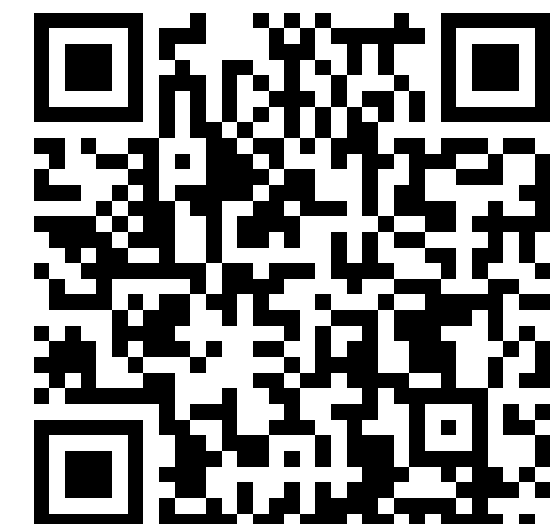
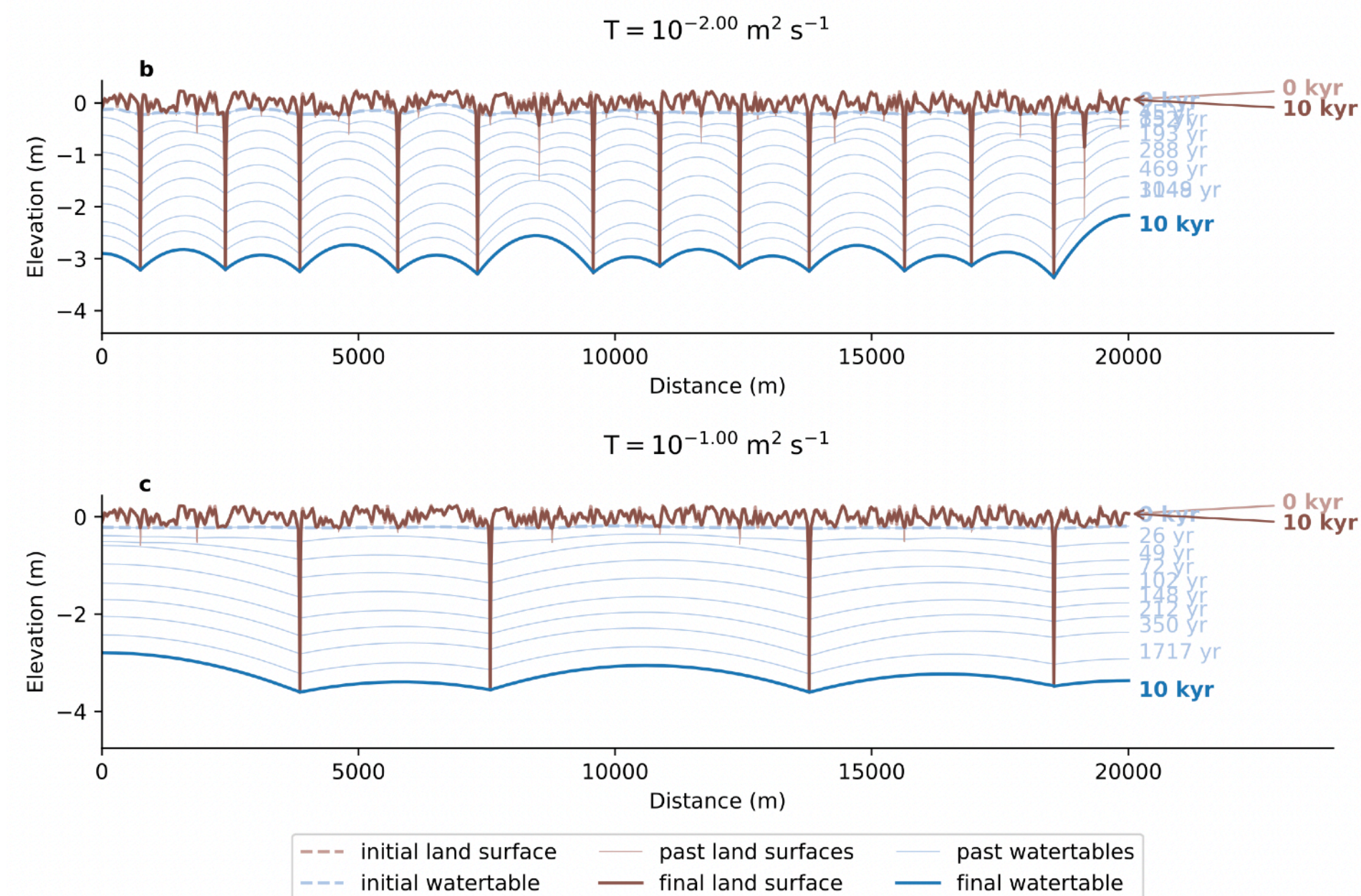
