Climate Fact Sheet

Upper Tempisque basin - Costa Rica

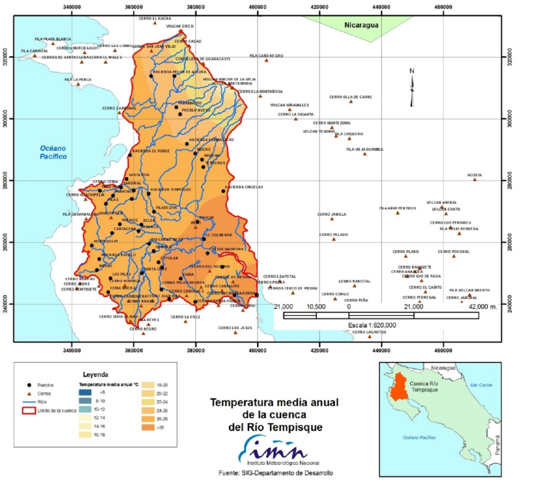
At a glance

The Regional Climate Factsheet provides brief and concise information on possible future climate developments for the Upper Tempisque basin in the 21st century. It was developed as a contribution to the activities of the project "Enhancing Climate Services for Infrastructure Investments" which is focused on a bridge located over the Tempisque river in the route 21, in Guanacaste, Costa Rica. The Factsheet summarizes the results of 28 regional climate model simulations. The information is based on two different climate scenarios, called Representative Concentration Pathways (RCPs). RCP8.5 represents a high-emission scenario, and RCP2.6 a low-emission scenario. Twelve different parameters for climate change are presented, which are relevant for various societal sectors, such as infrastructure. They are supplemented by an expert judgement of the reliability of the shown changes. At the end of the 21st century, the annual mean near-surface temperature increases between +1.0 °C and +1.4 °C in RCP2.6, and between +2.6 °C and +4.9 °C in RCP8.5; these increases are robust for both scenarios. For the annual precipitation at the end of the 21st century the projections show changes between -27.7 % and +39.9 % for RCP2.6, and between -75.5 % and +39.6 % for RCP8.5. For annual precipitation, the changes projected under RCP8.5 for the end of the 21st century are robust.

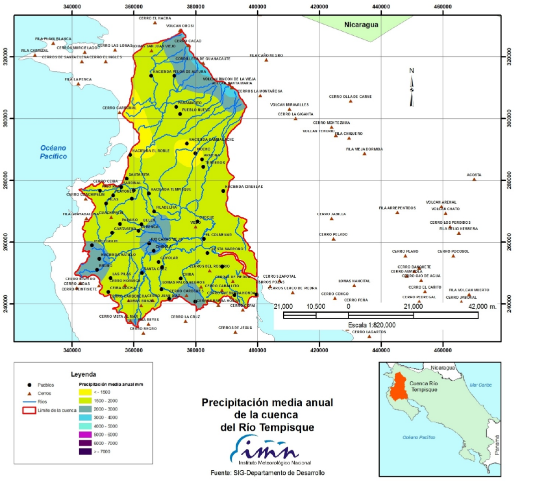
	Climate Changes for the end of the 21st century		
Parameter	High-emission scenario	Low-emission scenario	Details
Temperature	increase	increase	pp. 6, 13
Days with Tmax ≥ 30°C	increase	increase	pp. 6, 13
Days with Tmax ≥ 36°C	increase	increase	pp. 7, 13
Days with Tmax ≥ 40°C	increase	no changes	pp. 7, 13
Nights with Tmin ≥ 25°C	increase	increase	pp. 8, 13
Consecutive days with Tmin ≥ 36°C	increase	increase	pp. 8, 13
Consecutive days with Tmin ≥ 40°C	increase	no changes	pp. 9, 13
Precipitation	decrease	no changes	pp. 10, 13
Wet days	decrease	no changes	pp. 10, 13
Dry days	increase	no changes	pp. 11, 13
95th percentile of precipitation	tendency towards increase	no changes	pp. 11, 13
99th percentile of precipitation	tendency towards increase	no changes	pp. 12, 13

Today's climate

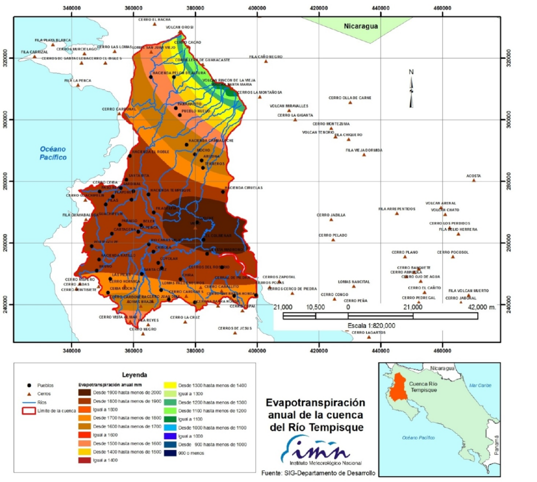
The climate of the Tempisque basin can be characterized as warm tropical climate with a rainy season from May to October and a dry and transitional season in the other months of the year. In the Köppen-Geiger climate classification, the regions is classified as Aw (Tropical savanna climate). The whole Tempisque basin can be divided into three parts (upper, middle and lower). Today's climate is presented for the entire basin, with the upper part being subject of the evaluation of the projected climate changes in this fact sheet.



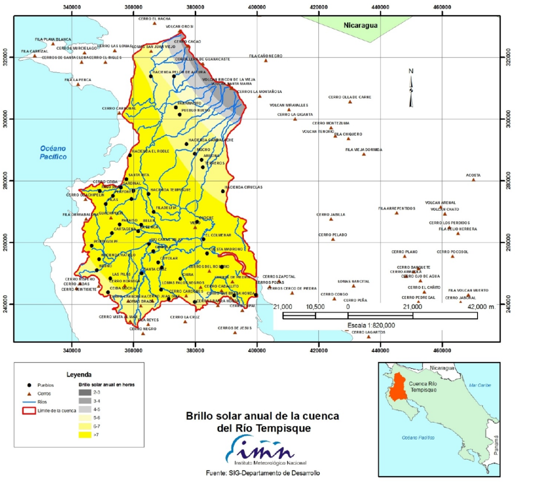
The **annual mean temperature** ranges from 22 °C and 24 °C in the upper part, from 26 °C to 28 °C in the middle part and reaches about 28 °C in the lower part of the Tempisque basin.



Annual precipitation amounts to 1500 to 3000 mm/year in the upper part, 1500 to 2000 mm/year in the middle part and about 1500 to 3000 mm/year in the lower part of the Tempisque basin.



The total **annual evapotranspiration** amounts to 1200 to 1300 mm/year in the upper part, 1900 to 2000 mm/year in the middle part and about 1600 to 1900 mm/year in the lower part of the Tempisque basin.



The upper part of the Tempisque basin experiences about 3 to 4 **sunshine hours** a day, whereas in the middle and lower part of the basin about six to seven sunshine hours a day can be expected.

