Environment and Climate Regional Accession Network ECRAN

Environment and Climate Regional Accession Network (ECRAN)

Task 1: Position paper on modelling activities -

Compilation of documents on modelling activities carried out by the ECRAN beneficiary countries_

Support to adaption planning - Step A

ENVIRONMENT AND CLIMATE REGIONAL ACCESSION NETWORK - ECRAN

CLIMATE ADAPTATION EXERCISE

TASK 1: POSITION PAPERS ON MODELLING ACTIVITIES

SUPPORT OF THE IDENTIFICATION OF ADAPTION OPTIONS (ADAPTION PLANNING) – STEP A: CLIMATE ADAPTION TOOL: PRIORITISATION OF ADAPTION NEEDS

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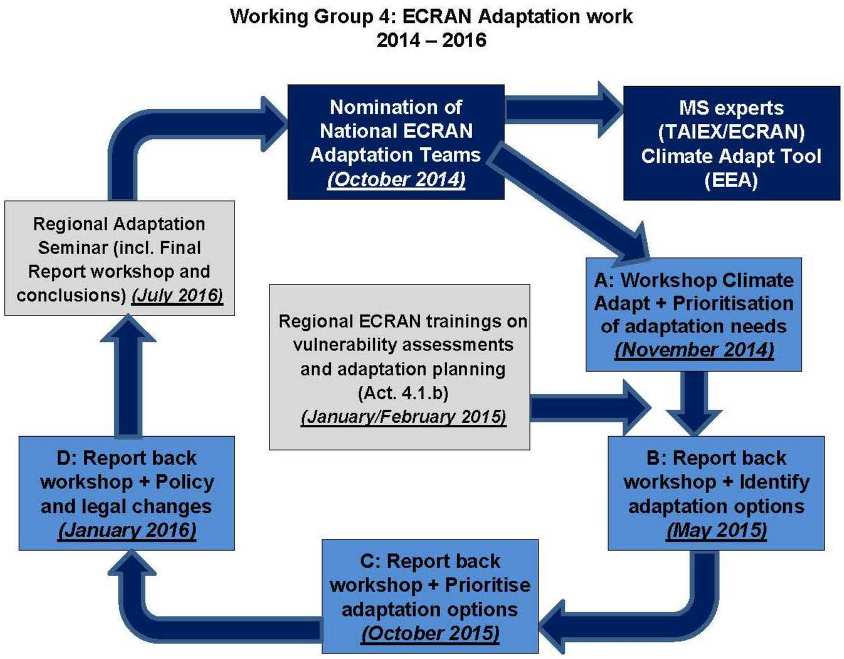
[1] *This designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo Declaration of Independence.

Background

ECRAN Climate Adapt Activities

Within its Climate Component, ECRAN will promote 'climate-proofing' action by further encouraging

adaptation in key vulnerable sectors which would in turn, enable planning for a more resilient infrastructure, and would support better informed decision-making by addressing gaps in knowledge about adaptation. ECRAN will address adaptation action by coordinating adaptation activities with the European Climate Adaptation Platform (Climate-ADAPT) as the 'one-stop shop' for adaptation information in Europe.



The ECRAN Adaptation Programme includes a series of workshops that will guide the National ECRAN Adaptation Teams through the different stages towards developing a national climate adaptation policies and legislation (Activity 4.2). This will be combined with regional training sessions that support Beneficiary Countries' experts from the selected technical areas to carry out risk and vulnerability assessments and adaptation planning (Activity 4.1.b).

Knowledge base for adaptation

Reference is made to the EEA studies and activities on the climate change impacts, vulnerability and adaptation, all available on the EEA website[2]. Two particular publications are of particular importance:

- Climate change, impacts and vulnerability in Europe (EEA indicator report, Nov 2012)[3]
- National adaptation policy processes in Europe (EEA report published 14 Oct 2014)[4]

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[2] http://www.eea.europa.eu/themes/climate/publications?b_start:int=0

[3] http://www.eea.europa.eu/publications/climate-impacts-and-vulnerability-2012

[4] http://www.eea.europa.eu/publications/national-adaptation-policy-processes

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As a part of a first step to prepare the ground for adaptation there is a need to develop a sound knowledge base. The importance of having *'better informed decision-making'* is also highlighted in the EU Climate Change Adaptation Strategy, which includes this as one of its three main objectives (EC, 2013). Scientific knowledge, however, needs to be combined with practical and administrative knowledge. In this context cooperation between scientists, policy actors and other stakeholders such as civil and business NGOs is fundamental.

- As a first step Establish *Exposure Units*, *Receptors* and *Risk Assessment Endpoints* (climate thresholds):
  - The *exposure unit* represents the system considered to be at risk, often defined in terms of geographical extent, location and distribution of a variety population of *receptors* at risk.
  - These *receptors* are selected to represent important aspects of the exposure unit, particularly those of significance to the decision-making process.
  - *Assessment endpoints* are chosen to help establish the acceptability of the risk posed to the exposure unit(s) by future circumstances and decisions, including those regarding climate change risk management.
- For a preliminary screening:
  - Identify and define a set of climate and non-climate variables or factors for the exposure unit and for which the receptors may be sensitive;
  - Collect and assess the available data set;
  - Assess the available models and model data (climate, hydrological, impacts);
  - Use climate scenarios to help determine the climate change dependent risk to the receptors;
  - Use non-climate scenarios (population, socio-economic scenarios) to help determine the nature of the non-climate dependent risk.
- There are open sources and references of the main observational station datasets (temperature and precipitation) that can be used for vulnerability assessment work:
  - Global Historical Climatology Network (GHCN-Monthly and GHCN-daily): Global daily data of temperature (max, min and mean) and precipitation from over 43,000 stations (about 8,500 of which are regularly updated with observations from within the last month) for a period starting already from the 19th century[5].
  - E-OBS gridded dataset: E-OBS is a daily gridded observational dataset for precipitation, temperature and sea level pressure in Europe. The full dataset covers the period 1950-01-01 until 2013-12-31. Currently it is maintained and elaborated as part of the UERRA project (EU-FP7).[6]
  - MED-HYCOS (Mediterranean Hydrological Cycle Observing System): Network of hydro-meteorological real time or near real time data collecting platforms (DCPs) on the main rivers of the Mediterranean catchments. (Albania, Bosnia, Croatia, former Yugoslav Republic of Macedonia).[7]
- The CORDEX tool is providing global coordination to produce improved regional climate change projections of all land regions world-wide. The results are fed into the climate change impact and adaptation studies within the timeline of the Fifth Assessment Report (AR5) of the IPCC. [8]

[5] http://www.ncdc.noaa.gov/data-access/quick-links#ghcn

[6] http://eca.knmi.nl/maxtemp_EOBS.php

[7] http://medhycos.mpl.ird.fr/

[8] http://cordex.dmi.dk/joomla/ and http://www.euro-cordex.net/ and http://wcrp-cordex.ipsl.jussieu.fr/

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Development of position papers on specific adaptation topics

During the November 2014 ECRAN Adapt STEP A Workshop (see above and also at www.ecranetwork.org), it was agreed to complete the following three tasks and report on their progress to the ECRAN team by the deadlines indicated. The outputs will serve as input and background to the so called STEP B Workshop to be held in May 2015.

Task 1. Position paper on modelling activities (climate models, impact models) performed in your country. Deadline: **1 February 2015.**

Considering past weather events will help to gain a better understanding of the current vulnerability of a country and current impacts of climate change. It will help determine a country's sensitivity to current weather and thus, provide significant insight for the current adaptation needs. From there climate models give an outlook on the long-term changes/changes over time and give directions for related adaptation action and needs.

The countries were invited to prepare a position paper on the available relevant existing work, such as national risk or vulnerability assessments and the availability and use of climate models, which can provide an excellent starting point for answering these questions. It was expected that information could be obtained from national Met Offices.

The position paper should be up to 2 pages.

Task 2: The countries were asked to make a qualitative vulnerability assessment of **2 sectors** in their respective countries (first sector: Water resources and links to DRM and cross border aspects) and the second sector of their own choosing. Method: Use the Adaptation Support Tool of Climate-Adapt. Deadline: **2 April 2015.**

The countries were invited to prepare two short qualitative vulnerability studies for the water sector and the second sector, which they selected themselves.

- As a first step, available information for the country's future threats (e.g. sectoral vulnerability assessments) and opportunities would need to be collected and analysed.
- If the available information base was not sufficient for elaborating adaptation responses for the two sectors (water and the other chosen sector), additional assessments would need to be carried out. Various approaches for risk assessments are available, e.g. from the UK and Germany and were addressed in the November workshop. Methods of measuring physical vulnerability normally range from the empirical methods to the use of models. The following empirical methods could be considered for the studies:
  - **Analysis of observed damage** Based on the collection and analysis of statistics of damage that occurred in recent and historic events. Relating vulnerability to different hazard intensities.
  - **Expert opinion** Based on the asking groups of experts on vulnerability to give their opinion, for instance on the percentage damage they expect for a particular sector having different intensities of hazard/impact.
  - **Score Assignment:** Method using a questionnaire with different parameters to assess the potential damages in relation to the different hazard levels.

Each vulnerability assessments should range between 5 - 10 pages for each sector (excluding the annexes).

Task 3: the countries were asked to identify the adaptation needs and prepare a position paper

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based on vulnerability assessments of their two sectors.. Method: Use the Adaptation Support Tool Deadline: **1 May 2015.**

The countries were asked to prepare a a position paper based on vulnerability assessment for each of the two studied sectors, and identify the adaptation needs and a list of options. These will be later assessed and elaborated.

The two adaptation options papers should contain up to 5 pages each.

This document summarises the results of Task 1 only. Hereafter the position papers on modelling activities (climate models, impact models) performed in the ECRAN beneficiaries are presented in the annex for:

- Albania
- Croatia
- Bosnia and Herzegovina
- The former Yugoslav Republic of Macedonia
- Kosovo*
- Serbia
- Turkey

Please note that the attached position papers have not been reviewed by the ECRAN Team. The National Adapt Teams agreed to distribute the Task 1 position paper among the regional stakeholders.

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Annex I: Position Papers of Beneficiary Countries

The position papers from the ECRAN beneficiaries are included in this section, which is a compilation of the documents submitted to the project and have not been reviewed by the ECRAN Adaptation Team.

Albania

Introduction

Studies on Climate change impacts in Albania have been carried out since 1993 with the very first project '*Implications of Climate Change for the Albanian Coast*'[9], implemented in the frame of the Coastal Areas Management Program of UNEP/MAP. This study is followed by the First and Second National Communications to UNFCCC[10], prepared by the Climate Change Programme of UNDP, in the frame of the projects '*Enabling activities for the preparation of national communications of Albania related to the UNFCCC*'. In all these reports the respective Vulnerability and Adaptation Chapters consist of climate change scenarios, impact analysis of current and expected climate changes, assessment of adaptation measures and actions. The Third National Communications to UNFCCC is under preparation.

Impact analysis of current and expected climate change and adaptation was focused on sectors/systems:

- Water resources (FNC, SNC and TNC);
- Natural ecosystems (FNC, TNC);
- Managed ecosystems (agriculture, forestry- FNC);
- Energy, transport (FNC, SNC);
- Tourism (FNC, SNC and TNC);
- Population (FNC, SNC and TNC);
- Health (FNC and TNC);
- Natural disasters related to climate (TNC).

The most important and detailed results in the modelling and climate impact were received through implementation of the project, '*Identification and Implementation of Adaptation Response Measures in the Drini - Mati River Deltas*' (DMRD), a pilot MSP project, financed by GEF/UNDP/Government of Albania[11].

[9] Available at http://www.unepmap.org/index.php?module=library&mode=mts&action=results&_stype=3&s_category=MAP%20Technical%20Reports%20MTS&s_descriptors=Climate%20change

[10] Available at http://www.al.undp.org/content/albania/en/home/library/environment_energy/

[11] Available at http://www.al.undp.org/content/albania/en/home/library/environment_energy/

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Other important contribution on climate modelling and impact analysis is provided by two other projects, financed by World Bank, already finalized[12]:

- *Reducing the Vulnerability of Albania's Agricultural Systems to Climate Change: Impact Assessment and Adaptation Options'*;
- *Climate Vulnerability Assessments: An Assessment of Climate Change Vulnerability, Risk, and Adaptation in Albania's Energy Sector*.

1. Methodological approach

This report describes only the methodological approach used in the project implemented by the Climate Change Programme of UNDP.

1.1 Climate Modelling

The Climate Change scenarios for temperature, precipitation, mean sea level pressure and sea level rise are developed by using the model MAGICC/SCENGEN (v. 5.3, v 2)[13]. As in vulnerability assessment is recommended to use a range of SRES scenarios with a variety of assumptions to capture the range of uncertainties associated with driving forces and emissions, the global model MAGICC is run by using the following scenarios from different SRES families: A1BAIM, A2ASF, B1IMA, B2MES, A1T-MES, A1FI-MI[14].

Change fields, scaled in SCENGEN by the global-mean temperature change derived from MAGICC are used to develop the climate scenarios. The changes are generated for each emission scenario up to the year 2100, by using a multi-model average. The justifications for use of a multi-model average are two-fold. First, multi-model averages are less spatially noisy. Second, by many measures of skill, multi-model averages are often better than any individual model at simulating the present-day climate.

A climate-change projection is the change between a model simulation of present climate[15] and the model climate projection for a period in the future, under a specific emissions scenario. The changes in annual and seasonal patterns of temperature, precipitation and mean sea level pressure are generated for every ten years starting with 2020 up to 2100. It is to be noted that the time horizon means that the model is run for a period of 30 years, e.g. for the year 2050 the running time is from 2035 to 2065. The likely changes temperature, precipitation and mean sea level pressure are calculated. For the impact analysis mainly the projections for temperature and precipitation are considered.

