

Climate Analysis of Temperature on the hottest day of the year

Horizons Region, New Zealand

Climate Change Projections from CCAM-Downscaled CMIP6 Simulations

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1 Executive Summary

Temperature on the hottest day of the year (TXx) is a crucial indicator of extreme heat, providing insight into climate extremes relevant for public health, agricultural productivity, infrastructure resilience, and ecosystems in the Horizons region. This synthesis integrates multi-model climate projections based on downscaled CMIP6 simulations using the CCAM model to characterise historical patterns and future changes in TXx for the baseline period (1986–2005) and three future periods: 2021–2040, 2041–2060, and 2080–2099, under four greenhouse gas (GHG) emissions scenarios (SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5).

Historical simulations show very high agreement among models, with TXx averaging near 27°C regionally, and spatial deviations generally within $\pm 1^\circ\text{C}$. This provides high confidence in the baseline pattern and means projected changes can be interpreted reliably. Projections under all scenarios indicate region-wide increases in TXx, with magnitude and confidence rising under higher GHG emissions and later time periods. By 2021–2040, regional mean increases over the 1986–2005 baseline are very likely in the range of $+1^\circ\text{C}$, with model agreement extremely high and minimal spatial divergence. By mid-century, projected increases strengthen to between $1.5\text{--}2.5^\circ\text{C}$ (scenario dependent), and by 2080–2099, the warming signal is larger still. Under SSP5-8.5, mean TXx increases could approach $+5^\circ\text{C}$, with maximum grid cell increases locally exceeding 6°C .

Model agreement is exceptionally strong for the sign of change (virtually certainty across all scenarios), but some uncertainty remains in precise magnitudes, particularly under more extreme emissions pathways and in complex topography. Ensemble analyses show that maximum model projections closely approximate the P95 (upper percentile) change, while minimum projections more poorly represent the P5 (lower percentile), especially where there is greater model spread.

These increases in annual extreme temperatures will elevate heat stress risk, challenge water resources, heighten wildfire potential, and stress infrastructure. The spatial pattern of increases is relatively uniform, but inland and elevated areas tend to warm more than coastal sites. Effective adaptation strategies—such as upgrading infrastructure for heat, strengthening public health systems, and adjusting agricultural practices—will be essential under all scenarios, with urgency increasing as emissions and warming rise. In all, the synthesized evidence provides extremely high confidence that the Horizons region faces a future of more intense extreme heat, the scale of which will be determined by global efforts to curb atmospheric GHG emissions.

2 Introduction

Temperature on the hottest day of the year (TXx) provides a key measure of extreme heat exposure, with direct implications for societal wellbeing, ecosystem resilience, and climate adaptation planning. This synthesis report aims to provide a clear, evidence-based understanding of TXx behaviour and change for the Horizons region, drawing on twelve detailed sub-reports (available on request from Bodeker Scientific) and the visual analysis of CCAM-downscaled CMIP6 projections.

The objectives of this synthesis are to:

1. Describe the historical spatial distribution of TXx across the Horizons region,
2. Assess projected future changes in TXx under a range of emission scenarios (SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5),
3. Examine the temporal evolution of TXx changes into near-, mid-, and late-century windows,
4. Evaluate model agreement to quantify robustness,
5. Identify sub-regions most vulnerable to amplified extreme heat, and
6. Characterise and interpret the uncertainties inherent to these projections.



TXx is particularly relevant for adaptation because peak temperatures can drive acute impacts: increased mortality and morbidity during heatwaves, stress on water infrastructure and energy supply, lost productivity, agricultural yield losses, and negative consequences for biodiversity. Even modest increases in TXx can raise the frequency and intensity of extreme heat events, amplifying their risks. As such, understanding the projected spatial and temporal behaviours of this variable is fundamental for risk assessment and proactive adaptation planning.

Projected increases in TXx mean that current infrastructure design criteria, which are often based on historical extremes, may become inadequate, requiring upgrades or new standards. Health systems must prepare for potentially more frequent heat-related emergencies, especially among vulnerable populations. Agricultural adaptation might include shifting sowing dates, crop varieties, and increased irrigation, recognising the longer and more severe heat events projected. Ecosystem management plans must anticipate changing stress thresholds for native species and altered fire regimes. Adaptation options include enhancing the thermal efficiency of buildings, increasing green spaces, ensuring ample water and electricity supply, and improving early warning and public health communication systems.

The synthesis uses a multi-model ensemble approach, enhancing the robustness of conclusions despite residual uncertainties from model differences, GHG emission pathways, and natural climate variability. Throughout, the focus is on scientific coherence and actionable insight for stakeholders and policymakers, providing a resource for informed adaptation planning in a warming climate.

3 Understanding Temperature on the Hottest Day of the Year

Temperature on the hottest day of the year (TXx) is defined as the annual maximum of daily maximum temperature (T_{max}) for each grid cell and year, measured in degrees Celsius ($^{\circ}\text{C}$). For each year, the highest recorded daily maximum temperature is identified from daily data. The annual maxima are then averaged over a baseline period (e.g., 1986–2005) to characterise the historical climatology, or over future periods when considering projections.

TXx is driven predominantly by synoptic-scale meteorological events that induce heatwaves, such as anticyclonic conditions, persistent clear skies, and strong solar radiation combined with subsiding warm air masses. In New Zealand, regional features such as foehn wind events, local topography, land-sea contrasts, and proximity to large water bodies or orographic influences also modulate TXx spatially and temporally. Trends and changes in TXx are influenced by several processes: elevated atmospheric GHG concentrations raise background temperatures and enhance the probability and intensity of heatwaves; changes in atmospheric circulation and frequency of blocking highs further modulate the highest extremes.

In climate models, TXx is calculated from the downscaled daily T_{max} fields, capturing both regional climate drivers and the effect of projected global warming. The magnitude of TXx responses can be amplified by soil moisture feedbacks, land use changes, or reduced evaporative cooling in a drier future. As such, TXx serves as an indicator of extreme temperature risk in a way that is more sensitive to climate change than average temperatures, and is a key reference metric for adaptation and risk assessment across multiple sectors.

4 Climate Modelling Framework

The projections synthesised in this report were generated using the Conformal Cubic Atmospheric Model (CCAM) by Earth Sciences New Zealand; ESNZ. We acknowledge ESNZ and thank them for making these simulations freely and easily available. CCAM is a regional climate model that dynamically downscales outputs from global climate models to produce higher-resolution climate projections over New Zealand. Papers describing the generation of these climate projections for New Zealand are available [here](#) and [here](#).



Regional climate modelling is necessary because global climate models typically operate at spatial resolutions that are too coarse to adequately represent New Zealand's complex topography. Mountains, coastlines, and local climatic gradients strongly influence regional climate and require higher spatial resolution to be represented realistically.

Six CMIP6 global climate models were used to drive the CCAM simulations:

1. **ACCESS-CM2** is the second-generation coupled climate model developed by the Australian research community through the Australian Community Climate and Earth System Simulator (ACCESS) project. It combines atmospheric, oceanic, sea-ice, and land-surface components and was developed jointly by the Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation (CSIRO). The model is widely used for climate projections in the Australia/New Zealand region, including studies of temperature, precipitation, and extreme events.
2. **AWI-CM-1-1-MR** is a coupled Earth system model developed by the Alfred Wegener Institute in Germany. One of its key strengths is in representing ocean and sea-ice processes. Its ocean component uses an unstructured mesh, allowing much finer spatial resolution in regions of interest such as the polar regions while retaining manageable computational costs elsewhere. The model is frequently used in studies of polar climate change and large-scale ocean circulation.
3. **CNRM-CM6-1** is developed by the Centre National de Recherches Météorologiques and Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique (CERFACS) in France. It includes interactive representations of the atmosphere, ocean, land surface, and sea ice, together with substantial improvements over earlier versions in cloud physics and surface processes. The model is widely used in both European and international climate assessments.
4. **EC-Earth3** is a European climate model developed by a consortium of research institutions from several countries, building on operational weather-forecasting systems from the European Centre for Medium-Range Weather Forecasts (ECMWF). It incorporates sophisticated atmosphere, ocean, land, and sea-ice components and is designed to support a broad range of climate applications, from seasonal forecasting to long-term climate projections. It performs particularly well in reproducing large-scale patterns of historical climate.
5. **GFDL-ESM4** is an Earth System Model developed by the Geophysical Fluid Dynamics Laboratory (GFDL), part of the US National Oceanic and Atmospheric Administration (NOAA). In addition to the physical climate system, it includes detailed representations of biogeochemical cycles, allowing interactions between climate, ecosystems, and atmospheric composition to be simulated. The model is widely used for studies of carbon cycling, ocean processes, and future climate change.
6. **NorESM2-MM** is the medium-resolution version of the second-generation Norwegian Earth System Model, developed by a consortium led by the Norwegian Climate Centre. It is based partly on components from the Community Earth System Model but incorporates substantial Norwegian developments, particularly in aerosol processes and ocean dynamics. The model is commonly used in research on high-latitude climate, atmospheric circulation, and climate feedbacks.

These six models cover a range of equilibrium climate sensitivities (ECSs; see Figure 1) and allow some sense of uncertainty associated with model structure and climate sensitivity to be quantified.

Four Shared Socioeconomic Pathway (SSP) emissions scenarios were considered:

1. **SSP1-2.6**: A low-emissions pathway consistent with strong global mitigation efforts and relatively limited future warming.
2. **SSP2-4.5**: An intermediate pathway representing moderate emissions reductions and moderate warming.
3. **SSP3-7.0**: A medium-to-high emissions pathway associated with substantial future warming.

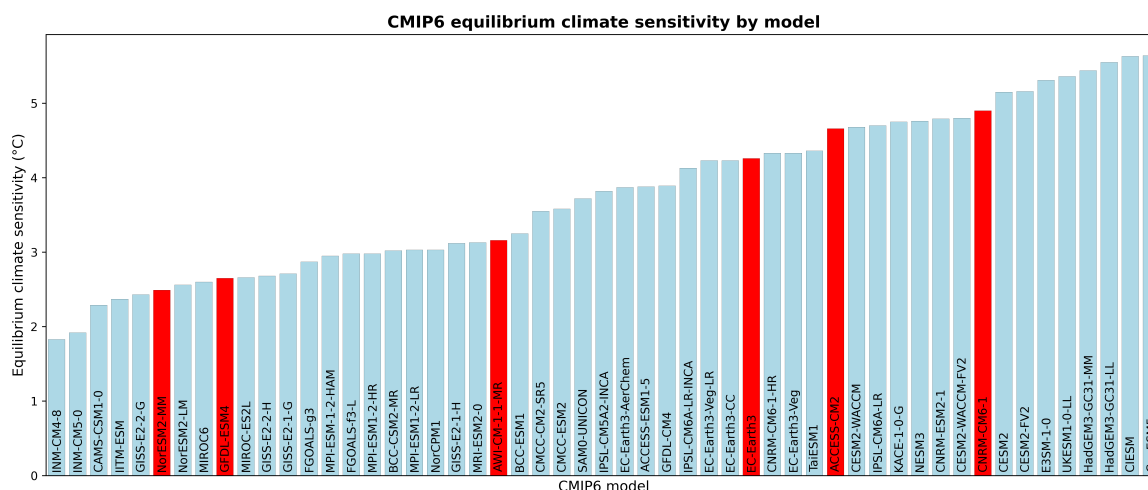


Figure 1: The location of the six guiding CMIP6 models across the full range of equilibrium climate sensitivities (ECSs) of all 53 CMIP6 models. The original of this figure can be downloaded [here](#).

4. **SSP5-8.5:** A high-emissions pathway characterised by continued growth in GHG emissions and large increases in global temperature.

Three future periods were examined:

1. 2021–2040 (near future)
2. 2041–2060 (mid-century)
3. 2080–2099 (late century)

All projections were evaluated relative to a baseline period of 1986–2005. Although the radiative forcing (the rate at which energy is being added to the climate system compared to the pre-industrial baseline) increases to 2.6 W m^{-2} under SSP1 by 2100, to 4.5 W m^{-2} under SSP2 by 2100, to 7.0 W m^{-2} under SSP3 by 2100, and to 8.5 W m^{-2} under SSP5 by 2100, one should not expect that there will always be a consistent (monotonic) increase or decrease for some climate variable from SSP1-2.6 to SSP2-4.5 to SSP3-7.0 to SSP5-8.5 since the pathways to that 2100 end point can be very different, and over the near-term to mid-century, natural variability can dominate the climate signal; often the climate signal only emerges later in the century. This is demonstrated in Figure 2. It is clear from this figure that both over the near-future and mid-century, the year-to-year variability (unforced climate variability), and inter-model spread, obscures any statistically significant separation of the projections under the four different SSPs.

The availability of a set of six ensemble members, rather than relying on a single simulation, is a key strength of the modelling framework used in this assessment. Ensemble approaches allow both the central tendency and uncertainty of projected changes to be assessed. That said, an ensemble of six models does not capture the potential full range of variability. By considering the ECS of each of these models in the context of the much wider range of 53 CMIP6 models (see Figure 1), a method was developed to generate a more complete picture of the potential uncertainty in projected changes. That method is discussed in the companion “overview” report to this TXx-specific report. Uncertainty probability density functions (PDFs) generated using this method appear in many of the plots shown herein.

5 Temperature On The Hottest Day Of The Year Climatology: 1986 to 2005

The CCAM simulated temperature on the hottest day of the year fields, averaged over the period 1986–2005, are shown in Figure 3. This variable is not seasonally disaggregated and so the fields shown in Figure 3 are representative of the whole year. Because the differences between these fields are not readily apparent, dif-

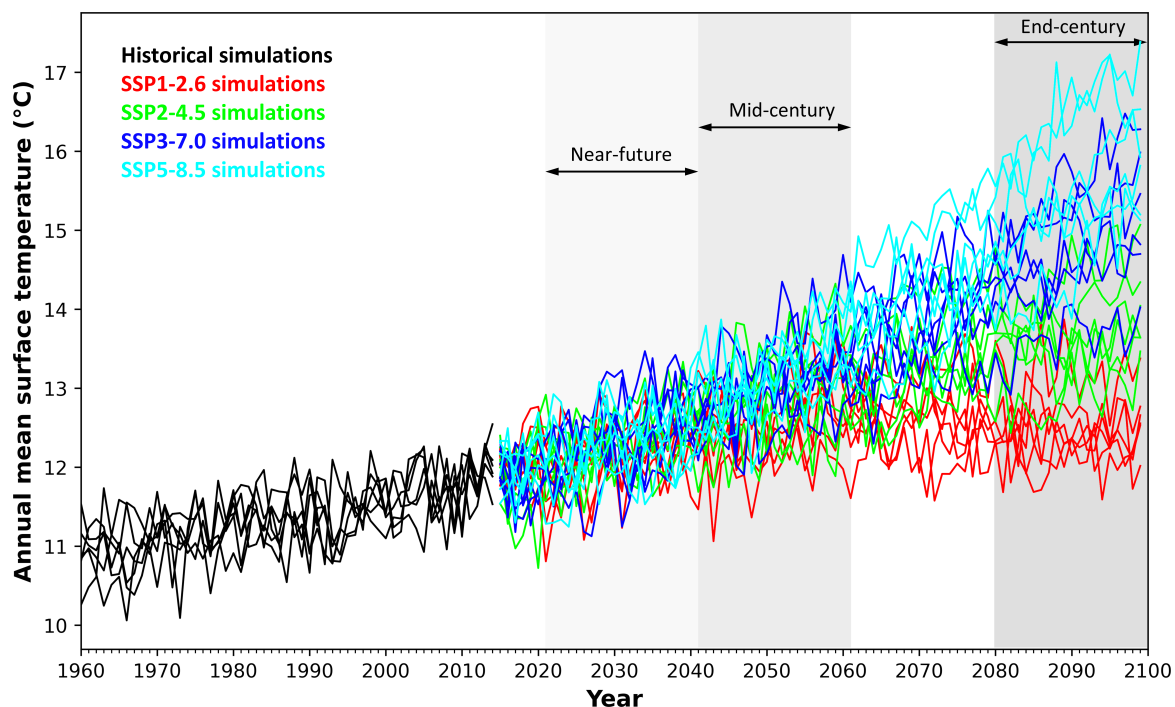


Figure 2: Annual mean temperature time series extracted from the six different model simulations, for the Horizons region, for the historical baseline (black traces) and for the four different SSP scenarios (SSP1-2.6 in red; SSP2-4.5 in green, SSP3-7.0 in blue and SSP5-8.5 in cyan). Also shown are the three different analysis periods that are considered below. The original of this figure can be downloaded [here](#).

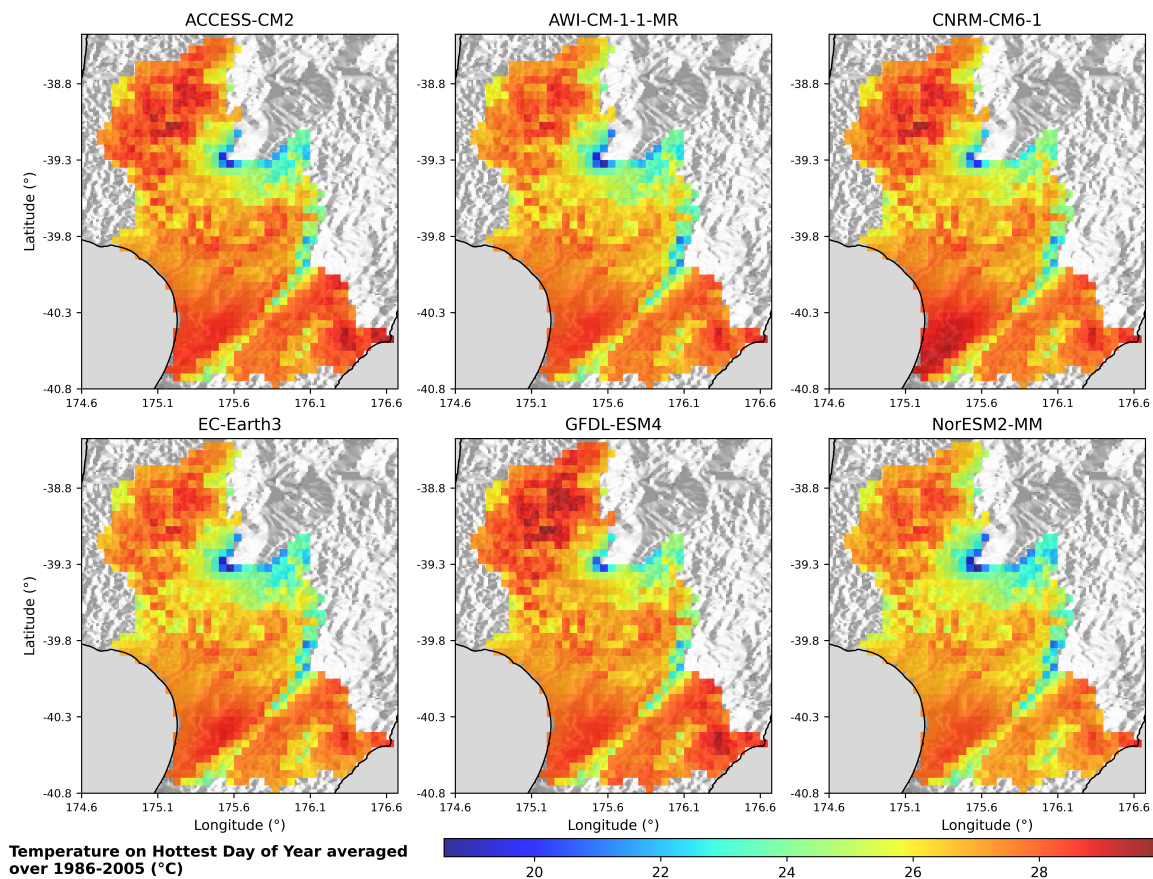


Figure 3: Temperature on the hottest day of the year fields as simulated by the CCAM model and averaged over the period 1986 to 2005. The original of this figure is available [here](#).



ferences between each field and the multi-model mean are shown in Figure 4.

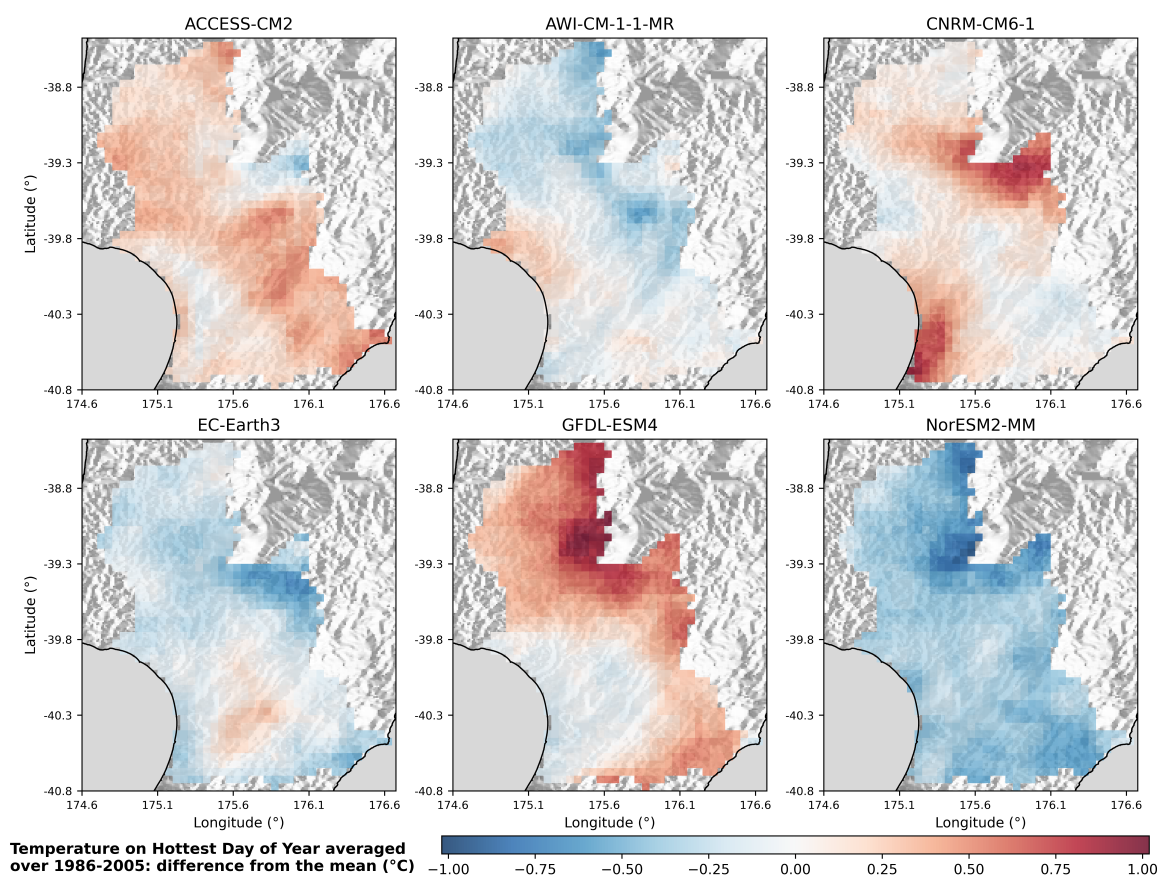


Figure 4: Differences from the multi-model mean. The original of this figure is available [here](#).

For the historical baseline period (1986–2005), the CCAM-downscaled model ensemble exhibits a coherent spatial pattern of TXx across the Horizons region. The multi-model mean TXx is near 27°C, indicating that annual extreme daily maximum temperatures are already significant climate features. The spatial variability is modest relative to the regional mean, highlighting the dominant influence of regional climate rather than small-scale heterogeneity.

Mapped fields from individual models show broad agreement: TXx values are consistently higher in inland and low-elevation western and northern regions, gradually giving way to cooler maxima approaching higher terrain in the east and along mountain ranges. Coastal moderation is evident, with the lowest TXx values nearer to the ocean and central highlands. The inter-model difference fields demonstrate that deviations from the multi-model mean are generally contained within $\pm 1^\circ\text{C}$, with regional excursions rarely exceeding this on either side. The spatial patterns of these deviations are weakly structured, with the model ensemble largely capturing consistent patterns in both spatial gradients and absolute values.

Statistical evaluation further confirms high model agreement for the TXx climatology. Spatial correlations (R^2) for the historical TXx fields typically exceed 0.91; in other words, the pattern and ranking of modelled TXx values match closely between models and the ensemble mean. Model biases for historical TXx are small compared to the magnitude of projected future changes, elevating confidence in using these simulations for change assessment. Regions of more pronounced model divergence are generally associated with topographic transitions or land-sea boundaries, but these local discrepancies do not undermine the overall model consensus.

The observed spatial pattern anchors confidence in future projections: the models agree in their simulation not only of the regional climate of extremes but also their most significant spatial patterns, suggesting that the ensuing changes in TXx due to global climate warming can be interpreted with robust scientific credibility for



the Horizons region.

6 Near-Future Projections (2021–2040)

For the near-future period (2021–2040), all model projections and scenarios assessed for the Horizons region point to a robust increase in TXx. The warming signal is evident across all SSP scenarios, with model ensemble means generally indicating an increase close to or slightly above 1°C when compared with the 1986–2005 baseline. This response is widespread, with every grid cell in the region exhibiting projected warming. Inter-model agreement is high, as reflected in the consistently positive changes and narrow spread in the ensemble means. The magnitude of projected change varies somewhat among scenarios and models, but all suggest higher future annual extreme temperatures.

