The
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

October 2015

Edition 125

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CONTENTS

The Months Ahead

The theme of Artificial Intelligence will continue to be explored over the coming months looking at the various components, how they are linked and their relevance in terms of underwriting, triage and claims handling.

What does a valid claim look like and can our systems detect correlation and variance? Can they 'learn as they go'?

October Already

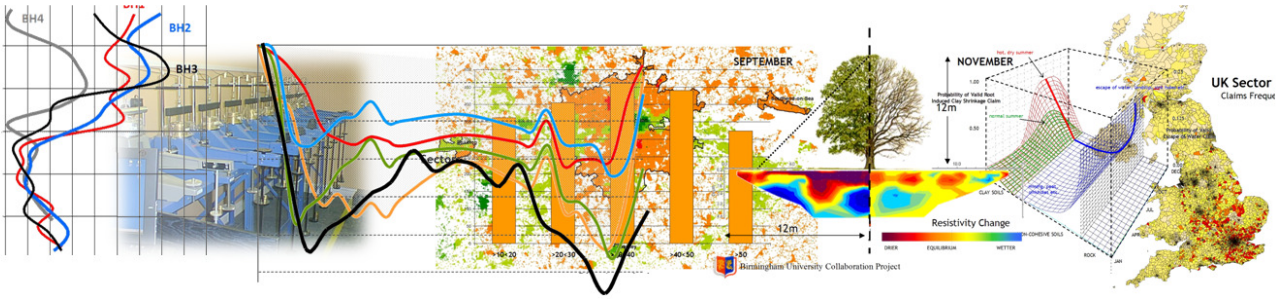
An uneventful year in terms of domestic subsidence, at least in terms of claims received.

The collapse of a road in St Albans associated with old clay workings featured in the news last week with some dramatic pictures in the press and initial reports that the cause might have been an escape of water from a service pipes weakening the backfill of a clay working. Investigations into causation are underway and backfilling with foamed concrete nearly complete under the direction of the Council. St. Albans is an area known for problems of this sort apparently.

Last week BBC4 showed the amazing story of an oak tree, filmed over a 12 month period. The program contained lots of facts and figures, details of how the oak 'sees' as well as the hormonal control and defence mechanisms. One team of researchers measured water uptake, which is of particular interest in terms of root induced clay shrinkage. More inside.

We look at data from the TRE web site to see if we can detect a periodic signature at the site of the Aldenham willow.

This month we start to describe how we use Big Data and analytics to build intelligent systems. All very topical and hopefully with a practical bias. Not to mention IBM Watson's possible involvement.



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St. Albans Road Collapse

A large hole, around 20mtrs across and 10mtrs deep, appeared in Fontmell Close, St Albans last week blocking off access to around 50 homes.

One of the local councillors suggested that the sinkhole could have been caused by a water leak, but the precise cause has yet to be established. Google Street View reveals extensive relaying of the water service beneath the footpath.

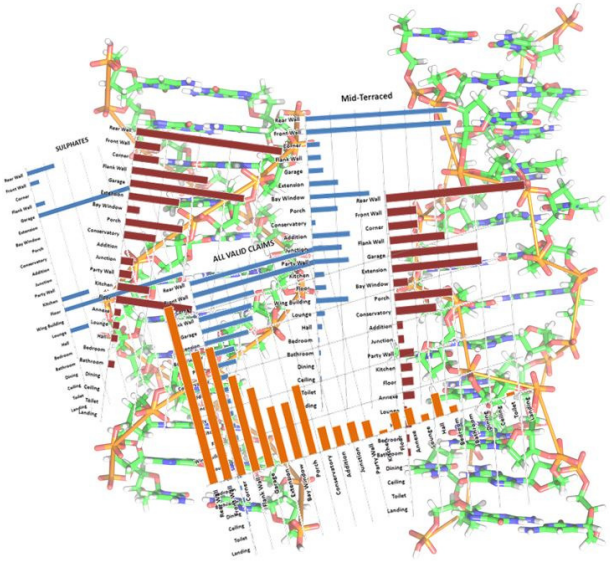
Tony Bracegirdle from GCG supplied the above map confirming the site to have been a clay pit prior to development.

Intelligent Systems

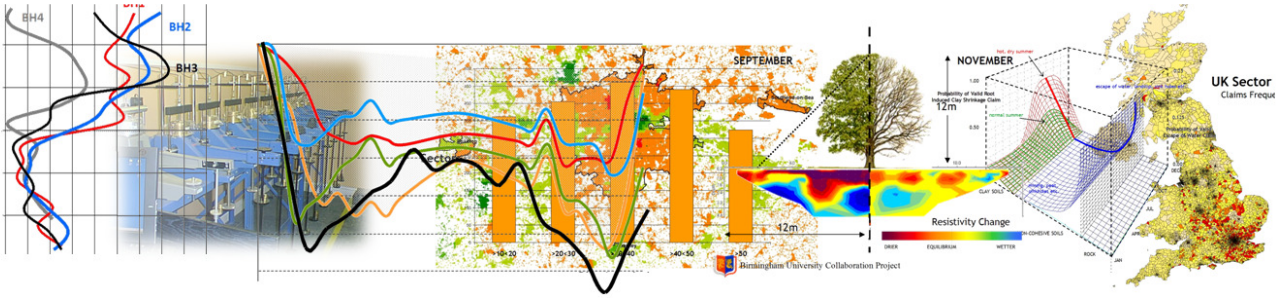
What does a valid claim look like? What are the flags that can help us identify causation?

