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The Visual Exploration of Insurance Data in Google Earth

Aidan Slingsby[1], Jason Dykes[1], Jo Wood[1], Matthew Foote[2], Mike Blom[3]

[1]The giCentre, Department of Information Science, School of Computing, City University, Northampton Square, London, EC1V 0HB, UK
Tel. +44 (0)20 7040 8800
a.slingsby@soi.city.ac.uk; jwo@soi.city.ac.uk; jad7@soi.city.ac.uk

[2]Willis Research Network, Ten Trinity Square, London, EC3P 3AX, UK
footem@willis.com

[3]Willis Analytics, Ten Trinity Square, London, EC3P 3AX, UK
Tel. +44 (0)20 7488 8111
blomm@willis.com

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1. Introduction

The global insurance industry is concerned with the management of financial risk. The distribution and level of potential risk to an individual insurance company is dependent on its portfolio, comprising individual policies, each of which has its own specific terms, conditions and exceptions. In many cases, insurers will look to transfer some or all of the aggregate risk of these policies through a second level of insurance, termed reinsurance. In order to manage and spread their risk, individual insurance and reinsurance companies must each fully understand the composition and spatial distribution of their exposure (the specific objects that they insure) and the potential losses that they might incur. Insurance cover for losses incurred from catastrophic events is a particularly important part of the insurance industry. Catastrophic events and exposure are inherently spatial, yet the availability and use of spatial data and methods for assessing risk in the insurance industry has been inconsistent (BNSC/Infoterra, 2001). The potential for the use of such information is significant, particularly in the areas of underwriting where the location and characterisation of risk (resulting from events such as floods, earthquakes and windstorms) affects the pricing and rating of insurance and catastrophe risk assessment where models are used to estimate the frequency and severity of potential loss for particular portfolios.

Visualization and geovisualization techniques can both complement and help communicate the results of GIS and other analyses in the exploration of multivariate datasets (MacEachren et al 1999; Gahegan, 2005) and may provide insights and solutions for managing exposure and potential loss. Graphical techniques and the use of geobrowsers such as Google Earth[1] are also being used in a communicative role to engage a variety of different audiences within insurance companies with information about policies, exposure and potential losses (e.g. Lloyds, 2005). Such techniques are being used by a huge and growing online community[2], have visualization applications in science[3] and also provide scope for geovisualization (Wood *et al,* 2007). In this paper, we focus on one particular geo-browser, Google Earth, which provides access to a rich array of datasets including aerial imagery, roads, administrative boundaries and photographs and, importantly, allows additional data to be added through the well-documented KML format.

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[1] http://earth.google.com/ (we are using version 4.2).

[2] For example, those listed at http://earth.google.com/gallery/index.html

[3] For example, NASA's Goddard Space Flight Center: http://svs.gsfc.nasa.gov/

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Google Earth can be used in three interesting ways. Firstly, its easy to use KML input file format allows anyone to augment Google Earth's rich datasets with 'volunteered' geographical information (Goodchild, 2007). For example, it has been used effectively in relation to catastrophic events (Miller, 2006), widely demonstrating the power of combining datasets spatially to mainstream computer users. Secondly, Google Earth has the flexibility to support a wide range of visual encodings for exploring multivariate spatial datasets; for example, Pezanowski *et al* (2007) extended the user interface to support complex spatial querying. Slingsby *et al* (2007a) discuss how cartographic bias in Google Earth can be identified and, at least in some cases, overcome. Finally, its intuitive user interface and the streaming technology it uses to collect data from remote servers, allows spatial data to be disseminated and presented to wide groups of users.

