ESF projekts „Starpnozaru zinātnieku grupas un modeļu sistēmas izveide pazemes ūdeņu pētījumiem”

Reconstructing the groundwater flow in the Baltic Basin during the Last glaciation

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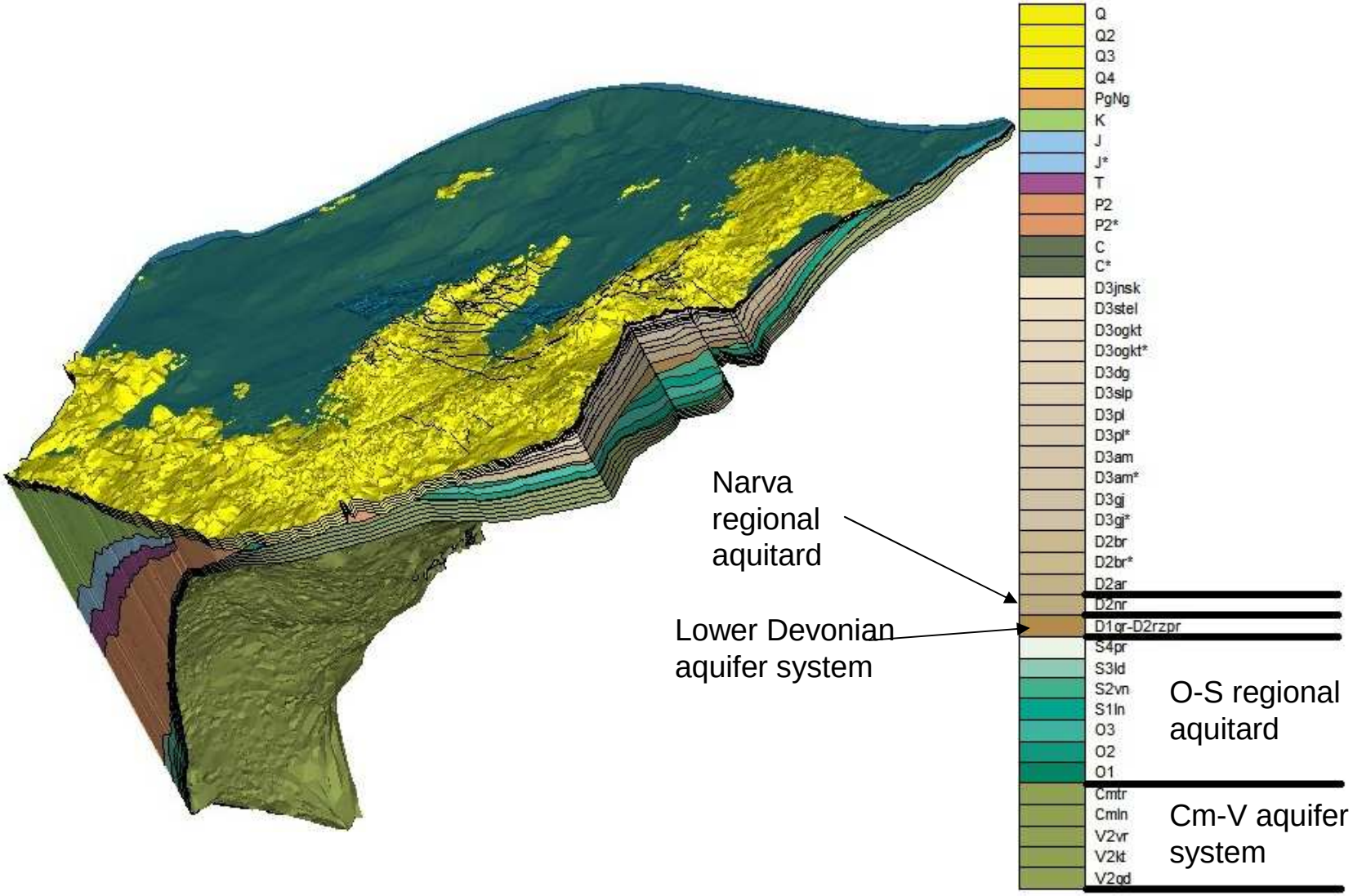
The Baltic Basin

