Development of a 3D groundwater flow model in semi-arid to arid regions: The western drainage basin of the Dead Sea (Israel and West Bank)

Hydrogeology of Arid Environments, Hannover, 16.03.2012

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Introduction

Important questions

- catchment characteristics
- structural geology of catchment
- hydrogeology
- recharge conditions
- groundwater flow dynamics
- water balance
- findings of model and research

→

Conceptual model

Numerical model

Model calibration

Results + Conclusion

Open questions

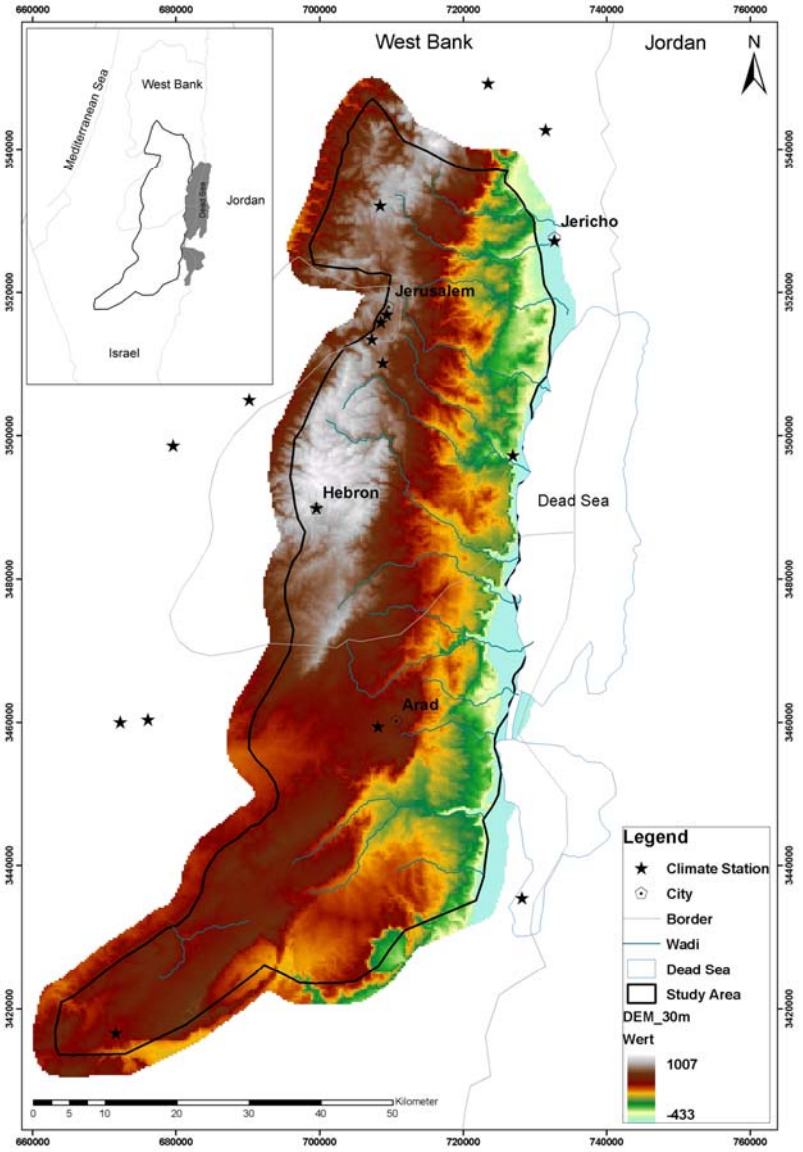
- consequences of steady state model
- transient conditions
- coupling of hydrological and groundwater flow model
- scenarios

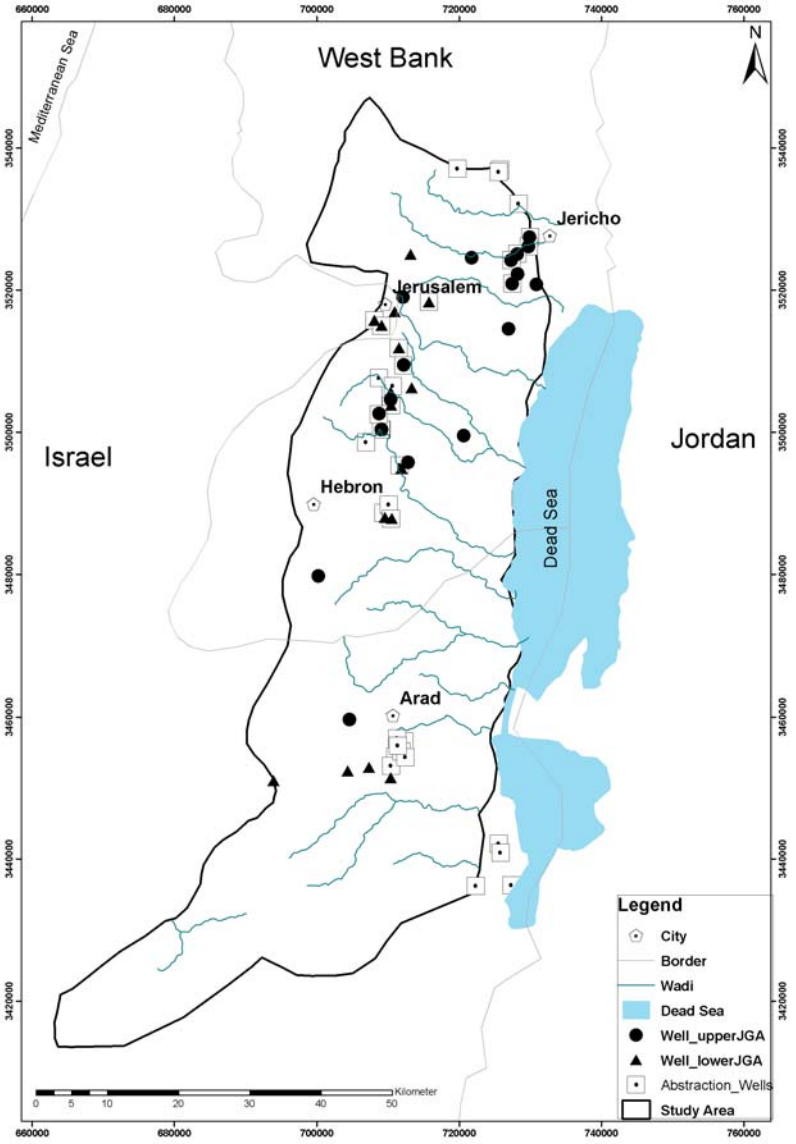
→

Findings?

Outlook

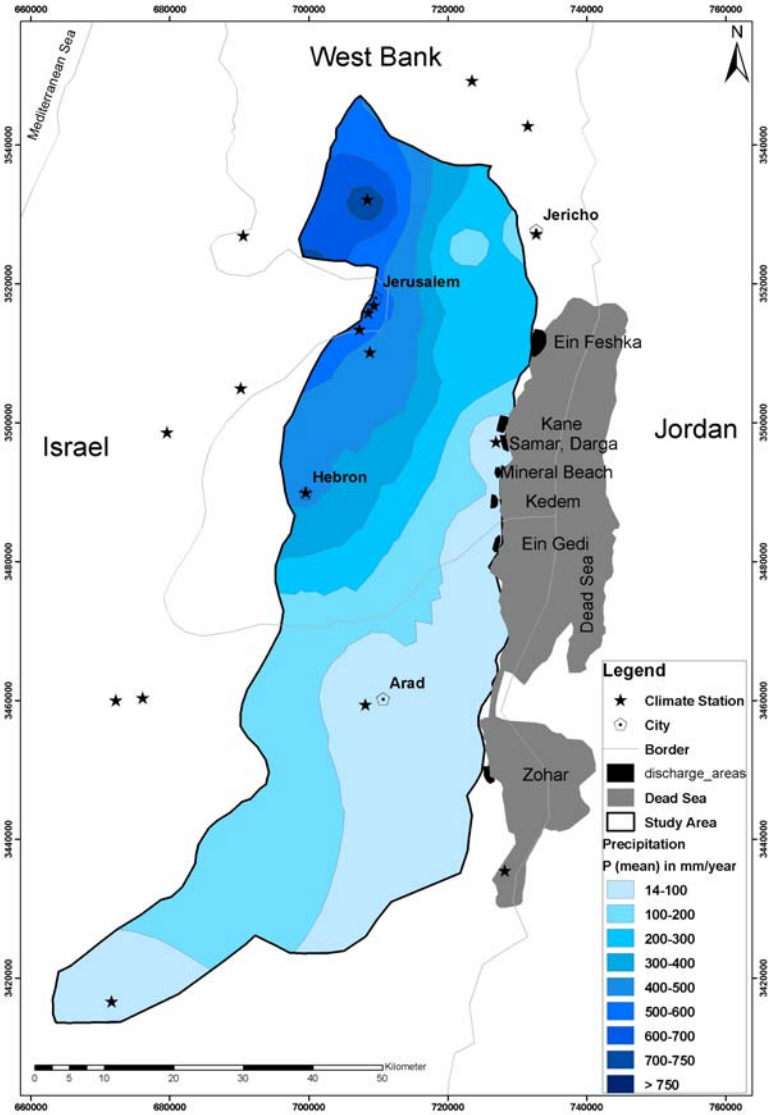
Characterization of study area





Evaluation and Regionalisation data

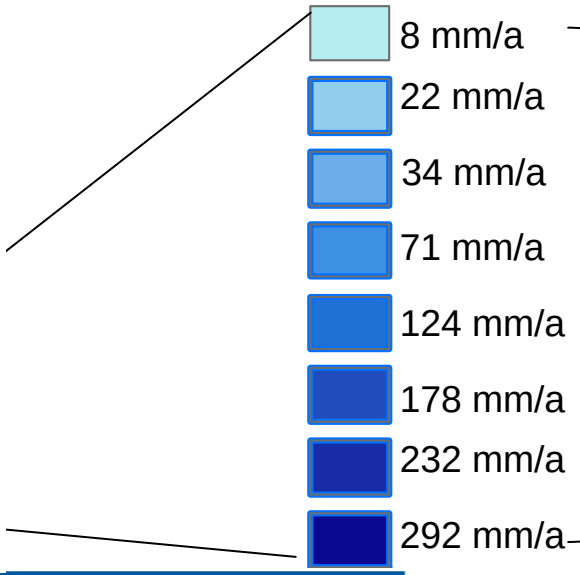
Groundwater Recharge



Various methods estimating recharge:

- chloride mass balance (Theiss, 1937; Sanford, 1994; Marei et al., 2010)
- soil moisture deficit method (Lerner et al. 1998)
- empirical relations, e.g. Guttman (2000):

