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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November 2013

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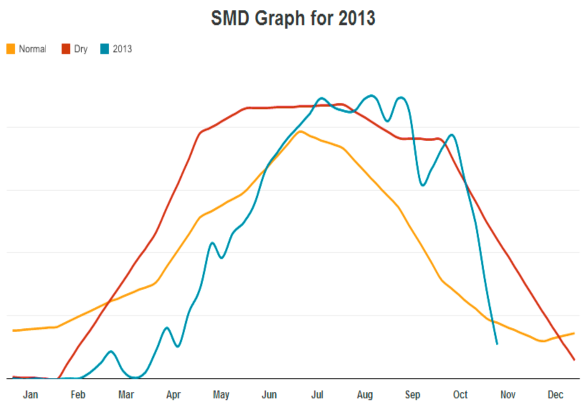
Issue 102, November, 2013



The above plot of the Soil Moisture Deficit (SMD - data courtesy of the Met Office) shows the late but steep rise of the deficit, persisting later into the year than usual, and diminishing over the last few weeks. So far there is no suggestion that this year has been a surge.

Subsidence Forum

The training day held at the BRE delivered good value for money with some excellent speakers.

Mike Duckworth put heave into context. He estimated that only 1.7% of the claims received related to heave and yet it occupies so much of our time. Derry Baxter from the FOS outlined their thinking on timeframes and answered some challenging questions from the floor.

Rachel Bolt updated everyone on current case law, particularly Berent, Robbins and Khan-v-Kane. Patrick Issacs outlined some case studies involving both heave and subsidence, which was interesting.

Robbins Appeal

The appeal by Bexley Council was dismissed, and the original judgement upheld at appeal.

In a nutshell, Bexley's case was that even had they reduced the crown by 25%, current thinking following Hortlink suggested this would not have been enough to prevent damage. They argued that not taking action earlier had little bearing on the outcome.

The Appeal Court dismissed this argument, finding that doing nothing was not an acceptable defence when it had been demonstrated that nearby trees of the same species, of a similar size and distance from other properties had caused damage.

For an expert and detailed assessment of the judgement, visit our web site, and select 'Newsletters' and then 'Plexus Review'.

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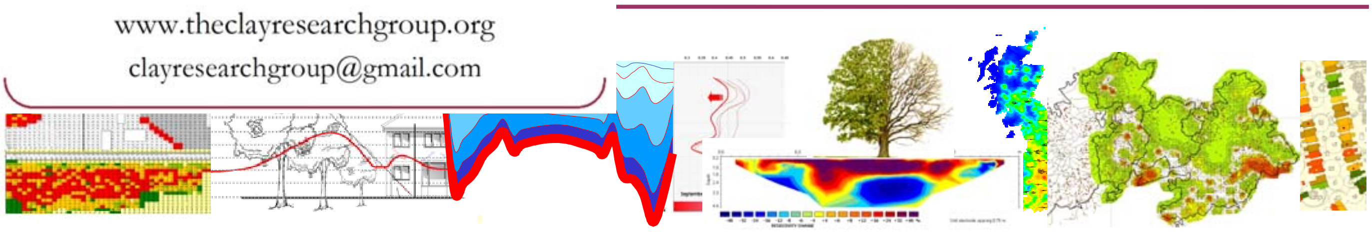

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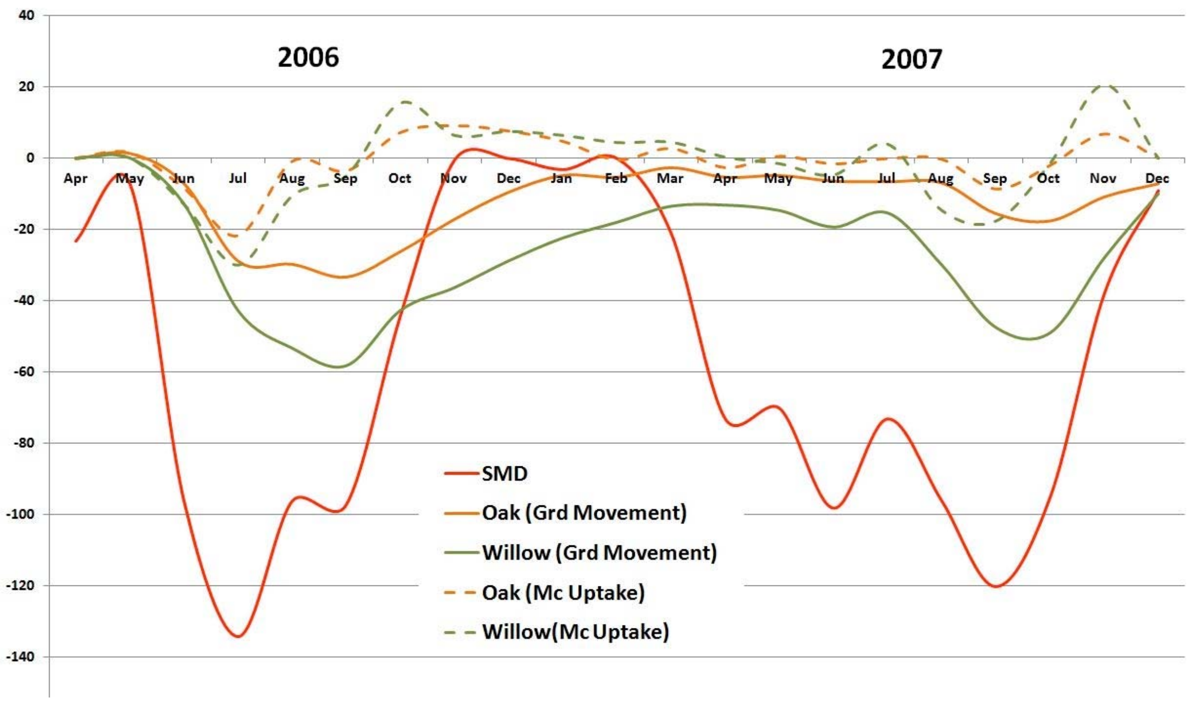
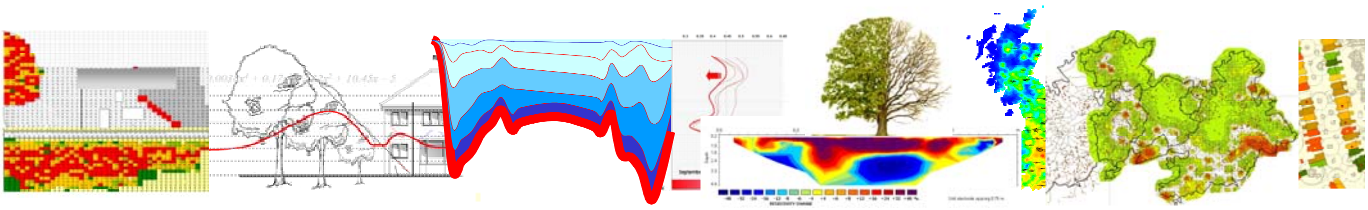
Correlation between Soil Moisture Deficit, Ground Movement, and by inference, Water Uptake of the Aldenham Willow and Oak over a Two Year Period.



