Changing rainfall extremes with climate change in New Zealand

Guidance for Decision-makers

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Summary: key messages

- This document summarises recent findings on how climate change is affecting extreme rainfall over Aotearoa New Zealand.
- Extreme rainfall is seen to become more intense across the country as a consequence of human-induced climate change, and is expected to continue doing so in future.
- The largest increases are in Northland and the Southern Alps, with smaller increases in the east of the South Island.
- Week-long events are becoming about 3% more intense per degree Celsius of warming while hour-long events are increasing at about 18% per degree Celsius.

1 Introduction

Heavy rainfall events occur when conditions force water-laden air to release its water. As the climate warms the air holds more water vapour, with the potential to release an accordingly larger amount of rain during extreme events. This document assesses the newest evidence[1] on how warming will affect extreme rainfall across New Zealand[2].

We analyse data from three models[3] of how the climate should change under human influence, all slightly different in complexity, detail and size of dataset. Since each model has strengths and weaknesses, agreement between models contributes to confidence in the accuracy of our predictions. All three models have been run at various stages of global warming, ranging from a pre-industrial climate, through the present day, to a range of warmer futures.

2 Extreme rainfall changes across the country

Figure 1 shows maps of how day-long extreme rainfall is expected to change with climate warming. Reds indicate rainfall becoming heavier and blues the opposite. The maps are for the 1-in-100-year rainfall amount but maps for other levels of extremeness are similar. The three models agree that extreme rainfall intensifies with warming: about 9%/degree according to CAM5.3 and CCAM, nearer

[1]Recent research has been undertaken with support from the Deep South National Science Challenge, the MBIE Endeavour Whakahura project , and the MBIE Smart Ideas EWERAM project.

[2]HIRDS v4 (the High Intensity Rainfall Design System, https://hirds.niwa.co.nz/) is the authoritative resource for extreme rainfall across New Zealand. The guidance in this document updates the climate change factors used in HIRDS v4.

[3]The three models are CAM5.3 (NCAR Community Atmosphere Model v5.3), CCAM (CSIRO Conformal Cubic Atmospheric Model), and weather@home/ANZ (Australia/New Zealand). weather@home/ANZ has many thousands of years of simulations run at a spatial resolution of 50km, while CAM5.3 and CCAM have fewer years of simulation but at a higher spatial resolution (25km and 12km respectively).

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6%/degree according to weather@home/ANZ. CAM5.3 and CCAM have greater increases at higher elevations. Small changes, or even a reduction of extreme rainfall amounts, occur in eastern regions. The largest increases in intensity occur in Northland, with notable increases also in Southland.

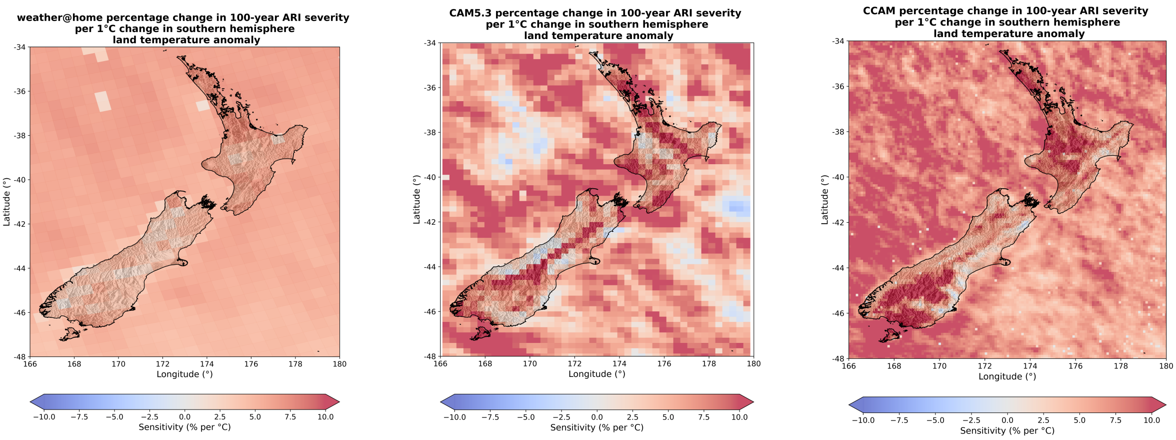

Figure 1: *Maps of changes in the 1-in-100 year daily rainfall amount from three models, expressed as percentage change per degree Celsius of warming: weather@home/ANZ (left), CAM5.3 (middle) and CCAM (right).*

