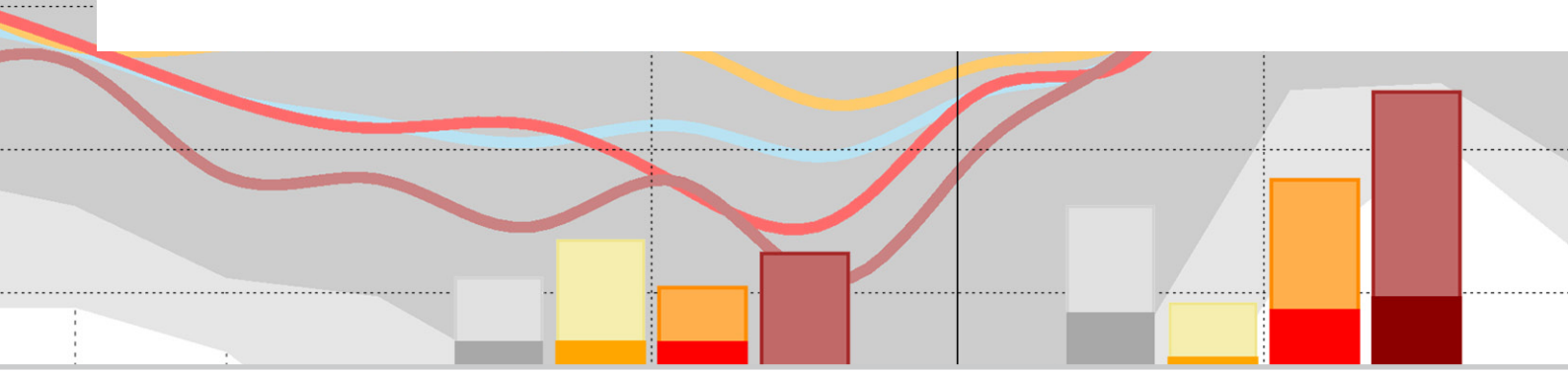
Climate-Fact-Sheet

Burkina Faso - Mali



Abstract

The region encompassing Burkina Faso and Mali is characterized by tropical wet dry climates in the south (Aw), semi-arid (BSh) conditions in some central parts of Mali and the northern half of Burkina Faso and arid desert climates (BWh) in the northern half of Mali. The southern regions are characterized by a unimodal rainfall regime, with a marked rainy and a marked dry season. The region receives rainfall mainly between May and November, when the Inter-Tropical Convergence Zone (ITCZ) is in its northernmost position. Maximum rainfall occurs in August. Annual rainfall is largest in the south and reaches up to 1100 mm per year. Towards the north, total rainfall amounts are decreasing rapidly with the northern desert regions of Mali receiving very little rainfall amounts all year round. In the dry months between December and March, almost no rain falls at all. Wet season rainfall amounts show a remarkable inter-annual variability. The region is further characterized by rather uniform distribution of annual mean temperature, ranging between 27 to 30 °C. Seasonal temperature variations are more pronounced in the north with temperatures ranging from 15 to 35°C, while in the south temperatures are always above 18 °C. Hottest months are May and June, coldest months are December and January.

Mean annual temperature has increased since the beginning of the 20th century. For the future, temperature projections from global climate models suggest a strong increase in temperature. For the end of the century a warming in the range of 2.6 to 4.7 °C (compared to the reference period from 1961 to 1990) is likely. Furthermore, a strong increase in the duration of heat waves as well as a strong reduction in cold spell length are projected.

A decrease in annual total precipitation has been observed in the past. For the future, the majority of the climate models project a continuation of the negative trend in precipitation amounts. For the end of the century a change in annual total precipitation in the range of -12 to +11 percent (compared to the reference period from 1961 to 1990) is likely. Furthermore, projections suggest a tendency towards slightly more intense but less frequent heavy rainfall events.

The climatic water balance is projected to decrease in the future. However, the projection of change in the water balance is affected by a large spread and therefore deemed to be not very robust. The same holds true for the robustness of projected changes in solar irradiance and mean wind speed, with the median projections suggesting little change over the 21st century.