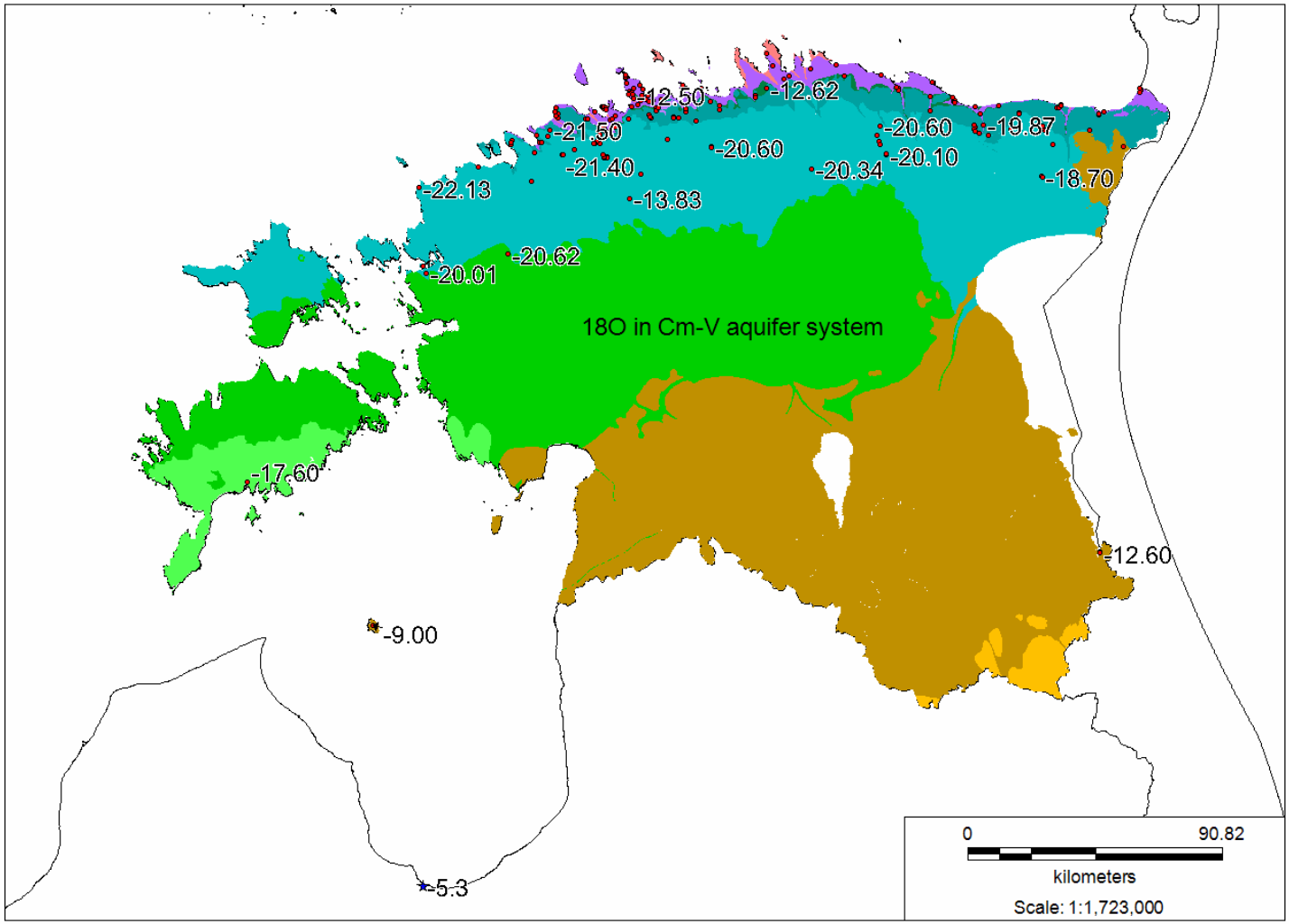


Virbulis et al, under revision

The age of the groundwater in the Baltic Basin

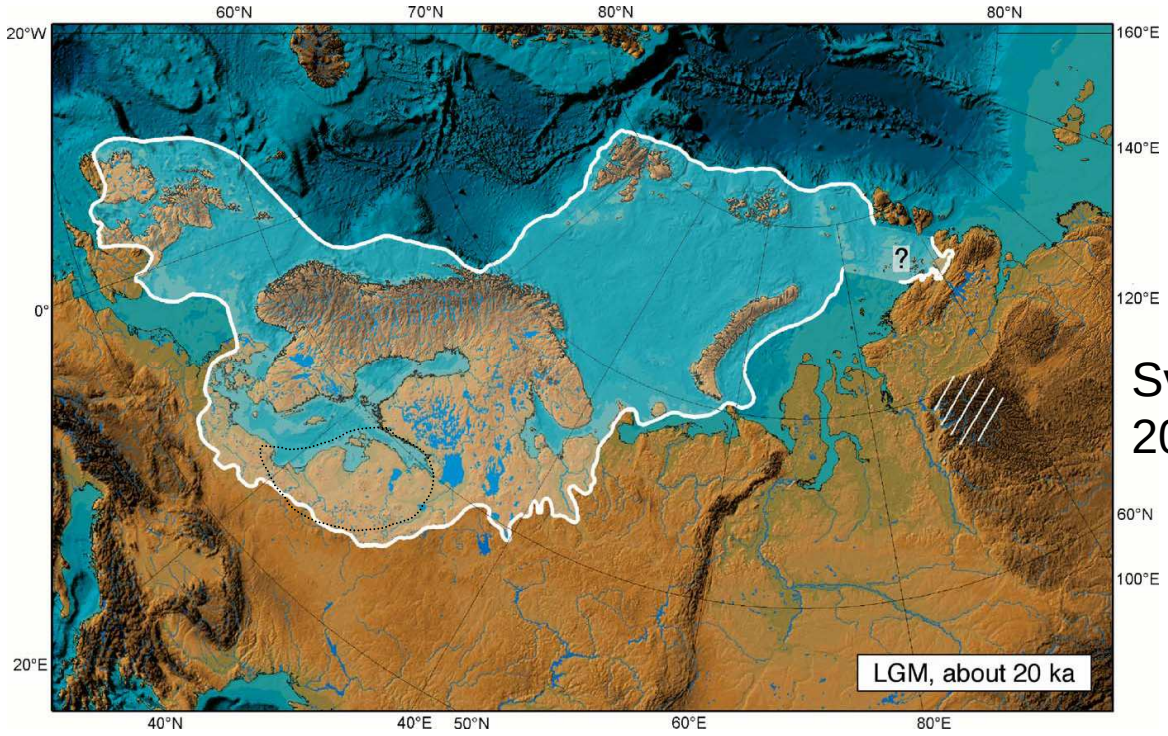
- Groundwater in the Baltic Basin, according to its chemical and isotope composition can be subdivided into three broad age groups:
  - “Contemporary” (Last 10 th. y.)
  - Quaternary (glacial and interglacial)
  - Pre-Quaternary

The presence of glacial meltwater in the Cm-V aquifer system



- Raidla V (2010) + Partly unpublished data from Institute of geology at Tallinn University of Technology

