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IN THE MATTER of the Resource Management Act 1991 (**RMA**)

AND

IN THE MATTER of the Freshwater Planning Instrument Parts of the Proposed Otago Regional Policy Statement 2021

STATEMENT OF EVIDENCE OF
MICHAEL JAMES SALINGER FOR Wise Response Society Inc

23 JUNE 2023

SUMMARY OF EVIDENCE

My name is Michael James Salinger and I am a climate scientist. I summarise my evidence according to the key headings in this statement, as follows:

Climate Change

New Zealand regional temperatures have warmed by 1.2°C over the period 1870 – 2020, with warming owing to greenhouse gases contributing 0.8°C. Projections indicate a further 0.3° to 1.5°C by 2040, and up to 3.5°C by 2090. The 1.5°C threshold is expected to be passed in the current decade.

Future Climate Projections

Without effective greenhouse gas policies to reduce global emissions rapidly between 1.5°C is expected to occur by 2040 and 2 to 3°C by 2090. Annual rainfall changes of -5 to +50%. Decreases occur in eastern Otago. Summers are drier in the east and winters are wetter everywhere. The latter will lead to water shortages owing to higher temperatures leading to high evapotranspiration (water loss from the soil). The situation is more accentuated in 2090 projections.

Greenhouse Gas policy

Keeping global warming less than 1.5°C or 2°C clearly requires control of all greenhouse gases, especially methane (CH_4). CO2 emissions must halve by 2030, reduce to zero by 2050 with CH_4 down by 70%.

Conclusion

This evidence strongly suggests a drying in the summer hydrological environment without rapid reduction in greenhouse gas emissions.

INTRODUCTION

1. My name is Michael James Salinger.

2. I am a climate scientist. I hold the qualifications of B.Sc (Geography & Zoology), Ph D (climate science) and M Phil (1st class hons) in Environmental Law.

3. I am climate scientist of international repute, the first to uncover climate warming in New Zealand region in the 1970s. Contributions have been made to the Nobel Peace Prize (2007) together with Intergovernmental Panel on Climate Change (IPCC) colleagues for ground-breaking work on climate change. Several Visiting Professor positions have been held including Stanford and University of Florence (Italy). Over 200 publication of climate change to the public. Recent awards include the Jubilee Medal, premier award from the for New Zealand Institute of Agricultural and Horticultural Science for lifetime achievements in climate and agricultural science.

4. I am a Companion of the Royal Society of New Zealand and a member of the Meteorological Society of New Zealand.

5. I have been retained by Wise Response to prepare a statement of evidence on climate change.

6. In preparing this evidence I have read the following documents:

   (a) Ministry for the Environment 2018. *Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment, 2nd Edition*. Wellington: Ministry for the Environment.

   (b) van Vuuren DP, Edmonds J, Kainuma M, Riahi K, Thomson A, Hibbard K, Hurtt GC, Kram T, Krey V, Lamarque JF, Masui T, Meinshausen M, Nakicenovic N, Smith S, Rose SK. 2011a. The representative concentration pathways: an overview. Climatic Change 109: 5–31.

   (c) IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. A Report of the Intergovernmental Panel on Climate Change. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, 36 pages. (in press). https://IPCC_AR6_SYR_SPM.pdf

CODE OF CONDUCT

7. I have read the Environment Court Code of Conduct for expert witnesses and agree to comply with it.

8. I confirm that the topics and opinions addressed in this statement are within my area of expertise except where I state that I have relied on the evidence of other persons. I have not omitted to consider materials or facts known to me that might alter or detract from the opinions I have expressed.