In this month's edition we look at the application of 'Big Data' and explore how systems can help us identify these elements and going forward, how they can learn from their experience. Can they be used to build tools that might be useful to claims handlers and engineers?

Past editions of the newsletter have carried graphs and described the logic for each of the individual elements, but how are they assembled and codified?



Data is the engine behind intelligent systems - their DNA - and deriving patterns associated with various elements is the key to their 'intelligence'.



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Starting at the Beginning

The database.

Data is usually sequenced by date of receipt of claim, and this disguises the links that may exist between various elements. To reveal those links - associations between sometimes disparate objects - the data has to be re-ordered, many times, taking each column in turn.

On the following page, a much simplified table shows how the structure is changed to retrieve the intelligence it contains.

In example 2, the columns are sorted by soil, followed by claim status - is the claim valid or not?

A pattern starts to emerge showing the possible link between clay soils and valid claims. This is then refined by adding the season to see if there is a link between geology and weather.

In example 3 (bottom image) the database is sorted by (1) soil type, then by (2) weather (using SMD value) and finally (3) by claim validity.

The output reveals relationships between these elements, clarifying that valid claims are more likely to be related to clay soils and drier weather.

Not all data has a relationship to the operating peril or status and the system is codified to measure relationships using correlation techniques.

As a very general rule, correlations greater than 0.7 are regarded as quite strong.

To the above we can add location to derive which rooms - which areas of the building - are related to which peril or the claim status.

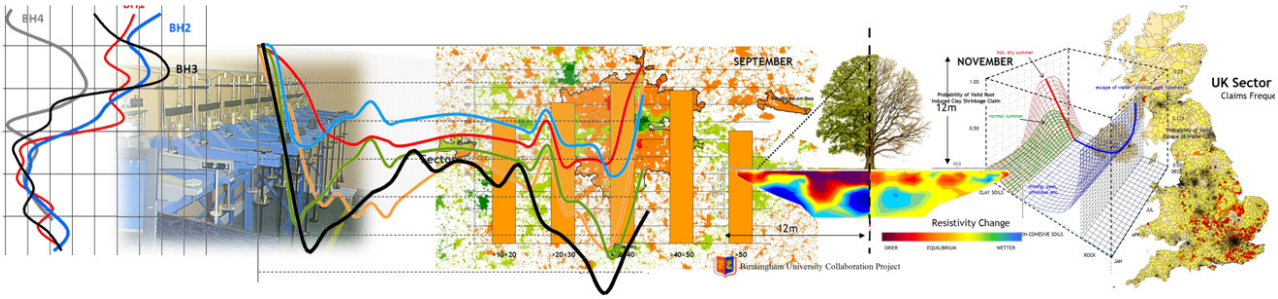
An example is that sulphate claims are linked to damage to floors, which is reinforced by the age of the property. Sulphates were often associated with houses built around the 1950's.

Also, there would more than likely be other claims in the area to reinforce the score. Vulnerable houses were often built on estates.

In general, damage to floors suggests a low risk of the claim being valid. In the case of sulphates the age of the property is an over-riding flag. So, "damage to 'floor' = low probability of valid claim unless property built 1950 + other sulphate claims in sector".

Spatial analysis is central to risk in the case of subsidence, and using sector data reveals links with the underlying geology. Associating the BGS maps with the database allows auto-population of the 'soil' column of the database, which can be over-ridden by the user following investigations.

Plus census data for housing population/frequency/social housing etc..



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Initial screenshot of database prior to interrogation

1

Valid?	Cause?	Date	Soil	Weather	Room	Location
Y	root/clay	August	Clay	119	Porch	Front
N	Expansion	December	Clay	38	Lounge	Bay Window
Y	EoW	February	Drift	2	Garage	Side
N	Shrinkage	June	Drift	93	Hall	Side
N	Old Damage	May	Clay	87	Kitchen	Rear
Y	root/clay	October	Clay	126	Lounge	Front
Y	root/clay	September	Clay	128	Lounge	Bay Window

2 1

2

Valid?	Cause?	Date	Soil	Weather	Room	Location
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Sorting by Soil and then Validity

3 1 2

3

Valid?	Cause?	Date	Soil	Weather	Room	Location
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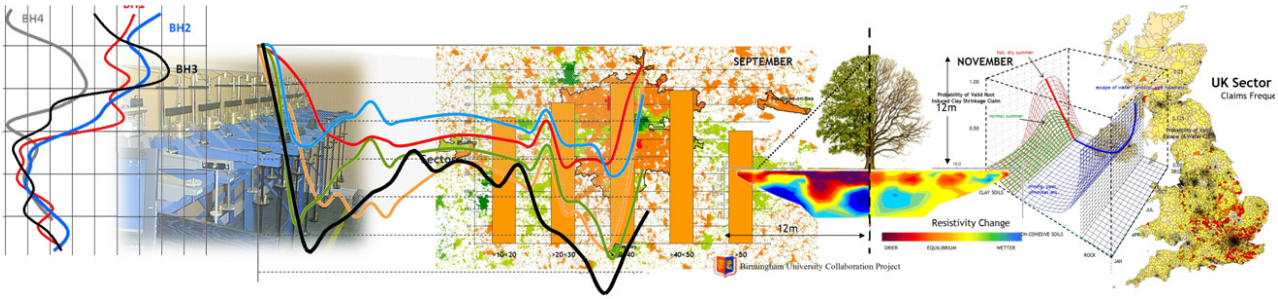
Sorting by Soil, Weather and then Validity



