What will the climate of Aruba look like in 2050 and 2100?

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and Water Management

Climate scenarios for Aruba

PHOTO NOEL WERLEMAN

The **Departamento Meteorologico Aruba** (**DMA**) is Aruba's official source of weather, climate, and earthquake information. The DMA issues official forecasts and weather warnings to keep people safe and protect property and the environment. These climate scenarios are an important part of this task. The department was founded in October 2010, after the weather service of the Dutch Antilles was shut down. The department is located near the Queen Beatrix International Airport.

The **International Panel on Deltas and Coastal Areas** (**IPDC**) helps deltas, coasts, and islands adapt to climate change. It supports them in protecting ecosystems, livelihoods, and economies. Initiated by the Government of the Netherlands, and supported by Deltares and Stichting Climate Adaptation Services, the IPDC provides technical expertise for climate scenarios, risk assessments, and adaptation planning. On Aruba, the IPDC works to strengthen the island's resilience to climate impacts and support national adaptation strategies. These climate scenarios are an important part of that work.

The **Royal Netherlands Meteorological Institute** (**KNMI**) is the national institute for weather and climate in the Netherlands. It conducts scientific research on climate change, represents the Netherlands in the IPCC, and advises the government on climate and weather risks.
KNMI develops high-quality climate scenarios that translate global climate research into regional insights. The climate scenarios for Aruba are based on KNMI's 2023 scenarios for the Netherlands, improved and adapted to the Aruban context.

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Foreword

Our Climate, Our Future: A Call to Resilience

It is our distinct honor to present this pivotal report on the future climate scenarios for Aruba. For generations, our island has been defined by the sun, the sea, and the wind. These elements have shaped our culture, driven our economy, and forged the resilient spirit of the Aruban people. However, as the scientific findings in this report make clear, the very environment that sustains us is changing at a pace that demands our immediate and undivided attention.

The *Climate Scenarios for Aruba* report serves not merely as a forecast, but as a clarion call. The data is unequivocal: our future will be hotter, drier, and defined by a rising sea. We are looking at a reality where the "extreme" heat of today could become the normal baseline of tomorrow, and where our precious water resources will face unprecedented pressure. The scenarios for 2050 and 2100 paint a picture of an island that must adapt to survive and thrive.

Yet, this report is not a document of despair; it provides guidance to inspire resilience. Understanding the magnitude of the challenge is the first step toward overcoming it. The scenarios outlined here provide the evidence base we need to make hard but necessary decisions. We must move beyond 'hypothetical discussions' and into the realm of national climate action. This means restoring our fragile ecosystems, future-proofing our critical infrastructure, reimagining our water management strategies, protecting our vulnerable coastal ecosystems, and preparing our public health systems for a warmer world.

We cannot control the global emissions that drive these changes, but we have absolute agency over how we prepare for them. Building climate resilience is not just an environmental imperative; it is an economic and social one. It is about safeguarding our lives and livelihoods, and ensuring that the Aruba we pass to our children is safe and habitable.

The production of this critical knowledge would not have been possible without the dedication of our partners. I wish to extend my deepest gratitude to the Departamento Meteorologico Aruba (DMA) and the Royal Netherlands Meteorological Institute (KNMI). Your scientific rigor has given us the clarity we need to act. I also thank the International Panel on Deltas, Coastal Areas, and Islands (IPDC) for their invaluable global perspective on our local challenges. A special word of appreciation goes to Mr. Robert-Jan Moons, whose contribution and continued commitment in this project have been instrumental in bringing this work to fruition.

Let this report be the catalyst for a unified national effort. The time for waiting has passed. Let us use this knowledge to build a stronger, safer, and more sustainable Aruba for all.

Ryan R. Peterson, PhD
Chairman
National Climate Resilience Council of Aruba

The climate is changing; what does this mean for Aruba?

It's getting warmer

By 2050, Aruba's average temperature is expected to be about 0.8 to 1.3 °C higher than today, and by 2100 it could be up to 3.3 °C warmer. As temperatures rise all year round, Aruba will face higher temperatures than ever before, and the heat season will last longer. The heat can cause health problems, especially for vulnerable people.

It's getting drier

Aruba is expected to receive less rain in the future. In the best case, the change will be small, but in the worst case, rainfall could drop by half by 2100. Just like today, rainfall will vary a lot from year to year, with some years much drier than others. The dry season may also last longer. This will put extra pressure on nature, farming, and water resources.

The sea-level is rising

As a result, the sea around Aruba could be about 24 cm higher by 2050 than today, and by 2100 up to 48 to 82 cm. Over the next few hundred years, the sea will keep rising, and a rise of more than 1 meter is only a matter of time. This means smaller beaches and a greater risk of flooding and storm damage along the coast.

What now?

Climate change brings challenges for Aruba. The effects are already being felt through higher temperatures, longer dry periods and rising sea levels — signs that adaptation is needed now. Aruba can strengthen its resilience by protecting water resources, improving infrastructure, and helping communities to cope with heat.

