A Spatial Analysis Of Potential Local Climate Change Impacts and Their Relationship with Land Use Changes

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1. Introduction

This research aims to relate observed changes in phenological events with change in land use. In order to investigate the potential impacts of local climate changes.

Land use and land cover changes have been described as the major drivers of climate change (Feddema et al., 2005; Strengers et al., 2010) and is used as input into many climate change models. These tend to operate at relatively coarse spatial scales but much recent research has identified the need to identify the local interactions of land use and land use changes with local climate changes in order to understand better understand how the impacts of climate changes will vary spatially (Poulter et al., 2010a; Soares-Filho et al., 2006; Malhi et al., 2008; Cochrane and Barber, 2009). So for example local changes in land use have been found to effect local climate which in turn results in further land use changes (Poulter et al., 2010a; Aragão et al., 2008).

Phenology describes environmental events related to biotic development. Phenological events have a long history of being recorded by interested volunteers and include such things as first flowering and first leaf dates for plants, the first or last dates when migratory birds are observed and the dates when other phenomena are first observed (e.g. frogs spawn). The data frequently have long records covering 100s of years sometimes and many of these are being collated and made freely available. For example, in the UK, spatio-temporal data describing different phenological events are held by The Woodland Trust, and can be viewed on their website (http://www.naturescalendar.org.uk/).

Changes in the timing of natural events may indicate the impacts of local changes in climate.

2. Methods

This analysis compared local data on urban land change between the 1930's and 2007 summarised over 1km grid squares with local data on the rate of advance of different phenological events. The aim was to determine the whether any local climate effects could be observed from phenological changes and whether they could be explained by changes in the urban environment.

2.1 Land Use Change Data

The urban land use changes in are shown in Figure 1. Generally, these show considerable expansion of the urban areas and decreases in rural areas, although there are some issues with directly comparing the digitised 1930's Stamp data with the 2007 Land Cover Map. This will be specifically considered as this research develops.

