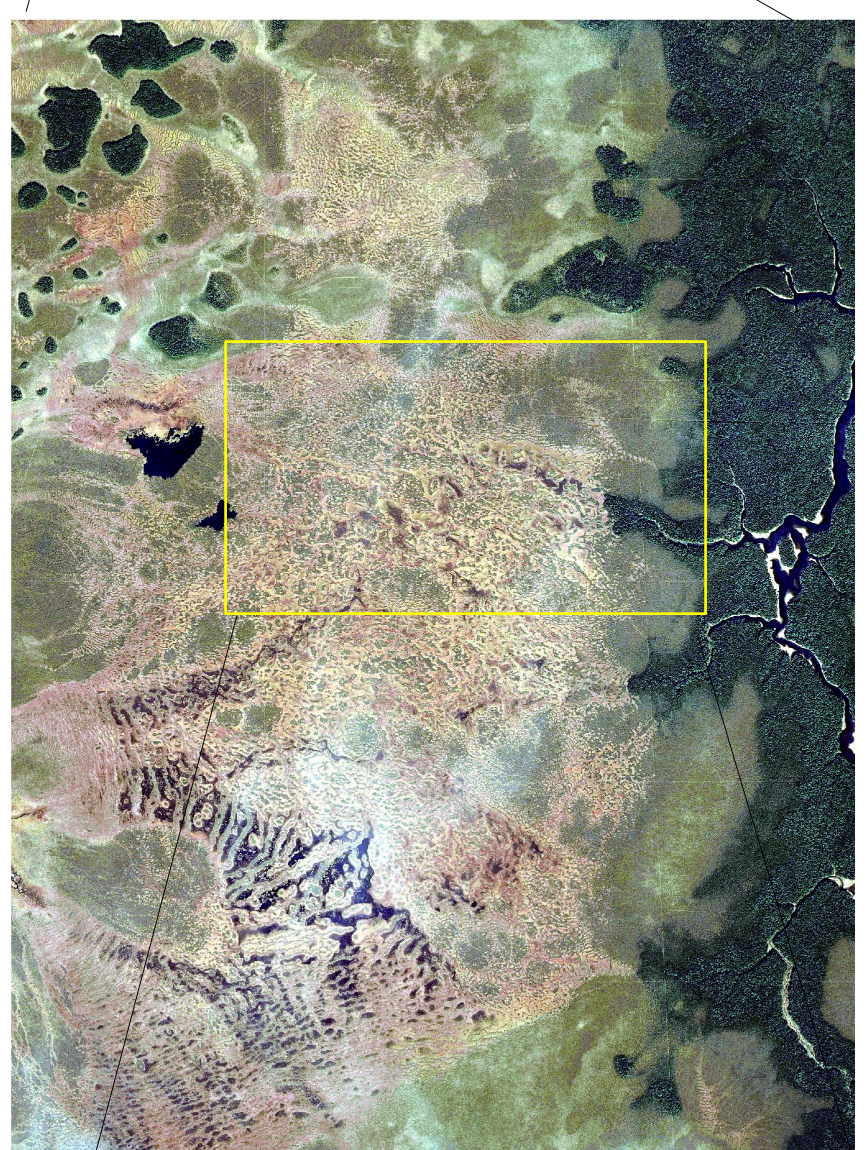
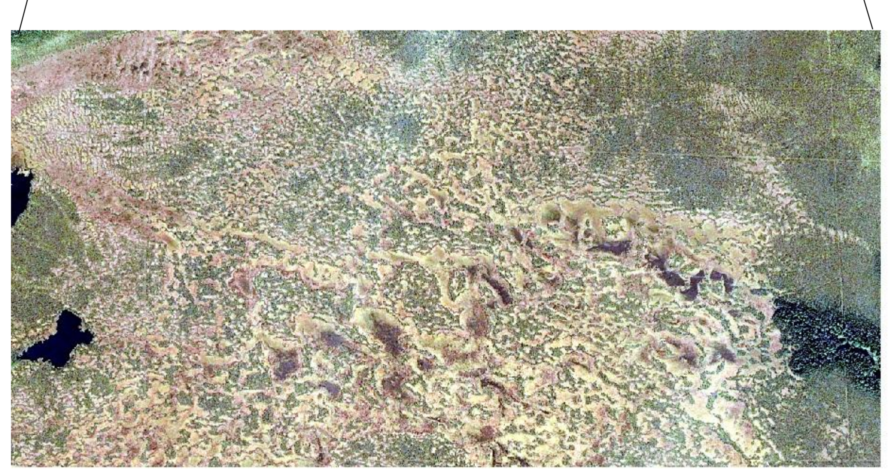