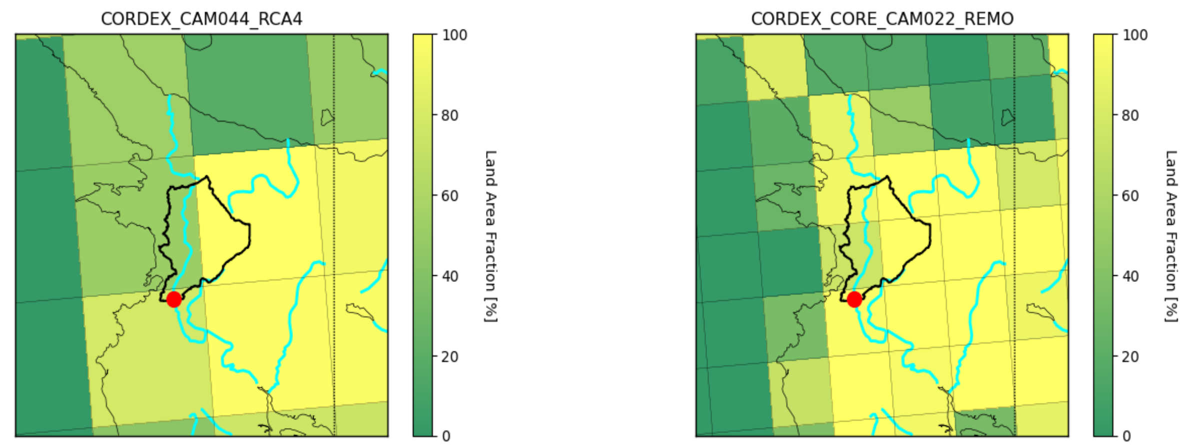
Severe flooding can occur in the Tempisque basin, most frequently around October. Most of the floods occur in the central part of Guanacaste, lower Tempisque basin. In the North Pacific, flooding can last from 3 to 4 days as a general average and 10 days as extreme cases. In these periods, precipitation accumulates to between 100 to 300 mm on average. During some storms, 400 to 700 mm have been recorded. In the periods of storm the maximum peak of rain is between 250 and 380 mm.

Projected climate changes

Climate projections

Climate models can be used to calculate projections for future climate. These provide answers to the question: "What if?" How will the climate develop under certain conditions, for example if humans emit additional greenhouse gases into the atmosphere? To this end, emission scenarios for the 21st century are developed based on various assumptions, e.g. on the development of population, human culture, technology and the economy. Such emission scenarios, called "Representative Concentration Pathways" (RCPs) are widely used today. They are defined by the radiative forcing at the end of the 21st century and represent different development paths of greenhouse gas concentrations and associated emissions. For example, the representative concentration path "RCP4.5" leads to a radiative forcing of about 4.5 W/m^2 at the end of the 21st century. This physical threshold value can be reached by various socio-economic developments, which also take into account climate policy measures, for example. The concentration path of RCP2.6 implies very ambitious measures to reduce greenhouse gas emissions and even "negative emissions" by the end of the 21st century. It leads to a radiative forcing of about 3 W/m^2 around 2040 and then decreases to a value of 2.6 W/m^2 towards the end of the 21st century. RCP2.6 thus represents a path with lower emissions compared to other RCPs. RCP8.5, on the other hand, describes a continuous increase in greenhouse gas emissions, reaching a radiative forcing of 8.5 W/m^2 by the end of the 21st century. In this fact sheet, projections are based on the two Representative Concentration Pathways RCP2.6 and RCP8.5. The projected changes shown in this Climate Fact Sheet are based on an ensemble of climate projections which were created in the context of CORDEX-Central-America (CORDEX-CAM044) and the CORDEX-CORE initiative (see page 16 for more information), where global climate projections are regionally refined by regional climate models. The CORDEX-CAM044 simulations are calculated on a common grid with a horizontal grid resolution of about 50 x 50 km (0.44° x 0.44°), the CORDEX-CORE simulations have a finer grid resolution of about 25 x 25 km (0.22° x 0.22°). The finer resolution allows a better representation of physical processes in the atmosphere and resolves better orographical structures like mountaineous terrain. Two distinct future time periods are considered and opposed to the climate reference period of 1971 to 2000: 2036-2065 for the middle of the 21st century and 2069 to 2098 for the end of the 21st century.

Representation of the Upper Tempisque basin on the CORDEX-CAM044 and CORDEX-CORE CAM022 model grid



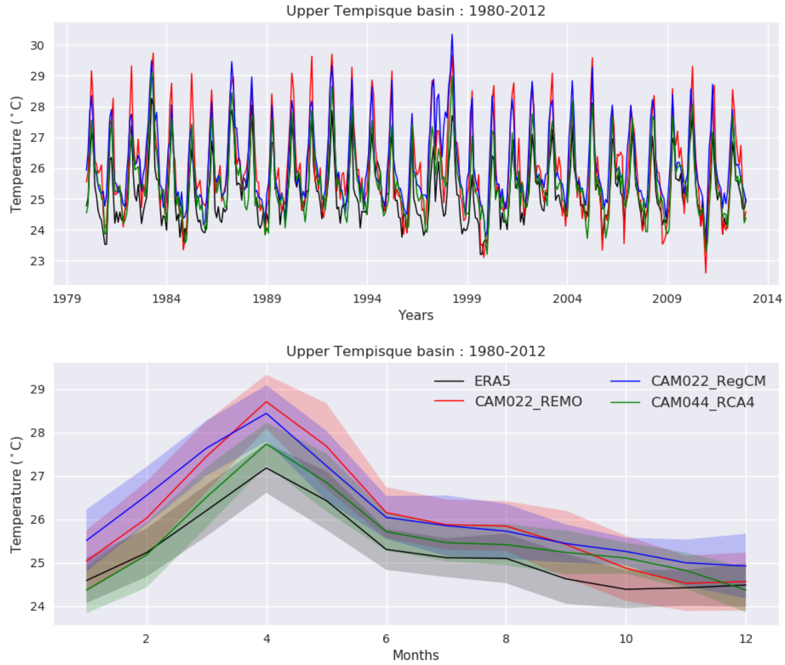
The Bridge over Rio Tempisque, National Route 21 crosses the Tempisque river close to Liberia Airport in the province of Guanacaste. Due to the relatively coarse grid resolution of the CORDEX-CAM044 and even the CORDEX-CORE CAM022 simulations, the location of the bridge itself is still badly resolved by the models. In addition, the region is quite heterogenous in terms of land-sea distribution, orography and consequentially long-term mean temperatures and precipitation. We thus take the approach to average relevant climate information from the CORDEX simulations for a larger region of interest, namely the catchment of the river Tempisque upstream of the bridge (Upper Tempisque basin). The region (black line) is shown on the two grid resolutions in the figures above, where the Land Area Fraction per gridbox is shown exemplarily for the regional model RCA4 in 0.44° (left, 50 km resolution) and REMO2015 on 0.22° (right, 25 km resolution). The location of the bridge (10.56226N, 85.59023W) is indicated by the red circle. The climate projections for the region of the Upper Tempisque basin are calculated as area weighted mean values of all grid boxes located in the Upper Tempisque basin.

Evaluation of the hindcast simulations

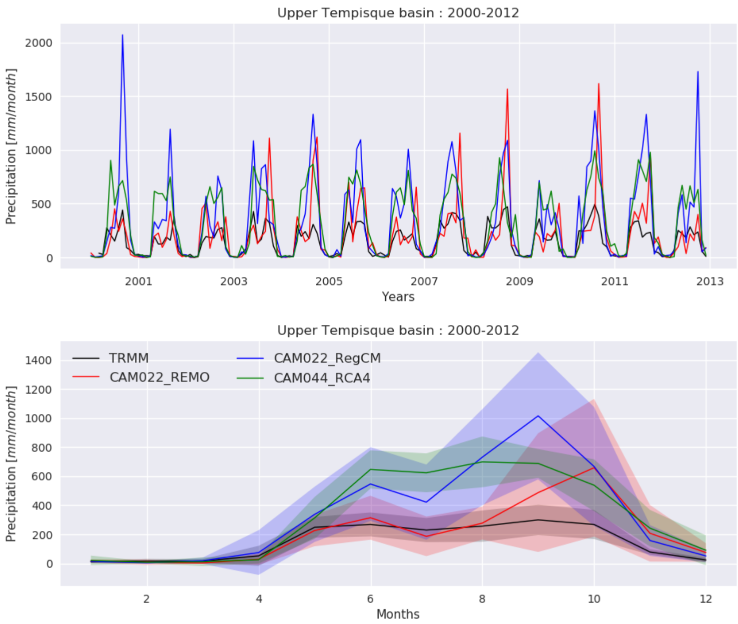
Before a regional or global climate model can be applied for future climate projections, the ability of the model to correctly reproduce present day climate has to be demonstrated. For this purpose, simulations of today's climate are conducted. These simulations are driven and initialized with reanalysis data, which is assumed to be our "best guess" for realistic climate conditions. For the CORDEX-CAM044 model domain, such a hindcast simulation is available for the RCM RCA4, which is used for the majority of the simulations. For the CORDEX-CORE CAM022 model domain, hindcast simulations are available for both REMO2015 and RegCM4-7. A list of the simulations used in this fact-sheet can be found on page 16. The hindcasts use ERA INTERIM reanalysis data as boundary conditions and were run (at least) for the period from 1979 to 2012. For comparison, we use the ERA5 reanalysis data for temperature and the TRMM (Tropical Rainfall Measuring Mission) observations for precipitation (see page 16 for more information). All values shown are area averaged for the Upper Tempisque basin shown on page 3.

