TA-9755 GEO: East-West Highway (Shorapani-Argveta Section) Project, Georgia

Climate Risk and Vulnerability Assessment

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FutureWater Report 189

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1 Description of the Project

1.1 Background

Due to its geographic location, Georgia’s role as a major transit country is significant. Transport of goods into and through Georgia has increased over the past 10-15 years. Almost two-thirds of goods in Georgia are transported by road, and haulage by domestic and international truck companies is very evident on the country’s highways. Many of the roads are however poorly equipped to cope with the volume of traffic and the proportion of heavy vehicles, and factors such as insufficient dual carriageways, routing through inhabited areas and inadequate maintenance and repair, hinder throughputs and increase transit times. This creates difficulties for haulage companies and their clients, truck drivers, motorists and residents. The government of Georgia has therefore launched a program to upgrade the major roads of the country, including part of the East-West (E60) Highway. This climate risk and vulnerability assessment (CRVA) examines the proposed components for section Shorapani-Argveta (F4) of the East-West Highway Road Project. The proposed improvement for the Shorapani-Argveta section requires the construction of 12 tunnels (6 double tubes), 14 bridges, 4 interchanges and several deep cuttings and high embankments with a total length of 14.7 km.

1.2 Scope of work

Since 2014, the Asian Development Bank (ADB) has required that all investment projects consider climate and disaster risk and incorporate adaptation measures in projects at-risk from geo-physical and climate change impacts. This is consistent with the ADB’s commitment to scale up support for adaptation and climate resilience in project design and implementation, articulated in the Midterm Review of Strategy 2020: Meeting the Challenges of a Transforming Asia and Pacific (ADB, 2014a), in the Climate Change Operational Framework 2017–2030: Enhancing Actions for Low Greenhouse Gas Emissions and Climate-Resilient Development (ADB, 2017), and in the Climate Risk Management in ADB Projects guidelines (2014b).

The principal objective of a climate risk and vulnerability assessment (CRVA) is to identify those components of the Project that are at risk of failure, damage and/or deterioration from natural hazards, extreme climatic events or significant changes to baseline climate design values (ADB, 2011, 2014 and 2017). This serves to improve the resilience of the infrastructure to the impacts of climate change and geo-physical hazards, to protect communities and provide a safeguard so that infrastructure services are available when they are needed most. As part of this process, the nature and relative levels of risk are evaluated and determined to establish priorities for remedial action.

Working closely with ADB and the project design consultant team (IRD Engineering), a (i) climate screening has been carried out and the sensitivity of the project components to climate and/or weather conditions has been assessed, and (ii) climate risks and adequacy of proposed technical solutions have been assessed.

The following tasks are formulated for this CRVA:

I. In coordination with the project design consultant team: review the current design specifications (i.e. explicit and implicit climate-related assumptions), identify key areas of the design’s vulnerability to climate, and identify key variables/proxies and location(s) to model so that specifications can be tested/updated for climate-proofing over design life;

II. Develop projections for the key variables/proxies and location(s) to [2050] for mid (RCP 4.5) and high (RCP 8.5) scenarios, presenting outcomes that capture model uncertainty of temperature vs. precipitation rather than just the average of the ensemble.

III. In coordination with the project design consultant team: identify a sub-set of those model runs which appropriately captures a range of feasible outcomes against which the current design specifications can be tested and with which the design specifications can be updated and costed.

1.3 The project road

The foreseen Project Road is located west of the Likhi Range which connects the Greater and Lesser Caucus Mountains (see Figure 1). The Project corridor is set within a landscape of mountains, rolling hills and valley plain. The existing road (see Figure 2) is located within the bottom of the river valley and as such the elevation only varies between 200 and 170 meters above sea level. Two main rivers are found within the Project area, the Kvirila and the Dzirula river. The confluence of both rivers occurs in Shorapani adjacent to the Project road. Other small tributaries within the area include the Borimela River (which the Project road crosses), and the Ajamura and Samanishvilisghele rivers, both of which located on the south bank of the Kvirila river at some distance from the Project road. The proposed improvement for the Shorapani-Argveta section F4 East-West Highway requires the construction of 12 tunnels (6 double tubes), 14 bridges, 4 interchanges and several deep cuttings and high embankments with a total length of 14.7 km.

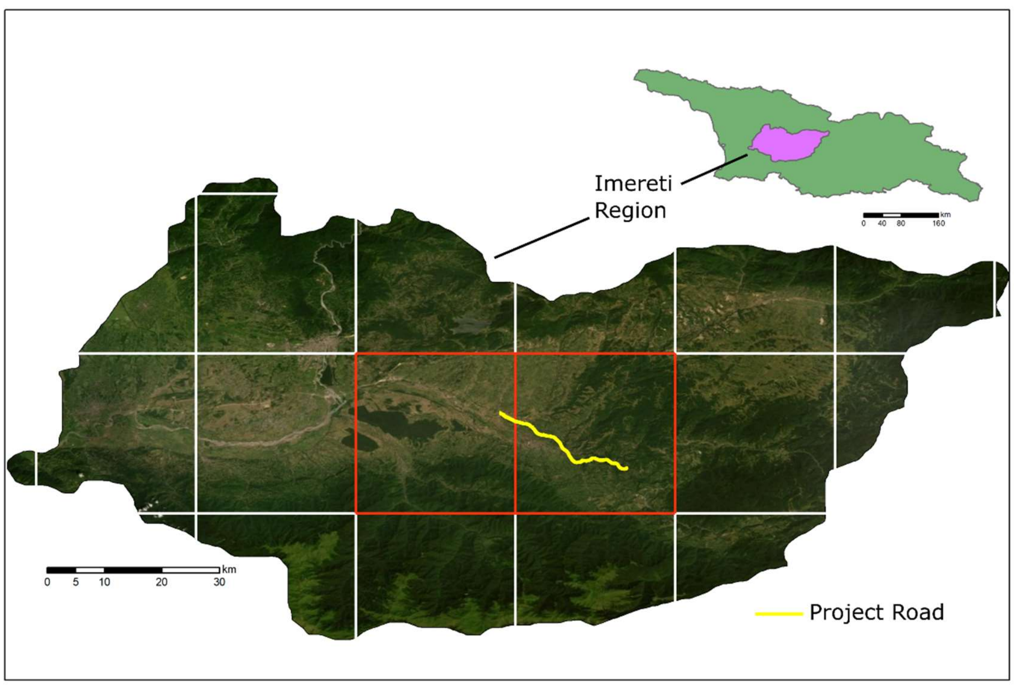

Figure 1. Location of the F4 Shorapani-Argveta section of the East-West Highway Road Project and the NASA-NEX-GDDP data grid.

Figure 2: Impression of current road. (Photo credits: IRD Engineering).

2 Climate Change Projections

2.1 Changes in Climatic Means

Climate change projections for the foreseen location of the Shorapani–Argveta road section of the East-West Highway are constructed using the NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) dataset. This dataset comprises global downscaled climate scenarios that are derived from the General Circulation Model (GCM) runs conducted under the Coupled Model Intercomparison Project Phase 5 (CMIP5) and across two of the four greenhouse gas emissions scenarios known as Representative Concentration Pathways (RCPs). The CMIP5 GCM runs were developed in support of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5). The NASA-NEX-GDDP dataset includes downscaled projections for RCP 4.5 and RCP 8.5[1] from the 21 models and scenarios for which daily scenarios were produced and distributed under CMIP5. Each of the climate projections includes daily maximum temperature, minimum temperature, and precipitation for the periods from 1950 through 2100. For this climate risk and vulnerability assessment (CRVA), the climate projections for the foreseen location of the project road are evaluated for the intermediate future around 2050 (2035 – 2064) and compared to a reference period (1976 – 2005) covering the same time span. The spatial resolution of the dataset is 0.25 degrees (25 km x 25 km at the equator). The full results are presented in Appendix 1, the most relevant projected changes in climatic means are summarized below. (https://nex.nasa.gov/nex/projects/1356/).

2.1.1 Precipitation trends

The analysis of the NASA NEX-GDDP dataset indicates that for precipitation (annual sum) the range in the climate change projections is large, meaning that there is a large uncertainty in the future precipitation. However, in the ensemble mean (top right panel Figure 3) a (weak) trend can be identified for future precipitation compared to the historical reference: under both the RCP 4.5 and RCP 8.5 the annual precipitation sum is expected to increase by about 2 – 3%, from 900 mm/yr to 925 – 935 mm/yr. In both RCP4.5 and RCP8.5, the spread between the GCMs is equally large for the future period, indicating a large uncertainty in the future precipitation under both RCP's (see also Figure 4).

2.1.2 Temperature trends

The analysis of the NASA NEX-GDDP dataset indicates that the air temperature shows strong increasing trends for all GCMs. Under the RCP 4.5, the annual daily maximum temperature is expected to increase on average by about 2.1 degrees from 17.8 to 19.9 degree Celsius (middle right panel in Figure 3). Similarly, but to a lesser degree, the annual daily minimum temperature is expected to increase on average by about 1.8 degrees from 6.4 to 8.2 degree Celsius (bottom right panel in Figure 3). Under the RCP 8.5, an even stronger increasing trend in air temperatures is projected; the annual daily maximum temperature is expected to increase on average by 2.9 degrees from 17.8 to 20.7 degree Celsius. The annual daily minimum temperature is expected to increase on average by 2.5 degrees from 6.4 to 8.9 degree Celsius. The uncertainty range of future temperature is larger for RCP 8.5 compared to RCP 4.5 (see also Figure 4), but under both

[1] Since the release of Intergovernmental Panel on Climate Change's fifth Assessment Report, four representative concentration pathways (RCPs) have been defined as a basis for long-term and near-term climate modeling experiments in the climate modeling community. The four RCPs together span the range of radiative forcing values for the year 2100 as found in literature, from 2.6 to 8.5 Wm^{-2}. Climate modelers use the time series of future radiative forcing from the four RCPs for their climate modeling experiments to produce climate scenarios. RCP4.5 is a medium stabilization scenario implying a stabilization of greenhouse gas concentrations halfway the 21st century and RCP8.5 is a very high baseline emission scenario (business as usual).

RCPs the maximum air temperatures are expected to increase more than minimum air temperatures. This implies a larger diurnal temperature range for the future.

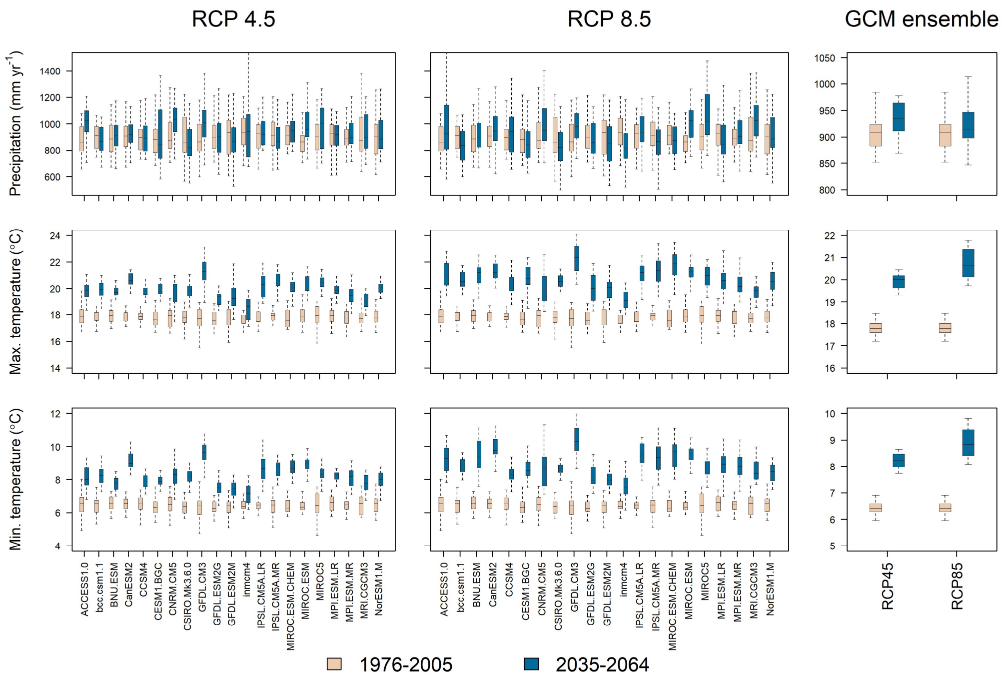

Figure 3. Climate (change) projections for the reference period (1976 – 2005) and intermediate future (2035 – 2064) for the 21 GCMs under RCP 4.5 and RCP 8.5.

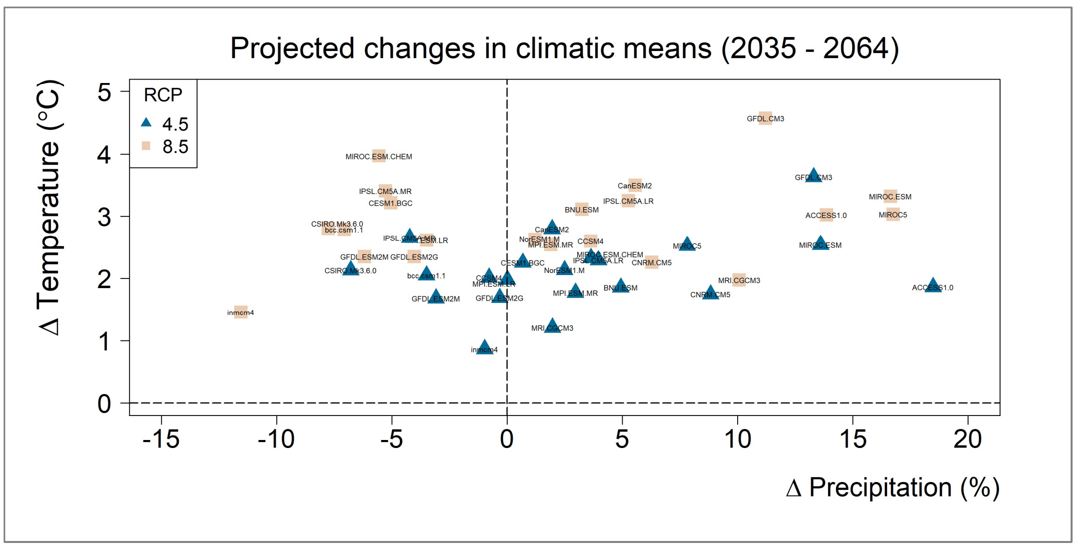

Figure 4. Projected changes in climatic means for the intermediate future (2050) for 21 GCM's under the RCP 4.5 and RCP 8.5.

2.2 Changes in climate extremes

More important to the F4 Shorapani–Argveta road section of the East-West Highway road project are foreseen changes in climatic extremes. Projections for changes in climate extremes have been constructed using the CLIMDEX Climate Extremes Indices (www.climdex.org), which are developed by the Expert Team on Climate Change Detection and Indices (ETCCDI). The 21 downscaled GCMs included in the NASA NEX-GDDP dataset have been used as input to construct the CLIMDEX Climate Extremes Indices. All 27 indices related to precipitation (11) and temperature (16) have been constructed using the GCM ensemble under the RCP 4.5 and RCP 8.5. For both RCPs, one GCM is omitted (ACCESS1-0) because it has projection values too far out of the range of the other GCMs. The full results are presented in Annex 1; the most relevant projected changes in climate extremes are summarized below.

2.2.1 Precipitation extremes

The estimation of changes in precipitation extremes is done for events with return periods of 25, 50, and 100 years, which are used in the project's engineering design. This is done by analyzing the distribution of the percentual change (%) for each downscaled climate model for each of those return periods. Different percentiles of this distribution are considered (5th, 25th, 50th, 75th, 95th), besides the mean of the GCM ensemble, and separately for RCP 4.5 and RCP 8.5.

The analysis indicates that extreme precipitation events in the high tail of the GCM projections are expected to increase in intensity. Considering the large uncertainty in climate modeling and large probability that outliers imply unreliable projections, the 75th percentile value of the GCM ensemble is assumed to provide a robust estimate for sensitivity analysis of project components. For events with 1:50 and 1:100 years return period, the 75th percentile value of the ensemble projects an increase in maximum daily precipitation of about 10% to almost 20% increase under the RCP 4.5 and RCP 8.5 respectively. Therefore, it is advised to do sensitivity tests of project components designed to withstand events of up to 20% increased daily precipitation input.

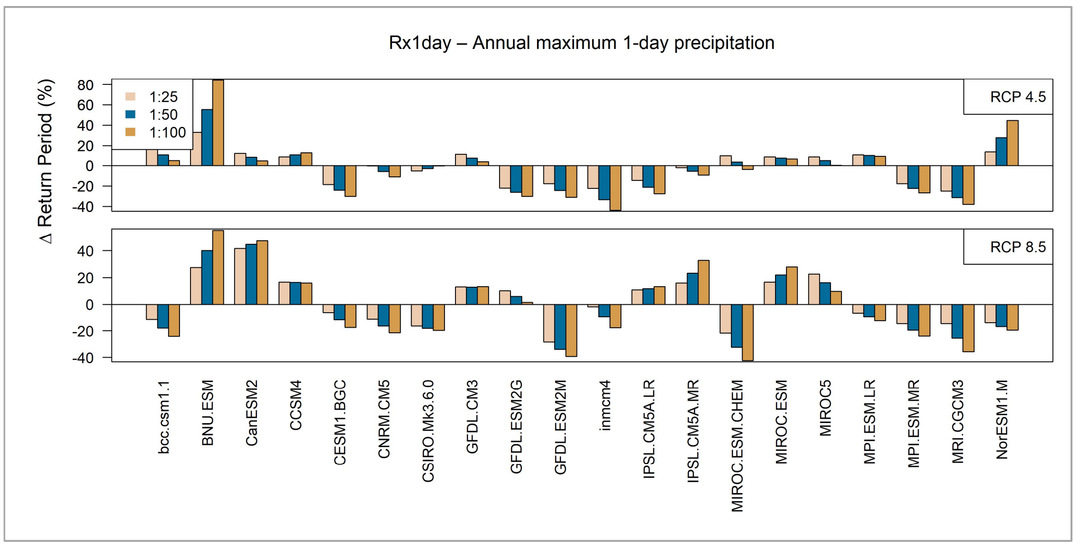

Figure 5. Projected change (%) in return periods of annual maximum 1-day precipitation for the intermediate future (2050) under the RCP 4.5 and RCP 8.5

Table 1. Projected change (%) in different return levels of maximum 1-day precipitation at different percentiles in the GCM model ensemble for RCP 4.5 and RCP 8.5

	Percentile in downscaled GCM ensemble				
RCP 4.5	5th	25th	50th	75th	95th
Δ 1:25 years return level	-22.5	-17.7	4.3	11.3	17.5
Δ 1:50 years return level	-31.5	-22.8	0.2	9.1	29.1
Δ 1:100 years return level	-38.2	-28.1	-2.0	5.3	46.7
RCP 8.5					
Δ 1:25 years return level	-22.1	-14.2	-4.1	16.0	28.1
Δ 1:50 years return level	-32.5	-18.0	-9.6	16.3	40.4
Δ 1:100 years return level	-39.4	-22.1	-15.0	13.9	47.7

Analysis on annual maximum 5-day consecutive precipitation events show a similar trend (see Figure 6 and Table 2). In the high tail of the GCM projections the 5-day precipitation extremes are expected to increase in intensity. For events with 1:50 and 1:100 years return period, at the 75th percentile of the GCM ensemble, an increase of about 15 – 25% in annual maximum 5-day consecutive precipitation is expected under both the RCP 4.5 and RCP 8.

