Impacts of Climate Change on Urban Infrastructure & the Built Environment

A Toolbox

Tool 2.6: Other Hazards

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1. Introduction

To date, the effects of climate change have largely focussed on large scale climatic phenomena, such as changes to temperature, rainfall and the associated impacts that such changes will likely impart on their receiving environments.

Comparatively little research has been carried out for other climatic factors that are already deemed as 'hazardous' due to the problems they cause for human systems (for example, fog) or for when they reach extreme levels (such as wind).

Whilst our understanding of changes in extremes is generally much more limited than that of changes in average climate conditions a key lesson from many climate studies is that even small changes in average climate can lead to a disproportionate increase in the incidence of damaging extremes (Reisinger et al., 2010). Therefore, understanding and assessing the risk that other hazards such as extreme temperatures, fog, snowfall, lighting, hail and drought can impact on physical and social systems under climate change forms an integral part of improving resilience against such threats.

This section summarises the general information on the assessment of climate change effects that is available for these 'other hazards' as they apply to the New Zealand situation. An assessment of such impacts, whether or not they are of current concern, should be considered when thinking about climate change, alongside other, more common impacts (such as flooding, sea level rise and storm surge, heavy rainfall induced landslides, heavy rainfall and urban drainage, and supply and demand of potable water, which are described in [Sections 2.1 to 2.5] of this Toolbox).

1.1 Understanding and analysing extreme events that apply to other hazards

Most of the projected changes in extremes (as they relate to hazards) for New Zealand have focussed on changes in the 'average climate' as superimposed on historical variability. More recent work with more complex regional climate simulations offers the ability to investigate not only changes in the mean climate, but to also simulate possible changes in the distribution of extremes (Mullan et al., 2008). Such work will offer a more realistic and relevant understanding of changes in extremes and regional and local variations, but quantitative results of such studies have only recently started to be produced in peer-reviewed literature.

Therefore, for some hazards we do not have a high degree of understanding how these might be affected under climate change, however such hazards have been included in this section for completeness.

1.2 A reasoned approach to decision making in the absence of hard data

In general, even though specific studies have yet to be carried our in New Zealand (and in some cases the world) for certain hazards under climate change, scientists surmise that with more ‘energy’ in the climate systems by way of heat (increased global temperature) and therefore convective activity (increase water vapour/rainfall in the atmosphere) other related hazards are, on balance, likely to follow accordingly. That is, whilst detailed studies of how the frequency of how lightning might be affected by climate change have yet to be quantified in detail, scientists currently assume that with increased convective activity, as has been projected with confidence using climate models, we could potentially see an associated increase in the frequency of lightning strikes (which are associated with high levels of convective activity).

This is not sufficient enough information to say with complete confidence that there will indeed be a greater number of lightning strikes as a result of climate change but simply that given the weight of our current understanding of how the present climate system works, there is a greater chance than not, that lightning strikes will increase as the globe warms. Whilst not an ideal approach, some hazards highlighted without quantitative evidence here are considered to be of less risk to society should they alter under climate change, and it is perhaps for this reason that research funding has not yet been applied to better understand such hazards. It is expected that researchers will begin to look more closely at such hazards over the coming years as our computer modelling capability improves.

1.3 A note on projections

It is important to realise that climate change projections, particularly with respect to temperature and rainfall, are able to replicate annual variability over and above changes to the average state. It is this annual variability that will ensure every subsequent year will not necessarily be warmer than the previous year, as natural variability exerts a dominant influence over any human-induced climate change. However the important point to note is that when considering extreme conditions, an extreme year in 2050 (for example) will be over and above anything that modern human civilisation has experienced to date. Therefore our perception of what we consider as ‘extreme’ today will not necessarily be comparable with what we could experience in the future for a similar ‘extreme’ event, due to the continual increase in the baseline average conditions.

2. Extreme temperatures

As noted in the introduction to this section, even a small change in average conditions can impart a large impact on extremes. This is certainly the case for high temperatures. Figure 1 (from Reisinger, 2009) illustrates this concept using changes in average temperature and the occurrence of temperature extremes. The occurrence of specific temperatures (or any other climate extreme) follows a roughly bell-shaped distribution, where most occurrences fall near the average condition, and a lesser number of events are higher or lower than this average. A modest shift in this distribution, assuming that the shape of the distribution itself is not changed, will result in a significant increase or decrease in the number of events that exceed a specific threshold. Impacts of climate change are often related to changes in extreme events that exceed some limit that society is adapted to (e.g., overtopping stop banks, exceeding indoor temperatures that lead to health risks for vulnerable populations, or decrease in soil moisture below the minimum needed for plant growth) (Reisinger et al., 2010).