Climate Change

9. Regional warming is projected for the New Zealand region because of increases in Greenhouse Gases in the atmosphere. For the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment, four forcing scenarios have been developed, known as representative concentration pathways (RCPs) (van Vuuren et al, 2011a). These are much the same as the sixth assessment report. The pathways are identified by their approximate total (accumulated) radiative forcing at 2100 relative to 1750 owing to increases in Greenhouse Gases:

   2.0 $W\ m^{-2}$ for RCP2.0
   4.5 $W\ m^{-2}$ for RCP4.5
   6.0 $W\ m^{-2}$ for RCP6.0
   8.5 $W\ m^{-2}$ for RCP8.5

10. Based on the pathways developed by the IPCC NIWA subsequently produced pathway interpretations for New Zealand - two stabilisation pathways (RCP2.6 and RCP4.5), and two growth pathways, the last being essentially 'business as usual' (RCP6.0 and RCP8.5) with very high greenhouse gas concentrations by 2100 and beyond, are used (MfE. 2018). The lowest (RCP2.6) is a stabilization scenario equivalent to 1.5°C of warming. These are shown in Figure 1.

11. Figure 1 compares the RCP atmospheric carbon dioxide concentrations with an earlier scenario. Although the IPCC Assessment Report 4 and Assessment Report 5 concentrations do not correspond directly to each other, CO_2 concentrations under RCP4.5 and RCP8.5 are similar to those of the earlier scenarios B1 and A1FI, respectively. This comparison is done to show that the modelling for those two scenarios are similar.

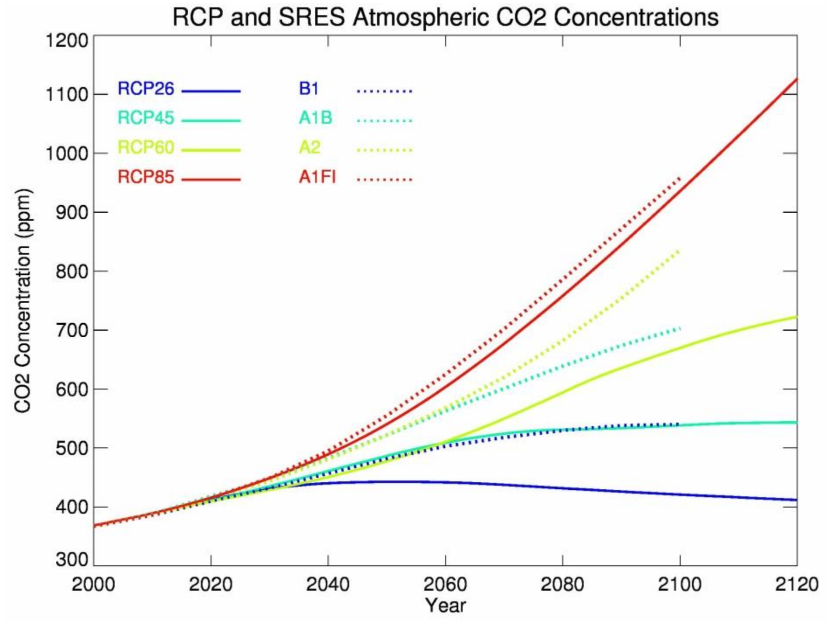


Figure 1: Atmospheric carbon dioxide concentrations for the IPCC Fourth Assessment (dotted lines, SRES concentrations) and for the IPCC Fifth Assessment (solid lines, RCP concentrations)

