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

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

September 2015

Edition 124

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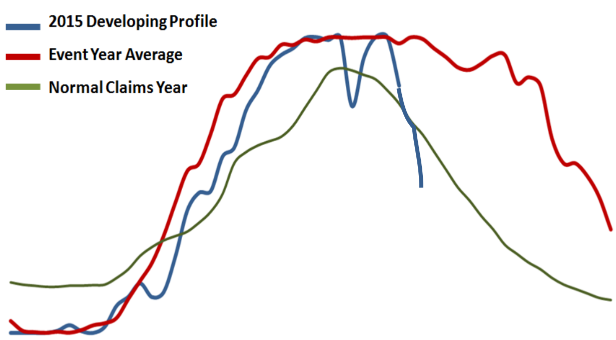
SMD GRAPH

August 2015



SMD data provided courtesy of the Met Office. Data for Tile 161, medium AWAC, grass cover. See page 8 for Met Office summary of August weather.

August Update

This month's edition reviews the subsidence model in greater detail and looks at weather patterns, reporting from a range of sources.

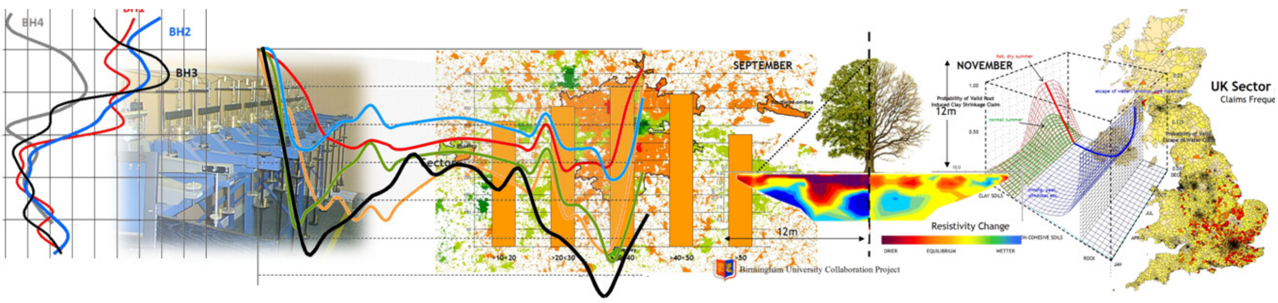
The National Oceanographic and Atmospheric Administration (NOAA) reported on the 13th August that El Nino is likely to be the strongest on record, which often leads to wetter than average winters in the southern United States but dry conditions in Australia, Indonesia and India.

Here in the UK the threat of an increase in subsidence claims resulting from the steep rise in the SMD in June/July seems to have passed with the development of the 'saw-tooth' profile (see blue line, left) associated with intermittent bursts of heavy rainfall.

Local weather differences continue to protect the UK from an increase in claims associated with global warming. When they do eventually arrive, are the current soil tests overkill when we need to identify plastic soils?

Does testing to determine soil plasticity (i.e. "is it clay?") need to be simplified? Rolling out threads of clay and determining moisture content when they reach a certain diameter is a rough and ready test at best. Does it add anything?

Nature carries a report from Zhu Liu, an ecologist at Harvard University, suggesting that China's emissions may have been over-estimated in the past by as much as 14%, although it is still the world's largest emitter of carbon dioxide.



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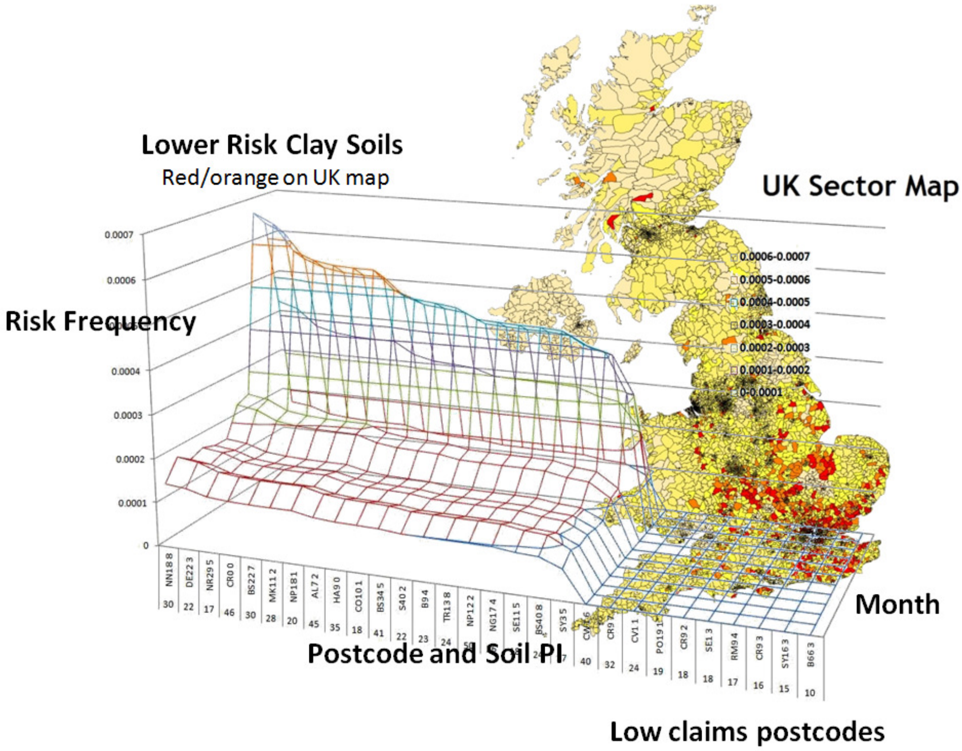
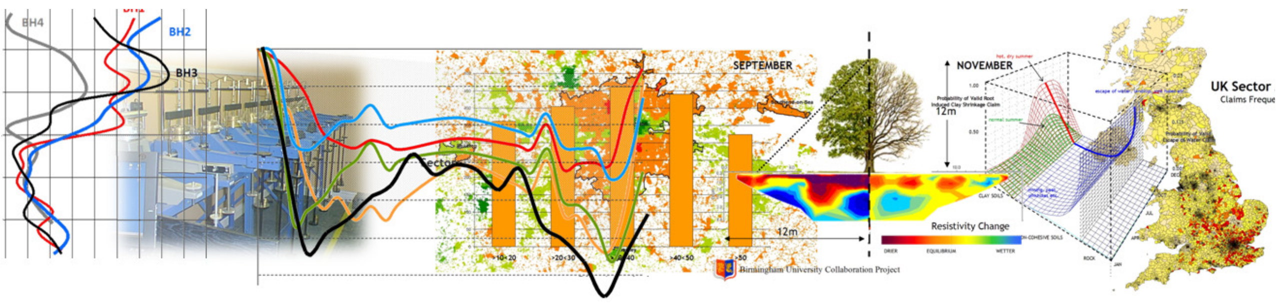
3D Model of Subsidence Risk

