Introduction

There is a majority in scientific agreement that the global climate is changing. Overall, warming of global and regional climates is occurring and, although climate variation is a natural phenomenon, the accelerated rate at which this is occurring indicates this is very likely due to human influences. Changes to the local climate of the Severn Estuary (see Figures 1 and 2) will have impacts on its social, economic and natural environment and it is important to understand these changes for effective adaptation. Current research and evidence for the estuary suggests that air and sea temperatures are rising in line with global trends. Local impacts include coastal flooding and erosion. A significant proportion of critical infrastructure such as roads, rail tracks, power stations and industrial developments are located on low lying land and, therefore, are potentially at risk from these impacts.

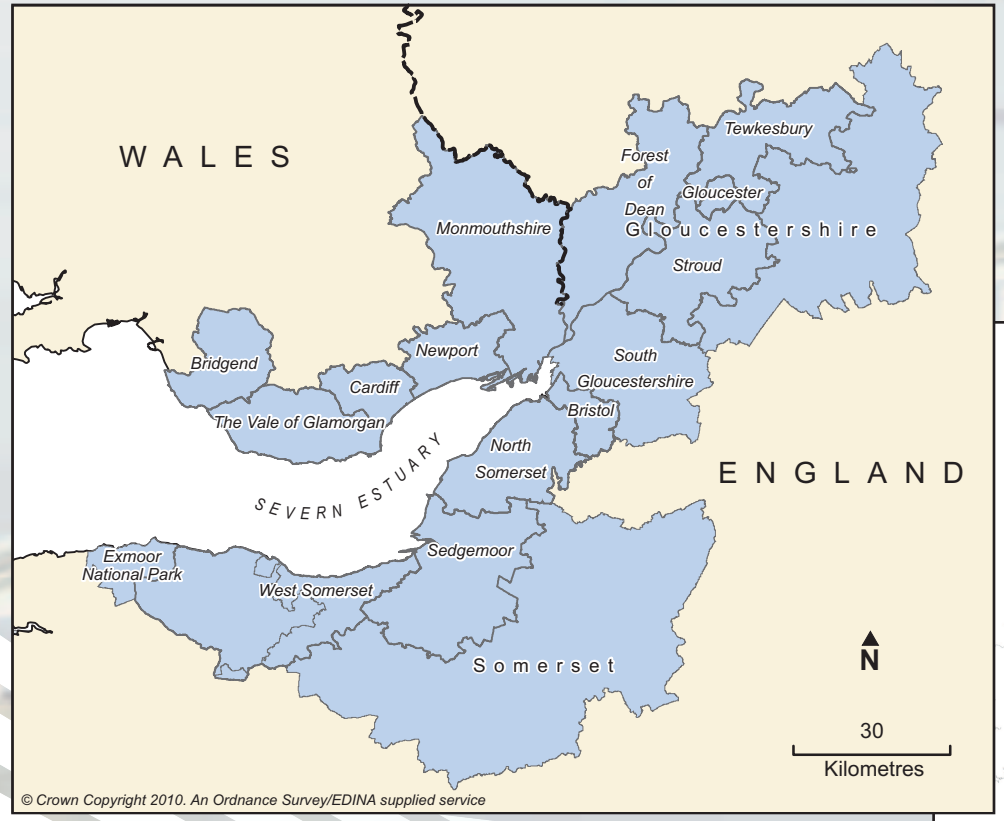


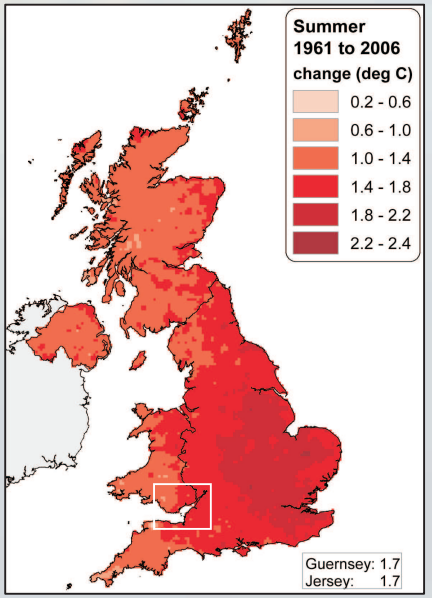
Figure 1: Geographical remit of Severn Estuary

