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Effect of DEM resolution on calculated shallow groundwater flow directions and catchment boundaries

Jana Erdbrügger (1), Ilja van Meerveld (1), Kevin Bishop (2), and Jan Seibert (1)

(1) University of Zurich, Department of Geography, Hydrology and Climate, Switzerland (jana.erdbruegger@geo.uzh.ch), (2) Swedish University of Agricultural Sciences, Institutionen för vatten och miljö, Sweden

Since it is usually difficult to determine the groundwater surface itself, digital elevation models (DEMs) of the surface are often used to estimate the flow directions and catchment boundaries. In humid climates, it is assumed that the groundwater surface follows the surface topography but high-resolution elevation data also include many small-scale features that likely do not affect the direction of the groundwater flow or only under special conditions. The optimal resolution of the DEM for determining flow directions is not known yet. The aim of this study is to determine how much the DEM derived flow directions and catchment boundaries depend on the surface topography data that are used for these calculations.

We measured groundwater levels in a small subscatchment in the Krycklan catchment in northern Sweden to determine the optimal DEM resolution to describe the groundwater surface. The catchment is located about 100 km northwest of Umeå. It is typical of the boreal zone and consists for the most part of forests, peatlands and lakes. We compared the groundwater gradients and flow directions from these data with different DEM derived gradients and directions.

For the topographic analyses, the LiDAR based elevation data were smoothed with various filters (e.g., Gaussian filters) and resampled to obtain lower resolution elevation data. We then determined the flow directions for these different DEMs. The aim was to determine where in the catchment the calculated flow directions are most sensitive to the topographic data and how the catchment boundaries change when different resolution topography data are used for the calculations. In addition, we investigated for which DEMs the correlation with the measured groundwater levels was best.

The results of the topographic analyses show that for some areas the calculated flow directions depend strongly on the resolution and smoothing of the elevation data. The topography data also affected the calculated catchment areas. These topographic analyses help to estimate uncertainties in the topography-based groundwater flow directions and thus indicate where groundwater level measurements are particularly valuable to determine the flow direction.