Changes in extreme climate events over New Zealand from the beginning to the end of the 21st century

S. Kremser[1], G.E. Bodeker[1], B. Lewis[1], N. Zeiher[1], A. Sood[2], J. Lewis[1], and D. Sawyer[1]
[1]Bodeker Scientific, Alexandra, New Zealand
[2]NIWA, Wellington, New Zealand

Motivation

- Changes in the strength and frequency of extreme weather events will significantly impact adaptation capacity in human society and ecosystems.
- Atmosphere-Ocean General Circulation Models (AOGCMs) are traditionally used to simulate current and future climate, but cannot provide high-resolution information on changes in extremes on regional scales due to their coarse spatial resolution. Dynamical downscaling is therefore required where AOGCM simulations provide the boundary conditions for higher-resolution Regional Climate Models (RCMs).
- RCM simulations can obtain their boundary conditions from any AOGCM simulation (which is turn takes as input a prescribed greenhouse gas (GHG) emissions scenario) to investigate changes in extreme events. However, as RCM simulations are computationally expensive, ensembles using different AOGCM boundary conditions and GHG emissions scenarios have few members and do not account for the full range of uncertainty.
- To quantify changes in extreme weather events, climate change projections for a wide range of possible future GHG emissions scenarios and for a range of climate models are required. An approach, based on pattern scaling (referred to as the 'Ensemble Approach'), is described below.

Temperature extremes for New Zealand

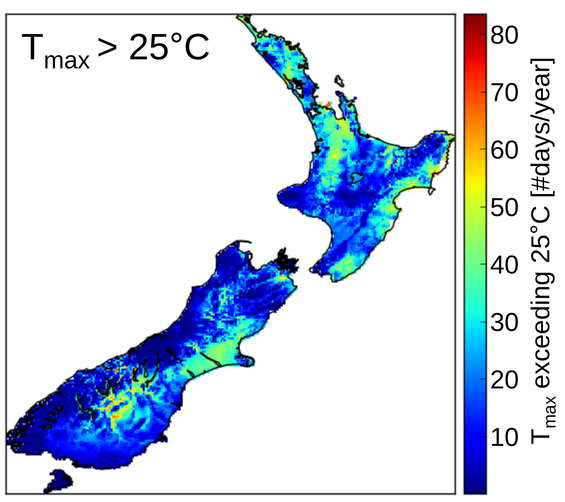


Figure 1: Number of days per year where the daily maximum temperature (T_{max}) exceeds 25°C for the period 2091 to 2100 under RCP 2.6.

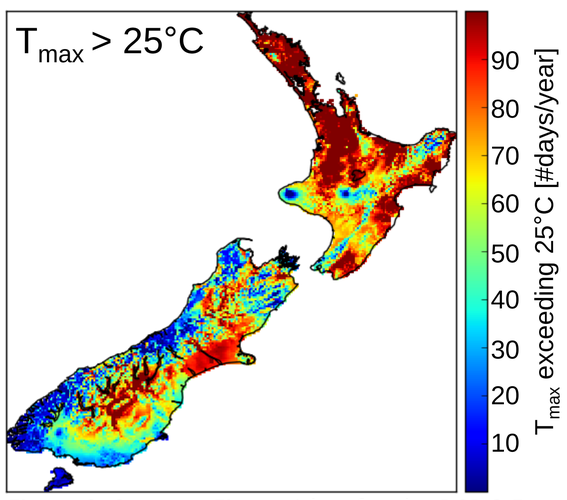


Figure 2: Same as Figure 1 but for the RCP 8.5 emissions scenario.