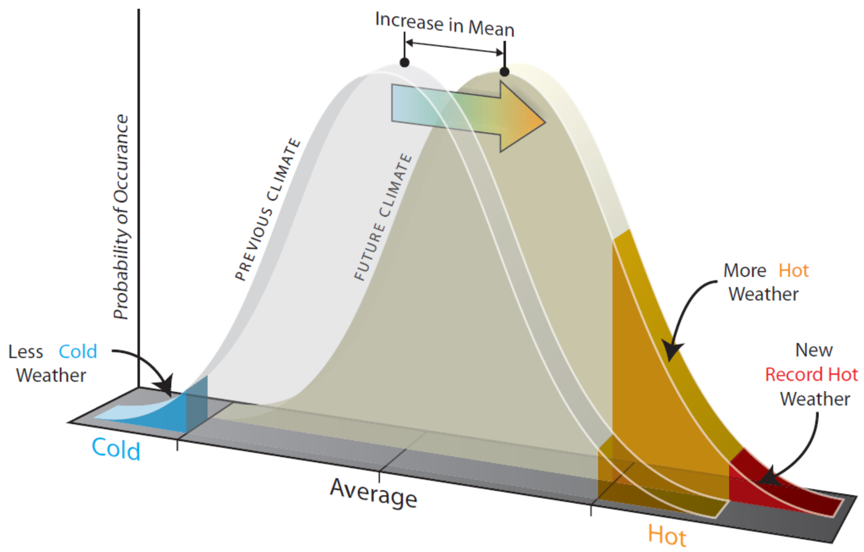

Figure 2.1: Illustrative diagram of the changes in the occurrence of extremes for a small shift in the average climate. The diagram shows a probability distribution of the occurrence of temperature extremes under a reference climate and for a future climate shifted towards higher average temperatures. This shift results in a significant increase in the number of occurrences of hot weather, and the occurrence of more record hot weather, even though the increase in mean temperature is well within the typical range of temperatures experienced under the reference climate conditions. Conversely, this shift results in a significant decrease in the occurrence of extreme cold weather (e.g., frosts). Figure from Reisinger (2009), based on (Solomon et al., 2007) WGI Box TS.5 Figure 1.

Figure 2.1 demonstrates that even modest changes in the average climate, which as such may well lie within the range of natural variability that is currently experienced, can lead to a significant change in the damages caused by extreme events (e.g., flooding, heat-induced mortality, or loss of agricultural production) (Reisinger et al., 2010).

In addition to changes in mean temperature, daily temperature extremes (overnight minimum and daily maximum) will also vary with regional warming. Climate model simulations using the NIWA regional climate model based on the UK Met Office Unified model (Mullan et al., 2008) have shown that by 2080–2099 (compared with 1980–1999 and using B2 and A2 emission scenarios) the number of hot days (above 25ºC) will increase across New Zealand. For example, most of Otago and Southland can expect between 10 and 40 additional 'hot days' whilst Northland could expect up to 70 additional hot days per year for the A2 scenario compared with today.

Planning for such changes in extreme conditions will be necessary for social reasons, such as the potential number of heat-stress related illnesses that might result from such conditions, putting additional pressure on regional health services.

Such extremes will also have a considerable impact on horticultural systems, for not only are the number of hot days likely to increase markedly (even under a modest B2 scenario) associated with this, there will likely be a reduced number of frost (below freezing) days as well (Mullan et al., 2008).

3. Drought

Drought magnitude and frequency are expected to increase in a warmer climate as evapotranspiration increases, unless this increase is compensated by a simultaneous increase in precipitation. Mullan et al. (2005) concluded from a study using two IPCC Third Assessment Report (TAR) models that a current 1-in-20 year drought could occur at least twice as often in eastern parts of New Zealand (parts of Northland, Bay of Plenty, Wairarapa, Marlborough, Canterbury and Otago) under a warming of about 2°C.

An extensive recent study by Clark et al. (2011) established distinct regional differences across New Zealand in changes to drought vulnerability projected under future climate change. The study found an increase in drought (about ten percent additional time spent in drought in the coming century) on the east coast of the North and South Island being the most plausible and consistent outcome. This is consistent with the result of the Mullan et al. (2005) study that: drought risk is expected to increase during this century in all areas that are currently drought prone, under both the 'low-medium' and 'medium-high' scenarios. More specifically, less likely but identifiable upper and lower drought scenarios for the coming century range from: a strong shift toward an arid climate over most agricultural regions with well over a doubling of time spent in drought across most of New Zealand; to an environment of minimal increases from current levels isolated to eastern agricultural regions (Clark et al., 2011).