$R = 0.8 \times (P - 360)$	if $P \geq 650$ mm/a
$R = 0.534 \times (P - 216)$	if 650 mm/a $> P \geq 300$ mm/a
$R = 0.15 \times P$	if $P < 300$ mm/a



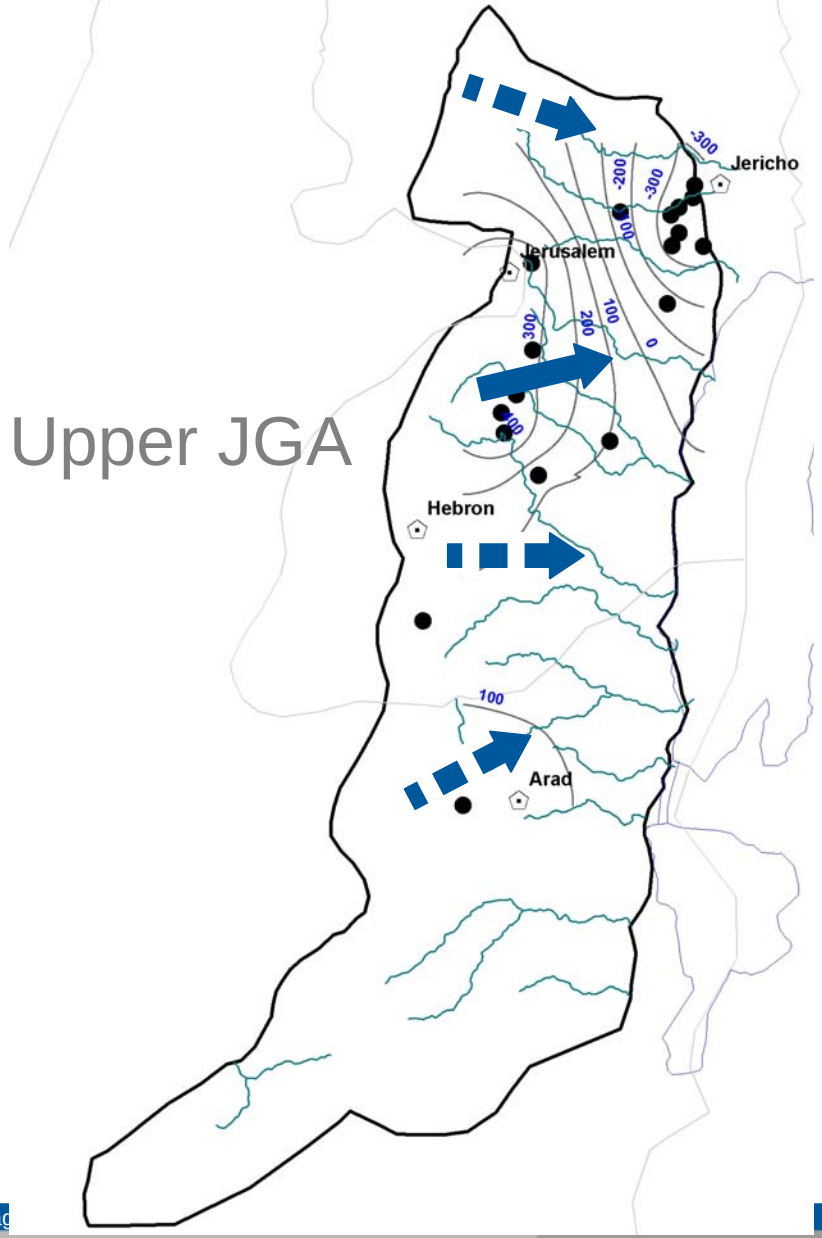
total average of annual recharge:

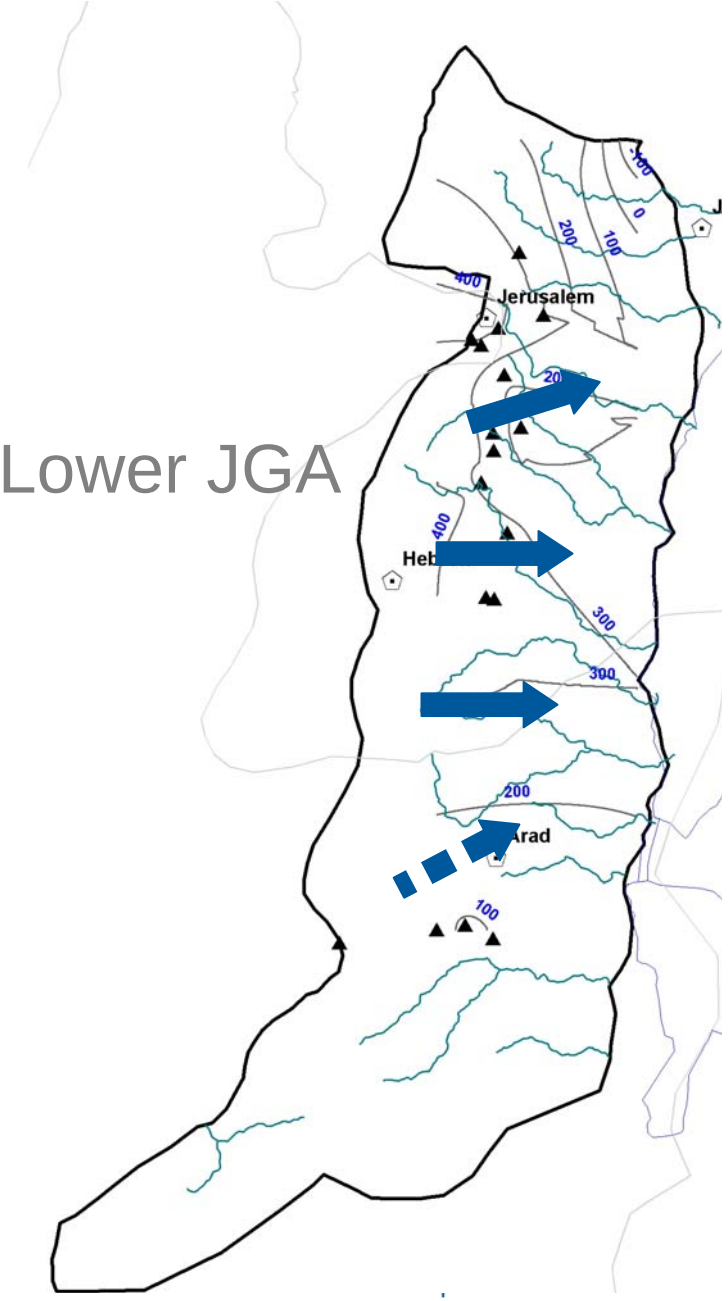
186 MCM/a

Gräbe et al., 2012

Evaluation and Regionalisation data

Groundwater Contour Map



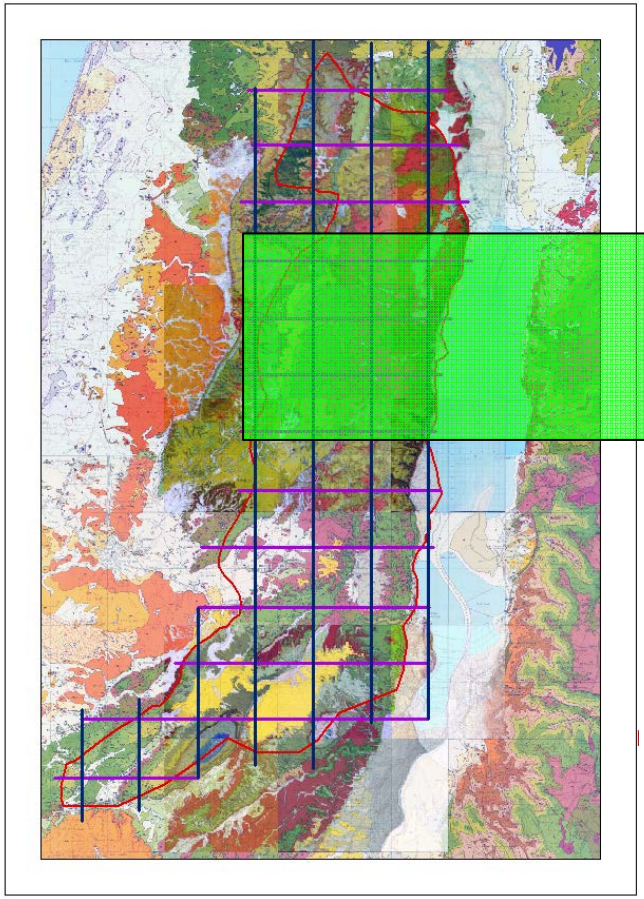


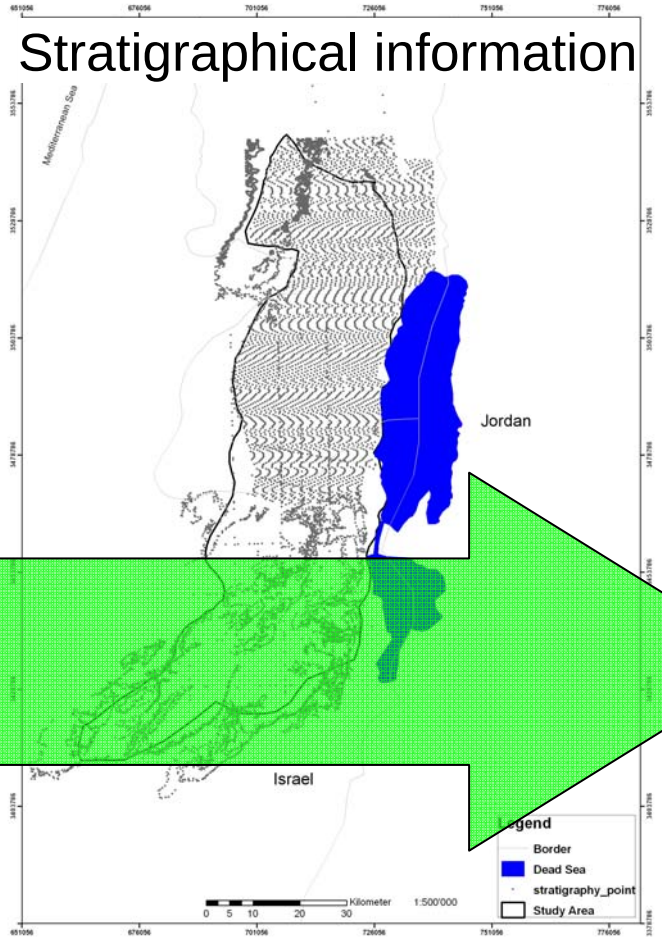
Geological 3D model

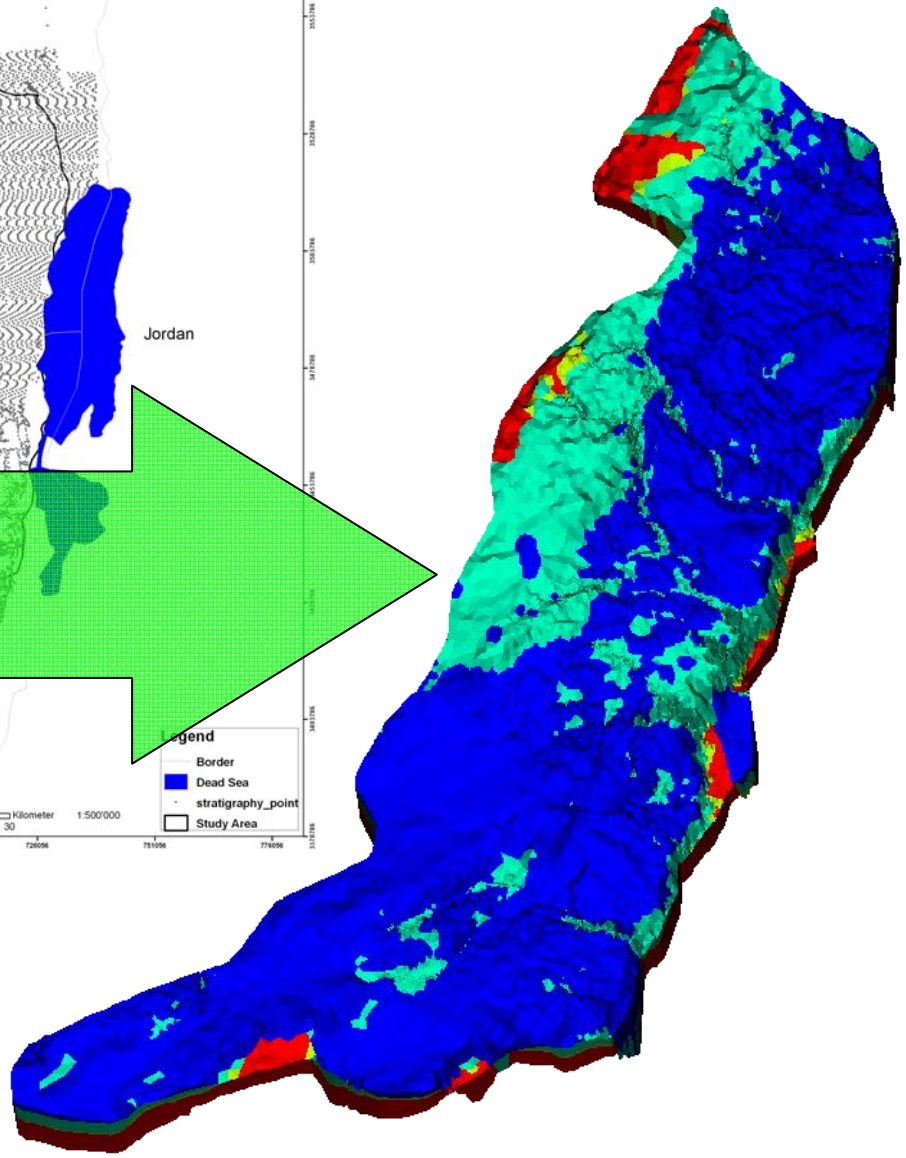
Structural model

Stratigraphical information

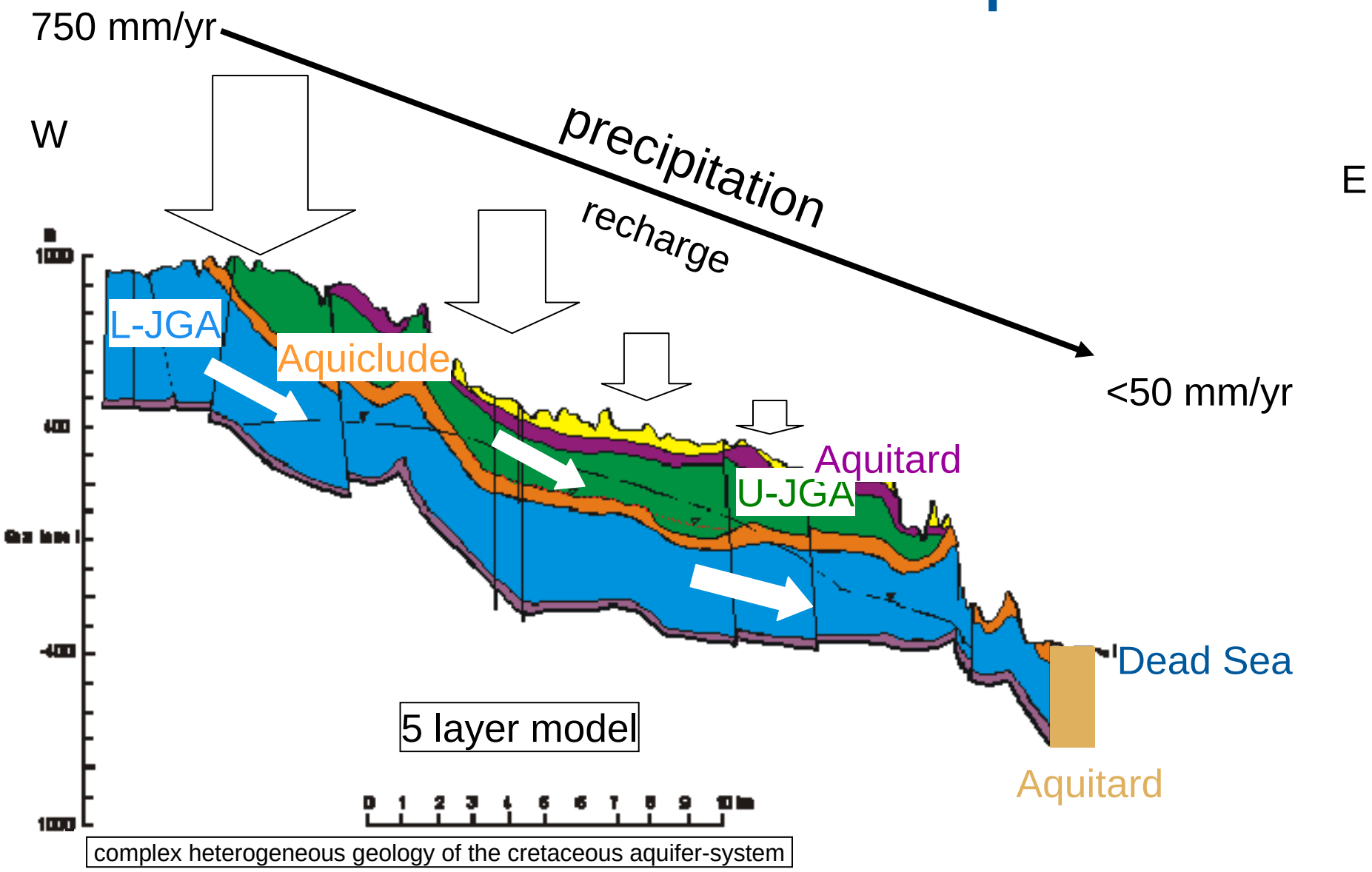
Geology







Conceptual model



complex heterogeneous geology of the cretaceous aquifer-system

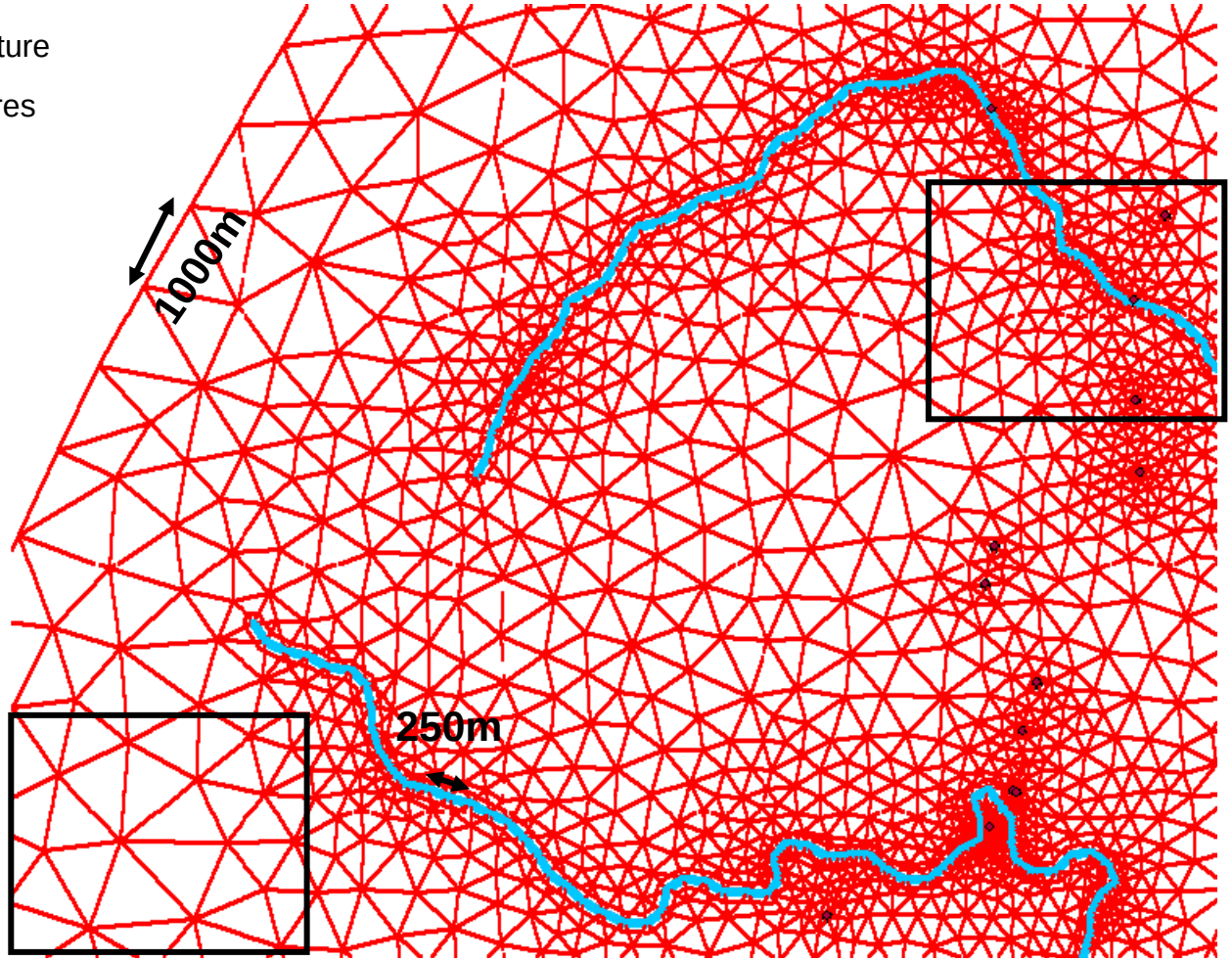
Changed after: **CH2M-Hill (2001).**

Groundwater flow model – OpenGeoSys

Mesh

Terms and conditions for unstructured mesh:

- specified procedure to represent the nature
- important hydraulic + geometric structures
- mesh density

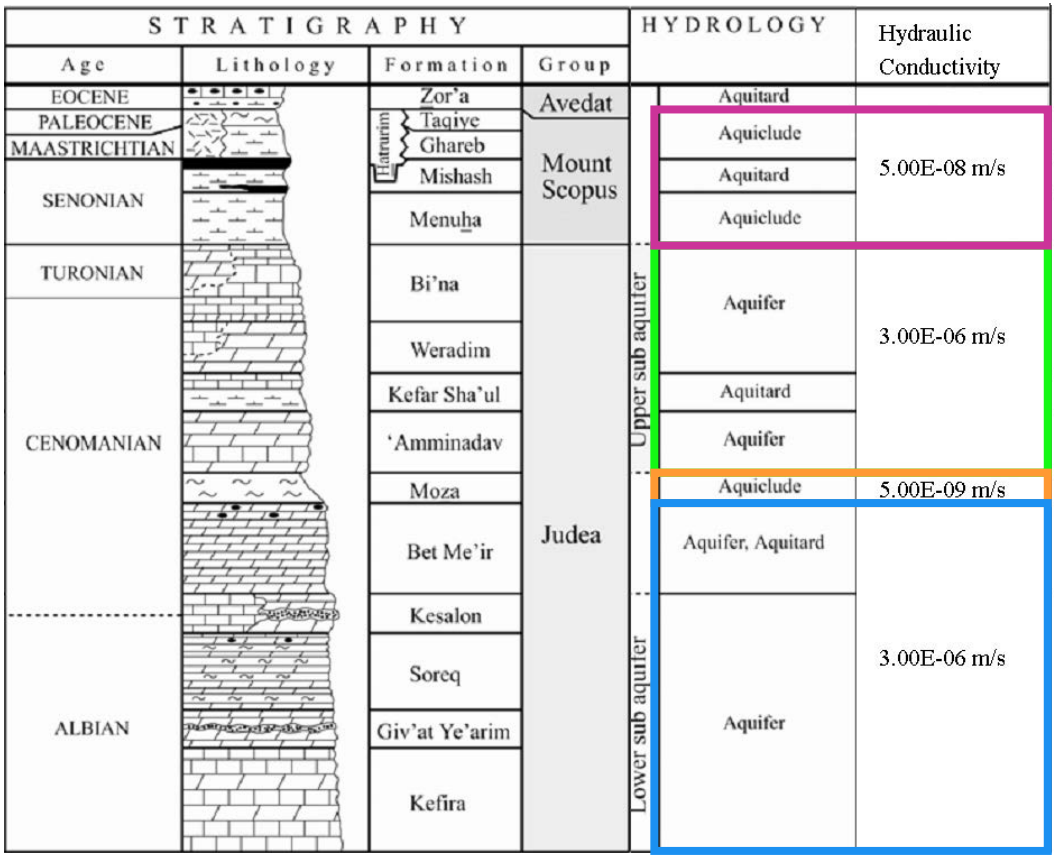


OpenGeoSys

- Kolditz et al. (UFZ)
- finite element method
- outcropping layer
- 184.841 elements
- 114.327 nodes

Parameterization of aquifer system

Hydraulic conductivity



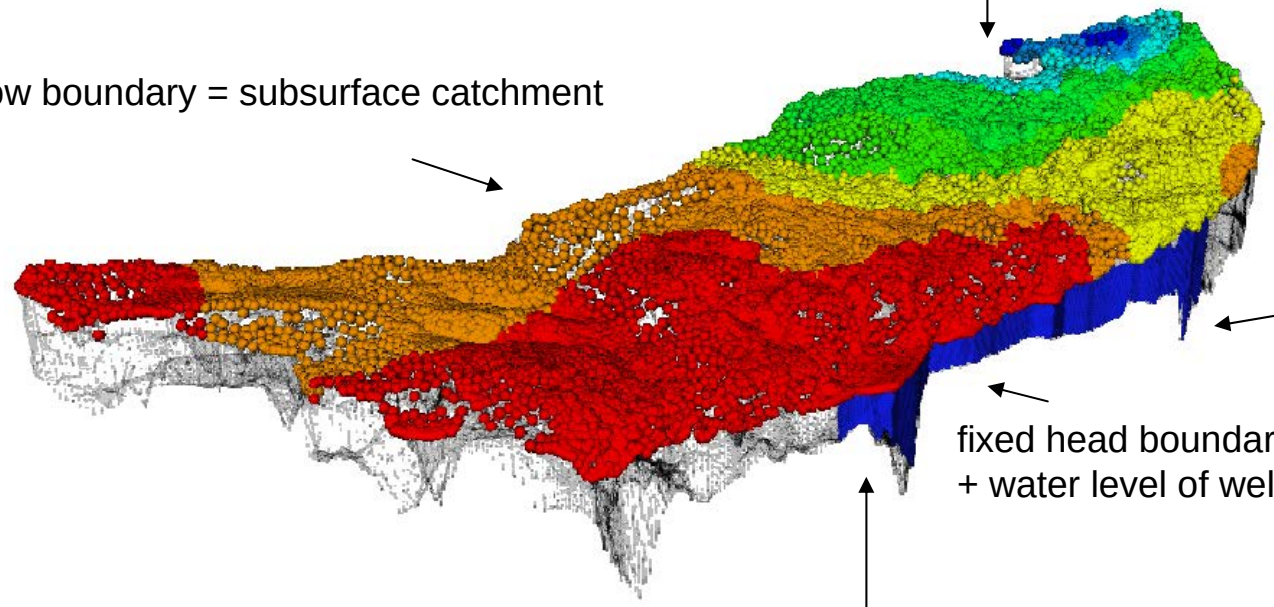
Hydraulic conductivities based on literature data of Hydrol. Service, Rep. Hydro/6/78 cited in Arad, 1984; Weinberger & Rosenthal, 1996; Guttman, 2000; Laronne Ben-Itzhak & Gvirtzman, 2005; Shalev et al., 2009.

Groundwater flow model- OpenGeoSys

Boundary conditions

source term : Groundwater recharge

no flow boundary = subsurface catchment



outflow to Dead Sea

fixed head boundary = Dead Sea water level
+ water level of wells

vertical boundary

Rink et al., 2011

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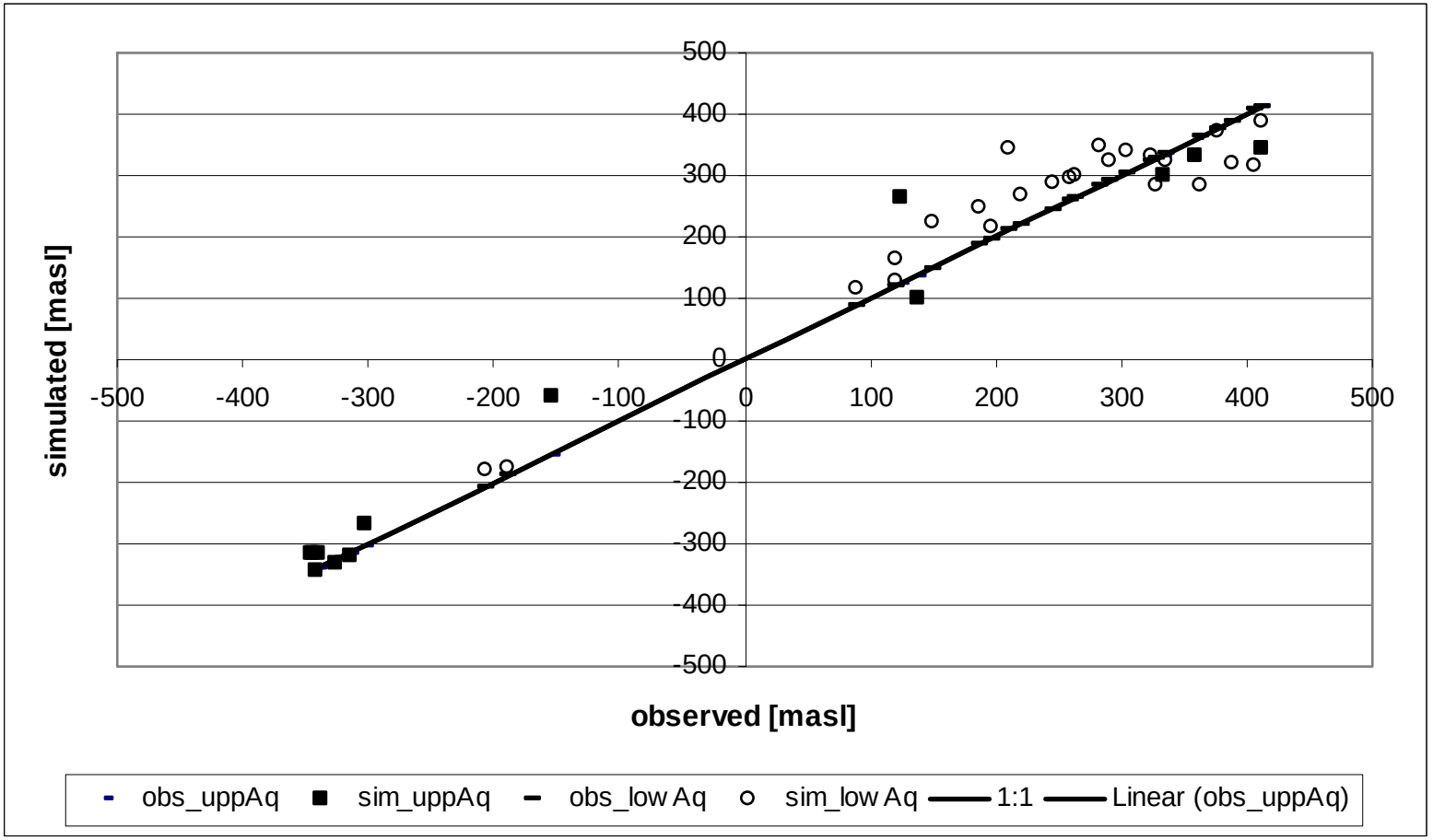
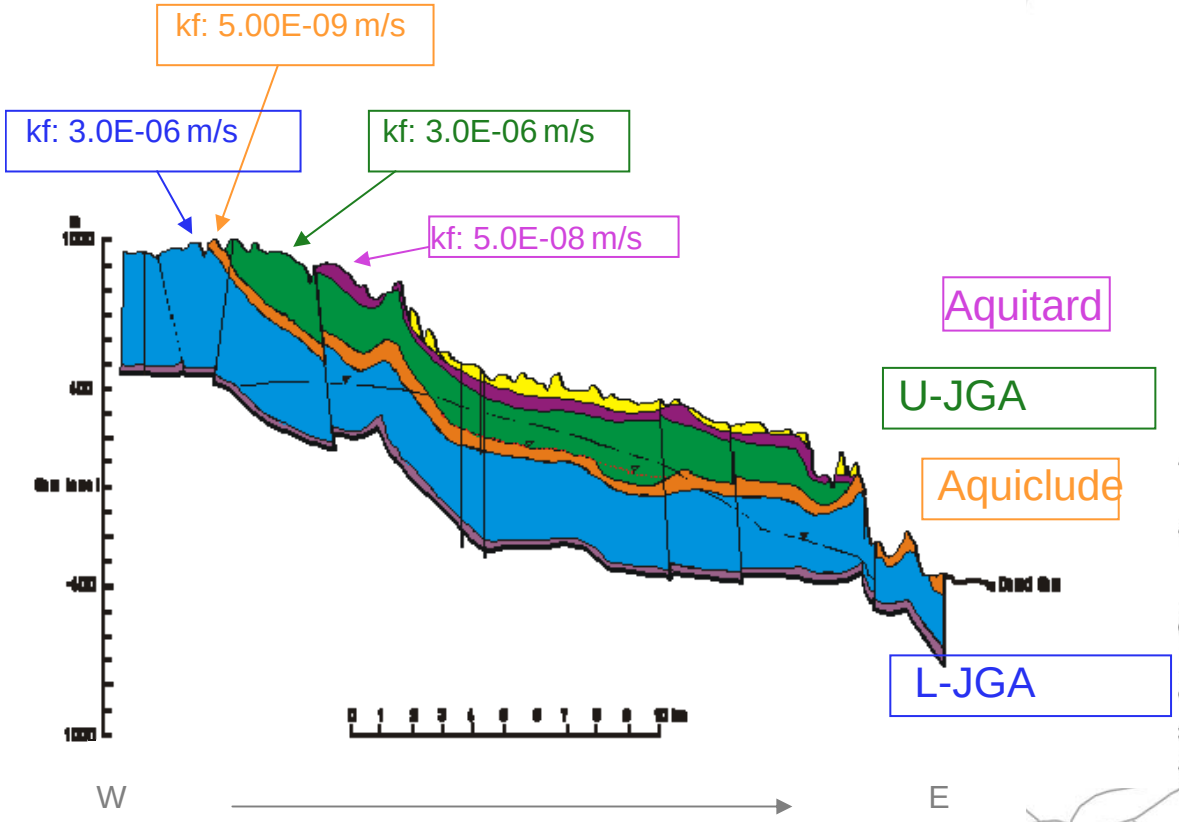
Results: steady state conditions



