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Coastal Flooding and Climate Change in Ireland

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Coastal Flooding and Climate Change in Ireland

By Richard Cantwell

Climate change will have many impacts on Ireland, more erratic weather conditions leading to increased rainfall and more intense storms as well as water shortages in summer months. One important component of change is rising sea levels. Globally sea levels are expected to rise by 3 to 4mm per year, increasing to 15mm per year by 2100. In Ireland satellite measurements have shown that sea level has risen by 3.18mm per annum between 1993 and 2018 [ref 1].

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Rising sea levels alone are leading to increases in coastal flooding in Ireland, however there are additional factors that act to multiply these increases. Extreme Sea Levels are caused by a combination of waves, tides and storm surges. Due to Ireland's location it is highly exposed to storms in the Atlantic ocean. The number and intensity of storms in the North Atlantic is expected to increase, as marine heatwaves add more energy to the oceans [ref 2]. Low pressure systems cause elevated water height, with each millibar drop in air pressure causing a 1cm rise in the water column. Increased wind speeds cause increased wave heights, extreme wave heights have increased by 1cm per year between 1985 and 2018 globally, however under some scenarios extreme waves may become less common by 2100 [ref 3]. When low pressure systems combine with onshore winds dangerous storm surges can occur. If the storm surge occurs at the same time as a high spring tide then the coastal water level can be much higher than normal.

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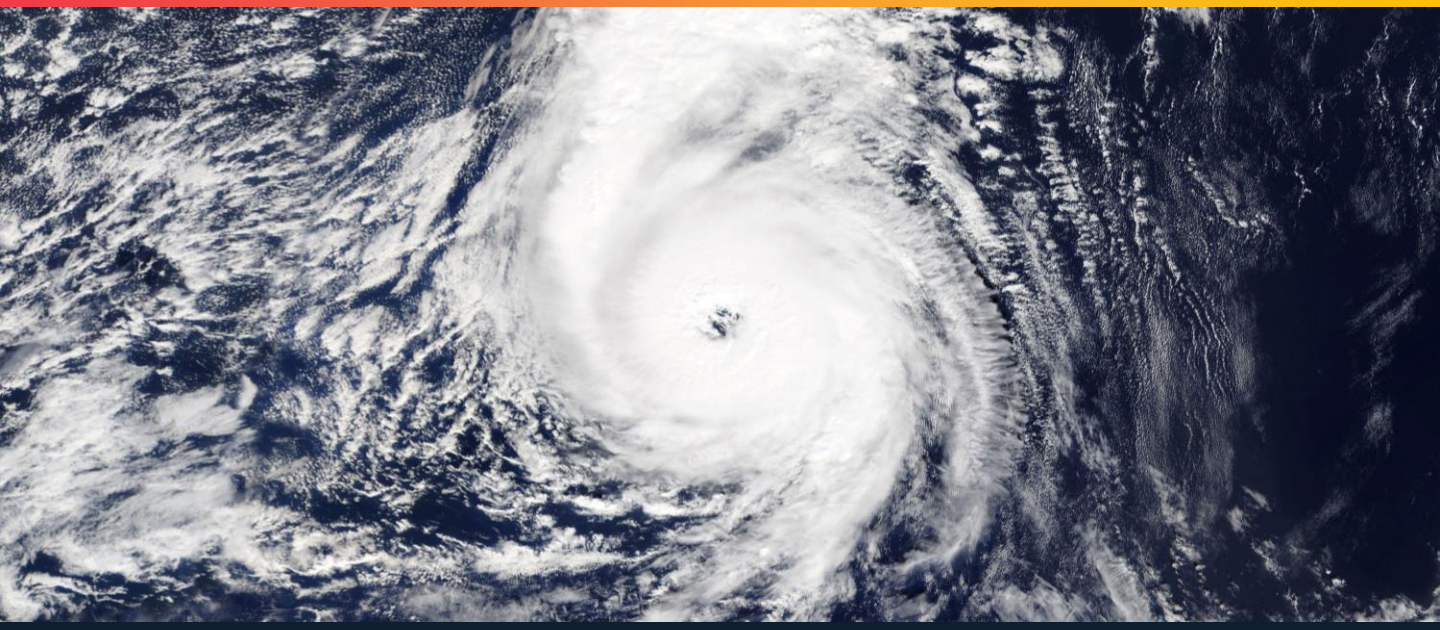
Rare Events Becoming More Frequent

