Relative sea level change in the Forth and Tay Estuaries, Scotland

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Introduction

With increasing sea levels projected until beyond 2100, localised studies of relative sea level change are recommended (Solomon et al., 2007; Lowe et al., 2009). The Forth and Tay Estuaries are valuable ecologically and economically, with several regional designations, large cities and industrial areas. Since 1897 tide gauges have been periodically located at sixteen locations within the Forth and Tay Estuaries (Figure 1), including several previously unseen tide gauge.

Glacio-isostatic adjustment (GIA) induced land movement is typically causing land-level rise in Scotland, but some peripheral areas are experiencing subsidence (Shennan et al., 2011; Milne et al., 2006). As a consequence, most of the Scottish coastline is experiencing decreased levels of relative sea level rise compared to southern England and Wales (Figure 2).

Considering the reduced rates of relative sea level rise predicted along the Forth and Tay Estuaries, this localised study of the region provides greater insight into the contrast between the UK-wide, global and regional sea level trends. It also poses a question, what rate of sea level change could the region have experienced if the GIA had been negligible? A simple model is provided here.

Method of correcting and collating data

Data were collected from various international, national and local institutions including the Permanent Service for Mean Sea Level, British Oceanographic Data Centre, National Tidal and Sea Level Facility, UK Hydrographic Office, Perth Harbour Authority, Scottish Environment Protection Agency, Tay Estuary Research Centre and Forth Ports Limited. Data were converted into the same temporal format and validated with neighbouring sites.

The relative sea level rate was calculated for each site and then 5 stable sites were chosen to form a ‘Combined Forth and Tay Estuaries’ dataset spanning 1900 to 2010. The data are compared here with a modelled GIA-adjusted dataset, the method for which is explained further in the next section.

As part of the lead-author’s PhD, these tide gauge data, at different frequencies, were used to analysis storm surge events and adapt two relative sea level projection models.

Relative sea level rates across the Forth and Tay Estuaries

Douglas (1997), Jevrejeva et al. (2008) and Church and White (2006) identified the average global sea level rise to be between 18.5 and 19.5 cm between 1900 and 1995/2004. Church and White (2011), using a tide gauge dataset from 1880 to 2009, suggested the global sea level rise has been 1.7 mm a⁻¹ (Solomon et al., 2007). These rates are considerably higher than those observed in the study region. Data from individual sites within the study region are presented in Figure 3.

Conclusions

- Historically, relative sea levels in the Forth and Tay Estuaries have risen by an average of 3.6 cm since 1900
- GIA has potentially inhibited 5.7 cm of regional relative sea level rise since 1900
- This model follows a simplistic method and would benefit from long-term GPS records

References


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