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Part of



Ex-Tropical Cyclone Dovi Crosses New Zealand
Impacts and Possible Future Cyclone-Related Risks
(reissue of February 2022 article)

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Preface

Tropical cyclone Vaianu, due to make landfall in New Zealand on April 12th, 2026, has been described primarily as a significant potential wind event. The team at ClimSystems is reissuing the report we wrote on the impacts of Tropical Cyclone Dovi, which caused widespread disruption across the North Island in 2022. We encourage the public to heed the warnings issued by our partners at MetService New Zealand. We work closely with our national agency, which is the official government-authorized provider of severe weather warnings in New Zealand.

Summary

Cyclone Dovi weakened before landfall over the North Island of New Zealand on February 13, 2022, but still caused damage with heavy rain and strong wind gusts over 130 km/h. The disruptions included power outages, flooding, fallen trees, and closed roads, resulting in interruptions to traffic flows. Some were also injured, including at least one clean-up-related hospitalisation with both arms broken and rib and spinal injuries incurred during clean-up from the storm. Tidy up work has taken weeks, and the financial cost to communities and individual households has been substantial.

The low-pressure cyclone that developed in the Coral Sea transitioned to an ex-tropical low-pressure system before reaching New Zealand. However, heavy rainfall and wind gusts over 100km/h occurred in several regions. The storm peaked between 05:00 and 16:00 on 13th February, as recorded by ERA5 data. The data were validated against local observations. Therefore, local observations and the ERA5 high-resolution global reanalysis gust product represent a potentially viable dataset for synoptic risk analysis. Heavy rainfall affected parts of the North Island and the upper South Island as a thick band of cloud extending from Ex-Tropical Cyclone Dovi engulfed the country over the 12 and 13th February 2022. Some rainfall totals in the past 24 hours include Wellington Airport (121 mm), Ngawi (99 mm), Farewell Spit (92.6 mm), Kaikoura (92 mm), Castle Point (81 mm). Auckland registered wind gusts over 130 km/h, with maximum wind gusts over 150 km/h in more exposed coastal areas.

Despite the limited acknowledgement of tree failures in regulations, they caused some of the most devastating impacts of this event. The cost of removing trees is significant for local government and can place even greater pressure on individuals if they fall within private properties. Although studies have excluded the impact of wind in criteria for selecting urban trees (Vogt et al., 2017), knowledge of where to plant trees, which species to grow and in what arrangement could improve the resilience of urban trees

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and reduce the costs associated with their failure. While tree diversity is encouraged (Jactel et al., 2017), tree height is also key to effective vegetation management (Zörner et al., 2018). It is also suggested that native species are more resistant to high winds and that planting groups rather than individual trees enhance their resilience, reducing their exposure to forest edge effects (Duryea & Kampf, 2007).

Cyclone-related gust speeds demonstrated an increasing trend between 1981 to 2021, with the fingerprint of climate change, in various regions: Northland, Auckland, Waikato, Taranaki, and Southland of New Zealand. The most impacted areas include the exposed west coast and Southland. Cyclone activity could become more severe and frequent as climate change leads to warmer ocean surfaces, higher subsurface ocean temperatures, and greater atmospheric energy. The CMIP6 models in the IPCC AR6 report produced future projections of gust-speed changes for each region. Given the models' limitations, the uncertainty envelope is wide. However, some regions clearly express an increasing gust speed signal.

As the climate warms, these devastating events are expected to intensify. Preparing the built environment for these events could lessen detrimental social, economic and environmental consequences. Should we adopt more robust adaptation measures that consider power distribution, early warning systems, property and building material resilience and urban ecological restoration?

Introduction

The frequency and intensity of extreme weather events, such as tropical cyclones, are expected to increase with climate change (IPCC, 2012). A handful of extreme events from 2021 include a snowstorm in January that cost Spain about USD\$1.6 billion, Cyclone Ana in Fiji left nearly 20,000 homeless, and a heatwave in Canada that led to the death of 569 people over five days (Aljazeera, 2021). These events demonstrate the immense impact that extreme weather can have on communities, their homes, and livelihoods. A better understanding of these events could lead to more effective adaptation strategies at the regional scale. For example, the resilience of the built environment could be strengthened by adjusting infrastructure policy to ensure that only durable building materials are employed based on the most significant risks posed to that region.

Impact of Ex-Tropical Cyclone Dovi in New Zealand

We have collected a wide range of scientific and social information to evaluate Dovi's impact on New Zealand. First, we examined historical changes in wind gusts by

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comparing the 2011–2021 decade with the 1981–2010 decade (Figure 1). Then, we delved into forecasted infrared satellite imagery (Figure 3), real-time infrared satellite imagery (Figure 4), and wind gust speeds (Figure 5). Finally, we ran future models of extreme wind speeds across three of New Zealand's regions (Waikato, Auckland, and Wellington) to gauge possible changes by 2090 using robust CMIP6 data.