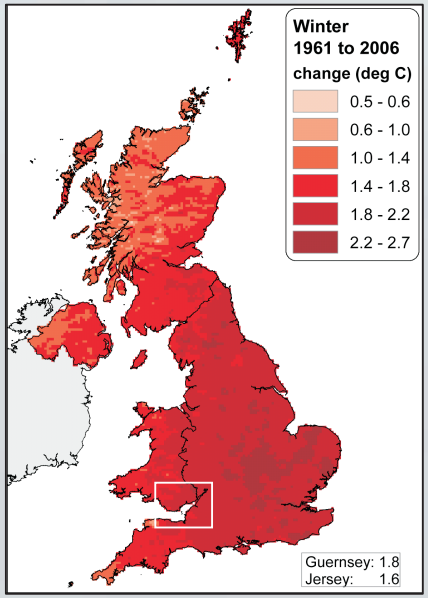
Key observed trends for the UK & Severn Estuary

- ✓ Average UK land air temperature has risen since 1961 (Figures 3 and 4). Winter temperatures in the Severn Estuary have increased between 1.4 and 2.2°C. Summer temperatures have increased between 1 and 1.8°C.
- ✓ UK marine air and sea surface temperatures have increased by about 0.7 °C per decade since the 1980s. There are strong regional variations. Sources suggest Severn Estuary sea surface temperatures are higher upstream than they are downstream (e.g. ranging between 11-13.5°C in 2006[1]).
- ✓ UK relative sea level rose by about 1mm/year during the 20th century, but this rate increased during the 1990s and 2000s.
- ✓ All regions of the UK, including the Severn Estuary, have experienced an increase in heavy winter precipitation events since the 1960s (Figures 5 and 6). During the same time period, heavy summer precipitation events have decreased over the Severn Estuary area.
- ✓ The frequency of severe wind storms in the UK has increased since 1960, but not above levels recorded during the 1920s (a particularly stormy period). Recent research for the southern UK, including the Severn Estuary region, has supported this trend [2].

Note: The majority of climate change information and data exists at national scale; therefore generalisations have been made to extrapolate Severn Estuary specific details from evidence for Wales, west Midlands, south west England and the Severn River Basin. Regional research is continuing [3]. (Source for above information: UK Climate Projections 2009 (UKCP09) [4, 5] and Marine Climate Change Impacts Partnership (MCCIP) [6]).

Figure 2: UKCP09 regions



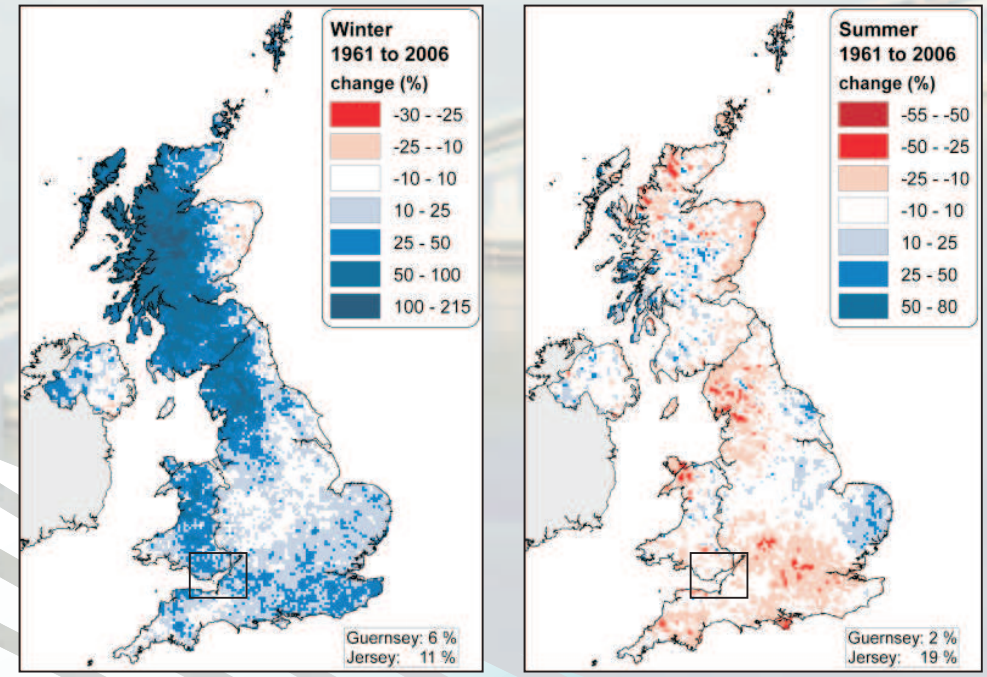


Figures 3 and 4: Winter & summer warming 1961-2006 (source UKCP09)