12. There has been at least 1.2°C warming in the New Zealand region (Figure 2) since the 19th century (Figure 2).

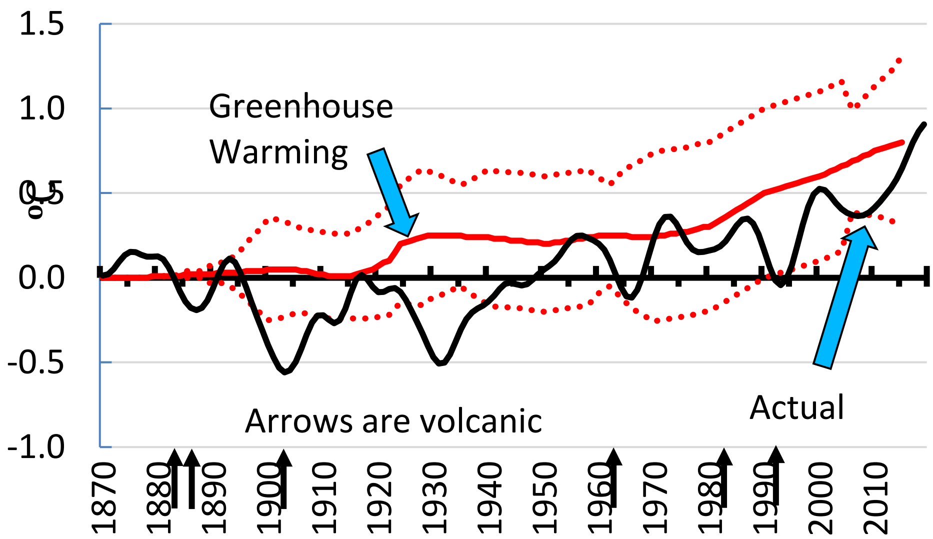


Figure 2. New Zealand temperatures (smoothed, in black) 1870 – 2020 and regional temperatures because of the greenhouse effect (red), and volcanic cooling episodes.

13. Figure 3 shows the bias-adjusted sea surface temperatures used to force the NIWA General Circulation Model and Regional Circulation Model, presented here only for the average over the RCM domain (Ackerley et al, 2012). For the pathways, except RCP2.6, sea temperatures continue to increase throughout the twenty-first century, with a much larger rate of change from the high greenhouse gas pathway (RCP8.5).

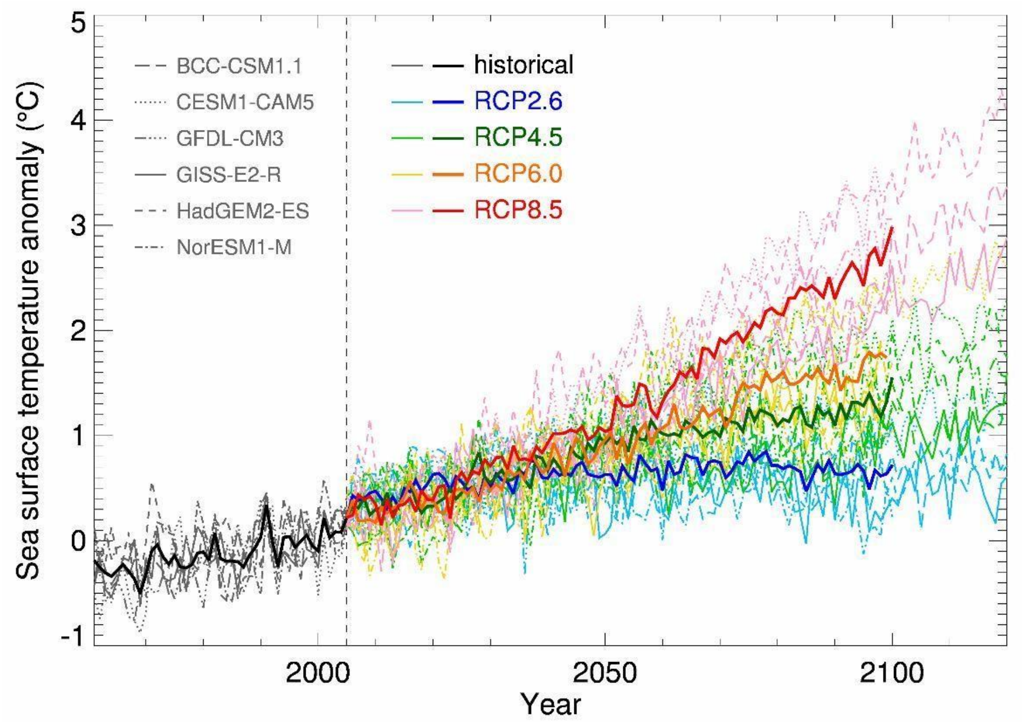


Figure 3: Bias-adjusted Sea surface temperatures, averaged over the Regional Climate Model domain for New Zealand, for six CMIP5 global climate models, and for the historical simulations (here 1960–2005) and four future simulations (RCPs 2.6, 4.5, 6.0 and 8.5), relative to 1986–2005

14. The bias correction and downscaling procedures were performed separately by NIWA on the New Zealand regional climate model (RCM) data for the primary climate variables of minimum and maximum temperature and precipitation.