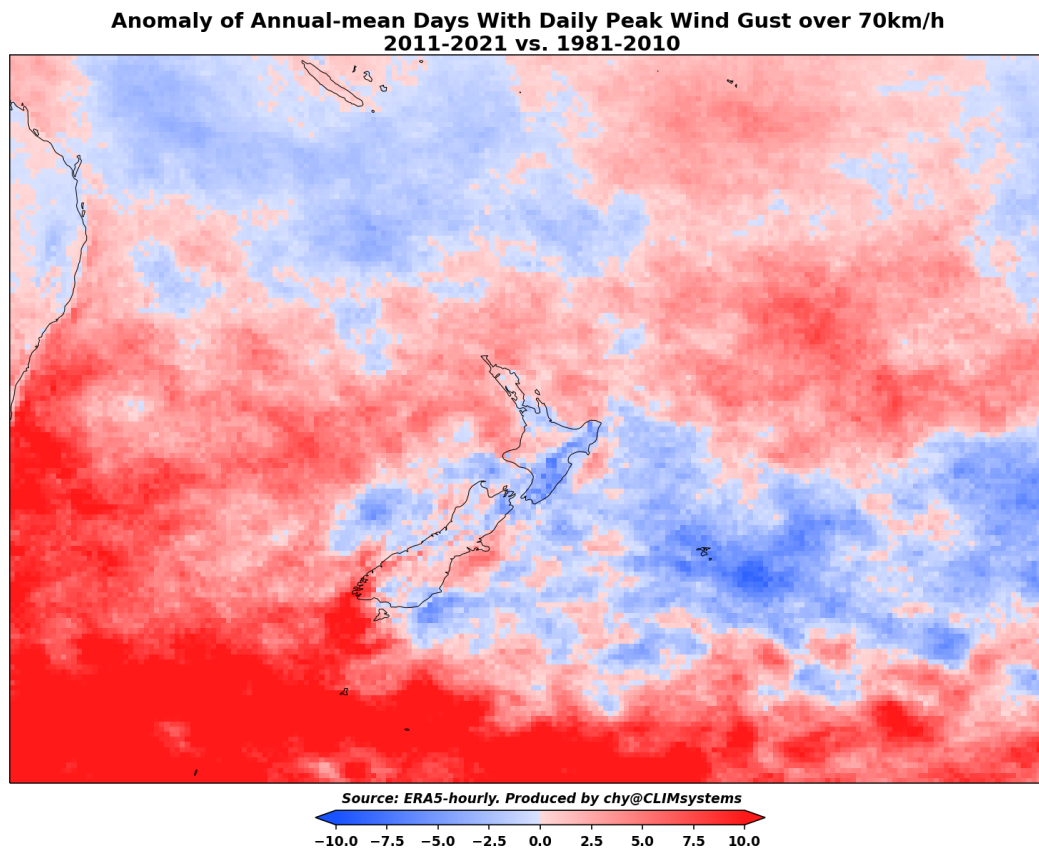


Figure 1. We conducted a rapid assessment of decadal variability in wind gust speeds across the New Zealand domain using ERA5 data. In Northland, Auckland, Taranaki, and Southland, the number of gusts above 70km/h shows an increasing trend. The map displays the number of days exceeding 70km/h increased around New Zealand from 2011 to 2021, compared to 1981 to 2010.

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Decadal Variations of Number of Days Hourly Gust Speed Exceed 70km/h in regions of New Zealand (ERA5 data)

