Refereed Report: Protection of Fairbourne Village. Dr Graham Hall.

Detailed examination of the Independent Peer Reviewed Report.

Dr Veronica Edmonds- Brown

University of Hertfordshire.

Correspondence address: Dept Geography, Environment and Planning. University of Hertfordshire, College Lane. Hatfield, Herts, AL109AB

Email: v.r.edmonds-brown@herts.ac.uk

Summary

Dr Graham Hall has produced a thorough report on the risk of flooding to Fairbourne Village. It assesses the current protection in place as well as putting forward relatively low-cost alternative additions. Compared to the current suggestion of a village re-location, these additions would be more cost effective and have the advantage of using natural processes to gain considerably greater protection. Supplementary measures include reinstating the drainage ditches and upgrading the tidal gate, which will have additional advantages for the adjacent agricultural land. The measures suggested would not impact on the local SSSI Arthog bog. Other measures such as reducing wave energy with use of groynes or an offshore reef are again comparatively low-cost and known to be an effective approach.

The author has run data for a range of scenarios in support of the proposed additions, and the models have been well designed and based on worst case conditions. The suggested additions would provide effective protection at least until 2065 and likely well beyond.

On the other hand, the proposed relocation of Fairbourne village is heavily reliant on model predictions rather than evidence-based data. Figures and tables of data purporting to support the predictions are stated as fact but not evidence based. Use of terms such as 'may' 'might' 'potentially' 'could' 'perhaps' and 'suggests' are used liberally in the reports and documents that make these predictions. The terminology used are indicators of a level of uncertainty that is not being considered with decision making. The tidal flood data from 2011 used in the decision-making was again from models without real world testing, and consequently lacks precision. This report is out of date since the 2016 flood alleviation work, so no longer relevant.

The most interesting and relevant findings from Dr Halls report was that the risk to the village is not from sea level rise or extreme storm surges but from surface runoff from heavy rainfall events inland. Hall's report takes this into account and has covered all flooding issues. The main flood risk area is the caravan park to the south of the village at the Friog corner where is evidence of erosion, and caravans are, by definition, homes that are mobile.

The range of alternatives presented in the report are all viable approaches. One or several of these would significantly reduce flood risk to the village and therefore a managed retreat is an unnecessary action.

Detailed examination of the Independent Peer Reviewed Report.

Each section of the report is discussed below with critical comments where required and occasional suggestions. An appendix with supplementary information is supplied.

1. Introduction.

Factual information on the settlement is provided in the first paragraph and then moves on to the planning decisions. These decisions appear to come chiefly from the West of Wales Shoreline Management Plan by Haskoning (2012) and to be based solely on model data with no ground truthing. For example, the reference to the work carried out by Robins 2011 would relate more to Barmouth, as Fairbourne could not be considered to have a 'complex estuarine' environment (see appendix 1). This information has been out of date since the 2016 flood alleviation scheme. The satellite data used for predictions within Robbins's report, for reasons discussed later, have fundamental issues with data accuracy.