Table 1: Projected changes in winter and spring mean temperature (in °C) from NIWA, between 1986–2005 and 2031–2050 for Otago, as derived from statistical downscaling. The changes are given for three RCPs (8.5, 6.0, and 4.5), where the ensemble-average is taken over (41, 18, 37) models for Otago respectively.

Otago	Summer	Autumn	Winter	Spring	Annual
RCP 8.5	0.9 (0.2, 1.7)	1.0 (0.6, 1.5)	1.1 (0.7 to 1.5)	0.8 (0.3 to 1.3)	0.9 (0.6, 1.5)
RCP 6.0	0.8 (0.1, 1.4)	0.8 (0.1, 1.2)	0.8 (0.3 to 1.3)	0.6 (0.0 to 1.0)	0.7 (0.1, 1.1)
RCP 4.5	0.8 (0.2, 1.4)	0.8 (0.3, 1.3)	0.9 (0.6 to 1.4)	0.7 (0.3 to 1.1)	0.8 (0.4, 1.2)
RCP 2.6	0.6 (0.2, 1.3)	0.7 (0.2, 1.1)	0.7 (0.2, 1.2)	0.5 (0.1, 0.9)	0.6 (0.3, 1.1)

15. The values in each column represent the ensemble average, and in brackets the range (5th percentile to 95th percentile) over all models within that ensemble. The RCPs show annually a temperature mean increase of between 0.6 to 0.9°C, with the 5% and 95% range of 0.3 to 1.5°C.

Precipitation Projections

16. As with temperature, climate change precipitation projections are now presented for 2040 in Table 1, with maps in Figure 4. Projected precipitation change is given both for eastern Otago (Dunedin), and western Otago (Queenstown).

17. The mid-range projections for eastern Otago annual are for an increase of between 3 to 6 percent for 2040 with the 5th to 95th percentile range of -1 to 14 percent. However, western Otago shows a median increase of 7 to 16 percent with the 5th to 95th percentile showing is a wide range of precipitation change from -5 percent to +53 percent. The seasonal ranges are more extreme.

18. Overall, it is highly likely that for winter there will be increased westerly winds during winter, and weaker westerlies in summer.

Future projections

19. Near end of century (2090) projections are shown in Figure 5. The trends are similar in pattern to the 2040 projections, but more extreme, with wetter winters and drier summers.

Table 2 Projected changes in winter and spring mean precipitation (in %) from NIWA, between 1986–2005 and 2031–2050 for Dunedin and Queenstown, as derived from statistical downscaling. The changes are given for three RCPs (8.5, 6.0, and 4.5), where the ensemble-average is taken over (41, 18, 37) models respectively.

Otago Dunedin	**Summer**	**Autumn**	**Winter**	**Spring**	**Annual**
RCP 8.5	3 (-13, 16)	2 (-7, 11)	10 (-5, 22)	9 (-2, 21)	6 (1, 14)
RCP 6.0	3 (-13, 16)	-1 (-11, 10)	7 (-6, 15)	6 (-5, 16)	3 (-1, 9)
RCP 4.5	4 (-6, 12)	1 (-5, 12)	5 (-7, 16)	5 (-3, 13)	4 (-1, 9)
RCP 2.6	4 (-3, 10)	3 (-4, 10)	4 (-3, 14)	3 (-2, 10)	4 (1, 8)
Queens-town	Summer	Autumn	Winter	Spring	Annual
RCP 8.5	4 (-20, 20)	1 (-11, 14)	4 (-3, 14)	17 (-9, 40)	16 (-1, 28)
RCP 6.0	3 (-28, 28)	3 (-14, 35)	27 (-7, 84)	14 (-10, 64)	12 (-5, 53)
RCP 4.5	4 (-10, 20)	3 (-8, 12)	19 (-10, 52)	8 (-6, 28)	9 (-4, 21)
RCP 2.6	5 (-4, 16)	5 (-5, 15)	10 (-6, 30)	7 (-3, 19)	7 (-1, 18)

20. The figures in Table 2 show the annual mean rainfall changes for the four RCPs over New Zealand annually, and for the four seasons.

