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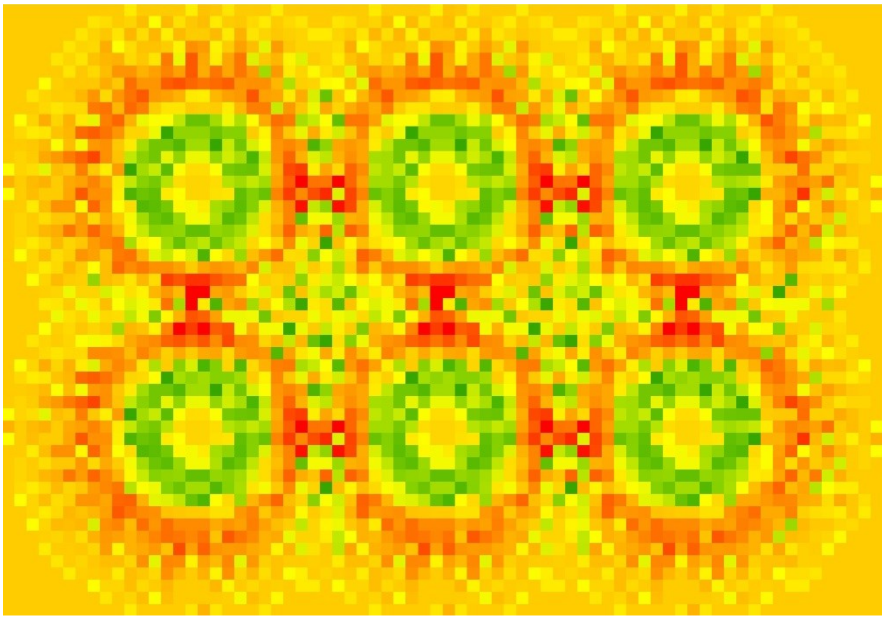
User Guide for the Topographical Accumulation Zones dataset

GeoAnalytics & Modelling Programme

Open Report IR/17/046



BRITISH GEOLOGICAL SURVEY
GEOANALYTICS & MODELLING PROGRAMME
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User Guide for the Topographical Accumulation Zones dataset

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Editor
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Keywords

Report; Accumulation.

Front cover

Cover picture details, delete if no cover picture.

Bibliographical reference

CARTWRIGHT, C E . 2017. User Guide for the Topographical Accumulation Zones dataset. *British Geological Survey Open Report*, IR/17/046. 18pp.

Keyworth, Nottingham British Geological Survey 2017

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Foreword

This report presents a description and review of the methodology developed by the British Geological Survey (BGS) to produce a national scale assessment of Topographical Accumulation Zones. The method has been critically assessed and its fitness for purpose determined by user specialists in geospatial analysis at the BGS. The purpose of this user guide is to enable users to know how the data was created and understand its potential applications and limitations.

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Summary

This report presents a description and review of the methodology developed by the British Geological Survey (BGS) to produce a national scale assessment of Topographical Accumulation Zones. The method has been critically assessed and its fitness for purpose determined by geospatial analysis specialists in the BGS.

Acknowledgements

A large number of individuals in the BGS have contributed to the development of this dataset. This assistance has been received at all stages of development. The author would particularly like to thank Dr Murray Lark for his help and advice on the interpretation of the algorithms tested, and his suggestions for using artificial digital terrain models (DTM) to help visualise the results. I would also like to thank Dr Chris Williams for his scientific evaluation of the GIS process and the key staff whom have helped to review draft chapters of this report, and the individuals whom have contributed to the project, in particular:

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Marieta Garcia-Bajo

Russell Lawley

Kathryn Lee

Jennifer Richardson

1 Introduction

Founded in 1835, the British Geological Survey (BGS) is the world's oldest national geological survey and the United Kingdom's premier centre for earth science information and expertise. The BGS provides expert services and impartial advice in all areas of geoscience. Our client base is drawn from the public and private sectors both in the UK and internationally.