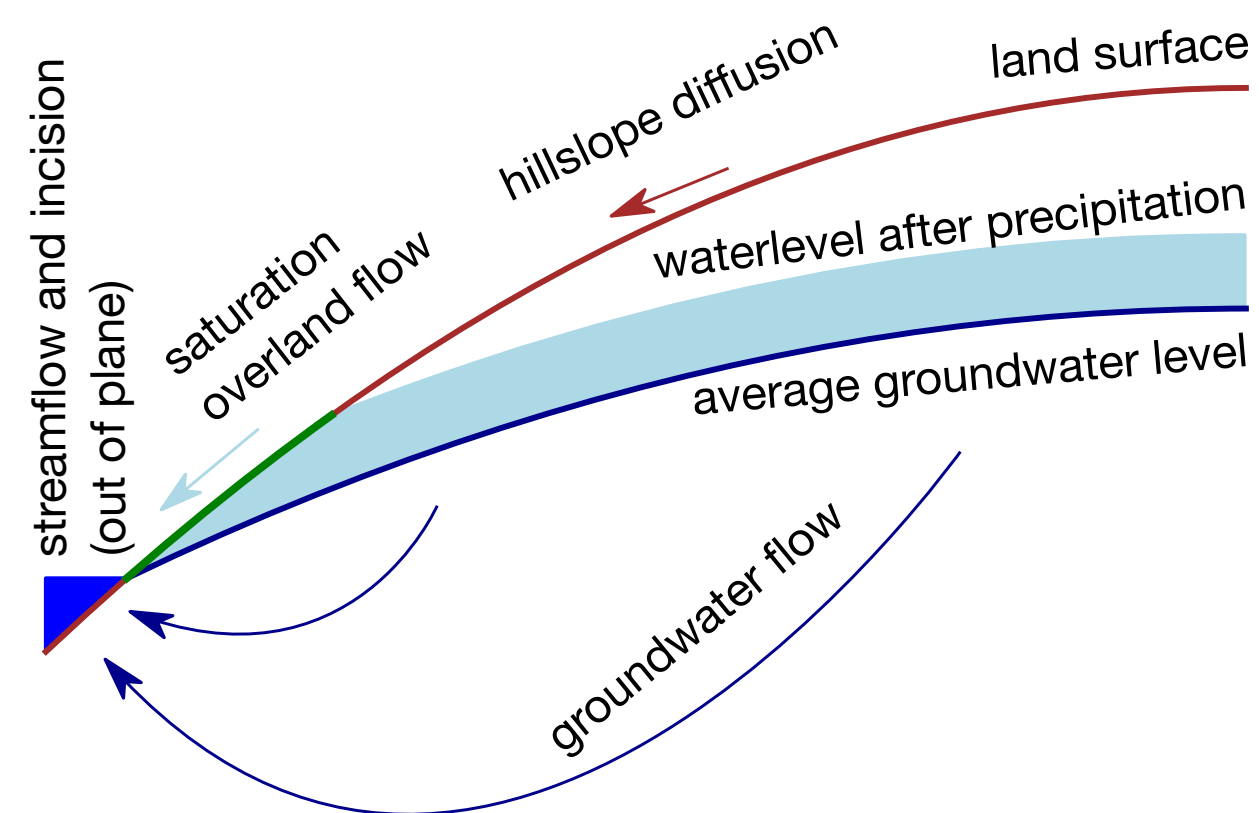