According to an IPCC 2019 report [ref 4] "Extreme sea level events that are historically rare (once per century in the recent past) are projected to occur frequently (at least once per year) at many locations by 2050 in all RCP scenarios" This is especially true in Ireland, where even a 0.5m rise in sea level above levels seen in 2000 would result in extreme sea levels which currently have a return rate of 100 years occurring every 2 years, and 1,000 year events expected to be seen once every 13 years or so.

Extreme Sea Level, Dublin Bay (m)	Return Period (Years)	Return Period with 50cm Sea Level Rise (Years)
5.55	50	1
5.62	100	2
5.70	200	3
5.82	1000	13

Adapted from Farrell (2007) [ref 5].



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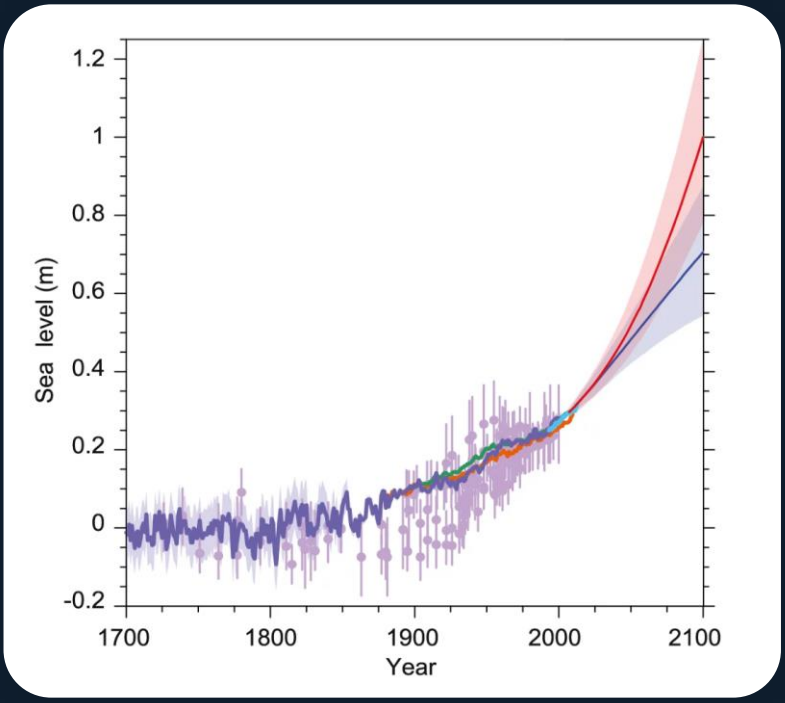
Global Scenarios

There are 4 main Representative Concentration Pathways (RCPs) used in the literature [ref 6]. These correspond to different concentrations of greenhouse gas in the atmosphere, leading to differing amounts of temperature rise and thus different extreme sea levels. They are based on different assumptions about population and economic growth, sources and consumption of energy, and changes in land use in the 21st century. RCP 2.6 is the most ambitious target, involving extreme and immediate cuts to carbon emissions. Even if that target is achieved temperatures will continue to rise as the elevated levels of carbon dioxide currently in the atmosphere will take hundreds of years to dissipate [ref 7].

RCP	Scenario	Description	Temperature Rise 2050	Temperature Rise 2100
2.6	Extreme Carbon Cuts	Emissions peak in 2020 and reduce to zero in 2080	1.0c	1.1c
4.5	Moderate Carbon Cuts	Emissions peak in 2050 and decline to 2000 levels	1.4c	1.8c
6.0	Minor Carbon Cuts	Emissions double by 2060 and decline but only to 2030 levels	1.3c	2.2c
8.5	Business as Usual	Emissions continue to increase at the present rate	2.0c	3.7c