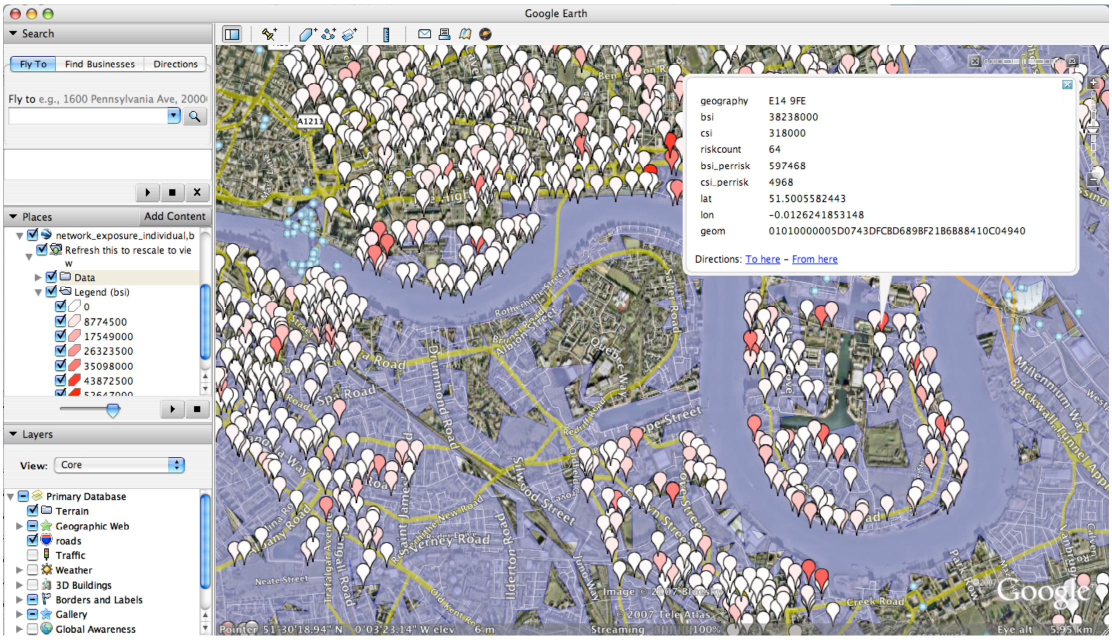

Figure 1: Exposure (plotted as point data) coloured by the building sum insured (see legend), shown with a flooding event with a 500 year return period. Data supplied by Willis Analytics (sums insured are representative only).

In this paper, we provide examples of how Google Earth can be used to interactively explore exposure, catastrophic events and potential loss information to answer questions of relevance to the insurance industry. We hope that some of the ideas presented here will give practical and useful ideas for individuals and organisations working in or with the insurance industry.

2. Interactive mapping

2.1. Mapping

A simple but effective means for visually interpreting spatial data is to map it and compare with other spatially-referenced data. KML[4] is the XML-based markup language used to import spatial data into Google Earth. It allows data to be specified as `<Placemarks>`, each of which has a geometrical description (as points, lines and/or polygons) and a visual appearance (colour, transparency, line thickness, icon). Hypertext descriptions containing further information can be associated and are available on-demand from the Google Earth interface.

Flooding is an example of an event that may be strongly related to potential loss. Mapping exposure with flooding extents and inspecting data for individual data points on-demand may help portfolio

[4] http://code.google.com/apis/kml/documentation/ (we are using KML version 2.1).

managers evaluate geographical relationships between exposure and potential loss and communicate the complexity and spatial variation of this relationship to others (figure 1).

2.2. Filtering by attribute

The combination of Google Earth and KML provides the means to encode interactive behaviours for zooming and filtering operations that support Shneiderman's (1996) "visual information-seeking mantra: overview first, zoom and filter, then details-on-demand" (Wood *et al*, 2007). As shown in figure 1, KML can be used to specify details-on-demand behaviour through hypertext descriptions. KML can also be used to specify the filtering of data by attribute, by space and by time.

Filtering by attribute can be achieved by using KML to structure the data into a hierarchical set of `<Folders>` that reflect the attribute structure. These are displayed in the Google Earth "Places" panel, enabling users to turn on and turn off different levels of the hierarchy. Filtering by different combinations of attribute can be achieved by restructuring the hierarchy.

