Policy Briefings

BASQUE CENTRE FOR CLIMATE CHANGE
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THE PAST, PRESENT AND FUTURE OF THE SEA LEVEL IN THE BASQUE COUNTRY

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1. Changes to the sea level in the past

Numerous climate changes have taken place throughout the history of the Earth. Indeed, the Quaternary period that we are currently living in, covering the last 2.6 billion years of the Earth's history, is characterised by the occurrence of a large number of climatic oscillations between cold glacial stages and warmer interglacial intervals. Records show large accumulations of ice on the continents during the glacial stages, whose length reduced significantly during the interglacial phases. These climatic oscillations have generated significant changes in the sea level, with levels peaking during the warm and minimum stages during glacial periods. These differences in the sea level during the glacial and interglacial periods were over 100 m, as can be seen in Figure 1.

The temperature in the interglacial period prior to the one in which we are currently living (Last Interglacial stage, LIG) was between 1-2 ° C higher than today and different paleontological records show that sea level was between 4 and 6 m above current levels(1). A recent study conducted jointly by scientists from the University of the Basque Country, the Basque Centre for Climate Change (BC3) and the University of Coimbra has determined that the sea level during the LIG reached 4.5 m above the current mean level in the Cantabrian sea, running along the coastline inland.

Key points

- ***The sea level has significantly changed throughout the Earth's history.***
- ***120,000 years ago, during the earlier interglacial period, the sea level was 4.5 m higher than the current mean level in Bilbao.***
- ***The sea level rose by 2mm per year in the Basque coast during the twentieth century, 4 times faster than over the previous 7,000 years.***
- ***The mean global sea level could reach 53-98 cm by the end of the century in the worst case scenario (RCP8.5).***
- ***In the Basque coast, the latest regionalised forecasts show values of 41-57 cm (for RCP4.5 and 8.5 forecasts, respectively).***

The LIG, which peaked about 125,000 BP years ago, gave way to the last glacial period, whose maximum was recorded about 20,000 years ago BP. The sea level at this time was 120-130 m below the current level(2).

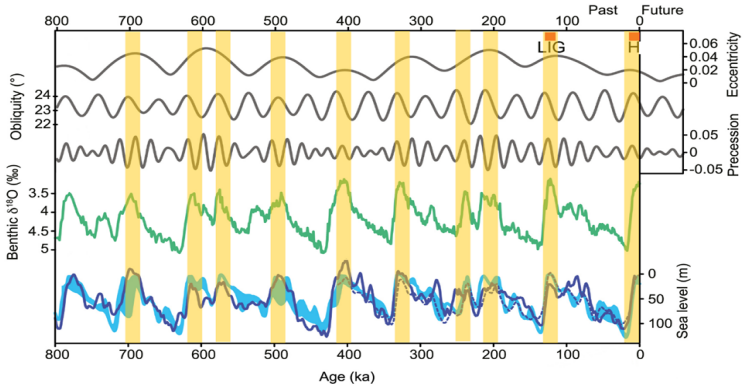

Figure 1. Alternating glacial and interglacial cycles over the past 800,000 years. The yellow stripes identify the temperate phases while the blue lines represent

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The sea level returned to current levels due to the retreat of glaciers that brought an end to the last ice age about 11,000 years ago. However, this has not risen at a constant rate, instead undergoing two phases: first, a rapid sea level rise, at a mean speed of 10 mm per year, with peaks of up to 40 mm per year. During the second phase, 7000 years ago BP, speed is drastically reduced 1 (Figure 2).