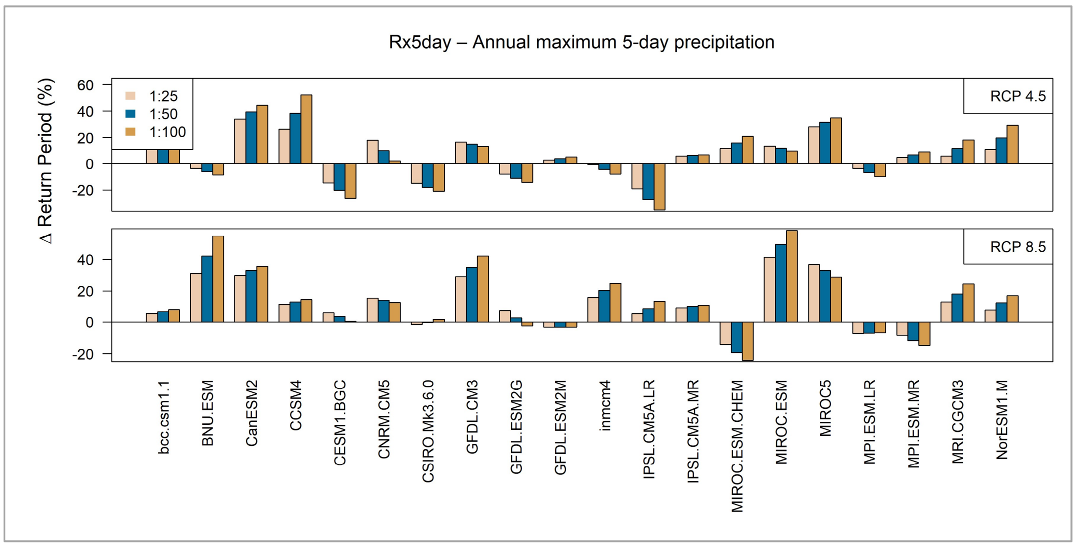

Figure 6. Projected change (%) in return periods of annual maximum 5-day precipitation for the intermediate future (2050) under the RCP 4.5 and RCP 8.5

Table 2. Projected change (%) in different return levels of maximum 5-day precipitation at different percentiles in the GCM model ensemble for RCP 4.5 and RCP 8.5

	Percentile in downscaled GCM ensemble				
RCP 4.5	5th	25th	50th	75th	95th
Δ 1:25 years return level	-15.1	-3.7	6.1	17.0	34.6
Δ 1:50 years return level	-20.6	-6.4	8.5	16.8	40.1
Δ 1:100 years return level	-26.7	-8.9	8.1	23.0	52.9
RCP 8.5					
Δ 1:25 years return level	-8.6	3.6	8.6	19.1	36.9
Δ 1:50 years return level	-11.9	2.0	11.3	23.4	42.4
Δ 1:100 years return level	-15.1	-0.2	12.9	25.8	55.1

Further, while an increase in extreme precipitation events is expected, the data also indicates that longer dry spells can be expected (see Figure 7 and Table 3). At the 75th percentile of the GCM model ensemble, the number of annual consecutive dry days are projected to increase by about 10 to 20 days/yr under the RCP 4.5 and RCP 8.5 respectively. At the 1:100 years return level the annual consecutive dry days are therefore expected to increase from 40 days to about 50 – 60 days per year.

In contrast, the number of consecutive wet days (with precipitation > 1 mm per day) are expected to remain stable for the intermediate future under both RCPs (see Figure 8 and Table 4). At the 75th percentile and 1:100 years return level this amounts to about 30 consecutive wet days per year. The values for the dry and wet spells thus suggest that the intensity but not the duration of precipitation events is expected to increase in the future.

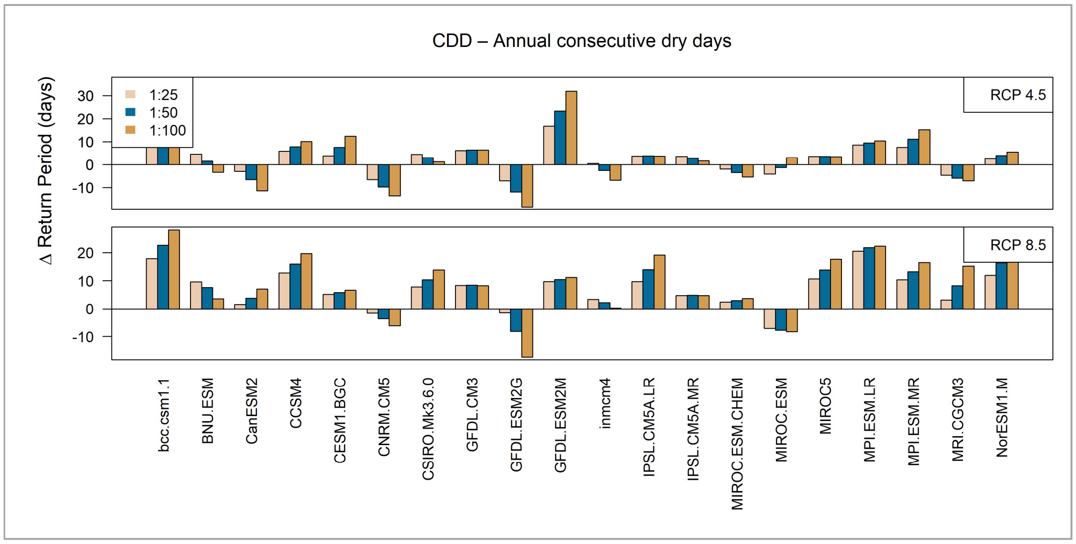

Figure 7. Projected change (days) in return periods of annual consecutive dry days for the intermediate future (2050) under the RCP 4.5 and RCP 8.5

Table 3. Projected change (days) in different return levels of annual consecutive dry days at different percentiles in the GCM model ensemble for RCP 4.5 and RCP 8.5

	Percentile in downscaled GCM ensemble				
RCP 4.5	5th	25th	50th	75th	95th
Δ 1:25 years return level	-6.6	-2.2	3.7	6.0	17.1
Δ 1:50 years return level	-9.8	-2.8	3.3	7.6	23.7
Δ 1:100 years return level	-13.9	-5.8	3.3	10.2	32.2
RCP 8.5					
Δ 1:25 years return level	-1.9	2.9	8.0	10.4	18.0
Δ 1:50 years return level	-7.8	3.6	8.3	13.9	21.8
Δ 1:100 years return level	-8.7	3.7	9.7	18.0	22.6

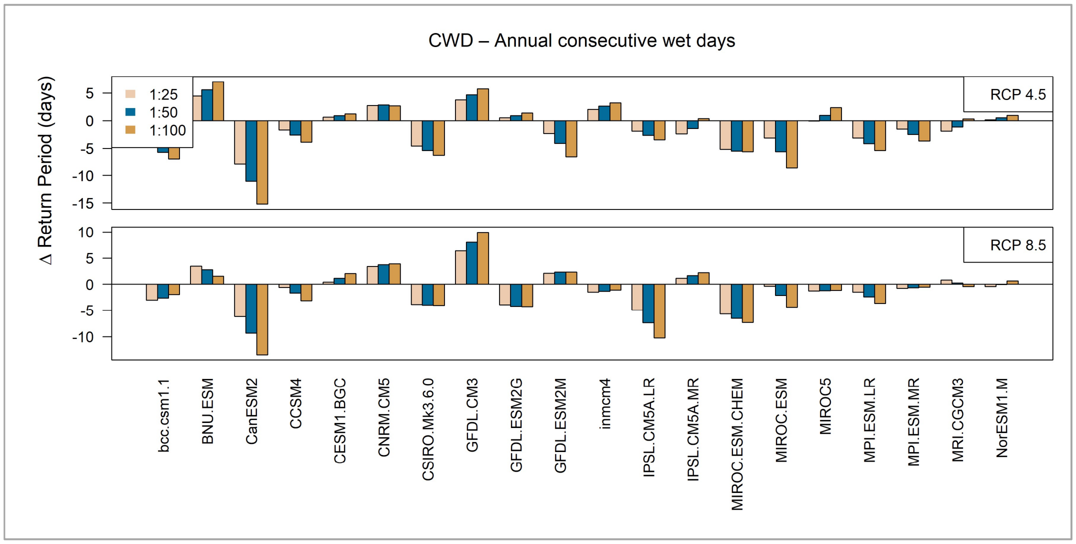

Figure 8. Projected change (days) in return periods of annual consecutive wet days for the intermediate future (2050) under the RCP 4.5 and RCP 8.5

Table 4. Projected change (days) in different return levels of annual consecutive wet days at different percentiles in the GCM model ensemble for RCP 4.5 and RCP 8.5

RCP 4.5	Percentile in downscaled GCM ensemble				
	5th	25th	50th	75th	95th
Δ 1:25 years return level	-5.3	-3.1	-1.8	0.5	3.8
Δ 1:50 years return level	-6.0	-4.5	-1.9	0.9	4.7
Δ 1:100 years return level	-9.0	-5.8	-1.6	1.6	5.8
RCP 8.5					
Δ 1:25 years return level	-5.7	-3.3	-0.7	0.9	3.6
Δ 1:50 years return level	-7.5	-3.0	-1.3	1.2	3.9
Δ 1:100 years return level	-10.4	-4.1	-1.1	1.6	4.2

2.2.2 Temperature extremes

Analysis on temperature extremes indicates that minimum and maximum temperatures are both expected to significantly increase under the RCP 4.5 and RCP 8.5. At the 75th percentile of the 1:100 years return level, the annual maximum of daily maximum temperature (i.e. warmest day of the year) is projected to increase by 2.9 °C under the RCP 4.5 and by 5.0 °C under the RCP 8.5 (see Figure 9 and Table 5). Similarly, but to a lesser degree, the annual minimum of daily minimum temperature (i.e. coldest night of the year) is expected to increase at the 75th percentile by 2.5 °C under the RCP 4.5 and by 3.3 °C under the RCP 8.5 (see Figure 10 and Table 6). This indicates that overall the 21 GCMs project a more rapid increase in maximum air temperatures than in minimum air temperatures, which makes it likely that the diurnal temperature range will become larger in the future.

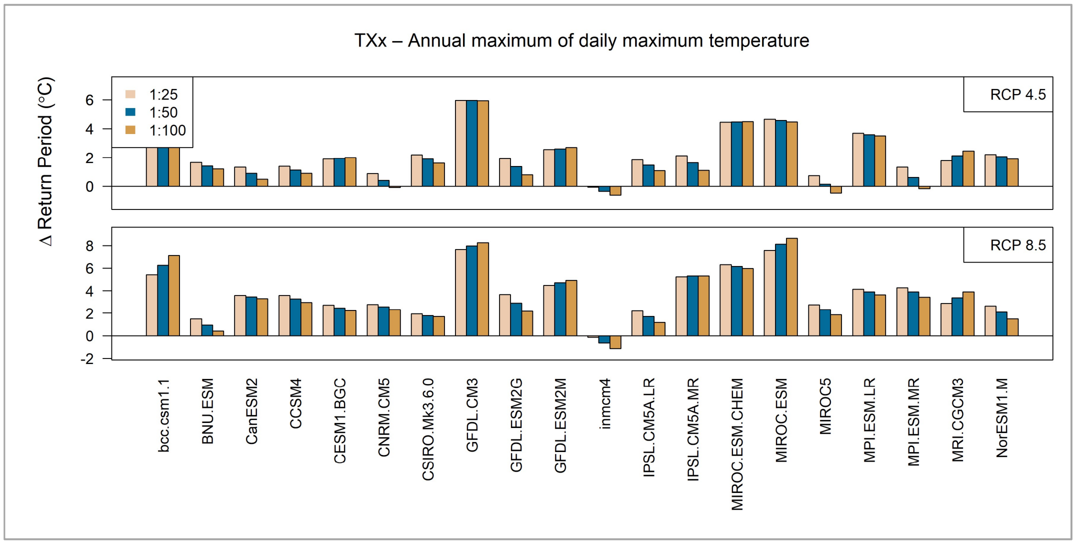

Figure 9. Projected change (°C) in return periods of annual maximum of daily maximum temperature for the intermediate future (2050) under the RCP 4.5 and RCP 8.5

Table 5. Projected change (°C) in return levels of annual maximum of daily maximum temperature at different percentiles in the GCM model ensemble for RCP 4.5 and RCP 8.5

RCP 4.5	Percentile in downscaled GCM ensemble				
	5th	25th	50th	75th	95th
Δ 1:25 years return level	0.7	1.4	1.9	2.8	4.8
Δ 1:50 years return level	0.1	1.1	1.8	2.9	5.7
Δ 1:100 years return level	-0.5	0.7	1.4	2.9	6.0
RCP 8.5					
Δ 1:25 years return level	1.4	2.7	3.6	4.7	7.6
Δ 1:50 years return level	0.9	2.3	3.3	4.9	8.0
Δ 1:100 years return level	0.3	1.8	3.1	5.0	8.3

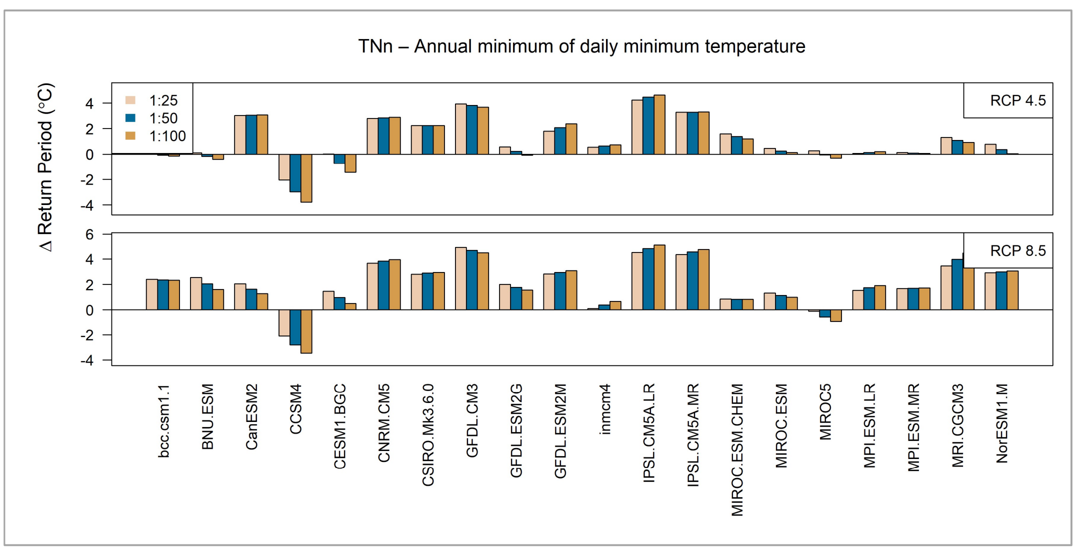

Figure 10. Projected change (°C) in return periods of annual minimum of daily minimum temperature for the intermediate future (2050) under the RCP 4.5 and RCP 8.5.

Table 6. Projected change (°C) in return levels of annual minimum of daily minimum temperature at different percentiles in the GCM model ensemble for RCP 4.5 and RCP 8.5

RCP 4.5	Percentile in downscaled GCM ensemble				
	5th	25th	50th	75th	95th
Δ 1:25 years return level	-0.1	0.1	0.7	2.4	3.9
Δ 1:50 years return level	-0.9	0.1	0.5	2.4	3.8
Δ 1:100 years return level	-1.6	-0.1	0.5	2.5	3.7
RCP 8.5					
Δ 1:25 years return level	-0.2	1.4	2.2	3.1	4.5
Δ 1:50 years return level	-0.7	1.1	1.9	3.2	4.7
Δ 1:100 years return level	-1.1	1.0	1.8	3.3	4.8

Further, while a substantial increase in air temperatures is expected according to the GCM multi-model ensemble, the data also indicates that significant more summer days (daily maximum temperature > 25 °C) and fewer icing days (daily maximum temperature < 0 °C) are expected for the intermediate future compared to the reference period. At the 75th percentile of the 1:100 years return level, the number of annual summer days are expected are projected to increase by 36 days under the RCP 4.5 and by 45 days under the RCP 8.5 (see Figure 11 and Table 7).

Similarly, but conversely and to a lesser degree, at the 75th percentile of the 1:100 years return level, the average number of annual icing days are expected to decrease by about 10 days from under the RCP 4.5 and 8 days under the RCP 8.5 (Figure 12 and Table 8). In short, analysis on the GCM multi-model ensemble using the CLIMDEX Climate Extremes Indices indicate that all temperature extremes change to the warmer side.

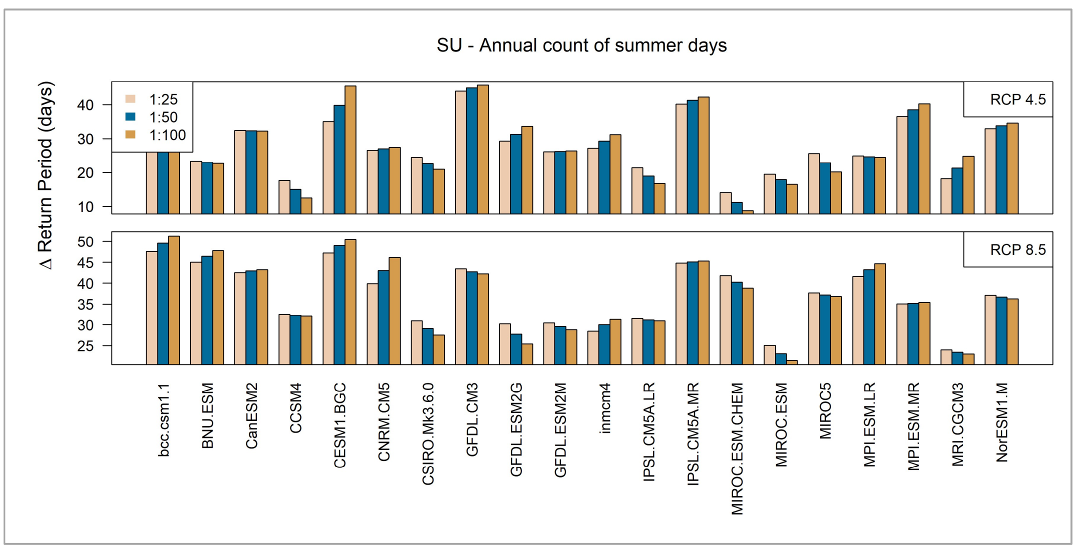

Figure 11. Projected change (days) in return periods of annual count of days where daily maximum temperature exceeds 25 °C (summer days) for the intermediate future (2050) under the RCP 4.5 and RCP 8.5.