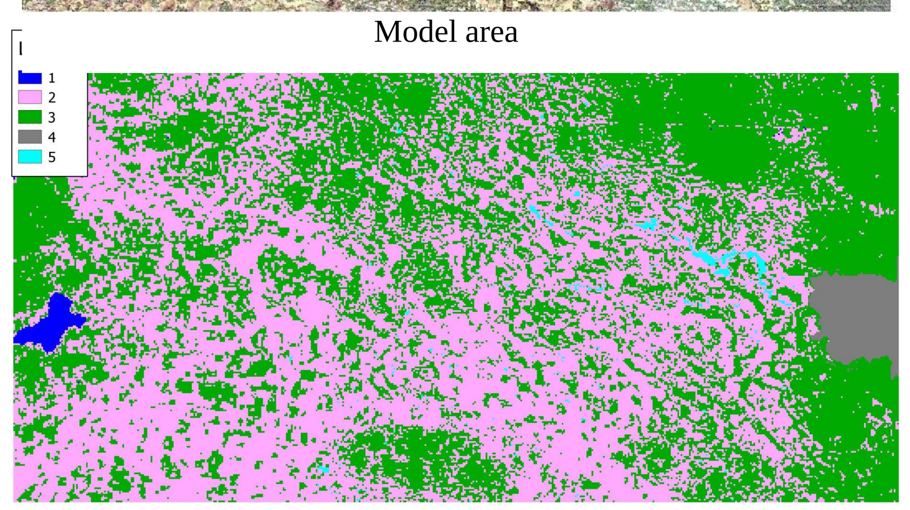
Khanty-Mansiysk region. Landsat image



QuickBird image



Model area



Land unit types
in model area Mukhrino developed by supervised classification GRASS: total map correctness 92.11 %
1:deep lake 2: hollow 3: ryam 4: river valley 5: hollow-lake

The Study Area

The study area, consisting of a vast, pristine complex bog (mire), is located in Western Siberia (figure 1). The investigated mire is located 30 km SE from the town Khanty-Mansiysk, capital of Khanty-Mansiysk autonomous region-Yugra, Russia.
Geographically the mire belong to the Middle Taiga sub-Zone [Krivolutskiy, 1998].This zone include many large convex oligotrophic (sphagnum) mires [Ivanov, 1976]. Peatland accumulation started around 10000 years BP [Neuschtadt, 1977]. The mire is formed from two different (in northern and southern parts) foci of peatland initiation and has the actual area 74.5 km^2. The mire complex is drained at the Eastern margin by the Mukhrinka river and in the West by the Big river. No clear drainage system is present inside the mire complex.
The peatland has a convex shape with vertical elevation difference from the centre to the periphery of 2.2 m. Average peat depth is 3.3 m, maximum 5.5 m. The most abundant peat species are fuscum-peat (35,33 %), complex-peat (14,5 %) and hollow-peat (6,8 %) [Zarov, 2013]. Dominant microlandscapes are ridge-hollow complexes in the central flat parts and "ryam" (pine-shrubs-sphagnum biocenosis), occupy the moderate sloped areas (figure 2).