The elephant in the room is the reliance on the use of computer models and for both long term climate prediction and sea level rise, these cannot provide a great level of accuracy and can therefore not be validated. Unfortunately, this does not seem to be taken into consideration when used for policy decisions (see appendices 4 and 5 for real world data illustrating this). Predictions, especially climate model predictions are a gross simplification of the real world. There are huge gaps in scientific understanding and knowledge of ocean processes and its coupling with the atmospheric processes. These models are therefore intrinsically unreliable, Murphy et al (2004); McKitrick (2010); Frank (2019); Connelly and Connelly (2014) and Găinuşă-Bogdan et al (2018). In addition, they include model assumptions which introduce their own bias (Lacis et al 2010). Their unreliability is in part because of the use of linear models for what are essentially nonlinear, dynamic and occasionally chaotic systems (Annan and Hargreaves 2004; Mukhin et al 2015 and King 2019). Consequently, climate model data does not track real time climate and over time the discrepancy can be seen to get larger (see appendix 5). When one examines the published accounts of climate model performance it reveals that there is also a propagation of calibration error and apparently neither parameter uncertainties nor systematic energy flux errors are ever propagated through any step-wise simulation of global climate (Gleckler et al., 2008; Knutti et al., 2008; Fildes and Kourentzes, 2011). Finally, there has been a lack of critical thinking in terms of data sources, data 'adjustments' and start dates. Claims that extreme weather events are due to climate change cannot be substantiated. Climate models are very poor predictors of this (Allan, 2003 and van Oldenborgh et all, 2021) and there is far more evidence that extreme events have closer correlation with Pacific Decadal Oscillations (PDOs) such as El Nino events (Zanardo er al 2019). In terms of El Nino events NASA do continuous real time monitoring of SST (Sea Surface Temperatures) to detect whether incipient El Nino's are likely and these have a maximum prediction time of a year. The terms 'predictions' should provide a clue here – climate models rarely provide probabilities and when they do, they have an extremely large error rate.

Dr Hall goes on to critically assess the model predictions for the village which have been used in the Shoreline Plan and decision making. There is no doubt about his conclusions: there is no evidence that the predicted sea level rises given in the tables from previous reports are accurate, essentially because there is no real-world data to base them on. In the UK the best measure we have of sea level rise is our network of tidal gauges (Woodworth et al. 1999). The UK has a fractal coastline – a large, convoluted length, but served by only 44 tidal gauges networked to record seal level changes. Every gauge relates to an individual bathymetry, and areas of coastline, even short distances apart, will show different sea levels – hence the need for the setting of chart datum. These tidal gauges have an additional and important role in that they are also used to calibrate satellites. Satellite data around the coast cannot measure with any precision coastal sea level. Tidal movement, wave height etc are confounding factors and because of their trajectories satellites cannot measure for example mean high water tides on a regular basis. In terms of sea level rise the best parameter to measure this remain our tidal gauges and very little of the coastline is accounted for. As a consequence, there continue to be issues with data accuracy when making predictions (Wallingford report 2015). Interestingly, since being networked, UK sea level rise has remained linear. There is currently no sign of accelerated rise – claims of acceleration are not supported by the raw data. If one takes the annual relative sea level trends from PSMSL tide gauge data from 1900 to 2015 around the North Sea, the average annual rise is negative -0.76 mm. If one removes the sites where, for geological reasons, there is a decrease in sea level, then the annual mean is 1.4 mm (Wallingford 2015). This is lower than the global estimates of 3.3 mm per year (NASA 2019). Barmouth is the closest tidal gauge to Fairbourne, but again has a very different bathymetry, and is also within an estuary, so cannot be used as a realistic proxy. See appendix 1. Marine Digimap of the area.

2. Sea level and wave height forecasting.

This is covered in some depth with the main risk mentioned in previous reports being an increase in coastal storms. No evidence-based data is presented for this in the decision to relocate (see appendix 2 for rates of extreme wind events); rising sea level which are again based on model predictions alone and with little trend date to suggest this is accelerating, (see appendix 3) and runoff from surrounding hills during high rain events. Runoff is likely to be the major flood concern and several viable solutions to mitigate have been presented in Hall's report.

Figure 4 of this report provides a graph giving predicted sea level rise from several referenced sources (note: from data taken from a very different bathymetry, Barmouth NOT Fairbourne). All but one model (DEFRAs) indicates a slow linear increase over time. The DEFRA model is an outlier here. This report has taken a level of 0.5m increase over a 43-year period – this is an approximate mean for the five models used by Philips et al. (2017) and includes the DEFRA outlier. Given the long-term records from Wallingford (2015) and Woodworth et al (1999) the 0.5m is an overestimate. This report is essentially using the worst-case scenario for its own data modelling.