Table 7. Projected change (days) in return levels of annual summer days (°C > 25) in the GCM model ensemble for RCP 4.5 and RCP 8.5

RCP 4.5	Percentile in downscaled GCM ensemble				
	5th	25th	50th	75th	95th
Δ 1:25 years return level	17.4	22.8	26.4	33.5	40.3
Δ 1:50 years return level	14.8	22.3	26.7	35.0	41.4
Δ 1:100 years return level	12.3	20.8	27.0	36.0	45.7
RCP 8.5					
Δ 1:25 years return level	25.0	30.8	37.4	42.8	47.2
Δ 1:50 years return level	23.4	29.9	37.0	43.1	49.0
Δ 1:100 years return level	22.9	30.4	36.6	44.8	50.5

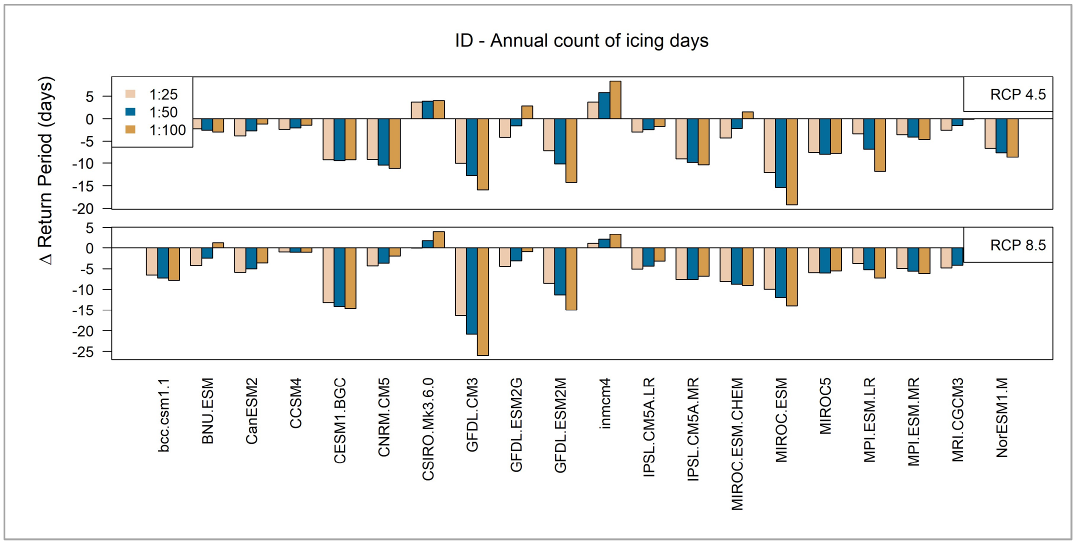

Figure 12. Projected change (days) in return periods of annual count of days where daily maximum temperature is below 0 °C (icing days) for the intermediate future (2050) under the RCP 4.5 and RCP 8.5

Table 8. Projected change (days) in return levels of annual icing days (°C < 0) in the GCM model ensemble for RCP 4.5 and RCP 8.5

RCP 4.5	Percentile in downscaled GCM ensemble				
	5th	25th	50th	75th	95th
Δ 1:25 years return level	3.7	-2.9	-4.0	-7.9	-10.1
Δ 1:50 years return level	4.0	-2.2	-4.0	-9.6	-12.9
Δ 1:100 years return level	4.3	-0.9	-4.2	-10.6	-16.1
RCP 8.5					
Δ 1:25 years return level	0.0	-4.1	-5.0	-7.7	-13.3
Δ 1:50 years return level	1.8	-2.9	-5.1	-7.8	-14.4
Δ 1:100 years return level	3.4	-1.0	-4.6	-8.1	-15.5

3 Climate Risks and Vulnerabilities

The transport infrastructure in Georgia is vulnerable to projected changes in climate variables. Foreseen changes in air temperature, precipitation, and associated extreme weather events can result in the following impacts on the project road (ADB 2011):

Table 9. Potential impacts of climate change on road infrastructure (ADB 2011)

Projected climate change	Impacts on Road Transport Infrastructure
Increases in hot days and heat waves	• Deterioration of pavement integrity, such as softening, traffic-related rutting, and migration of liquid asphalt due to increase in temperature • Thermal expansion of bridge expansion joints and paved surfaces
Increases in temperature in very cold areas	• Changes in road subsidence and weakening of bridge supports due to thawing of permafrost • Reduced ice loading on structures such as bridges
Later onset of seasonal freeze and earlier onset of seasonal thaw	• Deterioration of pavement due to increase in freeze–thaw conditions
Increase in intense precipitation events	• Damage to roads, subterranean tunnels, and drainage systems due to flooding • Increase in scouring of roads, bridges, and support structures • Damage to road infrastructure due to landslides • Overloading of drainage systems • Deterioration of structural integrity of roads, bridges, and tunnels due to increase in soil moisture levels
Increases in drought conditions	• Damage to infrastructure due to increased susceptibility to wildfires • Damage to infrastructure from mudslides in areas deforested by wildfires

Figure 13. Examples of flooding and mass movement phenomena that have occurred in Georgia. Adapted from: Gaprindashvili and Van Westen (2016).

The geoportal of Natural Hazards and Risks in Georgia (http://drm.cenn.org) identifies 10 natural hazards for Georgia, 9 of which (earthquakes excepted) are directly related to changes in the climate: flooding, landslides, mudflows, rockfall, snow avalanches, wildfire, drought, windstorm and hailstorm. The following natural hazards to which infrastructure components of the project road may be exposed are assessed in context of increased risk hazard level due to projected climatic changes (see Figure 14):

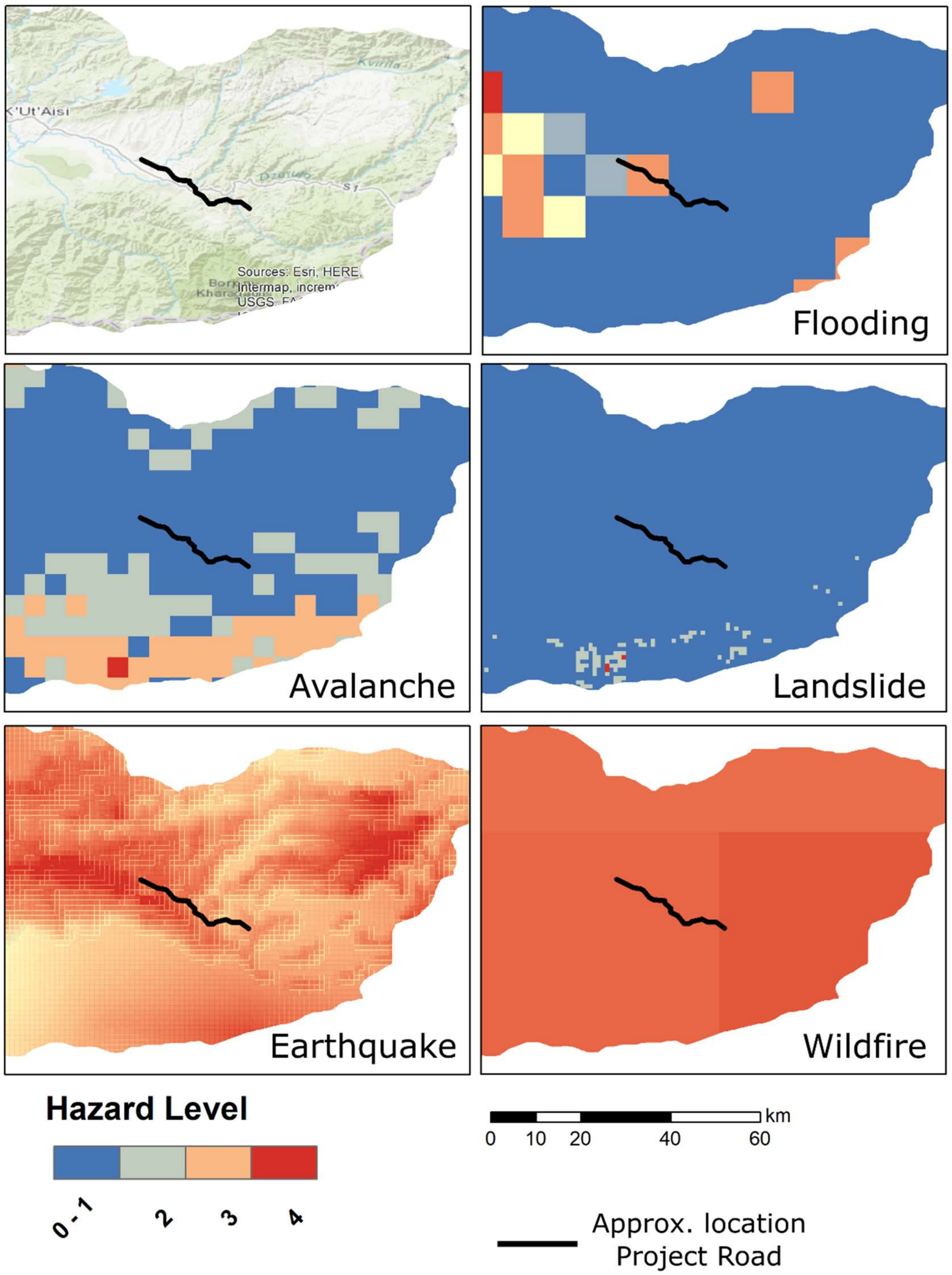

Figure 14. Current natural hazard risks in the project area (source: https://www.geonode-gfdrrlab.org/)

3.1 Flooding and Inundation

The terrain within the Project area is very dissected along the existing E60 highway, which is characteristic for mountainous relief. The foreseen Project road alignment is cut by numerous minor rivers, streams and man-made canals. The Dzirula and Kvirila rivers together with their numerous tributaries form the hydrographic network in the area. The two main rivers and streams have mixed feeding regimes, both by precipitation and groundwater. The rivers are characterized by flooding in spring and low-water in summer. The Project road design is strongly aligned to the course of the Kvirila river along almost the entire length of the F4 Shorapani–Argveta road section section. The projected increase in extreme precipitation events would therefore increase the risk of flooding or inundation of road infrastructure, e.g. due to overloading of drainage systems. This may lead to increased scouring and riverbank erosion. The projected increase in intensity of extreme precipitation events implies that this risk increases in the future.

3.2 Landslide, Rockfall, Avalanche

Within the Project area only a few areas prone to landslides have been identified. However, the main rivers in the Project area and their inflows have formed wavy, uneven relief on the area, which is mostly due to ongoing to erosion processes. In certain areas this relief is characterized by relatively soft, smoothed landforms which can be susceptible to landslide due to heavy precipitation events. Considering the projected increase in extreme precipitation events it can be assumed that the risk of landslides may increase in the future.

Further, the Project road design alignment requires several rock cut sections (see Figure 15) which will lead to exposed and potentially unstable rock walls alongside the Project road. Geotechnical survey has shown that the geology of many rock layers in the Project area consist of sedimentary rock layers such as limestone, mudstone and sandstone. These sedimentary rock layers show deeply weathered thickness (weathered soil and highly weathered rock). The projected increase in diurnal temperature variability may result in later onset of seasonal freeze and earlier onset of seasonal thaw. This may lead to an increase in freeze–thaw conditions which could increase the risk of slope instability and occurrence of rockfall due to weathering effects.

Projected increase in extreme precipitation events may, during cold weather conditions, also result in extreme snowfall events which may result in avalanching, especially if combined with warm spells, which are likely to increase under the projected climate change scenarios.

3.3 Heatwave, Drought, Wildfire

The substantial projected increase in air temperatures as well as annual number of days where daily maximum temperature exceeds 25 °C, indicates that heat waves are more likely to occur and may last longer. This poses potential increased risks related to asphalt pavement integrity and thermal expansion of bridge expansion joints and paved surfaces. Wildfires may also occur more frequently, especially considering the projected increase in annual consecutive dry days. This may lead to increased drought conditions which could result in an increased risk for wildfires. The risk of mudflows may also increase as their occurrence is linked to deforestation by wildfire and increasing precipitation extremes.

Figure 15. Examples of landslide and rockfall prone areas in or close to the Project area

3.4 Vulnerable components in the design

Considering the type of climate hazards and risks in the project area, and the area-specific climate change projections, the most serious threat comes from the expected increase in extreme precipitation events. This may lead to higher extreme discharges that exceed the systems' design capacity and cause flooding or inundation of road infrastructure. More extreme precipitation events can also lead to increased slope instability alongside the Project road, causing more frequent and more powerful landslides, rockfalls and/or avalanches. The projected increase in diurnal temperature variability may lead to an increase in freeze–thaw conditions. This may result in deterioration of road pavement integrity and further increase the risk of slope instability, making any road stretches close to steep terrain more vulnerable to mass movement phenomena.

4 Current Design under Climate Change

4.1 Bridges

For bridges the projected increases in intensity of extreme precipitation events poses the most serious risk. However, it is concluded by the project design consultant team (IRD Engineering) that the current bridge designs can handle the expected 10-20% increase in extreme precipitation intensities. During the design process of section F4 of the East-West Highway project both hydrological and hydraulic design variables have been assessed using a very precautionary approach, which included much higher extreme inputs, higher return periods, high freeboards and design provisions generally considering wide margins. For bridges, river discharge simulations were run with both 100 and 200 years return period and show that in all cases bridge freeboards are particularly high, exceeding 12 m above river water level all cases. In fact, switching from 100 to 200 years return period only provides an increase in river water level in the range of 10-30 centimeters. So, interaction with the deck is not expected under any foreseeable circumstances. Extreme discharge events may lead to increased scouring around bridge foundations and support structures and cause riverbank erosion, which should be monitored.

4.2 Tunnels

The increased intensity and frequency of heavy precipitation events could lead to tunnel water inflow and create unsafe driving conditions. A potential increase in the frequency of landslides and rockfall could negatively affect tunnel portals. According to the design team drainage systems have sufficient capacity to cope with future increases in extreme rainfall. Retaining walls and mass movement protection structures are included in the current design.

4.3 Drainage systems

Similar to bridges, the projected increases in intensity of extreme precipitation events poses the most serious risk to the drainage systems, which need to have sufficient capacity to cope with increased amounts of water. The project design consultant team reviewed performance of the proposed drainage structures (culverts, ditches and platform drains) under the assumption of an 20% increase in daily maximum precipitation. The review indicates that the capacity of the drainage structures is well in excess of any potential climate change induced increased flow. Similar to bridges, the Project road drainage structures are designed according to higher return periods (1:50 return level instead of 1:20 or 1:30 return levels) and the highest discharge values ever estimated with different formulas for the region (see paragraph 3.4 IRD report hydraulic report section F4). The resulting unitary contribution adopted for drainage design is for that reason very large: it is equal for small durations to 50.46 $m^3/s/km^2$ which can be expressed as an equivalent rainfall of 180 mm/h. This is a rainfall rate for which a driver has almost no visibility. Thus, the adoption of higher return periods plus the choice of extreme rainfall rates already broadly embed the case of higher occurrence frequency for extremes events due to a change in climate forcing. Based on the design assessment provided above, the project design consultant team proposes to not make any modifications to the drainage design at this stage.

4.4 Mass movement protection and retaining walls

The stability of the slopes alongside the new road alignment has been investigated in a geotechnical study and the new road alignment design avoids the most vulnerable sites and otherwise proposes retaining structures in the design. Due to a potential future increase in frequency of rockfall and landslides, these structures may require higher maintenance than currently anticipated. While potential increased weathering of slopes may increase the risk of slope instability, the design of retaining structures (taking also into account seismic loading) can be assumed to be appropriately dimensioned to provide protection against rockfall and/or landslides. Risk mitigation against these natural hazards, however, may require more focus on routine inspections and timely maintenance. A decrease in the cut slope and a concurrent increase in the overall slope buffer area could also be considered in areas where slope stability for mass movement is of concern.

4.5 Road pavement

The project road design includes two types of road pavement, (1) rigid cement-concrete pavement for the highway (main road of F4 Rikoti-Argveta section) and (2) flexible asphalt concrete for interchanges and secondary roads. The projected significant increase in air temperatures and increase in diurnal temperature variability may both negatively impact the road pavement integrity. Temperature changes can induce heavy stresses in rigid cement pavement in particular. Warping stresses, because of a daily variation in temperature gradient across the thickness, may lead to curling of the cement slab edges. Frictional stresses, because of seasonal temperature variation resulting in overall changes in slab temperature, may lead to pavement failures such as cracking and joint spalling. Freezing and thawing action of accumulated water can further aggravate and/or accelerate these temperature stress induced pavement failures. The diurnal temperature range, the number of hot days and occurrence of heat waves is projected to increase substantially.

Flexible asphalt concrete pavement is less affected by temperature induced stresses, but deterioration of asphalt pavement integrity, such as softening, and traffic-related rutting could accelerate due to foreseen increases in air temperature in the region. The use of stone mastic asphalt (SMA) as the wearing course could be considered, as SMA is more thermo-stable than classic asphalt mixtures. SMA was created as alternative to classic asphalt mixtures exactly to prevent deformations due to exposure to higher temperatures. By using road pavement with such high capability, it can reasonably be assumed that foreseen temperature increases would be well within the range of the operational temperature range of the asphalt. The potential impact of temperature increases on the asphalt (if any) is that the life of the pavement surfacing could be shorter and overlay work would possibly need to be planned at a shorter interval. More routine maintenance may also be required.

5 Conclusions and Recommendations

The present Climate Risk and Vulnerability Assessment (CRVA) reviewed the current project design documents under the proposed Shorapani–Argveta road section of the East-West Highway Road Project in Georgia, in the context of expected climate change for the area around 2050. The analysis was done based on the NASA-NEX ensemble of downscaled General Circulation Models (GCMs). The analysis uses the full ensemble for both a medium-case emissions scenario (RCP4.5) and a business as usual emissions scenario (RCP8.5). For extreme precipitation, a newly-developed tool was applied to assess the distribution of the % change in maximum 1-day precipitation for each climate model across the ensemble for key return periods.[a]

- Temperature increases by about 2.1 °C (RCP4.5) to 2.9 °C (RCP8.5) are to be expected;
- Minimum and maximum temperature are likely to change inconsistently, with maximum air temperatures increasing more than minimum air temperatures. This implies a larger diurnal temperature range for the future;
- Extremes related to temperatures (e.g. warm spells, extremely warm days) are likely to increase in frequency and intensity;
- Precipitation totals are likely to stay reasonable constant;
- Precipitation extremes are likely to increase in frequency and intensity. Maximum 1-day precipitation volumes with return periods of 25, 50 and 100 years are expected to increase by about 10% to 20%.

The increase in extreme precipitation events is considered as the most important climate risk for the Project road. This may lead to higher extreme discharges that exceed the systems' design capacity and cause flooding or inundation of road infrastructure. More extreme precipitation events can also lead to increased slope instability alongside the Project road, causing more frequent and more powerful landslides, rockfalls and/or avalanches. In addition, the projected increase in diurnal temperature variability may lead to an increase in freeze–thaw conditions. This may result in deterioration of road pavement integrity, resulting in more frequent maintenance requirements. It can also further increase the risk of slope instability, making any stretch of road close to steep terrain more vulnerable to such mass movement phenomena. According to the design team, the structures at risk of flooding (e.g. bridges, road sections) are sufficiently dimensioned to cope with return levels 10-20% higher than used in the original design calculations, which can be reasonably assumed. Retaining walls and mass movement protection structures are in place.

This CRVA relies on climate model projections and therefore is prone to uncertainties. The downscaled climate models used in this study have a spatial resolution of about 25 km, whereas climate change signals may vary strongly over short distances, in particular in mountainous terrain. There is often also a large spread in the climate model projections. Therefore the full ensemble of models has been analyzed and the uncertainty range is displayed in all figures in this report.