Our innovative digital data products aim to help describe the ground surface and what's beneath across the whole of Great Britain. These digital products are based on the outputs of the BGS, research programmes, and our substantial national data holdings. This data coupled with our in-house Geoscientific knowledge are combined to provide products relevant to a wide range of users in central and local government, insurance and housing industry, engineering, environmental business, and the British public.

Further information on all the digital data provided by the BGS can be found on our website at http://www.bgs.ac.uk/products/home.html or by contacting:

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2 About the Accumulation Zones Dataset

2.1 BACKGROUND

Reading and interpreting the landscape is an integral part of understanding the geomorphological processes that have helped shape what we see today. In recent years, new methods in formally classifying topographical features have emerged through the availability of increasingly accurate digital terrain models (DTMs). Scientists are now familiar with extracting and analysing various forms of surface definition (e.g. slope, plan, profile, curvature, etc.), through the use of desktop GIS. However, not all landform definitions have been so readily available, especially outputs known as 'third-derivative' features (Evans, 2013; Kimerling, Buckley, Muehrcke, & Muehrcke, 2009). This analysis focuses on one such feature, a component of debris flow characterised as an area that is topographically suitable for accommodating a build-up of locally sourced loose material: 'Topographical Accumulation Zones' (TAZ).

2.2 THE DEFINITION OF A TOPOGRAPHICAL ACCUMULATION ZONE

A topographical accumulation zone is an area of land surface that can slow down, hold, and eventually release locally sourced loose material over time. The type of materials that can accumulate may range from the natural occurrence of geological debris, anthropogenic activity (e.g. slag heaps), or snow. In some cases, biologically related features may be considered, for example peat. For an area to qualify as a potential accumulation zone it must be capable of acting as a transitional 'sticking point' along a path of moving material. In a geological context, the area must have a local source of material and an opening for release once the zone is fully accommodated.

2.3 TOPOGRAPHICAL MECHANISMS

Areas capable of accumulating loose material must have topographical deceleration mechanisms in place capable of slowing down converging material (MacMillan & Shary, 2009). Zones that are likely to accumulate loose material are sites showing a concave plan, and a concave profile leading onto a level plateau or ledge (Figure 1). An accumulation zone must be topographically susceptible to loose material from surrounding terrain; in a geological context, this would be from an adjacent elevated area. Finally, the site must have the capacity of releasing its stored material. Various triggers may cause this, (e.g. a loss of structural integrity due to increased weight (precipitation), or material build-up exceeding the zone's accommodation capacity), but an outlet (a descending slope at some stage along the plateau) must be present, enabling the continued movement of material away from the site. If an outlet is not present, and the loose material lands on a flat surface with no potential for further movement, this would be classed as a Scree. There is an important distinction between an accumulation zone and a scree in a hazard context, as the potential impact of a long term build-up of loose materials on neighbouring areas is likely to be greater than those areas adjacent to a Scree.

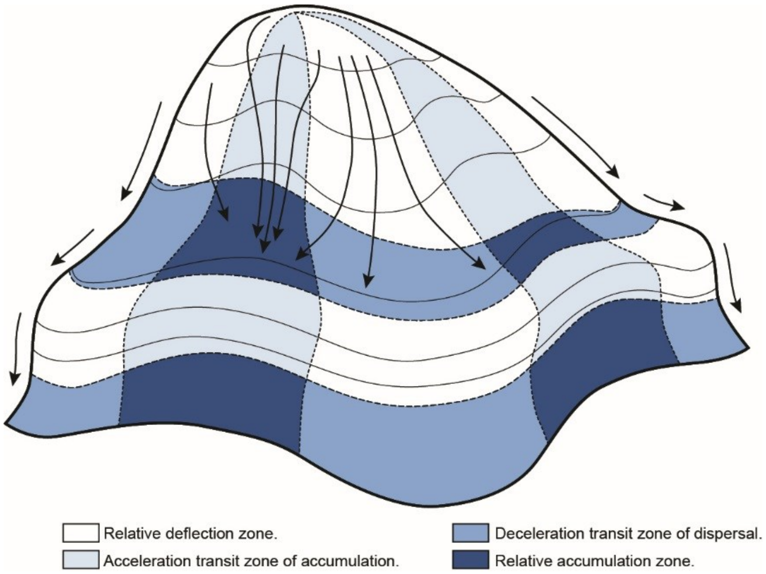

Figure 1: The two deceleration mechanisms behind the accumulation of in situ surface materials (P. A. Shary, 2006).