# Groundwater exerts a strong effect on drainage density and landscape evolution

Elco Luijendijk

University of Bergen, Department of Earth Science (soon)

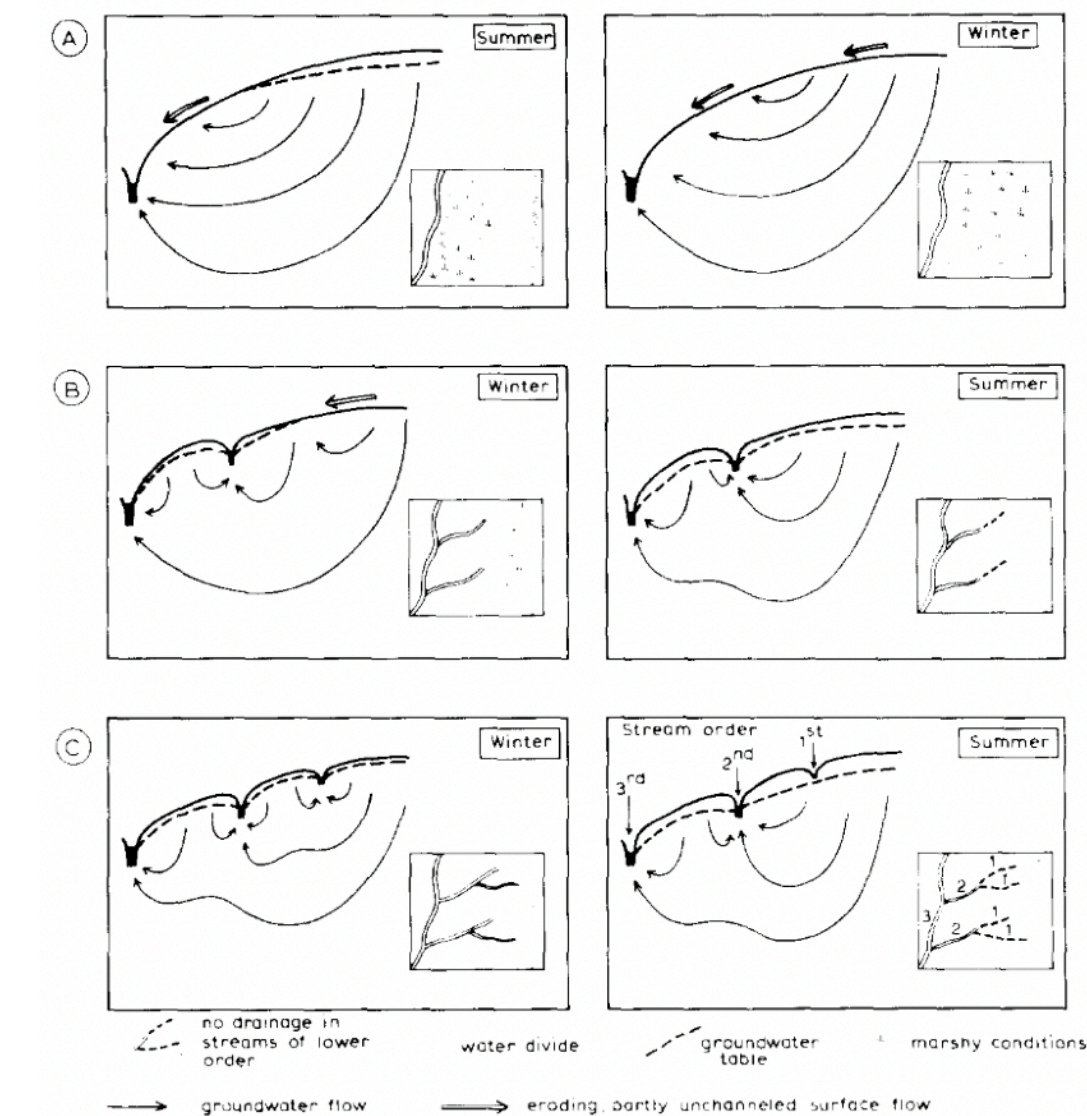
elco.luijendijk@posteo.net





# Groundwater flow & stream incision

- The potential effects of groundwater on stream incision have been frequently discussed in literature:
  - Groundwater controls baseflow
  - Depth of groundwater table controls saturation overland flow, streamflow and incision
- However, until recently no systematic model studies of coupled groundwater, surface water and erosion
- This presentation: Results of a new groundwater flow, overland flow & erosion model (GOEMod)
- Results recently published in ESURF, model code freely available on GitHub: <https://github.com/ElcoLuijendijk/goemod>