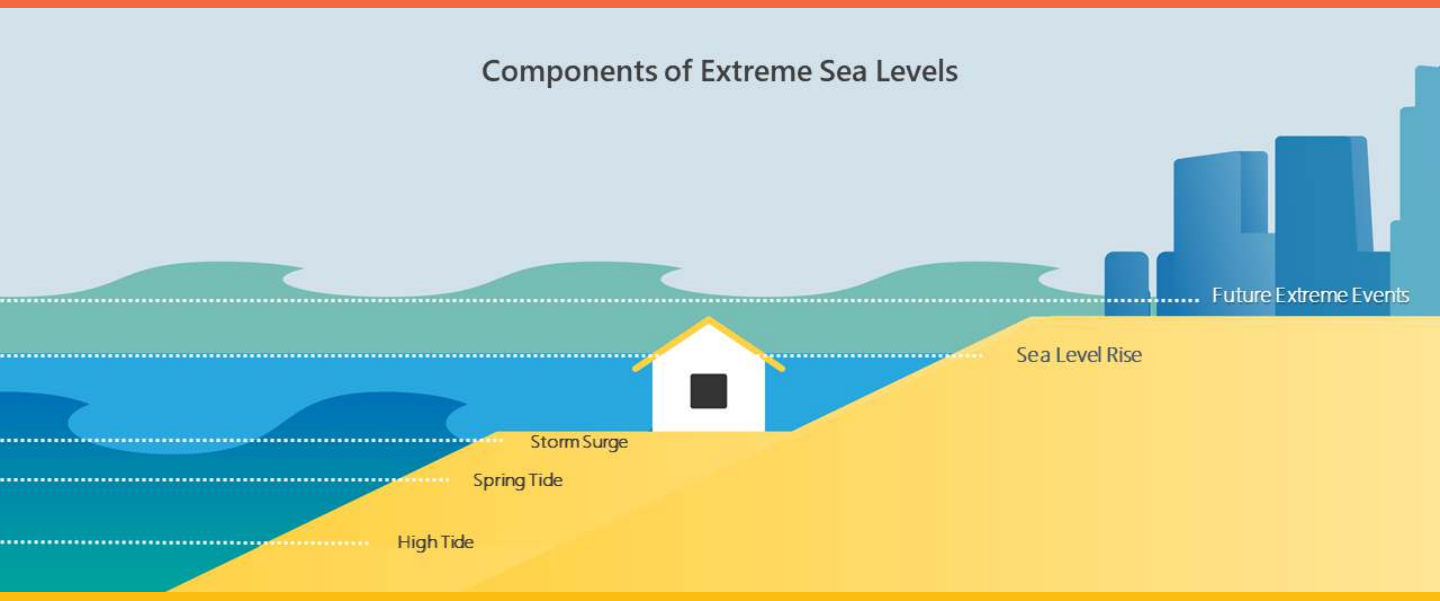
Figures are global and are relative to the 1986-2005 period. Source: IPCC [ref 8].

These rising temperatures will directly lead to increased sea levels, due to polar ice cap melting in Greenland and Antarctica, glacier melting and thermal expansion.



*Global Sea Level Rise, under RCP 2.6 (red) and RCP 8.5 (*blue). Source IPCC [*ref 9*].
Shaded areas represent likely ranges, solid lines represent central estimates. Levels prior to 2000 are from a range of sources, including tide gauges, and altimeter data.

Recent research [ref 10] on storm surge projections for Europe suggests that climate change will lead to increased extreme sea levels over and above sea level rise alone. The magnitude of these increases depends on location and RCP, but in the North Atlantic a 100 year event is expected to consist of between 64 and 88cm of additional water level by 2100.