A graph comparing ground movement and moisture uptake within influencing distance of the Aldenham Willow and Oak. The amplitude of movement at the site of the oak is around half that of the site of the willow, reflecting the variable geology. The oak site has bands of sand and gravel. The willow site is a more homogenous clay with less variability.

The estimate of water uptake (shown here as a negative value) is calculated using ground movement and does not include 'free water' uptake. The peak moisture uptake in 2006 was in July, and later (September) in 2007. The periodic signature of the SMD starts earlier, but extends over a longer term. The trees are still taking water after July 2006, but a reduced amount.



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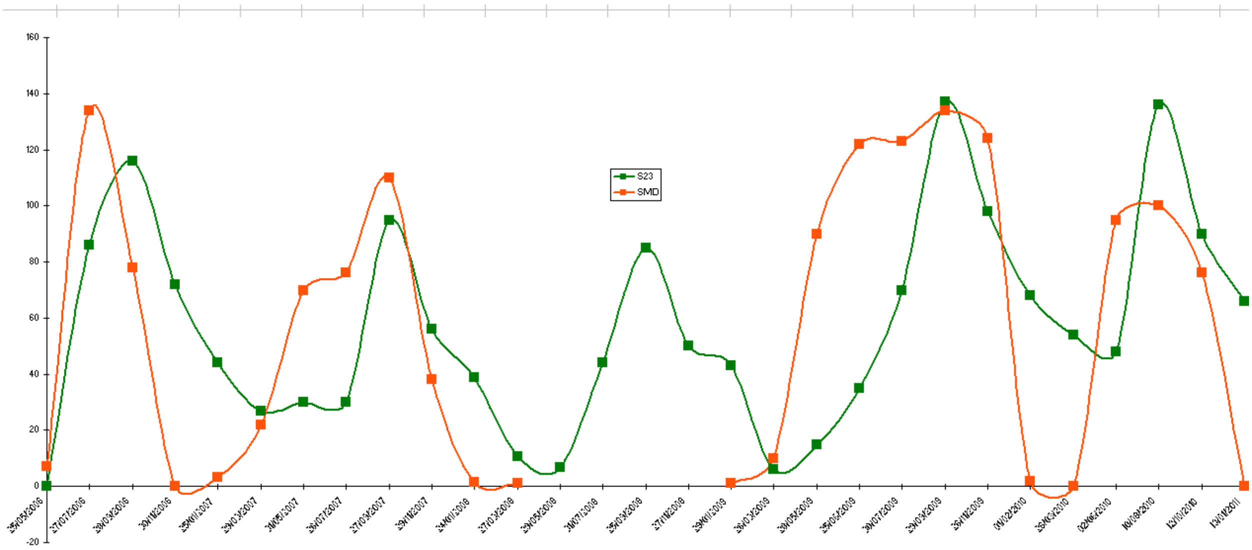


The plot of the Soil Moisture Deficit (red line), plotted along with ground movement (green line) at Station 23 of the Aldenham Willow reveals the interval between them. The SMD starts earlier and lasts longer, and ground movement follows, towards the end of the soil drying.

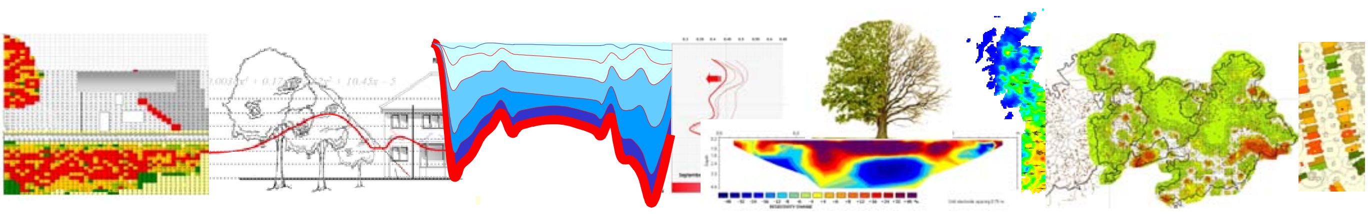
The Link Between Level Monitoring and Weather

Correlations between levels and SMD, temperature and hours of sunshine.