Glacial history of the Baltic Basin



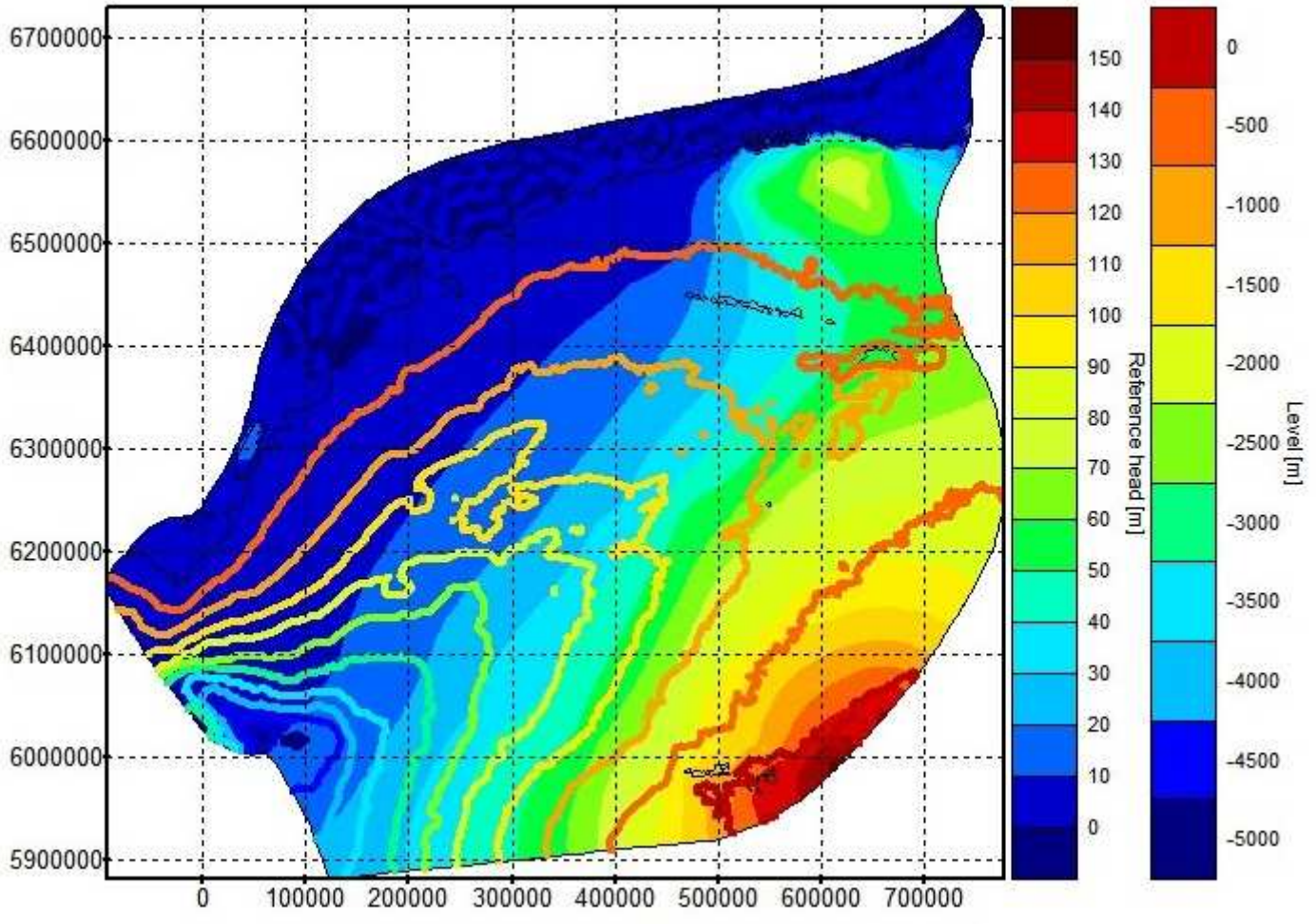
Svedsen et al., 2004

- The Baltic Basin has been covered by the Scandinavian ice sheets at least 5 times
- The last, Late Weichselian, glaciation was present in the Baltic Basin territory for at least 19 thousand years

Modelling setup

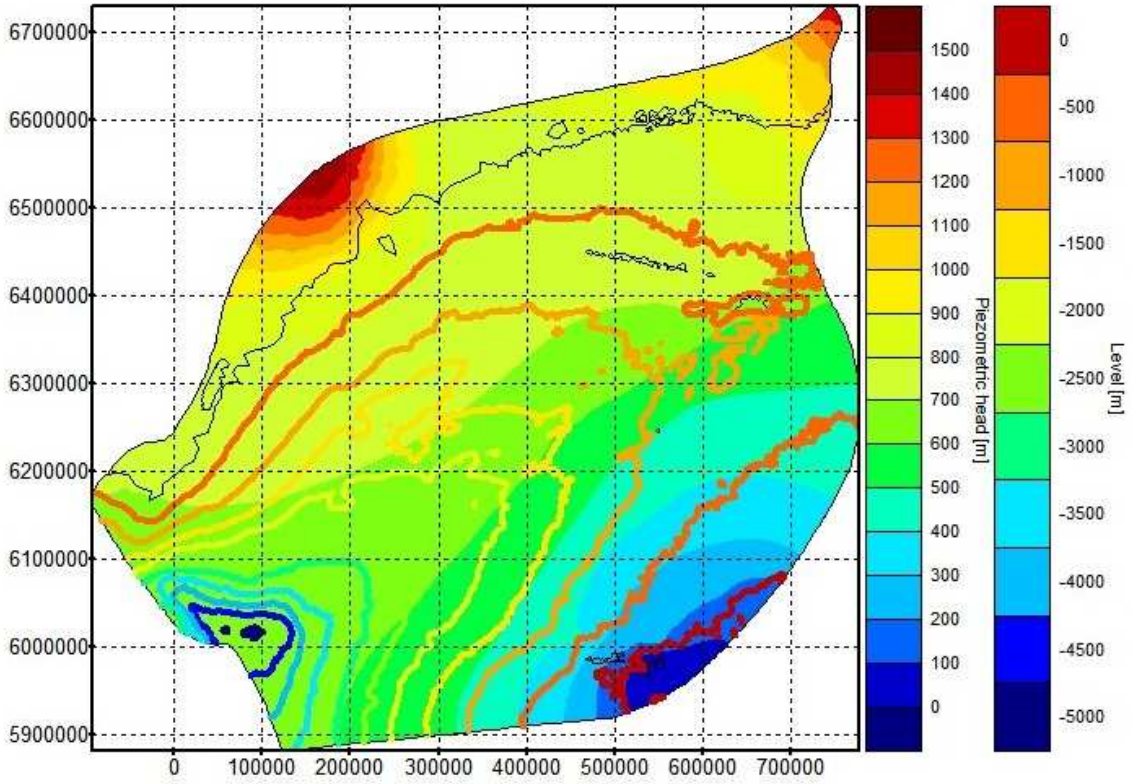
- “Preindustrial” contemporary groundwater flow as intial stage
- Geometry corrected for subglacial topography: subsidence of Earth crust surface due to ice weight (ICE-6G model (Argus&Peltier, 2010))
- 19 consecutive modelling steps spanning the time from 10 – 28ka BP through the last glacial advance and deglaciation (ICE-6G model (Argus&Peltier, 2010))
- Two modelling settings
  - Constant head
  - Constant flux
- The base of the ice sheet is considered temperate, no permafrost
- No density changes considered
- No change in sediment conductivities
- No change in Quaternary cover

