

Harry Ridgewell: So how has Hawaii been affected by rising sea levels in the last 10 years?

Chip: Well the primary effect of rising sea levels has been to affect our beaches, we have a statewide problem with beach erosion, we've measured the historical changes of all the sandy beaches on the islands of Kauai, Oahu, and Maui, and an average of about 70% of the many thousands of data points we have or locations along those beaches, are showing a chronic erosion trend. So it's very difficult to directly link any sort of beach behaviour to sea level rise, but when it comes to long term persistent trends in shoreline erosion, certainly, if there's a long term sea level rise taking place it's an obvious connection to make.

Chip: We've attempted to publish on this, we have published on this. So the primary impact of rising sea level has been to generate this situation of retreating shorelines, chronically eroding beaches. We have also begun to see some very high tides, which we have adopted the name King Tides for this. Last year in 2016, in fact, we saw the highest tides in the 100 year record of the Honolulu tide gauge, we saw the highest water levels occurring in the late spring, and in the summertime. Those manifest themselves as salt water flooding up into our storm drain infrastructure, and blocking runoff or rainfall runoff from draining into the ocean.

Chip: A few places, the salt water came up through the storm drain, and ponded on the roads, this is a pretty typical behaviour for this sort of infrastructure in the context of sea level rise. In fact, Miami Beach has seen this a lot, and they are spending hundreds of millions of dollars in re-engineering their drainage infrastructure. We have one location called Mapunapuna, which is an industrial area by the Honolulu airport, which is actually reclaimed land, and it has been flooding at the highest tides of the year for over a decade.

Chip: And so it's a little sort of natural urban laboratory where we see water coming up through the storm drains, and flooding into the streets. And that's the primary impact of sea level rise so far.

Harry Ridgewell: And how do you think future sea level rise will affect Hawaii?

Chip: Well the National Oceanic and Atmospheric Administration has published a model, a report in which they model high tide flooding. They provide a threshold of half a metre above mean high, or high water for the Honolulu tide gauge, in fact they give thresholds for all the NOAA maintained tide gauges on the U.S. coast. And when you look at the potential flooding at half a metre above mean high, or high water in the context of the sea level rise scenario, the future sea level rise scenarios that NOAA has also published, depending on the sea level rise scenario we could be seeing this high tide flooding within two decades, close to a decade from now.

Chip: And this simply means more of what I've already described. More coastal erosion, more storm drain flooding to the point where it may become serious enough where we expect eventually it would become serious enough that we'd

have to take some sort of response in the form of adaptation of some type. So we expect not only to see a sort of permanent inundation associated with global mean sea level rise, but prior to that, potentially decades prior to that, we will be visited by these extreme high tides that will come and then disappear with greater magnitude and growing frequency.

Harry Ridgewell: And what is Hawaii doing to mitigate the effects of rising sea levels?

Chip: Well a study was just released in December by the Hawaii Climate Change Adaptation and Mitigation Commission. It was a comprehensive study of the impacts of future sea level rise, my research team modelled coastal erosion, wave run-up, storm drain flooding, groundwater inundation, and then passive saltwater flooding under a number of sea level rise scenarios. Roughly half a foot, one foot, two feet, and then basically a metre. And we discovered a number of things.

Chip: One is that there's a critical point that exists some place between two feet and three feet of sea level rise, where the amount of damage due to wave run-up, and hydrostatic flooding, which is just flooding that comes up through the storm drain, and groundwater inundation the amount of damage really accelerates. And so we are concerned with that sea level rise range between two and three feet, that rapid acceleration of impact, and flooding, and damage is something we need to be prepared for. And so there is effort at the state level, and the county levels to develop policies to encourage adaptation.

Chip: In fact the city, and county of Honolulu Climate Change Commission, which I sit on, has just adopted a recommendation that a sea level rise exposure area of three point two feet, which was mapped in that Hawaii State report that came out in December, be adopted as a hazard overlay for all city, and county planning, and projects, and activities of all sorts. What's nice is that the modelling that was done in association with that state report produced GIS layers that are available online.

Chip: We have the Hawaii Sea Level Rise Viewer, and for all the Hawaiian Islands you can see the impacts of sea level rise as they were modelled, and a three point two sea level rise exposure area is identified, and that makes a convenient policy regime, or hazard overlay in which everything from Federal, on down through different jurisdictions, and even private corporations, and private landowners can see what the model results indicate for their land area of concern. And begin to develop adaptation strategies, and price these out, and think about how all of us are going to meet this challenge.