Two extracts from the precise levelling data from the site of the Aldenham Willow are reproduced on the following page. The stations radiating away from the tree have been plotted. The cross stations have been omitted. The exercise sought to understand the relationship between weather and ground movement by looking at correlation on a by-station basis. When the weather changed, how long did it take the ground to respond?

The data in the left table records the weather around the same time that levels were taken. On the right, the weather data was moved forward one interval – either a month, or two months depending on the frequency of site visits – to see what effect the weather had one interval forward. If it rained in March, was the effect immediate, or did it take time to influence ground movement?

continued …



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Initial Correlation

	Levels & SMD	Levels & Temp	Levels & Sunshine
S10	-0.3531578	-0.1148978	0.067052787
S9	-0.4322386	-0.0940303	0.156413956
S8	-0.4750671	-0.1184824	0.184190463
S7	-0.4972462	-0.1840527	0.120244245
S6	-0.4758309	-0.1779081	0.118691008
S5	-0.4374856	-0.2456435	0.011231352
S4	-0.3005675	-0.1918623	0.028482442
S3	-0.4029117	-0.2383045	0.023013079
S2	-0.4247263	-0.2752763	0.003405112
S1	-0.4581596	-0.1893329	0.114244717
S17	-0.2950644	-0.2064375	0.043704039
S18	-0.4143238	-0.1107213	0.190704925
S19	-0.5268465	-0.2349148	0.072260504
S20	-0.5726034	-0.2814195	0.046485796
S21	-0.4552793	-0.1590452	0.146732285
S22	-0.4784121	-0.1364375	0.178980117
S23	-0.3228097	-0.0835889	0.216255961
S24	-0.336443	-0.0299112	0.194475777

Moving Weather Data Ahead

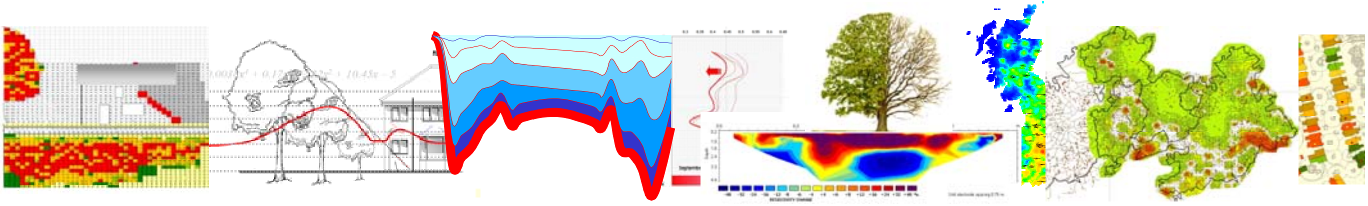
	Levels & SMD	Levels & Temp	Levels & Sunshine
S10	-0.4198074	-0.2889583	-0.157310538
S9	-0.5368039	-0.3608212	-0.176078277
S8	-0.6749434	-0.5355155	-0.300097606
S7	-0.7179122	-0.6480233	-0.404380763
S6	-0.713091	-0.6572454	-0.413880556
S5	-0.6500903	-0.6901119	-0.488266609
S4	-0.5534846	-0.6286758	-0.444558851
S3	-0.6245255	-0.6989299	-0.486536162
S2	-0.638455	-0.7632651	-0.553050744
S1	-0.7184144	-0.7349077	-0.484481553
S17	-0.4938826	-0.6119089	-0.440838618
S18	-0.6845932	-0.623633	-0.369889967
S19	-0.6953802	-0.661959	-0.435238375
S20	-0.7458973	-0.7312746	-0.50374449
S21	-0.6962843	-0.6368464	-0.402441315
S22	-0.7167657	-0.6128711	-0.378250424
S23	-0.5397443	-0.4518205	-0.258583642
S24	-0.4258694	-0.0130297	-0.08041424

By moving the weather along, the correlation between levels and the SMD improved from 0.42 to 0.62. The improvement for temperature was 0.17 to 0.57 and for hours of sunshine, the improvement was 0.106 to 0.376 – by averaging the readings across all stations and comparing them with the specified element. The temperature had the greatest influence, followed by the hours of sunshine, and then the SMD, confirming that weather data does have a predictive value.

In the following pages we explore a method of using live weather data in our analysis of the months following May to enhance our understanding of the link using the most readily available data – temperature, hours of sunshine and rainfall.

For this exercise we have added together the maximum temperature and hours of sunshine by month (as supplied by the Met Office from their Heathrow station), and subtracted rainfall, and then compared them with claim notifications to see if there is a relationship. As the majority of claims are linked to the weather, there has to be of course, but what are the best elements, and how strong is the link?

To commence, we review the current model and explore its predictive value. Is there a link between claim numbers and the SMD in late May? If there is, just how robust is it? Our current thinking is that roots coming back to life following the winter hibernation may be the subject of hormonal stimulation on encountering a dry (or drying) soil, but we have no evidence to support this. Is the correlation simply a fluke? On the other hand, can we ignore a better than 80% success rate that the model enjoys?



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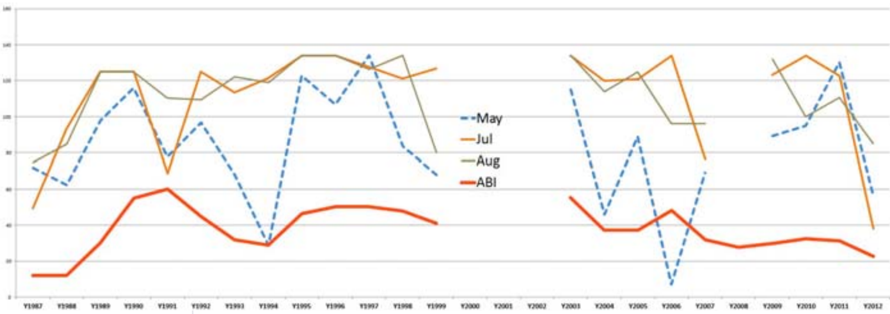
Predicting Surge using SMD at the end of May, and Developing Weather Patterns in the Summer.