Initial conditions



- Infiltration from the surface
- Hydrostatic groundwater flow

Constant head

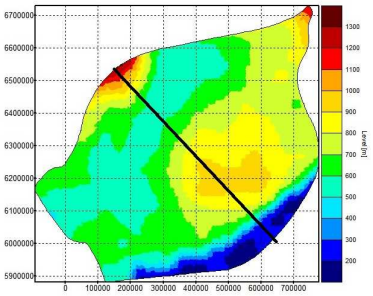


•Two main areas of meltwater intrusion into the Cm-V aquifer system:

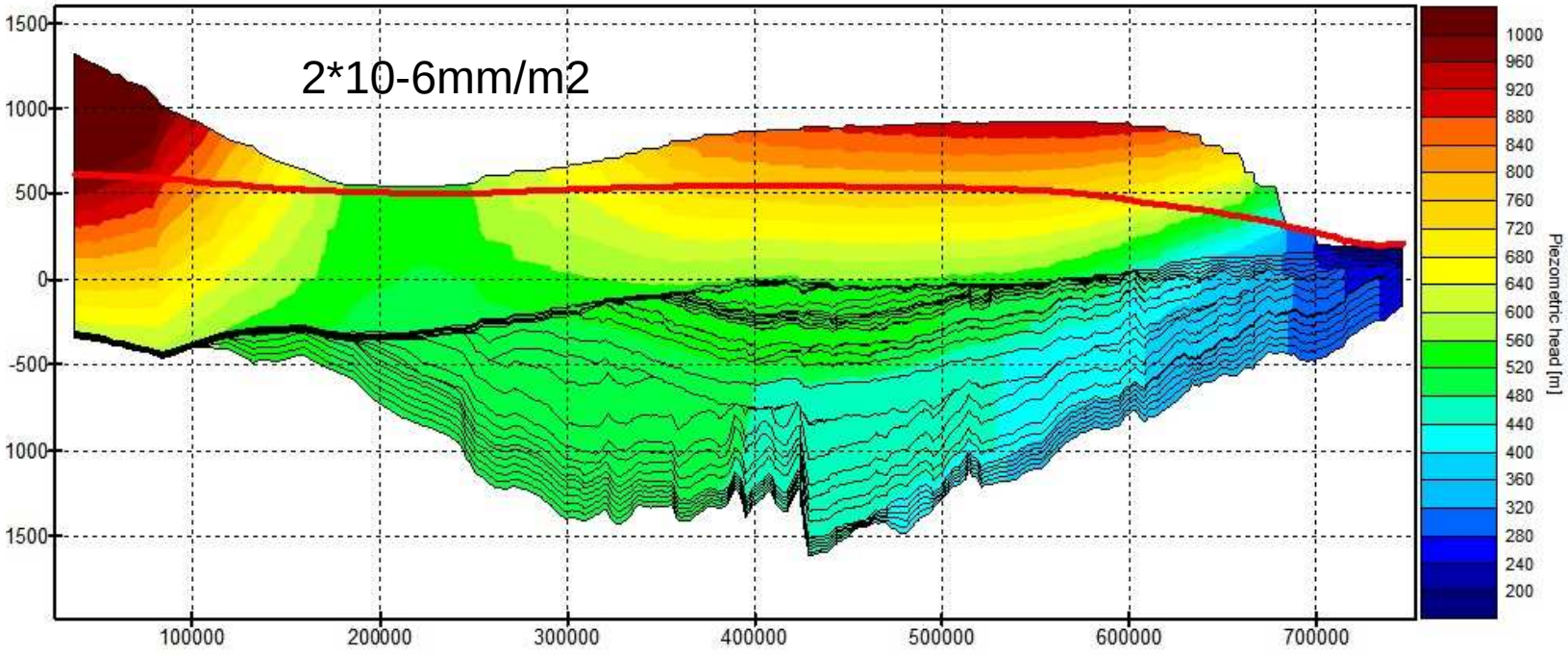
In Finnish bay and around Gotland

•The Western intrusion area has been present for longer time period

•Reversed groundwater flow direction for 14 th.y.