Zusammenfassung

Das Klima der Region, welche die Länder Burkina Faso und Mali umschließt, variiert von tropischen, wintertrockenen Bedingungen (Aw) im Süden über Steppenklima (BSh) in einigen zentralen Regionen bis hin zu Wüstenklima (BWh) im Großteil des Nordens. Niederschlag tritt vorwiegend zwischen Mai und November auf, August ist generell der feuchteste Monat. Die räumliche Verteilung der jährlichen Niederschläge zeigt einen deutlichen Süd-Nord-Gradienten mit etwa 1100 mm im Süden und fast keinem Niederschlag im Norden. Der Niederschlag ist in der Region weiterhin durch eine starke zeitliche Schwankung geprägt. Jahresmitteltemperaturen zeigen eine geringe räumliche Variabilität zwischen 27 und 30 °C. Der Jahresgang der Temperatur ist im Norden (zwischen 15 und 35 °C) deutlich ausgeprägter als im Süden. Die wärmsten Monate sind Mai und Juni, am kühlsten ist es im Dezember und Januar.

Beobachtete Jahresmitteltemperaturen zeigten in der Vergangenheit einen Zunahme. Für die Zukunft projizieren Klimamodelle für die Region einen starken Temperaturanstieg. Zum Ende des Jahrhunderts kann eine Temperaturzunahme zwischen 2.6 und 4.7 °C im Vergleich zum Basiszeitraum von 1961 bis 1990 als wahrscheinlich betrachtet werden. Einhergehend mit dem Temperaturanstieg sind eine starke Ausdehnung von Hitzeperioden sowie eine deutliche Verkürzung von Kälteperioden.

Für den Jahresniederschlag wurde in der Vergangenheit eine Abnahme beobachtet. Für die Zukunft projiziert die Mehrzahl der Klimamodelle eine Fortführung des negativen Niederschlagstrends. Zum Ende des 21. Jahrhunderts kann eine Niederschlagsveränderung zwischen -12 und +11% im Vergleich zum Basiszeitraum von 1961 bis 1990 als wahrscheinlich betrachtet werden. Weiterhin wird eine Tendenz zu etwas stärkeren aber etwas weniger häufigen Starkniederschläge von den Modellen projiziert. Für die klimatologische Wasserbilanz zeigt sich eine Tendenz zur Abnahme in den Daten der Klimamodelle, jedoch ist diese Größe mit großen Unsicherheiten behaftet. Für die solare Einstrahlung und die mittlere Windgeschwindigkeit werden nur geringe Änderungen projiziert, aber auch diese Größen können nur bedingt verlässlich von Klimamodellen wiedergegeben werden.

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On behalf of KFW

BMZ Federal Ministry for Economic Cooperation and Development

CSC Climate Service Center Germany

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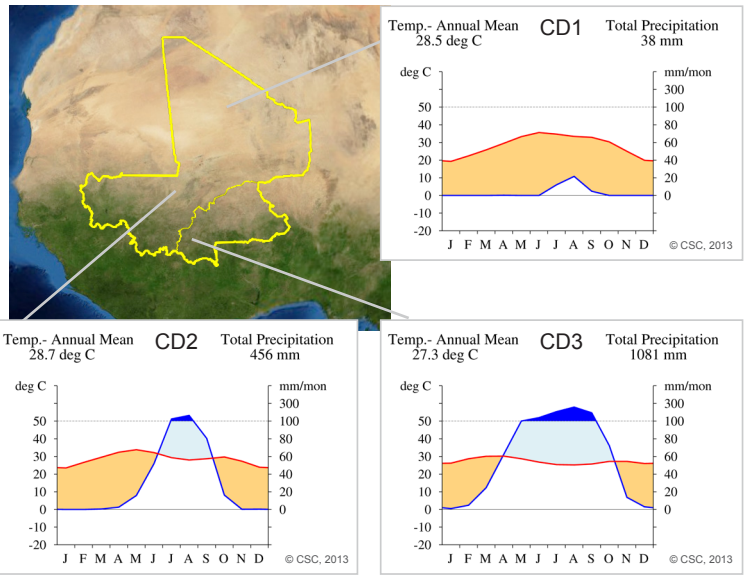
Current climate