6 References

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Appendix 1: Climate Model Analyses

6.1 NASA-NEX-GDDP Projections of Future Climate

Table 10. GCMs included in the NASA-NEX-GDDP dataset

Model	Research centre	Country	Resolution (Original)		Resolution (NASA-NEX)	
			Lat (°)	Lon (°)	Lat (°)	Lon (°)
ACCESS1-0	BCC	Australia	1.25	1.88	0.25	0.25
BCC-CSM1-1	GCESS	China	2.79	2.81	0.25	0.25
BNU-ESM	NSF-DOE-NCAR	China	2.79	2.81	0.25	0.25
CanESM2	LASG-CESS	Canada	2.79	2.81	0.25	0.25
CCSM4	NSF-DOE-NCAR	USA	0.94	1.25	0.25	0.25
CESM1-BGC	NSF-DOE-NCAR	USA	0.94	1.25	0.25	0.25
CNRM-CM5	CSIRO-QCCCE	France	1.40	1.41	0.25	0.25
CSIRO-MK3-6-0	CCCma	Australia	1.87	1.88	0.25	0.25
GFDL-CM3	NOAAGFDL	USA	2.00	2.50	0.25	0.25
GFDL-ESM2G	NOAAGFDL	USA	2.02	2.00	0.25	0.25
GFDL-ESM2M	NOAAGFDL	USA	2.02	2.50	0.25	0.25
INMCM4	IPSL	Russia	1.50	2.00	0.25	0.25
IPSL-CM5A-LR	IPSL	France	1.89	3.75	0.25	0.25
IPSL-CM5A-MR	MIROC	France	1.27	2.50	0.25	0.25
MIROC5	MPI-M	Japan	1.40	1.41	0.25	0.25
MIROC-ESM	MIROC	Japan	2.79	2.81	0.25	0.25
MIROC-ESM-CHEM	MIROC	Japan	2.79	2.81	0.25	0.25
MPI-ESM-LR	MPI-M	Germany	1.87	1.88	0.25	0.25
MPI-ESM-MR	MRI	Germany	1.87	1.88	0.25	0.25
MRI-CGCM3	NICAM	Japan	1.12	1.13	0.25	0.25
NorESM1-M	NorESM1-M	Norway	1.89	2.50	0.25	0.25

The NASA-NEX-GDDP Projections are evaluated at the following time horizons:

- Reference period : 1976 – 2005
- Intermediate future (2050) : 2035 – 2064

Table 11. Average and range of climate projections for the intermediate future for the ensemble of 21 GCM under RCP 4.5 and RCP 8.5.

GCM ensemble	RCP 4.5 1976 - 2005			RCP 4.5 2035-2064			RCP 8.5 1976 - 2005			RCP 8.5 2035-2064		
	pr	Tmax	Tmin	pr	Tmax	Tmin	pr	Tmax	Tmin	pr	Tmax	Tmin
Mean	907.6	17.8	6.4	935.2	19.9	8.2	907.6	17.8	6.4	924.1	20.7	8.9
p05	853.8	17.3	6.1	877.0	19.4	7.8	853.8	17.3	6.1	870.3	19.8	8.2
p25	883.5	17.6	6.3	912.7	19.6	8.0	883.5	17.6	6.3	898.4	20.1	8.4
p50	908.6	17.8	6.4	935.0	20.0	8.2	908.6	17.8	6.4	915.2	20.7	8.8
p75	923.9	18.0	6.6	964.4	20.2	8.5	923.9	18.0	6.6	946.4	21.3	9.4
p95	974.2	18.4	6.9	975.2	20.3	8.6	974.2	18.4	6.9	1005.7	21.6	9.8

6.2 CLIMDEX Climate Extremes Indices

Table 12. CLIMDEX precipitation indices

Index name	Description	Unit
1. PRCPTOT	Annual total wet-day precipitation; annual sum of precipitation in days where precipitation is at least 1mm	mm
2. SDII	Simple precipitation intensity index; sum of precipitation in wet days during the year divided by the number of wet days in the year	mm
3. Rx1day	Annual maximum 1-day precipitation	mm
4. Rx5day	Annual maximum 5-day consecutive precipitation	mm
5. R95pTOT	Annual total precipitation exceeding 95th percentile threshold (very wet days); annual sum of precipitation in days where daily precipitation exceeds the 95th percentile of daily precipitation in the reference period	mm
6. R99pTOT	Annual total precipitation exceeding 99th percentile threshold (extremely wet days); annual sum of precipitation in days where daily precipitation exceeds the 99th percentile of daily precipitation in the reference period	mm
7. R1mm	Annual count of days where daily precipitation exceeds 1mm per day; number of wet days	days
8. R10mm	Annual count of days where daily precipitation exceeds 10mm per day; number of heavy precipitation days	days
9. R20mm	Annual count of days where daily precipitation exceeds 20mm per day; number of very heavy precipitation days	days
10. CCD	Annual maximum consecutive dry days; annual maximum length of dry spells, sequences of days where daily precipitation is less than 1mm per day.	days
11. CWD	Annual maximum consecutive wet days; annual maximum length of wet spells, sequences of days where daily precipitation is at least 1mm per day	days

Table 13. CLIMDEX temperature indices

Index name	Description	Unit
12. TXx	Annual maximum of daily maximum temperature	Celsius
13. TXn	Annual minimum of daily maximum temperature	Celsius
14. TNx	Annual maximum of daily minimum temperature	Celsius
15. TNn	Annual minimum of daily minimum temperature	Celsius
16. DTR	Mean annual diurnal temperature range; annual mean difference between daily maximum and daily minimum temperature	Celsius
17. SU	Summer days; annual count of days where daily maximum temperature exceeds 25 degrees Celsius	days
18. TR	Tropical nights; annual count of days where daily minimum temperature exceeds 20 degrees Celsius	days
19. FD	Frost days; annual count of days where daily minimum temperature drops below 0 degrees Celsius	days
20. ID	Icing days; annual count of days where daily maximum temperature is below 0 degrees Celsius	days
21. WSDI	Warm spell duration index; annual count of days which are part of a warm spell, defined as at least 6 consecutive days where the daily maximum temperature exceeds the 90th percentile of daily maximum temperature for a 5-day running window surrounding this day during a reference period.	days
22. CSDI	Cold spell duration index; annual count of days which are part of a cold spell, defined as at least 6 consecutive days where the daily minimum temperature is below the 10th percentile of daily minimum temperature for a 5-day running window surrounding this day during a reference period.	days

23. GSL	Growing season length; annual count of days between the start of the first spell of warm days in the first half of the year, and the start of the first spell of cold days in the second half of the year. Spells of warm days are defined as six or more days with mean temperature above 5 degrees Celsius; spells of cold days are defined as six or more days with a mean temperature below 5 degrees Celsius.	days
24. TX90p	Warm days; annual percentage of days above the 90th percentile of reference daily maximum temperature	%
25. TN90p	Warm nights; annual percentage of days above the 90th percentile of reference daily minimum temperature	%
26. TX10p	Cold days; annual percentage of days below the 10th percentile of reference daily maximum temperature	%
27. TN10p	Cold nights; annual percentage of days below the 10th percentile of reference daily minimum temperature	%

6.2.1 Climdex indices RCP 4.5

Listed here are the Climdex indicator values under the RCP 4.5 for the reference period (1981 - 2010) and intermediate future (2035 – 2064). For each CLIMDEX index the annual mean of the 21 GCMs and the range (5th – 95th percentile) between them is given.

Table 14. Climdex indicator values RCP 4.5

Pr. index	**Ref_{mean}**	**Ref_{p05}**	**Ref_{p95}**	**2050_{mean}**	**2050_{p05}**	**2050_{p95}**
climdex.prcptot	868.5	685.1	1074.2	898.3	682.7	1144.1
climdex.sdii	5.7	4.3	7.3	6.0	4.6	7.8
climdex.rx1day	40.2	22.5	64.3	42.0	25.3	65.1
climdex.rx5day	76.5	48.2	111.3	81.8	51.8	121.6
climdex.r95ptot	194.8	84.9	337.2	232.6	104.0	381.7
climdex.r99ptot	60.7	0.9	152.0	80.0	2.7	181.9
climdex.rnnmm	156.2	118.3	195.2	151.8	114.6	192.2
climdex.r10mm	21.9	12.6	32.5	24.0	14.8	34.7
climdex.r20mm	5.3	1.3	10.6	6.3	1.9	11.9
climdex.cdd	18.8	11.3	29.2	20.7	11.9	33.4
climdex.cwd	12.0	7.1	19.7	11.8	7.2	18.3
Temp. index	**Ref_{mean}**	**Ref_{p05}**	**Ref_{p95}**	**2050_{mean}**	**2050_{p05}**	**2050_{p95}**
climdex.txx	35.7	33.0	38.5	38.5	35.7	41.5
climdex.txn	-3.3	-7.4	0.2	-1.9	-6.0	1.5
climdex.tnx	20.8	19.0	23.0	23.3	21.0	25.7
climdex.tnn	-14.5	-20.0	-9.6	-12.7	-18.9	-7.6
climdex.dtr	11.4	10.9	11.9	11.7	11.1	12.3
climdex.su	111.7	95.5	126.9	140.9	124.0	156.7
climdex.tr	3.7	0.0	11.3	26.6	6.7	51.8
climdex.fd	95.1	78.7	111.2	75.3	55.3	93.1
climdex.id	5.3	0.6	11.7	3.0	0.1	8.6
climdex.wsdi	6.9	0.0	19.7	52.0	14.5	98.9
climdex.csdi	4.2	0.0	13.3	1.3	0.0	6.9
climdex.gsl	264.2	242.6	290.5	288.8	256.2	328.8
climdex.tx90p	10.6	5.1	16.8	29.6	16.4	43.2

climdex.tn90p	10.5	5.6	16.2	34.8	18.9	54.5
climdex.tx10p	10.5	5.9	15.6	3.9	1.1	7.7
climdex.tn10p	10.5	6.0	16.3	4.1	1.0	8.0

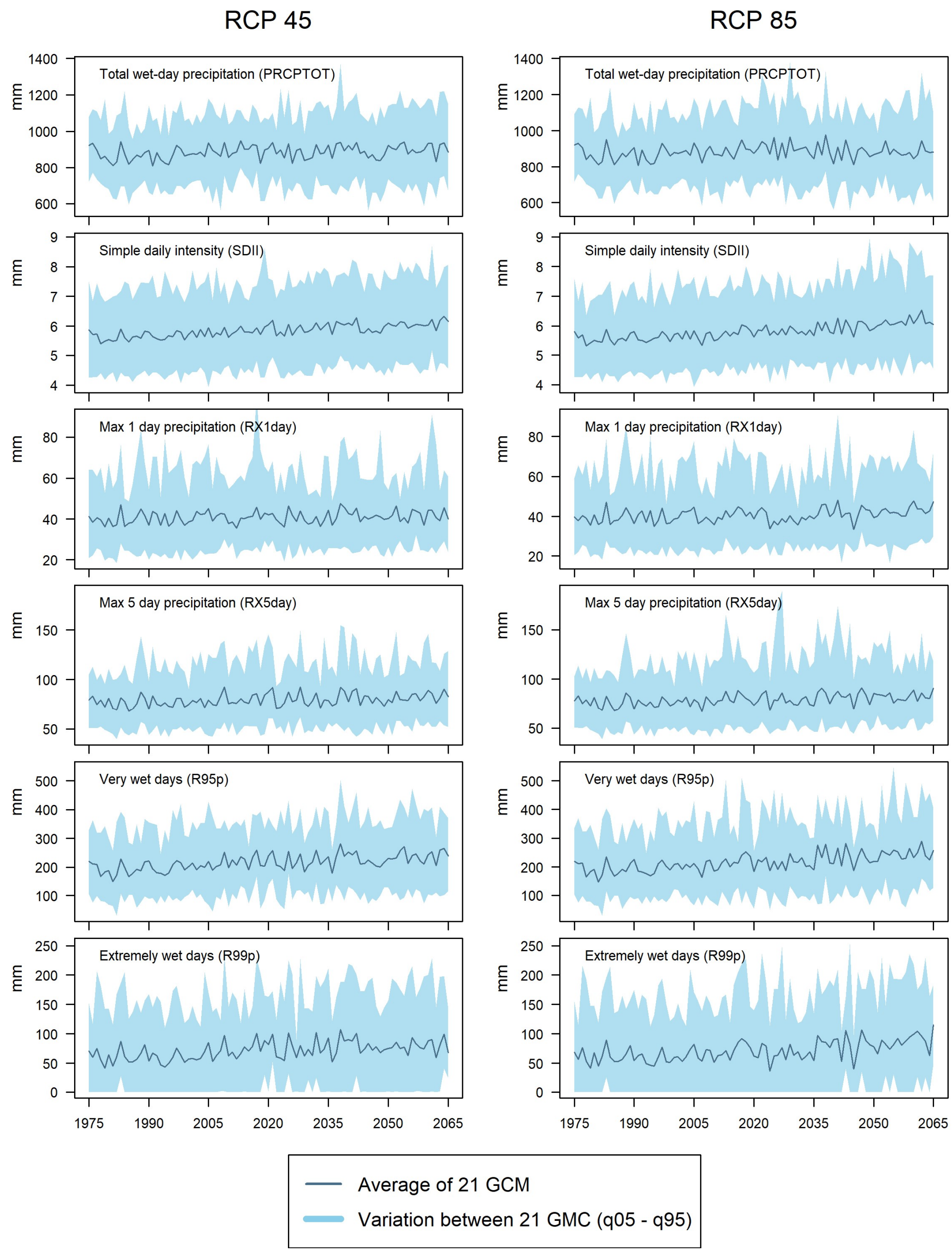
6.2.2 Climdex indices RCP 8.5

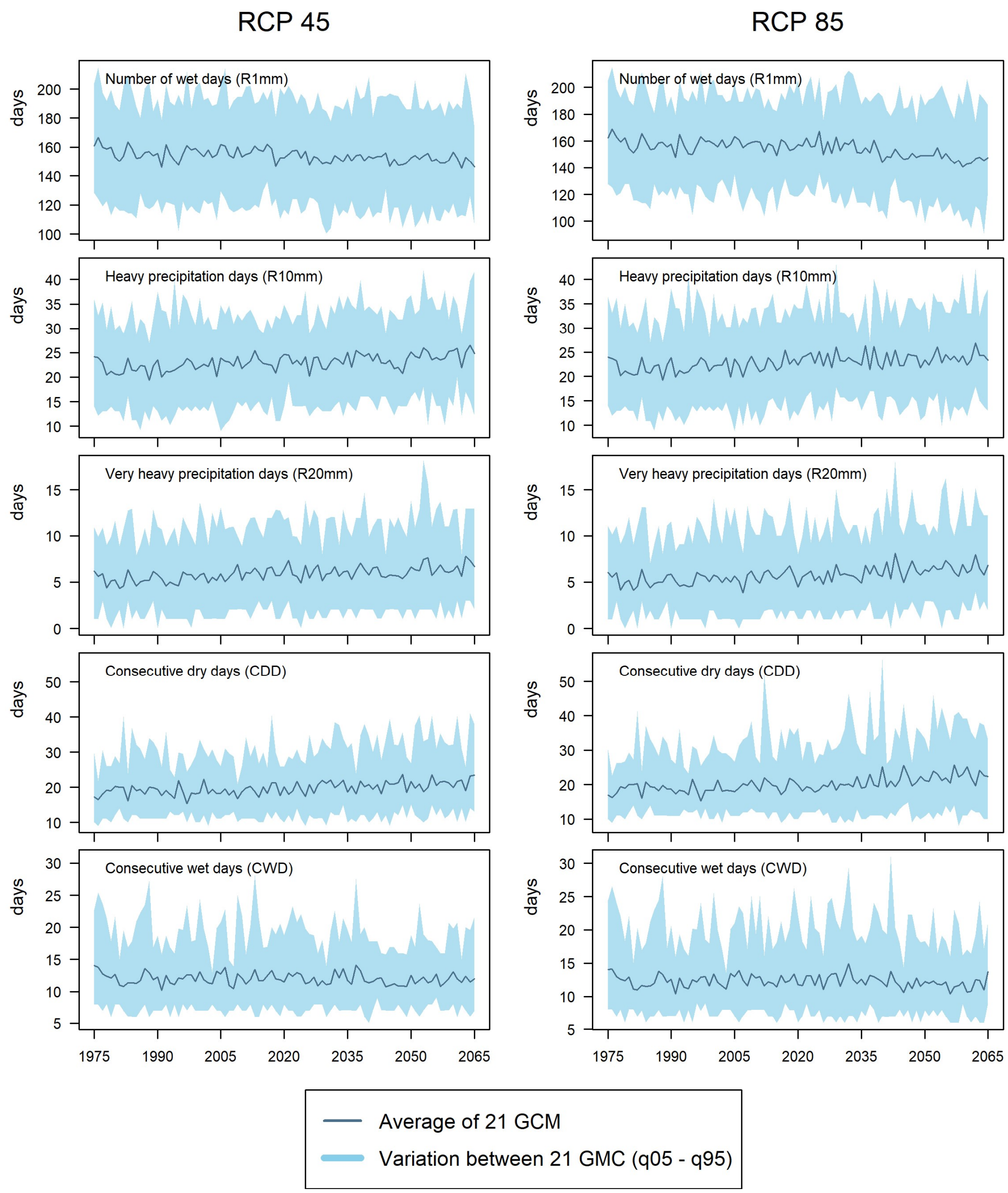
Listed here are the Climdex indicator values under the RCP 8.5 for the reference period (1981 - 2010) and intermediate future (2035 – 2064). For each CLIMDEX index the annual mean of the 21 GCMs is given and the range (5th – 95th percentile) between them.