21. The projected changes for 2090 are shown in Figure 5 for annual, summer and winter changes.

22. Figure 6 shows the effect of increased temperature on rainfall, with a 7 percent increase per 1°C. The impact of this is to produce one more day of rainfall with 25 mm or more per annum.

23. More important is the rapidity of change as climate system impacts are speeding up as illustrated by the Auckland Anniversary Floods and cyclone Gabrielle impacts.

24. The climate scenarios show more drying in the summer owing to increased temperature for Otago, which increases evapotranspiration and water loss to the atmosphere, and lower summer rainfall.

Greenhouse gas policy

25. While CO_2 is the dominant greenhouse gas, keeping global warming less than 2°C or 1.5°C clearly requires control of all greenhouse gases and especially methane (CH_4) - the second most significant. The shorter half-life of CH_4 allows the more intense warming from CH_4 to be ameliorated quickly. "Early mitigation of CH_4 emissions would significantly increase the stabilising global warming below 1.5 °C, alongside

having co-benefits for human and ecosystem health"[1]. The analysis for IPCC AR6 shows that the broader effects of methane, on atmospheric chemistry and ozone levels in urban areas, also need to be recognised as sensitive to the global average atmospheric CH_4 concentration.

26. The importance of CH_4 is recognised explicitly in greenhouse gas emission scenarios now being used across all climate models for the IPCC AR6 assessment report. Changes in emissions, relative to those in 2015, for both CO_2 and CH_4, in the region covering New Zealand would assist in keeping warming lower[2].

27. Atmospheric CH_4 has been increasing since late 2006, and the importance of rectifying this to address climate targets is becoming increasingly recognised by scientists. A recent analysis of the CH_4 budget was presented at the American Geophysical Union conference in Washington DC in December 2018[3]; and in a paper on ways of managing methane emissions[4].

28. To limit the global temperature increase to 1.5 °C, global net CO2 emissions need to halve by 2030 and be zero by 2050.

29. Even then the rate of emissions abstraction from the atmosphere needs to be at about 50% of the current discharge rate by 2100 and climbing[5]. Transitioning rapidly to renewables out of fossil fuels would enable this to occur.

30. To limit the global temperature increase to 1.5°C, CH_4 needs a decline of 70% by 2050 globally. Because our emissions are higher per capita, cuts must be deeper.

Dated this 23 day of June 2023

Michael James Salinger

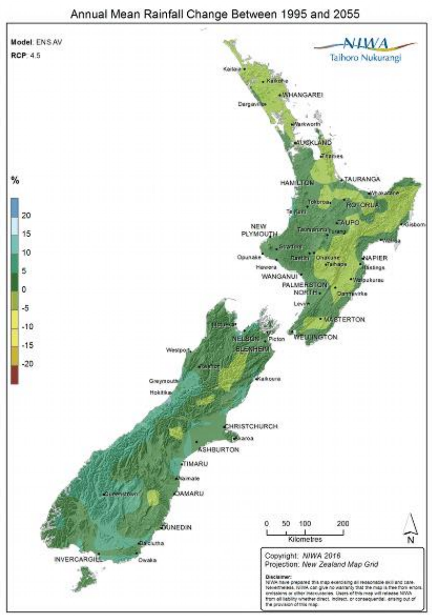
[1] Collins, W. J., C. P. Webber, P. M. Cox, C. Huntingford, J. Lowe, S. Sitch, S. E. Chadburn, E. Comyn-Platt, A. B. Harper, and G. Hayman (2018), Increased importance of methane reduction for a 1.5 degree target, Environmental Research Letters, 13(5), 054003.