The wire-frame model below and on following pages represents the risk of subsidence categorised by cause (i.e. the spatial element at either postcode sector or unit level sorted by geology) and season (risk by month) with plots for event and normal years restricted to postcodes on clay.



The simplified postcode sector graph above has been produced using MS Excel and the only limitation is the inability to produce 3D graphs for the amount of data the spreadsheet contains. For ease of use the extremes at each end of the geological spectrum have been plotted. Above, lower shrinkage clay sectors as they merge with the 'low/no claims' sectors and on the following page, sectors with non-cohesive soils - sands, gravels and mixed drift deposits with a PI less than 20% and subject to escape of water and a reduced periodic signature.



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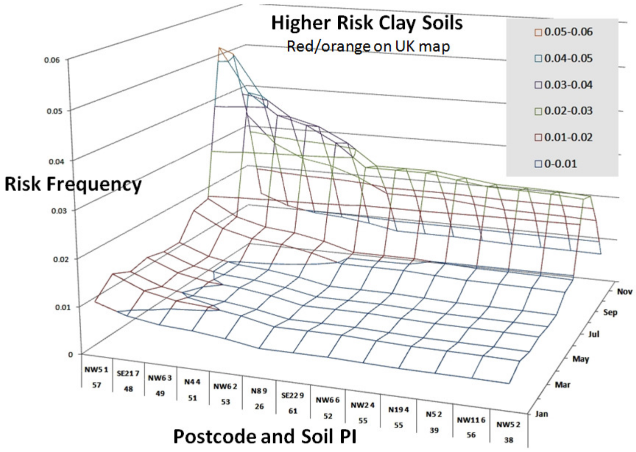
Risk Model



Higher risk clay postcodes with risk plotted by month shown left. The model accounts not only for surge and normal years but differentiates between 'all residential' and 'private only' taking account of social housing.

Below, the risk on non-cohesive soils which is less volatile and not as susceptible to seasonal change.

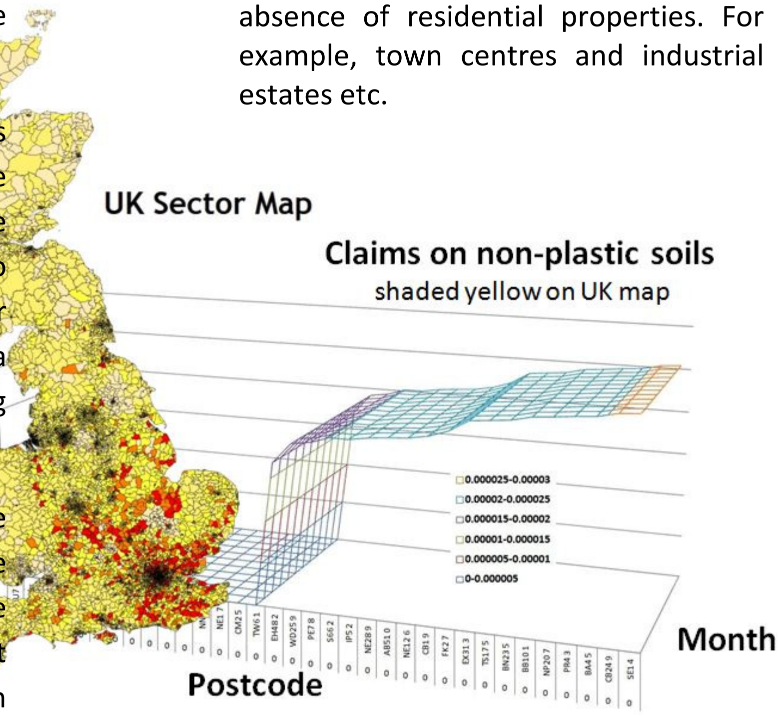
Between the two extremes around 20% or so of UK postcodes are low risk with little claims experience.

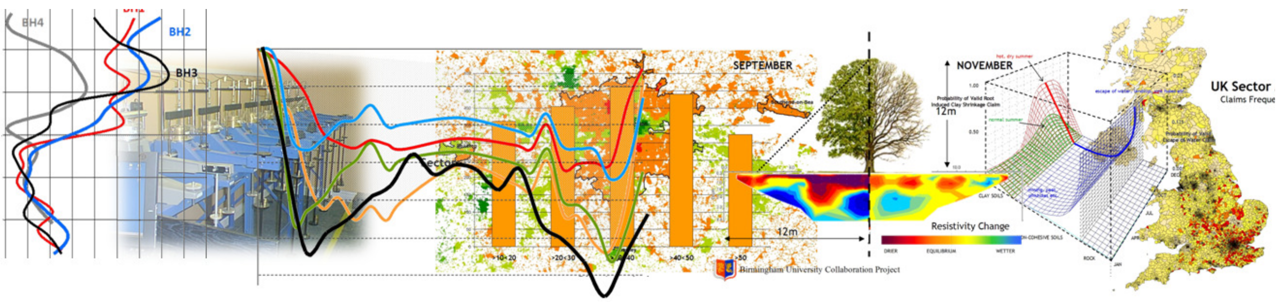
This may be associated with geology or absence of residential properties. For example, town centres and industrial estates etc.