Harry Ridgewell: Do you think it's best that areas of Hawaii which are affected by flooding put up flood defences, or move?

Chip: I think there will be a combination. Ultimately, outside of this century hopefully, beyond this century hopefully, we're looking at multi-meter sea level rise. The last time Earth's surface was as warm as it is now, was roughly a 125,000 years

ago during what's known as the Eemian Interglacial, and sea level was over six metres higher at that time.

Chip: So I think over the course of more than a century we are looking at multi-meter sea level rise. Unless we are successful in engaging in negative emissions, and pulling CO2 out of the atmosphere, but then again we still have enormous inertia in the climate system largely through the ocean. So I'm not sure if we can avoid multi-meter sea level rise so much as simply put it off into further into the future. That's a round about way of saying that ultimately our communities are going to have to withdraw from lands lying within one metre and potentially even two metres of current high tides.

Chip: But the timing of when that withdraw has to take place is the question. So if west Antarctic Ice Sheets begins to accelerate its retreat, if Greenland begins to further accelerate, are we looking at one metre of sea level rise before the end of the century? Or are we looking at one metre of sea level rise after the end of the century? These are still, this is still an area that is a little bit vague.

Chip: So one way to think about this from a policy point of view, is through risk tolerance. A sort of quick way to describe this is, if you build a gazebo on your beachfront property you have high risk tolerance. You can tolerate getting it wrong. Sea level could rise, and you gazebo could be affected, and it's potentially moveable, or you could take it down, it's not a big loss.

Chip: On the other hand if you build a nuclear power plant on your beachfront property, you have low risk tolerance. And so in planning, the amount of risk tolerance for your project might guide your choice of sea level scenario for the nuclear power plants you can't afford to get it wrong, you might plan for a metre of sea level rise occurring earlier this century, perhaps even two metres of sea level rise, perhaps even three metres of sea level rise if you want to be sure that you avoid some sort of catastrophic elements in sea level rise, catastrophic loss of portions of Greenland or Antarctic Ice Sheets.

Chip: So this is guidance that the U.S. Army Corps of Engineers provides, and also the National Oceanic and Atmospheric Administration, it's called Scenario Planning, and for large, expensive public infrastructure projects with high budgets, and low risk tolerance, you would plan for a higher sea level rise so that you err on the side of caution. And policies sort of gives you a glimpse of how to develop policies in this same vein.

Harry Ridgewell: Do you think that any of the islands of Hawaii could go underwater, or become uninhabitable in the future?

Chip: Well I doubt. These are shield volcanoes they are large mountain systems, each island has ridge tops that are a couple of thousand feet high. We're not going to lose the Hawaiian Islands, but we have developed the low lying coastal plain immediately adjacent to the ocean, so we have built in the most vulnerable area when it comes to sea level rise. We are already experiencing the impacts in

terms of managing our beaches. Unfortunately over the last half century authorities have allowed the construction of seawalls, on a shoreline that is retreating when you build a wall you negatively impact the beach.

Chip: In fact we have an epidemic of beach loss in Hawaii because we've built seawalls to protect property rather than taking into account the fact that they are very damaging to beaches. And being a tourist destination, we really can't afford to lose any beaches, and with accelerating sea level rise now occurring, we need to figure out how we are going to maintain beaches for future tourism and for our children. And to maintain the high quality lifestyle that we enjoy here in Hawaii, how are we going to have beaches and beachfront development in an era of rising sea levels? This is one of the problems we are currently wrestling with.

Chip: But, so it's not a question of are we going to lose the islands, it's a question that has a lot more granularity to it. A lot more detail property by property, road by road, environment by environment, how are we going to manage this problem of flooding and erosion related to sea level rise?

Harry Ridgewell: So sorry, when I say islands, you don't think any of the minor islands ... because I thought Hawaii was made up of thousands of tiny little islands. You don't think any of them could either become uninhabitable, or go under water then in the future?

Chip: Well there are eight main Hawaiian Islands that are habitable. There are a number of very small offshore islets, that are not inhabited. They for the most part, are wildlife refuges. Then north of the main Hawaiian Islands there is Papahānaumokuākea, which is also called the Northwest Hawaiian Islands. These are atolls, these are low lying islands, there are no residences up there, there are stations of wildlife managers associated with federal agencies, and state agencies.