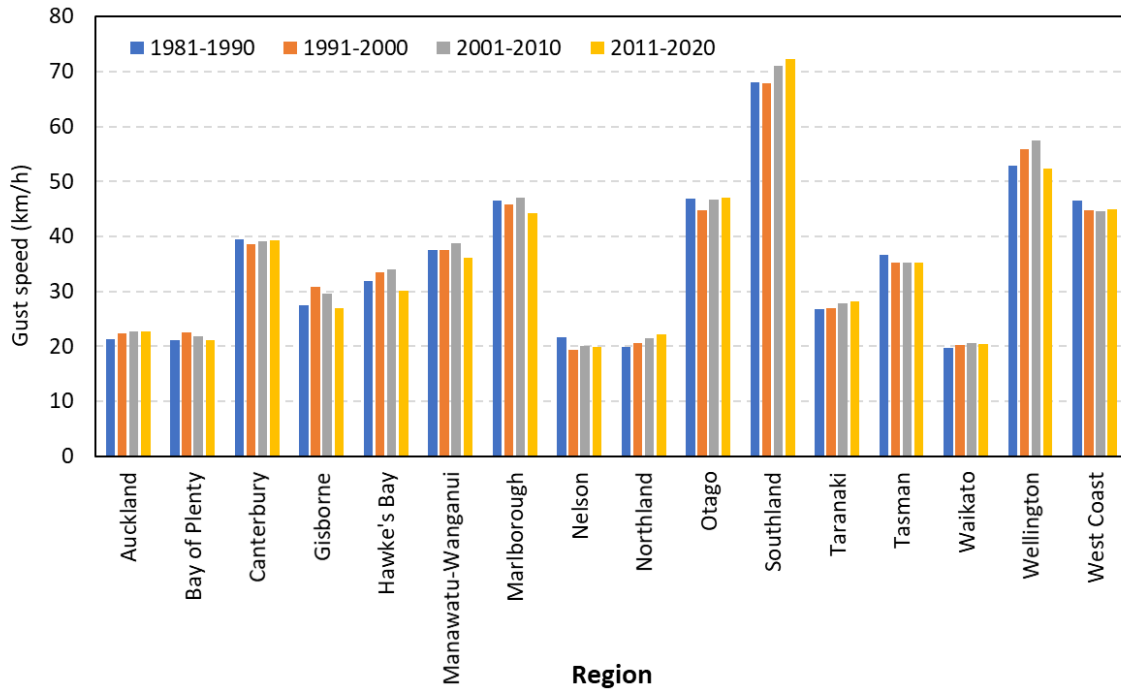


Figure 2. Regional changes in gust speeds (km/h) over four historical decades between 1981 and 2020. Most regions generally show a rise in gust speeds, particularly in the Southland and Wellington districts.

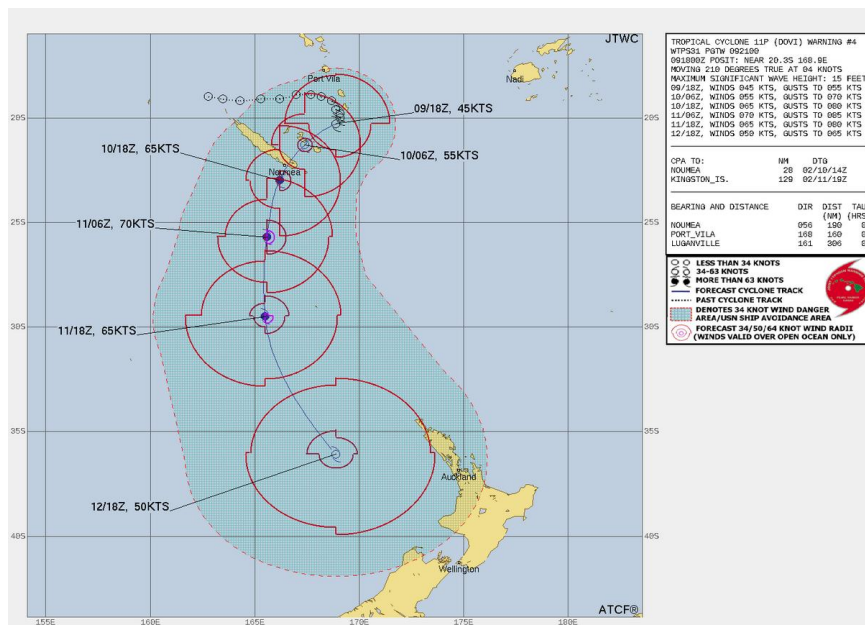


Figure 3. Forecasted impact of Cyclone Dovi and its pathway towards New Zealand (JTWC, 2022)

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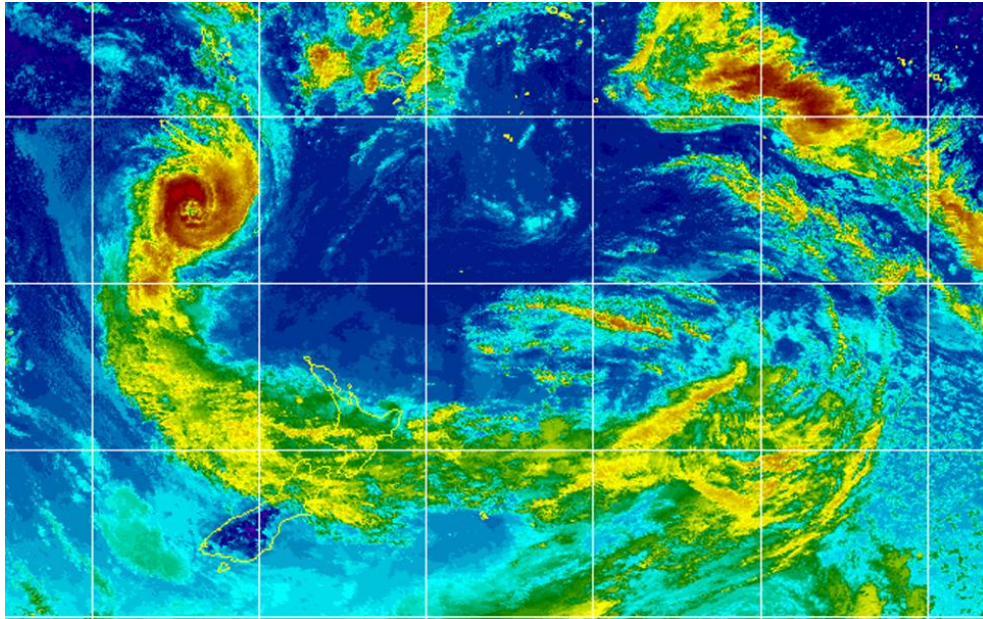