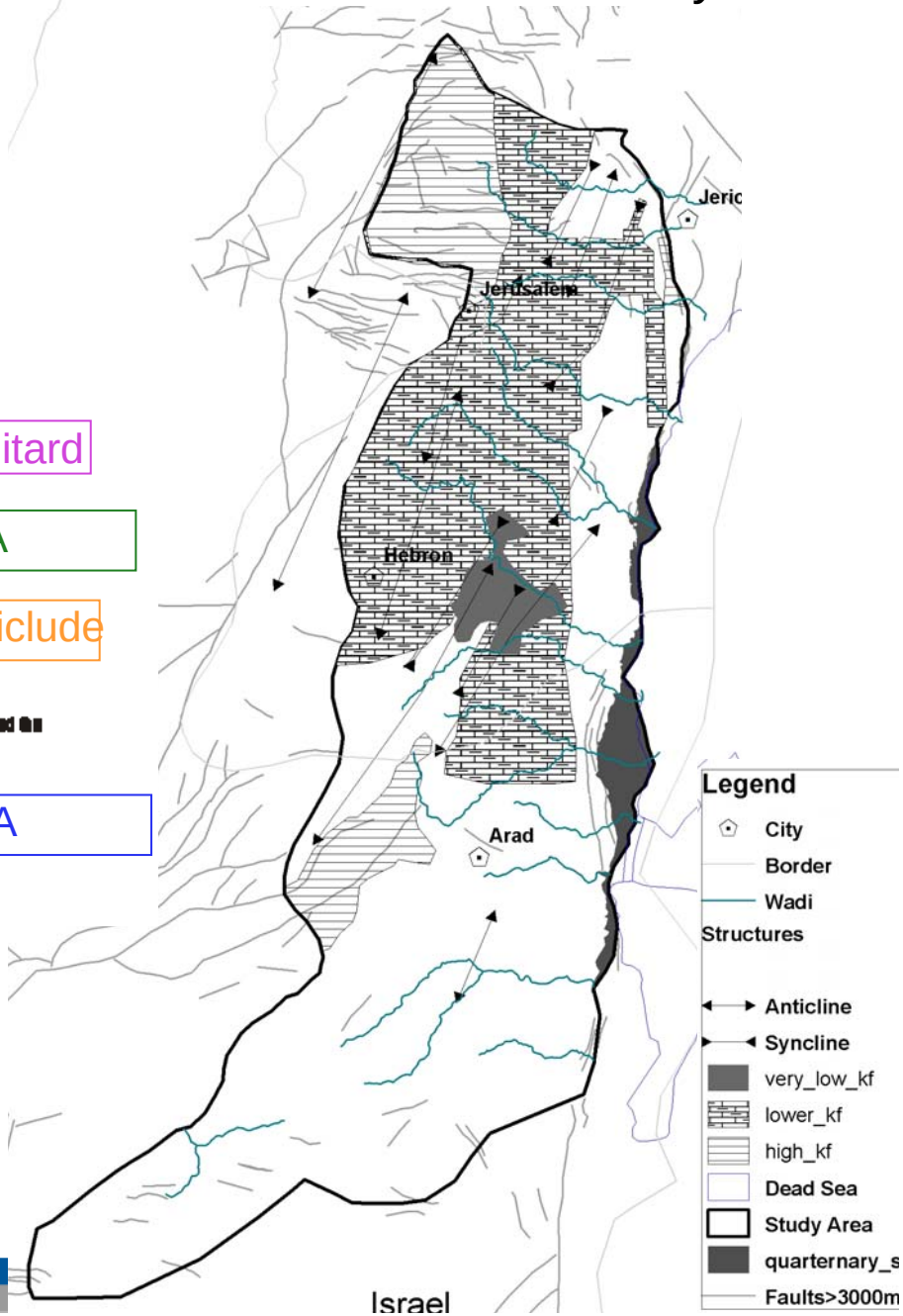
R^2=0.9677 (upper JGA) and R^2=0.8995 (lower JGA)

