



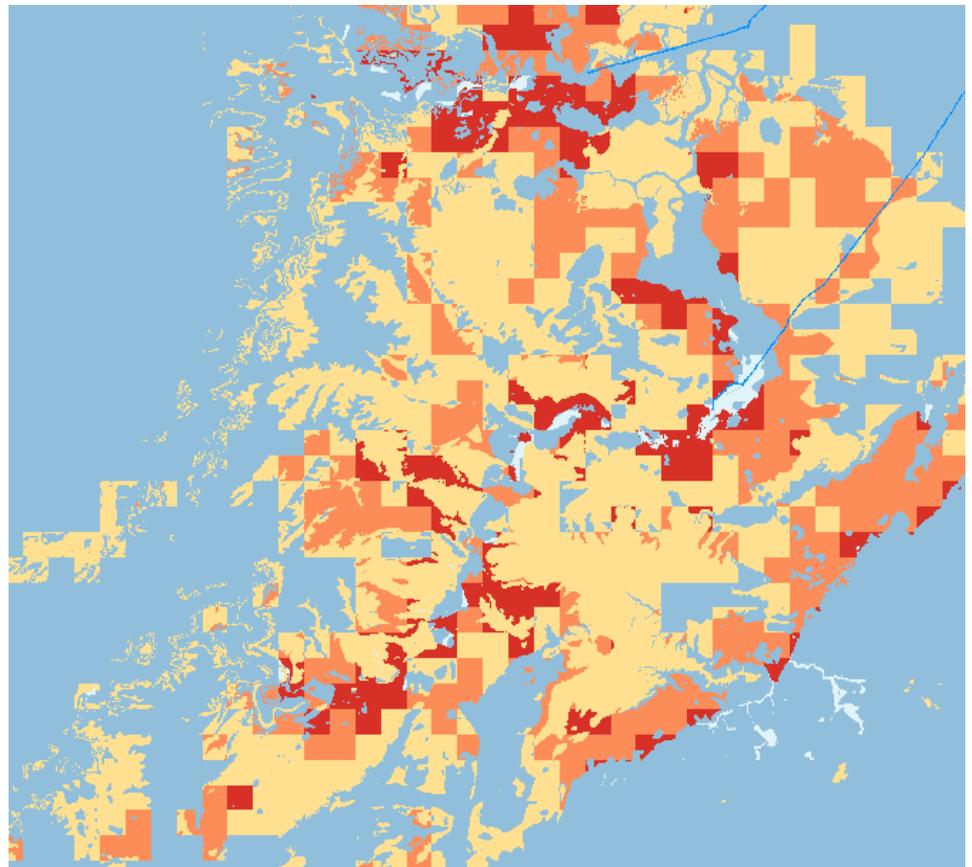
**British
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

User Guide for the British Geological Survey GeoClimate: Clay Shrink-Swell dataset

GeoAnalytics & Modelling Programme

Open Report OR/18/006



BRITISH GEOLOGICAL SURVEY

GEOANALYTICS & MODELLING PROGRAMME

OPEN REPORT OR/18/006

User Guide for the British Geological Survey GeoClimate: Clay Shrink-Swell dataset

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SW corner 0,0
Centre point 350000,550000
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Map

Sheet 0, 1:50 000 scale,
GeoClimate

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BRITISH GEOLOGICAL SURVEY

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The British Geological Survey is a component body of the Natural Environment Research Council.

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Summary

This report describes the national scale assessment of Climatic Hazards and Natural Geological Events for Great Britain, this first dataset provides information on Shrink–Swell geohazards. The methods used to create the dataset have been critically assessed and its fitness for purpose determined by specialists in the BGS.

This document outlines the background to why the suite of datasets were created, their potential uses and provides a brief description. Technical information regarding the GIS and how the data was created is described and advice is provided on using the dataset.

Acknowledgements

A number of individuals in the GeoAnalytics & Modelling and Engineering Geology & Infrastructure Programmes have contributed to the project. This assistance has been received at all stages of the study. In addition to the collection and processing of data, many individuals have freely given their advice, and provided the local knowledge. Key staff have helped to review draft chapters of this report.

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 survey and 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 and environmental business, and the British public.

This document provides information for users on the GeoClimate: Clay Shrink-Swell dataset for a national scale assessment of potential climatic influences on geohazards for GB. This is a stand-alone product, using data from the BGS GeoSure shrink-swell layer, the BGS Groundwater ZOODRM distributed recharge model and Met Office UKCP09 (11RCM) climate change predictions. The purpose of this dataset is to provide information on the potential for increased risk of Shrink-Swell susceptibility from climate change, using geology, groundwater and geotechnical information as the indicator.

