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Clay Research Group

RESEARCH AREAS

Climate Change : Data Analysis : Electrical Resistivity Tomography
Time Domain Reflectometry : BioSciences : Ground Movement
Soil Testing Techniques : Telemetry : Numerical Modelling
Ground Remediation Techniques : Risk Analysis
Mapping : Software Analysis Tools
Electrokinesis Osmosis
Intelligent Systems

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Climate : Telemetry : Clay Soil : BioSciences : GIS & Mapping
Risk Analysis : Ground Remediation : Moisture Change
Data Analysis : Numeric Modelling & Simulations : Software

Edition 129

February 2016

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Edition 129, February, 2016

The Memory of our A.I. Application

This month's edition explores what might be considered the memory of an AI system. How does the application know what a valid claims looks like? What are the metrics that determine risk?

The data tell us that old houses are riskier than new ones, and by how much. Similarly, by analysing past claims we can understand which parts of the building are most vulnerable and how the location of damage varies by cause and in some instances, time of year and prevailing weather conditions.

Over following months we look at pattern matching, the learning module and building the system.

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Call for Papers

Aston Conference, 22nd June 2016

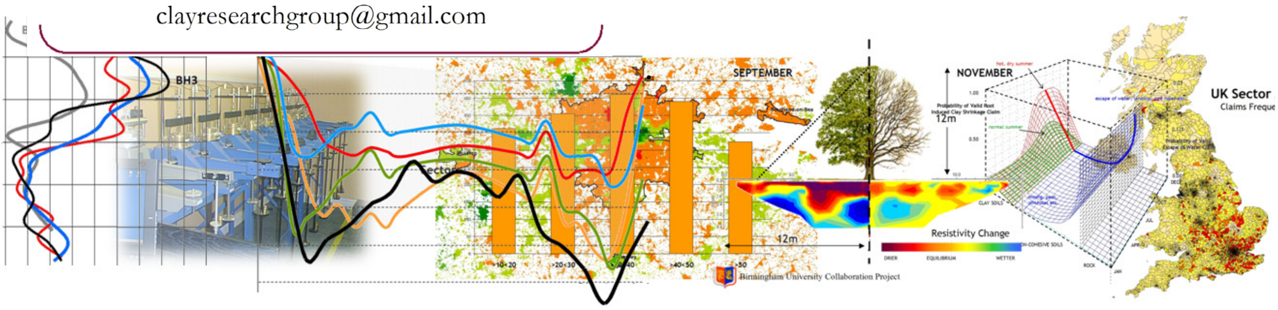
ASTON UNIVERSITY
BIRMINGHAM

Papers are invited for the Annual Subsidence Conference held at Aston University. As ever we look to the future and try to anticipate the implications of changes that are taking place in terms of business process and technology.

Last year we heard about 'management by consensus'. The approach whereby staff design the process that they carry out. The outcome is a reduction in both enquiries and complaints. Customer and staff satisfaction levels have improved.

Regarding the more technical aspects we heard from Prof. Jefferson and Dr. Nigel Cassidy about advances in the treatment and measurement of soils including the use of EKO treatment and an update on electrical resistivity. We understand a further application for UKCRIC funding is being prepared. More news following a presentation in March at Birmingham University.

Papers or outline suggestions for topics should be forwarded to m.sadeghzadeh@aston.ac.uk in the first instance. The annual conference has been running for over 10 years and gives everyone a chance to catch up with colleagues, enjoy a good lunch and hopefully learn about current developments.



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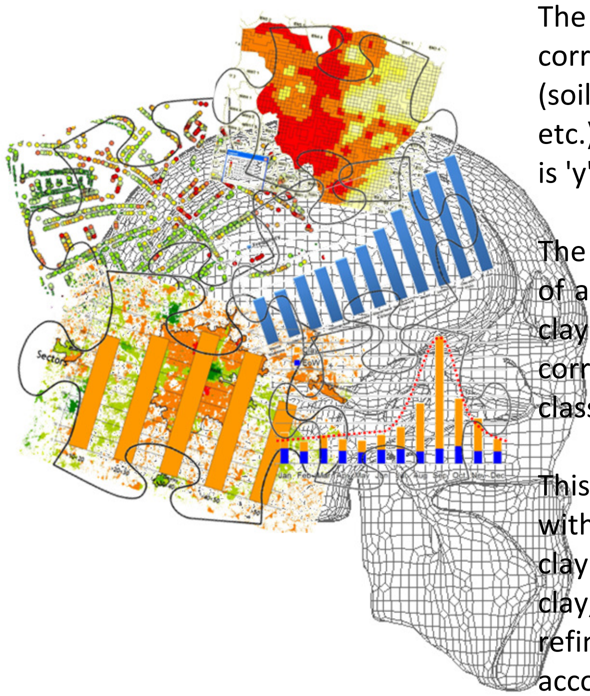
Assembling the Pieces

The Memory of a Basic AI Application

Building a digital model of the various elements and how the system responds when they combine delivers what we might regard as the memory of a basic AI system. The components described on following pages provide a frequency distribution or logical value derived from analysis of historic claims.