Results: findings

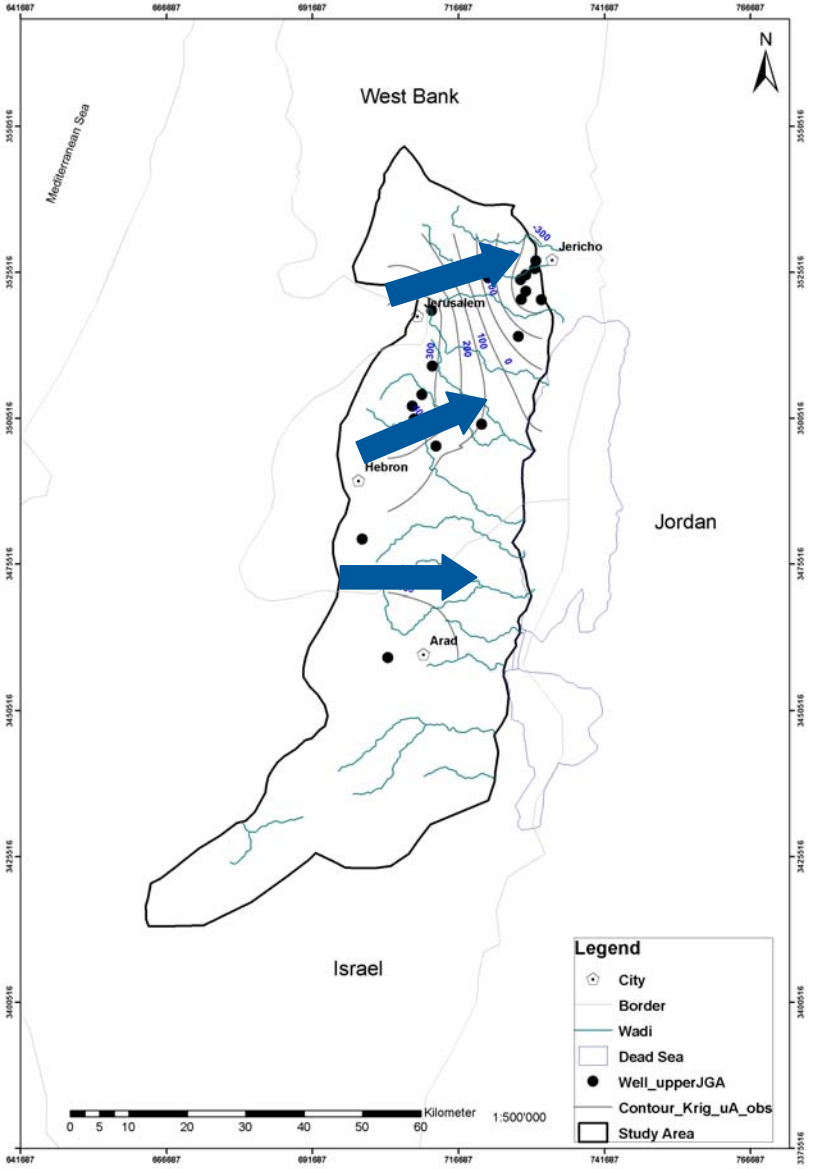


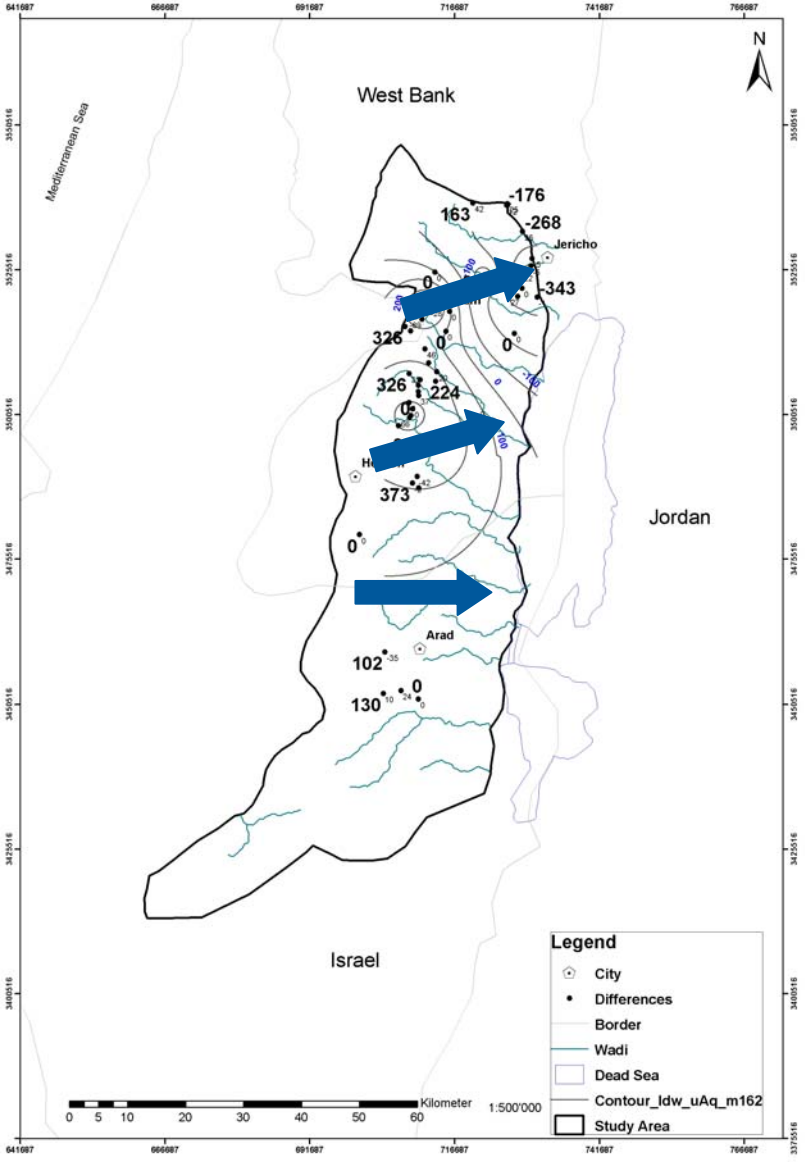
Simplified cross section: changed after: CH2M-Hill (2001).

