MCCIP Marine Climate Change Impacts Partnership

Topic

Sea Level (observed)

Author(s)

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Executive summary

Global-average sea level rose during the 20th century at an average rate of 1-2 mm/year, with some consensus on the larger value by the research community. The rate was larger (approximately 3 mm/year) during the 1990s. UK sea level records are consistent with these values but with smaller trends observed in Scotland (where the land is uplifting) than in the south of the UK. Extreme sea levels are also known to have increased, both on global-average and UK bases, following to some extent the rise in mean levels but also subject to long term changes in meteorological forcings.

Full review

Tide gauges (also called 'sea level recorders') have been used to monitor long term changes in annual **mean sea level (MSL)** around the UK for over a century. These data, together with those from other countries, are archived at the Permanent Service for Mean Sea Level (PSMSL) at the Proudman Oceanographic Laboratory.

The PSMSL data set has been used in all the IPCC Scientific Assessments (e.g. Church *et al.,* 2001) and by other expert working groups (e.g. WCRP, 2006). The IPCC 3rd and 4th Assessment Reports concluded that global sea level has risen during the last 100 years at an average rate of 1-2 mm/year, with some consensus on a value around 1.7 mm/year, with evidence for an acceleration to approximately 3 mm/year or more during the 1990s. The higher rate in the 1990s is also supported by data from precise **satellite radar altimetry** (TOPEX/POSEIDON and Jason-1 missions).

The UK possesses a small number of long sea level records, which are fortunately distributed around the coastline. Figure 1 shows the time series from Aberdeen, North Shields, Sheerness, Newlyn and Liverpool. Over their whole record lengths they indicate sea level trends of 0.69 (0.06), 1.94 (0.10), 1.68 (0.08), 1.75 (0.10) and 1.35 (0.11) mm/year (numbers in brackets being the formal standard errors). These trends are broadly consistent with those reported globally, and with a lower trend in Scotland where a contribution from land uplift can result in a smaller rate. This latter point is even clearer if one computes trends in sea level relative to that observed at Newlyn over their common epochs (1916 onwards) obtaining:

Aberdeen - Newlyn = -0.93 (0.13) mm/year
North Shields - Newlyn = 0.28 (0.12)
Sheerness - Newlyn = 0.55 (0.14)
Liverpool - Newlyn = 0.66 (0.21)

The details of this analysis are discussed in Woodworth *et al.* (1999), which also describes the construction of a '**UK Sea Level Index**'. An updated version of this index is shown in Figure 2. It was made by detrending each of the five long records over 1921-1990 and then by averaging the residuals from the trend. Woodworth *et al.* (1999) referred to a downturn of sea levels since the 1970s but it is clear that from about 1990 the mean level has re-established itself and is increasing as fast or faster than for the 20th century overall. This finding is similar to the conclusions of a global study by Holgate & Woodworth (2004).

The reasons for the observed rise in UK and global sea levels during the 20th century have been discussed extensively in the IPCC and WCRP reports. In brief, there remains a gap (known as the 'enigma') between the reported trends and those, which can be properly explained on the basis of oceanic **thermal expansion**, glacier melting and other processes. However, the gap becomes smaller in recent decades during which ocean and other data sets are more complete and more representative of global-average conditions.

The WCRP report contains a detailed discussion of changes in extreme sea levels, which often lead to flooding. A general conclusion based on tide gauge observations complemented by numerical modelling is that at most locations there is so far little evidence for extreme sea levels changing by amounts significantly different to MSL. However, that conclusion is limited to those parts of the world where adequate historical data exist. In the last few years, there has been great progress in collecting and interpreting observations and in the making of predictions of extreme sea level. However, there is all-round need for sustained observational data sets and for a range of improved numerical modelling and statistical techniques. Together these will lead to the improved understanding of past changes and projections of future ones.