[12] available at http://hdl.handle.net/10986/16198

[13] http://www.cgd.ucar.edu/cas/wigley/magicc/

[14] See SNC, DMRD reports

[15] In this report period 1961-90 is considered as climatic baseline

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To evaluate the expected impacts of sea level rise, the model DIVA[16] was run in parallel with MAGICC (with the same scenarios as in MAGICC) for the Albanian coastal part[17].

1.2 Model Validation

The General Circulation Models (GCMs) used to run SCENGEN are selected on the basis of their ability to accurately represent current climate, for Europe and Balkan as well as for the globe. In Albanian case the annual precipitation is used as the validation variable. Precipitation is more difficult to model than temperature and models do less well in simulating precipitation than temperature, so using precipitation is a stringent test of the model skill. For this model validation the statistics used are: pattern correlation (r), root-mean-square error (RMSE), bias (B), and a bias-corrected RMSE (RMSE-corr).

After a detailed statistical analysis of these parameters five top models that better simulate the present precipitation pattern are selected: BCCR-BCM2 (Norway); CNRM-CM3 (France); GFDLCM21 (USA); UKHADCM3 (UK); INCM-30 (Russia).

1.3 Climate Change Scenarios

The seasonal and annual expected changes in temperature and precipitation patterns for Albania, developed by using the mentioned methodology have a low resolution (50*50 km), that is not appropriate for adaptation. Given that a statistical downscaling process up to 1*1 km, taking into account the topography, is carried out for different parts of Albanian territory as per project focus.

1.4 Climate Indices

The changes in following climate indices are evaluated for the use in impact analysis:

- Maximum temperatures ≥ 35°C**Fout! Bladwijzer niet gedefinieerd.**;
- Minimum temperatures < -5°C;
- Hazardous precipitation;
- Number of days with hazardous precipitation and SPI3 values;
- Expected changes in growing season;
- Degree days for heating and cooling;
- Tourism climate index (TCI).

2. Impacts analysis

The impact analysis is based on the three main approaches:

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16 DIVA, a fully dynamic and interactive tool (product of the DINAS-COAST consortium), consists of a global coastal database, a model, a set of scenarios and a GUI that enables its users to simulate the effects of climate and socioeconomic change and of adaptation on natural and human coastal systems at national, regional and global scales.

17 Source: Albania's Second National Communication to UNFCCC

- Modelling;
- Analogue studies;
- Expert judgement.

For impact analysis of climate change in different sectors/systems the following methods are used:

- Water resources: WATBAL, WEAP, empirical statistical models;
- Agriculture: CROPWAT 8, statistical models, analogue studies, expert judgment;
- Forestry: statistical models to evaluate the shift in bioclimatic floors, DIVA (expected changes in coastal forestry areas), analogue studies, expert judgment;
- Biodiversity : GIS maps to evaluate the loss of biodiversity from sea level increase; DIVA (total wetland area, net loss of wetland area, low unvegetated wetlands area), empirical models analogue studies, expert judgment;
- Tourism : Statistical models , Tourism Comfort Index[18] , expert judgment , GIS;
- Population & settlements: GIS maps and DIVA to evaluate the population and the loss of settlements threatened by the sea level rise in coastal areas;
- Energy: LEAP to develop the scenarios of the energy demand and supply under the climate change conditions.

3. Adaptation Analysis

Adaptation responses and decisions proposed by each and every sector/system are categorized as measures and strategies that contribute either to[19]:

- Building adaptive capacity – creating the information (research, data collecting and monitoring, awareness raising), supportive social structures (organisational development, working in partnership, institutions), and supportive governance (regulations, legislations, and guidance) that are needed as a foundation for delivering adaptation actions; or
- Delivering adaptation actions – actions that help to reduce vulnerability to climate risks, or to exploit opportunities (classified as EbA, CbA, hard engineering)

In TNC another classification for adaptation measures is used: green, grey, soft and fiscal adaptation measures.

There are many different criteria that might in principle be used for prioritization. The criteria already used by the adaptation team within the Climate Change Programme have been grouped under five separate ***Heading Criteria***, which may themselves help to prompt the inclusion of other criteria that may be important in specific circumstances. The Heading Criteria have been developed within a ***Scoring Rate***.

[18] After Mieczkowski Z (1985) The tourism climatic index: a method of evaluating world climates for tourism. Can Geogr 29: 220–233

[19] See the Project Synthesis report 'Identification and Implementation of Adaptation Response Measures in the Drini - Mati River Deltas'

The Heading Criteria are:

- *Financial Indicative Cost* - covering the secured and estimated cost and expenditure associated with the project and the sources of finance.
- *Time Frame Criteria* - measure or action in question to the time implementation planning, that may impact on the timing or success of a proposed project.
- Potential *Partnership* - particularly in relation to support for or opposition to a proposed project and mobilization of additional funds.
- Principle of *Additionality* Criteria - that assesses existing institutions or related activities/measures that could provide additional values.
- Win-Win Criteria - covering the wider economic framework (costs, benefits and affordability), relating directly to the nature of the project and how it can be implemented successfully to increase the resiliency of ecosystems and protection of the community.

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Croatia

Climate modelling

National Meteorological and Hydrological Service (DHMZ) supports various regional climate modelling activities. A group of currently three experts; Ivan Güttler, Ph.D. Mirta Patarčić, M.Sc., Lidija Srnec, M.Sc. and until recently Čedo Branković, Ph.D., is active in model development and evaluation. The main modelling tool is regional climate model RegCM4. Additionally, results of the EU FP6 project ENSEMBLES and recent CORDEX activity are used in estimating the uncertainty related to model formulation. Standard analysis includes an evaluation of the model systematic errors and estimation of historical and projected climate changes and trends. Some of the results are published in scientific papers as well as in the national reports on climate change. The group is active in introducing obtained results to various stakeholders in the process of mitigation and adaptation on climate change.

Current major activities include:

1. Contribution to the Croatian Science Foundation project CARE. Several high-resolution simulations will be performed in the scope of this project during the period 2014-2018;
2. Results of the CARE project (simulations at 12.5 km horizontal resolution) and of the internal DHMZ modelling activities (simulations at the 50 km horizontal resolution) are planned to be submitted to the common CORDEX database.

In order to: (1) fully support all activities related to regional climate modelling, (2) to extend the analysis of the large climate model ensembles and (3) to provide requested data to various impact and end users, an extension of DHMZ computing and data archiving capacities and an increase in the number of group members is needed in near future.

Risk Assessment

Croatia has a legal obligation to prepare risk assessments at all three levels of government – national, regional and local. Risk assessment is not oriented to the climate change but assesses the vulnerability from all natural and technological threats. The focus is on identification, classification and evaluation of threats and at exposure of people, material goods and environment. The impact of climate change is mentioned in the context of extreme weather events.

Disaster Risk Assessment in the Republic of Croatia is currently under preparation (to be completed by the end of 2015). In this document, climate change is not treated as a separate risk but as a driving force of other risks (such as drought, extreme temperatures, extreme precipitations, soil salinization, floods) and as important factor in the risk analysis such as the occurrence of harmful organisms and plant and animal diseases, and the occurrence of epidemics and pandemics. In addition to analysis of threats, calculation will also include analysis of vulnerability of society to disasters.

Upon completion of the Risk Assessment, Strategy for Disaster Risk Reduction will be prepared. It will define next steps in reducing the vulnerability to the identified and emerging risks. Mitigation and adaptation to climate change will be significant parts of the future Strategy for Disaster Risk Reduction, taking in consideration the existing historical data on damages.

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Bosnia and Herzegovina

Compiled by: Ozren Laganin, Milica Djordjevic, Ines Cizmic, Igor Kovacic, Goran Trbic, Sabina Hodzic, Nenad Trbic, Tatjana Kapetanovic, and Bakir Krajinovic.

Situation Analysis

As a result of historic and current greenhouse gas emissions, and recent vulnerability estimates, Bosnia and Herzegovina will be exposed to climate change impacts that could have consequences for its entire society. Opportunities to protect against such impacts at the local level are quite limited, but there are still numerous options for climate change adaptation.

The observed climate change, with respect to the reference period of 1961-1990, shows an increase in annual air temperature in the range of 0.4 to 0.8°C whilst the temperature increases during vegetation periods were up to 1.0°C. Over the past several decades, increased climate variability has been noted in all seasons and across the entire territory of Bosnia and Herzegovina: five of the past 12 years were very dry to extremely dry, and four of these years were characterised by extreme flood events. The past four years (2009-2012) have all been characterised by extreme events: flooding in 2009 and 2010, drought and high heat in 2011 and 2012, cold weather? in early 2012, and strong wind in mid-2012.

At the same time, decrease in the number of days with rainfall exceeding 1.0 mm and an increase in the number of days with intensive rainfall caused disruptions in the pluvio-metric regime. Pronounced change in the annual rainfall patterns, coupled with temperature increases, is one of the key factors causing more frequent and intensive occurrences of draught and floods on the territory of Bosnia and Herzegovina. Risk of forest fires is highly significant in the southern parts of the country.

The analyses of the observed climate change in the country are based on the data from a homogeneous series of observations from 22 meteorological stations and from approximations where appropriate. Climate change determinants were established based on an analysis of temperature change and precipitation change. Detailed analyses covered: changes in annual temperature and precipitation for the periods 1961-1990 and 1981-2010; trends in temperature and precipitation changes; and extremes in temperature and precipitation for cities of Banja Luka, Sarajevo and Mostar for the period 1960-2010.

Models for Projections of Future Climate Change

The Initial and Second National communication have recognized the following sectors as the most vulnerable to climate change in Bosnia and Herzegovina: agriculture, water resources, human health, forestry and biodiversity, as well as the vulnerable ecosystems.

Detailed analyses were conducted of the long-term climate change vulnerability and impacts in these sectors based on the SRES climate scenarios A1B and A2. These reference or “baseline” scenarios are defined by the IPCC special report on emission scenarios (Nakicenovic and Swart, 2000) and each makes assumptions about greenhouse gas emissions from the future technological, social and economic development based on human activity. In terms of GHG concentrations, A1B is characterized as a “medium” scenario and A2 as a “high” scenario according to the projected levels

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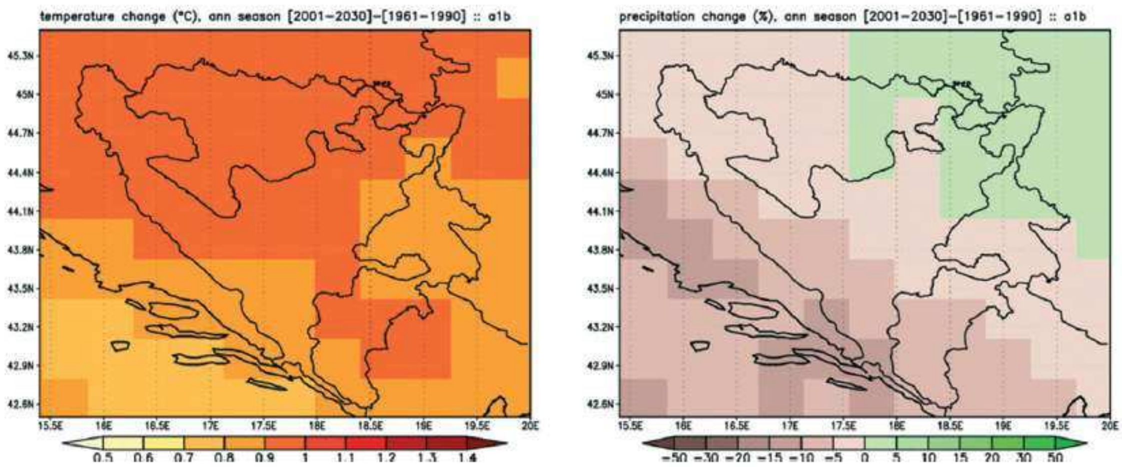
of greenhouse gases in the atmosphere. In the A1B scenario, the value of the atmospheric concentration of carbon dioxide (CO2), one of the greenhouse gases is approximately 690 parts per million (ppm) at the end of 21st century, and in the A2 scenario it is approximately 850 ppm.

Model results were analysed for the time series 2001- 2030 and 2071-2100. This section focuses on two basic ground meteorological parameters: air temperature at 2 meters and accumulated precipitation. Changes in these parameters are shown with reference to mean values from the so-called base (standard) period of 1961-1990.

<u>A1B scenario, 2001-2030</u>

According to climate model results, the mean seasonal temperature changes for the observed thirty-year period 2001-2030 are expected to range from +0.6 to +1.4°C, depending on the season and the region of Bosnia and Herzegovina. The biggest changes will be during the months of June, July and August (JJA), with predicted changes of +1.4 in the north and +1.1°C in southern areas. During the months of December, January and February (DJF) changes are approximately +0.7°C, with maximum values in central parts of BiH. During the months of March, April and May (MAM) changes are slightly bigger than during DJF, with values ranging from +0.8 to +0.9. During the months of September, October and November (SON) changes range from +0.6 in the western part of the country to +0.8, in the eastern part. Figures for precipitation changes show that the models resulted in both positive and negative variations of this parameter. Positive changes in precipitation, i.e. an increase, may be seen during the March, April, May (MAM) season, i.e. +5% in the north and northeast, and during the June, July and August (JJA) season in almost the entire territory, with a maximum of +15%, with the exception of the southeast. The biggest deficit is predicted along the south-western border of BH, with a maximum of -20%.