Introduction

The climate scenarios for Aruba show what the island's future climate could look like in 2050 and 2100. These scenarios are based on strong scientific knowledge. They provide the knowledge necessary to reduce safety risks and help policymakers and other professionals prepare the island for the future.

These scenarios are based on those for the Netherlands, which were created by the Royal Netherlands Meteorological Institute (KNMI) and published in 2023 [1]. You can find in-depth information at the end of this report. For the scientific methods, results and background, there is a technical report available.

The climate is changing

It is certain that human activities are warming the planet by releasing greenhouse gases. The IPCC concluded in its Sixth Assessment Report of 2021 [2] that the Earth's temperature has never risen as quickly as it has now. In 2024, the average temperature across the globe was 1.5 °C higher than it was in the pre-industrial period (1850–1900). With further warming, the frequency and intensity of heatwaves, extreme rainfall, and droughts will continue to increase worldwide. Some changes, like the warming of the oceans, the melting of ice sheets, and the rise in sea level, will continue for hundreds or thousands of years. In addition, hurricanes are becoming stronger and they can become major hurricanes more quickly. The IPCC concludes that small islands like Aruba already face increasing risks [3].

Observed climate change on Aruba

Aruba's climate is already changing. Since 1985, the beginning of our observations, the temperature is rising with around 0.2 °C each decade. The amount of rain that falls varies a lot from year to year, with some years being much wetter or drier than others. Tropical storms and hurricanes can bring a lot of rain.

For example, during the years with Hurricanes Ivan (2004) and Omar (2008), the amount of rain was about three times higher than usual. Strong El Niño events can cause drier years. In 2015, a strong El Niño year, Aruba received less than 140 millimeters of rain, about one-third of the normal amount.

Climate change impacts

Rising temperatures and sea levels are already affecting Aruba. More extremely hot days impact island life and increase electricity use for air conditioning. Warmer ocean temperatures cause corals to bleach. This harms coral reefs, which protect the coast. Higher sea levels cause beaches to disappear and make flooding from waves and storm surges more likely, especially when heavy rain occurs at the same time. These risks are greater because many houses as well as hotels are located near the coast. Aruba's economy depends for a large part on tourism, which is very sensitive to climate change.

Current climate

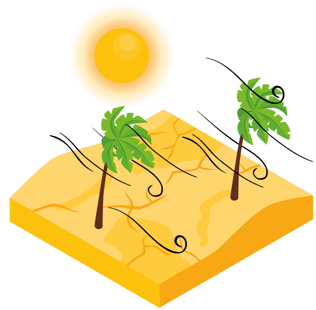
Aruba has a semi-arid to arid climate, characterized by generally warm and dry conditions throughout the year.

These graphs show the observed climate on Aruba for each year from 1985 to 2024, compared to the 1991–2020 average, which is defined as the normal. Normally, the temperature on Aruba is 28.5 °C. The warmest months are July and August, but the island experiences very little seasonal temperature variation throughout the year. Annual rainfall averages about 498 mm, with a distinct wet season from September to January, a dry season from February to May, and a transitional period between June and August. The normal wind speed is 7.6 m/s, predominantly from the east.

wet years

Wet years can often be linked to years with hurricanes that passed through the Caribbean resulting in rainfall and waves on Aruba, causing floodings

dry years



Dry years can often be linked to El Niño years. During these years, the trade winds are stronger, causing higher average wind speeds

What are anomalies?

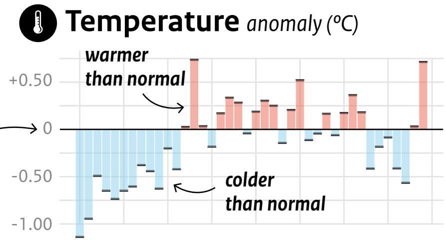
Anomalies show how different a year is from what's normal. In this case, normal is defined as the average of the years 1991-2020.

Imagine you know the average amount of rain Aruba gets each year.

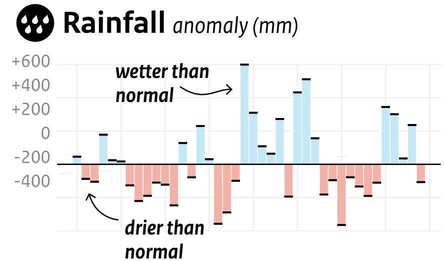
- If one year it rains less than normal, the bar goes down — that means it was a dry year.
- If one year it rains more than normal, the bar goes up — that means it was a wet year.

The bigger the bar, the bigger the difference from normal!