Figure 4. Infrared satellite image of Cyclone Dovi approaching New Zealand on 10th February 2022 (University of Wisconsin, 2022). At this stage, the tropical cyclone was still intact. Although in the following days, it dissipated over New Zealand, with its ex-tropical winds having the most impact on our cities.

The ERA5 data displays hourly wind gusts that swept across New Zealand over the 12th and 13th of February (Figure 5). The strongest winds appear to have reached the west coast of New Zealand on Saturday night and engulfed the rest of the country by Sunday. The gusts had moved east of New Zealand late on Sunday evening. At 9 am on Sunday, 13th February, the pressure dropped from above 1000 hPa to less than 900 hPa, indicating the ex-tropical cyclone's 'eye' passing through the Waikato.

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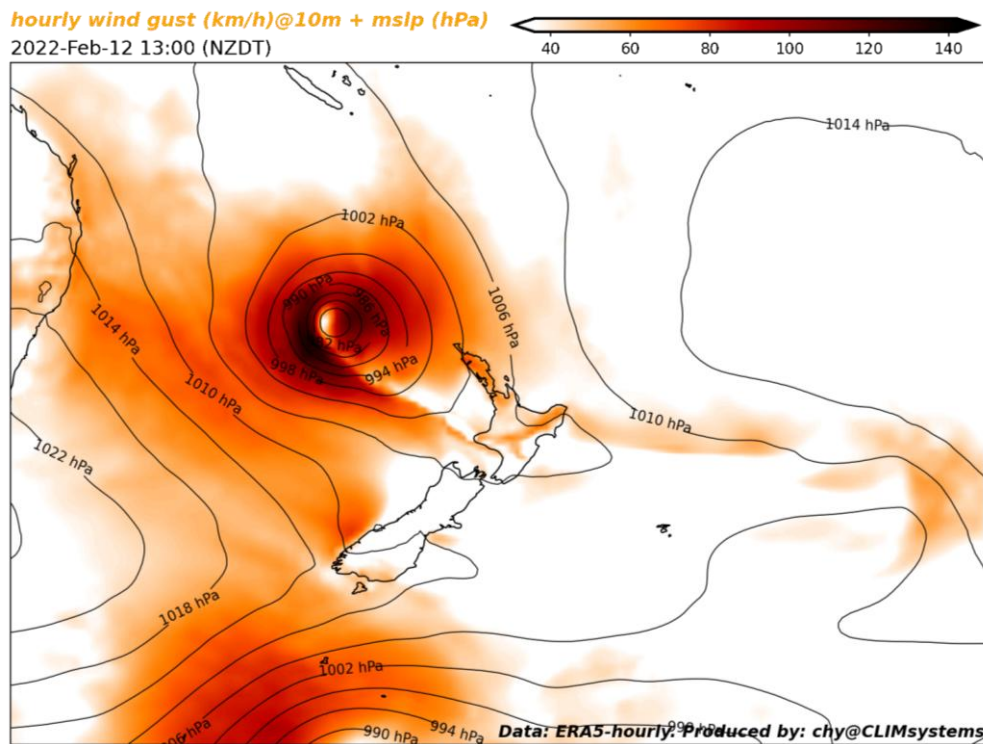


Figure 5. The GIF displays ERA5 Hourly wind gust data for 12-13 February.

The region which experienced the strongest gusts was Marlborough, with speeds exceeding 130 km/hr. Other areas that recorded gusts up to 120 km/hr were Taranaki, Wellington and Waikato. Consistent with the graphic above, the strongest gusts were felt across these districts on Sunday (13th) morning, around 9-10 am. Northland, Gisborne, and Auckland experienced similar gust speeds of about 100-110 km/hr. The Bay of Plenty and Nelson experienced gusts of up to about 95 km/hr (Figure 6).