Objectives

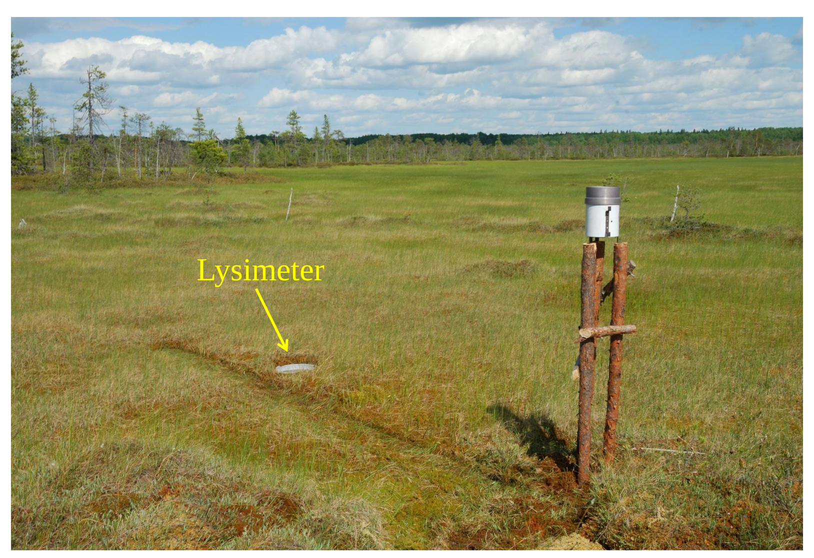
- To improve the knowledge of hydrology of peatland mires of the Middle Taiga Zone
- To estimate the main hydrological parameters of: evaporation, evapotranspiration, precipitation;
- To develop a modeling tool which can be used to predict spatially distributed water-flows of a pristine bog complex

Lysimeter study and 1-D modeling

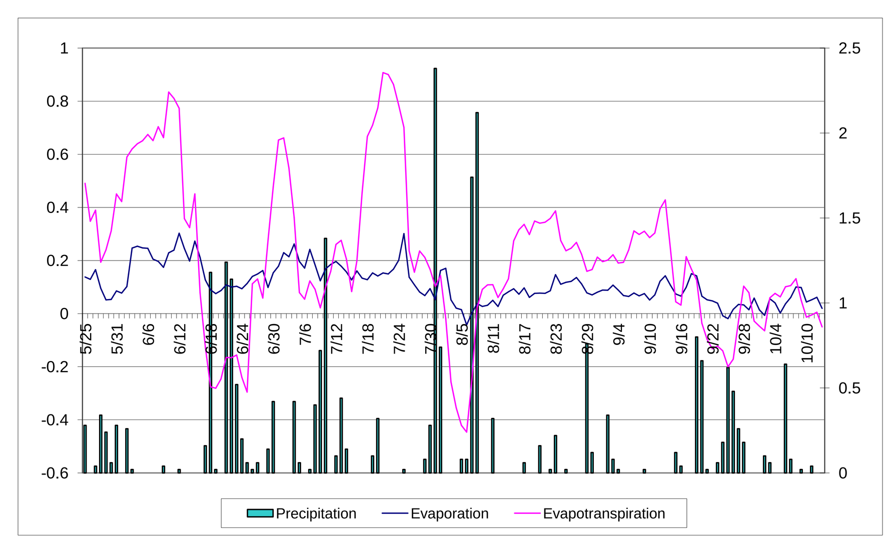
Both evaporation (E) and evapotranspiration (ET) were measured by bucket lysimeters (⌀ 0.35 m, depth 0.40 m) one with open water and second one filled by hollow vegetation (brown mosses, sedges and Scheuchzeria). Each bucket had a hydrological mini-diver DI501 (accuracy 0.5 cm, resolution 0.2 cm) measuring a water level with period every 1 hour. IF necessary water was taken out or added. Air pressure compensation was done with a baro-diver DI500 (accuracy 0.5 cm, resolution 0.1 cm). Buckets were active from May – October. The waterlevel changes in the lysimeter "water" was accepted as the of precipitation (P) - open water evaporation (Eo) . The difference between waterlevel changes in lysimeter "water" and lysimeter "hollow" was described to transpiration effect (crop factor ET). From the recorded water level E and ET were calculated by:

$$E_{evap\ i} = \frac{(H_{evap\ i+7} - B_{i+7}) - (H_{evap\ j=i-6} - B_{j=i-6})}{14} \qquad ET_{evapotranspiration\ I} = \frac{(H_{evaptransp\ i+7} - B_{i+7}) - (H_{evaptransp\ j=i-6} - B_{j=i-6})}{14}$$

The calculated crop factor was used to predict waterlevel change in piezometers with waterpressure loggers (Diver) installed in the area from measured precipitation and Eo . The crop factor of ryam was elaborated by iteration. .

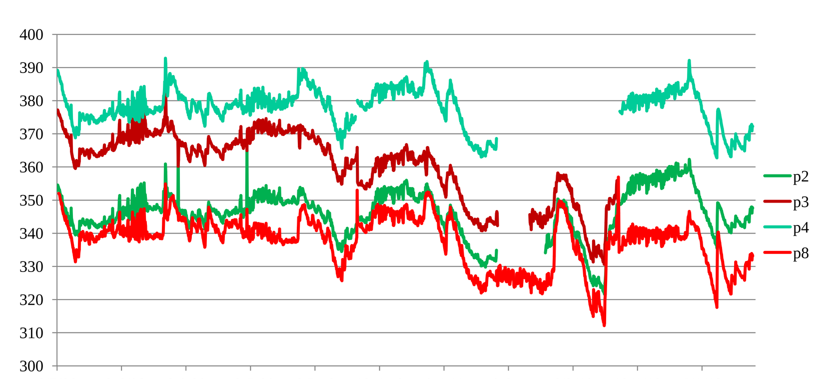


Rain gage and lysimeter for open water evaporation measurement *Photo: E.Zarov*