Future projections for the Severn Estuary

- Figures 5 and 6 show average change in seasonal mean precipitation for 1961 to 2006, highlighting how seasonality has become more prominent. Mean levels of precipitation are projected to continue becoming much more seasonal. By 2080, an average increase in winter mean precipitation levels of about 23% is projected whilst during the summer a decrease of about 24% is projected* for the Severn Estuary area (see Figure 7).
- Figure 8 highlights the increases projected in both winter and summer mean air temperature across the Severn Estuary area. By 2080, winter mean temperature is projected to rise by about 2.8°C and summer mean temperature by about 3.9°C*. Marine air temperature for the Severn Estuary is projected to rise in line with land air temperature.
- Sea level at Cardiff is projected to rise by about 30-40cm by 2080**, assuming a medium greenhouse gas emissions scenario.
- Both milder, wetter winters and warmer, drier summers could create both negative and positive implications for coastal communities, local industry and the natural environment around the Severn Estuary. It is important to note that, regardless of the greenhouse gas emissions scenario used, all projections for the future local climate show significant changes and some level of adaptation will be necessary.

Note: Figures 7 and 8 assume central estimates for each emissions scenario and are based on data available for south Wales, south west England and the Severn River Basin (data source UKCP09 [7, 8]).
**Precipitation and temperature projections are determined using the 1961 to 1990 30 year average baseline level.*
***Sea level projections are determined using the 1990 baseline level.*



Figures 5 and 6:Winter & summer precipitation change (%) 1961 to 2006 (source UKCP09)

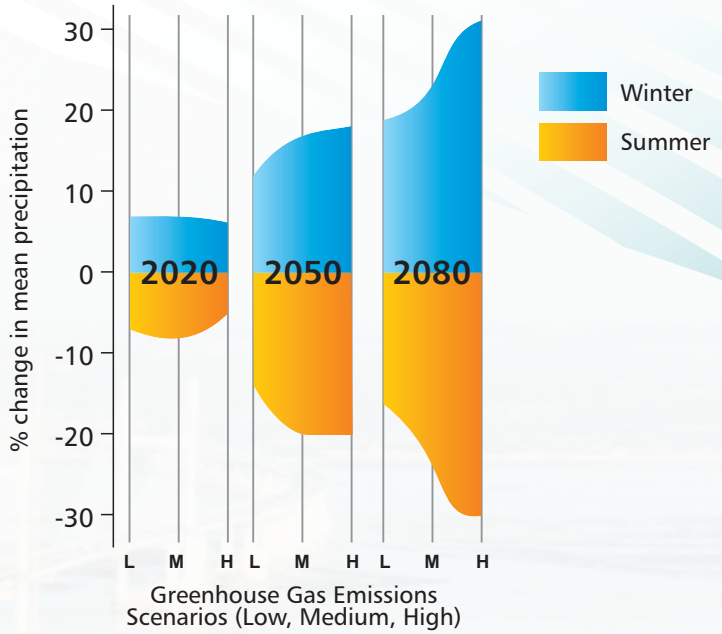


Figure 7: Projected percentage change (%) in mean precipitation for winter and summer, 2020 to 2080, using low, medium and high greenhouse gas emissions scenarios

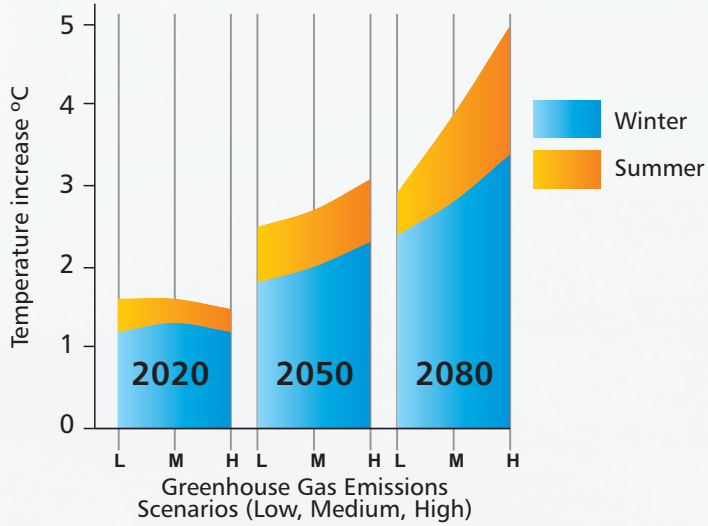


Figure 8: Projected air temperature increase (°C) for winter and summer, 2020 to 2080, using low, medium and high greenhouse gas emissions scenarios