Storm wave height does not show a trend in increased frequency of occurrence or height, and note that the storm that impacted large areas of the UK in 2014 did not cause flooding to Fairbourne. The joint fact sheet on Sea level Rise and Storm Surges (DEFRA; Met Office; EA. UKcp 18) states there is no evidence to indicate an increase in storm surges. This fact sheet and the supporting documents are again based on predictions rather than real-world data.

3. Current flood protection scheme.

This section contains details of what is in place and identifies that the main risk is from extreme rainfall events. The author notes, correctly, that for this to occur it is likely to involve a number of meteorological factors including flood waters from inland occurring at the same time.

4. Proposed flood protection scheme.

This section has been extensively explored and well researched. The attention to detail and scope is far above what one would receive from a consultancy or government agency. The approach has been holistic including geology, sea defenses, railway and estuary embankment, proposed flood embankment, internal drainage, retention pond and sea water interception are all covered, and each of these has been explored in detail. The Friog corner has been surveyed and found to be a potential area of weakness with shingle spit erosion identified. The solution proposed is viable and cost effective – the report notes that angular rock material from inland quarries would provide greater stability to the beach area, preferably material greater than 15 cm could be used in beach replenishment (Fig 18 in the report). An alternative is also proposed, which considers sediment retention. Other options suggested include the use of groynes to interrupt longshore drift or the creation of an artificial reef. The use of groynes is well established but does deplete sediment from further down the coast and will eventually need replacing, whereas artificial reefs are longer lasting. They are a more recent addition to coastal protection but have produced excellent results in reducing wave energy (Nautilus Consultants Ltd. 2003).

Dealing with internal drainage by maintaining / reinstating the ditches is sound land management and the embankments appear to be providing adequate protection. In figure 29 of the report, the route of the proposed embankment extension is given and routing of drainage waters are covered in figures 31 &

35. This is a comprehensive view of all the issues and include consideration of using a French drain. These additional options are more concerned with landward flood issues rather than seaward.

5. Hydrological modelling.

The hydrological models use an extreme event and from the model predictions the sea defenses hold up well. More of an issue is the excess water from the surrounding hills and rivers under extreme rainfall events. Surface runoff obviously increased but the model suggests the rivers are unlikely to over top their banks. The cited report by Owen on behalf of the Environment Agency on Fairbourne flood alleviation relates to a desk study and examination of pits, essentially archaeological work, which is all inland with no relevance to sea level or coastal flooding.

6. Outer flood protection area.

The focus here is on the Arthog Bog, where this SSSI appears to have developed into a raised bog. Excess water from this area appear to flow mostly towards the tidal gate. The suggestion of an upgrade on the tidal gate would be beneficial in dealing with inland runoff in the future.

7. Summary of works for proposed scheme.

An excellent summary with logical sequence of works that could be carried out. The risks are ALL related to land rather than coastal flood issues. The schemes proposed are well designed and would significantly reduce flood risk. Monitoring is included here – lack of monitoring and maintenance is a common management failing. Expected outcomes and possible interventions are included here. All of these are sound options.

8. Conclusions and recommendations

Use of worst-case scenarios of a 0.5m sea level rise (this is assuming mean linear increases for the UK, with a 0.2m being more realistic) and a possible 2.5m storm surge height (may not occur) then the village is in a good position until at least 2065 and likely beyond. The previous models are no longer relevant since the flood alleviation scheme carried out in 2016. The storm beach and sea wall are 4.5m above the level of the maximum spring tide providing adequate protection for this low-lying land.

9. Discussion.

A thoughtful and evidence-based discussion. This is an essential part of the report that needs to be read. The likelihood of overtopping the wall even if the exaggerated predictions come to pass is infinitesimally small. It is clear therefore that the brochure 'Fairbourne: a framework for the future' is both misleading and irresponsible.