The system 'learns from its history', finding correlations between sometimes disparate items (soil type, vegetation, weather, age of property etc.) to deliver quantifiable outputs of the form 'x' is 'y' times riskier than 'z'.

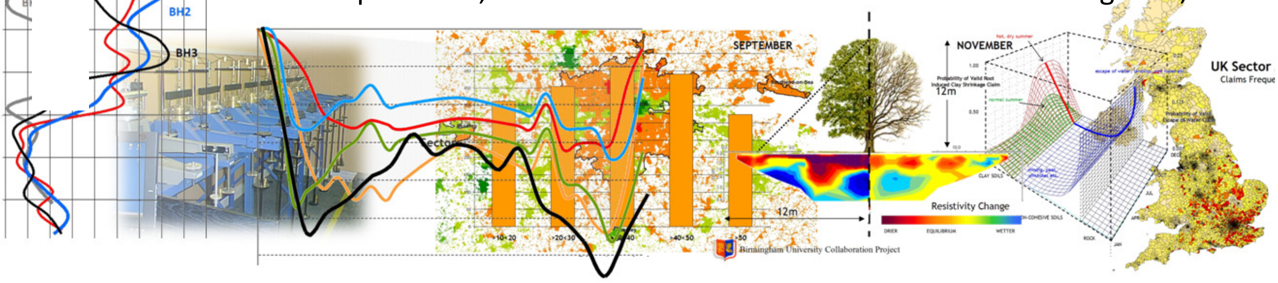
The application scans the data and selects claims of a particular type. For example, 'sort on all valid clay shrinkage claims'. The next step is to identify correlations. What are the characteristics of this class of claim?

This also helps to identify and quantify variation within the class - for example, understanding that clay shrinkage claims require the geology to be clay, and determining any periodic signature and refining the risk still further by classifying according to PI.

The next stage requires a pattern recognition module that views the combined output from all of the individual analyses that have been undertaken. Now that we have the class identified, exactly what does a valid claim look like? How does it differ from a repudiation? Where it differs, can we see by how much, and in what respect? What does it mean if the difference is say 0.32 or 0.76?

And then we have to ensure the system can learn as times change. How does it detect the relevant factors and when it discovers change how does it respond? Clearly the outcome from a single claim can't undermine the rules established by looking at many but how is the system coded to recognise change and ignore it when it isn't relevant?

In future editions we explore (a) pattern matching, (b) learning and (c) building the system. How do systems 'recognise' patterns and how do they handle variations? We have obtained the help of Walt, the lead character from the TV series 'Breaking Bad', to



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The A.I. Jigsaw

Understanding the Components using Frequency Distribution Analysis

Plotting frequency distributions of the various elements helps us assign values to each but also to recognise patterns. What does a valid claim under a certain peril look like when expressed as a number? Is the age of property or the area of damage a potential indicator of claim validity and if so, by how much when expressed as a probability? Can the individual elements be combined to enhance their value? Is a particular part of a building more vulnerable in certain ages of house at a particular time of year for a certain peril? On the next few pages we list some of the building blocks.

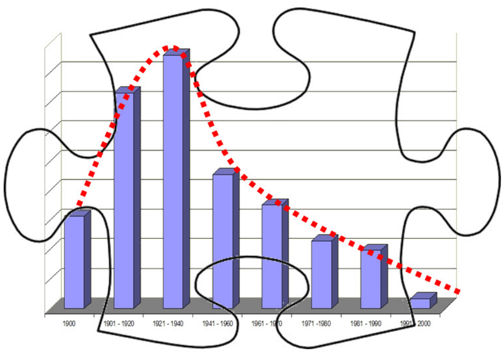
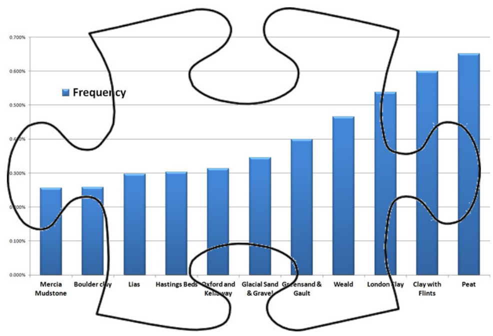


Figure 1 - Risk by Age of Property

Distribution curve for risk by age of property expressed on a normalised scale using claim frequency divided by housing population by year of construction (not damage notification) showing the risk increasing with age and quantifying the difference,

Figure 2 - Risk by Soil Type

Distribution of risk by soil type. Although peat isn't widespread, in terms of frequency (numbers of houses damaged over total population) it is at the top of the list.