The results obtained in the Clark et al. (2011) study point to a number of areas where future adaptation analysis and responses might be targeted. The changing nature of drought through the next century highlights that basing responses on an historically determined understanding of what is normal will increasingly put Governments and farm managers in a weakened position to manage drought risk. Given the most likely scenario found for increasing drought in eastern regions, planning efforts to ascertain and improve resilience to drought and climate variability are warranted.

4. Extreme winds

A number of international studies suggest an increase in the frequency of strong winds under climate change (e.g. Rockel and Woth, 2007), but until recently there was very little information available for New Zealand (Reisinger et al., 2010). This is largely because wind is a particularly challenging climatic variable to work with and therefore, to model because wind varies greatly over short distances and time periods.

A recent report prepared by NIWA for the Ministry of Agriculture and Forestry (Mullan et al., 2011) has however managed to examine wind patterns over New Zealand, with a particular focus of how these patterns might change due to climate change. This was achieve using several parallel and complementary approaches using low resolution global pressure and wind fields and high resolution three dimensional dynamical output from the NIWA regional climate model.

Principal findings from the Mullan et al. (2011) study are that the frequency of extreme winds over this century is likely to increase in almost all regions of New Zealand in winter and decrease in summer, especially for the Wellington region and South Island. However, and importantly, the magnitude of the increase in extreme wind speed is not large, only a few per cent greater by the end of the century under a A1B (middle of the range) emission scenario (Mullan et al., 2011). The study also concluded that cyclone activity over the Tasman Sea could increase in summer and decrease in activity south of New Zealand.

The study noted that whilst New Zealand might expect vigorous small-scale convection to become more common (and more intense) in a future warmer climate, further work is still required to relate such sever weather events to quantitative changes in extreme surface winds.

5. Snowfall

It is generally expected that snowfall and thus snow cover will decrease and snowlines rise as the climate warms. However, there are confounding issues. Warmer air holds more moisture, and during winter this moisture could be precipitated as snow at high elevations. There could also be instances of increased winter snowfall to low elevations, for the same reason. However, with the expected increase in temperatures, any snow cover will melt more quickly, and thus the duration of seasonal snow lying on the ground is expected to be shortened (Mullan et al., 2008).

Projections of snow amount changes to 2100 from the NIWA regional climate model, run under the A2 emissions scenario, result in decreases in seasonal snow almost everywhere (Mullan et al., 2008). This is particularly evident in the South Island, but decreases also occur over the North Island central plateau.

A decrease in winter snowfall and an earlier spring melt can cause marked changes in the annual cycle of river flow. Research on these effects on flow in rivers in New Zealand is ongoing [for further information, contact NIWA].

6. Fog

To date, no studies have been specifically carried out in New Zealand to determine how climate change will affect the likelihood of increased or decreased fog occurrences. Indeed, the international literature is virtually void of any such studies.

NIWA’s regional climate model could be used to determine whether the expected changes in temperature and rainfall would likely result in greater or fewer fog events than is presently experienced in New Zealand, but such studies have not as yet been undertaken.

7. Lightning and hail

Again, there is very little information available either globally, or for New Zealand, on the anticipated impact of climate change with respect to lightning and hail. Similar to fog, such events are highly localized and require specific atmospheric conditions to exist for such hazards to eventuate.

A report prepared by NIWA for the New Plymouth District Council concluded that mechanisms of climate variability (ENSO and IPO) and climate change are factors that are expected to change the risk from lightning (Gray and Salinger, 2006). Analysis of nearer-term climate phenomena such as the Interdecadal Pacific Oscillation (IPO) status suggests that the climate is now in transition from the positive to negative phase and that should this continue then over the next decade or so. A change in phase of the IPO is likely to produce more La Niña like conditions, thus lowering the lightning risk slightly. However, there is an expectation for the IPO to return to its westerly phase after 2020 with a likely increase in the lightning risk.

The report further concluded that climate scenarios of significant increases in westerly winds and increases in precipitation for the later decades of the 21st century as a result of climate change strongly imply an increase in storms that produce high cloud to ground lightning strikes. In other words, the convective conditions required to produce lightning are likely to increase, however without further modelling analysis the frequency of such events, much less how these conditions might be experienced across New Zealand has yet to be determined (Gray and Salinger 2006).

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