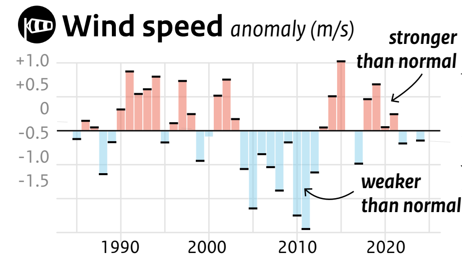
So, anomalies help us see which years were abnormal. This way, we can see if the climate of Aruba is changing. For example, for temperature, you can see that in recent years the temperature is often higher than usual, meaning that the climate is warming.
The wind speed graph shows many negative anomalies (lower speed than normal) in recent years. This is most likely due to a change in measurement methods—such as data coming from a different station—rather than an actual change in climate.



In recent decades, there is a clear rise in temperature, resulting in an increasing number of years that are warmer than average. Because Aruba lies in the tropics, where both seasonal and year-to-year temperature variations are small, this warming is quickly noticeable and already has visible impacts on the island's environment and society.



Rainfall shows large interannual variability, ranging from around 150 mm in very dry years to over 1000 mm in particularly wet years. This strong variability can mask the drying trend.



Wind speeds also fluctuate from year to year, and there is a relationship between wind speed and rainfall: years with stronger winds often coincide with drier than usual conditions, while years with lower wind speeds tend to be wetter.

Climate scenarios for Aruba

We use the latest climate models to explore what the future climate of Aruba might look like.

To cover the range of possible futures, we created four different scenarios that show how the climate could change in 2050 and 2100. The differences between the scenarios are due to uncertainties about the future, mainly because we don't know exactly how much greenhouse gas the world will emit or how the climate will react to those emissions. We first divide the possible futures by emission levels (low and high), and then by how dry Aruba could become (mild or strong drying). Together, these four scenarios give a realistic picture of the range of future climates that Aruba may face. We also include a moderate emissions scenario to meet the needs of policy making.

Scenarios with high, moderate and low emissions

The first difference between the scenarios comes from the amount of pollution released into the air. Greenhouse gases, such as carbon dioxide (CO2), trap heat as if the Earth is covered by a blanket, making the planet warmer.

	Strong drying	Mild drying
High CO_2 emissions	1	2
Medium CO_2 emissions	3	4
Low CO_2 emissions	5	6

How much these gases are released depends on global action and climate policy.

In the low emissions scenario, countries take strong action to meet the Paris Agreement goals, keeping global warming to about 0.8°C (0.4°C–1.5°C) by 2100.

In the high-emission scenario, emissions keep increasing, and the planet warms by about 4°C (2.8°C–5.6°C) by 2100.

The moderate scenario shows what would happen if only modest climate actions are implemented, resulting in around 1.9°C (1.3°C–2.9°C) of warming by 2100. Each scenario helps to show what different global choices today could mean for Aruba's climate in the future. We don't know which of the scenarios is more likely.

Scenarios with strong and mild drying

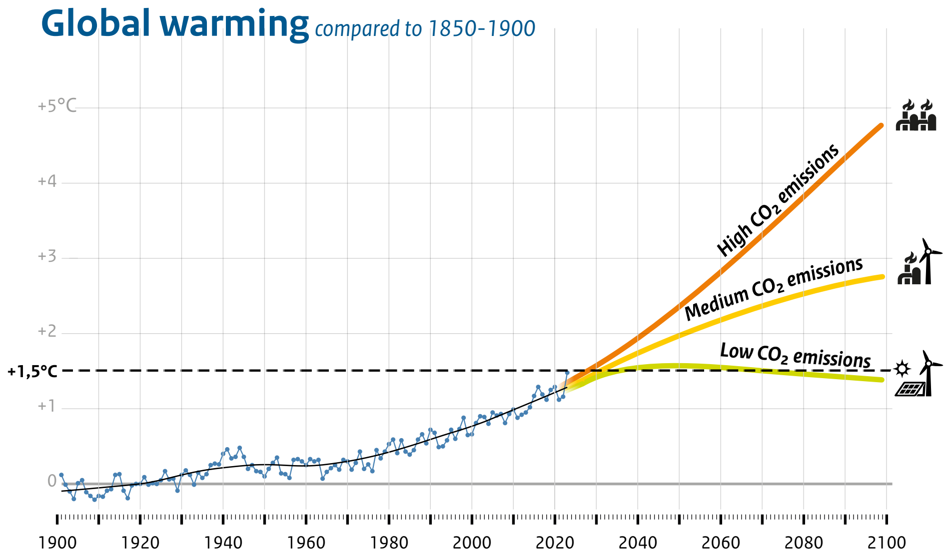
Each emission scenario includes two versions—one with strong drying and one with mild drying. This distinction reflects the uncertainty in how rainfall over Aruba may change in a warming world. Some scenarios indicate that Aruba could become much drier, while others suggest only a modest decrease in rainfall. By providing both versions, we capture this range of possible future conditions. Combining the strong and mild drying scenarios with the three emission levels gives a total of six scenarios.