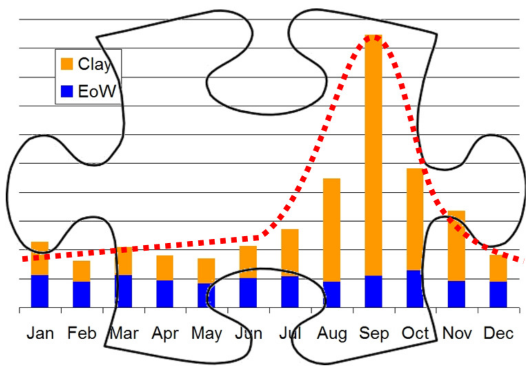
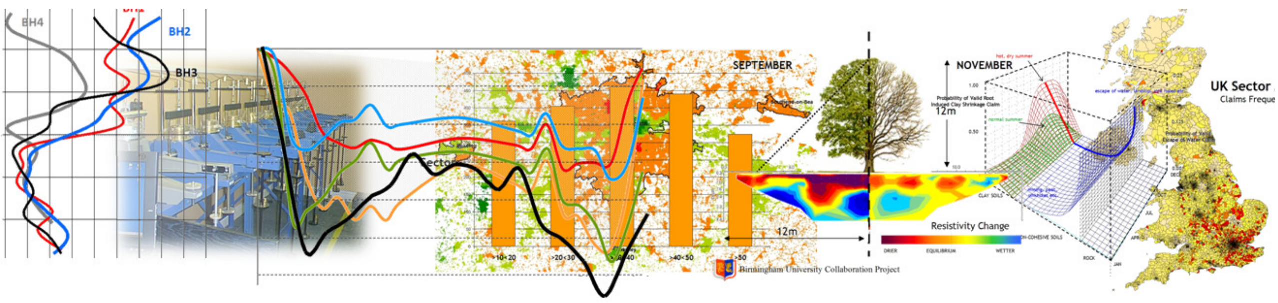


Figure 3 - Claim Notification

Risk by month in terms of count of claims notified and peril. A periodic signature is linked to claims on clay soils. Subsidence due to escape of water (leaking drains etc.) has a fairly constant profile throughout the year.



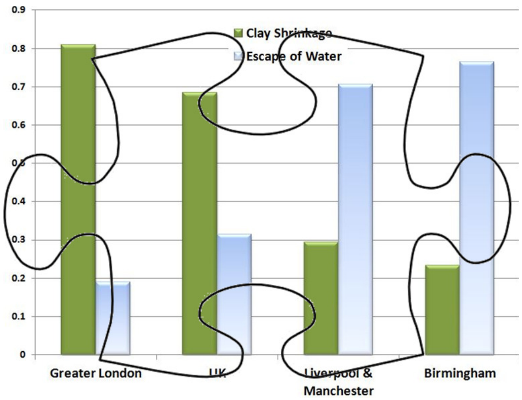
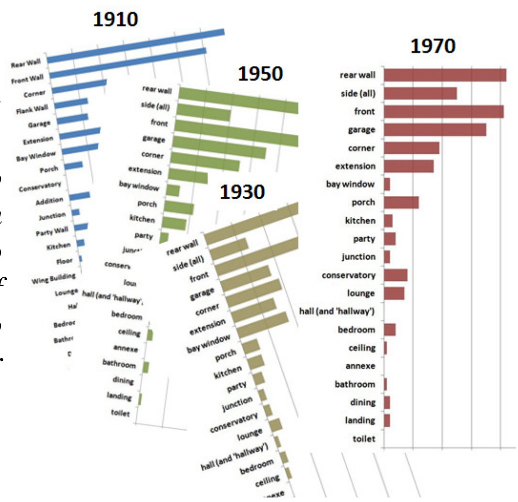


Figure 4 - Risk by City

Geology is a key driver in terms of subsidence but how does this play out in terms of relative risk between cities? The analysis reveals that if you live in Birmingham and are unfortunate enough to have a claim, the most likely peril by a long way is escape of water - a leaking drains or, less likely, a leaking water service pipe. In London, the most likely peril is clay shrinkage.

Figure 5 - Area of Damage by Age of Property

If older houses are riskier (due perhaps to shallower foundations, rigid drain connections that are more vulnerable to ground movement etc), does the area of vulnerability change over time due to methods of construction perhaps, or changing layouts?



