# MERSİN CLIMATE CHANGE RISK AND VULNERABILITY ASSESSMENT REPORT

MERSİN METROPOLITAN MUNICIPALITY

June 2024

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**Mersin – June 2024**

Some parts of this report has been replicated from existing "SECAP-Mersin Sustainable Energy and Climate Change Action Plan 2023"

## MAYOR'S PRESENTATION

Due to the progress of industry and the consumption of fossil fuel, greenhouse gas emissions resulting from human activity are increasing at rates faster than ocean and forest areas can hold. Our country is in a geographical area that will be most affected by climate change, as there will

certainly be disasters related to climate change and the efforts to fight it. This issue is one of the most important for us to solve. Day by day, local governments are developing and implementing strategies for confronting climate change. Mersin is one of the most developed provinces of Türkiye. With its fertile soil and growth of agricultural products, it stands out against the rest of the country. Mersin is also advanced in technology, as it has rich natural and underground resources, as well as port activities and an oil refinery. Due to its international port and adjacent free zone, Mersin provides global trade connections to many provinces, especially in eastern and central Anatolia.

Our increasingly growing city is also one of the most affected by climate change, which will have a negative impact on our agriculture and industry. As people's welfare increases, so do new lifestyles and new technologies, which can affect not only the environment of our province, but also our country and the rest of the world. Actions conducted by local governments to reduce greenhouse gas emissions and climate change adaptation efforts are vital. Cities with high population, production, and consumption also have elevated levels of pollutants which trigger and worsen climate change.

The Mersin Metropolitan Municipality has shown our determination in this fight by becoming members of international organizations such as ICLEI (Local Governments for Sustainability) and GCoM (Global Covenant of Mayors for Climate and Energy). For an environmentally friendly world and a better future, we must reduce carbon emissions in the fields of transportation, energy, services, and construction. We must also focus our efforts on activities that are in accordance with environmental standards and actions that reduce the impact of climate change. I hope and wish that this study will contribute to national, regional, and urban climate change policies and aid in meeting our goals for a sustainable future.

**Vahap SEÇER**

Mayor of Mersin Metropolitan Municipality

MERSİN METROPOLITAN MUNICIPALITY

DEPARTMENT OF CLIMATE CHANGE
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| | |
|---|---|
| AFOLU | Agriculture, Forestry and Other Land Use |
| AFAD | Disaster and Emergency Management Presidency |
| C40 | C40 Cities Climate Leadership Group |
| COP | Conference of the Parties |
| CORINE | Coordination of Information on the Environment |
| EMRA | Energy Market Regulatory Authority |
| GCoM | Global Covenant of Mayors for Climate and Energy |
| GDP | Gross Domestic Product |
| GHG | Greenhouse Gas Emissions |
| GPC | Global Protocol for Community-Scale Greenhouse Gas Emission Inventories |
| ICLEI | Local Governments for Sustainability |
| IPCC | Intergovernmental Panel on Climate Change |
| IPPU | Industrial Processes and Product Use |
| KGM | General Directorate of Highways |
| MGM | General Directorate of Meteorology |
| MMM | Mersin Metropolitan Municipality |
| MoAF | Ministry of Agriculture and Forestry |
| MoCT | Ministry of Culture and Tourism |
| MoEUCC | Ministry of Environment, Urbanisation and Climate Change |
| MoIT | Ministry of Industry and Technology |
| MoTI | Ministry of Transport and Infrastructure |
| NDC | Nationally Determined Contribution |
| OECD | Organisation for Economic Co-operation and Development |
| OGM | General Directorate of Forestry |
| TUBITAK MAM | The Scientific and Technological Research Council of Türkiye - Marmara Research Center |
| TurkStat | Turkish Statistical Institute |
| UNFCCC | United Nations Framework Convention on Climate Change |
| WRI | World Resources Institute |
| WWTP | Wastewater Treatment Plant |

# 1. INTRODUCTION

Climate change, which is considered one of the most important problems facing our planet in the 21st century, is triggered by the accumulation of greenhouse gases in the atmosphere caused in part by various human activities such as the use of fossil fuels and land use changes. As a result of the researches carried out by the scientific community, it is foreseen that if the global warming process continues at the current rate, many severe disasters such as extreme weather events, floods, widespread and severe drought events and forest fires will arise in the climate zone including our country.

Furthermore, it is known that approximately 60% of greenhouse gas emissions worldwide are generated within cities mainly due to energy consumption. Therefore, it is predicted that efforts conducted at the city level will contribute significantly to combating global climate change, leading to an intensified focus on such endeavors. Cities, due to the activities taking place within their boundaries, make substantial contributions to the process of climate change. Conversely, the events expected to occur as a result of climate change threaten the existence of the systems that make up cities. At the urban scale, especially in areas such as infrastructure, public health, and water resource management, higher vulnerabilities to the impacts of climate change are expected. For these reasons, it is acknowledged that local climate change action plans should contain objectives aimed at both rapidly and fairly reducing the city's contributions (i.e. greenhouse gas emissions) to climate change and enhancing the city's capacity to adapt to climate change.

Many municipalities in our country are currently preparing climate change action plans and in this context, they are also members of various international voluntary initiatives. Mersin Metropolitan Municipality became a member of the Global Covenant of Mayors for Climate and Energy (GCoM) in 2021, one of the most important of these initiatives. GCoM has been signed by 50 municipalities from our country, 15 of which are metropolitan municipalities. This initiative, which was first launched in 2008 within the European Commission, aims to support local governments in achieving climate and energy targets and to bring together many cities and regions that want to implement the targets set within the framework of the Covenant. Municipalities that are parties to the GCoM are obliged to prepare action plans containing the measures they plan to implement in terms of greenhouse gas emission reduction and adaptation to climate change. Therefore, the role of local governments in combating climate change is increasing day by day.

Within the scope of the project, it was aimed to conduct a climate change risk and vulnerability assessmentassessment for climate hazards that will be most affected by climate change impacts, to identify adaptation measures, and to prepare the climate change action plan based on thorough evaluations.

Within the scope of the study:

- Information  limateological conditions affecting climate change in Mersin was collected.
- Stakeholders who will contribute to assessment were determined, and evaluation meetings were organized.
- Climate risk assessment was made to identify both vulnerable sectors and vulnerable social segments within the scope of adaptation to climate change.
- Incorporating all the obtained outputs, the "Mersin Sustainable Energy and Climate Action Plan" was prepared.

The institutions and organizations included in the preparation of the action planning are given in Table 1.1. It is envisaged that the stakeholders will contribute towards both in providing data specific to Mersin and determining the actions regarding with reduction of GHG emissions and improving adaptive capacity to climate change. Approximately 40 people representing the project stakeholders participated in the opening meeting held on September 6, 2022, and the project team presented the scope of the project including detailed information about the data needs and sources, the expectations from the stakeholders and the steps to be followed.

**Table 1.1:** Institutions and organizations involved in the project

| Public institutions and organizations | Representatives of the private sector, Universities, NGOs |
|---|---|
| Mersin Metropolitan Municipality<br>- Directorate of Climate Change and Zero Waste<br>- Directorate of Environmental Protection and Control<br>- Directorate of Studies and Projects<br>- Directorate of Technical Works<br>- Directorate of Housing and Urbanisation<br>- Directorate of Parks and Gardens<br>- Directorate of Transportation<br>- Directorate of Agricultural Services<br>Mersin Water and Sewerage Administration (MESKİ)<br>Akdeniz Municipality<br>Anamur Municipality<br>Bozyazi Municipality<br>Mersin Yenişehir Municipality<br>Mezitli Municipality<br>Mut Municipality<br>Silifke Municipality<br>Tarsus Municipality<br>Toroslar Municipality<br>Erdemli Municipality<br>Aydıncık Municipality<br>Çamlıyayla Municipality<br>Gülnar Municipality<br>Mersin Governorship<br>Mersin Provincial Directorate of Industry and Technology<br>Mersin Provincial Directorate of Environment, Urbanisation and Climate Change<br>Mersin Provincial Directorate of Agriculture and Forestry<br>Mersin Regional Directorate of Forestry<br>Mersin Provincial Directorate of National Education<br>SSI Mersin Provincial Directorate<br>Mersin Provincial Directorate of Culture and Tourism<br>Mersin Provincial Directorate of Disaster and Emergency<br>Meteorology 6. Regional Office<br>Anamur, Mersin and Silifke Meteorological Directorates<br>Directorate of Highways Mersin 5. Regional Office<br>6. Regional Directorate of Turkish State Railways<br>TURKSTAT Adana Regional Office<br>6. Regional Directorate of State Hydraulic Works | Mersin Chamber of Commerce and Industry (MTSO)<br>Mersin-Tarsus Agricultural Product Processing Specialization Organized Industrial Zone (TÜİOSB)<br>Mersin Tarsus Organized Industrial Zone<br>Mersin Chamber of Agricultural Engineers<br>Mediterranean Chamber of Agriculture<br>Mut Chamber of Agriculture<br>Chamber of Environmental Engineers<br>Chamber of Civil Engineers<br>Chamber of Urban Planners<br>Chamber of Forest Engineers<br>Chamber of Electrical Engineers<br>Mersin Chamber of Maritime Commerce<br>Chamber of Landscape Architects<br>Aksa Natural Gas Çukurova General Directorate<br>Kalde Energy Electricity Generation Co. Inc.<br>ŞİŞECAM - Soda, Glass Packaging and Flat Glass Production Facilities<br>Eren Holding - Medcem Cement<br>ÇİMSA - Mersin Factory<br>İZOCAM - Glass Wool and Foamboard Production Facilities<br>Tarsus University<br>Mersin University<br>Toros University<br>Çağ University<br>Agriculture and Rural Development Support Agency (TKDK)<br>Mersin Tourism Operators Association (MERTİD)<br>Entrepreneurial Business Women's Association (GIŞKAD)<br>Çukurova Development Agency<br>Mersin Investor Business People Association (MERYAD)<br>Toroslar Electricity Distribution Company<br>Mersin International Port Management (MIP)<br>Akdeniz Clean Air Center<br>TEMA Foundation<br>MENKOBIRLİK<br>Yenişehir Clean Environment Inc. |

In order to obtain the necessary data for risk and vulnerability analysis, the GHG emission inventory and develop actions for mitigation and adaptation, TUBITAK MAM and Mersin Metropolitan Municipality project teams organized series of one-on-one meetings on 26-27 October 2022 with the officials of Mersin Metropolitan Municipality, Directorate of Environmental Protection and Control, Directorate of Climate Change and Zero Waste, Directorate of Reconstruction and Urbanisation and Directorate of Transportation and officials of Mersin Regional Directorate of Forestry, Mersin

Agriculture and Forestry Directorate, Mersin Environment, Urbanisation and Climate Change Directorate, Mersin Industry and Technology Directorate and Mersin Chamber of Commerce and Industry (MTSO).

Finally, 8 sectoral meetings were held between 2-5 May 2023 in order to determine the actions applicable to reduction of GHG emissions and increase the capacity to adapt to climate change. Within 8 online meetings organized for different areas (e.g. buildings and infrastructure, transportation, industry and energy, waste and wastewater management, agriculture and livestock, forestry and water resources, tourism and cultural heritage and coastal areas and fishery), general information about the Mersin GHG emissions inventory and the details of the calculations made for the relevant sectors were shared, and the opinions and suggestions of the participants were obtained. In addition, mitigation and adaptation measures for the relevant areas were discussed and potential strategies were presented to evaluation of participants through online surveys.

Finally, stakeholders came together to clarify the actions that can be implemented in Mersin to reduce greenhouse gas emissions and increase the capacity to adapt to climate change. 8 sector-based roundtable meetings were held physically at the Mersin Metropolitan Municipality meeting hall. Approximately 90 people representing the relevant departments of Mersin Metropolitan Municipality, district municipalities and all other stakeholders participated in the meetings. During the meetings, the current situation assessment, sub-actions, responsible and related institutions/units, implementation period, performance indicators and performance targets of the actions determined for each sector were discussed. Prior to the 4 parallel sessions, short informative speeches were made on behalf of Mersin Metropolitan Municipality and TUBITAK MAM teams, and the action tables created on the basis of the relevant sector were explained to the participants with TUBITAK MAM representatives as table moderators, and their opinions and suggestions were received. The action tables were updated by taking into account the issues communicated within the framework of the meeting. Afterwards, the tables were finalized by taking the written opinions and suggestions of the stakeholders on the actions.

# 2. COMBATING CLIMATE CHANGE AND ITS IMPACTS

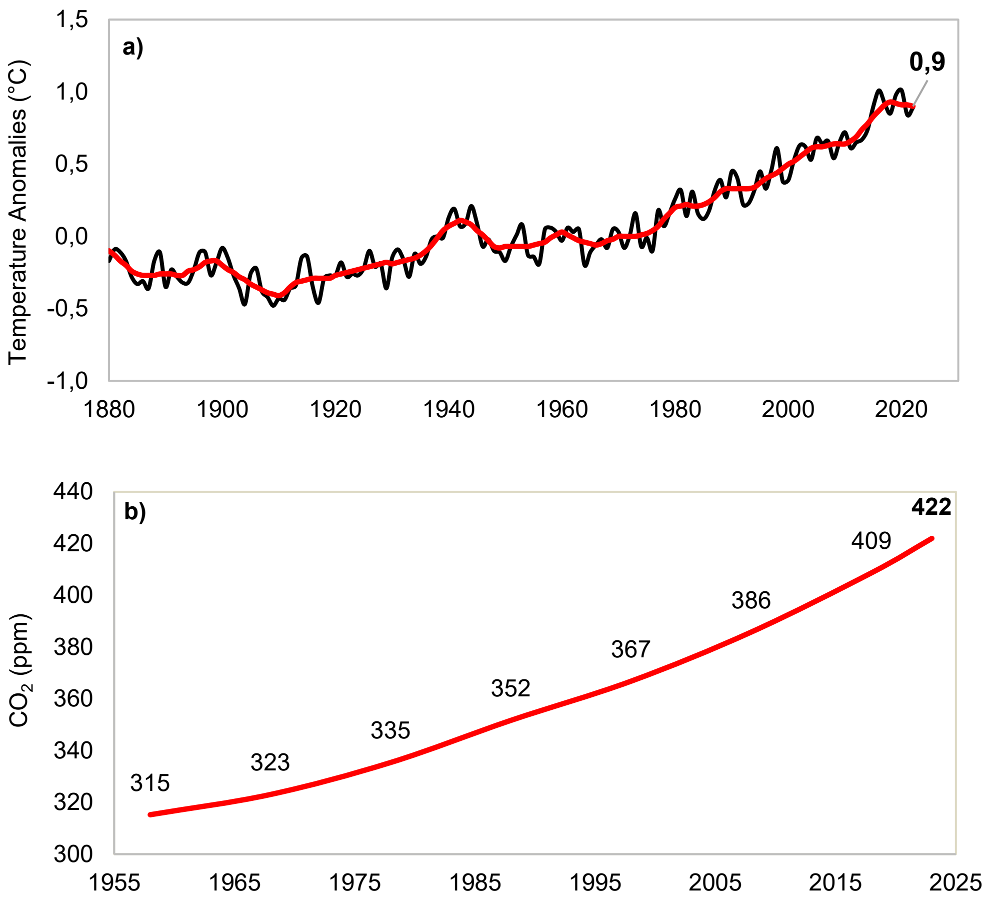
## 2.1. Climate Change

Climate change is defined as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (UNFCCC, 1992). The increase in extreme weather events and changes in vegetation cover in recent years are among the significant consequences of climate change. The rise in average temperatures, noticeable changes in precipitation regimes and amounts, heatwaves, droughts, excessive rainfall, and increased occurrences of floods, hailstorms, storms, and tornadoes have a substantial impact on various sectors and daily life, particularly in agriculture, health, and energy sectors. Severe weather events categorized as *"Heat Waves", "Extreme Rainfall", "Flood", "Meteorological and Hydrological Drought", "Ecological and Agricultural Drought", "Tropical Cyclones/Winter Storms and Storms", "Hurricane", "Hail", "Lightning", "Extreme Winds"* and *"Fire Weather"* have shown visible changes associated with climate change. These changes are ***identified*** in the high and medium confidence range to be ***linked*** to human activities, as stated in the latest assessment report prepared by the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2021).

According to the IPCC 6$^{th}$ Assessment Report published in 2022, the Mediterranean Basin, which includes our country, is projected to be among the most affected regions by climate change. It is estimated that the agriculture, forestry and water resources, as well as the energy, health, transportation, and tourism sectors, will experience significant impacts due to climate change in our country with its semi-arid climate. Given our country's semi-arid climate, the increase in temperatures will lead to increased evaporation rates, decreased rainfall and soil moisture in a large part of our country, and a rise in severe weather events and associated disasters. This will have a severe impact on the agricultural sector, while the competition for water resources between the agriculture, tourism, textile manufacturing, and drinking/utility water sectors, already under water stress, will further intensify (IPCC, 2021).

The increase in global temperature and atmospheric carbon dioxide concentration, as observed since the pre-industrial era, is primarily attributed to the changes and variability in the absorption, transmission, and reflection-scattering of solar radiation by the atmosphere (including clouds, aerosols, and air molecules) and the Earth's surface (such as water bodies like oceans, seas, and lakes, snow surfaces, ice caps, vegetation, etc.). This increase in temperature is influenced by natural factors such as the Earth's precession and the El Niño phenomenon, as well as anthropogenic (human-induced) factors including rapid population growth, increased consumption patterns, industrialization, energy production, and the use of fossil fuels.

Human activities, particularly the combustion of fossil fuels, have significantly contributed to the rise in global surface temperature (Figure 2.1a) and atmospheric carbon dioxide concentration (Figure 2.1b), and these trends continue to persist.




**Source:** (NASA, 2023)

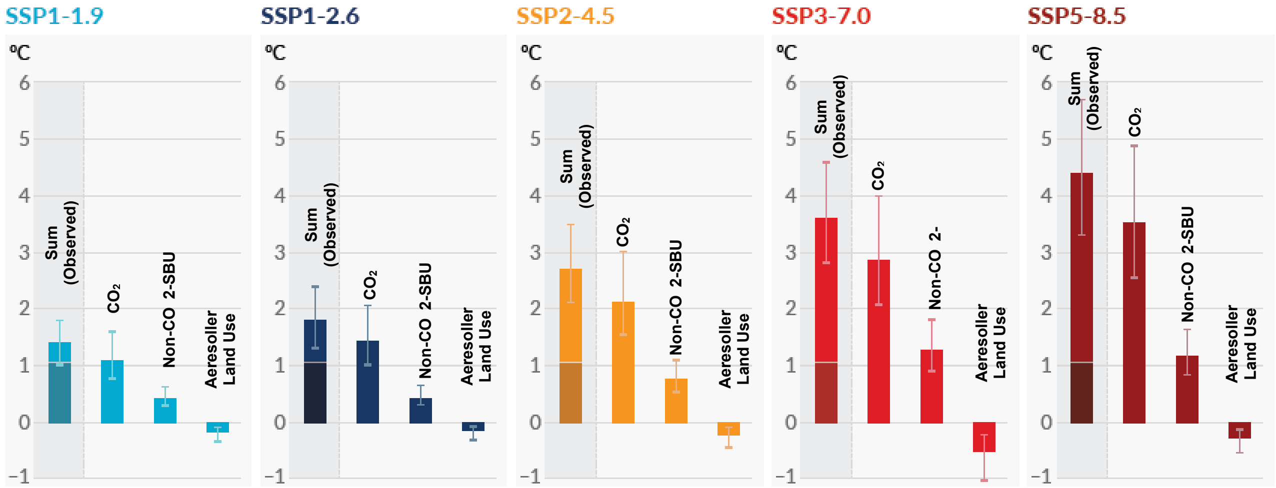
**Figure 2.1:** a) Change of global surface temperature, b) Change of atmospheric carbon dioxide concentration

Since the pre-industrial era, the global average surface temperature has increased by approximately 1°C. This number is increasing by 0.2 every 10 years, and the current warming trend is advancing at an unprecedented pace.

Today's atmospheric concentration of $CO_2$ has risen to 50% above the pre-industrial levels. The concentration, measured as 280 ppm in 1850, reached to 422 ppm by mid-2023, and the 350 ppm safety limit has already been exceeded. For this reason, negotiations are being carried out at the international level and various steps are being taken to limit the countries' GHG emissions.

The IPCC 6$^{th}$ Assessment Report emphasizes the need for these efforts to be faster and more effective. It states that the evidence attributing changes observed in extreme events such as heatwaves, heavy rainfall, droughts, and tropical cyclones to human influence has strengthened since the 5$^{th}$ Assessment Report. The link between increased greenhouse gas concentrations resulting from human activities and climate change has been consistently expressed with increasing confidence starting from the 2nd Assessment Report to the latest, the 6th Assessment Report. The IPCC 1st Assessment Report (1990) stated that human activities significantly increased greenhouse gas concentrations in the atmosphere. The 2nd Assessment Report noted the distinction between signals of human-induced climate change and natural variability, highlighting the visible impacts of human activities on the global climate. The 3rd Assessment Report pointed to new and strong evidence indicating that a significant portion of the warming over the past 50 years is due to human activities. The 4th and 5th Assessment Reports strongly emphasized that climate change is most likely caused by human activities.

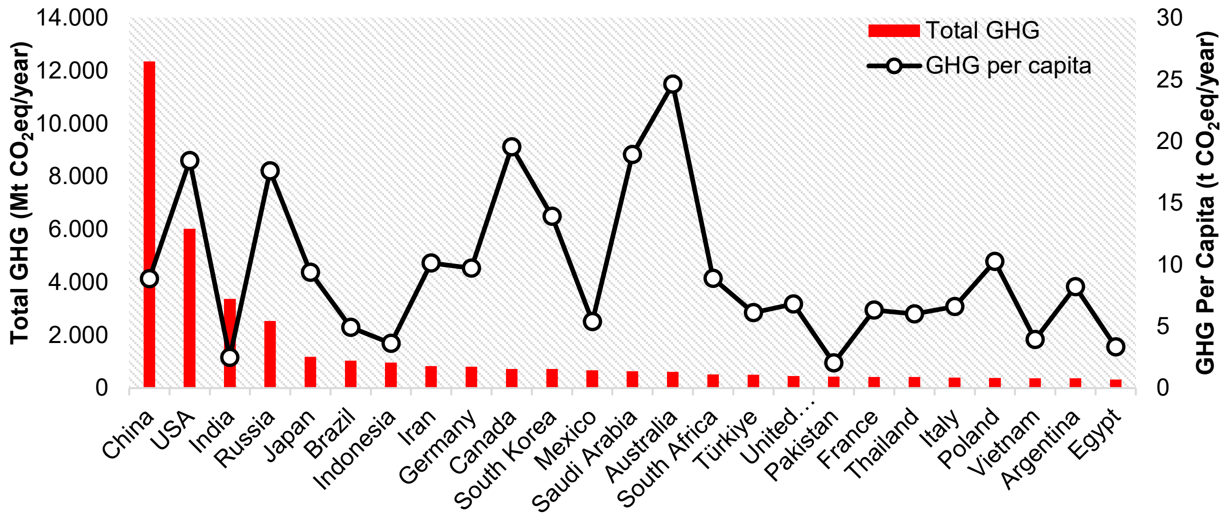
In the 6th Assessment Report, five new emission scenarios covering the future developments of anthropogenic factors related to climate change are considered for the near-term (2021-2040), mid-term (2041-2060), and long-term (2081-2100) periods, relative to the period of 1850-1900. According to the scenario results (Figure 2.2), global surface temperature will continue to increase at least until the middle of the century under all emission scenarios. If there is no reduction in $CO_2$ and other greenhouse gas emissions in coming years, the targets of 1.5°C and 2°C will be exceeded in the 21st century (IPCC, 2021). Therefore, in order to achieve the targets, countries need to make significant improvements in addition to their current plans and policies.




**Source:** (IPCC, 2021)

**Figure 2.2:** Change in global surface temperature in 2081–2100 (ºC)

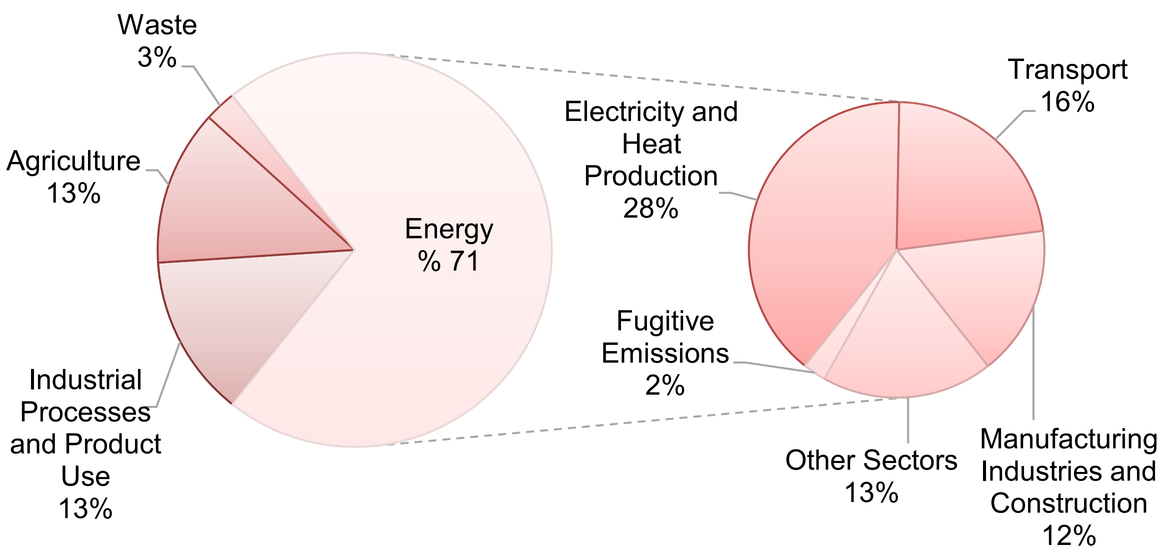
Türkiye ranks 16th among the 25 countries with the highest greenhouse gas emissions in 2019 (Figure 2.3). China is the world's top greenhouse gas emitter with a rate of 26.4%. China is followed by the United States with 12.5% and India with 7.1%. The U.S. reduced its per capita greenhouse gas emissions from 23.4 t/year in 1990 to 18.2 t/year by 2019, while China increased its greenhouse gas emissions from 2.8 t/year to 9 t/year, and China increased its GHG from 1.4 t/year to 2.5 t/year. Türkiye, as a developing country, currently causes 1% of global greenhouse gas emissions and ranks 16th. Its' 3.8 t/year per capita greenhouse gas emissions in 1990 reached 5.9 t/year by 2019.




**Kaynak:** (CW, 2019; WB, 2019)

**Figure 2.3:** Greenhouse gas emissions by country

Türkiye's total greenhouse gas emissions in 2021 is 564 Mton $CO_2e$. With 402 Mton $CO_2e$, the energy sector accounts for 71% of total emissions. The agricultural sector has a rate of 12.7% with 72 Mton $CO_2e$, industrial processes and product use have a rate of 13.3% with 66.7 Mton $CO_2e$ and the waste sector has a rate of 3% with 15 Mton $CO_2e$ (Figure 2.4).




**Source:** (TurkStat, 2023)

**Figure 2.4:** Distribution of GHG by sector

## 2.2. International Negotiation Processes and Türkiye's Position

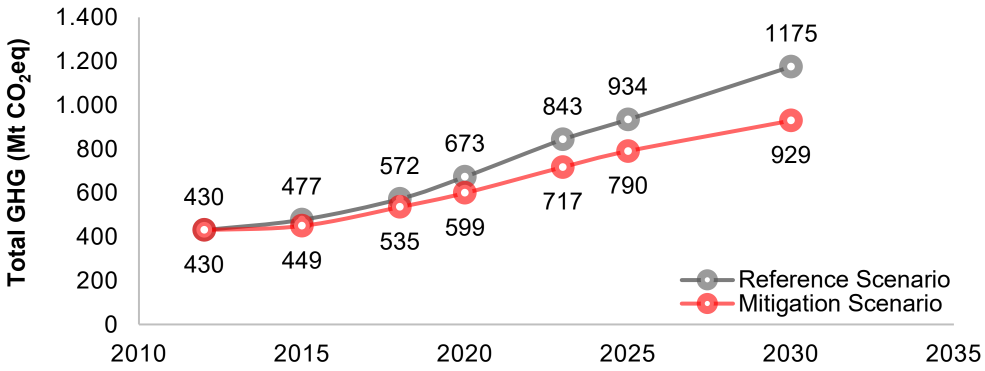
The first and most significant step taken at the international level to address the impacts of global warming caused by human activities was the United Nations Framework Convention on Climate Change (UNFCCC), which was opened for signature at the United Nations Conference on

Environment and Development (the Rio Earth Summit) in 1992. At the time of the Convention's opening for signature, Türkiye was included in Annex I (industrialized countries and countries in transition to a market economy) and Annex II (industrialized countries) lists, and it continued to remain in Annex I by being granted special conditions at the 7th Conference of the Parties held in 2001. Türkiye became a Party to the Convention on 24 May 2004, which entered into force on 21 March 1994, becoming the 189th Party.

On the other hand, the Kyoto Protocol, which was signed at the 3rd Conference of the Parties in 1997 and entered into force on 16 February 2005, sets quantified emission limits or reduction commitments for the Annex I Parties of the Convention listed under Annex B. However, Türkiye, which became a Party to the Protocol on 26 August 2009, was not included in Annex B as it had not become a Party to the Convention when the Protocol was adopted, and therefore, it did not have any quantified emission limitation or reduction obligations (MoEUCC, 2021).

Countries that are Parties to the UNFCCC are represented at the Conference of the Parties (COP), which is the highest decision-making body of the Convention, and all Parties come together annually to continue negotiations on climate change. The 21st Conference of the Parties (COP21), held in Paris in November 2015, was a significant turning point as the legally binding international Paris Agreement was adopted to strengthen the global response to the threat of climate change.

The Paris Agreement aims to limit global warming to well below 2 °C, preferably to 1.5 °C, compared to pre-industrial levels. It also emphasizes the need for Parties to make their "nationally determined contributions" (NDCs), demonstrating their best efforts and enhancing these efforts in coming years, accelerating the provision of financial resources, technology transfer, and capacity-building support from developed country Parties to developing countries, particularly Small Island Developing States, and undertaking absolute emission reduction targets (UNFCCC, 2015). The Agreement entered into force on 4 November 2016, requiring the approval of 55 countries representing at least 55% of global emissions. Türkiye, which signed the Agreement on 22 April 2016, ratified it in the Turkish Grand National Assembly as of 6 October 2021. The "Law on the Approval of the Paris Agreement" was published and entered into force in the Official Gazette numbered 31621 on 7 October 2021. Prior to the adoption of the Paris Agreement at COP21, countries submitted their intended nationally determined contributions (INDCs) regarding greenhouse gas emission reductions to the UNFCCC Secretariat. Türkiye, in its national contribution submitted to the Secretariat on 30 September 2015, declared its aim to achieve a 21% reduction in greenhouse gas emissions by 2030 compared to projected levels (Figure 2.5).




**Source:** (MoEU, 2015)

**Figure 2.5:** Nationally Determined Contribution of Türkiye

In order to achieve the set reduction target, various plans and policies have been determined, including increasing electricity generation capacity from solar and wind energy, commissioning one nuclear power plant, reducing the rate of energy losses, reducing fuel consumption from road transportation, phasing out old vehicles, improving the energy efficiency of new and existing buildings, supporting good agricultural practices, promoting waste recycling and energy recovery from waste, increasing carbon sinks, conducting forest rehabilitation and pasture improvement projects (MoEU, 2015). Prior to the COP21, national commitments on mitigation and adaptation were prepared as intended nationally determined contributions (INDCs), which were later formalized as Nationally Determined Contributions (NDCs) and submitted to the Secretariat after the approval of the Paris Agreement. In Türkiye, efforts to update the NDC were carried out in 2022, and it was announced that the reduction target for 2030 was raised to 41% and emissions are expected to peak in 2038, as reported during COP27.

## 2.3. Local Climate Change Policies

Local governments play a significant role in both reducing greenhouse gas emissions and adapting to climate change. Urban activities account for approximately 60% of global greenhouse gas emissions and 78% of energy use (UN, 2021). In the global ranking of cities' carbon footprints, Istanbul ranks 26th, while Ankara ranks 80th, with Seoul, Guangzhou, and New York City being in the top three (GGMCF, 2021). Cities also harbor vulnerable structures in the face of climate change impacts such as anticipated temperature increases, sea-level rise, and altered precipitation patterns. Therefore, efforts by local governments to reduce greenhouse gas emissions and enhance climate change adaptation are of great importance, and such initiatives have gained momentum in our country.

Climate change action plans to be prepared by local governments should include targets to reduce the city's contributions to climate change (i.e. greenhouse gas emissions) quickly and fairly and to increase the city's capacity to adapt to climate change impacts. In this context, it was aimed to prepare local climate change action plans in 30 Metropolitan Municipalities in our country by 2024.

In line with this goal, efforts are underway to support local governments to prepare their climate change action plans. Currently, studies are being carried out within the provincial and district municipalities for the preparation of Local Climate Change Action Plans (LCCAP). In this context, there are various voluntary initiatives in the international arena, and one of the most important of these is the Global Covenant of Mayors for Climate and Energy (GCoM), which has been signed in our country by 50 municipalities, 15 of which are metropolitan cities. This initiative, which was first launched in 2008 within the European Commission, aims to support local governments in achieving climate and energy targets and to bring together many cities and regions that want to implement the targets set within the framework of the convention. Municipalities that are parties to the Convention are obliged to prepare action plans containing the measures they plan to implement in terms of greenhouse gas emission reduction and adaptation to climate change (GCoM, 2022). Another initiative established by local governments to combat climate change at the international level is the Local Governments for Sustainability (ICLEI). This association, whose main purpose is to increase capacity building and cooperation of local governments under the theme of sustainability, has over 2,500 members, 8 of which are from our country (ICLEI, 2021).

There are many studies already completed or ongoing by local governments, especially metropolitan municipalities, for the preparation of greenhouse gas emission inventories and climate change action plans. Mitigation and adaptation actions that can be generally implemented by local authorities are given in Table 2.1.

**Table 2.1:** Mitigation and adaptation actions that can be implemented by local authorities

| Sector | Mtitigation | Adaptation |
|---|---|---|
| **Energy** | • Reducing fossil fuel use<br>• Renewable energy use<br>• Efficient street lighting | • Strengthening the electricity transmission and distribution infrastructure<br>• Increasing the resilience of grids to climate change |
| **Industry** | • Improvement of processes, identification of the best available techniques<br>• Reduction of fuel and electricity consumption | • Determination of climate resistance, preparation of action plans |
| **Buildings/Housing** | • Increasing energy efficiency<br>• Thermal insulation<br>• Energy-efficient design during the construction phase and completion of energy identity documents<br>• Green roof applications<br>• Awareness-raising activities | • Disaster management<br>• Awareness-raising activities<br>• Strengthening infrastructure in buildings |
| **Transportation** | • Low-carbon emission network<br>• Increasing the use of electric and hybrid vehicles | • Improvement of traffic signaling systems |

| Sector | Mtitigation | Adaptation |
|---|---|---|
| | • Saving energy and fuel with efficient technologies<br>• Dissemination of intelligent transportation systems<br>• Enabling public transport<br>• Encouraging pedestrian access<br>• Expansion of bicycle paths | |
| **Waste and Wastewater** | • Obtaining energy from landfill gas<br>• Reduction of emissions from storage<br>• Ensuring solid waste and wastewater recovery<br>• Reducing water losses in drinking water supply and distribution systems in order to protect existing water resources | • Reducing industrial waste and ensuring recycling<br>• Creation of waste collection points<br>• Positioning of containers in such a way that they are not affected by weather conditions<br>• Ensuring that the treated water is reused<br>• Taking measures to save water in car washes |
| **Agriculture** | • Reduction of the use of chemical fertilizers<br>• Installation of solar energy for use in agricultural activities<br>• Realization of animal and plant production suitable for the region<br>• Modification and alteration of tillage practices<br>• Carrying out afforestation works on the edges of agricultural areas | • Expansion of systems to reduce water consumption<br>• Determination of drought resistant plant pattern<br>• Improving food safety<br>• Encouraging urban agriculture |
| **Other (Water resources, food security, public health, heat island, land use, AFOLU etc.)** | • Obtaining agricultural fertilizer from animal waste<br>• Land consolidation<br>• Use of organic fertilizers<br>• Reduction of heating, cooling and electricity consumption in health institutions | • Establishment of early warning systems in response to flash floods and floods<br>• Rainwater collection<br>• Agricultural drought management<br>• Combating water and foodborne diseases<br>• Being prepared for epidemic diseases<br>• Switching to natural soil floor in parks and gardens<br>• Increasing carbon sink sources |

# 3. MERSIN IN GENERAL

## 3.1. The Importance of Mersin

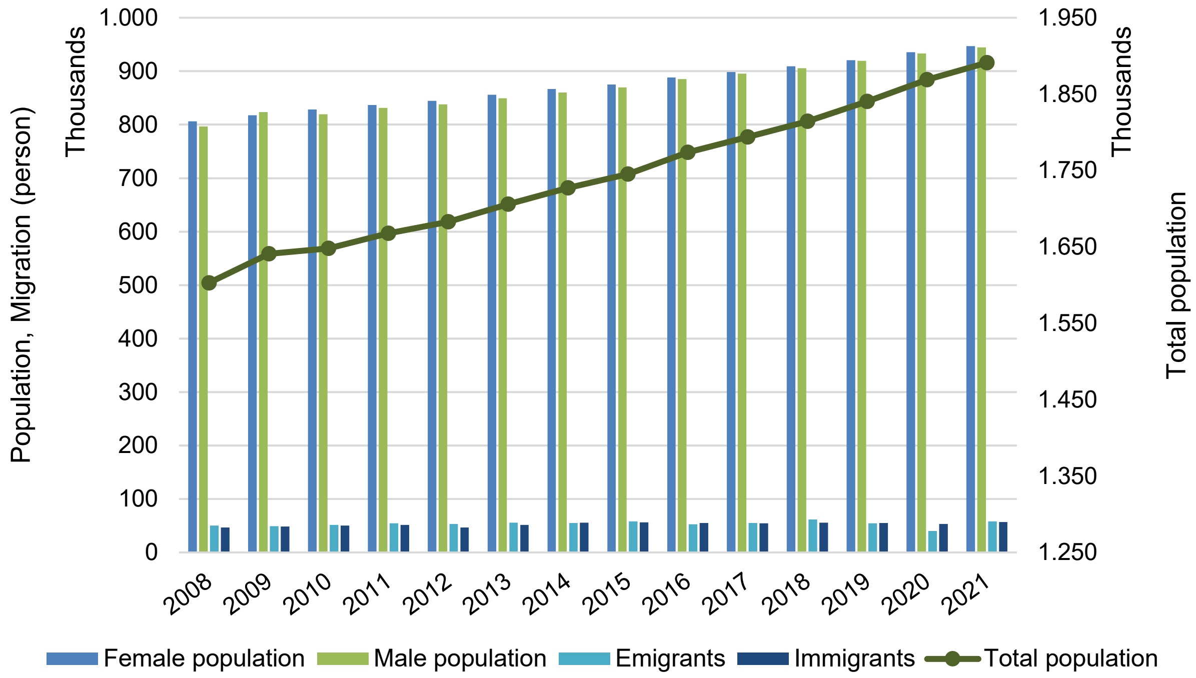
Mersin, which was known as Cilicia in classical times, is located in a region that has hosted different civilizations, ranging from the Hittites to the Persians, from the Macedonians to the Byzantines. As the 9th largest province in terms of areal coverage in Türkiye, Mersin encompasses significant tourist attractions such as the Cennet-Cehennem Cave, Aya Thekla Church, and the Temple of Zeus. With its 321 km long coastline, Mersin is also one of the important residential areas for summer tourism in our country. In addition to the central districts of Akdeniz, Mezitli, Yenişehir, and Toroslar, it has a total of 13 districts including Anamur, Aydıncık, Bozyazı, Silifke, Tarsus, Çamlıyayla, Erdemli, Gülnar, and Mut. The international port and adjacent free zone in Mersin provide a connection for global trade, particularly for many provinces located in Eastern Anatolia and Central Anatolia regions (GM, 2022).


**Source:** (GM, 2022; AA, 2014; MMM, 2023)

**Figure 3.1:** Photos of Mersin

## 3.2. Population

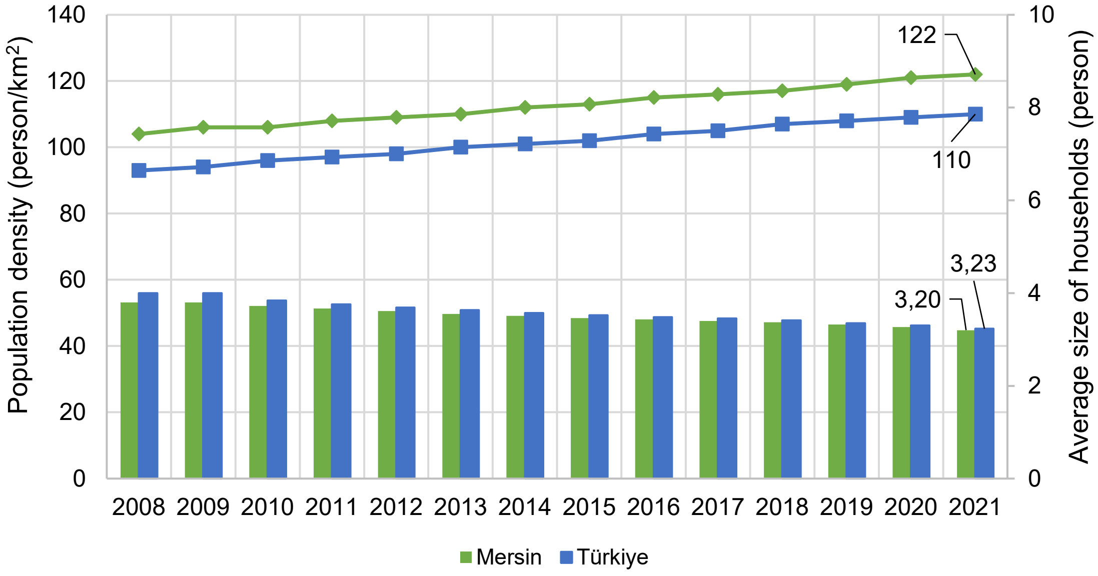
The population of 1,488,755 of the Mersin province in 2000 has increased by approximately 27% in the last 21 years and reached 1,891,145 in 2021. Mersin is the 11th largest province in Türkiye. As shown in Figure 3.2, the female and male populations are very close to each other. The majority of population lives in urban areas, and between 1990 and 2000, the urban population increased by 23.67% and the rural population by 30.92%. Mersin province received 57,213 immigrants in 2021 and 57,930 migrated. Between 2016 and 2019, Mersin province received migration from outside of Türkiye, approximately 81% of which were foreign nationals, while 17,401 people, 59% of whom were foreign nationals, migrated from Mersin in the same time period. On the other hand, there has not been a steady increase or decrease in migration inwards or outwards over the years. The difference between the migration received and the migration given in 2021 is 717 people. While 10% of the immigration received was from Adana, 12% of the migration given was to Istanbul (TurkStat, 2023).




**Source:** (TurkStat, 2023)

**Figure 3.2:** Population and migration change in Mersin province (2008-2021)

The average household size of 3.7 in 2010 showed a decreasing trend and decreased to 3.2 people in 2021. This number is 3.23 for the average of Türkiye. The number of illiterates decreased from 36,077 in 2017 to 28,917 in 2021. As can be seen in Figure 3.3, as of 2021, the area of the province is 15,853 km$^2$ and the population density is approximately 122 people/km$^2$ (TurkStat, 2023).




**Source:** (TurkStat, 2023)

**Figure 3.3:** Change in population density and household size in Mersin (2008-2021)

## 3.3. Geography

In terms of surface area of Mersin province, 53% is covered with forest and nursery, 21% is covered with agricultural land, 22% is comprising non-agricultural land, and around 4% is covered by meadows and pastures. Geographically, the province is located between the latitudes of 36-37° North and the longitudes of 33-35° East. With an area of 15,853 km$^2$, Mersin has a coastline of 321 km and a land border of 608 km. It is bordered by the provinces of Konya, Karaman, and Niğde to the north, Antalya to the west, Adana to the east, and the Mediterranean Sea to the south. Mersin is divided into 13 districts.


**Figure 3.4:** Map of Mersin Province

Mersin province is predominantly composed of high, rugged, rocky Western and Central Taurus Mountains. The plains and gently sloping areas are developed in the central parts of the province, as well as in areas such as the provincial capital, Tarsus and Silifke, where these mountains extend towards the sea. In the northern part of the province, between the mountains or in the higher regions, there are flat or gently sloping areas. Mersin province is not rich in rivers. The most important rivers in the province are the Göksu and Berdan rivers.

### 3.4. Climate Conditions

Mersin province's coastal areas have a typical Mediterranean climate, with hot and dry summers and mild and rainy winters. As you move inland from the coast, a continental climate is observed. In the higher regions of the province, summers are cool and dry, while winters are cold and snowy. According to the climate statistics for Mersin province from 1940 to 2021 provided by the Turkish State Meteorological Service (MGM), the lowest average temperatures are around - 6.5°C in January and February, and the average temperatures during the hottest months, from June to September, are around 39.9°C. The annual average temperature is 19.2°C. The average daily sunshine duration is 7.5 hours, and the annual average number of cloudy days is 40.7 days. The average number of rainy days is approximately 57 days. The average sea water temperature in this region is measured to be 20.8°C.

Based on the data from 1940 to 2021, the annual average precipitation in Mersin province is 613.9 mm. The highest rainfall occurs in November (average 76.9 mm), December (average 138.5 mm), January (average 119.9 mm), February (average 85.2 mm), and March (average 56.4 mm). Precipitation measurements at the MGM's stations indicate that rainfall is higher in mountainous areas. In the coastal regions, the prevailing wind directions are southwest to west. The annual average wind speed in the city is about 2.1 m/s. The relative humidity is on average 64.1% over the past 30 years. Throughout the year, these values range between 60.0% and 66.6% (MGM, 2022).

### 3.5. Economics

Mersin is one of the most developed provinces of Turkey in many areas. The most important reasons for this development are its fertile soil, advanced industrial status, rich in natural and underground resources, port activities in Mersin and the presence of Mersin oil refinery. While 40% of the income is derived from industry and 30% from agriculture, 10% is obtained from the trade sector. Approximately 32% of Mersin's 517,000 working population is employed in the agricultural sector. With an area of 1,585,300 hectares, Mersin constitutes approximately 2% of the total area of Turkey and agricultural production is carried out on 21% of the province's surface area (PDEUCC, 2022). Mersin ranks 28th in terms of the value of animal products in 2020 with 816.3 million TL, 24th in terms of the value of livestock in 2021 with approximately 3.5 billion TL and 2nd after Konya and Antalya with 17 billion TL in terms of the value of crop production in 2021.

Mersin, 2020 yılı hayvansal ürünler değeri bakımından 816,3 milyon TL ile 28. sırada, 2021 yılı canlı hayvan değeri bakımından yaklaşık 3,5 milyar TL ile 24 sırada ve 2021 yılı bitkisel üretim değeri bakımından 17 milyar TL ile Konya ve Antalya'dan sonra 2. sırada yer almaktadır (TurkStat, 2023).

According to the 2021 Report of Mersin Chamber of Commerce and Industry (MTSO), a total of 177,000 hectares of agricultural land is cultivated in the province. Mersin ranks 2nd in Türkiye in terms of vegetable production with a share of 7.5% and 1st in fruit production with a share of 16%. Mersin is the 3rd largest province in Türkiye in terms of the value of crop production, and the annual production value has expanded by 31%. The area planted with ornamental plants has increased by 32% compared to the previous year, reaching 1,054,606 $m^2$, while the production quantity has increased by 17% to reach 31,991,610 units. Mersin accounts for 2% of Türkiye's ornamental plant production and ranks 10th among the provinces that produce ornamental plants. Mersin is also the top exporter of fresh fruits and vegetables in Türkiye, covering 21% of the country's total exports in that category. In terms of greenhouse cultivation, the areas have expanded by approximately 19% to reach 223,893 decares, constituting 37% of Türkiye's total and placing Mersin in the 1st position (MTSO, 2022). According to the Mediterranean Exporters' Associations (AKİB) export of fresh fruits and vegetables from Mersin has increased from a total of $ 639,988,782 in 2020 to $ 655,911,594 in 2021.

