



Landscape-analysis based visualization of drumlins

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Drumlins are elongate, streamlined, hills that form sub-glacially, parallel to ice flow. Their number, size, orientation and distribution contain information about ice sheet conditions during their formation such as flow direction and velocity. Objective and consistent mapping of drumlins is therefore paramount for reconstructing ice sheet dynamics from palaeo evidence.

Drumlins can be mapped in the field or from remotely sensed data, for instance digital elevation models (DEMs). Whilst automated techniques are reproducible, their accuracy rates are currently inadequate and manual mapping techniques remain prevalent.

Manual techniques involve the use of visualization-based methods; for example, *relief-shading*, *gradient*, and *curvature*. Here, we develop a technique that assists visualization by isolating drumlins from other components of the landscape. As in Smith & Clark (2005), we use the region surrounding Lough Gara, Ireland, as a study area. Using a sliding 1 km wide median filter, the hills underneath the drumlins (~ 200 m wide) are removed. An envelope, varying laterally on a scale of ~ 1 km, is placed around the upper and lower bounds of the drumlins' topography. Drumlins of ~ 2 m to > 10 m high are then displayed in greyscale stretched (from black to white) between these limits. The 1×1 km box was chosen to exploit the difference in size-scale between the hills and drumlins, following the former whilst averaging out the latter, in order to optimally separate them. In terms of landforms identified, the technique is similar to *curvature* and *orthogonal relief shading*, but exceeds other methods. It is important to note that, in contrast to relief shading, the landscape-analysis technique is not biased by the azimuth of illumination.