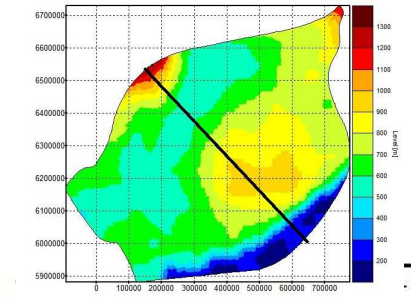


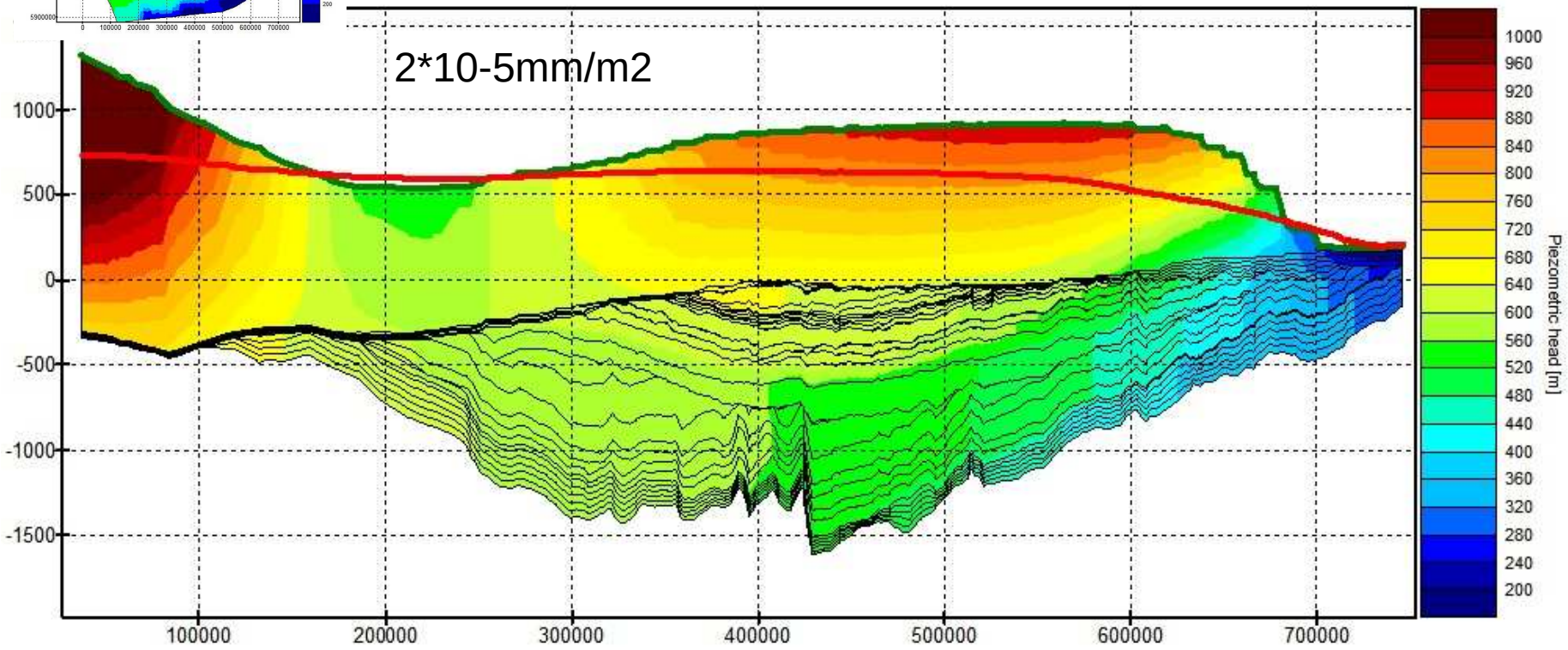
Constant flux



- Two constant flux simulation runs
  - Q=2*10-5mm/m^2
  - Q=2*10-6mm/m^2

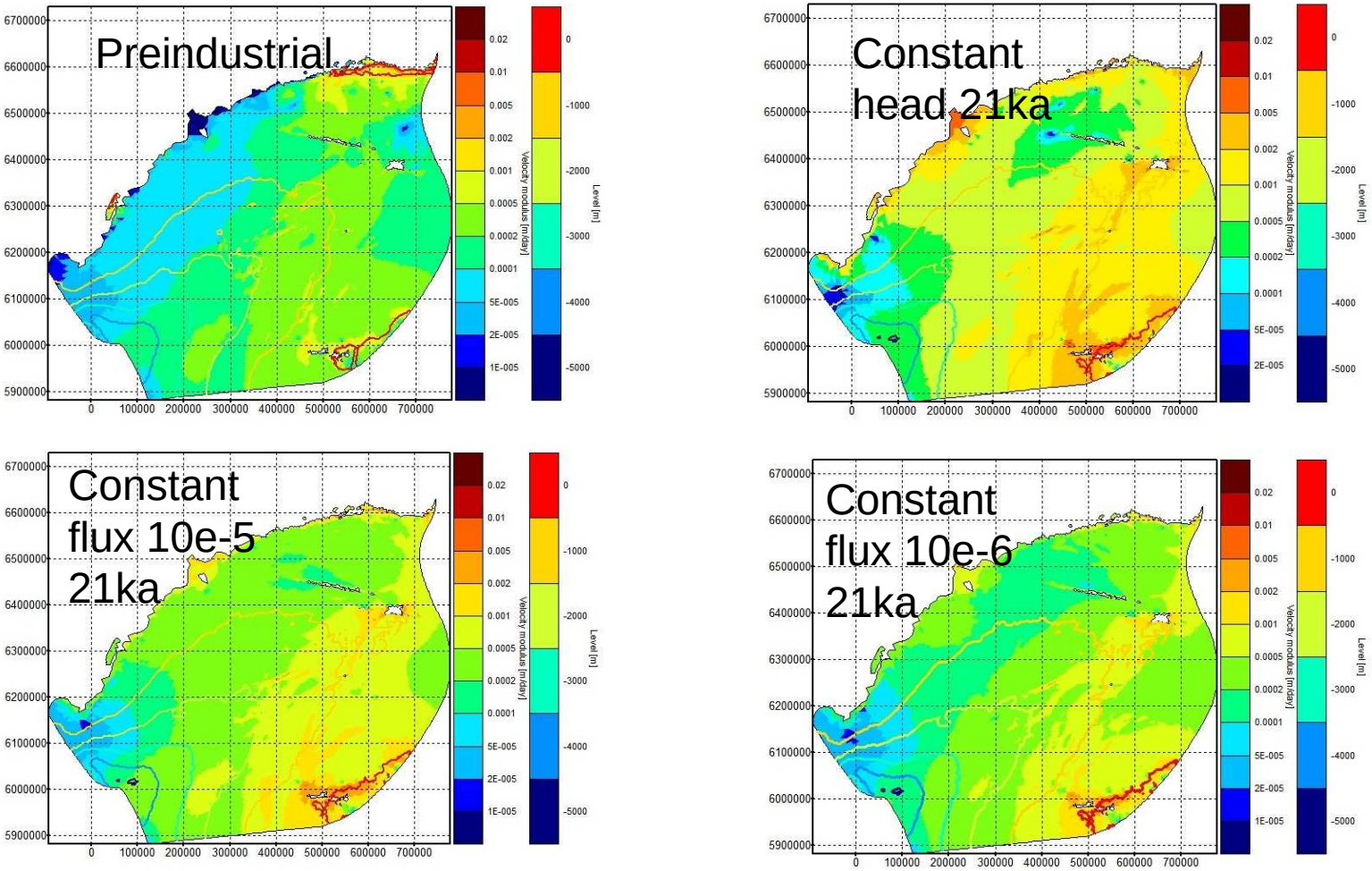
Constant flux





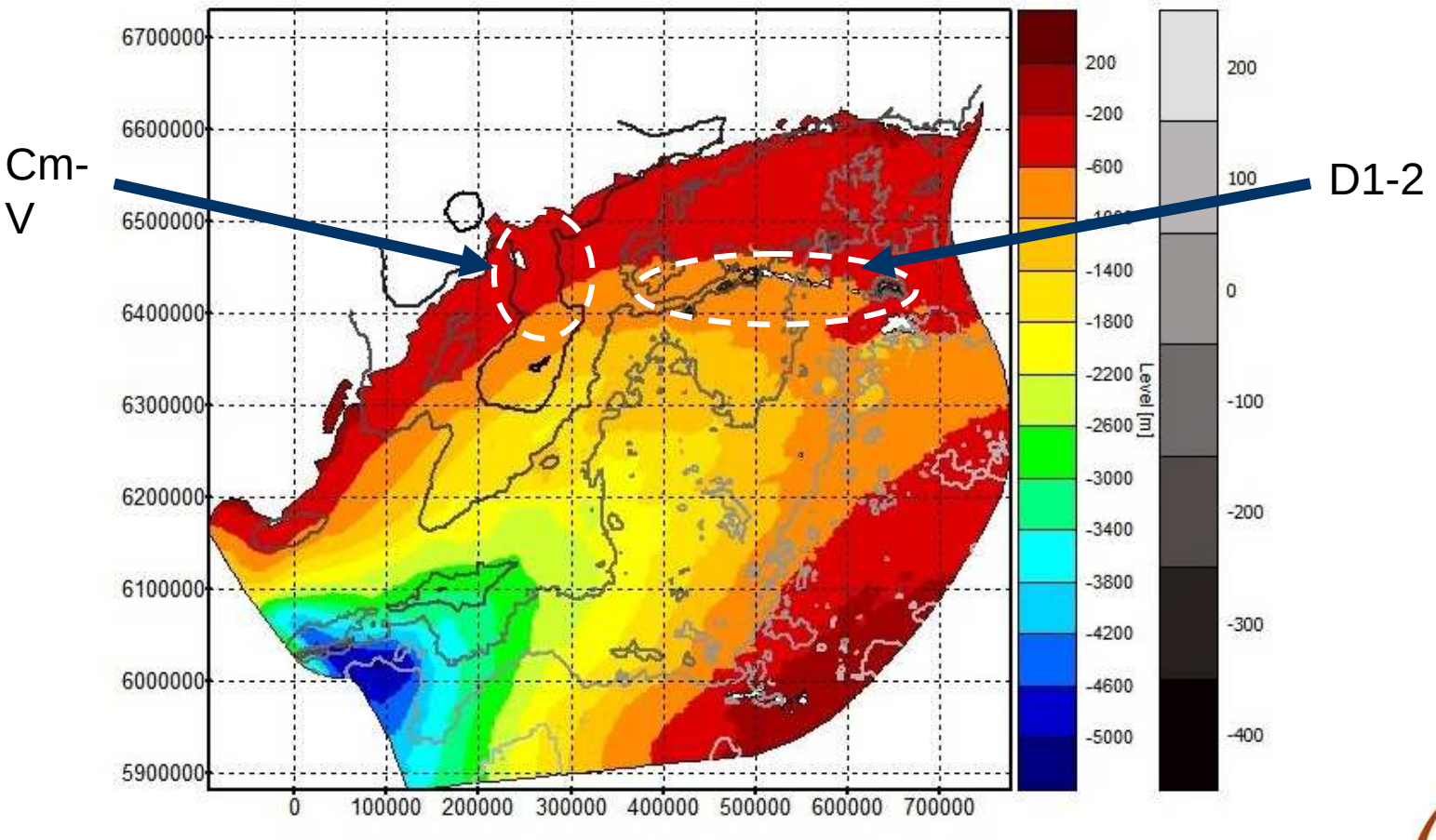
- More realistic piesometric head distribution
- Very little of the meltwater intruded, suggesting dominant meltwater transport along the surface and intra glacier

Velocity change



- Groundwater flow velocity modulus increases times in constant head scenario, while in constant flux scenario it increases 2 and 4 times respectively