The livestock sector is carried out in mountainous regions and highlands. The total proportion of non-agricultural land, meadows and pastures in the province is about 26%. The beekeeping sector has developed in the province. Although the province has extensive coasts in the Mediterranean region, fish production is about 28,800 tons (TurkStat, 2023). There are 20 sea bream-sea bass production facilities with a total capacity of 49.8 thousand tons per year, one trout production facility with a capacity of 287 tons per year, three blackfish production facilities with a capacity of 170 tons per year, and four sea bass production facilities with a capacity of 70 tons per year. Apart from sea bream-sea bass production, the other fish farming facilities are land-based. The rivers of Tarsus, Berdan, and Tragon are abundant with freshwater fish. Mersin, which is rich in forest areas, has the third-largest forest cover in Türkiye, occupying 53% of its land area. The coastline from Anamur to Tarsus is covered with maquis vegetation. Among the maquis vegetation, there are wild olive and stone pine trees called "Delice". While dense forests are found up to an altitude of 2,200 meters from the maquis zone, dwarf and sparse forests are present in higher regions. Oak, mastic, sandalwood, myrtle, and juniper trees are found in forested areas up to an altitude of 600 meters. Various types of pine trees, fir trees, and cedar trees are found in higher elevations. The forested and maquis areas cover 785,000 and 100,000 hectares, respectively. Every year, 3,500 tons of resin and 250,000 $m^3$ of industrial timber are obtained from these forests.

According to industrial registration records, the manufacturing industry accounts for 89% of the enterprises operating in the industrial sector in Mersin province. Among the sub-sectors of the manufacturing industry, food product manufacturing constitutes 32%, followed by machinery and equipment manufacturing, rubber and plastic product manufacturing, fabricated metal product manufacturing, mineral product manufacturing, clothing manufacturing, chemical and chemical product manufacturing, and wood, wood product, and mushroom product manufacturing with percentages of 11%, 8%, 8%, 7%, 7%, 5%, and 5%, respectively. Developments in foreign trade volume in 2021 were parallel to the national trends. Mersin experienced a 31% increase in export volume and a 39% increase in import volume compared to 2020. The manufacturing industry played a determining role in this, while the agricultural sector also made a contribution. Mersin companies conducted exports worth $4.2 billion and imports worth $3.9 billion in 2021 (MoIT, 2021).

Mersin province is among the rich provinces in terms of minerals. The General Directorate of Mineral Research and Exploration has carried out studies in Mersin and its surrounding areas, resulting in the identification of metallic minerals such as chromium, as well as iron, copper-lead-zinc deposits, and industrial raw material sources including primarily dolomite and barite, as well as cement raw materials, phosphate, limestone, and magnesite beds and formations. Chrome, copper, iron, quartzite, aluminum, barite, and dolomite are extracted in this province, and some of these minerals are exported to foreign countries through the Port of Mersin.

Mersin Free Zone with an area of 860,076 m² opened in 1987 and is the first free zone of our country. In 2020, $2,520,963,199 trade occurred. There are a total of 406 companies in the region with 293 domestic, 79 foreign and 34 domestic-foreign partnerships. Mersin Port is among the top 92 in the world with its container volume, and ranks 1st in Türkiye with its 2.6 million TEU container business volume. Freight traffic handled increased by 10% annually to 36.4 million tons. Mersin ranks 4th in Türkiye in terms of the number of ships calling at ports for operations. Mersin Technology Development Zone (Mersin TEKNOPARK) was established in 2006 and 86 companies operate within.

Mersin, due to its geographical location; covers a significant part of the Eastern Mediterranean Basin to the west of the Çukurova part of the Mediterranean Region. With 321 km long coastline, it has one of the longest coastlines in Türkiye. From Tarsus to Anamur, Mersin has a great potential in terms of tourism with its ancient cities, historical and natural values.

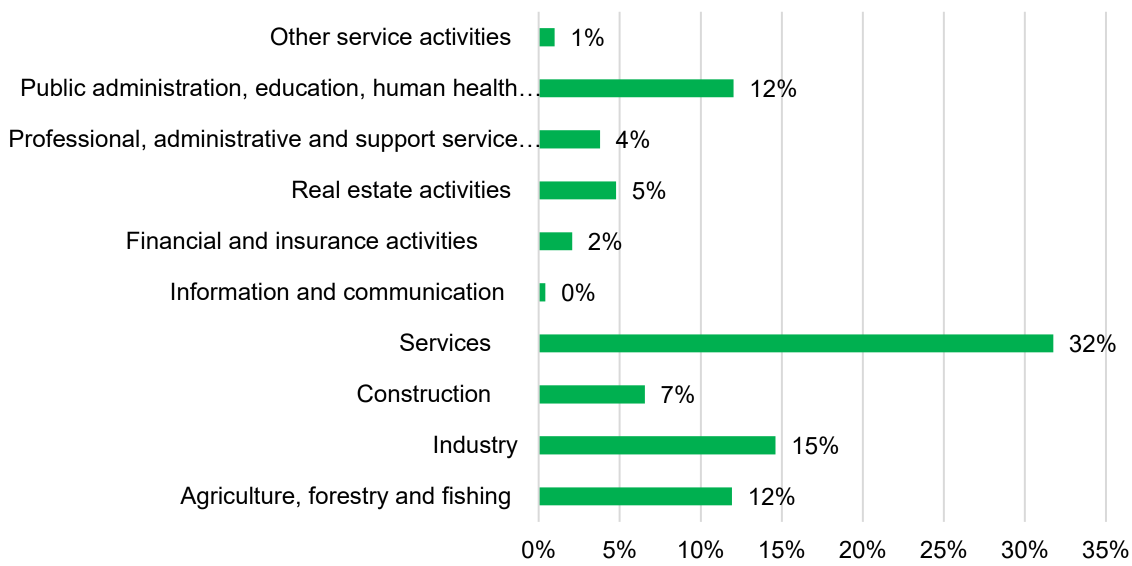
The region consisting of natural beaches and 108 km of sandy coastline, is also very rich in terms of historical and cultural values. Mersin, which has been a settlement since the Neolithic period, has many archaeological and historical artifacts from the Chalcolithic, Hittite, Roman, Byzantine and Ottoman civilizations. There are two centers that are the most important in terms of faith tourism in the province. First, the House and Well of St. Paul, one of Jesus' Apostles, in Tarsus were declared a place of pilgrimage by the Vatican. The other is St. Aya Tekla (Meryemlik), in Silifke/Başucu which is important for the Muslim and Christian world and is accepted as a place of pilgrimage in the early

Christian period, are the most important religious visiting centers. In addition, the Ashabı Kehf Cave of Tarsus is also located within the borders of the province.

In order to shift the yacht tourism to the Eastern Mediterranean, marina projects in accordance with international standards are being developed and Mersin Main Marina with a capacity of 500 yachts has been built. Yacht Basen with a capacity of 300-350 yachts operates in Mersin Çamlıbel region in which blue cruise, daily tour and moonlight tours are also made. There are also healing water springs in the region, highlanding, suportive activities, paragliding, sailing sports, underwater diving, rafting, water skiing activities can be done. A significant number of people in the region migrate to the cooler Taurus plateaus in the summer months and revive the highland tourism.

The per capita gross domestic product (GDP) value of Mersin province increased from 15,207 TL in 2011 to 74,343 TL in 2021. Mersin is the 10th largest province with a share of 1.9% in Türkiye's GDP (TurkStat, 2023). According to the 2019 data, TURKSTAT ranked Mersin 4th among the provinces that contributed the most to the 0.9% increase of the annual GDP compared to the

previous year with the chained volume index (Figure 3.5).




**Source:** (TurkStat, 2023)

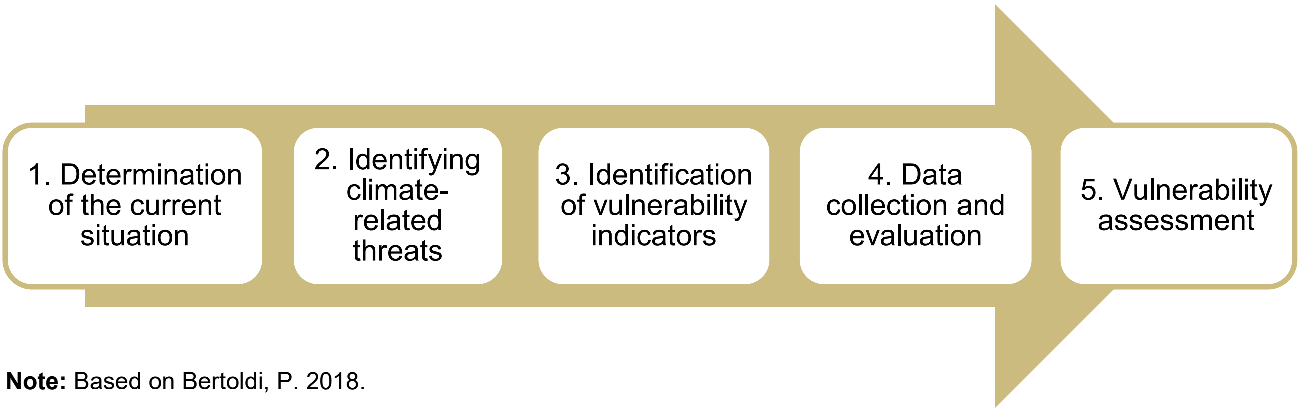
**Figure 3.5:** Distribution of Mersin gross domestic product according to economic activity

# 4. ASSESSMENT OF CLIMATE RISK, VULNERABILITY AND ADAPTIVE CAPACITY

In the implementation of the climate change adaptation planning process, the methodology, which is outlined by the EU Climate Adaptation Platform (Climate-ADAPT) and prioritized for our country, basically consists of 6 steps and adopted in this study (Climate ADAPT, 2022; MoEUCC_b, 2020). Accordingly, the steps to be followed in the development of the adaptation action plan are

1. Organizing administrative processes / ensuring prerequisites
2. Climate change risk and vulnerability assessment
3. Identifying adaptation measures
4. Assessment/prioritization of adaptation measures
5. Implementation of adaptation actions
6. Monitoring and evaluation

There are two approaches that are basically followed in risk and vulnerability assessment within the scope of climate change adaptation, namely spatial impact modeling and indicator-based assessment, and the second approach has been taken into consideration within the scope of the Project studies (Bertoldi P., 2018).




**Note:** Based on Bertoldi, P. 2018.

**Figure 4.1:** Risk assessment approach for climate change adaptation

In the first stage, a survey was conducted to obtain stakeholders' views on the areas expected to be affected by climate change in Mersin province and the measures that can be implemented within the scope of adaptation to climate change. The survey was answered by 108 respondents in Mersin and the institutional distribution of the respondents is presented in Figure 4.2.

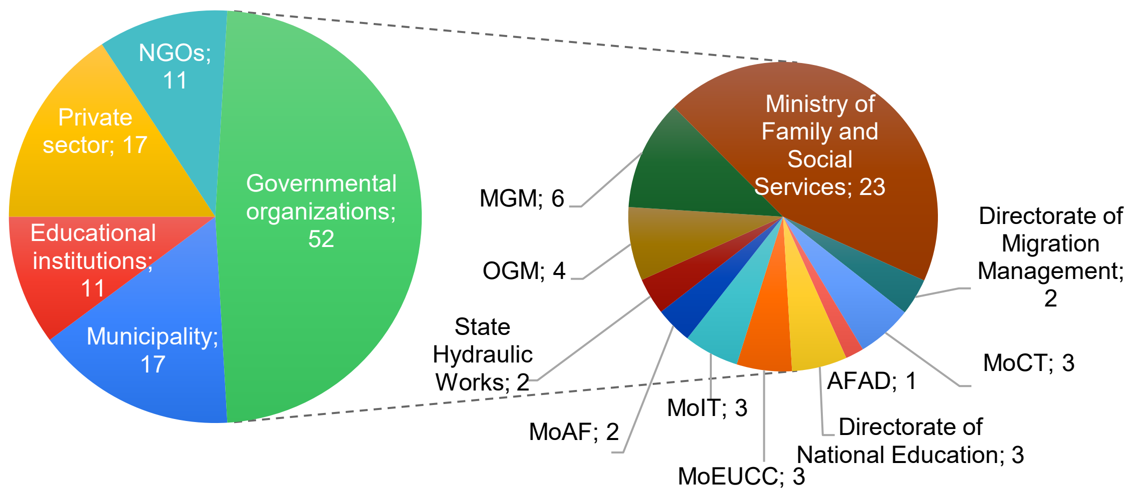



**Figure 4.2:** Institutional distribution of survey respondents

According to the general evaluation results of the questionnaire, the majority of the respondents indicated that the impacts of climate change expected to have an impact on Mersin will be primarily temperature increase, drought and forest fires (Figure 9.3), while on a sectoral basis, land use, forestry and biodiversity, agriculture and animal husbandry, and water resources are among the sectors expected to be most affected (Figure 9.4).

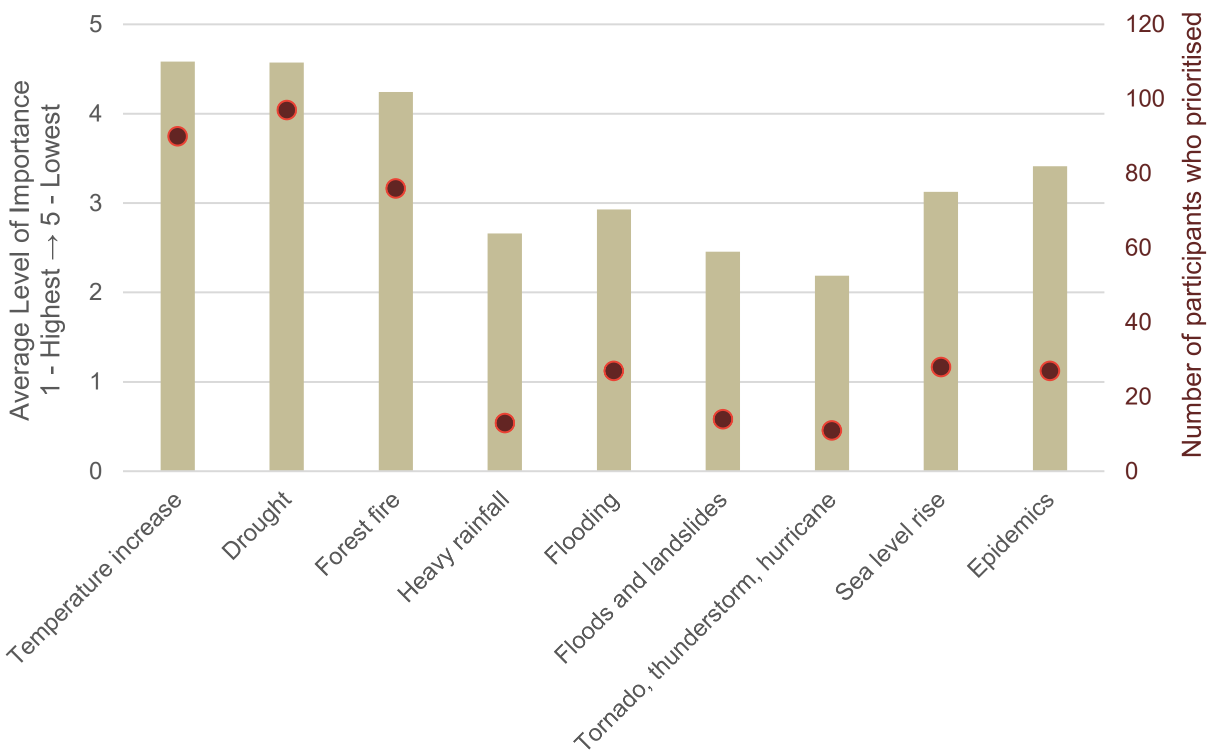



**Figure 4.3:** Prioritization of climate change impacts according to survey respondents

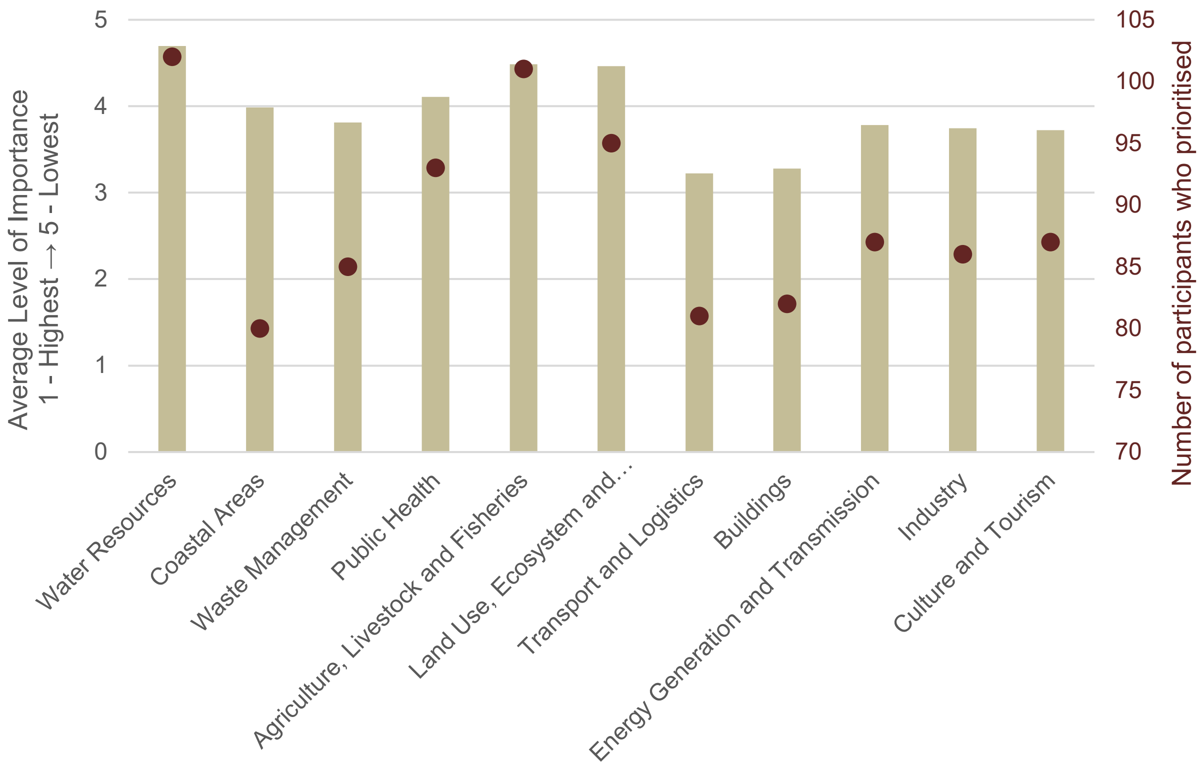



**Figure 4.4:** Prioritization of sectors according to survey respondents

## 4.1. Climatological Analysis

### 4.1.1 Temperature

In order to determine the climatic characteristics of Mersin province, long-term (1963-2021) data sets of the General Directorate of Meteorology (MGM) observation stations were analyzed.. Table 9.1 shows annual and seasonal average temperatures for some selected districts. Anamur, Silifke, Erdemli and Akdeniz stations, which are located along the shoreline and at elevations close to sea level, have long-term annual average temperatures of around 19.5$^{o}$C, while the long-term annual average temperature of Mut, which is located at a higher altitude and where the sea effect is felt relatively less, is around 18$^{o}$C. Long-term average temperatures in Fall, Winter and Spring are also relatively higher in the coastal districts. However, long-term summer average temperatures show that Mut is about 1-2$^{o}$ C warmer than the other stations. The main reason for this is that the thermal air circulation (thermal circulation) that occurs as a result of the temperature and density difference between land and sea and the resulting sea breezes (cooler winds blowing from the sea towards land) lose their effect inland.

**Table 4.1:** Annual and seasonal average temperatures in Mersin Province (°C)

| Station name | Annual Average Temperature (1959-2021) | Fall Seasonal Average Temperature (1959-2021) | Winter Seasonal Average Temperature (1959-2021) | Spring Seasonal Average Temperature (1959-2021) | Summer Seasonal Average Temperature (1959-2021) |
|---|---|---|---|---|---|
| **Anamur-17320** | 19.54 | 21.55 | 12.27 | 17.21 | 27.14 |
| **Silifke-17330** | 19.59 | 21.68 | 11.20 | 17.93 | 27.54 |
| **Mersin-17340** | 19.40 | 21.46 | 11.29 | 17.71 | 27.12 |
| **Erdemli-17958** | 18.67 | 20.64 | 10.73 | 16.74 | 26.57 |
| **Mut-17956** | 17.95 | 19.19 | 7.60 | 16.50 | 28.52 |

"Long Term Average Maximum Temperatures", "Long Term Annual Maximum Temperatures", "Seasonal Average Maximum Temperatures" and "Long Term Averages of Seasonal Maxima" are given in Table 9.2 for Anamur, Silifke, Erdemli, Akdeniz and Mut. "Long Term Average Maximum Temperatures", where the maxima of each month are taken into account, are around 28.7, 29.9, 28.5, 28.0 and 30.0° C for Anamur, Silifke, Erdemli, Akdeniz and Mut, respectively. However, the "Long Term Annual Maximum Temperature Averages", which take into account the maxima realized in each year, are 38.5, 38.9, 36.4, 35.3 and 41.8° C for these districts, respectively, and it is seen that Mut has much higher values in maximum temperatures than other districts. If we look at the "Seasonal Average Maximum Temperatures" and "Long Term Averages of Seasonal Maximum Temperatures"; it is seen that these values are 30.7 and 34.0, 20.2 and 22.0, 28.4 and 32.0, 32.8 and 34.2° C for the Autumn, Winter, Spring and Summer seasons, respectively for Akdeniz district.It can be said that the values are similar for other coastal districts. In Mut district, these values are higher in the order of 31.9 and 37.9, 18.2 and 20, 29.9 and 35.0, 40.3 and 41.7°C.

**Table 4.2:** Long-term temperature data for Mersin province (°C)

| Station name | Long Term Average Maximum Temperature (1959-2021) | Long Term Average Annual Maximum Temperatures (1959-2021) | Fall Seasonal Average Maximum Temperature (1959-2021) / Seasonal Maxima Long Run Average (1959-2021) | Winter Seasonal Average Maximum Temperature (1959-2021) / Seasonal Maxima Long Run Average (1959-2021) | Spring Seasonal Average Maximum Temperature (1959-2021) / Seasonal Maxima Long Run Average (1959-2021) | Summer Seasonal Average Maximum Temperature (1959-2021) / Seasonal Maxima Long Run Average (1959-2021) |
|---|---|---|---|---|---|---|
| **Anamur-17320** | 28,74 | 38,52 | 30,68 / 34,68 | 20,02 / 21,46 | 27,24 / 31,86 | 36,85 / 38,43 |
| **Silifke-17330** | 29,90 | 38,87 | 32,39 / 36,28 | 20,63 / 22,40 | 29,74 / 34,03 | 36,86 / 38,55 |
| **Mersin-17340** | 28,03 | 35,28 | 30,69 / 34,03 | 20,17 /22,00 | 28,42 / 31,96 | 32,83 / 34,23 |
| **Erdemli-17958** | 28,48 | 36,35 | 31,10 / 34,62 | 20,21 / 21,95 | 28,78 / 33,04 | 33,81 / 35,50 |
| **Mut-17956** | 30,06 | 41,78 | 31,87 / 37,94 | 18,23 / 19,97 | 29,86 / 35,01 | 40,27 / 41,70 |

The monthly "Average Maximum Temperature", "Monthly Long Term Observed Maximum Temperature", "Monthly Long Term Average Minimum Temperature" and "Monthly Long Term Average Temperature" changes for the Reference Period (RP) between 1963-2021 are shown in Figure 9.5. It can be said that there are no significant differences in the above four parameters for Anamur, Silifke and Mersin Center (Akdeniz). While Mersin's average temperature values are at a minimum of 10° C in January, they reach maximum values around 27° C in July-August. Long-term monthly minimum values occur in January with 1-2° C, and in July-August the minimum values reach 21° C and then decline. Mean Maximum Temperature values (red) calculated within the RP reached 19-20° C in winter and 33° C in July-August-September. Monthly Long Term Average Maximum Temperatures (yellow) reached 25° C during the winter months and reached the highest values of 41-42° C in September. Looking at Mut MGM station data, it is seen that the average minimum temperatures are lower compared to Anamur, Silifke, Erdemli and Mersin, hovering around 3° C below zero. In each of the parameters of Average Temperature, Average Maximum Temperature and Monthly Long Term Maximum Temperature, it is seen that it has higher values around 30° C, 40.5° C and 46° C, respectively, compared to the other 4 districts.

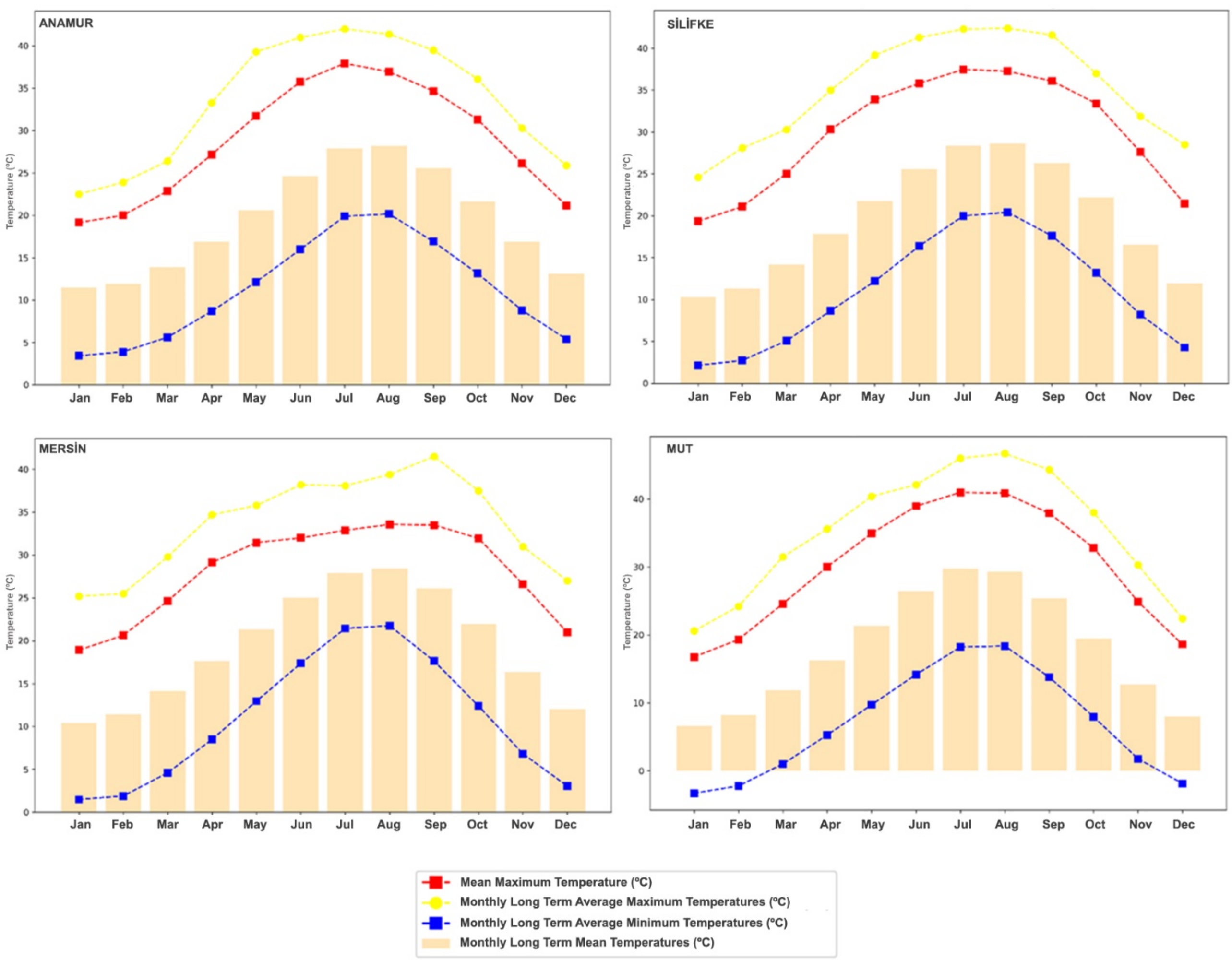



**Figure 4.5:** Long-term monthly average temperature distributions of Mersin province

Some statistical methods such as trend analysis are used to determine how a variable shows a trend and the intensity of the trend over time. One of the benefits of trend analysis is that it provides information about the future trend based on the assumption that the statistical properties of the past data set are preserved. Among parametric tests, the most widely used tool for the assessment of climate parameters is linear trend analysis. By applying an analysis in which the deviations (differences) of the annual average temperature data of Mersin province from the 59-year RP values are considered as an independent variable and the years as a dependent variable, the trend in the deviations of the annual average temperatures of the province and some selected districts from the long-term temperature averages both annually and seasonally is shown in Figure 9.6. When the deviations in annual averages are analyzed with time (Figure 9.6), it is seen that the slope values are around 0.05, 0.03, 0.03, 0.03 and 0.04 for Mersin, Anamur, Silifke and Mut, respectively, and the correlation coefficients (degree of relationship) are significantly high at 0.83, 0.60, 0.49, and 0.63, respectively. For Mersin and Mut, the period when the deviations from the averages were negative continued until 1994, while the deviations became positive after 1994 (annual average temperatures were higher than the long-term average annual temperature). It is also seen in the figure that the positive differences from the RD average temperatures tend to increase towards 2021. For example, for Mersin, while the positive differences around 1994-2008 hovered around 0.5-1.0$^{o}$ C, these values can be seen to vary between 1.2-2.2$^{o}$ C between 2008-2021. From this point of view, it can be said that annual average temperatures for Mersin province have been increasing over time and this trend will continue in the future if these RP statistical properties remain the same. In Anamur and Silifke districts, deviations of annual average temperatures from the RP values have become positive after 1996, except for a few exceptional years. For Anamur and Silifke districts, it can be seen that there has been an increase in positive values especially after 2008.

In order to examine the change of seasonal temperature averages over time, the changes of "seasonal temperature averages" for Mersin, Anamur and Mut districts and their differences from RP seasonal averages over time are shown in Figure 9.7, Figure 9.8 and Figure 9.9. For Mersin province, seasonal differences are strongly correlated with time and the trend is positive (Figure 9.7). The correlation coefficients for Mersin in winter, spring, summer and fall were 0.45, 0.65, 0.84 and 0.72, respectively. It can be said that the differences for all seasons shifted towards positive values approximately after 1994. The correlation coefficient is highest in the summer season and deviations increase up to 1.5-2$^{o}$ C after 1994. Although the differences of the seasonal temperature averages of Anamur, Silifke, Erdemli and Mut districts from the long-term (RP) seasonal averages have been analyzed separately, only Anamur, which is a coastal district, and Mut, which is relatively farther away from the sea and has a relatively higher sea level than the others, are shown in Figure 9.8 and Figure 9.9.

Considering the changes in Anamur Winter, Spring, Summer and Fall temperature deviations over time (Figure 9.8), it is seen that there is a positive trend, although it is slightly lower than Mersin station, there is a strong positive relationship and the correlation coefficients are 0.19, 0.34, 0.62 and 0.57, respectively. The lowest relationship is observed in Winter and then in Spring, while the highest relationship is observed in Summer and then in Fall. Except for some exceptional years, it can be said that the trend shifted to a positive direction towards the end of the 1990s. It can be seen in Figure 9.9 that a similar change is also valid for Mut district. Similarly, the lowest correlation for Mut was calculated to be in Winter and Spring. It is observed that the differences of seasonal temperature averages from the long term in summer and autumn months, where the correlation is the highest with 0.52 and 0.54, have shifted to a positive trend after 1994 and 1999, respectively. Positive temperature differences can range from about 0.5 to 2.0$^{o}$ C for the Summer season and from about 0.5 to 2.5$^{o}$ C for the Autumn season.

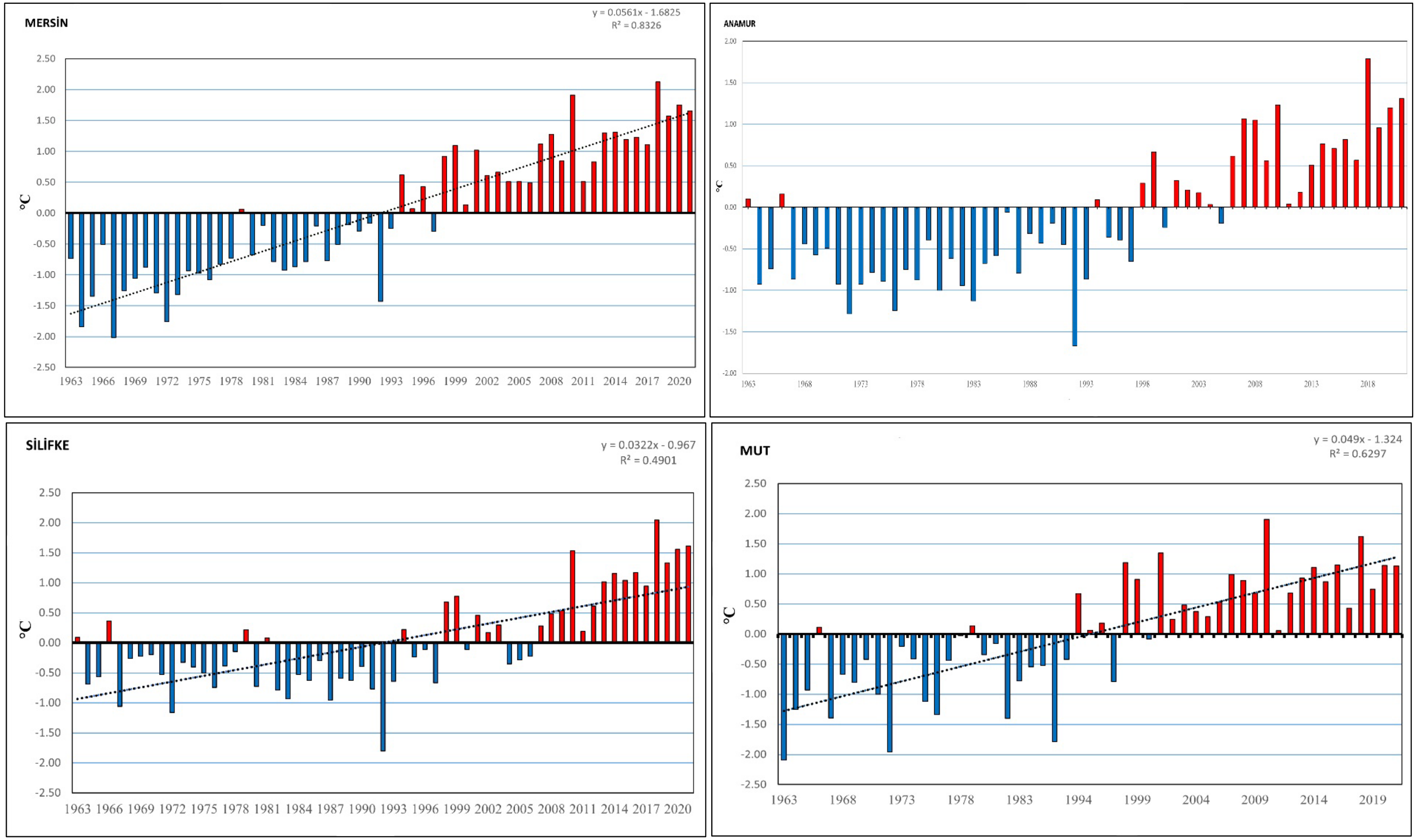



**Figure 4.6:** Annual average temperature deviations of Mersin districts 1963-2021 period

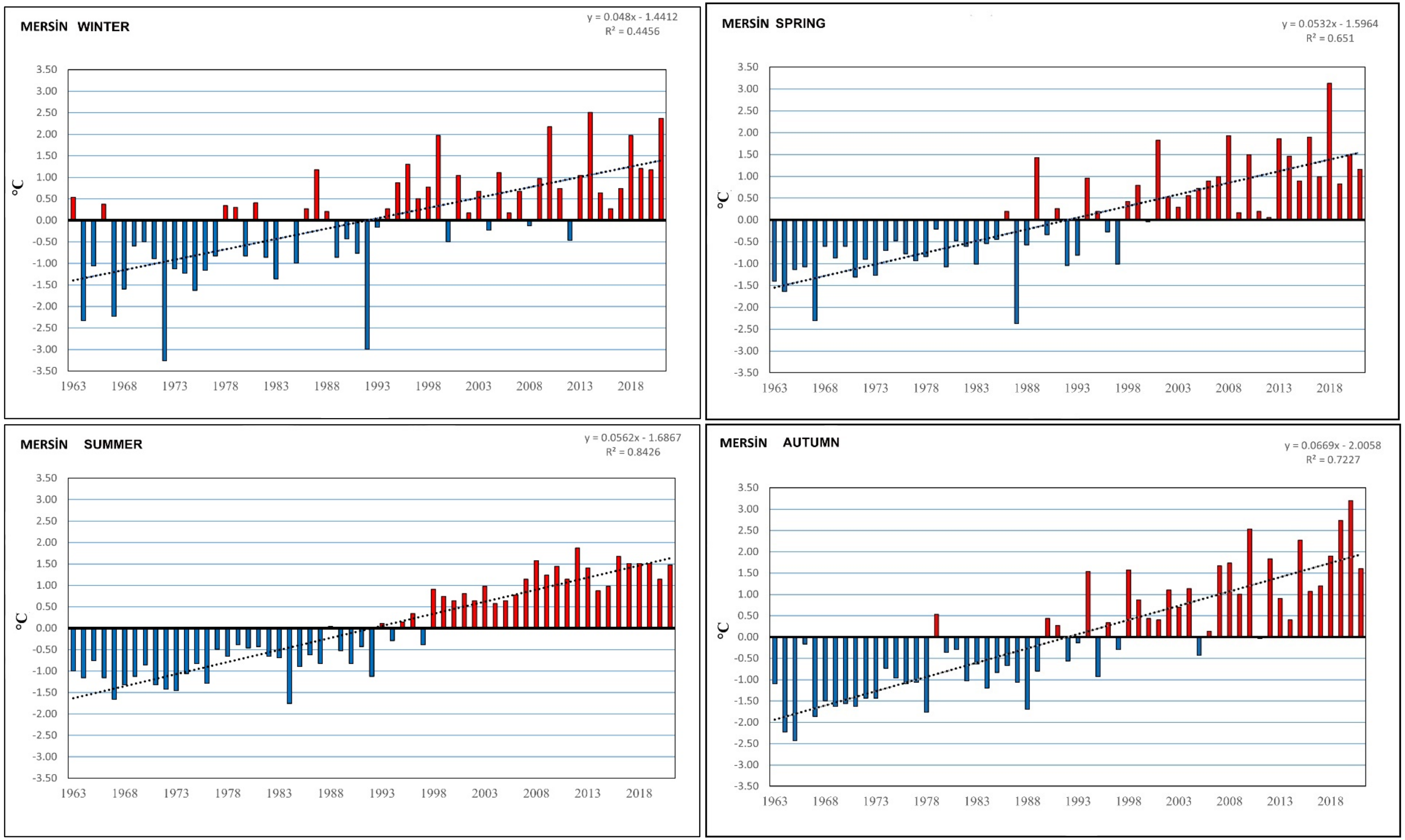



**Figure 4.7:** Seasonal average temperature evaluations for Mersin station for the period 1963-2021

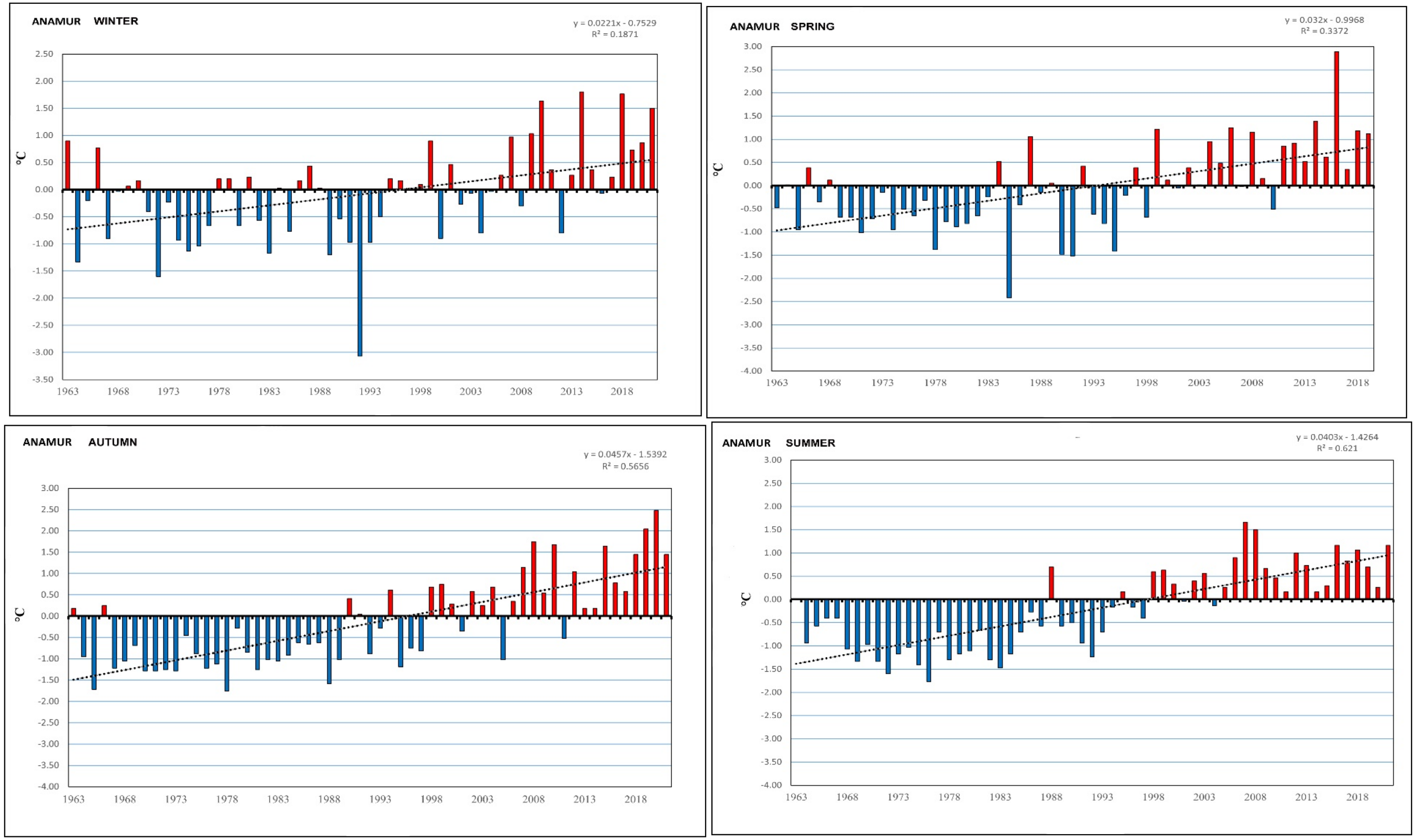



**Figure 4.8:** Seasonal average temperature evaluations for Anamur station for the period 1963-2021

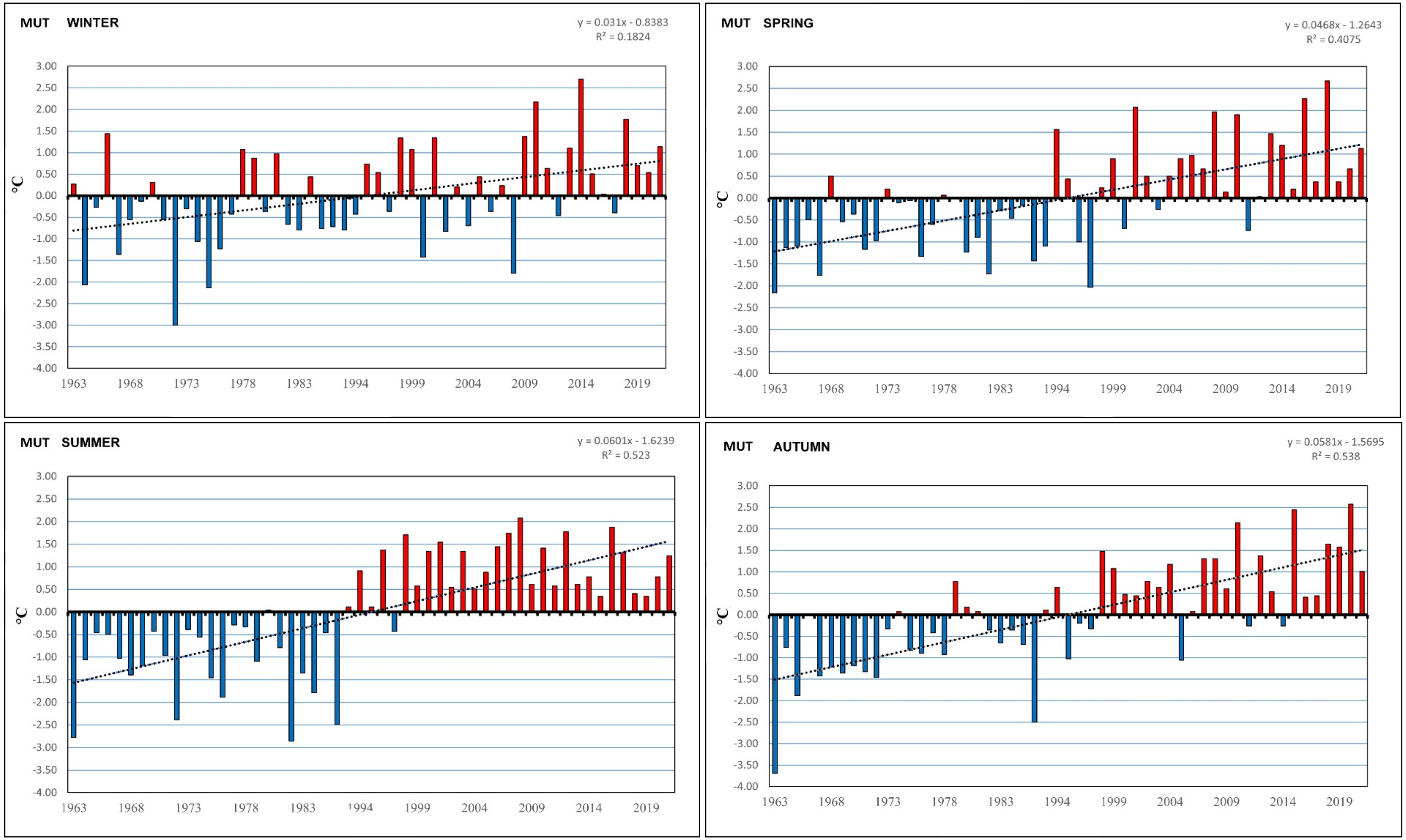



**Figure 4.9:** Mut station seasonal average temperature assessments for the period 1963-2021

1963-2021 RP "Long Term Average Maximum Temperature - LTAMT" and "Long Term Average Annual Maximum Temperature - LTAAMT" are calculated as 30.1$^{o}$ C and 41.8$^{o}$ C, respectively. "In the calculation of Long Term Average Maximum Temperature, the average of the maximum temperature values of each month for any year is calculated as the annual average maximum temperature. The "Long Term" (1963-2021) averages of these annual average maximum temperatures give us the "Long Term Average Maximum Temperature - LTAMT". In the LTAAMT calculation; the maximum temperature value occurring in any given year is considered as the maximum temperature of that year. The 1963-2021 RP average of the annual maximum temperature values calculated in this way gives the LTAAMT. The change in the difference of maximum temperatures from their long-term averages over time is important as it is one of the characteristics of the change in Mersin climate. Considering the temperature increases that are being experienced especially in the Eastern Mediterranean basin and predicted by climate projections, it becomes important to know the direction and severity of the change in maximum temperatures.