We have records covering 16 years. 4 of those years were below a value of 100mm deficit for week 22 (end of May/beginning of June), correctly identifying a surge potential. 10 correctly forecasted a normal year. Expressed as frequency, the model correctly identified the claim situation in September as early as late May in 87.5% of the years listed.

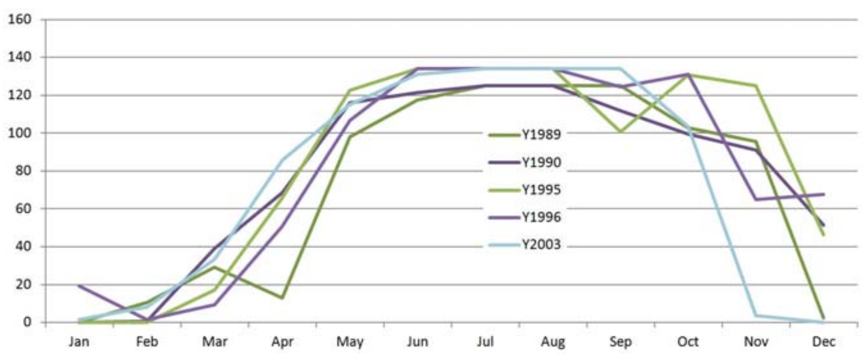
Only 1 out of the 16 incorrectly predicted a normal year (2006 was a surge, although more modest than others) and 1 a surge (2011 was a normal year but summer weather was unusual – see elsewhere). The model was wrong in 15% of the cases. To summarise, the SMD at the end of May provides a suggestion (but no more) of what the summer holds, some four months in advance. The false positives are equally balanced between the two types of year. That is to say, the model doesn't sound alarm bells every year in the hope of getting it right occasionally.

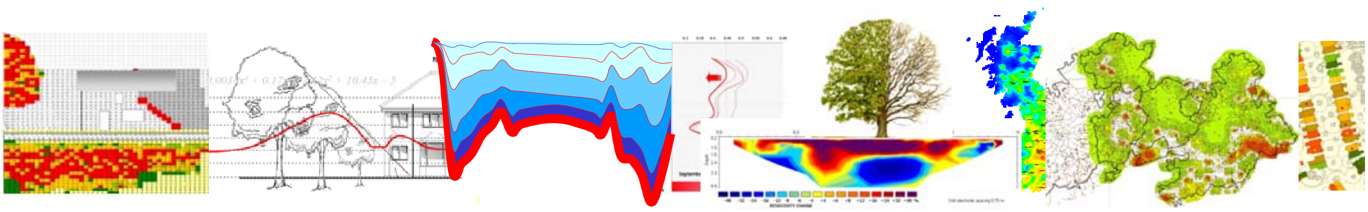
Plotting the monthly SMD and claims by year reveals that July provides the best correlation, followed by August. As both are summer months, they have a reduced benefit as a predictive tool. May provides a useful guide and comes third in the table – see below.



Left, the correlation between monthly SMD and claims. Below, left, the results in rank order. July has the highest correlation, and May is third. Below, the surge years plotting the SMD by month.

Jul	1st
Aug	2nd
May	3rd
Oct	4th
Mar	5th
Jun	6th
Apr	7th
Jan	8th
Dec	9th
Sep	10th
Feb	11th
Nov	12th





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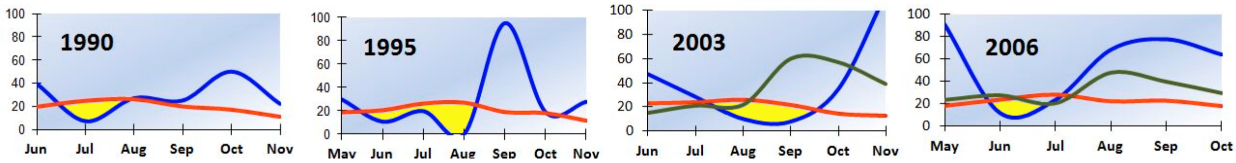
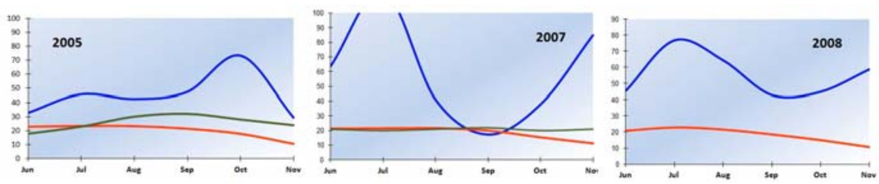
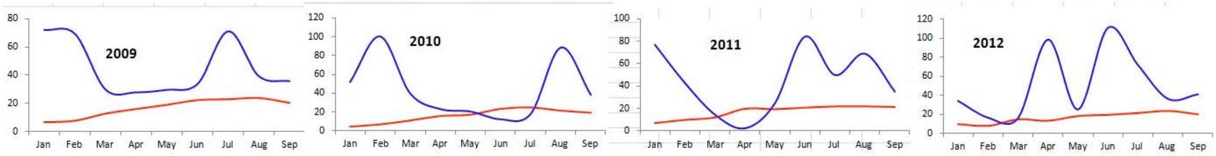
Surge Years & Weather Patterns