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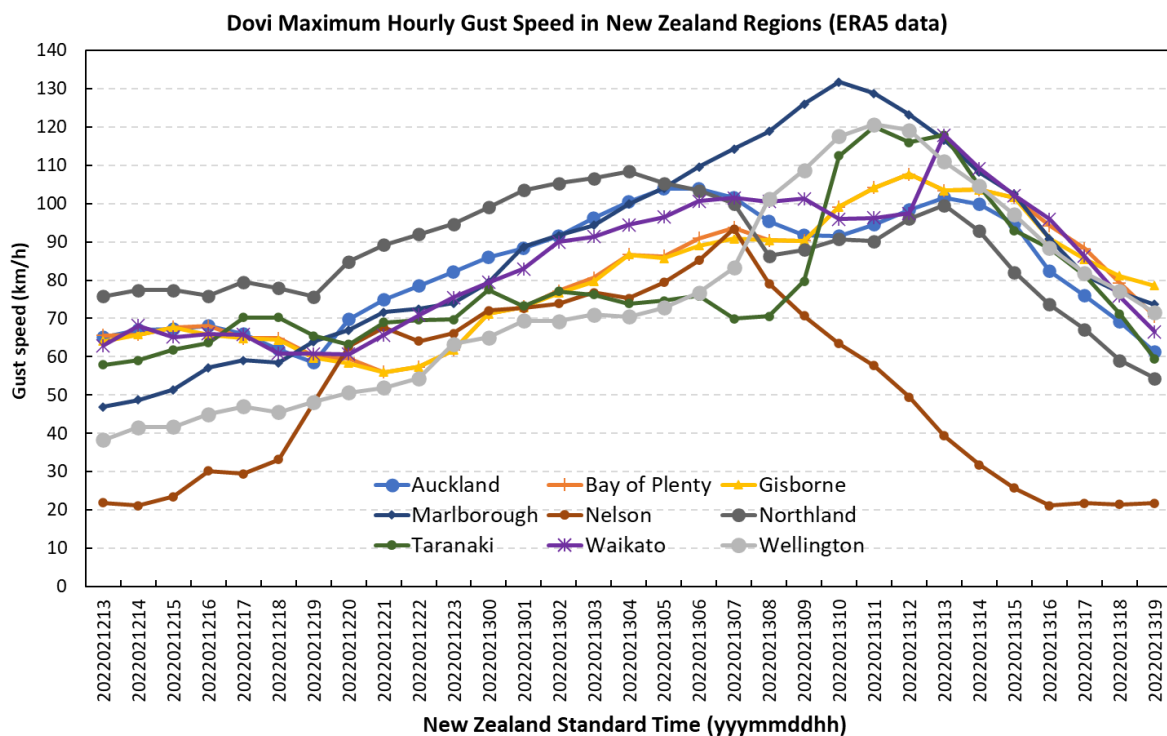


Figure 6. ERA5 estimated the Dovi landfall process in New Zealand; the timeline, gust speeds, and distribution are consistent with local observations, allowing for discrepancies in local detail.

Social and Economic Impacts

Major infrastructure was temporarily closed or disrupted throughout many cities in New Zealand during the extreme wind event. Auckland Harbour Bridge closed before reopening as wind gusts hit 109km/h. In Wellington, flooding and slips forced the evacuation of homes and led to road closures. Thousands were without power in Northland, boats were torn from moorings in Russell, and Air New Zealand cancelled at least 100 flights. Financial assistance was released for deluged South Island farmers while several state highways closed around the country. One man was taken to Waikato Hospital with serious injuries after a tree fell on a car. Police urged people to avoid non-essential travel as gale-force winds struck, with gusts between 130km/h and 150km/h.

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Figure 7. Ex-tropical Cyclone Dovi's strong gusts caused disruptions throughout Hamilton and the region (lower right image from Kayne Sutherland, all others by ClimSystems staff). The lower right panel exemplifies the damage caused by one tree that fell across Pukete Road in Hamilton, which caused its closure, the snapping of the underground water line for that side of the street, and serious uplifting of the sidewalk.

Vector said the storm brought “extremely challenging” weather conditions with gusts of up to 150km/h, leading to widespread power outages in nearly every part of Auckland. Some customers were without power for days. At the worst point of Dovi's transect of New Zealand, about 50,000 customers were without power for at least a brief period. Later that afternoon, the number had fallen to about 14,000. “This number continued to change as the crews assess each area and are able to get a clearer picture of the extent of the damage,” said Vector's GM Operations and Maintenance Manager, Marko Simunac.