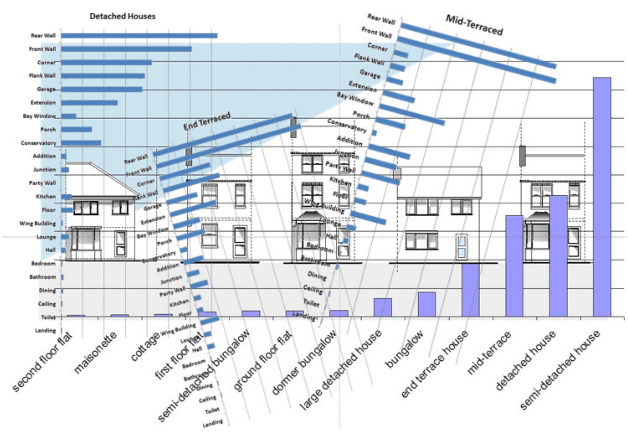
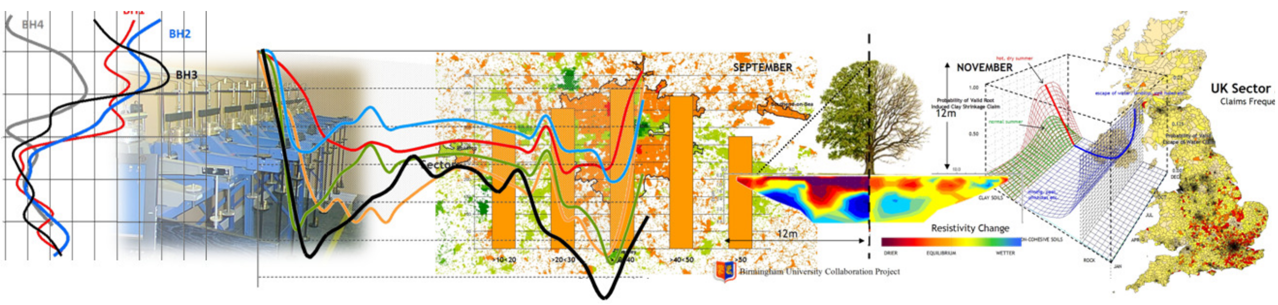


Figure 6 - Area of Damage by Style of Property

Does the style of the property - terraced, semi-detached, bungalow etc., - influence the pattern of distress? The absence of a flank wall suggests that terraced houses may have a different characteristic than say a detached house. But exactly what is the difference?



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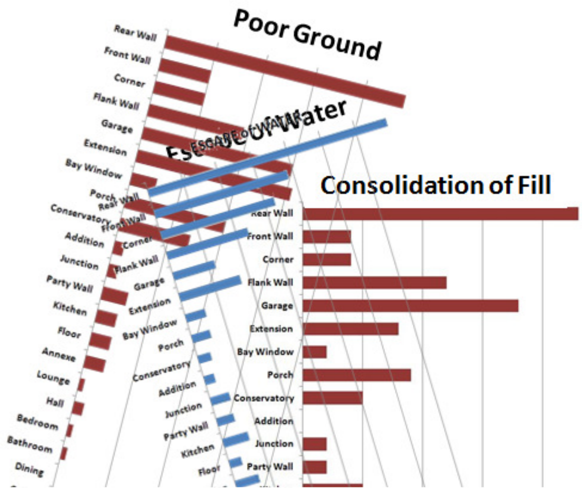

Figure 7 - Cause of Damage

Does a particular peril - for example, root induced clay shrinkage, sulphates, heave etc., - cause damage in different locations to subsidence resulting from water escaping from drains?

If so, does the location of damage vary by house style as described in Fig. 6 and/or by age of property as described in Fig. 1? If so, by how much?

Figure 8 - Cause of Damage - Example

The distribution (right) relates to sulphate damage claims and the combination of 'damage to floors' and 'garage' reflect the most common attributes of this class of claim. Combine with the age of property, location of similar claims in the area and description of damage - "raised floor, white salts along crack etc" - improves the chances of arriving at a correct diagnosis.

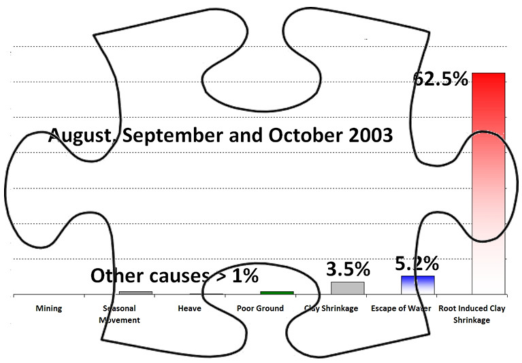

Figure 9 - Peril by Season

Likelihood of peril by month, variable by season and prevailing weather conditions referencing the Soil Moisture Deficit (SMD) and Met Office data, adjusting for surge years where possible.