Further information on all the digital data provided by the BGS can be found on our website at <http://www.bgs.ac.uk/data/digitaldata/digitaldata.cfm> or by contacting:

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2 About the GeoClimate Dataset

2.1 BACKGROUND

Public understanding of the effect of ground conditions on the safety of their property and the implication for the value of their property is growing. Local councils are under increasing pressure from central government to provide environmental information. Information about geological hazards is needed, in particular, the identification of areas with a potential for ground movement.

In response to this, The British Geological Survey initiated a development programme to produce datasets that identified and assessed potential geohazards threatening the human environment in Great Britain. Along with the GeoSure ground stability datasets, the programme also generated:

- Superficial Deposit Thickness Models
- Ground permeability data
- Susceptibility to groundwater flooding data
- Geological indicators of past flooding data
- GIS data identifying potential radon hazard
- mining hazards (Non-coal) data
- GeoSure Shrink-Swell 3D London & the Thames Valley data
- GeoSure Debris Flow data

2.2 WHO MIGHT REQUIRE THIS DATA?

Natural ground stability hazards may lead to financial loss for anyone involved in the ownership or management of property, including developers, householders or local government. These costs could include increased insurance premiums, depressed house prices and, in some cases, engineering works to stabilise land or property. These hazards may also impact on anyone involved in the construction of large structures (deep foundations, basements), infrastructure networks (road or rail) or utility companies.

Armed with knowledge about potential hazards, preventative or mitigative steps can be put in place to alleviate the impact of the hazard to people, property and infrastructure. The cost of such prevention may be very low, and is often many times lower than the repair bill following ground movement.

The identification of areas of potential increased risk of Shrink–Swell susceptibility from climate change will be of use to all users planning for longer-term resilience such as developers, construction companies, and utility companies, consulting engineers, builders, loss adjusters, the insurance industry, architects and surveyors.

2.3 WHAT THE DATASET SHOWS?

Shrink-swell is recognised as the most significant geohazard across Great Britain. The purpose of this dataset is to provide information on the change in susceptibility of Shrink–Swell across Great Britain due to a changing climate and the associated changes in soil moisture.

Swelling clays can change volume due to variation in moisture, this can lead to ground movement, particularly in the upper two metres of the ground, or where excavated and exposed, that may affect many foundations. Ground moisture variations may be related to a number of factors, including weather variations, vegetation effects (particularly growth or removal of trees) and the activities of people that might cause changes to the ground conditions. Such changes can affect building foundations, pipes or services.

This stand-alone product consists of a suite of data layers, in Geographical Information System (GIS) format that temporally identifies areas of shrink–swell hazard with a change in susceptibility of clay shrink-swell across GB. The UKCP09 climate projections for rainfall and temperature have been utilised to project changes in clay shrink-swell susceptibility, provided for the time periods 2020s, 2050s and 2080s.

‘GeoClimate’ utilises the medium emissions scenario of the UKCP09 climate projections (<http://ukclimateprojections.metoffice.gov.uk/>). It is essentially a national hazard susceptibility map, showing change in susceptibility with time, due to changes in climate. This methodology has been developed by Engineering Geologists, Hydrogeologists, Geophysicists and Information Developers at the British Geological Survey and is presented as GIS data layers.

GeoClimate: Shrink-Swell is provided in two options, a simple overview dataset (GeoClimate Basic) and a detailed dataset (GeoClimate Premium). The content of each is described below.

GeoClimate Basic:

- Freely available suite of layers under Open Government Licence
- Provides a 2km generalised vector grid of the projected effects of climate change on clay shrink-swell susceptibility in GB, calculated for 11 year windows.
- Provided for 3 time periods
 - 2030 (2025 to 2035)
 - 2050 (2045 to 2055)
 - 2080 (2075 to 2085)
- 1 projection is provided for each time period: average climate projection
- Based on the average outcome for the medium emissions scenario and the most susceptible GeoSure value (worst case) within the grid cell.

GeoClimate Premium:

- More detailed suite of layers, provided in polygons that are derived from BGS GeoSure vector data.

- It provides a higher resolution (1:50K) view of the GeoClimate shrink-swell projections, calculated for 11 year windows.
 - 2020 (2015 to 2025)
 - 2030 (2025 to 2035)
 - 2040 (2035 to 2045)
 - 2050 (2045 to 2055)
 - 2080 (2075 to 2085)
- 3 projected scenarios for each time period: average, wetter and drier climate projections are provided

3 GeoClimate Basic: Technical Information

3.1 DEFINITIONS

Hazard: A potentially damaging event or phenomenon.