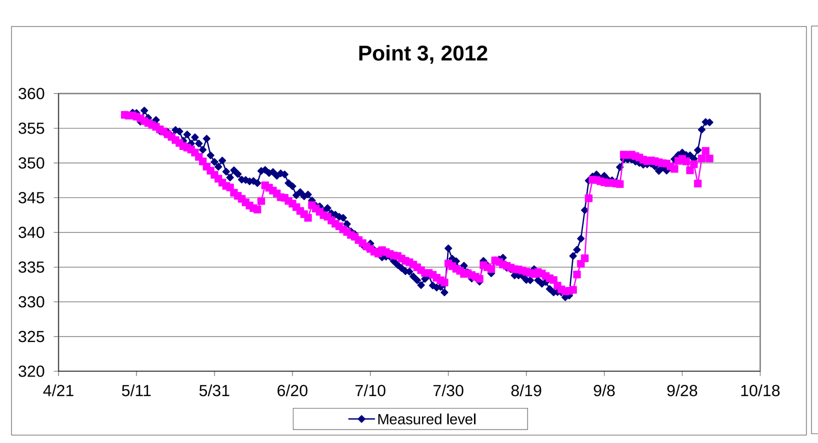


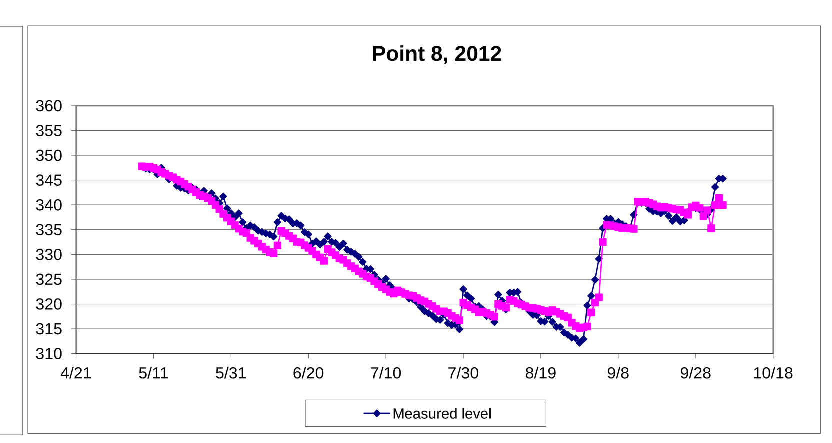
Recorded precipitation and water level change in lysimeters 2009
Lysimeter "water = Evaporation, lysimeter "hollow" = evapotranspiration

Installing Diver in piezometer
In Ryam. *Photo: E.Lapshina*

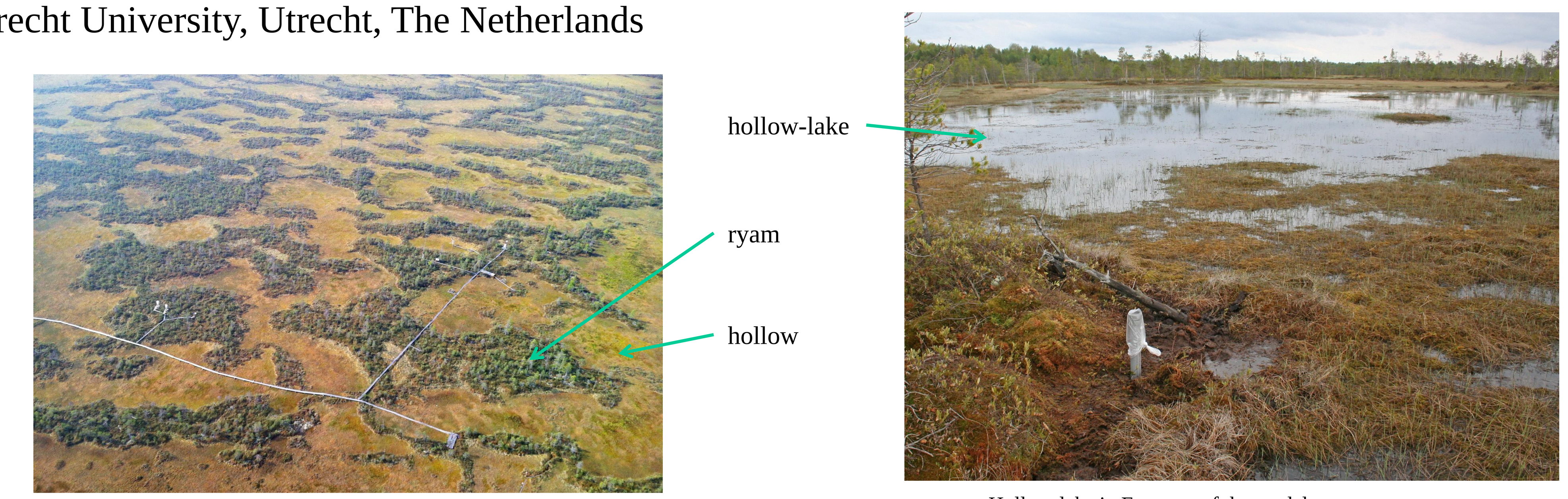


Recorded water level in 4 piezometers





Recorded water level in 2 piezometers and predicted level by forward 1D modeling with daily precipitation and ET