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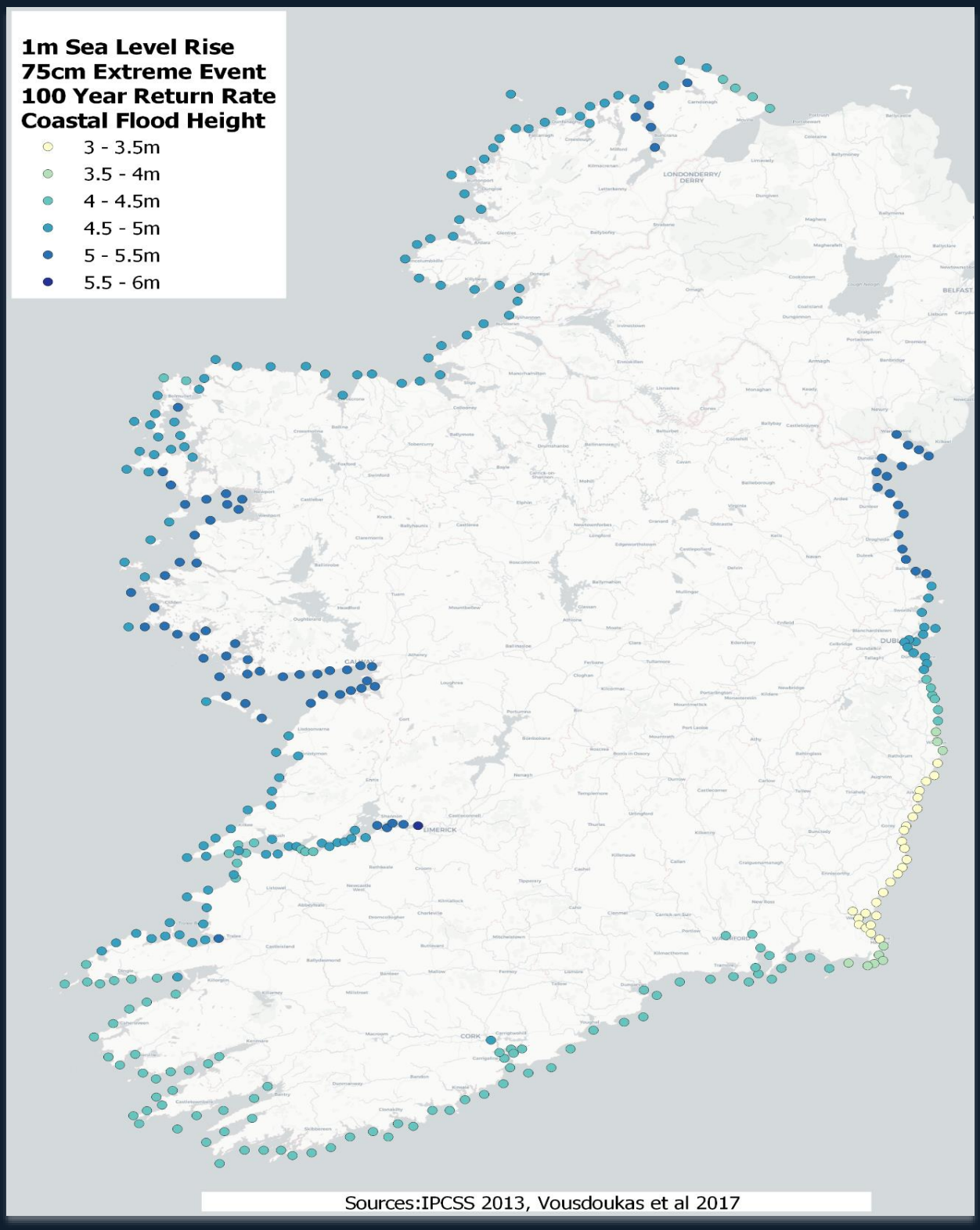
Irish Context

In 2013 the Office of Public Works published the Irish Coastal Protection Strategy Study (ICPSS) [ref 11] which modelled possible inundation areas around the coastline based on historical extreme sea levels across a range of return rates with an additional 0.5m and 1m sea level rise.

For this exercise the 100 year return rate levels at 337 points around the Irish coastline from the ICPSS with a 1 meter rise in sea levels was used. To this a further 75cm was added to account for projected increases in extreme sea levels, that figure being the midpoint of the 100 year range predicted for the North Atlantic.

With the extreme sea level heights chosen the next step is to map out the impacted areas based on a Digital Terrain Model. For this exercise the 25m resolution EUDEM version 1.1 [ref 12] model was used. EUDEM is an openly licenced Europe-wide elevation model, based on a weighted combination of two widely used global elevation models, ASTER GDEM and SRTM. The model was published in 2016. While EUDEM has a vertical accuracy (measured by Root Mean Square Error, RMSE) of +/- 7 metres it performs well when used for regional level flood modelling [ref 13].