3 Extreme rainfall changes across event duration

Figure 2 summarises how the warming influence on extreme rainfall differs for various event durations, using the one model that provides suitable data (CCAM). Changes are calculated for rainfall durations from 1 hour to 168 hours (7 days), and for return periods from 10 to 500 years; we show the North and South Islands separately, with spatial patterns within each island resembling Figure 1 for all durations and return periods. The intensity increases most (by about 18%/deg) for hour-long events, least (by about 5%/deg) for week-long events, and increases by intermediate amounts for intermediate durations. Increases in intensity are about the same across return periods (event rarity).

ARI (years)	Island	Precipitation duration												
		1 hours	2 hours	3 hours	6 hours	12 hours	24 hours	36 hours	48 hours	72 hours	84 hours	96 hours	120 hours	168 hours
500	north	18.4	18.9	18.3	15.6	12.0	9.3	8.5	8.0	7.4	7.2	7.0	6.7	6.4
	south	16.9	17.4	16.4	13.5	10.3	7.7	6.7	6.0	5.2	4.9	4.7	4.3	3.9
250	north	18.3	18.7	18.2	15.4	11.8	9.1	8.4	7.8	7.2	7.0	6.8	6.6	6.2
	south	16.8	17.4	16.4	13.4	10.1	7.6	6.6	5.9	5.1	4.9	4.6	4.3	3.9
200	north	18.3	18.7	18.2	15.3	11.7	9.1	8.3	7.8	7.2	6.9	6.8	6.5	6.1
	south	16.8	17.4	16.3	13.4	10.1	7.6	6.6	5.9	5.1	4.8	4.6	4.2	3.9
100	north	18.2	18.6	18.0	15.1	11.5	8.9	8.1	7.6	7.0	6.7	6.6	6.3	5.9
	south	16.8	17.3	16.3	13.2	9.9	7.4	6.4	5.7	4.9	4.7	4.5	4.1	3.8
50	north	18.0	18.4	17.8	14.9	11.3	8.7	7.9	7.3	6.7	6.5	6.3	6.1	5.7
	south	16.7	17.3	16.2	13.1	9.7	7.2	6.3	5.6	4.8	4.6	4.4	4.0	3.7
20	north	17.8	18.2	17.5	14.5	10.9	8.3	7.5	7.0	6.4	6.1	5.9	5.7	5.3
	south	16.5	17.2	16.1	12.9	9.4	7.0	6.0	5.3	4.6	4.4	4.2	3.8	3.5
10	north	17.6	17.9	17.1	14.1	10.4	7.9	7.1	6.6	6.0	5.7	5.6	5.3	5.0
	south	16.4	17.1	15.9	12.6	9.1	6.7	5.8	5.1	4.4	4.2	4.0	3.7	3.4

Figure 2: *Increases in extreme rainfall under climate warming (% per degree Celsius of warming) for rainfall durations from 1 hour to 168 hours (7 days), and for return periods from 10 to 500 years.*

4 Concluding remarks

This document presents the current evidence of what we expect to happen on average under human-induced climate change. However, extreme rainfall events are rare. That means that trends are unlikely to be noticeable in any particular location in the coming decades: after all, we expect a 1-in-50 year class event to happen only once over the next 50 years, on average. The vagaries of weather will surely produce different changes over the coming decades than the strict numbers presented here, but these estimates represent the newest guidance on what we should prepare to expect.