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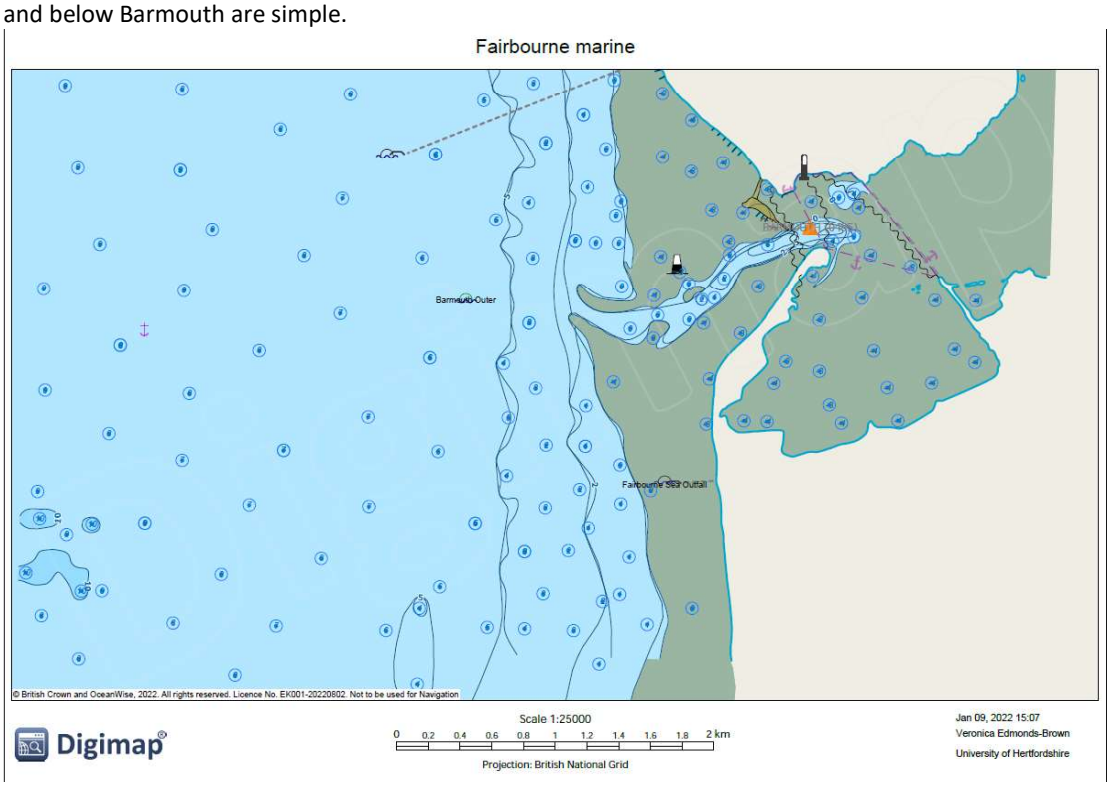