The inundation model used is a simple 'bathtub' type model, which assumes that areas below a certain elevation around the coastline will be inundated. Low lying inland areas which are not connected to the sea have been removed.



Map 1: ICPSS 100 year return rate flood depths above Ordnance Datum, with a 1m rise in sea level and a projected increase in extreme sea levels of 75cm.

Map 2: Extent of a 100 year coastal flood in the Dublin region, with a 1m rise in sea level and projected increase in extreme sea levels of 75cm.

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Predicting Financial Impact on Properties

Overlaying address points from the Q4 2019 Eircode Address Database (ECAD) from Eircode [ref 14] onto the DTM gives an inundation depth model which can be used to estimate the costs of coastal flooding on residential and commercial property.

The output of the model shows that some counties are more impacted than other, both in raw numbers of properties and percentage of properties in the county. While Dublin is the county with the most impacted properties, it is Louth and Clare which see the highest proportion of properties impacted.

County	Flooded Addresses	% of Total Addresses
LOUTH	11248	19.0%
CLARE	8696	13.3%
LIMERICK	5426	5.8%
WATERFORD	2724	4.5%
DUBLIN	23435	3.9%
GALWAY	4501	3.5%
KERRY	2417	2.9%
MEATH	2326	2.8%
DONEGAL	2519	2.6%
WICKLOW	1571	2.5%
WEXFORD	1420	1.8%
SLIGO	610	1.6%
MAYO	1020	1.3%
CORK	2659	1.0%
TOTAL	70,572	3.1%

It should be noted that these figures are for coastal flooding only. In typical scenarios in Ireland numerous types of flood act together, with storms bringing heavy rainfall as well as storm surges. If rivers with high water levels meet high sea levels then even more flooding can be expected to occur.

Previous research [ref 15] using similar techniques has estimated that the cost of an extreme coastal flood event could be in excess of €1Billion. Rebasing this on the ICPSS study data with new extreme event data, a revised DTM and the latest address point data shows that this figure has increased significantly.

The average cost of a flood related insurance claim is unclear, as it is not published directly by Insurance companies. The AA mentioned an average cost of €27,000 [ref 16] for domestic flood damage in 2016, while figures released by Insurance Ireland in 2012 show average claims of €16,500 for households and €47,000 for commercial property damage as a result of the flood event in October 2011 [ref 17]. Applying inflation and other factors to these figures we have assumed an average household claim of €21,450 and an average commercial claim of €80,720. We can estimate the cost of climate change influenced sea level rise on property in Ireland at over €2 Billion.

County	Residential Costs	Commercial Costs	Total Costs
DUBLIN	€ 461,453,850	€ 155,143,840	€ 616,597,690
LOUTH	€ 220,506,000	€ 78,136,960	€ 298,642,960
CLARE	€ 158,215,200	€ 106,550,400	€ 264,765,600
LIMERICK	€ 101,694,450	€ 55,293,200	€ 156,987,650
GALWAY	€ 82,003,350	€ 54,728,160	€ 136,731,510
CORK	€ 47,854,950	€ 34,548,160	€ 82,403,110
DONEGAL	€ 48,927,450	€ 35,758,960	€ 84,686,410
WATERFORD	€ 45,752,850	€ 22,924,480	€ 68,677,330
KERRY	€ 47,897,850	€ 7,506,960	€ 55,404,810
WICKLOW	€ 41,720,250	€ 46,333,280	€ 88,053,530
MEATH	€ 26,469,300	€ 15,013,920	€ 41,483,220
WEXFORD	€ 25,611,300	€ 30,431,440	€ 56,042,740
MAYO	€ 17,846,400	€ 15,175,360	€ 33,021,760
SLIGO	€ 8,966,100	€ 15,498,240	€ 24,464,340
TOTAL	€ 1,334,919,300	€ 673,043,360	€ 2,007,962,660

These figures are for properties only. They do not include costs of repairing infrastructure or motor vehicles impacted by coastal flooding.

Next Steps

Future refinements to this analysis would include an analysis of county development plans to assess the prevalence of development land in potentially impacted areas, the use of very high resolution height data from LiDAR. The analysis does not take into account the presence of coastal protection infrastructure both existing and planned. Modelling the potential costs and savings of this infrastructure would be useful.

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