Chip: So yes, these atolls are low lying. There are also atolls elsewhere in the Pacific throughout Micronesia, and in the South Pacific as well, where you have communities of thousands of people. These low lying atolls are challenged by sea level rise, but there are steps to be taken to adapt to sea level rise. I don't think these islands automatically become unlivable, I don't think we should assume, or project what the future of these low lying islands will be.

Chip: I think the communities there need to continue to think about the intersection between their culture, their lifestyles, future sea level rise, and different types of living shorelines, engineered shorelines, and community adjustments that can be made to adapt to the rising sea level.

Harry Ridgewell: If sea level rise does mean low lying islands in the South Pacific like Kiritimati, do become uninhabitable and people are forced to move, do you think that countries which are responsible for a larger percentage of greenhouse gas emissions, and have a higher standard of living, should have to take a larger share of future climate refugees?

Chip: I think that there is an enormous responsibility that lies on the major greenhouse gas emitting countries. The industrialised world is responsible for this sea level rise, for the global warming in general, and I think there is an ethical obligation among these industrialised nations to, number one, extremely, rapidly, eliminate greenhouse gas emissions. We may have already missed the opportunity to stop warming at one and half degrees celsius. We are closing in on the opportunity to stop warming at two degrees by some estimates the carbon budget in the atmosphere only holds another 15 to 20 years before we pass a 66 percentile probability of violating the 2.0 celsius threshold. That was identified and the Paris accord in 2015.

Chip: Instead of decreasing greenhouse gas emission, the current projections are for rising energy demand, which will be met with a combination of deployment of renewable energy, as well as fossil fuels growing GDT globally, the rise of China, and India into the middle class. These are all going to ... they are projected as requiring increased energy demand and that can only partially be filled by renewable energy as rapidly as we are deploying renewable energy, the demand is exceeding that.

Chip: And so as has been published in a number of papers, we need to essentially get to zero carbon emissions by mid-century, but instead I've seen projections of 15% increase in carbon emissions as we approach mid-century. If this is the case, then we have limited our options, you could engage in geo-engineering, we could move into removing CO2 from the atmosphere known as negative emissions, but in all these cases there's enormous risk.

Chip: Geo-engineering has enormous risk of changing rainfall patterns, changing wind patterns, changing ocean circulation, and of course that could affect food growth, and drought, and the localised and regional climate in areas affecting the balance of world power. When you play with climate and food distribution, and water resources through geo-engineering. We don't really know, we know next to nothing about geo-engineering. And when it comes to negative emissions, we know even less, it's all speculative. There have been very few studies, and relying on these technological solutions, I believe, is a huge mistake.

Chip: Instead we need to immediately decrease greenhouse gas emissions, and it's not happening fast enough. It's almost as if the world needs to go on a wartime footing. Mobilisation for a crisis is what we are faced with right now, and we are not mobilising with that sort of urgency. As to your original question, yes, I believe the industrialised nations are responsible for the crisis of global warming, and there is an ethical obligation to help with the adaptation to the results, to the impacts of global warming.

Harry Ridgewell: Are you frustrated by the lack of agreed international targets to combat global warming, and Trump for announcing that he will pull out of the Paris Agreement?

Chip: I'm probably beyond frustrated, and into depressed. So there's several things to say there. Number one, I am extremely proud of our state of Hawaii, we have just this year signed into law requirements that all development projects consider the impacts of future sea level rise in their design. We have signed into law a legal requirement to be carbon neutral by the year 2045. We have established now over several administrations, governor's administrations, to move to zero carbon emissions in our energy regime by 2045. And in fact, we are on track to have 100% renewable energy in the state of Hawaii by the year 2040. We are currently at about 26% renewable energy in the state of Hawaii, the hard work still sort of lies ahead getting the last bit is going to be very difficult.

Chip: All of the Governors, excuse me all of the Mayors of the counties of Hawaii have agreed to what's known as the Aloha Challenge, which is to increase local food production, to increase green environmental education, to turn all of our fleets, our transportation fleets into electric vehicles, to increase the bikeability, and walkability of our communities. There's enormous progress all over Hawaii, and in fact we are modelling for the world what it takes for a community to go to zero carbon by mid-century.