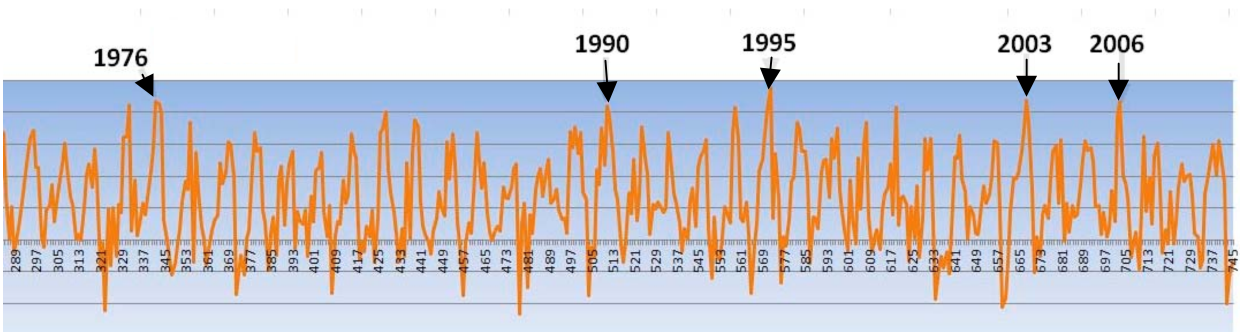
The graphs above plot actual rainfall and temperature data supplied by the Met Office (Heathrow station) for the event years indicated. The periods where the temperature (red) exceeds rainfall (blue) are shaded yellow. The green lines plots claims for years 2003 and 2006. It can be seen (particularly in the case of 2006) that there is a delay between the dry spell and peak claim notifications. The delay is around a month in 2003, and two months in 2006.



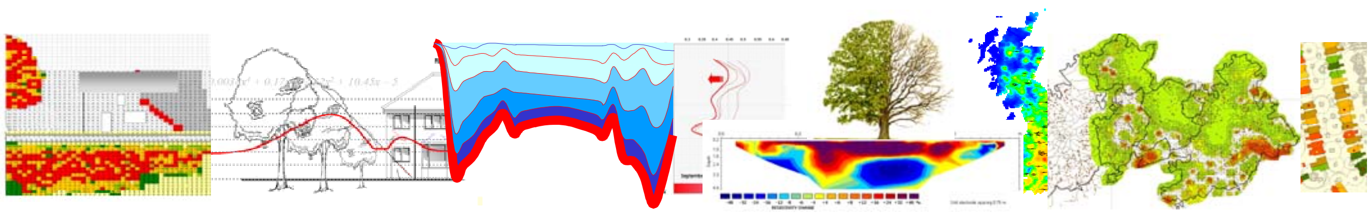
In contrast, rainfall often (but not always) exceeds temperature throughout the summer months in non-event years. Claims remain fairly steady – see green line in 2005 and 2007.



Recent years have shown a similar pattern, apart from 2010 with a cross-over between June and July. Although 2011 exhibits this pattern, it occurs in April/May, and prior to deciduous trees coming into leaf.



Surge years identified by the difference between normalised "temperature minus rainfall". Values of 0.8 identify the years shown, and take account of the soil conditions at the beginning of the year, before the trees come into leaf.



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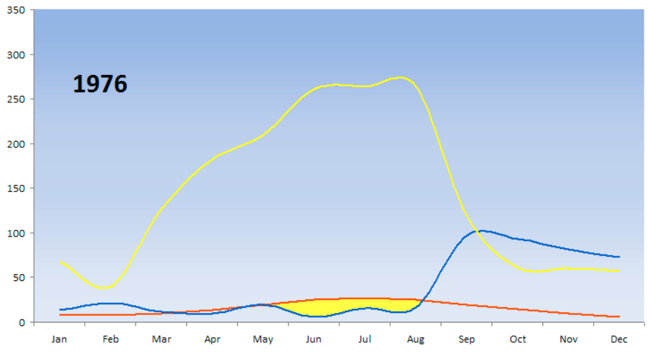
Surge Years & Weather Patterns



What happened in 1976? Similar profiles to other surge years, with the rainfall plot falling below the temperature to produce a deficit.

On this graph we have included hours of sunshine – yellow line. The slow build up culminates in peak sunshine and low rainfall coinciding from June through to August.