Observed mean values are taken from literature and available global data sets (averaged over the whole region):

- Major climate zones (see also climate diagrams - CD1-3): Tropical wet dry climates (Aw) in the south (CD3), semi-arid (BSh) conditions in some central parts of the region (CD2) and arid desert climates (BWh) in the north (CD1)
- Annual mean temperature: ~28 °C
- Annual total precipitation: ~400 mm/yr
- Annual mean actual evaporation: ~300 mm/yr
- Annual mean climatic water balance: ~100 mm/yr
- Intensity of heavy rain events*: 23 mm/day
- Mean duration of dry spells*: 418 days **
- Mean duration of heatwaves*: 7 days
- Mean duration of cold spells*: 11 days
- Annual mean solar irradiance (surface): ~1420 kWh/(m^2 and yr)
- Annual mean wind speed (10 m above surface): ~3.5 m/s

Reported recent extreme events:

- Mali was affected by serious drought events in 2005 and 2010 which affected the lives of about 1.5 Million people.
- Flood-events in Burkina Faso in 2009 caused economic damage of about 150 Million US$.



The climate parameters marked with * are defined in the manual „How to read a Climate-Fact-Sheet“. Whenever mentioned in the fact-sheet, statistical significance is indicated at the 95 percent confidence level. The description of the climate zones is based on the Köppen-Geiger climate classification. ** A dry spell in the northern parts of the region can last several years.

Historical climate trends (based on the global CRU data set and literature sources)

- Mean annual temperature has increased by approximately 1 °C since the beginning of the 20th century. This increase is over the major parts of the region statistically significant. Only in the southern parts observed temperature increase was lower and statistically insignificant.
- An increase has been observed in the minimum temperatures, whereas no clear change was observed in maximum temperatures.
- On the long term a decrease in annual total precipitation by about 13 percent has been observed during the last century. During the last 20 years, however, a trend for slightly wetter conditions are observed for the Sahel zone.
- Recent positive rainfall trends are more pronounced in the eastern parts of the region.
- In central and northern Mali an increase in the frequency of dust events has been observed.

Summary of projected future climate (for the end of the century and combined for all scenarios)

Temperature The median projection of change in annual mean temperature is for an increase of 3.7 °C by 2100, with projected change very likely to fall in the range from 2.2 to 5.2 °C. Confidence in these figures is high. The change in temperature can be considered to be strong. The median projection of change in maximum temperature is for an increase of 3.2 °C by 2100 and in the minimum temperature for an increase of 3.6 °C.

Heatwaves The median projection of change in the duration of long-lasting heatwaves is for an increase of 26 days by 2100, with projected change very likely to fall in the range from 14 to 76 days. Confidence in these figures is high. The change in the duration of long-lasting heatwaves can be considered to be strong.

Cold spells The median projection of change in the duration of long-lasting cold spells is for a decrease of 7 days by 2100, with projected change is very likely to fall in the range from -16 to -3 days. Confidence in these figures is medium. The change in the duration of long-lasting cold spells can be considered to be strong.

Solar irradiance The median projection of change in annual mean solar irradiance is for no substantial change until 2100, with some projections showing an increase and some a decrease. Projected change is very likely to fall in the range from -5 to +1 percent. Confidence in these figures is medium. The change in annual mean solar irradiance can be considered to be weak.

Precipitation The median projection of change in annual total precipitation is for a slight decrease of 4 percent by 2100, but some projections show an increase. Projected change is very likely to fall in the range from -25 to +20 percent. The projected change in precipitation is for a slight decrease for the months January to July (up to -11 percent) and for a slight increase in the remaining months from August to December (up to +11 percent). Confidence in these figures is low. The change in annual total precipitation can be considered to be weak.

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Evaporation The median projection for annual mean actual evaporation is for no substantial change until 2100, with some projections showing an increase and some a decrease. Projected change is very likely to fall in the range from -20 to +16 percent. Confidence in these figures is low. The change in annual mean actual evaporation can be considered to be weak.