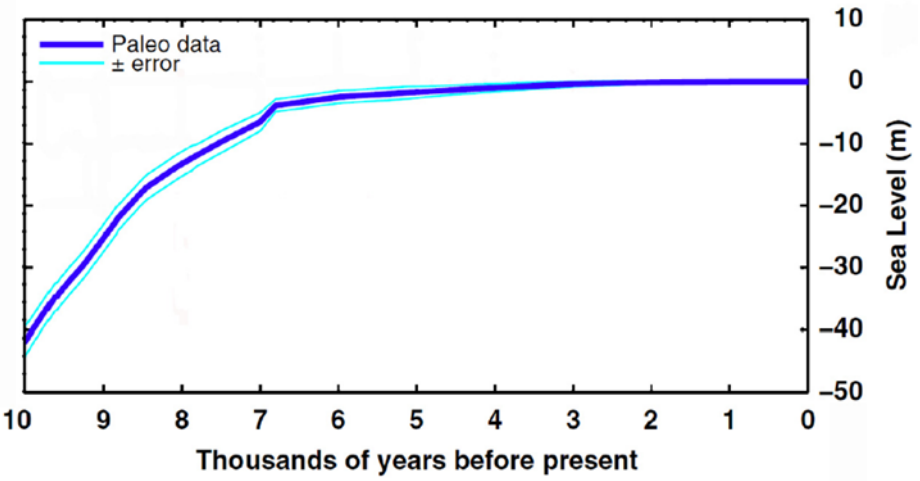

Figure 2. Global changes in sea level for approx. the last 10,000 years BP (Holocene age) (Church *et al*., 2008).

Researchers at the University of the Basque Country have been able to observe this process involving a rise in sea level in the Basque coast based on the sedimentary records on marshes of the Basque coast. They have also identified two clearly different coeval phases: an initial rapid rise in sea level at the end of the last glacial period, which increased from approximately 27 m 10,000 years ago BP to 5m 7,000 years ago BP. The rate of increase measured during this period ranged from between 9 and 12 mm per year, with a mean speed of 10 mm per year, i.e., 1 m per century. Sea level increases levelled off from 7,000 BP onwards, with a reduction of half a millimetre per year (about 20 times lower than the previous period)[3,4] (see Figure 3).

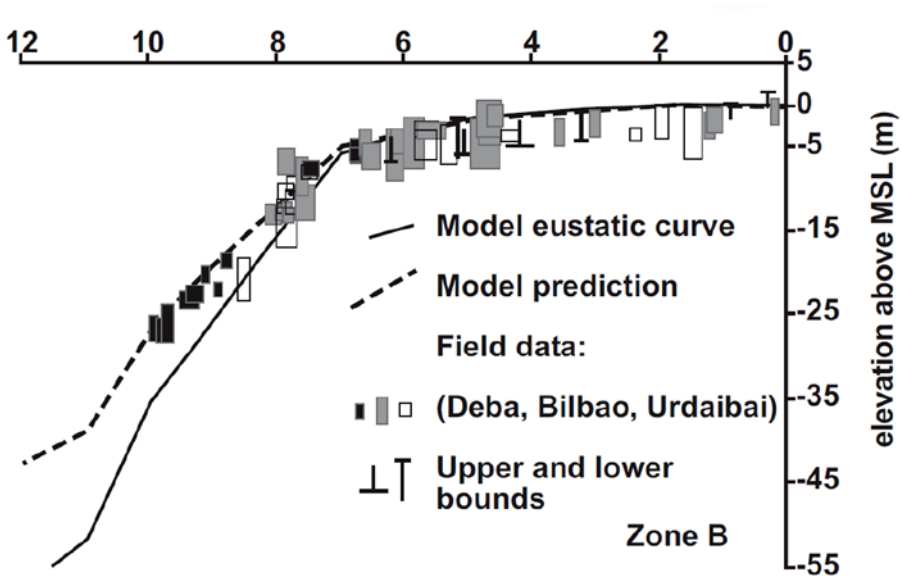

Figure 3. Changes in sea level in the Basque coast over the last 12,000 years (Holocene age) (Leorri et al. (2012).

2. The sea level during the 20th century

While the last hundreds of thousands of years have been characterised by significant climatic changes, accompanied by major changes in terms of sea level, the nature of current climate change is very different. The latest report from the Intergovernmental Panel on Climate Change (IPCC) published in 2014 states that global warming is unequivocal and is human-induced. Some of the effects of these changes are already being observed: from 1880 to 2012 the mean Earth temperature has increased by 0.85°C, while the concentration of carbon dioxide in the atmosphere has increased from 285 ppm during the pre-industrial era to 402 ppm, as recorded in January 2016. The sea level is rising as a result of this warming, with significant damage associated with extreme events being reported. Some of these effects are also expected to be accentuated in the future. In fact, while there has been a drastic reduction in emissions in the short-term, the inertia of the climate system will generate effects that mankind will have to face, including the rising sea level.