Risk: The impact of the hazard on people, property or capital.

For example, a shrinkable clay could be perceived as a hazard, but the likelihood of it causing structural damage would be the risk.

A high hazard does not necessarily translate to a high risk. For example, if a particular location has a relatively high ground stability hazard, but the properties that are built there have taken this into account, and are designed to withstand the hazard, they will not have a comparable level of risk as the risk of loss has been mitigated as a result of the design of the property.

GeoClimate does not identify the cost of a hazard being realised, and therefore does not consider risk. GeoClimate examines the conditions that leave an area exposed to a hazard and the change in potential for this hazard to worsen due to climatic change.

3.2 SCALE

The GeoClimate dataset is produced for use at 1:50 000 scale providing 50m ground resolution.

3.3 ATTRIBUTE TABLE FIELD DESCRIPTIONS

Table 1 – Basic product attributes

Field Name	Field Description
CLASS	Classification of hazard using values:- Improbable, Possible, Probable, Unavailable
LEGEND	Description of hazard
VERSION	Dataset name and version number

3.4 CREATION OF THE DATASET

GeoClimate combines and interprets data on shrink-swell hazard susceptibility, BGS groundwater model and UKCP09 climate change projections, to project future shrink-swell hazard (Figure 1). A robust methodology has been developed by expert BGS Geological Engineers, Groundwater Geologists and GIS specialists. The source datasets utilised in the development of GeoClimate: Shrink-Swell are:

- **BGS GeoSure Subsidence:** BGS GB dataset providing geological information on natural ground instability, providing 5 classes from Hazard Rating A (predominantly non-plastic ground conditions) to Hazard Rating E (predominantly very high plasticity ground conditions)

- **Zooming Object Oriented Distributed Recharge (ZOODRM) model:** Provides gridded daily soil moisture deficit (SMD) values for UK, based on inputted rainfall and surface values.
- **11 RCM UKCP09 climate models:** The UKCP09 medium emissions scenario was used to force the 11 Regional Climate Model simulations, providing absolute values provided as continuous daily projections from 1950 to 2099.

In addition, further research is incorporated including:

- **A Days in Drought (DiD) value,** calculated from the ZOODRM groundwater model and 11RCM projections,
- **Modified Plasticity Index (IP') values,** extracted from the BGS GeoSure Shrink–Swell layer. The output is a GeoClimate Volume Change Potential (VCP) score

GeoClimate Basic is derived from the same methodology as GeoClimate Premium, and is a lower resolution summary product, providing information on the average climate change scenario and the highest susceptibility GeoSure shrink-swell value within the 2km grid cell.

Table 1 shows the product attributes. Table 2 shows the ratings for GeoClimate Basic product.

The GeoSure Shrink–Swell rating does not change for a geological deposit. However, the projected changes in climate vary across GB, and therefore the GeoSure shrink-swell rating letter is combined with a number that represents the days in drought projected for that area.

Table 2 GeoClimate Basic VCP ratings, showing the effect of projected climate change on clay shrink-swell susceptibility.

			GeoSure Modified Plasticity Index (IP') Value				
			<10	10-20	20-40	40-60	>60
		Score	A	B	C	D	E
Days in Drought (DiD)	<100	1	A1 Improbable change	B1 Improbable change	C1 Improbable change	D1 Improbable change	E1 Improbable change
	100-115	2	A2 Improbable change	B2 Improbable change	C2 Improbable change	D2 Improbable change	E2 Improbable change
	115-130	3	A3 Improbable change	B3 Improbable change	C3 Improbable change	D3 Possible increase	E3 Possible increase
	130-145	4	A4 Improbable change	B4 Improbable change	C4 Possible increase	D4 Probable increase	E4 Probable increase
	>145	5	A5 Improbable change	B5 Possible increase	C5 Possible increase	D5 Probable increase	E5 Probable increase

Example Score Interpretation: The GeoClimate Basic rating for the area of interest is Probable (Red) in the 2050 projection. This shows that it is probable that the likelihood of clay shrink-swell occurring in this area, causing subsidence in low-rise buildings, will increase due to changes in climate, by 2050.

For all GeoClimate Basic results, the rating provided is the highest Geoclimate value within the selected 2km pixel. For a more precise rating, please consult the GeoClimate Premium product (Section 4).

