Review of esurf-2021-33

Marijn van der Meij (Referee)

Referee comment on "Transmissivity and groundwater flow exert a strong influence on drainage density" by Elco Luijendijk, Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2021-33-RC1, 2021

The author presents a detailed and well-documented model named GOEMod that simulates the effect of stream incision on landscape evolution through groundwater and overland flow. The model simulates a set of hydrological and geomorphological processes that affect the groundwater level, stream incision and drainage density. He identified a process he calls groundwater capture, where streams with high incision rates draw the water table below neighbouring streams. With a sensitivity analysis the author identifies the soil transmissivity as main parameter controlling the drainage density.

The manuscript is well written and the model is very well documented. As the author mentions in his Introduction, groundwater flow is often simplified or not at all included in current landscape evolution models. This work shows a potentially important control of groundwater flow on landscape evolution.

However, I think that the manuscript can improve on three points and would benefit greatly from additional discussion of the model and its results. The three points are the balance of the manuscript, the selected set of parameters and a comparison of model results with field evidence. I address these points in more detail in the general comments below. Next to that, I added several specific comments and technical corrections to the attached document. I look forward to seeing the revised manuscript.

With best regards,

Marijn van der Meij

1 Balance of the manuscript

In the title and abstract, the manuscript is presented as a study to identify the relation between groundwater flow and drainage density. For this purpose, the model GOEMod was developed. The manuscript itself however leans very much towards the model development and description of model behaviour and only shortly addresses the validity of the model and lacks a comparison with field evidence to support the model findings. I suggest to address the other comments below to improve the balance between model description and interpretation of the findings in the manuscript.

2 Selected parameters

The setting of the model is a humid climate zone and is roughly based on The Netherlands. The model builds further on stream density studies from the Netherlands (lines 40-41 & 50-52). Also, data from The Netherlands are used to parametrize the model. This data includes rainfall data, porosity, transmissivity and stream slope. However, there are several parameter choices in the model that deviate from this setting to simplify calculations or achieve a better model result:

- The transmissivity, porosity and slope parameters are adjusted (lines 284-289 & 398-400);
- The runtime of the model is set to 100.000 years;
- The elevation downstream of the model domain does not change over time (lines 225-226) and precipitation is also constant (lines 114-116).

Over the long simulation span of 100.000 years, downstream elevation cannot be assumed constant due to fluctuating sea water levels. Also, rainfall cannot be assumed stable over this time period. Fluctuations in these parameters will likely have a larger influence on stream incision than groundwater capture over these geological time scales.

This make me wonder if groundwater capture as resulting from the model is a realistic process in real landscapes, or whether it can only be simulated in modelling studies due to the unlikely conditions when under which it seems to occur. I would like to see some discussion in the manuscript on how realistic the parameter choices are and how likely it is that groundwater capture plays a role in the evolution of real landscapes.

3   Field evidence

Following from the previous comment, I'm also missing a comparison of model results with field data to further support the concept of groundwater capture and the effect of transmissivity on drainage density. These points are briefly mentioned in the Introduction (lines 20-21 & 28-32), but are not discussed in the light of the model results. I would like to see such a comparison in the paper to further support the model results, for example in the form of a case study or as a meta-analysis of areas with different transmissivity and drainage densities.

Please also note the supplement to this comment:
https://esurf.copernicus.org/preprints/esurf-2021-33/esurf-2021-33-RC1-supplement.pdf