Average annual temperature change in °C (left) and precipitation change in % (right)

Annual temperature changes range from 0.8 to 1°C, with higher values in the north and in the west of the country (figure above),. Annual precipitation change is negative in the entire territory, ranging from 0 to -10%., with the exception of the northeast, where precipitation is expected to increase by up to 5%.

<u>A1B scenario, 2071-2100</u>

Results for the A1B scenario during the period 2071-2100 show that spatial distribution of changes in corresponding parameters, mainly the temperature, are similar to the previously observed period

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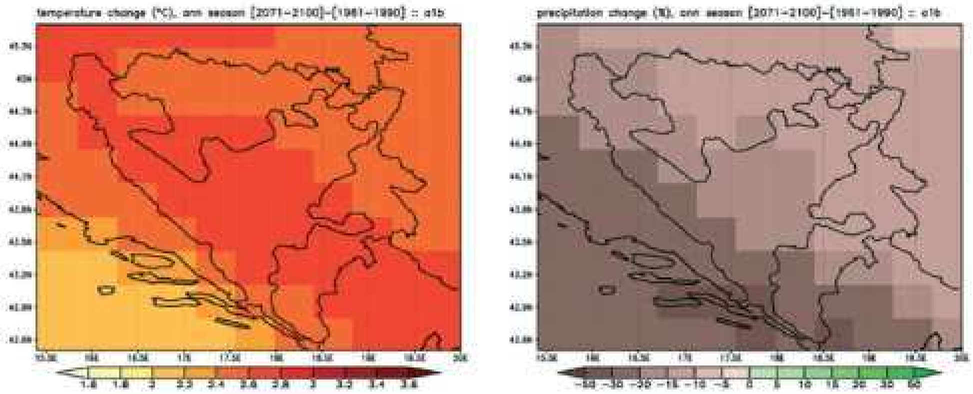
2001-2030, but with a greater magnitude of changes. This time, changes in temperature range from +1.8 to +3.6°C. The biggest changes of +3.6°C are again predicted for the months of June, July and August (JJA). During the winter season (December-January-February), maximum is again predicted in central regions, with values up to 2.4°C. During the March-April-May season temperature changes from 2.4 to 2.6°C at the entire territory. Finally, during the September – October – November season changes range from 2.0 to 2.4°C.

During this period, there is almost no season or region that is characterized by a positive precipitation anomaly. Large negative anomalies are predicted for the December-January-February (DJF) and September-October-November (SON) seasons, with changes ranging from -15 to -50%. The March-April-May season is characterized by values of approximately -10% for the entire territory. The deficit during the June-July-August season (JJA) is greater in southern than in northern regions ranging from -30 to 0%.



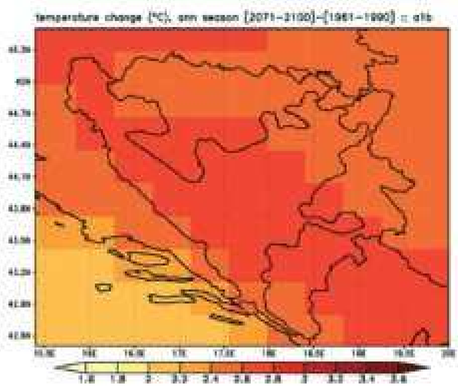
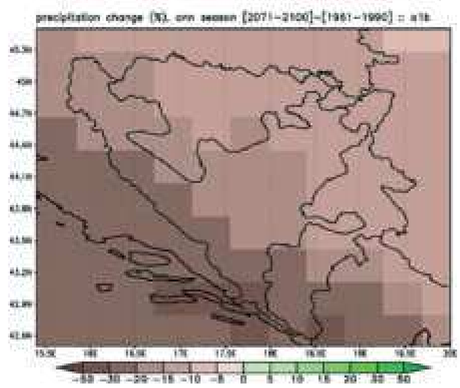
Annual temperature changes range from 2.4 to 2.8°C, with greater values in the south and in the west of the country. Annual precipitation change is negative in the entire territory, ranging from -30 to -10%.

<u>A2 scenario, 2071-2100</u>

In the A2 scenario for the period 2071-2100, the expected increase in temperature in the entire territory of BiH ranges from 2.4 to 4.8°C. The biggest increase will be during the months of June, July and August (JJA) season with values above 4.8°C. During the December, January and February (DJF) season; the maximum predicted change is approximately 3.6°C. The March, April and May (MAM) season have predicted values ranging from 3.4 to 3.6°C. During the September, October and November (SON) season the changes are again bigger in the western part of the country, ranging from 2.8 to 3°C. With the exception of the DJF season, the A2 scenario has a negative anomaly in terms of accumulated precipitation across the entire territory. With the exception of the south eastern regions, the December, January and February (DJF) season has a positive anomaly across almost the entire territory, ranging from 0 to +30%. The biggest changes in this scenario are predicted during the June, July and August (JJA) season, with values of -50%.

During the March, April and May (MAM) season and the September, October and November (SON) season, anomalies range from -30 to 0%. Annual temperature changes under the A2 scenario range from 3.4 to 3.8°C for this period (figure below). Annual precipitation change is negative throughout the entire territory, ranging from -15% to 0%.

Temperature change (°C), annual season (left) and precipitation change (%) (right)

Summary of scenarios

Results from two global climate models: SINTEX-G and ECHAM5 indicate a mean seasonal temperature increase averaging +1°C by 2030 compared to the base period 1961 – 1990 over the whole Bosnia and Herzegovina. The largest increase of +1.4°C is expected during summer time (June – August). For the A2 scenario (2071-2100), the rapid temperature increase of +4°C yearly average is expected, while the expected increase in temperature during summer time will go up to +4.8°C. Models indicate uneven precipitation changes. A slight increase in precipitation in mountain and central areas is expected, while negative precipitation anomalies are projected for the other areas. According to the A2 scenario for the period 2071-2100, negative precipitation is expected across the whole B-H territory. The largest precipitation deficit of up to 50% compared to the base period 1961-1990 is expected during summer months.

Temperature change in °C, SINTEX -5 model.

	A1B 2001-2030	A1B 2071-2100	A2 2071-2100
DJF	0.6 – 0.9	1.8 – 2.4	2.4 – 3.6
MAM	0.8 – 0.9	2.4 – 2.6	3.4 – 3.8
JJA	1.1 – 1.4	3.4 – 3.6	4.6 – >4.8
SON	0.5 – 0.9	2.0 – 2.4	2.8 – 3.2
YEAR	0.8 – 1.0	2.4 – 2.8	3.4 – 3.8

Temperature change in °C, ECHAM5 model

	A1B 2001-2030	A1B 2071-2100	A2 2071-2100
DJF	0.2 – 0.5	3 – 3.8	3.2 – 4
MAM	< 0.2	2.2 – 2.6	2.6 – 3.2
JJA	0.5 – 0.8	4 – 4.2	4.4 – 4.8
SON	0.9 – 1.1	3.4 – 3.8	3.8 – 4.2
YEAR	0.4 – 0.6	3.2 – 3.6	3.6 – 4.0

Precipitation change in %, SINTEX -5 model

	A1B 2001-2030	A1B 2071-2100	A2 2071-2100
DJF	-15 – -5	-50 – -10	-5 – 30

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MAM	-10 – 5	-15 – 0	-30 – 0
JJA	-5 – 15	-30 – 0	-50 – 0
SON	-10 – 20	-50 – -15	-30 – 0
YEAR	-20 – 10	-30 – -10	-15 – 0

Precipitation change in %, ECHAM5 model

	A1B 2001-2030	A1B 2071-2100	A2 2071-2100
DJF	0 – 10	-15 – 5	-30 – 15
MAM	0 – 15	-5 – 15	-10 – 10
JJA	-10 – 10	-50 – -20	-50 – -20
SON	-10 – 5	-30 – -5	-20 – 0
YEAR	-5 – 10	-15 – -5	-20 – -5

Results from the several regional climate models, in accordance with the SRES scenarios of future climate A1B and A2 (Nakicenovic and Swart, 2000), will be used in the process of development of the Third National Communication of B-H. These models are defined by Fourth Report of IPPC/AR4, and RCP8.5 scenario of future climate (Moss et al., 2008), as defined by the Fifth IPPC Report (IPCC – AR5).

Results of the regional climate model EBU-POM (Djurdjevic and Rajkovic, 2010) will serve as a basis for future changes of extreme precipitation regime which may cause possible risks of landslides, floods and other natural disasters. Results of this models were used as a basis for impact analyses and vulnerability of socio-economic sectors to the climate change in the Second National Communication to the UNFCCC (Trbic et al., 2015)

Horizontal resolution of these results is 25 km, and time resolution span is 6 hours, that will enable improved insight in the possible changes of short-term extensive precipitations that in the most cases cause the natural disasters. As an additional data source, the non-hydrostatic regional model NMMB (Janjic and Gall, 2012) will be used, due to its high horizontal resolution of 8km and time resolution of 6h, for the period 2011-2100 obtained by regionalization of scenario RCP8.5.

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The Former Yugoslav Republic of Macedonia

As a country that is Party to the United Nations Framework Convention on Climate Change (UNFCCC) as a non-Annex I country and party to the Kyoto Protocol, the former Republic of Macedonia adopted three National Communications on Climate Change (in the year 2003, 2008 and 2014).

The preparation and adoption of the Third National Communication on Climate Change (2014) came as an obligation according to the Law on Ratification of the United Nations Framework Convention on Climate Change, the Law on Environment and The Programme on Adoption of the EU Acquis. The preparation of these three plans was supported by the Global Environmental Fund (GEF) and the UNDP. The thematic reports were prepared by the relevant scientific and specialized institutions: MANU (Macedonian Academy of Science and Arts), the Research Centre for Energy, Computer Science and Materials and UHMR (National Hydro-met Office) as well as by other relevant experts.

In the following text, the climate vulnerability and climate change scenarios up to 2100 developed by the National Hydro-met Office are presented.

Climate Variability

Analysis of the multi-year variation of the mean annual temperature shows that in the most recent 20 years (1994-2012) the mean annual temperature has been constantly higher than the multi-year average. Differences in the mean annual temperature in comparison with the period from 1961 to 1990 range from 0.2°C to 0.5°C. This is consistent with results from the broader region. The warmest years recorded on the territory for the period between 1951 and 2012 and for which data from all meteorological stations are available are 1952, 1994, 2008, 2007 and 2010. The highest maximum air temperature in the country – an unprecedented 45.7°C – was measured on July 24, 2007. A similar analysis of precipitation for different regions of the country by years and by seasons – with a special focus on May and November as the months with the most rainfall throughout the year – indicated a general trend of decrease in rainfall. However, due to the fluctuations in levels of precipitation from year to year, it is difficult to establish the exact amount of this decrease in annual precipitation totals.

Analysis of data on the extreme weather events (1961-2012) indicated that the number of summer days has increased significantly in recent years compared to the number at the beginning of the analysed period. Similarly, there has been a significant increase in the number of tropical nights in recent years. An analysis of cold waves and cold weather concluded that cold waves occurred much less frequently than heat waves. While there was a general trend of decline in the number of ice days per year, there was no general change in the number of annual frost days.

Climate Change Scenarios up to 2100

Climate change projections were carried out with the use of the MAGICC/ SCENGEN software package Version 5.3. Six IPCC SRES/AR4 scenarios were used in the process: A1B-AIM, A1FI-MI, A1T-MES, A2-AS, B1-IMA and B2-MES, and air temperature and precipitation changes were assessed for the period 2025–2100 (reference period: 1961–1990). Data from 18 models were used in the estimation, generating results for two central geographical points. Scenarios were generated for four characteristic years, for each central point, for each of the three values of climate sensitivity, and for

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each of the six scenarios. Values were produced for air temperature and precipitation changes monthly and seasonally.

The modelling results led to the following conclusions:

1. It is probable that there will be a continuous increase in temperature in the period 2025–2100;
2. Compared with the period 1961–1990, the predicted changes for the period 2025-2100 will be most intense in the warmest period of the year;
3. It is possible that the average monthly temperatures at the turn of winter into spring will be levelled in this period;
4. A decrease in precipitation is predicted in the period 2025–2100, in all seasons and at the annual level, with the maximum decrease in the summer season;
5. The intensity of changes is greatest in the warm part of the year (in July and August, there may be no precipitation at all); and
6. In the cold period of the year, decreases in precipitation of up to 40% of the average monthly quantities are predicted.

In order to examine the robustness of their findings, the modellers also studied differences between the findings obtained and findings from three previous modelling efforts that produced projections for the former Republic of Macedonia. The primary cause for the differences in the results was judged to be the use of different principles when estimating changes.

In the Third National Communication on Climate Change (2014), an analysis of impacts, vulnerability and adaptive capacity for eight sectors: agriculture and livestock, biodiversity, forestry, human health, tourism, cultural heritage, water resources, and socio-economic development were undertaken.

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Kosovo*

The development of the Climate Change Framework Strategy (CCFS) has been initiated in December 2012 by the Ministry of Environment and Spatial Planning (MESP) with support from UNDP. The present Climate Change Framework Strategy is an initial step in an adaptive management feedback policy process. It is also an opportunity to look for mitigation and adaptation measures that will boost sustainable development. Therefore, it consists of two components: Low Emission Development Strategy (LEDS) and the National Adaptation Strategy (NAS) presented in this strategy subsequently in two sections.

Although Kosovo* has not participated in or signed the *UN Framework Convention on Climate Change* (UNFCCC) and its Kyoto Protocol yet, it has the responsibility to respond to the requirements of the Convention and the Protocol, as one of the signatories of the Energy Community Treaty. The Energy Community Treaty also sets clear reduction targets for the energy use while it demands increase in the share of renewable energies.

The present Climate Change Framework Strategy is an initial step in an adaptive management feedback policy process. It is also an opportunity to look for mitigation and adaptation measures that will boost sustainable development. It is crucial for responding and anticipating the impacts of climate change in Kosovo*.