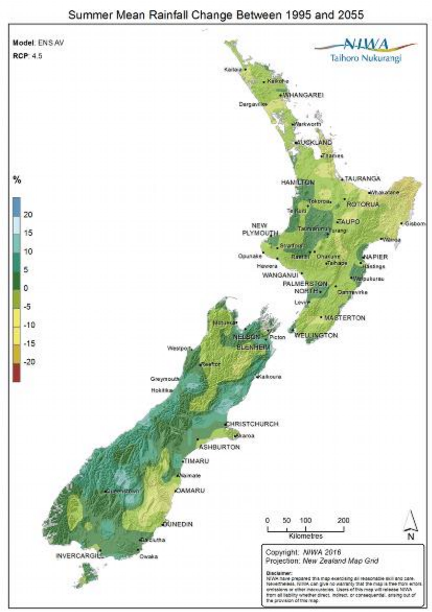
[2] Emissions data used here are publicly available at: https://tntcat.iiasa.ac.at/SspDb/dsd

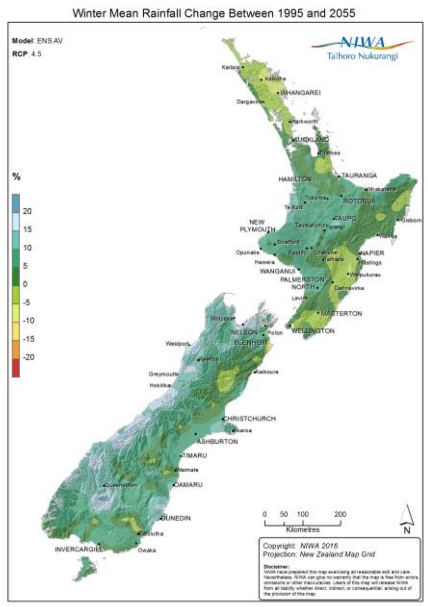
[3] Dlugokencky, E., M. Manning (presenter), E. Nisbet, and S. Michel (2018), Recent Increases in the Burden of Atmospheric CH4: Implications for the Paris Agreement, in AGU Fall Meeting: Rising Atmospheric Methane: Causes and Consequences, Washington DC.

[4] Nisbet, E. G., Fisher, R. E., Lowry, D., France, J. L., Allen, G., Bakkaloglu, S., et al. (2020). Methane mitigation: methods to reduce emissions, on the path to the Paris agreement. *Reviews of Geophysics*, 58, e2019RG000675. https://doi.org/10.1029/2019RG000675.

Figure 4. RCP climate projections for 2050.