Past and potential future extreme sea levels around the UK are currently under study in several NERC projects. Extreme sea levels are known to be related to some extent to the **North Atlantic Oscillation** (Woodworth *et al.,* 2007). However, the extent to which coastal flooding of the magnitude of

the 1953 event (Wolf & Flather, 2005) might occur in the presence of a general sea level rise has so far been subjected to only preliminary study (e.g. Flather *et al.,* 2001; Lowe *et al.,* 2001) and POL/Defra/EA studies are ongoing to better estimate future extremes using ensemble climate-surge model simulations.

Figures

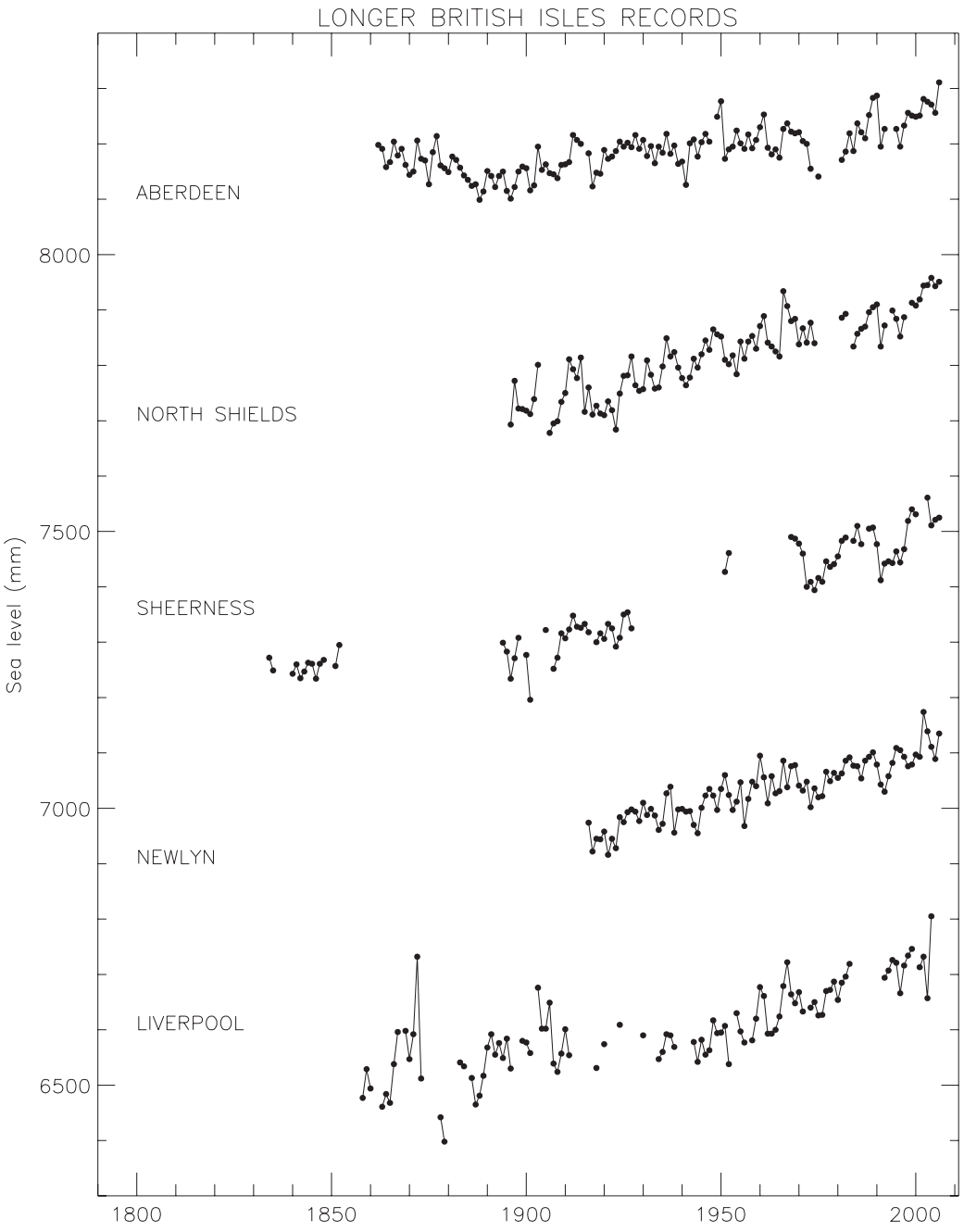

Figure 1: Time series of annual mean sea level for the 5 longest records from the UK. Each time series has an arbitrary offset.