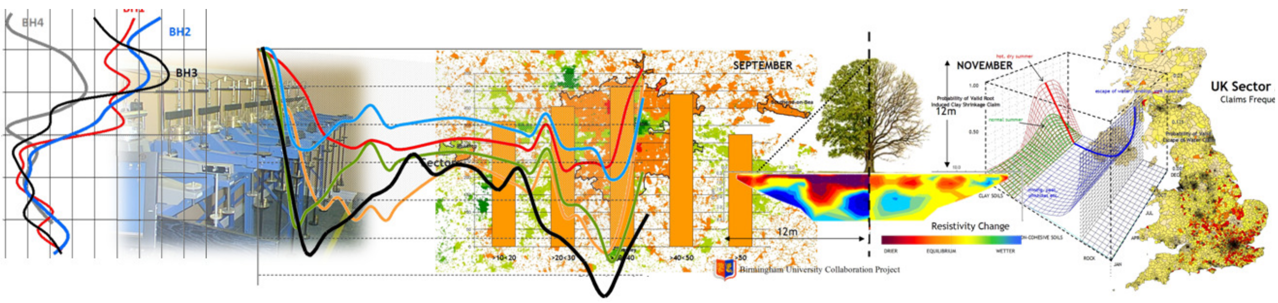

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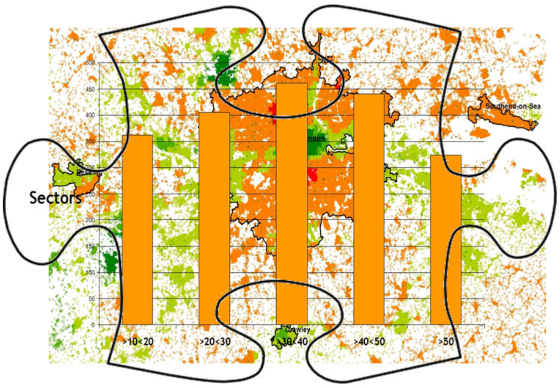
Figure 10 - Soil Risk by PI

The risk posed by differing soil types varies as we have seen on previous pages, but within the clay series is there a link to the shrink/swell potential, and if so is this associated with prevailing weather?



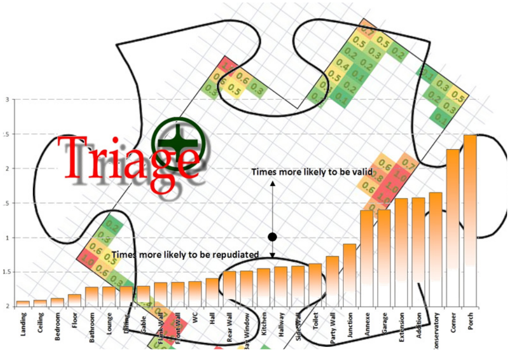
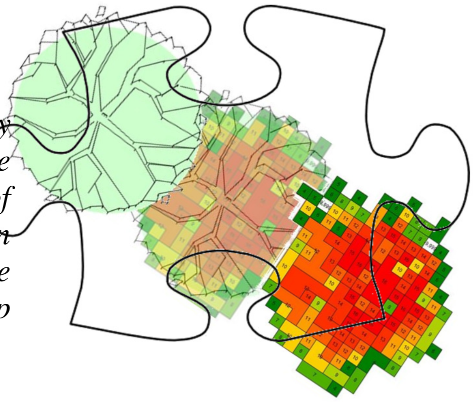


Figure 11 - Building Vulnerability

Building vulnerability by location of damage and association with claim validity. For example, 'damage to corner' claims are twice as likely to be accepted than declined. Module is linked to digital floor plans of vulnerability discussed in later edition.

Figure 12 - Tree Risk Data

Taking account of vegetation on clay soil. Risk variable by species, distance and tree height. Takes account of shrubs and trees. Relies on conversation management to retrieve full data on species and ownership and mapping for location.



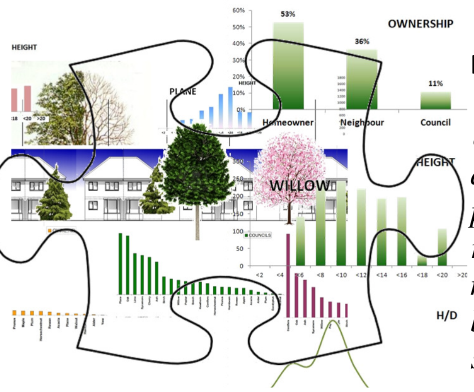
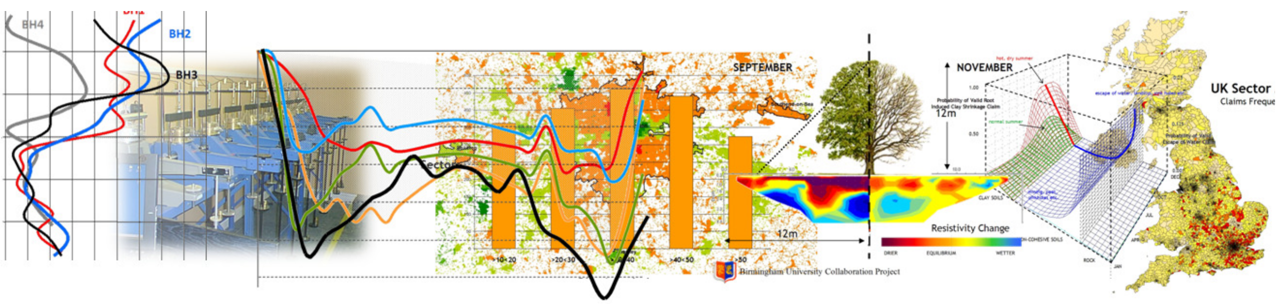