1. Alternatives considered: Possible Development Scenarios

Global prediction models

In case of development of Climate Change Strategy (mitigation and Adaption), UNDP expert used the GAINS model. The US based International Futures considers Kosovo* as part of a group of countries together with Serbia and Montenegro due to lack of separate historic statistical data. So only very general observations regarding scenarios for Kosovo* are possible until separate datasets are developed and entered in these models for the country.

The GAINS model1 is a set of models managed by the IIASA (Austria) on behalf of the EU. It includes various scenarios and data resulting from different EU research project. Below the projections from some of these scenarios are presented for the group of countries.

Often, technical measures are not sufficient anymore, and public authorities, non-governmental organizations and private companies are looking for other solutions to ensure that the vulnerable water resources are managed in a sustainable manner. However, current institutional arrangements are often insufficient to manage these new challenges adequately and innovative and adaptive ways for the governance of climate adaptation are required.

Within this context, Kosovo* is faced with great challenges to make its public governance system more resilient and flexible, for instance related to: 1) dealing with uncertainties in decision-making, in particular related to the unpredictable future of climate change, for example by means of long term scenario analyses, risk assessments and vulnerability assessments; 2) introduction of integrated approaches and adaptive management concepts;

[*] this designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo* Declaration of Independence.

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The 39 interventions presented in the previous section have been evaluated, based on multi-criteria analysis (MCA), in order to provide an overall ordering of interventions and to distinguish between short term, medium term and long term interventions.

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Montenegro

Compiled by: Sanja Pavicevic, Slavica Micev, Mladenka Vujosevic, Tonka Popovic, Tanja Mirkovic, Miras Drljevic

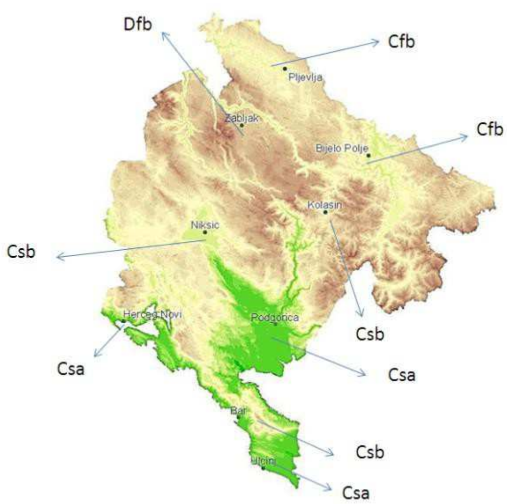
Situation Analysis

Montenegro is located in the central part of the warm moderate zone of the northern hemisphere (*41 ° 52 'and 43 ° 32' North Latitude and 18 ° 26 'and 19 ° 22' East Longitude*). Montenegro has a Mediterranean climate, with warm and somewhat dry summers and moderately cold and pretty wet winters.

Table 1. IHMS data for the period climatological normals (1961-1990):

Mean annual air temperature	11,2°C
Mean annual rainfall	1.500,5 mm
Mean intensity of heavy rains in the days with over 20 mm	38,2 mm/day
The mean length of the dry season	28,7 day/year
Average length of frost period	71,5 day/year
The mean length of heat waves	7,5 day/year
Climate classification - 3 climate types	Cs-Mediterranean, Cf-moderately warm and wet, Df-snowy-forest climate

Figure 1. Spatial distribution of meteorological stations whose data were used to update the data and verification of the EBU-POM regional climate model; the figure shows the climate classification by Köppen



Observed extreme weather and climate events by 2010:

- more frequent extreme high maximum and minimum temperatures;

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- more frequent and longer heat waves;
- increasing number of very hot days and nights;
- smaller number of frosty days and very cold days and nights;
- more frequent droughts;
- increasing number of forest fires;
- interruption dry period followed by heavy rainfall;
- more frequent occurrence of storms (cyclones) during the colder half of the year;
- reducing the number of consecutive days with rain;
- reduce the number of days with heavy precipitation;
- an increase in the intensity of rainfall and
- reduction of total annual snowfall.

As part of the SNC, the chapter „*Vulnerability and adaptation to climate change“* consists of 4 parts:

- 1st part analyzes the climate variability and change observed by 2010 in Montenegro;
- 2nd part analyzes the vulnerability of Montenegro to climate change and extreme events. It used indicators based on the impact of climate change (i.e. Impact indicators) and projections of extreme climatic events using a regional climate model EBU-POM;
- 3rd part analyzes the vulnerability by sector on the basis of impact indicators and future exposure to climate and extreme events;
- 4th part proposes appropriate adaptation measures.

Vulnerability and adaptation to changed climate conditions was addressed in the Initial National Communication (INC) on Climate Change to the UNFCCC. One of the goals of the Second National Communication is **obtain quantitative vulnerability assessment with focus on water resources, agriculture and forestry, public health and coastal areas**, as these were identified in INC as further priority steps. It is important to note that the quantitative estimates of vulnerability take into account the observed and projected changes in extreme weather and climate events, and thus provide the necessary information to open a new chapter in understanding and managing risk.

Climate variability and climate change observed to 2010 were analysed in accordance with the definitions of the IPCC. So atmospheric and climate variability in Montenegro is usually affected by the following:

- North Atlantic Oscillation (NAO),
- Genoa cyclone and Siberian High,
- air depression in the Adriatic, the cyclone's path across the Adriatic and the Mediterranean Sea, while the presence of high pressure over North Africa,
- the impact of El Niño in situations when it is very developed, and
- Impact of atmospheric blocking system.

Monitoring and evaluation of climate indicate that the climate of Montenegro changed as a result of global climate change and variability. The clearest indicators are: a significant increase in air

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temperature, the increase in sea surface temperature and mean sea level, changes in extreme weather and climate events.

Given that climate change is related to the long-term successive changes (increase or decrease) in mean state of the atmosphere, and that is one of the clearest signals of climate change change in air temperature, were analysed:

- changes in annual temperatures in the period 1951-2012;
- mean decade values of annual air temperature;
- mean value for the period 1961-1990, and
- decade deviation (Δ) of climatological normals.

Four Montenegrin municipalities (Zabljak, Pljevlja, Podgorica and Bar) were selected as representatives of a particular type of climate. Data quality was also considered during this selection.

Table 2. Mean annual air temperature for 4 municipalities' representatives of climate types

	Climatological normal	Decade						
Regions	'61-'90²	'51-'60	'61-'70	'71-'80	'81-'90	'91-'00	'01-'10	Δ
Municipality of Zabljak	4,6	5,1	4,7	4,5	4,7	5,4	6,0	+1,4
Municipality of Pljevlja	8,1	8,6	8,1	7,9	8,2	8,8	9,1	+1,0
Municipality of Podgorica	15,3	15,5	15,4	15,0	15,4	15,8	16,3	+1,0
Municipality Bar	15,5	15,7	15,7	15,3	15,6	15,9	16,8	+1,3

(Δ - deviation of the Decade (2001-2010) annual temperature of climatological normals)

As for the precipitation, as described in the INC:

- no significant reduction in total annual precipitation;
- in the normal range of rainfall increases in the fall, and decreases in the spring, summer and winter;
- In statistical terms, there is a significant increase in rainfall in September in the Zeta-Bjelopavlicki region.

Overall, these changes indicate a change in precipitation regime that take extreme character.

Table 3. Decadal annual precipitation (mm)

	Climatological normal	Decade						
Regions	'61-'90	'51-'60	'61-'70	'71-'80	'81-'90	'91-'00	'01-'10	Δ
Municipality of Zabljak	1.455,4	-	1.514,2	1.564,4	1.287,5	1.370,1	1.610,6	+155,2
Municipality of Pljevlja	796,5	735,7	783,8	865,4	740,4	733	839,86	+43,4
Municipality of Podgorica	1.657,9	1.632,1	1.756,7	1.695,2	1.521,7	1.593,7	1.781,6	+123,7
Municipality Bar	1.390,9	1.414,1	1.473,2	1.480,5	1.218,9	1.241,9	1.463,9	+73

(Δ - Deviation of the Decade (2001-2010) annual precipitation of climatological normals)

According to the available sequence data IHMS for the period 1980-2012 for the temperature of the sea surface from the station in Bar, and the sea level in the period 1965-2011 years:

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- Sea Surface Temperature increases by about + 0.02 ° C per year;
- Each decade is higher than the previous, and the highest was last with an average annual temperature of 18.3 ° C;
- sea level is rising, with small changes from year to year during the first decade of the 21st century.

Table 4. Decadal value of the annual sea surface temperature in Bar

Decade	Sea Surface Temperature (°C)
1981 – 1990	17,9
1991 – 2000	18,1
2001 – 2010	18,3

A more detailed analysis of changes in sea surface temperature and its level due to climate change and variability is conducted by the Project CAMP ("*The Integrated Coastal Zone Management of Montenegro").* Some very serious problems were identified during its implementation:

- quality of meteorological and hydrological data;
- the availability of the data string, and
- lack of observation stations in the coastal areas,

which provides little basis for assessing current and future changes in sea level.

Climate analysis was performed by climate decades, to obtain a summary of the observed extreme events in Montenegro in the past 15 years and their projections parallel to the EBU-POM regional model. What we can immediately notice is that the trends observed and projected climate change matched well.

Table 5. Decadal Records largest maximum air temperature in the period 1951-2010.

	Decade					
Regions	**'51-'60**	**'61-'70**	**'71-'80**	**'81-'90**	**'91-'00**	**'01-'10**
Municipality of Zabljak		30,4	28,2	30,6	31,3	32,4
Municipality of Pljevlja	38,0	35,0	33,2	36,2	38,2	38,1
Municipality of Podgorica	41,2	40,6	39,2	41,4	41,6	44,8
Municipality Bar	35,4	35,9	36,8	37,7	37,0	36,6

Table 6. Decadal records the smallest minimum air temperature in the period 1951-2010.

	Decade					
Regions	**'51-'60**	**'61-'70**	**'71-'80**	**'81-'90**	**'91-'00**	**'01-'10**
Municipality of Zabljak		-26,4	-22,7	-26,4	-25,7	-24,6
Municipality of Pljevlja	-29,4	-29,0	-27,0	-29,2	-26,7	-23,5
Municipality of Podgorica	-9,7	-9,2	-8,5	-9,6	-8,4	-6,7
Municipality Bar	-7,0	-7,2	-4,9	-4,4	-5,3	-4,3

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Table 7. Decadal records largest maximum daily rainfall during the period 1951-2010.

	Decade					
Regions	**'51-'60**	**'61-'70**	**'71-'80**	**'81-'90**	**'91-'00**	**'01-'10**
Municipality of Zabljak		207,4	146,5	122,6	144,2	141,3
Municipality of Pljevlja	55,5	79,4	90,2	123,5	77,9	81,1
Municipality of Podgorica	128,4	128,2	133,7	226,8	108,4	145,9
Municipality Bar	180,8	135,4	157,1	224,0	124,2	200,7

According to the available data of the A series of measurements since 1949, and from individual stations from 1958 until present day (IHMS), it is evident that there a more frequent extreme heat waves since 1988. These are particularly strong and long-lasting during August.

Current situation - Observed extreme events (Source: The observations of IHMS)

- more frequent extreme maximum and minimum temperatures;
- more frequent and longer heat waves;
- increasing number of very hot days and nights;
- smaller number of frosty days and very cold days and nights;
- more frequent droughts;
- increasing number of forest fires;
- interruption dry periods followed by heavy rainfall;
- more frequent occurrence of storms (cyclones) during the colder half of the year;
- reduction in the number of consecutive days with rain;
- reduction in the number of days with heavy precipitation;
- an increase in the intensity of rainfall
- reduction of total annual snowfall

Droughts

In Montenegro to the implementation of the IPA project *Drought Management Centre for South Eastern Europe (DMCCSEE)* in 2012 permanent monitoring of drought was established. The following resulted were obtained:

- homogenization of precipitation data carried out;
- archives made on the impact of the drought of 2000;
- continuous monitoring of drought monitoring SPI index established ;
- application WINISAREG models for irrigation scheduling tested;
- application of remote monitoring drought tested (i.e. via satellite)
- folders on vulnerability of Montenegro to the drought created.

Table 8. Typical dry year in Montenegro arranged by decades

Decade	'51-'60	'61-'70	'71-'80	'81-'90	'91-'00	'01-'10
Dry year	1953	1962, 1967, 1969	1978	1981, 1982, 1985, 1988, 1989	1993, 1994, 1996, 1999	2003, 2007, 2008, 2011

The results show that the decade of the '81 -'90 drought more frequent. The following figure was done by analysis of the SPI index for three typical dry year in Montenegro:

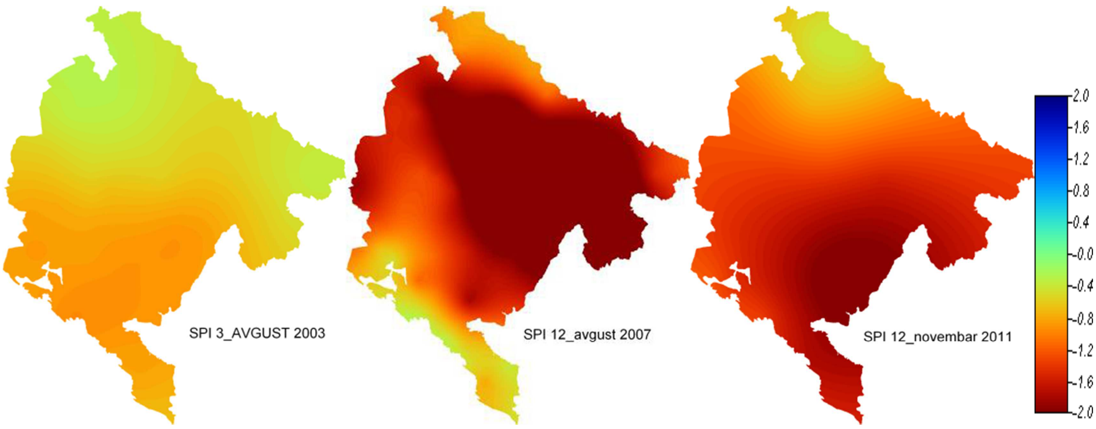

Figure 2. Map intensity of droughts in 2003, 2007 and 2011 expressed through anomalies SPI index: SPI3 - agricultural drought of 2003, SPI12 - hydrological drought in 2007 and 2011

Heat waves

Monitoring and evaluation of climate in Montenegro shows that the heat waves are a growing phenomenon and that their length shows great variability from year to year. Long term prospects display a trend of successive increase in their duration.