The seasonal variation of LTAMT and LTAAMT values of Mersin and Anamur districts over time is shown in Figure 9.10 and Figure 9.11. Although similar figures were prepared for Silifke, Erdemli and Mut districts, the analyses were carried out for Anamur and Mersin since the seasonal characteristics of the LTAMT and LTAAMT variables of Silifke and Erdemli districts are similar to those of Anamur district and the LTAMT and LTAAMT values of Mut district do not show a significant trend over time. Mersin LTAMT values have been positive and increasing in the summer season since the late 1990s. It is observed that the annual averages of the monthly maximum values show increases of up to 2-3$^{o}$ C compared to the long-term averages; again, it is seen that LTAAMT values have continuously taken positive values for the summer season since the beginning of the 2000s and increases of up to 2 – 5$^{o}$ C. For Mersin, it is observed that the differences remain positive in the fall season, especially since the beginning of the 2000s, and LTAMT and LTAAMT values increase up to 4$^{o}$ C and 7$^{o}$ C, respectively. It can be said that both LTAMT and LTAAMT values for the winter season have remained positive since the 2000s, albeit slightly. In the spring season, deviations hovered around positive and negative values, with LTAMT values slightly more positive.

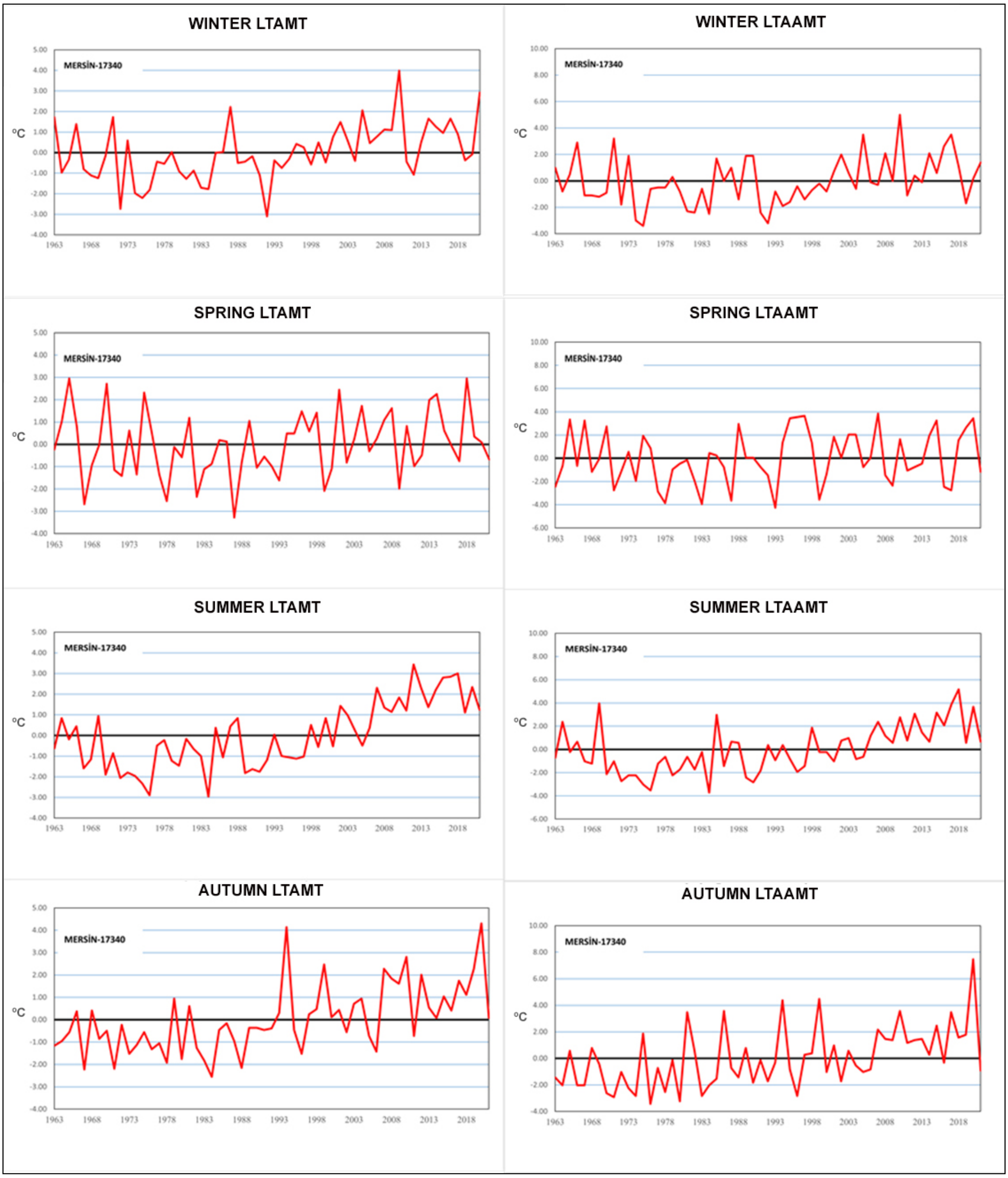



**Figure 4.10:** LTAMT and LTAAMT values for Mersin station

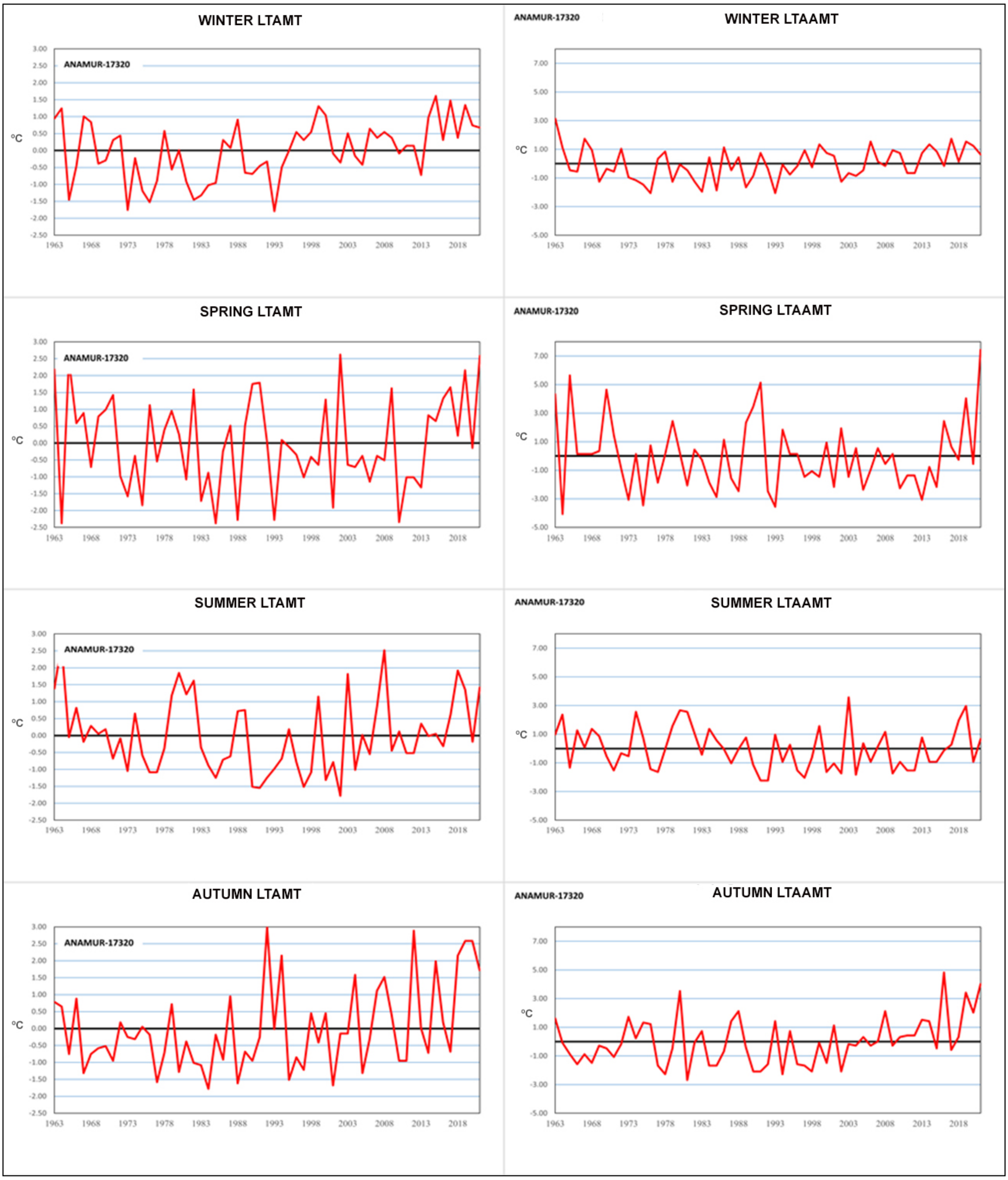



**Figure 4.11:** LTAMT and LTAAMT values for Anamur station

The time variation of seasonal LTAMT and LTAAMT values of Anamur district is given in Figure 9.11. It is observed that summer LTAMT values have been peaking up to 1.5-2°C since 2000s and generally remain positive. It can be said that a similar change is not the case for the LTAAMT. Annual maximum temperatures are found to oscillate around the long-term maximum temperature. In the fall, it is noteworthy that the peaks in the positive direction of the LTAMT values are much larger than the peaks in the negative direction. Positive LTAMT values go up to around 2-2.5° C, while negative LTAMT values only stay around minus 0.5°C. Autumn LTAAMT values, on the other hand, have been in a positive phase since the 2000s and deviations of up to 3-5°C can be observed. For Anamur (for Silifke, Erdemli and Mut), it is seen that there is no downward or upward trend in LTAMT and LTAAMT variables in winter and spring seasons. It is observed that the differences in maximum temperatures tend to increase more significantly in Summer and Autumn.

### 4.1.2 Precipitation

In order to reveal the precipitation amount and regime of Mersin province, the data of MGM meteorological observation stations within the borders of Mersin province were taken into consideration. The observation periods for Anamur, Mersin, Silifke and Mut are 1948-2022, 1948-2021, 1930-2021 and 1959-2011, respectively. The evaluations were made for the central district of Mersin, Akdeniz, Anamur, Silifke and Mut districts. In addition to annual rainfall totals, deviations of seasonal rainfall totals from their long-term averages were also calculated. In addition, the ratio of the monthly maximum total precipitation value to the total precipitation of the relevant year, which may be a sign of irregularity in precipitation (the effect/contribution of heavy downpours to total precipitation), was calculated for the long term.

As shown in Table 4.3, the long-term averages of total annual precipitation at Anamur, Mersin, Silifke and Mut stations are 941.9 mm, 599.6 mm, 563.6 mm and 395.6 mm, respectively. The long-term averages of monthly maximum precipitation were calculated as 293.6 mm, 196.1 mm, 180.6 mm and 122.4 mm for Anamur, Mersin, Silifke and Mut, respectively. It is observed that Anamur has much higher values than other districts in both total precipitation and maximum precipitation, with Mersin Akdeniz ranking second. The highest precipitation occurred in the winter season and these values are around 553.8 mm, 342.1 mm, 329.3 mm and 218.2 mm in the above order. Although Anamur district is the district with the highest rainfall in all seasons except summer, it is also noteworthy that it receives the least rainfall among these four districts in the summer season. Although fall precipitation is slightly higher than spring precipitation for Akdeniz and Silifke districts, it can be said that spring and fall precipitation values are close to each other, including Mut district: Mersin (118,1-115,6 mm), Silifke (120,3-104,1 mm) ve Mut (76-85 mm). Table 4.4 provides information on seasonal minimum rainfall. The winter minimum precipitation averages for Anamur, Mersin, Silifke and Mut were 93.9 mm, 52.7 mm, 51.5 mm and 33.9 mm, respectively. The summer minimum precipitation averages were 3.1 mm, 5.4 mm, 4.6 mm and 4.9 mm, respectively, and the fall and spring minimum precipitation averages were close to each other

**Table 4.3:** Annual and seasonal total precipitation data in Mersin Province

| Stations | Long-term Average of Annual Totals | Long-term Average of Monthly Maximum Observed Precipitation | Monthly Maximum Precipitation / Long-term Average of Total Annual Rainfall Rates | Fall Seasonal Total Rainfall Average | Winter Seasonal Total Average Precipitation | Spring Seasonal Total Average Precipitation | Summer Seasonal Total Average Precipitation |
|---|---|---|---|---|---|---|---|
| Anamur | 941.89 (1948-2022) | 293,55 | 0,3145 | 190,08 | 553,75 | 160,61 | 7,38 |
| Mersin (Akdeniz) | 599.61 (1948-2021) | 196,12 | 0,3162 | 118,11 | 342,08 | 115,61 | 21,10 |
| Silifke | 563.56 (1930-2021) | 180,59 | 0,3234 | 120,27 | 329,26 | 104,08 | 9,96 |
| Mut | 395.63 (1959-2011) | 122,44 | 0,3096 | 75,97 | 218,23 | 84,91 | 16,52 |

**Table 4.4:** Long-term seasonal total precipitation data in Mersin Province

| Stations | Fall Minimum Precipitation Long-term Average | Winter Minimum Precipitation Long-term Average | Spring Minimum Precipitation Long-term Average | Summer Minimum Precipitation Long-term Average |
|---|---|---|---|---|
| Anamur | 18,98 | 93,93 | 17,72 | 3,13 |
| Mersin (Akdeniz) | 10,53 | 52,70 | 11,59 | 5,43 |
| Silifke | 14,53 | 51,52 | 13,46 | 4,62 |
| Mut | 11,66 | 33,91 | 12,06 | 4,89 |

Annual total precipitation and deviations of annual totals from the mean for Mersin Akdeniz, Anamur, Silifke and Mut Districts are shown in Figure 4.12. It is observed that the annual total precipitation in Mersin Akdeniz district averaged 600 mm in the period 1948-2018, oscillated around +/- 200 mm from the average, and reached maximum and minimum values of 1000 mm and 400 mm. Although there is no significant trend in terms of decrease or increase in the deviations (red) of long-term annual total precipitation from average values, it was determined that annual precipitation totals were above the averages in the 2008-2018 period. The total annual precipitation of Anamur district is around 1000 mm and it is observed that maximums up to 1500-1700 mm and minimums up to 500 mm occur from time to time. It can be said that there is no noticeable deviation from the averages, no positive or negative trend. For Silifke, which has around 560 mm of long-term annual total precipitation, and Mut, which has around 400 mm, there is no decreasing or increasing trend in total annual precipitation over time.

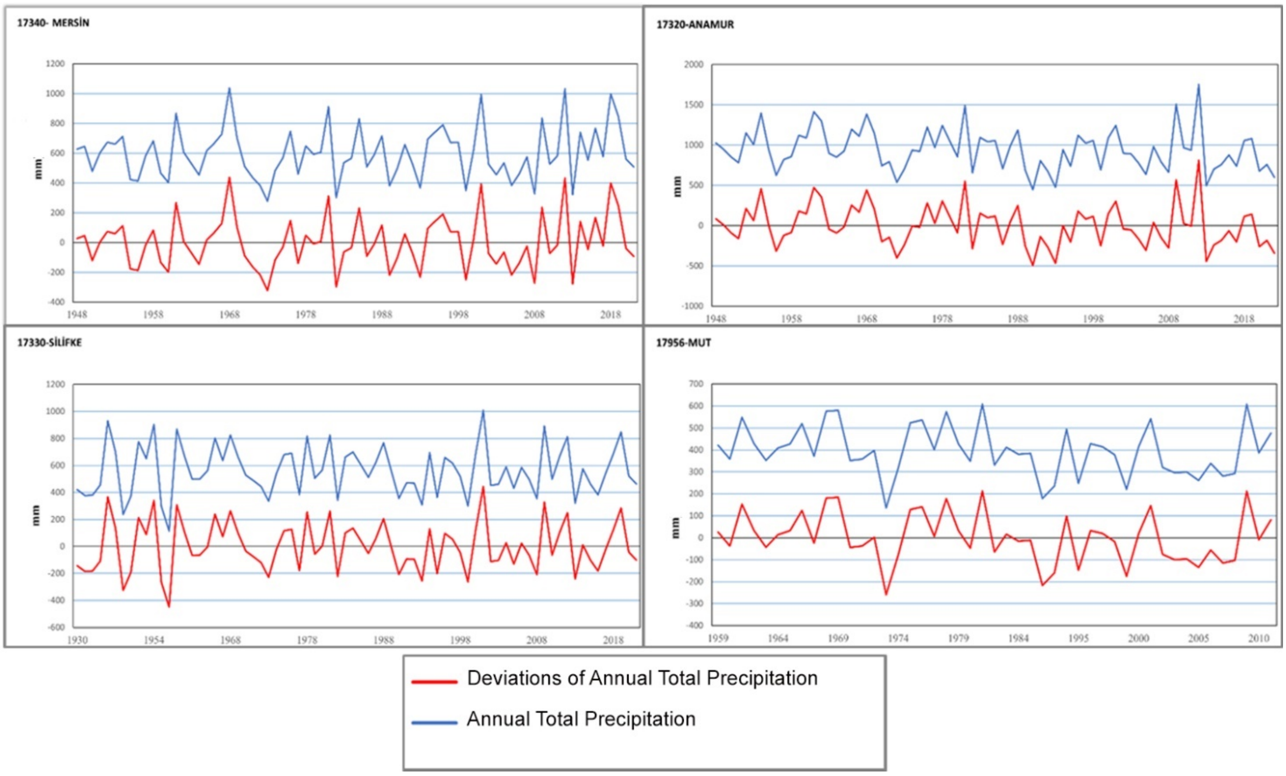



**Figure 4.12:** Annual total precipitation and deviations of annual totals from the mean in Mersin province

It is desirable that the precipitation falls regularly throughout the year, that it does not come in the form of sudden heavy downpours that will cause floods and overflows, and that there is no or minimal loss of life and property. Monthly maximum precipitation values occurring throughout the year were found using the long-term monthly total precipitation dataset, and then time series were created by determining the ratio of these values to the total precipitation occurring throughout the year ("RATIO" - Monthly maximum precipitation observed during the year / annual total precipitation). Figure 4.13 shows the annual observed monthly maximum precipitation, the ratio of maximum to annual total precipitation and the annual total precipitation. Table 4.3 shows the long-run averages of "RATIOs" for each district. The maximum monthly precipitation observed for Mersin Akdeniz reaches 350 mm and in some cases 500-650 mm. The contribution of these maxima to the total annual precipitation is shown in blue as "RATIO". Keeping in mind that the long-term average precipitation in Mersin is approximately 600 mm, it can be seen that maxima of 300 mm and above will cause "RATIOs" of 0.5 and above. It can be evaluated that the contribution of monthly maximum precipitation to the high amount of total precipitation occurring during the year will be large. If we give examples of extremes; it can be seen that 45%, 68% and 50% of the total annual precipitation exceeding 1000 mm in 1968, 2000 and 2018 occurred within a month. Abundant annual precipitation with low "RATIOS" (blue) is desirable and indicates that precipitation occurs more regularly throughout the year. The long-term average of "RATIOs" for Mersin is calculated as 0.31, and it can be said that the number of years with "RATIOs" of 0.4 and above is also considerable. Similar analyses were conducted for Anamur, Silifke and Mut.


**Figure 4.13:** Annual maximum precipitation data for Mersin province

It is seen that the long-term (1948-2022) average of the "RATIO" of Anamur monthly maximum precipitation to total annual precipitation is 0.31; however, in some years, the ratios can exceed 0.35, even up to 0.6. For example, for the years 1974, 1991 and 2022, the "RATIOs" reached approximately 0.5, 0.55 and 0.6, and 425 mm, 440 mm and 460 mm of the total precipitation of approximately 950 mm, 800 mm and 770 mm, respectively, occurred within a mnth. For Silifke and Mut districts, the average of these "RATIOs" is around 0.32-0.31, similar to Anamur, and in some rare years the "RATIOS" exceed 0.4. Considering that the largest contribution to the total annual precipitation is the precipitation that occurs in the winter season, examining the deviations of the average precipitation in the winter season from the long-term averages will further clarify the regularity-irregularity of precipitation discussed above. Figure 4.14 shows the deviations of winter precipitation totals from the mean for these four districts. For Mersin (red), which has an average annual precipitation value of approximately 600 mm, deviations take extreme values for many years, exceeding 300 and even 400 mm. Compared to Mersin, the frequency of extreme positive oscillations for Anamur district is less frequent and their severity is more limited considering that the total annual average precipitation value is around 1000 mm. For Silifke, the frequency is high but the severity is lower than in Mersin, and for Mut, both the frequency and severity of positive deviations are low. In the light of these data, in general, it can be said that Anamur, Silifke and Mut receive relatively more regular precipitation than Mersin Akdeniz.

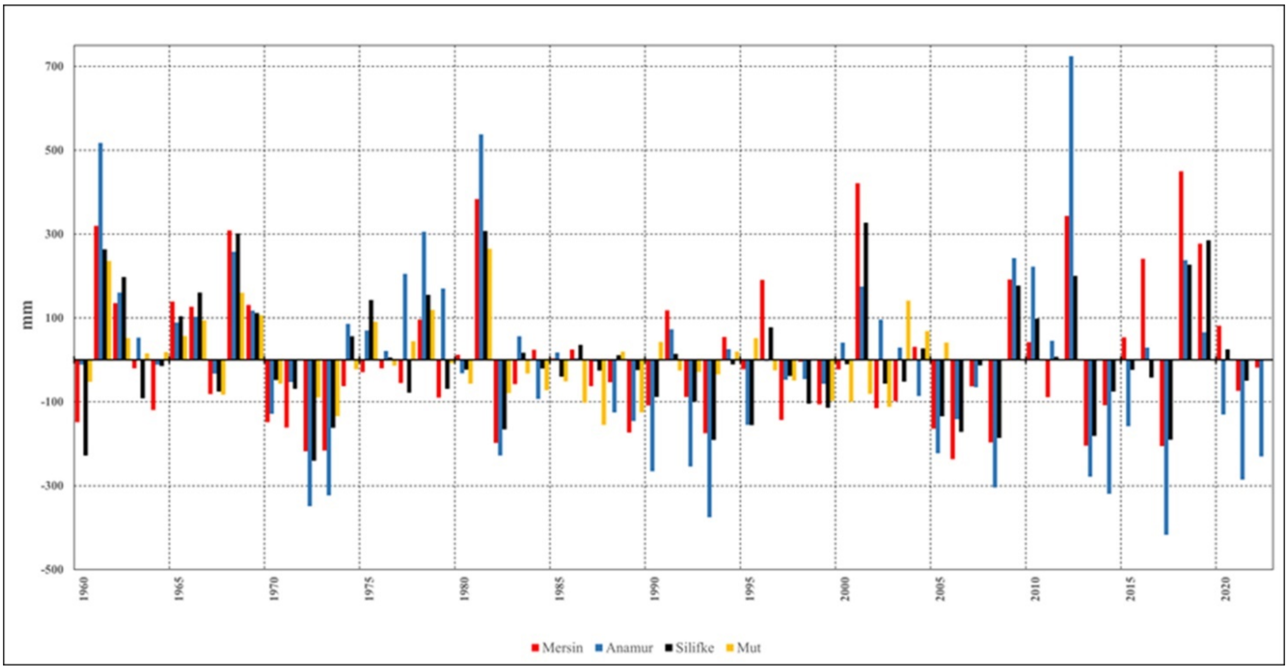



**Figure 4.14:** Deviations of winter precipitation totals of four districts from the mean

### 4.1.3 Sea Surface Temperature

According to the long-term data of the Mediterranean Sea between 1940 and 2015, annual mean sea surface temperature change and anomaly values compared to the reference period of 1940-1970 are given between Figure 4.15 and Figure 4.18. Sea surface temperature in the Mediterranean Sea increased in all seasons compared to the reference period.

ERA 5 re-analyses were used to analyze the changes in sea surface temperatures for Mersin province. ERA 5 is a climate dataset developed by the European Joint Research Center (ECMWF). The re-analyses data sets are suitable for analyzing weather and climate phenomena around the world. ERA 5 provides high resolution (0.25º) data over a wide time span (from 1979 to the present) of various parameters such as atmosphere, sea surface and ice cover. The spatial distribution of the model calculation points for the Mersin assessment is given in Figure 4.19. The temporal variation of sea surface temperature at these points is given in Figure 4.20. The sea surface temperature trend of the province was estimated by applying an analysis in which model outputs are an independent variable and years are a dependent variable. The annual average sea surface temperature slope indicates an increase at all points.

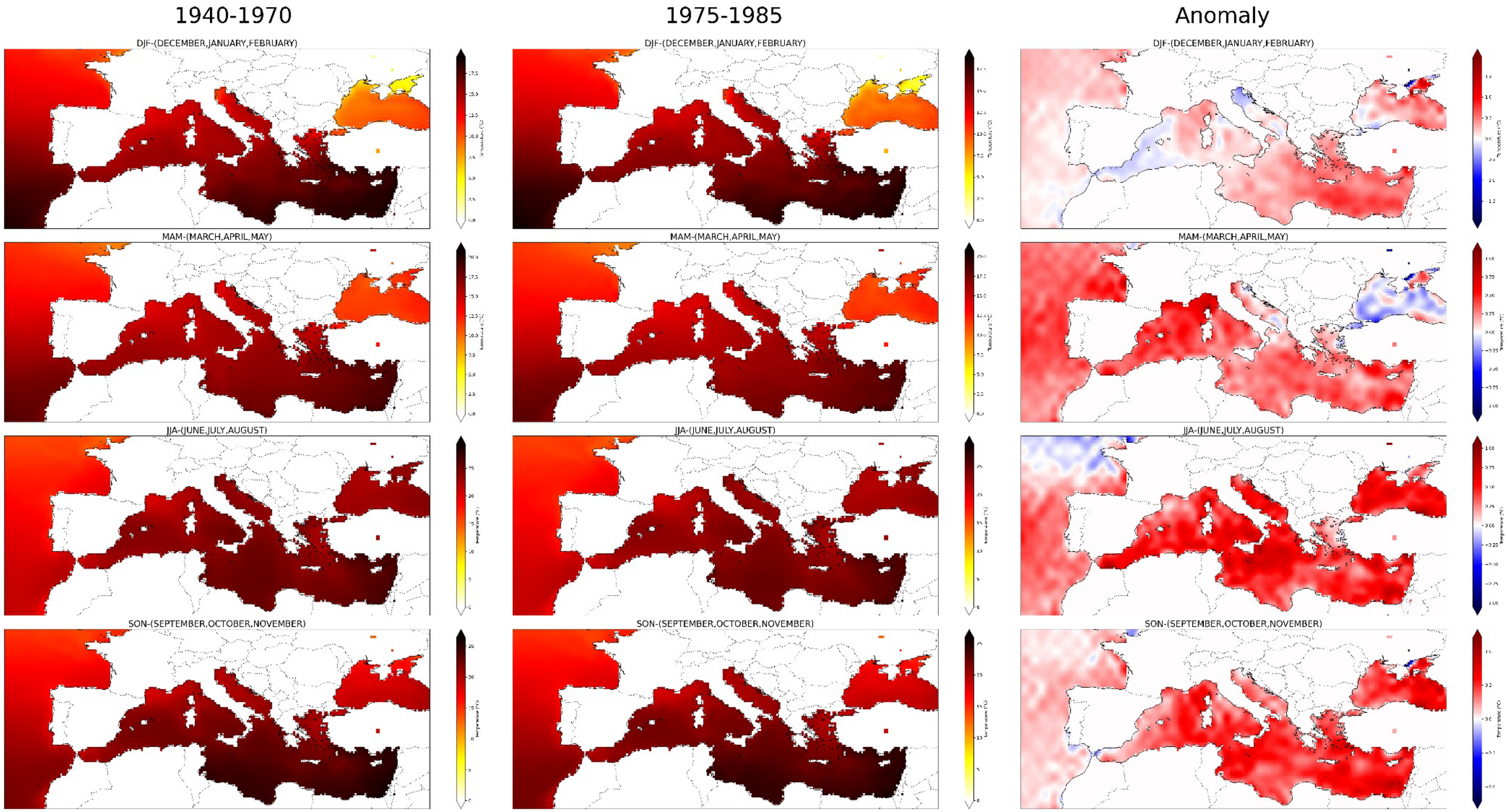



**Figure 4.15:** Mediterranean SST change between 1975-1985 (Ref: 1940-1970)

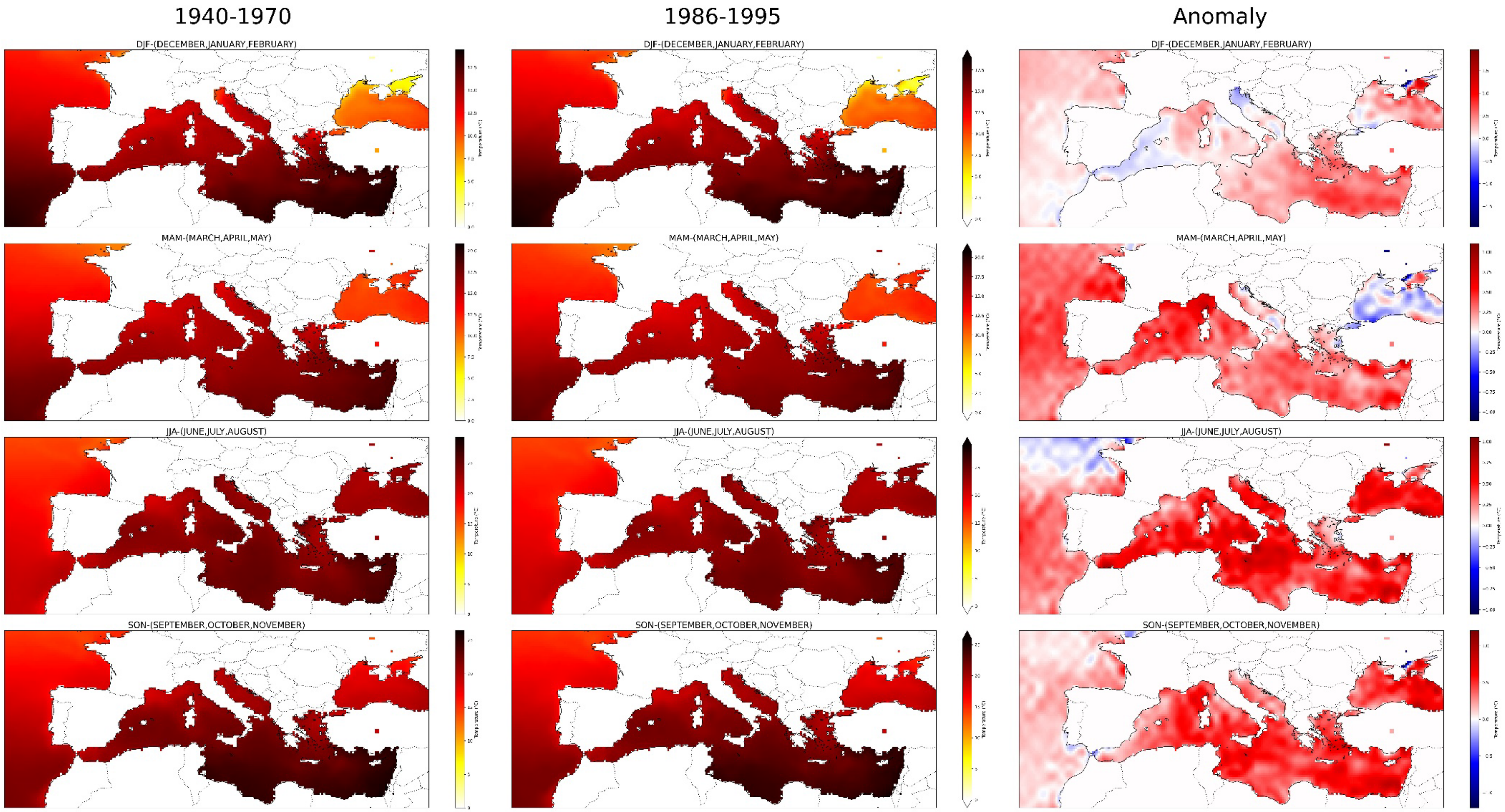



**Figure 4.16:** Mediterranean SST change between 1986-1995 (Ref: 1940-1970)

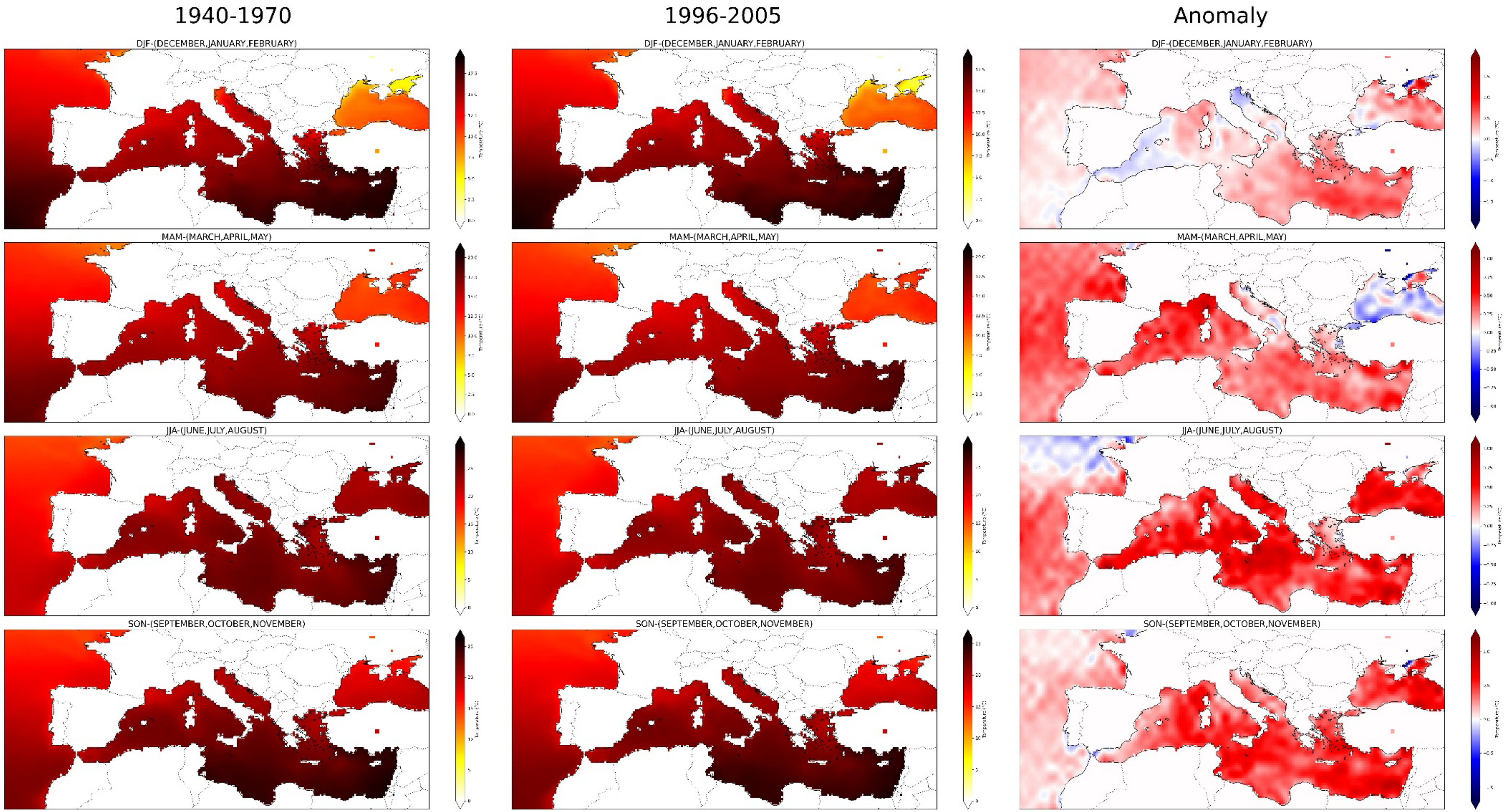



**Figure 4.17:** Mediterranean SST change between 1996-2005 (Ref: 1940-1970)

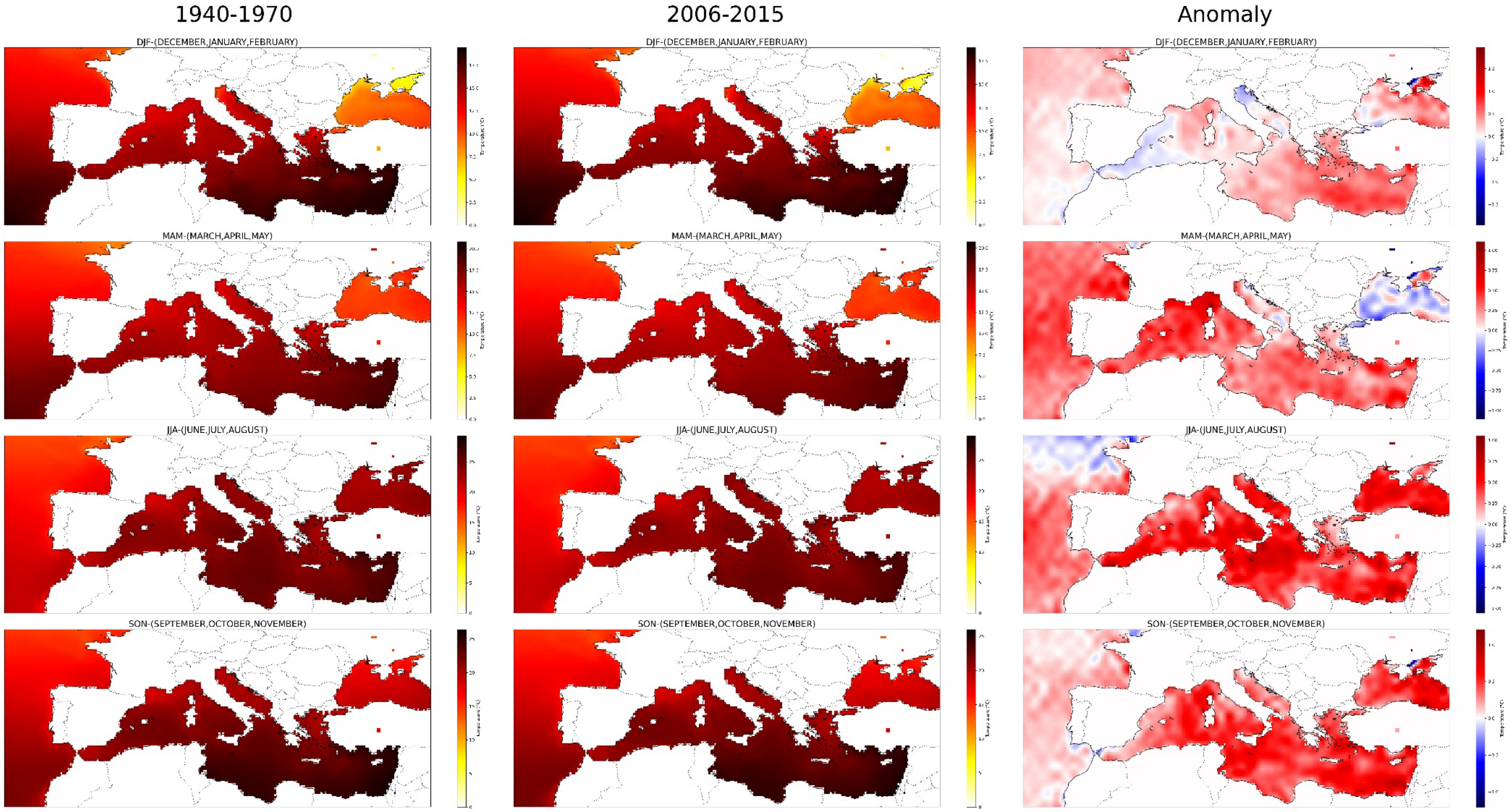



**Figure 4.18:** Mediterranean SST change between 2005-2015 (Ref: 1940-1970)

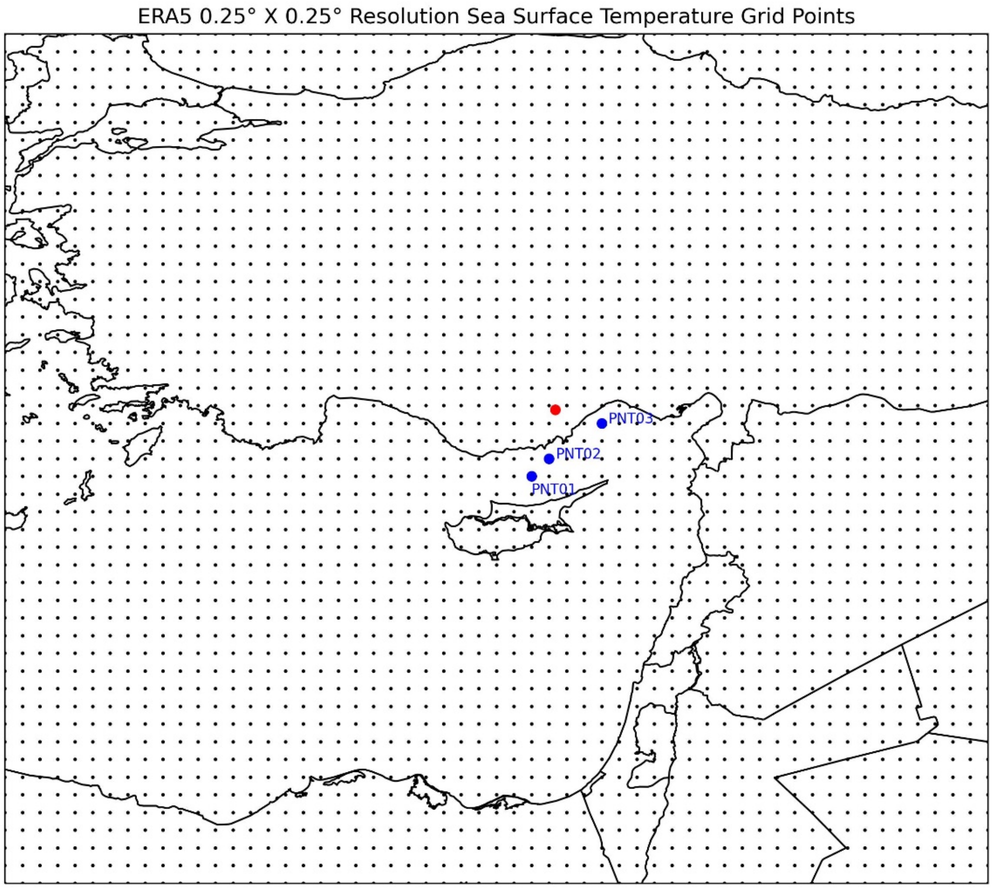



**Figure 4.19:** ERA5 Model calculation points selected for Mersin


**Figure 4.20:** Sea surface temperatures at the determined grid points

### 4.1.4 Extreme Events

Determining the characteristics of long-term past meteorological extreme events (such as type, frequency, duration and severity) is important in determining the adaptation measures of the sectors operating in Mersin province against climate change and taking the necessary measures and minimizing the loss of life and property of the people in the region. In this context, the change in the frequency of hail, floods, storms, meteorological frost, drought, lightning strikes, tornadoes, landslides and forest fires over time, obtained from MGM and covering the years 1975-2021, was analyzed. Figure 4.21 shows the change in the number of extreme events over time. It can be seen that most of these incidents were rare until the 2000s. It is seen that the number of hail, flood and storm events remained low until the 2000s and has been increasing since the 2000s, with a rapid increase especially between 2018-2021. Although tornadoes were reported only 4 times until 2010, they occurred approximately 40 times between 2011 and 2021. Hail and flood events have also been on the rise since the 2000s and have accelerated further since 2018. In general, it can be seen that there has been a noticeable increase in all extreme events since the 2000s and that these increases have accelerated even more in 2018.

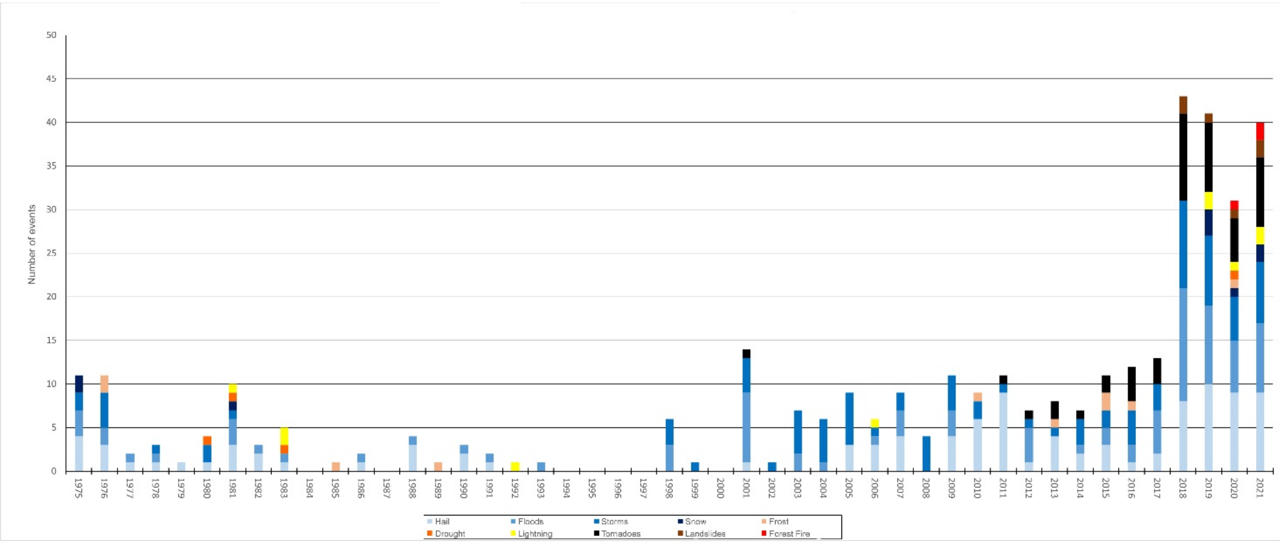



**Figure 4.21:** Extreme weather events occurring across Mersin

## 4.2. Analysis of Climate Projections

### 4.2.1 Changes in Major Climate Parameters

Global Circulation or Climate Models are developed by the IPCC to determine the extent and possible impacts of anthropogenic-induced climate change and scenarios are produced and their results are compared. These scenarios are constructed from optimistic scenarios with low emissions to pessimistic scenarios with high emissions and are named RCP2.6, RCP 4.5, RCP 6.0 and RCP 8.5. Within the scope of the "Strengthening Climate Change Adaptation Action in Turkey Project", climate projections were carried out for the Mediterranean Region using HADGEM-2 ES, MPI-ESM-MR and CNRM-CM5.1 climate model (SYGM, 2016; MoEUCC, 2020).

Within the scope of RCP 4.5 Scenario, HADGEM-2 ES Climate Model projected that the average temperature of the region, which was 12.8 °C between 1971-2000, will increase by 1.9 °C in 2021-2040, 2.4 °C between 2041-2060, 3 °C in 2080 and 3.3 °C in 2100. According to the MPI-ESM-MR model, the average temperature increase will be 1.2 °C in 2040 and will reach 1.8 °C in 2100. The CNRM-CM5.1 climate model predicts an increase in the average temperature of the Mediterranean

Region by 0.9 °C in 2040, 1.3 °C in 2060 and 2.2 °C in 2100. According to the RCP 8.5 Scenario, which is the pessimistic scenario, HADGEM-2 ES Climate model predicts that the temperature of the region will increase by 2 °C in 2040 and 5.5 °C in 2100. The MPI model predicts a 4.2°C increase towards 2100, while the CNRM model outputs predict increases above 4°C by the end of the century.

According to the HADGEM-2 ES Climate model within the scope of the RCP 4.5 Scenario, the Mediterranean Region, which had a total annual precipitation value of 660.9 mm between 1971-2000, is calculated to decrease by 6.3% in 2021-2040, 5.6% between 2041-2060, 14.1% in 2080 and 14.6% in 2100. The MPI-ESM-MR model predicts that total precipitation will decrease by 11.8% in 2040 and 11.6% in 2100. The CNRM-CM5.1 climate model calculates that the precipitation change in the basin will be 3% in 2040, 4.3% in 2080 and 8% in 2100. According to the pessimistic RCP 8.5 Scenario, the HADGEM-2 ES Climate model predicts that the basin precipitation will decrease by 1% in 2040 and 16.4% in 2100. While the MPI model calculates a very significant decrease of 25.7% towards 2100, the CNRM model outputs indicate that precipitation will decrease by 10.8% in the basin by the end of the century. Both scenarios and all three models for the Mediterranean Region predict a significant decrease in precipitation; however, the decrease in the RCP8.5 scenario is much more drastic than in the RCP4.5 scenario.