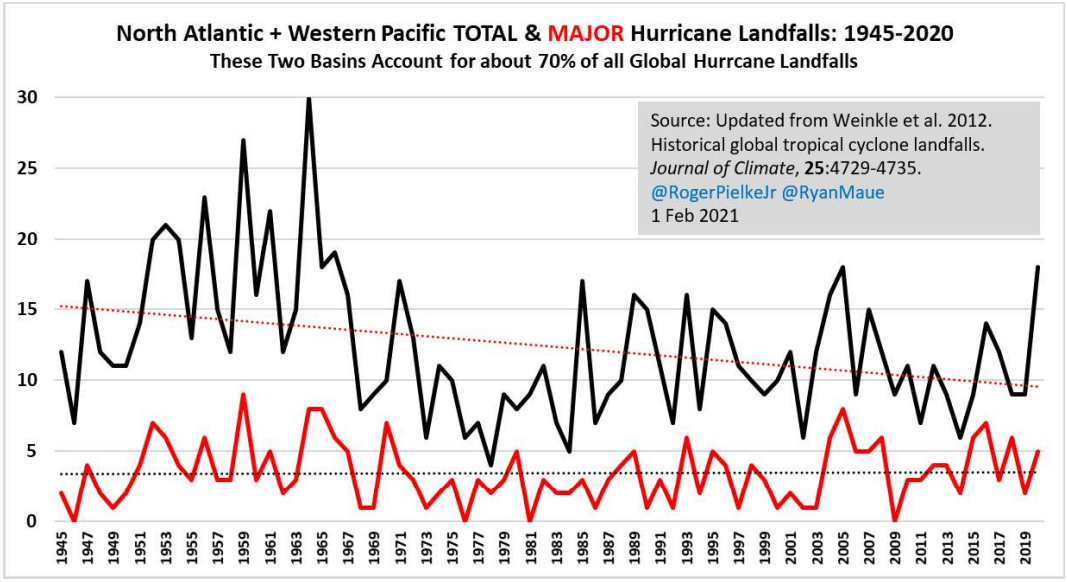
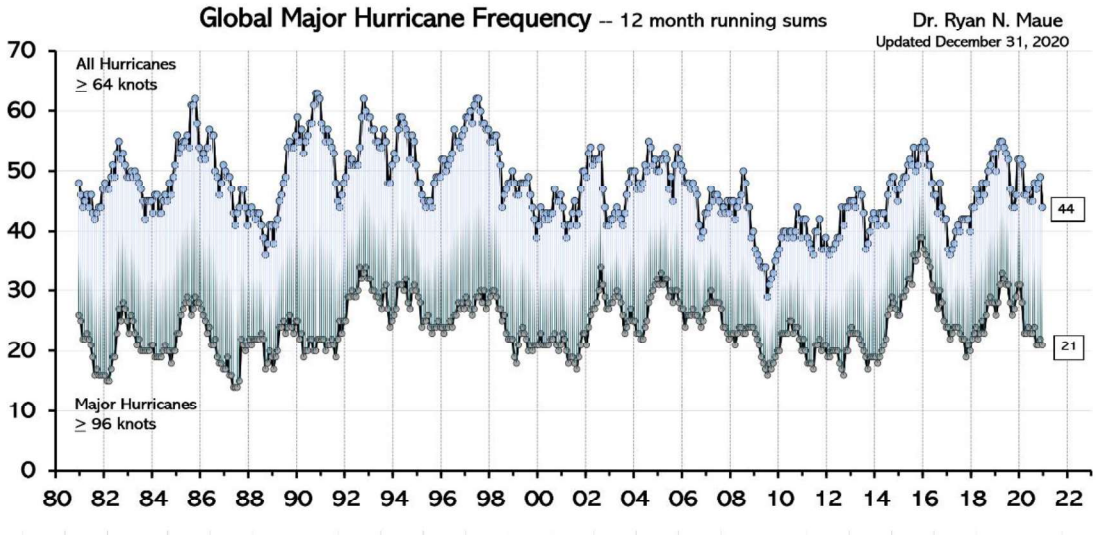
Appendix