The risk frequency values are adjusted according to user requirements and can be linked to a weather model.

By plotting the two extremes - surge and normal years - the risk frequency value for the clay sectors can be linked to an SMD algorithm to factor risk 'live' as the weather data is received. See following page.

The graphs illustrated here are small extracts from the 10,000 or so postcode sectors. The model of risk at full postcode level contains in excess of 1.7m records.





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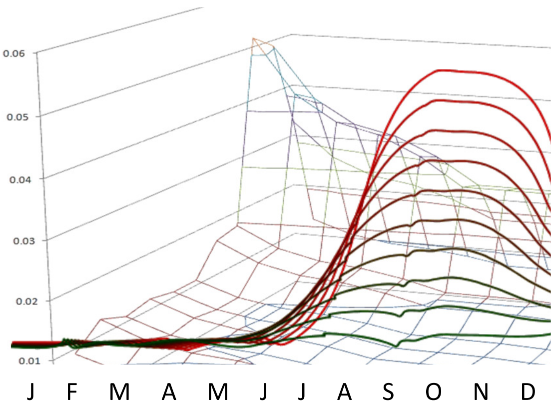
Adjusting the Model to Take into Account Current Weather Conditions

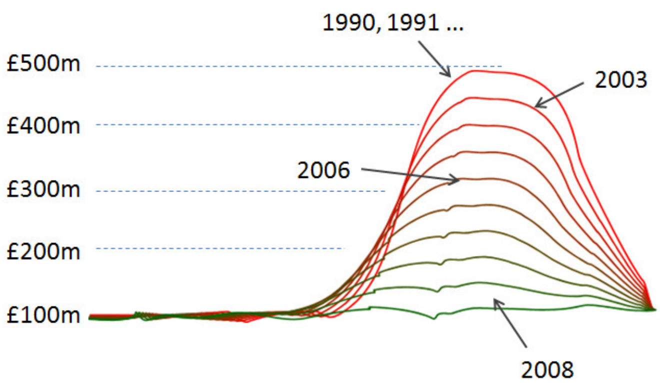
The top graph plots the month-by-month signature of claim fluctuations related to outcropping clay soils for a range of weather conditions.

The top profile, shown by a red line, represents a particularly dry year with high temperatures and low rainfall. The green line represents a benign claims year with heavy rainfall.

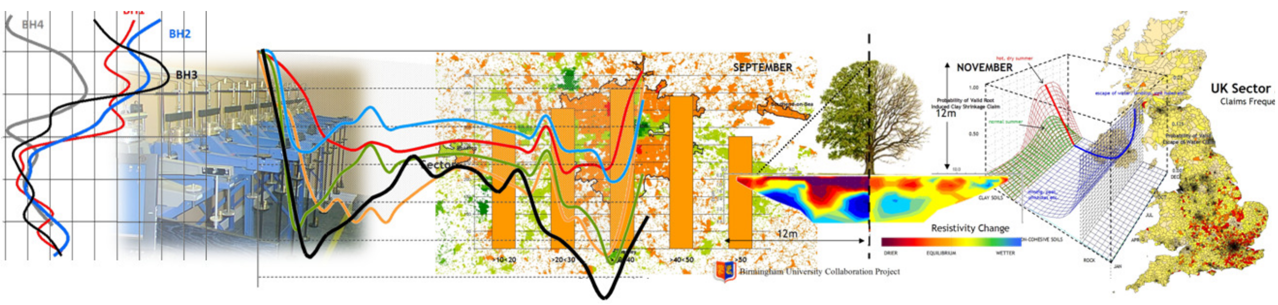
The 'weather regulator' graph superimposed onto the 3D postcode sector map for the clay series.



Below, years associated with each of the profiles. For example, 2003 was particularly dry with little rainfall which resulted in high claim numbers for a selection of sectors on clay soil. In contrast, 2008 was milder with more rainfall and consequentially, fewer claims.



Associating profiles with particular claim years illustrates the significance of clay soils in terms of their contribution to claim numbers, volatility and cost.



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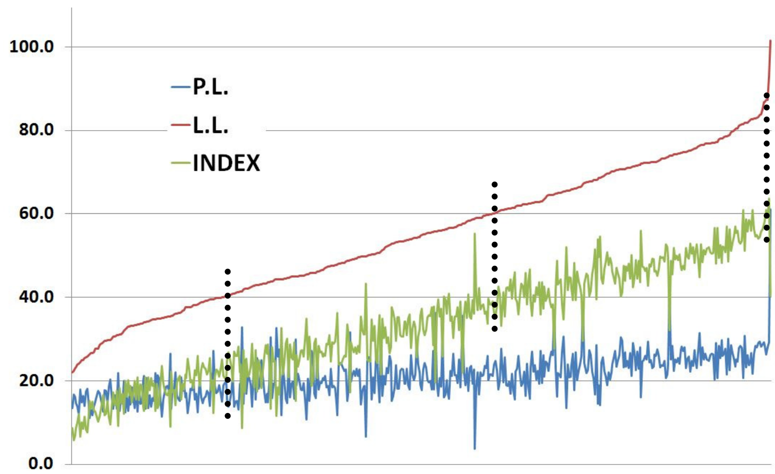
Atterberg Limits - Assessing Plasticity

BRE Digest 412 deals with the issues surrounding soil testing in detail. Here we look at Atterberg Limits and in particular, the value of testing for the Plastic Limit, bearing in mind the issues raised in BRE 412 and comments made by Richard Driscoll relating to assessing desiccation using moisture content comparisons with the LL and PL.

In most cases where damage is thought to be the result of root induced clay shrinkage and Third Party trees are involved, it is customary to obtain soil samples and carry out a range of tests. But just how useful are some of the tests, what are their purpose and how do they compare?