The groundwater outcrop erosion model by De Vries (1976)  
[https://doi.org/10.1016/0022-1694\(76\)90004-4](https://doi.org/10.1016/0022-1694(76)90004-4)

Earth Surf. Dynam., 10, 1–22, 2022  
<https://doi.org/10.5194/esurf-10-1-2022>  
© Author(s) 2022. This work is distributed under the Creative Commons Attribution 4.0 License.

Earth Surface Dynamics  
Open Access  
EGU

**Transmissivity and groundwater flow exert a strong influence on drainage density**

**Elco Luijendijk**

independent researcher: Isernhagener Straße 88, 31063 Hanover, Germany

Correspondence: Elco Luijendijk (elco.luijendijk@posteo.net)

Received: 6 April 2021 – Discussion started: 21 April 2021

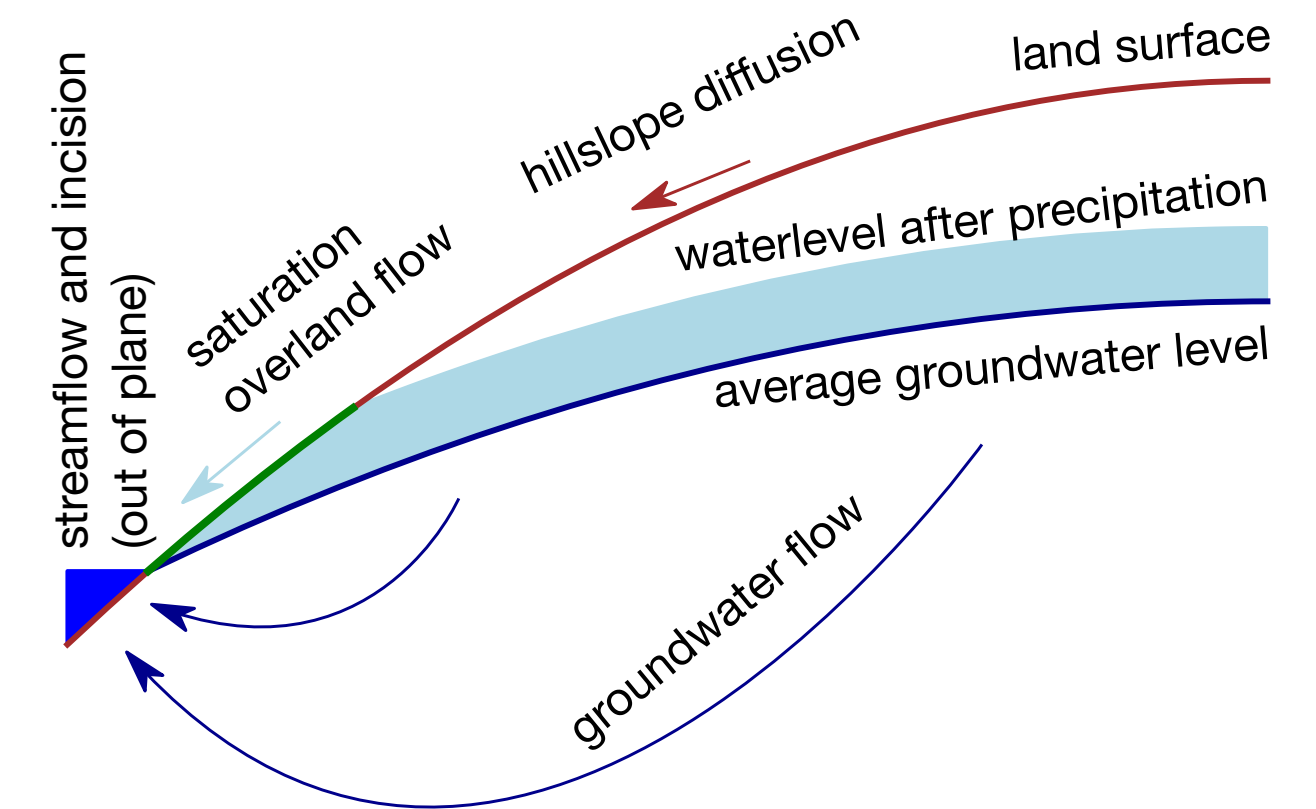
Revised: 6 August 2021 – Accepted: 2 November 2021 – Published: 6 January 2022