Natural variability and trends

Regional climate scenarios

Climate models generally operate on a large scale, representing large-scale global circulations and how they change. To translate these large-scale models towards small-scale regions, such as Aruba, we use historical observations.

These past records “correct” the model so that it represents how the local climate responds to broader climate patterns, allowing us to project future conditions more accurately. The resulting climate scenarios are therefore optimized for the location of the island’s measuring station, situated at the airport. However, since weather conditions can vary across the island, locally the climate may differ from the modeled scenarios.

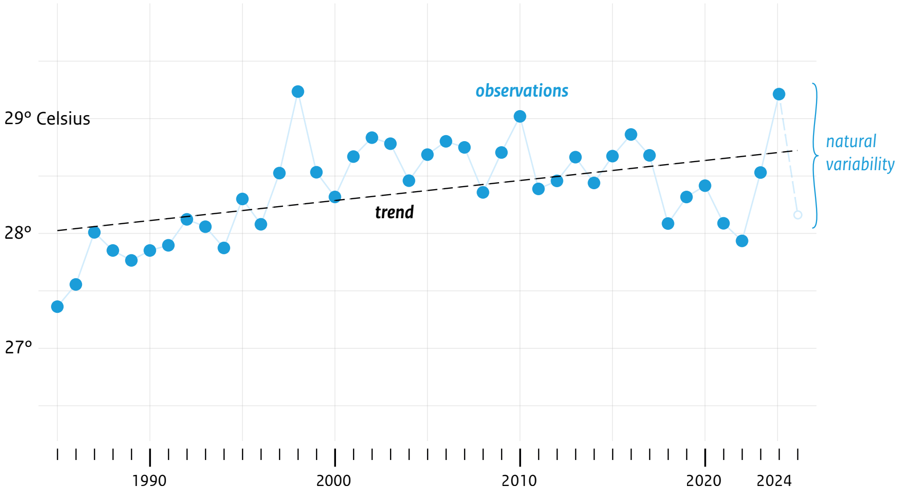


Natural variability and trends

The climate naturally varies because of interactions between the atmosphere, oceans, land, and ice caps. Events like El Niño and La Niña are good examples of this natural variability. They influence temperature, wind, and rainfall on a regional scale.

We cannot predict this kind of variability from year to year. So, we can’t say whether 2046, for example, will be warm or cold, wet or dry. What we can do is look at the long-term trend. If the scenarios show that the climate will get warmer, then the chance that 2046 will also be warm, increases.
It is important to remember that even in the highest emission scenario, not every single

Average temperature *Beatrix International Airport*



year will be hotter than today. The key change is in the average over several decades, which will become warmer. For instance, if the scenarios suggest that average temperatures will rise by the end of the century, some years around that period may be warmer, while others could still be cooler. Those ups and downs are part of the natural variability of the climate.

Temperature

It’s getting warmer

1991-2020 28.5° Celsius	strong drying	mild drying
high CO_2 emissions	31.5°	31.8°
medium CO_2 emissions	30.1°	30.1°
low CO_2 emissions	29.2°	29.2°

PRESENT

In the current climate on Aruba, the annual average temperature is 28.5 °C. Aruba has a tropical climate, temperature variations are mild, with the warmest months from August to October with an average temperature of 29.5°C and the coolest months from December to February with an average temperature of 27.3°C. This seasonal variation is smaller than the typical day–night temperature difference.

FUTURE

The temperatures on Aruba will keep rising in the future. How much they’ll continue to rise depends on the scenario. Under the low-emission scenario, temperatures are expected to increase until around 2050, after which they will stabilize. In the high-emission scenario, temperatures keep increasing, reaching several degrees higher by 2100. The strongest warming is expected during the wet and transition seasons, which are already the warmest times of the year. By the end of the century, the average annual temperature could be higher than today’s warmest month, which is around 30 °C in September.
Differences are largest between the emission scenarios, but also appear between the strong and mild drying pathways. Natural variations such as El Niño and La Niña will continue to affect temperatures from year to year.

Did you know that...

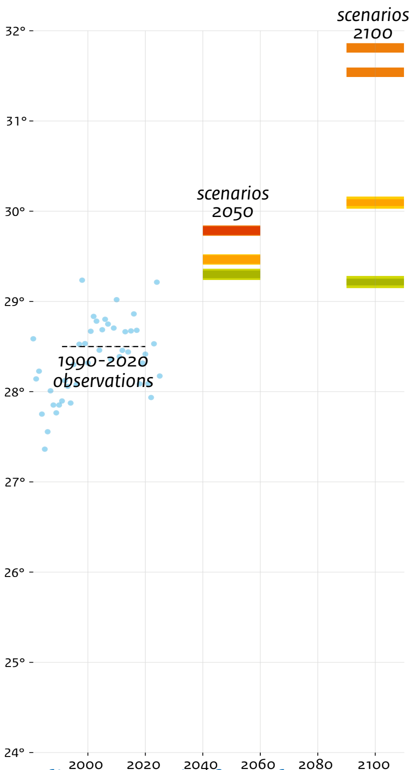
... temperature alone doesn’t tell the whole story of how hot it feels? The perceived heat depends on a combination of factors like temperature, wind, humidity and sunlight. Less wind, high humidity and a lot of sunlight can drastically increase the perceived temperature.