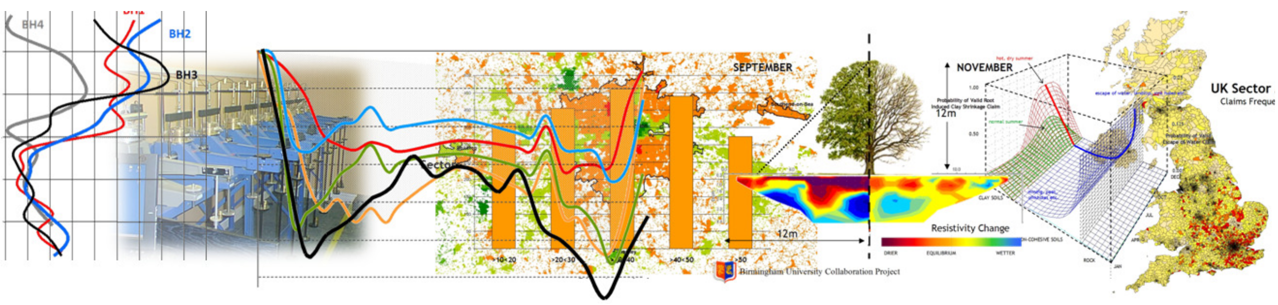
Below we have plotted the results of Atterberg Limits from over 1,000 samples comparing the PI and PL with the LL, plotted in ascending order.



What is clear is that the Plastic Limit increases with the LL and although there is some scatter (see insets below main graph), the 'noise' doesn't change the fact that, in general, the LL is all that is needed to assess whether a soil is shrinkable and the broad category in terms of low, medium, high etc.

Does knowing whether the soil has a PI of say 38 or 45% change the outcome? In the light of Richard Driscoll's explanation, is an understanding of the relationship between moisture content and index properties central to determining desiccation? The Atterberg Limits simply determine whether the soil is plastic and undergoes volumetric change in relation to a fluctuating moisture content. Where other tests (suctions, oedometers) confirm desiccation, do we need the uncertainty that measuring the PL delivers?

A LL greater than 40% tells us that the soil is plastic for the purpose of assessing whether it is subject to volumetric change related to Mc. The above graph suggests that the soil behaves plastically if the LL is greater than 40%. A PI in the range 20 - 40% can be inferred from a LL between 40 - 60%, and a PI of between 40 - 60% inferred from a LL of between 60 - 80%.



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Atterberg Tests - The Plastic Limit.

Time for Change?

The LL has a much wider range making it far easier to determine plasticity.

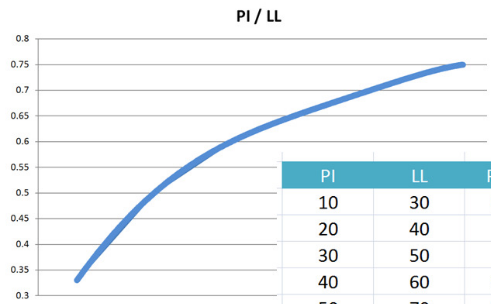
For clay soils in our sample, the LL is 60% compared with 20% for the PL and 40% for the PI.

In summary, the LL test is more reliable than the PL test and the wider range makes assessment of plasticity far easier.

The PL test is less reliable and adds little to our understanding. Particularly so where a supplementary test is used to provide evidence of desiccation.

Rolling out threads of soil to determine whether they crumble beyond a particular moisture content is at best crude and of limited reliability. Any notion of 'accuracy' is mute given the changes in structure and mineralogy over just a few metres in the ground. We simply need to know if the soil undergoes volumetric change in relation to its moisture content and the LL test is more reliable and sufficient for our needs.

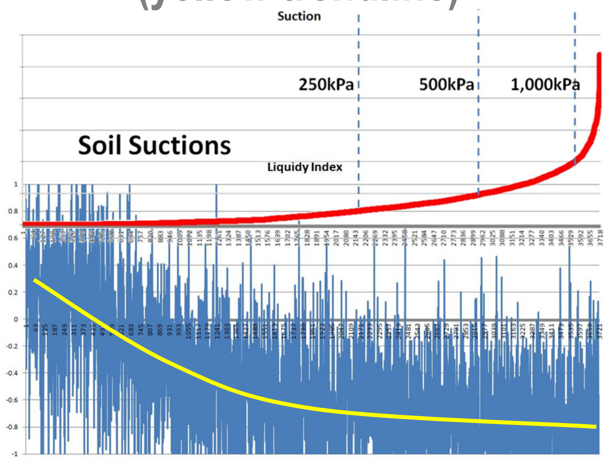
Below, a chart graphing the relationship between the LL and the PI together with a table showing the underlying data.

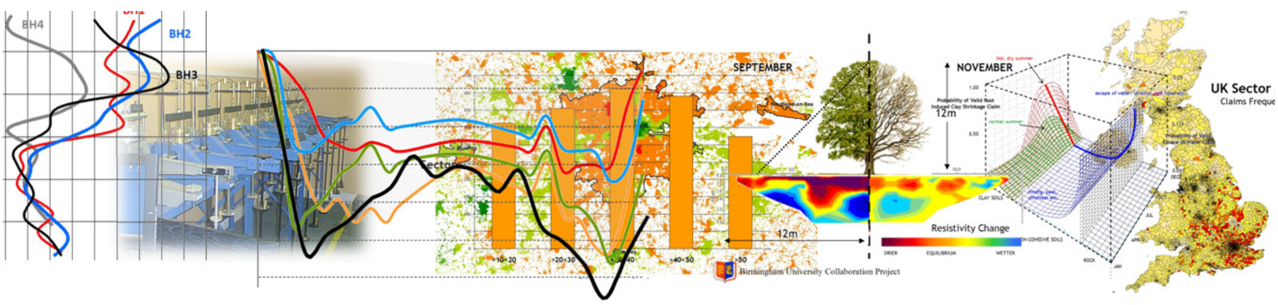


PI	LL	PI / LL
10	30	0.33
20	40	0.5
30	50	0.6
40	60	0.66
50	70	0.71
60	80	0.75

Where we simply need to understand that the soil is a shrinkable clay and setting aside using the Atterberg indices as a means of correlating with the Mc to determine desiccation, the LL alone should suffice.