Water balance The median projection of change in the annual mean climatic water balance is for a decrease of 9 percent by 2100, but some projections show an increase. Projected change is very likely to fall in the range from -100 to +52 percent. Confidence in these figures is low. The change in the annual mean climatic water balance can be considered to be weak.

Dry spells The median projection of change in the duration of long-lasting dry spells is for no substantial change until 2100, with some projections showing an increase and some projections a decrease. Projected change is very likely to fall in the range from -14 to +41 days. Confidence in these figures is low. The change in the duration of long-lasting dry spells can be considered to be weak.

Heavy rains The median projection of change in the intensity of heavy rain events is for a slight increase of 4 percent by 2100, but some projections show a decrease. Projected change is very likely to fall in the range from -28 to +35 percent. The median projection for the frequency of heavy rain events is for a decrease of 6 percent by 2100. Confidence in these figures is low. The change in the intensity and frequency of heavy rain events can be considered to be weak.

Wind speed The median projection of change in annual mean wind speed is for no substantial change until 2100, with some projections showing an increase and some projections a decrease. Projected change is very likely to fall in the range from -3 to +7 percent. Confidence in these figures is medium. The change in the annual mean wind speed can be considered to be weak.

Note: The Climate-Fact-Sheets provide an overview of projected possible changes for selected climate parameters at the national or regional level. The Climate-Fact-Sheets are generated on the basis of the best currently available multi-model ensembles of regional and/or global climate models. Accordingly, the Climate-Fact-Sheets provide a first impression of the magnitude of potential future climate change averaged over a given country/region. As such, the information presented in the Climate-Fact-Sheets does not contain information on the finer local scale changes that may occur, and which may be of more interest, in for example, impact or adaptation studies. The Climate-Fact-Sheets are not intended, nor were they designed, to provide this kind of information. If more local scale information is the nature of your interest, or requirement, then alternative methods or tools should be used. Finally, the description of the current climate of the country as well as the observed historical trends is kept to a minimum, as the focus of the Climate-Fact-Sheets is on projected future changes.

Data sources and references

Data sources:
All projections (except information on the sea level) are based on the results of the global climate model projections, which are the base of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4 - www.ipcc.ch).
Information on current climate and historical trends, as well as the climate diagrams, are based on the available global data set compiled by the Climatic Research Unit from the University of East Anglia. Also data from the so called WATCH forcing data (compiled within the EU-project WATCH - Water and Global Change) has been used. Data on evaporation, wind speed and solar irradiance has been taken from reanalyses data (ERA-interim) compiled by the European Centre for Medium-Range Weather Forecasts (ECMWF).

References:
Information on recent extreme events and their impacts has been taken from: http://www.preventionweb.net

Information on the classification of climate zones and of the current climate has been taken from the following literature:
Kottek, M., Grieser J., Beck C., Rudolf B. and Rubel F. (2006): World Map of the Köppen-Geiger climate classification updated. In: Meteorologische Zeitung, 15, 259-263.
Oki T. and S. Kanae (2006): Global Hydrological Cycles and World Water Resources. Science 313, 1068.

Information on historic trends and for projected future changes (mainly for cross-checking) has been taken from the following literature (in alphabetical order):
Christensen, J.H. et al. (2007): Regional Climate Projections. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
Climate Change (2007): Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry et al. Eds.,Cambridge University Press, Cambridge, UK, 469-506.
Dai, A. et al. (2004): The recent Sahel drought is real. International Journal of Climatology, 24(11), 1323-1331.
Lebel, T., & Ali, A. (2009): Recent trends in the Central and Western Sahel rainfall regime (1990–2007). Journal of Hydrology, 375(1), 52-64.
Nicholson, S. E. (2001): Climatic and environmental change in Africa during the last two centuries. Climate Research, 17(2), 123-144.