Temperature (1980 to 2012)

The figures on the right show the mean temperature for the period from 1980 to 2012 for the reference dataset and the hindcast simulations. On the upper panel, a timeseries of monthly temperatures is shown, whereas on the lower panel, the mean annual cycle for the same period is depicted. The highlighted areas indicate twice the standard deviation of the individual values.
As can be seen, the temporal development as well as the mean annual cycle of temperature are well simulated by the models for the period of 1980 to 2012, with some higher positive biases of the CORDEX-CORE CAM022 simulations for the warmest period.



Precipitation (2000 to 2012)



For the precipitation observations, only a short overlap period of 2000 to 2012 with the hindcast simulations is available, which means that the evaluation of the precipitation is less comprehensive than the evaluation of temperature. All three models are generally able to reproduce the observed annual cycle of precipitation. However, the CORDEX-CORE CAM022 simulations show an overestimation of the precipitation mainly from August to October, whereas the CORDEX-CAM044 simulation shows a constant positive offset during the whole wet period. Part of the overestimation results from single years where the models produce extremely high precipitation amounts as compared to the TRMM observations (see upper figure on the left).

Symbols of the expert judgement on the robustness of the projections

⬆	**Increase:** At least 2/3 of the simulations project increases, a minimum 50% of all simulations show even significant increases	⇧	**Tendency towards an increase:** At least 2/3 of the simulations project increases, but only less than 50% of all simulations show significant increases
⬇	**Decrease :** At least 2/3 of the simulations project decreases, a minimum 50% of all simulations show even significant decreases	⇩	**Tendency towards a decrease:** At least 2/3 of the simulations project decreases, but only less than 50% of all simulations show significant descreases
▲▼	**Unclear:** At least 50% of all simulations project significant changes, but there is no 2/3 majority agreeing on the direction of changes	△▽	**No changes:** less than 50% of all simulations project significant changes, and there is no 2/3 majority agreeing on the direction of changes

Each climate parameter presented on the following pages is complemented by an expert judgement on the robustness of the projected changes, which is described above. To judge on the robustness of the projected changes, the agreement of the projections on the sign of the projected changes, as well as the statistical significance of the changes projected by each single simulation is taken into account. Statistical significance is calculated using the Mann-Whitney test (respectively U-test), which is applied for each model simulation individually. The hypothesis of the test is that the distribution of the annual values of the respective index in future climate differs from today's distribution, where a confidence level of 0.95 is assumed.

Please consider:

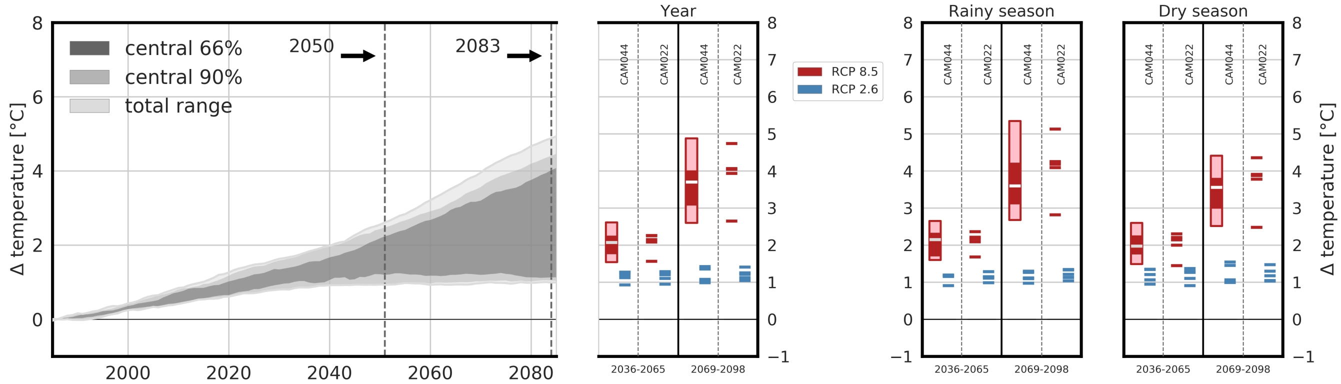
The definition of each climate index is given on page 15. Their graphical representation is explained on page 14. All climate indices are displayed with the identical method. The changes of the annual values are additionally given in table form on page 13. In addition to the figures, the projected changes for each index for the middle and the end of the 21^{st} century are given as short narratives.

All indices which are given in units of days/year, days, or nights/year are rounded to full days, the other values are rounded to the first decimal place.

In view of the overestimation of precipitation of some of the simulations in the Upper Tempisque basin, the climate change signals of precipitation have to be treated with care.

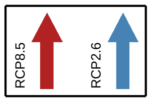
Projected changes of temperature-based indices

Temperature

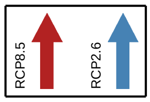


For the two RCPs an increase of the temperature is projected.

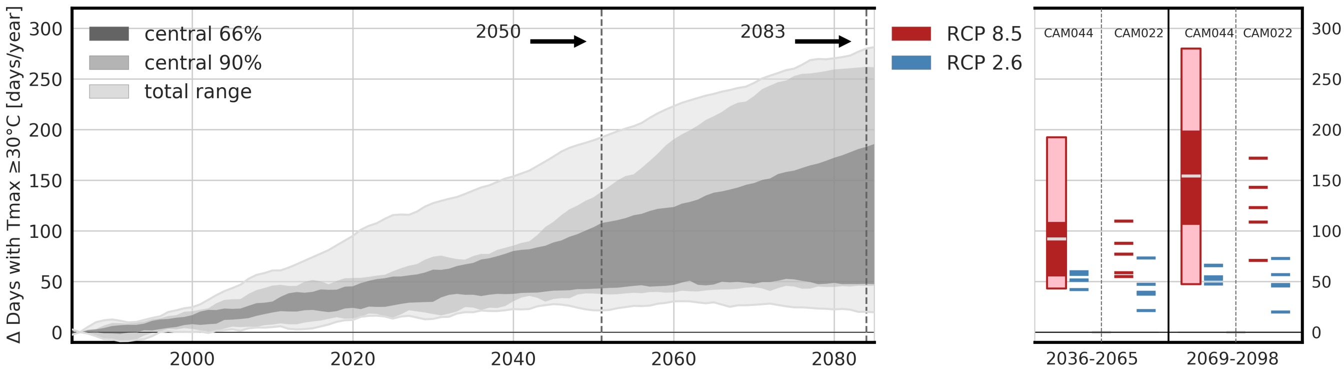
The bandwidth of projected annual changes for the **middle of the 21st century** spans from +1.5 to +2.6 °C for RCP8.5, and from +0.9 to +1.3 °C for RCP2.6.