**Abstract.** The extent to which groundwater flow affects drainage density and erosion has long been debated but is still uncertain. Here, I present a new hybrid analytical and numerical model that simulates groundwater flow, overland flow, hillslope erosion and stream incision. The model is used to explore the relation between groundwa-

<https://doi.org/10.5194/esurf-10-1-2022>

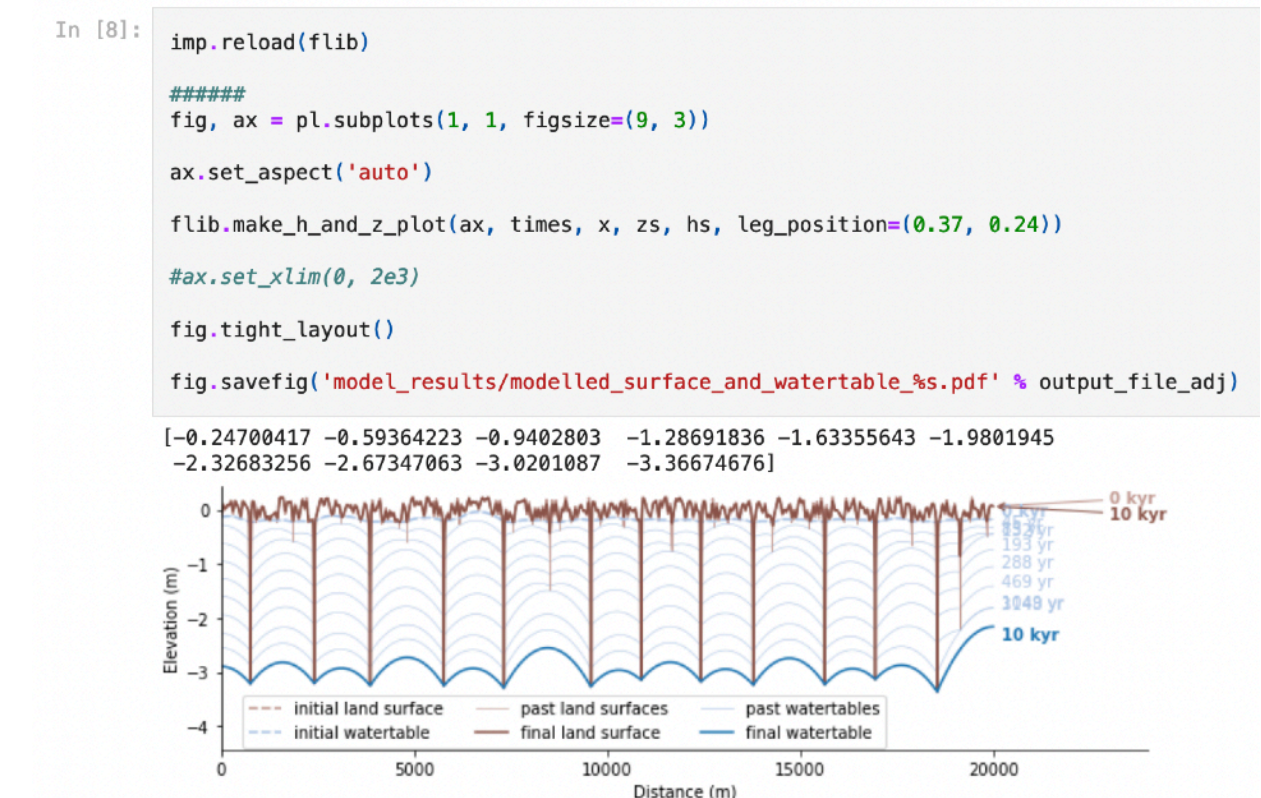
# Groundwater, surface water & erosion model, GOEMod