In addition, within the scope of IPCC studies, climate projections are made with 40 different global climate models in the CMIP5 (Fifth Coupled Model Intercomparison Project) experiment. In this study, RCP2.6, RCP4.5, RCP6.0 and RCP8.5 scenarios for Mersin and the average of the projections obtained from the CMIP5 experiment were used.

For the climate projection analysis of Mersin province, projections for the years 1900-2100 were evaluated and climate projections were given for the parameters of average temperature (°C) and average annual precipitation (mm/day). Temperature data for all scenarios show an increase since 2000 (Figure 4.22).

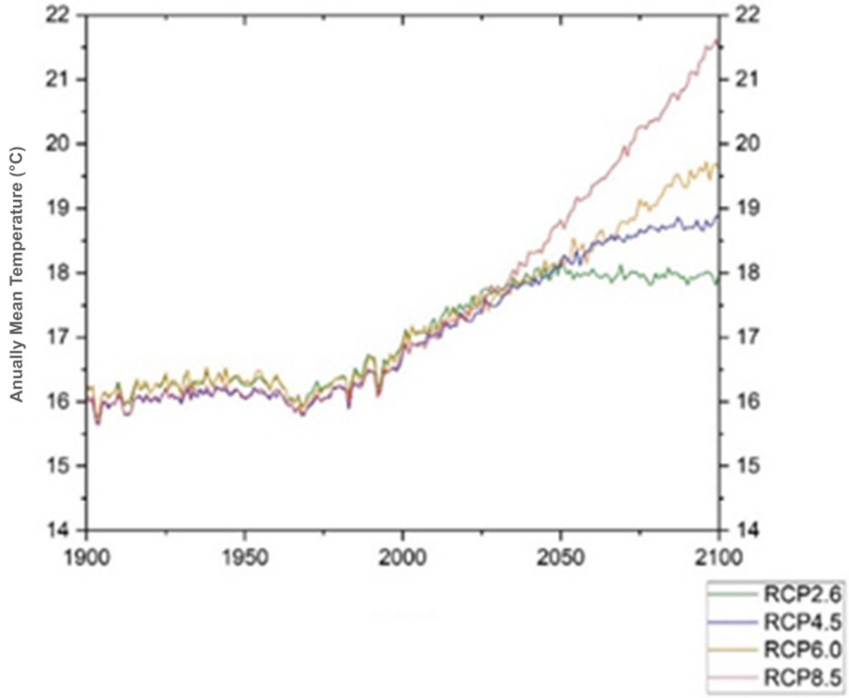



**Figure 4.22:** Average temperature change between 1900-2100 in Mersin province (°C)

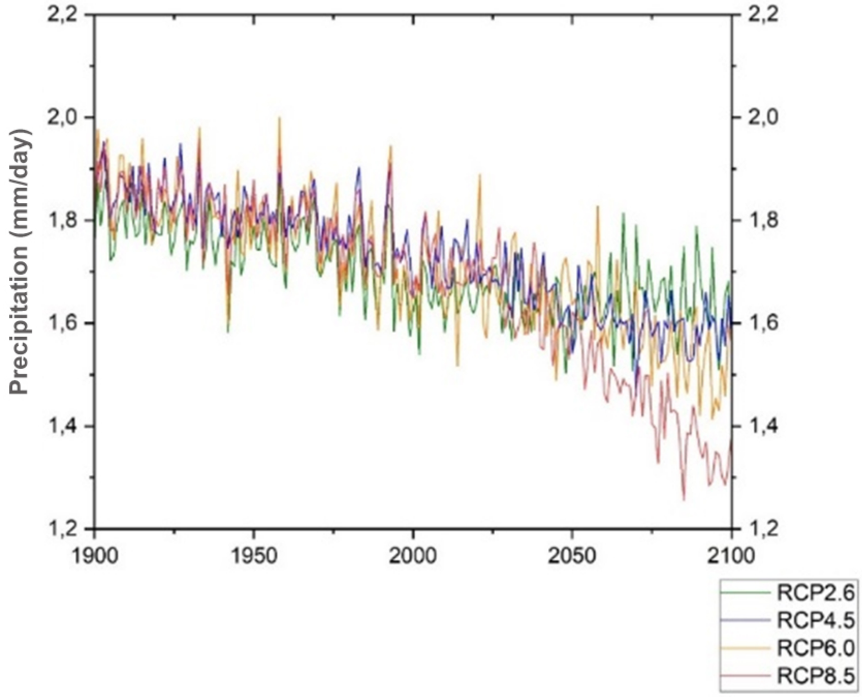



**Figure 4.23:** Annual average precipitation change between 1900-2100 in Mersin province (mm/day)

According to the model results, a decrease in average annual precipitation is predicted for all scenarios (Figure 4.23).

Climate projections with a resolution of 0.2°-0.2° (~ 20 km horizontal resolution) within the scope of the "Turkey Climate Projections and Climate Change with New Scenarios - TR2015-CC, 2015" project carried out by the General Directorate of Meteorology in 2015 were used in the analysis. HadGEM2-ES, MPI-ESM-MR and GFDL-ESM2M global climate models were run using RCP4.5 and RCP8.5 scenarios and temperature and precipitation projections were produced for a period covering 2016-2099. The regional climate model grids within Mersin province and the districts of Akdeniz, Anamur, Mut, Silifke and Tarsus are shown in Figure 4.24. Considering the closest model grid points to these districts, the changes of average temperature and total precipitation values with time depending on three different global models (MPI, HadGEM and GFDL) are analyzed and given in Figure 4.25 - Figure 4.34 for Anamur, Mut, Mersin Akdeniz and Tarsus districts. In some cases, there are significant differences between the models.

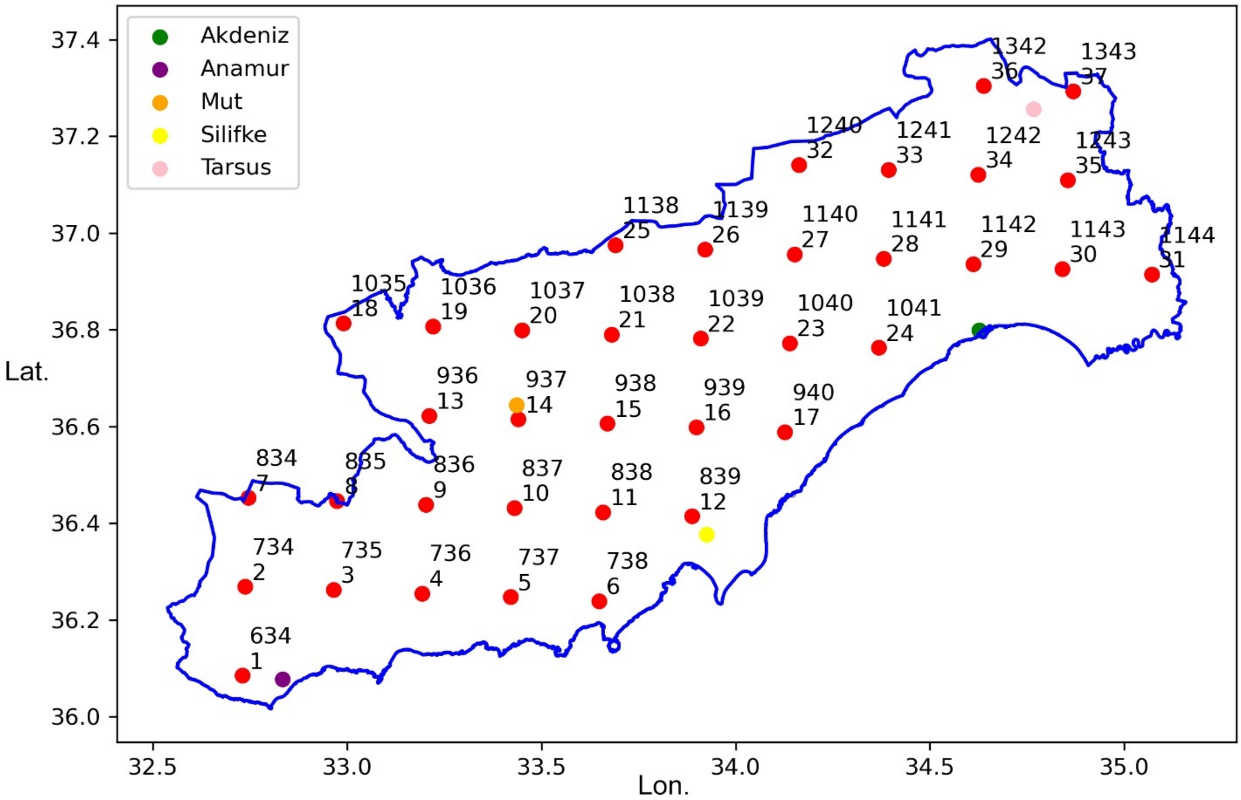



**Figure 4.24:** Grid points in Mersin province in MGM climate projections

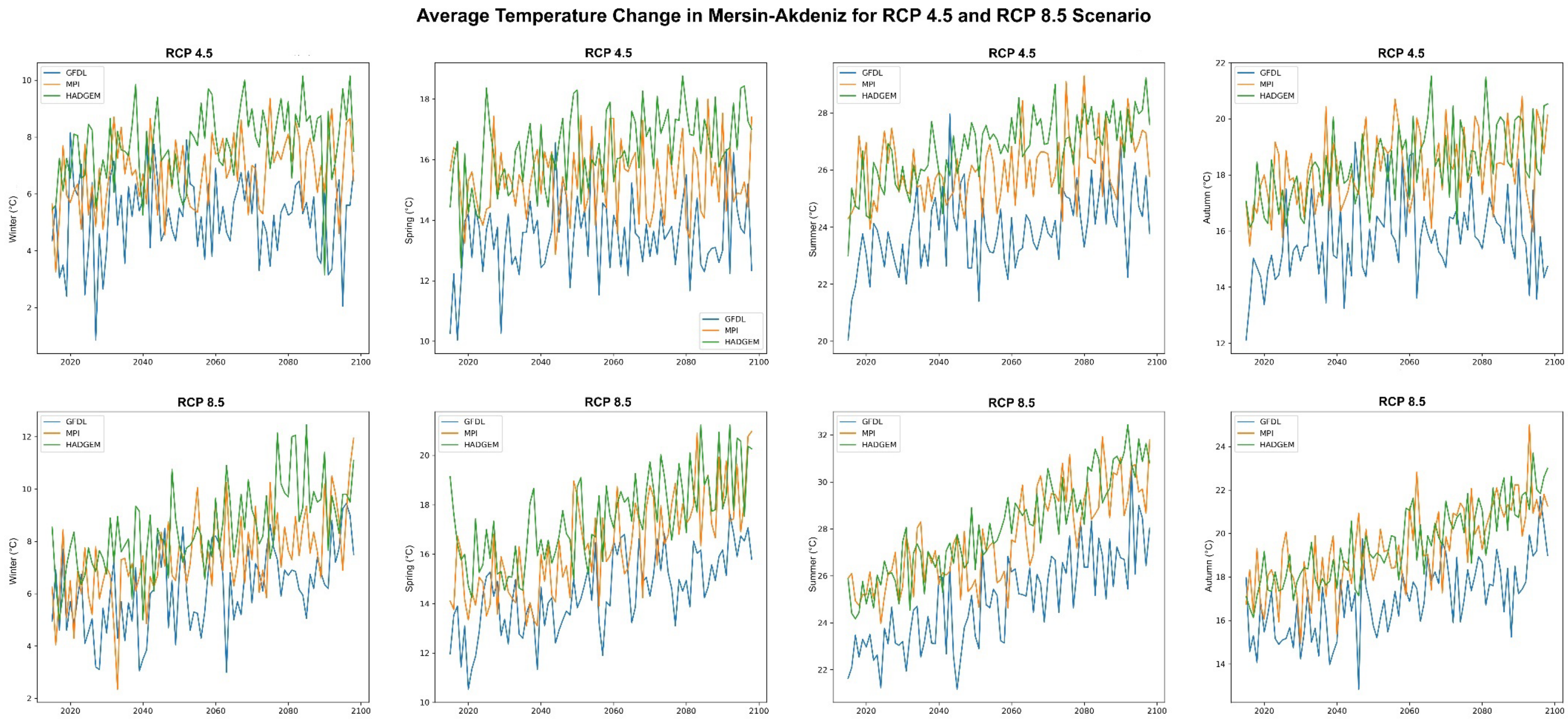



**Figure 4.25:** Projection of average temperature change in Mersin Akdeniz district (°C)

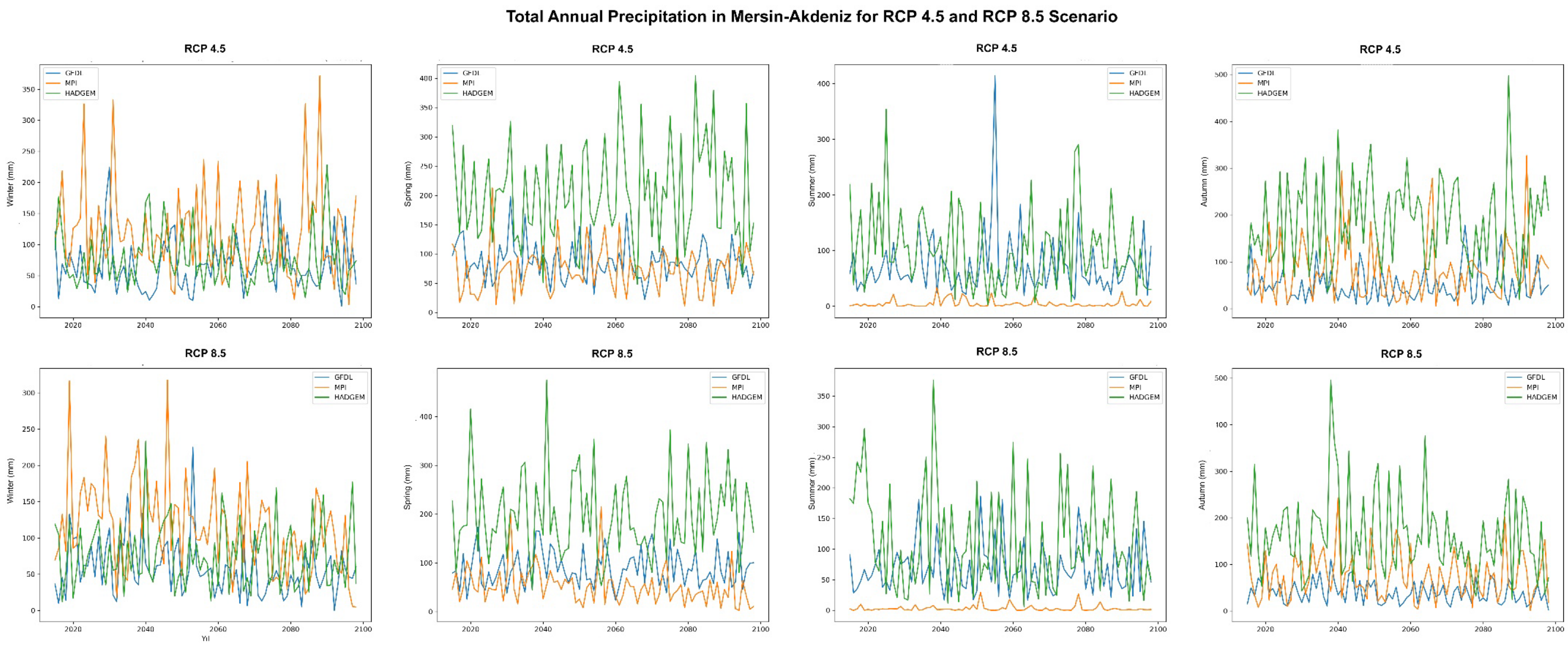



**Figure 4.26:** Projection of total annual precipitation in Mersin Akdeniz district (mm)

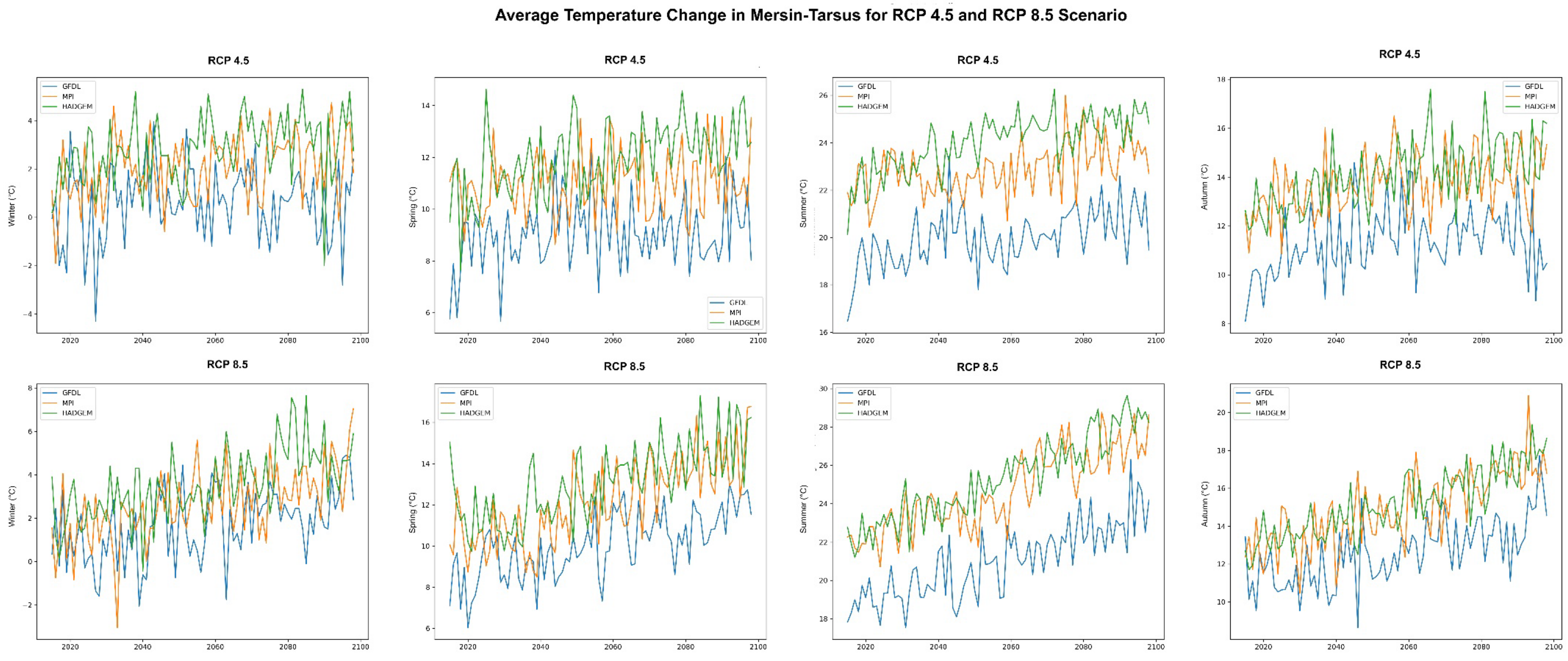



**Figure 4.27:** Projection of average temperature change in Tarsus district (°C)

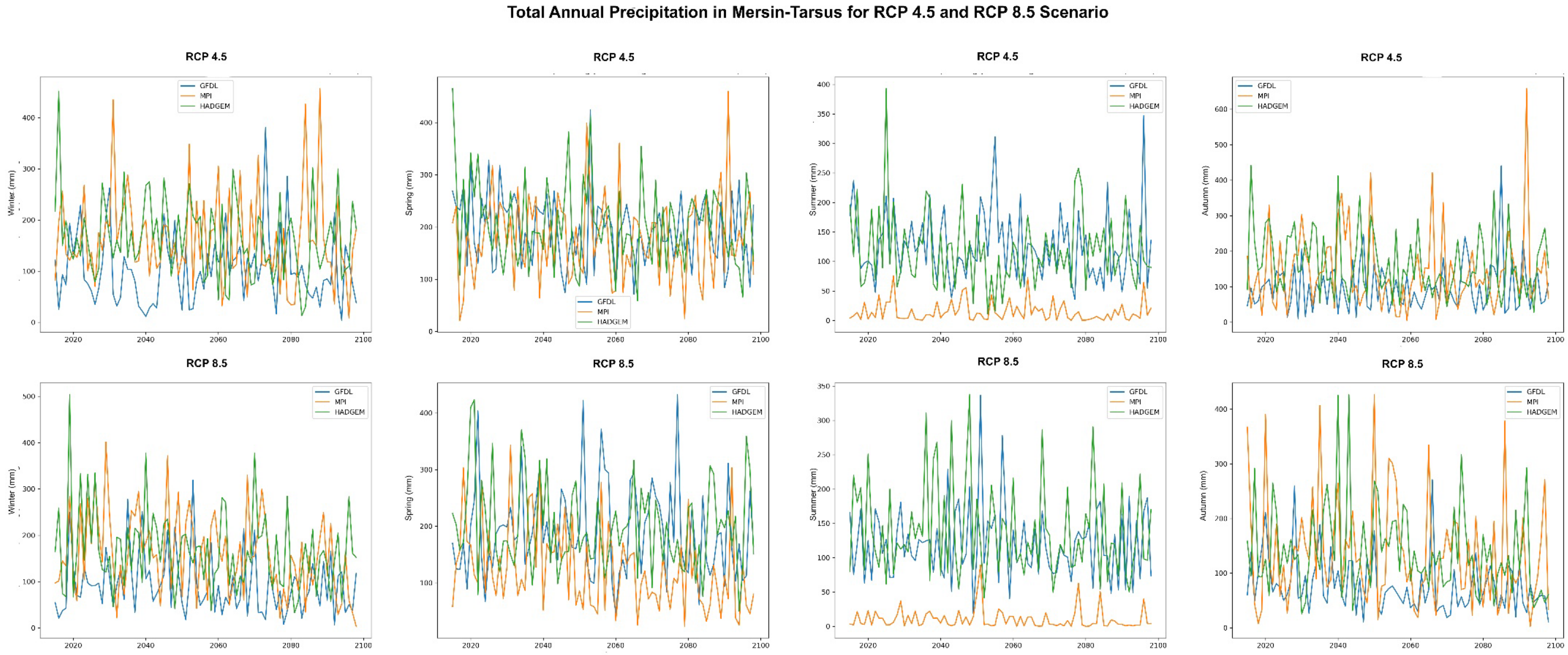



**Figure 4.28:** Projection of total annual precipitation in Tarsus district (mm)

Average Temperature Change in Mersin-Silifke for RCP 4.5 and RCP 8.5 Scenario

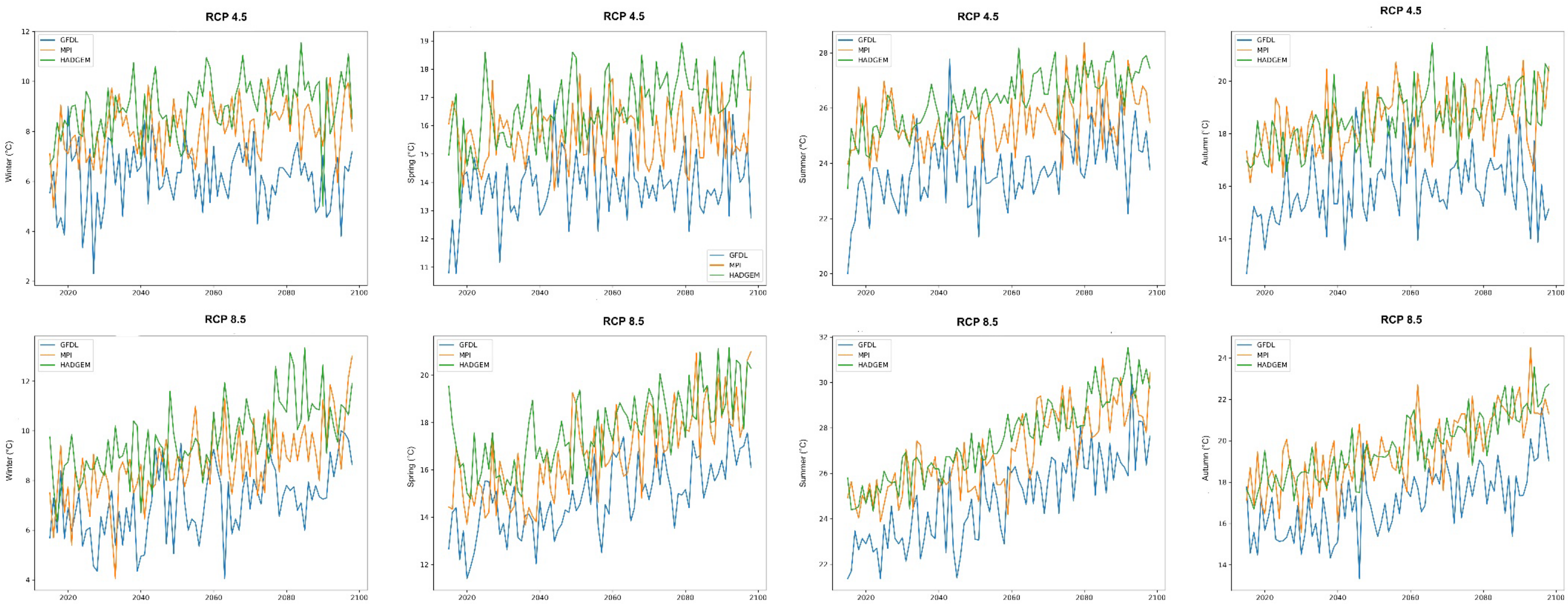



**Figure 4.29:** Projection of average temperature change in Silifke district (°C)

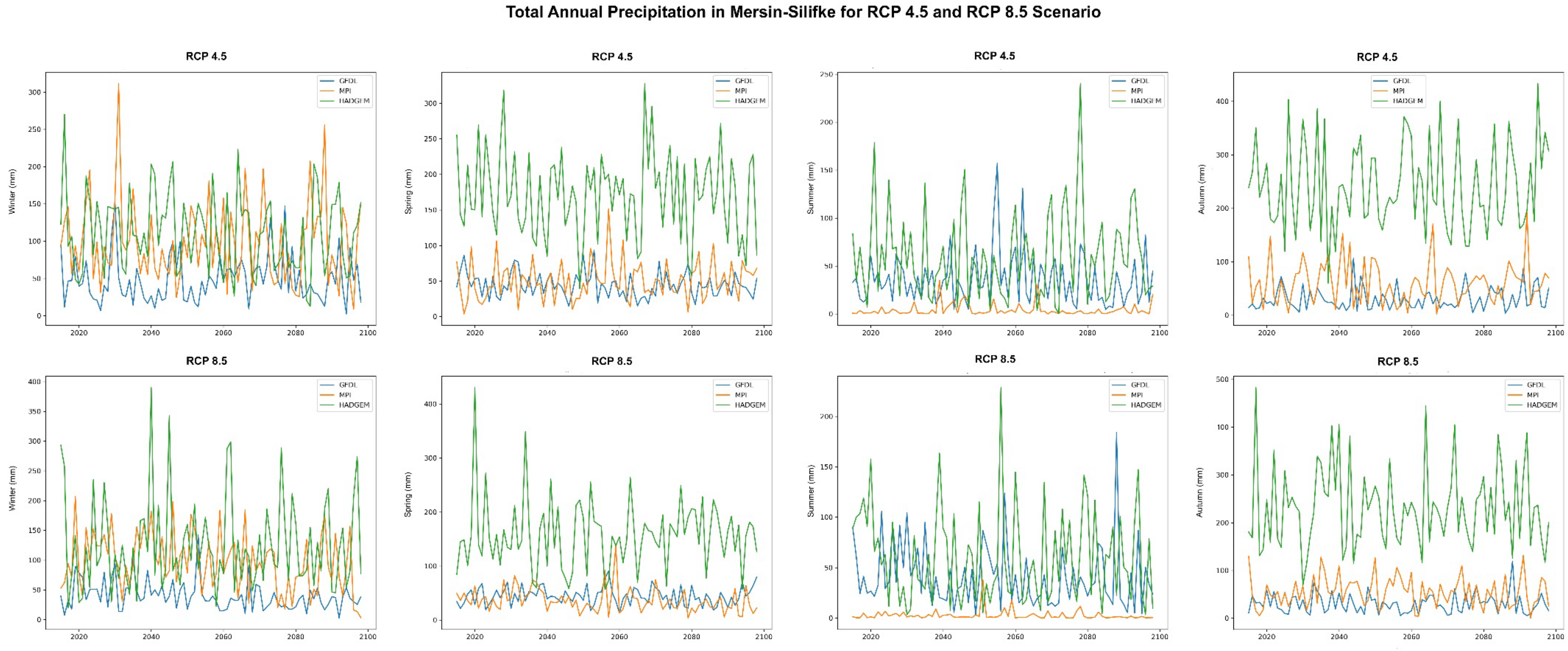



**Figure 4.30:** Silifke district annual total rainfall projection (mm)

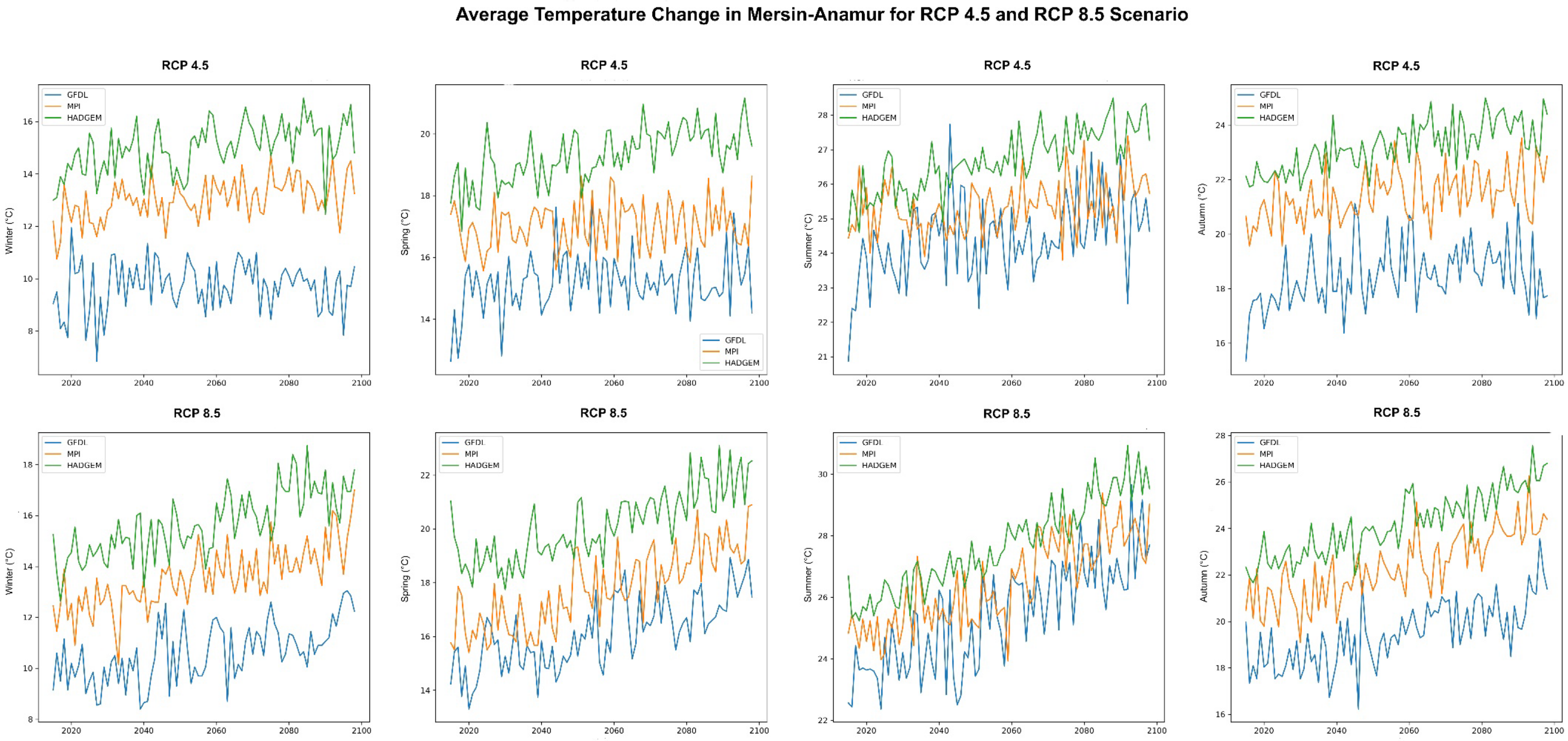



**Figure 4.31:** Projection of average temperature change in Anamur district (°C)

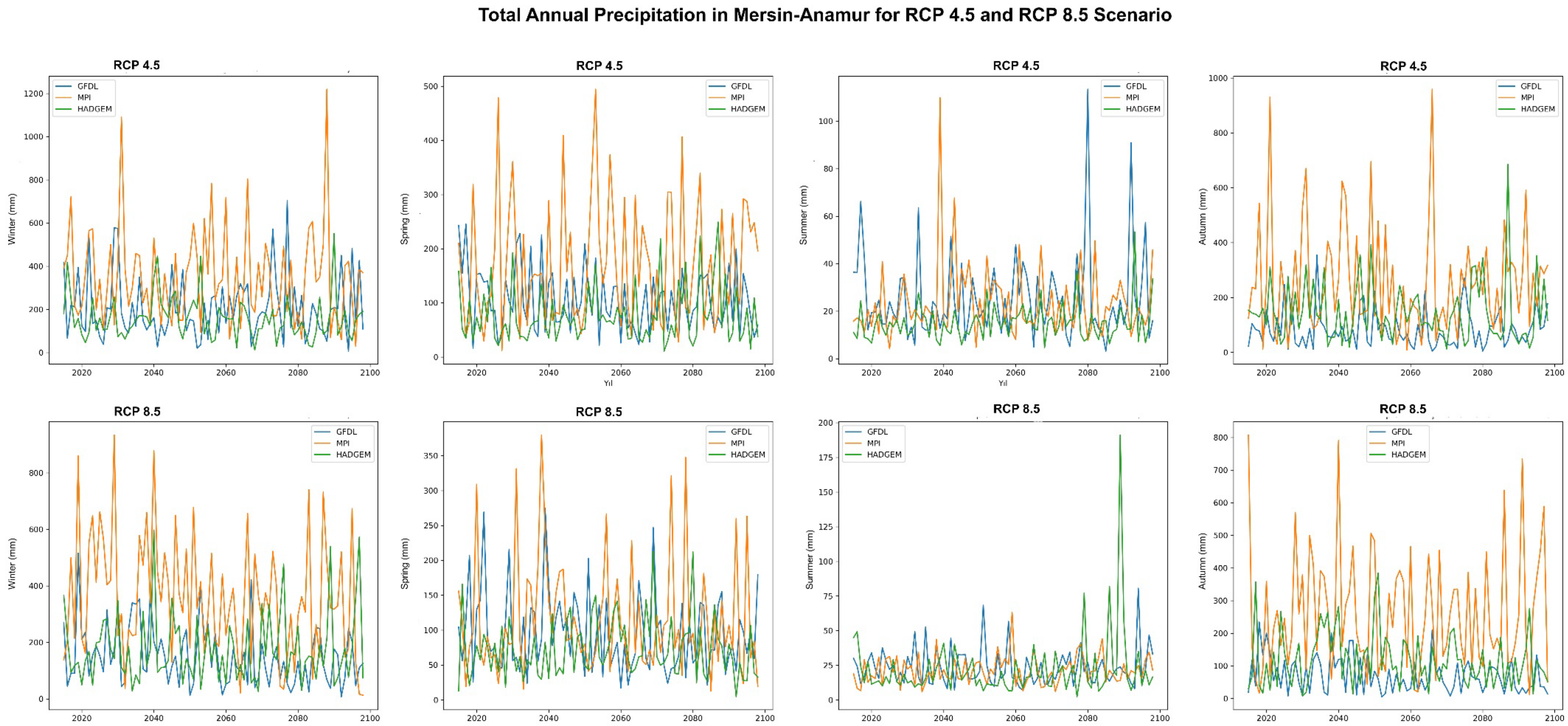



Figure 4.32: Projection of total annual rainfall in Anamur district (mm)

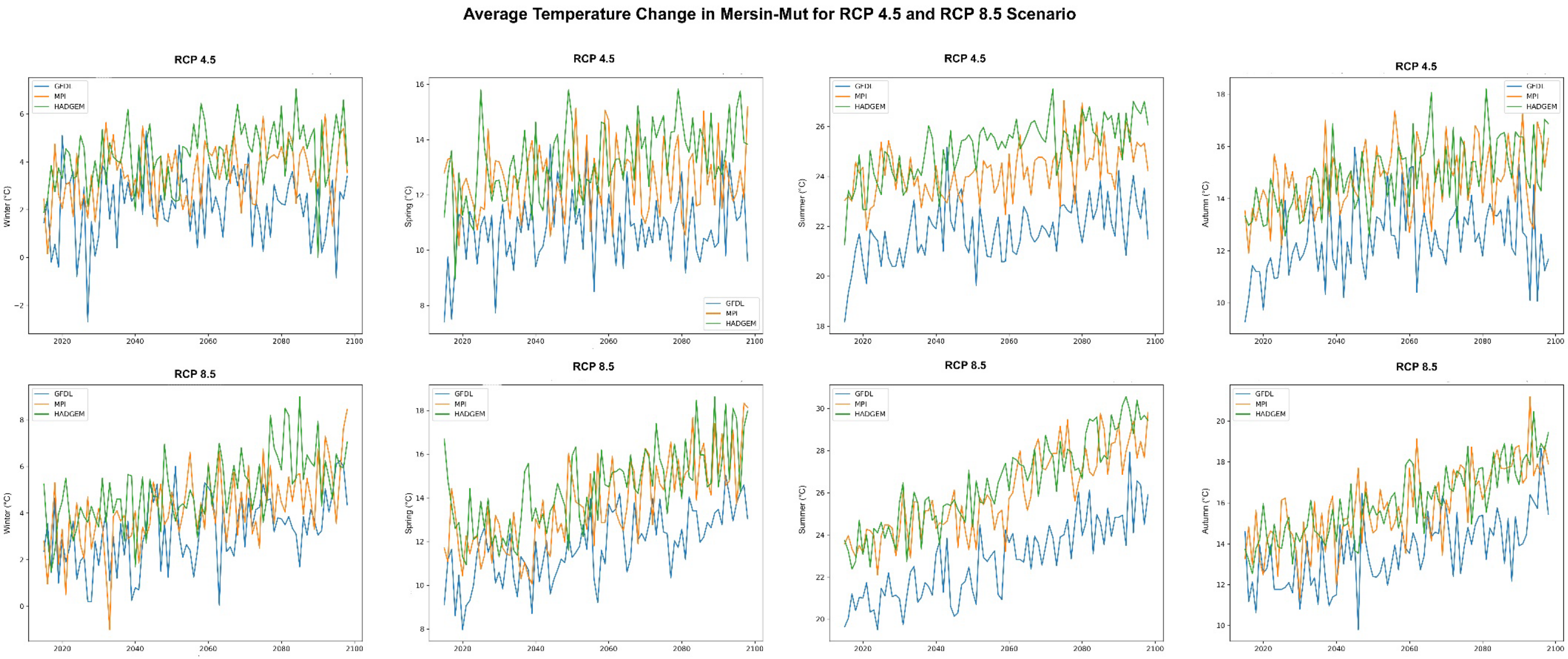



**Figure 4.33:** Projection of average temperature change in Mut district (°C)

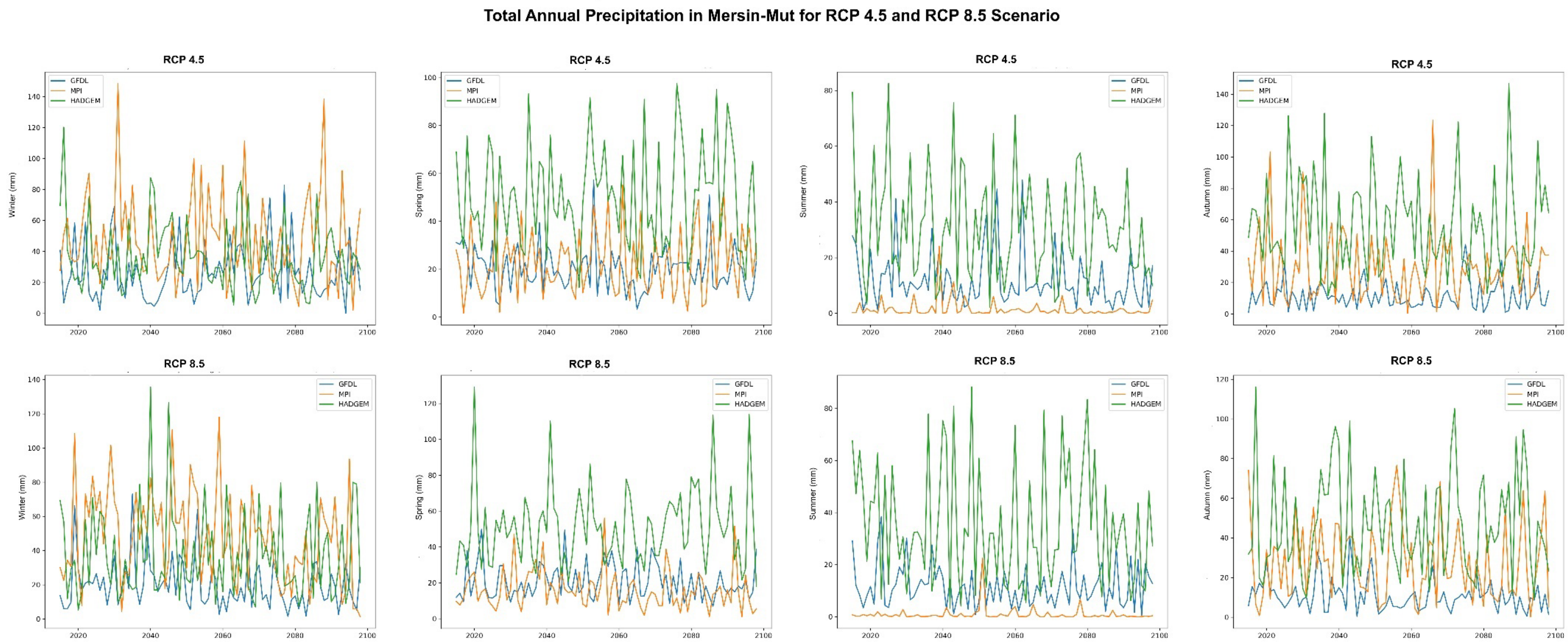



**Figure 4.34:** Mut district annual total rainfall projection (mm)

For Mersin Akdeniz, all 3 models predict significant increases in temperatures by 2100. According to the RCP8.5 scenario, this increase is projected to be about 4 Cº for the Akdeniz winter, 4-6 Cº for spring, 4-6 Cº for summer and 2-3 Cº for fall. In 2020, the winter season temperature will be about 6º C, while in 2100 it will be about 9º C; temperatures of 12-14º C in the spring season will rise to 16-20º C; 22-26º C in the summer season will rise to 28-30º C; and 16-17º C in the fall season will rise to 20-22º C.

According to the projections, there are significant differences in Mersin and Tarsus temperatures. Projections show that Tarsus will have lower temperatures than Mersin Akdeniz. Temperatures in 2020 are projected to increase from about 1-2º C in winter to about 2-4º C in 2100; spring temperatures of 9-11º C will increase to about 11-14º C; summer temperatures of 19-22º C will reach 24-28º C; and fall temperatures of 11-13º C will reach 14-16º C.

Anamur 2020 winter temperatures are approximately 10º C, 12º C and 14º C, taking into account the differences between the models, and towards 2100, temperatures will increase to 12º C, 14º C and 17º C; spring 14º C, 16º C and 19º C to 17º C, 18º C and 21º C; summer 24º C and 25º C to 27º and 30º C; and fall 18º C, 20º C and 22º C to 20º C, 24º C and 26º C. For each model, temperature increases between 2020-2100 are projected to be about 2 Cº, 2 Cº, 3 - 5 Cº and 2 - 6 Cº for winter, spring, summer and fall, respectively.

Since Mut district is located approximately 50 km inland from the coast, it is estimated that the changes in temperature and precipitation will be relatively different compared to other districts. It is expected that Mut will be colder than Akdeniz in all seasons. Winter temperatures of 2020 are projected to increase from 2 – 3º C to 4 – 6º C, spring temperatures from 11 – 12º C to 12 – 16º C, summer temperatures from 20 – 24º C to 24 – 28º C and fall temperatures from 12º C – 14º C to 16º – 18º C. Seasonal temperature increases are projected to be in the range of 2 – 3º C, 1 – 4º C, 4º C and 4º C for winter, spring, summer and autumn, respectively.

Looking at the projections of the seasonal total precipitation for the aforementioned districts of Mersin, it is seen that there are significant differences between the 3 models from time to time. According to all models, it is predicted that there will be a noticeable decrease in precipitation in Mersin Akdeniz district in winter season, while there will be no significant change in terms of decrease or increase trend in spring, summer and fall seasons. Although there are differences between the models, it is predicted that winter precipitation may decrease from 75-150 mm to 50-100 mm.

It is observed that Anamur precipitation will be higher than Mersin Akdeniz in all seasons except summer. According to GFDL-HadGEM and MPI models, it is predicted to vary around 150 mm and 400 mm in winter, 75 mm and 150 mm in spring, 25 mm in summer, and 75 mm and 200 mm in fall, respectively. Total seasonal precipitation shows significant fluctuations between years, with significant differences between models.

It is seen in all models that Mut will receive less precipitation than Mersin and Anamur. Seasonal precipitation does not change much over time. Precipitation in winter, spring, summer and fall seasons is expected to be around 20-60 mm, 20-40 mm, 5-20 mm and 5-40 mm, respectively. It is observed that there are very significant differences in precipitation projections between the models.

Tarsus precipitation is predicted to be higher than Mersin Akdeniz and it is shown that this difference will occur mostly in the winter season. Winter and spring precipitation is expected to decrease slightly over time. Winter precipitation is expected to decrease from approximately 100-250 mm to 75-150 mm. It is seen that spring precipitation will decrease from approximately 150-200 mm to 100-150 mm. In general, there is no significant change in summer and fall precipitation in terms of increasing or decreasing trend. According to MPI, GFDL and HadGEM model outputs, summer precipitation is expected to be around 10-20 mm, 200 mm and 225-250 mm, respectively, while in the fall season it is expected to be around 125 mm, 75 mm and 100 mm, respectively. Changes in precipitation between years in terms of significant increases and decreases should be noted.

### 4.2.2 Changes in Extreme Climate Parameters

As a result of climate change, it is observed that there is a significant increase in extreme weather events in terms of both severity and duration. Many sectors are directly or indirectly affected by this situation. The most important parameter taken into account during the evaluation of extreme weather events in climate change studies are climate indices used in many different disciplines. For index calculations, a total of 27 basic climate indices related to temperature, precipitation and period have been determined as a result of the joint work of the World Meteorological Organization Climate Commission and Climate and Ocean - Variability, Prediction and Change (CLIVAR). 20 of these indices were taken into account in the study. Within the scope of IPCC studies, climate projections are made with 40 different global climate models in the CMIP5 (Fifth Coupled Model Intercomparison Project) experiment. In this study, RCP4.5, RCP6.0 and RCP8.5 scenarios for Mersin and the average of the projections obtained from the CMIP5 experiment were used. The average results of the models run as Ensemble are analyzed for 20 extreme climate parameters for Mersin (Mersin Akdeniz and Anamur districts). Although the resolution of the models is relatively low (1º and 2.5º), the fact that the projections are obtained by running about 15 to 25 models together is very valuable. Figure 4.35 shows the CMIP5 grid points (red) and the locations of Anamur, Silifke, Mut, Akdeniz and Tarsus districts (blue). Projections of extreme climate parameters for Mersin Center and Anamur districts were calculated.