For the **end of the 21st century,** the projected annual increases for RCP8.5 is between +2.6 and +4.9 °C, and for RCP2.6 between +1.0 and +1.4 °C.

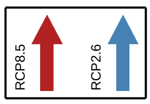


Days with Tmax ≥ 30°C

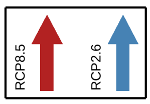


For the two RCPs an increase of the number of days with Tmax ≥ 30°C is projected.

The bandwidth of projected annual changes for the **middle of the 21st century** spans from +43 to +192 days/year for RCP8.5, and from +21 to +73 days/year for RCP2.6.

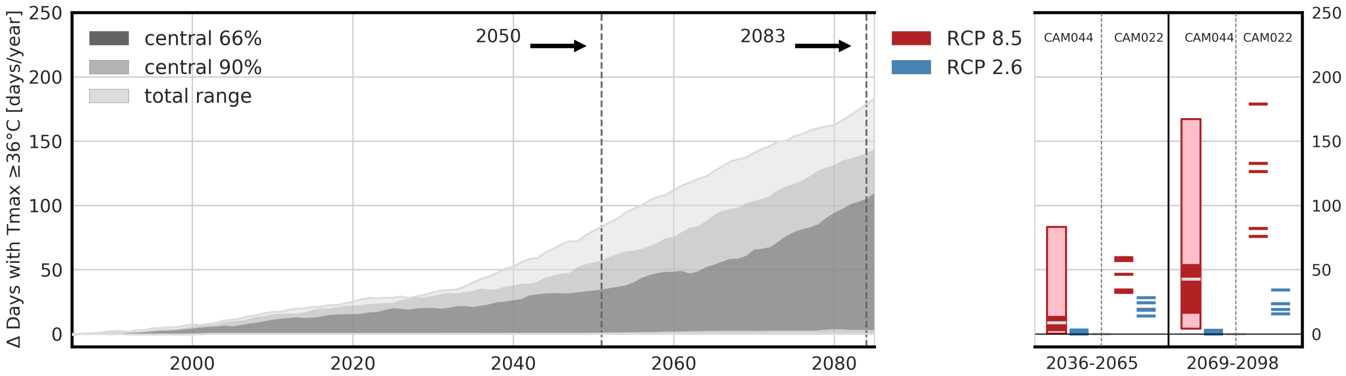


For the **end of the 21st century,** the projected annual increases for RCP8.5 is between +47 and +280 days/year, and for RCP2.6 between +20 and +73 days/year.



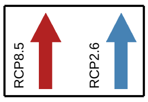
Projected changes of temperature-based indices

Days with Tmax ≥ 36°C

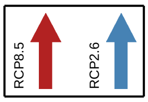


For the two RCPs an increase of the number of days with Tmax ≥ 36°C is projected.

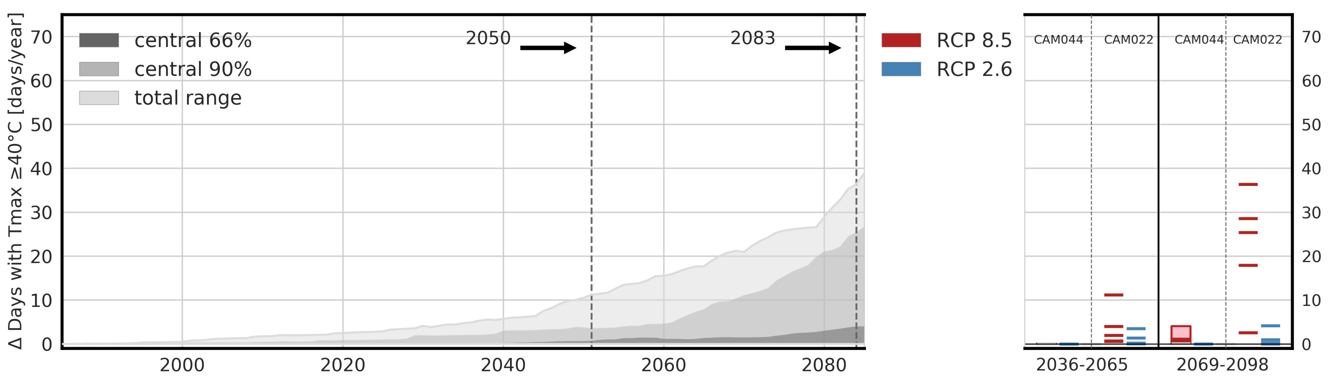
The bandwidth of projected annual changes for the **middle of the 21st century** spans from 0 to +83 days/year for RCP8.5, and from 0 to +28 days/year for RCP2.6.



For the **end of the 21st century,** the projected annual increases for RCP8.5 is between +4 and +179 days/year, and for RCP2.6 between 0 and +34 days/year.

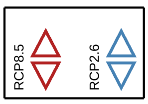


Days with Tmax ≥ 40°C

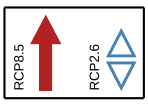


For the two RCPs an increase of the number of days with Tmax ≥ 40°C is projected.

The bandwidth of projected annual changes for the **middle of the 21st century** spans from 0 to +11 days/year for RCP8.5, and from 0 to +4 days/year for RCP2.6.

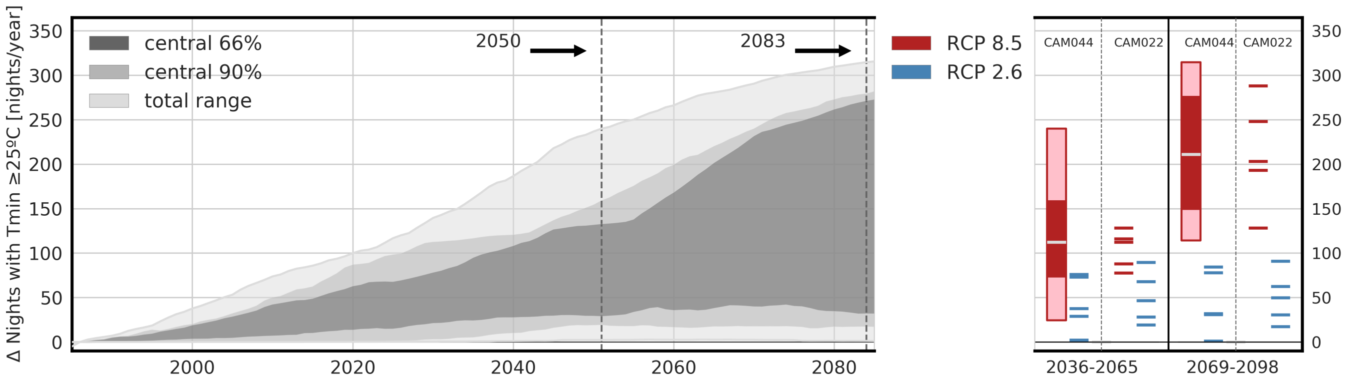


For the **end of the 21st century,** the projected annual increases for RCP8.5 is between 0 and +36 days/year, and for RCP2.6 between 0 and +4 days/year.



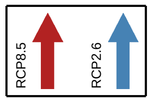
Projected changes of temperature-based indices

Nights with Tmin ≥ 25°C

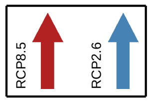


For the two RCPs an increase of the number of nights with Tmin ≥ 25°C is projected.