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Legend

Statistical information:

very likely: light-coloured
(90 % of model simulations)

likely: dark-coloured
(66 % of model simulations)

Median
(50 percent-value of model simulations)

Emission scenarios:

- all scenarios combined
- low scenario (B1)
- medium scenario (A1B)
- high scenario (A2)

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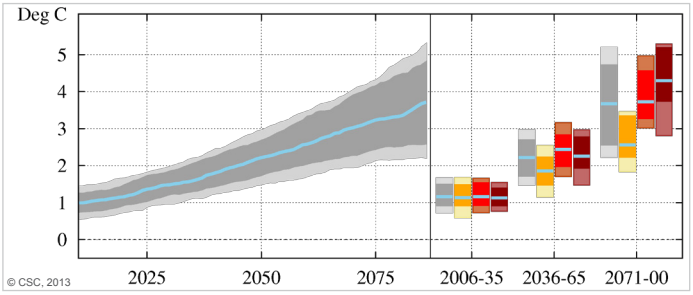
Projections of possible development of temperature, heatwaves and cold spells

Annual mean temperature

- Median projection of change in annual mean temperature is for an increase of 3.7 °C by 2100.
- Likely range: 2.6 to 4.7 °C; very likely range: 2.2 to 5.2 °C

Separate scenario examination (by 2100):

- **Low-Scenario B1:** Median +2.6 °C
- **High-Scenario A2:** Median +4.3 °C



Maximum and minimum temperature

The trends of maximum and minimum temperature are consistent with the trend of annual mean temperature depicted above.

- Median projection of change in maximum temperature is for an increase of 3.2 °C by 2100.
- Median projection of change in minimum temperature is for an increase of 3.6 °C by 2100.

in °C	Scenario	Measure	Max-Temperature	Min-Temperature
2071-2100	ALL	Median **likely** very likely	3.2 **2.5 to 3.8** 1.7 to 5.4	3.6 **2.6 to 4.5** 2.0 to 5.7
	B1	Median **likely** very likely	2.5 **2.0 to 3.2** 1.7 to 3.8	2.6 **2.3 to 3.5** 2.0 to 4.1
	A1B	Median **likely** very likely	3.2 **2.9 to 4.4** 2.8 to 5.4	3.6 **3.2 to 4.7** 3.1 to 5.7
	A2	Median **likely** very likely	3.5 **3.2 to 5.0** *	4.3 **3.9 to 5.3** *

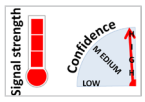
* The amount of available data is not sufficient to project the range for „very likely“ for A2

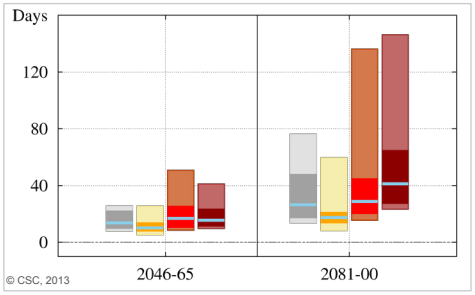
Heatwaves

- **Median projection of change in the duration of long-lasting heat-waves is for an increase of 26 days by 2100.**
- Likely range: 17 to 48 days; very likely range: 14 to 76 days

Separate scenario examination (by 2100):

- **Low-Scenario B1:** Median +17 days
- **High-Scenario A2:** Median +41 days





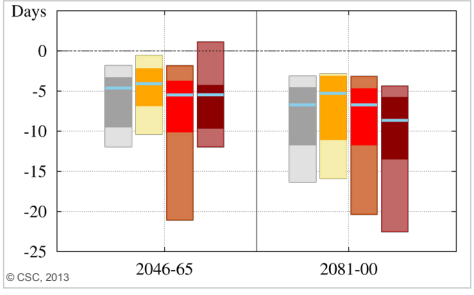
Cold spells*

- Median projection of change in the duration of long-lasting cold spells is for a decrease of 7 days by 2100.
- Likely range: -12 to -5 days; very likely range: -16 to -3 days

Separate scenario examination (by 2100):

- **Low-Scenario B1:** Median -5 days
- **High-Scenario A2:** Median -9 days

* Note that it is possible that the absolute decrease in the duration of cold spells might be larger than the actual cold spell length (as given in the current climate section) due to a slight mismatch between models and observations.