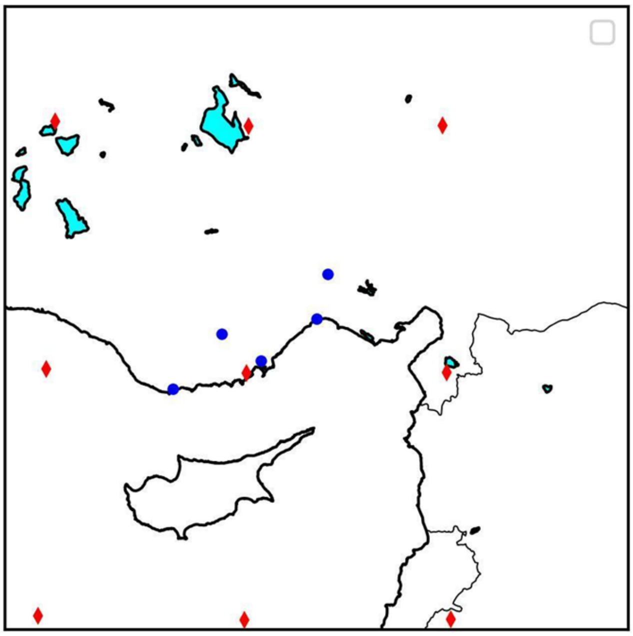
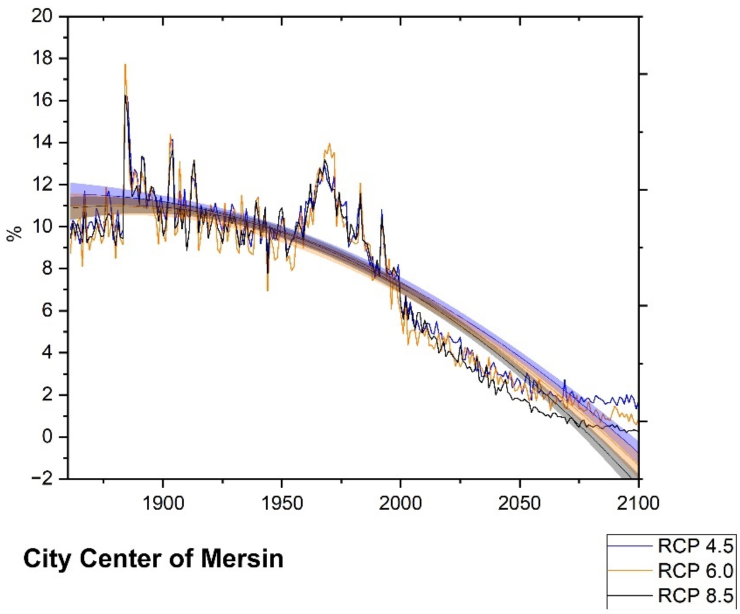


**Figure 4.35:** CMIP5 Grid points (red)

Cool Days (days when Tmax < 10% of normal)

The indicator, which is the percentage expression of the number of days when the daily maximum temperature is within the 10th percentile, refers to the cold extreme. According to the outputs of the ensemble of 24 models (Figure 4.36), while the indicator was 8% in the early 2000s, it is predicted to decrease to 2% and 0% in the RCP4.5 and RCP8.5 cases towards the end of the 21st century.



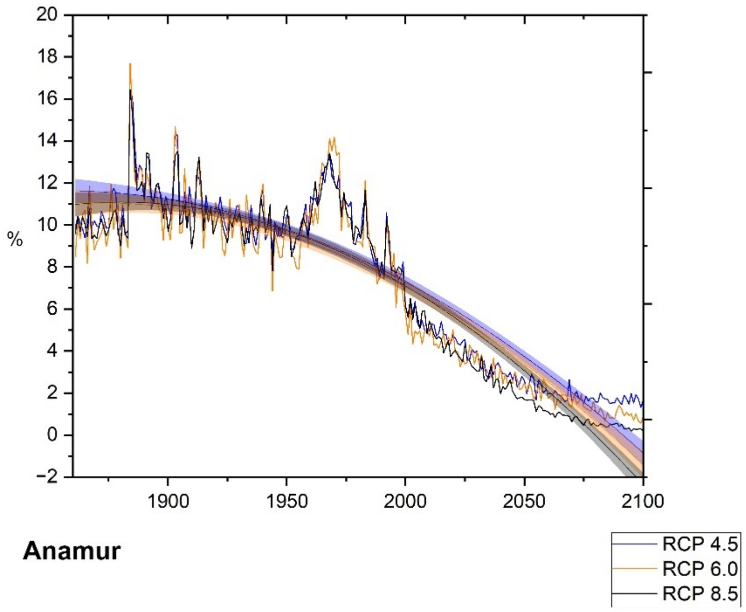
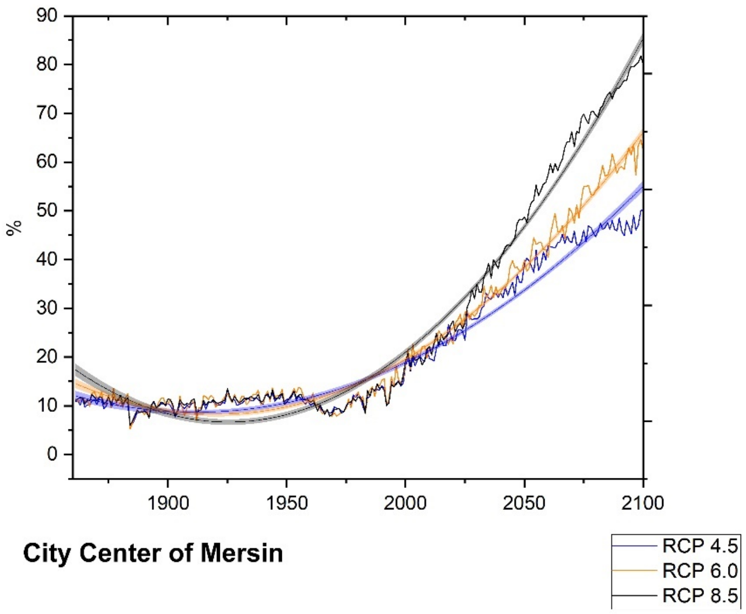



**Figure 4.36:** Change in cool days in Mersin between 1900-2100 (%)

Warm days (Tmax > 90% of normal)

The Hot Days indicator, which refers to the number of days when the daily maximum temperature is above the 90th percentile, represents hot extremes, and according to the ensemble model projections consisting of 24 models (Figure 4.37), the indicator, which was 14% at the beginning of the 2000s, is projected to increase rapidly towards the end of the century, reaching 47%, 63% and 80% at RCP4.5, RCP6.0 and RCP8.5, respectively.



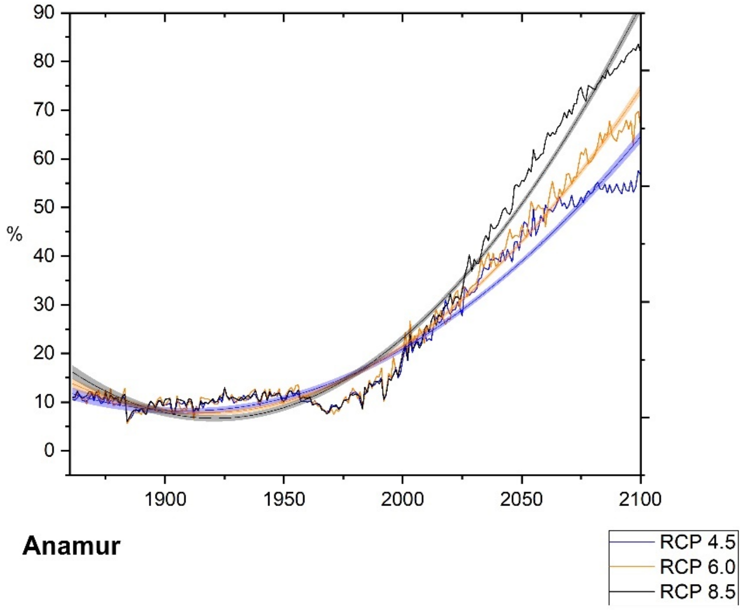
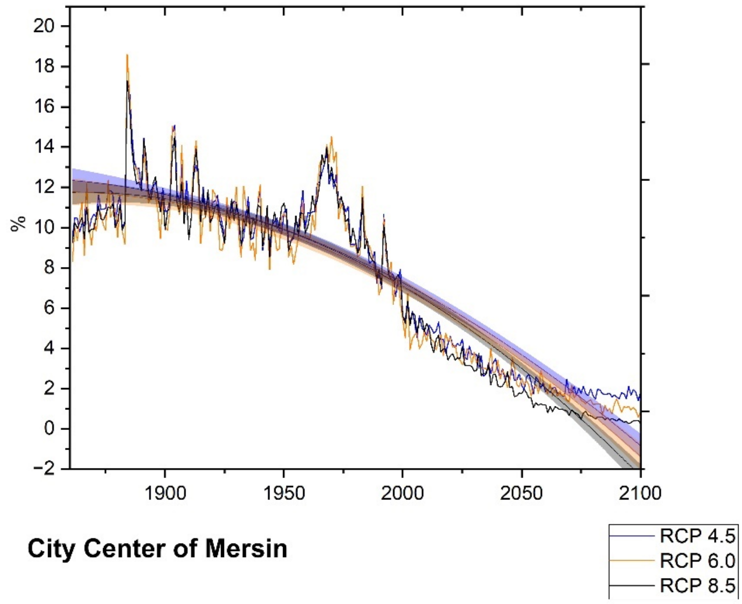



**Figure 4.37:** Change in hot days between 1900-2100 in Mersin (%)

**Cool nights (days when Tmin < 10% of normal)**

Percentage of days with daily minimum temperature within the 10th percentile, representing cold extremes. For RCP4.5, RCP6.0 and RCP8.5 scenarios, 25, 15 and 24 different models, respectively, were used to generate ensemble model projections (Figure 4.38). According to indicator projections, cool nights in the early 2000s are around 7%, while by the end of the century the indicator drops to around 1%.



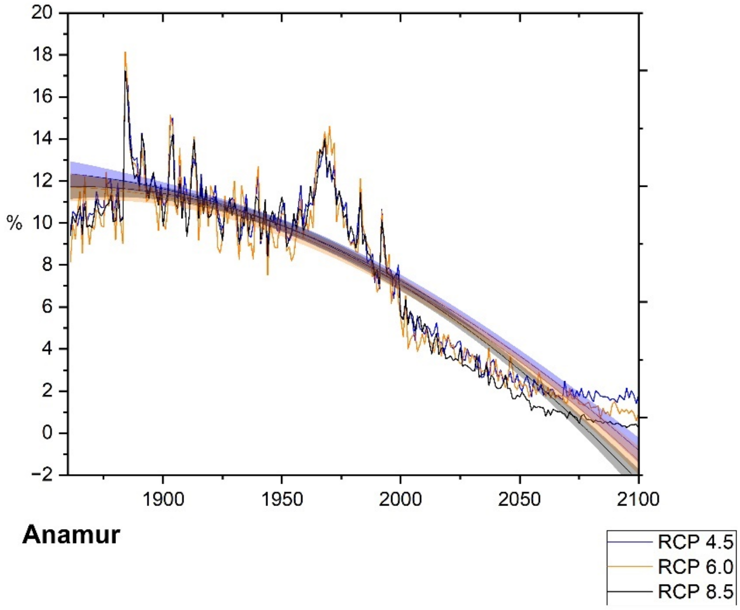
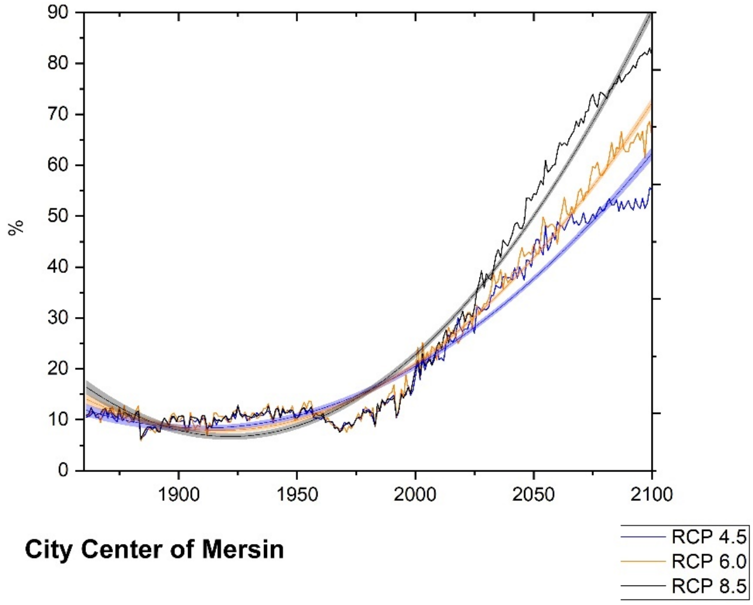



**Figure 4.38:** Change in cool nights in Mersin between 1900-2100 (%)

**Warm nights (days when Tmin > 90% of normal)**

The index, expressed as the percentage of days with a daily minimum temperature above the 90th percentile, represents the warm extreme. According to the ensemble model projections consisting of 25, 15 and 24 different models for the RCP4.5, RCP6.0 and RCP8.5 scenarios, respectively (Figure 4.39), the Warm Nights index, which is around 20%, is projected to increase to 55%, 65% and 82% by 2100, respectively, according to the scenarios.



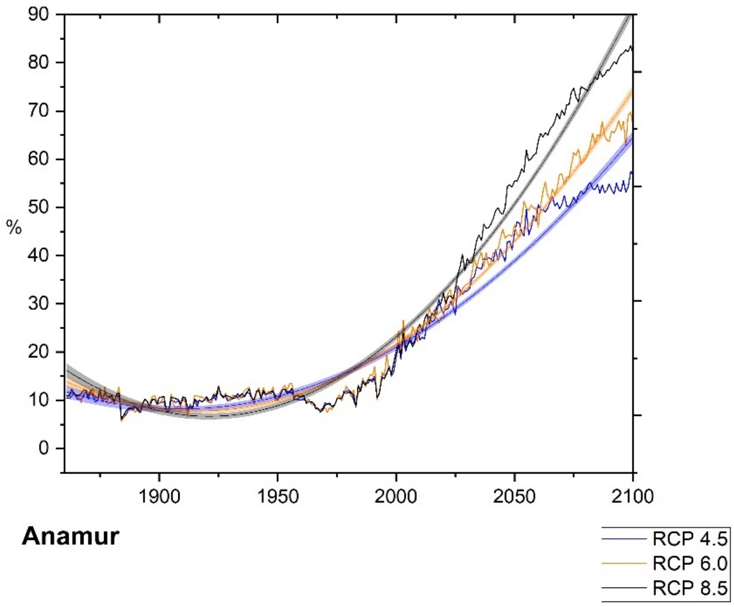
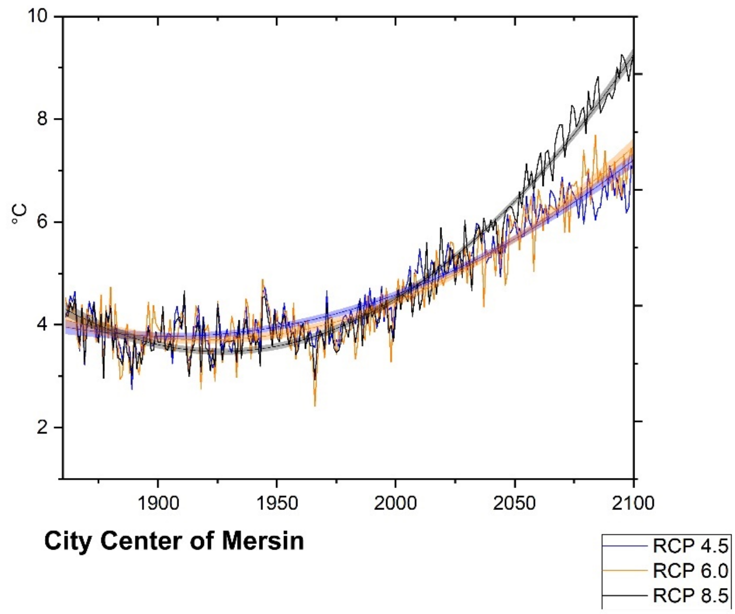



**Figure 4.39:** Change in warm nights in Mersin between 1900-2100 (%)

**Annual Minima of Daily Maximum Temperatures**

The indicator, expressed as the annual minima of daily maximum temperatures, has shown relatively close changes in the RCP4.5 and RCP6.0 scenarios, and is projected to increase from 4.2° C in the 2000s to 7° C by the end of the century, according to the ensemble model projections consisting of 25, 15 and 24 different models (Figure 4.40). This value is projected to be about 9° C for RCP8.5.



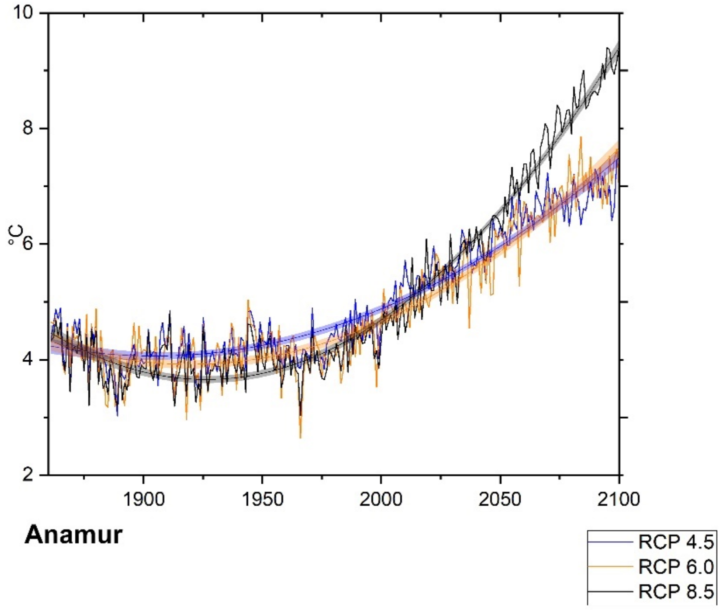
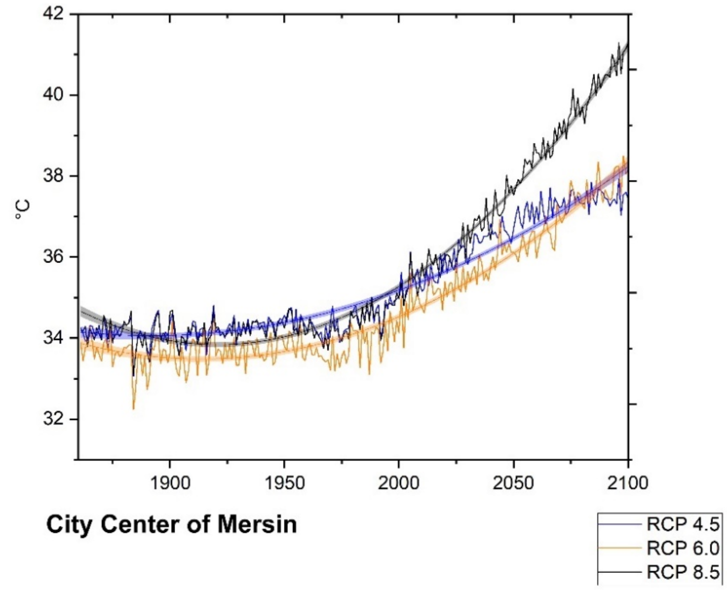



**Figure 4.40:** Annual minima of daily maximum temperatures between 1900-2100 in Mersin (°C)

#### Annual Maxima of Daily Maximum Temperatures

Annual maximum of daily maximum temperatures, representing the warmest daily maximum of the year. Ensemble runs consisting of 23 models for RCP4.5, 13 models for RCP6.0 and 3 different models for RCP8.5 were used to generate the projections. According to the projections of the Annual Maximum of Daily Maximum Temperatures indicator (Figure 4.41), the index is projected to increase from about 34.5$^{o}$ C in the early 2000s to 37.8$^{o}$ C for RCP4.5 and RCP6.0 and 41$^{o}$ C for RCP8.5 by the end of the 21st century.



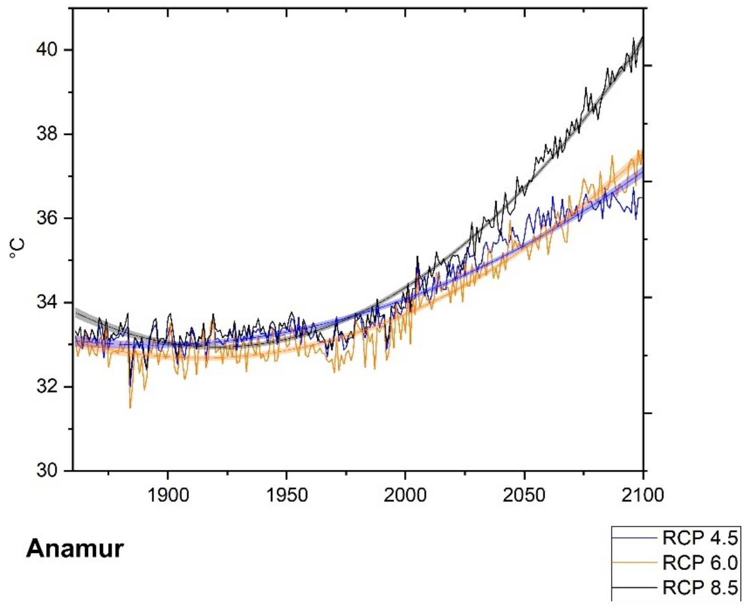
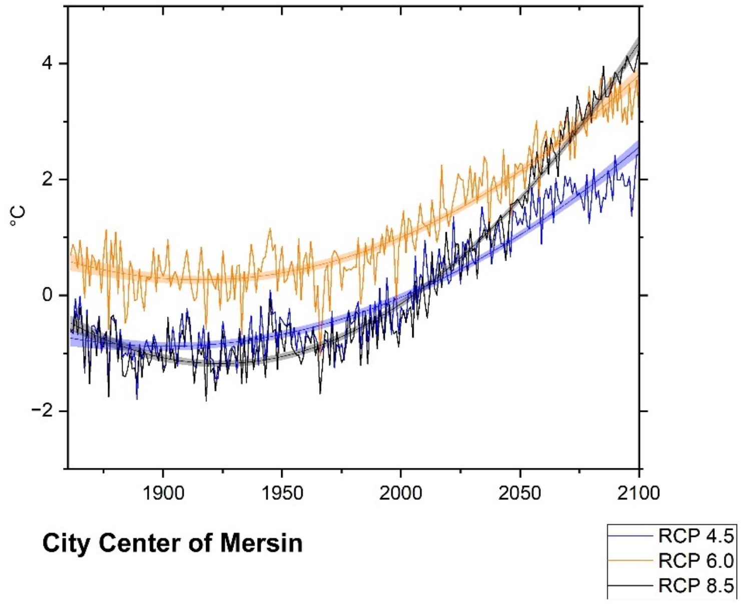




**Figure 4.41:** Annual maxima of daily maximum temperatures between 1900-2100 in Mersin (°C)

### Annual Minima of Daily Minimum Temperatures

For the projections of the indicator representing the coldest temperature of the year, ensemble runs consisting of 25, 15 and 24 different models were used for RCP4.5, RCP6.0 and RCP8.5 scenarios, respectively (Figure 4.42). In the early 2000s, the index value was 0° C according to RCP4.5 and RCP8.5 scenarios and 1° C according to RCP6.0, while by 2100, the indicator projections are projected to be 2.5° C, 4° C and 4.2° C according to RCP4.5, RCP6.0 and RCP8.5 scenarios, respectively.



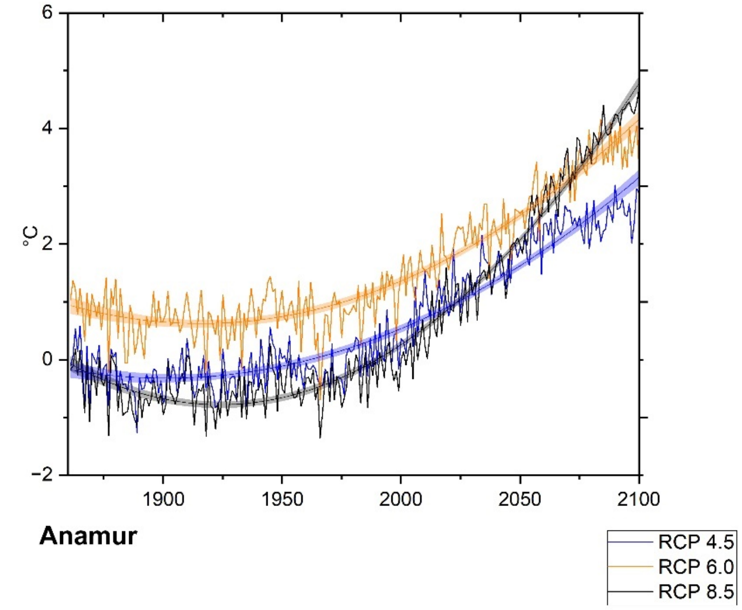
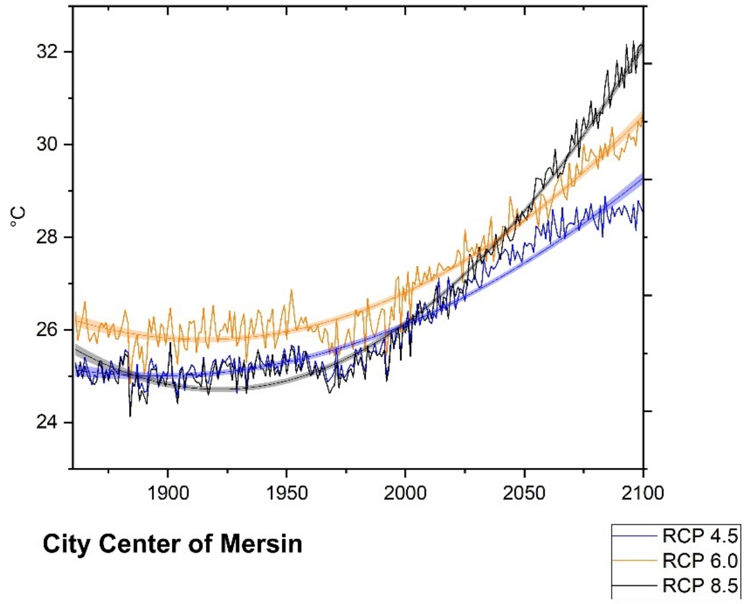




**Figure 4.42:** Annual minima of daily minimum temperatures between 1900-2100 in Mersin (°C)

### Annual Maxima of Daily Minimum Temperatures

It is the annual maximum of daily temperatures and is a climate parameter representing the maximum temperatures of the year. Ensemble runs consisting of 23, 13 and 3 different models for RCP4.5, RCP6.0 and RCP8.5 scenarios, respectively, were used to calculate the projections. According to the ensemble projections (Figure 4.43), in the early 2000s the index is projected to reach 26° C for RCP4.5 and RCP8.5 and 27° C for RCP6.0, while by the end of the century it is projected to reach 28.5° C, 30.3° C and 32° C, respectively.



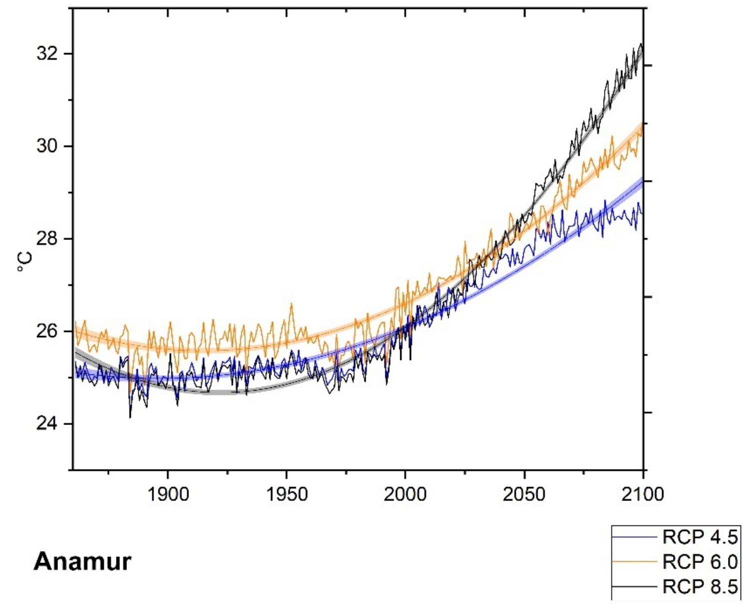




**Figure 4.43:** Annual maxima of daily minimum temperatures between 1900-2100 in Mersin (°C)

### Warm Spell Duration Indicator

For the calculation of the index, ensemble models consisting of 25, 25 and 24 different models were run for RCP4.5, RCP6.0 and RCP8.5 scenarios, respectively (Figure 4.44). The indicator for the number of at least 6 consecutive days with maximum temperatures of 90% or more is projected to decrease from about 8.5 in the early 2000s to 8, 7.5 and 7 by 2100 for RCP4.5, RCP6.0 and RCP8.5, respectively.

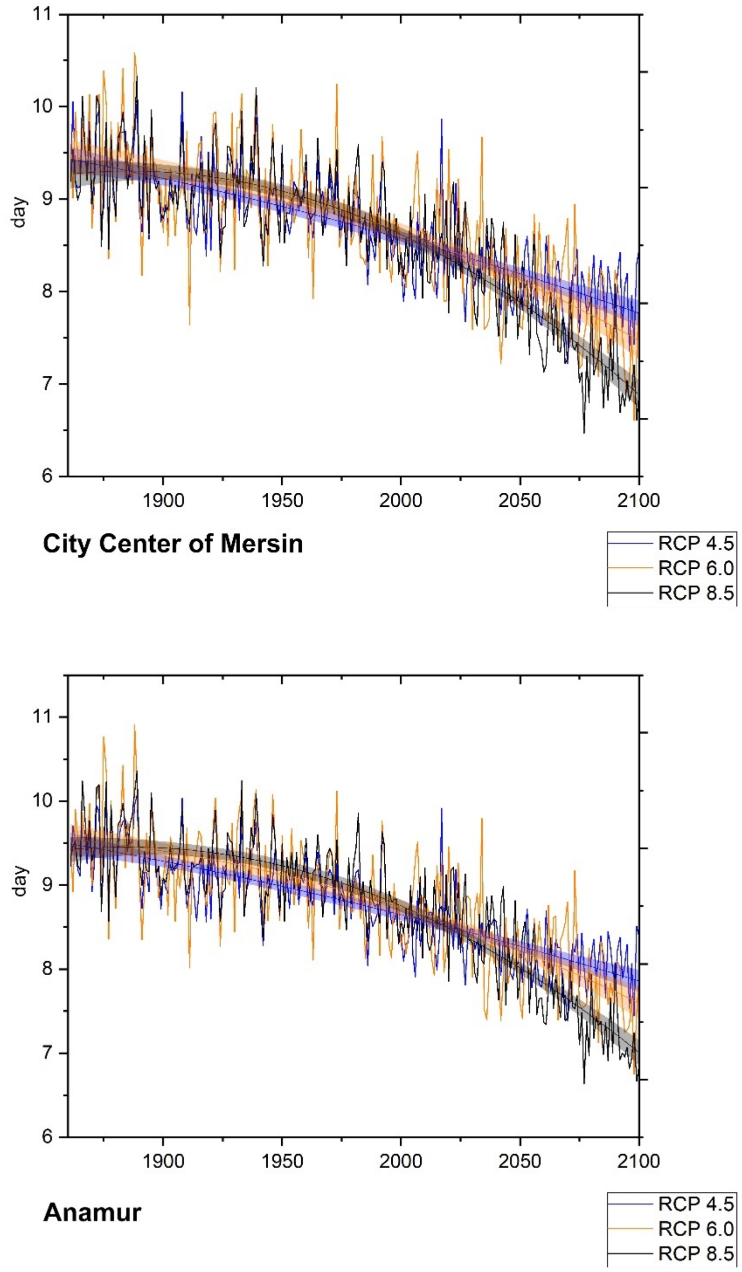
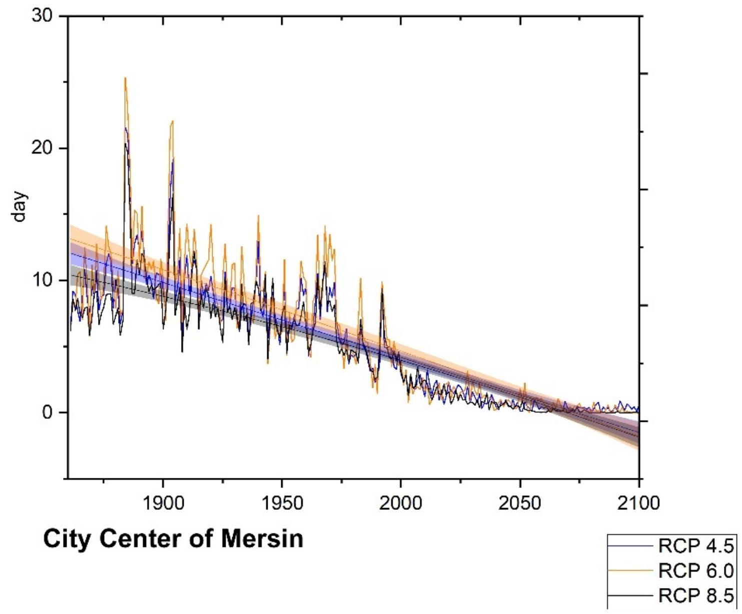



**Figure 4.44:** Change in warm spell duration indicator values between 1900-2100 in Mersin (days)

### Cold Spell Duration Indicator

The projections of the number of cold spell duration indicator (Figure 4.45), which expresses the number of at least 6 consecutive days with a minimum temperature of 10% of normal, are the projections generated by running ensemble runs consisting of 25, 15 and 24 different models for the RCP4.5, RCP6.0 and RCP8.5 scenarios, respectively. It is observed that there is not much of a noticeable difference between the scenarios in terms of the indicator. Towards the end of the century, it is projected that the value will drop to 0 (zero), down from about 3 in the 2000s.



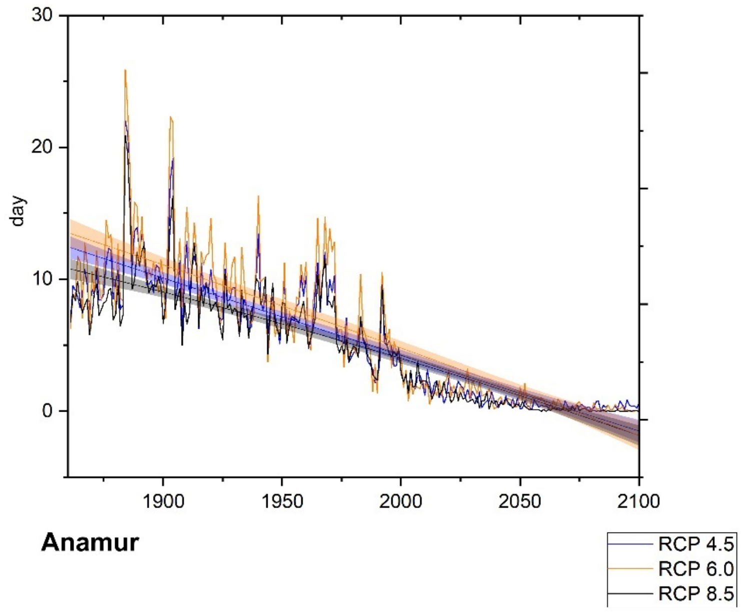




**Figure 4.45:** Change in cold spell duration indicator values between 1900-2100 in Mersin (days)

**Number of ice days**

Number of days with daily maximum temperature below 0°C and projections are shown in Figure 4.46. In the 2000s, the index takes the values of approximately 13, 16.5 and 10 at RCP4.5, RCP6.0 and RCP8.5, respectively, while by the end of the century, these values are projected to be 7.5, 10 and 4, respectively.

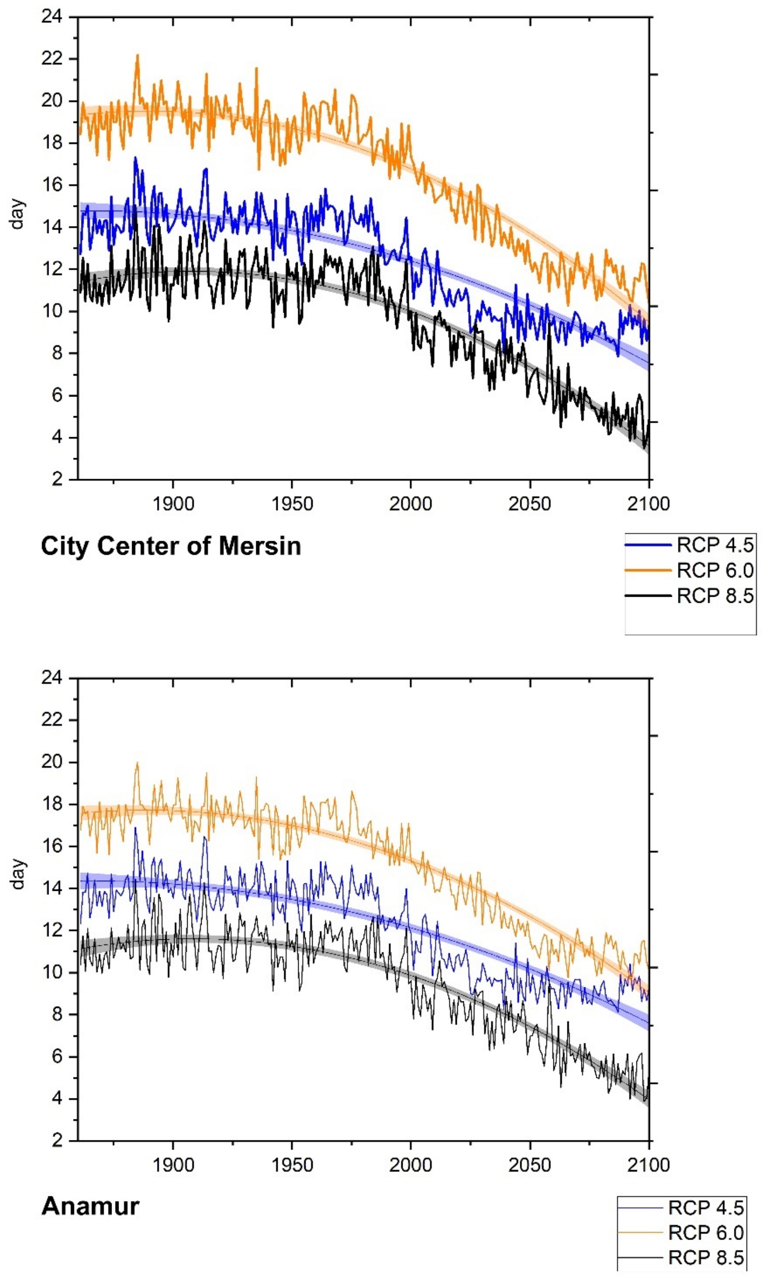



**Figure 4.46:** Number of ice days in Mersin province between 1900 and 2100 (days)

### Growing Season Length

The length of the growing season, which is the sum of the days between the first 6 days when the temperature is greater than 5ºC and the first 6 days when the temperature is less than 5Cº, is shown in Figure 4.47. Plant growing season length increases according to each scenario. According to the projections calculated by the ensemble runs using 25, 15 and 24 different climate models based on the RCP4.5, RCP6.0 and RCP8.5 scenarios, respectively, the length of the growing season in the early 2000s is almost the same for each scenario and is approximately 350 days. By the end of the century, these values are projected to be approximately 360 days or more.

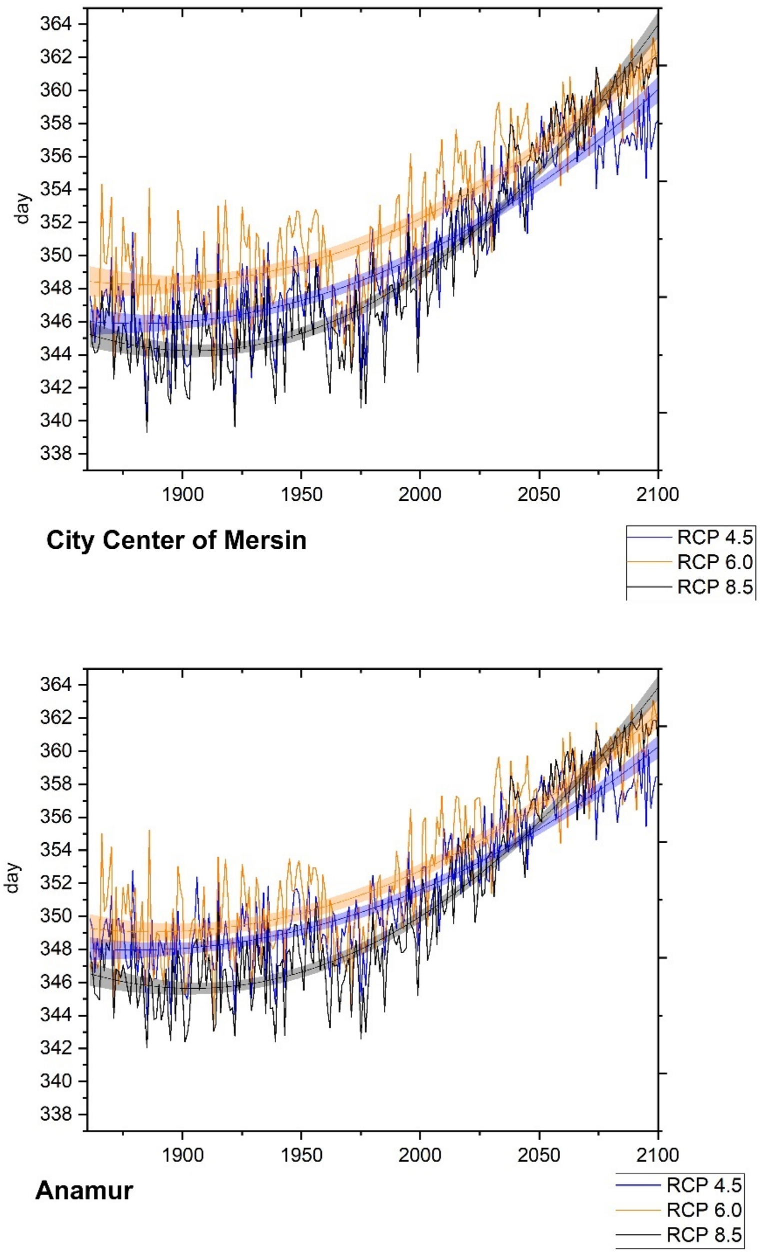



**Figure 4.47:** Growing season length values (days) in Mersin between 1900-2100

## Number of Days with 1mm or More Precipitation

Indice represents the lowest 1-day precipitation during the year. Projections were calculated for RCP4.5, RCP6.0 and RCP8.5 scenarios by running ensemble runs of 25, 15 and 24 different climate models, respectively (Figure 4.48). The number of days with the lowest 1-day precipitation is projected to decrease from about 80 days in the 2000s to about 67 days in the RCP4.5 and RCP6.0 cases and to about 55 days in the RCP8.5 scenario by the end of the century.

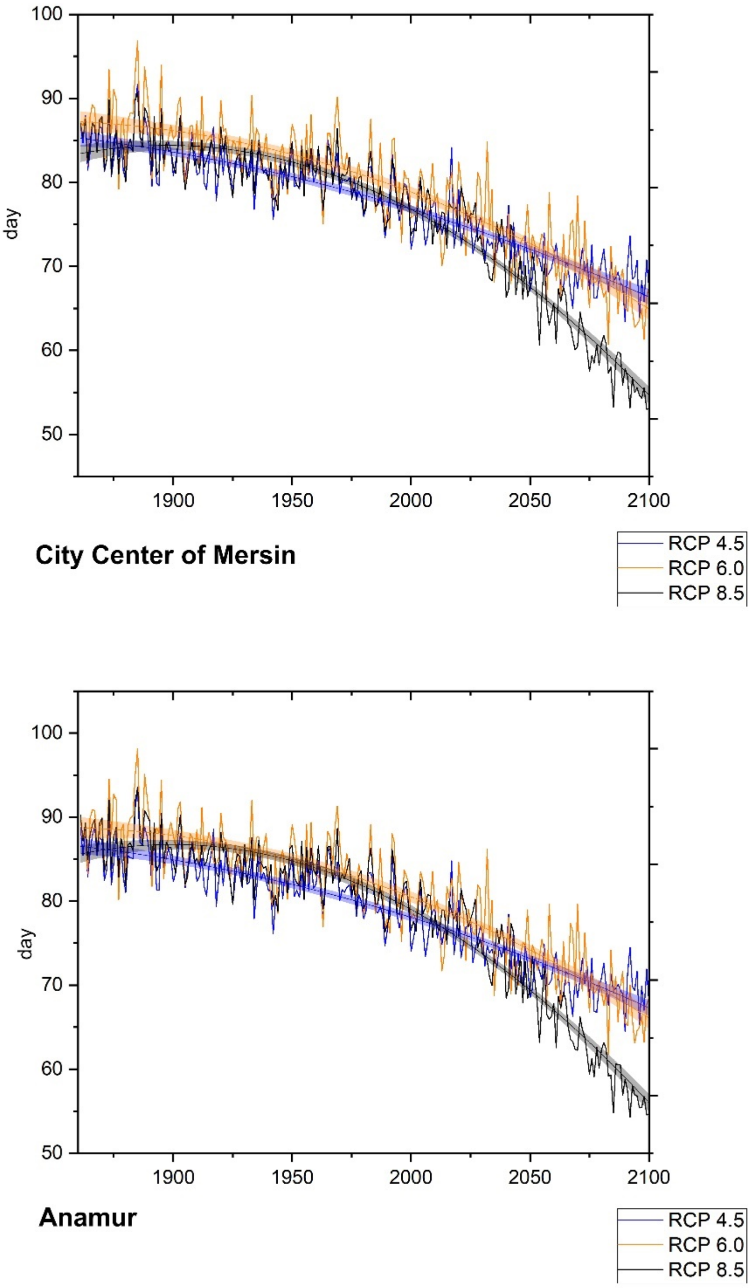
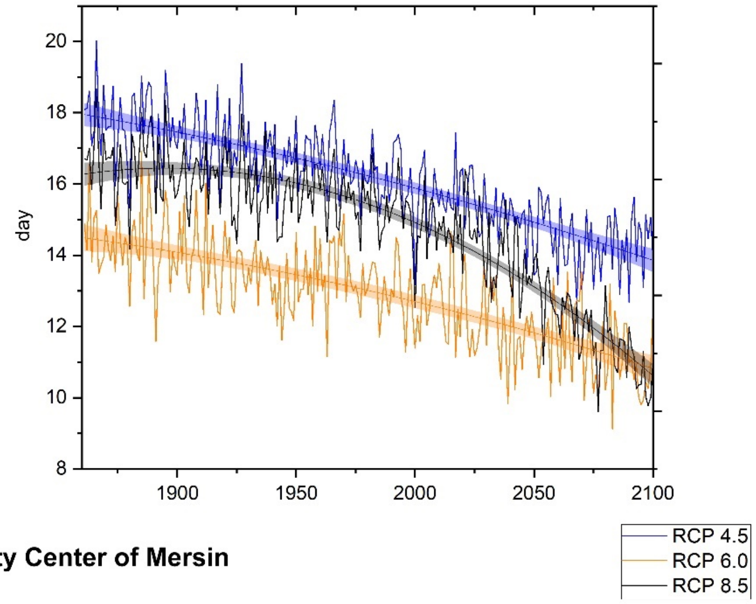


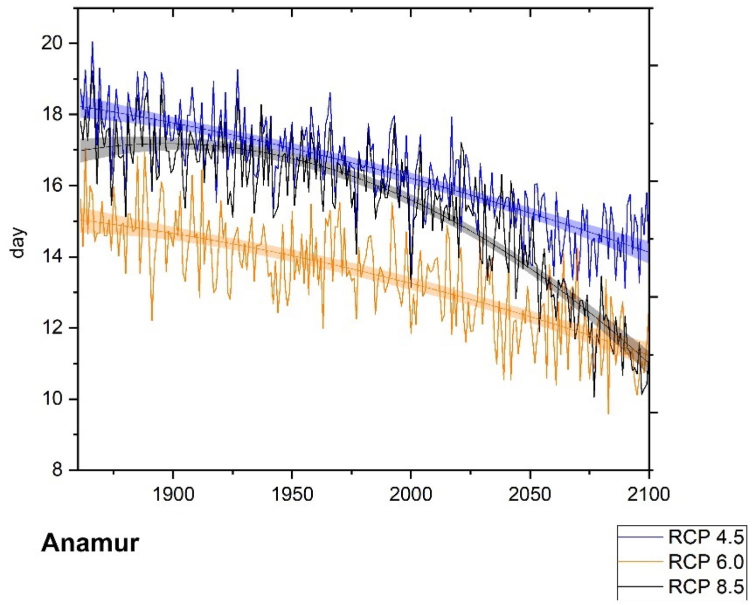

**Figure 4.48:** Number of days with 1 mm or more precipitation between 1900-2100 in Mersin (days)

## Number of Days with 10mm or More Precipitation

The number of consecutive days with precipitation of 10 mm or more is calculated by running ensemble runs of 25, 25 and 24 different models for 3 different scenarios and is shown in Figure 4.49. In the early 2000s, the number of days with precipitation of 10 mm or more for the RCP4.5, RCP6.0 and RCP8.5 scenarios will be approximately 16, 13 and 15, respectively, while by the end of the century, these values are projected to decrease to approximately 14 for RCP4.5 and 10.5 for RCP6.0 and RCP8.5.