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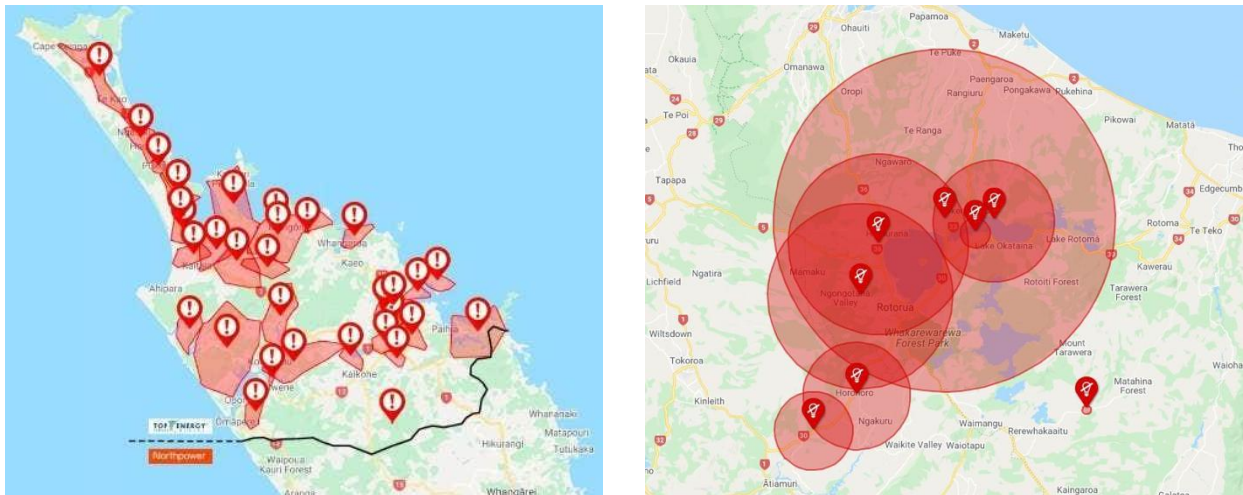


Figure 8. Power outages impacted most of Northland (Stuff, 2022) and many households in the Bay of Plenty (NZ Herald, 2022).

In Hamilton City, the cost of Cyclone Dovi was estimated at about \$1 million (HCC, 2022). This cost has mostly been attributed to operational clean-up fees for tree damage and the replacement of streetlight poles. Weeks later, the clean-up continues, with many jobs still to be completed around the city. Hamilton City Council received more than 700 calls, 1,500 service requests and 120 emails from the public. Insurance companies were also swamped with calls regarding damage to homes and personal belongings.



Figure 9. Large trees were ripped out of the ground, blocking roads until contractors could remove them (local images from Hamilton, ClimSystems staff).

Besides the interruption this event caused to major infrastructure, including roads, powerlines, and waterways, private households were also affected. One family (who wish to remain anonymous) was forced out of their home for 5 days during the storm because a large tree on their property split (see Figure 10). Luckily, no one was hurt, and the tree did not fall on their house. However, the cost of removing the tree (about \$35,000) alongside their need to relocate for several days came as a shock. The family also mentioned that finding arborists during this busy time was difficult, as many were

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swamped with council-contracted jobs. Although their house was insured, they were not covered in this case, as only the tree was damaged and was removed before it could hit the house. Other private landowners across Hamilton City were likely faced with similar issues, where costs can mount up quickly. Importantly, household insurance does not cover the removal of damaged trees. Damage to a house is covered only if the tree falls on it, and even then, it is unclear whether the cleanup of the fallen tree is covered by insurance or only the damage to the home. Currently, there appears to be inadequate support for these incidents. Tree management guidelines and policies to reduce the risks and costs associated with tree failures may need to be updated as extreme weather events intensify. Besides financial liability, removing trees also changes a home's ambience, value, and results in the loss of several services.



Figure 10. The removal of a large tree from a private property after the extreme winds led to its collapse (Anonymous family in Hamilton). The image on the left was before, and the image on the right was after the ex-tropical cyclone and tree removal.

The benefits of urban vegetation are well known. Trees provide shade, privacy, cooler temperatures (mitigating the urban heat island effect), and support birds and other treasured biodiversity. Urban vegetation also improves microclimates by absorbing pollutants and providing cooling. Carefully planning the position of trees and which species you plant, which significantly impact their resilience to such events, could save significant resources in the long term as the frequency of such extreme weather events rises. Although frost tolerance, air temperature, drought, radiation, and soil characteristics are commonly examined for urban tree selection, wind resistance is not (Vogt et al., 2017). Including wind resistance and related tree characteristics, such as species height and root depth, in the selection of urban trees may be critical to alleviating some of the significant impacts of extreme events like ex-cyclone Dovi.

Climate Modelling of Extreme Wind Speed

Ex-tropical cyclones can have devastating consequences for communities, which will likely exacerbate as the climate warms (Bruyère et al., 2019). Gauging how frequently extreme weather events, such as ex-tropical cyclones, occur and the magnitude of their impact can provide invaluable insight for decision-makers. Risk and hazard assessment are crucial for improving risk management strategies, enabling building codes and practices to be refined to account for regional impacts.