2.4 WHAT THE DATASET SHOWS

The Topographical Accumulation Zone data consists of 3 data layers in a Geographical Information System (GIS) format that identify areas that are topographically suitable for the accumulation, and eventual release, of loose materials.

2.5 WHO MIGHT REQUIRE THIS DATA?

Situations that are topographically suitable for containing a potential build-up of loose materials may lead to concerns over ground stability. Accumulation zones can be incorporated alongside other datasets (e.g. debris flow hazard, etc.) providing an enhanced level of understanding over the stability of areas that are potentially affected by land movement. Armed with this knowledge, preventative steps can be made to contain, maintain or revise how the land is to be used. Identifying these areas can assist regional and local government planners in making development plans, and establish the potential, or suitability of the land.

2.6 HOW TO USE THESE DATA

Using more than one scale of DTM is advised due to the sensitivity of topographical accumulation zones to scale. Higher cell resolutions are more prone to surface errors, and lower resolution cells can over generalise. Therefore using the term 'visible' in the legend as a proxy term for the occurrence of accumulation is necessary due to the scale dependency of the dataset.

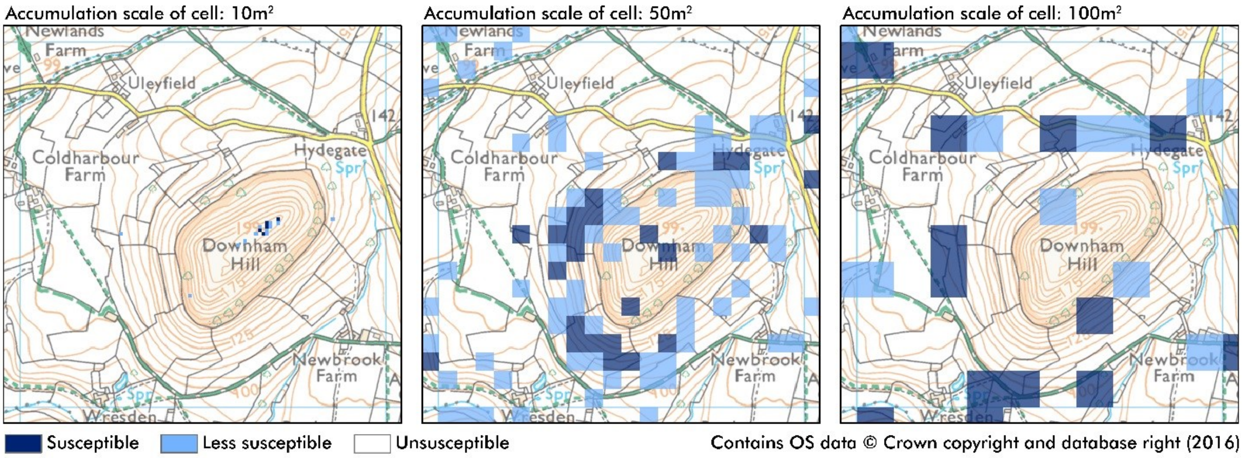

Figure 2 The 3 data layers provided ($10m^2$, $50m^2$, and $100m^2$)

The user will need to review the different data outputs and select the most appropriate scale for their needs by considering the topographic relief of the area under investigation, and the type of geomorphological process being modelled. The 50m DTM appears to work well in relation to 1:25 000 scale topographical map information (Figure 2); and is considered a useful scale to use with anthropogenic orientated data (MacMillan & Shary, 2009).