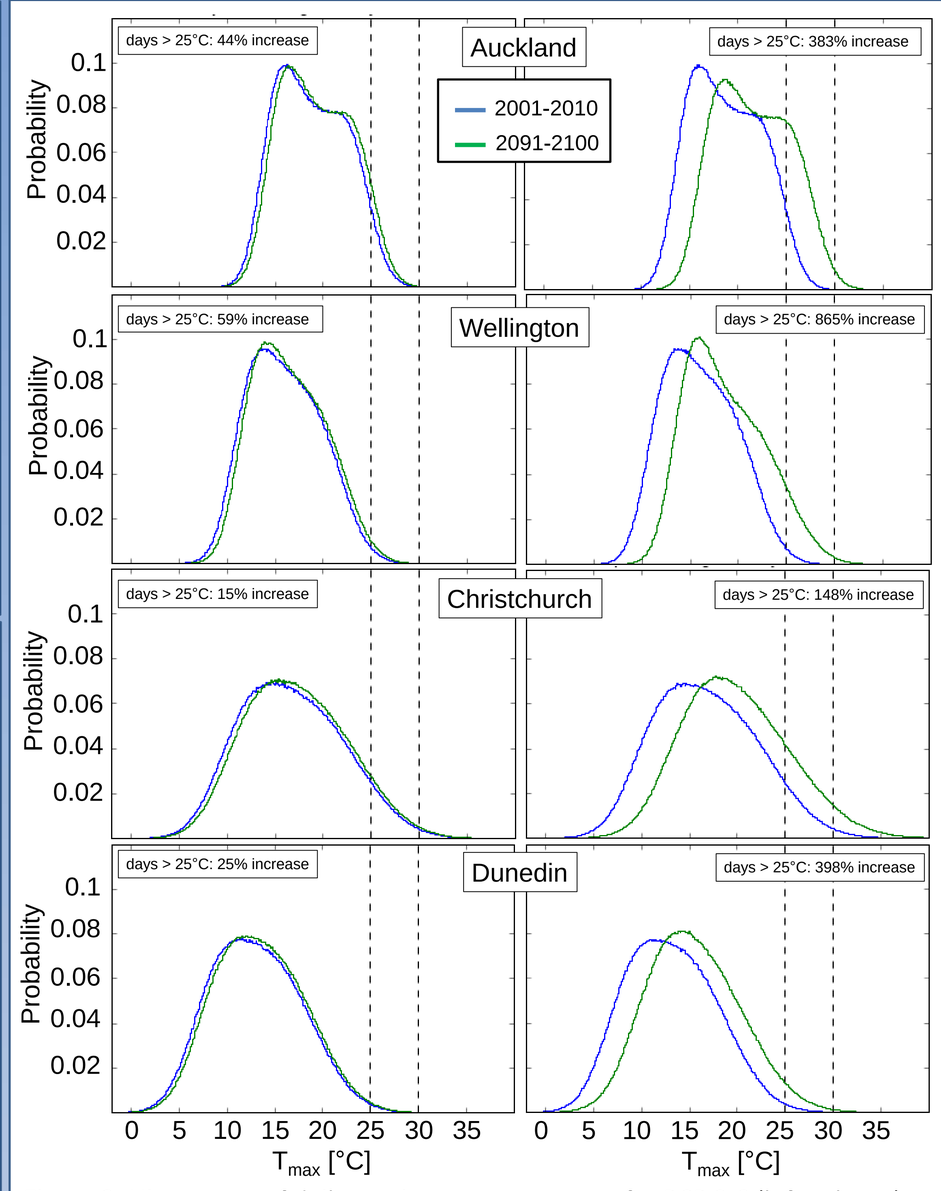


Figure 3: Histograms of daily maximum temperature for RCP 2.6 (left column) and RCP 8.5 (right column) scenarios for the four population centres. A T_{max} value exceeding the thresholds (dashed lines) is considered an extreme value.