One study modelled the effect of a significant ex-tropical cyclone hitting the northern areas of New Zealand (Boutle et al., 2021), using different precipitation and wind scenarios based on historical ex-tropical cyclone records, thereby identifying possible extremes in temperature, rainfall, maximum wind gusts, and specific humidity. Ultimately, their model suggests that planning and development should consider the impacts of ex-tropical cyclones when selecting building materials and designs.

Due to ex-tropical Dovi's impact of gusts on New Zealand, we have compiled extreme wind speed change projections for New Zealand's regions by 2090. The following figures depict future changes in extreme wind speeds for Waikato, Auckland, and Wellington at the time slices of 2030, 2050, and 2090 under an SSP5-8.5 climate scenario. The inter-model variability of factors driving extreme wind speed changes in CMIP6 GCMs is considerable, both for increases and decreases, owing to the random nature of gusts and model limitations.

The extreme wind data explores future extreme wind speeds across the entire range of return periods from one to 10,000 years. The RITS document deferred to the Australia/New Zealand wind standards for guidance. Here, we recognise that Hamilton and the wider region lie within Zone A for wind risk, and analysis is focused on these standards. It is important to note that currently, Hamilton's extreme wind speeds fall below the regional standard, which elucidates why the baseline wind speeds adopted in this analysis (from the wider region) are lower than the standards set for Zone A in AS/NZS1170.2:2011 Structural design actions Part 2: Wind actions.

Nevertheless, extreme winds could become more frequent and stronger and serious planning and action should be considered. Although the median change in extreme wind speed is predicted to decline in Waikato, there is significant variability, and this trend is clearly positive by 2090 under the different return periods. Across all three regions, the variability (length of box-and-whisker plots) increases with longer return periods, as expected. Auckland shows a similar trend to Waikato, with unclear changes

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in extreme wind speeds in 2030 and 2050, but a more obvious positive signal (a greater risk of higher extremes) by 2090. Wellington is predicted to experience the greatest rise in extreme wind speeds, with a positive median change (%) for all scenario periods.

Extreme winds have a haphazard nature. Hence, the difficulties in predicting extreme wind speeds from historical data. However, historical changes in extremes point to the value of making adaptation decisions based on the worst-case scenario. Adopting climate-resilient strategies can mitigate the costs, physical destruction, and disruption to life and economic activities caused by these events.

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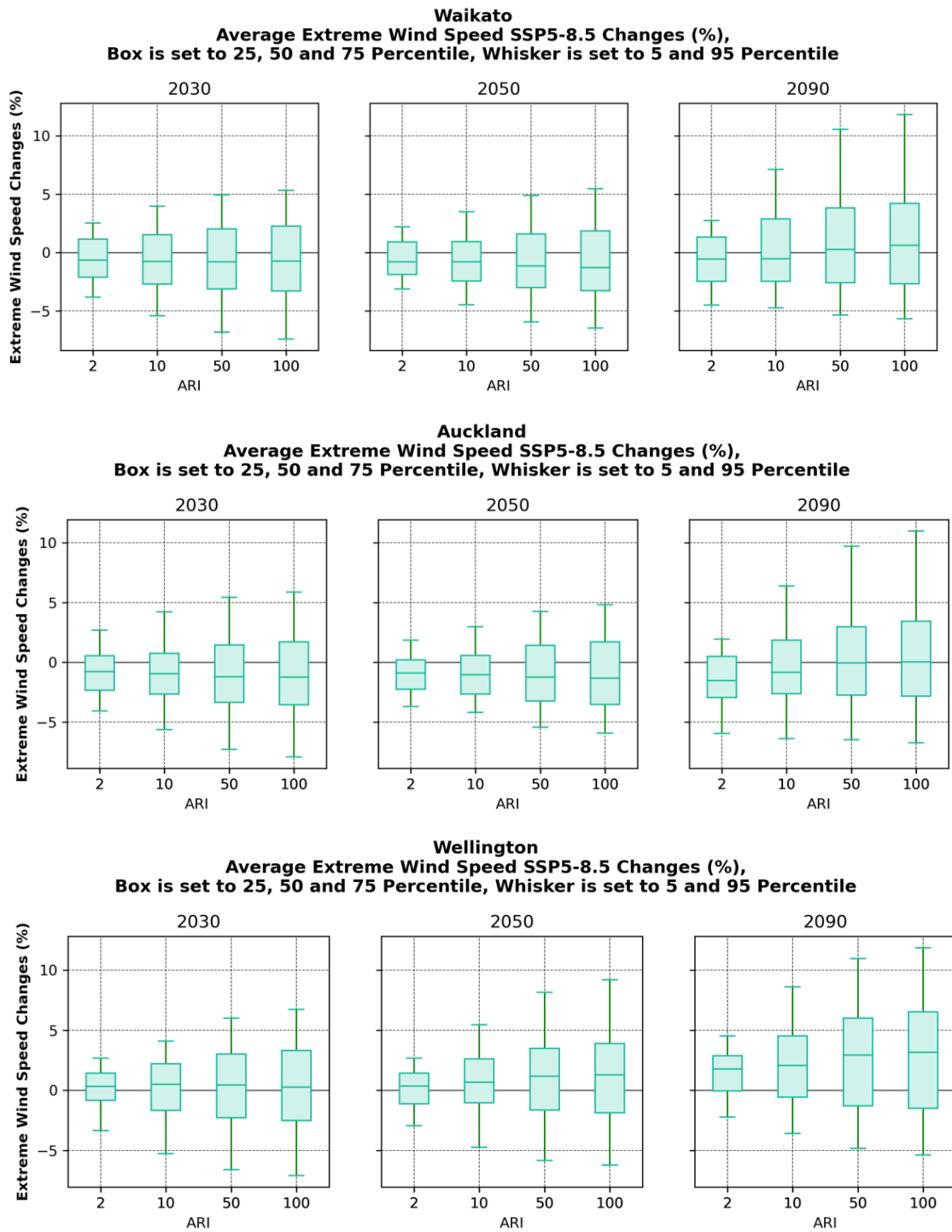