Figure 13 - Spatial Data on Trees

Using our LiDAR imagery from 2005 and aerial photography flown in 1996, plotting tree locations (present or removed), estimating height and modelling potential root overlap beneath buildings and then superimposing claims experience to derive risk.



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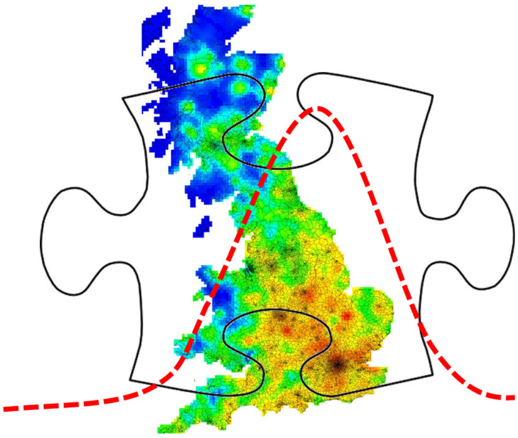
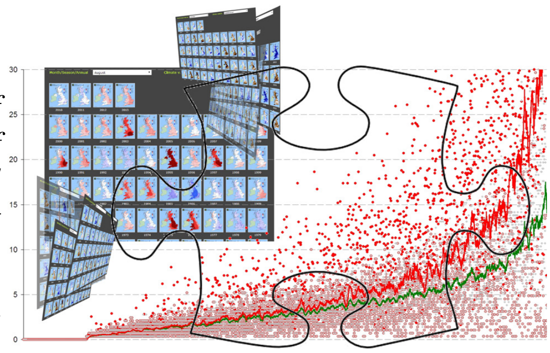


Figure 14 - Historic Claims Data

Distribution curve for risk by location in the UK reflecting historic claims data, climate and month of notification (for clay soils only). Inference for social demographics although not directly used for this purpose in claim assessment. In some north London sectors, likelihood of valid reaches nearly 90%.

Figure 15 - Weather and Climate

Are certain soil types vulnerable to prevailing weather conditions and if so, what are the implications of climate change? Is there a biased distribution of risk and if so, what weather conditions drive which peril, by how much and where? Right, a graph showing normal (green) and surge (red) years by postcode sector taking into account weather.



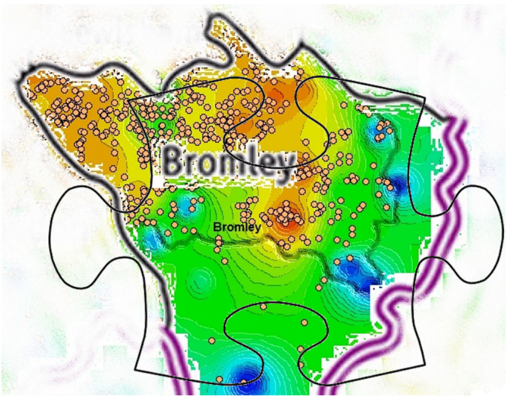


Figure 16 - Detailed Mapping and Analysis of High Risk Areas

Spatial distribution to determine where the risk lies plotting demographic information from the Census (style and age of property, social indicators, occupation etc.), claim frequency, soils and trees (where relevant).