We have already seen how the rise in sea levels levelled out over the past 7000 years BP. However, there has been a global acceleration in sea level rises from the twentieth century onwards. The speed at which the sea level is rising in different marshes in the Basque Country during the twentieth century has been recorded as being 2 mm per year, 4 times faster than in the previous 7,000 years. These observations based on recent geological records of the marshes match the instrumental record measurements, specifically involving data obtained by tide gauges from Brittany and Santander (Figure 4).

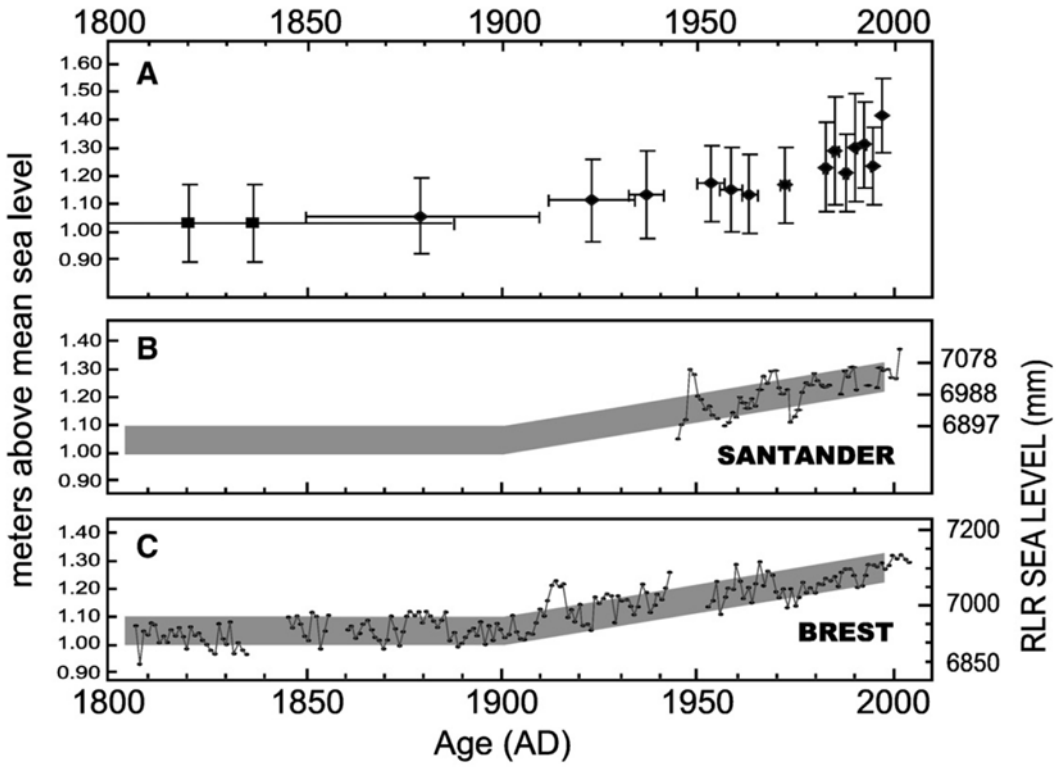

Figure 4. Increase in sea level from 1800 to the present day. The top figure (A) shows the results obtained from the sedimentary record of the Ostrada marsh (Plentzia, Bizkaia). The figures below represent the trendline obtained in ostrada (shaded area) compared with tide gauge measurements from Santander (B) and Brittany (C)[5].

High-resolution satellite altimetry data has been available since 1993, showing a global sea level rise of 3.2± 0.4 mm per year for the 1993-2012 period. 6. The data would therefore seem to suggest that there is a higher than estimated acceleration in the rise of sea level based on geological and instrumental records in the early twentieth century.

3. How will the sea level change in the future?

Global forecasts

The latest IPCC report anticipates an acceleration in sea level rises during this century, in line with the observations during the twentieth century. This increase varies according to different scenarios obtained from process-based models, which differ, particularly from the middle of the century onwards. The more moderate global scenario (RCP 2.6) shows a likely increase range of 21-61 cm by 2100, while the most pessimistic scenario estimates a range of 53-98 cm, as shown in Figure 5[6].