1. Bathymetry. Digmap of the west Wales coastline from above Barmouth to just below Fairbourne. The red triangle is the tidal gauge station at the end of an inlet. Contour lines for the rest of the coastal area above and below Barmouth are simple.



2. Many claims that severe wind events have been more frequent in last few decades – but no actual increase in trend for hurricanes / hurricane intensity.





3. Claims that rising sea levels will be from melting ice - as a result of climate warming. https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level. The amount of sea level rise due to melting (with a small addition from groundwater transfer and other water storage shifts) from 2005–2013 is claimed to be nearly twice the amount of sea level rise due to thermal expansion. The decadal average loss from glaciers in the World Glacier Monitoring Service's reference network quintupled over the past few decades, from the equivalent of 6.7 inches (171 mm) of liquid water in the 1980s, to 18 inches (460 mm) in the 1990s, to 20 inches (-500 mm) in the 2000s, to 33 inches (850 mm) for 2010-2018. The data illustrates that the arctic had far greater temperatures in the 1940s with significant ice melt which were subsequently regained. 2021 has seen greater increases in ice gained in the arctic.

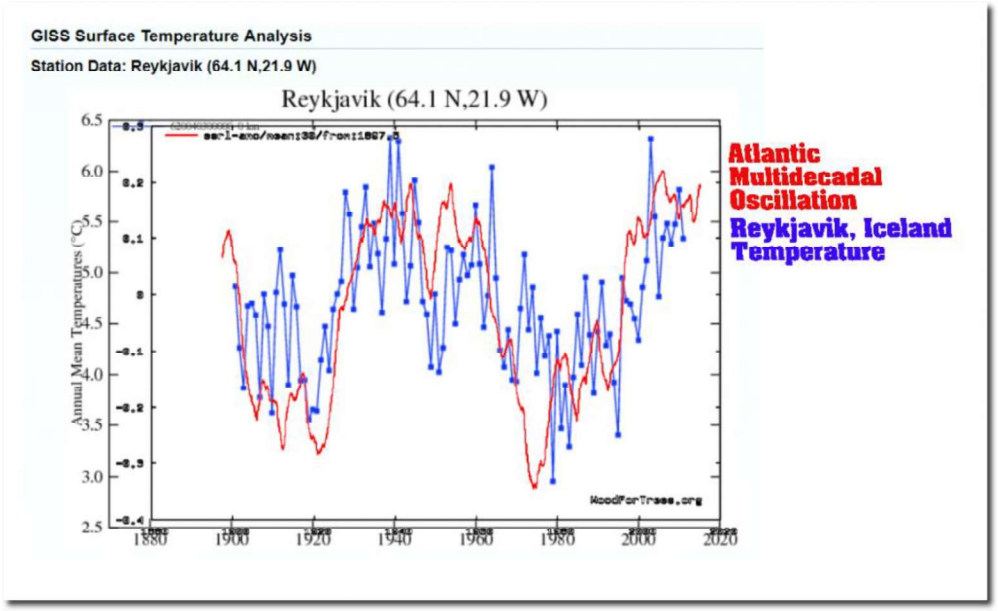
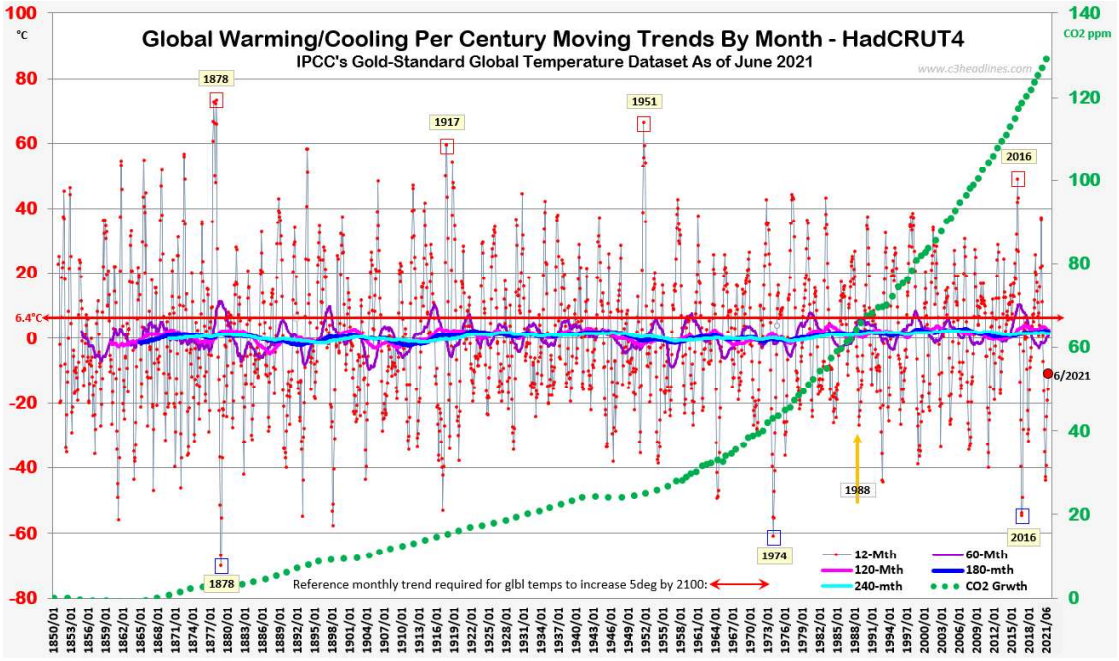