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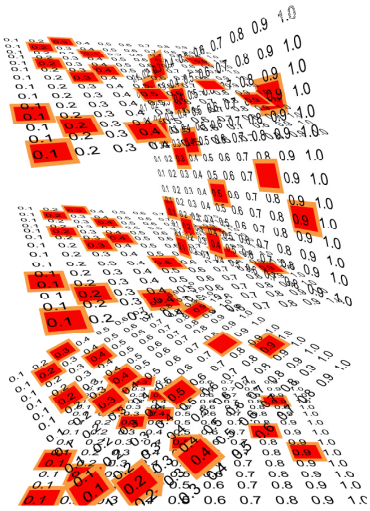
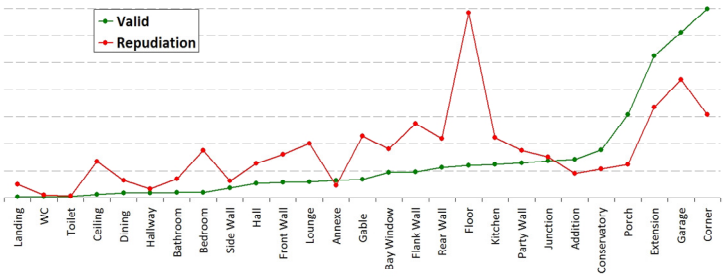
An example of a simple system-learning solution is shown below. By interrogating a claim database and counting the number of records that contain a particular phrase or element (here we search both by room and external location – "hall" and "rear wall" for example) the system detects similarities and variance between them. It is identifying characteristics and distinguishing features by class - in this instance by claim validity and operating peril.



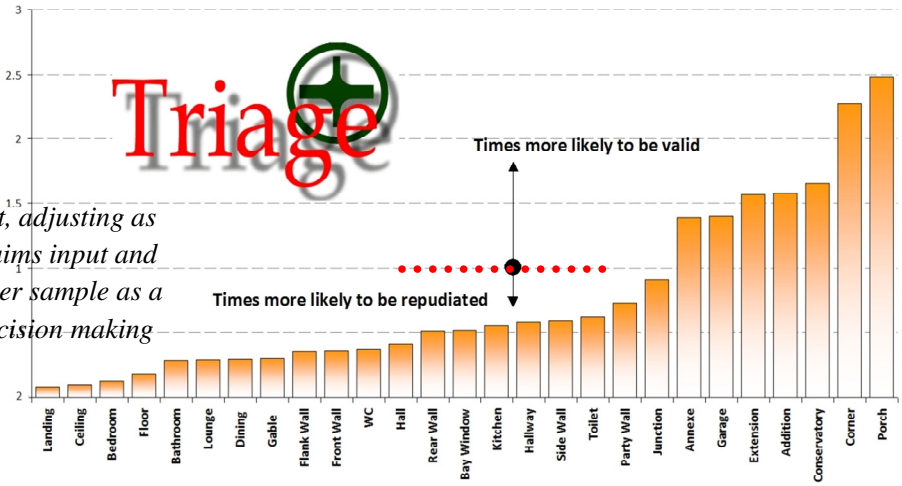


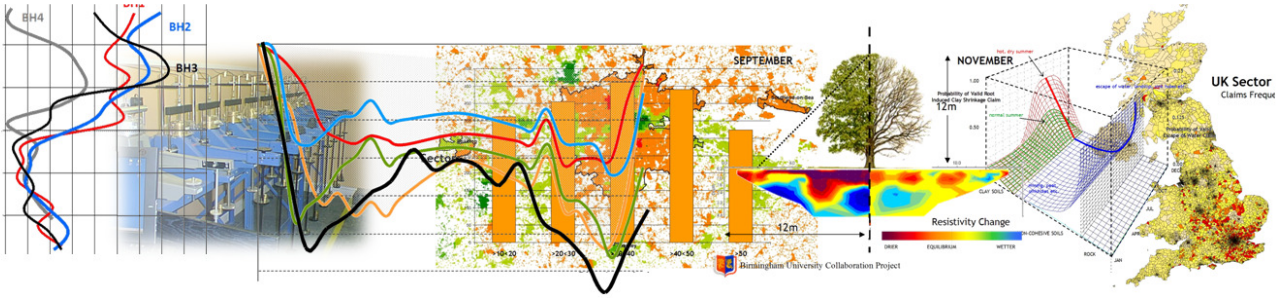
'Detecting the difference' using database records. First, sort the elements into a rank order – this is the green line on the graph plotting valid claims by location. Then determine variance.

'Corners' are more likely to be associated with valid claims and floors with repudiations. The benefit of this is that difference can be quantified. "How many times more likely …".

The graph below illustrates the output from a sample of around 10,000 claims. We have used a "times more likely to be valid" approach. If the database has, say, 20 records of damage to a corner, of which 15 were valid and 5 repudiated claims, then notification of damage to a 'corner' would be three times more likely to be valid in the Triage application.