2.3. Filtering by space

Google Earth and KML can be used to allow a user to spatially select data and retrieve information based on this selection using the `<NetworkLink>` element. When the user selects data, Google Earth sends the coordinates of the user's selection back to the server as an HTTP request. These can be interpreted by a server-side script[5], which can retrieve spatially relevant results of analyses, encode the results as KML and then return this KML to the user. These may be the results of simple summary statistics or complex GIS or other analyses, run on demand or precomputed.

Figure 2 shows a simple example in which the user selects exposure data by framing it in Google Earth through zooming and panning. The coordinates of the selected area are sent through the `<NetworkLink>` to a server-side script that calculates the average, minimum and maximum building sum insured (BSI) and contents sum insured (CSI) for the selected area. These are returned as KML, and are displayed on the left in figure 2.

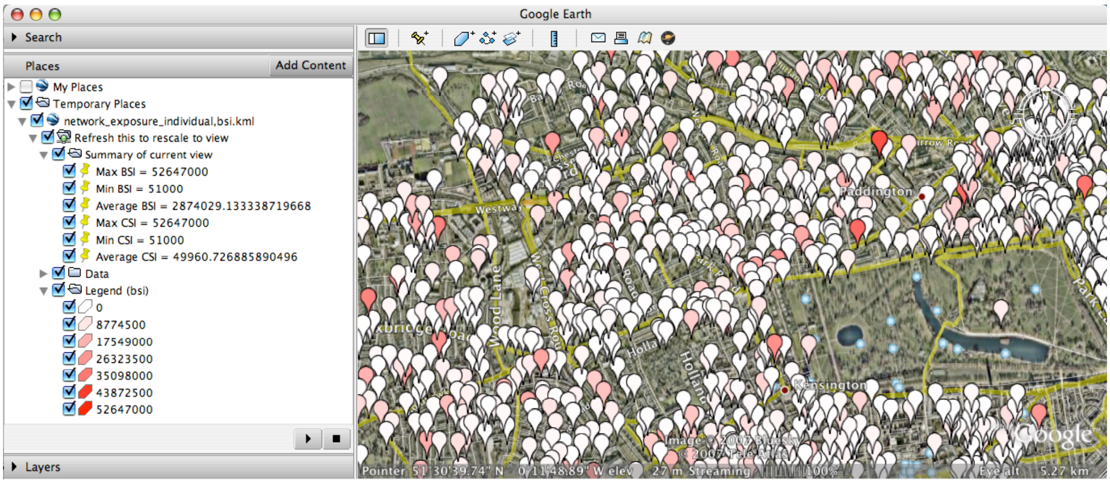

Figure 2: User selection of a spatially-constrained subset of data, and its subsequent summarisation (see statistical summary on the left).

[5] Perl, ASP, JSP, PHP are suitable server-side scripts which are capable of connecting to databases and producing KML.

2.4. Filtering by time

<Placemarks> can be mapped onto a timeline using the <TimeSpan> tag. Where <TimeSpan> tags are present in a KML file, Google Earth displays an appropriately scaled interactive timeline, enabling the user to filter the display of data by time. The timeline can also be "played" allowing temporal structure to be shown through animation. Figure 3 is an example developed and used by Lloyds, in which the timeline is used to show changes in the value of aggregate exposure over the course of a year. Such data can also be presented as symbols, as more appropriate area symbolism than perspective height or as continuous datasets (Wood and Dykes, 2008).