Table 15. Climdex indicator values RCP 8.5

Pr. index	**Ref_{mean}**	**Ref_{p05}**	**Ref_{p95}**	**2050_{mean}**	**2050_{p05}**	**2050_{p95}**
climdex.prcptot	869.6	682.1	1082.2	883.3	663.3	1130.6
climdex.sdii	5.6	4.3	7.1	6.0	4.6	7.9
climdex.rx1day	39.7	22.3	64.1	42.2	24.7	66.2
climdex.rx5day	76.1	47.8	111.9	82.3	52.0	129.0
climdex.r95ptot	194.2	83.8	339.6	239.4	106.1	395.9
climdex.r99ptot	60.6	0.8	156.5	83.1	6.1	185.8
climdex.rnnmm	158.0	120.8	196.2	148.6	110.1	189.8
climdex.r10mm	21.8	12.4	32.8	23.7	14.1	34.7
climdex.r20mm	5.2	1.2	10.6	6.4	1.9	12.2
climdex.cdd	18.6	11.3	29.3	21.8	11.3	36.3
climdex.cwd	12.3	7.4	20.2	11.9	7.1	19.7
Temp. index	**Ref_{mean}**	**Ref_{p05}**	**Ref_{p95}**	**2050_{mean}**	**2050_{p05}**	**2050_{p95}**
climdex.txx	35.7	33.0	38.5	39.6	36.7	42.7
climdex.txn	-3.3	-7.5	0.2	-1.4	-5.8	2.1
climdex.tnx	20.8	18.9	23.1	24.4	22.3	26.9
climdex.tnn	-14.4	-20.0	-9.6	-11.9	-17.7	-7.2
climdex.dtr	11.4	10.9	11.9	11.8	11.1	12.6
climdex.su	111.6	95.4	127.0	148.7	128.7	165.2
climdex.tr	3.5	0.0	11.0	41.5	18.2	67.0
climdex.fd	95.2	79.1	111.3	69.3	46.3	89.8
climdex.id	5.3	0.6	11.6	2.4	0.0	7.6
climdex.wsdi	6.7	0.0	20.2	82.2	30.1	145.8
climdex.csdi	4.0	0.0	12.8	1.5	0.0	6.9
climdex.gsl	264.2	242.4	291.4	299.4	263.6	343.0
climdex.tx90p	10.6	5.1	16.8	38.8	23.0	55.2
climdex.tn90p	10.5	5.5	16.3	45.7	29.3	64.6
climdex.tx10p	10.5	6.0	15.7	2.9	0.6	6.3
climdex.tn10p	10.5	6.1	16.2	3.5	0.5	7.5

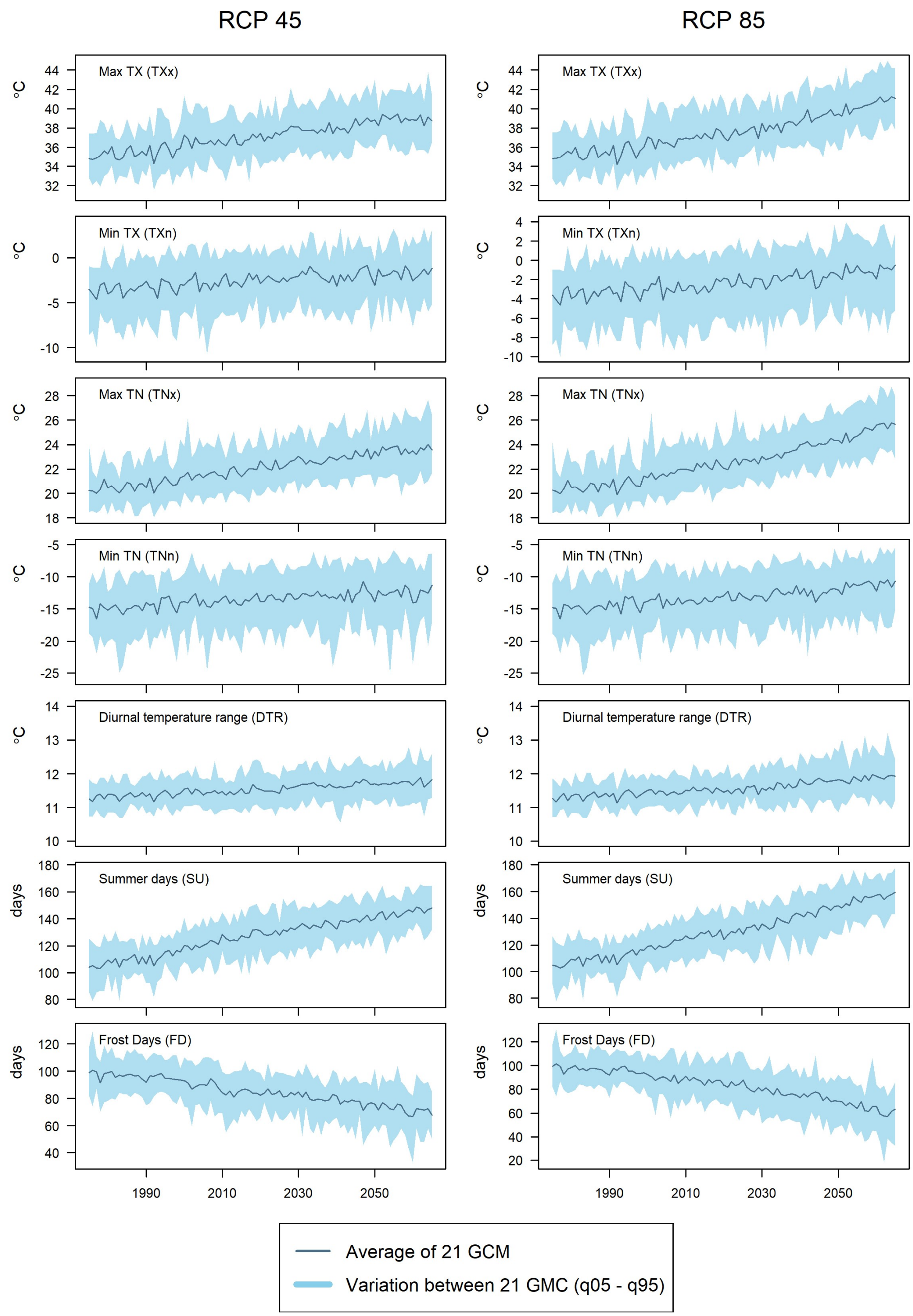
6.2.3 *CLIMDEX Precipitation indices*

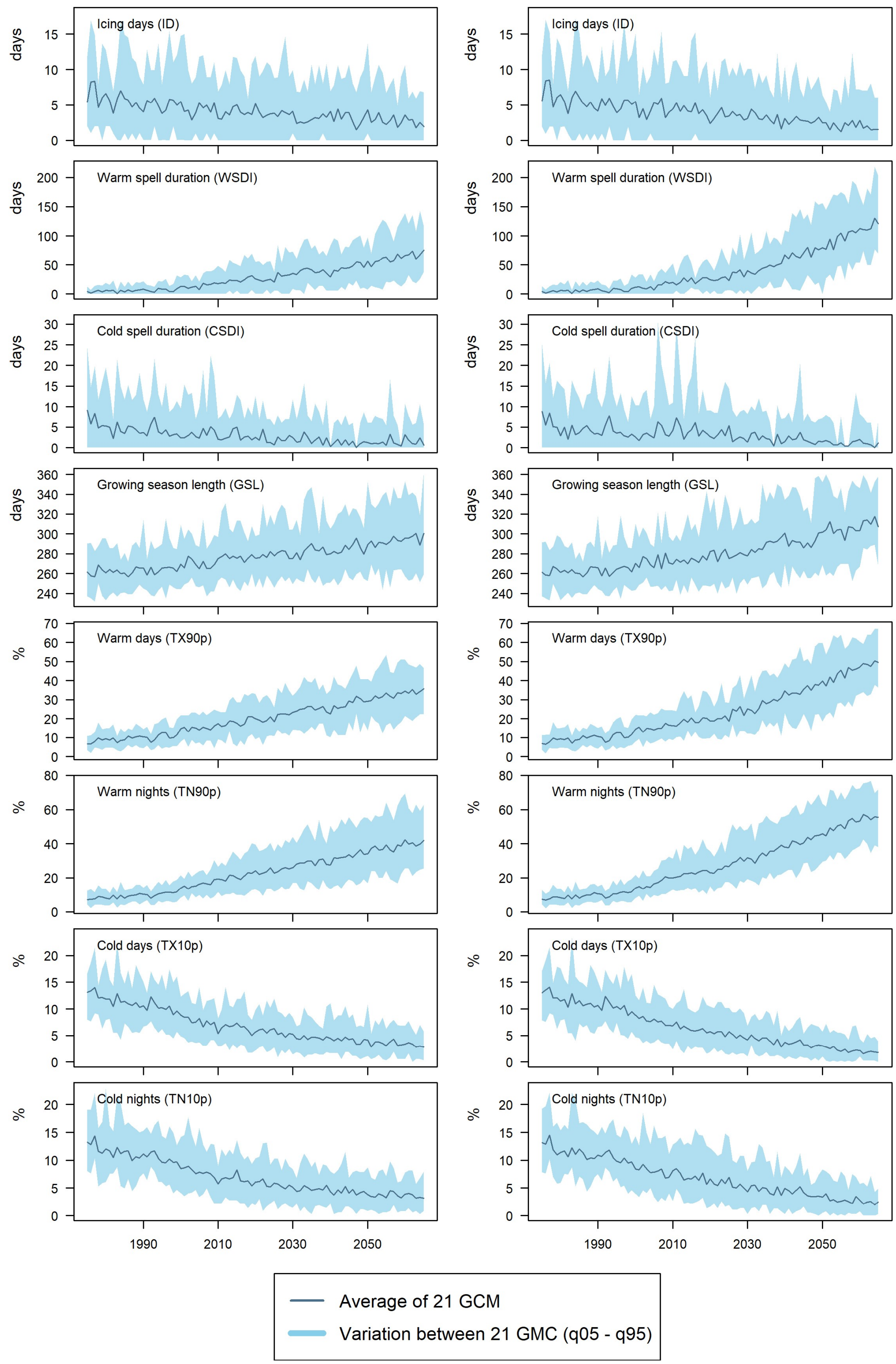




RCP 45
RCP 85
Number of wet days (R1mm)
Heavy precipitation days (R10mm)
Very heavy precipitation days (R20mm)
Consecutive dry days (CDD)
Consecutive wet days (CWD)
days
1975
1990
2005
2020
2035
2050
2065
Average of 21 GCM
Variation between 21 GMC (q05 - q95)

6.2.4 CLIMDEX Temperature indices




Icing days (ID)
Warm spell duration (WSDI)
Cold spell duration (CSDI)
Growing season length (GSL)
Warm days (TX90p)
Warm nights (TN90p)
Cold days (TX10p)
Cold nights (TN10p)
days
%
1990
2010
2030
2050
Average of 21 GCM
Variation between 21 GMC (q05 - q95)

6.2.5 *CLIMDEX Return periods Precipitation*

The estimation of changes in precipitation extremes is done for the return periods of 25, 50, and 100 years. This is done by analyzing the distribution of the percentual change (%) for each downscaled climate model for each of those return periods.

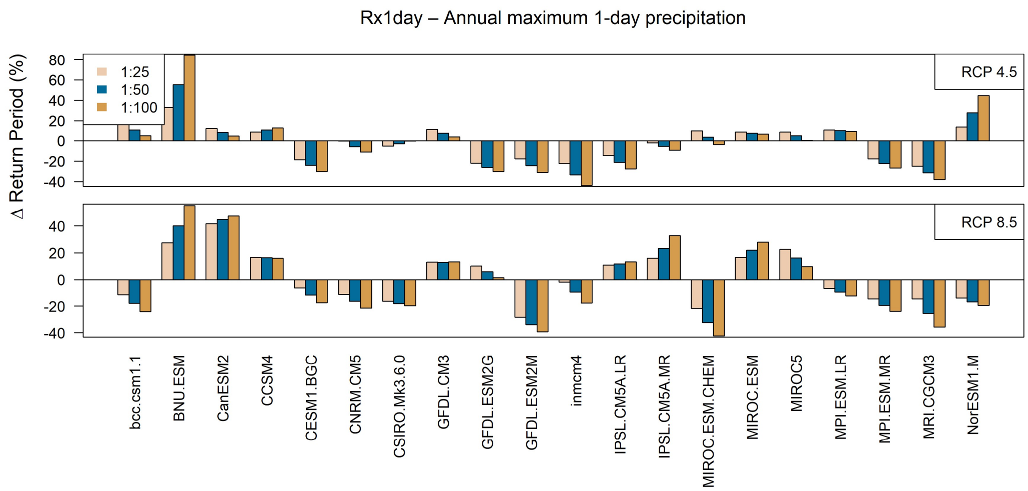


Table 16. CLIMDEX Rx1day – Annual maximum 1-day precipitation (RCP 4.5)

Rx1day	RCP 4.5 1976 - 2005			RCP 4.5 2035 - 2064			Δ RCP 4.5 (%)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	47.8	54.1	61.1	55.8	60.1	64.0	16.7	11.0	4.8
BNU.ESM	53.8	57.0	59.7	71.5	88.6	110.3	33.0	55.5	84.7
CanESM2	42.8	46.9	51.0	48.1	50.9	53.4	12.4	8.6	4.7
CCSM4	68.1	74.3	80.2	74.2	82.4	90.6	8.9	10.9	12.9
CESM1.BGC	85.6	101.2	119.2	69.8	76.7	83.4	-18.4	-24.2	-30.1
CNRM.CM5	82.9	94.8	107.4	82.7	89.4	95.6	-0.3	-5.7	-11.0
CSIRO.Mk3.6.0	86.4	94.7	102.7	81.9	92.0	102.4	-5.2	-2.9	-0.3
GFDL.CM3	59.4	67.1	75.2	66.3	72.2	78.0	11.6	7.7	3.7
GFDL.ESM2G	59.1	69.1	80.3	46.1	50.9	56.2	-22.1	-26.2	-30.0
GFDL.ESM2M	69.8	82.9	97.9	57.5	62.6	67.5	-17.7	-24.5	-31.1
inmcm4	87.9	109.5	137.0	68.2	72.8	77.0	-22.4	-33.5	-43.8
IPSL.CM5A.LR	49.8	57.2	65.4	42.6	45.1	47.4	-14.5	-21.2	-27.5
IPSL.CM5A.MR	57.9	65.9	74.4	56.8	62.2	67.5	-1.9	-5.7	-9.4
MIROC.ESM.CHEM	65.0	81.1	101.3	71.6	83.8	97.5	10.1	3.3	-3.8
MIROC.ESM	50.3	54.3	58.1	54.7	58.6	62.1	8.8	7.9	6.8
MIROC5	90.5	104.8	120.7	98.7	109.9	121.1	9.1	4.9	0.4
MPI.ESM.LR	81.1	90.3	99.8	90.2	99.8	109.4	11.1	10.5	9.6
MPI.ESM.MR	90.8	104.4	118.9	74.7	81.1	87.2	-17.7	-22.4	-26.7
MRI.CGCM3	93.0	112.6	136.4	69.9	77.3	84.8	-24.9	-31.4	-37.9
NorESM1.M	59.3	63.5	67.2	67.6	81.0	97.2	14.0	27.7	44.7

Table 17. CLIMDEX Rx1day – Annual maximum 1-day precipitation (RCP 8.5)

Rx1day	RCP 8.5 1976 - 2005			RCP 8.5 2035 - 2064			Δ RCP 8.5 (%)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	47.8	54.1	61.1	42.3	44.4	46.3	-11.6	-17.9	-24.2
BNU.ESM	53.8	57.0	59.7	68.5	79.9	92.8	27.4	40.1	55.3
CanESM2	42.8	46.9	51.0	60.6	67.9	75.1	41.7	44.8	47.3
CCSM4	68.1	74.3	80.2	79.4	86.5	93.0	16.5	16.3	15.9
CESM1.BGC	85.6	101.2	119.2	80.1	89.2	98.4	-6.4	-11.8	-17.5
CNRM.CM5	82.9	94.8	107.4	73.5	79.1	84.3	-11.4	-16.5	-21.5
CSIRO.Mk3.6.0	86.4	94.7	102.7	72.2	77.5	82.5	-16.5	-18.2	-19.7
GFDL.CM3	59.4	67.1	75.2	67.1	75.7	85.1	13.0	12.9	13.2
GFDL.ESM2G	59.1	69.1	80.3	65.2	73.2	81.5	10.3	6.1	1.4
GFDL.ESM2M	69.8	82.9	97.9	50.0	54.8	59.5	-28.3	-34.0	-39.2
inmcm4	87.9	109.5	137.0	86.3	99.1	112.7	-1.9	-9.5	-17.8
IPSL.CM5A.LR	49.8	57.2	65.4	55.2	64.0	74.0	10.9	11.8	13.3
IPSL.CM5A.MR	57.9	65.9	74.4	67.1	81.3	98.7	15.9	23.3	32.7
MIROC.ESM.CHEM	65.0	81.1	101.3	50.9	54.8	58.4	-21.8	-32.5	-42.3
MIROC.ESM	50.3	54.3	58.1	58.6	66.2	74.3	16.6	21.8	27.9
MIROC5	90.5	104.8	120.7	110.9	121.8	132.3	22.6	16.3	9.6
MPI.ESM.LR	81.1	90.3	99.8	75.5	81.6	87.3	-7.0	-9.7	-12.5
MPI.ESM.MR	90.8	104.4	118.9	77.4	84.0	90.4	-14.7	-19.6	-24.0
MRI.CGCM3	93.0	112.6	136.4	79.3	83.9	87.7	-14.7	-25.5	-35.7
NorESM1.M	59.3	63.5	67.2	51.0	52.8	54.1	-14.0	-16.8	-19.4

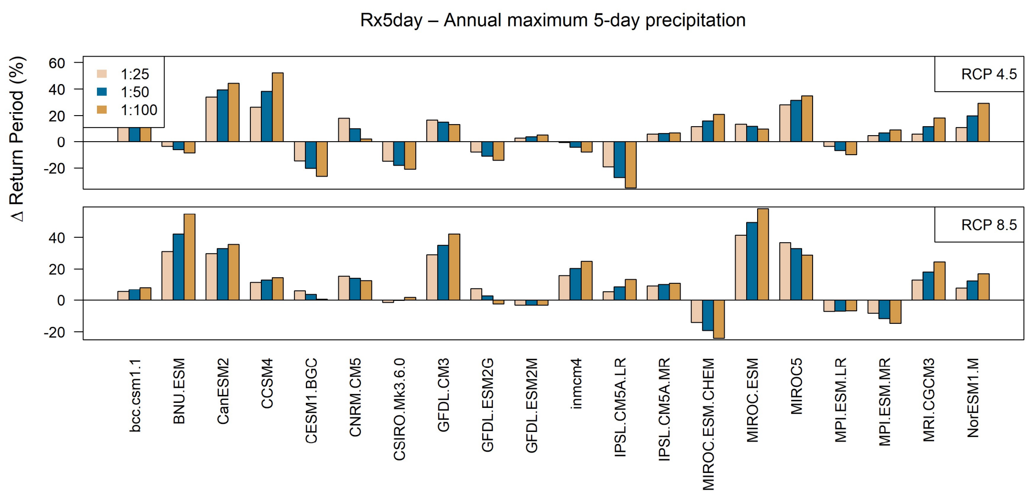


Table 18. CLIMDEX Rx5day – Annual maximum 5-day precipitation (RCP 4.5)

Rx5day	RCP 4.5 1976 - 2005			RCP 4.5 2035 - 2064			Δ RCP 4.5 (%)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	90.2	95.7	100.8	132.2	148.4	165.5	46.5	55.1	64.1
BNU.ESM	118.9	130.6	142.0	114.5	122.5	129.8	-3.7	-6.2	-8.6

CanESM2	71.5	73.6	75.3	95.8	102.5	108.7	33.9	39.3	44.4
CCSM4	126.9	134.3	140.8	160.4	185.9	214.5	26.4	38.4	52.3
CESM1.BGC	155.1	181.3	211.8	132.4	144.6	156.2	-14.6	-20.3	-26.2
CNRM.CM5	135.9	155.7	177.9	160.3	171.6	181.5	17.9	10.2	2.0
CSIRO.Mk3.6.0	140.3	154.5	168.4	119.4	126.8	133.2	-14.9	-18.0	-20.9
GFDL.CM3	98.1	104.4	110.2	114.5	120.0	124.7	16.7	15.0	13.2
GFDL.ESM2G	105.9	120.3	136.1	97.6	107.0	116.9	-7.9	-11.0	-14.1
GFDL.ESM2M	110.2	119.4	128.2	113.1	124.2	135.2	2.7	4.0	5.5
inmcm4	145.1	160.4	175.7	144.0	153.4	161.7	-0.7	-4.3	-8.0
IPSL.CM5A.LR	109.3	127.6	148.5	88.5	92.7	96.3	-19.0	-27.4	-35.1
IPSL.CM5A.MR	110.1	119.9	129.3	116.8	127.6	138.3	6.1	6.5	7.0
MIROC.ESM.CHEM	114.1	132.5	153.0	127.5	153.5	185.0	11.7	15.9	20.9
MIROC.ESM	99.6	109.8	120.2	113.0	122.8	132.2	13.4	11.8	10.0
MIROC5	130.9	144.8	159.2	167.7	190.5	214.8	28.1	31.5	35.0
MPI.ESM.LR	138.6	149.5	159.7	133.5	139.3	144.0	-3.7	-6.8	-9.8
MPI.ESM.MR	130.9	141.6	151.9	137.2	151.4	165.8	4.9	6.9	9.2
MRI.CGCM3	157.3	175.4	193.6	167.0	195.8	228.7	6.1	11.7	18.1
NorESM1.M	101.2	103.1	104.4	112.4	123.5	135.1	11.0	19.8	29.3