Self-regulating output, adjusting as it learns from new claims input and benefiting from a larger sample as a result, helps build decision making tools.





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What Could Possibly go Wrong?

Examining the Data

Taking the example on the previous page, it is important to examine the data structure before undertaking analysis.

For example, the number of claims involving 'damage to side wall' may be under-estimated if we don't understand that this term may appear elsewhere as 'gable' or 'flank'.

Similarly, extensions are high risk and the analysis must capture both room ('kitchen') as well as location ('rear elevation') and whether the structure is an addition.

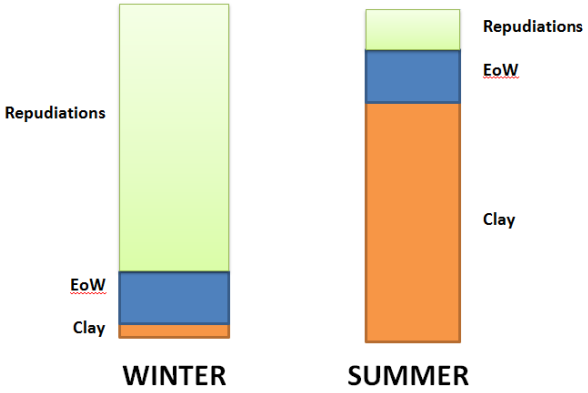
And then we have the problem around whether we are using data from a surge or a normal year.

Our analysis uses a '1 surge year in 5' structure to ascribe a probability. As claim numbers reduce and weather becomes less predictable that may need re-visiting.

For example, the chances of a claim being valid on clay is far higher in a surge year than in a normal year. In a surge year, the probability might be 80% or so, whereas in a quieter year that value may be around 20%.

See graph, right. Escape of water claims

Clay shrinkage claims are far fewer in winter months than in the summer. The difference below (clay is shown coloured brown) influences the outcome of the probability calculation.



This dynamic distribution over twelve months, varying by prevailing weather conditions has to be taken into account.

How can we take account of this change over time? Or, how can the system 'learn as it goes'?

Tree control measures and the reduced risk presented by modern houses have to be recognised which is where the AI element comes in.

It takes two forms. One is looking at a dynamic world and detecting change quickly. The other aspect is automating certain tasks. Future editions cover these topics.

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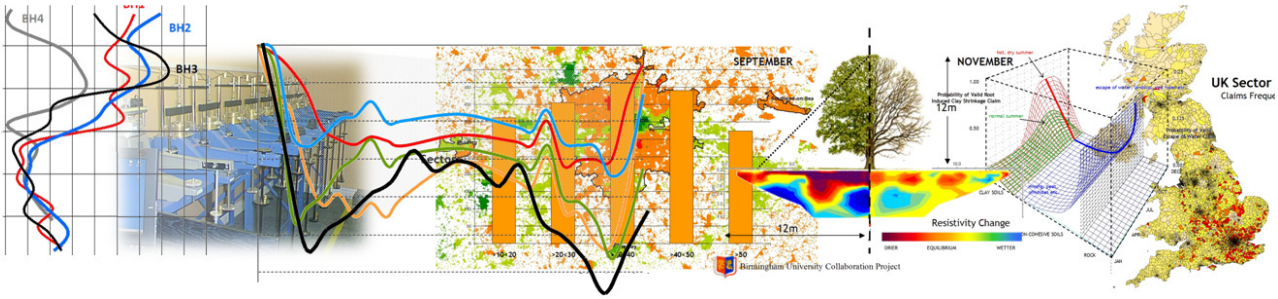

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A Year in the Life of an Oak Tree

"Oak Tree : Nature's Greatest Survivor" gave a fascinating account of the trials and tribulations of a 400 year old oak over a twelve month period.

Screened on BBC4 on the 1st October (still available to view on iPlayer until the end of the month) the program was enthusiastically and knowledgeably presented by Dr. George McGavin.

It filmed researchers producing a 3D map of the oak using LiDAR and then using the survey to estimate that it had 700,000 leaves with a total area of 700 sq mtrs.

Another team based at East Malling excavated the root system of a 15 year old sapling whilst others measured water flow through the trunk using electrical resistivity.

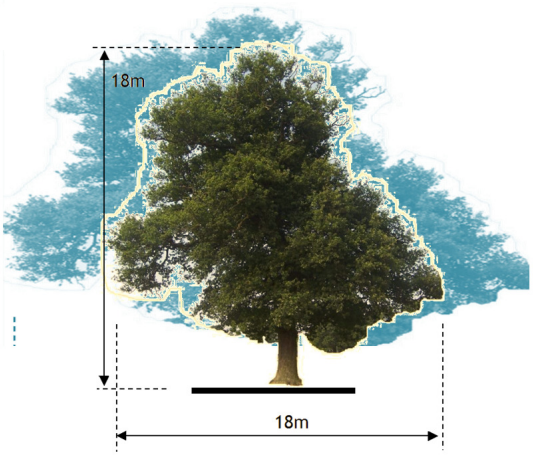
In addition, Dr. McGavin explained the role of hormones in regulating growth and mobilising defences as well as some high resolution pictures of bugs that call the tree home.

The oak was 19mtrs tall with a 30mtr diameter canopy and estimated to weigh around 10 tonnes. In the year of filming, the tree produced 230kg of wood by new growth.