The spatial structure of projected changes in TXx is relatively weak, with limited spatial patterning. While some models suggest slightly greater warming in eastern or inland sub-regions, these differences are modest. The models show only weak correspondence in fine-scale patterns (as indicated by low R^2 values), but this does not undermine the confidence in the overall regional warming signal. The range between minimum and maximum projections at the grid scale provides a realistic indication of ensemble uncertainty; regression diagnostics confirm that maxima closely proxy the 95th percentile outcomes, while minima supply an approximate lower bound, albeit with slightly lower reliability for the 5th percentile.

In summary, by the near-future period, it is very likely that the Horizons region will experience an increase in TXx of approximately 1°C or more compared to the 1986–2005 baseline, with rapid adaptation potentially required to manage the emerging risk of more frequent or severe annual temperature extremes. The strength and pervasiveness of the warming signal are extremely likely, with only minor uncertainty regarding local spatial heterogeneity.

6.1 SSP1-2.6: Extremely likely modest, region-wide TXx increases

The projected changes in temperature on the hottest day of the year from 1986–2005 to 2021–2040 under the SSP1-2.6 scenario, as simulated by the six different models, are shown in Figure 5. Under the low emissions pathway (SSP1-2.6), the Horizons region is projected to experience an extremely likely increase in TXx for the 2021–2040 period. All models in the ensemble agree on a warming signal, with mean increases clustering near 1°C. The model spread is low to moderate, with individual means ranging from 0.6°C to 1.4°C, and even minimum ensemble members indicating no significant risk of localised cooling (though it should be noted that some models show an occasional negative change, e.g., the AWI-CM-1-1-MR model shows a change of -0.064°C at 174.925°W, 39.825°S, which is why the colour bar in Figure 5 shows both positive and negative values). The standard deviation of the model means is under 0.3°C, which reinforces robust inter-model agreement concerning both the direction and general magnitude of change.

Spatial patterns show relatively uniform warming across the region, with subtle regional distinctions such as minor warming enhancements in the east and south, but without striking hotspots or outliers. Grid-point minima remain mostly positive, with no credible model-based evidence for grid cells experiencing cooling or loss of extreme warmth in the near term. Areas of complex topography exhibit slightly more variability among models but do not present a qualitative deviation from the overall warming trend. Regression analyses confirm that the model maximum provides a reliable approximation for the P95 field, with the minimum serving as a less consistent, but still useful, estimate for the P5 field.

Subregional projections echo these findings: all major subregions, from the coast to upland plateaux, show increases in mean TXx, with the largest absolute rises in areas such as Puketoi ki Tai and Tararua. This warming is projected with high confidence, supported by strong spatial and inter-model consistency. In summary, it is very likely that every part of the Horizons region will see a higher annual maximum daily temperatures in the

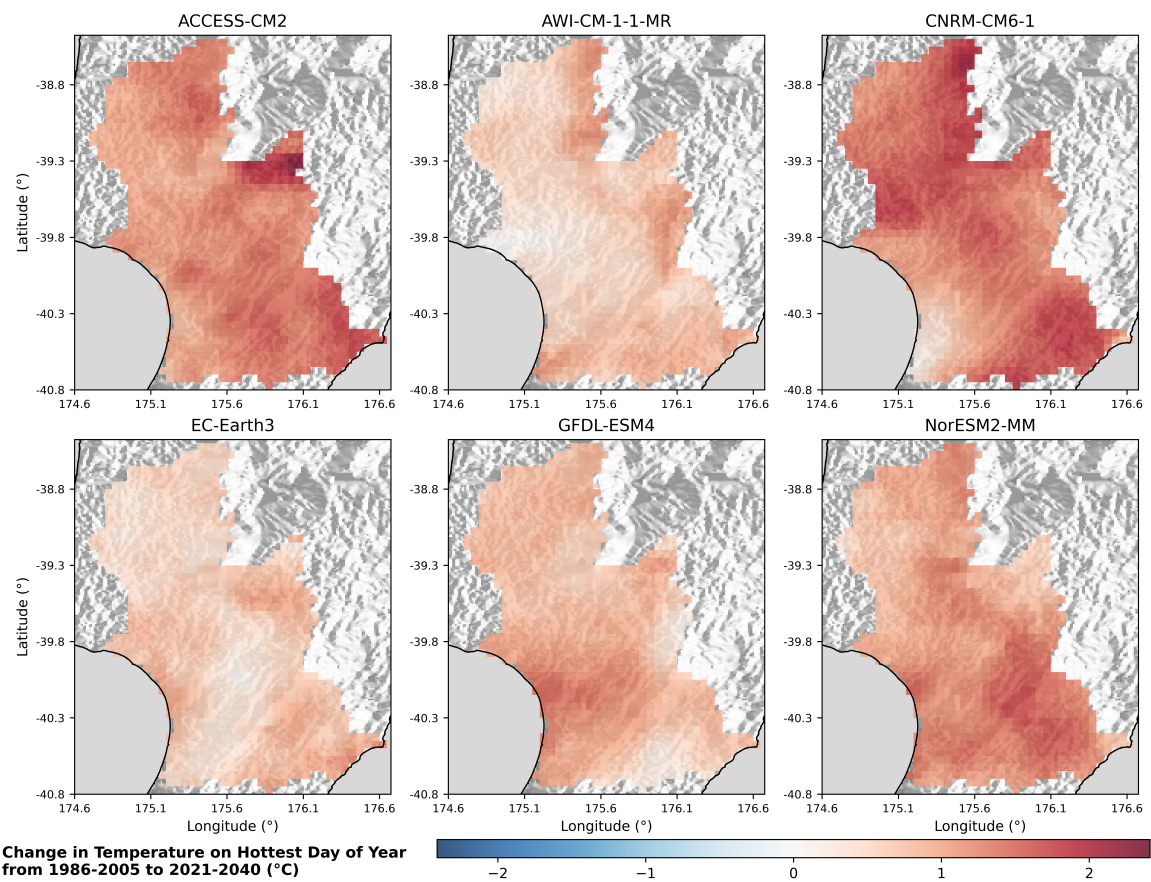


Figure 5: Projected changes in temperature on the hottest day of the year from 1986-2005 to 2021-2040 under the SSP1-2.6 scenario. The original of this figure is available [here](#).



near future, with little uncertainty in the direction of change and only moderate scenario- or model-driven uncertainty in precise magnitude.

6.2 SSP2-4.5: Extremely likely moderate, region-wide T_X increases

The projected changes in temperature on the hottest day of the year from 1986-2005 to 2021-2040 under the SSP2-4.5 scenario, as simulated by the six different models, are shown in Figure 6. For the intermediate

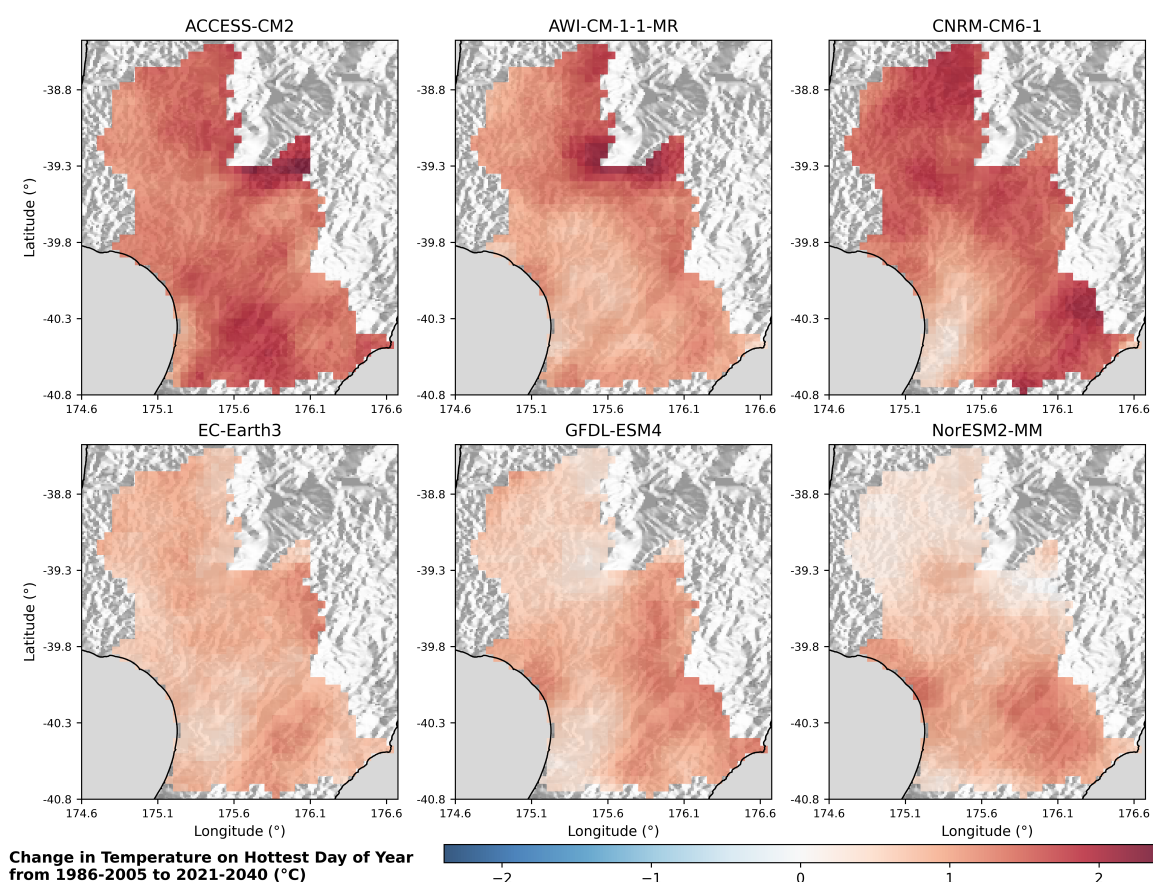


Figure 6: Projected changes in temperature on the hottest day of the year from 1986-2005 to 2021-2040 under the SSP2-4.5 scenario. The original of this figure is available [here](#).

emissions scenario (SSP2-4.5), projections for the period 2021–2040 show a robust and spatially uniform increase in T_X, typically just over 1°C above the historical baseline. Ensemble means range from about 0.7°C to 1.5°C, indicating only minor differences in magnitude between models. Spatial heterogeneity is weak; the warming signal is pervasive, without marked gradients between the eastern and western sub-regions, and no discernible elevation-driven pattern is evident in projected change.

All models agree that the direction of change is positive across the region: no model simulates cooling across any subregion. Minimal negative values may occur locally in grid cells for some models, but these are very rare and inconsequential in the overall regional pattern. The agreement in both the occurrence and strength of the warming is reflected in a tight model spread of mean increases and relatively low spatial standard deviations.

Uncertainties are modest, with regression diagnostics confirming that the maximum change across the ensemble robustly estimates the P95 value, while the minimum provides a reasonable but imperfect lower bound (5th percentile). This further strengthens confidence that the warming is not only likely, but extremely likely in every part of the Horizons region. Subregional variation is mostly restricted to slightly larger increases in central and upland areas and more moderate rises, but still strongly positive, near the coast.



As such, by the early 21st century, the Horizons region should expect very likely increases in annual maximum temperature, with the full model ensemble strongly supporting a future of hotter extreme days irrespective of moderate scenario or structural model divergence.

6.3 SSP3-7.0: Extremely likely moderate, region-wide TXx increases

The projected changes in temperature on the hottest day of the year from 1986-2005 to 2021-2040 under the SSP3-7.0 scenario, as simulated by the six different models, are shown in Figure 7. Under the SSP3-7.0 scenario

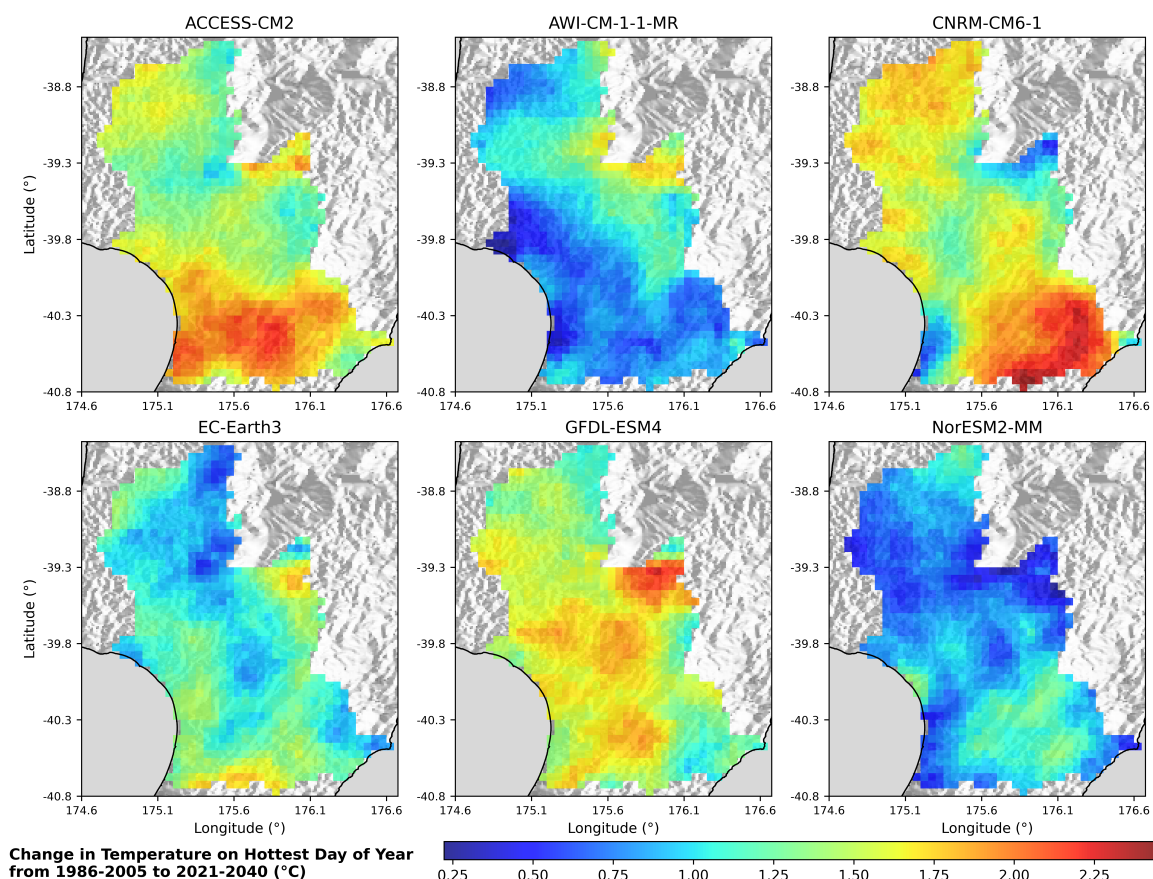


Figure 7: Projected changes in temperature on the hottest day of the year from 1986-2005 to 2021-2040 under the SSP3-7.0 scenario. The original of this figure is available [here](#).

substantial increases in TXx are also projected for 2021–2040. Regional warming is again pervasive, with mean model projections generally between 1.1°C and 1.4°C, and no models indicating cooling in any part of the Horizons region (note the change in the colour bar compared to Figure 6 resulting from none of the models generating an negative change values). The maximum projected warming in some local pockets reaches as high as 2°C, but even the grid points with the smallest increases remain above 0.2°C. This highlights the extremely likely nature of a universal warming trend, regardless of the model chosen.

Spatial variability is present where some models project stronger warming in lower valleys or toward the central and southeastern subregions, but these differences are subtle and do not significantly alter the core message of widespread, strong increases. The inter-model spread in means is small relative to the overall change, and the spatial R² values remain low, implying that most of the warming is regionally uniform.

Uncertainty analysis reveals that the model maximum remains a very reliable estimate for the 95th percentile, while the minimum agrees well with the 5th percentile, with regression slopes close to unity, particularly for the upper tail. Subregional analysis confirms that all constituent parts of the Horizons region will warm, with mean increases above 1°C and likely clustering around 1.2–1.4°C depending on local topography and proximity



to the coast.

Therefore, the SSP3-7.0 scenario also points to an extremely likely and regionally consistent increase in hottest-day annual temperatures, reinforcing that scenario choice, even in the near term, results primarily in differences of magnitude, not direction or spatial coverage of the warming signal.

6.4 SSP5-8.5: Extremely likely moderate, region-wide increases in TXx

The projected changes in temperature on the hottest day of the year from 1986-2005 to 2021-2040 under the SSP5-8.5 scenario, as simulated by the six different models, are shown in Figure 8. Projections under

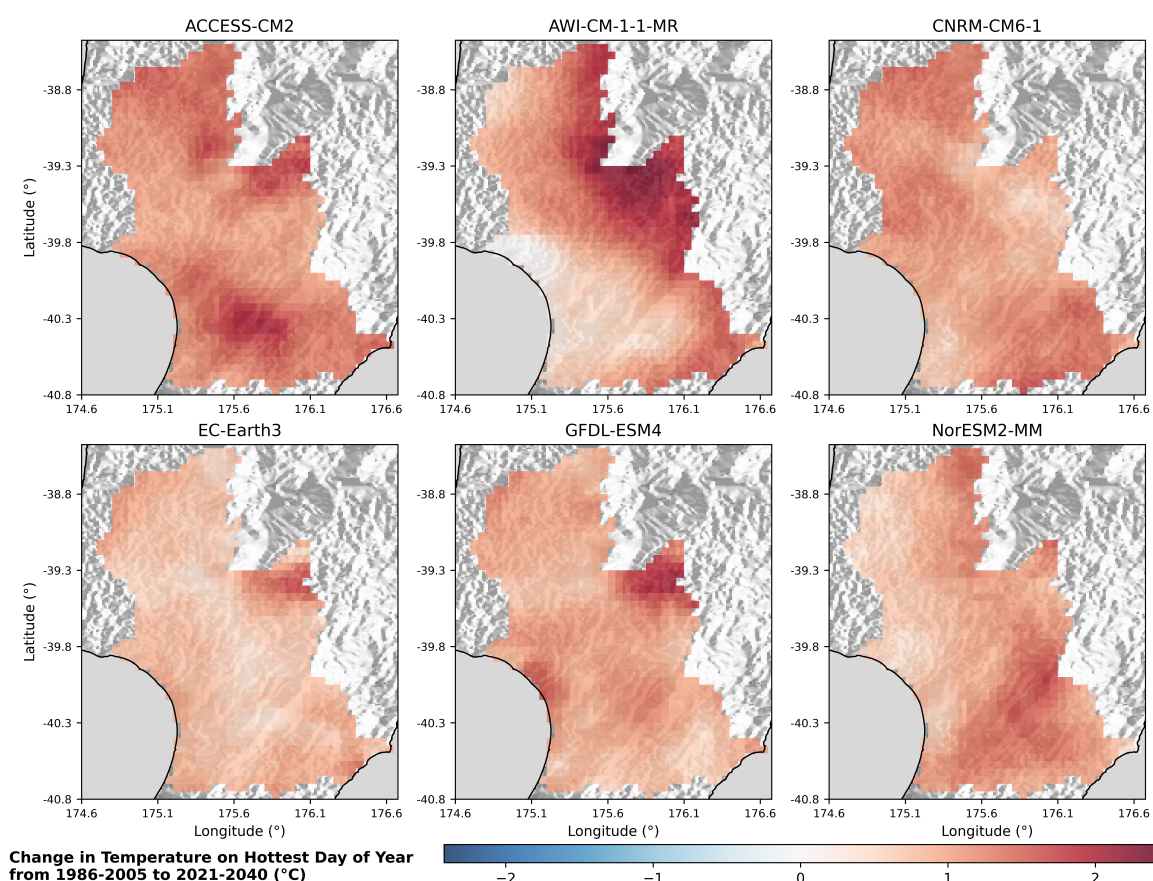


Figure 8: Projected changes in temperature on the hottest day of the year from 1986-2005 to 2021-2040 under the SSP5-8.5 scenario. The original of this figure is available [here](#).

the extreme emissions scenario (SSP5-8.5) for the 2021–2040 period indicate pervasive and robust increases in TXx throughout the Horizons region. Ensemble means cluster just above 1°C, ranging from about 0.8°C to 1.3°C, and all models universally indicate warming in every grid cell and subregion. Spatial patterning is subtle, without strong gradients between inland, upland, or coastal zones, and the low mean R^2 reflects this homogeneity; minor differences are present but are much smaller than the overall region-wide signal.

Inter-model spread is moderate (mean standard deviation of the means is about 0.3°C), but the direction of change is unequivocal: no individual model or grid point in the multi-model mean suggests cooling, and local maxima reach as high as 2°C in limited areas of some models. Regression analysis of uncertainty fields confirms that the model maximum closely approximates the 95th percentile of projected changes, with high confidence, while the minimum, although slightly under-representing the 5th percentile, still provides a generally reasonable lower bound for the envelope of future outcomes.

Sub-regionally, the strongest increases in TXx are projected for central, inland, and elevated zones (e.g., Upper



Rangitikei, Volcanic Plateau); increases of 1.1°C or more are expected. The smallest increases occur in coastal and lowland regions like Whanganui-Manawātū Lakes, where changes remain positive but slightly more modest (typically under 0.9°C). The pattern of adaptation needs will follow these gradients, with all subregions requiring planning for increased frequency and/or intensity of annual heat extremes. In summary, it is extremely likely that annual maximum temperatures will rise across the entire Horizons region in this timeframe, with only minor spatial differences and negligible scenario-related uncertainty in the direction of change.

6.5 Comparison Across Scenarios

Across all four SSP scenarios, the near-future period (2021–2040) is characterised by an extremely likely and spatially widespread increases in TXx across the Horizons region. The magnitude of the mean warming varies little between scenarios (generally about 1°C in all cases), although scenarios of higher GHG emissions exhibit marginally greater maxima and a slightly wider envelope of possible local changes. The signals across individual models are highly consistent regarding both the sign and the general size of regional mean changes, with differences between projections far smaller than their agreement on a warming trend. Uncertainty in spatial detail is present, reflected in low R^2 values, but does not materially affect confidence in the regional warming signal. Model maximum projections serve as reliable proxies for scenario-specific upper-end risks, while the minimum values provide plausible lower bounds, albeit less conservatively. In summary, regardless of emissions pathway, it is extremely likely that the Horizons region will see increased hottest-day temperatures within the coming decades, with only modest differences in magnitude among the four scenarios.

7 Mid-Century Projections (2041–2060)

During the mid-century period (2041–2060), projections indicate a further intensification of increases TXx across the Horizons region for all SSP scenarios. The increase in TXx is regionally extensive and, by this period, the magnitude of change is generally greater than in the near-future, with mean ensemble projections between about 1.5°C and 2°C depending on the scenario. All models continue to project only increases, not decreases, for every grid cell, consistent across both high- and low-emission scenarios, confirming the extremely likely nature of the warming signal.

The spatial structure in the projected changes remains subdued across the region. While some subregions, particularly the upland or inland areas, see slightly stronger warming, the overall warming remains relatively uniform, as indicated by low spatial R^2 values across all models. While inter-model variability increases compared to the near-future, mainly as a function of emissions uncertainty, model agreement on the sign and large-scale magnitude of change remains high. Uncertainty analyses demonstrate that the maximum model projections serve as reliable proxies for the 95th percentile of projected change fields, supporting robust interpretation of upper-end risks; minimum values are less reliable as lower bounds but are still generally positive everywhere.

The distinctions between emissions scenarios become more pronounced by mid-century, with the highest increases seen in the high-emissions SSP3-7.0 and SSP5-8.5 scenarios, and lowest in the mitigated pathway SSP1-2.6 scenario. Nevertheless, even under the most optimistic scenario, increases exceed 1°C virtually everywhere, highlighting the persistence of the climate change signal. At subregional scale, the pattern of larger increases inland and more moderate changes near the coast continues, although the magnitude of the differences remain modest relative to regional mean warming. In summary, the period 2041–2060 will be typified by widespread, very likely increases in TXx, demanding sustained adaptation and resilience-building throughout the Horizons region.