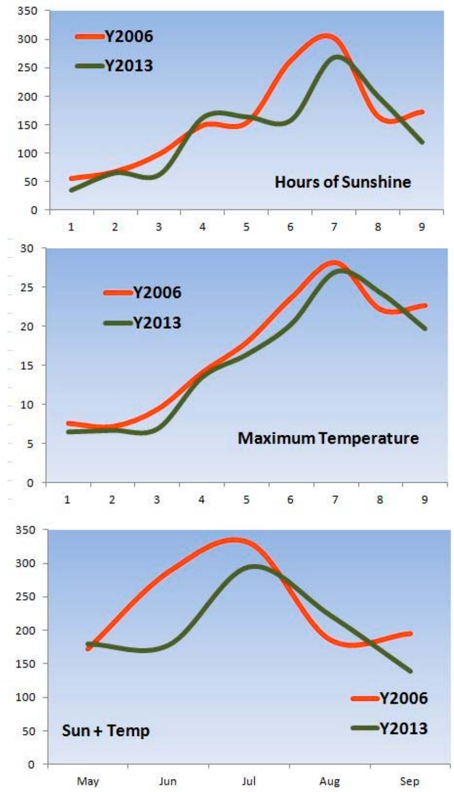
[(Temp+Sun)-Rain] = **Claims?**

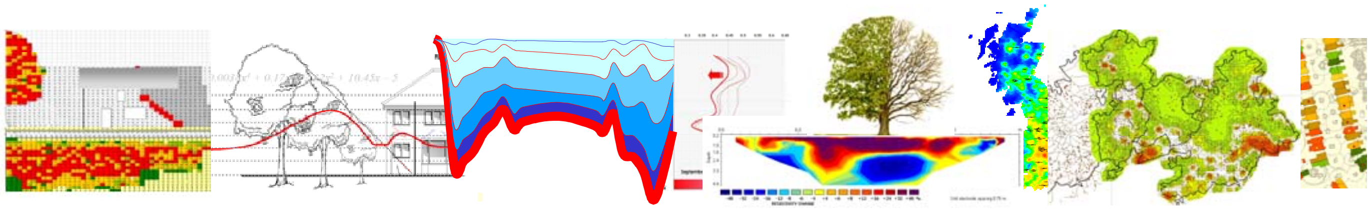
Would combining the elements that trigger water uptake (i.e. temperature + rainfall) and then subtracting rainfall deliver an improved correlation and allow 'live' tracking of surge years?

Right are plotted the temperature and hours of sunshine graphs (top two) for two years with a very similar SMD profile. There is little to distinguish between the top two elements.

If there is a difference in claim numbers (and we have yet to know whether this is the case), would the (temp + sun) – rainfall plot provide a distinguishing feature?

On the following page an initial appraisal of the technique is undertaken for a selection of surge and normal years.





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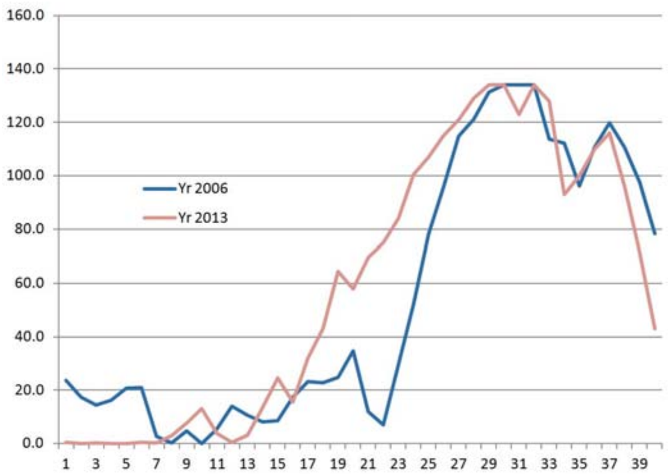


2006 –v- 2013

SMD plots for 2006 (a surge year) and 2013 are remarkably similar, and yet delivering different claim numbers – as far as we know at least. So far 2013 appears to be recording 'normal' claim numbers, although the ABI have yet to release Q3 data and this early view will need to be re-visited early in 2014.

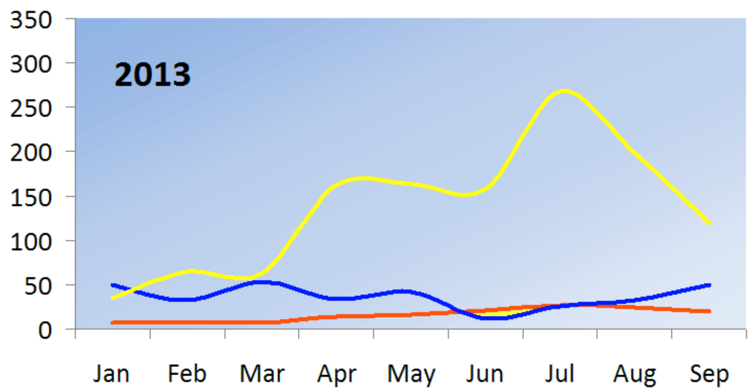
If it turns out that there is no difference, then the SMD figures reveal their value. If there is a difference, what could it be, and could it assist in further refining the model?

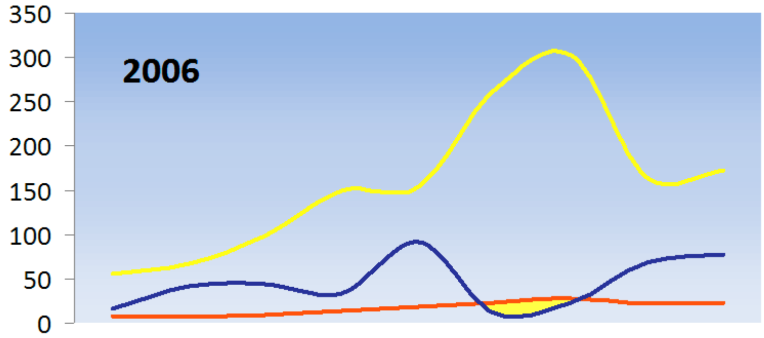
Sunshine and Claims

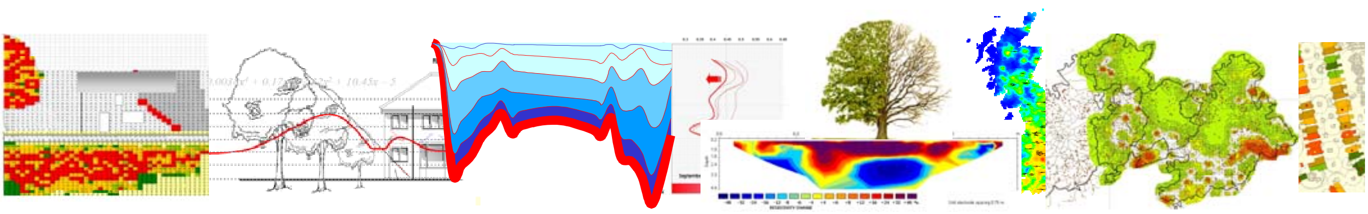
Comparing the weather plots – temperature with rainfall – reveals similar profiles for the two years. They cross (i.e. temperature exceeds rainfall) in June but for a short period only. Preceding this, there was more rainfall in 2006, in the month of May.