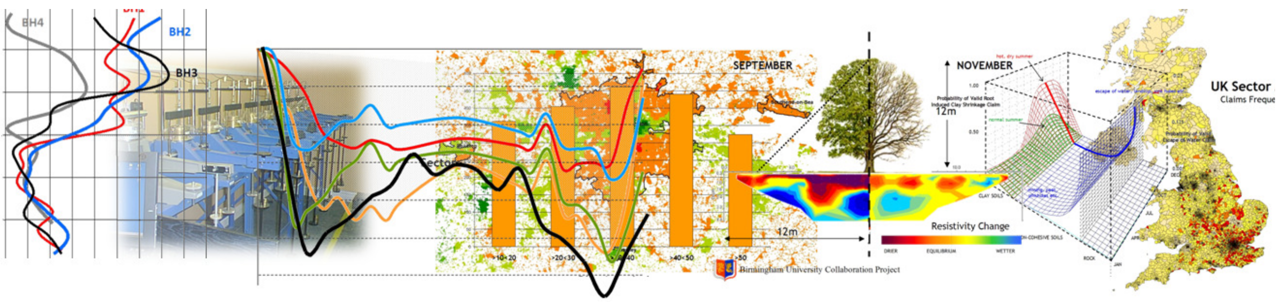


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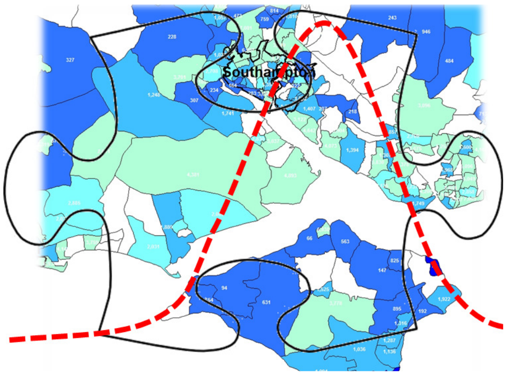
Figure 17 - Operating Peril

Frequency distribution of claims relating to individual perils - escape of water shown right. Whilst clay shrinkage claims have a high correlation with time of year and relationship between damage and vegetation, EoW claims are based on inference of perhaps older houses and a particularly vulnerable geology.



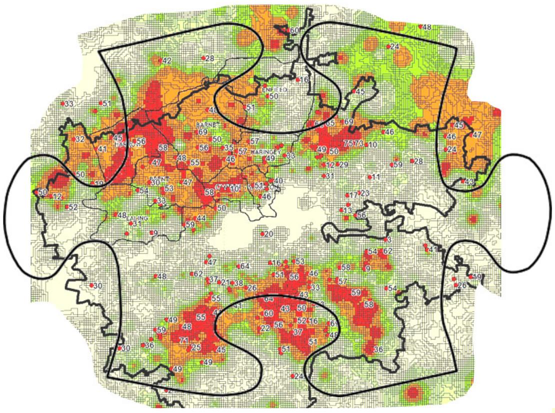


Figure 18 - The Geology

The geological risk particularly for clay shrinkage areas where data from actual site investigations can deliver the P.I. and at a depth where mature trees exert most influence.

Figure 19 - A unique grid

Our digital model is a 250m tiled grid, each square carrying a score between 0 - 1 and combining the various factors described above using a Bayesian approach.

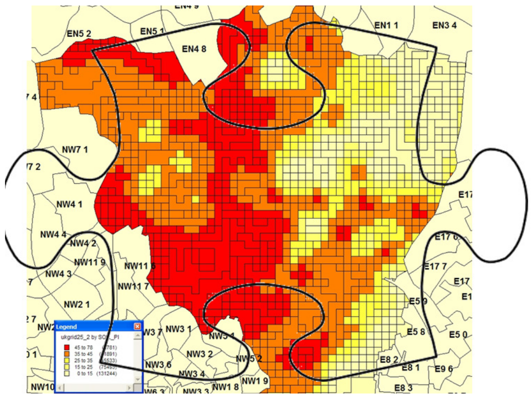
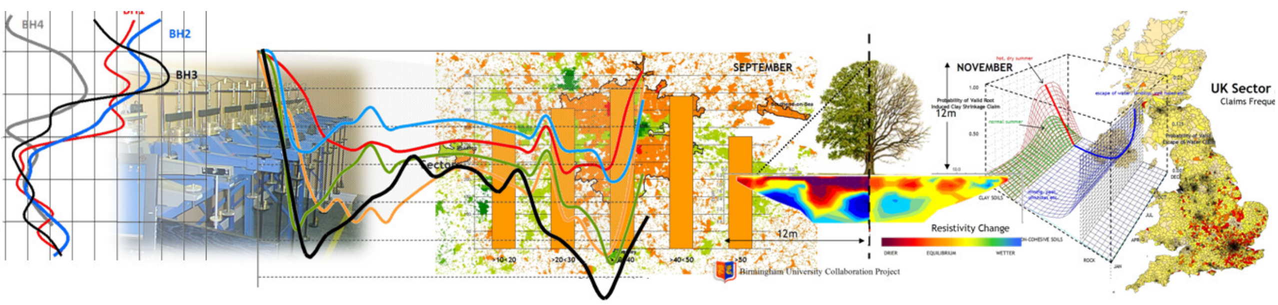


Figure 20 - Highest Resolution Possible

House-by-house or street level analysis delivers the most accurate model and back aggregation to sector level perhaps the easiest to handle by most claims systems although there can be considerable variation across a sector containing around 2,000 houses on average.