Figure 11. Extreme wind speed change projections for Waikato, Auckland and Wellington.

Lessons Learned from Ex-Tropical Cyclone Dovi

Extreme weather events can have severe social and economic consequences. While the irregular occurrence of these events has led to their lack of attention in the past, they will likely increase in frequency and intensity with climate change (Panteli & Mancarella, 2015). Although winds are inherently haphazard and difficult to model accurately, this analysis suggests a positive extreme wind signal across many regions of New Zealand. Furthermore, the latitudes at which tropical cyclones typically occur are also predicted to widen, with increasing mid-latitude suitability (New Zealand) as the Intertropical Convergence Zone (ITCZ) strengthens and shifts towards the equator (Studholme et al., 2021).

Socially, the weather has a dramatic effect on demographic structures and characteristics. As urban populations grow, the density and age of buildings increase, increasing communities' vulnerability to hazards. For example, the impact on one building can have knock-on effects on surrounding buildings in densely populated areas. Similarly, with age, buildings and materials weaken, so extreme weather events can have a heightened effect on older structures.

The economic cost of extreme weather events like Dovi will also likely rise as they become more frequent under climate change. At the district scale, Dovi cost Hamilton City Council about \$1 million in call-out fees and clean-up costs that have continued for several weeks since the event. Individuals have also faced significant financial burdens, with one family paying about \$35,000 out of pocket to remove a large fallen tree on their property.

Risk management is the key to reducing the probability of extreme events leading to devastating consequences. For local government, risk management may include building regulations, educational tools on improving property resilience and warning services (McBean, 2004). The adaptive capacity of specific homes will vary with different hazards and features – knowledge of the main threats that your property faces can guide the selection of adaptation options. For example, adapting to extreme winds may include using natural or constructed barriers, removing hazardous structures that could collide, replacing old building materials with more resilient ones, and applying regular and more aggressive tree pruning. Currently, there are few guidelines to support risk-based vegetation management (see ENA, 2016). Comprehensive regulations that mitigate costs may become more necessary as the frequency of these events increases.

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While tree failures accounted for a significant share of the impact from this event, planting trees can also be a pragmatic solution for future extreme weather events. 'Greening' cities or urban ecological restoration is another adaptive movement expanding around the world (Foster et al., 2011). Restoring highly modified urban environments provides a wealth of benefits, including enhancing biodiversity and many ecosystem services. Some of the most valuable ecosystem services include carbon sequestration, regulation of water flow and climate (i.e., mitigating the urban heat island effect), provision of clean water, and maintenance of soil quality (Benayas et al., 2009). Areas prone to high winds may consider planting native, wind-resistant trees such as *Hedycarya arborea* (pigeonwood), *Metrosideros excelsa* (pohutukawa) or *Griselinia littoralis* (New Zealand broadleaf). Trees can act as wind barriers and are typically more resilient when planted in groups than when planted alone (Duryea & Kampf, 2007).

This article outlines the impact of ex-tropical Cyclone Dovi on New Zealand, with specific examples focused on Hamilton City. Comparing historical wind speeds with the gusts that reached up to 130 km/hr last month, and future climate predictions based on CMIP6, point to a 'positive' signal in line with changes over the last 30 years; therefore, extreme wind speeds will likely increase over time. Looking ahead, implementing effective adaptation strategies will be fundamental to mitigating the impact of these extreme weather events.

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