Table 19. CLIMDEX Rx5day – Annual maximum 5-day precipitation (RCP 8.5)

Rx5day	**RCP 8.5 1976 - 2005**			**RCP 8.5 2035 - 2064**			**Δ RCP 8.5 (%)**		
GCM	**Return Period**			**Return Period**			**Return Period**		
	25 yr	**50 yr**	**100 yr**	**25 yr**	**50 yr**	**100 yr**	**25 yr**	**50 yr**	**100 yr**
bcc.csm1.1	90.2	95.7	100.8	95.1	102.2	109.0	5.5	6.8	8.1
BNU.ESM	118.9	130.6	142.0	155.8	185.5	220.0	31.0	42.1	54.9
CanESM2	71.5	73.6	75.3	92.8	97.8	102.0	29.8	32.8	35.6
CCSM4	126.9	134.3	140.8	141.4	151.7	161.1	11.4	12.9	14.4
CESM1.BGC	155.1	181.3	211.8	164.1	187.7	212.9	5.8	3.6	0.5
CNRM.CM5	135.9	155.7	177.9	156.8	177.8	200.2	15.3	14.1	12.5
CSIRO.Mk3.6.0	140.3	154.5	168.4	138.1	154.3	171.4	-1.5	-0.2	1.8
GFDL.CM3	98.1	104.4	110.2	126.5	140.9	156.6	29.0	35.0	42.1
GFDL.ESM2G	105.9	120.3	136.1	113.9	123.5	132.7	7.5	2.7	-2.5
GFDL.ESM2M	110.2	119.4	128.2	106.7	115.6	124.1	-3.2	-3.3	-3.2
inmcm4	145.1	160.4	175.7	168.1	192.9	219.3	15.9	20.3	24.8
IPSL.CM5A.LR	109.3	127.6	148.5	115.0	138.6	168.3	5.2	8.6	13.3
IPSL.CM5A.MR	110.1	119.9	129.3	120.3	132.0	143.3	9.3	10.1	10.8
MIROC.ESM.CHEM	114.1	132.5	153.0	98.0	107.1	116.1	-14.1	-19.1	-24.1
MIROC.ESM	99.6	109.8	120.2	140.8	164.2	190.4	41.3	49.5	58.5
MIROC5	130.9	144.8	159.2	178.9	192.6	204.9	36.7	33.0	28.7
MPI.ESM.LR	138.6	149.5	159.7	128.8	139.1	149.0	-7.1	-7.0	-6.7
MPI.ESM.MR	130.9	141.6	151.9	120.0	125.2	129.6	-8.3	-11.6	-14.7
MRI.CGCM3	157.3	175.4	193.6	177.6	207.0	240.9	12.9	18.0	24.4
NorESM1.M	101.2	103.1	104.4	109.3	116.0	122.1	8.0	12.5	17.0

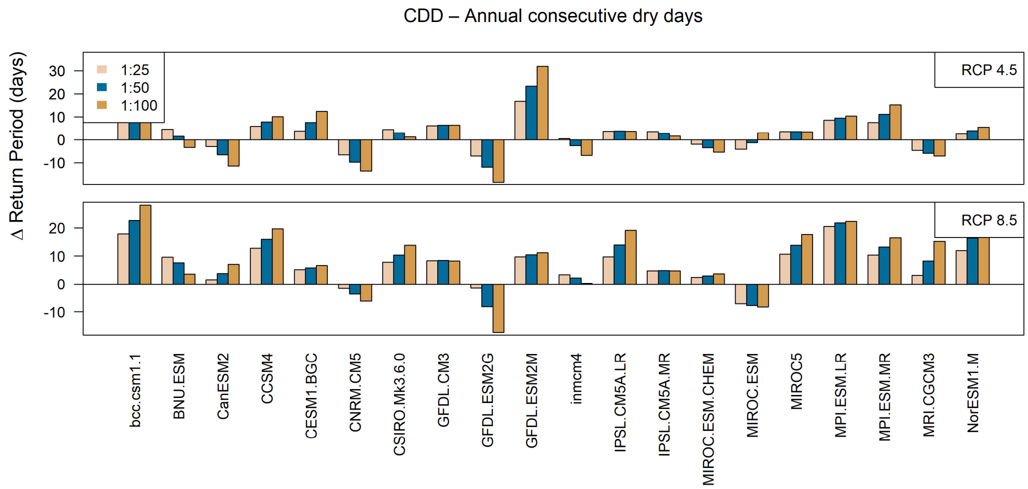


Table 20. CLIMDEX CDD – Annual consecutive dry days (RCP 4.5)

CDD	RCP 4.5 1976 - 2005			RCP 4.5 2035 - 2064			Δ RCP 4.5 (days)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	27.1	29.5	31.7	52.4	60.5	68.9	25.3	31.0	37.2
BNU.ESM	27.1	33.2	41.2	31.7	34.8	37.9	4.7	1.6	-3.3
CanESM2	23.7	28.7	35.0	20.7	22.2	23.5	-3.0	-6.5	-11.4
CCSM4	31.8	34.6	37.2	37.6	42.4	47.3	5.9	7.8	10.1
CESM1.BGC	36.1	39.7	43.2	39.9	47.2	55.7	3.8	7.5	12.5
CNRM.CM5	36.3	42.5	49.5	29.8	32.8	35.9	-6.5	-9.7	-13.7
CSIRO.Mk3.6.0	41.0	45.3	49.5	45.5	48.4	50.9	4.5	3.1	1.3
GFDL.CM3	29.8	32.9	35.9	36.0	39.3	42.4	6.2	6.4	6.4
GFDL.ESM2G	37.2	46.6	58.4	30.1	34.8	39.9	-7.0	-11.9	-18.4
GFDL.ESM2M	26.9	29.9	32.7	43.7	53.2	64.6	16.7	23.3	31.9
inmcm4	34.5	40.3	47.0	35.1	37.7	40.2	0.6	-2.6	-6.8
IPSL.CM5A.LR	32.2	35.9	39.4	36.0	39.6	43.1	3.8	3.8	3.7
IPSL.CM5A.MR	26.8	30.2	33.8	30.4	33.0	35.5	3.6	2.9	1.7
MIROC.ESM.CHEM	26.1	29.9	33.9	24.2	26.4	28.5	-1.9	-3.5	-5.4
MIROC.ESM	27.7	30.1	32.3	23.6	28.8	35.4	-4.1	-1.3	3.1
MIROC5	29.3	32.1	34.9	32.9	35.7	38.4	3.6	3.6	3.5
MPI.ESM.LR	35.1	39.8	44.7	43.7	49.3	55.1	8.6	9.5	10.4
MPI.ESM.MR	33.9	36.2	38.2	41.4	47.2	53.4	7.5	11.1	15.2
MRI.CGCM3	35.5	38.3	40.8	30.8	32.4	33.7	-4.7	-5.9	-7.1
NorESM1.M	25.7	27.1	28.2	28.2	31.0	33.7	2.5	3.9	5.5

Table 21. CLIMDEX CDD – Annual consecutive dry days (RCP 8.5)

CDD	RCP 8.5 1976 - 2005			RCP 8.5 2035 - 2064			Δ RCP 8.5 (days)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	27.1	29.5	31.7	45.0	52.1	59.9	17.9	22.6	28.2
BNU.ESM	27.1	33.2	41.2	36.7	40.8	44.8	9.6	7.6	3.6

CanESM2	23.7	28.7	35.0	25.3	32.5	42.0	1.6	3.8	7.1
CCSM4	31.8	34.6	37.2	44.5	50.6	56.8	12.8	16.0	19.6
CESM1.BGC	36.1	39.7	43.2	41.3	45.5	49.8	5.1	5.8	6.6
CNRM.CM5	36.3	42.5	49.5	34.7	38.9	43.4	-1.6	-3.6	-6.2
CSIRO.Mk3.6.0	41.0	45.3	49.5	48.7	55.7	63.3	7.8	10.4	13.8
GFDL.CM3	29.8	32.9	35.9	38.1	41.3	44.2	8.3	8.4	8.2
GFDL.ESM2G	37.2	46.6	58.4	35.6	38.4	41.0	-1.5	-8.2	-17.4
GFDL.ESM2M	26.9	29.9	32.7	36.6	40.3	43.9	9.7	10.5	11.2
inmcm4	34.5	40.3	47.0	37.9	42.6	47.3	3.4	2.2	0.3
IPSL.CM5A.LR	32.2	35.9	39.4	42.0	49.8	58.6	9.8	14.0	19.1
IPSL.CM5A.MR	26.8	30.2	33.8	31.6	35.1	38.6	4.8	4.9	4.8
MIROC.ESM.CHEM	26.1	29.9	33.9	28.5	32.9	37.6	2.4	3.0	3.7
MIROC.ESM	27.7	30.1	32.3	20.6	22.4	24.1	-7.1	-7.7	-8.3
MIROC5	29.3	32.1	34.9	39.9	46.0	52.5	10.6	13.9	17.6
MPI.ESM.LR	35.1	39.8	44.7	55.6	61.5	67.0	20.5	21.7	22.3
MPI.ESM.MR	33.9	36.2	38.2	44.2	49.4	54.6	10.3	13.2	16.4
MRI.CGCM3	35.5	38.3	40.8	38.6	46.5	56.0	3.1	8.2	15.2
NorESM1.M	25.7	27.1	28.2	37.6	43.4	49.7	11.9	16.4	21.4

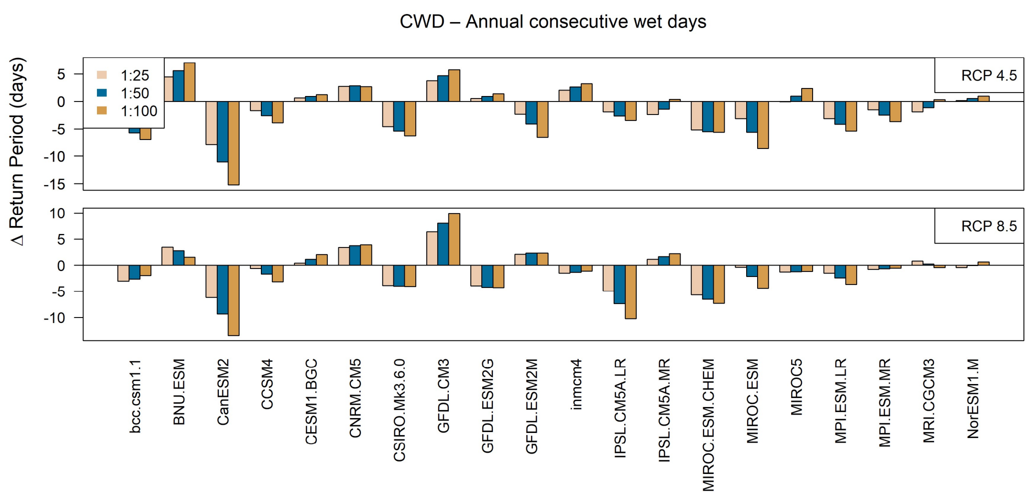


Table 22. CLIMDEX CWD – Annual consecutive wet days (RCP 4.5)

CWD	RCP 4.5 1976 - 2005			RCP 4.5 2035 - 2064			Δ RCP 4.5 (days)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	25.5	28.5	31.6	20.9	22.8	24.6	-4.6	-5.7	-7.0
BNU.ESM	27.4	31.8	36.7	31.8	37.4	43.8	4.4	5.6	7.0
CanESM2	34.4	42.5	52.5	26.4	31.4	37.3	-7.9	-11.1	-15.2
CCSM4	17.8	20.5	23.6	16.1	17.9	19.7	-1.7	-2.6	-3.9
CESM1.BGC	13.9	14.8	15.7	14.5	15.7	16.9	0.6	0.9	1.2
CNRM.CM5	17.5	20.8	24.8	20.3	23.6	27.4	2.7	2.8	2.7
CSIRO.Mk3.6.0	16.8	18.2	19.6	12.1	12.8	13.4	-4.6	-5.4	-6.3
GFDL.CM3	18.6	21.2	24.0	22.4	25.8	29.7	3.7	4.7	5.7

GFDL.ESM2G	24.7	27.9	31.1	25.2	28.8	32.5	0.5	0.9	1.4
GFDL.ESM2M	21.3	24.7	28.6	19.0	20.6	22.1	-2.3	-4.1	-6.5
inmcm4	15.8	16.5	17.2	17.8	19.2	20.4	2.0	2.6	3.2
IPSL.CM5A.LR	25.8	29.8	34.1	23.9	27.1	30.6	-1.9	-2.6	-3.5
IPSL.CM5A.MR	22.6	25.7	29.0	20.2	24.3	29.4	-2.4	-1.4	0.4
MIROC.ESM.CHEM	24.8	27.8	30.9	19.7	22.3	25.3	-5.2	-5.5	-5.6
MIROC.ESM	22.3	26.1	30.4	19.1	20.5	21.8	-3.2	-5.6	-8.6
MIROC5	14.5	15.6	16.6	14.4	16.5	18.9	-0.1	1.0	2.3
MPI.ESM.LR	16.0	18.4	21.1	12.9	14.2	15.7	-3.1	-4.2	-5.4
MPI.ESM.MR	16.2	18.2	20.2	14.6	15.7	16.6	-1.5	-2.5	-3.7
MRI.CGCM3	18.0	20.2	22.4	16.1	19.0	22.6	-1.9	-1.2	0.3
NorESM1.M	24.3	28.1	32.3	24.5	28.6	33.3	0.2	0.5	1.0

Table 23. CLIMDEX CWD – Annual consecutive wet days (RCP 8.5)

CWD	**RCP 8.5 1976 - 2005**			**RCP 8.5 2035 - 2064**			**Δ RCP 8.5 (days)**		
GCM	**Return Period**			**Return Period**			**Return Period**		
	25 yr	**50 yr**	**100 yr**	**25 yr**	**50 yr**	**100 yr**	**25 yr**	**50 yr**	**100 yr**
bcc.csm1.1	25.5	28.5	31.6	22.4	25.9	29.7	-3.1	-2.6	-1.9
BNU.ESM	27.4	31.8	36.7	30.8	34.6	38.3	3.5	2.8	1.5
CanESM2	34.4	42.5	52.5	28.2	33.2	39.0	-6.2	-9.3	-13.4
CCSM4	17.8	20.5	23.6	17.2	18.9	20.5	-0.6	-1.7	-3.1
CESM1.BGC	13.9	14.8	15.7	14.3	16.0	17.8	0.4	1.1	2.0
CNRM.CM5	17.5	20.8	24.8	20.9	24.5	28.7	3.4	3.7	3.9
CSIRO.Mk3.6.0	16.8	18.2	19.6	12.9	14.2	15.6	-3.8	-4.0	-4.0
GFDL.CM3	18.6	21.2	24.0	25.0	29.2	33.9	6.4	8.0	9.9
GFDL.ESM2G	24.7	27.9	31.1	20.8	23.7	26.9	-3.9	-4.2	-4.3
GFDL.ESM2M	21.3	24.7	28.6	23.4	27.0	30.9	2.1	2.3	2.3
inmcm4	15.8	16.5	17.2	14.3	15.2	16.1	-1.5	-1.3	-1.1
IPSL.CM5A.LR	25.8	29.8	34.1	20.9	22.4	23.9	-4.9	-7.4	-10.3
IPSL.CM5A.MR	22.6	25.7	29.0	23.7	27.3	31.2	1.2	1.6	2.2
MIROC.ESM.CHEM	24.8	27.8	30.9	19.1	21.3	23.7	-5.7	-6.5	-7.3
MIROC.ESM	22.3	26.1	30.4	21.9	24.0	26.0	-0.4	-2.1	-4.4
MIROC5	14.5	15.6	16.6	13.2	14.4	15.5	-1.3	-1.2	-1.1
MPI.ESM.LR	16.0	18.4	21.1	14.5	16.0	17.5	-1.5	-2.4	-3.6
MPI.ESM.MR	16.2	18.2	20.2	15.4	17.5	19.7	-0.7	-0.7	-0.5
MRI.CGCM3	18.0	20.2	22.4	18.8	20.4	21.9	0.8	0.2	-0.4
NorESM1.M	24.3	28.1	32.3	23.9	28.1	32.9	-0.4	0.0	0.6

6.2.6 *CLIMDEX Return periods Temperature*

The estimation of changes in temperature extremes is done for the return periods of 25, 50, and 100 years. This is done by analyzing the distribution of the change (in °C) for each downscaled climate model for each of those return periods.