7.1 SSP1-2.6: Extremely likely moderate, region-wide TXx increases

The projected changes in temperature on the hottest day of the year from 1986-2005 to 2041-2060 under the SSP1-2.6 scenario, as simulated by the six different models, are shown in Figure 9. Under this scenario, the

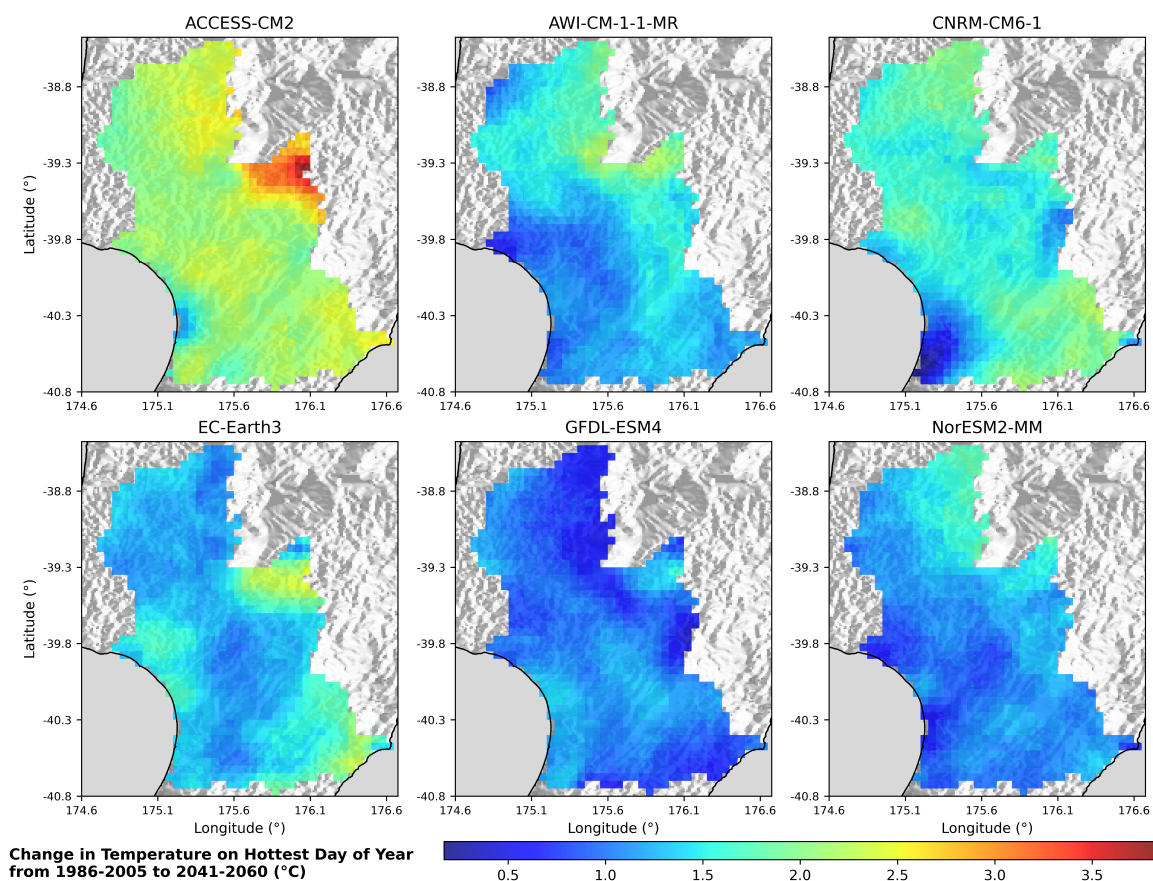


Figure 9: Projected changes in temperature on the hottest day of the year from 1986-2005 to 2041-2060 under the SSP1-2.6 scenario. The original of this figure is available [here](#).

Horizons region is projected to see a virtually certain increase in TXx by 2041–2060 relative to the 1986–2005 baseline. All models agree on increases, with ensemble means for the increase in TXx typically falling between 1.0°C and 2.2°C depending on the model and grid cell. The regional average is around 1.5°C. The minimum projected warming is positive in every grid cell and ensemble member, confirming the extremely likely nature of widespread warming irrespective of modest differences in model structure or detail.

Spatial variability across the region is limited; while there are hints of stronger warming in some eastern or inland subregions, these are not robust or strongly expressed. Model agreement is strongest at the regional scale, with low spatial standard deviations for both model means and subregional projections. The confidence in the sign of change is extremely high, and while there is some difference in magnitude, this is within a moderate range which is well below the size of the warming signal itself.

Uncertainty diagnostics indicate that the maximum model projection for any point is a good indicator of the P95 upper-end outcome, underscoring a reliable upper estimate for potential risk planning; the minimum model result fits the P5 lower bound more moderately. In summary, by mid-century, even in a low-emissions future, the Horizons region will experience a near-universal increase in the hottest day temperature, with a best estimate near 1.5°C and extremely high confidence in the sign and general size of change.



7.2 SSP2-4.5: Extremely likely moderate, region-wide increases in TXx

The projected changes in temperature on the hottest day of the year from 1986-2005 to 2041-2060 under the SSP2-4.5 scenario, as simulated by the six different models, are shown in Figure 10. Within the SSP2-4.5

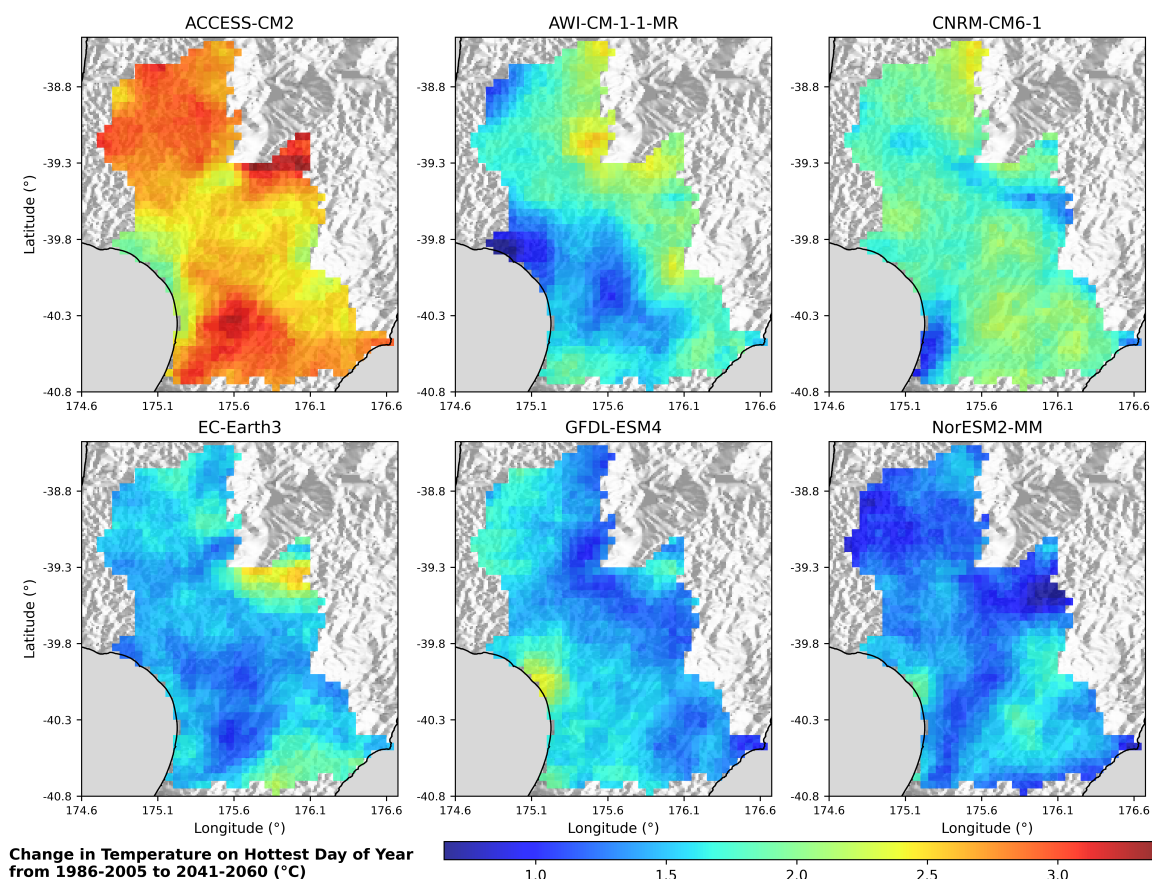


Figure 10: Projected changes in temperature on the hottest day of the year from 1986-2005 to 2041-2060 under the SSP2-4.5 scenario. The original of this figure is available [here](#).

pathway, projections indicate even stronger increases in TXx by 2041–2060. All ensemble members show a very likely increase, with mean projected changes clustering near 1.8°C across the region. The range among ensemble mean values is moderate (1.3°C to 2.7°C), but every model, grid cell, and subregion, projects an increase in TXx, signalling extremely likely area-wide increases in the hottest annual temperature.

The spatial distribution of change is relatively uniform, and the low intra-model standard deviation (around 0.24°C) reinforces that the bulk of the regional warming signal is not concentrated in specific hotspots or major spatial gradients. Subregional differences are subtle, with only minor elevation or inland-versus-coastal contrasts observable in projected mean values. The increase in TXx is robust, with high model agreement, and is consistent with patterns observed for other climate variables and global climate projections for New Zealand.

Uncertainty evaluation again endorses use of the model maximum as a practical approximation for the upper P95 outcome, while the minimum is a less precise, but still generally applicable, indicator for the P5 lower bound. Overall, projections point to extremely likely and spatially coherent increases in the hottest day temperatures throughout the Horizons region. Differences between scenarios grow more noticeable compared to the near-term, but the main message of widespread increases in extreme daily maximum temperatures remains incontrovertible.



7.3 SSP3-7.0: Extremely likely moderate, spatially pervasive TXx increases

The projected changes in temperature on the hottest day of the year from 1986-2005 to 2041-2060 under the SSP3-7.0 scenario, as simulated by the six different models, are shown in Figure 11. Mid-century projections

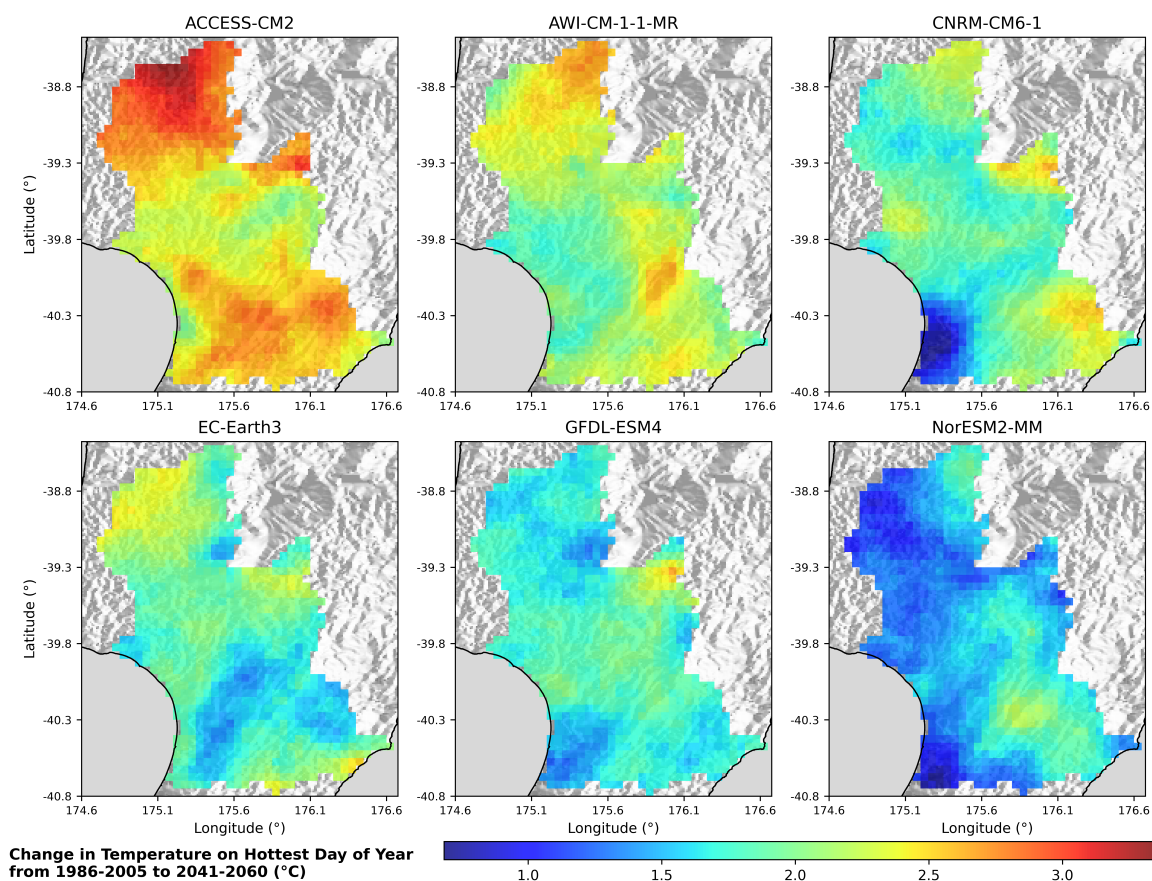


Figure 11: Projected changes in temperature on the hottest day of the year from 1986-2005 to 2041-2060 under the SSP3-7.0 scenario. The original of this figure is available [here](#).

under SSP3-7.0 show a very likely substantial increase in TXx across the Horizons region. The regional mean increase reaches close to 2°C, with all models and subregions showing only positive changes. The range of mean projected change by model is around 1°C, but at every grid point, all ensemble members project warming with no model simulating cooling anywhere.

Spatial patterns again indicate subtle distinctions, with slightly greater warming in certain eastern and central subregions, but the variation between highest and lowest increases within each model is modest compared to the inter-model range. The standard deviation of projected warming (about 0.26°C) further illustrates the moderate, but not overwhelming, uncertainty at local scales. The spatial R^2 remains quite low, highlighting that the principal signal is region-wide increase rather than sharp spatial differentials or focused hotspots.

Uncertainty diagnostics support very high confidence (slope nearly unity for model maximum versus P95) in the interpretation that the model range brackets the likely variation. Inter-model agreement is extremely high compared to the scale of possible outcomes, with all plausible projections falling into a band above 1°C increase in TXx. In summary, there is extremely high certainty of a region-wide, moderate-to-strong increase in TXx across the Horizons region by mid-century under this emissions pathway.



7.4 SSP5-8.5: Extremely likely strong, region-wide increases in TXx

The projected changes in temperature on the hottest day of the year from 1986-2005 to 2041-2060 under the SSP5-8.5 scenario, as simulated by the six different models, are shown in Figure 12. For the SSP5-8.5 high

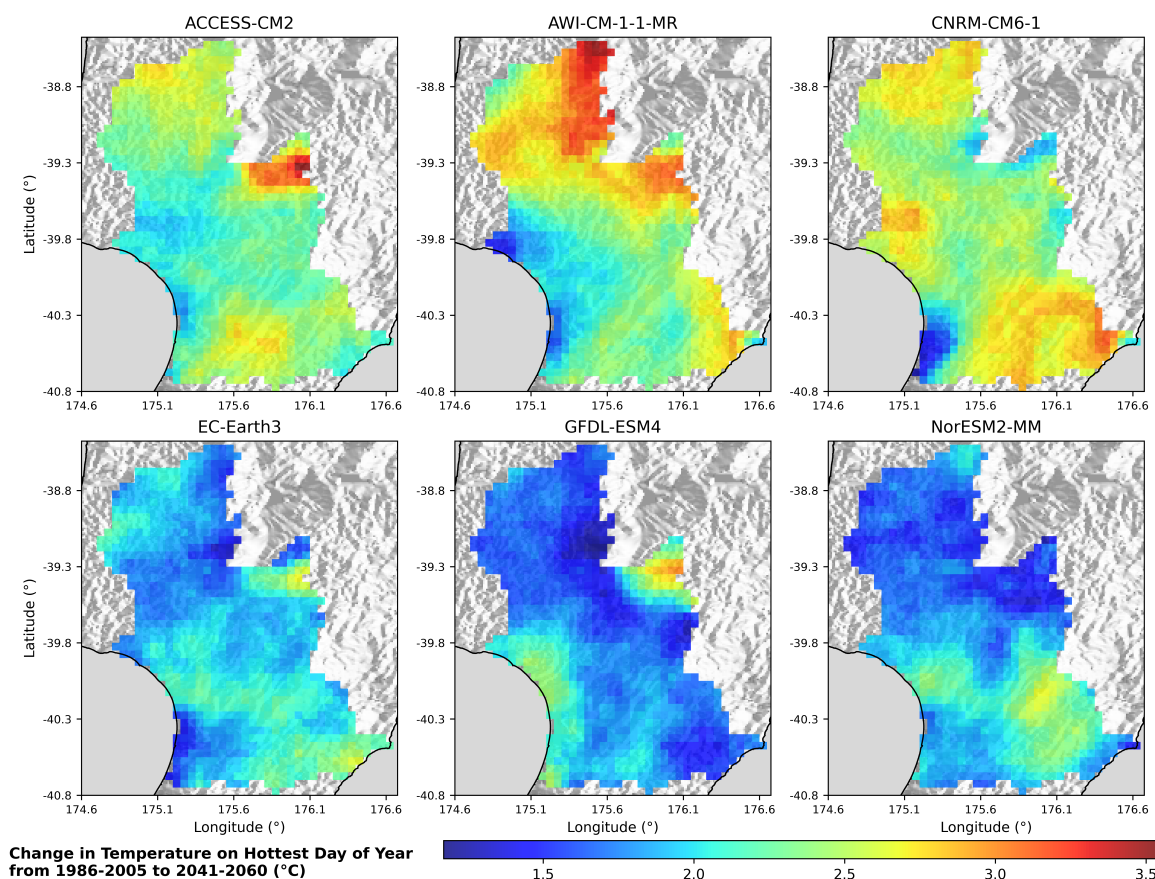


Figure 12: Projected changes in temperature on the hottest day of the year from 1986-2005 to 2041-2060 under the SSP5-8.5 scenario. The original of this figure is available [here](#).

emissions scenario, projections to 2041–2060 indicate a substantial and extremely likely increase in TXx for all of the Horizons region. The regional mean model increase is just over 2°C, with grid point and subregional means spanning a moderate range from about 1.8°C (minimum ensemble mean) to 2.5°C (maximum). All model combinations and spatial locations project only positive changes.

The spatial signature of change is homogenous, with only minor gradients; topographic or coastal influences yield small differences compared to the dominant regional warming. The mean intra-model standard deviation is below 0.3°C, and the low spatial R^2 indicates much of the change is a general uplift and not location-dependent. Grid point maxima can exceed 3°C in some ensemble members, meaning that while the majority of the region experiences moderate increases, some isolated areas may face stronger extremes. The signal is extremely robust: model agreement exceeds 99% probability and the likelihood of decreases in TXx, or non-significant changes, is exceptionally unlikely throughout the region.

Uncertainty summary analyses confirm that the maximum projection at each grid cell serves as a reliable, extremely likely proxy for the 95th percentile; the minimum is a credible, though less conservative, lower bound (with some underestimation of the true P5 at certain locations). Upper Rangitīkei, Tararua, and Volcanic Plateau continue to show slightly higher absolute changes, but even domains with the lowest projected warming (e.g., Whanganui-Manawātū Lakes) remain above 1.8°C. In summary, it is extremely likely that pronounced warming of extreme maximum temperatures will materialise across all contexts of the Horizons region by mid-century, with high regional uniformity and moderate, rather than major, scenario-driven uncertainty.



7.5 Comparison Across Scenarios

In the mid-century period, all four SSP scenarios project a widespread and extremely likely increase TXx across the Horizons region. The magnitude of the changes diverges further between scenarios compared to the near-term, with SSP1-2.6 yielding the lowest ensemble means ($\sim 1.5^{\circ}\text{C}$), while SSP3-7.0 and SSP5-8.5 produce larger regional increases (generally 2°C or more). Despite these quantitative differences, all scenarios and models demonstrate unanimity on the sign of change; no model or location projects decreases in TXx. Spatial patterns remain weak, with only minor local variability in projected increases, and model maxima serving as reliable proxies for high-end risks throughout. Model agreement remains extremely high on the occurrence and regional uniformity of warming, even as uncertainty regarding precise local magnitudes and the envelope of upper extremes grows. In summary, regardless of emissions pathway, the mid-century period will witness a marked, spatially pervasive increases in TXx, highlighting the need for sustained regional adaptation and planning for extreme temperature events.

8 Late-Century Projections (2080–2090)

By the end of the century (2080–2099), the temperature on the hottest day of the year is projected to increase substantially and nearly uniformly throughout the Horizons region, regardless of scenario. The magnitude of region-wide mean increases in TXx becomes more strongly differentiated by emissions pathway: under SSP1-2.6, increases are typically $1.2\text{--}1.5^{\circ}\text{C}$; for SSP2-4.5, about 2.5°C ; SSP3-7.0, about 4°C ; and SSP5-8.5, near 5°C . This scenario-driven divergence is the dominant feature of the late-century projections, while the spatial pattern within the region remains surprisingly homogenous, major spatial gradients are absent, with maximum hot spot and minimum cool spot changes closely clustering around the scenario-dependent mean.

All models, scenarios, and grid cells point to only increases in TXx, with ensemble minimum values remaining well above zero and maxima reaching $6\text{--}8^{\circ}\text{C}$ in the highest emissions scenarios. The inter-model spread grows modestly, but the robust agreement on sign (increases everywhere), order of magnitude, and spatial coverage persists. High-end model projections (95th percentile) can be confidently determined from the model maxima, serving for risk identification in adaptation planning; model minima systematically under-represent the 5th percentile and should be interpreted with greater caution as true lower-bound estimates.

Subregional differences persist, with slightly greater warming simulated inland and in the northern or high altitude regions (e.g., NorthernZone-Taumarunui, Volcanic Plateau), and more moderate increases near the coast (e.g., Whanganui-Manawatū Lakes, Horowhenua). These differences are minor compared to the total magnitude of change governed by scenario choice. The overwhelming message is that, regardless of spatial or model differences, the Horizons region will see a pronounced, spatially coherent increase in annual extreme maximum temperatures by 2080–2099, with the risk and severity of heat extremes being fundamentally governed by global emissions outcomes.

8.1 SSP1-2.6: Extremely likely modest, region-wide increases in TXx

The projected changes in temperature on the hottest day of the year from 1986–2005 to 2080–2099 under the SSP1-2.6 scenario, as simulated by the six different models, are shown in Figure 13. Under this scenario, projections for 2080–2099 show a very likely and regionally uniform increase in TXx across the Horizons region. All models project increased TXx, with mean warming around 1.3°C and ensemble member ranges extending from approximately 0.8°C to 1.9°C . Maximum local increases can approach 3.5°C in highly responsive models or subregions, but the more typical model–ensemble maxima are below 2°C for most of the region. The spatial pattern is muted, with weak gradients—regional increases are nearly uniform, and subregional differences are minimal compared to the overall scale of the warming.

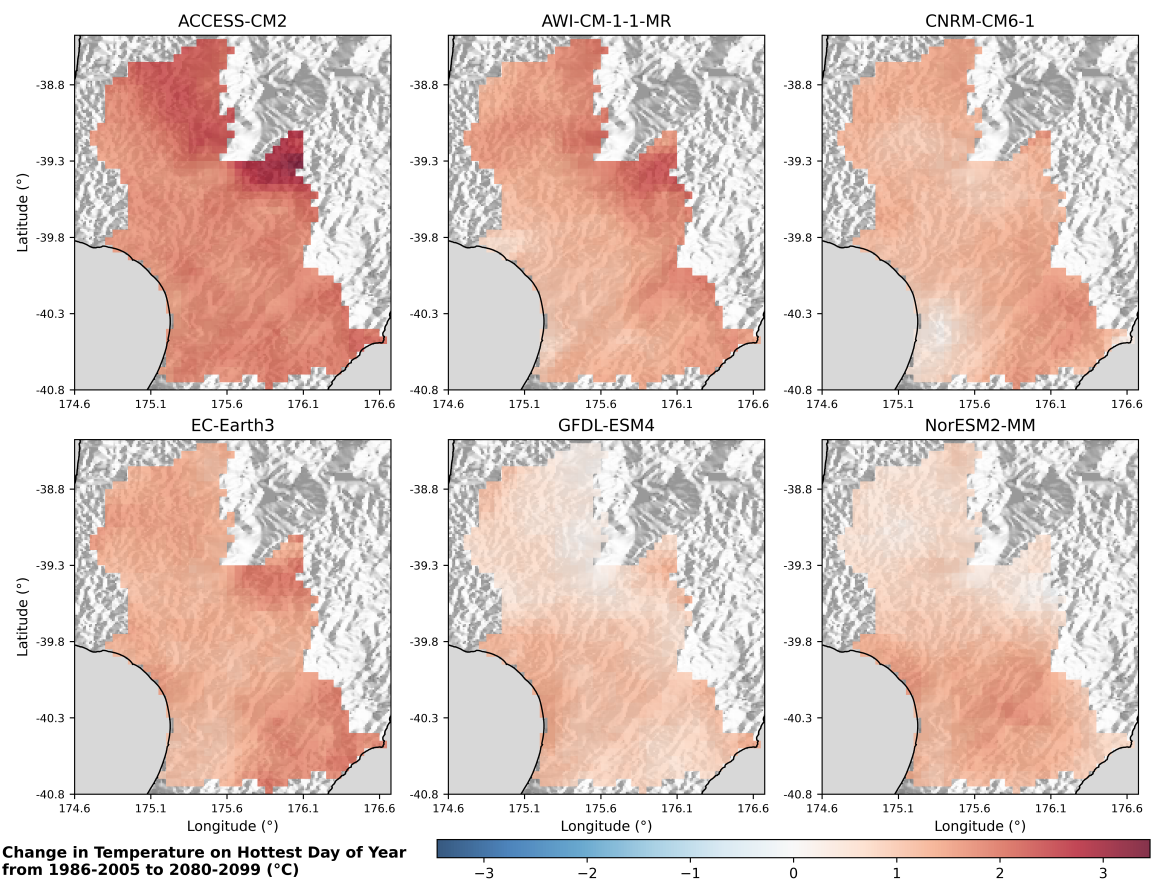


Figure 13: Projected changes in temperature on the hottest day of the year from 1986-2005 to 2080-2099 under the SSP1-2.6 scenario. The original of this figure is available [here](#).