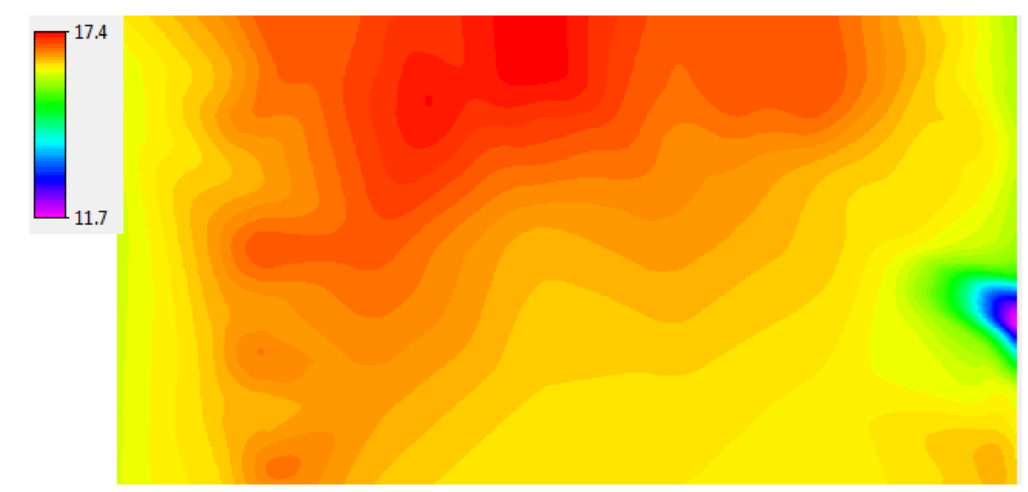
Summer overview part of the model area *Photo: E.Lapshina*

Hollow-lake in East part of the model area.
In the background: mixed forest of the river valley *Photo E.Lapshina*

3-D Modeling

For modeling waterlevels and waterflows we used MODFLOW included in:
PCraster 4.1.0 http://pcraster.geo.uu.nl
A 6-layer model was developed . Cell size = 5 x 5 m, time step = 1 day
Model area = 2680 x 1415 m Total = 910.128 cells

Digital elevation map (DEM): Field measurments with differential GPS (Maxor-GGDT) at network with mesh size 100 x 100 m., partly at 10x10 m. (horizontal accuracy 3 mm, vertical accuracy 5 mm). Elevation was measured at average moss heads in raised parts (ryam) and in ridge-hollow complexes only the hollow parts. Interpolation of elevation data with SAGA



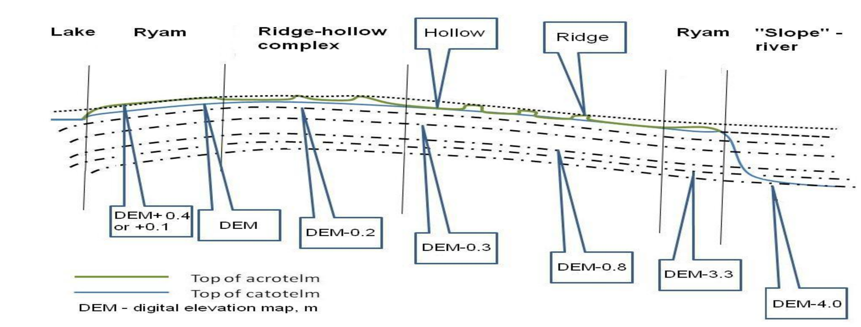
Digital Elevation Map (m. + reference level)