Potential impacts on the Severn Estuary

The impacts of climate change on a local scale, such as the Severn Estuary, can be explored through Figure 9. Climate change is a global issue but it will potentially cause a variety of local impacts on natural, social and economic structures. For example, climate change is already causing land air and sea surface temperatures to become warmer in the summer and winter across the Severn Estuary. This could have a direct impact on coastal and marine ecosystems as species struggle to adapt. This in turn can lead to the loss of habitats that make up the several environmentally protected areas of the Severn Estuary. One of the knock-on effects of this would be a review of all current protected area designations at national and international levels. There are many other impacts associated with changing temperatures, such as the potential for increased tourism in the summer months and also adaptation issues for the agriculture industry in terms of soil quality and types of crops that will grow in a new local climate.

A key consideration for the Severn Estuary is defending the critical infrastructure along the low-lying coast from flooding and the erosion impacts of severe storms. Potential changes in storminess, sea level and wave climate can lead to major economic and social losses if current coastal engineering is breached or overtopped. Therefore, future coastal defence considerations should take into account projected extremes in order to minimise the social and economic impacts of severe weather events.

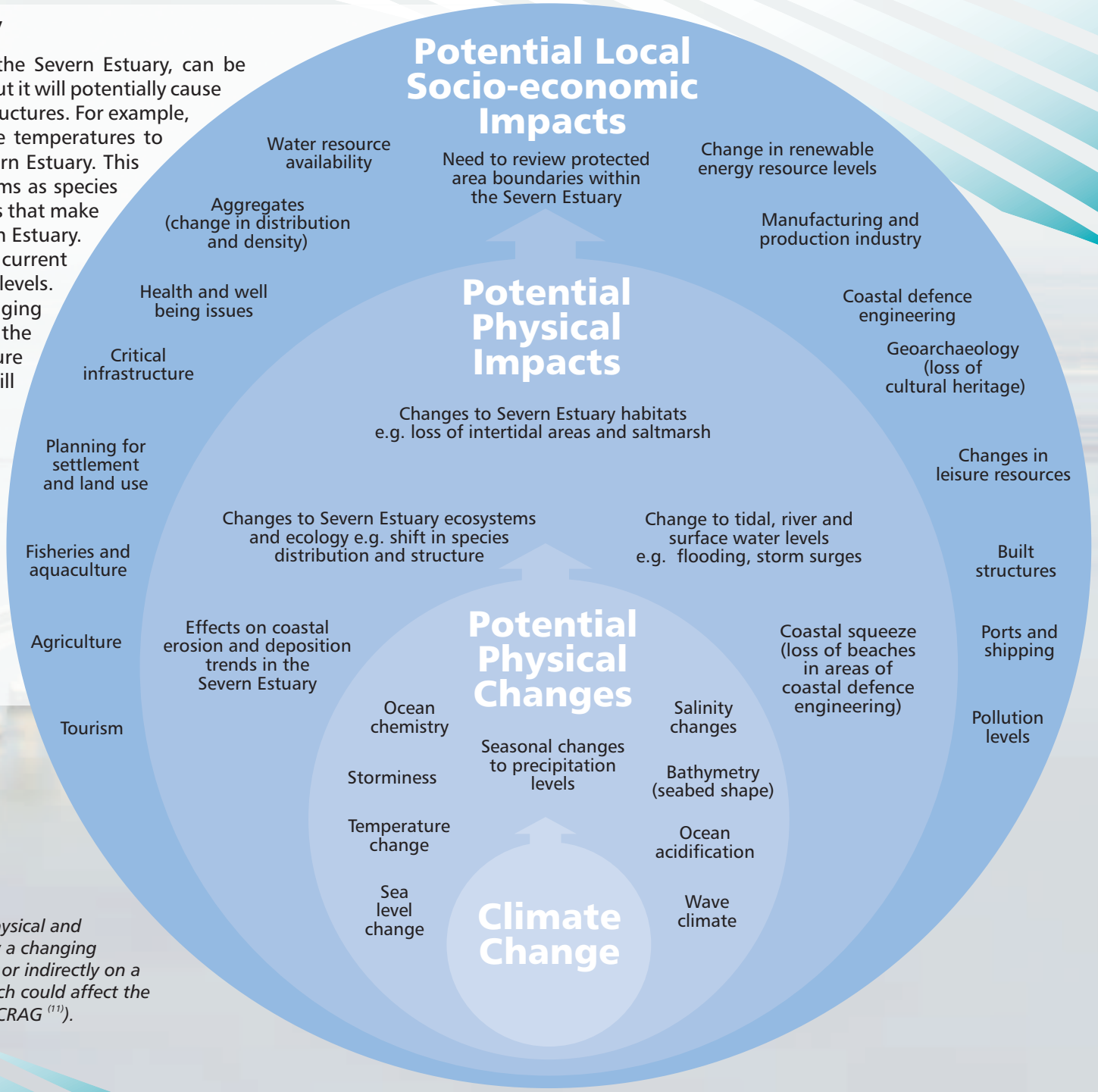


Figure 9: Diagram showing how climate change can cause local physical and socio-economic impacts on the Severn Estuary. This highlights how a changing climate can affect modern ways of life by impacting either directly or indirectly on a range of social, economic and environmental factors, many of which could affect the Severn Estuary. (Range of impacts identified by MCCIP[9, 10] and SECCRAG [11]).

What about uncertainties associated with the projections?

There are a number of uncertainties associated with climate change projections and it is important to consider these when looking at future scenarios. Key uncertainties are identified as those associated with [12]:

Key uncertainties are those associated with:

- Climate modelling due to incomplete understanding of the climate system
- Natural climate variability
- Greenhouse gas emissions and difficulties in predicting future amounts
- Issues with downscaling data and translating it to regional and local scales
- Extreme scenario projections*
- Marine climate change projections*