High confidence attaches to these projections due to the universal sign of change, the robust ensemble mean, and the high correlation (R^2 near 0.88) between model maxima and the P95 field (for upper-end risk proxying) as well as the strong positive correspondence of minima and P5, albeit with some tendency for minima to slightly under-represent true lower bounds in a small number of cells. Subregionally, hottest-day temperatures increase everywhere: inland and southeast areas (e.g., Taranaki, Puketoi ki Tai) experience the largest mean changes, while coastal and lake-adjacent subregions (e.g., Horowhenua, Whanganui-Manawātū Lakes) manifest slightly lower, yet still strongly positive, increases.

In summary, it is extremely likely that the Horizons region will experience a modest but regionally consistent increase in TXx under SSP1-2.6 by the end of the century, with differences between grid points and subregions negligible compared with the dominant global warming signal.

8.2 SSP2-4.5: Extremely likely strong, region-wide TXx increases

The projected changes in temperature on the hottest day of the year from 1986-2005 to 2080-2099 under the SSP2-4.5 scenario, as simulated by the six different models, are shown in Figure 14. Projections this scenario

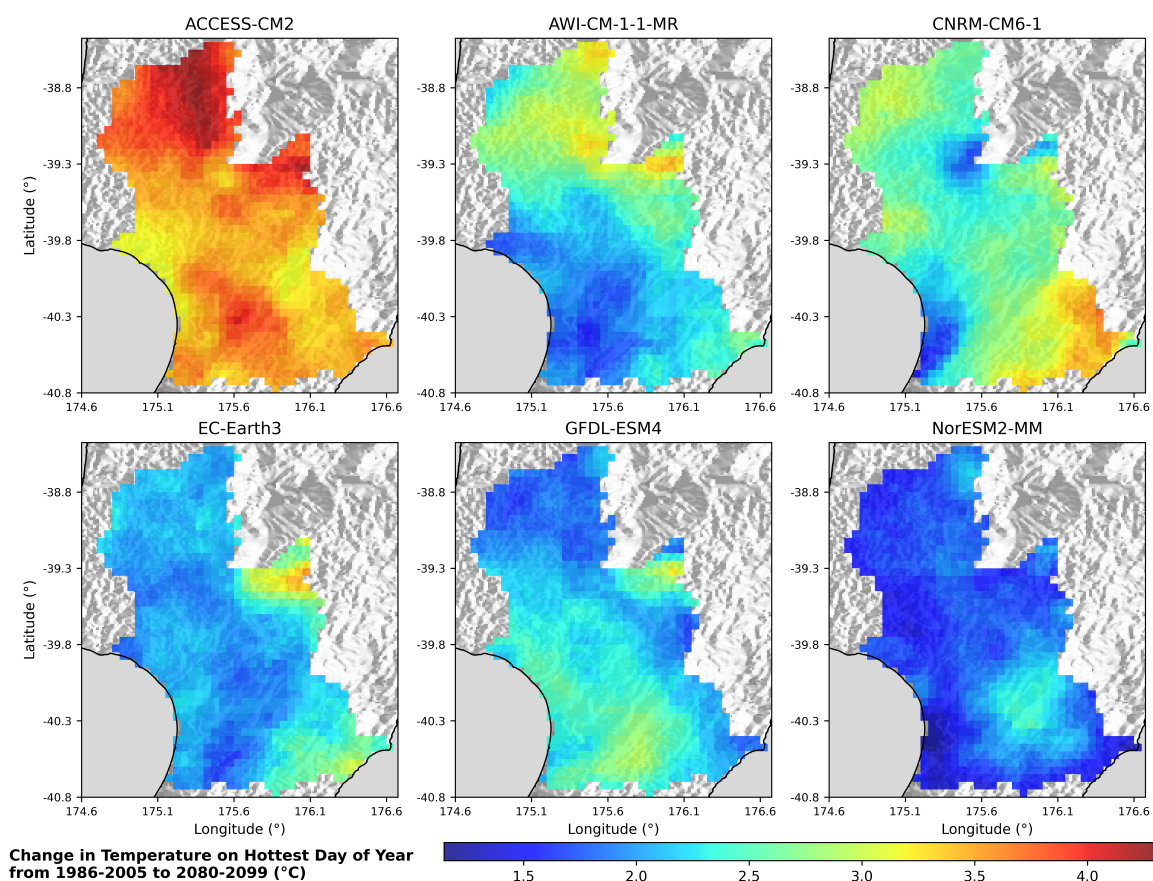


Figure 14: Projected changes in temperature on the hottest day of the year from 1986-2005 to 2080-2099 under the SSP2-4.5 scenario. The original of this figure is available [here](#).

show a robust and spatially pervasive increase in TXx for the Horizons region by 2080–2099. The mean increase in TXx across all models is about 2.5°C, with the model means spanning 1.8°C to over 3.6°C, and the maximum projected increases locally exceeding 4°C in some models. All grid cells and subregions indicate positive change, reinforcing the extremely likely nature of the regional signal. The inter-model spread (ensemble mean standard deviation below 0.6°C) is moderate but does not challenge the overall consensus on direction or order of magnitude of change.

The spatial pattern is again close to uniform, with no pronounced subregional gradients; mean intra-model



spatial variability is substantially less than the aggregate regional warming. Areas with the largest changes include Puketoi ki Tai, Upper Rangitikei, and Tararua (means up to 2.6°C or more), while the smallest projected increases are found in Whanganui-Manawātū Lakes and Horowhenua (mean increases just above 2°C). Regression diagnostics show the maxima are likely to provide a credible P95 proxy, while minima serve as plausible, though not perfect, P5 lower bounds.

In summary, late-century TXx increases in the Horizons region, under the intermediate SSP2-4.5 scenario, are very likely to be substantial, spatially coherent, and nearly universal, with only minor local differences weakly influencing the overwhelmingly strong warming signal.

8.3 SSP3-7.0: Very likely significant, spatially wide-spread increases in TXx

The projected changes in temperature on the hottest day of the year from 1986-2005 to 2080-2099 under the SSP3-7.0 scenario, as simulated by the six different models, are shown in Figure 15. For the SSP3-7.0

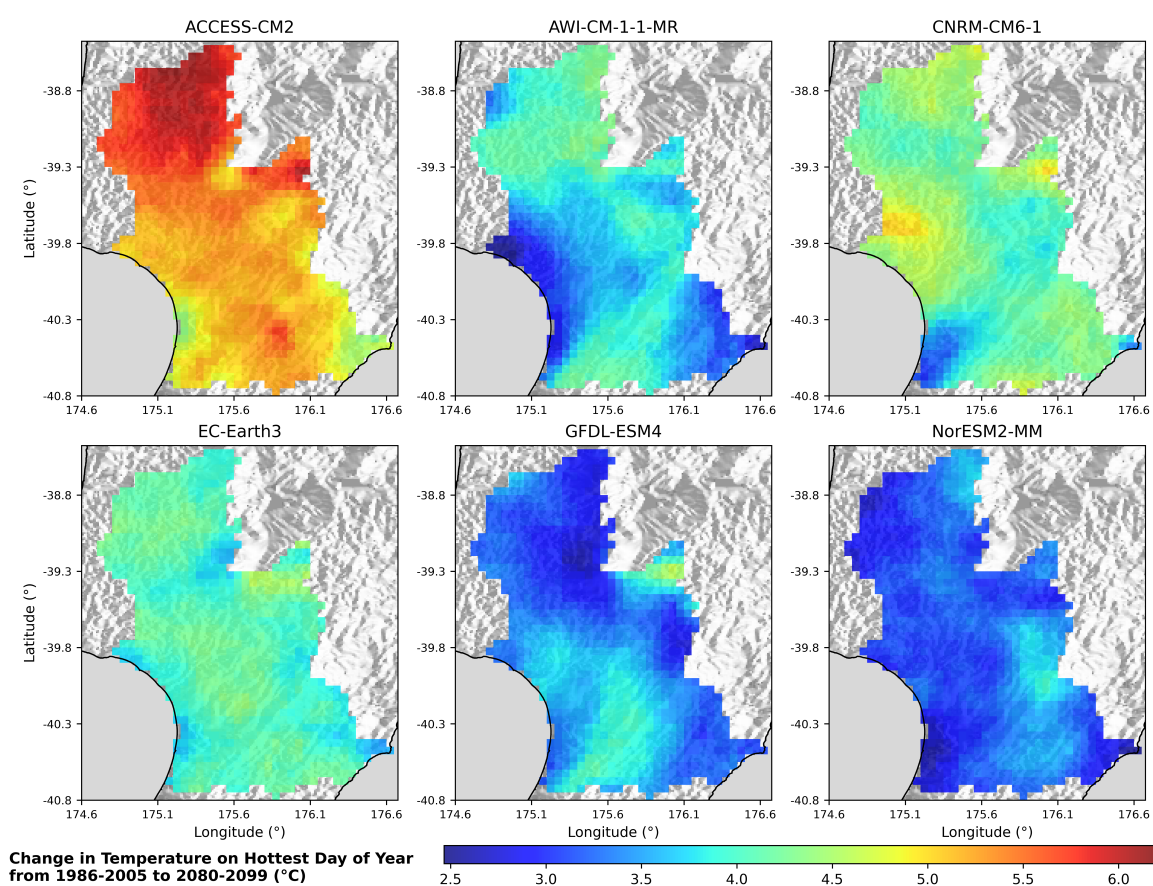


Figure 15: Projected changes in temperature on the hottest day of the year from 1986-2005 to 2080-2099 under the SSP3-7.0 scenario. The original of this figure is available [here](#).

scenario, TXx increases become substantial and even more spatially uniform across the Horizons region by 2080–2099. Ensemble mean projected warming is about 4°C, with individual model means ranging between 3.2°C and 5.3°C. The difference between highest and lowest changes within any model or subregion is minor compared to the dominant scenario-driven warming; maxima exceed 5°C or even approach 8°C locally in the most responsive models, and all grid cells display only positive changes. The spatial R^2 is very low, indicating a near-universal distribution of warming and the absence of sharp local gradients.

Inter-model agreement is robust, with ensemble standard deviation much less than the mean change and high confidence (IPCC: very likely, >90% probability) in both the direction and general scale of increases in TXx. The minimum modelled change in TXx is above 3°C even in cool spots, and maxima define the upper end



(95th percentile) very reliably. Subregional differences remain secondary with the largest projected changes persisting in inland and elevated subregions (NorthernZone-Taumarunui, Upper Rangitikei, Volcanic Plateau), while coastal and southern regions experience slightly smaller, but still prominent, increases.

In summary, by the end of the 21st century, SSP3-7.0 signals a region-wide shift to higher annual temperature extremes, with mean TXx increases near 4°C and only minor nuance in spatial patterning within the Horizons region. These findings carry extremely high confidence and reflect a very likely future of widespread extreme heat if high emissions continue.

8.4 SSP5-8.5: Virtually certain large, spatially uniform TXx increases

The projected changes in temperature on the hottest day of the year from 1986-2005 to 2080-2099 under the SSP5-8.5 scenario, as simulated by the six different models, are shown in Figure 16. Under this scenario,

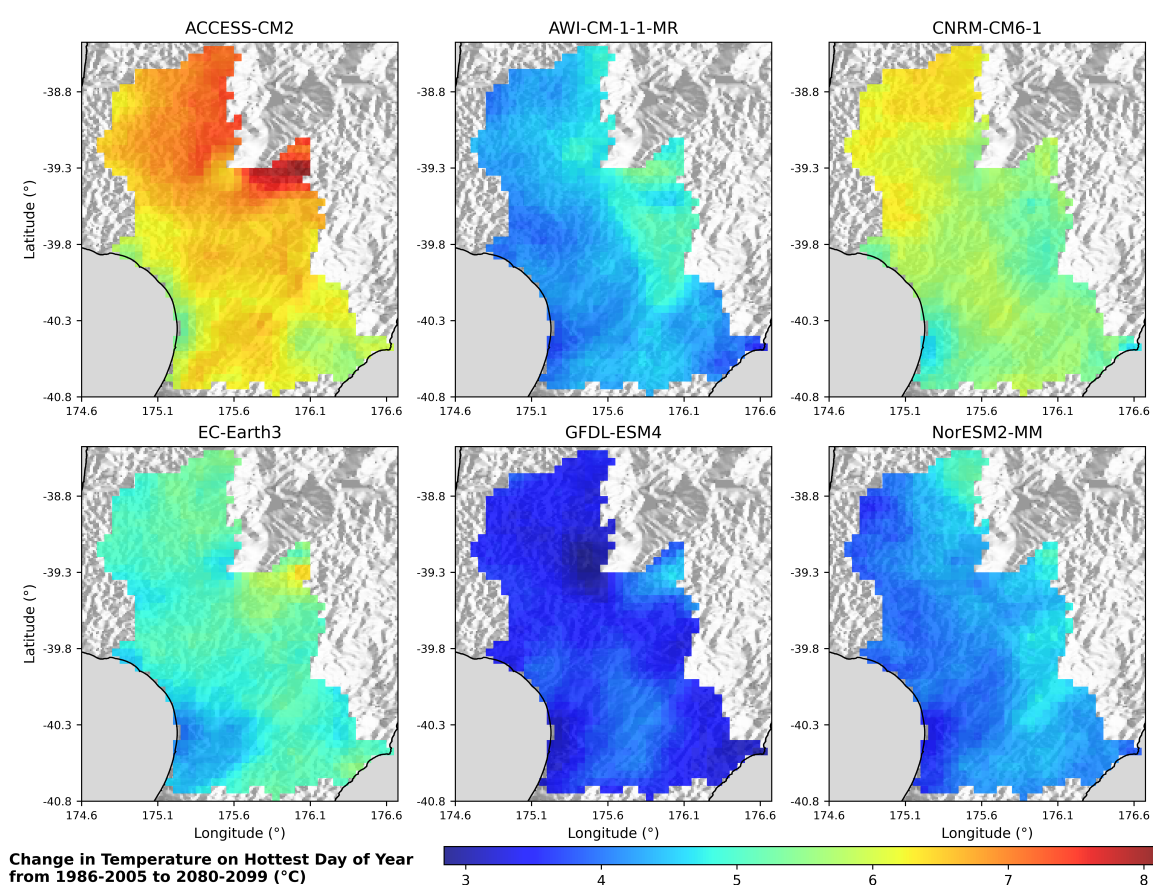


Figure 16: Projected changes in temperature on the hottest day of the year from 1986-2005 to 2080-2099 under the SSP5-8.5 scenario. The original of this figure is available [here](#).

pronounced, pervasive increases in TXx are projected for the Horizons region by 2080–2099. Mean projected increases are near 5°C, with individual model means spanning 3.6°C to as high as 6.5°C. Model maxima can approach or reach 8°C; even the minimum projected increase at any location remains above 3.5°C, confirming the extremely likely (virtually certain) occurrence of both large magnitude and universal warming in annual extreme maximum temperature. The signal is spatially coherent with no major spatial gradients and only minor subregional or local distinctions being resolved.

Model agreement remains very high, with standard deviations substantially lower than the mean change magnitude, and the spatial R^2 remains low, again indicating that the dominant climate change signal greatly outweighs intra-regional variability. Regression diagnostics confirm the strong suitability of model maxima as proxies for the 95th percentile, while minima are less reliable, often underestimating the 5th percentile but



always remaining positive. All scenarios reflect consistently positive change in all subregions, with the largest increases in northern and inland uplands and the lowest in Southwest coastal and lake regions, but these differences are small compared to the regional warming mean.

In summary, for late-century under high emissions, an extreme but regionally uniform increase in TXx is virtually certain across the Horizons region. The implications for the frequency and severity of heat extremes are profound, underscoring the dominant role of emissions pathway choice in shaping the regional climate risk landscape.

8.5 Comparison Across Scenarios

Comparison across all scenarios by late century reveals that the magnitude of projected TXx increases is fundamentally governed by emissions trajectory. SSP1-2.6 results in the most modest increases (about 1.3°C), while SSP5-8.5 yields extremely large regional changes (mean ~5°C, maxima up to 8°C). Despite these magnitude differences, all scenarios and models unanimously indicate increases in TXx everywhere, i.e., no cooling is projected under any pathway or ensemble member. The spatial pattern remains homogenous, with local details secondary to the dominant global warming signal. The model maximum at each grid cell provides a reliable estimate of the upper bound of change; minima continue to serve as plausible but less conservative lower bounds. The confidence in sign, origin, and dominant spatial coherence of TXx change is extremely high. In summary, choice of emissions scenario has increasingly stark consequences for the magnitude of extreme temperature risk by 2080–2099, but all plausible futures entail extensive and robust increases in annual maximum temperature across the Horizons region.

9 Evolution of Regional Hot-spots

A full breakdown of projected changes in temperature on the hottest day of the year by region is given in the Appendices. What follows below is a brief overview of those results.

The spatial distribution of projected changes in TXx across sub-regions and timeframes highlights a general pattern of widespread increases in TXx, but with some consistent relative regional hotspots and cold spots.

In the historical baseline, TXx is highest in inland, low-elevation western and northern parts, with cooler maxima in highlands and closer to the coast. As climate change progresses through the century, these gradients persist but are modulated by the scale of warming imposed by the different emissions scenarios.

In the near-term (2021–2040), projected increases in TXx are relatively uniform across the region and between scenarios; however, slightly greater warming is seen in the southeast (Puketoi ki Tai, Tararua) and, to a lesser extent, other interior sub-regions. These areas stand out with model mean TXx increases approaching or just exceeding 1.1°C under even the lowest emissions scenario, underscoring their role as early indicators of regional heat intensification.

By mid-century (2041–2060), all scenarios show further increases, with local hotspot behaviour most notable in Upper Rangitikei and Volcanic Plateau, where the largest projected mean increases sometimes exceed 1.6–2.0°C, and model spread broadens correspondingly. These regions, with their topographically complex and semi-inland location, are predisposed to stronger warming due to weaker maritime moderation and a pronounced response to changes in synoptic-scale airflow. The southeast remains an area of larger increases, while coastal lowland sub-regions (e.g., Horowhenua and Whanganui-Manawatū Lakes) consistently exhibit the smallest projected increases. This pattern is robust across all scenarios.

For the end of the century (2080–2099), spatial contrasts in TXx changes are further amplified under higher emissions. Under SSP5-8.5, for instance, regional means increase by nearly 5°C, with locally higher values in northern and inland sub-regions (NorthernZone-Taumarunui, Upper Rangitikei, Volcanic Plateau). These



hotspots reflect both baseline vulnerability (historically warmer and further from coastal influences) and amplified future risk. Conversely, moderating effects remain evident along the coastal-southern margin (Horowhenua, Whanganui-Manawatu Lakes) where regional mean increases, although large, remain slightly below the regional peaks.

Model spread in these hotspots also tends to be larger, reflecting both increased absolute warming and increased uncertainties under stronger climate forcing. Across all periods, no sub-region projects a decrease or stabilisation: hotspots are relative, not absolute, and the universal signal is robust increases in TXx. Areas consistently showing the highest projected changes in TXx, especially central, northern, and southeastern inland sub-regions, should therefore be prioritised for adaptation measures focusing on infrastructure, heat health, agricultural practices, and emergency management, reflecting their relative heat exposure risk and the very high likelihood of future intensification.

10 Understanding Projection Uncertainty

10.1 Why uncertainty matters

Uncertainty in climate projections is central to effective adaptation planning because it defines the range of plausible heat extremes, exposure thresholds, and risk levels communities may face over coming decades. Projections of TXx do not represent deterministic outcomes, but span a range of possible futures conditional on emissions, model representation of climate processes, and internal system variability. Understanding and communicating this uncertainty allows decision makers to gauge both the risks of under- and over-adapting, and to evaluate the robustness of their plans under different warming trajectories.

Uncertainty evolves across scenarios and time horizons. In the near term, uncertainties are governed mainly by model differences and internal climate variability; in the late century, the main source is divergence between emissions scenarios. Within any scenario and period, local-scale uncertainty (for example, at particular towns or sub-regions) will often be larger than the regional mean, arising from topographic complexity, ensemble size limitations, or model parameterisation differences. For climate services, quantifying these uncertainties with percentiles, spread, and ensembles is key: it provides a probabilistic framing for the magnitude, spatial pattern, and timing of extreme high temperature increases. As such, reporting uncertainty is not a limitation, but a tool for risk-aware, adaptive, and flexible planning.

10.2 Interpreting Ensemble Spread

The six-model ensemble used here provides a valuable window into inter-model structural uncertainty for TXx. Areas and periods where all models agree on both the sign and magnitude of change (e.g., extremely likely warming across the entire Horizons region) lend strong confidence to the conclusions. Near-perfect spatial agreement for historical TXx ($R^2 > 0.91$) demonstrates that the models capture the major physical drivers of extreme temperature in the region, increasing credibility in projections for future decades.

For future periods, ensemble spread is low in the near term and grows by late century and under high-emissions scenarios. Nevertheless, even as spread increases, the models virtually never disagree on the sign of the change for TXx. Where spatial R^2 in projected changes is low, that indicates that the spatial structure of the change (fine-grained local differences) is less robustly simulated than the regional mean change. This should not be interpreted as lack of confidence in the warming signal but rather that detail at kilometre scale is less certain than the regional or sub-regional scale. Areas where model spread is largest (e.g., in complex terrain or where local factors may enhance or reduce warming) highlight where site-specific planning must account for a wider plausible envelope. As such, ensemble analysis underpins both the assessment of confidence and the targeting of adaptation responses according to risk.



10.3 Minimum, Maximum and Percentile Fields

The minimum and maximum values across the six-model ensemble are often used to bound the plausible range of future TXx changes. For upper-end (P95) outcomes, the maximum projected change is consistently a very good approximation: regression analyses yield high R^2 (>0.8), near-unity slopes, and mean offsets near zero. This indicates that, for TXx in the Horizons region, the largest increases found among the models can be interpreted as a robust estimate of the most extreme plausible warming under current ensemble design.

For lower-end outcomes (P5), the minimum projected change serves only as a rough guide: correspondence with the formal 5th percentile is much weaker (R^2 typically between 0.46 and 0.88, with noted biases especially where spread is large). In practice, minima across small ensembles tend to overstate uncertainty in the lower tail, sometimes suggesting lower extremes that are statistically less plausible. As such, for risk management and critical infrastructure planning, the maximum (as a P95 proxy) provides a reliable upper bound, essential for assessing the impacts of worst-case warming, while the minimum (as a P5 proxy) should be interpreted with more caution and, where possible, replaced by explicit percentile calculations. This distinction allows for nuanced estimation of risk envelopes and helps clarify the confidence with which heat adaptation planning can proceed.

11 Equilibrium Climate Sensitivity and Temperature on the hottest day of the year change

11.1 Understanding ECS

Equilibrium climate sensitivity (ECS), i.e., the magnitude of global temperature increase following a doubling of atmospheric carbon dioxide, partly accounts for differences in modelled TXx projections across the six CMIP6 models. Models with larger ECS values generally simulate greater overall warming, reflecting in higher projected increases in TXx, especially under scenarios with strong radiative forcing (SSP3-7.0 and SSP5-8.5). However, TXx is a complex index: while ECS modulates the magnitude of regional and local warming, additional factors such as modelled shifts in synoptic patterns, land–sea temperature contrasts, feedbacks involving soil moisture and cloudiness, and the regional topographic detail all influence outcomes.

Across the Horizons region, baseline model agreement and low historical spread in the simulations suggests that model structure (which includes an inherent ECS) is only one source of projection difference. The fact that spatial structure in projected changes exhibits modest (but not perfect) correlation with ECS indicates that warming is widespread, but that the most extreme TXx values may be accentuated in models with higher ECS, especially where amplified by local feedbacks. While ECS is a valuable metric for interpreting coarse differences in TXx projections, it is not the sole determinant of local or annual maximum temperature extremes, and so spatial and physical mechanisms must be considered for a rounded understanding of uncertainty.

12 Sources of Uncertainty

12.1 Emissions Uncertainty

By the late 21st century, the primary lever of uncertainty in TXx projections for the Horizons region is emissions uncertainty: the degree to which global efforts succeed or fail in limiting increases in atmospheric greenhouse gas concentrations. The spread in TXx increases between low (SSP1-2.6) and high (SSP5-8.5) emissions scenarios is substantial with regional mean changes progressing from near 1°C up to 5°C or more, and with outlier grid cells experiencing even greater intensification under continued high emissions. This divergence becomes pronounced after mid-century and is virtually absent for near-future (2021–2040) projections, highlighting that



policy decisions and mitigation efforts in the next two decades will strongly influence heat exposure risk by the century's end.

12.2 Climate Model Uncertainty

Climate model uncertainty reflects differences in how models simulate physical processes, feedbacks, circulation changes, and land–atmosphere interactions. For TXx, model spread is small for the historical period, grows over time, but remains less than the signal of projected warming. Inter-model agreement is extremely high regarding the sign of change, but some degree of magnitude uncertainty is irreducible, particularly in topographically complex areas or where local feedbacks are strongly non-linear. The ensemble used here likely brackets the central range but not the full spectrum of plausible responses; nonetheless, the strong inter-model consensus supports high confidence in the overall direction of change.