Structures: Anticline + Syncline

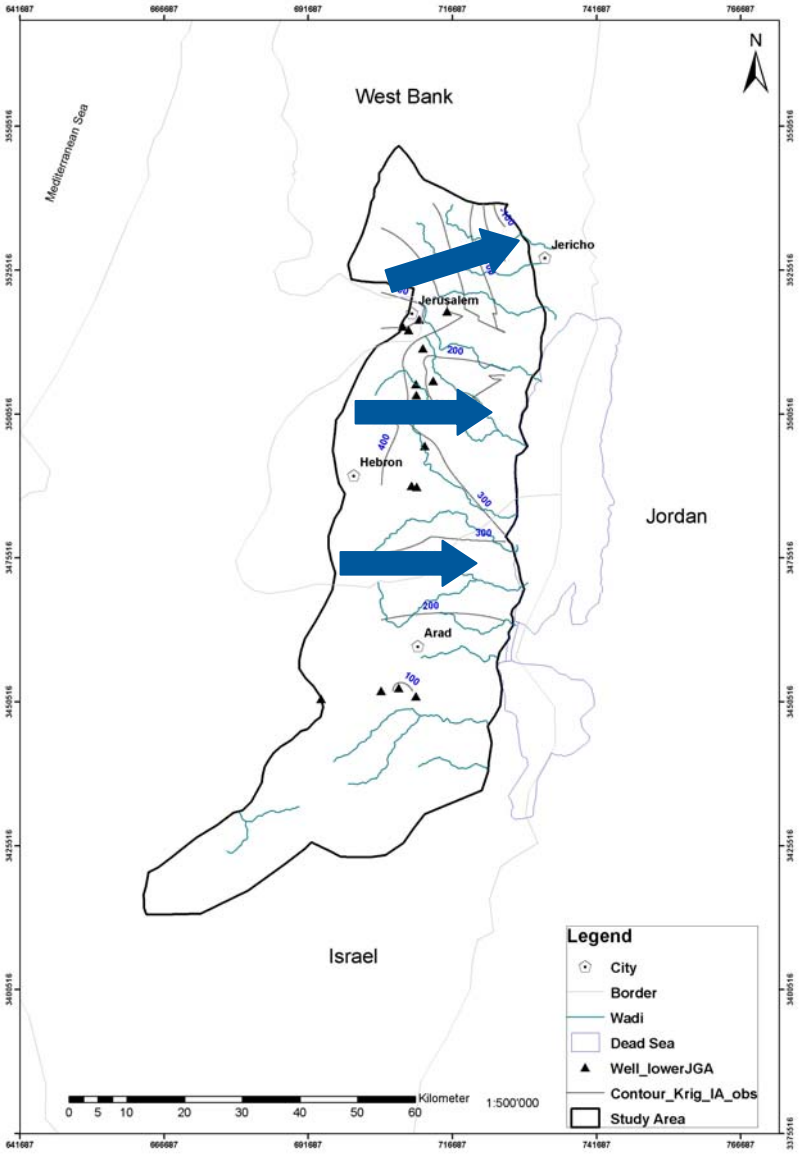


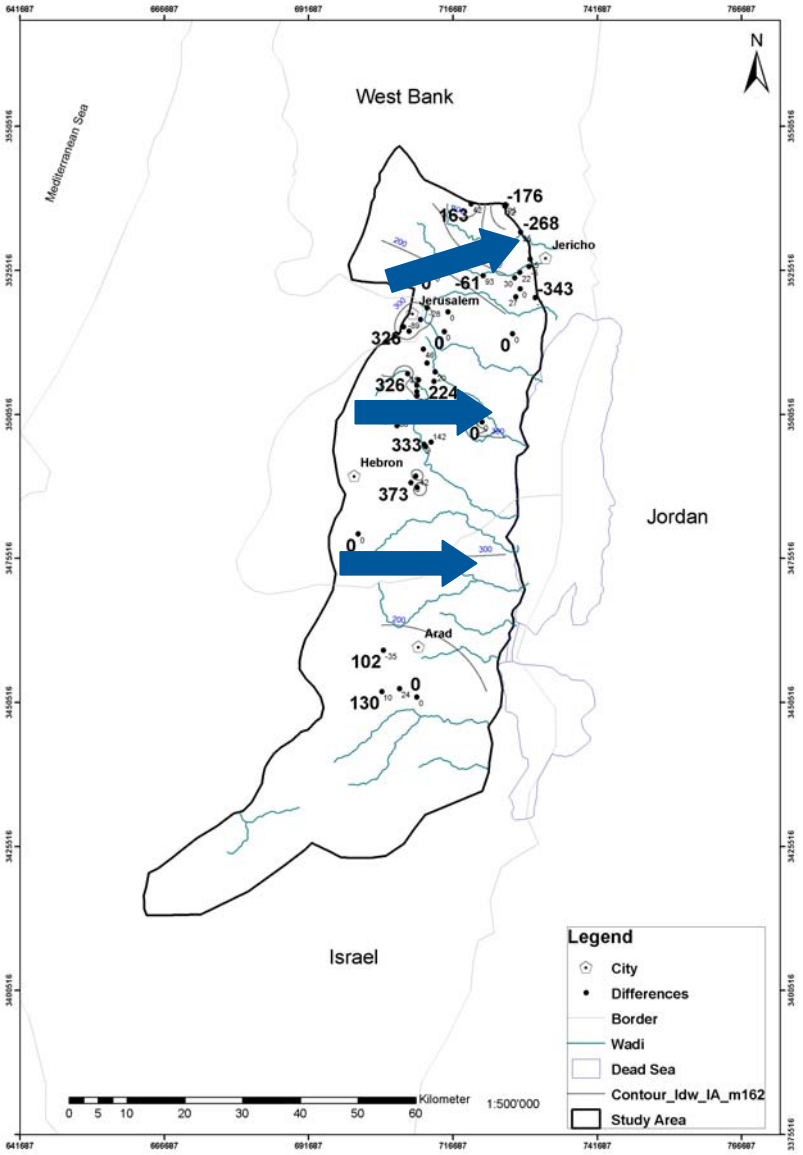
Results: steady state conditions



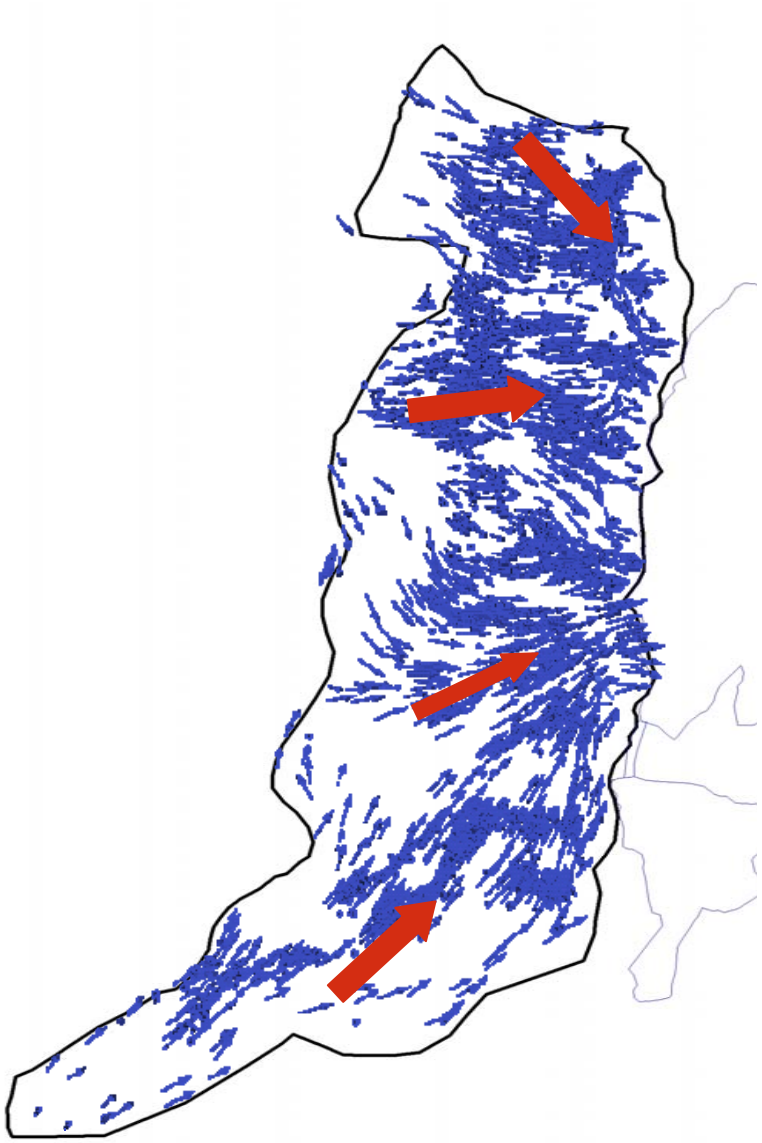


Results: steady state conditions

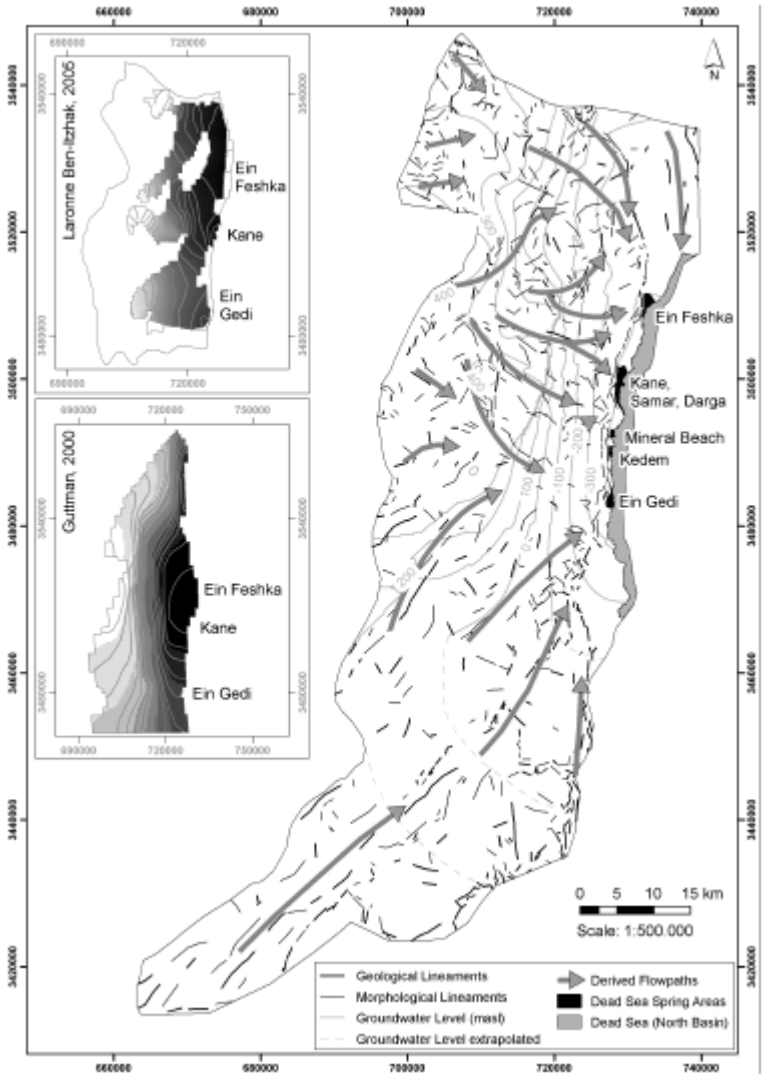




Results: groundwater flow dynamics

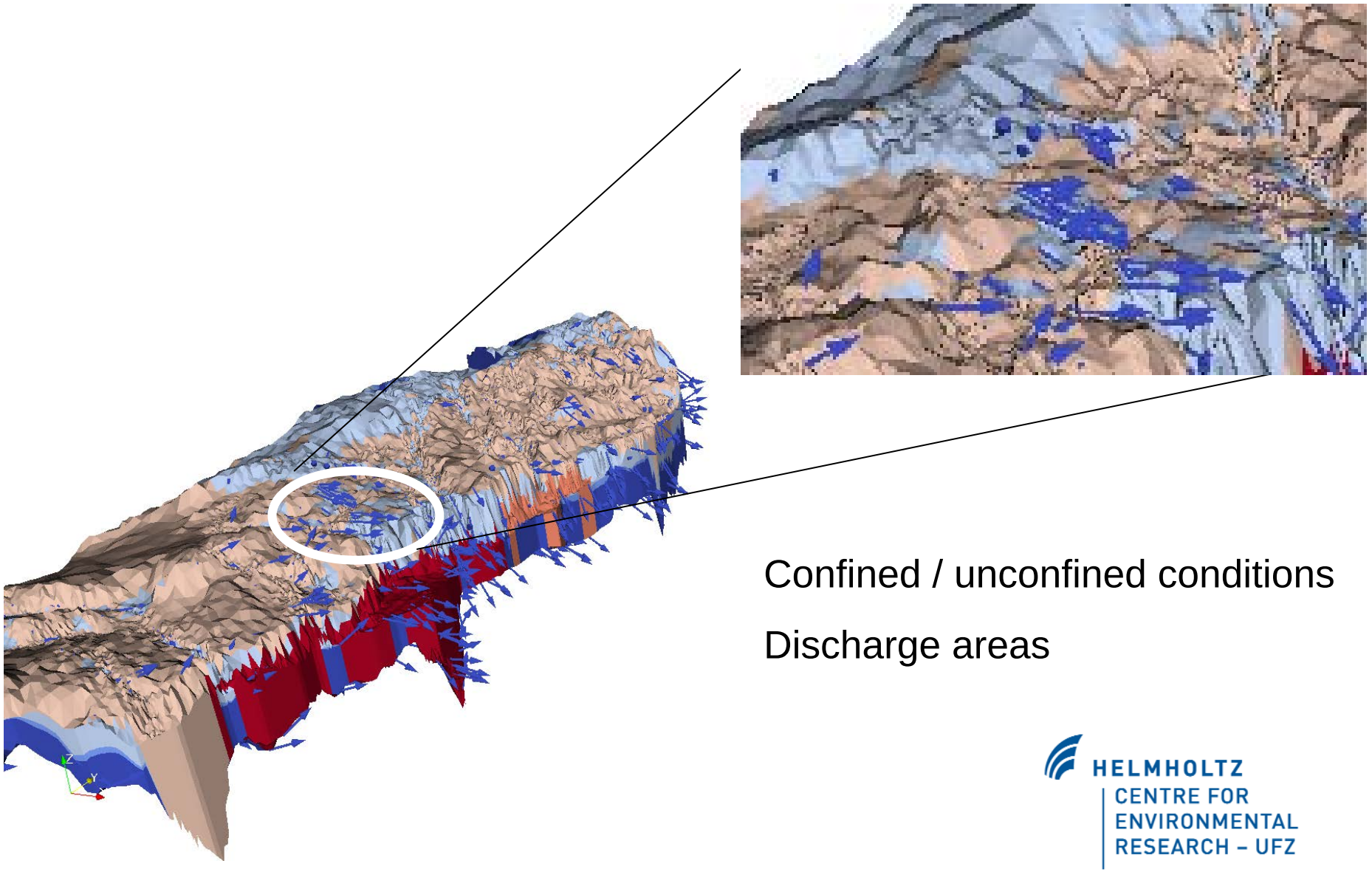


Groundwater flow directions (Gräbe et al., 2012)



Results from the lineament-analysis (Mallast et al., 2011)

Results: groundwater flow dynamics



Confined / unconfined conditions

Discharge areas

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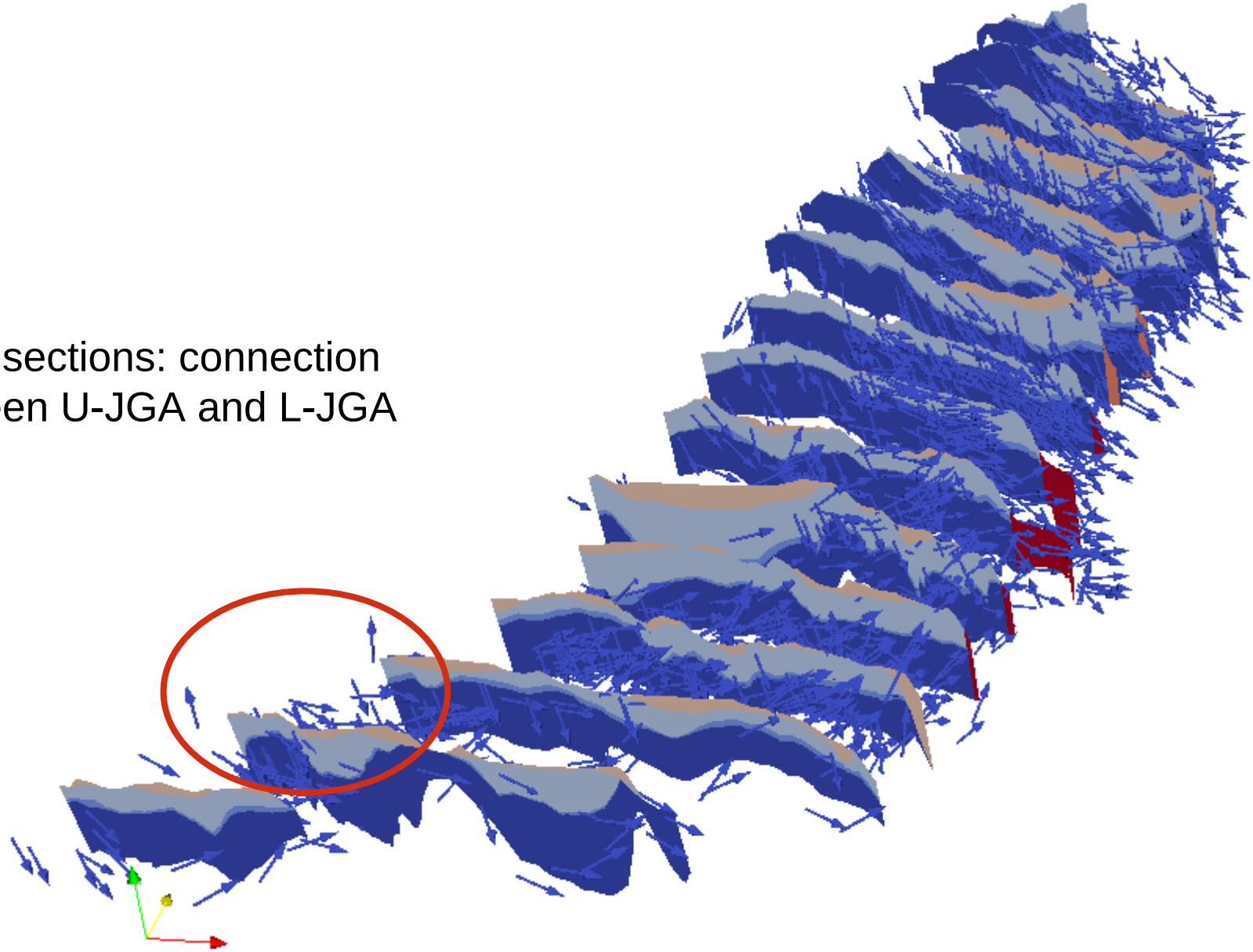
Results: groundwater flow dynamics