***Heavy rains**

Heavy rains leading to floods usually affect the area of Tara and Lim in the colder season (October - March). Through the research conducted in the CAMP project, at the level of the observed data and resulting damage on the fact the storm, it can be said that the storms (cyclones developed very) frequent and intense occur by 1998, bringing, especially on the coast, a large amount of rainfall, storm up hurricane-force winds, high waves and flooding wide areas along the coast.

Table 9. Average rainfall intensity on days with heavy rainfall

	Climatological normals	Decade					
Regions	'61-'90	'51-'60	'61-'70	'71-'80	'81-'90	'91-'00	'01-'10
Municipality of Zabljak	37,4		39,3	36,5	37,3	38,2	38,9
Municipality of Pljevlja	29,2	27,1	29,9	29,4	30,9	29,1	30,7
Municipality of Podgorica	39,8	34,6	38,1	39,7	41,6	40,1	50,0
Municipality Bar	38,8	36,7	38,6	39,3	38	37,1	63,3

The results show that:

- Intensity of heavy rainfall shows decadal variability except in Northern-region above 1,000 meters above the sea level where the increase for the last two decades;
- Strongest rainfall was during the '01 -'10 on the coast, and Zeta-bjelopavlicki region, and then Northern-region up to 1,000 meters above sea level, where almost the same intensity was during the decade '81 -'90;
- Long-term changes in relation to the climatological normal are positive and in line with the expected qualitative changes EBU-POM model.

Through research conducted in the CAMP project, at the level of the observed data and resulting damage on the fact the storm, it can be said that the storms (cyclones developed very) frequent and intense occur by 1998, bringing, especially on the coast, a large amount of rainfall, storm up hurricane-force winds, high waves and flooding wide areas along the coast. Series of cyclones and local instability were registered during the decade '01 -'10 accompanied by heavy rains, floods, snowfall and stormy winds.

Table 10. Annual amount of snow cover (cm)

	Climatological normals	Decade					
Regions	'61-'90	'51-'60	'61-'70	'71-'80	'81-'90	'91-'00	'01-'10
Municipality of Zabljak	8.707		10.025	7.901	8.194	6.400	6.642*
Municipality of Pljevlja	790	940	876	755	723	706	800*
Municipality of Podgorica	31	59	24	30	39	7	14*
Municipality Bar	-	-	-	1	2	2	0

Vulnerability of Montenegro on climate change and extremes

In this chapter, we used indicators to describe the state of the climate and the impacts of climate change on various natural and social systems that are exposed to it. The indicators are grouped into six different categories and they are:

- Atmosphere and Climate (e.g. air temperature increase, decrease frosty days, reducing the amount of rainfall, retreat of snow cover);
- Coast and coastal area (e.g. the increase in sea surface temperature, sea level rise);
- water resources (e.g., river flow);
- agriculture (e.g. plant productivity due to temperature rise);
- forestry (e.g. the development of pests and diseases due to the increase in temperature and

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decrease in precipitation, index of species of forest trees);

- health (e.g. more frequent heat waves, floods, allergic respiratory diseases caused by pollen, especially in children, the frequent incidence of heart attack and stroke during the low air pressure, large temperature fluctuations and humid hot days).

In this section, the focus is vulnerability to climate extremes and water, and their negative consequences for human security and sustainable development. Vulnerability is treated as defined by the IPCC, i.e. as a function of exposure, sensitivity and adaptive capacity.

Scenarios of climate extremes

With reference to the methodology, two widely used methods are statistical and dynamic methods. Dynamic scaling (Eng. Dynamical downscaling) assumes the introduction of a Regional Climate Model

RCM high-resolution global model results used as lateral boundary conditions, producing their own integration results from decomposition of the order of 10 km above the selected areas.

Based on the monitoring and evaluation of climate in Montenegro, and the analysis of extremes, from a set of climate indices were selected 5 of the air temperature and 3 of the precipitation. These indices are analysed in terms of the normal climate, which is considered the period 1961-1990 in terms of projected climate that prevailed in the scenarios A1B and A2 in the periods 2001-2030 and 2071-2100. For such calculations is applied regional climate model EBU-POM, whose results are used in making INC.

In addition to these 8 indices, it was also analysed changes in the total annual amount of snow and the changes mean daily maximum wind speed. These changes are calculated from the direct output of the EBU-POM model and expressed as percentages relative to the base period 1961-1990.

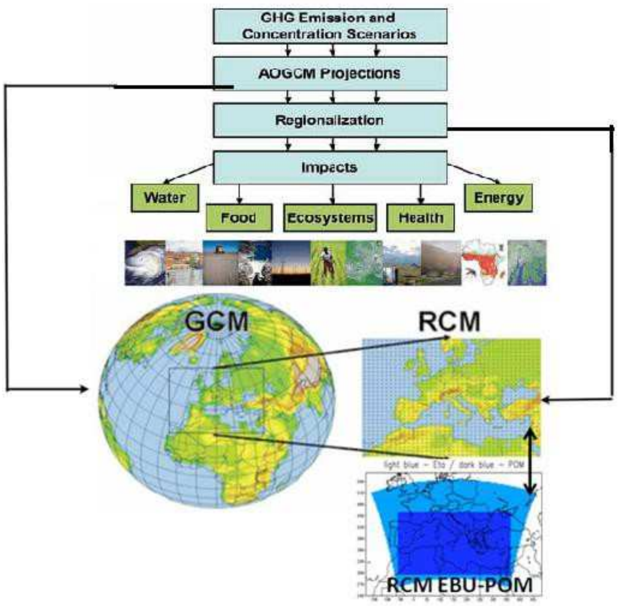

Figure 3. Schematic representation of the process of regionalization scenarios of climate change[§§§§§]

[§§§§§] *Sources, WMO, SNC*

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Climate model

EBU-POM6 is a regional climate model that represents a system of two coupled regional models, one for the atmosphere and one of the oceans.

Due to the complexity of the climate system, all climate models, including the EBU-POM, carry a certain degree of approximation of various geophysical processes for which the model results contain a certain level of errors/deviations from the observed flood conditions. This deviation model is verified through simulation of the existing climatic conditions for the period 1961-1990 climatological normals. In order to significantly reduce the error, applied the method by which the quantile modelling results were statistically adjusted and were selected weather stations to the observed data quality, completeness series and spatial distribution.

So is selected 9 meteorological stations where measurements and observations performed continuously, and these are: Bar, Herceg Novi, Kolasin, Niksic, Podgorica, Podgorica, Ulcinj, and Zabljak, and because of the completeness of a series and geographical position and station in Bijelo Polje, although with a lower level of the program of work.

Assumptions

The main assumption is based on a variety of long-term trends in emissions of greenhouse gases (GHG), which are actually the result of various economic and demographic trends and different interests regarding sustainability. According to a special IPCC report on emission scenarios[******], the so- called SRES scenarios were defined four families of scenarios, A1, B1, A2 and B2, each of which includes proper narrative scenarios.

In the SNC special attention is given to the results of experiments/scenarios A1B and A2, which are relative to the concentration of greenhouse gases are defined as "medium" or "high" scenario.

<u>The results of the climate model</u>

Days with frost (index number of frosty days-FD): Projections EBU-POM model indicate a decrease in the number of frosty days in the future.

Duration frost period: Length frost period will be shorter and shorter, depending on the analyzed scenarios and time period. This means that the last frost (frost Spring Time) increasingly move to the beginning of the year, and the first frost (autumn frost) towards the end of the year. Therefore, in the future can expect longer periods of frost.

Warm days (index of the number of hot days-TX90p) will significantly increase during the year and up to several times by the end of the twenty-first century.

Heat waves (heat waves Index-WSDI) will appear more often and last longer in all areas of Montenegro, and especially on the coast.

[******] *The Special Report on Emissions Scenarios (SRES, Nakicenovic and Swart, 2000).*

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The duration of the growing season (index vegetation length-GSL) is longer for both scenarios during the 21st century where the major changes in the beginning of the occurrence of the vegetation period of change in its completion.

Drought periods (Index consecutive days without rain-CDD) are longer in both scenarios considered, especially in northern areas.

Rainy period (index number of consecutive days with rain exceeds 1 mm day-CWD) for both scenarios and time periods, decreases, which is in line with all the long dry periods, and supports the thesis about possible arid climatic conditions in the future.

Days of heavy rains (index number of days with precipitation greater than 20 mm RR20mm) are reduced or only in a few cases, very little increase.

Changes in the total annual snowfall are negative for both scenarios and both time periods. This decrease in the annual snowfall is greater than the decrease in total rainfall, which was expected due to the fact that due to the increase in air temperature snowfall excreted in the form of rain.

Changes in mean daily maximum wind speed: Average daily wind speed according to EBU-POM projections decreases during the year by about 5% over the period (1961-1990) and it more or less uniformly for both scenarios and time periods in all areas of Montenegro.

Floods are one of the most common natural disasters and cause the greatest damage. They have a direct and indirect influence. The first is reflected in the loss of lives and damage to households and indirect through increased exposure to other hazards such as contaminated water supplies, landslides and disorganization of traffic and trade.

Due to the geomorphological characteristics of the territory of Montenegro, floods may threaten settlements, agricultural, forest and other land, and roads in the river valleys and ravines. In particular, it should be noted that all the rivers in Montenegro in its upper course, or throughout their length, torrential character. This means that there are large differences in flow of larger and smaller waters and regular occurrence of torrential waves with a significant concentration of sediment. There are two issues that stand out and make Montenegro highly vulnerable to flooding:

- The first problem is the large number of towns and villages located on the banks of major rivers, making them potentially more vulnerable than large spills water from river beds;
- Another problem is the problem of Skadar Lake and river Bojana, Cetinje and Niksic field that can threaten important agricultural areas, material goods and the urban area of the municipality of Cetinje.

Table 11. Summary of projected changes in extreme events compared to the period from 1951 to 2010 [8] [††††††]

Index / variable	Expected qualitative change	Quantitative changes			
		units of changes	A1B 2001-2030	A1B 2071-2100	A2 2071-2100
The number of frosty days	The decrease in all locations	days / year	-1 to -16	-5 to -43	-6 to -61

†††††† *Source: Results of the EBU-POM regional climate model, SNC*

Last Spring starting frost	Moving to the beginning of the year	days / year	-0.6 to -13	-13 to -30	-19 to -36
The first autumn frost	Moving towards the end of the year	days / year	0 to 9	5 to 22	8.9 to 28
Number of very hot days	Significant increase during the year and up to several times by the end of the twenty-first century	days / year	33 to 48	110 to 182	144 to 239
The average length of heat waves	The extension at all locations	days / year	0.5 to 2	2 to 9	4 to 15
The frequency of heat waves	Significant increase in all locations	days / year	2 to 3.8	7 to 10	9 to 10
Length of growing season	prolongation	days / year	0 to 16	3 to 56	3 to 70
Number of consecutive days without rain	increase	days / year	1 to 5	3 to 6	5 to 7
Number of consecutive days with rain	reduction	days / year	0.5 to -0.7	-0.2 to -2	-0.1 do -2.4
Number of days with precipitation over 20mm	reduction	days / year	0 to -3.6	-0.5 to -10	0 to -7
Average rainfall intensity on days with more than 20mm	mostly increase	mm / day	0.9 to 4.1	-2.4 to 1.3	0.9 to 4.7
Annual accumulated snow	The reduction, significant in the northern regions	%	-25	-50	-50
Mean daily maximum wind speed	The annual reduction.	%	-5	-5	-5
	Increase the seasonal level in the south-eastern part of Montenegro, for the summer season	%	+2	+2	+3

Scenarios and projections

Scenarios and projections of regional climate model that includes extreme events for the reference period 2000-2100 show that, in Montenegro, it can expect constant growth temperature during successive thirty-year period in the twenty-first century.

Under this scenario, the rate of increase in temperature will be higher in the second half of the twenty-first century to the final annual mean temperature anomalies for the last thirty years averaged + 3.5 ° C compared to the normal climatological period 1961-1990.