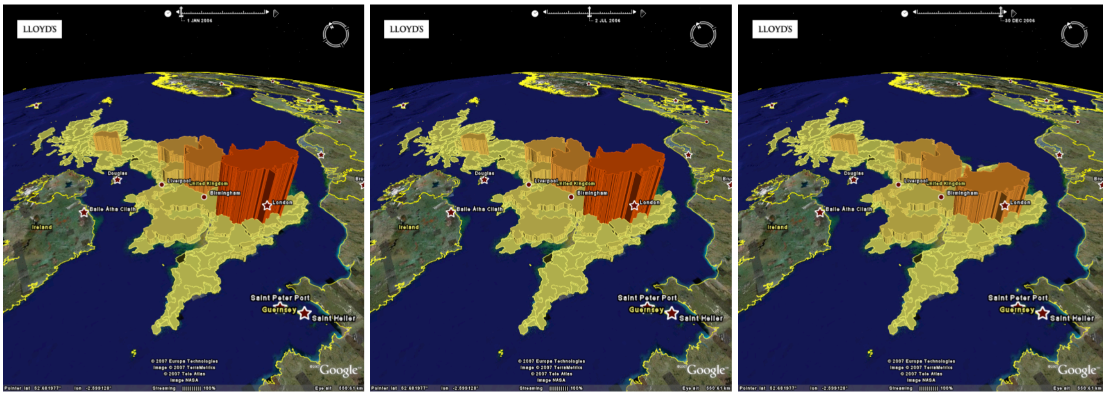

Figure 3: Changes in aggregate exposure by sum insured for flooding areas in 2006 (January, July and December) by UK flooding region (UK Environment agency). Source: Lloyds (used with permission).

2.5. Comparison with ancillary data

In addition to users' own data, Google Earth's built-in aerial imagery provides valuable geographical context for helping users understand the structure of the data in localised areas. In figure 4, the aerial imagery indicates that exposure is unevenly distributed within the postcode sectors shown. Ancillary datasets, such as ground-based photographs or information about local building characteristics, add essential context when the structure of aggregate data is visually analysed. Many useful datasets are provided centrally as Google Earth layers. Others layers may be added using KML.

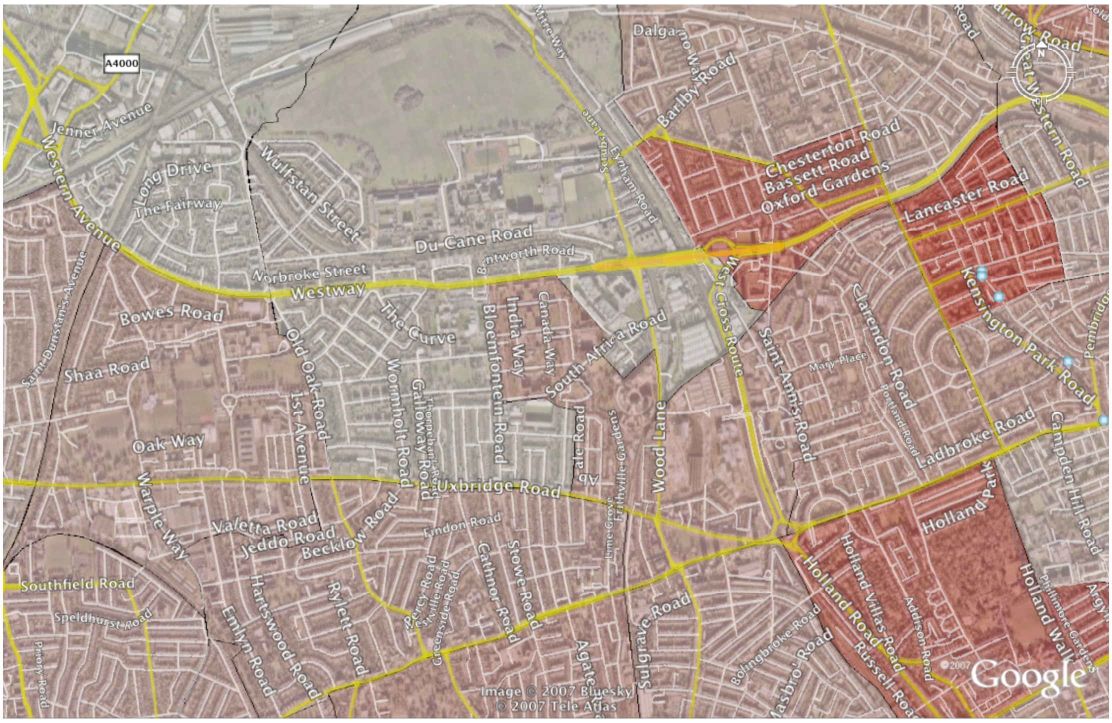

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Figure 4: Postcode sectors coloured by average buildings sum insured (normalised by area). Visual comparison with aerial imagery shows that the postcode sector in the upper left is less densely built up than the other postcode sectors, partly accounting for its low aggregate insured value. Data supplied by Willis Analytics (sums insured are representative only).