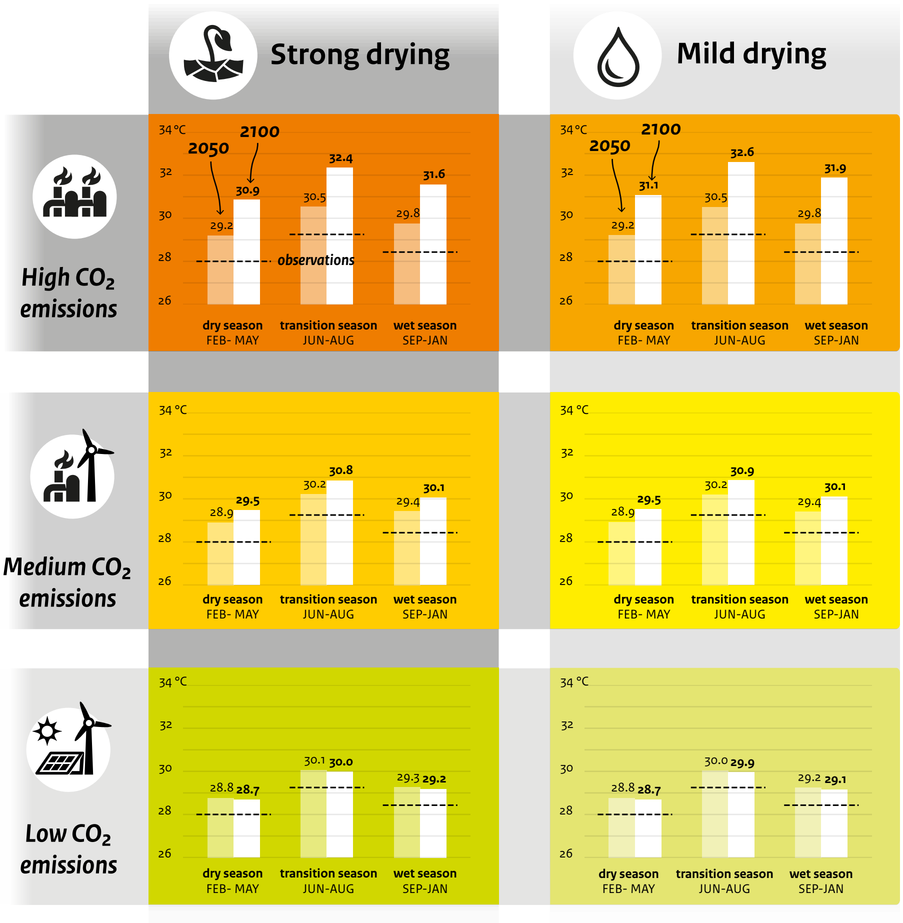
Heat in the sea

The sea around Aruba is also warming up. Since 1970, it has warmed by approximately 0.14°C every decade. Marine heat waves happen when the sea is much hotter than normal for several days. These hot events are happening more often, and with higher temperatures.
As the oceans keep warming, marine heat waves will become more common. As with hot days on land, what is now considered hot may become normal in the future. How warm the sea gets will depend on how much the world continues to emit greenhouse gases.