The distinguishing feature may be the difference in hours of sunshine (yellow line) as recorded by the instruments at Heathrow, and published by the Met Office.

In 2006, a peak value of 302 hours was recorded in July. For 2013, in the same month, the value was less – 268 hours.







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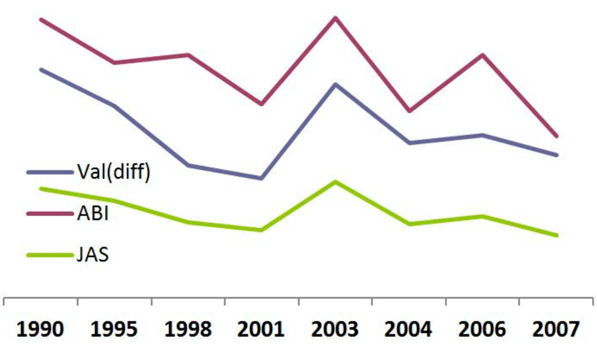
	Val(diff)	ABI	JAS
1990	45.06	55	21.61
1995	37.98	46.5	19.09
1998	26.19	48	14.87
2001	23.58	38.3	13.4
2003	42.15	55.4	22.98
2004	30.6	37	14.47
2006	32.16	48	16.16
2007	28.21	32	12.33
	0.74952		0.88932



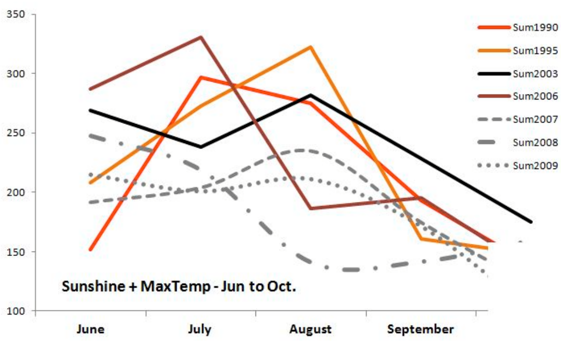
Above is a table plotting the relationships between three elements. Val(diff) is 'temp + sun) – rainfall' for the year – each years values have been summed. JAS uses the summed values for the summer months of July, August and September.

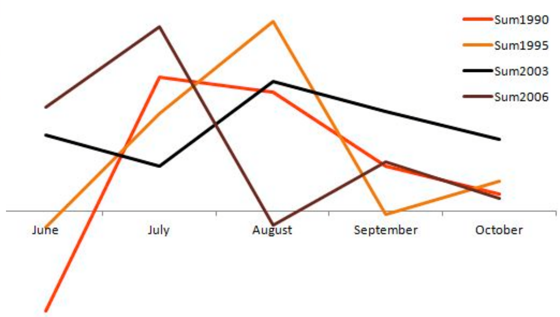
'ABI' is the annual number of claim notifications as recorded by the ABI – the figure should be multiplied by 1,000.

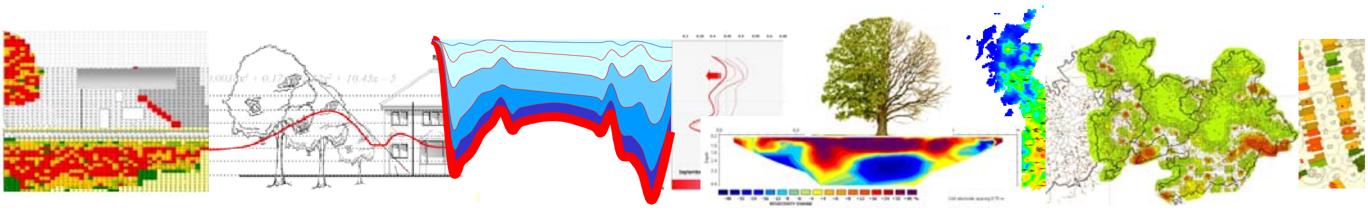
To the right of the table, the results are plotted graphically, and a correlation can be easily seen. The bold red figures beneath the table indicate the correlation between the ABI claim figures and each column of figures.

The correlation with claim numbers for [(t+s)-r] = 0.749 for the full year, and 0.889 for the selected summer months. This is a very strong correlation indeed, and suggests that live tracking of these values on a daily or weekly basis from June onwards would be useful in anticipating claim numbers a few weeks (or even a few months) ahead.

Below are two further graphs exploring the relationship between normal and surge years from June through to September (left) and October (right). Both use the same data. The left hand graph plots 4 surge years (1990, 1995, 2003 and 2006) and 3 normal years (2007, 2008 and 2009 – all grey lines). The right hand graph plots the excesses of surge years over the average for normal years.







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In the Press – Extracts from Journals and Periodicals

The Vadose Zone Journal and Tree Physiology etc., have a significant number of papers devoted to water loss due to vegetation, and associated ground movement. Research is aimed at understanding the impact of climate change associated with an increase in CO^2 and how this will influence the distribution of species, but also drought induced stress.

Researchers are also exploring how moisture loss and species identification can be undertaken remotely, using satellite data.

Below are a few extracts that have relevance in the field of root induced clay shrinkage.