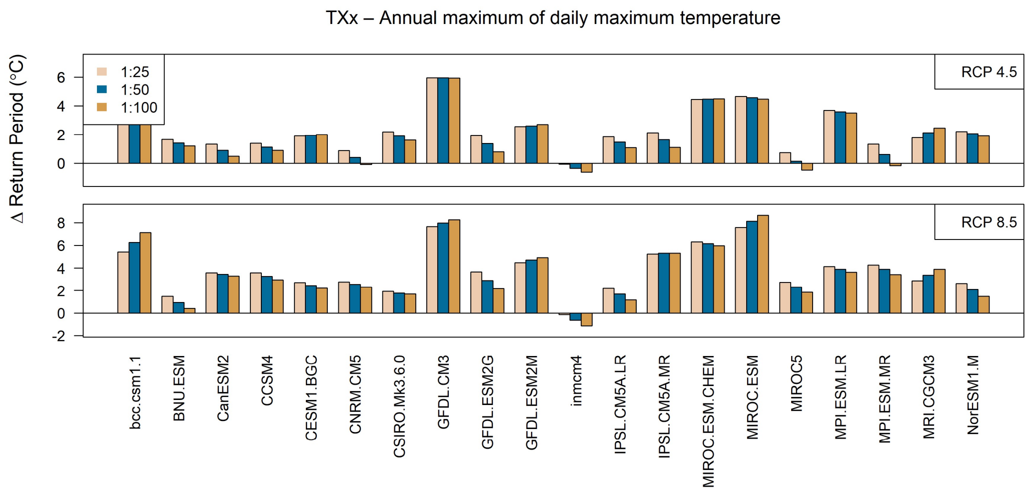


Table 24. CLIMDEX TXx – Annual maximum of daily maximum temperature (RCP 4.5)

TXx	RCP 4.5 1976 - 2005			RCP 4.5 2035 - 2064			Δ RCP 4.5 (°C)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	38.0	38.2	38.3	42.8	43.9	44.9	4.8	5.7	6.6
BNU.ESM	38.9	39.7	40.4	40.6	41.1	41.6	1.7	1.4	1.2
CanESM2	38.4	39.0	39.5	39.8	39.9	40.0	1.3	0.9	0.5
CCSM4	40.2	40.9	41.5	41.6	42.1	42.4	1.4	1.1	0.9
CESM1.BGC	39.5	39.9	40.3	41.4	41.9	42.3	1.9	1.9	2.0
CNRM.CM5	39.6	40.6	41.5	40.4	41.0	41.5	0.9	0.4	-0.1
CSIRO.Mk3.6.0	41.1	42.2	43.3	43.3	44.1	44.9	2.2	1.9	1.6
GFDL.CM3	38.2	38.5	38.7	44.2	44.4	44.6	6.0	5.9	5.9
GFDL.ESM2G	39.8	40.8	41.7	41.7	42.1	42.5	1.9	1.4	0.8
GFDL.ESM2M	39.1	40.0	40.7	41.7	42.6	43.4	2.6	2.6	2.7
inmcm4	40.4	41.2	42.0	40.3	40.9	41.3	-0.1	-0.3	-0.6
IPSL.CM5A.LR	38.5	39.3	40.0	40.4	40.8	41.1	1.8	1.5	1.1
IPSL.CM5A.MR	39.3	40.1	40.9	41.4	41.8	42.0	2.1	1.6	1.1
MIROC.ESM.CHEM	37.3	37.7	38.1	41.7	42.2	42.6	4.4	4.5	4.5
MIROC.ESM	37.6	38.1	38.5	42.3	42.6	42.9	4.7	4.6	4.5
MIROC5	39.9	40.9	41.8	40.6	41.0	41.3	0.7	0.1	-0.5
MPI.ESM.LR	40.8	41.4	41.9	44.5	45.0	45.4	3.7	3.6	3.5
MPI.ESM.MR	41.0	42.2	43.4	42.3	42.8	43.2	1.3	0.6	-0.2
MRI.CGCM3	39.0	39.3	39.5	40.7	41.4	42.0	1.8	2.1	2.5
NorESM1.M	40.2	41.2	42.2	42.4	43.3	44.1	2.2	2.1	1.9

Table 25. CLIMDEX TXx – Annual maximum of daily maximum temperature (RCP 8.5)

TXx	RCP 8.5 1976 - 2005			RCP 8.5 2035 - 2064			Δ RCP 8.5 (°C)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	38.0	38.2	38.3	43.4	44.4	45.4	5.4	6.2	7.1
BNU.ESM	38.9	39.7	40.4	40.4	40.6	40.8	1.5	0.9	0.4
CanESM2	38.4	39.0	39.5	42.0	42.5	42.8	3.6	3.4	3.3
CCSM4	40.2	40.9	41.5	43.8	44.2	44.5	3.6	3.3	3.0
CESM1.BGC	39.5	39.9	40.3	42.2	42.4	42.6	2.7	2.5	2.2
CNRM.CM5	39.6	40.6	41.5	42.3	43.2	43.9	2.8	2.6	2.3
CSIRO.Mk3.6.0	41.1	42.2	43.3	43.0	44.0	45.0	1.9	1.8	1.7
GFDL.CM3	38.2	38.5	38.7	45.9	46.5	46.9	7.7	8.0	8.2
GFDL.ESM2G	39.8	40.8	41.7	43.4	43.7	43.8	3.7	2.9	2.2
GFDL.ESM2M	39.1	40.0	40.7	43.6	44.7	45.7	4.5	4.7	4.9
inmcm4	40.4	41.2	42.0	40.3	40.6	40.8	-0.1	-0.6	-1.1
IPSL.CM5A.LR	38.5	39.3	40.0	40.7	41.0	41.2	2.2	1.7	1.2
IPSL.CM5A.MR	39.3	40.1	40.9	44.5	45.4	46.2	5.2	5.3	5.3
MIROC.ESM.CHEM	37.3	37.7	38.1	43.6	43.9	44.1	6.3	6.1	6.0
MIROC.ESM	37.6	38.1	38.5	45.2	46.2	47.1	7.6	8.1	8.7
MIROC5	39.9	40.9	41.8	42.7	43.2	43.6	2.8	2.3	1.8
MPI.ESM.LR	40.8	41.4	41.9	44.9	45.3	45.6	4.1	3.9	3.6
MPI.ESM.MR	41.0	42.2	43.4	45.2	46.1	46.8	4.3	3.9	3.4
MRI.CGCM3	39.0	39.3	39.5	41.8	42.6	43.4	2.9	3.4	3.9
NorESM1.M	40.2	41.2	42.2	42.8	43.3	43.7	2.6	2.1	1.5

TXn – Annual minimum of daily maximum temperature

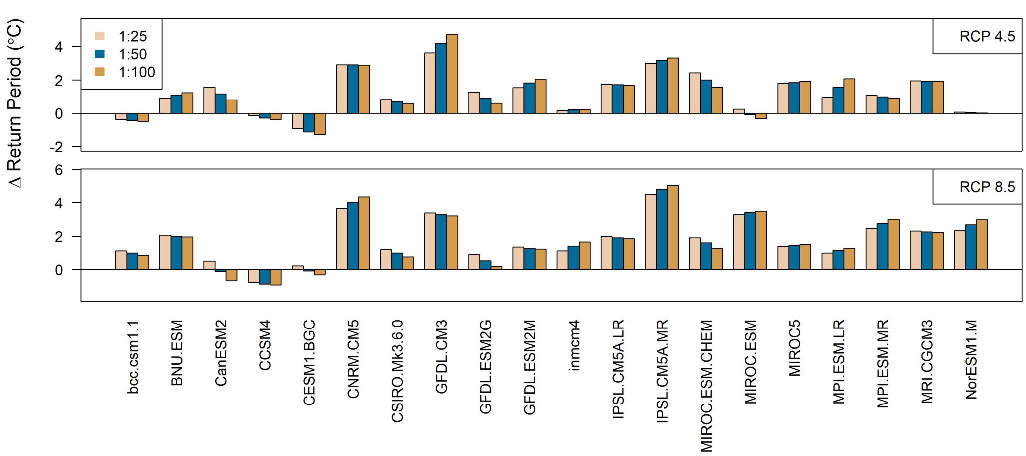


Table 26. CLIMDEX TXn – Annual minimum of daily maximum temperature (RCP 4.5)

TXn	RCP 4.5 1976 - 2005			RCP 4.5 2035 - 2064			Δ RCP 4.5 (°C)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	1.3	2.0	2.5	1.0	1.5	2.0	-0.4	-0.4	-0.5
BNU.ESM	0.4	0.5	0.6	1.3	1.6	1.8	0.9	1.1	1.2

CanESM2	1.6	2.4	3.1	3.2	3.6	3.9	1.6	1.2	0.8
CCSM4	1.1	1.5	1.7	0.9	1.2	1.3	-0.2	-0.3	-0.4
CESM1.BGC	1.8	2.3	2.7	0.9	1.2	1.5	-0.9	-1.1	-1.3
CNRM.CM5	0.9	1.3	1.5	3.8	4.2	4.4	2.9	2.9	2.9
CSIRO.Mk3.6.0	-0.3	0.2	0.6	0.5	0.9	1.1	0.8	0.7	0.6
GFDL.CM3	0.4	0.8	1.0	4.0	4.9	5.7	3.6	4.2	4.7
GFDL.ESM2G	0.9	1.6	2.2	2.2	2.5	2.8	1.3	0.9	0.6
GFDL.ESM2M	0.1	0.3	0.4	1.7	2.1	2.5	1.5	1.8	2.1
inmcm4	0.4	0.8	1.0	0.6	1.0	1.2	0.2	0.2	0.2
IPSL.CM5A.LR	0.4	0.8	1.0	2.1	2.5	2.7	1.7	1.7	1.7
IPSL.CM5A.MR	-0.1	0.2	0.3	2.9	3.3	3.7	3.0	3.2	3.3
MIROC.ESM.CHEM	1.0	1.7	2.4	3.4	3.7	3.9	2.4	2.0	1.6
MIROC.ESM	1.5	2.1	2.5	1.7	2.0	2.2	0.2	-0.1	-0.3
MIROC5	2.3	2.7	3.1	4.0	4.6	5.0	1.8	1.8	1.9
MPI.ESM.LR	1.1	1.3	1.4	2.0	2.8	3.4	0.9	1.5	2.1
MPI.ESM.MR	0.0	0.4	0.6	1.1	1.4	1.5	1.1	1.0	0.9
MRI.CGCM3	-0.5	-0.3	-0.1	1.4	1.6	1.8	2.0	1.9	1.9
NorESM1.M	1.1	1.3	1.5	1.2	1.4	1.5	0.1	0.0	0.0

Table 27. CLIMDEX TXn – Annual minimum of daily maximum temperature (RCP 8.5)

TXn	**RCP 8.5 1976 - 2005**			**RCP 8.5 2035 - 2064**			**Δ RCP 8.5 (°C)**		
GCM	**Return Period**			**Return Period**			**Return Period**		
	25 yr	**50 yr**	**100 yr**	**25 yr**	**50 yr**	**100 yr**	**25 yr**	**50 yr**	**100 yr**
bcc.csm1.1	1.3	2.0	2.5	2.5	2.9	3.3	1.1	1.0	0.8
BNU.ESM	0.4	0.5	0.6	2.4	2.5	2.5	2.1	2.0	2.0
CanESM2	1.6	2.4	3.1	2.1	2.3	2.4	0.5	-0.1	-0.7
CCSM4	1.1	1.5	1.7	0.3	0.6	0.8	-0.8	-0.8	-0.9
CESM1.BGC	1.8	2.3	2.7	2.0	2.3	2.4	0.2	-0.1	-0.3
CNRM.CM5	0.9	1.3	1.5	4.5	5.3	5.9	3.7	4.0	4.3
CSIRO.Mk3.6.0	-0.3	0.2	0.6	0.9	1.2	1.3	1.2	1.0	0.8
GFDL.CM3	0.4	0.8	1.0	3.8	4.1	4.2	3.4	3.3	3.2
GFDL.ESM2G	0.9	1.6	2.2	1.8	2.1	2.4	0.9	0.5	0.2
GFDL.ESM2M	0.1	0.3	0.4	1.5	1.6	1.6	1.4	1.3	1.2
inmcm4	0.4	0.8	1.0	1.6	2.2	2.6	1.1	1.4	1.7
IPSL.CM5A.LR	0.4	0.8	1.0	2.4	2.7	2.9	2.0	1.9	1.9
IPSL.CM5A.MR	-0.1	0.2	0.3	4.4	4.9	5.4	4.5	4.8	5.0
MIROC.ESM.CHEM	1.0	1.7	2.4	2.9	3.4	3.7	1.9	1.6	1.3
MIROC.ESM	1.5	2.1	2.5	4.8	5.5	6.0	3.3	3.4	3.5
MIROC5	2.3	2.7	3.1	3.6	4.2	4.6	1.4	1.4	1.5
MPI.ESM.LR	1.1	1.3	1.4	2.1	2.4	2.7	1.0	1.2	1.3
MPI.ESM.MR	0.0	0.4	0.6	2.5	3.1	3.6	2.5	2.8	3.0
MRI.CGCM3	-0.5	-0.3	-0.1	1.8	2.0	2.1	2.3	2.3	2.2
NorESM1.M	1.1	1.3	1.5	3.4	4.0	4.4	2.3	2.7	3.0

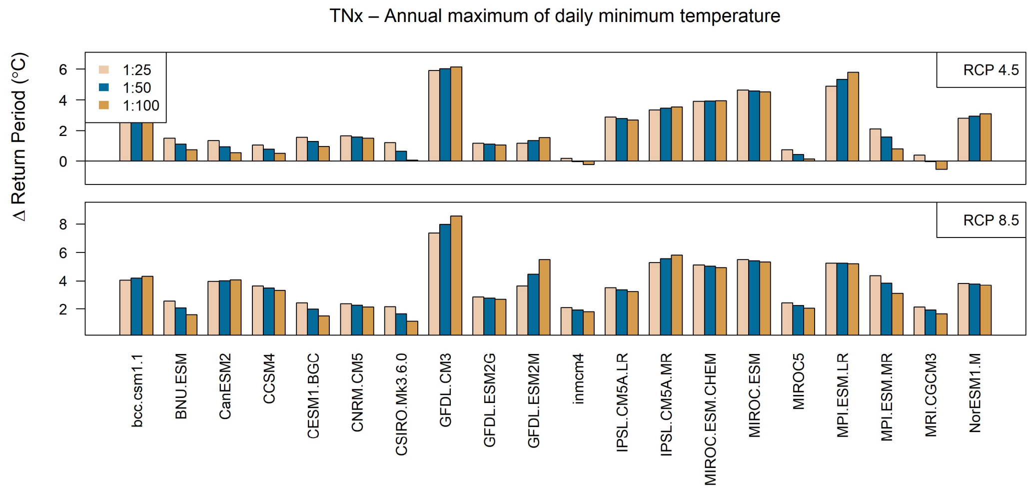


Table 28. CLIMDEX TNx – Annual maximum of daily minimum temperature (RCP 4.5)

TNx	RCP 4.5 1976 - 2005			RCP 4.5 2035 - 2064			Δ RCP 4.5 (°C)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	22.5	22.8	23.0	26.1	26.5	26.8	3.7	3.7	3.8
BNU.ESM	25.2	26.0	26.8	26.7	27.1	27.5	1.5	1.1	0.7
CanESM2	23.6	24.1	24.6	24.9	25.1	25.2	1.3	0.9	0.5
CCSM4	23.7	24.4	25.0	24.8	25.2	25.5	1.0	0.8	0.5
CESM1.BGC	24.3	25.1	25.9	25.8	26.3	26.8	1.5	1.3	0.9
CNRM.CM5	22.3	22.6	22.9	23.9	24.2	24.4	1.6	1.6	1.5
CSIRO.Mk3.6.0	25.6	26.6	27.6	26.8	27.3	27.6	1.2	0.6	0.1
GFDL.CM3	22.4	22.6	22.7	28.3	28.6	28.8	5.9	6.0	6.1
GFDL.ESM2G	22.4	22.9	23.4	23.5	24.0	24.5	1.2	1.1	1.0
GFDL.ESM2M	22.7	23.1	23.4	23.8	24.4	24.9	1.2	1.3	1.5
inmcm4	27.2	28.1	28.9	27.4	28.1	28.7	0.2	0.0	-0.2
IPSL.CM5A.LR	22.2	22.5	22.7	25.1	25.3	25.4	2.9	2.8	2.7
IPSL.CM5A.MR	23.6	23.9	24.2	26.9	27.4	27.8	3.3	3.5	3.5
MIROC.ESM.CHEM	21.1	21.4	21.6	25.0	25.3	25.6	3.9	3.9	3.9
MIROC.ESM	21.1	21.4	21.6	25.7	26.0	26.1	4.6	4.6	4.5
MIROC5	22.4	22.8	23.1	23.1	23.2	23.2	0.7	0.4	0.1
MPI.ESM.LR	22.5	22.9	23.3	27.4	28.2	29.1	4.9	5.3	5.8
MPI.ESM.MR	23.6	24.7	26.0	25.7	26.3	26.8	2.1	1.6	0.8
MRI.CGCM3	25.4	26.4	27.3	25.8	26.3	26.8	0.4	0.0	-0.5
NorESM1.M	23.4	23.9	24.5	26.2	26.9	27.6	2.8	2.9	3.1

Table 29. CLIMDEX TNx – Annual maximum of daily minimum temperature (RCP 8.5)

TNx	RCP 8.5 1976 - 2005			RCP 8.5 2035 - 2064			Δ RCP 8.5 (°C)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	22.5	22.8	23.0	26.5	26.9	27.3	4.1	4.2	4.3
BNU.ESM	25.2	26.0	26.8	27.8	28.1	28.4	2.6	2.1	1.6

CanESM2	23.6	24.1	24.6	27.6	28.2	28.7	4.0	4.0	4.1
CCSM4	23.7	24.4	25.0	27.3	27.9	28.3	3.6	3.5	3.3
CESM1.BGC	24.3	25.1	25.9	26.7	27.1	27.4	2.4	2.0	1.5
CNRM.CM5	22.3	22.6	22.9	24.7	24.9	25.0	2.4	2.2	2.1
CSIRO.Mk3.6.0	25.6	26.6	27.6	27.8	28.3	28.7	2.1	1.6	1.1
GFDL.CM3	22.4	22.6	22.7	29.8	30.5	31.2	7.4	8.0	8.6
GFDL.ESM2G	22.4	22.9	23.4	25.2	25.7	26.1	2.8	2.8	2.7
GFDL.ESM2M	22.7	23.1	23.4	26.3	27.5	28.9	3.6	4.5	5.5
inmcm4	27.2	28.1	28.9	29.3	30.0	30.7	2.1	1.9	1.8
IPSL.CM5A.LR	22.2	22.5	22.7	25.7	25.8	25.9	3.5	3.4	3.2
IPSL.CM5A.MR	23.6	23.9	24.2	28.9	29.5	30.1	5.3	5.6	5.8
MIROC.ESM.CHEM	21.1	21.4	21.6	26.3	26.4	26.5	5.1	5.0	4.9
MIROC.ESM	21.1	21.4	21.6	26.6	26.8	27.0	5.5	5.4	5.3
MIROC5	22.4	22.8	23.1	24.8	25.0	25.2	2.4	2.2	2.0
MPI.ESM.LR	22.5	22.9	23.3	27.8	28.2	28.5	5.3	5.3	5.2
MPI.ESM.MR	23.6	24.7	26.0	27.9	28.6	29.1	4.4	3.9	3.1
MRI.CGCM3	25.4	26.4	27.3	27.5	28.3	29.0	2.1	1.9	1.6
NorESM1.M	23.4	23.9	24.5	27.2	27.7	28.2	3.8	3.8	3.7

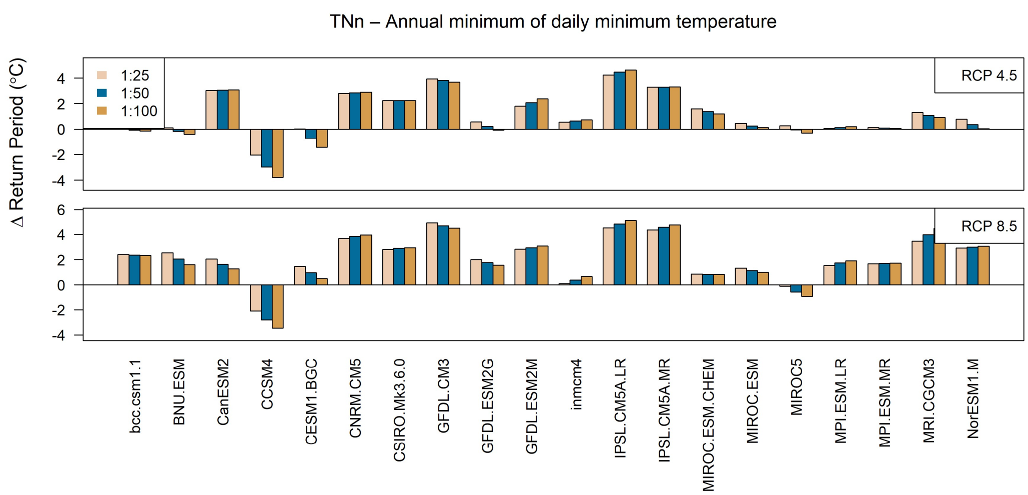


Table 30. CLIMDEX TNn – Annual minimum of daily minimum temperature (RCP 4.5)