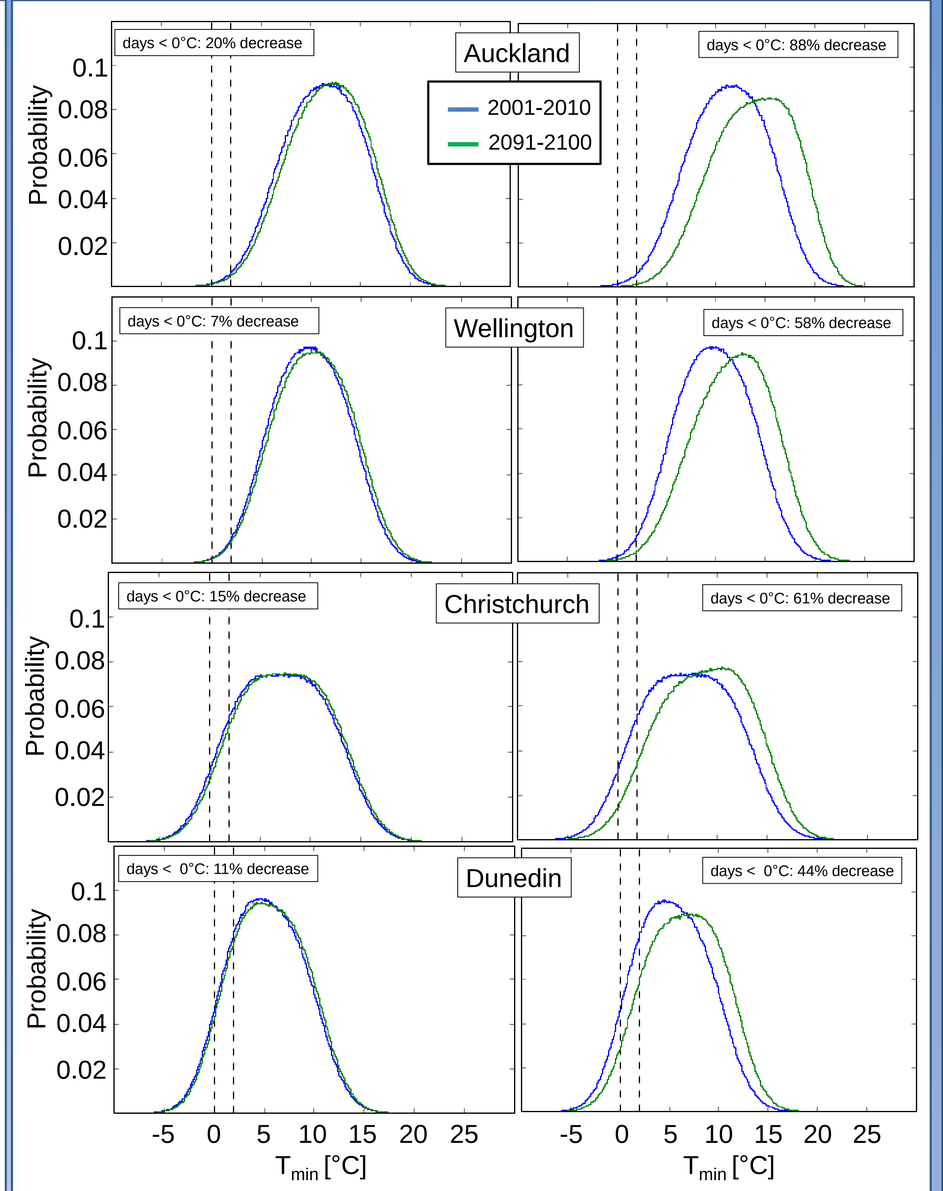
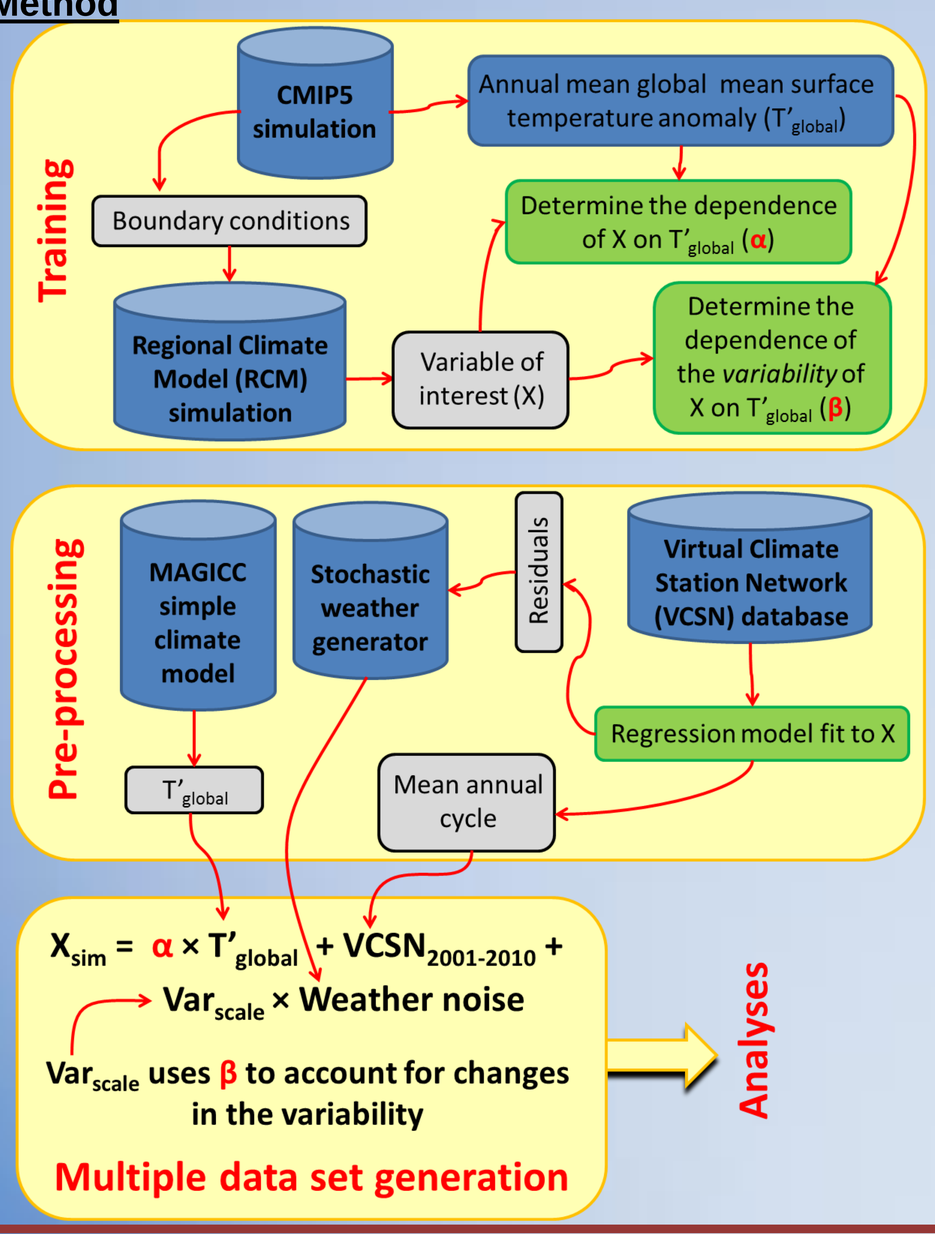