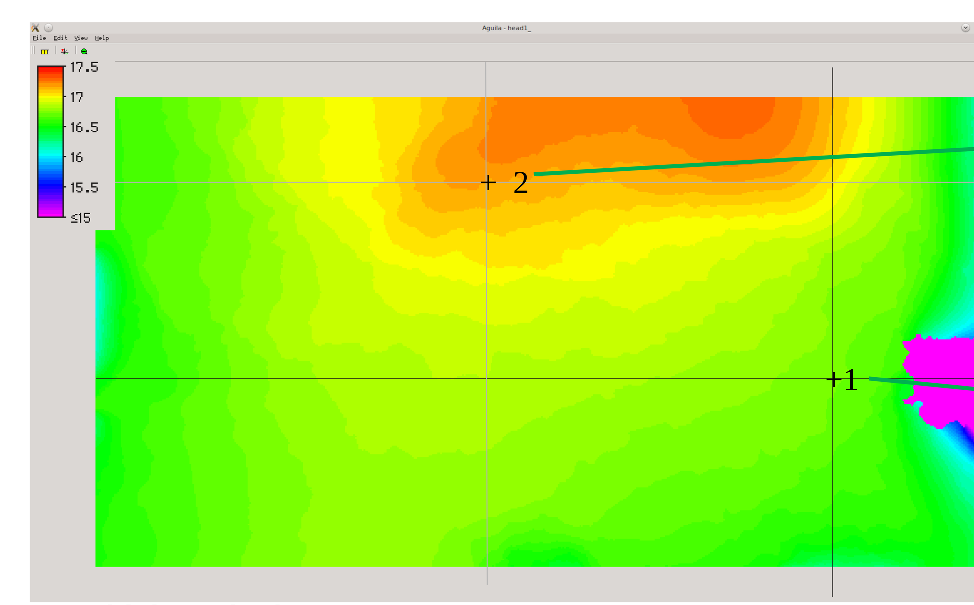
Recharge (m/day) was calculated from the yearly average rain+snow minus yearly average evapotranspiration over the period 1991-2001 available at:
http://ads.nipr.as.jp/index.html
For Evapotranspiration (E and ET) the crop factors developed by the Lysimeter study:
E(lake)=E(Hollow-lake)=0.62, E(ryam)=0.39, E(hollow)=0.55

Modelscheme

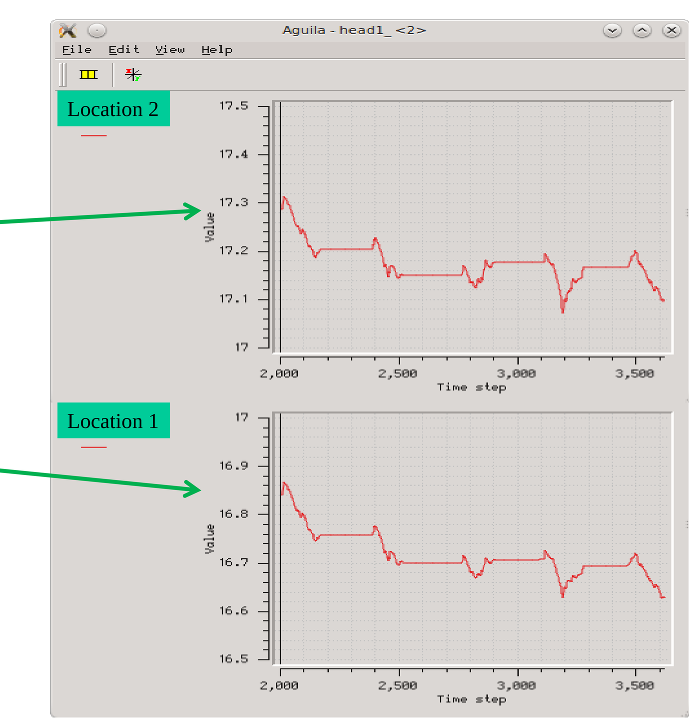
Microlandscape	1 layer	2 layer	3 layer	4 layer	5 layer	6 layer
Pounds	50000	50000	50000	10000	10000	0.01
Hollow	10000	5000	10	2.7	0.1	0.01
Ryam	500	200	100	2.7	0.1	0.01
Slope	50000	50000	50000	50000	50000	0.01