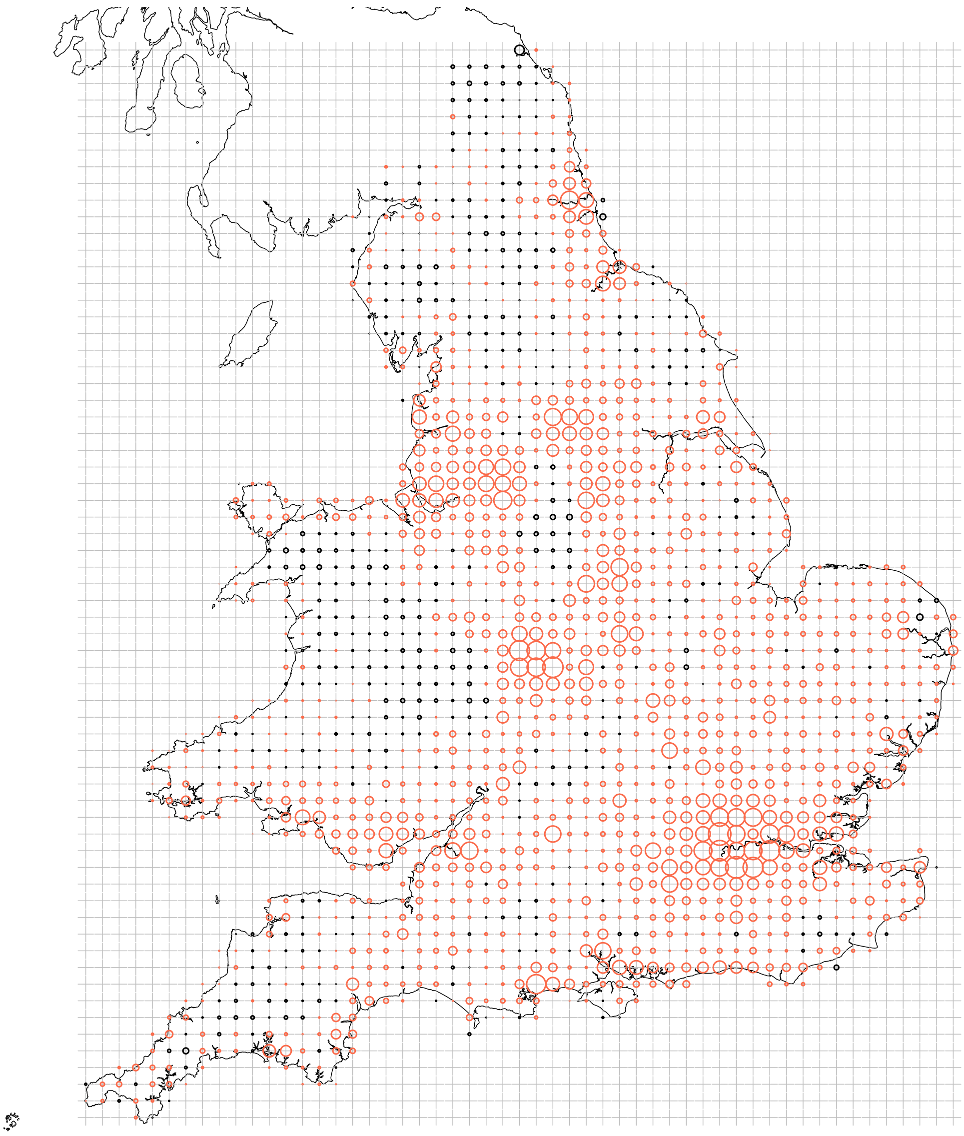

Figure 1. Urban land use changes 1930s to 2007 summarised over 10km grid squares. Increases are in red and decreases are in black, with the size of the plot character indicating the magnitude of change.

2.2 Phenological Changes

Phenology data was provided by The Woodlands Trust describing a number of different types of events with data runs from 1900 to 2011. In this work phenological events that were analysed included:

- the date of the first and last recorded sighting of swallows;
- the date of the first recording of the cuckoo;
- the date of the first flowering of blackthorn, hawthorn and horsechestnut;
- the date of the first recorded wasp queen and frog spawn.

2.3 Analysis

A standard regression model was used to analyse the changes phenological events by regressing Julian day against year as in the following:

$$Day = \beta_0 + \beta_1 Year \qquad (1)$$

However, the elevation of the observation location would be expected to affect the timing of the event, with locations at higher altitudes being colder and thus the date of the first observation being later, due to plant development being driven by temperature. Elevation for the location of each observation was extracted from the Google Elevation API (now defunct) and Equation 1 was expanded to:

$$Day = \beta_0 + \beta_1 Year + \beta_2 Elev \qquad (2)$$

By adding an Elevation term to the model, coefficient for Year represents changes in Day beyond that due to elevation of the observation location. In order to allow for elevation an elevation corrected index of date can be created. This is an estimate of the date for a given location if it were located at sea level, rather than its actual elevation. This is achieved by subtracting the contribution of elevation from the estimate of Day:

$$Day.EC = Day - \beta_2 * Elev \qquad (3)$$

where Day.EC is an elevation corrected indicator.

The spatial variation in the advancement (or other) of phenological events was then analysed by including the elevation corrected indicator of Day in a geographically weighted regression (GWR) analysis (Brunsdon et al., 1996) in the following way:

$$Day.EC = \beta_{0(u_i,v_i)} + \beta_1 Year_{(u_i,v_i)}) \qquad (4)$$

where (u_i, v_i) is a vector of two dimensional co-ordinates describing the location of *i* over which the coefficient estimates are assumed to vary.

The GWR analysis was run over the same 10km grid used to model land use changes.

3. Results and Discussion

For each of the phenological events the (elevation corrected) date of the first / last observation was analysed against year using a geographically weighted regression. Some of these are shown in Figure 2.

It is evident at that different rates of change are associated with different events, with some events advancing (getting later in the year) and others getting earlier. On-going work will seek to unpick the reasons for this, which may be due to biases in the volunteered phenology data. Future research will investigate the properties and qualities of the phenology datasets using the methods described in Brunsdon and Comber (2012), before formally seeking to link the results of the geographically weighted analysis to the land cover change data. These will be presented at the conference.