Soil Suctions (red) -v- Mc compared with (PL + 2%) (yellow trendline)





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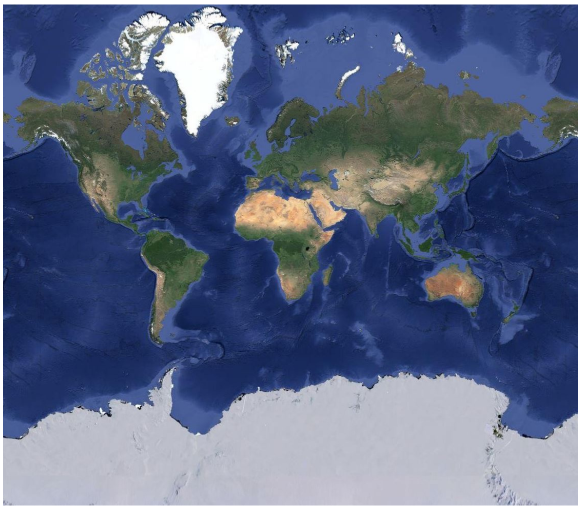
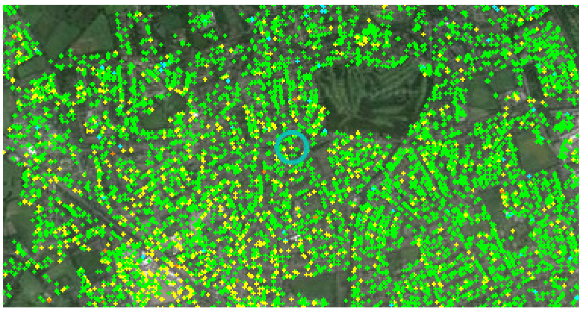
TREmaps - InSAR Satellite Imagery

TRE (www.treeuropa.com) have produced an excellent map of the world using satellite imagery and their web site provides access to a range of data including the ground instability series from the BGS.

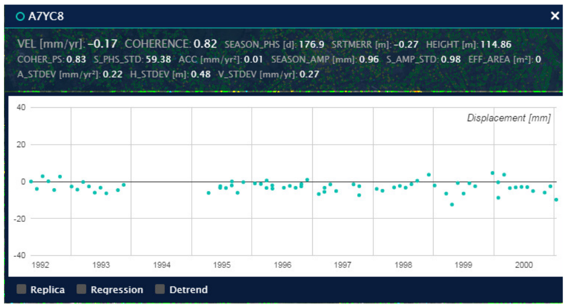


Users can enter a location which opens in Google Earth.

As an introduction, select 'Harrow' where it says location and then from the top left hand corner of the new screen select 'London City, ERS, D, Sqeesar' to access ground data. See output below.



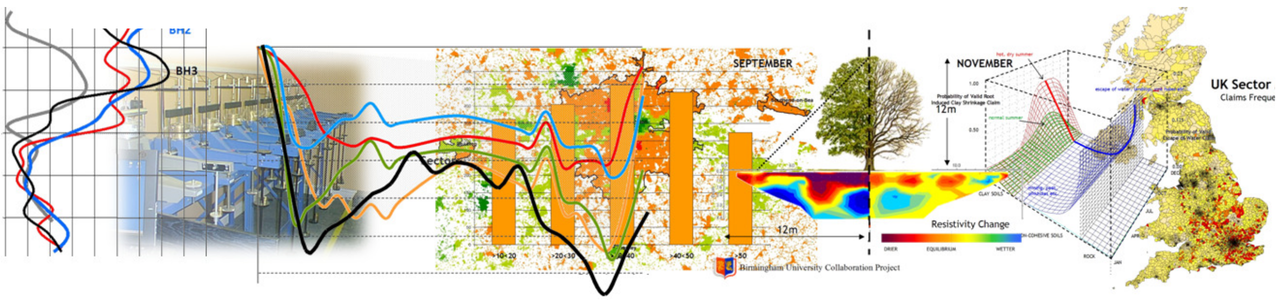
Select one of the dots, and a further screen appears listing readings over time.



Data is available from 1992 to 2000 and includes velocity, season, area, height, coherence and a range of standard deviations. Ground displacements are shown as a row of dots with movement in mm.

By clicking on one of the dots, measured movement is listed. In the example selected, the point was +7.99mm on 24th December, 1999 and -9.2mm on the 23rd April, 1999. In total, 17.99mm of movement over 8 month period.

The data tend to be more useful when plotting ground movement associated with tunnelling for example. We do not see any correlation with seasonal, root induced clay shrinkage but a more detailed study is being undertaken. Fortunately, the satellite data includes the willow at the Aldenham Research Site and although the term over which readings were taken differs from those taken by GeoServ, detection of a seasonal pattern should help to clarify the usefulness.