12.3 Natural Climate Variability

Internal variability that arises from natural climate fluctuations such as ENSO, decadal oscillations, or unforced year-to-year weather events, remains a meaningful driver of short-term uncertainty. While it can mask or amplify long-term climate trends, its influence wanes as the climate signal strengthens, especially by late century and under strong emissions scenarios. In the near term, however, natural variability can produce ranges in TXx that are comparable to (or larger than) model or scenario spread, underscoring the need for cautious interpretation of short-window projections and for risk management strategies that accommodate episodic extreme events.

12.4 Downscaling Uncertainty

The projections are derived using the CCAM regional climate model. Regional downscaling provides substantial benefits because it improves representation of New Zealand's complex topography and climatic gradients. However, downscaling introduces its own uncertainties associated with model parameterisations, boundary conditions, and spatial resolution. Although these uncertainties are difficult to quantify directly, they should be recognised when interpreting local-scale projections. Importantly, the broad consistency of projected regional patterns across multiple climate models suggests that the major conclusions of this report are unlikely to be substantially altered by downscaling uncertainties.

13 Confidence Assessment

The synthesis of modelled changes in TXx for the Horizons region supports a confidence assessment using IPCC terminology. For all time periods and across all emissions scenarios, there is extremely high confidence (virtually certain, >99% probability) that TXx will increase regionally. The strength and spatial coherence of the signal are exceptionally robust: the entire ensemble of CMIP6 models assessed projects positive changes, supported by high spatial correlation between models in both baseline and projected change fields.

The magnitude of change under low-emissions pathways is likely to very likely (66–90% or higher probability) to be modest (+1°C by mid-century), and extremely likely (>95% probability) to be substantial and widespread under higher-emissions scenarios, with increases of +4 to +5°C possible for the end of the century. Model agreement for the direction of change is extremely high throughout, bolstering reliability of regional mean projections.

Uncertainty remains in local spatial detail due to model structure, downscaling, and natural internal variability.



These uncertainties are largest for sub-regional or site-specific outcomes, especially in zones of complex topography or land–sea transition. The ensemble maximum provides a credible approximation of high-percentile (P95) changes, supporting high confidence for upper-bound risk assessment; the minimum (as a proxy for P5) is less reliable but still supports the central warming narrative. In summary, conclusions regarding regionally coherent, significant increases in TXx are supported with very high confidence, with lower—but still robust—confidence for fine-scale local or extreme low-end outcomes.

14 Conclusions

The evidence from downscaled CMIP6 simulations unequivocally establishes that the Horizons region will experience significant increases in temperature on the hottest day of the year (TXx) across all emission scenarios, timeframes, and spatial sub-domains. The signal is robust for both the occurrence and magnitude of regional increases, with model agreement highest for direction and regional mean, and slightly lower (but still strong) for fine-scale local changes. The historical fidelity of the models for TXx provides a secure anchor for interpreting projected changes.

By 2021–2040, extremely likely modest increases ($+1^{\circ}\text{C}$) in TXx will manifest across the region, setting the stage for more pronounced change in the subsequent decades. By mid-century, projected mean increases reach $+2^{\circ}\text{C}$ under high emissions, with uncertainties growing but never undermining the signal's direction or spatial consistency. For late century (2080–2099), the difference between plausibly mitigated (SSP1-2.6) and unmitigated (SSP5-8.5) emissions pathways is stark: while TXx increases under SSP1-2.6 level off at $+1.5^{\circ}\text{C}$, they may exceed $+5^{\circ}\text{C}$ under SSP5-8.5, with hotspots in inland, northern, and southeastern sub-regions.

Strong ensemble evidence supports the use of the model maximum as a robust upper-bound indicator for extreme outcomes, though caution is warranted when interpreting the minimum as a lower-bound due to ensemble size and non-linear spread. Regardless, the compelling scientific consensus is that adaptation is required, ranging from infrastructure upgrades and urban heat mitigation to strategic health and land management planning. In summary, the likelihood of more intense annual heat extremes in the Horizons region is extremely high, and the scale of adaptation required will be commensurate with the trajectory of emissions reductions achieved globally in the coming decades.

15 Appendices

A map of the sub-regions reported on below is provided in Figure 17. Some of these sub-regions exhibit a wide range of elevations which can increase the spatial heterogeneity of the data, especially for temperature related climate variables. This is visible in the larger 1σ standard deviations for those regions listed in the tables below which represent the *spatial spread* of the values within each region (not the intrinsic uncertainty on the values). Histograms of elevations for each region, at the native resolution of the CCAM model, are shown in Figure 18. The Volcanic Plateau, Upper Rangitikei, and, to a lesser extent, the Western Ruahine regions contain a significant number of model cells at elevations above 700 m. For locations at elevation extremes within any region, the regional average values listed in the tables below may not be indicative of the value at that specific location and the user would do better to consult the data shown as maps for the whole Horizons region and consider the CCAM model value closest to their location.

15.1 Region: NorthernZone-Taumarunui

Area: 5084.04 km²

A plot of the evolution in temperature on the hottest day of the year from the 1986-2005 baseline over this



Figure 17: A map of the regions reported on in these appendices.

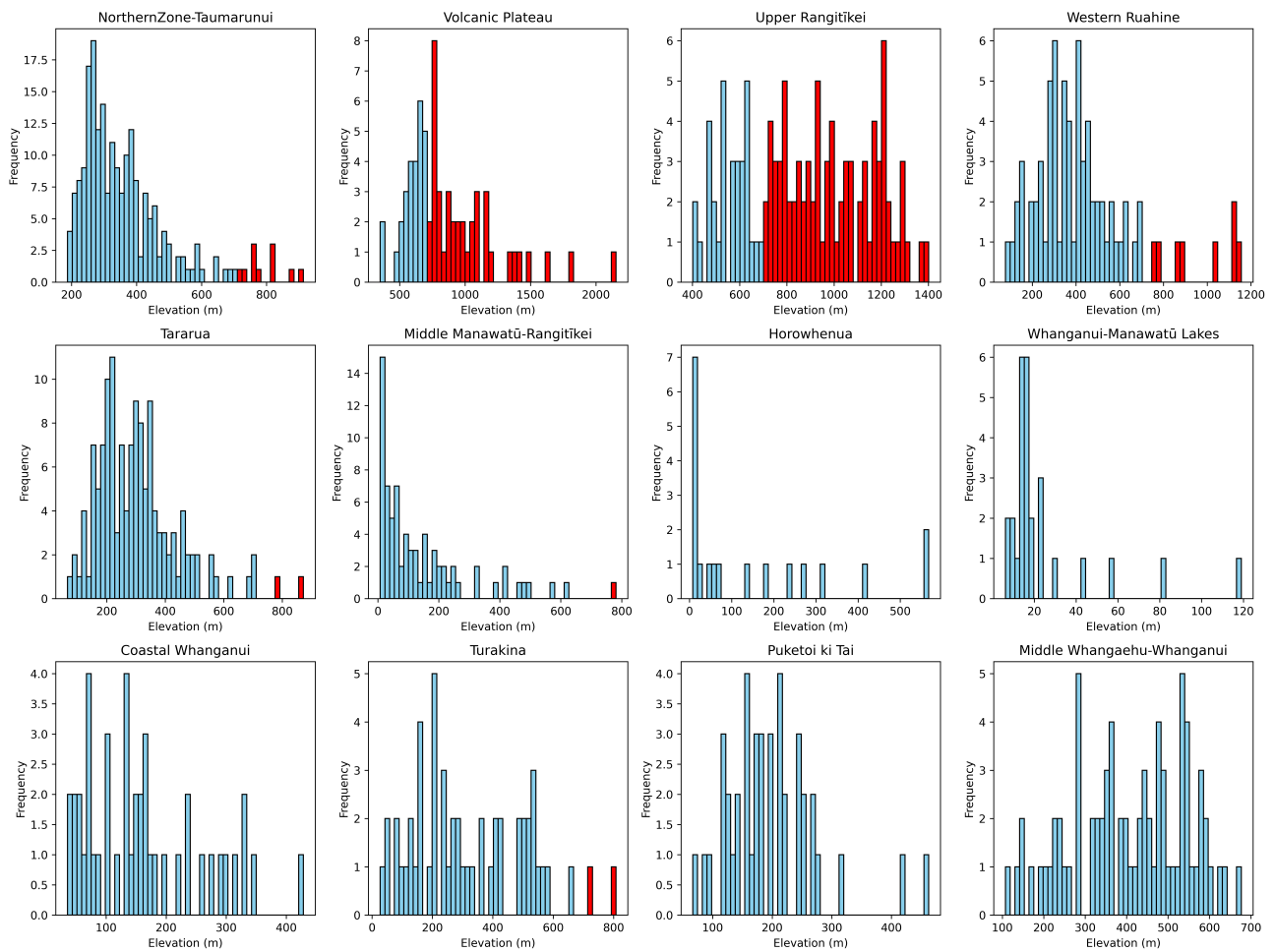


Figure 18: Histograms showing the number of CCAM model cells at each elevation. Histogram bars at elevations exceeding 700 m are shown in red. The original of this figure is available [here](#).



region is shown in Figure 19. The statistical summary of projected changes in temperature on the hottest

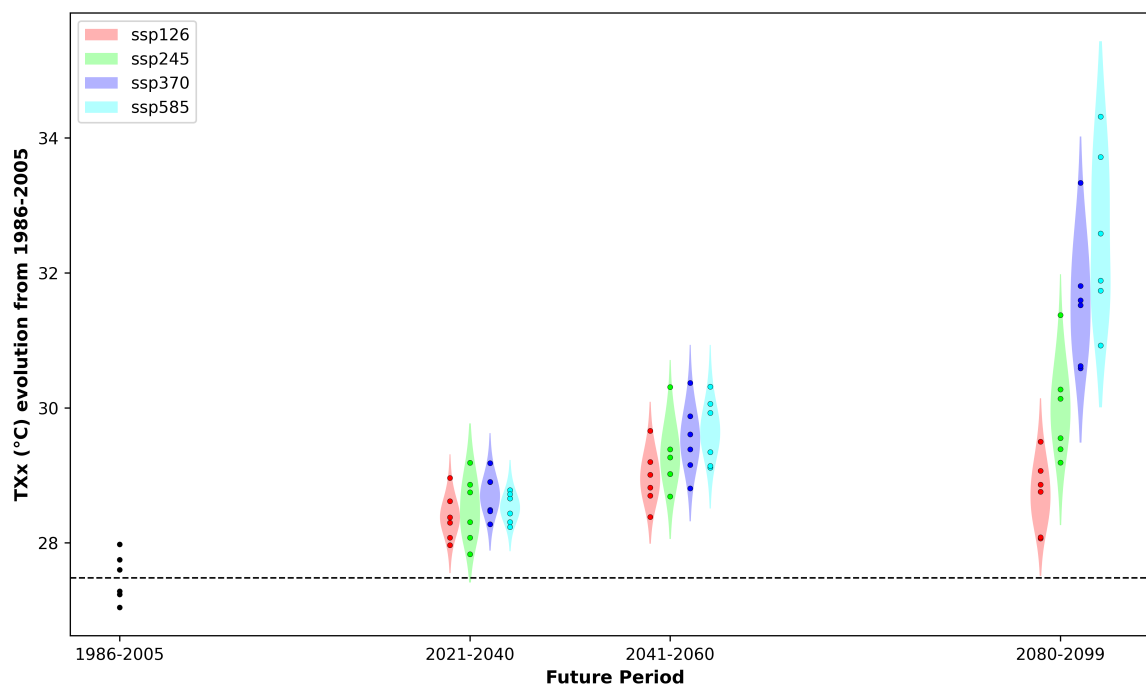


Figure 19: The time evolution of temperature on the hottest day of the year from the 1986-2005 baseline in units of °C over the NorthernZone-Taumarunui region. This variable is not seasonal and so the results shown here are for the whole year. The violin plots show indicative uncertainties derived using the ECS-based uncertainty analysis explained in the main report. Small circles show the individual model values extracted from the data files provided by MfE. The projections under the different SSP scenarios are shown in different colours. The change values for future periods, extracted from the data files, are offset by the *mean* of the baseline model data. The original of this figure can be downloaded [here](#).

day of the year over this region is shown in Table 1. For the NorthernZone-Taumarunui region, climate model projections show robust increases in TXx through the 21st century, relative to the 1986–2005 baseline. By mid-century (2041–2060), increases are likely under all scenarios, with mean changes ranging from about 1.5°C for low emissions (SSP1-2.6) up to 2.2°C under high emissions (SSP5-8.5). Early-century (2021–2040) changes are smaller, around 1°C, and similar across scenarios. By late-century (2080–2099), scenario divergence becomes pronounced: TXx change remains close to 1.2°C under SSP1-2.6, but increases to 2.5°C (SSP2-4.5), 4.1°C (SSP3-7.0), and up to around 5°C for SSP5-8.5, making high-end increases extremely likely under strong emission growth. The magnitude of projected increases is very likely to exceed natural variability, which is relatively low (mean spatial standard deviations <0.2°C) in all periods.

Model agreement is strong on the warming direction, but the spread between scenarios increases sharply by late-century, with the inter-scenario agreement nearly disappearing. Across models within each scenario, consensus remains high for direction and broad magnitude, providing high confidence in the qualitative signal and likely quantitative range under each pathway. It is virtually certain that TXx will increase through the century, with the degree of change strongly scenario-dependent.

15.2 Region: Volcanic Plateau

Area: 1664.65 km²

A plot of the evolution in temperature on the hottest day of the year from the 1986-2005 baseline over this region is shown in Figure 20. The statistical summary of projected changes in temperature on the hottest day of the year over this region is shown in Table 2. Projections across all emissions scenarios indicate a likely increase in TXx relative to the 1986–2005 baseline, with magnitude and uncertainty strongly dependent on scenario and time period.



Metric	Period	SSP scenario			
		SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Multi-model mean	Baseline	27.48 ± 0.88	27.48 ± 0.88	27.48 ± 0.88	27.48 ± 0.88
	2021-2040	0.90 ± 0.12	1.02 ± 0.09	1.22 ± 0.04	1.04 ± 0.12
	2041-2060	1.48 ± 0.08	1.80 ± 0.07	2.05 ± 0.11	2.17 ± 0.08
	2080-2099	1.24 ± 0.06	2.50 ± 0.08	4.10 ± 0.08	5.05 ± 0.15
Multi-model P50	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.91 ± 0.12	1.04 ± 0.09	1.23 ± 0.04	1.05 ± 0.12
	2041-2060	1.49 ± 0.08	1.81 ± 0.07	2.06 ± 0.11	2.18 ± 0.08
	2080-2099	1.26 ± 0.07	2.52 ± 0.08	4.13 ± 0.08	5.11 ± 0.14
Multi-model minimum	Baseline	27.04 ± 0.92	27.04 ± 0.92	27.04 ± 0.92	27.04 ± 0.92
	2021-2040	0.45 ± 0.09	0.33 ± 0.09	0.72 ± 0.12	0.64 ± 0.12
	2041-2060	0.88 ± 0.17	1.18 ± 0.14	1.30 ± 0.22	1.58 ± 0.08
	2080-2099	0.48 ± 0.14	1.69 ± 0.12	2.96 ± 0.13	3.44 ± 0.13
Multi-model P5	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.38 ± 0.09	0.28 ± 0.09	0.70 ± 0.07	0.63 ± 0.10
	2041-2060	0.84 ± 0.09	1.00 ± 0.10	1.27 ± 0.15	1.44 ± 0.09
	2080-2099	0.44 ± 0.13	1.38 ± 0.10	2.68 ± 0.10	3.23 ± 0.13
Multi-model maximum	Baseline	27.99 ± 0.87	27.99 ± 0.87	27.99 ± 0.87	27.99 ± 0.87
	2021-2040	1.49 ± 0.22	1.71 ± 0.18	1.70 ± 0.08	1.40 ± 0.22
	2041-2060	2.18 ± 0.19	2.83 ± 0.13	2.89 ± 0.23	2.87 ± 0.22
	2080-2099	2.02 ± 0.29	3.89 ± 0.23	5.85 ± 0.18	6.83 ± 0.26
Multi-model P95	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.49 ± 0.18	1.90 ± 0.22	1.81 ± 0.11	1.49 ± 0.20
	2041-2060	2.22 ± 0.23	2.72 ± 0.12	2.94 ± 0.21	2.98 ± 0.18
	2080-2099	2.18 ± 0.26	3.80 ± 0.20	5.79 ± 0.15	7.25 ± 0.20

Table 1: The statistics of the projected changes in temperature on the hottest day of the year in units of °C over the NorthernZone-Taumarunui region. Baseline values are shown in absolute units while values for each of the three future periods are shown as changes from the baseline. This variable is not seasonal and so the results shown here are for the whole year. The uncertainties on each value are indicative of the *spatial spread* of the values across the region, not the inter-model spread. The inter-model spread should be diagnosed from the multi-model minimum (and its associated 5th percentile row) and the multi-model maximum (and its associated 95th percentiles).



Metric	Period	SSP scenario			
		SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Multi-model mean	Baseline	25.25 $\pm$ 1.72	25.25 $\pm$ 1.72	25.25 $\pm$ 1.72	25.25 $\pm$ 1.72
	2021-2040	1.00 $\pm$ 0.07	1.12 $\pm$ 0.05	1.15 $\pm$ 0.05	1.15 $\pm$ 0.11
	2041-2060	1.52 $\pm$ 0.09	1.79 $\pm$ 0.09	1.92 $\pm$ 0.11	2.04 $\pm$ 0.10
	2080-2099	1.23 $\pm$ 0.09	2.45 $\pm$ 0.10	3.98 $\pm$ 0.09	5.02 $\pm$ 0.14
Multi-model P50	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.01 $\pm$ 0.07	1.14 $\pm$ 0.05	1.16 $\pm$ 0.05	1.15 $\pm$ 0.11
	2041-2060	1.53 $\pm$ 0.09	1.81 $\pm$ 0.09	1.92 $\pm$ 0.11	2.05 $\pm$ 0.10
	2080-2099	1.24 $\pm$ 0.09	2.46 $\pm$ 0.11	4.01 $\pm$ 0.09	5.07 $\pm$ 0.14
Multi-model minimum	Baseline	24.58 $\pm$ 1.79	24.58 $\pm$ 1.79	24.58 $\pm$ 1.79	24.58 $\pm$ 1.79
	2021-2040	0.51 $\pm$ 0.09	0.38 $\pm$ 0.09	0.64 $\pm$ 0.13	0.62 $\pm$ 0.13
	2041-2060	0.68 $\pm$ 0.12	1.16 $\pm$ 0.09	1.39 $\pm$ 0.15	1.40 $\pm$ 0.11
	2080-2099	0.33 $\pm$ 0.12	1.75 $\pm$ 0.08	2.87 $\pm$ 0.13	3.17 $\pm$ 0.20
Multi-model P5	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.39 $\pm$ 0.09	0.29 $\pm$ 0.11	0.65 $\pm$ 0.10	0.49 $\pm$ 0.15
	2041-2060	0.74 $\pm$ 0.08	0.98 $\pm$ 0.10	1.31 $\pm$ 0.15	1.24 $\pm$ 0.14
	2080-2099	0.29 $\pm$ 0.14	1.40 $\pm$ 0.10	2.67 $\pm$ 0.12	3.18 $\pm$ 0.13
Multi-model maximum	Baseline	26.05 $\pm$ 1.68	26.05 $\pm$ 1.68	26.05 $\pm$ 1.68	26.05 $\pm$ 1.68
	2021-2040	1.70 $\pm$ 0.10	1.83 $\pm$ 0.17	1.60 $\pm$ 0.09	1.89 $\pm$ 0.26
	2041-2060	2.32 $\pm$ 0.21	2.69 $\pm$ 0.21	2.57 $\pm$ 0.25	2.92 $\pm$ 0.22
	2080-2099	2.13 $\pm$ 0.30	3.77 $\pm$ 0.27	5.56 $\pm$ 0.31	7.01 $\pm$ 0.28
Multi-model P95	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.68 $\pm$ 0.10	2.08 $\pm$ 0.17	1.68 $\pm$ 0.09	1.78 $\pm$ 0.18
	2041-2060	2.40 $\pm$ 0.21	2.72 $\pm$ 0.21	2.60 $\pm$ 0.18	2.92 $\pm$ 0.21
	2080-2099	2.30 $\pm$ 0.30	3.61 $\pm$ 0.27	5.53 $\pm$ 0.26	7.22 $\pm$ 0.26

Table 2: The statistics of the projected changes in temperature on the hottest day of the year in units of $^{\circ}\text{C}$ over the Volcanic Plateau region. Baseline values are shown in absolute units while values for each of the three future periods are shown as changes from the baseline. This variable is not seasonal and so the results shown here are for the whole year. The uncertainties on each value are indicative of the *spatial spread* of the values across the region, not the inter-model spread. The inter-model spread should be diagnosed from the multi-model minimum (and its associated 5th percentile row) and the multi-model maximum (and its associated 95th percentiles).

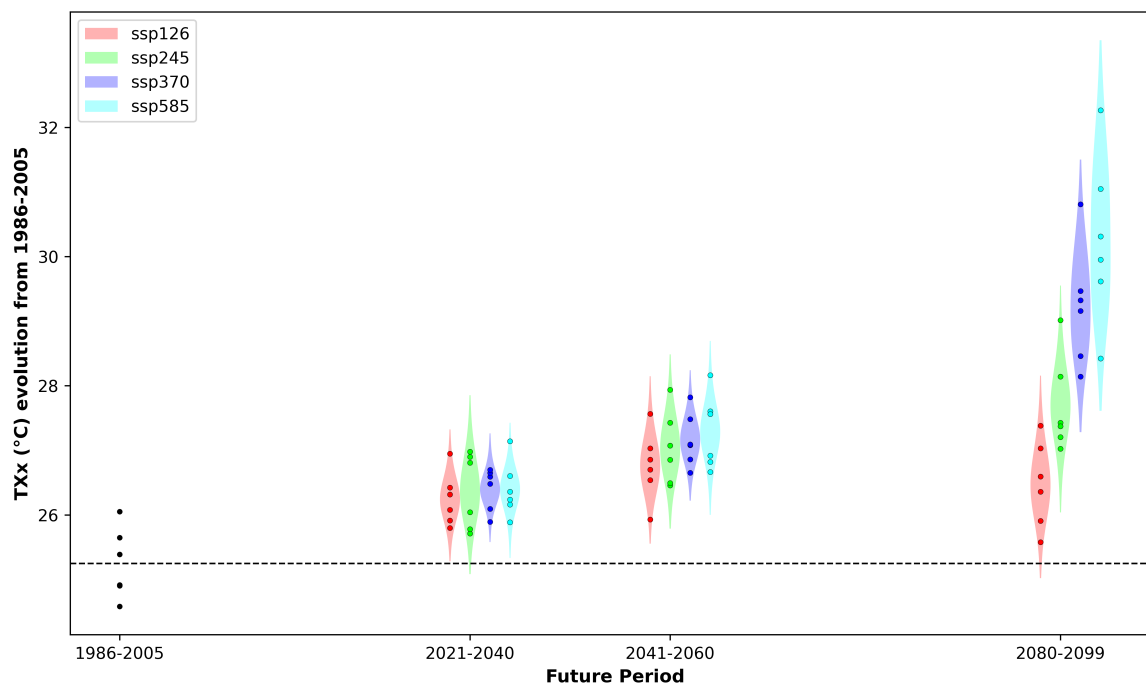


Figure 20: The time evolution of temperature on the hottest day of the year from the 1986-2005 baseline in units of °C over the Volcanic Plateau region. This variable is not seasonal and so the results shown here are for the whole year. The violin plots show indicative uncertainties derived using the ECS-based uncertainty analysis explained in the main report. Small circles show the individual model values extracted from the data files provided by MfE. The projections under the different SSP scenarios are shown in different colours. The change values for future periods, extracted from the data files, are offset by the *mean* of the baseline model data. The original of this figure can be downloaded [here](#).

For 2021–2040, all scenarios show a very likely increase of approximately 1.0–1.2°C. Model agreement is moderate (around 75%), and the inter-scenario spread is small, supporting high confidence in near-term projections of increasing TXx. By 2041–2060, projected increases rise to around 1.5°C (low emissions) up to nearly 2.0°C (high emissions), with reduced agreement (about 44%), indicating emerging scenario dependence.

By 2080–2099, scenario divergence is pronounced: TXx rises roughly 1.2°C under low emissions (SSP1-2.6), to over 5°C under high emissions (SSP5-8.5). Across-scenario agreement essentially vanishes (<1%), reflecting very likely strong dependence on future emissions choices. The upper bound in SSP5-8.5 suggests extreme warming (TXx up to ~7°C above baseline), while SSP3-7.0 and SSP2-4.5 show intermediate increases.

Spatial variability (standard deviation) in TXx is significantly smaller for the projections compared to the baseline, suggesting the increases are spatially fairly uniform across the Volcanic Plateau. Given multiple models and scenario consistency in early periods, it is virtually certain that TXx will increase, with projected magnitude very likely strengthening later and depending on mitigation actions.