Temperature

Warming over time



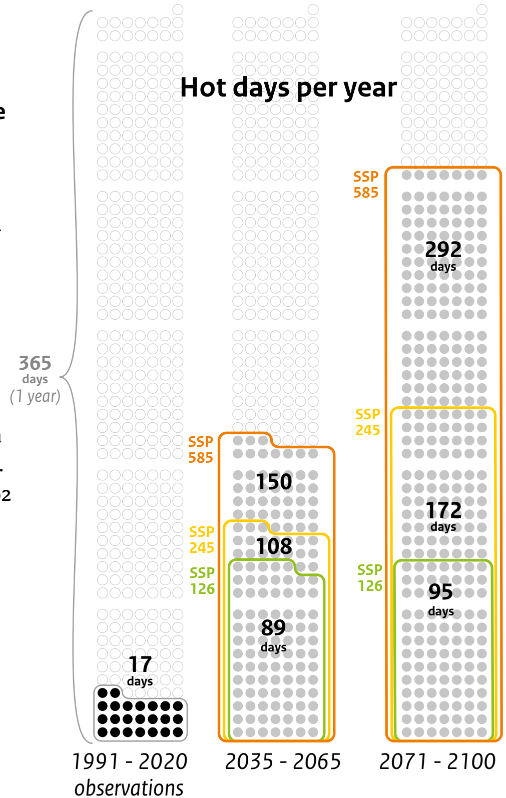


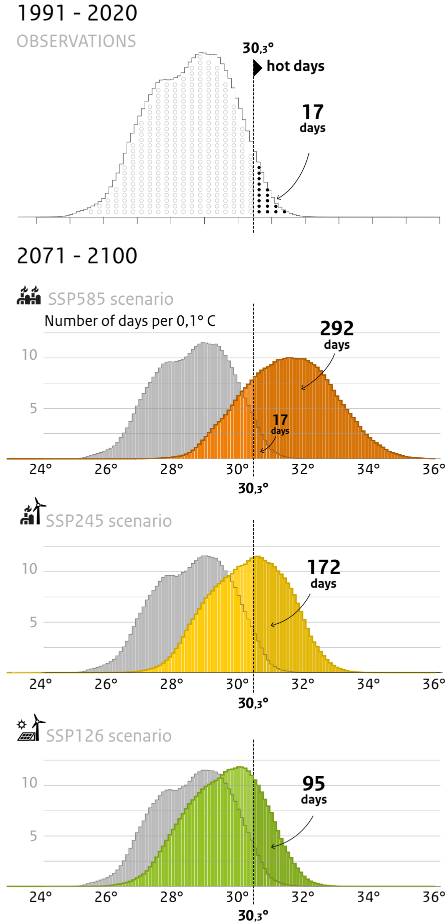
Temperature

More hot days

The average temperature on Aruba will increase. As a consequence, the number of hot days will increase and the warmest days will become even warmer.

This means that Aruba will often experience temperatures that were not experienced before. Hot days are here defined as days where the average temperature reaches above 30.3. In the current climate, an average year has 17 hot days. Around 2050, in the low-emission scenario an average year has 89 hot days and in the high-emission scenario 150 hot days. By the end of the century, in the low-emission scenario an average year will have 96 hot days. In the high-emission scenario there will be 292 hot days. This means 9.5 months of the year will experience heat, making what is now considered hot effectively the new normal.





Rainfall

It’s getting drier

PRESENT

Rainfall is very important for Aruba, this is clear from the fact that the seasons are called the dry and the wet season. In the current climate, the annual average rainfall is 498 mm/yr. However, the amount of rainfall is very variable over the years and tightly connected to El Niño and La Niña. There are dry years with less than 200 mm rainfall per year, like 2001 and 2015. And wet years with more than 1000 mm rainfall, like 2004 and 2011. Due to the high year-to-year variability, no clear trend is visible in the observations.

1991-2020 498 mm	strong drying	mild drying
high CO_2 emissions	242 mm	459 mm
medium CO_2 emissions	395 mm	490 mm
low CO_2 emissions	464 mm	500 mm

FUTURE

Most future scenarios for rainfall on Aruba point to a drier climate in the coming decades. The drying signal is strongest in the high-emission and strong-drying scenarios, where annual rainfall could be reduced by up to half compared to today. In the low- and middle-emission or mild-drying scenarios, changes are smaller. On top of this trend, the year-to-year variation takes place. All seasons are projected to become drier, with the dry season lasting longer and the wet season recovering less. In these drier future climates, extremely dry years could become even more severe, partly influenced by natural climate patterns such as El Niño and La Niña.

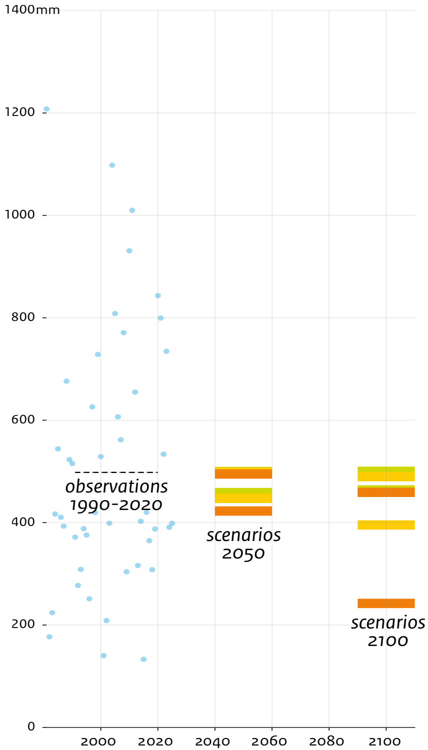
Did you know that...