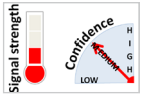


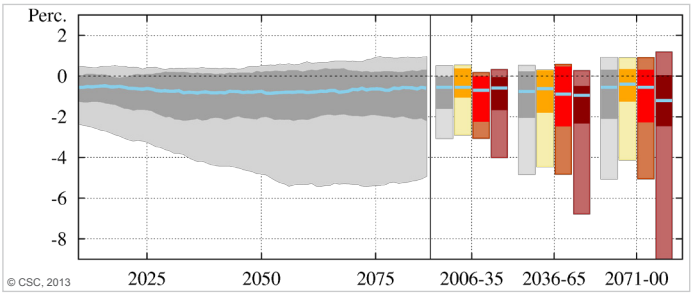
Projections of possible development of solar irradiance

- Median projection of change in solar irradiance is for no substantial change until 2100, with some projections showing an increase and some a decrease.
- Likely range: -2 to 0 percent; very likely range: -5 to +1 percent

Separate scenario examination (by 2100):

- **Low-Scenario B1:** Median ±0 percent
- **High-Scenario A2:** Median -1 percent





All projected changes presented in the Climate-Fact-Sheet are with respect to the reference period from 1961 to 1990.
The evaluation of the signal strength includes not only the actual climate change signal but also the statistical significance of the projected change.
The assessment of the confidence in the climate model projections is based on the models‘ performance in simulating today’s climate as well as on the bandwidth of projected climate change. This bandwidth results from the fact that every climate model projects a slightly different climate change signal.

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Median
(50 percent-value of model simulations)

Emission scenarios:

all scenarios combined
low scenario (B1)
medium scenario (A1B)
high scenario (A2)

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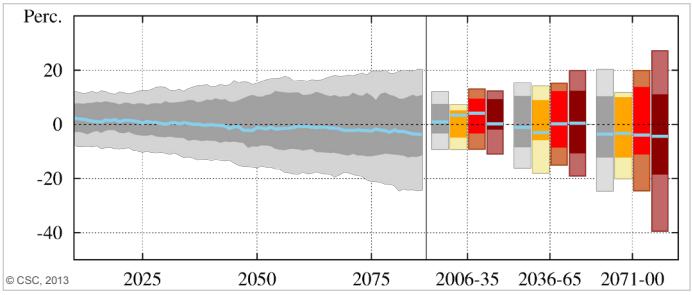
Projections of possible development of precipitation and water availability

Annual total precipitation

- Median projection of change in annual total precipitation is for a slight decrease of 4 percent by 2100, but some projections show an increase.
- Likely range: -12 to +10 percent; very likely range: -25 to +20 percent

Separate scenario examination (by 2100):

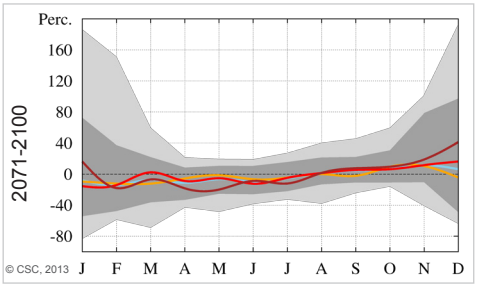
- **Low-Scenario B1:** Median -3 percent
- **High-Scenario A2:** Median -4 percent



Precipitation seasonality

- Median projection of change in total precipitation is for a slight decrease for the months January to July (up to -11 percent) and for a slight increase in the remaining months from August to December (up to +11 percent).
- Likely range: -54 to +72 percent (first half of the year from January to July) and -48 to +96 percent (remaining months).

The **A2-Scenario** shows lightly more pronounced precipitation decrease and increase in the respective months than the **B1-Scenario**.