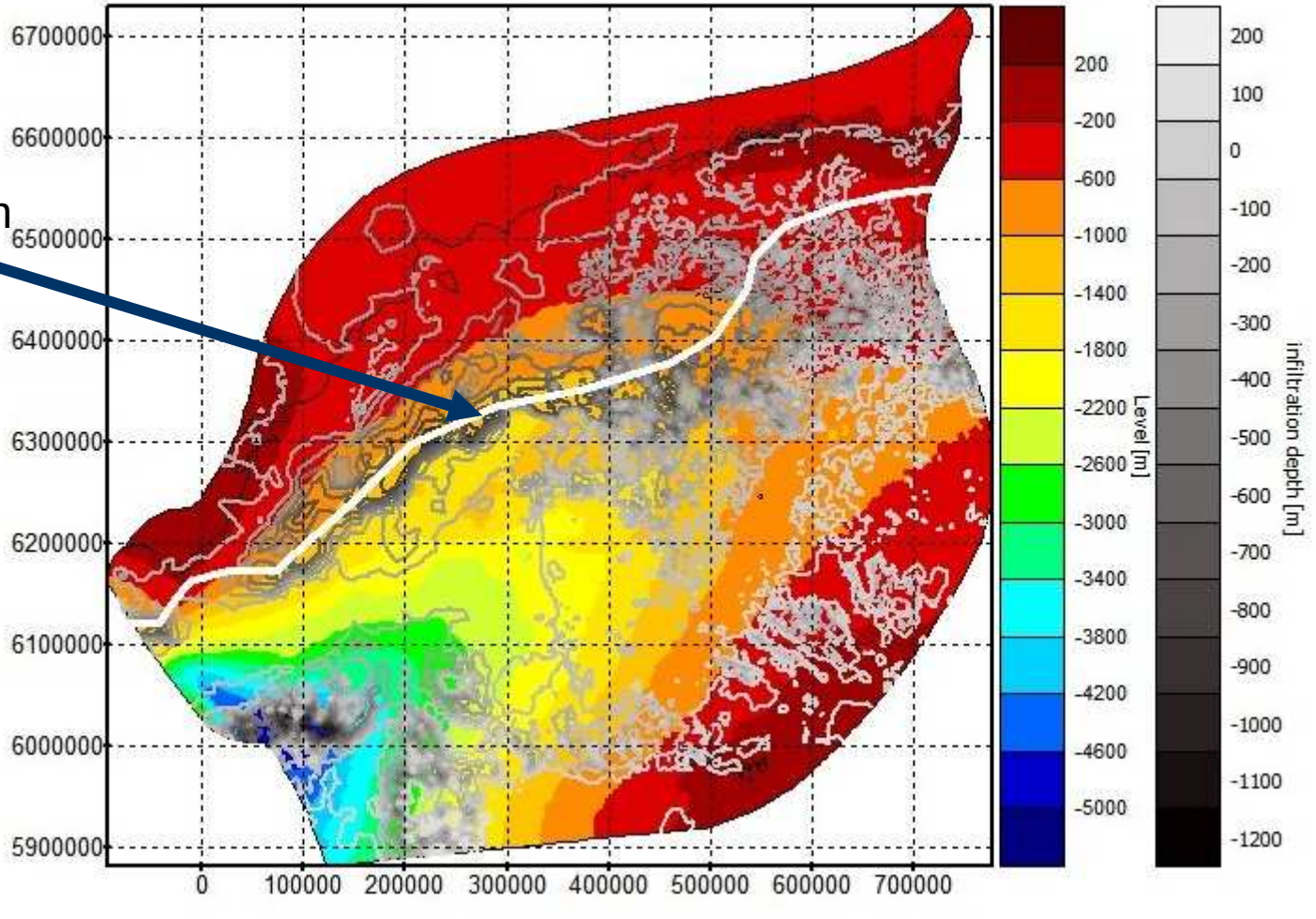
Infiltration of the meltwater



- Particle tracing analysis for Vz for whole simulation period (17ka)