- Modelled processes: Steady-state groundwater flow, saturation overland flow, streamflow & incision, hillslope diffusion
- Integration of overland flow and incision equations to bridge precipitation event & long-term erosion timescales
- Water fluxes modelled in 2D cross-section, streamflow and incision in out of plane direction



Modelled hydrological & erosion processes  
Luijendijk (2022) Earth Surface Dynamics

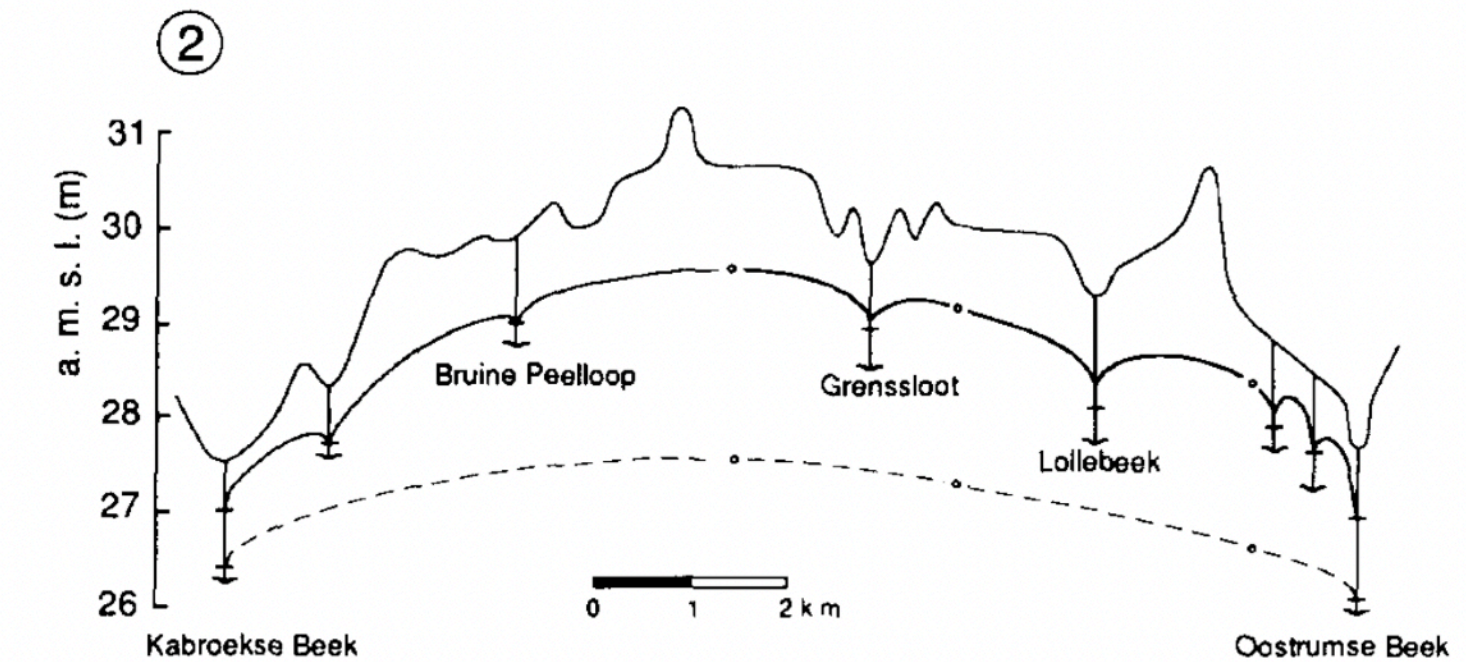
Make a figure of the default model run:





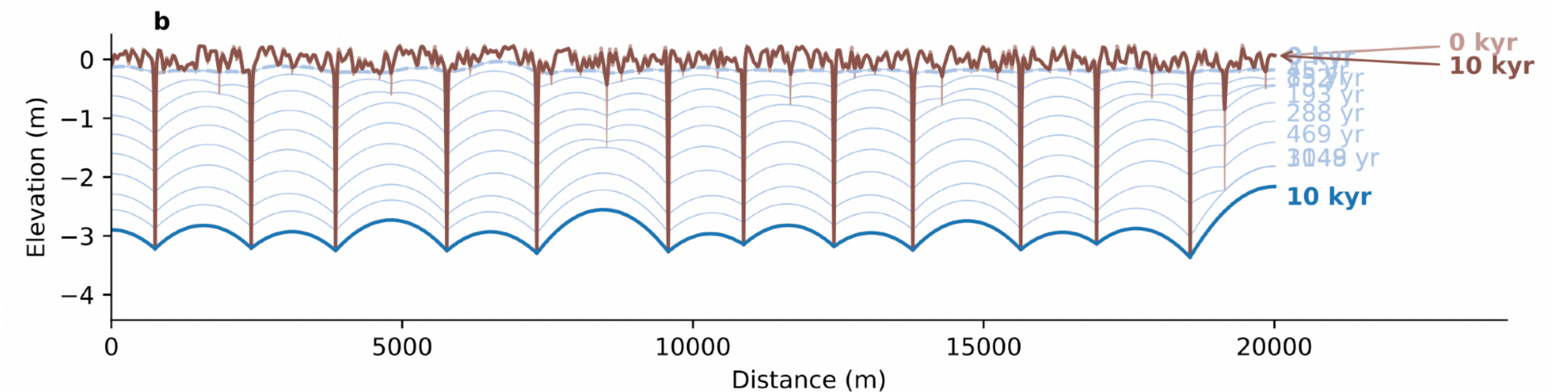
# Model results: Groundwater flow & transmissivity control drainage density

- Default model run: Humid climate, based on southern Netherlands -> close match to current drainage density and incision after model run of 10,000 years (i.e. post glacial)
- Models with high transmissivity result in much lower drainage density and vice-versa

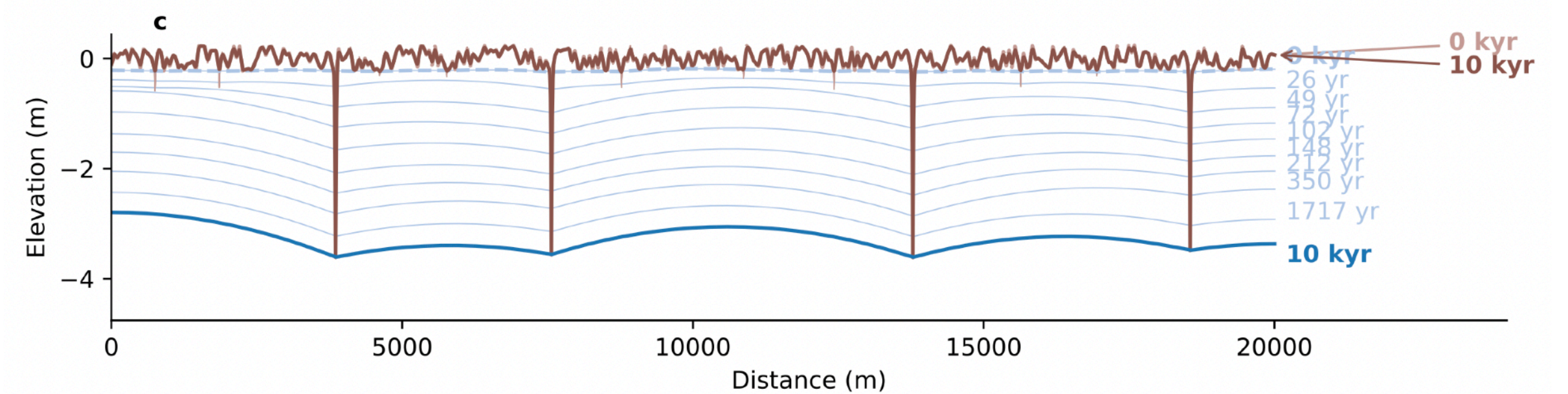


Stream network in southern Netherlands  
De Vries (1994) Jnl. of Hydrology

$$T = 10^{-2.00} \text{ m}^2 \text{ s}^{-1}$$



$$T = 10^{-1.00} \text{ m}^2 \text{ s}^{-1}$$



--- initial land surface    --- past land surfaces    --- past water tables  
 --- initial watertable    --- final land surface    --- final watertable

The effect of variation in transmissivity (T) on drainage density  
Luijendijk (2022) Earth Surface Dynamics