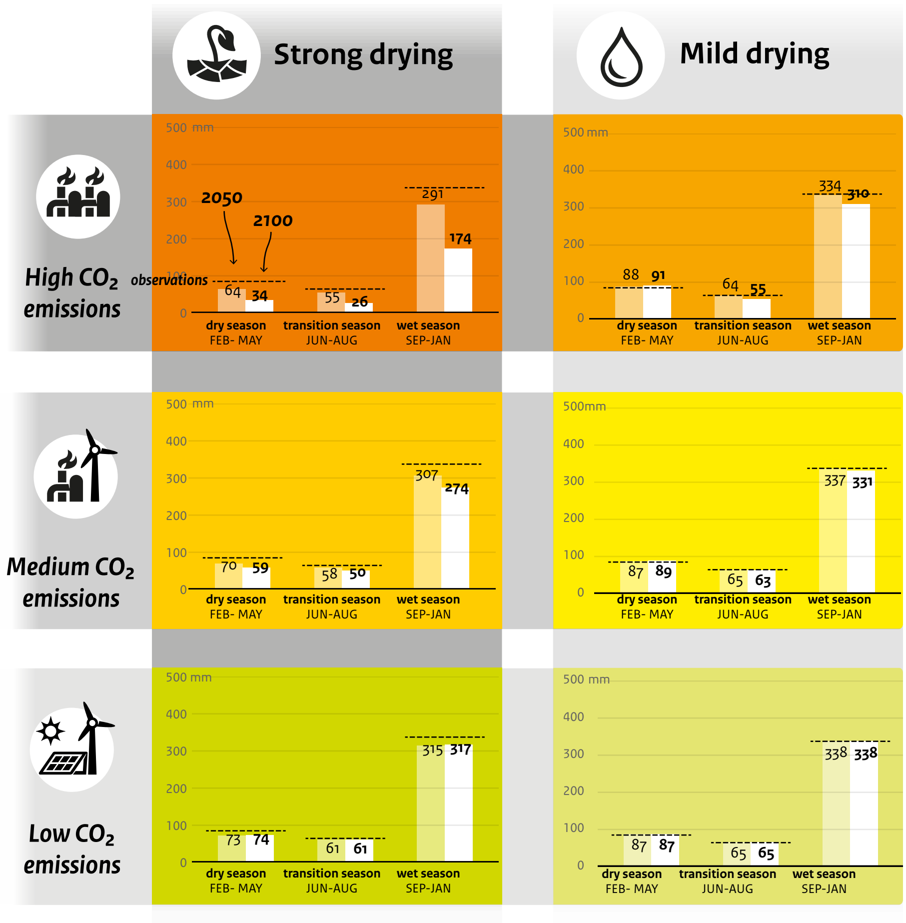
... Aruba’s rainfall varies strongly from year to year? During El Niño events, the island often experiences much less rain, while La Niña years tend to be wetter. Climate models project that we might move to a more El Niño like climate in the future, but recent observations show a La Niña trend instead, a topic still debated among researchers.

For the mild-drying and low-emission scenarios, these year-to-year variations will continue to play a key role in shaping risks and guiding decisions.

Rainfall

Drying over time

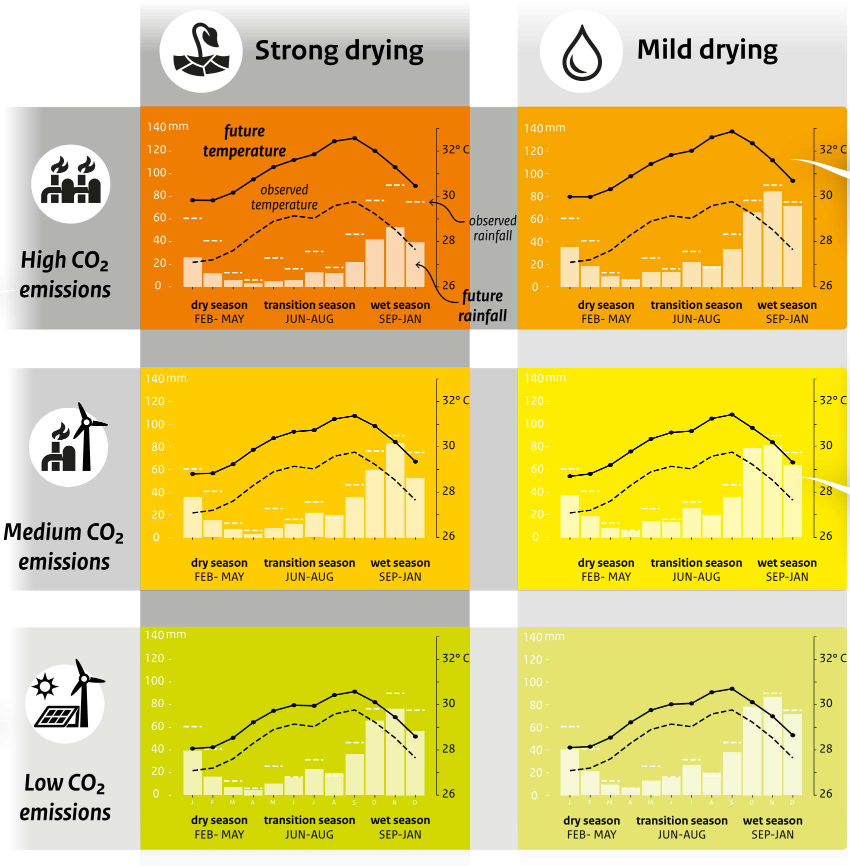




Climate change

In the high emission scenario, the dry season is prolonged for the normally wet season months January and September are just as dry as the dry season months in the current climate.