Table 1. Horizontal hydraulic conductivity of different layers, m/day

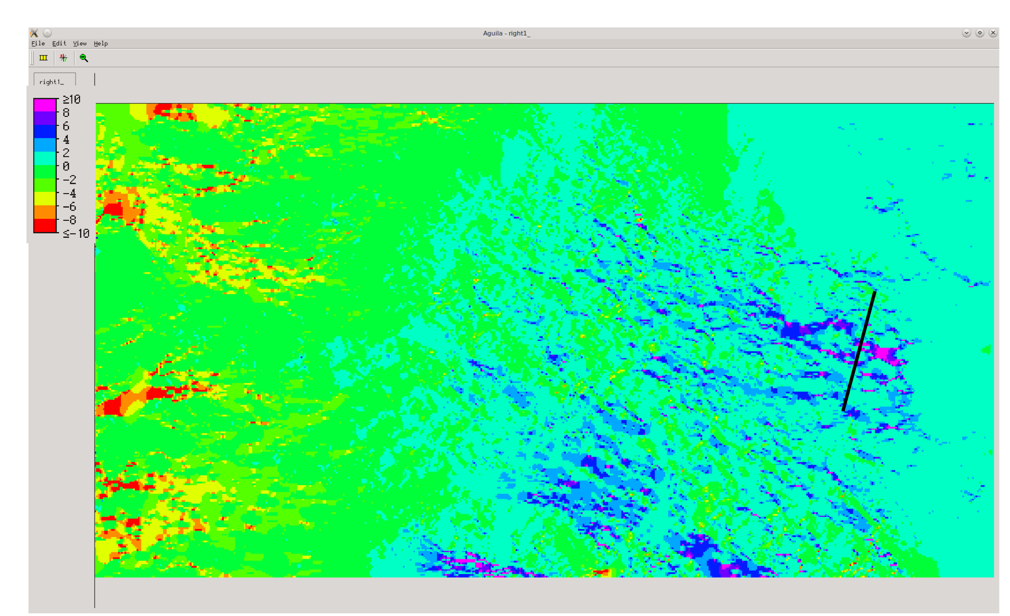




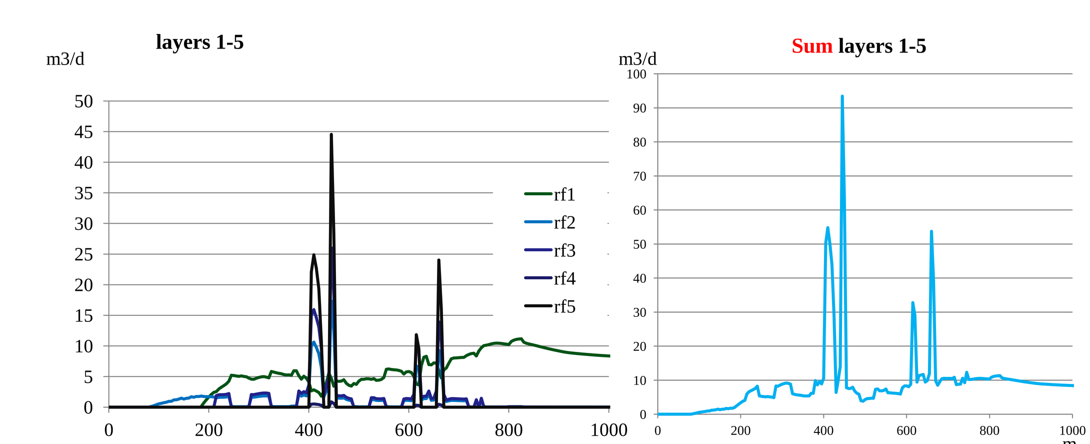
Modeled water level map: timestep 2000
purple:= river valley: not modeled + selected points for display timeseries



Time series of modeled waterl evel at selected points



Modeled flow at time step 2000. m^3/day
Positive values: flow direction W >> E
Negative values : flow direction E >> W
—— cross section



Flow through **cross section** in m^3/day
Left: flow by layer Right: accumulated flow