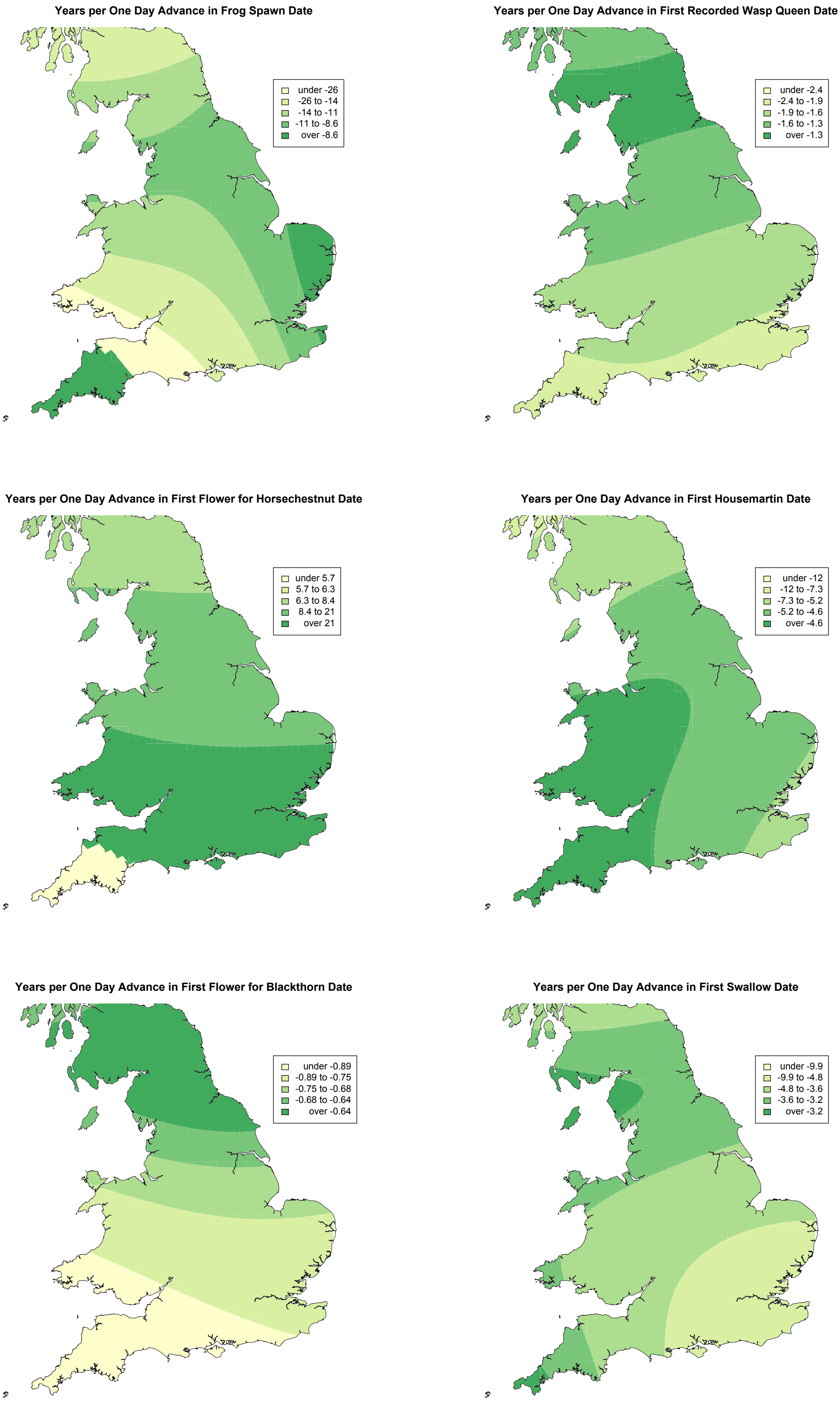

Figure 2. Varying rates of advancement / regression associated with different phenological events.

Much research is currently interested in how crowdsourced or volunteered geographical information might be used in formal scientific analyses. As yet little research has developed formal informatics based methods for assessing the quality and reliability of such data, other than to "accept what the crowd says" (e.g. Haklay et al., 2010). Much recent research has found that the crowd may be confused and that more sophisticated methods are needed (Comber et al., in press). These include the many informatics based approaches, for example, ones that are able to reason with belief and uncertainty, if such data are to be used in scientific analyses and not collected under a formal experimental design framework.

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Biography

Lex Comber is a Reader in Geographic Information at the University of Leicester.
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