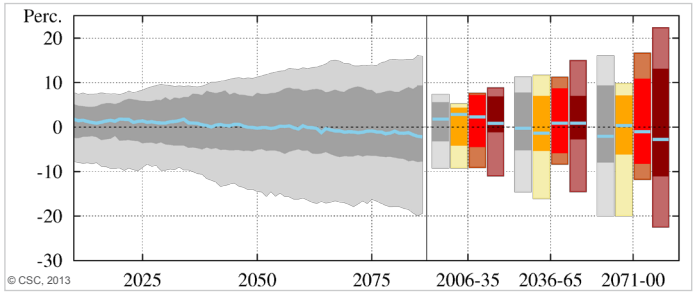


Evaporation

- Median projection of change in actual evaporation is for no substantial change until 2100, with some projections showing an increase and some a decrease.
- Likely range: -8 to +9 percent; very likely range: -20 to +16 percent

Separate scenario examination (by 2100):

- **Low-Scenario B1:** Median ±0 percent
- **High-Scenario A2:** Median -3 percent



Climatic water balance (difference between annual mean precipitation and annual mean actual evaporation)

- Median projection of change in the climatic water balance is for a decrease of 9 percent by 2100, but some projections show an increase.
- Likely range: -73 to +34 percent; very likely range: -100 to +52 percent

Separate scenario examination (by 2100):

- **Low-Scenario B1:** Median -9 percent
- **High-Scenario A2:** Median -15 percent

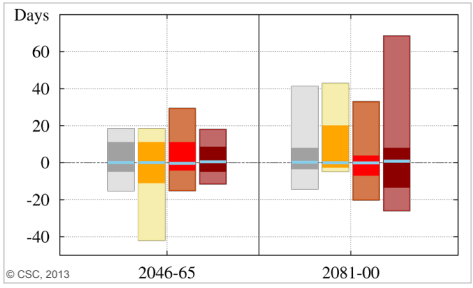
The climatic water balance is derived from projected precipitation and projected actual evaporation amounts. Therefore the bandwidth of both parameters is accumulated in this parameter. Due to this, the climatic water balance shows a rather high bandwidth.

Dry spells

- Median projection of change in the duration of long-lasting dry spells is for no substantial change until 2100, with some projections showing an increase and some projections a decrease.
- Likely range: -3 to +8 days; very likely range: -14 to +41 days

Separate scenario examination (by 2100):

- **Low-Scenario B1:** Median ±0 days
- **High-Scenario A2:** Median +1 day



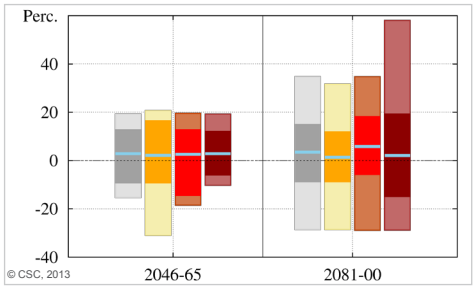
Heavy rains*

- Median projection of change in the intensity of heavy rainfall events is for a slight increase of 4 percent by 2100, but some projections show an decrease.
- Likely range: -9 to +15 percent; very likely range: -28 to +35 percent

Separate scenario examination (by 2100):

- **Low-Scenario B1:** Median +1 percent
- **High-Scenario A2:** Median +2 percent

A heavy rain event of today's intensity is projected to occur 6 percent less frequently in the future.



* Note that for the intensity of heavy rainfall events only wet days (days with rainfall of more than 1 mm/day) have been considered for the analysis. For the frequency of heavy rainfall events, however, all days (including days without rainfall) have been counted.

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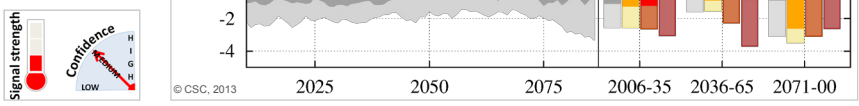
Projections of possible development of wind speed

- Median projection of change in annual mean wind speed is for no substantial change until 2100, with some projections showing an increase and some projections a decrease.
- Likely range: -1 to +4 percent; very likely range: -3 to +7 percent

Separate scenario examination (by 2100):

- **Low-Scenario B1:** Median +2 percent
- **High-Scenario A2:** Median +3 percent



Ordering party:

KfW Development Bank
Palmengartenstrasse 5-9
60325 Frankfurt

Contact details of editors:

Climate Service Center
Fischertwiete 1
D-20095 Hamburg
Telephone: +49-(0)40-226 338 424
E-Mail: csc-anfragen@hzg.de
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