Figure above illustrating Eastern Arctic temperatures closely track the Atlantic Multidecadal Oscillation and show no correlation with atmospheric CO_2. Source: https://data.giss.nasa.gov/cgi-bin/gistemp/show_station.cgi?id=620040300000&dt=1&ds=1 and https://www.woodfortrees.org/plot/esrl-amo/mean:60/from:1897.5

4. Figure below examining past warming using HadCRUT4, not seeing significant increases.



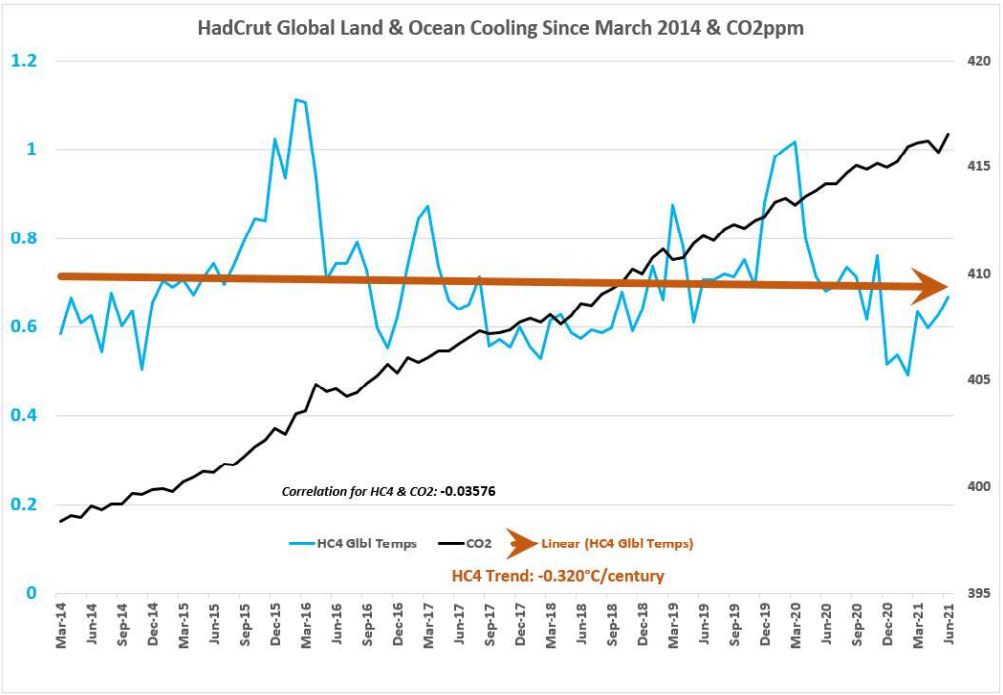


Figure above gives the IPCC's Gold-Standard Temperature Data (HardCRT): Last 7.25 Years, the world has been cooling. UK's global land & ocean dataset of temperature measurements confirms a 7 year and 3 month span of cooling, as of the end of month, June 2021. (Met Office). Plus, the correlation between the global temps and atmospheric CO2 levels is negative for that period: -0.036. This is contrary to what was predicted. Source: Met Office 2021.

5. Climate models – issues with accuracy. 73 climate model predictions plotted. The thick black line is the mean of the 73. The clue circles are balloon data and the blue squares are satellite temperature records. Second graph gives temperature anomalies.