3 Technical Information

3.1 SCALE

The topographical accumulation zone dataset is produced for use at three scales: $10m^2$ cell/grid resolution; $50m^2$ cell/grid resolution; and $100m^2$ cell/grid resolution. Selecting an appropriate scale of DTM is the most important stage before processing an output. Using the wrong resolution may result in scattered or irrelevant results (Drăguţ & Blaschke, 2006). Most DTM analysis is performed using data resolutions anywhere between the 1m (Micro) - 10km (Meso) scale range (Ahnert, 1988), with the majority of these falling between 5-10m scales (MacMillan & Shary, 2009). For accumulation zones, using two or more datasets within a range that holds a spatial relationship with the subject, or the geo-hazard under investigation, will provide a more meaningful result.

3.2 FIELD DESCRIPTIONS

Contained within the attribute table, the CLASS field provides a numeric scale of the topographical suitability for accumulation to be visible at that scale, where 1 is considered unlikely, through to 3 which is considered to be high suitability. Using the term 'visible' is necessary due to scale dependency of the dataset. The Legend (text) field describes the level of topographical suitability for accumulation. The Version field is a product release reference showing the year of release, followed by an annual centric sequenced version number, e.g. 2017.2 would be indicative of a subsequent dataset release in the same year.

Table 1 Attribute table field descriptions

CLASS	LEGEND	SCALE	VERSION
1	Accumulation unlikely to be visible at this scale	1:50 000	2017.1
2	Moderate suitability for accumulation to be visible at this scale	1:50 000	2017.1
3	High suitability for accumulation to be visible at this scale	1:50 000	2017.1

3.3 CREATION OF THE DATASET

The Shary algorithm (Appendix 1) was performed on an artificially created DTM environment designed to help identify the appropriate areas that adhere to the topographical mechanisms 2.3 suitable for accumulation to occur, Figure 3. Accumulations zones showing high potential are shown in red. Areas considered most likely to retain a build-up of loose material (i.e. Saddles) show up well, and the areas with lower potential (Breaks of slope) are indicated at a reduced level of intensity.