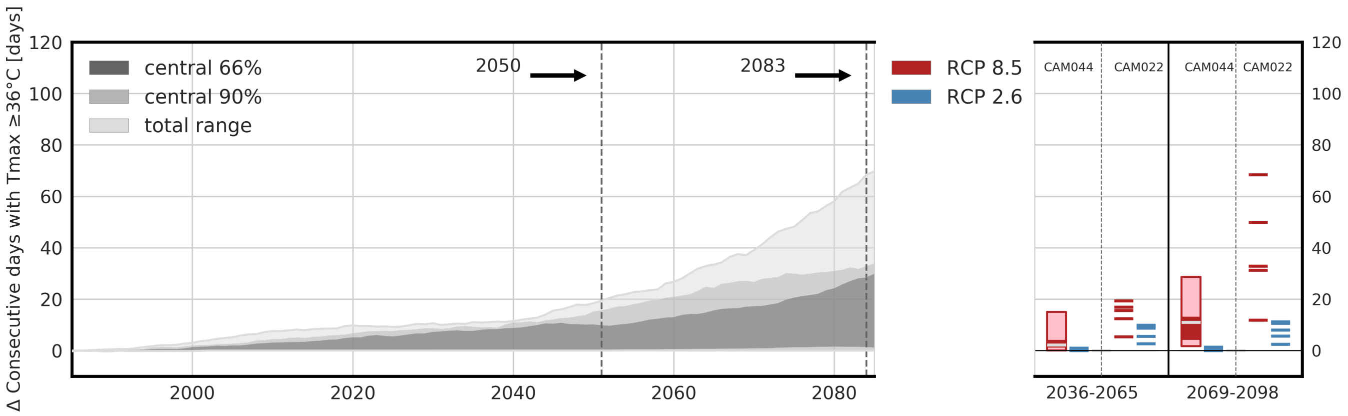
The bandwidth of projected annual changes for the **middle of the 21st century** spans from +24 to +240 nights/year for RCP8.5, and from +2 to +89 nights/year for RCP2.6.



For the **end of the 21st century,** the projected annual increases for RCP8.5 is between +114 and +315 nights/year, and for RCP2.6 between +1 and +91 nights/year.

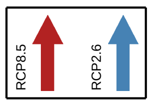


Maximum number of consecutive days with Tmin ≥ 36ºC

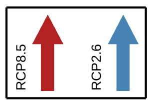


For the two RCPs an increase of the maximum number of consecutive days with Tmax ≥ 36°C is projected.

The bandwidth of projected annual changes for the **middle of the 21st century** spans from 0 to +19 days for RCP8.5, and from 0 to +10 days for RCP2.6.

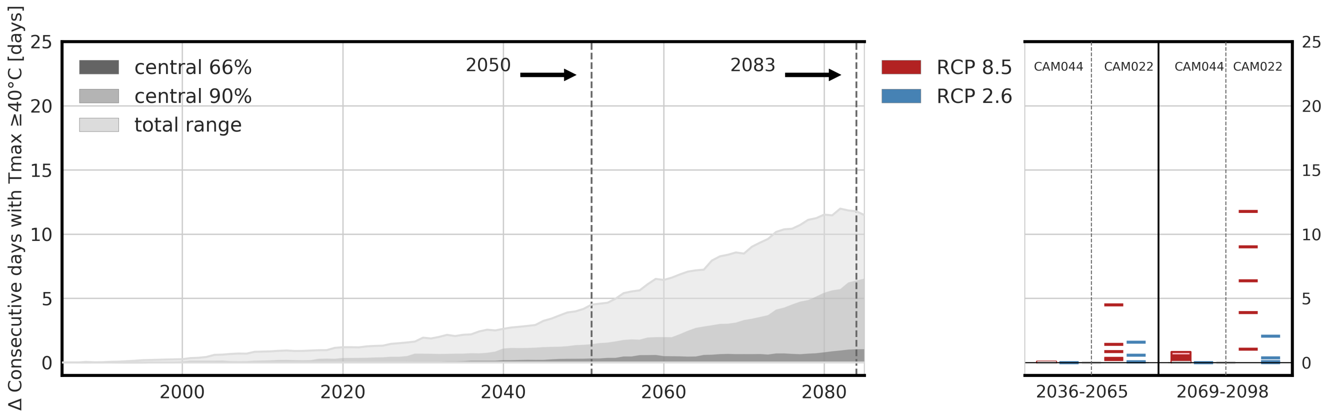


For the **end of the 21st century,** the projected annual increases for RCP8.5 is between +2 and +68 days, and for RCP2.6 between 0 and +11 days.



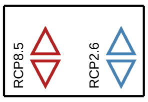
Projected changes of temperature-based indices

Maximum number of consecutive days with Tmin ≥ 40°C

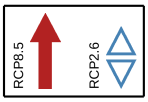


For the two RCPs an increase of the maximum number of consecutive days with Tmax ≥ 40°C is projected.

The bandwidth of projected annual changes for the **middle of the 21st century** spans from 0 to +5 days for RCP8.5, and from 0 to +2 days for RCP2.6.

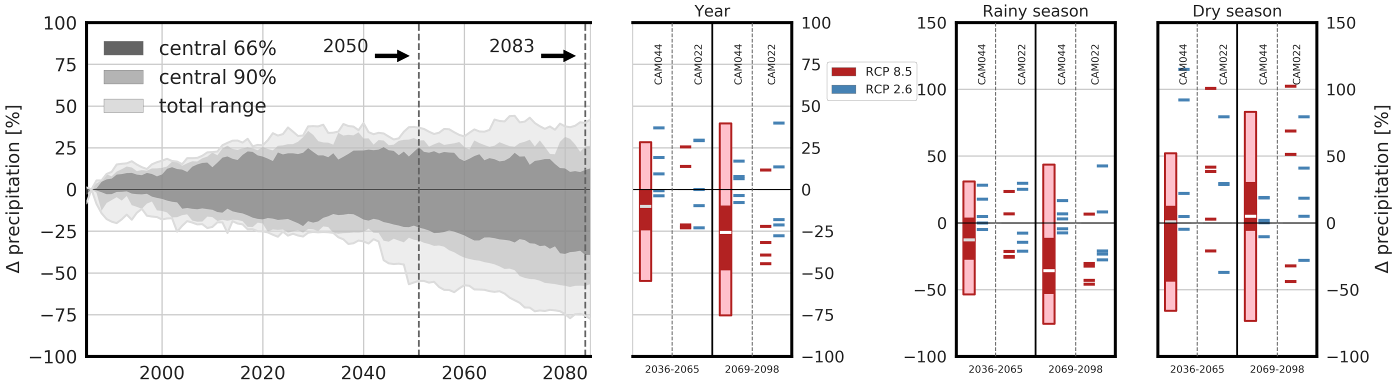


For the **end of the 21st century,** the projected annual increases for RCP8.5 is between 0 and +12 days, and for RCP2.6 between 0 and +2 days.



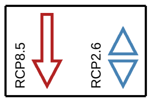
Projected changes of precipitation-based indices

Precipitation

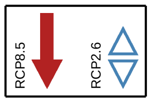


For the different RCPs no clear signal of the precipitation sum is projected.

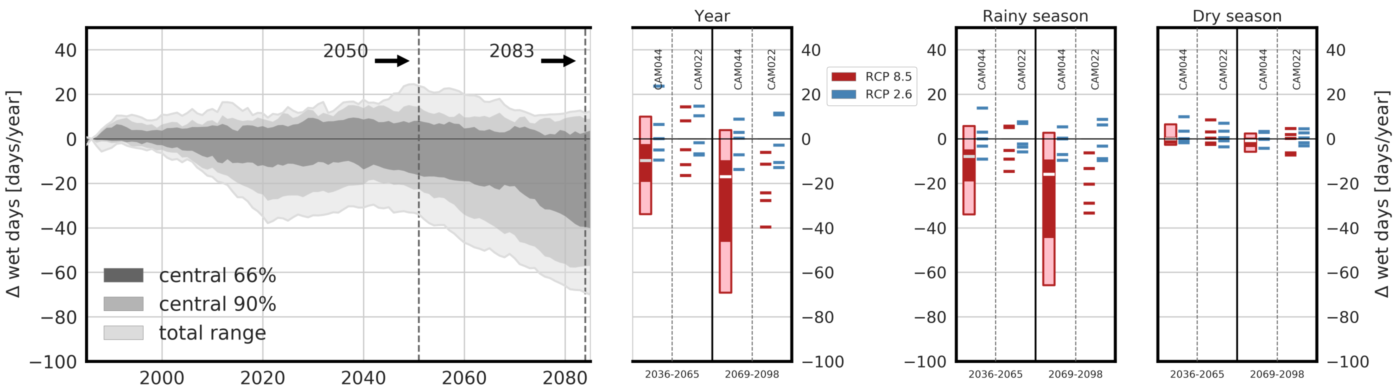
The bandwidth of projected annual changes for the **middle of the 21st century** spans from -54.8 to +28.3 % for RCP8.5, and from -23.0 to +37.0 % for RCP2.6.