3. Spatial aggregation

Patterns in spatial data are scale dependent (Openshaw et al, 1987). However, the aggregation of data also introduces the 'modifiable aerial unit problem (MAUP)', where the patterns may be dependent on the units into which points are aggregated, as illustrated in figure 4. The ability to explore spatial data at different spatial scales and units of aggregation is therefore important. Where the data are disaggregated, there is potential to study the stability of patterns across spatial scales.

Google Earth does not provide built-in spatial aggregating functionality (except for collocated point `<Placemarks>`); however, spatial aggregation can be implemented in a number of ways. It can be performed on demand using a server-side script through the `<NetworkLink>` as described in section 2.3. Alternatively, multiple aggregations can be precomputed and included in a single KML file grouped either into `<Folders>` or mapped to the timeline using the `<TimeSpan>` element. Figure 5 shows the former case, in which the user can select the required spatial aggregation in the "Places" panel. In the latter case, the timeline is used, not to interactively select by time, but to interactively select or "play" (animate) through all the different spatial aggregations.

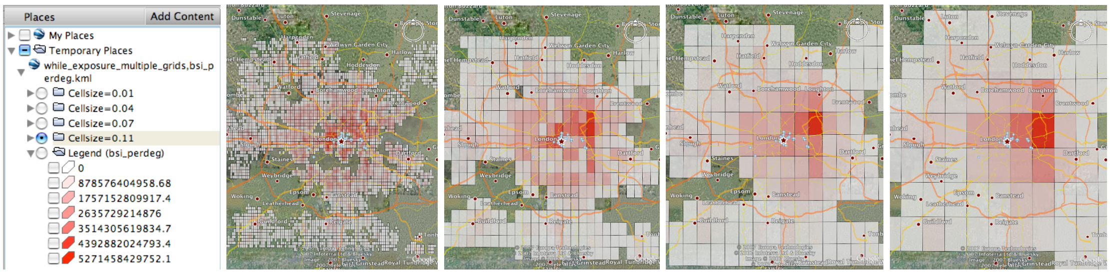

Figure 5: Four different spatial scales of aggregation (exposure coloured by buildings sum insured) in four different layers. The user can select which layer (spatial aggregation) to view. Data supplied by Willis Analytics (sums insured are representative only).

4. New views of spatial data

The ability to explore, compare and relate multiple spatial and aspatial views of data are key to data analysis through geovisualization (Haslett *et al.,* 1990; Dykes, 1997, 1998; Andrienko and Andrienko, 1999; Slingsby *et al*., 2007b). KML can be used to describe aspatial and semi-spatial visual encodings and project them onto the surface of Earth. Here, we employ a rectangular cartogram (Krevelda and Speckmann, 2006) and a choropleth map for presenting potential loss by département in France. Potential loss is typically estimated using CAT models that take information on exposure and policies, and output the mean loss estimate and standard deviation resulting from multiple simulated catastrophic events (Grossi *et al*, 2005). Relating client portfolios to model output is a key component in managing exposure and loss. Considering multiple views with different emphases may help in this process.