**City Center of Mersin**

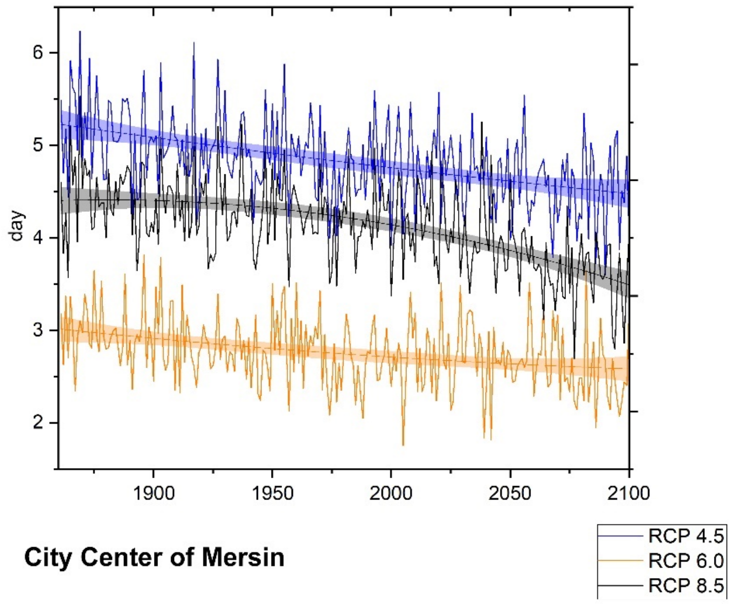



**Anamur**

**Figure 4.49:** Number of days with 10 mm or more precipitation between 1900-2100 in Mersin (days)

### Number of Days with 20mm or More Precipitation

Ensemble model projections generated from a similar number of models as above are shown in Figure 4.50. In the early 2000s, according to the RCP4.5, RCP6.0 and RCP8.5 scenarios, the values of the index are approximately 4.5, 4 and 2.5 days, respectively, while by 2100 it is projected to decrease to approximately 4.5, 2.5 and 3.5 days, respectively.



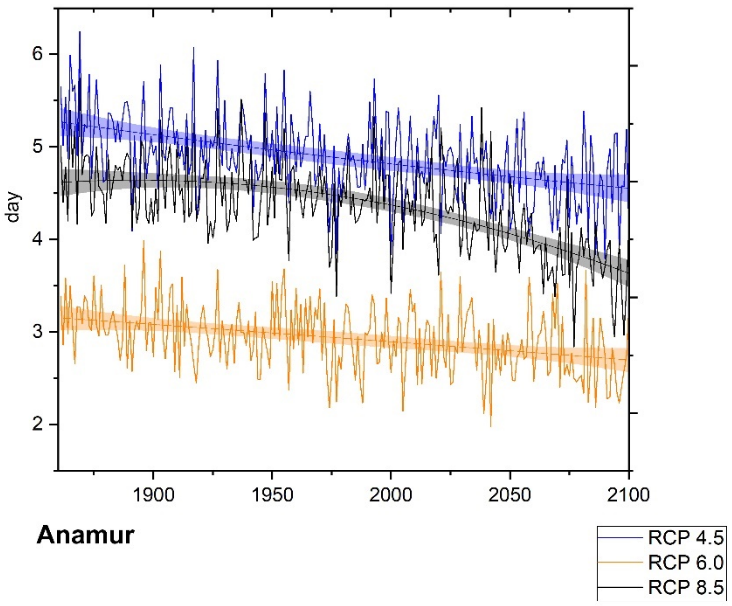
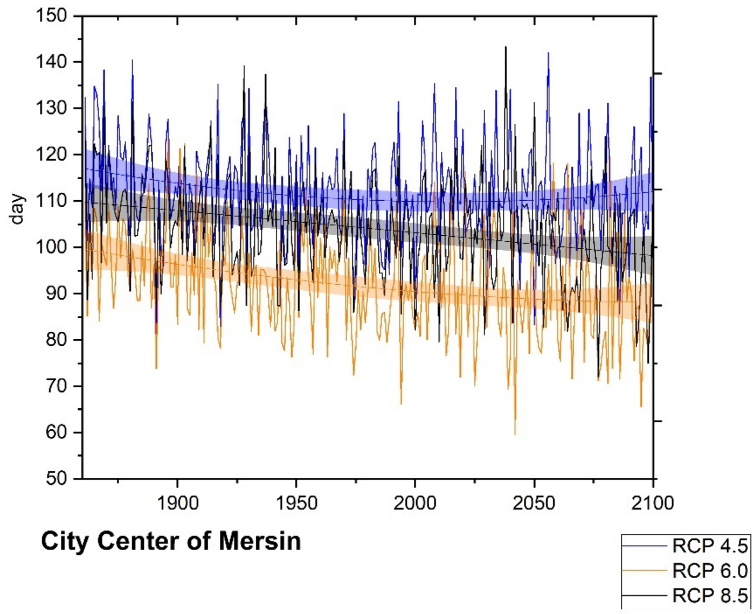




**Figure 4.50:** Number of days with 20 mm or more precipitation between 1900-2100 in Mersin (days)

**Number of Heavy Precipitation Days**

For days with precipitation of 1 mm or more, it expresses the annual sum of the precipitation of days with precipitation above the 95th percentile. Ensemble projections generated from 25, 15 and 24 different models according to the scenarios are shown in Figure 4.51. According to the RCP4.5, RCP6.0 and RCP8.5 scenarios, the index in the early 2000s is approximately 110 days, 90 days and 102 days, respectively. There is a slight decrease in index values towards the end of the century. There is a slight increase in the index compared to the RCP4.5 scenario, while the other two scenarios show little change.



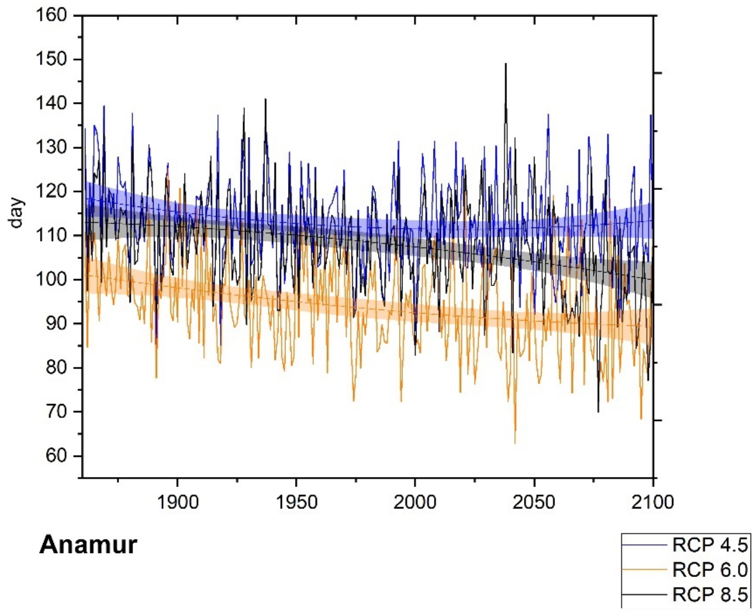




**Figure 4.51:** The amount of precipitation for heavy precipitation days between 1900-2100 in Mersin (mm/yıl)

## Number of Very Heavy Precipitation Days

In the calculation of the projections of the index, which expresses the annual sum of the precipitation of days with precipitation above the 99th percentile for days with precipitation of 1 mm or more, ensemble projections consisting of 25, 15 and 24 different models were prepared depending on the scenarios (Figure 4.52). Although values have varied widely over the years, a general increase is predicted towards the end of the century. In the early 2000s, the index takes values of 33 days, 27 days and 30 days, respectively, according to the scenarios. By late 2100, these values are projected to increase to approximately 36, 30 and 38, respectively.

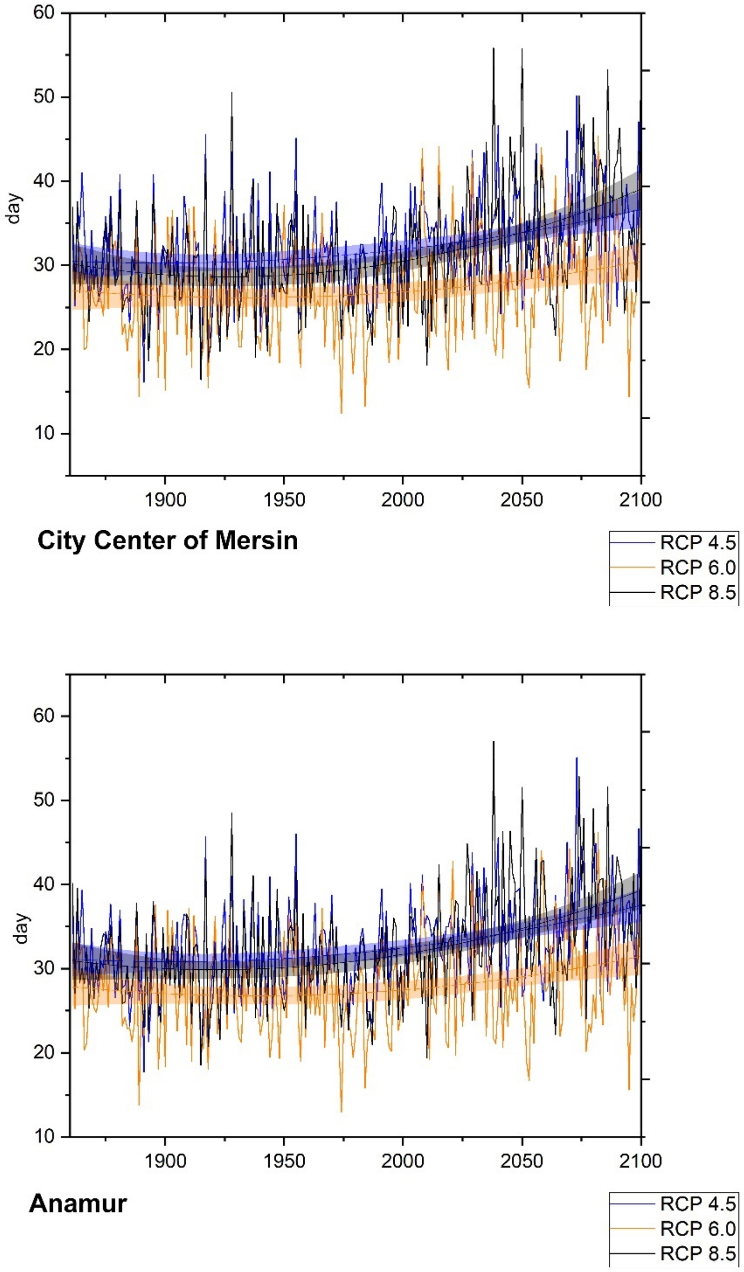
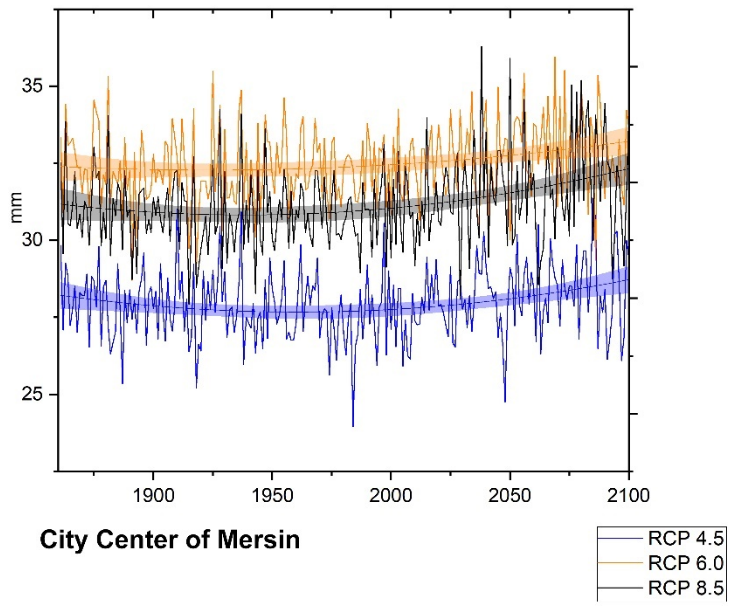



**Figure 4.52:** The amount of precipitation for very heavy precipitation days between 1900-2100 in Mersin (mm/yıl)

### Maximum 1-day Precipitation

Similar to above, different ensemble model projections were used in the calculation of the projections of the index expressing 1-day maximum precipitation (Figure 4.53). In general, little change in the indicator is foreseen towards the end of the century. In the 2000s, according to the scenarios, the indicator will be about 28, 32.5 and 31.5 mm/day, respectively, while by the end of the century, the indicator is projected to be about 28, 33.5 and 32 mm/day, respectively.



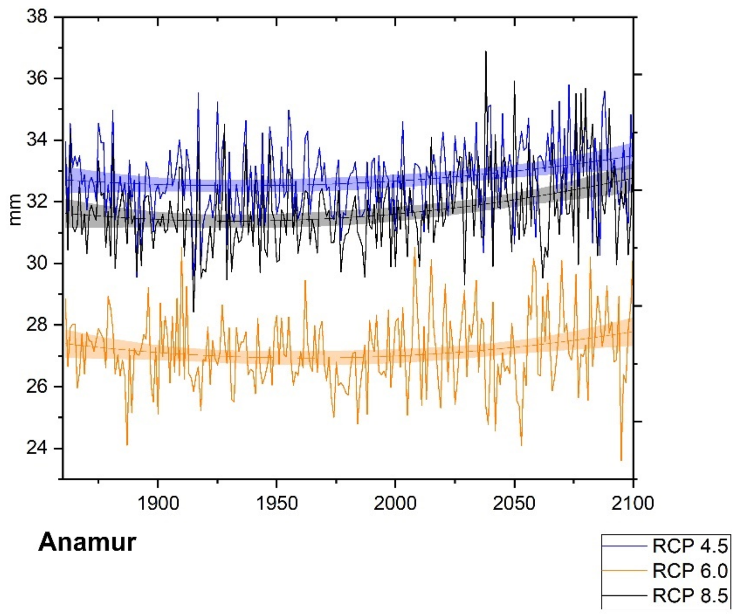
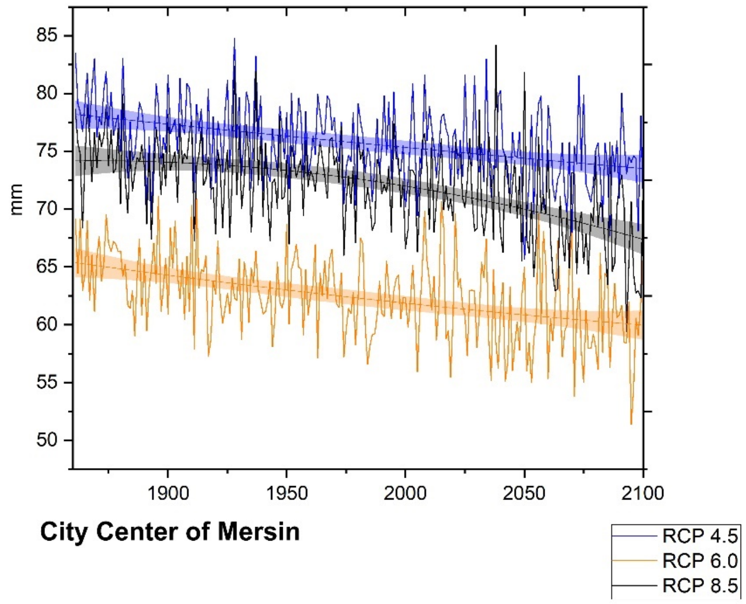




**Figure 4.53:** Maximum 1-day precipitation between 1900-2100 in Mersin (mm/gün)

#### Maximum 5-day Precipitation

Projections of the 5-day consecutive maximum precipitation indicator (Figure 4.54) were obtained by applying the ensemble runs and it is predicted that there will be slight decreases in the indicator over time. According to the RCP4.5, RCP6.0 and RCP8.5 scenarios, the indicator is projected to be 73, 60 and 66 by the end of the century.



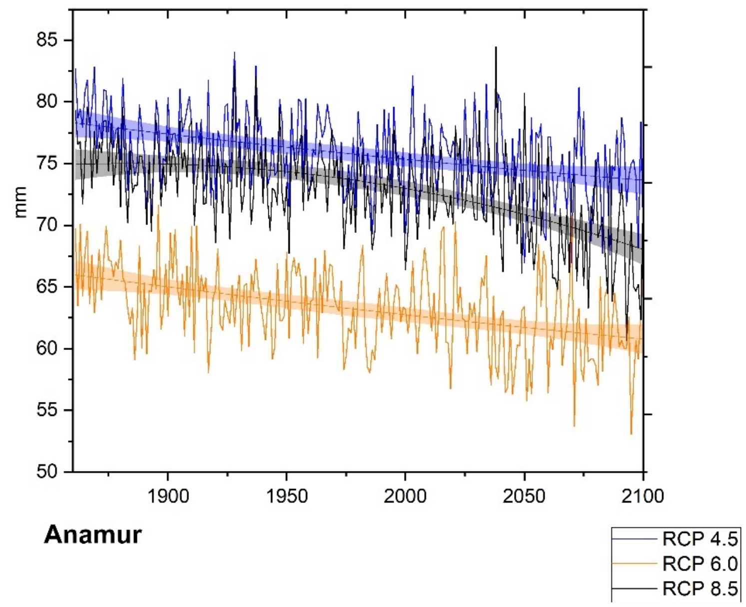




**Figure 4.54:** Maximum 5-day precipitation between 1900-2100 in Mersin (mm/gün)

### Annual Total Precipitation

Ensemble projections consisting of 25, 15 and 24 different climate models were realized according to RCP4.5, RCP6.0 and RCP8.5 scenarios (Figure 4.55). If we look at the projections of the change in Annual Total Precipitation over time, it can be said that the fastest and sharpest decline will be starting from 2025 under the RCP8.5 scenario. Although the decreases in precipitation according to the RCP6.0 scenario take similar values compared to the RCP8.5 scenario, it can be seen that the slope in the decrease is slightly less. In the early 2000s, Annual Total Precipitation for RCP4.5, 6.0 and RCP8.5 is projected to be around 520 mm, 460 mm and 505 mm, respectively, while by the end of the century it is projected to decrease to 470 mm, 370 mm and 360 mm, respectively.

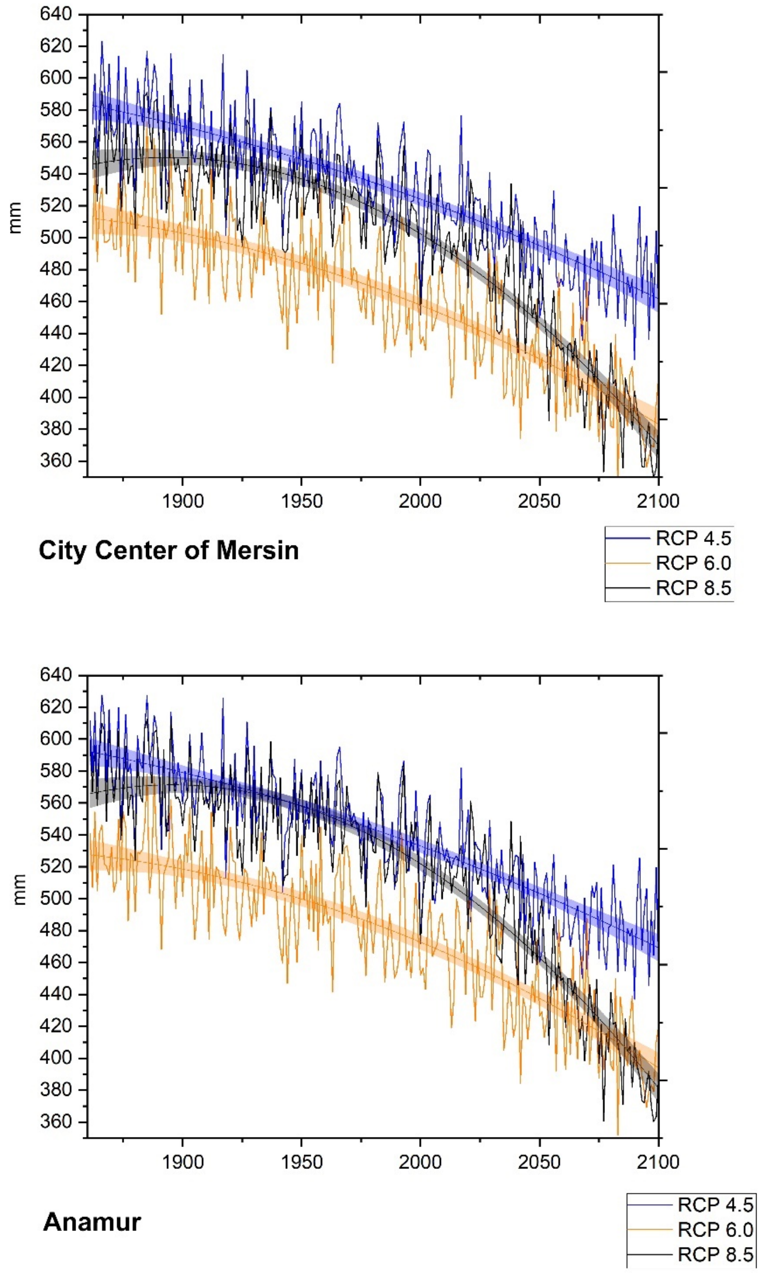



**Figure 4.55:** Annual Total Precipitation between 1900-2100 in Mersin (mm)

### 4.2.3 High Resolution Regional Climate Model Projections (MPI-CSC-REMO2009)

Climate projections generated by dynamically downscalled high-resolution regional climate models using global climate model outputs as initial conditions enable a better understanding of local climate change impacts, more comprehensive risk assessments, and the correct operation of sectoral planning and decision-making processes. The European Union Program of Copernicus (https://www.copernicus.eu/en/copernicus-services) provides data supply and analysis and services in many other areas such as atmosphere, sea, land, climate change, security and emergency and disasters. The results of the 0.05° - 0.05° high-resolution (~ 5 km horizontal resolution) climate projection, in which the MPI-ESM-LR global climate model developed at the Max Planck Institute and the Dutch CSC-REMO2009 regional climate model are coupled with each other, are analyzed for Mersin. The differences of the projected values of the main climate variables of temperature (air temperature at 2 m height) and total precipitation in the time periods between 2011-2040, 2041-2070 and 2071-2100 compared to the reference period 1970-2010 were analyzed. Precipitation changes, unlike temperature changes, are expressed as percentages instead of values. Figure 4.56 ve Figure 4.57 show the differences of monthly temperature projections from the reference period considering RCP4.5 and RCP8.5 scenarios. In the 2011-2040 period, according to the RCP4.5 scenario, temperatures are projected to increase by approximately 1°C, with the highest increase in April, while according to the RCP8.5 scenario, temperatures are projected to increase by approximately 1.5° - 2°C, with the highest increase in August. In the 2041-2070 period, according to the RCP4.5 scenario, temperatures are projected to increase by 0.5° – 1°C in all months compared to the previous period, with the highest increase of 2.5° – 3°C in August compared to the reference period. According to the RCP8.5 scenario for the same period, it is seen that the increases in temperature will be much higher than in the previous period, with the maximum increase of approximately 3.5° – 4°C in August. In the 2071-2100 period, it is observed that there is no significant increase in temperatures in the RCP4.5 scenario compared to the previous period, whereas there is a significant increase in temperatures in all months in the RCP8.5 scenario. The maximum increase is observed in August and April, respectively, and the increase in temperature in August reaches approximately 7°C.

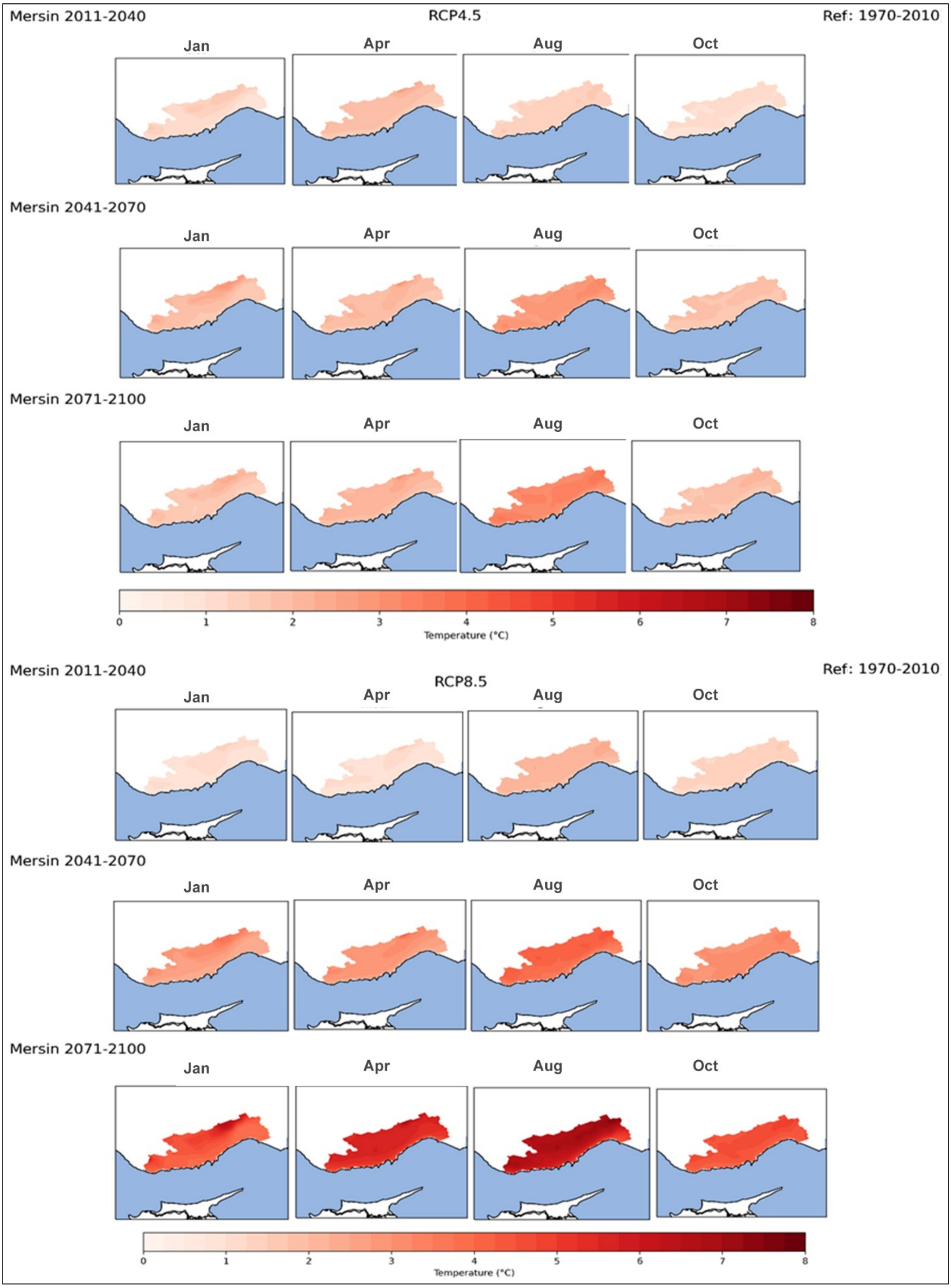



**Figure 4.56:** Temperature changes in Mersin according to RCP 4.5 and RCP 8.5

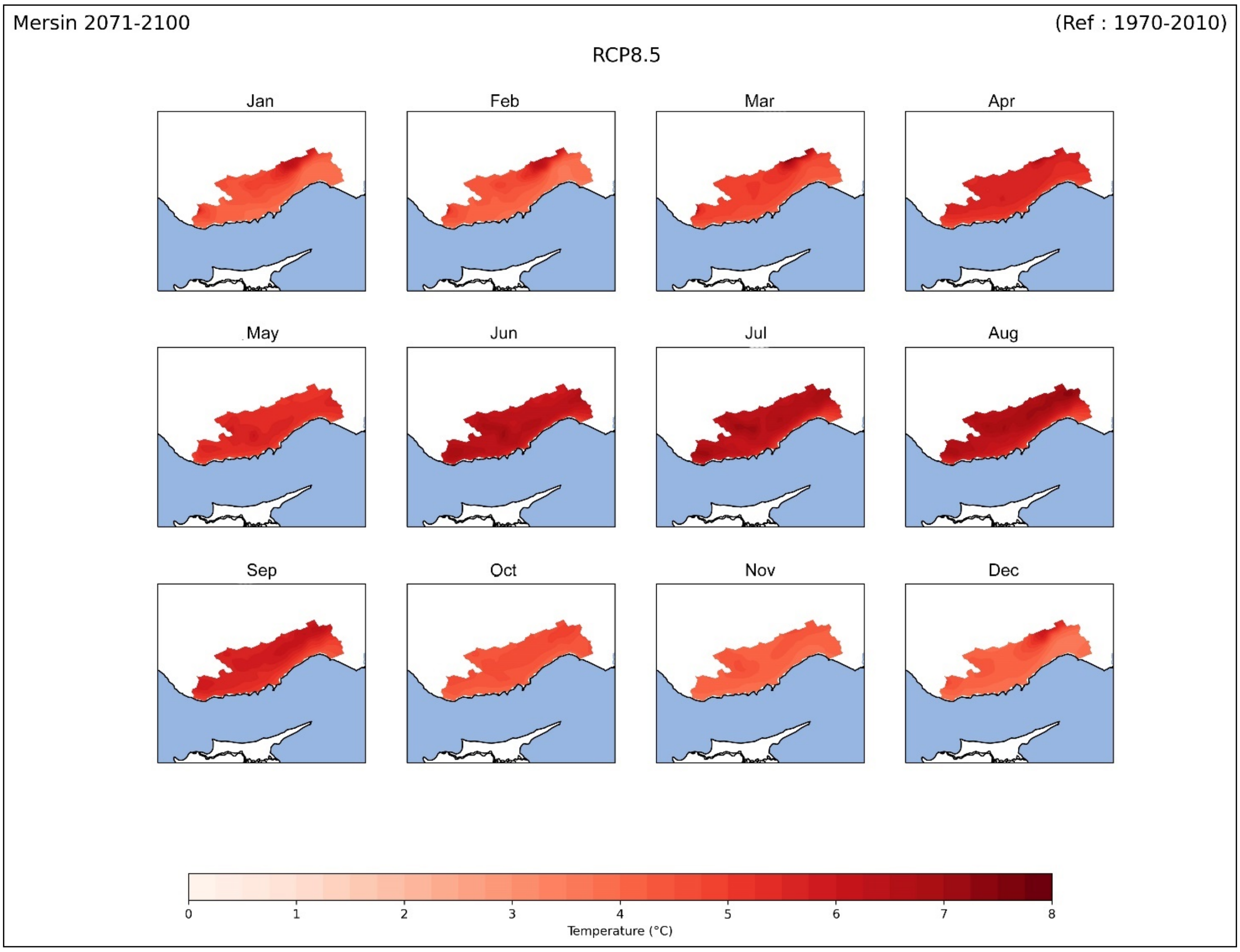



**Figure 4.57:** Monthly temperature changes in Mersin according to RCP 8.5

Considering the change in precipitation (Figure 4.58), it is seen that there is either not much change in precipitation in January, April and August or there is a partial decrease in percentage according to RCP4.5 scenario in the period 2011-2040. In October, it is seen that there will be an increase of up to 60% in precipitation. In the same period, according to the RCP8.5 scenario, a slight decrease of around 10-15% is expected for almost all of Mersin in August, while a slight increase or decrease in precipitation (-+10-15%) is expected in the other months. In the period 2041-2070, it is predicted that there will be a significant increase in precipitation in October, but there will be significant decreases (-30-40%) in other months, especially in August. According to the RCP8.5 scenario for the same period, the significant increase in precipitation in October in RCP4.5 is replaced by either a decrease or an increase in low values (+20%). The greatest decrease in precipitation occurs in August, by about 50% and up to 60% in some coastal areas. When it comes to the period of 2071-2100, according to the RCP4.5 scenario, it is predicted that the increase in precipitation in October will continue around 50%, while there will be a decrease in precipitation in January, April and August by 10-15%, 30-40%, and 10%, respectively. According to the RCP8.5 scenario for the same period, there will be significant decreases in January, April and August, and these decreases will be the highest in August and especially along the coastline. Precipitation decreases in January, April and

August are generally around 30%, 30% and 60% respectively. In October, it is predicted that there will be an increase of 30-40% in precipitation as in previous periods.

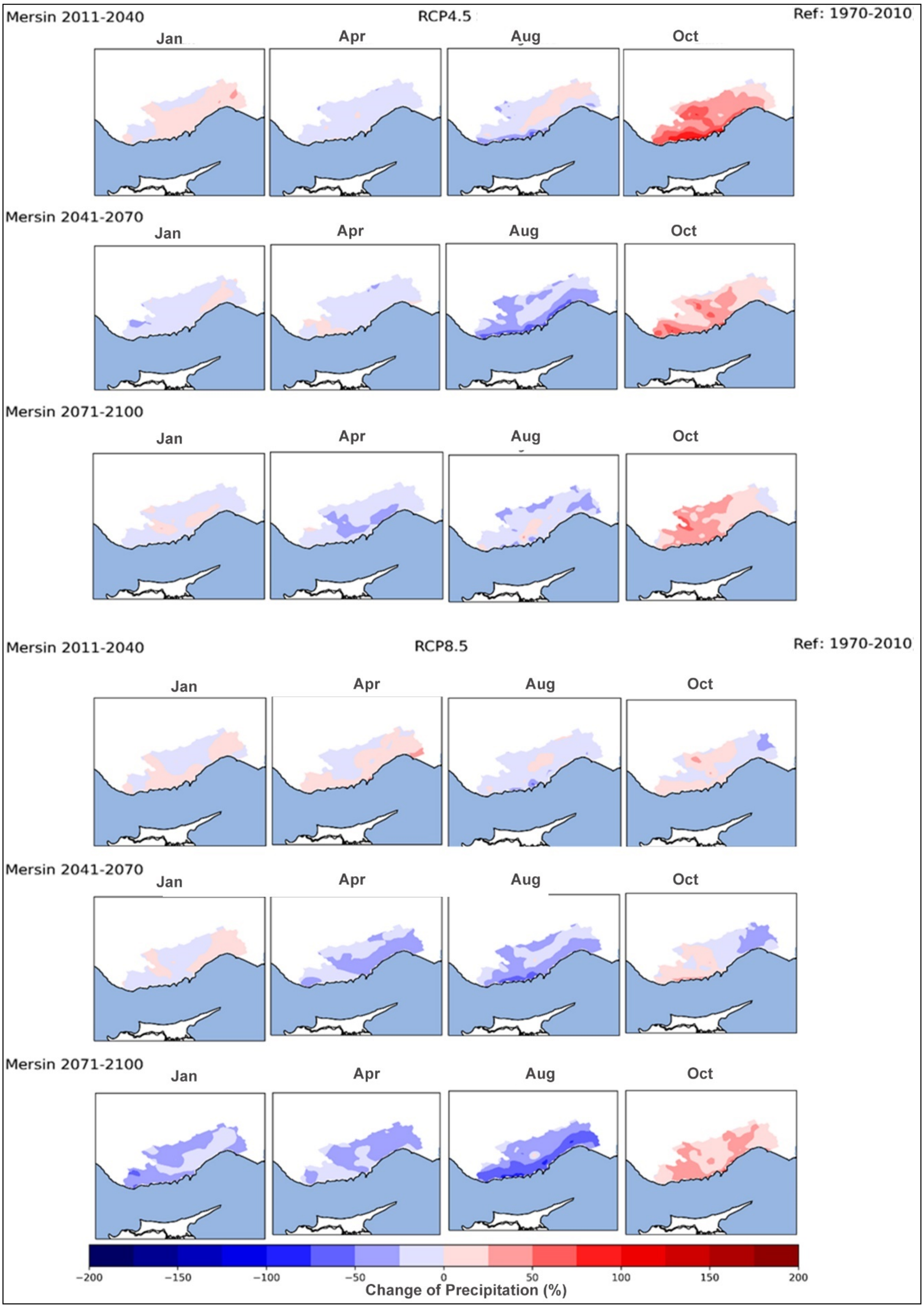



**Figure 4.58:** Changes in precipitation in Mersin according to RCP 4.5 and RCP 8.5

## 4.3. Climate Risk and Vulnerability Assessment

Climate change risk analysis includes the steps of identifying the climate change risks that provinces may face, assessing the impacts of these risks, prioritizing the risks, identifying strategies to manage the risks and implementing these strategies. The details of these steps are as follows:

*1. Identifying Climate Change Risks*

Climate change can affect provinces in different ways. For example, warmer weather, more rainfall, severe storms and flooding. Therefore, when identifying climate change risks in a settlement area, the climatic conditions of the region and climate change scenarios are taken into account.

*2. Assessing the Impact of Risks*

Each risk can have a different impact. For example, excessive rainfall can cause flooding, while high temperatures can cause urban heat islands. It is therefore important to assess the sector-specific impact of each risk.

3. *Prioritization of Risks*

Not all risks are equally important. Prioritization of risks specific to a residential area ensures that these risks are addressed in order of importance.

*4. Identifying Strategies to Manage Risks*

There are many strategies to mitigate climate change risks. For example, taking measures for infrastructure against flooding, planning for the increase in energy demand due to higher temperatures. Local governments can identify appropriate strategies to mitigate these risks. In this step, appropriate strategies are identified to mitigate the identified risks.

*5. Implementation of the Risk Management Plan*

Implementing risk management strategies increases the resilience capacity of local governments to climate change. This makes provinces safer, healthier and more livable. This step ensures the implementation of the identified strategies and determination of performance criteria for these strategies.

*6. Reviewing and Updating the Risk Management Plan*

Climate change is a constantly changing process and therefore it is important to regularly review and update the risk management plan. Local governments can update the risk management plan using information such as new scientific research and climate change scenarios. This step ensures that local governments are continuously prepared for climate change risks.

The steps mentioned above are the basic steps for conducting climate change adaptation risk analysis for residential areas. By following these steps, local governments can ensure that provinces become more resilient to climate change. Local governments can better cope with possible adversities in the future by identifying strategies to mitigate climate change risks according to the results of the risk analysis.

The Intergovernmental Panel on Climate Change (IPCC) recommends a three-dimensional framework for climate change risk assessment that takes into account the interaction between hazard, exposure and vulnerability (Figure 9.59). The IPCC defines a hazard as "the probable occurrence of a natural or human-induced physical event or trend that could cause loss of life, injury or other health effects, as well as damage to and loss of property, infrastructure, livelihoods, service provision and ecosystems". Therefore, a climate-related event (e.g. extreme weather events) or a trend in climate variables (e.g. increase in average temperatures) can be classified as a climate hazard. Exposure, the second component of risk assessment, is defined by the IPCC as "the presence of people; livelihoods; species or ecosystems; environmental functions, services and resources; infrastructure; or economic, social, environmental or cultural assets in places and environments that may be adversely affected". Therefore, while elements at risk (e.g. citizens, infrastructure, assets) can be identified for exposure assessment, changing the degree and duration of exposure can lead to increased or decreased risk (e.g. population density in coastal areas). Vulnerability, the final component of risk assessment, defined by the IPCC as "the tendency or predisposition to be adversely affected", encompasses various concepts and elements such as susceptibility to harm and lack of capacity to cope and adapt. Vulnerability incorporates two different characteristics: sensitivity, which depends on physical, social and economic factors (e.g. age distribution, type of materials used for infrastructure projects), and adaptive capacity, which depends on the ability of citizens and organizations to cope with and adapt to climate change-related impacts (e.g. availability of early warning systems, local knowledge) (IPCC, 2020).

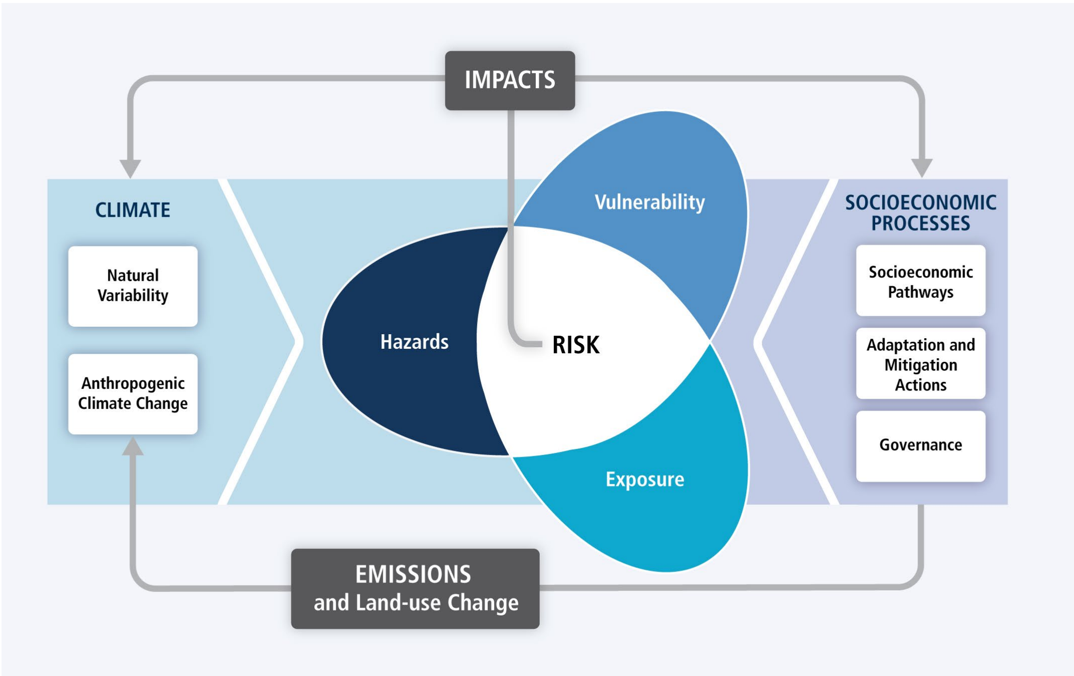



**Figure 4.59: IPCC risk assessment framework**

In the climate change impact and vulnerability analysis to be carried out within this framework, firstly, the impacts of climate change on the relevant infrastructure and services should be determined in the light of past meteorological data (average temperature increase, total precipitation, etc.), previous disasters (extreme weather events, forest fires, etc.) and national climate projections (temperature, amount and type of precipitation, etc.) for the relevant region. Afterwards, vulnerability areas that are expected to be most affected by climate change should be identified and risk assessments should be made for these areas. Figure 4.60 shows the studies that can be carried out in this context and some examples.

**Impact and vulnerability analysis**

- Identifying impacts in the light of regional climate projections
- Identifying the infrastructures expected to be most affected by climate change
- Risk and vulnerability assessment (probability and impact matrix) and prioritization of impacts

**Evaluation of adaptation measures**

- Identification and assessment of possible measures, e.g;
  - Grouping; 'soft' measures (flexible working hours on heatwave days etc.), 'grey' measures (strengthening infrastructure etc.), 'green' measures (increasing green areas etc.))
  - Exemplification (evaluation of existing good practices)

**Identification of adaptation measures**

- Assessment of possible measures (to what extent will the measure increase adaptive capacity and what are the other impacts of the measure (socio-economic, environmental, etc.)?
- Conduct cost/benefit analysis (CBA) and/or multi-criteria analysis (MCA)
- Prioritization of adaptation measures ('win-win': flood and flood management, green roofs, 'no-regret': e.g., new buildings built away from riverbeds, 'low-regret': e.g., construction of communal water reservoirs in risk areas, protection of natural areas)
- Determining the realization period of the action and key performance indicators on the basis of the measure

**Figure 4.60: Climate change adaptation assessment**

### 4.3.1 Determination of the Current Situation: Collection of Climate Data

In order to determine the probability of occurrence of climate risks, it is necessary to determine the frequency of occurrence of past events. For this reason, in order to determine the frequency of occurrence of climate risks in Mersin province, historical climatological data, weather reports and climate projections were evaluated.

### 4.3.2 Identifying Climate-Related Threats

Data on extreme weather events that occurred in Mersin province in the last 20 years are given in Figure 4.61. Hail has been recorded as the most common weather event in the region in recent years. After hail, storms and tornadoes, rainfall and flooding can be listed as other extreme weather events.

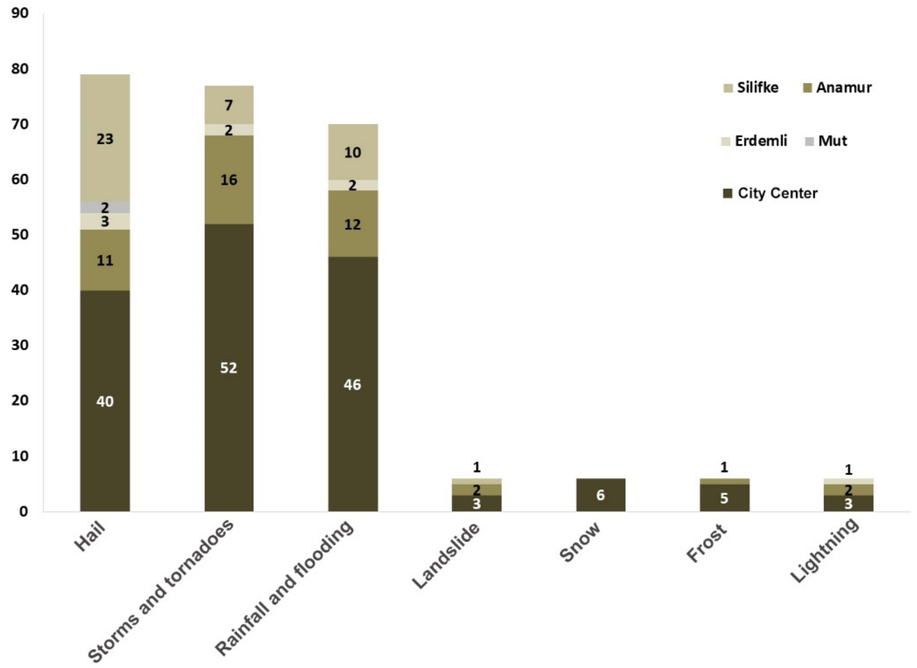



**Figure 4.61: Extreme events in Mersin in the last 20 years**

Mersin province has been assessed against climate risks of temperature increase, drought, extreme precipitation and flooding, storms and tornadoes, hail, snow, meteorological frost, forest fire and sea level rise.

## Temperature Increase

High temperatures have many negative impacts on cities. During periods of high temperatures, excessive use of air conditioning and other cooling systems directly increases the need for energy consumption. Temperature increases can lead to heat stroke, dehydration and other health problems in the elderly, children and individuals with chronic health problems. High temperatures can also lead to reduced water supplies, difficulties in obtaining drinking water and adversely affect agricultural activities. Temperature increases also lead to the formation of photochemical pollutants, such as ozone, and lower air quality levels. Temperature increases in the region are seen in the temperature trend analysis results and climate projections given under the climatological analysis heading in Chapter 6. During periods when daily maximum temperatures exceed 32ºC, these risks are more likely to ocur.

Climate projection data were utilized to determine the vulnerability of the region to the risk of temperature increase in the coming years. Climate projections with a resolution of 0.2° - 0.2° (~ 20 km horizontal resolution) within the scope of the "Turkey Climate Projections and Climate Change with New Scenarios - TR2015-CC, 2015" project carried out by the General Directorate of

Meteorology in 2015 were evaluated in the analyzes. HadGEM2-ES global climate model was run by MGM using RCP4.5 and RCP8.5 scenarios and temperature and precipitation projections were produced for a period covering 2016-2099. Maximum temperature projections for Akdeniz, Silifke, Anamur and Mut districts are given in Figure 4.62. Maximum temperatures are expected to increase in all scenarios and districts.