15.3 Region: Upper Rangitikei

Area: 2694.06 km²

A plot of the evolution in temperature on the hottest day of the year from the 1986-2005 baseline over this region is shown in Figure 21. The statistical summary of projected changes in temperature on the hottest day of the year over this region is shown in Table 3. Projected changes in TXx for Upper Rangitikei indicate a robust warming trend across all future emission scenarios, with the magnitude of change depending strongly on emissions pathway, especially by late century. By mid-century (2041–2060), average increases range from about 1.6°C under SSP1-2.6 (low emissions) to over 2.2°C under SSP5-8.5 (high emissions), relative to the 1986–2005 baseline. Distributions across models are tightly clustered in the near term (2021–2040), providing



Metric	Period	SSP scenario			
		SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Multi-model mean	Baseline	25.26 ± 1.54	25.26 ± 1.54	25.26 ± 1.54	25.26 ± 1.54
	2021-2040	0.99 ± 0.08	1.18 ± 0.08	1.27 ± 0.11	1.25 ± 0.18
	2041-2060	1.62 ± 0.23	1.80 ± 0.16	2.00 ± 0.13	2.19 ± 0.19
	2080-2099	1.41 ± 0.15	2.58 ± 0.19	4.04 ± 0.17	5.18 ± 0.23
Multi-model P50	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.00 ± 0.08	1.20 ± 0.09	1.28 ± 0.11	1.24 ± 0.18
	2041-2060	1.64 ± 0.23	1.81 ± 0.16	2.01 ± 0.13	2.20 ± 0.19
	2080-2099	1.42 ± 0.15	2.60 ± 0.19	4.07 ± 0.18	5.22 ± 0.23
Multi-model minimum	Baseline	24.72 ± 1.59	24.72 ± 1.59	24.72 ± 1.59	24.72 ± 1.59
	2021-2040	0.52 ± 0.16	0.46 ± 0.25	0.68 ± 0.20	0.71 ± 0.14
	2041-2060	0.95 ± 0.26	1.10 ± 0.18	1.55 ± 0.16	1.50 ± 0.11
	2080-2099	0.54 ± 0.22	1.77 ± 0.12	3.14 ± 0.17	3.78 ± 0.36
Multi-model P5	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.45 ± 0.16	0.53 ± 0.20	0.73 ± 0.16	0.53 ± 0.18
	2041-2060	0.83 ± 0.15	1.02 ± 0.13	1.57 ± 0.12	1.55 ± 0.12
	2080-2099	0.49 ± 0.22	1.68 ± 0.12	3.00 ± 0.15	3.67 ± 0.14
Multi-model maximum	Baseline	25.87 ± 1.45	25.87 ± 1.45	25.87 ± 1.45	25.87 ± 1.45
	2021-2040	1.52 ± 0.31	1.74 ± 0.26	1.76 ± 0.25	2.01 ± 0.20
	2041-2060	2.60 ± 0.48	2.69 ± 0.32	2.41 ± 0.23	2.74 ± 0.29
	2080-2099	2.29 ± 0.50	3.66 ± 0.24	5.32 ± 0.28	6.95 ± 0.52
Multi-model P95	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.60 ± 0.25	1.93 ± 0.33	1.84 ± 0.25	1.91 ± 0.24
	2041-2060	2.53 ± 0.42	2.70 ± 0.33	2.49 ± 0.27	2.89 ± 0.32
	2080-2099	2.45 ± 0.49	3.63 ± 0.30	5.28 ± 0.30	6.99 ± 0.41

Table 3: The statistics of the projected changes in temperature on the hottest day of the year in units of °C over the Upper Rangitikei region. Baseline values are shown in absolute units while values for each of the three future periods are shown as changes from the baseline. This variable is not seasonal and so the results shown here are for the whole year. The uncertainties on each value are indicative of the *spatial spread* of the values across the region, not the inter-model spread. The inter-model spread should be diagnosed from the multi-model minimum (and its associated 5th percentile row) and the multi-model maximum (and its associated 95th percentiles).

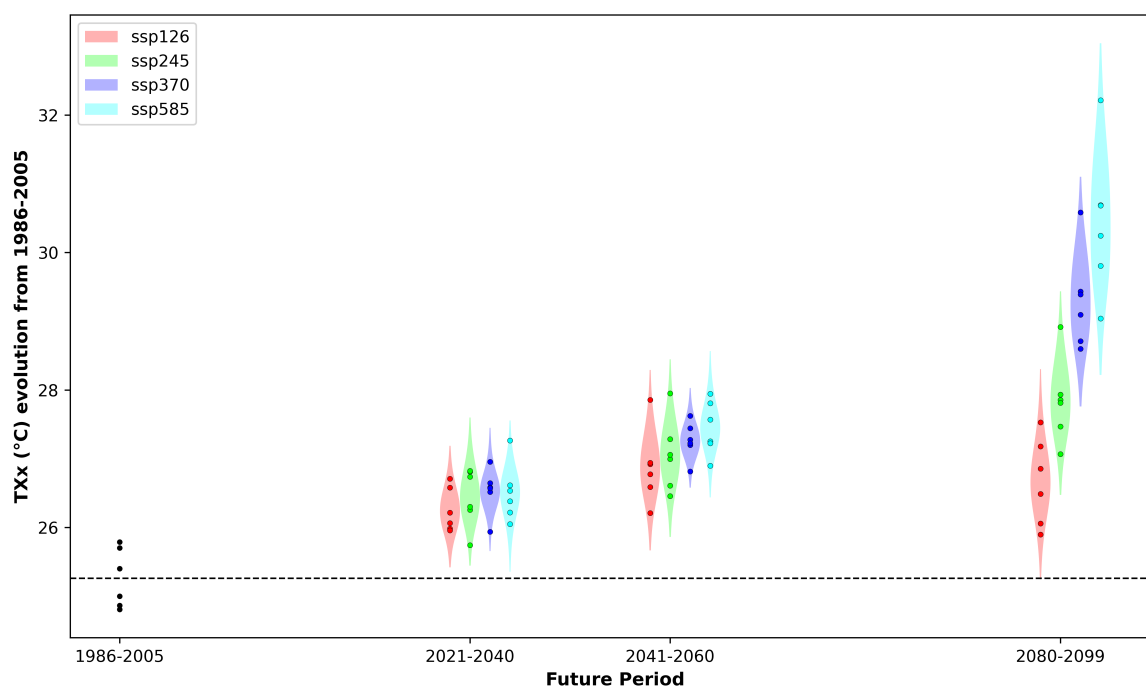


Figure 21: The time evolution of temperature on the hottest day of the year from the 1986-2005 baseline in units of °C over the Upper Rangitikei region. This variable is not seasonal and so the results shown here are for the whole year. The violin plots show indicative uncertainties derived using the ECS-based uncertainty analysis explained in the main report. Small circles show the individual model values extracted from the data files provided by MfE. The projections under the different SSP scenarios are shown in different colours. The change values for future periods, extracted from the data files, are offset by the *mean* of the baseline model data. The original of this figure can be downloaded [here](#).

high confidence and suggesting it is very likely the region will experience at least a 1°C increase regardless of scenario.

By late century (2080–2099), scenario divergence becomes much more pronounced, with SSP1-2.6 stabilising at around a 1.4°C increase, while more intense warming up to around 5.2°C occurs for SSP5-8.5. The lack of agreement between scenarios at century's end (agreement: <1%) underscores substantial scenario dependence and increased uncertainty, but the inter-model spread within scenarios remains moderate, lending high confidence to the direction of change. Spatial variability in the change, as indicated by standard deviations, is lower than the baseline but grows with stronger warming, particularly under high-emissions scenarios. It is virtually certain that Upper Rangitikei will warm, and extremely likely that the magnitude of annual maximum temperature increases will be dictated by future emissions choices.

15.4 Region: Western Ruahine

Area: 1758.32 km²

A plot of the evolution in temperature on the hottest day of the year from the 1986-2005 baseline over this region is shown in Figure 22. The statistical summary of projected changes in temperature on the hottest day of the year over this region is shown in Table 4. Projected changes in TXx for the Western Ruahine region indicate robust increases across all emissions scenarios. By mid-century (2041–2060), multi-model means suggest increases of approximately 1.4°C (SSP1-2.6) to 2.2°C (SSP5-8.5) relative to the 1986–2005 baseline, and these changes are likely, with high confidence due to the close central tendency among models for each scenario. For the near-term (2021–2040), there is already a projected increase in TXx of just over 1°C regardless of scenario, also likely with high confidence given inter-model consistency.

By the end of the century (2080–2099), the magnitude of projected changes in TXx diverges sharply by scenario.



Metric	Period	SSP scenario			
		SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Multi-model mean	Baseline	26.56 ± 1.25	26.56 ± 1.25	26.56 ± 1.25	26.56 ± 1.25
	2021-2040	1.02 ± 0.06	1.12 ± 0.12	1.30 ± 0.07	1.04 ± 0.10
	2041-2060	1.42 ± 0.06	1.72 ± 0.08	1.94 ± 0.10	2.15 ± 0.08
	2080-2099	1.38 ± 0.08	2.42 ± 0.07	4.03 ± 0.04	4.94 ± 0.07
Multi-model P50	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.02 ± 0.05	1.12 ± 0.12	1.31 ± 0.07	1.03 ± 0.09
	2041-2060	1.43 ± 0.06	1.74 ± 0.08	1.95 ± 0.10	2.16 ± 0.08
	2080-2099	1.38 ± 0.08	2.43 ± 0.06	4.05 ± 0.04	4.99 ± 0.06
Multi-model minimum	Baseline	26.21 ± 1.30	26.21 ± 1.30	26.21 ± 1.30	26.21 ± 1.30
	2021-2040	0.38 ± 0.15	0.77 ± 0.11	0.85 ± 0.16	0.56 ± 0.11
	2041-2060	0.98 ± 0.12	1.29 ± 0.12	1.55 ± 0.10	1.76 ± 0.08
	2080-2099	1.05 ± 0.10	1.88 ± 0.13	3.30 ± 0.17	3.82 ± 0.17
Multi-model P5	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.38 ± 0.10	0.73 ± 0.17	0.79 ± 0.18	0.53 ± 0.09
	2041-2060	0.82 ± 0.15	1.06 ± 0.18	1.46 ± 0.10	1.76 ± 0.10
	2080-2099	1.04 ± 0.09	1.64 ± 0.16	3.11 ± 0.11	3.61 ± 0.15
Multi-model maximum	Baseline	26.96 ± 1.21	26.96 ± 1.21	26.96 ± 1.21	26.96 ± 1.21
	2021-2040	1.51 ± 0.11	1.54 ± 0.09	1.75 ± 0.12	1.48 ± 0.22
	2041-2060	2.17 ± 0.12	2.55 ± 0.15	2.47 ± 0.15	2.52 ± 0.12
	2080-2099	1.74 ± 0.09	3.41 ± 0.18	5.21 ± 0.09	6.44 ± 0.10
Multi-model P95	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.67 ± 0.09	1.54 ± 0.08	1.86 ± 0.14	1.50 ± 0.18
	2041-2060	2.11 ± 0.08	2.49 ± 0.10	2.45 ± 0.13	2.60 ± 0.11
	2080-2099	1.75 ± 0.13	3.29 ± 0.15	5.11 ± 0.10	6.56 ± 0.07

Table 4: The statistics of the projected changes in temperature on the hottest day of the year in units of °C over the Western Ruahine region. Baseline values are shown in absolute units while values for each of the three future periods are shown as changes from the baseline. This variable is not seasonal and so the results shown here are for the whole year. The uncertainties on each value are indicative of the *spatial spread* of the values across the region, not the inter-model spread. The inter-model spread should be diagnosed from the multi-model minimum (and its associated 5th percentile row) and the multi-model maximum (and its associated 95th percentiles).

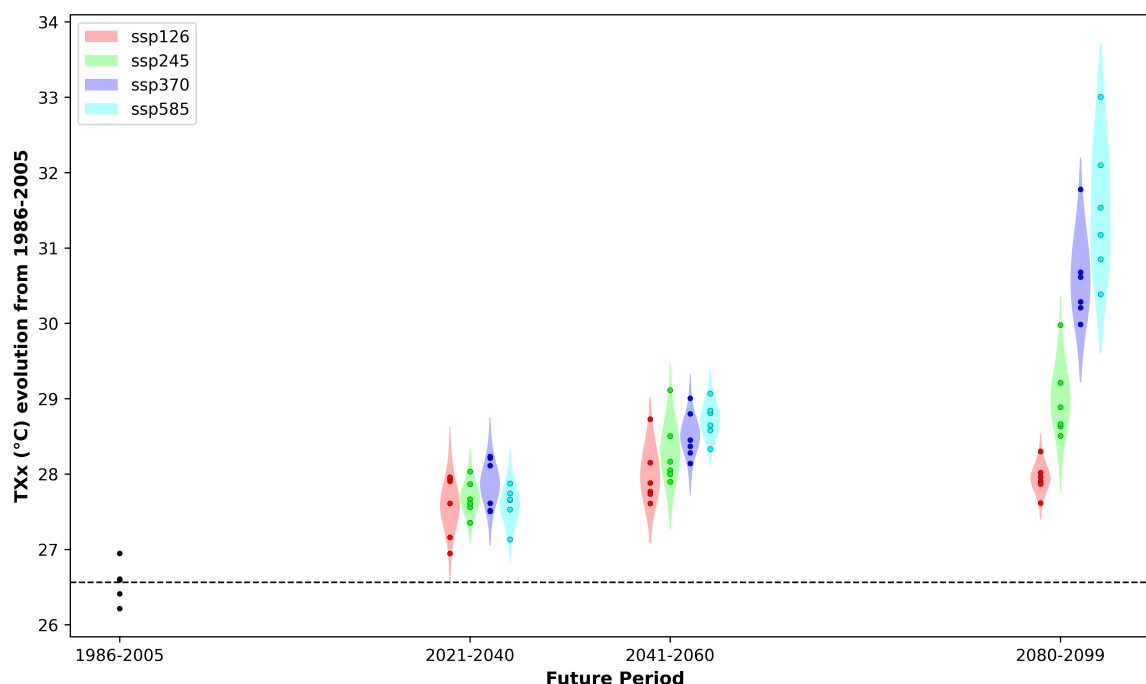


Figure 22: The time evolution of temperature on the hottest day of the year from the 1986-2005 baseline in units of °C over the Western Ruahine region. This variable is not seasonal and so the results shown here are for the whole year. The violin plots show indicative uncertainties derived using the ECS-based uncertainty analysis explained in the main report. Small circles show the individual model values extracted from the data files provided by MfE. The projections under the different SSP scenarios are shown in different colours. The change values for future periods, extracted from the data files, are offset by the *mean* of the baseline model data. The original of this figure can be downloaded [here](#).

Under low emissions (SSP1-2.6), increases stabilise at about 1.4°C, while under SSP3-7.0 and SSP5-8.5, TXx rises by around 4.0°C and 4.9°C, respectively. For these higher emissions scenarios, such substantial increases are extremely likely if emissions are not mitigated. The spatial variability within the region is modest (<0.1°C standard deviation for most projections), indicating spatially coherent warming.

Agreement across scenario projections diminishes markedly over time, with virtually no overlap by 2080–2099. This highlights very high confidence in significant temperature increases, but low agreement on the magnitude under divergent emissions pathways, reinforcing the importance of mitigation for limiting extreme heat.

15.5 Region: Tararua

Area: 3155.23 km²

A plot of the evolution in temperature on the hottest day of the year from the 1986-2005 baseline over this region is shown in Figure 23. The statistical summary of projected changes in temperature on the hottest day of the year over this region is shown in Table 5. The figure and associated statistics indicate a clear and consistent increase in TXx for Tararua across all emissions scenarios relative to the 1986–2005 baseline. All scenarios project an increase, but the magnitude of change by the end of the century varies strongly with emission pathway. For the near term (2021–2040), increases are modest and fairly similar across SSPs, with multi-model means between approximately 1.1°C and 1.4°C above the baseline, and model agreement is moderate (about as likely as not, with 52% cross-SSP agreement). By mid-century (2041–2060), divergence between scenarios grows, with SSP1-2.6 still near 1.5°C, and higher emission scenarios reaching around 2.3°C (SSP5-8.5). By late century (2080–2099), scenario dependency becomes pronounced and model agreement drops to zero, reflecting large inter-scenario spread: increases range from around 1.5°C for strong mitigation (SSP126) to nearly 5°C under very high emissions (SSP5-8.5). Across all periods, the inter-model spread within scenarios remains moderate—suggesting very likely warming, though the precise magnitude is scenario-dependent. Spatial vari-



Metric	Period	SSP scenario			
		SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Multi-model mean	Baseline	27.25 ± 0.89	27.25 ± 0.89	27.25 ± 0.89	27.25 ± 0.89
	2021-2040	1.09 ± 0.07	1.25 ± 0.07	1.42 ± 0.09	1.11 ± 0.06
	2041-2060	1.49 ± 0.09	1.81 ± 0.06	2.03 ± 0.07	2.27 ± 0.05
	2080-2099	1.45 ± 0.09	2.56 ± 0.08	4.00 ± 0.14	4.86 ± 0.11
Multi-model P50	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.10 ± 0.07	1.26 ± 0.07	1.43 ± 0.09	1.11 ± 0.06
	2041-2060	1.52 ± 0.10	1.82 ± 0.06	2.04 ± 0.07	2.28 ± 0.05
	2080-2099	1.46 ± 0.10	2.58 ± 0.08	4.02 ± 0.14	4.90 ± 0.11
Multi-model minimum	Baseline	26.80 ± 0.92	26.80 ± 0.92	26.80 ± 0.92	26.80 ± 0.92
	2021-2040	0.52 ± 0.15	0.86 ± 0.13	0.75 ± 0.10	0.69 ± 0.12
	2041-2060	0.98 ± 0.14	1.34 ± 0.10	1.54 ± 0.15	1.76 ± 0.15
	2080-2099	0.87 ± 0.13	1.89 ± 0.21	3.31 ± 0.17	3.66 ± 0.24
Multi-model P5	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.48 ± 0.09	0.77 ± 0.15	0.71 ± 0.11	0.66 ± 0.11
	2041-2060	0.85 ± 0.12	1.14 ± 0.08	1.46 ± 0.12	1.76 ± 0.08
	2080-2099	0.95 ± 0.12	1.69 ± 0.16	3.06 ± 0.19	3.58 ± 0.16
Multi-model maximum	Baseline	27.60 ± 0.87	27.60 ± 0.87	27.60 ± 0.87	27.60 ± 0.87
	2021-2040	1.63 ± 0.14	1.80 ± 0.16	2.08 ± 0.18	1.52 ± 0.16
	2041-2060	2.15 ± 0.15	2.66 ± 0.21	2.64 ± 0.11	2.75 ± 0.10
	2080-2099	1.89 ± 0.11	3.46 ± 0.15	5.13 ± 0.22	6.17 ± 0.21
Multi-model P95	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.77 ± 0.15	1.80 ± 0.14	2.25 ± 0.16	1.58 ± 0.14
	2041-2060	2.28 ± 0.19	2.59 ± 0.17	2.68 ± 0.11	2.86 ± 0.09
	2080-2099	2.05 ± 0.16	3.58 ± 0.15	5.12 ± 0.15	6.41 ± 0.14

Table 5: The statistics of the projected changes in temperature on the hottest day of the year in units of °C over the Tararua region. Baseline values are shown in absolute units while values for each of the three future periods are shown as changes from the baseline. This variable is not seasonal and so the results shown here are for the whole year. The uncertainties on each value are indicative of the *spatial spread* of the values across the region, not the inter-model spread. The inter-model spread should be diagnosed from the multi-model minimum (and its associated 5th percentile row) and the multi-model maximum (and its associated 95th percentiles).

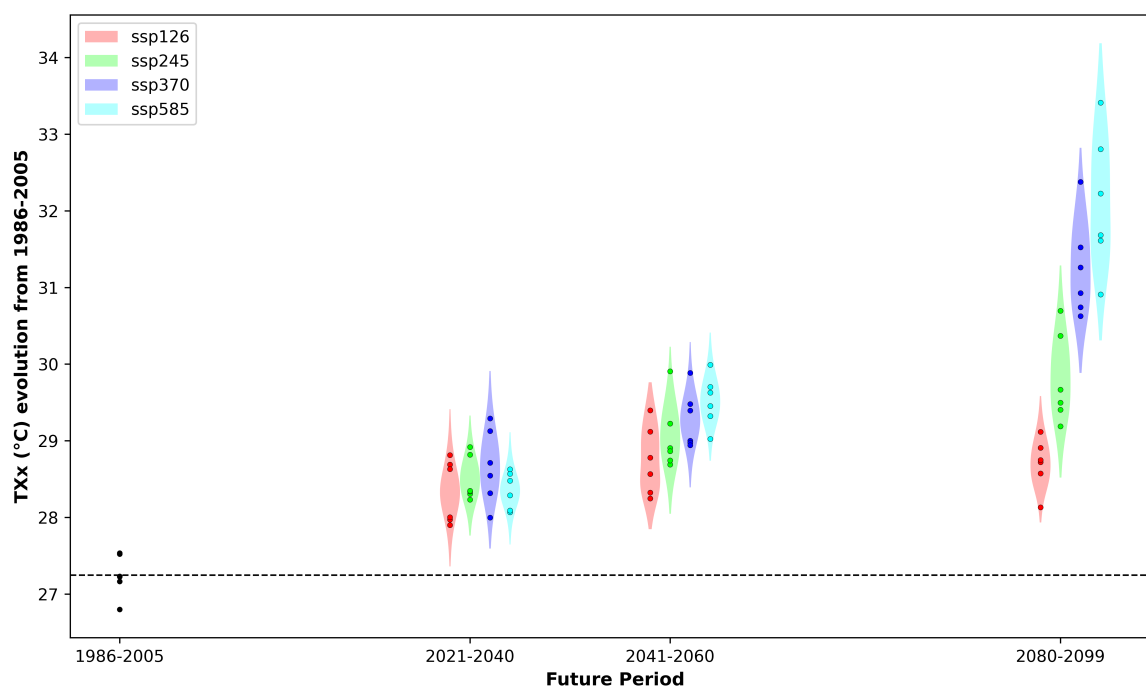


Figure 23: The time evolution of temperature on the hottest day of the year from the 1986-2005 baseline in units of °C over the Tararua region. This variable is not seasonal and so the results shown here are for the whole year. The violin plots show indicative uncertainties derived using the ECS-based uncertainty analysis explained in the main report. Small circles show the individual model values extracted from the data files provided by MfE. The projections under the different SSP scenarios are shown in different colours. The change values for future periods, extracted from the data files, are offset by the *mean* of the baseline model data. The original of this figure can be downloaded [here](#).

ability in temperature change is low relative to the magnitude of projected warming. It is virtually certain that TXx will increase in Tararua, with the extent of change extremely likely to depend on future emissions.

15.6 Region: Middle Manawatū-Rangitīkei

Area: 1838.51 km²

A plot of the evolution in temperature on the hottest day of the year from the 1986-2005 baseline over this region is shown in Figure 24. The statistical summary of projected changes in temperature on the hottest day of the year over this region is shown in Table 6. Projections for the Middle Manawatū-Rangitīkei region indicate a very likely increase in TXx under all emissions scenarios. By mid-century (2041-2060), multi-model mean increases relative to the 1986-2005 baseline range from about 1.3°C under low emissions (SSP1-2.6) to over 2.1°C under high emissions (SSP5-8.5), with likelihood increasing for higher emissions pathways. By late century (2080-2099), projected warming diverges markedly by scenario, remaining near 1.2°C under SSP1-2.6 but rising to nearly 4.7°C under SSP5-8.5. This indicates divergence in regional outcomes based on global emissions, with high emissions associated with much greater extreme heat.

Model projections are consistent in their direction of change (warming is very likely or extremely likely), though the magnitude of change and its inter-model range increase with time and emissions. The spread across scenarios and models is small for near-term periods but increases substantially after mid-century, with almost no agreement in magnitude by the late 21st century. Spatial variability (intra-region standard deviation) is low in all scenarios and periods, implying robust regional signals and spatial uniformity at the subregional scale. Overall, increases in extreme annual maximum temperatures is virtually certain, but the magnitude remains scenario-dependent, with low confidence in the precise change under divergent futures.



Metric	Period	SSP scenario			
		SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Multi-model mean	Baseline	27.55 ± 1.00	27.55 ± 1.00	27.55 ± 1.00	27.55 ± 1.00
	2021-2040	0.93 ± 0.07	0.93 ± 0.12	1.37 ± 0.08	0.98 ± 0.09
	2041-2060	1.32 ± 0.08	1.75 ± 0.07	1.81 ± 0.13	2.14 ± 0.09
	2080-2099	1.25 ± 0.09	2.35 ± 0.13	3.96 ± 0.12	4.74 ± 0.13
Multi-model P50	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.93 ± 0.07	0.93 ± 0.13	1.37 ± 0.08	0.98 ± 0.09
	2041-2060	1.33 ± 0.08	1.76 ± 0.07	1.82 ± 0.13	2.15 ± 0.09
	2080-2099	1.25 ± 0.09	2.36 ± 0.13	3.98 ± 0.11	4.78 ± 0.13
Multi-model minimum	Baseline	27.19 ± 1.05	27.19 ± 1.05	27.19 ± 1.05	27.19 ± 1.05
	2021-2040	0.40 ± 0.09	0.58 ± 0.15	0.75 ± 0.08	0.50 ± 0.09
	2041-2060	0.96 ± 0.12	1.20 ± 0.08	1.41 ± 0.20	1.81 ± 0.07
	2080-2099	0.85 ± 0.20	1.69 ± 0.15	3.10 ± 0.13	3.78 ± 0.19
Multi-model P5	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.40 ± 0.07	0.38 ± 0.14	0.72 ± 0.08	0.43 ± 0.07
	2041-2060	0.77 ± 0.07	0.89 ± 0.11	1.19 ± 0.19	1.75 ± 0.10
	2080-2099	0.79 ± 0.16	1.35 ± 0.12	3.04 ± 0.15	3.35 ± 0.14
Multi-model maximum	Baseline	27.86 ± 1.03	27.86 ± 1.03	27.86 ± 1.03	27.86 ± 1.03
	2021-2040	1.36 ± 0.10	1.66 ± 0.18	1.94 ± 0.12	1.61 ± 0.23
	2041-2060	2.04 ± 0.16	2.93 ± 0.21	2.63 ± 0.12	2.50 ± 0.20
	2080-2099	1.78 ± 0.08	3.65 ± 0.18	5.10 ± 0.15	6.31 ± 0.16
Multi-model P95	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.43 ± 0.13	1.53 ± 0.17	2.08 ± 0.12	1.56 ± 0.21
	2041-2060	1.95 ± 0.15	2.73 ± 0.18	2.49 ± 0.12	2.59 ± 0.25
	2080-2099	1.71 ± 0.07	3.47 ± 0.17	5.03 ± 0.12	6.42 ± 0.14

Table 6: The statistics of the projected changes in temperature on the hottest day of the year in units of °C over the Middle Manawatū-Rangitīkei region. Baseline values are shown in absolute units while values for each of the three future periods are shown as changes from the baseline. This variable is not seasonal and so the results shown here are for the whole year. The uncertainties on each value are indicative of the *spatial spread* of the values across the region, not the inter-model spread. The inter-model spread should be diagnosed from the multi-model minimum (and its associated 5th percentile row) and the multi-model maximum (and its associated 95th percentiles).