Chip: We are 1 million plus community of people that are heavily dependent on shipping to bring us our resources, and we realise that we're going to have to become more locally oriented in terms of food and manufacturing, and all of this. So that's a source of pride. A source of frustration is that our federal administration is moving in the wrong direction. I'm especially frustrated with the Environmental Protection Agency under Scott Pruitt. I don't understand the decisions that are being made there to roll back environmental protections, which have improved the health and safety of people in the United States.

Chip: Apparently they want to roll these back, I don't understand the scientific basis for their decision making, in fact, I question whether they have a scientific basis for their decision making. It appears to be more ... I'm not sure what the word is I'm searching for, but it's not scientific. And yet, I was engaged in a discussion just the other day with someone who pointed out that as the United States retreats from its position of global leadership, we are likely to see India and China step up and, in fact, when it comes to greenhouse emissions, and energy demand, India and China are the big players of the room.

Chip: And if they see this opportunity to step into a leadership vacuum, a global leadership vacuum created by the retreat of the United States, they don't want to get it wrong. They ... you know it's an opportunity and hopefully they will be heavily motivated, strongly motivated to take full advantage of that opportunity, and they are both already strongly oriented towards de-carbonizing their economies. And so that might be a silver lining that hopefully can play out in a positive way.

Harry Ridgewell: And what do you make of the news that many bills coming out of the sea level rise report weren't passed?

Chip: So the sea level rise report was released in December, the administration, the Governor's administration bills were already decided on long before the sea level rise report came out. The Hawaii Governor's administration had the deadline in August, I believe, for when bill that they wished to propose should be submitted for consideration.

Chip: The sea level rise report came out in mid to late December and the State Legislature, which makes our laws met in mid-January, so there was really almost no time to consider the sea level rise report in a slow and thoughtful way. Instead it was considered in a rapid and thoughtful way, as many of the recommendations in the report as possible were submitted to the legislature. I believe only one was finally approved, and that was the sea level rise be considered in all environmental assessments, and environmental impact statements.

Chip: So, I guess it was expected, I'm not surprised the timing of the release of the sea level rise report sort of pre-ordained that there would not have been much of a process behind developing the legislation coming out of it. Now there is a process going on now, for the 2019 legislature, but it's also maybe not necessary to create a whole host of laws. But instead to establish best management practises, to look at the counties, and have them develop policies for independent state departments, transportation, health, land and natural resources, et cetera.

Chip: To develop practises, so we don't necessarily need the legislature to get us moving quickly towards adapting to sea level rise.

Harry Ridgewell: And finally, how hopeful are you that global sea level rise will be tackled before it creates millions of climate refugees?

Chip: I'm not very hopeful at all. But there are more causes of climate refugees than just sea level rise. We are very likely looking at low latitude continental land areas in the tropics, becoming, large parts of those land areas, becoming unlivable. We may already be seeing the early signs of that. There have been studies indicating that the Syrian problem originated with a massive drought, the strongest drought in 900 years. That led to a breakdown in their farming system. There is a refugee crisis coming out of North Africa, and coming out of the Middle East that is influencing the politics of the European Union.

Chip: Brexit has its roots, ultra conservative politicians are finding more success than they had previously. So I think we are at the beginning of a refugee crisis which is very complex. Climate plays a role, drought, heat waves, fresh water crisis, fresh water scarcity, food scarcity, political turmoil, internal conflict, internal refugees. These things are all increasing. And the sea level rise is part of that, but I don't think sea level rise is yet responsible for significant refugee population, whereas I do see other elements of global warming being responsible in the form of changing temperatures, drought, rainfall, and all those rolling up into complexities of food and fresh water availability.

Harry Ridgewell: Okay. Thank you. Is there anything else that you would like to add?

Chip: Yeah, I would just add that we are in a crisis. We are deep into it. And our core humanitarian principles, our fundamental socio-economic framework is at risk. And the promise of some technological solution is extremely weak, so we need to disrupt our lives and immediately begin to de-carbonize in a much stronger way than we have, and we need to eliminate carbon dioxide emissions over the course of the next 30 years. That's it.

Harry Ridgewell: Okay. Thanks Chip. Are you happy for me to quote you on all of that one?

Chip: Yeah absolutely.