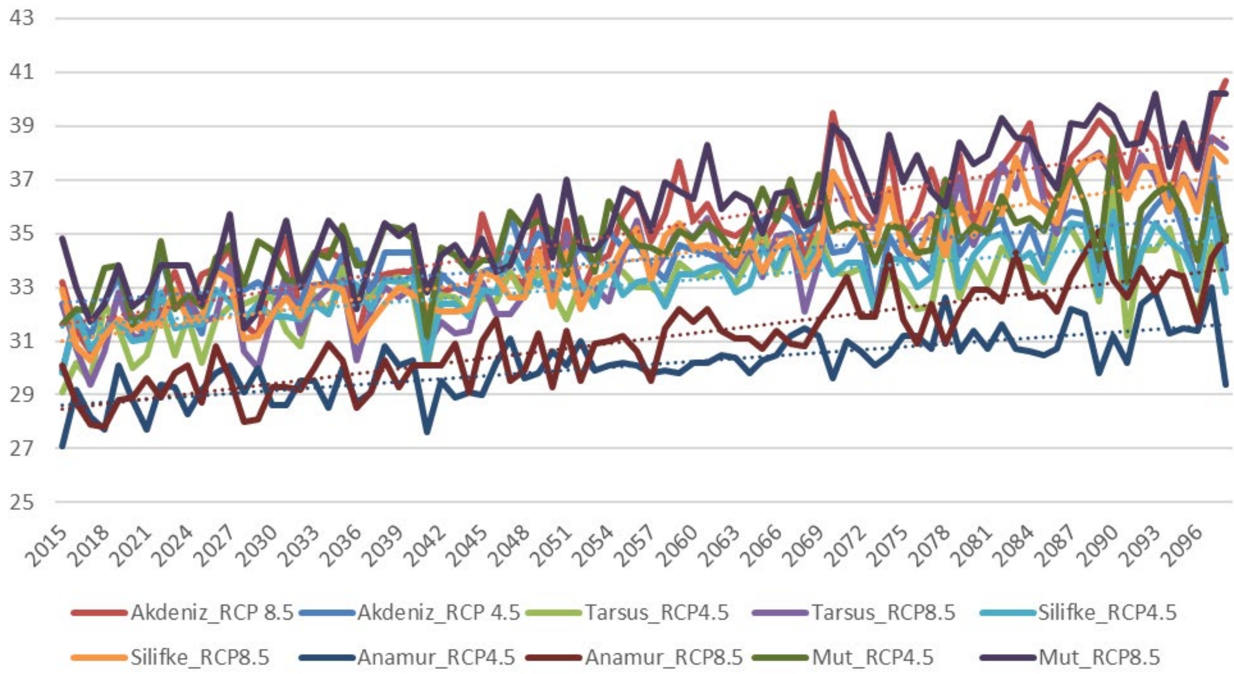



**Figure 4.62:** Forecasts of maximum temperatures

When temperature and humidity are combined, the level of warmth that people feel changes. Therefore, the apparent temperature or heat index is calculated by combining temperature and humidity to measure the thermal sensation of indoor conditions (Steadman RG, 1984). This index was developed by R. G. Steadman and is widely used to describe human thermal comfort. According to Steadman, the amount of moisture near the surface regulates the processes of evaporation and perspiration. Therefore, humidity level is as important as temperature in determining human comfort. However, as greenhouse gas concentrations in the atmosphere increase, tropospheric water vapor concentrations will also increase. This increase poses another threat to the human comfort range as increased humidity levels (Unal, Y., Tan, E., Mentes, S.S., (2013). Sensible temperature is an important tool used to determine the thermal sensation of indoor conditions.

According to the RCP4.5 and RCP 8.5 scenarios, sensible temperature values were calculated using the model's prediction values for the coming years and are given in Figure 4.63. According to the results, the sensible temperature is predicted to push 50 ºC. It is determined that the upward trend in sensible temperatures will continue in the future.

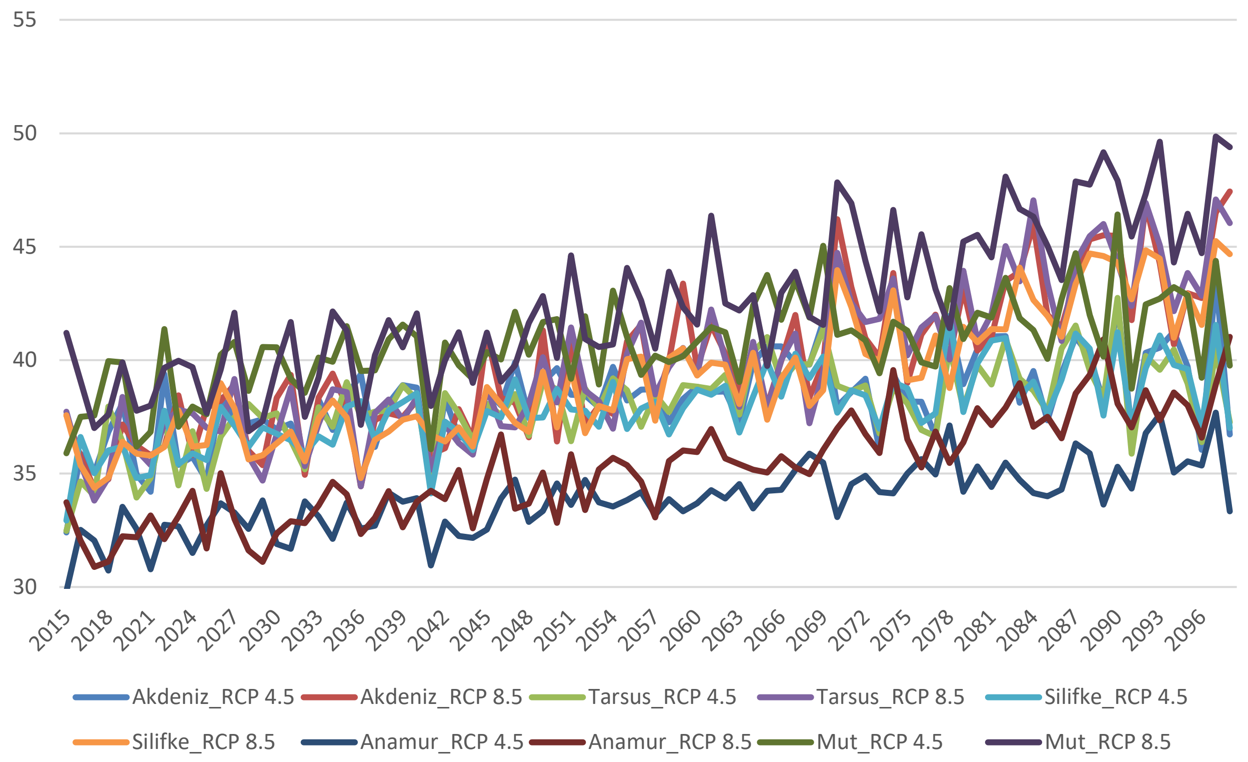



**Figure 4.63:** Sensible temperature forecasts

### Drought

Another climate risk identified for Mersin is drought. It is a climate risk that Mersin is likely to be exposed to due to the increasing average temperatures and decreasing precipitation trend in the region. According to the Turkey Drought Projections Report (MGM_b, 2021), the importance of a drought index based directly or indirectly on temperature inputs is increasing due to global warming. In this case, meteorological drought events that have occurred and are likely to occur across Turkey were analyzed. The analysis was examined in spatial and temporal dimensions using the Standardized Precipitation-Evapotranspiration Index (SPEI) method. Since the SPEI method is based on the climatic water balance (Precipitation - Evapotranspiration), it is recommended for the identification of dry periods (Vicente-Serrano et al., 2010). The classification of SPEI index values is defined as 2.00 and above (extremely humid), 1.50 -1.99 (very humid), 1.00 - 1.49 (moderately humid), 0-0.99 (slightly humid), 0 - (-0.99) (slightly arid), (-1.00) - (-1.49) (moderately arid), (-1.50) - (-1.99) (severely arid), (-2.00) and below (extremely arid).

SPEI drought index time series graphs provide information about the conditions or environment (semi-arid, arid, semi-humid, humid, or humid, etc.) in terms of climatic conditions. In order to evaluate the changes of humid and arid periods of the stations, the time series graphs of the current observations and HadGEM2-ES (RCP4.5) projection at SPEI-12-month scales are taken from the relevant report and shared in Figure 4.64. According to the 12-month evaluations of the SPEI value stated in the report, it is predicted by the projection studies that the region, which is currently defined as moderately arid, will continue to be moderately arid in the 2050 period. Municipal authorities may need to consider many measures to cope with drought, including water conservation, alternative water sources, water reuse and irrigation planning during drought periods.

Drought duration is the length of the period starting from when SPEI values are negative (including the starting month) and ending when they are equal to 0 (zero) consecutively (not including the ending month). More precisely, the number of months of drought from the start of the drought to the end of the drought is expressed by the drought duration.

In addition, drought severity is the cumulative SPEI values obtained by summing the remaining index values over the drought period. Drought severity refers to the magnitude of the drought. In other words, the drought severity experienced during the drought period indicates how severe the drought is. Therefore, it is important to consider factors such as drought duration and drought severity in drought analysis.

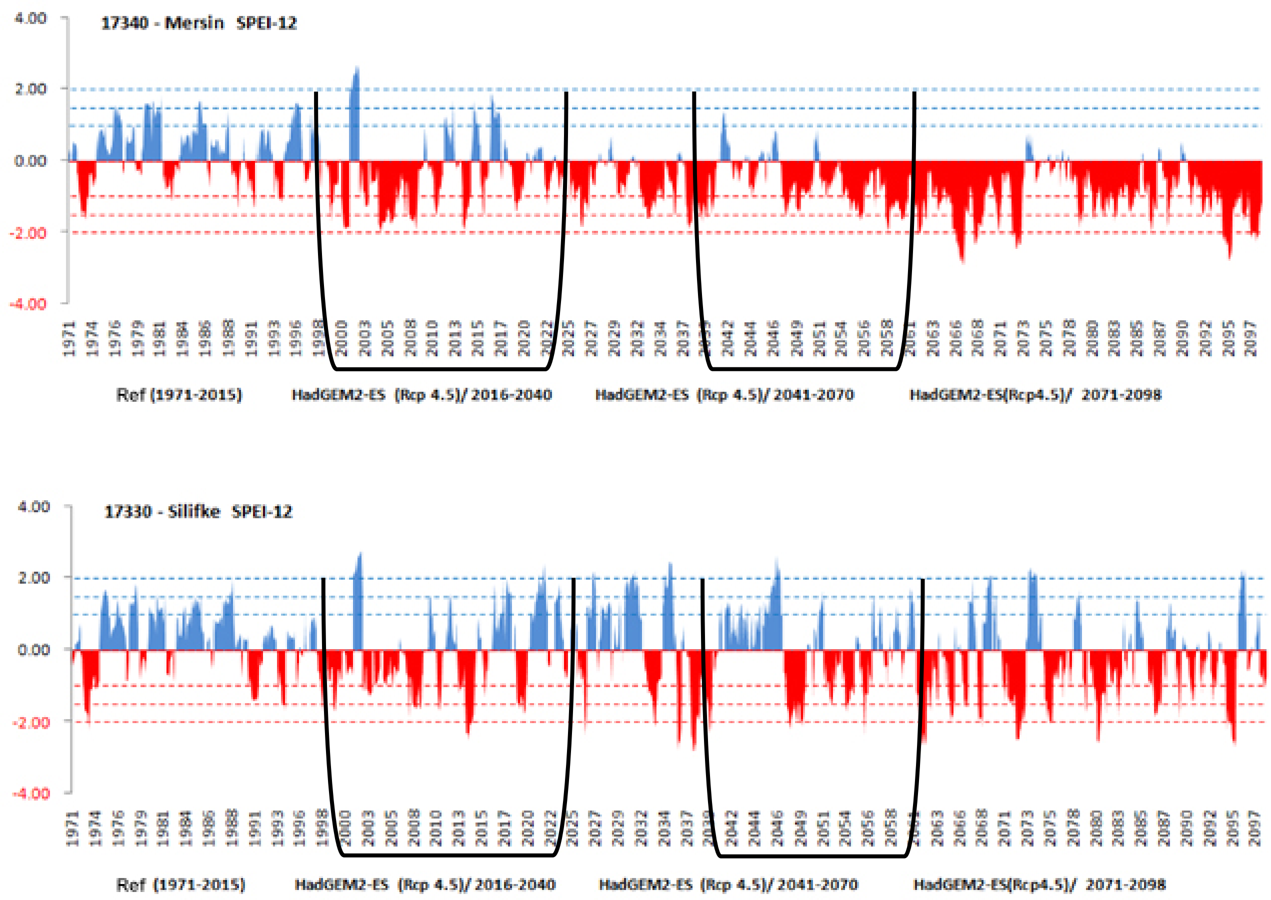
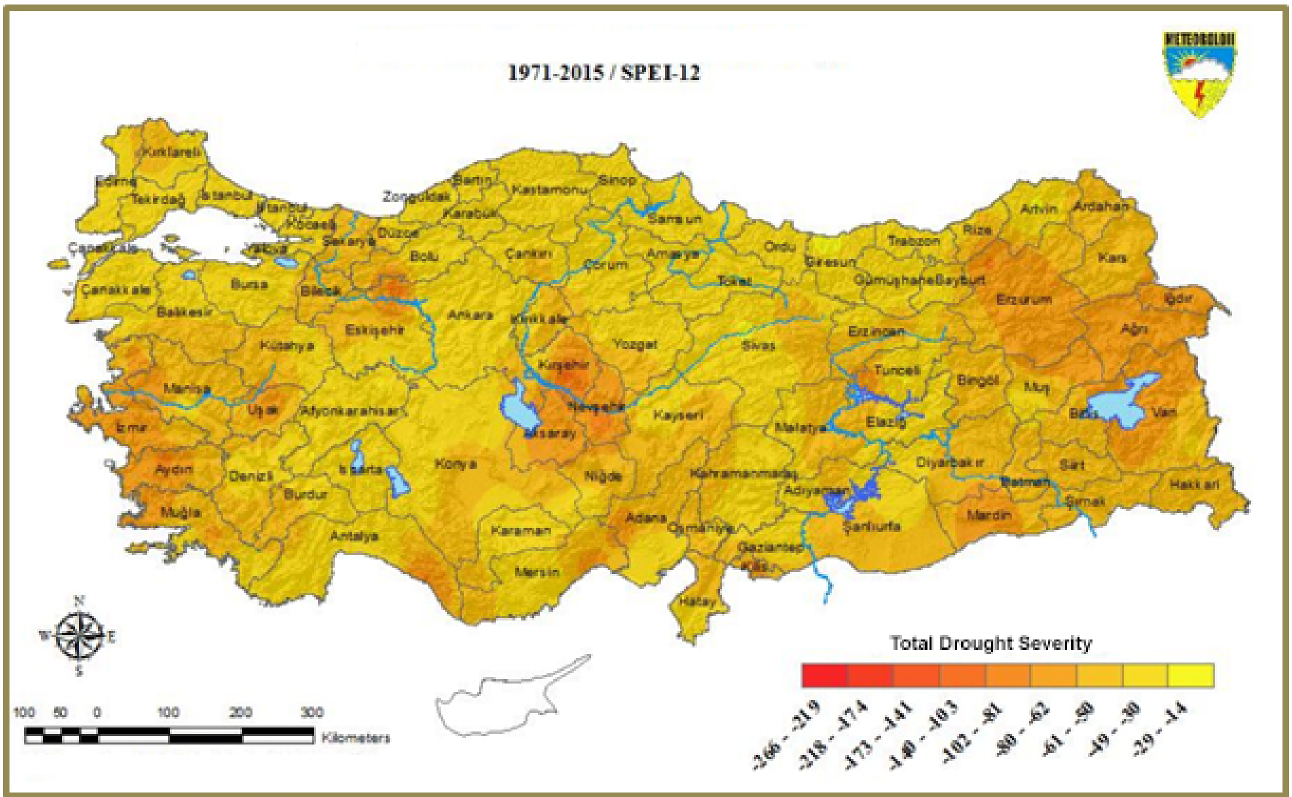



**Figure 4.64:** SPEI-12 Time-dependent Changes of HadGEM2-ES (RCP4.5) Projection at Mersin and Silifke Stations at Monthly Scales (MGM, 2021)

Drought maps representing the past situation and future projections prepared for Turkey are given. According to the results obtained from the relevant report, the total drought severity calculated as (-

80) - (-62) for Mersin between 1971-2015 is projected to be (-218) - (-174) between 2041-2070 according to the HadGEM2-ES model RCP4.5 scenario (Figure 9.65). With an average drought duration of 66-76 days, the province has a 20% frequency of dry day risk. For 2050, a significant increase in the number of dry days is expected in the region (161-228) and the probability of encountering risk is predicted to be 62% (Figure 4.66).



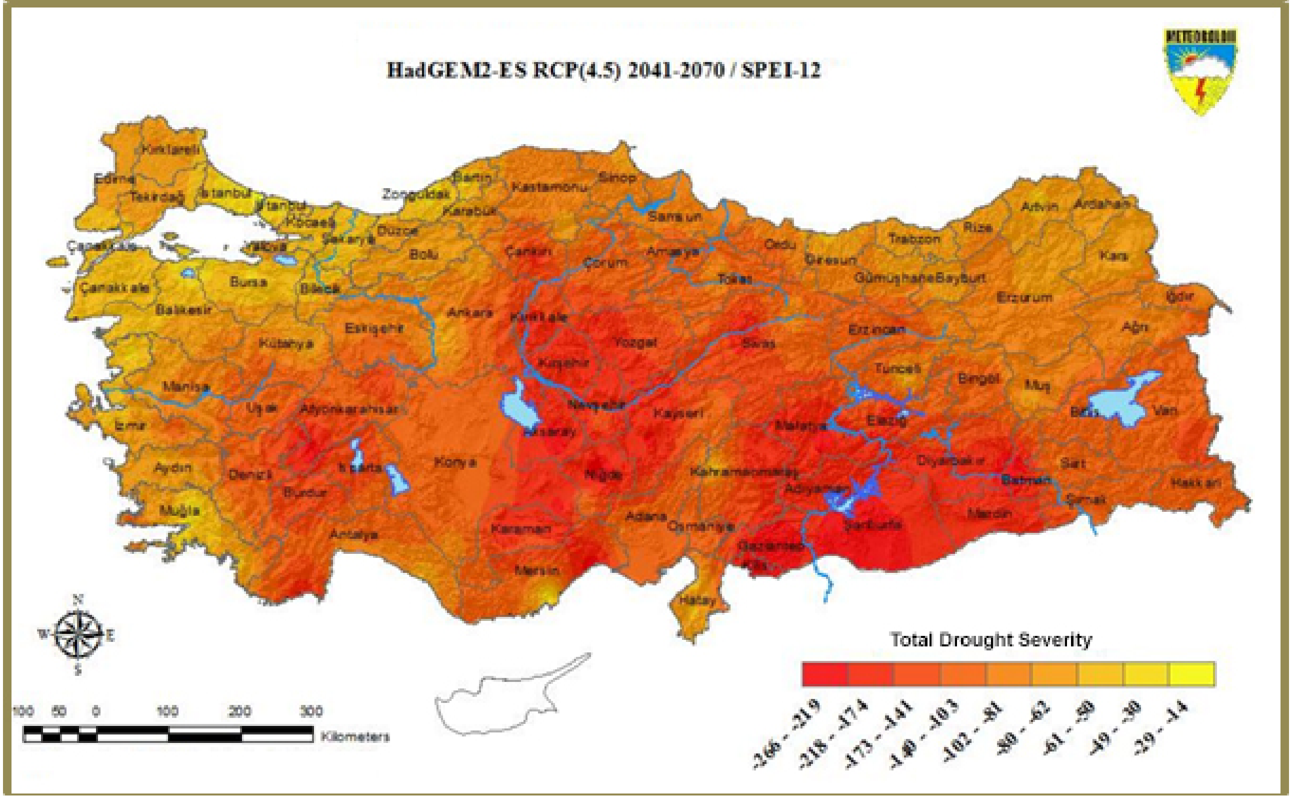
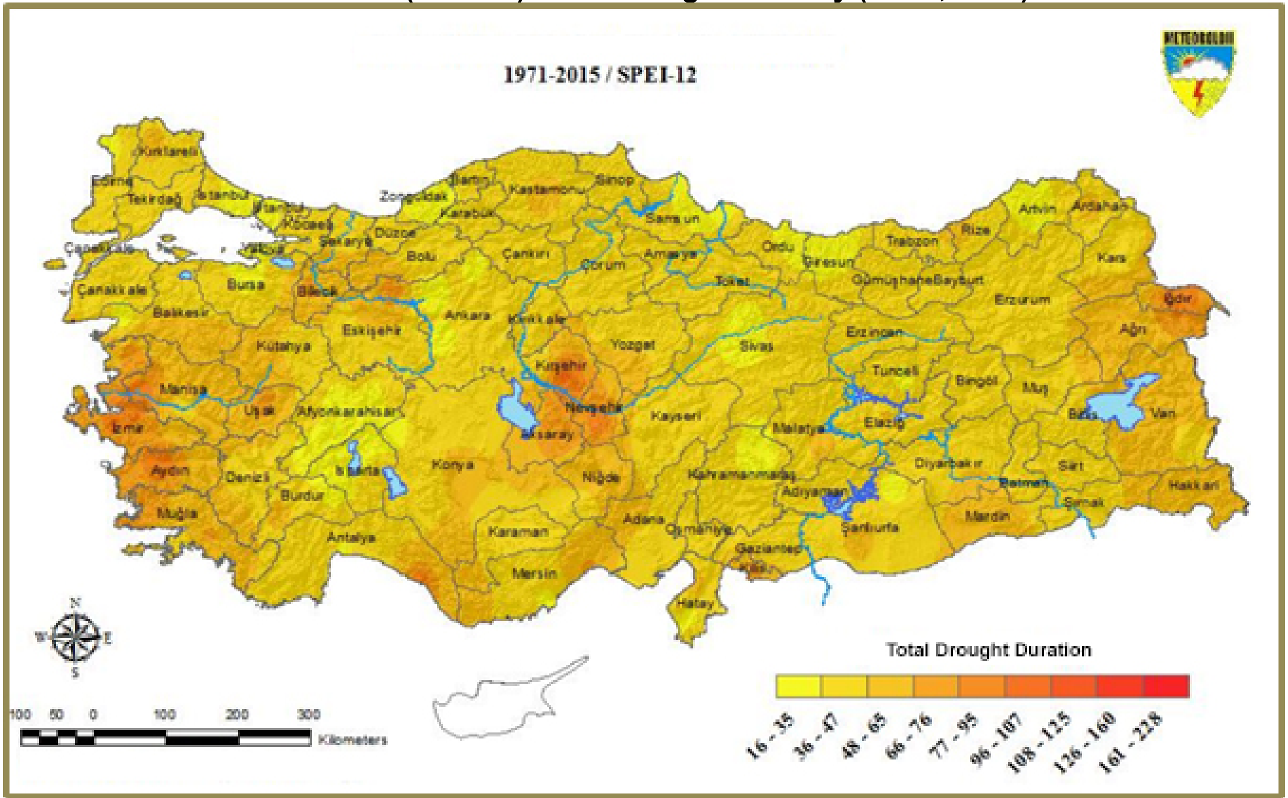



**Figure 4.65: SPEI-12 (1971-2015) Total Drought Severity and (2041-2070) HadGEM2-ES (RCP4.5) Total Drought Severity (MGM, 2021)**



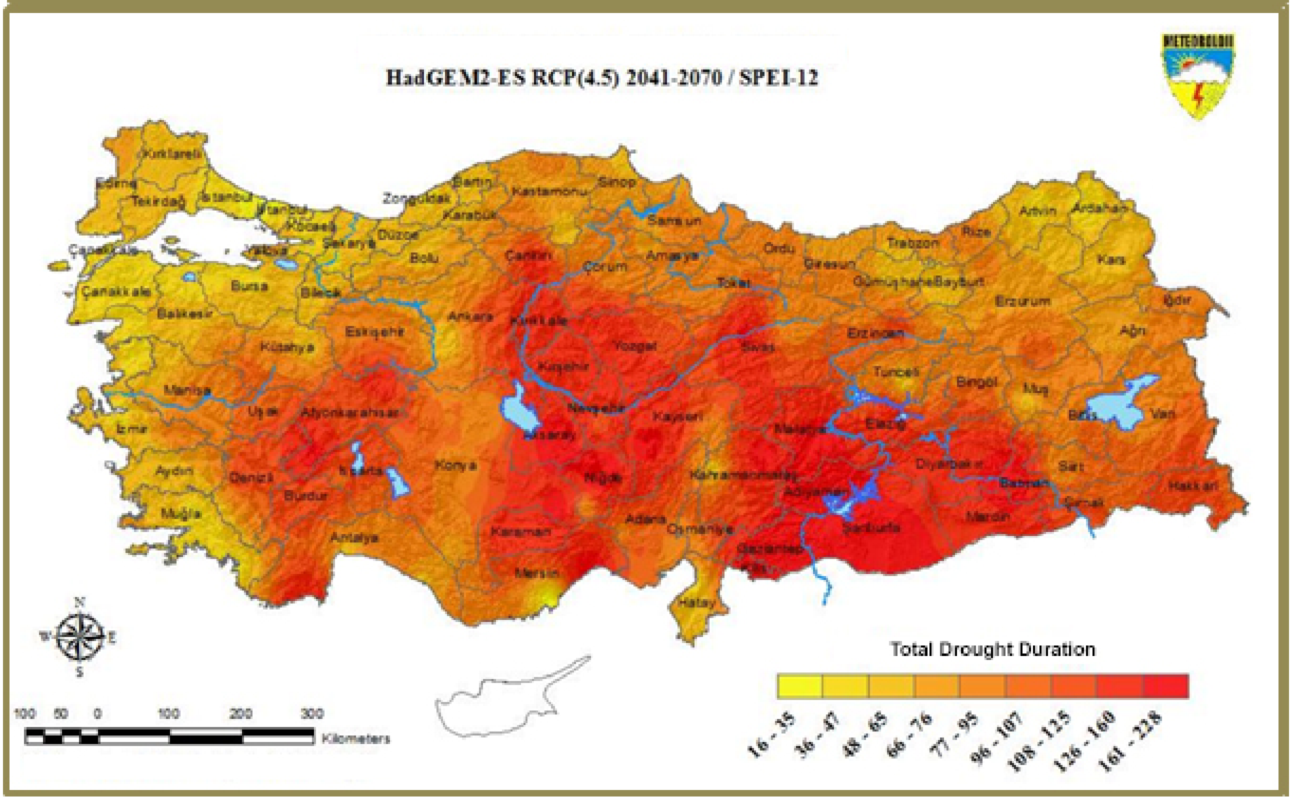




**Figure 4.66: SPEI-12 (1971-2015) Total Drought Duration and (2041-2070) HadGEM2-ES (RCP4.5) Total Drought Duration (MGM, 2021)**

## Heavy Rainfall and Flooding

Extreme rainfall and floods are a major climatic phenomenon for residential areas and can strain the city's infrastructure, cause serious damage to homes and businesses, and even lead to loss of life. These impacts can be manifested in various ways, such as damage to buildings by flood waters, inundation of infrastructure, collapse of roads and bridges. To combat extreme rainfall and flooding, it is important for cities to establish effective disaster management plans and strengthen infrastructure. These efforts should include measures such as managing flood waters, improving storm water drainage systems, and creating areas with permeable surfaces to reduce the impacts of floods. It is also crucial to increase the capacity for rapid response in the event of a disaster. In this way, loss of life and damage can be minimized.

According to the Eastern Mediterranean Basin Flood Management Plan prepared by the abrogated Ministry of Agriculture and Forestry General Directorate of Water Management (MoAF, 2019), the flood risk areas in Mersin were identified and the risk levels of the flood areas were determined by evaluating them in terms of health, environment, cultural heritage and economy according to the severity and recurrence interval of the flood. Flood impacts in these areas were also evaluated in terms of the population to be affected and the results are given in Table 4.5. In the economic evaluation, it was determined that Tarsus district will suffer the most damage and Silifke is the highest district in terms of the population to be affected.

**Table 4.5:** Flood risk assessment of Mersin

| District | Flood Risk Level | Maximum Population Affected (%) |
|---|---|---|
| Tarsus | Very High | 18,44 |
| Akdeniz | High | 13,26 |
| Silifke | Medium | 34,94 |
| Toroslar | Low | 0,25 |
| Yenişehir | Low | 2,00 |
| Bozyazı | Very Low | 13,33 |
| Erdemli | Very Low | 9,96 |
| Mezitli | Very Low | 1,71 |
| Anamur | Very Low | 3,47 |
| Aydıncık | Very Low | 0,24 |
| Çamlıyayla | Very Low | 0 |

Berden Stream, Kanal 1-2-3-6, Kuskun stream, Tarsus 1-2 streams, Kocadökük stream, Kocadere and Karabucak stream in Tarsus have been identified as very high in terms of priority of measures and measures for passage structure improvement, bed adjustment and cleaning, and embankment arrangement are recommended in the Eastern Mediterranean Basin Flood Management Plan (MoAF, 2019). It is stated in the report that similar measures should be taken for Deliçay, Kesikköprü Stream, İçme Stream, Çomaklı Stream and Melemez Stream in Akdeniz district in high priority class. In Silifke, which is in the medium priority class, it is recommended to take measures for Taşucu

Stream, Yeşilovacık Stream, Şehirler Stream, Akarca Stream, Bebek Stream, Afşar Stream, Yeşilovacık Stream, Şehitler Stream, Göksu River and Susanoğlu Stream.

When we look at the disaster data of MGM for the last 20 years (Figure 4.61), the frequency of encountering extreme precipitation and flood disasters at least once a year is determined as 55% in the central districts of Mersin, while it is calculated as 60% in other districts. As shown in Figure 4.50, when we examine the climate projections for 2050, it is seen that 20 mm/day of precipitation, which is defined as heavy precipitation by MGM, will fall in the region for more than 4 days on average per year. In Figure 4.53, it is determined that the average maximum precipitation amount to be experienced in 1 day is more than 30 mm/day. For the year 2050, the frequency of extreme precipitation and flood risk is predicted to be high when the relevant projections are analyzed.

The spatial distribution map of extreme precipitation and flood events in Mersin prepared by the European Severe Weather Center based on the information and data observed, reported or obtained from various news sources and verified during the period 2000 - 2022 is given in Figure 4.67.


**Figure 4.67:** Areal distribution of extreme precipitation events in Mersin (ESWD, 2023)

### Storms and Tornadoes

Storms and tornadoes can cause damage to buildings, trees and infrastructure in cities, as well as power outages, flooding and transportation problems. Winds above 34 knots are defined as storms by MGM. It is extremely important for cities to be prepared to deal with storms and tornadoes. Creating a good emergency plan, providing accurate information to the public and taking advanced infrastructure measures can increase resilience to such events. It is also crucial that buildings are constructed and regularly maintained to withstand the risk of storms and tornadoes. To minimize the impacts of storms and tornadoes on cities, it is necessary to follow meteorological forecasts, use early warning systems and raise public awareness. In this way, it may be possible to ensure the safety of people and minimize potential damages. It is also important to create a comprehensive disaster management strategy that includes recovery and recovery processes. In this way, cities can become more resilient and cope with disasters more effectively. When we look at MGM's disaster data for the last 20 years (Figure 4.61), the frequency of encountering storm and tornado disasters at least once a year is 90% in Mersin's central districts and 70% in other districts.

The areal distribution map of storm and tornado events in Mersin prepared by the European Severe Weather Center based on the information and data observed, reported or obtained from various news sources and verified during the period 2000 - 2022 is given in Figure 4.68. While tornadoes are more common in Silifke and Anamur regions, thunderstorms are generally recorded in Erdemli region. In the current situation, the probability of encountering storms and tornadoes is very high and it is predicted that the probability of encountering them at least once a year will continue in the future. The increasing intensity and impact of storms and tornadoes are closely related to changing climatic conditions. Increased surface and lower atmospheric temperatures, increased evaporation and increased water vapor content of the atmosphere lead to an increase in the formation of tornadoes. For this reason, it is predicted that the frequency of storms and tornadoes may increase in the coming periods.

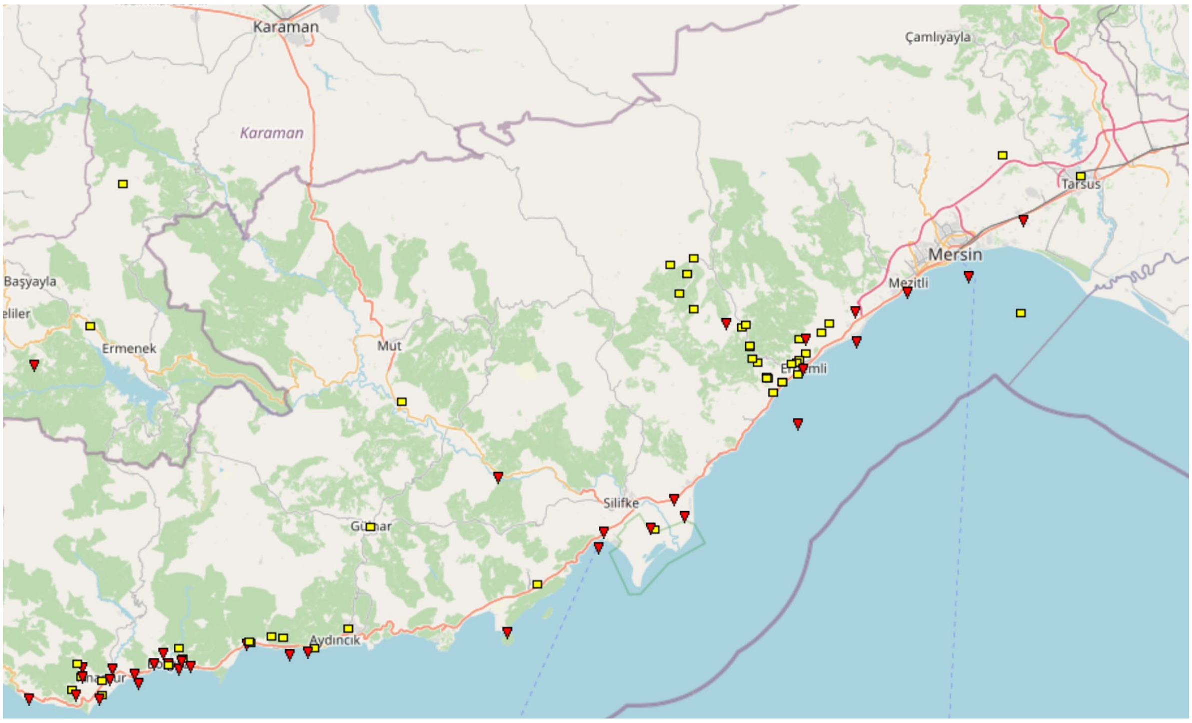



**Figure 4.68:** Areal distribution of storm and tornado events in Mersin (Yellow: Storm, Red: Tornado) **(ESWD, 2023)**

### Hail

In the formation of hail, cooled water droplets in Cumulonimbus (Cb) clouds are carried by upward movements and rise above the freezing level and freeze into ice. High intra-cloud circulation causes hailstones to grow. Fast upward drafts in the cumulonimbus are a sign of very warm air on the ground and cold air at the upper levels. The temperature difference between the cloud base and the top is large. For this reason, hail events are usually observed in warm seasons. They are very rare in the colder months when the freezing level is at or near the ground.

Hail events can cause serious damage to structures and facilities in the city. Hail can also damage power lines and infrastructure. In addition, hail can also have negative impacts on the agricultural sector. It can damage agricultural products and disrupt the harvest period.

When we look at MGM's extreme weather events for the last 20 years (Figure 4.61), the frequency of encountering hail at least once a year is determined as 50% in Mersin's central districts, while it is calculated as 75% in other districts. The spatial distribution map of hail events in Mersin prepared by the European Severe Weather Center based on the information and data observed, reported or obtained from various news sources and verified during the period 2000 - 2022 is given in Figure 4.69. It can be seen that hail events are mostly experienced in Erdemli, Silifke and Tarsus regions.

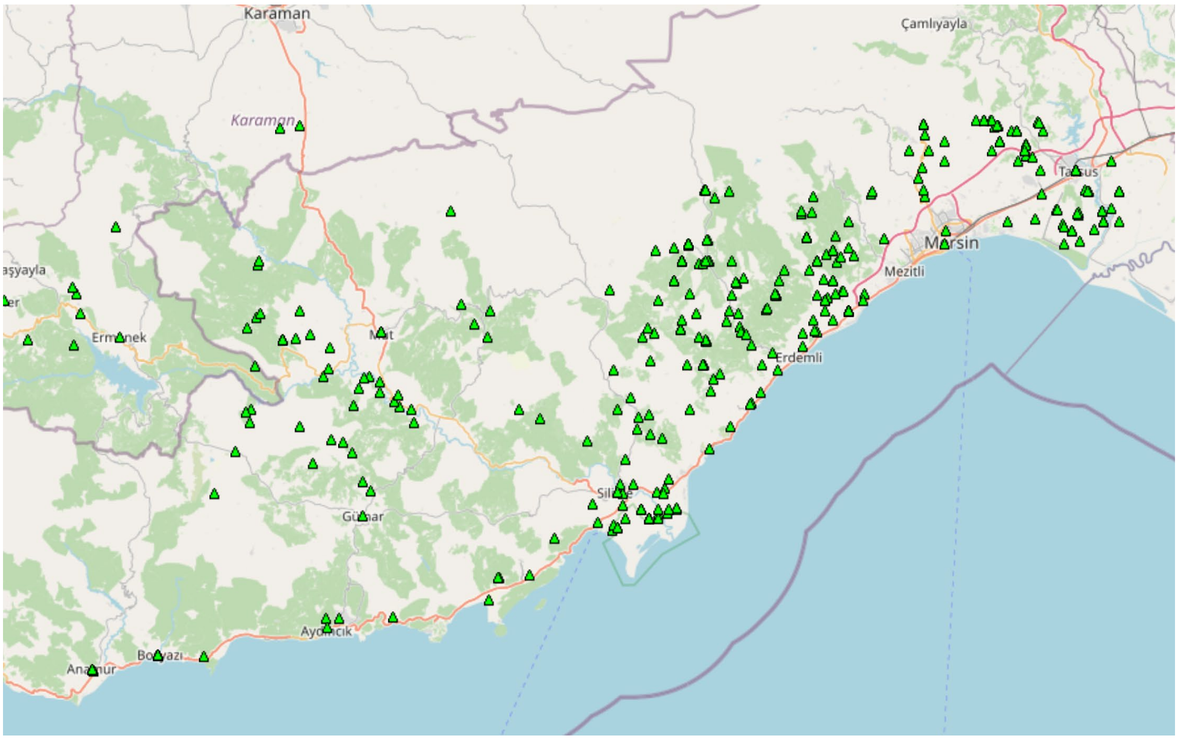



**Figure 4.69:** Areal distribution of hail events in Mersin (ESWD, 2023)

It is predicted that the probability of encountering hail events in the region today will continue with high frequency in the future periods due to high increases in surface temperatures and sudden changes to be experienced.

### Snow

Snowfall is usually formed by stratiform clouds. However, if it is in the form of showers, it comes from cumuliform clouds. Temperature is important for snowfall to occur. The temperature at ground level must be close to 0°C, at or below zero degrees Celsius.

Heavy snowfall is one of the events that adversely affects life in many aspects, especially transportation in cities. When we look at MGM's disaster data for the last 20 years (Figure 4.61), we see that there has been no recorded snow event except for the central district. In the central districts of Mersin, the frequency of encountering snow disasters at least once a year is determined as 15%. As shown in Figure 4.42 and Figure 4.46, the number of icy days approaches 0 in each scenario, and the minimum of minimum temperatures rises above 0°C.

It is predicted that the probability of encountering snow and icing events experienced in the region today will not increase in the future periods due to high increases in surface temperatures and sudden changes to be experienced.

### Lightning Strike

Lightning is a high-voltage electrification between the cloud and the ground. It is caused by the potential difference between the cloud and the ground, which have different electrical charges. Lightning occurs in vertically developed cumulonimbus (Cb) clouds, sometimes from the cloud to the ground and sometimes from the ground to the cloud. Lightning, thunder and downpours are symptoms of cumulonimbus clouds.

Lightning strikes can cause various adverse effects in urban areas, such as damage to buildings, fire risk, power outages and human health impacts. Lightning strikes can damage electrical systems in buildings, damaging roofs, walls and other components. Lightning strikes can also cause fires in buildings or surrounding vegetation. Lightning strikes can damage power lines or substations, leading to power outages. In addition to these effects, the energy waves generated by lightning strikes can harm people, causing electric shocks, burns and other serious injuries. Therefore, it should be taken into account that lightning strikes can cause serious problems in cities and necessary safety measures should be taken.

When we look at MGM's storm data for the last 20 years (Figure 4.61), the frequency of encountering storm and tornado disasters at least once a year in Mersin's central districts is determined as 15%, while it is calculated as 10% in other districts. Figure 4.70 shows the spatial distribution map of lightning strikes in Mersin prepared by the European Severe Weather Center based on the information and data observed, reported or obtained from various news sources and verified during the period 2000 - 2022. The number of lightning disasters recorded in the province is very low.

Currently, the increasing trend in the probability of encountering lightning strikes in the region is not significant. However, it is assumed that it will continue with similar frequency in the future due to high increases in surface temperatures and sudden changes in other climatic parameters.


**Figure 4.70:** Areal distribution of lightning strikes in Mersin (ESWD, 2023)

### Wildfires

The Fire-Weather Index is an approach for estimating the intensity of fire danger and the size of potential fires, produced by considering as inputs the variables of air temperature, relative humidity, wind speed of 10 meters, and total precipitation in the previous 24 hours for each day. For the data calculated and published by Copernicus Climate Service, the 3-hour outputs of various global and regional climate models are used. These climate models consist of several models developed by EURO-CORDEX. With the RCA4-RCM model, the necessary evaluations for the indices are made and the critical values required for the calculation of the index are produced. The use of the index provides guidance on developing firefighting strategies and responding more effectively to fire incidents. This information has been compiled for Mersin province and the fire weather index and the number of days with fire hazard are presented in Figure 4.71 and Figure 4.72 for future years according to different scenarios.

If the fire weather index is between 38-50, the fire risk is defined as "very high"; if it is above 50, it is defined as "extreme". When the calculation results are analyzed, Mersin is characterized as one of the provinces with "very high" fire risk. Again, when the model results are evaluated, it is expected that there will be an increase in the number of days with forest fire risk for Mersin in the future. These results are important for firefighting teams to direct their resources more effectively and to be better prepared for fire hazards.

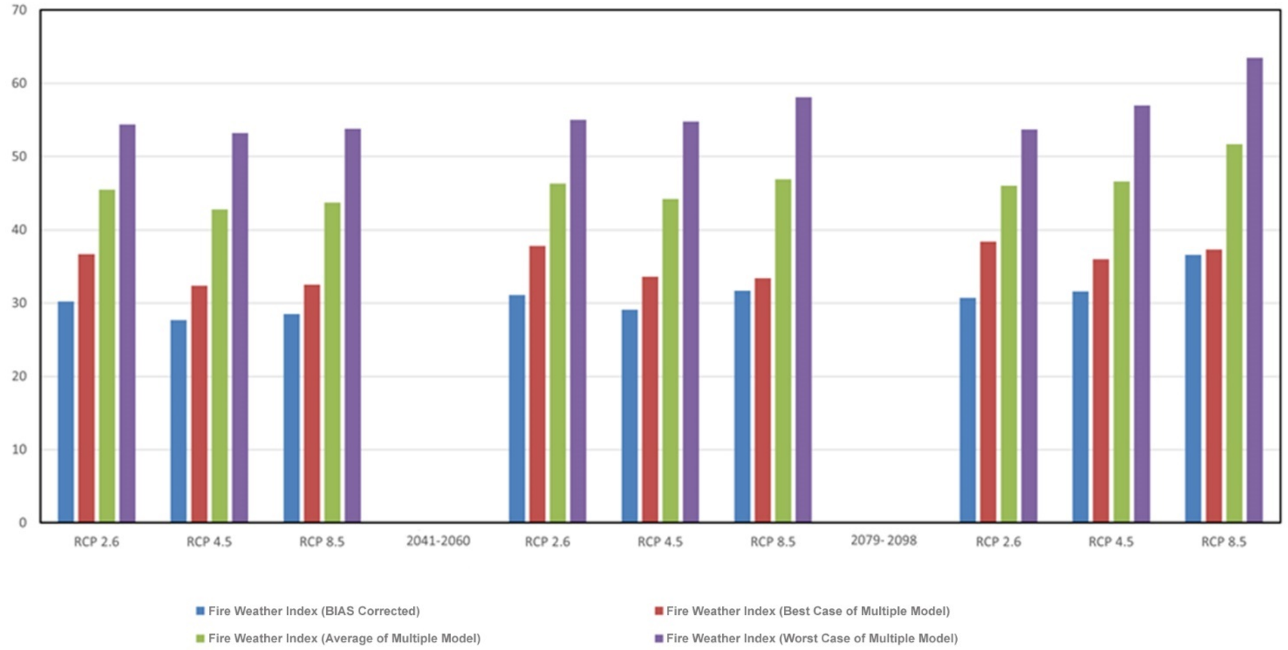



**Figure 4.71:** Average Fire Weather Index for Fire Season

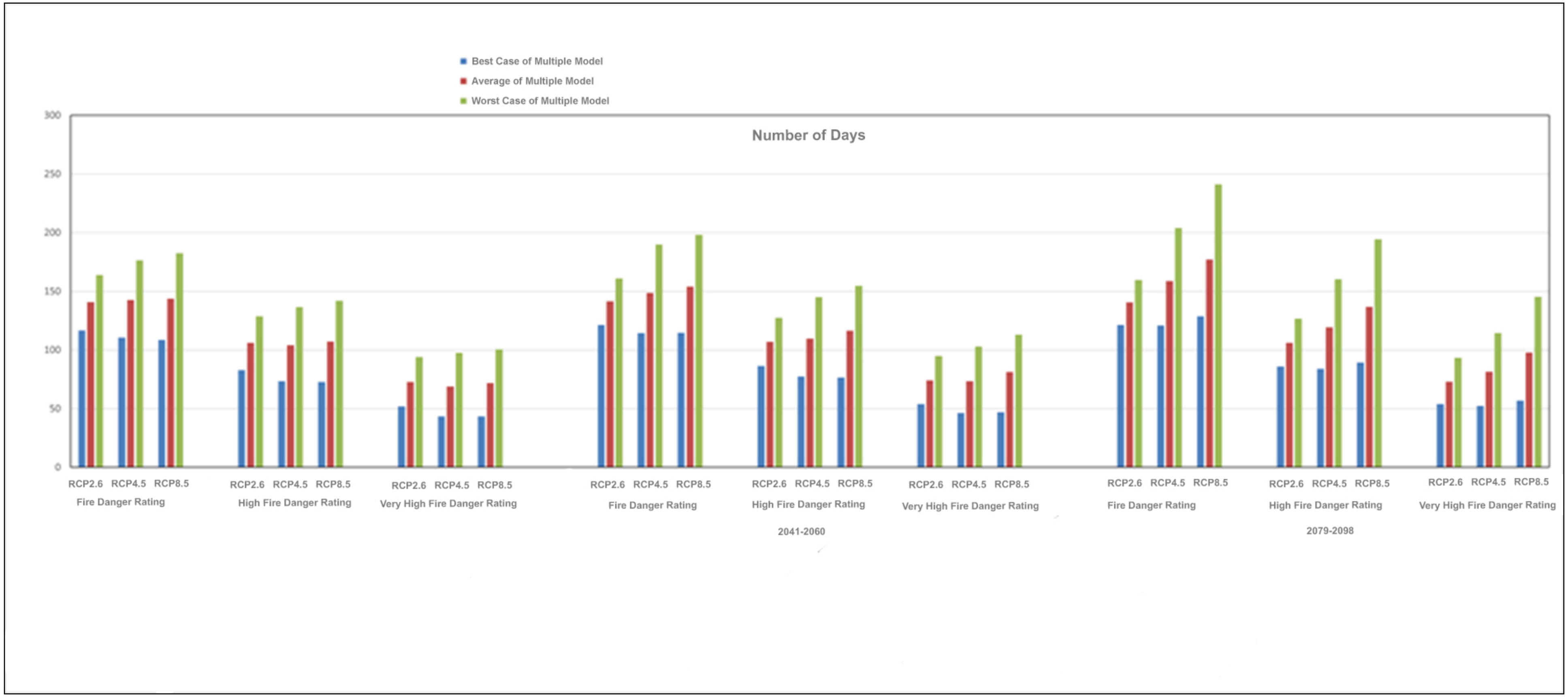



**Figure 4.72:** Number of days foreseen according to the Fire Danger Rating during the year

## Sea Level Rise

According to the IPCC 6th Assessment Report, it is predicted that the melting of glaciers will increase with global warming and that these effects will be felt more severely especially at the poles. It is stated that water forms below sea level will also be affected by these effects and an increase in sea levels is expected. Global average sea level increases vary regionally. Since the 1970s, a rapid increase in sea level has been observed with the increase in anthropogenic impacts. The rise values, which were 1.4 mm/year in the 1901-1990 period, were observed as 2.1 mm/year in the 1970-2015 period and 3.2 mm/year in the 1993-2015 period. In the 2006-2015 period, this increase was observed to be 3.6 mm/year. According to the RCP 8.5 scenario, a sea level rise of 10-20 mm/year is predicted until 2100. Therefore, based on the information obtained, the negative situations that may be caused by sea level changes and storm waves in our country are as follows. The assessments within the scope of the study were made to cover Mersin and the Eastern Mediterranean coastline. IPCC 6th Assessment Report and NASA's "Sea Level Change and Projection Tool" were used as data sets. Results were obtained according to various SSP simulations with reference to the period 1995-2014. A reference point (Latitude: 36º, Longitude 34º) representing Mersin and the Mediterranean coastline was selected. The simulation results of the sea water level change at the selected location for the most pessimistic scenario (SSP5-8.5), the most optimistic scenario (SSP1-2.6) and the middle path (SSP2-4.5) are shown in Figure 4.73.