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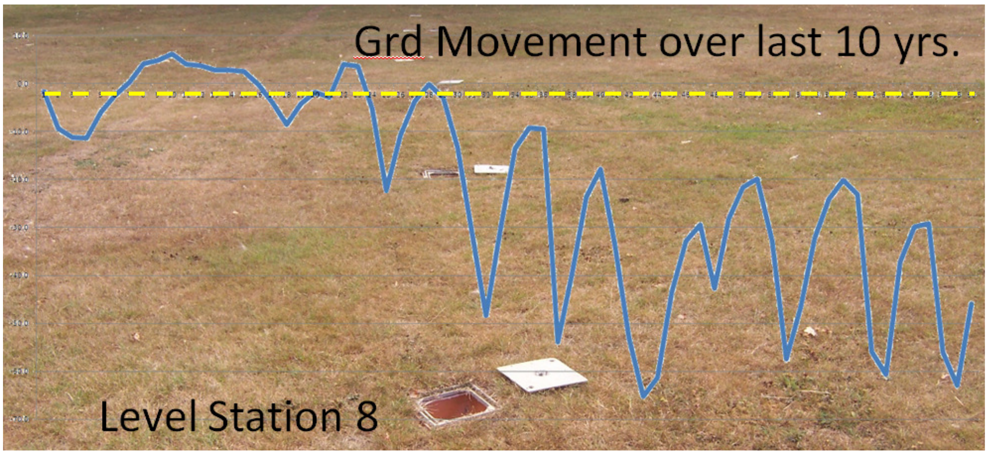
Ground Movement at Station 8

The most travelled ground station at Aldenham, covering nearly 1.2mtrs over 10 years.

Since level monitoring commenced in May 2006, station 8 of the Aldenham willow has travelled nearly 1.2mtrs over the 10 year term, taking into account the downward movement of the station in the summer and recovery over the winter.

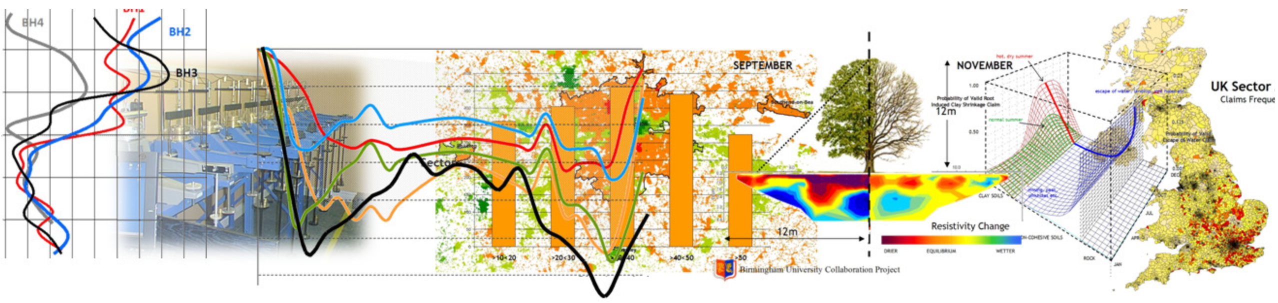


The blue line plots ground movement at Station 8 (galvanised cover removed to take reading) since 25th May, 2006, which was a 'mini-surge year' delivering around 48,000 claims. Although some modest rehydration took place in the winter of 2006, the general trend has been downwards since.

As can be seen from the profile above a persistent deficit is developing which, when combined with the existing drying beneath the canopy, will lead to stress.

The situation is a little unexpected given the heavy rainfall over recent years. This would normally rehydrate the soil surrounding a tree and particularly in the winter when it is out of leaf, but as the periphery of the root system is pressed into service, so the persistent deficit spreads further laterally.

There was a branch fall (picture right) within the crown at the time of an inspection in July, 2014 and although we can't confirm it is a direct result of stress associated with a water deficiency it is similar to the branch fall suffered by the Aldenham oak in 2007.



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Current Research - Trees

Two articles from the journal, "Urban Forestry and Urban Greening"
Published January, 2016 and notified by Keiron Hart, Tamla Trees Ltd.

"Local Impact of Tree Volume on Nocturnal Urban Heat Island: A Case Study in Amsterdam"
Azarakhsh Rafiee et al

The Free University of Amsterdam have recorded the significant benefit provided by crowns of trees in reducing temperatures in their vicinity. To summarise, the researchers noted:-

"The results indicate that tree volume has the highest impact on Urban Heat Island within a 40m radius, and that increasing tree canopy volume by 60,000m^3 in this area leads to a 1ºC reduction in temperature."

"**Below ground matters: Urban soil rehabilitation increases tree canopy and speeds establishment**"
Rachel M. Layman et al

In Arlington, Virginia researchers have found that improving the soil - or as they describe, *"compost amendment via subsoiling to 60cm depth, topsoil and rototilling"* - produced an increase in trunk cross section of 77% in one species and canopy volume of 84% in another.

Not all species responded as well (6 were included in the trial) but the authors believe the approach has considerable merit and may be useful in mitigating storm water flooding.