For the **end of the 21st century,** the projected annual changes for RCP8.5 is between -75.5 and +39.6 %, and for RCP2.6 between -27.7 and +39.9 %.

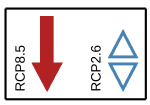


Wet days (precipitation ≥ 1 mm/day)

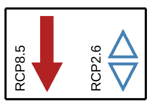


For the different RCPs no clear signal of the number of wet days is projected.

The bandwidth of projected annual changes for the **middle of the 21st century** spans from -34 to +14 days/year for RCP8.5, and from -10 to +24 days/year for RCP2.6.

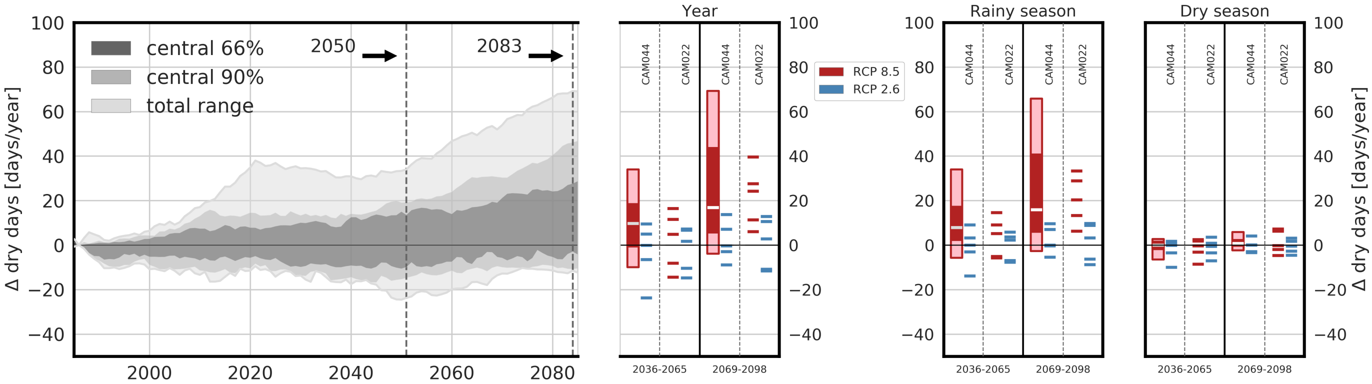


For the **end of the 21st century,** the projected annual changes for RCP8.5 is between -69 and +4 days/year, and for RCP2.6 between -14 and +12 days/year.



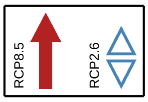
Projected changes of precipitation-based indices

Dry days (precipitation < 1 mm/day)

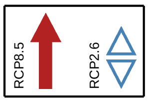


For the different RCPs no clear signal of the number of dry days is projected.

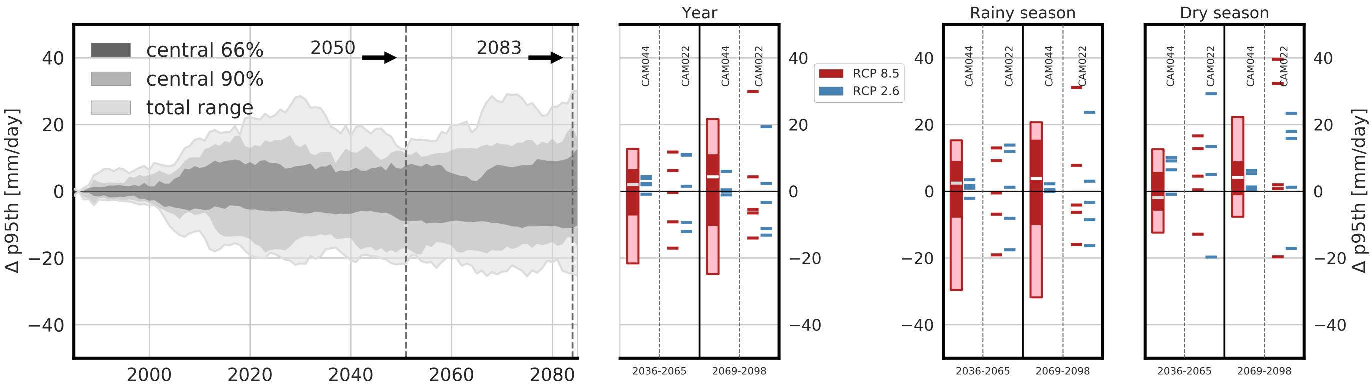
The bandwidth of projected annual changes for the **middle of the 21st century** spans from -14 to +34 days/year for RCP8.5, and from -24 to +10 days/year for RCP2.6.



For the **end of the 21st century,** the projected annual changes for RCP8.5 is between -4 and +69 days/year, and for RCP2.6 between -12 and +14 days/year.

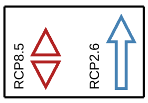


95th percentile of precipitation on wet days

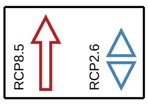


For the different RCPs no clear signal of the the 95th percentile of precipitation is projected.

The bandwidth of projected annual changes for the **middle of the 21st century** spans from -21.7 to +12.7 mm/day for RCP8.5, and from -12.0 to +11.0 mm/day for RCP2.6.

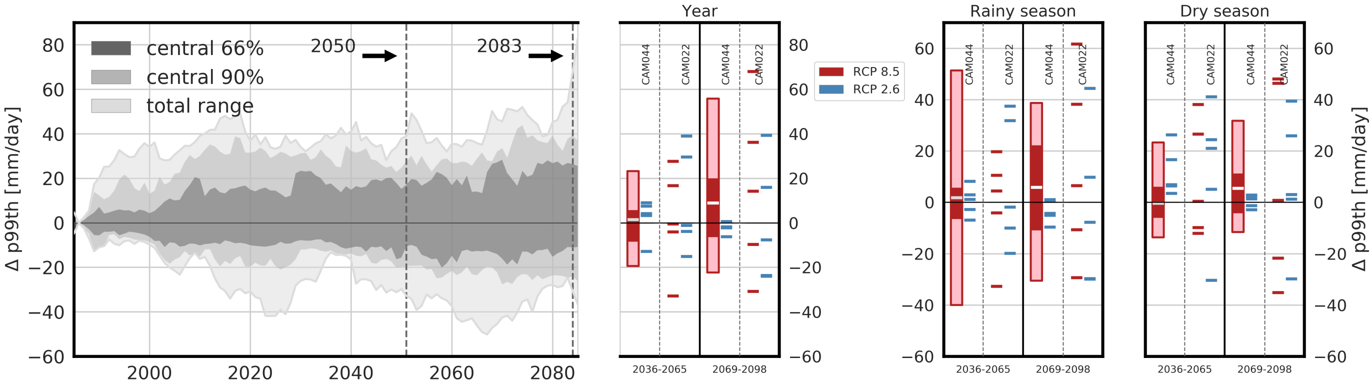


For the **end of the 21st century,** the projected annual changes for RCP8.5 is between -24.8 and +29.9 mm/day, and for RCP2.6 between -13.1 and +19.3 mm/day.