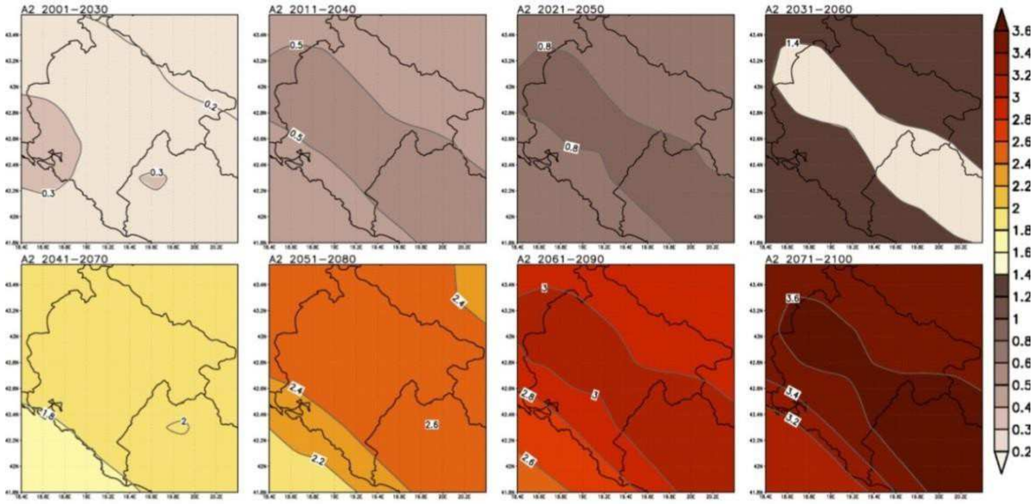

Figure 4. Change in mean annual temperature (° C) compared to the period 1961-1990, for the indicated sliding period of thirty years from 2001 to 2100 under scenario A2.

Scenarios and projections of regional climate model that includes extreme events for the reference period 2000-2100 show that changes in precipitation regime complex and according to the considered scenario in the first half of this century, the territory of Montenegro is divided into the northern areas of positive and negative anomalies to the south.

In mid-century, the area negative anomalies will slowly spread to northern parts so the two penultimate thirty-year periods we have a situation that approximately 90% of the territory has a negative anomaly of precipitation.

Finally, for the last thirty-year period we have the situation that the whole territory of a deficit in relation to the reference period 1961-1990, with a maximum of 10% of annual accumulation.

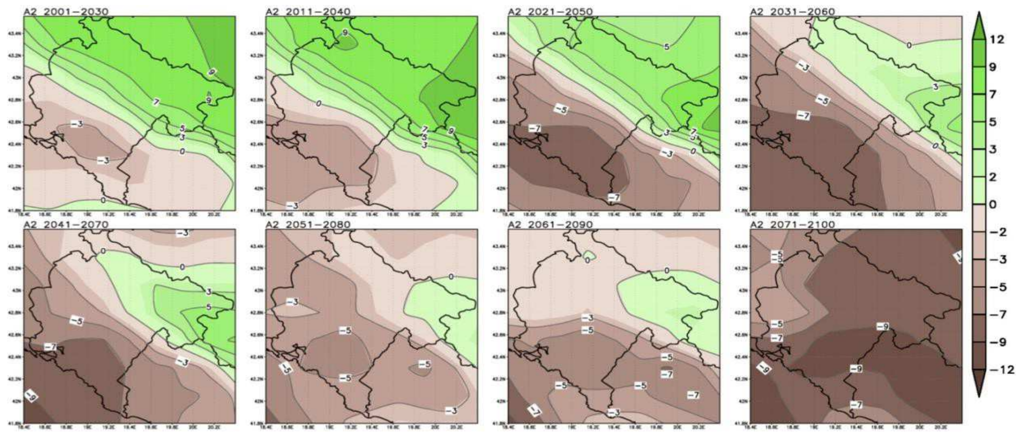

Figure 5. Change in mean annual rainfall accumulation (%) compared to the period 1961-1990, for the indicated sliding period of thirty years from 2001 to 2100 under scenario A2

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Air temperature changes in the 21st century with reference to 1961-1990	Projected precipitation changes in the 21st century with reference to 1961-1990
2001-2030, A1B **Summer**: 1.3°C in the north and 1° C in coastal areas. **Winter**: 0.5°C in the coastal part, 0.9°C in the northern part **Spring**: 0.8°C in the south, 1.1°C in the north **Autumn**: almost no differences in temperature change going from south to north, with more or less steady change in the entire territory of about 0.7°C.	**2001-2030, A1B** **Summer**: positive changes up to 5% for the central area of Montenegro. **Autumn**: positive changes up to 5% near the border with Bosnia and Herzegovina. **Winter, spring**: a decrease in precipitation up to 10%
2071-2100, A1B **Summer**: along the coastal area 2.4°C temperature increase, in the northern mountainous region 3.4°C **Winter and spring**: temperature increase of 1.6°C the coastal area and 2.6°C in the north **Autumn**: temperature increase of 1.6°C in the coastal region and 2.4°C in the northern area along the border with Serbia.	**2071-2100, A1B** **Winter**: 30% less in the central parts of Montenegro, values of up to -30% in the northern and coastal parts; **Spring**: about 10% less in the whole territory; **Summer**: a significant decrease in coastal areas, and a decrease in the central and northern parts of 15 to 20% less; **Autumn**: a significant decrease in precipitation from 30 to 50%.
2071-2100, A2 **Summer**: the greatest increase in the mountainous region in the north, with values over 4.8° C **Winter**: temperature increase along the Adriatic coast of about 2.6°C, and about 3.4°C in the northern parts **Spring**: temperature increase along the Adriatic coast of about 2.8°C, and about 3.6°C in the northern parts **Autumn:** spatial distribution of changes is far more uniform, in relation to other seasons, in the range of 2.6°C to 3°C	**2071-2100, A2** **Winter**: a precipitation increase of 5-10% is projected in the north-western parts, and a decrease of -5% to -10% in the other parts of the country; **Summer**: the biggest decrease, especially along the coast, of -50%. A decrease of -10% in the northern parts; **Spring and autumn**: a more uniform decrease with a mean value of -20%.
2001-2100, A2 The increase in air temperature during successive 30-year periods, and in the last 30th years up to 3.5 ° C; The speed of growth is greater in the second half of the 21st century; Except for periods at the beginning of this period, the temperature increase is greatest in the central parts of Montenegro, and the lowest mainly in the region's coast**.**	**2001-2100, A2** In the the first half of the 21st century, Montenegro is divided into the northern areas with increasing precipitation and south with a reduced amount of rainfall; Mid-century the area of reduction of rainfall will slowly spread to the northern parts, so that the two penultimate 30-year period, about 90% of the country have less rainfall compared to the 1961-1990; The last 30 years of this century the whole territory will have a deficit of rainfall up to 10% per annum; Viewed in relation to the total annual amount of precipitation, the most vulnerable part of the Montenegrin coast would be due to the fact that this area was adversely affected by deficit rainfall throughout the 21st century.

Limitations, disadvantages and related financial, technical and institutional needs in terms of vulnerability and adaptation measures

- Lack of an adequate policy framework, lack of technical and scientific research, the lack of data (there is no database to determine the impacts of climate change on different sectors / fields, e.g. on the impact of weather and climate on human health because the mandatory health records are not kept in a way that to enable easy acquisition of adequate data for such analysis);

- Lack of professional and scientific research on human health vulnerability to climate change;
- There is no national strategy to mitigate the effects of climate change on water resources, agriculture and coastal areas;
- State policy on the impact of climate change on agriculture is not defined;
- Low level of confidence of global and regional models - a small degree of confidence of global and regional models for the projection of an increase in sea surface temperature in the smaller local basins such as the Mediterranean and the Adriatic Sea.

The global models have relatively little decomposition to properly explain such small basins, and regional models such as the EBU-POM are not able to properly factor into consideration of the increase in sea level as a result of melting glaciers and eternal ice that are global and not regional problems.

Note: Homework 1 of Montenegrin WG4 to ECRAN has been prepared on the basis of findings of the Second National Communication on climate change to the UNFCCC as the latest official document of Montenegro in climate change area, and systematized all available public documents

References

- The Second National Communication On Climate Change of Montenegro to the UNFCCC (SNC)
- The Initial National Communication On Climate Change of Montenegro to the UNFCCC (INC)
- Archive and website of the Institute of Hydrometeorology and Seismology of Montenegro, www.meteo.co.me
- Website: www.unfccc.me
- Website: www.mrt.gov.me

Serbia

Climate and impact models

Climate Models

Global models and regional models used for dynamical downscaling in Serbia are presented below.

1) **RCM-SEEVCCC** is a 2-way coupled regional climate model (RCM), with the Eta/NCEP-Limited Area Model as its atmospheric part and the Princeton Ocean Model (POM) as its oceanic part. Model was used for dynamical downscaling of ECHAM4 and ECHAM5 global model outputs. In both cases model domain covers the Euro-Mediterranean region on the resolution of ~35 km.
   a) **ECHAM4** global model: present climate simulation for the period 1961-1990 and projections for the periods 2001-2030 and 2071-2100 according to A1B and A2 scenarios are completed. Model outputs are employed in the First and Second National Communication and different impact studies.
   b) **ECHAM5** global model: simulation of present (1961-1990) and future climate (2001-2100) is done applying A1B and A2 scenario. Bias corrected outputs are employed in the Second National Communication and different impact studies.
2) **NMMB**, the unified Non-hydrostatic Multi-scale Model developed at NCEP has been used for a number of operational and research applications in Republic Hydro-meteorological Service of Serbia. The NMMB can be run both as a global and as a regional model. In addition, there is a possibility to run model in a global setup with several on-line nested regional domains, which can be stationary or moving depending on user choice. In these experiments model has been used as a regional climate model for dynamical downscaling of two global datasets (ERA40 reanalysis and CMCC-CM global model outputs). The work has been carried out through OrientGate project. Outputs are used for climate indices calculation for Serbian territory (the document will be published soon).
   a) **ERA40** reanalysis: present climate simulation for the period 1971-2000 on 14 and 8 km resolution for greater part of Euro-Mediterranean region.
   b) **CMCC-CM** global model: projection for the period 1971-2100 was done for the part of Balkan Peninsula on the resolution of 8 km and using RCP8.5 climate change scenario.

All model data are bias corrected using observational dataset from the national meteorological network and/or ECA&D data for Serbian territory.

Impact Assessment

Hydrology

Statistically corrected values of 2m temperature and precipitation are used for hydrological HBV model forcing for Kolubara and Toplica rivers as part of the bilateral project "*Effects of climate change in the Kolubara and Toplica catchments*" carried out by the Norwegian Water Resources and Energy Directorate and Republic Hydro-meteorological Service of Serbia. Two time periods (2002-2030 and 2072-2100) and six combinations of regional and global models were considered. Model combinations are: ECHAM5/HIRHAM5, HadCM3Q0/CLM, ECHAM5/RegCM3, HadCM3Q0/HadRM3Q0, ECHAM5/RCM-SEEVCCC and ECHAM4/RCM-SEEVCCC.

CCWaterS project analyzed future groundwater resources in five pilot areas in Serbia. A1B was used as climate change scenario, with the future periods of 2021-2050 and 2071-2100 modelled. VNC linear regression model was used for hydrological modeling. The same method was applied in the analysis of changes in discharge for four catchments in Serbia: Kolubara, Mlava, Raska and Nisava as part of the project "*Potential impacts of climate changes on water resources in Serbia*". In this case two scenario were applied, A1B and A2, for the periods 2001-2030 and 2071-2100.

In project "*Study Water & Climate Adaptation plan for Sava river Basin - WATCAP*" a hydrological model HEC-HMS was developed. The model was using outputs from five global/regional climate models combinations: ECHAM5/RACMO, ECHAM5/REMO, ECHAM5/RegCM3, HadCM3/HadRM3, HadCM3/CLM. Time periods were 2011-2040 and 2041-2070 and applied scenario A1B. Within the model domain five discharge points in Serbia on four rivers: Drina, Lim, Kolubara and Sava were analyzed.

Agriculture, forestry, biodiversity and human health

Estimation of changes in the potential crop yield, for winter wheat, maze, soybean and sugar beet, following future climate change scenarios A1B for the period 2001-2030 and A2 for the period 2071-2100 and several locations in Serbia were obtained using the DSSAT-CSM model. Impact assessment for viticulture within the same periods and scenarios were done as well by applying different indices.

Statistically downscaled data from ECHAM5 model with the Met&Roll weather generator are used as input for BAHUS bio-meteorological model for providing the information on occurrence and severity of the several plant diseases for years 2030 and 2050. For the periods 2011-2040 and 2041-2070 and currently established trends of diseases and pests of the most important agricultural plants in Serbia an assessment of climate change impact on their future trends was made based on the expert judgment.

In forestry, projections with RCM-SEEVCCC/ECHAM4 are used in impact study on distribution of beach and oak forest stands. Model outputs are applied for calculation of two forest indices.

Expert judgment is applied in the case of the biodiversity and human health.

Risk and Vulnerability Assessment

National risk assessment is in progress. Methodology for the development of risk assessment and plans for protection and rescue in emergency situations cover different hazards for witch identification and risk assessment is in different jurisdiction. Covered hazards are:

- floods;
- earthquake, landslides, mudslides and erosion;
- extreme weather hazards (drought, severe wind, hail, blizzard, snow drift, glaze);
- technical - technological accidents and terrorist attacks;
- fire and explosion;
- demolition of the dams;
- nuclear accidents;
- epidemiological and sanitary hazards;

- epidemic;
- epizootic;
- plant diseases.

Serbia participated in the project "*Joint disaster management risk assessment and preparedness in the Danube macro-region (SEERisk)*". The aim of this project was to develop methodology in accordance with the European Directive "Risk Assessment and Mapping Guidelines for Disaster Management" which will be applied in the countries of South Eastern Europe. This methodology had been applied in Serbia in pilot area Kanjiza for drought and wild fires. The "*Guideline on climate change adaptation and risk assessment*" under the coordination of RHMS and in collaboration with other partners in the project is finalized.

Republic of Serbia also participates in the project "*Climate Change Adaptation in Western Balkan*". The project aims to reduce the risks of flood and drought as well as to strengthen regional cooperation in the field of integrated water resources management. City of Belgrade is the pilot area for urban planning.