*Largest uncertainties

References

[1]NEODASS (2006), in MCCIP (2008) Marine Climate Change Impacts Annual Report Card 2007-2008, Summary Report, MCCIP, Lowestoft, 8pp

[2]Allan, R., Tett, S., and Alexander, L. (2009) Fluctuations in autumn-winter severe storms over the British Isles: 1920 to present, International Journal of Climatology, Vol. 29: 357-371

[3]Severn Estuary Climate Change Research Advisory Group (SECCRAG) (2010), Citations Database, Cardiff University

[4]Jenkins, G.J., et al (2009) UK Climate Projections: Briefing report, Met Office Hadley Centre, Exeter, UK. ©Crown copyright 2009

[5]Jenkins, G.J., Perry, M.C., and Prior, M.J. (2008) The Climate of the United Kingdom and Recent Trends, Met Office Hadley Centre, Exeter, UK. © Crown copyright 2008

[6]MCCIP (2010) Marine Climate Change Impacts Partnership Annual Report Card 2010-11, Summary Report, MCCIP, Lowestoft, 12pp

[7,12]Murphy, J.M., et al (2009) UK Climate Projections Science Report: Climate change projections. Met Office Hadley Centre, Exeter. © Crown copyright

[8]Lowe, J.A., et al (2009) UK Climate Projections science report: Marine & coastal projections, Met Office Hadley Centre, Exeter, UK. © Crown copyright

[9]MCCIP (2009) Marine Climate Change Ecosystems Linkages Report Card 2009, Summary Report, MCCIP, Lowestoft,16pp

[10]Cooper, JAG (2009) Coastal economies and people in Marine Climate Change Ecosystems Linkages Report Card 2009, Online science reviews, 18pp

[11]Severn Estuary Climate Change Research Advisory Group (SECCRAG), meeting reports, 2007 to 2010, Cardiff University

Summary of key trends and projections for the Severn Estuary

Past:

Since the 1960s, rising trends have been observed for:

- ✓ average land air temperature
- ✓ marine air and sea surface temperature
- ✓ heavy winter precipitation events
- ✓ relative sea level
- ✓ severe wind storm events

There has been a decrease in heavy summer precipitation events.

Future:

Across all emissions scenario projections (low, medium and high), rising trends are predicted for:

- ✓ winter and summer mean land air temperature
- ✓ marine air and sea surface temperature
- ✓ winter mean precipitation
- ✓ relative sea level

Summer precipitation levels are projected to decrease by up to 30% of the levels experienced between 1961-1990 , potentially causing hotter and drier summers.

Contacts and further information

Produced by C. Hovey, Cardiff University Marine and Coastal Environment Research Group (MACE), as part of the IMCORE project (Innovative Management for Europe s Changing Coastal Resource).

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