"Midday infrared canopy to air temperature difference was used to manage post-harvest deficit irrigation of early season peach trees." **Vadose Zone Journal.** August edition. **"Management of Postharvest Deficit Irrigation of Peach Trees Using Infrared Canopy Temperature".** Huihui Zhang and Dong Wang.

Maybe in 10 years time or so, homes damaged by subsidence will have infrared detectors fitted to switch on (or switch off) rehydration systems?

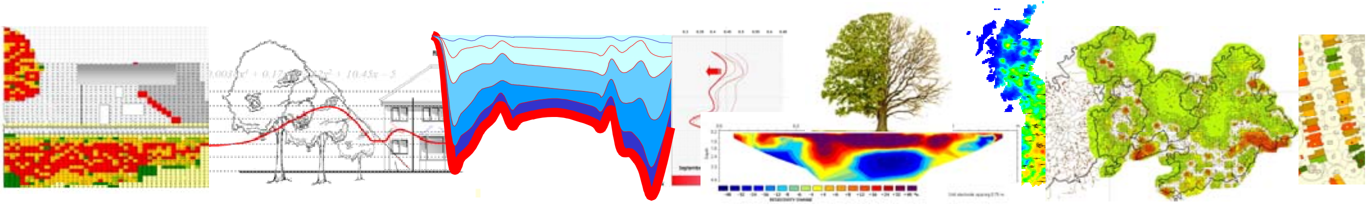
Remote sensing is another area of interest. Crop growth and watering regimes are a part, as is ground movement resulting from moisture fluctuations.

"Satellite-based radar interferometry can potentially offer an alternative methodology to estimate soil water storage change at field or regional scales. This paper introduces principles of satellite-based radar interferometry and identifies limitations and potential applications of the technique to measure surface elevation changes from clay shrinkage." **Vadose Zone Journal.** August edition. **"Satellite-Based Radar Interferometry to Estimate Large-Scale Soil Water Depletion from Clay Shrinkage: Possibilities and Limitations".** Bram te Brake, *et al.*

Tree physiology in response to stress is another area of interest, with quite a few articles appearing in Tree Physiology Journal, many with free access.

"The embolism threshold leading to irreversible drought damage was found to be close to 88% (for angiosperms), rather than the 50% previously reported for conifers. Hydraulic failure leading to irreversible drought-induced global dysfunction in angiosperm tree species occurred at a very high level of xylem embolism, possibly reflecting the physiological characteristics of their stem water-transport system." **Tree Physiology.** July edition. **"Xylem embolism threshold for catastrophic hydraulic failure in angiosperm trees".** Morgane Urli et al.

Although domestic subsidence doesn't attract a lot of attention in the academic press, there are many related fields of research that could, in time, change the way we handle claims.

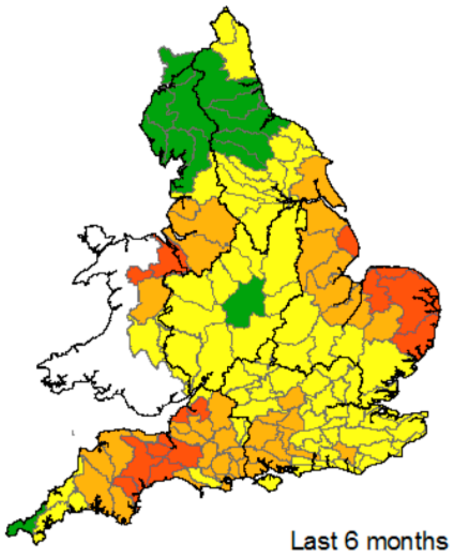


The Environment Agency

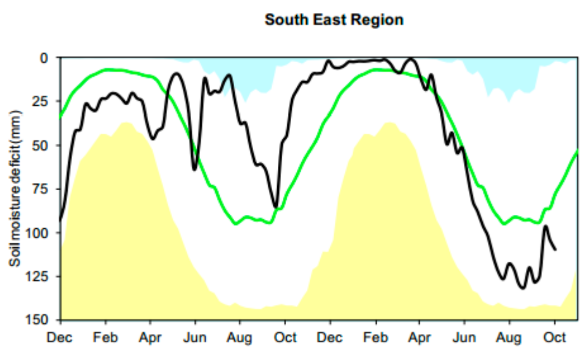
http://www.environment-agency.gov.uk/

The Environment Agency produce some excellent reports detailing rainfall and Soil Moisture Deficits and comparing them with long term averages (LTA).

Below are some extracts from their Monthly Water Situation Report for the end of September.



Although rainfall for the last 12 months has been around average, the last six months has been below normal on the clay belt (above). The SMD (below) tells a similar story.



Support Vector Machines for Tree Species Identification using LiDAR-derived Structure and Intensity Variables.

Zhenyu Zhang & Xiaoye Liu

Geocarto International, Volume 28, Issue 4, 2013

This study explores the use of LiDAR (light detection and ranging) to identify tree species.

This builds on the work of others, and expands the number of species that can be identified and enhances the accuracy of the process.

The journal abstract says *"This study demonstrated the success of the SVMs for the identification of the Myrtle Beech (the dominant species of the Australian cool temperate rainforest in the study area) and adjacent tree species – notably, the Silver Wattle at individual tree level using LiDAR-derived structure and intensity variables."*

"An accuracy of 92.8% was achieved from the SVM approach, showing significant advantages of the SVMs over the traditional classification methods such as linear discriminant analysis in terms of classification accuracy."

SVM stands for Support Vector Machines and is a pattern matching model based on algorithms that can learn from feedback. It builds an image of what it discerns to be a particular species of tree, and is then scored on initial matching, adjusting until it reaches the accuracy required by adjusting that pattern.