Of particular interest was the water uptake, bearing in mind our own estimates at Aldenham.

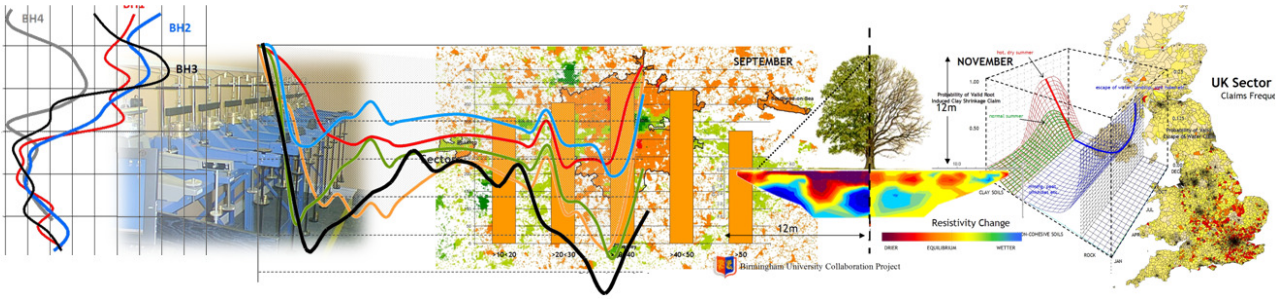
The research team calculated that the oak that formed the subject of the program had a water uptake of 70ltrs / hr. Over the 71 day term that measurements were taken it drank a total of 58,822ltrs water.

Moisture content data gathered by Southampton University using the neutron probe suggested that moisture uptake by the Aldenham oak was 172,000 ltrs over a year.



with the Aldenham oak? Picture shows the Aldenham oak superimposed onto the one that formed the subject of the program.

This equates to around 100 ltrs an hour averaged over a 10 hour day for the 6 month term that the tree is in leaf, variable by month/week/hour.



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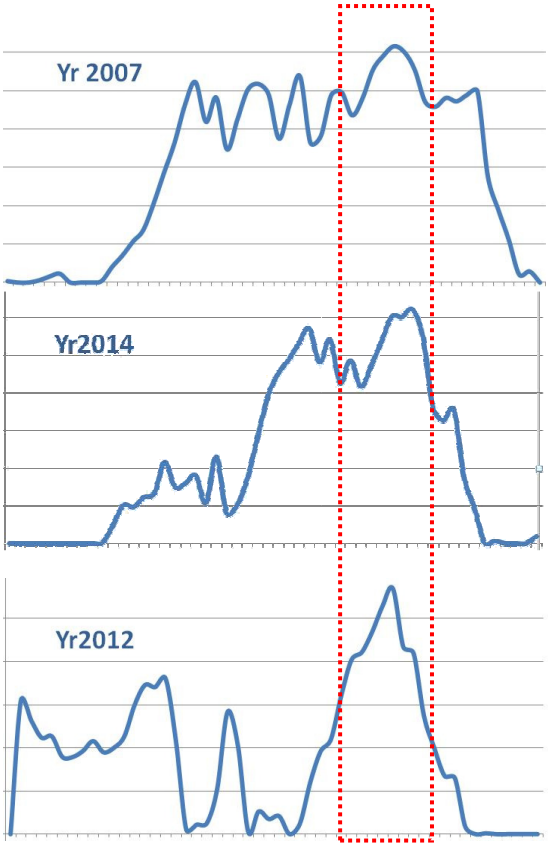
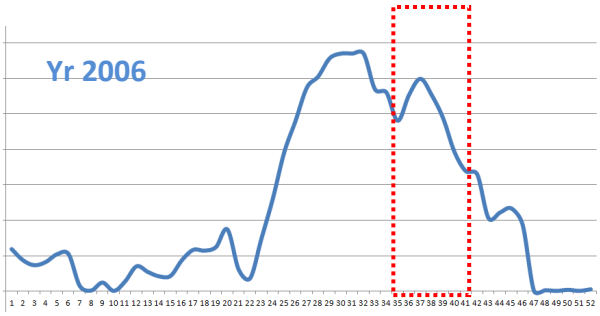
Do Indian Summers deliver high claim numbers?

Often, after a slow year in terms of subsidence claim numbers, hopes are temporarily raised when the sun eventually shines and people talk of a possible 'Indian Summer'. Can a late start really deliver an upturn in root induced clay shrinkage claims? To test the theory, we have plotted the SMD data for several years with an 'Indian summer' below.



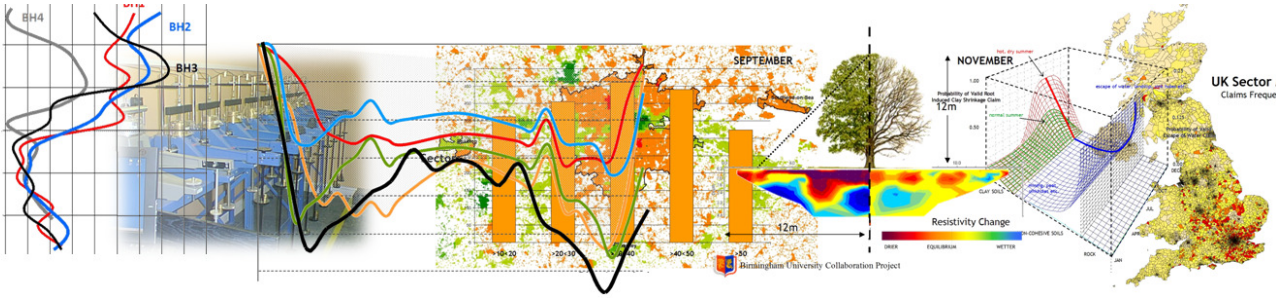
None delivered high claim numbers. This supports the view that it is the situation in the early months of the summer that determine water uptake and play a significant role in clay shrinkage claims.