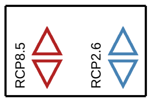
Projected changes of precipitation-based indices

99th percentile of precipitation on wet days

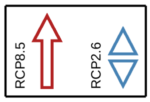


For the different RCPs no clear signal of the the 99th percentile of precipitation is projected.

The bandwidth of projected annual changes for the **middle of the 21st century** spans from -32.8 to +27.7 mm/day for RCP8.5, and from -15.1 to +39.0 mm/day for RCP2.6.



For the **end of the 21st century,** the projected annual changes for RCP8.5 is between -30.8 and +68.0 mm/day, and for RCP2.6 between -24.0 and +39.3 mm/day.



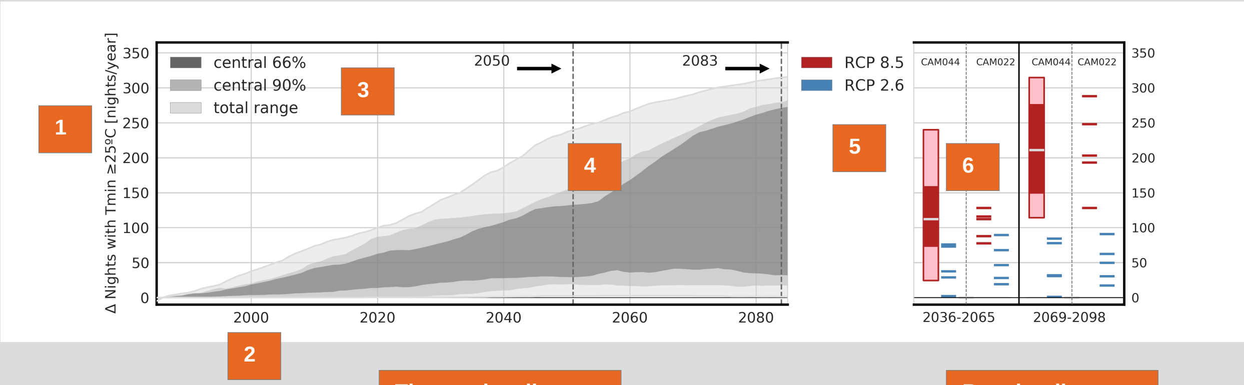
Overview
temperature-based indices

	projected climate changes	2036-2065 min	2036-2065 median	2036-2065 max	2069-2098 min	2069-2098 median	2069-2098 max
RCP8.5	Temperature [°C]	+1.5	+2.1	+2.6	+2.6	+3.8	+4.9
	Days with Tmax ≥ 30°C [days/year]	+43	+87	+192	+47	+136	+280
	Days with Tmax ≥ 36°C [days/year]	0	+12	+83	+4	+53	+179
	Days with Tmax ≥ 40°C [days/year]	0	0	+11	0	+1	+36
	Nights with Tmin ≥ 25°C [nights/year]	+24	+112	+240	+114	+207	+315
	Maximum number of consecutive days with Tmin ≥ 36ºC [days]	0	+4	+19	+2	+12	+68
	Maximum number of consecutive days with Tmin ≥ 40°C [days]	0	0	+5	0	+1	+12
RCP2.6	Temperature [°C]	+0.9	+1.2	+1.3	+1.0	+1.2	+1.4
	Days with Tmax ≥ 30°C [days/year]	+21	+49	+73	+20	+54	+73
	Days with Tmax ≥ 36°C [days/year]	0	+9	+28	0	+9	+34
	Days with Tmax ≥ 40°C [days/year]	0	0	+4	0	0	+4
	Nights with Tmin ≥ 25°C [nights/year]	+2	+42	+89	+1	+41	+91
	Maximum number of consecutive days with Tmin ≥ 36ºC [days]	0	+2	+10	0	+2	+11
	Maximum number of consecutive days with Tmin ≥ 40°C [days]	0	0	+2	0	0	+2

Overview
precipitation-based indices

	projected climate changes	2036-2065 min	2036-2065 median	2036-2065 max	2069-2098 min	2069-2098 median	2069-2098 max
RCP8.5	Precipitation [%]	-54.8	-11.2	+28.3	-75.5	-26.2	+39.6
	Wet days [days/year]	-34	-9	+14	-69	-19	+4
	Dry days [days/year]	-14	+9	+34	-4	+19	+69
	95th percentile of precipitation on wet days [mm/day]	-21.7	+1.5	+12.7	-24.8	+3.5	+29.9
	99th percentile of precipitation on wet days [mm/day]	-32.8	+0.5	+27.7	-30.8	+11.3	+68.0
RCP2.6	Precipitation [%]	-23.0	+4.7	+37.0	-27.7	+1.4	+39.9
	Wet days [days/year]	-10	-1	+24	-14	-1	+12
	Dry days [days/year]	-24	+1	+10	-12	+1	+14
	95th percentile of precipitation on wet days [mm/day]	-12.0	+2.1	+11.0	-13.1	+0.1	+19.3
	99th percentile of precipitation on wet days [mm/day]	-15.1	+3.8	+39.0	-24.0	-2.0	+39.3

Reading the climate change figures



Time series diagram

Boxplot diagram

1 Scale and units of the projected changes for the respective parameter.

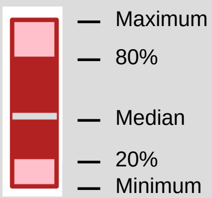
2 Time scale: years for the time series diagram and 30-year periods for the boxplot diagrams.

3 Legend for the time series diagram. The time series diagram integrates all projections, both the CORDEX-CAM044 and the CORDEX-CORE CAM022 simulations. The three levels of gray indicate the total range of projected changes (light gray), the range where the central 90 % of all projected changes fall within (medium gray) and the range covering the central 66 % of all projected changes (dark gray).

4 The **time series diagram** shows the projected 30-years running mean changes of the respective index with respect to the climate reference period of the years 1971 to 2000. The values are centered around the 15th year of each 30-years period, i.e. each value represents the mean value of the 30 years around this year.

5 Legend for the boxplot diagram. Colors are indicating the underlying emission scenario where RCP denotes Representative Concentration Pathways. RCP8.5: Pathway for a scenario with high greenhouse gas emissions. RCP2.6: scenario with smaller or even negative greenhouse gas emissions.

6 In the **boxplot diagram** the range of the projected changes is shown for two specific time periods relative to the climate reference period of 1971 to 2000. The middle of the 21st century is represented by the years 2036 to 2065, the end of the 21st century by the period from 2069 to 2098. The bars show some characteristics of the CORDEX-CAM44 and the CORDEX-CORE CAM22 ensembles of projections. Red color stands for the high-emission scenario (RCP8.5), the blue color stand for the low emission scenario (RCP2.6). Where the number of ensemble members falls below 6, the single simulation results are shown instead of the ensemble statistics.



The total range of projections is found between the minimum and maximum value indicated in the bars. The median denotes the simulation of which the value of projected changes is located in the center of the entire bandwith of the ensemble. In addition, those values are marked where 20% of the ensemble project changes below or above this value.