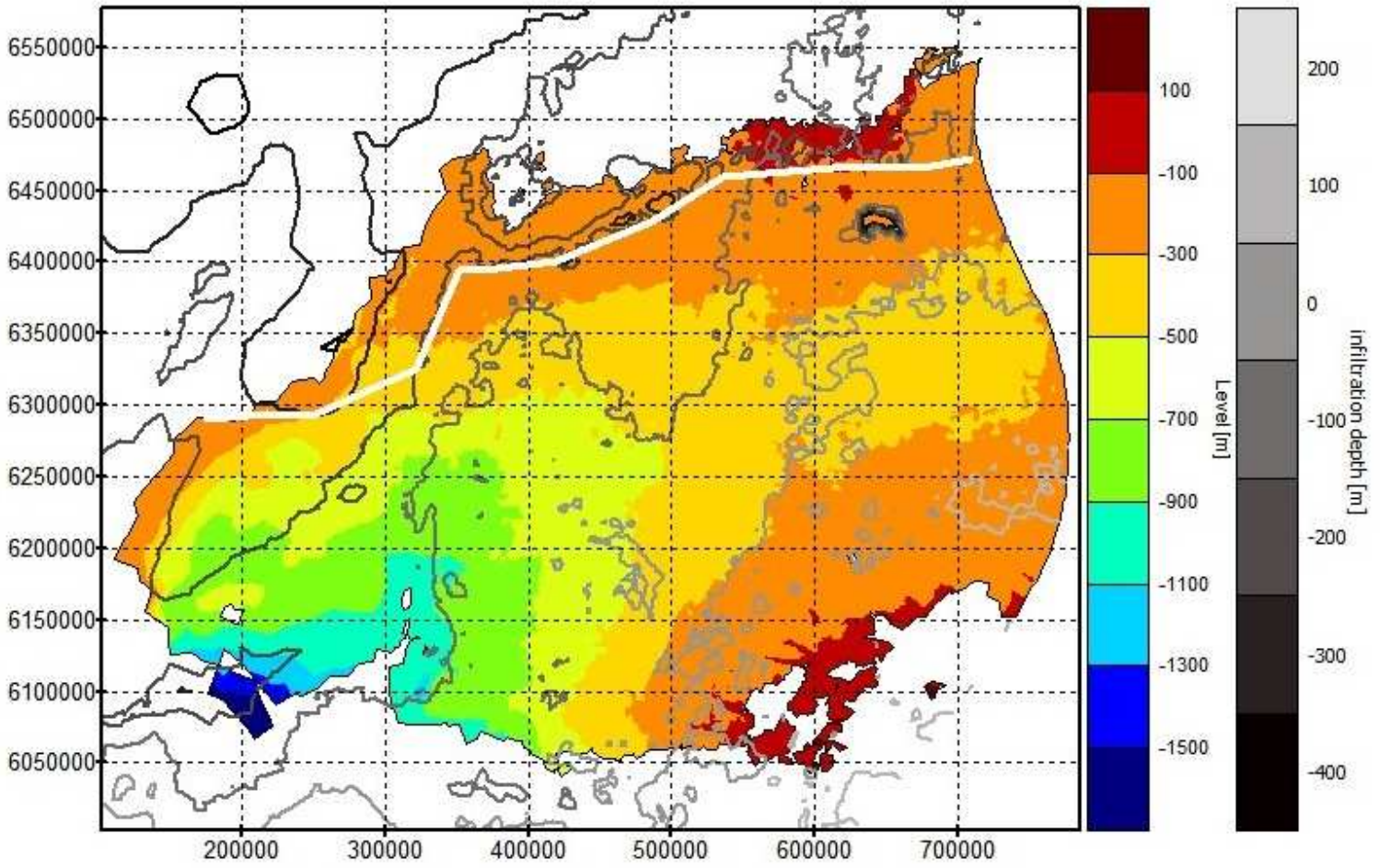
Infiltration of the meltwater

Propagation front



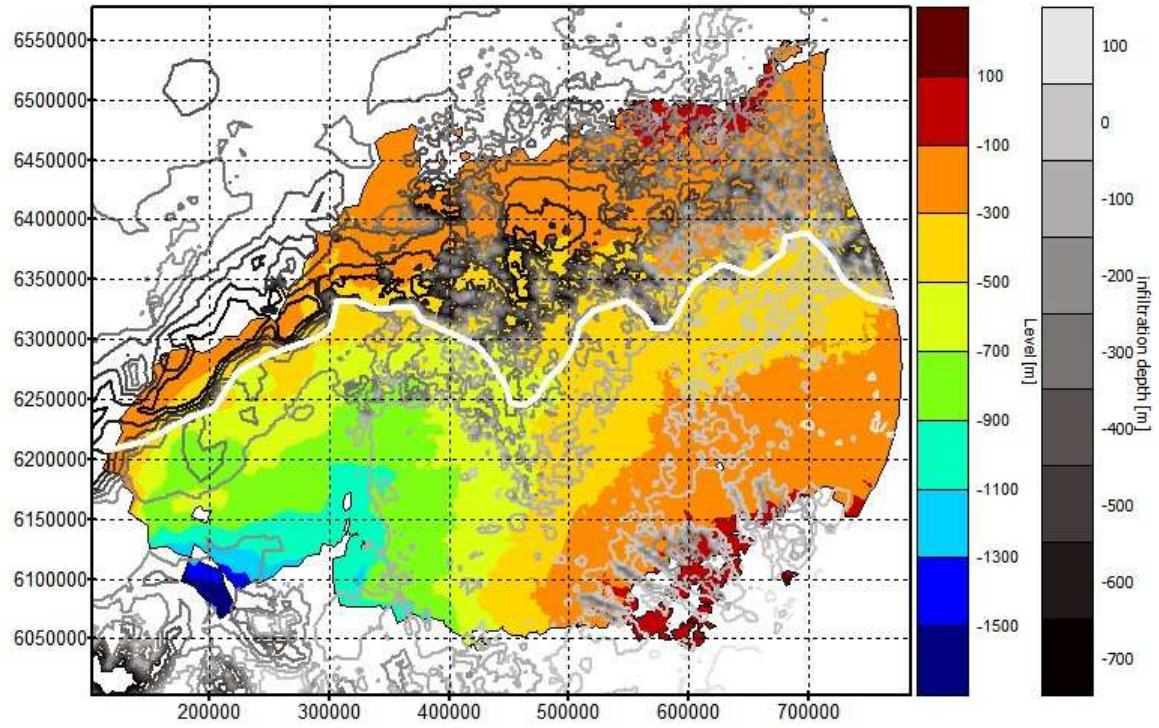
- By increasing the particle propagation 10 times (corresponding to 150 th. y.) the glacial meltwater reaches up to -1200m a.s.l. Depth

Lower Devonian aquifer



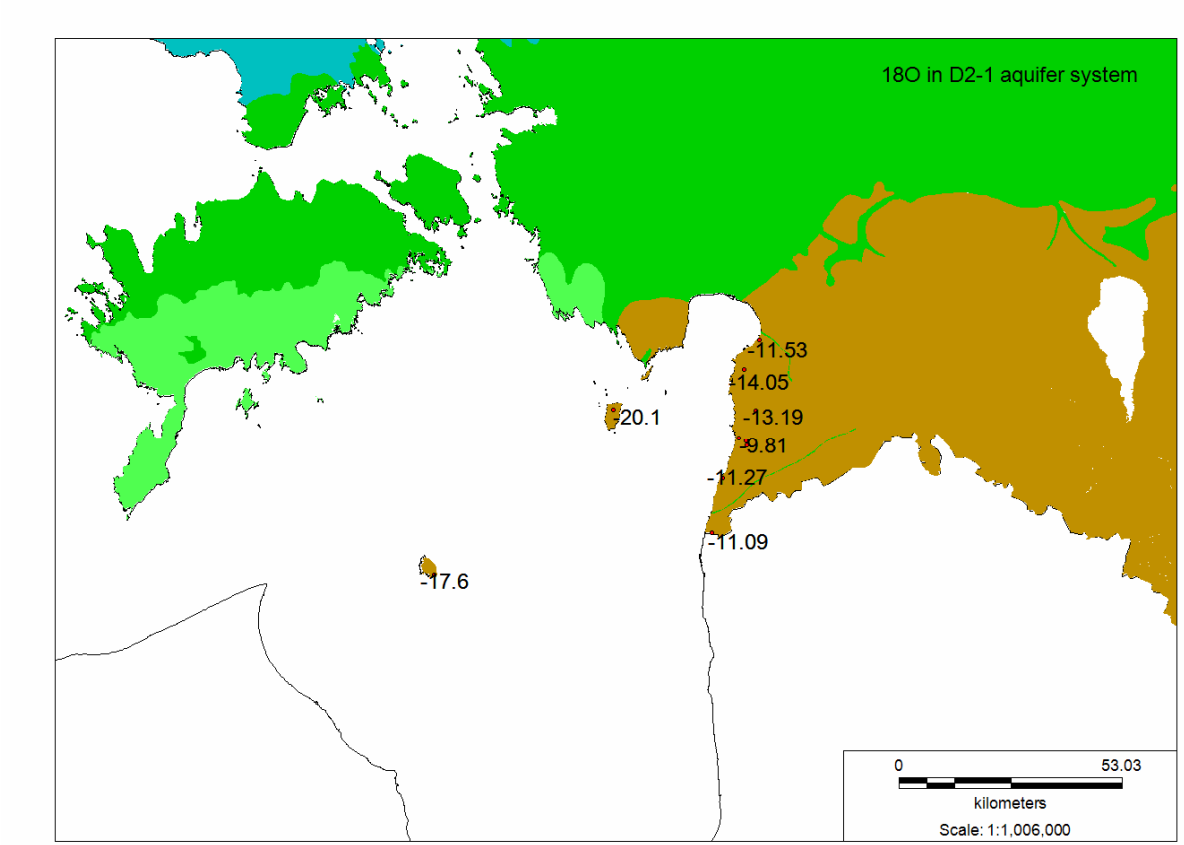
- In lower Devonian aquifer system meltwater propagates for some 10-15 km

Lower Devonian aquifer



- In the more shallow eastern part the modelling predicts approx half of the aquifer filed with meltwater

Lower Devonian aquifer system



- Glacial meltwater from the isotope studies suggested only in the western part of the aquifer
- Partly unpublished data from Institute of geology at Tallinn University of Technology

Conclusions and further perspective

- Under current ice thickness modelling scenarious two main intrusion sites – western being more important
- Reversed groundwater flow direction during the glaciation
- Only a very small fraction from the meltwater is intruded
- We favor constant flux scenario

Conclusions and further perspective

- Current simulations underestimate the volume of the meltwater intrusion in the Cm-V aquifer system
  - The water conductivity of the subglacial sediments is one of the main factors influencing the volume of the meltwater intruded and the flow velocities of the groundwater
  - Presence of paleoincisions in northern Estonia could significantly enchance the amount of the meltwater intruded
- Lower Devonian aquifer is a likely candidate to contain glacial meltwater
- The currently defined Eastern boundary of the Baltic Basin is irrelevant for the periods when groundwater flow was controlled by the glacier: the model should include part of the Moscow basin

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