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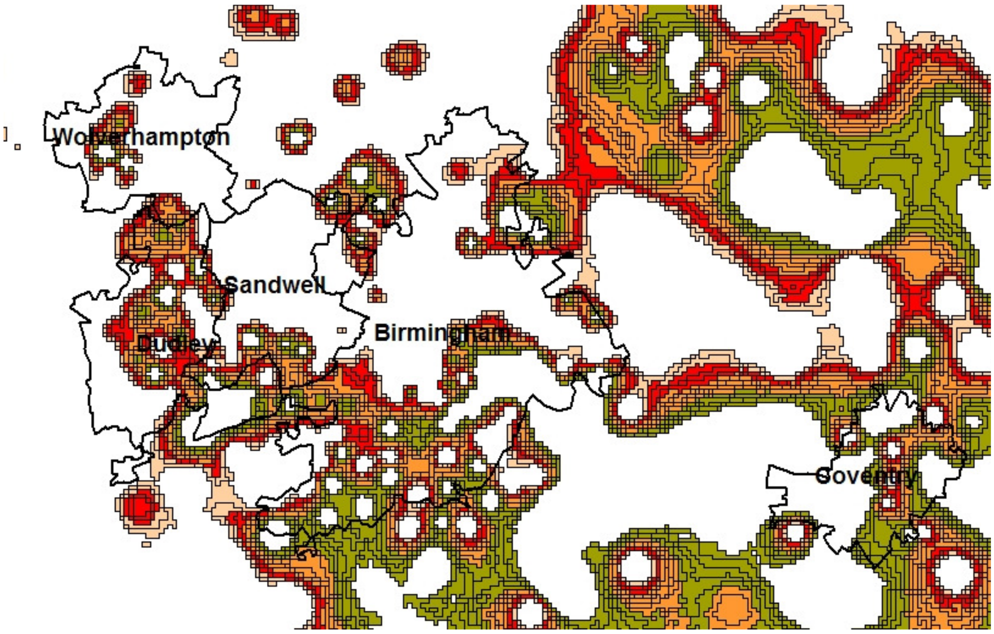
The Geology of the Midlands by clay soil PI

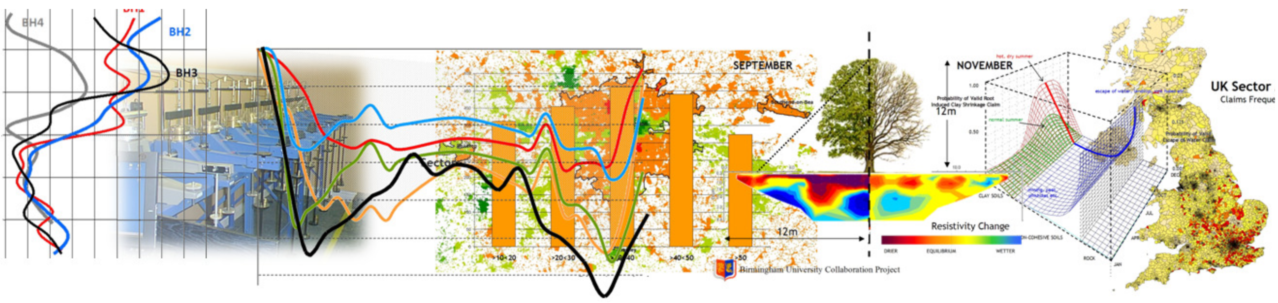
Below and on the following page, the shrink/swell characteristics of clay soils in the Midlands interpolated from boreholes and soil testing undertaken when investigating subsidence claims. Graded green (lowest volume change in category) to red (higher volume change) with orange as an intermediate within the range. The solid geology is predominantly Mercia mudstone with superficial deposits from the Boulder clay series where values represent the clay fraction.



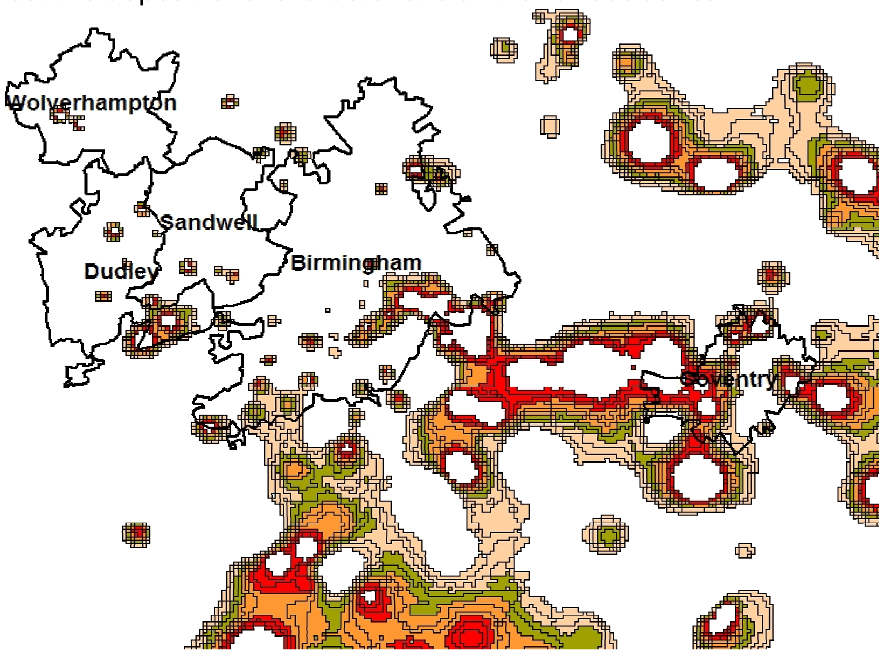
Clay soils with a PI in the range 8 - 20%.

The data have some shortcomings. First, the interpolation technique 'fills gaps' in the data which can lead to errors but this applies to all forms of geological mapping. Second, where there have been no investigations, we have no data and the engineer has to be careful when discounting clay shrinkage simply because the map has no values.

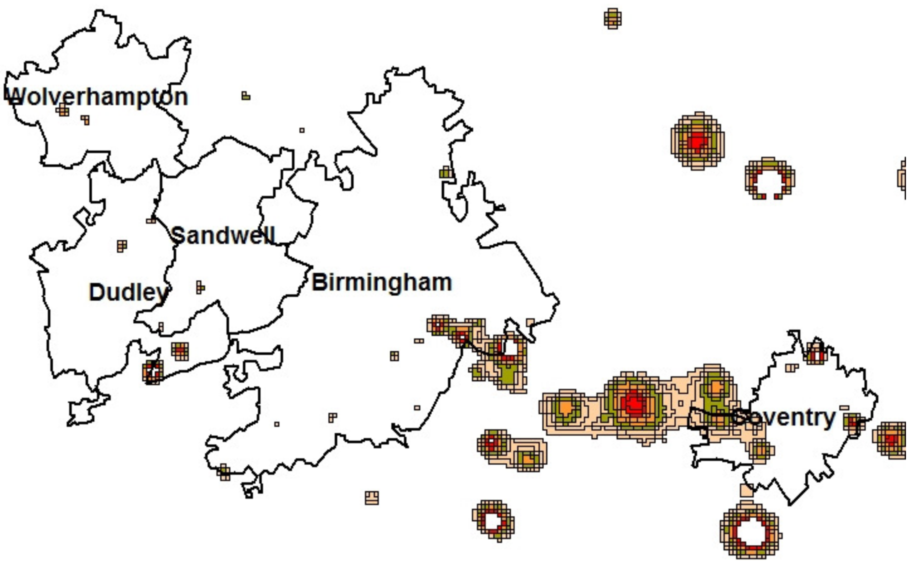
The map is particularly useful in high risk areas where there have been claims, investigations and soil testing. The data are best viewed as a supplement to the BGS series and can give useful indicators of the shrink/swell characteristics of clay soils in the vicinity.