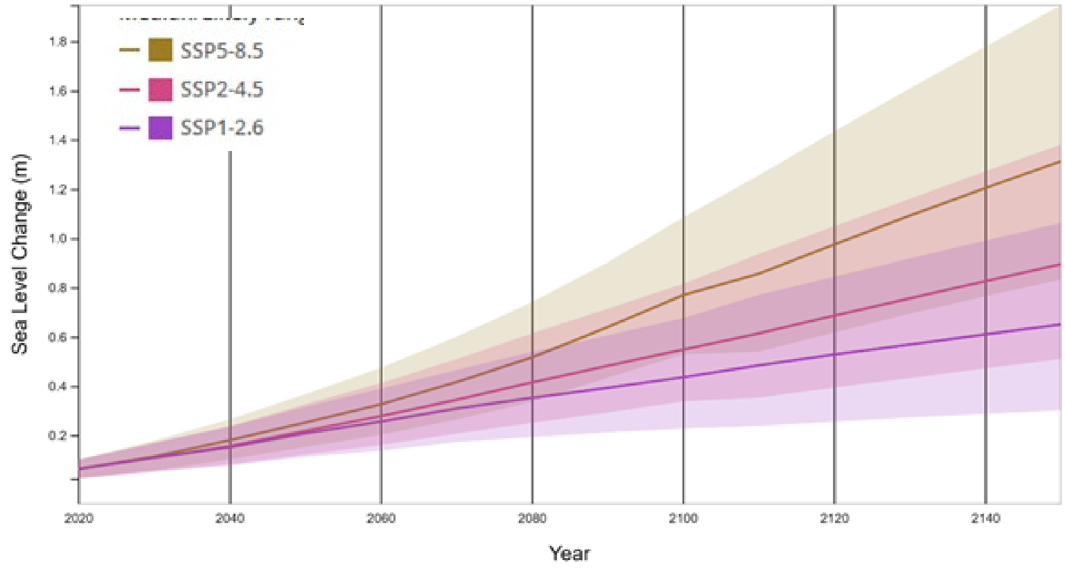



**Figure 4.73:** Sea level change according to SSP simulations

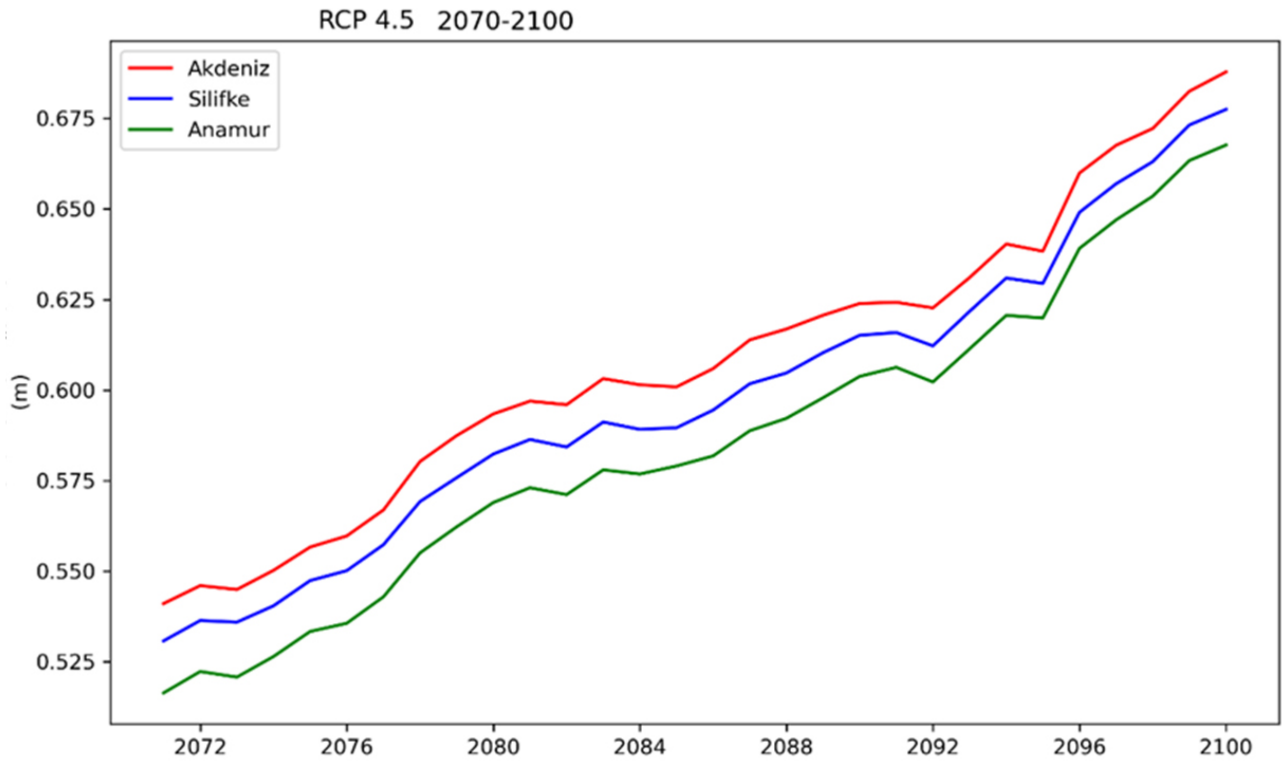
The change in the graph in Figure 4.73 for all scenarios and by years is given in detail in Table 4.6. According to the assessments, in the most optimistic scenario, the sea level in the region is projected to rise by approximately 0.2 m in 2050 and 0.35 m in 2100. In the worst case scenario, this increase is estimated to reach 0.25 m in 2050 and 0.8 m in 2100.

**Table 4.6:** Change values and total change amounts at the selected location point according to the SSP scenarios

| | SSP1-1.9 | SSP1-2.6 | SSP2-4.5 | SSP3-7.0 | SSP5-8.5 | SSP1-2.6 Low Confidence | SSP5-8.5 Low Confidence |
|---|---|---|---|---|---|---|---|
| **Total Change (m) (2030)** | 0.11 (0.03–0.18) | 0.11 (0.05–0.17) | 0.11 (0.06–0.17) | 0.11 (0.04–0.17) | 0.11 (0.06–0.18) | 0.11 (0.05–0.18) | 0.12 (0.05–0.19) |
| **Total Change (m) (2050)** | 0.18 (0.06–0.31) | 0.21 (0.11–0.32) | 0.22 (0.12–0.33) | 0.23 (0.13–0.34) | 0.25 (0.15–0.37) | 0.21 (0.11–0.35) | 0.26 (0.15–0.43) |
| **Total Change (m) (2090)** | 0.35 (0.15–0.57) | 0.39 (0.21–0.61) | 0.48 (0.29–0.71) | 0.56 (0.37–0.80) | 0.64 (0.43–0.90) | 0.40 (0.21–0.69) | 0.71 (0.43–1.24) |
| **Total Change (m) (2100)** | 0.35 (0.14–0.60) | 0.44 (0.23–0.68) | 0.55 (0.34–0.81) | 0.66 (0.43–0.95) | 0.77 (0.53–1.08) | 0.45 (0.23–0.78) | 0.88 (0.53–1.51) |
| **Total Change (m) (2150)** | 0.53 (0.18–0.93) | 0.65 (0.30–1.06) | 0.90 (0.51–1.38) | 1.13 (0.69–1.67) | 1.31 (0.83–1.95) | 0.70 (0.30–1.26) | 1.96 (0.83–4.81) |
| **Change Value (mm/yıl) (2040-2060)** | 4.0 (1.0–7.0) | 5.0 (2.0–8.0) | 5.0 (3.0–8.0) | 6.0 (3.0–9.0) | 7.0 (4.0–10.0) | 5.0 (2.0–9.0) | 7.0 (4.0–15.0) |
| **Change Value (mm/yıl) (2080-2100)** | 2.0 (0.0–5.0) | 4.0 (1.0–7.0) | 6.0 (3.0–10.0) | 9.0 (5.0–14.0) | 11.0 (7.0–17.0) | 4.0 (1.0–9.0) | 15.0 (7.0–30.0) |

Following the IPCC based time series, the period 2041-2070 was simulated for RCP 8.5 and the period 2071-2100 for RCP 4.5 using GTSM 3.0, Danish Meteorological Institute, EC-EARTH (GCM), HIRHAM5 (RCM) model configuration with various radiative forcing values (RCP 4.5 and RCP 8.5). The resolution on the coastline is specified as 0.1°x0.1°. In Mersin province, 3 points were selected to evaluate these simulation results. By entering the coordinates of Akdeniz (Center), Silifke and Anamur district center, the closest grid point on the sea was determined by the closest distance method and time series were plotted and given in

Figure 4.74. At all 3 points, despite the optimistic scenario, a rise in sea level exceeding 0.6 meters is expected in 2100.



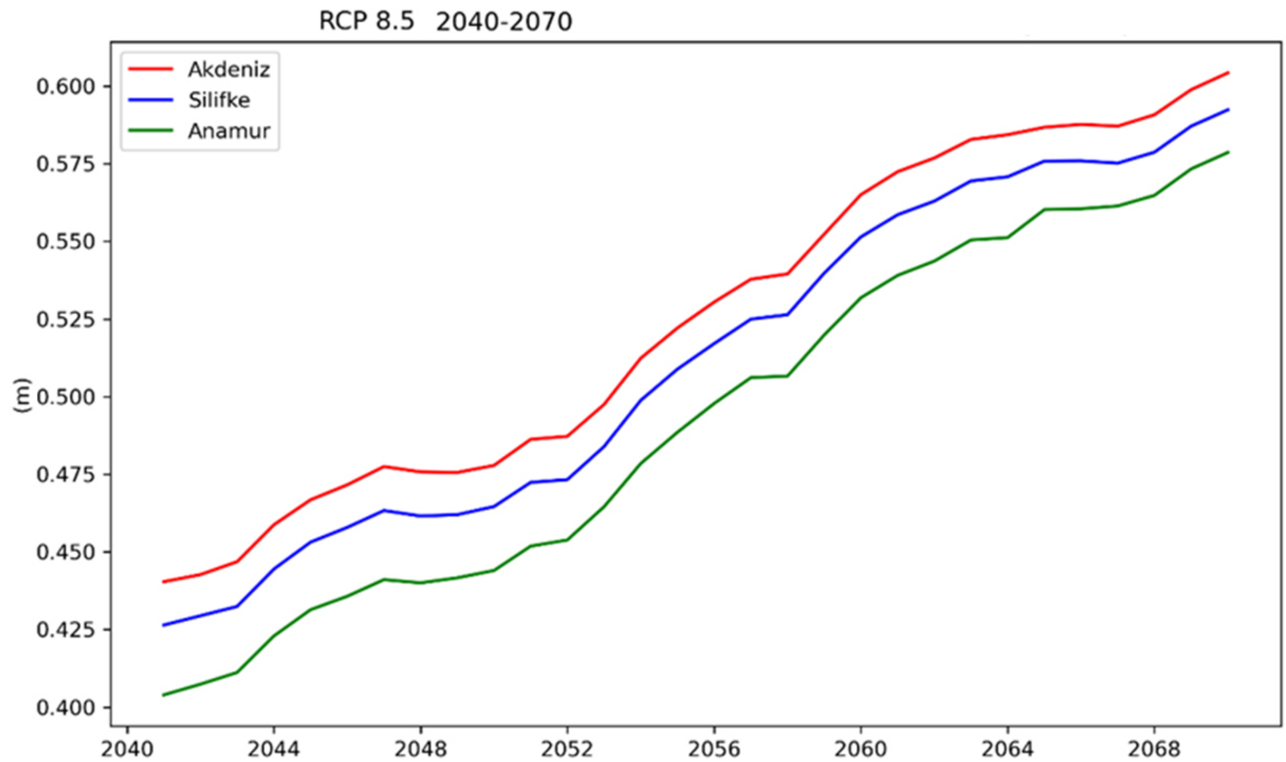




**Figure 4.74: District-based sea level change according to RCP 4.5 (2070-2100) and RCP 8.5 (2040-2070) scenarios**

As a result of two different assessments, the areas that will be affected in the province in case of a possible 0.8 m rise in sea level by 2100 are shown in Figure 4.75. It is thought that the sea level rise of approximately 0.8 m will affect Anamur and Silifke districts. Especially the Göksu Delta is predicted to be under risk.


**Figure 4.75:** Areas that would be affected if sea level rises by 0.8 m (Climate Central, 2023)

The expected changes in Eastern Mediterranean sea levels were obtained from Copernicus Climate Change Service based open access datasets. The purpose of these outputs is to predict sea level heights and to analyze the coastal changes such as coastal flooding and coastal erosion. The years 1951-1980 are taken as the reference period and the level changes in the target years are shown. According to the GTSM3.0-EC-EARTH-HIRHAM5 global climate model with RCP 8.5 scenario, the projected elevation values that will occur in the region by the end of 2050 are given in Figure 4.76. According to this scenario and model, it can be said that by the end of 2050, up to 0.5 meters of rise in the coastline is predicted.

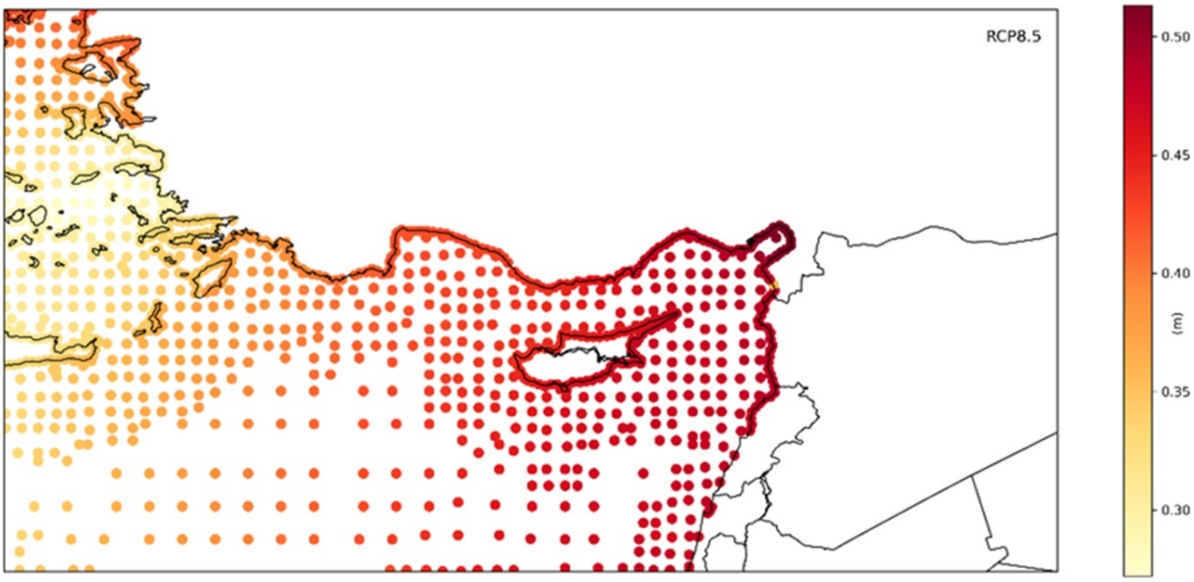



**Figure 4.76:** GTSM3.0-EC_EARTH_HIRHAM5 model sea level change in 2050

As a result of international studies, the increase in storm occurrences as a result of global climate change draws attention. "Storm surge" events, which are defined as storm waves, especially affect the settlement areas on the coastlines. Therefore, changes in sea levels and increases or decreases in the height of storm waves are important for coastal flooding. Storm wave heights are given in Figure 4.77. Although the wave heights caused by storms are generally distributed over the area in an increasing trend, especially in HadGEM3-based results as seen in Figure 4.77, it is also predicted to decrease in some places. Although the increases in these wave heights are quite limited compared to sea level rise, even the smallest increases in these waves are important in terms of coastal flooding and coastal erosion.

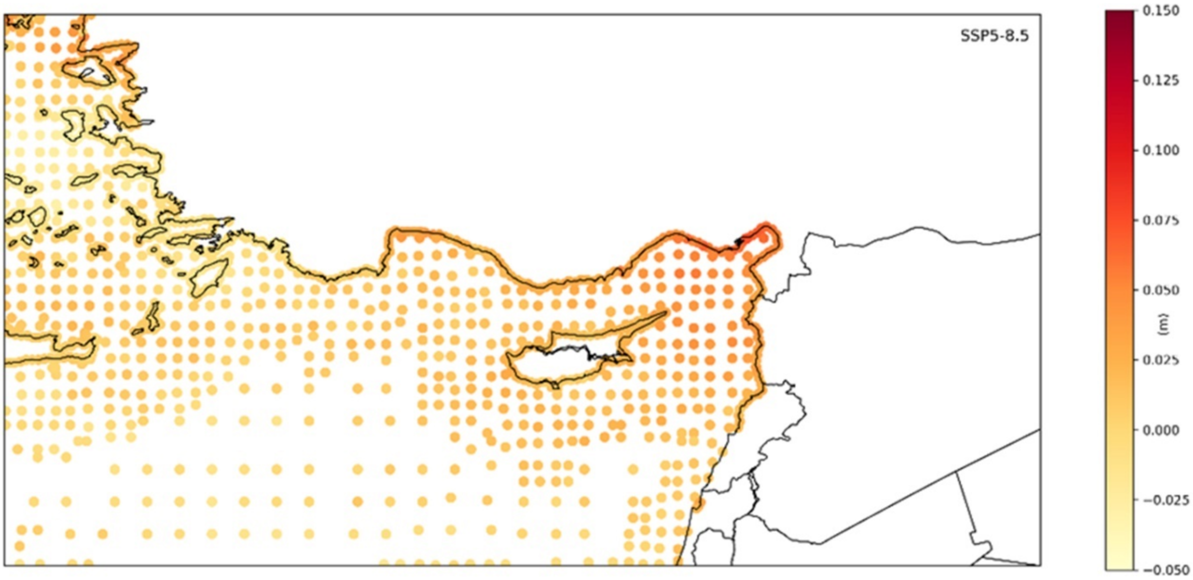



**Figure 4.77:** HadGEM3-GC31-HM-SST 2050 storm surge change

The projected increase in sea level and storm-induced wave heights in the region is expected to affect many sectors such as people living on the coastal line, commercial activities, transportation lines near the coast. According to the information obtained in most coastal flooding studies, digital elevation maps are used to define areas and simulate flood water heights and sea level rise along the coastline (Sande et al., 2012). Coastal flood risk analyses are performed by correlating the probability of flooding with the elevation obtained from the digital elevation map and the ratio of land/sea distribution on the coastline, as well as the socio-economic activities on the coastline. While conducting these analyzes, the lowest height level for risk management and identification of risky areas in coastal areas is taken as 5m (Elco et al., 2023). It is important to identify areas above and below 5 meters. In addition, taking into account the medium-scale weather movements that may occur on the coastline and storm-induced waves, which are called sea swell and are highly observed on the coastlines, it is very important to identify areas between 5m-10m and observe their distance to the shore. It was determined that the recurrence period was 1/200 years and a sea level rise of 2 meters increased the coastal flooding rate by 21% compared to the SRTM data (Elco. et al., 2022). However, it is also stated that simulations or risk analyzes created with digital elevation maps make high predictions compared to real events. In this context, areas likely to be affected by sea level and storm waves such as the topography and coastal flood risk map created for Mersin province in Figure 4.78 have been identified.

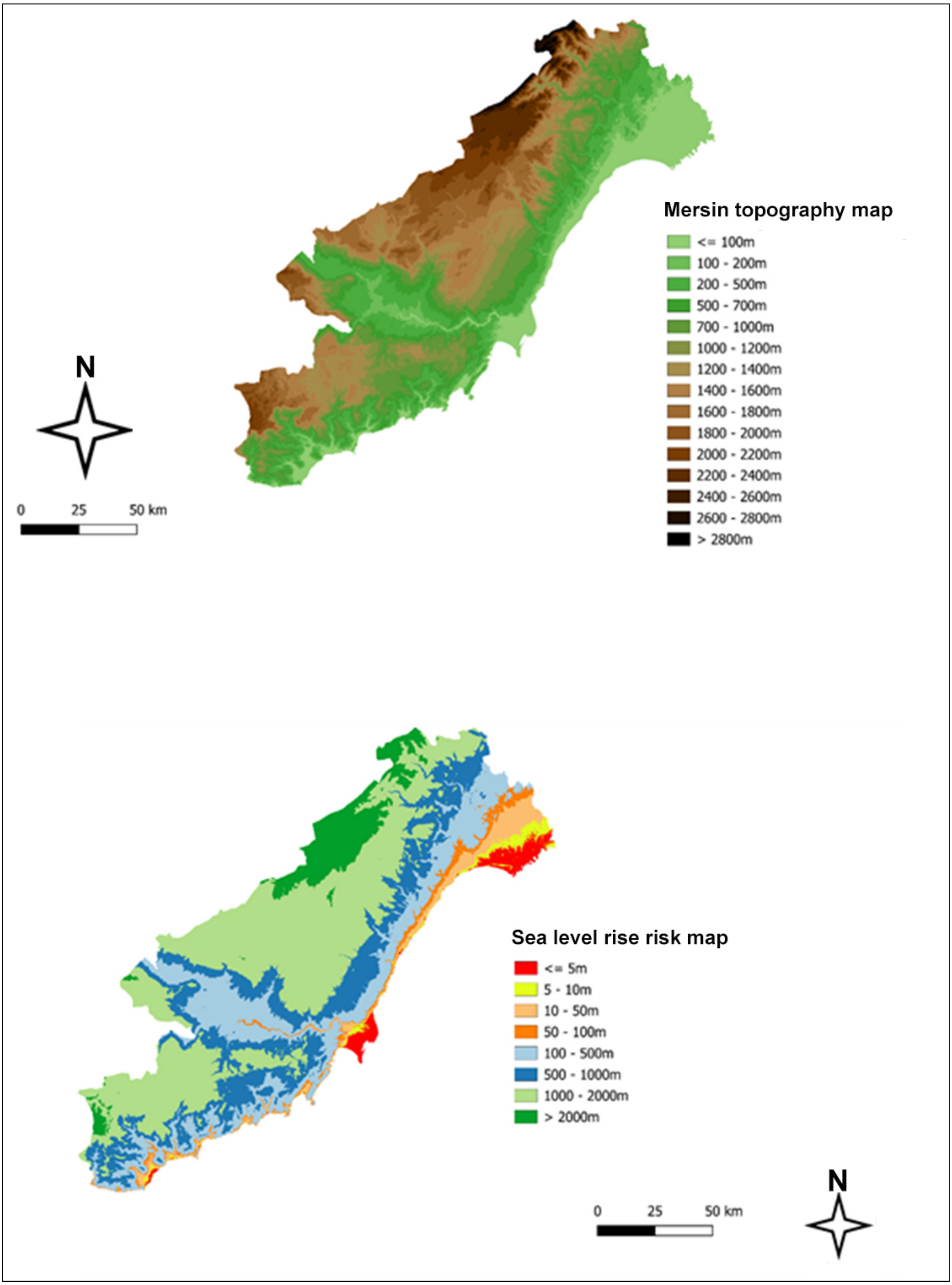



**Figure 4.78:** Mersin topography map and sea level rise risk map

Rises in sea level cause flooding of coasts and land, rise in groundwater levels and salinization in coastal plains, disruption of ecological balance, coastal erosion and soil loss. In addition to the physical effects of these impacts on coastal settlements, uses, marine structures, and agricultural production, there is a risk of multifaceted consequences on ecosystem and socio-economic processes.

### 4.3.3 Determination of the Probability of Occurence of Each Climate Risk

Identifying climate risks requires knowing the frequency of events that occurred in the past. For this reason, past climatological data, reports, model results and other data sources are evaluated to determine the risks of climate change. These data also help to produce anticipations about how the climate will change in the future. Thus, identifying climate risks should be considered as a valuable input in shaping future policies and strategies.

For the probability scoring of the climate risks identified within the scope of the study, an assessment was made according to the number of times these events were encountered at least once a year in the past years and the probability of encountering these risks once a year in the coming period. This assessment is based on the frequency of events in past years and future probabilities.

This assessment is an important step to determine the likelihood of climate risks and to be prepared for them. The number of times this event has occurred in previous years shows how often it has occurred. The likelihood of encountering these risks in the coming period is a factor that should be taken into account in future planning and risk management strategies.

The probability table obtained as a result of the frequency of occurrence of climate risks for Mersin province is given in Table 4.7. Weather reports published by the General Directorate of Meteorology, meteorological station data, regional climate projections of MGM (HadGEM2-ES) and average values of the results of all global climate models were obtained and used in the studies. When the results are analyzed, temperature increase, storms and tornadoes, forest fires, excessive rainfall and flooding are identified as the most likely climate risks. Drought, on the other hand, is not seen as a serious first risk for today, but it will most likely be a risk that the Mersin will face in 2050.

**Table 4.7:** Probability of climate risks occurring in Mersin

| Climate Risks | Evaluation Criteria | 2023 Likelihood Level | 2050 Likelihood Level | Change |
|---|---|---|---|---|
| **Temperature Increase** | Maximum Temperature, Warm Period Duration | **5** (Very High Probability) | **5** (Very High Probability) | ↔ |
| **Drought** | Number of Dry Days, SPEI 12 | **2** (Low Probability) | **4** (High Probability) | ↑ |
| **Extreme Rainfall and Flooding** | Number of events, Number of days with more than 20mm/day rainfall, Daily max. rainfall | **4** (High Probability) | **5** ((Very High Probability) | ↑ |
| **Storm and Tornadoes** | Number of Events | **5** ((Very High Probability) | **5** ((Very High Probability) | ↔ |
| **Hail** | Number of Events | **4** (High Probability) | **4** (High Probability) | ↔ |
| **Snow** | Number of Events, Number of Icy Days and Min. Min. of Temperatures Climate Indices | **1** (Very Low Probability) | **1** (Very Low Probability) | ↔ |
| **Lightning Strike** | Number of Events | **2** (Low Probability) | **2** (Low Probability) | ↔ |
| **Forest Fires** | Fire Weather Index | **4** (High Probability) | **4** (High Probability) | ↔ |
| **Sea Level Rise** | Sea level height | **1** (Very Low Probability) | **3** (Possible) | ↑ |

### 4.3.4 Identification of Sectors and Critical Infrastructures

Critical infrastructure refers to networks, assets, systems, structures or combinations thereof that may have impacts on the health, safety and economy of citizens due to the adverse effects of possible partial or complete loss of function on the environment, community order services (AFAD, 2014).

When identifying the sectors and critical infrastructures that will be affected by climate change in cities, it should be taken into account which sectors and infrastructures will be more at risk. The vulnerability of sectors and infrastructures to climate change and their role in meeting the basic needs of society and economic growth are important. The authority and capacity of local governments to adapt sectors and infrastructures to climate change and increase their resilience should also be determined.

onsidering these criteria, sectors and critical infrastructures that will be affected by climate change have been identified and given in Table 4.8.

**Table 4.8:** Sectors and critical infrastructures assessed within the scope of adaptation measures

| Sectors | Critical Infrastructure |
|---|---|
| **Urban life** | • Residential buildings<br>• Public buildings<br>• Hospital buildings and other health institution buildings<br>• Education buildings<br>• Hotels<br>• Commercial premises<br>• Construction activities |
| **Energy and Industry** | • Thermal power plants<br>• Renewable energy plants<br>• Energy transmission and distribution network<br>• Pipelines<br>• Industrial facilities |

| Sectors | Critical Infrastructure |
|---|---|
| | • Organized Industrial Zones<br>• Raw material supply chain<br>• Energy supply<br>• Logistics<br>• Water use<br>• E-Commerce<br>• Staff |
| **Transportation infrastructure** | • Roads, bridges and tunnels<br>• Road transportation<br>• Rail system lines<br>• Rail transportation<br>• Ports and piers<br>• Sea transportation |
| **Solid waste and wastewater management** | • Waste storage facilities<br>• Solid waste biological processing plants<br>• Waste incineration plants<br>• Wastewater treatment plants<br>• Waste recovery and recycling facilities<br>• Medical waste sterilization facilities |
| **Agriculture and livestock** | • Animal presence<br>• Meadow and pasture lands<br>• Agricultural land<br>• Agricultural enterprises |
| **Water resources** | • Surface and groundwater resources<br>• Basins<br>• Dams<br>• Water tanks<br>• Water and wastewater treatment plants<br>• Drinking water transmission lines, sewerage system and wastewater discharge lines |
| **Forest areas** | • Forest areas<br>• National Parks<br>• Flora<br>• Fauna<br>• Land ecosystem |
| **Coastal areas** | • Ports<br>• Other transportation structures<br>• Marinas<br>• Tourism facilities<br>• Commercial buildings<br>• Energy and industrial facilities<br>• Water and wastewater infrastructure<br>• Coastal settlements |
| **Fisheries** | • Fishing shelters<br>• Fishing fleet<br>• Fish farming facilities<br>• Fish farms<br>• Processing and evaluation facilities |
| **Tourism and cultural heritage** | • Accommodation facilities<br>• Coastal areas and beaches<br>• Historical and cultural touristic areas<br>• Museums and cultural centers<br>• Theaters and cinemas<br>• Travel agencies |

### 4.3.5 Assessment of the Impacts of Climate Risks by Sector

Climate change has become a rapidly increasing problem in recent years and the impacts of these changes on urban infrastructures are also increasing. These impacts vary for each sector and critical infrastructure. For example, increasing temperature and energy demand in cities can negatively affect energy infrastructure. Therefore, power generation based on renewable energy sources and infrastructure improvements can be made to increase energy efficiency. Climate change may lead to reduced water resources and increased flooding. Therefore, infrastructure improvements can be made to protect water resources in cities, strengthen water collection and storage systems, and ensure more efficient use of water. In addition, more frequent heavy rains can cause roads to become flooded. This can make it difficult to maintain safe transportation. In conclusion, the impacts of climate risks on sectors and their critical infrastructures vary considerably and may have different consequences on each critical infrastructure. The dimensions of these impacts were asked in the survey and it was requested to determine the impact of climate risks on the sector to which they relate. Impacts were evaluated on a scale of 1 (Very Low Impact) to 5 (Very High Impact) and the impact table prepared following the survey results is given in Table 4.9.

**Table 4.9:** Scale of impact of climate risks on sectors

| | Temperature Increase | Drought | Extreme Rainfall and Floods | Storms and Tornadoes | Hail | Snow | Lightning strike | Forest Fires | Sea Level Rise |
|---|---|---|---|---|---|---|---|---|---|
| **Water Resources** | 5 | 5 | 3 | 2 | 3 | 3 | 2 | 4 | 3 |
| **Coastal Areas** | 4 | 4 | 3 | 3 | 3 | 3 | 2 | 4 | 5 |
| **Waste Management** | 4 | 4 | 3 | 2 | 3 | 3 | 2 | 4 | 3 |
| **Public Health** | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 4 | 3 |
| **Agriculture, Livestock and Fisheries** | 5 | 5 | 4 | 4 | 4 | 3 | 2 | 4 | 4 |
| **Land Use, Ecosystem and Biodiversity** | 5 | 5 | 4 | 3 | 3 | 3 | 2 | 5 | 4 |
| **Transportation and Logistics** | 4 | 4 | 4 | 4 | 4 | 3 | 2 | 4 | 4 |
| **Buildings** | 4 | 4 | 4 | 3 | 4 | 3 | 3 | 4 | 4 |
| **Energy Generation and Transmission** | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 4 | 3 |
| **Industry** | 4 | 4 | 4 | 3 | 3 | 2 | 2 | 4 | 3 |
| **Culture and Tourism** | 4 | 4 | 4 | 4 | 3 | 3 | 2 | 4 | 4 |

### 4.3.6 Risk Assessment

Risk matrices have been prepared to assess the potential climate risks for Mersin province and their potential impacts on sectors. Climate change risk and vulnerability analysis for Mersin have been performed according to the following parameters and criteria:

**Climate-related hazards:** Drought, Water stress, Increased water demand, Fire weather (risk of wildfires), Urban flooding, River flooding, Coastal flooding (incl. sea level rise), Hurricanes, cyclones, and/or typhoons, Extreme wind, Storm, Heavy precipitation, Mass movement, Biodiversity loss, Loss of green space/green cover, Soil degradation/erosion,Other forms of climate-induced landscape shift/degradation, Infectious disease

**AssessedSectors or Services:** Agriculture, Forestry, Fishing, Mining and quarrying, Manufacturing, Electricity, gas, steam and air conditioning supply, Water supply, Sewerage, waste treatment and remediation activities, Waste management, Administrative and support service activities, Public administration and defence; compulsory social security, Conservation, Construction, Wholesale and retail trade; repair of motor vehicles and motorcycles, Transportation and storage, Accommodation and food service activities, Information and communication, Financial and insurance activities, Real estate activities, Professional, scientific and technical activities, Education, Human health and social work activities, Arts, entertainment and recreation

**Assessed Vulnerable Population Groups:** Women and girls, Children and youth, Elderly, Indigenous peoples, Marginalized/minority communities, Vulnerable health groups, Low-income households, Outdoor workers, Frontline workers

Efforts have been made to determine the potential impacts of these hazards on sectors and vulnerable community segments.

The potential impacts of evaluated climate hazards on vulnerable population groups and sectors most exposed are described in the following tables.

**Table 4.10:** Climate-related hazards risk definition matrix for Mersin

| Climate-related hazards | Vulnerable population groups most exposed | Sectors most exposed | Description of the impacts on vulnerable populations and sectors | Proportion of the population exposed to the hazard |
|---|---|---|---|---|
| Extreme heat waves/ Heat stress | Elderly<br>Outdoor workers<br>Vulnerable health groups<br>Low-income households | Agriculture /Livestock<br>Water supply<br>Electricity, gas, steam and air conditioning supply<br>Forestry<br>Human health and social work activities | Vital danger for chronic patients, elderly, and low income households due to energy poverty. Forest fires due to extreme heat. Increase in coolingenergy demand. Decrease in agricultural and livestock production. Reduction in dairy production. | 91-100% |
| Drought | Indigenous peoples<br>Low-income households<br>Vulnerable health groups | Agriculture /Livestock<br>Electricity, gas, steam and air conditioning supply<br>Water supply<br>Human health and social work activities | Decrease in agricultural production, soil degradation due to excessive irrigation. Decrease in energy production and water reserves. Food security risk. | 41-50% |
| Heavy precipitationI Urban/River flooding | Low-income households<br>Outdoor workers<br>Elderly | Agriculture /Livestock<br>Transportation and storage<br>Manufacturing | Submersion of transportation lines, residential areas, and agricultural lands due to surface flooding caused by excessive rainfall. Vital risk for low income | 31-40% |

| | | | | |
|---|---|---|---|---|
| | Indigenous peoples | Sewerage, waste management and remediation activities<br>Electricity, gas, steam and air conditioning supply | households and outdoor workers. Disruption of transportation services. Reduction in agricultural productivity. | |
| Fire weather (risk of forest wildfires) | Indigenous peoples<br>Vulnerable health groups<br>Low-income households | Forestry<br>Public administration and defence; compulsory social security<br>Agriculture /Livestock<br>Electricity, gas, steam and air conditioning supply | Decrease in forest areas. Fire and vital danger for settlements near forests. Decrease in bee and other insect populations. Vital danger for wild animals | ≤10% |
| Storm/ Extreme wind/Tornadoe | Low-income households<br>Outdoor workers<br>Indigenous peoples | Accommodation and food service activities<br>Agriculture /Livestock<br>Human health and social work activities<br>Transportation and storage<br>Construction | Roof damages in buildings due to excessive wind and storms. Damage to seedlings during flowering season. Vital danger for low income households due to CO poisoning. Damages in energy supply lines. | 11-20% |
| Hail Storm | Low-income households<br>Outdoor workers<br>Frontline workers | Agriculture /Livestock<br>Transportation and storage<br>Accommodation and food service activities | Impact on fruit and vegetable production during flowering season due to excessive hail. Reduction in agricultural yield. Damage to vehicles. | ≤10% |
| Sea level rise/ Coastal flooding and other events | Low-income households<br>Indigenous peoples<br>Elderly | Transportation and storage<br>Manufacturing<br>Accommodation and food service activities<br>Agriculture /Livestock<br>Sewerage, waste management and remediation activities | Submersion of residential, agricultural and industrial lands next to the coastal areas | ≤10% |
| Extreme cold/Snow and ice | Low-income households<br>Indigenous peoples<br>Elderly | Transportation and storage<br>Manufacturing<br>Accommodation and food service activities<br>Agriculture /Livestock<br>Sewerage, waste management and remediation activities | Disruption of transportation due to severe winter conditions. Disruption in energy/water supply. Decrease in agricultural yield due to spring frosts | ≤10% |

| | | | | |
|---|---|---|---|---|
| Lightning Strike | Low-income households<br>Outdoor workers<br><br>Frontline workers | Transportation and storage<br>Electricity, gas, steam and air conditioning supply<br>Accommodation and food service activities<br><br>Agriculture /Livestock | Disruption of energy supply. Vital danger for outdoor workers. | ≤10% |

A risk matrix is used to assess risk by considering the likelihood of an event occurring and weighing it against its corresponding impact. When creating a risk matrix, each potential impact is assigned a risk rating based on its likelihood of occurrence and what the consequences (severity) would be if it were to occur. In the risk matrix prepared within the scope of the study, the risk is classified in 3 categories as High, Medium and Low. Table 4.12 shows the 2023 risk matrix and Table 4.13 shows the 2050 risk matrix obtained as a result of the probability-impact assessment conducted for Mersin.

As a result of the risk and vulnerability analysis, temperature increase, storms and tornadoes, hail, heavy rainfall and flooding create high risks on critical infrastructures. In 2050, drought is categorised under high risk category for the region. Heavy snowfall and lightning strikes are climate events in the low risk category for the region. Sea level rise, which is defined as low risk in the current situation analysis, increases to medium risk class in the 2050 analysis. It has been determined that urban life, transport infrastructure, agriculture and animal husbandry are the sectors most affected by climate events today. However, it is predicted that coastal areas will also be included in this class in the future. All sectors are at high risk of being affected by different climate events. Therefore, actions to mitigate these risks should be implemented by local administrations. For this purpose, actions that will strengthen the adaptation capacity of Mersin province against climate change and increase its resilience are proposed for all sectors included in the analysis.

**Table 4.11:** Climate-related hazards risk assessment risk matrix for Mersin

| Climate-related hazards | Current probability of hazard | Current magnitude of impact of hazard | Expected future change in hazard intensity | Expected future change in hazard frequency | Timeframe of expected future changes |
|---|---|---|---|---|---|
| **Extreme heat waves/ Heat stress** | High | High | Increasing | Increasing | Medium-term (2026-2050) |
| **Drought** | Medium | Medium | Increasing | Increasing | Medium-term (2026-2050) |
| **Heavy precipitationl Urban/River flooding** | High | High | Increasing | Increasing | Medium-term (2026-2050) |
| **Fire weather (risk of forest wildfires)** | High | High | Increasing | Increasing | Medium-term (2026-2050) |
| **Storm/ Extreme wind/Tornadoe** | Medium Low | Medium | Increasing | Increasing | Medium-term (2026-2050) |

| | | | | | |
|---|---|---|---|---|---|
| Hail Storm | Medium Low | Medium High | Increasing | Increasing | Medium-term (2026-2050) |
| Sea level rise/ Coastal flooding and other events | Low | Low | None/Remains the same | None/Remains the same | Long-term (after 2050) |
| Extreme cold/Snow and ice | Low | Low | None/Remains the same | None/Remains the same | Long-term (after 2050) |
| Lightning Strike | Low | Low | None/Remains the same | None/Remains the same | Long-term (after 2050) |

**Table 4.12:** Current situation risk matrix for Mersin

| Climate Risks | Sectors | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Urban Life | Energy and industry | Transportation infrastructure | Solid waste and wastewater management | Agriculture and livestock | Water resources | Forest areas | Coastal areas | Fisheries | Tourism and cultural heritage |
| Extreme Heat Waves | High | High | High | High | High | High | High | High | High | High |
| Drought | Medium | Medium | Medium | Medium | Medium | Medium | Medium | Medium | Medium | Medium |
| Heavy Rainfall and Flooding | High | High | High | Medium | High | Medium | High | Medium | High | High |
| Storms and Tornadoe | High | High | High | Medium | High | Medium | High | High | High | Medium |
| Hail | High | Medium | High | Medium | High | Medium | Medium | Medium | Medium | Medium |
| Snow Extreme winter Cond. | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low |
| Lightning Strike | Medium | Medium | Low | Low | Low | Low | Low | Low | Low | Low |
| Forest Wildfires | High | High | High | High | High | High | High | High | Medium | High |
| Sea Level Rise | Low | Low | Low | Low | Low | Low | Low | Medium | Low | Low |

**Table 4.13:** Risk matrix for Mersin in 2050

| Climate Risks | Sectors | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Urban Life | Energy and industry | Transportation infrastructure | Solid waste and wastewater management | Agriculture and livestock | Water resources | Forest areas | Coastal areas | Fisheries | Tourism and cultural heritage |
| Temperature Increase | High | High | High | High | High | High | High | High | High | High |
| Drought | High | High | High | High | High | High | High | High | High | High |
| Heavy Rainfall and Flooding | High | High | High | High | High | High | High | High | High | High |
| Storms and Tornadoe | High | High | High | Medium | High | Medium | High | High | High | High |
| Hail | High | Medium | High | Medium | High | Medium | Medium | Medium | Medium | Medium |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Snow** | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low |
| **Lightning Strike** | Medium | Medium | Low | Low | Low | Low | Low | Low | Low | Low |
| **Wildfires** | High | High | High | High | High | High | High | High | Medium | High |
| **Sea Level Rise** | Medium | Medium | Medium | Medium | Medium | Medium | Medium | High | Medium | Medium |

### Sectoral Vulnerability Analysis Against Climate Hazards

The adaptive capacities of service sectors against primary (major) climate hazards were evaluated through Survey 3. Sectors resilient or vulnerable to these prioritized hazards were identified and shown in the table and chart below. The assessment was based on the potential future impacts (PI) of climate hazards on the service/sector and the current adaptive capacity (AC) of the service or sector. The evaluation criteria are defined as follows:

**Potential Impact (PI)**

- PI5-High-Sector/Service collaps. Unmanageable.
- PI4- Medium High- Sector/service disrupts
- PI3-Medium: Shows a tendency to deteriorate.
- PI2 - Sector/sector temporarily interrupt.
- PI1-Low- Sector/Service is not affected.

**Adaptive Capacity (AC)**

- AC5-Low- Very High investment required
- AC4-Medium Low- High investment Required
- AC3-Medium- Additional investment required
- AC2-Medium High- Additional improvement may be necessary.
- AC1-High- No improvement needed

**Table 4.14:** Sectoral Vulnerability Analysis for Mersin

| Climate-Related Hazards | Most Exposed Sectors | Potential Impact on Sector (PI1 Low - PI5 High) | Sector's Adaptive Capacity (AC1 Low – AC5 High) |
|---|---|---|---|
| Extreme Heatwaves / Heat Stress | Agriculture /Livestock | PI4- Medium High- Sector/service disrupts | AC2-Medium High- Additional improvement may be necessary. |
| | Water supply | PI2 - Sector/sector temporarily interrupt. | AC2-Medium High- Additional improvement may be necessary. |
| | Electricity, gas, steam and air conditioning supply | PI3-Medium: Shows a tendency to deteriorate. | AC2-Medium High- Additional improvement may be necessary. |
| | Forestry | PI2 - Sector/sector temporarily interrupt. | AC2-Medium High- Additional improvement may be necessary. |
| | Human health and social work activities | PI4- Medium High- Sector/service disrupts | AC4-Medium Low-High investment Required |
| **Drought** | Agriculture /Livestock | PI4- Medium High- Sector/service disrupts | AC3-Medium- Additional investment required |
| | Electricity, gas, steam and air conditioning supply | PI3-Medium: Shows a tendency to deteriorate. | AC2-Medium High- Additional improvement may be necessary. |

| | | | |
|---|---|---|---|
| | Water supply | PI3-Medium: Shows a tendency to deteriorate. | AC2-Medium High- Additional improvement may be necessary. |
| | Human health and social work activities | PI2 - Sector/sector temporarily interrupt. | AC2-Medium High- Additional improvement may be necessary. |
| **Heavy Rainfall and Floods** | Agriculture /Livestock | PI5-High- Sector/Service collaps. Unmanageable. | AC3-Medium- Additional investment required |
| | Transportation and storage | PI4- Medium High- Sector/service disrupts | AC3-Medium- Additional investment required |
| | Manufacturing | PI2 - Sector/sector temporarily interrupt. | AC2-Medium High- Additional improvement may be necessary. |
| | Sewerage, waste management and remediation activities | PI5-High- Sector/Service collaps. Unmanageable. | AC4-Medium Low-High investment Required |
| | Electricity, gas, steam and air conditioning supply | PI4- Medium High- Sector/service disrupts | AC2-Medium High- Additional improvement may be necessary. |
| **Forest Wildfire** | Forestry | PI5-High- Sector/Service collaps. Unmanageable. | AC3-Medium- Additional investment required |
| | Public administration and defence; compulsory social security | PI5-High- Sector/Service collaps. Unmanageable. | AC3-Medium- Additional investment required |
| | Agriculture /Livestock | PI2 - Sector/sector temporarily interrupt. | AC2-Medium High- Additional improvement may be necessary. |
| | Electricity, gas, steam and air conditioning supply | PI4- Medium High- Sector/service disrupts | AC3-Medium- Additional investment required |
| **Storm/ Extreme wind/Tornadoe** | Accommodation and food service activities | PI2 - Sector/sector temporarily interrupt. | AC2-Medium High- Additional improvement may be necessary. |
| | Agriculture /Livestock | PI2 - Sector/sector temporarily interrupt. | AC2-Medium High- Additional improvement may be necessary. |
| | Human health and social work activities | PI2 - Sector/sector temporarily interrupt. | AC1-High- No improvement needed |
| | Transportation and storage | PI2 - Sector/sector temporarily interrupt. | AC1-High- No improvement needed |
| | Construction | PI2 - Sector/sector temporarily interrupt. | AC1-High- No improvement needed |
| **Hail Storm** | Agriculture /Livestock | PI3-Medium: Shows a tendency to deteriorate. | AC2-Medium High- Additional improvement may be necessary. |
| | Transportation and storage | PI2 - Sector/sector temporarily interrupt. | AC1-High- No improvement needed |

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