Ministry of Agriculture and Environmental Protection, is implementing the project "*Second National Communication of the Republic of Serbia to the UNFCCC"*, supported by the GEF (UNDP is implementing agency). The document should be prepared by the end of 2015. In the field of adaptation to climate change under SNC, the chapter on the observed and projected climate change will be developed and also a chapter on the planning and implementation of measures to facilitate adequate adaptation to climate change in Agriculture, Forestry, Waters, Ecosystems and Biodiversity, and Health sectors.

Turkey

Climate Modelling Studies in Turkey

Several climate modelling studies have been carried out for Turkey and its surrounding in recent years. Detailed information could be obtained from the national communications submitted to United Nations Framework Convention on Climate Change.

Therefore, this report focuses on the on-going studies of Turkish State Meteorological Services and General Directorate of Water Management.

A. Regional Climate Model (RCM) Studies of Turkish State Meteorological Service (TR2013-CC)

RCM projections in the TR2013-CC by using dynamic downscaling method are based on general circulation models (GCM) in CMIP5 project and RCP scenarios. RCP4.5 is chosen as mild model and RCP8.5 as severe model.

TR2013-CC main characteristics

Data Sets of Global Model	Regional Model	Data Sets of Sensitiveness Analysis Test	Period
HadGEM2-ES MPI-ESM-MR *GFDL-ESM2M	RegCM4.3.4	• CRU (1971-2000) • UDEL (1971-2000) • UDEL-C (1971-2000)	1971-2000 (RF) 2013-2099

*running on

While domain was chosen, it was tried to catch optimum size to correctly demonstrate effects of sea and air masses, in addition to considering computing capacity and time schedule. Domain is located at 27.00o-51.00 o (N) and 5.00o-55.00o (E). Four RCPs that are used for IPCC-AR5 have been defined for radiatif forcing levels. In this study, 3 GCMs have been used, that also have been take part in AR5 and CMIP5.

Topography of domain in Regional Climate Model (RegCM4.3.4)

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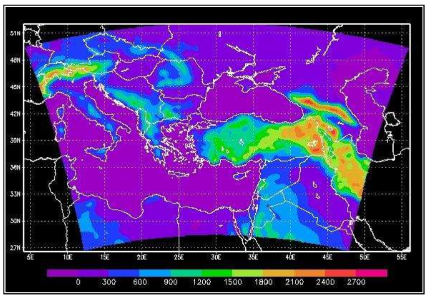

Representative Concentration Pathways (IPCC, 2013)

RCPs	Radiative Forcing	Time	Pathway shape	Concentration (CO_2 eq) ppm	Emissions (KYOTO -GHGs)
RCP 8.5	> 8.5 W/m2	In 2100	Rising	> ~1370 CO2-eq in 2100	Stabilization in 2100
RCP 6.0	~6.0 W/m2	After 2100 sonrası	Stabilization without overshoot	~850 CO2-eq (at stabilization after 2100)	Decreasing in last quarter of century
RCP 4.5	~4.5 W/m2	After 2100	Stabilization without overshoot	~650 CO2-eq (at stabilization after 2100)	Decreasing in middle of century
RCP3-PD*	peak at ~3W/m2 before 2100 and then decline	Before 2100	Peak and decline	peak at ~490 CO2-eq before 2100 and then decline	Decreasing in first quarter of century

Results of the Climate Modelling Study (TR2013-CC)

<u>HadGEM2-ES</u>

In study of reference run outputs, the model has much high consistency on summer and winter temperature. It is colder of 1.5-2 °C in spring and autumn and annual average is approximately 1 °C. Despite it considerably has consistence in winter precipitation, in terms of annual precipitation, it is wetter about %20.

HadGEM sensitiveness tests

Temperature (°C)	RCM	CRU	UDEL	RAW

Precipitation (mm/day)	RCM	CRU	UDEL	RAW

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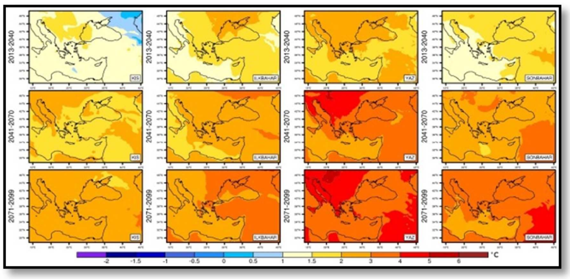
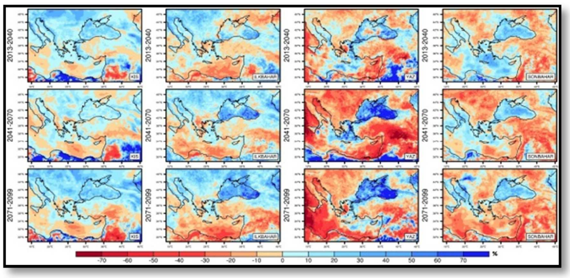
WINTER	0.436	0.561	0.258	1.762
SPRING	8.294	9.712	9.503	9.867
SUMMER	20.792	20.859	20.834	20.763
AUTUMN	10.412	12.480	12.177	12.349
ANNUAL(Average)	9.987	10.906	10.694	11.190

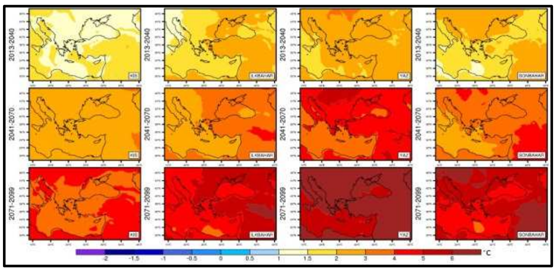
WINTER	2.159	2.126	2.064	2.452
SPRING	2.622	1.974	1.881	2.101
SUMMER	0.947	0.686	0.653	0.733
AUTUMN	1.830	1.333	1.347	1.497
ANNUAL(Average)	1.886	1.531	1.487	1.697

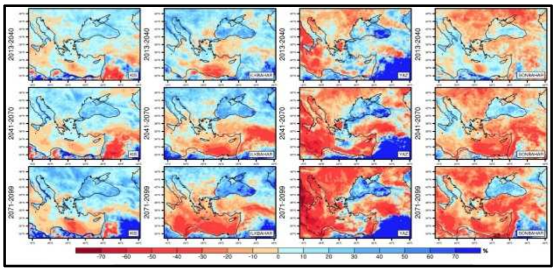
RCP4.5, HadGEM2-ES (temperature on left, precipitation on right)





RCP8.5, HadGEM2-ES (temperature on left, precipitation on right)





Looking at 2013-2099 precipitation and temperature, a significant rising of temperature attact attention from middle of the century in both scenarios RCP8.5 and RCP4.5. In particular, in RCP8.5 rising exceeds 6 °C. However, it is not detected an regularly upward or downward trend regarding precipitation. It can be said that the precipitation characteristics and regimes very likely will change.

MPI ESM-MR

In study of reference run outputs, the model has much high consistency in winter temperature. It is colder of 1.0-1.5 °C in summer, spring and autumn and annual average is approximately 1 °C colder. Despite it considerably has consistence in spring, autumn and annual average precipitation, it is 15-20% wetter in winter and %30 drier in summer.

MPI sensitiveness tests

Temperature (°C)	MPI/RCM	CRU	UDEL
WINTER	0.525	0.561	-0.076

Precipitation (mm/day)	MPI/RCM	CRU	UDEL
WINTER	2.52479	2.12642	1.97092

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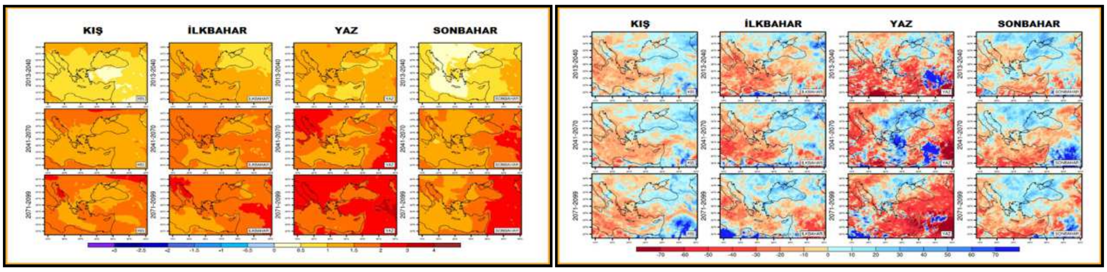
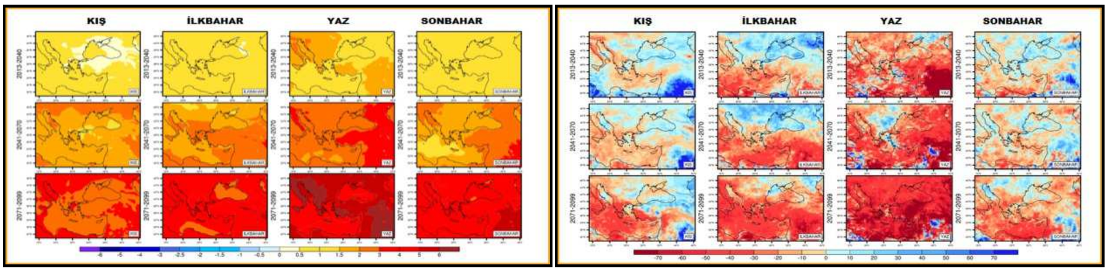
SPRING	8.628	9.712	9.309
SUMMER	19.603	20.859	20.700
AUTUMN	11.003	12.480	11.961
ANNUAL (average)	9.950	10.906	10.474

SPRING	1.92056	1.97368	1.87821
SUMMER	0.41729	0.68574	0.65310
AUTUMN	1.28402	1.33274	1.30774
ANNUAL (average)	1.53222	1.53063	1.45418

RCP4.5, MPI ESM-MR (temperature on left, precipitation on right)



RCP8.5, MPI ESM-MR (temperature on left, precipitation on right)



The findings based on MPI ESM-MR are very similar to those of HadGEM2-ES. Rising of temperature will be seen particularly in the last quarter of century. 4 °C rising according to RCP4.5 and exceeding 6 °C according to RCP8.5 are projected. Although there is no exact signal of trend on precipitations, southern parts will likely have less precipitations.

GFDL-ESM2M

The study with GFDL-ESM2M still continues and it is planned to complete this study in 2015.

B. Climate Modelling Studies of General Directorate of Water Management

The General Directorate of Water Management is executing “Climate Change Impacts on Water Resources” project started on 18th December 2013. The aim of the project is to determine the impacts of climate change scenarios on surface and underground water bodies and to identify the adaptation activities, implementation region based on river basin districts covering whole Turkey.

Methodology of the Project

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In the project 3 climate models are being run, which are in the archive of Coupled Model Inter-comparison Project (CMIP5) comprising the base of IPCC 5th Assessment Report, and RCM projections by using dynamic downscaling method are based on general circulation models (GCM); RCP4.5 is chosen as mild model and RCP8.5 as severe model. Projections are run for the years between 2015 and 2099, while the period between the years 1971-2000 has been chosen as reference years in compliance with the analysis tests. Please see the table below for the main characteristics of the Project.

Main characteristics of the project

Data Sets of Global Model	**Regional Model**	**Data Sets of Sensitiveness Analysis Test**	**Period**
HadGEM2-ES MPI-ESM-MR IPSL CM5A	RegCM4.3.4	• CRU (1971-2000) • UDEL (1971-2000) • UDEL-C (1971-2000)	1971-2000 (RF) 2013-2100

Although the project has been envisaged to be carried out based on river basins, models to be used, HadGEM2-ES, MPI-ESM-MR and IPSL CM5A , are being run for whole country, not for each river basin.

First, ERA 40 Reanalysis Data of ECMWF have been used as initial and boundary conditions for reference period (1971-2000) in a resolution of 50X50 km. and then 10X10 km. by HadGEM2-ES and MPI-ESM-MR, respectively. Then, bias correction with observed data between the years 1971-2000 for the resolution 10x10 km has been conducted. Second, RegCM4.3 has been used for RCP 4.5 and RCP 8.5, in the same resolution. Lastly, extreme conditions (extreme precipitation, heat waves, frost days etc.) have been determined, and 17 climatic indices have been analyzed.

The model outputs (precipitation, evapotranspiration, surface flow, etc.) of the climate models in the Project are the inputs for hydrogeological model.

The studies of the 3rd model are still being continued.

Results of the study

In this section, relatively the most important results of 4 of 17 climatic indices of both models are separately given below for 30-year-time periods.

<u>HadGEM-ES</u>

- o **FD0 Frost Days**

2015-2040 Time Period

- The northern part of Eastern and Central Anatolia will live frost days more than 120 days/year.
- 10-30 days below 0 ^{0}C may be possible in the coastal zones of Aegean, Mediterranean and Black Sea Regions according to RCP 4.5.

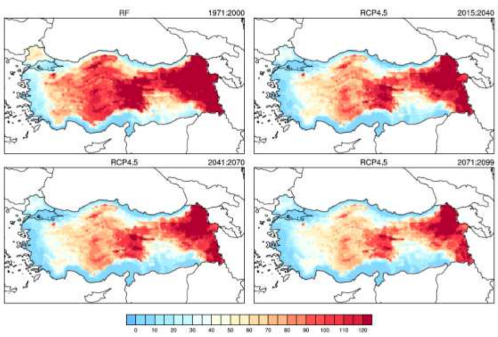
- The decrease of the number in frost days will most probably in the Eastern Anatolia for the both two scenarios.