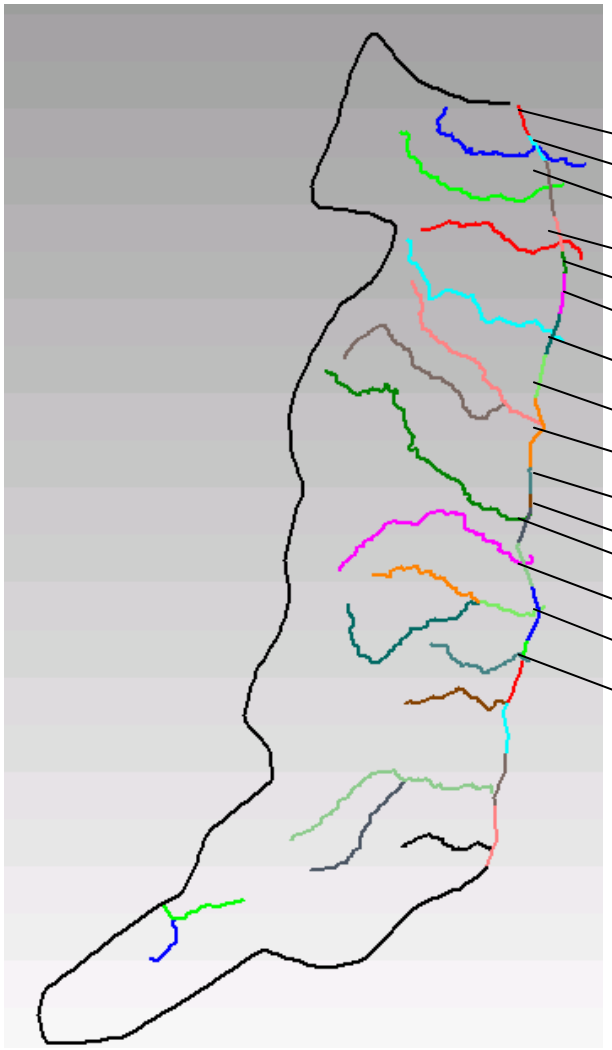
cross sections: connection between U-JGA and L-JGA



Check water balance: steady state conditions

In: 186 MCM/yr

Out: 186 MCM/yr

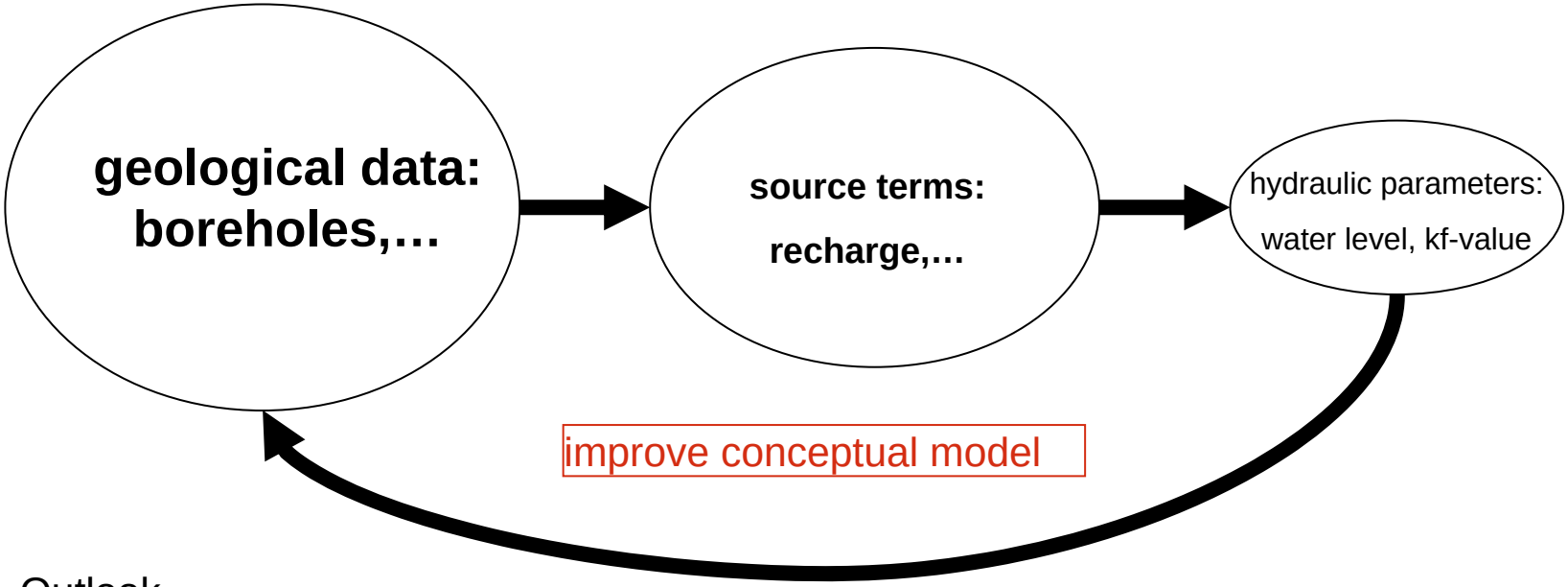


	model result
discharge_area	**discharge [m³/year]**
Auja	1.14E+07
Dujuk	4.89E+06
Perat	1.04E+07
Og	3.02E+07
Qalia	2.60E+06
Ein_Feshra	1.05E+07
Qidron	4.16E+07
Kane	3.33E+06
Darga_Tekoa	2.32E+05
Qedem	3.76E+06
David	3.64E+06
Arugot	9.25E+06
Hever	1.74E+07
Zeelim	1.38E+07
Massada	2.33E+07
	1.86E+08

→ discharge amounts are similar to observed one (Laronne Ben-Itzhak et al., 2005; Guttman, 2000)

Conclusion

- Model calibration with hydraulic heads + discharge rates
- Consider stationarity: groundwater level fluctuation
- Regard abstraction rates
- Adjust boundary conditions
- Discharge volumes are similar to those from previous studies in that area.



Outlook

- The transient (hydrological) model is in progress.

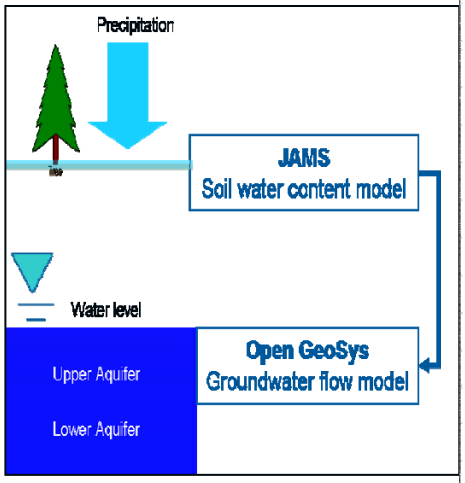
Outlook

J200g:

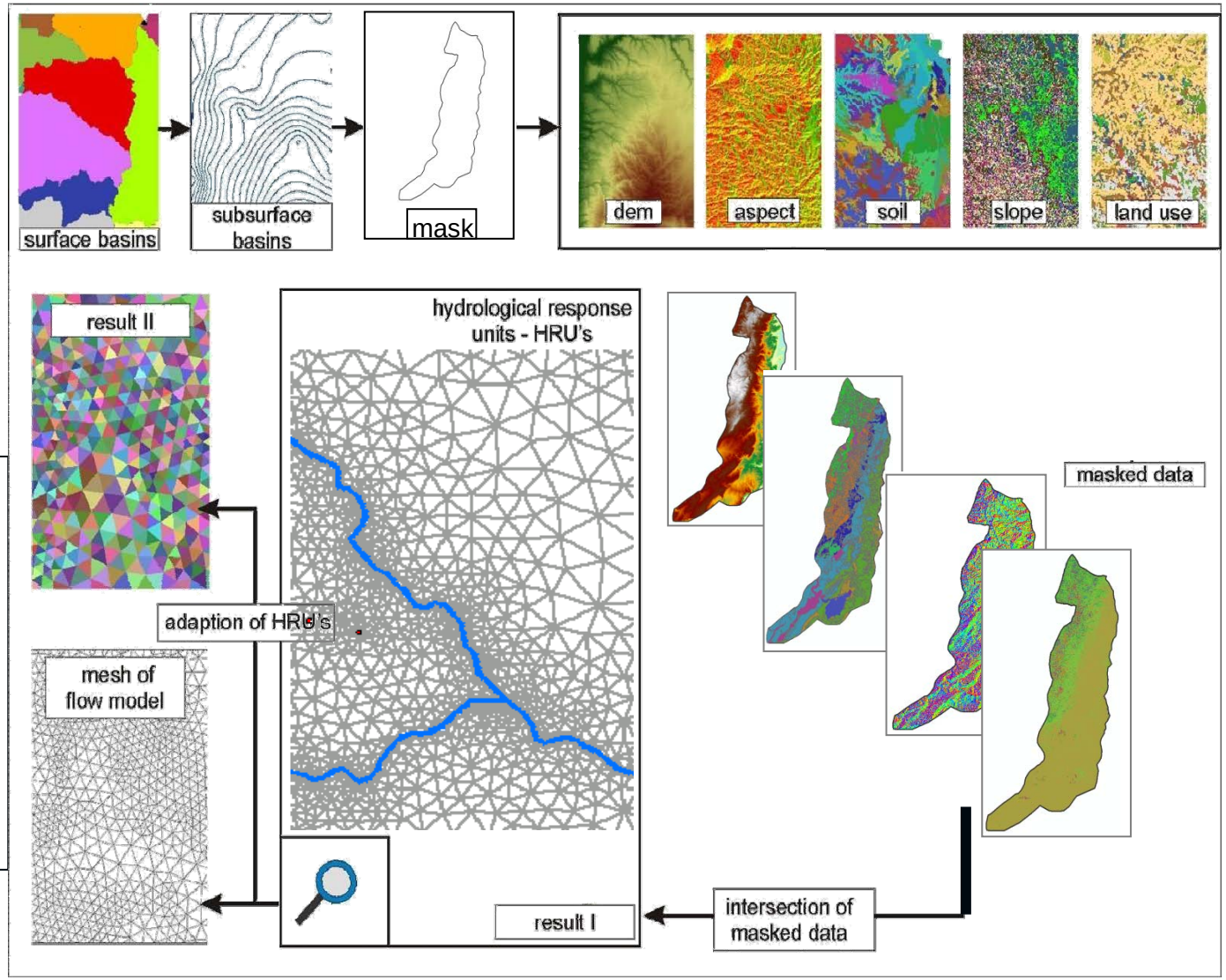
simplified hydrological model

calibration with runoff data

result: groundwater recharge



model coupling



Thank you for your attention!

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