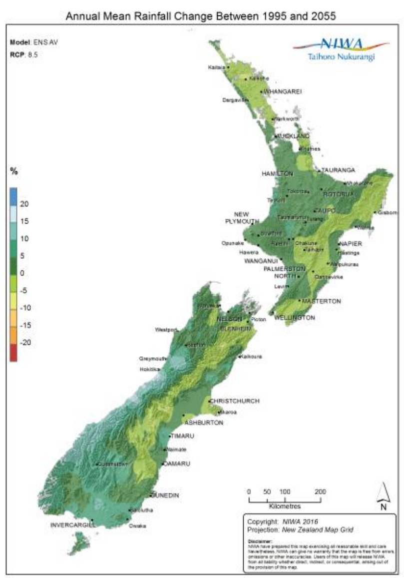


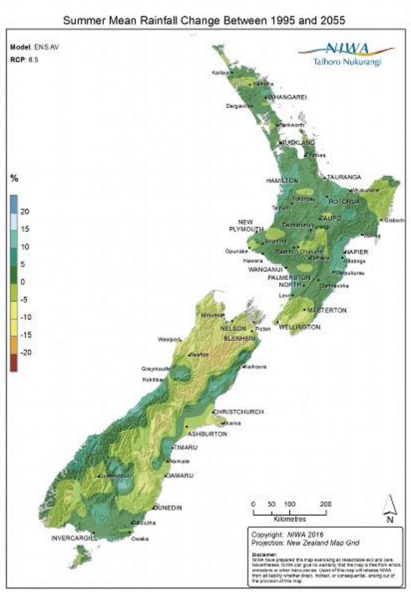




2040 RCP 4.5 Rainfall Scenarios (%) : Annual Summer Winter

2040 RCP 8.5 Rainfall Scenarios (%) : Annual Summer Winter





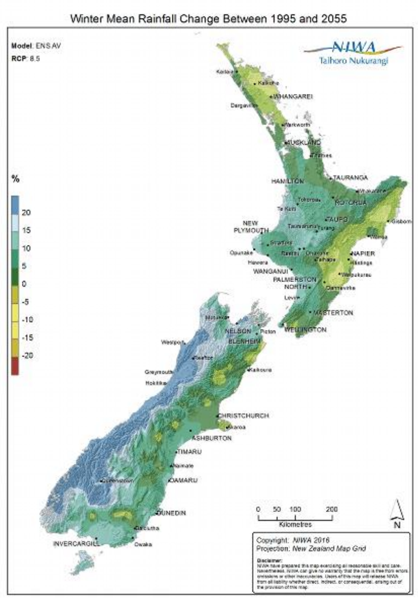
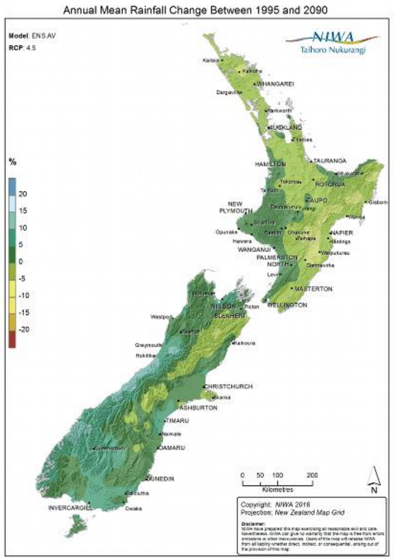
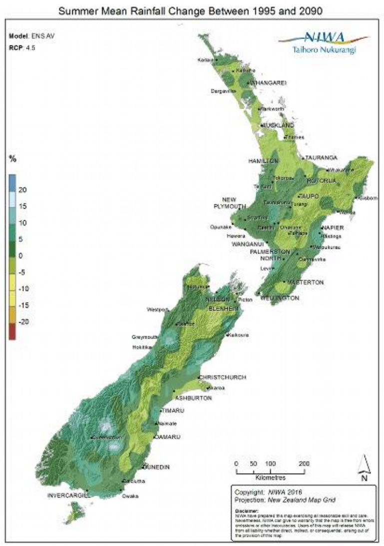
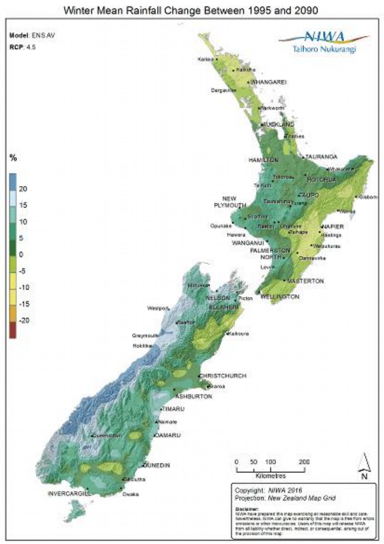


Figure 5. RPC climate projections for 2090.