2006 (above) started late, but only in terms of comparisons with the spring/summer rise of the SMD. In fact it (the SMD) peaked in June with a value of 134mm - the maximum on the deficit scale.

In keeping with the theme of system learning and AI, a sample of claims data will be entered into the IBM Watson application over the next month, if we can make the time, and we will report on the results when available.

This follows an introduction from our colleague Tony Boobier, Worldwide Executive at IBM, who has invited us to look at OLAP, the Online Analytical Processing tool - full report to follow.



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August Review

Met Office Charts
Rainfall and Temperature

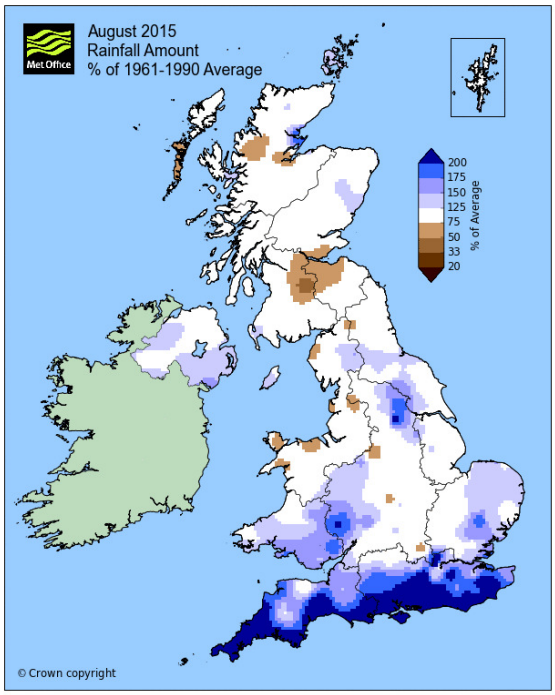
Right, August rainfall compared with a thirty year average - 1961 - 1990.

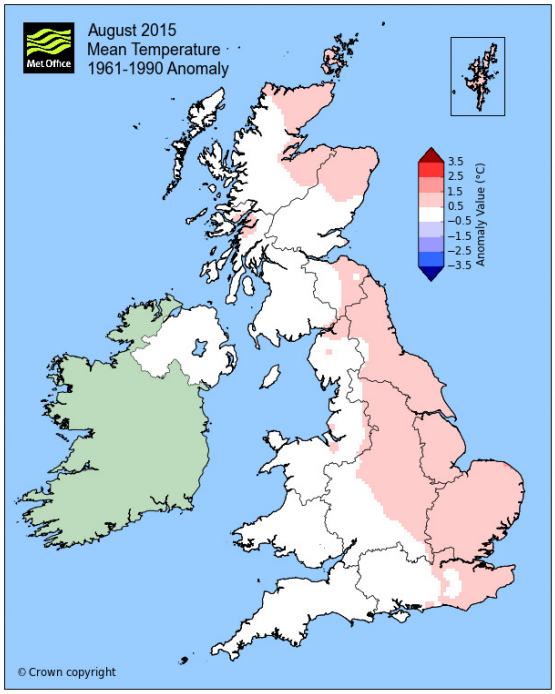
Far wetter on the south coast than the 30 year average which goes some way to explaining the low claim numbers for the summer months.

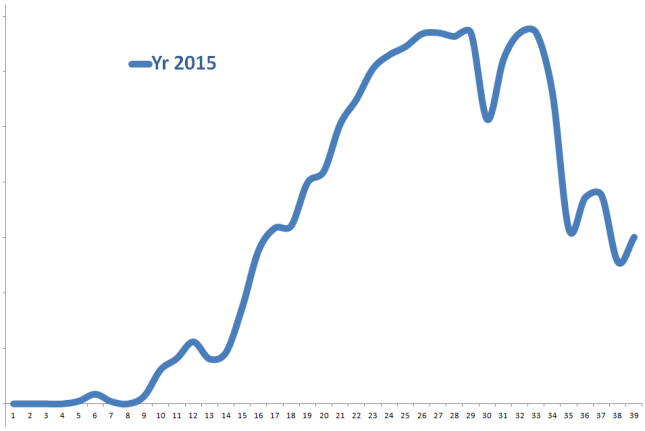
Bottom right, average temperatures generally, with slightly warmer than average values along the east coast.

For further information, including images of interactive weather charts, go to ...