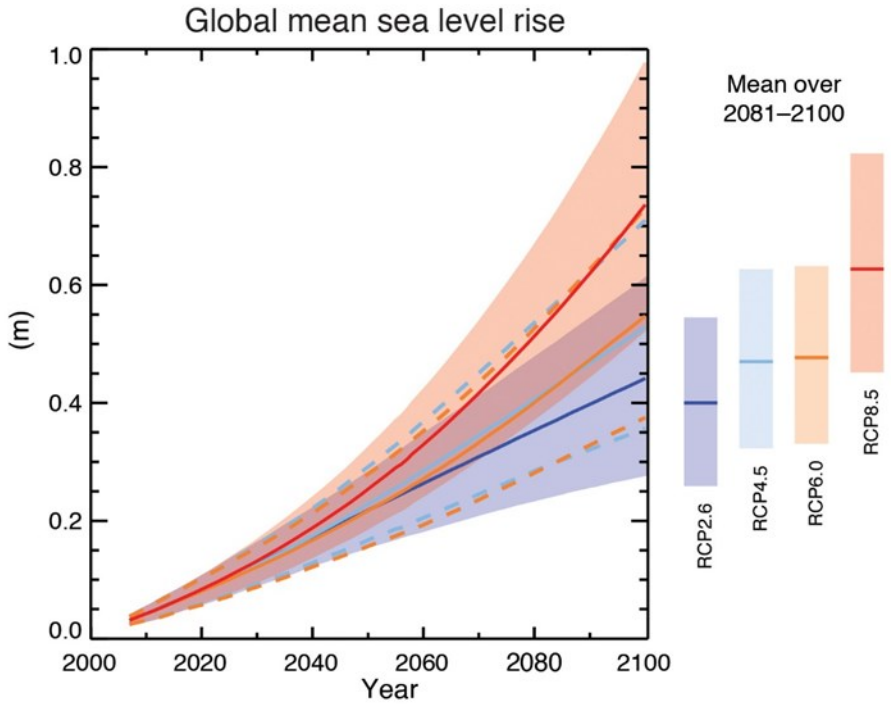

Figure 5. Process-based model forecasts of the mean global rise of the sea compared to the 1986-2005 period for the four RCP scenarios. The solid lines show the median forecasts, with the dashed lines representing the likely ranges for RCP4.5 and RCP6.0. while the shaded frames represent the likely ranges for RCP2.6 and RCP8.5. The temporary measurements for 2081-2100 are represented by coloured vertical bars[7] - Figure TS.22.

Up to the present day, the recorded sea level rise has been higher than estimated in previous IPCC forecasts, which have been estimated based on process-based models[8]. Up to now, the semi-empirical models have reproduced the changes in a more accurate manner, with these same models estimating higher increases by the end of the century (between 75 and 190 cm)[9]. However, it remains uncertain if the relationship between the sea level rise and temperature as reproduced in the semi-empirical models will remain the same in the future, which is precisely the main limitation of these models[10]. The IPCC leans more towards the results from process-based models shown in Figure 4[11]. In any case, there is a growing consensus among the scientific community that the most dire IPCC forecasts may occur by the end of the century, where even an increase of between 1 and 1.5 m cannot be ruled out[12].

Forecasts for the Basque coast

The first forecasts for future sea level rises in the Basque coast were developed by AZTI, taking the scenarios from the 4th IPCC Report[13] as a reference, specifically scenarios A1B and A2. The results showed a probable rise of between 28.5 and 48.7 cm by 2100[14], in line with global forecasts that estimate a global increase of between 18 and 59 cm by the end of the century.

The IPCC's latest report[15] shows significantly higher estimates, as we have seen, therefore making it seem reasonable to think that the regional increase is also higher than previously estimated. However, the available regionalised data currently estimate only a slightly higher increases of 41 cm in the intermediate scenario (RCP4.5) and 57 cm in the worst case scenario (RCP8.5)[12].

4. Conclusions

The sea level has varied significantly throughout the entire history of the Earth, particularly during the Quaternary period that we are living in today. However, the changes that are taking place today are of a very different nature and are mainly induced by mankind. There is great deal of uncertainty in terms of the speed and intensity of the changes that are expected to take place, as well as in relation to the rise in sea level. While the IPCC has developed four scenarios for the rise in the sea level during the 21st century, which show a broad range of variation on a global scale, the scientific consensus is that the rise may come close to the worst case scenario forecasts (RCP8. 5). According to this forecast, values of more than half a metre are expected in the Basque Costa by the end of the century.

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