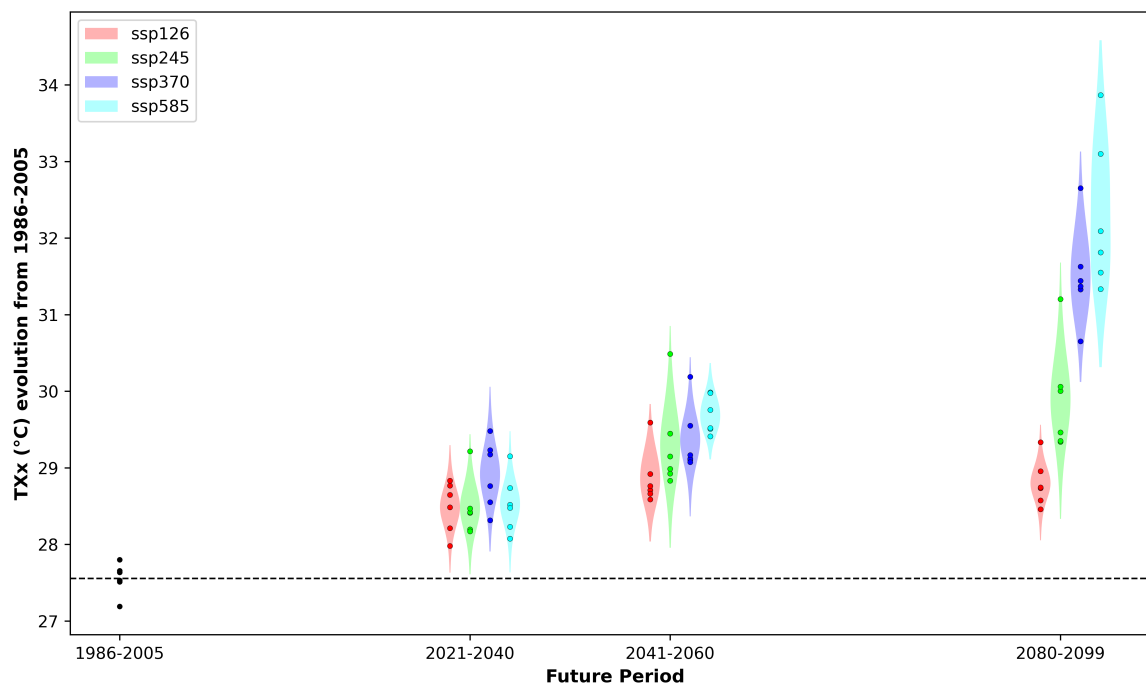


Figure 24: The time evolution of temperature on the hottest day of the year from the 1986-2005 baseline in units of °C over the Middle Manawātū-Rangitīkei region. This variable is not seasonal and so the results shown here are for the whole year. The violin plots show indicative uncertainties derived using the ECS-based uncertainty analysis explained in the main report. Small circles show the individual model values extracted from the data files provided by MfE. The projections under the different SSP scenarios are shown in shown in different colours. The change values for future periods, extracted from the data files, are offset by the *mean* of the baseline model data. The original of this figure can be downloaded [here](#).

15.7 Region: Horowhenua

Area: 448.71 km²

A plot of the evolution in temperature on the hottest day of the year from the 1986-2005 baseline over this region is shown in Figure 25. The statistical summary of projected changes in temperature on the hottest day of the year over this region is shown in Table 7. Projected changes in TXx for Horowhenua show a clear increasing trend throughout the 21st century, with the magnitude of change strongly dependent on emissions scenario. By 2021–2040, all scenarios indicate a likely increase of roughly 0.7–1.3°C above the 1986–2005 baseline. The spatial variability across the region (as measured by the standard deviation) is low for all scenarios, indicating this warming is spatially consistent within Horowhenua.

Further into the future, scenario dependence becomes pronounced. For 2080–2099, SSP1-2.6 (low emissions) projects a small increase (~1.1°C), while SSP3-7.0 and SSP5-8.5 (high emissions) show much greater increases (~3.8°C and ~4.5°C, respectively). The low inter-model spread for lower emissions scenarios suggests very high confidence in moderate increases in TXx, but the higher emissions pathways exhibit more variability, as shown in the wider violin plot distributions and larger spatial standard deviations.

Inter-model agreement decreases substantially over time (agreement drops to 0% by 2080–2099), reflecting greater uncertainty in extreme scenarios. Nevertheless, it is extremely likely that Horowhenua will experience higher annual temperature maxima regardless of pathway, and virtually certain under higher emissions. Overall, these results provide high confidence in the sign and pattern of change, with increasing likelihood and magnitude of extremes under less mitigated futures.



Metric	Period	SSP scenario			
		SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Multi-model mean	Baseline	27.36 ± 1.22	27.36 ± 1.22	27.36 ± 1.22	27.36 ± 1.22
	2021-2040	0.83 ± 0.04	0.74 ± 0.11	1.27 ± 0.10	0.86 ± 0.07
	2041-2060	1.22 ± 0.08	1.78 ± 0.05	1.60 ± 0.05	2.01 ± 0.11
	2080-2099	1.12 ± 0.06	2.23 ± 0.07	3.77 ± 0.21	4.53 ± 0.14
Multi-model P50	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.82 ± 0.05	0.75 ± 0.11	1.28 ± 0.10	0.86 ± 0.07
	2041-2060	1.23 ± 0.08	1.79 ± 0.05	1.61 ± 0.05	2.01 ± 0.12
	2080-2099	1.12 ± 0.06	2.24 ± 0.07	3.79 ± 0.21	4.57 ± 0.14
Multi-model minimum	Baseline	27.03 ± 1.24	27.03 ± 1.24	27.03 ± 1.24	27.03 ± 1.24
	2021-2040	0.35 ± 0.18	0.30 ± 0.05	0.67 ± 0.13	0.56 ± 0.11
	2041-2060	0.57 ± 0.26	1.18 ± 0.10	0.82 ± 0.09	1.65 ± 0.20
	2080-2099	0.58 ± 0.12	1.42 ± 0.06	2.81 ± 0.13	3.48 ± 0.18
Multi-model P5	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.32 ± 0.21	0.18 ± 0.06	0.62 ± 0.17	0.54 ± 0.10
	2041-2060	0.49 ± 0.15	0.98 ± 0.05	0.73 ± 0.07	1.58 ± 0.19
	2080-2099	0.57 ± 0.08	1.22 ± 0.07	2.77 ± 0.24	3.13 ± 0.13
Multi-model maximum	Baseline	28.02 ± 1.34	28.02 ± 1.34	28.02 ± 1.34	28.02 ± 1.34
	2021-2040	1.19 ± 0.12	1.36 ± 0.30	1.92 ± 0.12	1.14 ± 0.09
	2041-2060	2.12 ± 0.16	2.87 ± 0.18	2.51 ± 0.10	2.40 ± 0.11
	2080-2099	1.77 ± 0.14	3.55 ± 0.08	4.97 ± 0.15	6.22 ± 0.24
Multi-model P95	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.28 ± 0.12	1.37 ± 0.27	1.99 ± 0.07	1.17 ± 0.07
	2041-2060	1.99 ± 0.11	2.65 ± 0.16	2.55 ± 0.07	2.44 ± 0.13
	2080-2099	1.68 ± 0.08	3.35 ± 0.10	4.91 ± 0.19	6.22 ± 0.19

Table 7: The statistics of the projected changes in temperature on the hottest day of the year in units of °C over the Horowhenua region. Baseline values are shown in absolute units while values for each of the three future periods are shown as changes from the baseline. This variable is not seasonal and so the results shown here are for the whole year. The uncertainties on each value are indicative of the *spatial spread* of the values across the region, not the inter-model spread. The inter-model spread should be diagnosed from the multi-model minimum (and its associated 5th percentile row) and the multi-model maximum (and its associated 95th percentiles).

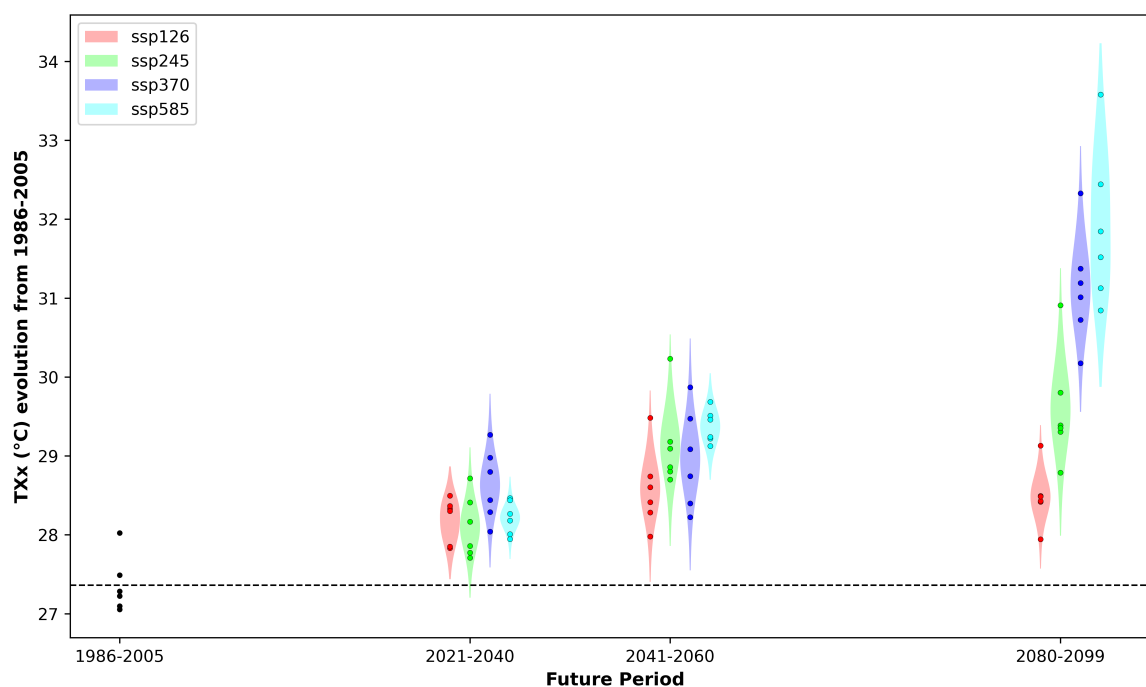


Figure 25: The time evolution of temperature on the hottest day of the year from the 1986-2005 baseline in units of °C over the Horowhenua region. This variable is not seasonal and so the results shown here are for the whole year. The violin plots show indicative uncertainties derived using the ECS-based uncertainty analysis explained in the main report. Small circles show the individual model values extracted from the data files provided by MfE. The projections under the different SSP scenarios are shown in shown in different colours. The change values for future periods, extracted from the data files, are offset by the *mean* of the baseline model data. The original of this figure can be downloaded [here](#).

15.8 Region: Whanganui-Manawatū Lakes

Area: 623.11 km²

A plot of the evolution in temperature on the hottest day of the year from the 1986-2005 baseline over this region is shown in Figure 26. The statistical summary of projected changes in temperature on the hottest day of the year over this region is shown in Table 8. Projections for the Whanganui-Manawatū Lakes region indicate a likely future increase in TXx throughout the 21st century, with the magnitude of change highly dependent on emissions scenario. For the near-term (2021–2040), all scenarios show a likely increase in TXx of about 0.8–1.2°C above the 1986–2005 baseline, with high inter-model and scenario agreement, yielding very likely outcomes. By mid-century (2041–2060), the spread between low (SSP1-2.6) and high (SSP5-8.5) scenarios increases; TXx rises by approximately 1.2°C (SSP1-2.6) to 1.9°C (SSP5-8.5). By the end of the century (2080–2099), the divergence becomes pronounced: under low emissions (SSP1-2.6) TXx increases by just over 1.1°C, while under high emissions (SSP5-8.5) it is projected to rise by 4.4°C, making such increases extremely likely under high-emission scenarios. Very low scenario agreement late in the century and greater inter-model spread under high emissions reflect increased uncertainty, but the direction of change is virtually certain. The spatial variability (standard deviation) of projections remains relatively small compared to the projected changes, strengthening confidence in the regional signal. Overall, the results underscore that mitigation significantly reduces extreme temperature increases for Whanganui-Manawatū Lakes.

15.9 Region: Coastal Whanganui

Area: 1048.57 km²

A plot of the evolution in temperature on the hottest day of the year from the 1986-2005 baseline over this region is shown in Figure 27. The statistical summary of projected changes in temperature on the hottest day

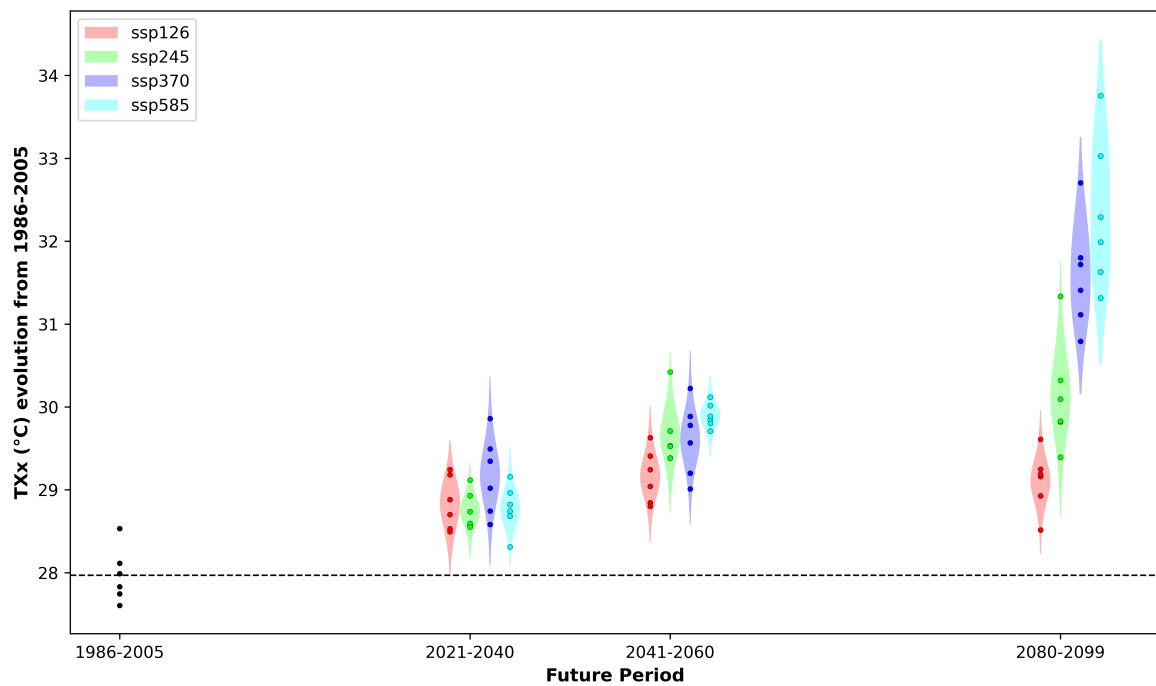


Figure 26: The time evolution of temperature on the hottest day of the year from the 1986-2005 baseline in units of °C over the Whanganui-Manawātū Lakes region. This variable is not seasonal and so the results shown here are for the whole year. The violin plots show indicative uncertainties derived using the ECS-based uncertainty analysis explained in the main report. Small circles show the individual model values extracted from the data files provided by MfE. The projections under the different SSP scenarios are shown in shown in different colours. The change values for future periods, extracted from the data files, are offset by the *mean* of the baseline model data. The original of this figure can be downloaded [here](#).

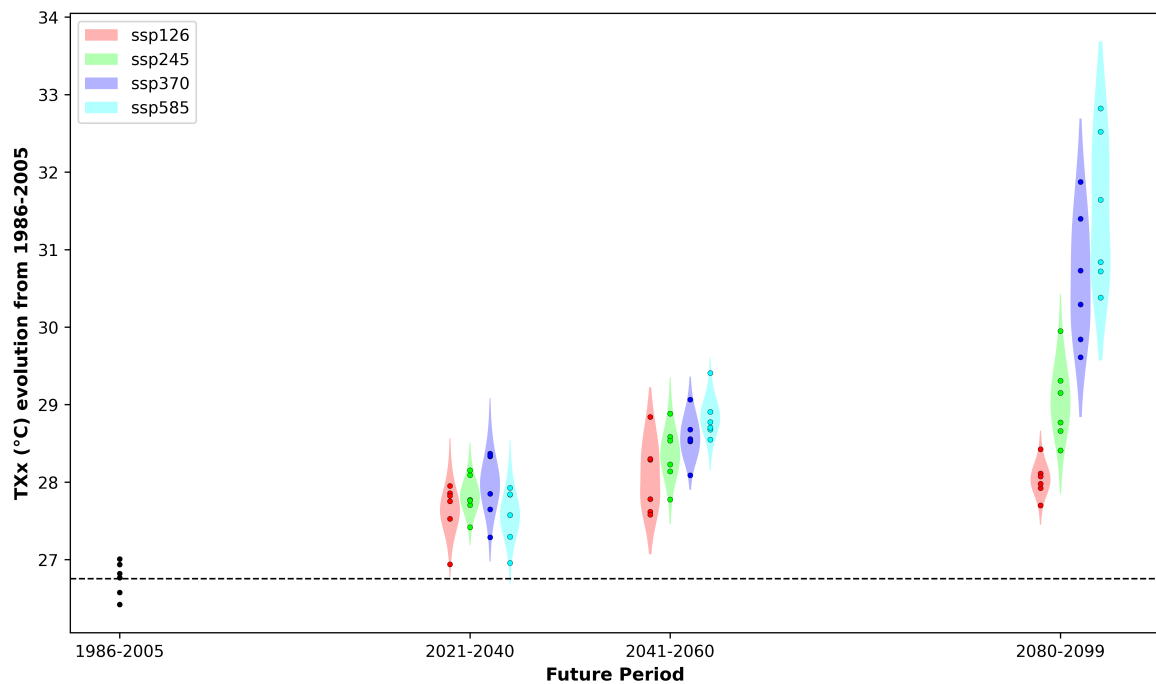


Figure 27: The time evolution of temperature on the hottest day of the year from the 1986-2005 baseline in units of °C over the Coastal Whanganui region. This variable is not seasonal and so the results shown here are for the whole year. The violin plots show indicative uncertainties derived using the ECS-based uncertainty analysis explained in the main report. Small circles show the individual model values extracted from the data files provided by MfE. The projections under the different SSP scenarios are shown in shown in different colours. The change values for future periods, extracted from the data files, are offset by the *mean* of the baseline model data. The original of this figure can be downloaded [here](#).



Metric	Period	SSP scenario			
		SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Multi-model mean	Baseline	27.97 ± 0.41	27.97 ± 0.41	27.97 ± 0.41	27.97 ± 0.41
	2021-2040	0.87 ± 0.09	0.78 ± 0.17	1.20 ± 0.10	0.81 ± 0.08
	2041-2060	1.19 ± 0.13	1.69 ± 0.07	1.64 ± 0.16	1.93 ± 0.15
	2080-2099	1.14 ± 0.11	2.16 ± 0.10	3.62 ± 0.16	4.36 ± 0.18
Multi-model P50	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.86 ± 0.09	0.78 ± 0.17	1.21 ± 0.10	0.81 ± 0.08
	2041-2060	1.20 ± 0.13	1.69 ± 0.07	1.64 ± 0.16	1.93 ± 0.15
	2080-2099	1.14 ± 0.11	2.17 ± 0.09	3.64 ± 0.17	4.41 ± 0.19
Multi-model minimum	Baseline	27.60 ± 0.42	27.60 ± 0.42	27.60 ± 0.42	27.60 ± 0.42
	2021-2040	0.39 ± 0.07	0.49 ± 0.19	0.61 ± 0.17	0.34 ± 0.11
	2041-2060	0.69 ± 0.23	1.28 ± 0.15	1.01 ± 0.31	1.66 ± 0.19
	2080-2099	0.55 ± 0.29	1.42 ± 0.22	2.80 ± 0.18	3.35 ± 0.19
Multi-model P5	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.30 ± 0.11	0.42 ± 0.22	0.53 ± 0.21	0.38 ± 0.06
	2041-2060	0.70 ± 0.22	1.11 ± 0.18	1.01 ± 0.30	1.61 ± 0.20
	2080-2099	0.60 ± 0.25	1.25 ± 0.21	2.65 ± 0.16	3.07 ± 0.19
Multi-model maximum	Baseline	28.53 ± 0.56	28.53 ± 0.56	28.53 ± 0.56	28.53 ± 0.56
	2021-2040	1.33 ± 0.09	1.17 ± 0.19	1.89 ± 0.13	1.23 ± 0.14
	2041-2060	1.69 ± 0.26	2.47 ± 0.26	2.25 ± 0.17	2.23 ± 0.12
	2080-2099	1.65 ± 0.12	3.37 ± 0.14	4.73 ± 0.21	5.79 ± 0.30
Multi-model P95	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.36 ± 0.11	1.14 ± 0.19	1.95 ± 0.06	1.27 ± 0.13
	2041-2060	1.72 ± 0.18	2.31 ± 0.19	2.30 ± 0.11	2.22 ± 0.12
	2080-2099	1.66 ± 0.07	3.18 ± 0.10	4.77 ± 0.21	5.93 ± 0.24

Table 8: The statistics of the projected changes in temperature on the hottest day of the year in units of °C over the Whanganui-Manawātū Lakes region. Baseline values are shown in absolute units while values for each of the three future periods are shown as changes from the baseline. This variable is not seasonal and so the results shown here are for the whole year. The uncertainties on each value are indicative of the *spatial spread* of the values across the region, not the inter-model spread. The inter-model spread should be diagnosed from the multi-model minimum (and its associated 5th percentile row) and the multi-model maximum (and its associated 95th percentiles).



of the year over this region is shown in Table 9. Projections of TXx for Coastal Whanganui indicate a clear and

Metric	Period	SSP scenario			
		SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Multi-model mean	Baseline	26.75 ± 0.55	26.75 ± 0.55	26.75 ± 0.55	26.75 ± 0.55
	2021-2040	0.89 ± 0.06	1.06 ± 0.07	1.22 ± 0.08	0.82 ± 0.08
	2041-2060	1.31 ± 0.09	1.60 ± 0.10	1.82 ± 0.06	2.08 ± 0.09
	2080-2099	1.28 ± 0.05	2.29 ± 0.04	3.87 ± 0.12	4.73 ± 0.12
Multi-model P50	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.89 ± 0.06	1.07 ± 0.07	1.22 ± 0.08	0.82 ± 0.08
	2041-2060	1.34 ± 0.09	1.61 ± 0.09	1.83 ± 0.07	2.09 ± 0.09
	2080-2099	1.28 ± 0.05	2.30 ± 0.04	3.91 ± 0.12	4.80 ± 0.13
Multi-model minimum	Baseline	26.42 ± 0.57	26.42 ± 0.57	26.42 ± 0.57	26.42 ± 0.57
	2021-2040	0.18 ± 0.15	0.66 ± 0.06	0.53 ± 0.18	0.17 ± 0.21
	2041-2060	0.81 ± 0.14	1.02 ± 0.20	1.33 ± 0.09	1.77 ± 0.18
	2080-2099	0.92 ± 0.15	1.65 ± 0.10	2.84 ± 0.21	3.62 ± 0.20
Multi-model P5	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.35 ± 0.10	0.67 ± 0.10	0.59 ± 0.16	0.26 ± 0.14
	2041-2060	0.61 ± 0.16	1.03 ± 0.11	1.37 ± 0.08	1.65 ± 0.16
	2080-2099	0.91 ± 0.09	1.51 ± 0.07	2.62 ± 0.16	3.32 ± 0.11
Multi-model maximum	Baseline	27.05 ± 0.51	27.05 ± 0.51	27.05 ± 0.51	27.05 ± 0.51
	2021-2040	1.27 ± 0.17	1.43 ± 0.12	1.70 ± 0.07	1.26 ± 0.17
	2041-2060	2.09 ± 0.09	2.17 ± 0.15	2.31 ± 0.08	2.65 ± 0.10
	2080-2099	1.67 ± 0.06	3.20 ± 0.07	5.12 ± 0.06	6.07 ± 0.22
Multi-model P95	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.46 ± 0.09	1.50 ± 0.09	1.92 ± 0.06	1.43 ± 0.11
	2041-2060	2.16 ± 0.13	2.23 ± 0.09	2.35 ± 0.10	2.57 ± 0.06
	2080-2099	1.68 ± 0.05	3.19 ± 0.10	5.37 ± 0.12	6.47 ± 0.27

Table 9: The statistics of the projected changes in temperature on the hottest day of the year in units of °C over the Coastal Whanganui region. Baseline values are shown in absolute units while values for each of the three future periods are shown as changes from the baseline. This variable is not seasonal and so the results shown here are for the whole year. The uncertainties on each value are indicative of the *spatial spread* of the values across the region, not the inter-model spread. The inter-model spread should be diagnosed from the multi-model minimum (and its associated 5th percentile row) and the multi-model maximum (and its associated 95th percentiles).

persistent warming signal across all emission scenarios and future periods. By mid-century (2041-2060), mean increases relative to the 1986-2005 baseline are likely, ranging from approximately 1.3°C under SSP1-2.6 to just above 2.1°C under SSP5-8.5. These increases in TXx accelerate towards the end of the century (2080-2099), with the largest increases (very likely) under high emissions (SSP5-8.5), exceeding 4.7°C. Lower emission scenarios project more modest increases (~1.3°C under SSP1-2.6), but all scenarios indicate continued increases in TXx, making higher maximum annual temperatures virtually certain for the region.