TNn	RCP 4.5 1976 - 2005			RCP 4.5 2035 - 2064			Δ RCP 4.5 (°C)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	-10.1	-9.2	-8.4	-10.0	-9.3	-8.6	0.1	-0.1	-0.2
BNU.ESM	-9.8	-9.1	-8.5	-9.7	-9.3	-8.9	0.1	-0.2	-0.4
CanESM2	-7.7	-7.0	-6.6	-4.7	-4.0	-3.5	3.0	3.1	3.1
CCSM4	-7.0	-5.7	-4.6	-9.1	-8.7	-8.4	-2.1	-3.0	-3.8
CESM1.BGC	-9.7	-8.5	-7.4	-9.7	-9.2	-8.9	0.0	-0.7	-1.5
CNRM.CM5	-9.8	-9.2	-8.8	-7.0	-6.4	-6.0	2.8	2.8	2.9
CSIRO.Mk3.6.0	-11.3	-11.0	-10.8	-9.0	-8.7	-8.6	2.2	2.2	2.2
GFDL.CM3	-9.6	-9.1	-8.7	-5.7	-5.3	-5.0	3.9	3.8	3.7

GFDL.ESM2G	-9.3	-8.6	-8.1	-8.8	-8.4	-8.2	0.6	0.2	-0.1
GFDL.ESM2M	-10.3	-9.8	-9.5	-8.5	-7.7	-7.1	1.8	2.1	2.4
inmcm4	-9.5	-9.0	-8.7	-9.0	-8.4	-7.9	0.5	0.6	0.7
IPSL.CM5A.LR	-11.3	-11.0	-10.8	-7.1	-6.6	-6.2	4.2	4.5	4.6
IPSL.CM5A.MR	-9.5	-9.2	-9.0	-6.3	-5.9	-5.7	3.3	3.3	3.3
MIROC.ESM.CHEM	-7.1	-6.7	-6.4	-5.5	-5.3	-5.2	1.6	1.4	1.2
MIROC.ESM	-6.9	-6.5	-6.3	-6.4	-6.3	-6.2	0.4	0.3	0.1
MIROC5	-6.3	-5.7	-5.3	-6.0	-5.8	-5.6	0.3	-0.1	-0.3
MPI.ESM.LR	-8.7	-8.5	-8.3	-8.7	-8.3	-8.1	0.1	0.1	0.2
MPI.ESM.MR	-9.4	-9.2	-9.0	-9.2	-9.1	-9.0	0.1	0.1	0.1
MRI.CGCM3	-9.8	-9.3	-8.9	-8.5	-8.2	-8.0	1.3	1.1	0.9
NorESM1.M	-9.4	-8.6	-8.1	-8.6	-8.3	-8.0	0.8	0.4	0.0

Table 31. CLIMDEX TNn – Annual minimum of daily minimum temperature (RCP 8.5)

TNn	**RCP 8.5 1976 - 2005**			**RCP 8.5 2035 - 2064**			**Δ RCP 8.5 (°C)**		
GCM	**Return Period**			**Return Period**			**Return Period**		
	25 yr	**50 yr**	**100 yr**	**25 yr**	**50 yr**	**100 yr**	**25 yr**	**50 yr**	**100 yr**
bcc.csm1.1	-10.1	-9.2	-8.4	-7.7	-6.8	-6.1	2.4	2.4	2.3
BNU.ESM	-9.8	-9.1	-8.5	-7.3	-7.0	-6.9	2.5	2.0	1.6
CanESM2	-7.7	-7.0	-6.6	-5.7	-5.4	-5.3	2.1	1.6	1.3
CCSM4	-7.0	-5.7	-4.6	-9.1	-8.5	-8.1	-2.1	-2.8	-3.5
CESM1.BGC	-9.7	-8.5	-7.4	-8.3	-7.5	-6.9	1.5	1.0	0.5
CNRM.CM5	-9.8	-9.2	-8.8	-6.1	-5.4	-4.9	3.7	3.8	3.9
CSIRO.Mk3.6.0	-11.3	-11.0	-10.8	-8.4	-8.1	-7.9	2.8	2.9	2.9
GFDL.CM3	-9.6	-9.1	-8.7	-4.7	-4.4	-4.2	4.9	4.7	4.5
GFDL.ESM2G	-9.3	-8.6	-8.1	-7.3	-6.9	-6.5	2.0	1.8	1.6
GFDL.ESM2M	-10.3	-9.8	-9.5	-7.5	-6.9	-6.4	2.8	3.0	3.1
inmcm4	-9.5	-9.0	-8.7	-9.4	-8.6	-8.0	0.1	0.4	0.7
IPSL.CM5A.LR	-11.3	-11.0	-10.8	-6.8	-6.2	-5.7	4.5	4.8	5.1
IPSL.CM5A.MR	-9.5	-9.2	-9.0	-5.2	-4.7	-4.3	4.4	4.6	4.7
MIROC.ESM.CHEM	-7.1	-6.7	-6.4	-6.3	-5.9	-5.6	0.9	0.8	0.8
MIROC.ESM	-6.9	-6.5	-6.3	-5.6	-5.4	-5.3	1.3	1.1	1.0
MIROC5	-6.3	-5.7	-5.3	-6.4	-6.3	-6.3	-0.1	-0.6	-1.0
MPI.ESM.LR	-8.7	-8.5	-8.3	-7.2	-6.7	-6.4	1.5	1.7	1.9
MPI.ESM.MR	-9.4	-9.2	-9.0	-7.7	-7.5	-7.3	1.7	1.7	1.7
MRI.CGCM3	-9.8	-9.3	-8.9	-6.3	-5.3	-4.5	3.5	4.0	4.5
NorESM1.M	-9.4	-8.6	-8.1	-6.5	-5.7	-5.0	2.9	3.0	3.1

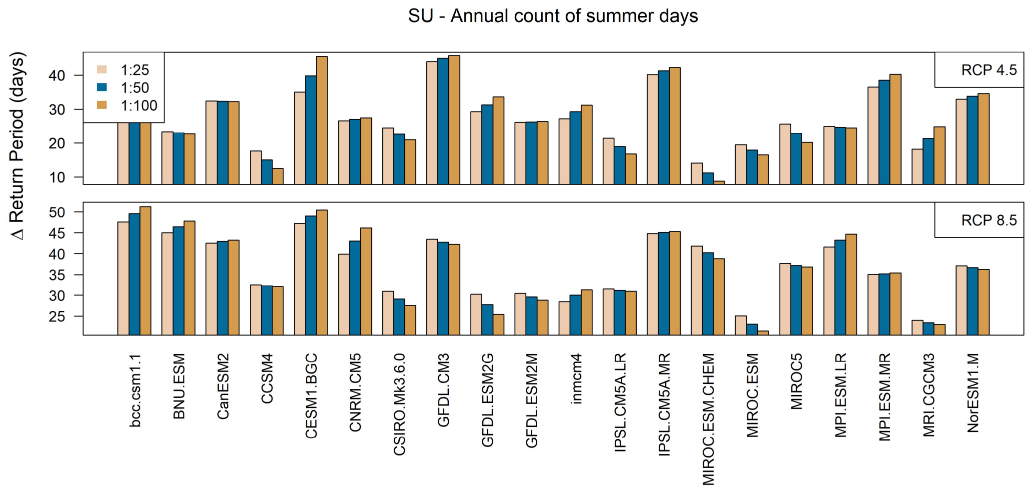


Table 32. CLIMDEX SU – Annual count of days where daily maximum temperature exceeds 25 °C (RCP 4.5)

SU	RCP 4.5 1976 - 2005			RCP 4.5 2035 - 2064			Δ RCP 4.5 (days)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	122.9	123.6	124.0	162.1	163.8	164.9	39.2	40.2	40.9
BNU.ESM	132.9	135.4	137.3	156.2	158.4	160.1	23.3	23.0	22.7
CanESM2	131.6	133.8	135.5	164.0	166.1	167.7	32.4	32.3	32.2
CCSM4	133.8	138.1	142.0	151.3	153.1	154.5	17.6	15.0	12.5
CESM1.BGC	127.6	130.0	131.9	162.7	169.8	177.5	35.1	39.8	45.7
CNRM.CM5	131.2	133.7	135.5	157.8	160.7	163.0	26.6	27.0	27.5
CSIRO.Mk3.6.0	138.7	142.7	146.0	163.2	165.3	166.9	24.5	22.6	21.0
GFDL.CM3	132.6	134.7	136.2	176.6	179.7	182.1	44.0	45.0	45.9
GFDL.ESM2G	130.3	133.7	136.6	159.5	165.0	170.2	29.2	31.3	33.6
GFDL.ESM2M	135.1	138.5	141.1	161.3	164.8	167.6	26.2	26.3	26.4
inmcm4	123.4	124.5	125.2	150.6	153.8	156.4	27.2	29.3	31.2
IPSL.CM5A.LR	137.2	140.6	143.3	158.6	159.5	160.0	21.4	18.9	16.7
IPSL.CM5A.MR	127.5	128.8	129.7	167.6	170.1	172.0	40.2	41.3	42.3
MIROC.ESM.CHEM	136.0	139.3	142.0	150.1	150.5	150.8	14.1	11.2	8.8
MIROC.ESM	138.5	141.4	143.7	157.9	159.2	160.1	19.5	17.9	16.5
MIROC5	133.2	137.4	141.1	158.9	160.2	161.2	25.7	22.9	20.2
MPI.ESM.LR	131.8	133.8	135.3	156.7	158.5	159.9	24.9	24.7	24.5
MPI.ESM.MR	126.2	126.9	127.3	162.7	165.4	167.5	36.5	38.5	40.2
MRI.CGCM3	130.8	133.3	135.2	148.9	154.6	160.0	18.1	21.3	24.8
NorESM1.M	128.9	131.2	133.0	161.8	165.0	167.6	32.9	33.8	34.6
Mean	122.9	123.6	124.0	162.1	163.8	164.9	39.2	40.2	40.9

Table 33. CLIMDEX SU – Annual count of days where daily maximum temperature exceeds 25 °C (RCP 8.5)

SU	RCP 8.5 1976 - 2005	RCP 8.5 2035 - 2064	Δ RCP 8.5 (days)
GCM	Return Period	Return Period	Return Period

	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	122.9	123.6	124.0	170.4	173.2	175.4	47.5	49.6	51.4
BNU.ESM	132.9	135.4	137.3	177.8	181.8	185.1	45.0	46.4	47.8
CanESM2	131.6	133.8	135.5	174.1	176.7	178.8	42.5	42.9	43.3
CCSM4	133.8	138.1	142.0	166.3	170.4	174.0	32.5	32.3	32.1
CESM1.BGC	127.6	130.0	131.9	174.8	178.9	182.3	47.2	49.0	50.4
CNRM.CM5	131.2	133.7	135.5	171.1	176.7	181.6	39.9	43.0	46.1
CSIRO.Mk3.6.0	138.7	142.7	146.0	169.7	171.8	173.5	30.9	29.1	27.5
GFDL.CM3	132.6	134.7	136.2	176.0	177.4	178.4	43.4	42.7	42.2
GFDL.ESM2G	130.3	133.7	136.6	160.5	161.4	162.0	30.2	27.7	25.4
GFDL.ESM2M	135.1	138.5	141.1	165.6	168.1	169.9	30.4	29.6	28.8
inmcm4	123.4	124.5	125.2	151.8	154.5	156.5	28.5	30.0	31.3
IPSL.CM5A.LR	137.2	140.6	143.3	168.7	171.7	174.2	31.5	31.1	30.9
IPSL.CM5A.MR	127.5	128.8	129.7	172.2	173.9	175.0	44.8	45.1	45.3
MIROC.ESM.CHEM	136.0	139.3	142.0	177.8	179.6	180.8	41.8	40.2	38.8
MIROC.ESM	138.5	141.4	143.7	163.5	164.4	165.0	25.0	23.0	21.4
MIROC5	133.2	137.4	141.1	170.8	174.6	177.9	37.7	37.2	36.9
MPI.ESM.LR	131.8	133.8	135.3	173.4	177.0	180.0	41.6	43.2	44.7
MPI.ESM.MR	126.2	126.9	127.3	161.2	162.1	162.6	35.0	35.2	35.4
MRI.CGCM3	130.8	133.3	135.2	154.8	156.7	158.1	24.0	23.4	23.0
NorESM1.M	128.9	131.2	133.0	166.0	167.9	169.2	37.1	36.7	36.3

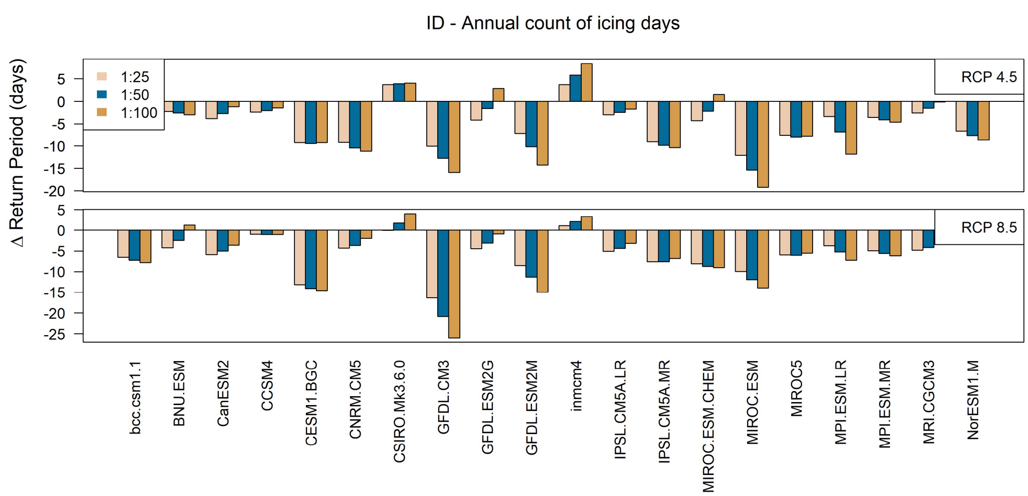


Table 34. CLIMDEX ID – Annual count of days where daily maximum temperature is below 0 °C (RCP 4.5)

ID	RCP 4.5 1976 - 2005			RCP 4.5 2035 - 2064			Δ RCP 4.5 (days)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	14.3	16.7	19.0	10.7	12.9	15.2	-3.7	-3.9	-3.9
BNU.ESM	11.0	13.3	15.9	8.7	10.7	12.9	-2.2	-2.6	-3.0
CanESM2	10.8	11.7	12.4	7.0	8.9	11.2	-3.8	-2.7	-1.2
CCSM4	11.8	13.7	15.5	9.4	11.6	14.0	-2.4	-2.1	-1.5
CESM1.BGC	18.3	20.6	22.7	9.0	11.1	13.5	-9.2	-9.5	-9.3

CNRM.CM5	16.1	20.8	26.3	6.9	10.4	15.2	-9.2	-10.4	-11.2
CSIRO.Mk3.6.0	12.6	13.9	15.1	16.3	17.8	19.1	3.7	3.9	4.0
GFDL.CM3	19.2	25.1	32.1	9.2	12.3	16.2	-10.0	-12.7	-15.9
GFDL.ESM2G	13.3	15.0	16.5	9.2	13.4	19.4	-4.2	-1.6	2.8
GFDL.ESM2M	17.5	23.0	29.8	10.4	12.8	15.6	-7.2	-10.2	-14.3
inmcm4	13.0	15.3	17.6	16.7	21.1	26.1	3.7	5.8	8.5
IPSL.CM5A.LR	10.4	11.4	12.4	7.4	9.0	10.6	-3.0	-2.4	-1.7
IPSL.CM5A.MR	15.4	18.3	21.5	6.3	8.5	11.1	-9.0	-9.9	-10.4
MIROC.ESM.CHEM	13.9	16.1	18.3	9.5	13.9	19.8	-4.3	-2.2	1.5
MIROC.ESM	16.7	21.1	26.2	4.7	5.8	6.9	-12.1	-15.4	-19.3
MIROC5	15.7	19.3	23.2	8.1	11.4	15.5	-7.5	-7.9	-7.7
MPI.ESM.LR	15.3	20.9	28.1	12.0	14.1	16.3	-3.3	-6.8	-11.8
MPI.ESM.MR	13.7	16.3	18.9	10.1	12.2	14.3	-3.6	-4.1	-4.6
MRI.CGCM3	11.2	12.1	12.9	8.6	10.6	12.8	-2.6	-1.5	-0.1
NorESM1.M	14.4	18.1	22.2	7.8	10.4	13.7	-6.6	-7.6	-8.6

Table 35. CLIMDEX ID – Annual count of days where daily maximum temperature is below 0 °C (RCP 8.5)

ID	RCP 8.5 1976 - 2005			RCP 8.5 2035 - 2064			Δ RCP 8.5 (days)		
GCM	Return Period			Return Period			Return Period		
	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr	25 yr	50 yr	100 yr
bcc.csm1.1	14.3	16.7	19.0	7.8	9.5	11.2	-6.5	-7.2	-7.8
BNU.ESM	11.0	13.3	15.9	6.7	10.8	17.1	-4.2	-2.5	1.3
CanESM2	10.8	11.7	12.4	4.9	6.6	8.7	-5.9	-5.0	-3.6
CCSM4	11.8	13.7	15.5	10.8	12.6	14.4	-1.0	-1.1	-1.1
CESM1.BGC	18.3	20.6	22.7	5.1	6.5	8.2	-13.1	-14.0	-14.5
CNRM.CM5	16.1	20.8	26.3	11.8	17.1	24.4	-4.3	-3.7	-1.9
CSIRO.Mk3.6.0	12.6	13.9	15.1	12.5	15.7	19.2	0.0	1.8	4.1
GFDL.CM3	19.2	25.1	32.1	2.8	4.2	6.1	-16.4	-20.9	-26.0
GFDL.ESM2G	13.3	15.0	16.5	8.9	11.9	15.7	-4.4	-3.1	-0.9
GFDL.ESM2M	17.5	23.0	29.8	9.0	11.7	14.9	-8.5	-11.3	-15.0
inmcm4	13.0	15.3	17.6	14.1	17.4	20.9	1.1	2.1	3.3
IPSL.CM5A.LR	10.4	11.4	12.4	5.3	7.1	9.2	-5.1	-4.4	-3.2
IPSL.CM5A.MR	15.4	18.3	21.5	7.7	10.8	14.6	-7.6	-7.6	-6.8
MIROC.ESM.CHEM	13.9	16.1	18.3	5.8	7.4	9.3	-8.1	-8.7	-9.0
MIROC.ESM	16.7	21.1	26.2	6.8	9.2	12.3	-9.9	-11.9	-13.9
MIROC5	15.7	19.3	23.2	9.7	13.3	17.7	-5.9	-6.0	-5.5
MPI.ESM.LR	15.3	20.9	28.1	11.5	15.7	20.9	-3.8	-5.2	-7.2
MPI.ESM.MR	13.7	16.3	18.9	8.7	10.7	12.8	-5.0	-5.6	-6.1
MRI.CGCM3	11.2	12.1	12.9	6.4	8.0	9.8	-4.8	-4.1	-3.1
NorESM1.M	14.4	18.1	22.2	11.4	16.4	23.1	-3.0	-1.7	0.9