Definition of the climate indices

Parameter	Definition	Reference
Rainy season	Period of the year where days with rain predominate consecutively and for several months. On the Pacific and Central Valley, it comprises the period from May to October. November is considered the month of transition from the rainy to the dry season on the Pacific side and April from the dry to the rainy season.	Instituto Meteorológico Nacional, (2020). Glosario Meteorológico, IMN. San José, Costa Rica. http://cglobal.imn.ac.cr/documentos/publicaciones/glosariometeorologico
Dry season	Period of the year characterized by dry days in a consecutive manner and over several months. On the Pacific and Central Valley, it covers the period from December to March. April is considered the month of transition from the dry to the rainy season and November from the rainy to the dry season on the Pacific side. On the Caribbean side there is no clearly defined dry season, that is, with a total absence of rain.	Instituto Meteorológico Nacional, (2020). Glosario Meteorológico, IMN. San José, Costa Rica. http://cglobal.imn.ac.cr/documentos/publicaciones/glosariometeorologico
Temperature	Defined as the temperature in 2 m height above surface.	Instituto Meteorológico Nacional, (2020). Glosario Meteorológico, IMN. San José, Costa Rica. WMO No.8 (2014) Guide to Meteorological Instruments and Methods of Observations, pages 31 and 63.
Days with Tmax ≥ 30°C	Number of days per year with daily maximum temperatures of at least 30 °C.	Adapted from Sillmann, J.; Kharin, V. V.; Zhang, X.; Zwiers, F. W. & Bronaugh, D.2013. Climate extremes indices in the CMIP5 multimodel ensemble: Part 1. Model evaluation in the present climate. Journal of Geophysical Research Atmospheres, 2013, 118, 1716-1733.
Days with Tmax ≥ 36°C	Number of days per year with daily maximum temperatures of at least 36 °C.	Adapted from Sillmann et al., 2013 (see above)
Days with Tmax ≥ 40°C	Number of days per year with daily maximum temperatures of at least 40 °C.	Adapted from Sillmann et al., 2013 (see above)
Nights with Tmin ≥ 25°C	Number of days per year with daily minimum temperatures of at least 25 °C.	Adapted from Sillmann et al., 2013 (see above)
Consecutive days with Tmin ≥ 36°C	Maximum annual duration [in days] of consecutive days with daily maximum temperatures of at least 36 °C.	Adapted from Sillmann et al., 2013 (see above)
Consecutive days with Tmin ≥ 40°C	Maximum annual duration [in days] of consecutive days with daily maximum temperatures of at least 40 °C.	Adapted from Sillmann et al., 2013 (see above)
Precipitation	The sum of annual and seasonal precipitation is calculated from daily precipitation sums. It contains liquid as well as solid precipitation.	AEMET Meteoglosario visual: https://meteoglosario.aemet.es/es/termino/494_precipitacion
Wet days	Number of days per year with daily precipitation (liquid and solid) of at least 1 mm.	Sillmann et al., 2013 (see above)
Dry days	Number of days per year with daily precipitation (liquid and solid) lower than 1 mm.	Sillmann et al., 2013 (see above)
95th percentile of precipitation	Value of total daily precipitation that is exceeded on five percent of all wet days per year.	Sillmann et al., 2013 (see above)
99th percentile of precipitation	Value of total daily precipitation that is exceeded on one percent of all wet days per year.	Sillmann et al., 2013 (see above)

Background information

Data sources for the climate projections

The projected climate changes presented in this Regional Climate Fact Sheet are based on regional climate projections, which are presented in the framework of the CORDEX initiative (http://www.cordex.org). The climate projections in this fact sheet are based on the Representative Concentration Pathways (RCPs), of which the RCP8.5 represents a high-emission scenario, and RCP2.6 a low-emission scenario. 28 climate projections were obtained from the ESGF data portal via the data node at the German Climate Computing Centre (https://esgf-data.dkrz.de). Of these, 10 simulations for the low-emission scenario (RCP2.6), and 18 simulations for the high-emission (RCP8.5) emission scenarios are available. The table below provides an overview of the regional climate models and their respective global forcing data. The CORDEX-CAM044 simulations are available on a grid with a spatial horizontal resolution of 0.44° (about 50 km), the CORDEX-CORE CAM022 simulations on a grid resolution of 0.22° (about 25 km).

High-emission scenario (RCP8.5)		
driving GCM and realization	RCM	grid resolution
CanESM2,r1i1p1	RCA4	0.44°
CSIRO-Mk3,r1i1p1	RCA4	0.44°
CNRM-CM5,r1i1p1	RCA4	0.44°
EC-EARTH,r12i1p1	RCA4	0.44°
IPSL-CM5A-MR,r1i1p1	RCA4	0.44°
MIROC5,r1i1p1	RCA4	0.44°
HadGEM2,r1i1p1	RCA4	0.44°
HadGEM2,r1i1p1	RegCM4-3	0.44°
HadGEM2,r2i1p1	RegCM4-3	0.44°
MPI-ESM-LR,r1i1p1	RCA4	0.44°
MPI-ESM-LR,r1i1p1	RegCM4-3	0.44°
GFDL-ESM2M,r1i1p1	RCA4	0.44°
NorESM1,r1i1p1	RCA4	0.44°
HadGEM2-ES,r1i1p1	REMO2015_v1	0.22
HadGEM2-ES,r1i1p1	RegCM4-7_v0	0.22
MPI-M-MPI-ESM-LR,r1i1p1	REMO2015_v1	0.22
MPI-M-MPI-ESM-LR,r1i1p1	RegCM4-7_v0	0.22
NCC-NorESM1-M,r1i1p1	REMO2015_v1	0.22

Low-emission scenario (RCP2.6)		
driving GCM and realization	RCM	grid resolution
EC-EARTH,r12i1p1	RCA4	0.44°
MIROC5,r1i1p1	RCA4	0.44°
HadGEM2,r1i1p1	RCA4	0.44°
MPI-ESM-LR,r1i1p1	RCA4	0.44°
NorESM1,r1i1p1	RCA4	0.44°
HadGEM2-ES,r1i1p1	REMO2015_v1	0.22
HadGEM2-ES,r1i1p1	RegCM4-7_v0	0.22
MPI-M-MPI-ESM-LR,r1i1p1	REMO2015_v1	0.22
MPI-M-MPI-ESM-LR,r1i1p1	RegCM4-7_v0	0.22
NCC-NorESM1-M,r1i1p1	REMO2015_v1	0.22

Other data sources

The precipitation observations ("TRMM (TMPA-RT) Near Real-Time Precipitation L3 1 day 0.25 degree x 0.25 degree V7") were created by the Goddard Earth Sciences Data and Information Services Center (Andrey Savtchenko) and published by the Goddard Earth Sciences Data and Information Services Center (GES DISC). They are available via: https://disc.gsfc.nasa.gov/datacollection/TRMM_3B42RT_Daily_7.html.
The ERA5 data was provided through the Copernicus Climate Change Service (C3S) (2017): ERA5: Fifth generation of ECMWF atmospheric reanalyses of the global climate (https://cds.climate.copernicus.eu).

The information on present day climate was provided by the Instituto Meteorológico Nacional (INM) of Costa Rica and is based on the following publications:
IMN. 2008. El clima, su variabilidad y cambio climático en Costa Rica. IMN.
Rojas, N. 2011. Estudio de Cuencas Hidrográficas de Costa Rica: Cuenca del Río Tempisque. IMN.
Solano, J.; Villalobos, R. 2009. Regiones y subregiones climáticas de Costa Rica. IMN

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Information, Literature and Weblinks:

https://www.gerics.de/products_and_publications/fact_sheets/index.php.de

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Cooperation Partners and technical team:

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CFIA: Federated Association of Engineers and Architects / Vladimir Naranjo Castillo and Luis Castro Boschini
CNE: National Commission for Risk Prevention and Emergency / Nazareth Rojas Morales
CONAVI: National Road Council / Luis Villalobos Pacheco
DCC: Climate Change Direction. Environmental and Energy Ministry (MINAE) / Iván Alonso Delgado
GIZ: Gesellschaft für Internationale Zusammenarbeit, on behalf of BMU / Federico Corrales Poveda
IMN: National Meteorological Institute / Francela Tencio Ávila
GERICS: Helmholtz-Zentrum Geesthacht - Climate Service Center Germany / Susanne Pfeifer, Tania Guillén Bolaños, Claas Teichmann, María Máñez Costa and Diana Rechid

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