Table 3 – GeoClimate Basic colours and susceptibility text

Colour (used in legend)	Associated susceptibility description
Blue	It is ‘improbable’ that foundations will be affected by increased clay shrink-swell due to climate change.
Yellow	It is ‘possible’ that foundations will be affected by increased clay shrink-swell due to climate change.
Red	It is ‘probable’ that foundations will be affected by increased clay shrink-swell due to climate change.
Grey	Input datasets are unavailable

The susceptibility ratings (Table 3) colour scheme is colour-blind safe.

3.5 TEMPORAL SCALE

For the GeoClimate Basic suite of layers, a susceptibility score is provided for the following 11-year time periods:

- 2030 (2025 to 2035)
- 2050 (2045 to 2055)
- 2080 (2075 to 2085)

3.6 COVERAGE

The GeoClimate products are national scale datasets covering Great Britain. The extent of the GeoClimate Basic shrink-swell suite of datasets, is shown in Figure 1.



Figure 1 - Coverage of GeoClimate Basic

3.7 DATA FORMAT

The GeoClimate dataset has been created as vector polygons and is available in a range of GIS formats, including ArcGIS (.shp), ArcInfo Coverages and MapInfo (.tab). More specialised formats may be available but may incur additional processing costs.

3.8 LIMITATIONS

- The GeoClimate dataset has been developed at 1:50 000 scale and must not be used at larger scales.
- GeoClimate is concerned with potential ground stability related to NATURAL shrink–swell geological conditions only.
- GeoClimate is based on, and limited to, an interpretation of the records in the possession of The British Geological Survey at the time the dataset was created.
- An indication of natural ground movement due to shrink–swell does not necessarily mean that a location will be affected by ground movement or subsidence. Such an assessment can only be made by inspection of the area by a qualified professional.

4 GeoClimate Premium: Technical Information

4.1 DEFINITIONS

Hazard: A potentially damaging event or phenomenon.

Risk: The impact of the hazard on people, property or capital.

For example, a shrinkable clay could be perceived as a hazard, but the likelihood of it causing structural damage would be the risk.

A high hazard does not necessarily translate to a high risk. For example, if a particular location has a relatively high ground stability hazard, but the properties that are built there have taken this into account, and are designed to withstand the hazard, they will not have a comparable level of risk. This is because the likelihood of the hazard causing any loss has been reduced due to the design of the property.

GeoClimate does not identify the cost of a hazard being realised, and therefore does not consider risk. GeoClimate only examines the conditions that leave an area exposed to a hazard and the change in potential due to climatic changes.

4.2 SCALE

The GeoClimate dataset is produced for use at 1:50 000 scale providing 50m ground resolution.

4.3 ATTRIBUTE TABLE FIELD DESCRIPTIONS

Table 4 – Premium product attributes

Field Name	Field Description
CLASS	Classification of hazard using values:- Highly Unlikely, Unlikely, Likely, Highly Likely, Extremely Likely
LEGEND	Description of hazard
VERSION	Dataset name and version number

4.4 CREATION OF THE DATASET

GeoClimate combines current GB subsidence hazard susceptibility, a GB groundwater model and climate change projections, to project future subsidence hazard (Figure 1). Expert BGS Geological Engineers, Groundwater Geologists and GIS specialists collaborated to generate a robust methodology. The datasets utilised and combined in GeoClimate are:

- **BGS GeoSure Subsidence:** BGS GB dataset providing geological information on potential subsidence, providing 5 classes from Hazard Rating A (pre-

dominantly non-plastic ground conditions) to Hazard Rating E (predominantly very high plasticity ground conditions)

- **Zooming Object Oriented Distributed Recharge (ZOODRM) model:** Provides gridded daily soil moisture deficit (SMD) values for UK, based on inputted rainfall and surface values.
- **11 RCM UKCP09 climate models:** UKCP09 medium emissions scenario was used to force the 11 Regional Climate Model simulations, providing absolute values to input into GeoClimate. The values provided are continuous daily projections from 1950 to 2099.

These datasets are used to produce a GeoClimate Volume Change Potential (VCP) score, which is based on:

- **Modified Plasticity Index (IP') values,** extracted from the BGS GeoSure Shrink–Swell layer,
- **A Days in Drought (DiD) value,** calculated from the ZOODRM groundwater model and 11RCM projections.

Table 5 shows the product attributes. Table 6 shows the ratings for the Premium product.