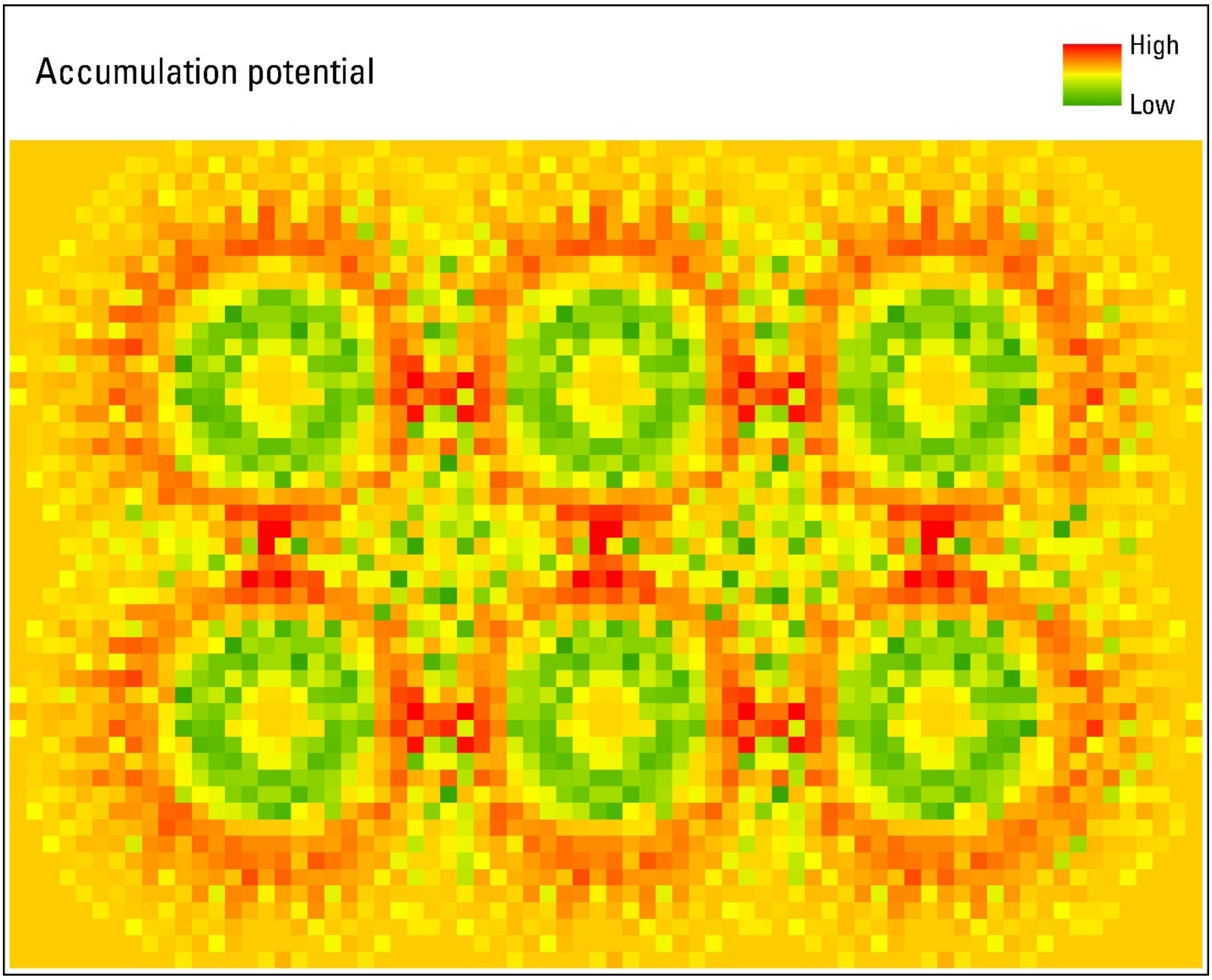

Figure 3 Results from the GIS process using the 'Shary' mean curvature (H).

It was then necessary to categorise the output into 5 distinct categories to clarify the results. Empirical trials revealed the Jenks natural breaks method statistical categorisation to be the most consistent representation of topographical accumulation (Figure 4). Other types of categorisation (e.g. Standard Deviation, Quantile, Equal Interval, etc.) tended to represent the output in a negative, central or positive bias.