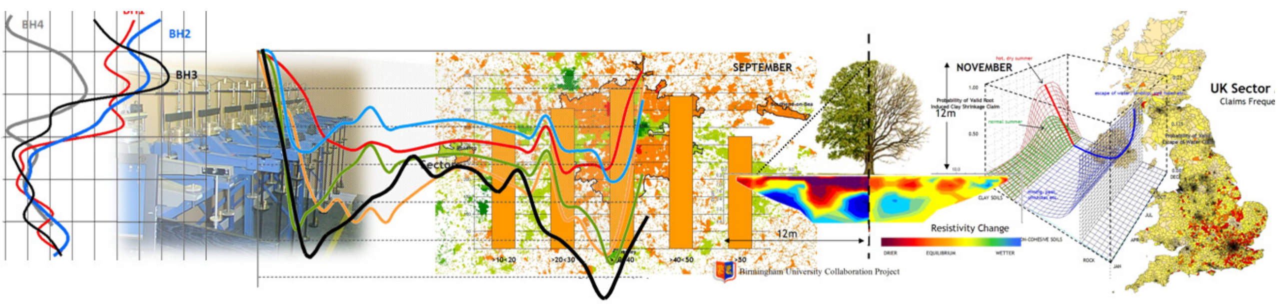
The interpolation techniques also produces circles or 'puddles' using extreme values (highest or lowest) as centroids and these may not reflect the depositional characteristic of the various series.



Clay soils with a PI in the range 20 - 30%.



Clay soils with a PI in the range 30 - 40%.



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PanGeo Project
Hazard mapping with support from the BGS

An ambitious project bringing together experts from several leading companies to deliver geohazard data including satellite imagery, ground movement and, in the case of the UK, the expertise of the BGS to interpret the data.

For full details visit the PanGeo web site at www.pangeoproject.eu.

Select the city of interest, viewing options (Google Earth, ESRI file etc.) and finally 'Get Data' to download a detailed pdf file complete with maps, analysis, data extracts and explanations. The document for London runs to some 194 pages.

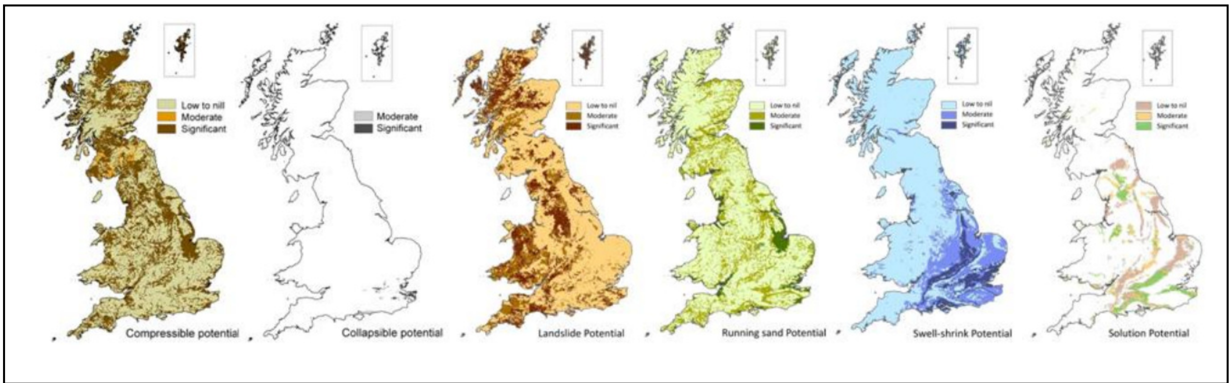
Land movement associated with deep tunnelling (London underground, services etc.), water extraction, anthropomorphic activity are all discussed. The BGS hazard maps are shown below.

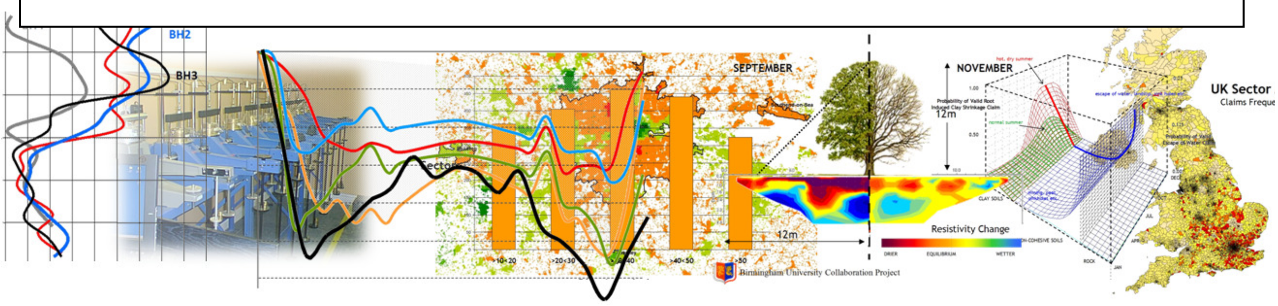
Met Office Report
August Update
Slightly cooler and more rainfall

"Despite a dry and sunny June and a brief heat-wave at the start of July, summer overall looks set to be cooler than average and cooler than either summer 2013 or 2014. It has also been rather wetter than average, however sunshine totals are expected to be near average." Extract from the Met Office web site, 31st August, 2015.