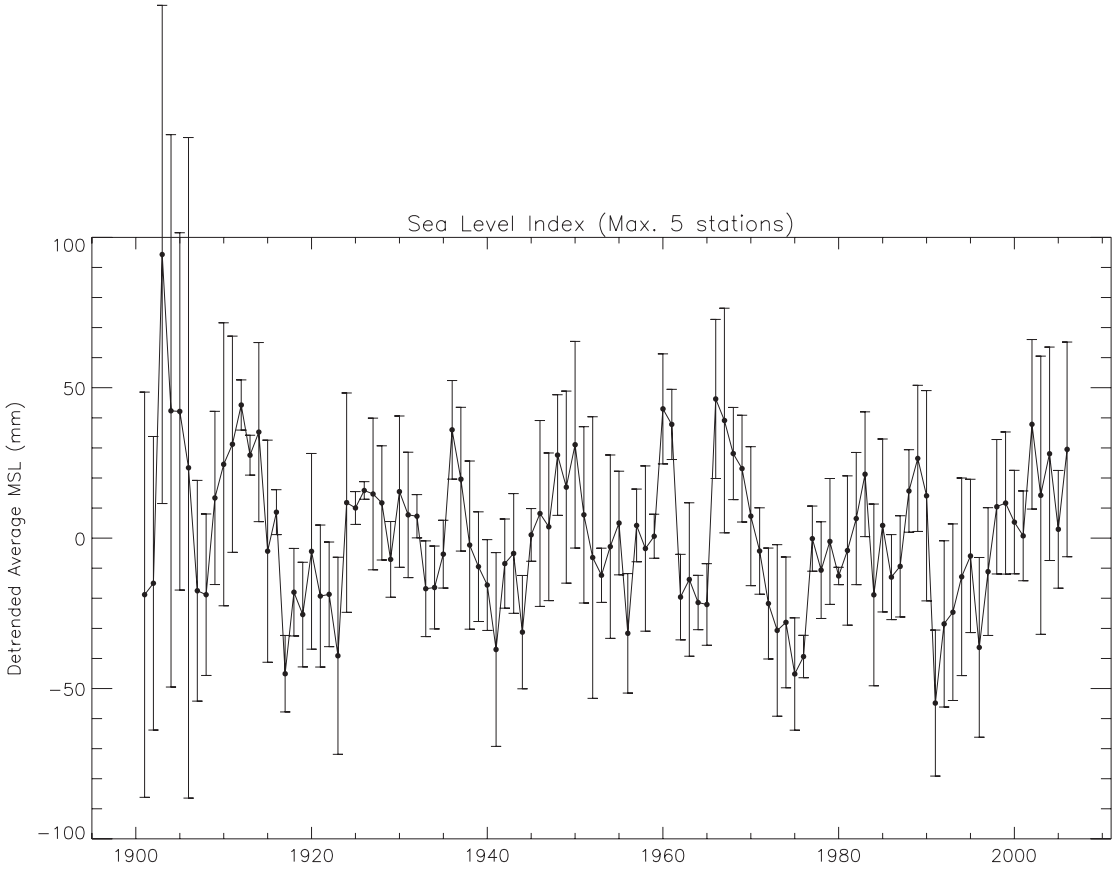

Figure 2: A 'sea level index' time series for the UK computed from the 5 long UK records as described above.

Confidence Assessments

What is already happening - High

We have **high confidence** that sea level has risen globally and around the UK during the 20th century. There is high confidence that sea level extremes have also increased in most locations. There is low confidence that extremes have changed in a significantly different way to mean sea levels.

Knowledge gaps

Not stated

Commercial impacts

Not stated

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