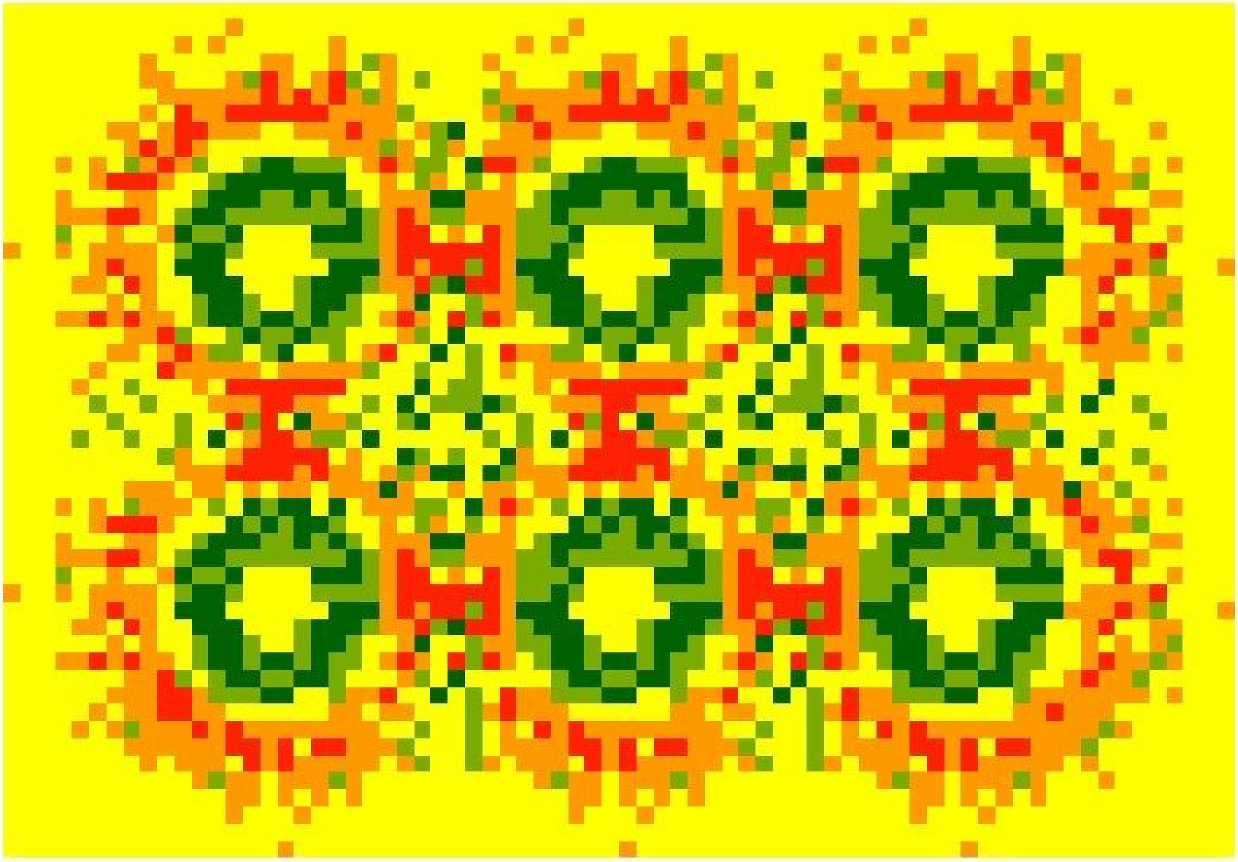

Figure 4 Isolating accumulation into 5 classes

(Red = high, Orange = moderate, and Green = low)

Embedding the artificial DTM into the NEXTMap^{TM} Digital Terrain Model allowed consistent classification of the accumulation zones across the full extent of the dataset, based on the 5 categories identified (Figure 4).

3.4 DATASET HISTORY

The BGS is committed to improving its data as more information or new processing techniques become available. Additional enhancements are made to the datasets for each new version. Below is an outline of the data history of the Topographical Accumulation Layer.

Version 1 (released 2017): Derived from NEXTMap^{TM} Digital Terrain Model v3.2 (2003), based on Shary algorithm (2002).

3.5 COVERAGE

Data is provided to identify the topographical potential for loose material accumulation in Great Britain.

Figure 5 The coverage of the topographical Accumulation Zone dataset

3.6 DATA FORMAT

The topographical accumulation zone dataset has been created as vector polygons and are available in a range of GIS formats, including ArcGIS (.shp). More specialised formats may be available but may incur additional processing costs.

3.7 LIMITATIONS

- The topographical accumulation zone dataset has been developed at 10, 50 and 100 m cell scales. All spatial analysis using these data should therefore be conducted using a minimum 10, 50 and 100 m cell resolution respectively.
- Topographical Accumulation Zones associated with features outside of the given 10, 50, and 100 m scale datasets may not be represented.
- The topographical accumulation zone dataset is based on, and limited to, an interpretation of the NEXTMap^{TM} Digital Terrain Model (DTM) at the time the dataset was created.
- An indication of high suitability for accumulation does not necessarily mean that a location will be affected by accumulation/debris movement.

4 Licensing Information

The British Geological Survey does not sell its digital mapping data to external parties. Instead, BGS grants external parties a licence to use this data, subject to certain standard terms and conditions. In general, a licence fee will be payable based on the type of data, the number of users, and the duration (years) of a licence.

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Appendix 1

Equation 1: A breakdown of the accumulation algorithm (P. Shary, 2012)

$H = (Kh + Kv)/2,$

$E = (Kv - Kh)/2,$

$Ka = H \times H - E \times E$

Where:

Kh = Profile

Kv = Plan

H = Mean Curvature

E = Difference Curvature

Ka = Total Accumulation Curvature

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British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details).

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