It goes on to say "Using provisional figures up to 26th August and then assuming average conditions for the final few days of the month, Met Office statistics show the UK mean temperature for this summer will be around 14 °C. This is 0.4 °C below the long term average (1981-2010).

Rainfall overall is slightly higher than average, with the UK so far having seen 271 mm of rain - which is 13 % above the long-term average."





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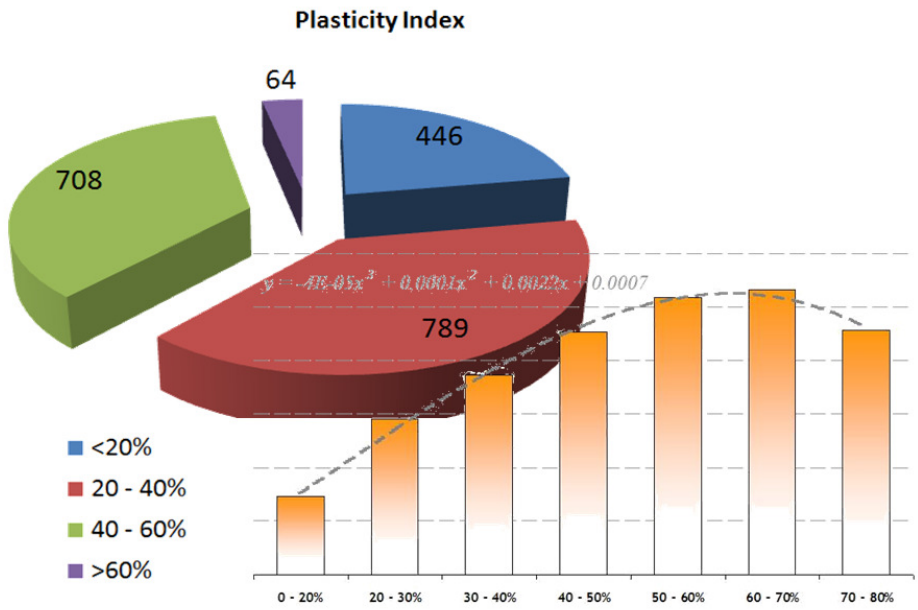
Distribution of PI by Postcode Sector

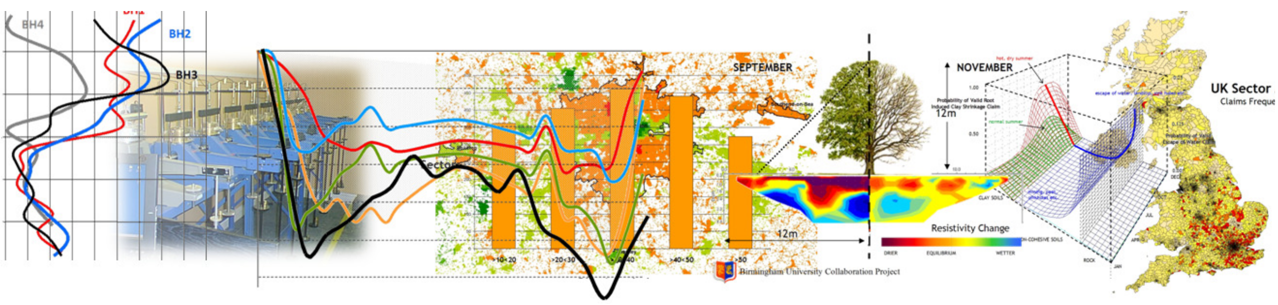
The pie chart below illustrates the distribution of clay soils by PI for those postcode sectors where investigations have been undertaken. There are 2007 sectors in total which amounts to around 20% of the UK.



The bar chart has appeared in earlier editions and represents the risk by PI expressed as frequency - that is to say, the number of claims from our sample on clay soil divided by the housing stock - all at postcode sector level.

It can be seen that the higher the PI the greater the risk, but fortunately the number of sectors with a PI of 60% or more (the highest risk) is fairly low at 64. The sectors with a PI less than 20% amounts to 446 and will include those where drift deposits contain a clay fraction sufficient to warrant testing following sieving.

The numbers quoted here are not meant to be definitive. They reflect areas of the UK where claims have led to investigations and soil testing. However, the totals agree broadly with those published by others including the BGS which suggests they are useful.



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Drought Damage to Trees

Thanks to Keiron Hart from Tamla Trees for his contributions

The following two extracts relating to tree damage following drought add some support to the suggestion put forward by some engineers (and contained in BRE Digest 298) that it is sometimes the case following minor damage (Category 2 or less) that cracks can, in some instances, just be repaired following winter recovery without the need to do anything with the tree. This may be associated with a reduction in moisture uptake related to physiological distress.

A study by Anderegg and his colleagues from Princeton University found that severe drought conditions can damage tree growth for periods of 3 - 4 years.

The team looked at tree-ring data for over 1,338 forest sites mainly in North America and Europe. The damage may be the result of leaf loss and vulnerability to pests and disease.

The results appear in a paper entitled "Pervasive drought legacies in forest ecosystems and their implications for carbon cycle models" published in the journal Science at:

http://www.sciencemag.org/content/349/6247/528.

This problem has also been highlighted by researchers Aaron Baird Berdanier and James Clark from Duke University who found that damage suffered by trees during a drought can reduce their long-term survival for up to a decade after the drought ends.

The research included a study of nearly 29,000 trees at two research forests in North Carolina. Their work appears in a paper entitled "Multi-year drought-induced morbidity preceding tree death in Southeastern US forests." *Ecological Applications*, 2015.

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

Reading Borough Council

Compensation Payments for Tree Related Damage

In response to a request from a local media outlet, Reading Borough Council in Berkshire revealed that in the last financial year it paid out damages on two subsidence claims, one for £39,000 and another for £26,000.