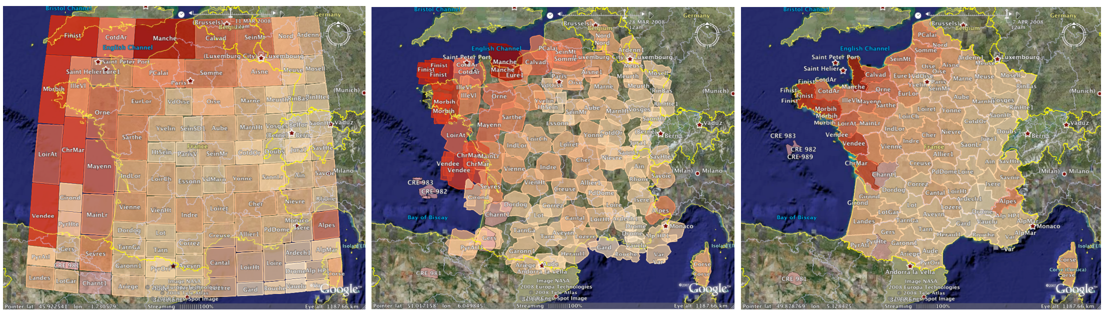

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Figure 6: Rectangular cartogram (squarified) showing CAT model output by French département, sized according to the average potential annual loss and coloured by the standard deviation (left); intermediate stage during transition (middle); map coloured by the standard deviation of annual loss by département (right). Data supplied by Willis Analytics.

Figure 6 (left) shows a squarified (Bruls *et al,* 2000) rectangular cartogram. Each rectangle represents a French département, sized by potential loss and coloured by the standard deviation estimated by a CAT model for a particular event type and a particular portfolio. Rectangles are as square as possible to enable relative sizes to be compared more easily and they are as close as possible to their true geographical position within the constraints of the squarified cartogram (Wood and Dykes, 2008). The cartogram shows that departments with larger potential losses have higher standard deviations around these losses, and that the highest potential losses and standard deviations tend to be in the North and West with the Alps as an outlier. The map in figure 6 (right) shows the geography most effectively and its relationship to the standard deviation (through colour) but does not show the magnitude of potential loss.

There is some evidence that animated transition is a useful way of relating multiple views of data (Heer and Robinson, 2007). We computed transitional stages between our spatial and semi-spatial views and mapped these to the timeline using the `<TimeSpan>` tag – as in section 3 – to allow the user to interactively relate these two views of the same data. Figure 6 (middle) shows an intermediate stage of the transition between the two complementary views. It may be useful to use this technique to compare other types of spatial and more abstract graphical representations.

5. Conclusions, implications and ongoing work

The relationships between the composition of portfolios and the geographies of exposure and potential losses are important factors in decisions about understanding, accommodating and transferring risk. We have shown how KML and Google Earth can be used for geovisualization in the insurance industry to explore these relationships. This may help analysts develop ideas about spatial patterns in data relating to exposure, risk and potential loss and communicate interesting aspects of these data and findings.

The examples presented here are indicative of cases where analysts and decision makers are using these technologies to share data and functionality to support their work. The techniques described provide plenty of scope for developing novel and bespoke views and interactions for the visual evaluation and synthesis of a range of data types used in the insurance industry with considerable potential benefit.

6. Acknowledgements

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Biography

Aidan Slingsby is a research fellow at the giCentre, City University London. He is interested in spatial data representation, methods for the visual analysis of large spatio-temporal datasets and computation methods that support this work. He works part time in the Willis Research Network and part time on other projects.

Jason Dykes is a senior lecturer in geographic information at the giCentre, City University London, with interests in developing and using interactive graphics to explore complex structured data sets. Jason has particular interest in the development and evaluation of geovisualization applications and the statistical analysis of spatial pattern.

Jo Wood is a senior lecturer in geographic information at the giCentre, City University London. He is particularly interested in analysing surfaces and hierarchies in applications ranging from geomorphometry to insurance risk. He is the author of the LandSerf GIS and other software packages in Java.

Matt Foote is Research Director of the Willis Research Network (www.willisresearchnetwork.com), an international group dedicated to researching the key issues facing the global insurance industry. He has 20 years experience in remote sensing, GIS and coastal geomorphology with publications in Transactions in GIS, Geomorphology and the Journal of Coastal Research.

Mike Blom has spent the last 3 years at Willis as a GIS developer, supporting the catastrophe analytics team through development and maintenance of various analysis tools looking at clustering, loss curves, exceedance probabilities, and probability distribution. He is currently finishing an MSc dissertation on natural energy resource distribution throughout the UK.