The GeoSure Shrink–Swell rating does not change for a geological deposit. However, the projected changes in climate vary across GB, and therefore the GeoSure shrink–swell rating letter is combined with a number that represents the days in drought projected for that area.

Table 5 – GeoClimate Premium: VCP ratings, showing the effect of projected climate change on clay shrink-swell susceptibility.

			GeoSure IP' Value				
			<10	10-20	20-40	40-60	>60
		Score	A	B	C	D	E
Days in Drought	<100	1	A1 No effect	B1 No effect	C1 No effect	D1 No effect	E1 No effect
	100-115	2	A2 No effect	B2 No effect	C2 No effect	D2 No effect	E2 No effect
	115-130	3	A3 No effect	B3 No effect	C3 No effect	D3 Small effect	E3 Small effect
	130-145	4	A4 No effect	B4 No effect	C4 Small effect	D4 Noticeable effect	E4 Noticeable effect
	>145	5	A5 No effect	B5 No effect except if external changes occur	C5 Small effect	D5 Major effect	E5 Major effect

Table 6 – GeoClimate Premium colours and legend descriptions

Colour (used in legend)	Associated susceptibility description
Blue	It is ‘highly unlikely’ that foundations will be affected by increased clay shrink-swell due to climate change.
Light Blue	It is ‘unlikely’ that foundations will be affected by increased clay shrink-swell due to climate change.
Yellow	It is ‘likely’ that foundations will be affected by increased clay shrink-swell due to climate change.
Orange	It is ‘highly likely’ that foundations will be affected by increased clay shrink-swell due to climate change.
Red	It is ‘extremely unlikely’ that foundations will be affected by increased clay shrink-swell due to climate change.
Grey	Input datasets are unavailable.

N.B. When it is ‘unlikely’ that foundations will be affected by increased clay shrink-swell due to climate change, unless external changes occur, examples of external changes include planting or removal of trees near the building or drainage changes.

The susceptibility ratings (Table 7) colour scheme is colour-blind safe.

4.5 TEMPORAL SCALE

For the GeoClimate Premium suite of layers, 3 layers are provided for the following 11-year time periods:

- 2020 (2015 to 2025)
- 2030 (2025 to 2035)
- 2040 (2035 to 2045)
- 2050 (2045 to 2055)
- 2080 (2075 to 2085).

The 3 layers provided for each time period are:

- Average (median average period of dry conditions)
- Drier (longest period of dry conditions)
- Wetter (shortest period of dry conditions)

4.6 COVERAGE

The GeoClimate products are national scale datasets covering Great Britain. The extent of the GeoClimate Premium shrink-swell layer is shown in Figure 2.



Figure 2 - Coverage of GeoClimate Premium

4.7 DATA FORMAT

The GeoClimate dataset has been created as vector polygons and is available in a range of GIS formats, including ArcGIS (.shp), ArcInfo Coverages and MapInfo (.tab). More specialised formats may be available but may incur additional processing costs.

4.8 LIMITATIONS

- The GeoClimate dataset has been developed at 1:50 000 scale and must not be used at larger scales.
- GeoClimate is concerned with potential ground stability related to NATURAL shrink–swell geological conditions only.
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- An indication of natural ground movement due to shrink–swell does not necessarily mean that a location will be affected by ground movement or subsidence. Such an assessment can only be made by inspection of the area by a qualified professional.

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- sell, assign, sublicense, rent, lend or otherwise transfer (any part of) the dataset(s) or the licence
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additional 'special conditions' in the licence documentation, addressing specific requirements within BGS's permitted usage.

5.1 GEOCLIMATE BASIC

GeoClimate Basic is made available under the Open Government Licence. To encourage the use and re-use of this data we have made it available under the Open Government Licence (www.nationalarchives.gov.uk/doc/open-government-licence/version/3/), subject to the following acknowledgement accompanying the reproduced BGS materials: "Contains British Geological Survey materials ©NERC 2018".

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6 Glossary

DiD	Days in Drought
IP'	Plasticity Index. The plasticity index (PI) is a measure of the plasticity of a soil. It is the size of the range of water contents where the soil exhibits plastic properties. The PI is the difference between the liquid limit and the plastic limit (PI = LL-PL).
UKCP09	United Kingdom Climate Projections 2009. UKCP09 was produced in 2009, funded by a number of agencies led by Defra. It is based on sophisticated scientific methods provided by the Met Office, with input from over 30 contributing organisations.
VCP	Volume Change Potential
ZOODRM	Zooming Object Oriented Distributed Recharge model
11RCM	11 Regional Climate Models