Inter-model spread, as seen in the violin plots, is moderate but grows notably under higher emission scenarios, especially by century's end. The model agreement across all SSPs is high for near-term periods but declines with time, with scenario agreement falling to zero by 2080-2099, reflecting high dependence on future emissions. Spatial variability of projected changes within Coastal Whanganui remains low to moderate throughout, with only slight increases in variability under the most extreme scenario.

Overall, it is extremely likely that the region will experience higher annual temperature extremes, with the magnitude closely linked to emissions pathway and high confidence in a significant upward trend.



15.10 Region: Turakina

Area: 1237.15 km²

A plot of the evolution in temperature on the hottest day of the year from the 1986-2005 baseline over this region is shown in Figure 28. The statistical summary of projected changes in temperature on the hottest

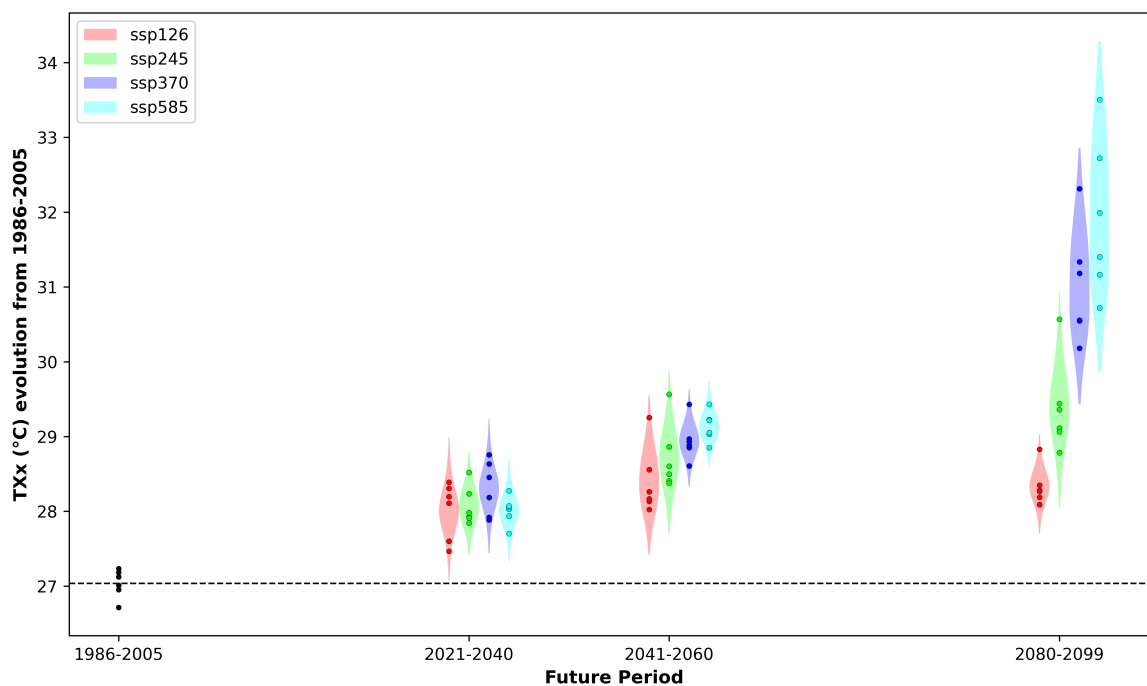


Figure 28: The time evolution of temperature on the hottest day of the year from the 1986-2005 baseline in units of °C over the Turakina region. This variable is not seasonal and so the results shown here are for the whole year. The violin plots show indicative uncertainties derived using the ECS-based uncertainty analysis explained in the main report. Small circles show the individual model values extracted from the data files provided by MfE. The projections under the different SSP scenarios are shown in different colours. The change values for future periods, extracted from the data files, are offset by the *mean* of the baseline model data. The original of this figure can be downloaded [here](#).

day of the year over this region is shown in Table 10. The Turakina sub-region is projected to experience a clear increase in TXx relative to the 1986–2005 baseline. For the near-term period (2021–2040), all emission scenarios show increases in TXx of approximately 1°C, with very likely high agreement across models for this period. By mid-century (2041–2060), projected changes diverge more strongly between scenarios, with mean increases ranging from around 1.4°C (SSP1-2.6) to 2.1°C (SSP5-8.5), indicating a likely scenario-dependent signal. End-of-century projections (2080–2099) show even greater separation: a modest increase remains under SSP1-2.6 (~1.3°C), while TXx increases reach nearly 4°C (SSP3-7.0) and nearly 5°C (SSP5-8.5), making such strong warming extremely likely under high-emission futures. The inter-model spread (as indicated by the violin plots and supported by spatial standard deviation values well below 0.1°C for most futures) suggests robust model agreement within scenarios, especially for near-term and low-emissions cases. However, scenario agreement drops to zero by century's end, highlighting substantial uncertainty driven by emissions pathway. In summary, substantial and very likely increases in hottest-day temperatures are projected for Turakina, with extremely likely greater warming if high global emissions persist.

15.11 Region: Puketoi ki Tai

Area: 966.64 km²

A plot of the evolution in temperature on the hottest day of the year from the 1986-2005 baseline over this region is shown in Figure 29. The statistical summary of projected changes in temperature on the hottest day



Metric	Period	SSP scenario			
		SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Multi-model mean	Baseline	27.04 ± 0.56	27.04 ± 0.56	27.04 ± 0.56	27.04 ± 0.56
	2021-2040	0.97 ± 0.05	1.03 ± 0.08	1.27 ± 0.04	0.97 ± 0.06
	2041-2060	1.36 ± 0.05	1.68 ± 0.05	1.91 ± 0.03	2.10 ± 0.07
	2080-2099	1.30 ± 0.05	2.35 ± 0.03	3.98 ± 0.04	4.88 ± 0.08
Multi-model P50	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.98 ± 0.04	1.04 ± 0.08	1.27 ± 0.04	0.98 ± 0.06
	2041-2060	1.38 ± 0.05	1.69 ± 0.04	1.91 ± 0.03	2.10 ± 0.07
	2080-2099	1.30 ± 0.05	2.36 ± 0.03	4.01 ± 0.04	4.93 ± 0.08
Multi-model minimum	Baseline	26.72 ± 0.56	26.72 ± 0.56	26.72 ± 0.56	26.72 ± 0.56
	2021-2040	0.39 ± 0.08	0.74 ± 0.07	0.74 ± 0.08	0.53 ± 0.13
	2041-2060	0.95 ± 0.08	1.24 ± 0.07	1.57 ± 0.08	1.76 ± 0.18
	2080-2099	1.01 ± 0.15	1.75 ± 0.08	3.10 ± 0.08	3.68 ± 0.10
Multi-model P5	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.40 ± 0.06	0.61 ± 0.09	0.73 ± 0.08	0.55 ± 0.11
	2041-2060	0.71 ± 0.12	1.02 ± 0.09	1.52 ± 0.11	1.76 ± 0.18
	2080-2099	0.90 ± 0.15	1.48 ± 0.08	2.88 ± 0.07	3.41 ± 0.08
Multi-model maximum	Baseline	27.35 ± 0.51	27.35 ± 0.51	27.35 ± 0.51	27.35 ± 0.51
	2021-2040	1.47 ± 0.12	1.53 ± 0.10	1.76 ± 0.09	1.44 ± 0.20
	2041-2060	2.22 ± 0.11	2.54 ± 0.11	2.40 ± 0.18	2.41 ± 0.11
	2080-2099	1.79 ± 0.09	3.53 ± 0.13	5.27 ± 0.12	6.47 ± 0.20
Multi-model P95	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.58 ± 0.08	1.51 ± 0.14	1.84 ± 0.10	1.41 ± 0.15
	2041-2060	2.13 ± 0.10	2.44 ± 0.06	2.35 ± 0.13	2.48 ± 0.14
	2080-2099	1.73 ± 0.10	3.34 ± 0.09	5.30 ± 0.08	6.66 ± 0.17

Table 10: The statistics of the projected changes in temperature on the hottest day of the year in units of °C over the Turakina region. Baseline values are shown in absolute units while values for each of the three future periods are shown as changes from the baseline. This variable is not seasonal and so the results shown here are for the whole year. The uncertainties on each value are indicative of the *spatial spread* of the values across the region, not the inter-model spread. The inter-model spread should be diagnosed from the multi-model minimum (and its associated 5th percentile row) and the multi-model maximum (and its associated 95th percentiles).

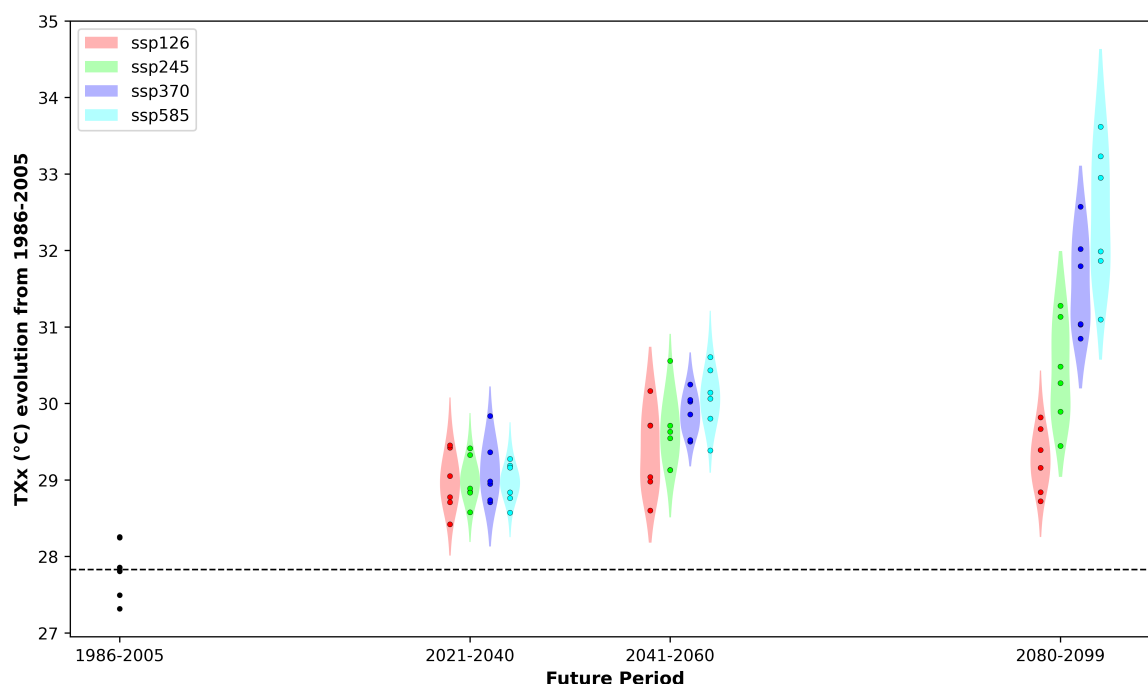


Figure 29: The time evolution of temperature on the hottest day of the year from the 1986-2005 baseline in units of °C over the Puketoi ki Tai region. This variable is not seasonal and so the results shown here are for the whole year. The violin plots show indicative uncertainties derived using the ECS-based uncertainty analysis explained in the main report. Small circles show the individual model values extracted from the data files provided by MfE. The projections under the different SSP scenarios are shown in shown in different colours. The change values for future periods, extracted from the data files, are offset by the *mean* of the baseline model data. The original of this figure can be downloaded [here](#).

of the year over this region is shown in Table 11. Projected changes in TXx for Puketoi ki Tai show a clear signal of increasing TXx which is very likely over the 21st century. For the near term (2021–2040), increases in TXx are projected in all scenarios, with multi-model means of about 1.1–1.3°C above the 1986–2005 baseline. Agreement across scenarios is high for this period (agreement ~78%), providing high confidence in the warming signal. By mid-century (2041–2060), the magnitude of projected warming becomes more differentiated by scenario, with TXx increases ranging from approximately 1.5°C (SSP1-2.6) to 2.2°C (SSP5-8.5). Agreement across scenarios drops to moderate levels (~35%), reflecting increased scenario dependence.

By late-century (2080–2099), scenario spread widens substantially: TXx is projected to rise by around 1.4°C under low emissions (SSP1-2.6), but up to 4.6°C under high emissions (SSP5-8.5). Agreement across scenarios is effectively absent at this range, underpinning the dominant influence of emissions pathway choices on long-term extremes. Across all scenarios and timeframes, inter-model spread is moderate; spatial variability is low relative to the magnitude of change. It is virtually certain that TXx in Puketoi ki Tai will continue to increase, with the magnitude of change depending strongly on future emissions.

15.12 Region: Middle Whangaehu-Whanganui

Area: 1816.56 km²

A plot of the evolution in temperature on the hottest day of the year from the 1986-2005 baseline over this region is shown in Figure 30. The statistical summary of projected changes in temperature on the hottest day of the year over this region is shown in Table 12. The climate projections for the Middle Whangaehu-Whanganui sub-region indicate clear increasing TXx trends throughout the 21st century. All scenarios show a likely increase in TXx relative to the 1986–2005 baseline, with the degree of warming dependant on the emissions pathway. For 2021–2040, all scenarios project an increase of around 1°C, reflecting very likely and robust increases in TXx, and high inter-model agreement. By 2041–2060, the mean increase strengthens, ranging from roughly



Metric	Period	SSP scenario			
		SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Multi-model mean	Baseline	27.83 ± 0.75	27.83 ± 0.75	27.83 ± 0.75	27.83 ± 0.75
	2021-2040	1.14 ± 0.07	1.15 ± 0.08	1.27 ± 0.13	1.14 ± 0.07
	2041-2060	1.54 ± 0.07	1.79 ± 0.11	2.04 ± 0.09	2.24 ± 0.10
	2080-2099	1.44 ± 0.05	2.59 ± 0.08	3.72 ± 0.18	4.63 ± 0.11
Multi-model P50	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.15 ± 0.07	1.16 ± 0.08	1.28 ± 0.13	1.14 ± 0.07
	2041-2060	1.57 ± 0.08	1.80 ± 0.11	2.05 ± 0.09	2.25 ± 0.10
	2080-2099	1.45 ± 0.05	2.63 ± 0.08	3.76 ± 0.18	4.68 ± 0.11
Multi-model minimum	Baseline	27.30 ± 0.79	27.30 ± 0.79	27.30 ± 0.79	27.30 ± 0.79
	2021-2040	0.57 ± 0.16	0.71 ± 0.10	0.79 ± 0.12	0.66 ± 0.13
	2041-2060	0.75 ± 0.08	1.23 ± 0.17	1.58 ± 0.12	1.54 ± 0.09
	2080-2099	0.74 ± 0.14	1.62 ± 0.20	2.98 ± 0.20	3.27 ± 0.12
Multi-model P5	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.51 ± 0.07	0.65 ± 0.11	0.62 ± 0.09	0.69 ± 0.11
	2041-2060	0.69 ± 0.07	1.05 ± 0.19	1.57 ± 0.09	1.61 ± 0.07
	2080-2099	0.77 ± 0.12	1.58 ± 0.14	2.75 ± 0.18	3.27 ± 0.17
Multi-model maximum	Baseline	28.34 ± 0.76	28.34 ± 0.76	28.34 ± 0.76	28.34 ± 0.76
	2021-2040	1.73 ± 0.09	1.68 ± 0.11	2.06 ± 0.23	1.51 ± 0.07
	2041-2060	2.34 ± 0.10	2.73 ± 0.10	2.43 ± 0.14	2.79 ± 0.22
	2080-2099	2.00 ± 0.12	3.46 ± 0.07	4.74 ± 0.25	5.79 ± 0.13
Multi-model P95	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.87 ± 0.12	1.72 ± 0.09	2.03 ± 0.21	1.63 ± 0.08
	2041-2060	2.56 ± 0.13	2.66 ± 0.10	2.59 ± 0.12	2.98 ± 0.21
	2080-2099	2.21 ± 0.09	3.82 ± 0.16	4.91 ± 0.21	6.28 ± 0.10

Table 11: The statistics of the projected changes in temperature on the hottest day of the year in units of °C over the Puketoi ki Tai region. Baseline values are shown in absolute units while values for each of the three future periods are shown as changes from the baseline. This variable is not seasonal and so the results shown here are for the whole year. The uncertainties on each value are indicative of the *spatial spread* of the values across the region, not the inter-model spread. The inter-model spread should be diagnosed from the multi-model minimum (and its associated 5th percentile row) and the multi-model maximum (and its associated 95th percentiles).



Metric	Period	SSP scenario			
		SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Multi-model mean	Baseline	26.66 ± 0.74	26.66 ± 0.74	26.66 ± 0.74	26.66 ± 0.74
	2021-2040	0.93 ± 0.04	1.01 ± 0.05	1.20 ± 0.04	0.97 ± 0.05
	2041-2060	1.39 ± 0.03	1.71 ± 0.03	1.88 ± 0.02	2.05 ± 0.03
	2080-2099	1.21 ± 0.05	2.34 ± 0.03	4.02 ± 0.03	4.88 ± 0.05
Multi-model P50	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.94 ± 0.04	1.02 ± 0.05	1.20 ± 0.04	0.98 ± 0.05
	2041-2060	1.41 ± 0.03	1.72 ± 0.03	1.89 ± 0.02	2.06 ± 0.03
	2080-2099	1.22 ± 0.05	2.36 ± 0.03	4.06 ± 0.04	4.95 ± 0.05
Multi-model minimum	Baseline	26.27 ± 0.77	26.27 ± 0.77	26.27 ± 0.77	26.27 ± 0.77
	2021-2040	0.38 ± 0.11	0.66 ± 0.09	0.69 ± 0.12	0.64 ± 0.09
	2041-2060	0.94 ± 0.07	1.33 ± 0.06	1.35 ± 0.11	1.72 ± 0.11
	2080-2099	0.82 ± 0.19	1.61 ± 0.12	3.11 ± 0.07	3.57 ± 0.09
Multi-model P5	Baseline	N/A	N/A	N/A	N/A
	2021-2040	0.33 ± 0.06	0.54 ± 0.10	0.67 ± 0.09	0.62 ± 0.08
	2041-2060	0.78 ± 0.08	1.09 ± 0.06	1.42 ± 0.08	1.59 ± 0.14
	2080-2099	0.76 ± 0.13	1.48 ± 0.05	2.83 ± 0.08	3.25 ± 0.08
Multi-model maximum	Baseline	27.03 ± 0.72	27.03 ± 0.72	27.03 ± 0.72	27.03 ± 0.72
	2021-2040	1.59 ± 0.19	1.52 ± 0.17	1.69 ± 0.09	1.32 ± 0.10
	2041-2060	2.10 ± 0.05	2.52 ± 0.09	2.34 ± 0.08	2.58 ± 0.15
	2080-2099	1.75 ± 0.06	3.43 ± 0.12	5.35 ± 0.13	6.53 ± 0.17
Multi-model P95	Baseline	N/A	N/A	N/A	N/A
	2021-2040	1.59 ± 0.09	1.57 ± 0.18	1.76 ± 0.09	1.35 ± 0.08
	2041-2060	2.13 ± 0.09	2.44 ± 0.08	2.43 ± 0.09	2.58 ± 0.12
	2080-2099	1.75 ± 0.08	3.34 ± 0.09	5.47 ± 0.08	6.88 ± 0.13

Table 12: The statistics of the projected changes in temperature on the hottest day of the year in units of °C over the Middle Whangaehu-Whanganui region. Baseline values are shown in absolute units while values for each of the three future periods are shown as changes from the baseline. This variable is not seasonal and so the results shown here are for the whole year. The uncertainties on each value are indicative of the *spatial spread* of the values across the region, not the inter-model spread. The inter-model spread should be diagnosed from the multi-model minimum (and its associated 5th percentile row) and the multi-model maximum (and its associated 95th percentiles).

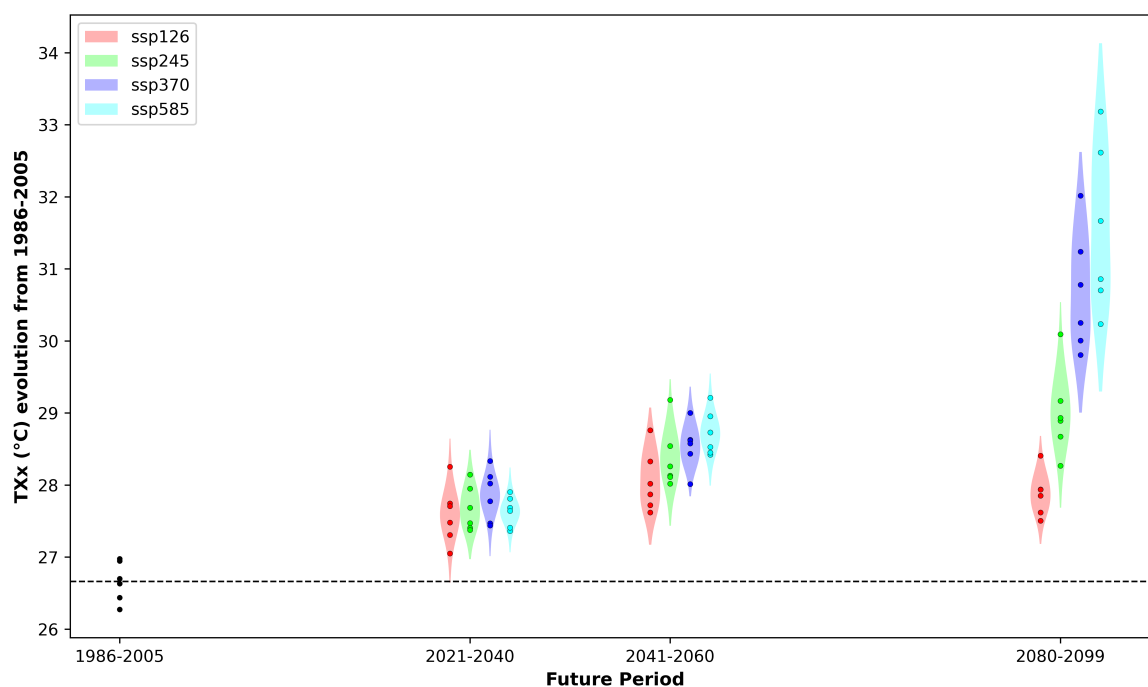


Figure 30: The time evolution of temperature on the hottest day of the year from the 1986-2005 baseline in units of °C over the Middle Whangaehu-Whanganui region. This variable is not seasonal and so the results shown here are for the whole year. The violin plots show indicative uncertainties derived using the ECS-based uncertainty analysis explained in the main report. Small circles show the individual model values extracted from the data files provided by MfE. The projections under the different SSP scenarios are shown in shown in different colours. The change values for future periods, extracted from the data files, are offset by the *mean* of the baseline model data. The original of this figure can be downloaded [here](#).

1.4°C (SSP1-2.6) to just over 2°C (SSP5-8.5), with continued likely warming and slightly increased scenario spread, and lowering overall scenario agreement. Toward century's end (2080–2099), divergence between scenarios becomes pronounced: SSP1-2.6 projects a stabilisation near 1.2°C above the 1986-2005 baseline, while higher emission pathways project increases exceeding 4°C (SSP3-7.0 and SSP5-8.5), with higher spatial variability and a complete loss of scenario agreement. The figure also shows consistent inter-model signals within each scenario, especially for earlier periods and lower emissions. The spatial standard deviation remains modest throughout, suggesting regionally uniform responses. It is virtually certain that TXx will increase in Middle Whangaehu-Whanganui, with the magnitude of future change extremely likely to depend on global emissions trajectories.