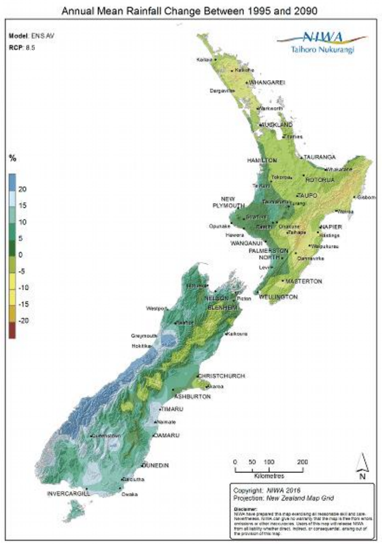


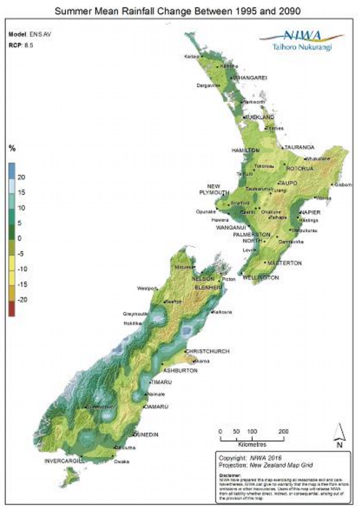


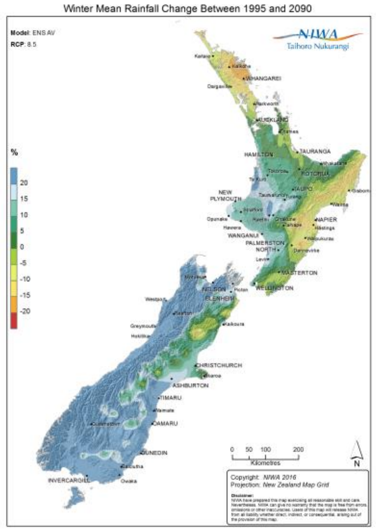


2090 RCP 4.5 Rainfall Scenarios (%) : Annual Summer Winter

2090 RCP 8.5 Rainfall Scenarios (%) : Annual Summer Winter







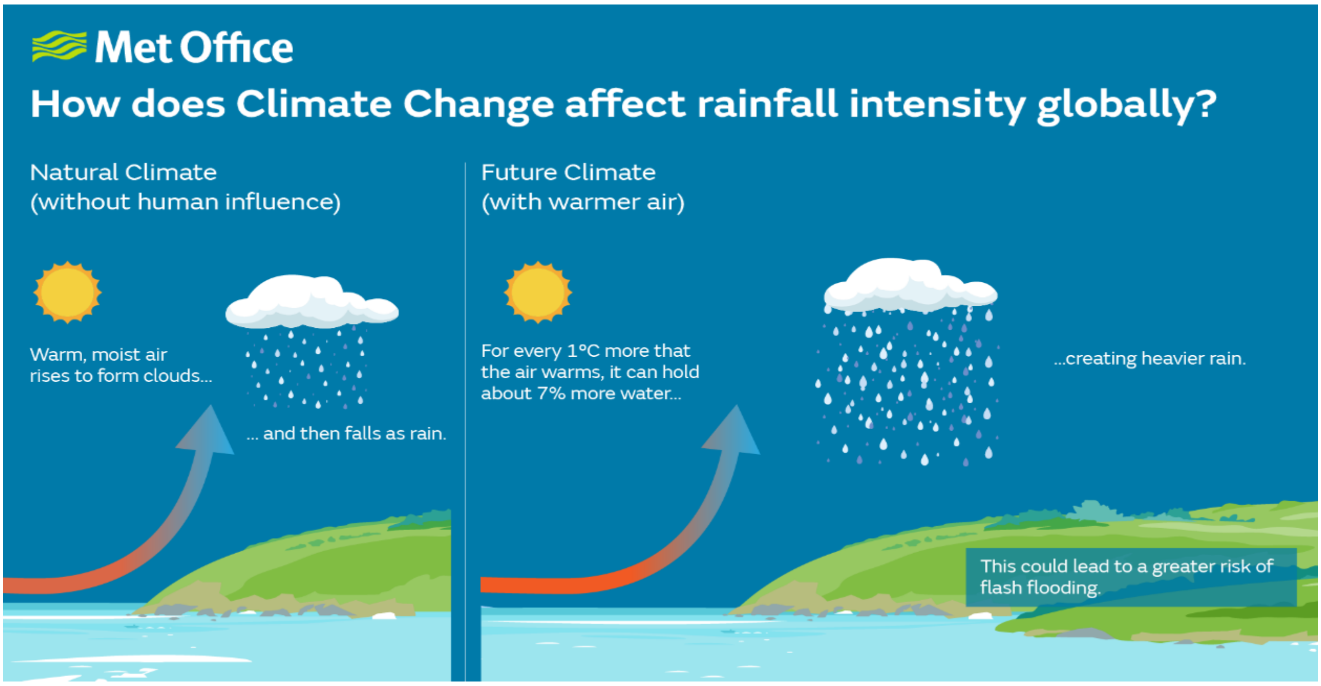


Figure 6. The effect of temperature increases on rainfall.