# Groundwater capture

- Groundwater capture controls drainage density:
  - Streams that incise faster draw the watertable below adjacent streams
  - Adjacent streams falls dry and loses baseflow and saturation overland flow
  - Groundwater capture more efficient with high transmissivity due to relatively flat watertable
- More results in: Luijendijk (2022)  
Transmissivity and groundwater flow exert a strong influence on drainage density, Earth Surf. Dynam. 10, <https://doi.org/10.5194/esurf-10-1-2022>

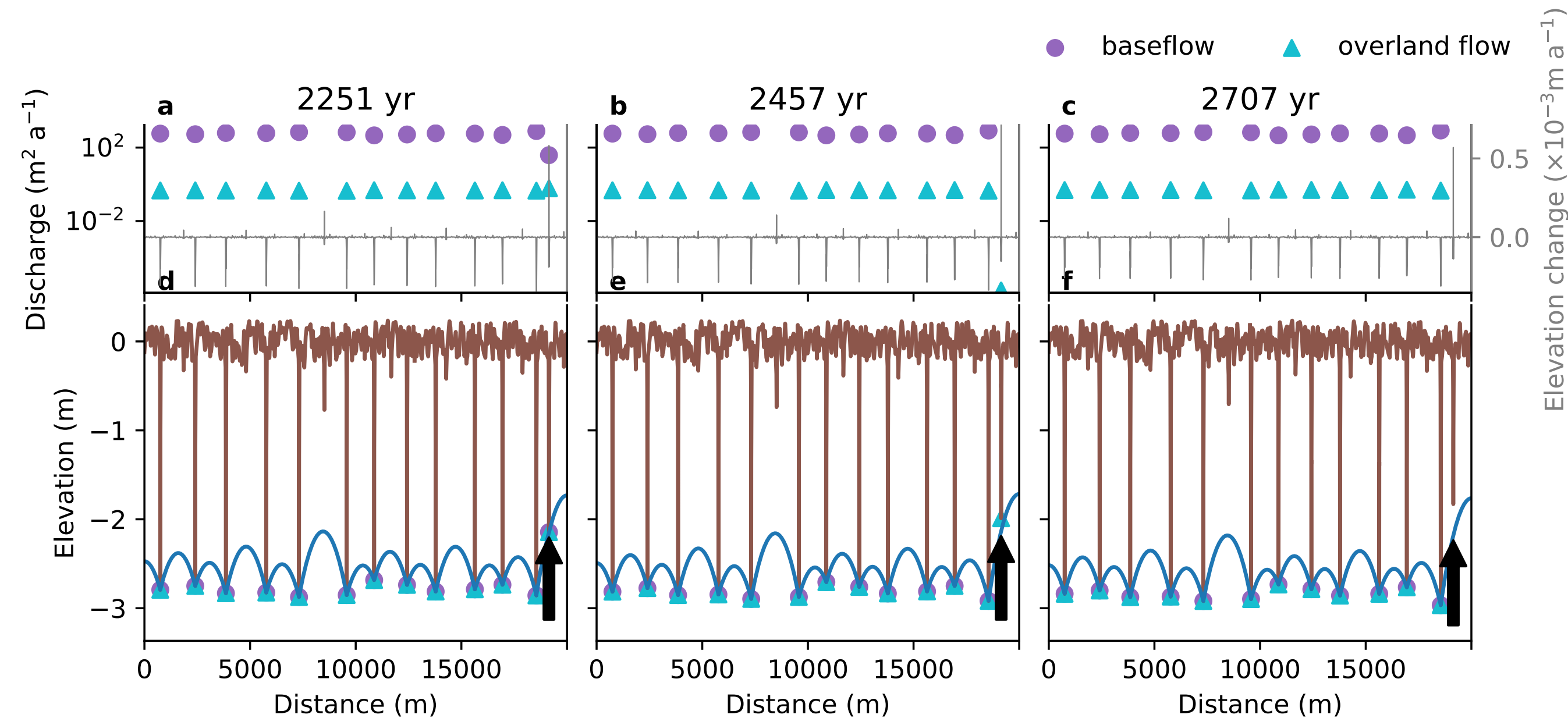


Illustration of groundwater capture  
Luijendijk (2022) Earth Surface Dynamics