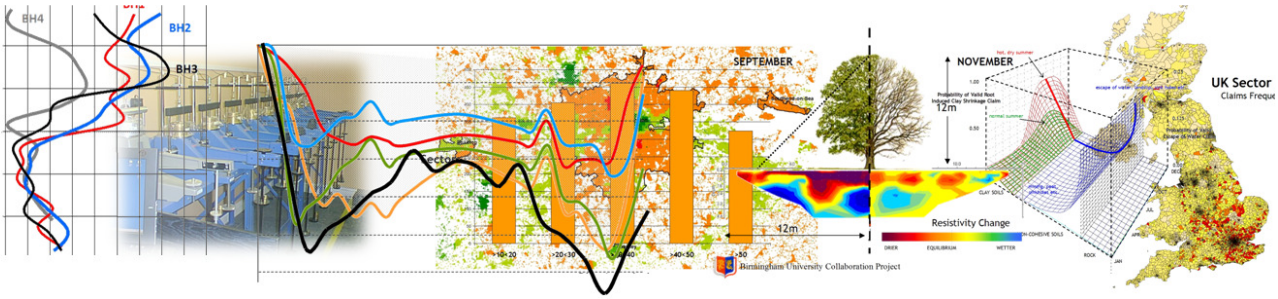
www.metoffice.gov.uk/public/weather







The current SMD has fallen away quite sharply following heavy rainfall and there is no prospect of a late surge in claims.



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"Stability monitoring of a rail slope using acoustic emission"

Dixon, Smith, Spriggs *et al*.
Download from NCE web site
Published online 06/05/2015

Heavy rainfall over recent years has resulted in an increase in the number of slope stability claims. Water reduces the friction between particles, increases the weight of the soil and the dynamic of downhill flow results in slippage.

This paper explores a means of monitoring movement using acoustic waves with the added benefit that alarms can be raised using SMS messaging.

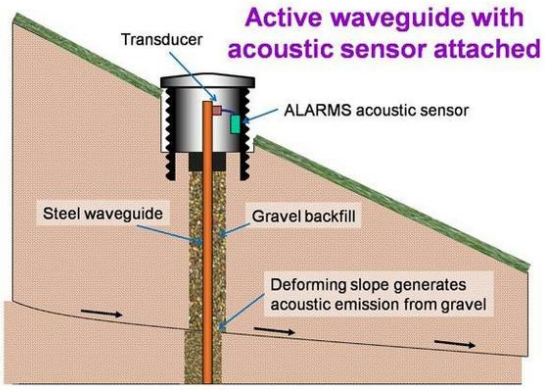
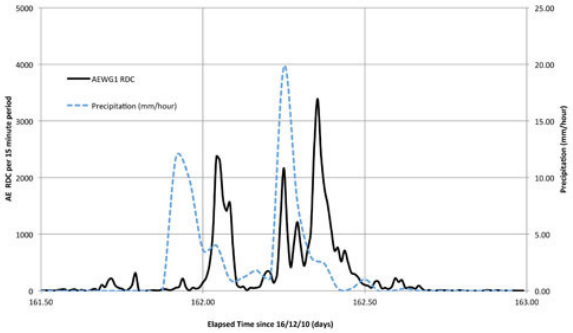


Image from the web illustrating the method. The waveguide sensor is embedded in gravel. Movement within the gravel emits a noise that is detected by the sensor.

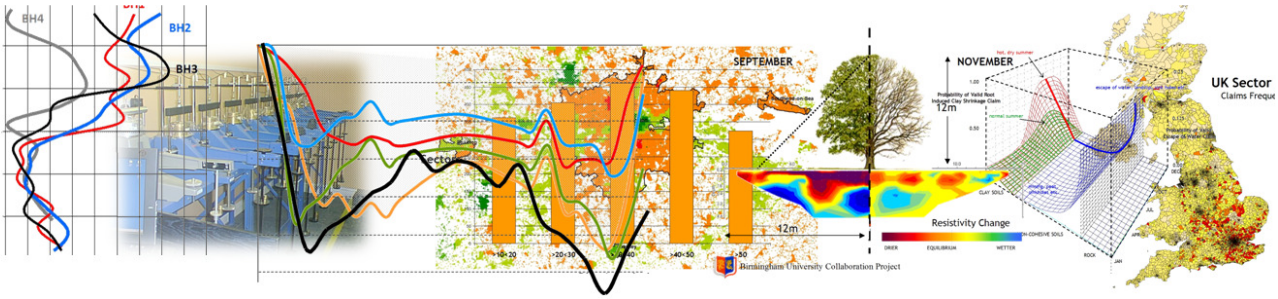
The abstract explains that the "acoustic emission rates generated by active waveguides are proportional to the velocity of slope movement."

The results are described graphically and the system records periods of active, rather than cumulative, movement although we assume this could be resolved in the software.



The above graph taken from the web site of Slope Alarms plots the relationship between rainfall (blue dotted line) and slope movement (black line). Visit their web site at www.slopealarms.com for more details.

The authors of the paper comprise a team of researchers from Loughborough University and the BGS with a contribution from Andrew Ridley of GeoObservations. Andrew developed the soil suction sensor in his time at Imperial College.



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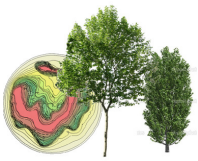


Tree News Snippets

Mapping Tree Density on a Global Scale
Crowther et al, Nature, 2015.

A study published in Nature suggests that whilst we thought there were around 61 trees per person, there may in fact be 422. Good news on the face of it, although the authors point out that the number of trees has halved since the birth of civilisation.

Spread of Oak Processionary Moth

Reports that the moth is spreading with a suggestion that the controls being trialled may not be effective.

Ring Barking Research
Paper published in the Journal of Urban Forestry and Urban Greening.