Figure 4: Histograms of daily minimum temperature for RCP 2.6 (left column) and RCP 8.5 (right column) scenario for the four population centres. A T_{min} value below the thresholds (dashed lines) is considered an extreme value.

Method



Results

- A newly developed approach, based on pattern scaling principles, has been applied to New Zealand to quantify changes in extreme weather events for a wide range of GHG emissions scenarios and a range of different model parameters. The probability density function used to detect extreme weather events therefore accounts for uncertainties in GHG emissions and uncertainties arising from the use of different climate models. Furthermore, any bias in the RCM simulations used in the training is corrected for.
- Unlike RCM simulations, this ensemble approach is not limited by the number of AOGCM simulations available and GHG emissions scenarios used in those simulations.
- Changes in weather extreme events are most pronounced under the RCP 8.5 emissions scenario. By the end of this century the North Island, Canterbury and parts of Central Otago will experience more than 90 days each year with T_{max} exceeding 25°C.
- Under RCP 8.5 the number of frost days (T_{min} < 0°C) will reduce by up to 88%, 58%, 61%, and 44% for Auckland, Wellington, Christchurch and Dunedin, respectively.
- Under RCP 8.5 the number of days with T_{max} > 25°C will increase by up to ~870% depending on location.

Outlook

- Derive extreme event statistics disaggregated by season.
- Looking a hot/cold spell lengths for the 4 main centres of New Zealand.
- Determine what fraction of extremes occurring within New Zealand is attributable to anthropogenic influence as described in Fischer and Knutti[1]

References:
[1] Fischer, E.M. and Knutti R., Anthropogenic contribution to global occurrence of heavy-precipitation and high extremes, Nature Climate Change, 5, 560-565, 2015.

Acknowledgements:
We would like to thank the CCII (Climate Change, Impact and Implication for New Zealand) programme for supporting this study.