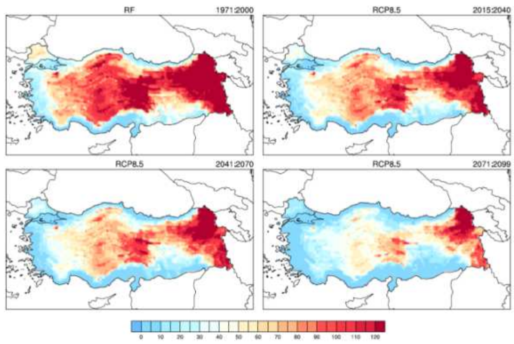
2041-2070 Time Period

- Central and the Eastern Anatolia are among the regions where the biggest decreases in the number of frost days are seen as 60-90 days in central part; and 100-120 days in the other.
- There may not be significant change in coastal zones.

2071-2099 Time Period

- Dramatic decreases in the number of days which are below 0 ^{0}C, nearly 40 days, may be observed and mostly in mountainsides of the Eastern Anatolia, while decrease may be 90-110 days as per RCP 8.5.
- That the decrease will expand from the coastal part to inward parts can be inferred**.**





  - **TX35 Summer Days**

2015-2040 Time Period

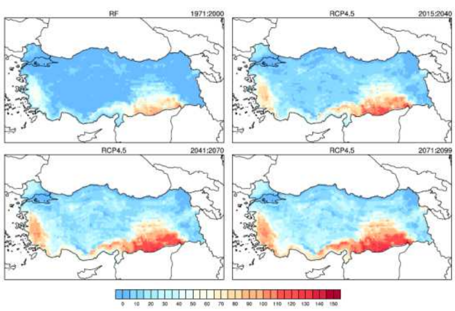
- The change in the number of the maximum temperature value higher than 35 ^{0}C may be 40-65 days in Aegean and Mediterranean Region, being 50-100 days in Southeastern Anatalia.

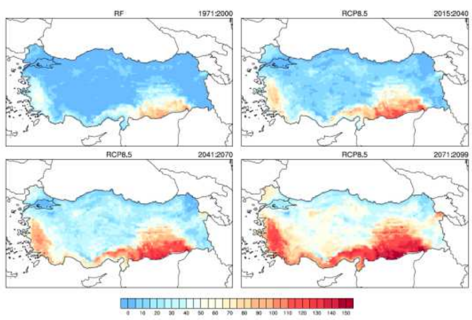
2041-2070 Time Period

- Significant increases in the number of summer days especially in the Southeastern Anatolia up to 100-130 days and 70-100 days in Aegean and Mediterranean Region are expected according to RCP 8.5.

2071-2099 Time Period

- 150 days/year in the most southern part of Southeastern Anatolia region may be seen as per RCP 8.5.





  - **R25 Extremely Rainy Days**

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2015-2040 Time Period

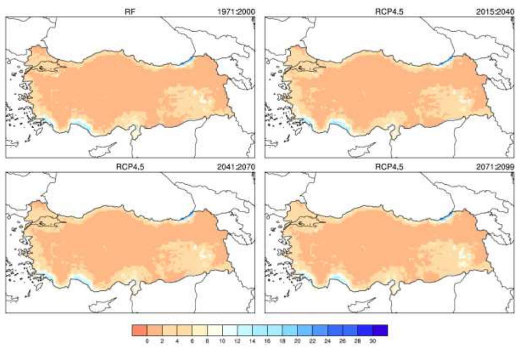
- That the number of extreme rainy days may change between 0-4 days in the all Central Anatoli, Marmara Region, Southeastern Anatolia and Southern Anatolia Region is seen.
- 1 or 2 days decreases may be seen in Thrace according to RCP 8.5.

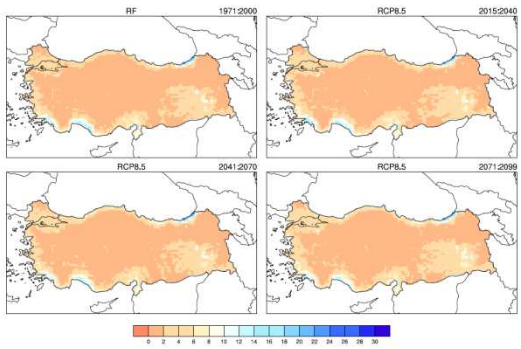
2041-2070 Time Period

- Black Sea Region may be exposed to 20-30 extreme rainy days, which is the biggest number among the all.

2071-2099 Time Period

- Nearly 10-day-increases per year are projected in the eastern part of the Black Sea Region.





- o **CDD Consecutive Dry Days**

2015-2040 Time Period

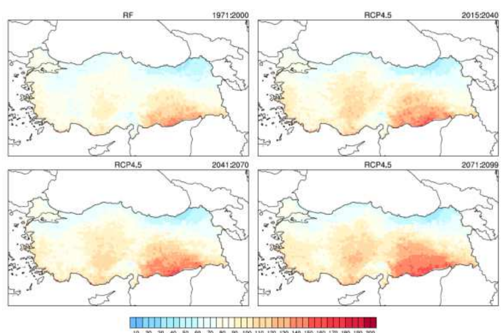
- It is seen that consecutive dry days will gradually increase and effectiveness area and time will expand more and more in this period.
- The numbers may be up to 100-130 days in Aegean, Mediterranean and Central Region as per RCP 4.5.

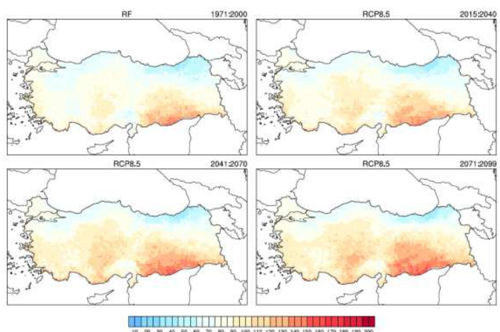
2041-2070 Time Period

- Dry days region will expand towards central Black Sea Region and the all-region may start to face dry days even in the rainy parts as per RCP 4.5.
- The number of the consecutive changes may be 100-150 in the southern part of the country, while that may be 30-40 days in the Central Anatolia with severe droughts according to RCP 8.5.

2071-2099 Time Period

- The all country may face serious socio-economic problems due to increasing consecutive dry days.





<u>MPI-ESM-MR</u>

- **FD0 Frost Days**

2015-2040 Time Period

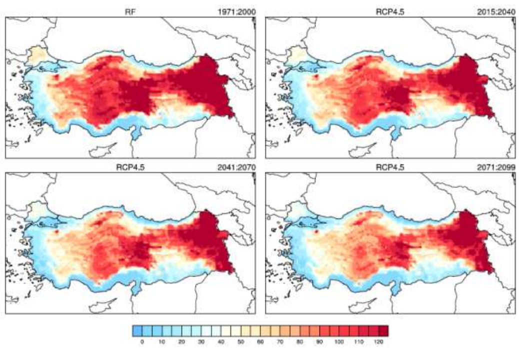
- The northern part of Eastern and the eastern side of the Central Anatolia will live frost days more than 120 days/year.
- The decrease of the number in frost days will decrease every 30 years, starting from the coastal sides to inward parts.

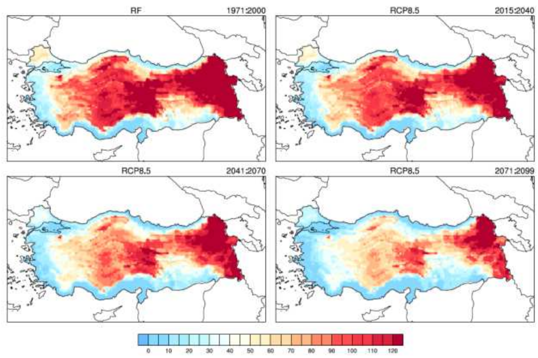
2041-2070 Time Period

- Decreases in the number of frost days are seen as 60-90 days in central part as per the both scenarios.

2071-2099 Time Period

- Gradual decreases in the number of days which are below 0 ^{0}C, nearly 70 days, may be observed in Central Anatolia, while decreases may be up to 120 days as per RCP 4.5; and up to 40-50 days as per RCP 8.5.
-





- **TX35 Summer Days**

2015-2040 Time Period

- The biggest change in the number of the maximum temperature value higher than 35 ^{0}C will be in Southeastern Anatalia Region, with 90-110 days.
- 10-20 day-increases are seen in Aegean and Mediterranean Region for the both scenarios.

2041-2070 Time Period

- Increases in the number of summer days with the value of 70-100 days in Aegean and Mediterranean Region.

2071-2099 Time Period

- Significant increases may be seen in the region along with the Mediterranean coastal zones and Toros Mountains up to 40-50days per year according to the RCP 8.5.
- 150 days/year in the most southern part of Southeastern Anatolia region may be seen as per RCP 8.5.

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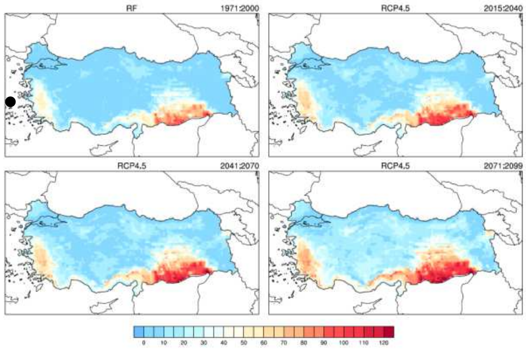
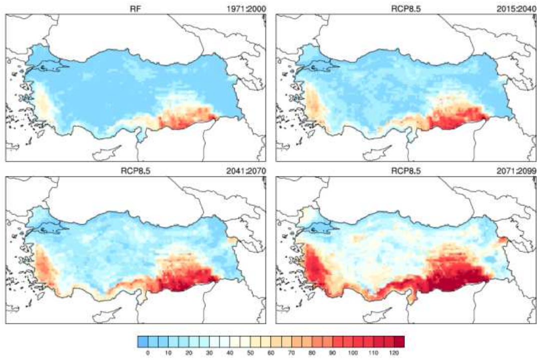




- **R25 Extreme Rainy Days**

2015-2040 Time Period

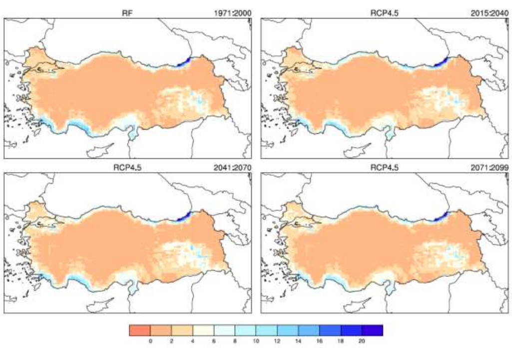
- That the number of extreme rainy days may change between 0-4 days in the all Central Anatolia, Marmara Region, Southeastern Anatolia and Southern Anatolia Region is seen.
- 1 or 2 days decreases may be clearly seen in all country.

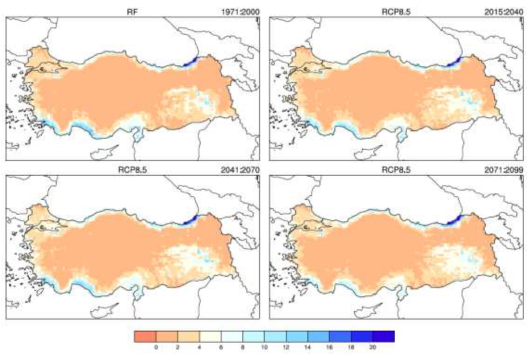
2041-2070 Time Period

- 22 days/year is the number that may be foreseen in the eastern Black Sea Region, indicating expected rainy days more than 25 mm as per RCP 8.5.

2071-2099 Time Period

- Increases may be seen in the southern parts of the Aegean Region.
- Extreme rainy days will be more than 20 days in the eastern Black Sea Region as per RCP 4.5.





- **CDD Consecutive Dry Days**

2015-2040 Time Period

- The possibility of the days without any precipitation through the 4 months in summer increases as per RCP 4.5.
- The most effected part of the country will be the Southeastern Anatolia Region with the number up to 120 days, and mean value of 100 days for other parts according to RCP 8.5.

2041-2070 Time Period

- It is seen that consecutive dry days will gradually increase and effectiveness area and time will expand more and more in this period.

2071-2099 Time Period

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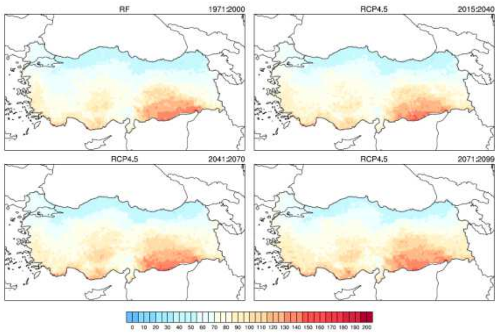
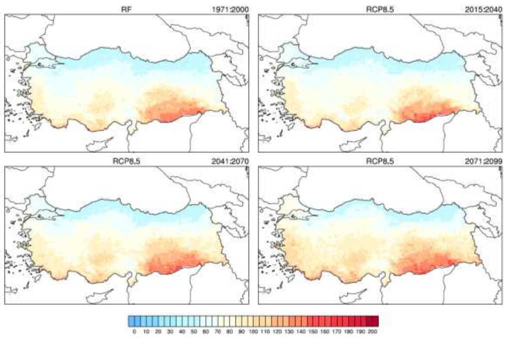
- It is expected that the number of the consecutive dry days in Southeastern Anatolia Region will be 170-180 days, while 100-120 days in the Mediterranean and 50-60 in Black Sea region according to RCP 4.5.
- That every region save for Black Sea will face 20-30 consecutive dry day-increases as per RCP 8.5.





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