Dr Glynn Percival of Bartlett Tree Research Laboratory based at the University of Reading has found that ring barking is not lethal to oak trees, but can kill birch trees.

The research found that oaks survived ring barking whatever season it was carried out, whereas birch trees were more sensitive if the ring barking was undertaken in the winter, when all of the trees died.

They were less vulnerable (40% of trees died) if it was carried out in the spring. Less severe girdling, of 25 and 50 per cent, was found not to affect the growth and vitality of either species.

GLO-Roots: an imaging platform enabling multidimensional characterization of soil-grown root systems
published in *eLife*, August 2015.

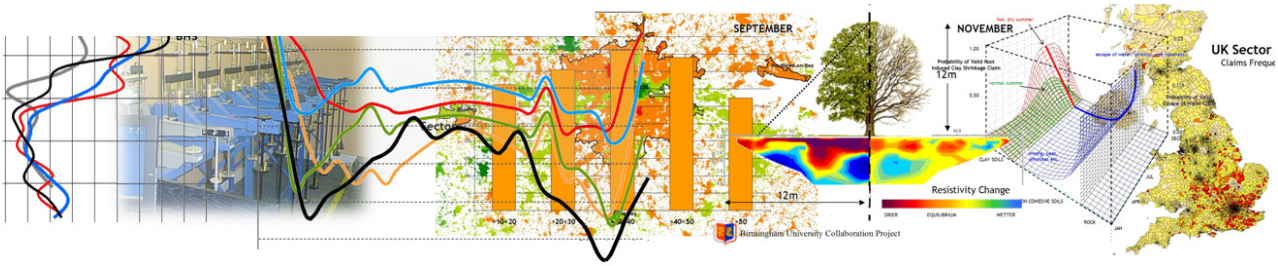
Rubén Rellán-Álvarez and his team describe a new imaging tool to study the dynamic growth of root systems in soil, and to uncover the molecular signalling pathways that control such growth in their paper.

Multi-year drought-induced morbidity preceding tree death in Southeastern US forests.
Ecological Applications
published in 2015.

Although it is probably less of a problem here in the UK with the current weather patterns, researchers Aaron Baird Berdanier and James Clark from Duke University have found that damage suffered by trees during a drought can reduce their long-term survival for up to a decade after the drought ends.

Whilst it is known that a severe drought can result in tree death, it wasn't appreciated that the effect could extend over such a long period.

The research included a study of nearly 29,000 trees at two research forests in North Carolina.



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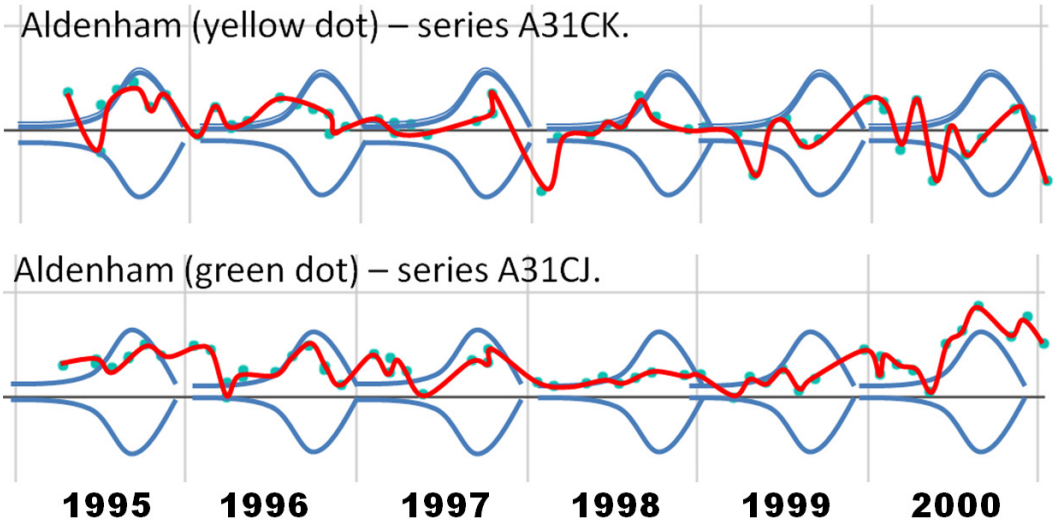
TRE Mapping at Aldenham

The use of satellite data to detect ground movement

The TRE satellite data includes coverage of the Aldenham Research Site in the vicinity of the willow tree. We have been gathering precise level data from this tree since 2006 and recorded a periodic signature typical of root induced clay shrinkage. See blue (bold) line below for anticipated characteristic seasonal signature. Two signatures have been used to take account of an inverted signal if the datum was moving in relation to the station.

This seasonal pattern is superimposed onto the satellite data (red line) to see if there is a correlation. The two data series (A31CK and A31CJ) are shown below.



The location of the datum for the series isn't known but it may not be a 'fixed' station. For example, it may be a roof or other clearly visible structure. It could be moving seasonally to confuse the signal. If the data could be re-run against a fixed structure (tall block of flats with deep foundations for example) the output might be more useful in handling domestic subsidence claims, although the resolution (by which we mean spacing between stations) suggests that we are some way away just now but well worth further consideration.

Note: Last month we looked at TRE maps but gave the wrong web address. It should be www.treuropa.com.