The relative change is highest in the dry season (high percentages), but the absolute change is highest in the wet season (amount of rainfall).



The hottest months (August-October) will warm the most.

In the moderate and high scenario, the average temperature rises each month by +1.5°C or more, taking the climate to a 'new normal'.

Wind

Wind speed increases

PRESENT

On average, Aruba experiences wind speeds of about 7.6 meters per second throughout the year. The island's winds are mainly driven by the trade winds, which blow steadily from the east almost all year round. Wind speeds are generally stronger during the dry and transitional seasons and weaker during the wet season.

1991-2020
7.6 m/s

	strong drying	mild drying
high CO_2 emissions	8.2 m/s	7.9 m/s
medium CO_2 emissions	7.9 m/s	7.8 m/s
low CO_2 emissions	7.7 m/s	7.7 m/s

FUTURE

Climate scenarios suggest that wind speeds on Aruba will remain relatively stable in the future, with only a slight increase expected across all emission scenarios. The increase is slightly stronger for the higher emissions scenario.
Most of this increase is projected to occur during the wet season. In the scenario that also shows stronger drying trends, the increase in wind speed appears to be more pronounced.

Did you know that...

... occasionally, when hurricanes or rain systems pass nearby and cut off the trade winds, the wind can temporarily weaken or even shift direction, a phenomenon known as a wind reversal. During a wind reversal, the wind cooling effect temporally disappears. With rising temperatures, this has a larger impact

Did you know that...

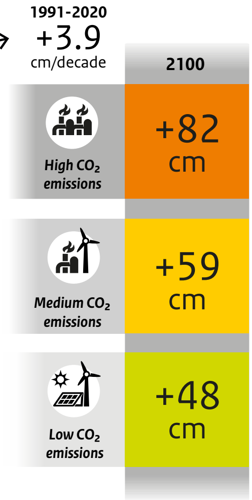
... when strong winds blow across the ocean, they can push warm surface water aside, allowing cooler water from greater depths to rise and replace it, a process known as upwelling. As a result, more wind can have a moderating effect on the warming of the sea surface water which influences drought and heat on the islands.

Sea level

The sea level rises

PRESENT

The sea level is rising. In the period 1993-2023, the sea level near Aruba has risen with approximately 3.9 centimeters per decade.
Rising sea levels pose a threat to the low-lying areas of Aruba like the well-known beaches. We see that the sea level is rising faster along the coast of South America than elsewhere in the Caribbean. The speed of the sea level rise in the Caribbean is comparable with the worldwide mean.



FUTURE

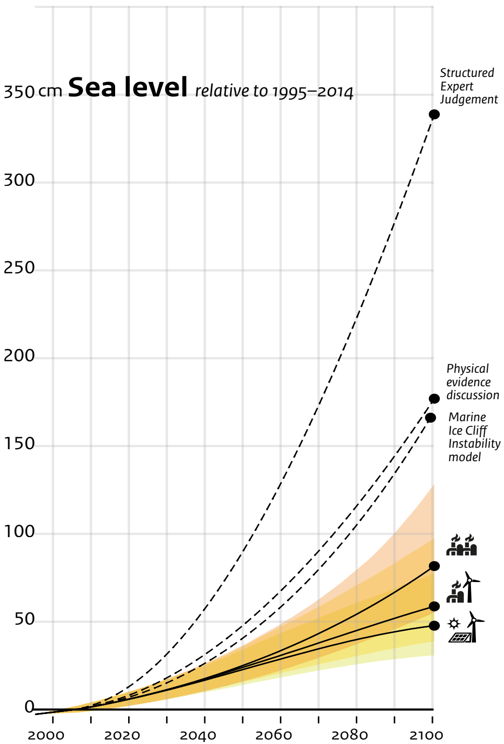
The sea level around Aruba will keep rising in the future. How much exactly is dependent on the emission scenario. The higher the emissions, the more warming takes place and the more the sea will rise. Up to 2050, the sea level rise is very comparable for each scenario. Later in the century, the emission scenario will have a larger impact on the resulting sea level rise. By around 2100, sea level could rise by up to about 3.4 meters if processes that are not well understood , mainly the potential instability of the Antarctic ice sheet, make a large contribution. These are the so-called low likelihood-high impact scenarios indicated by the dotted lines in the figure below.
During storms, high waves and storm surge occur on Aruba. The risen sea level will increase the impact of these high waves
Even in the lower emission scenario, sea level rise will continue not only during this century but for many years to come. This is because the ice sheets will continue to melt even when warming stops. As a result, it is no question whether the sea level will increase by more than a meter but when this will happen.

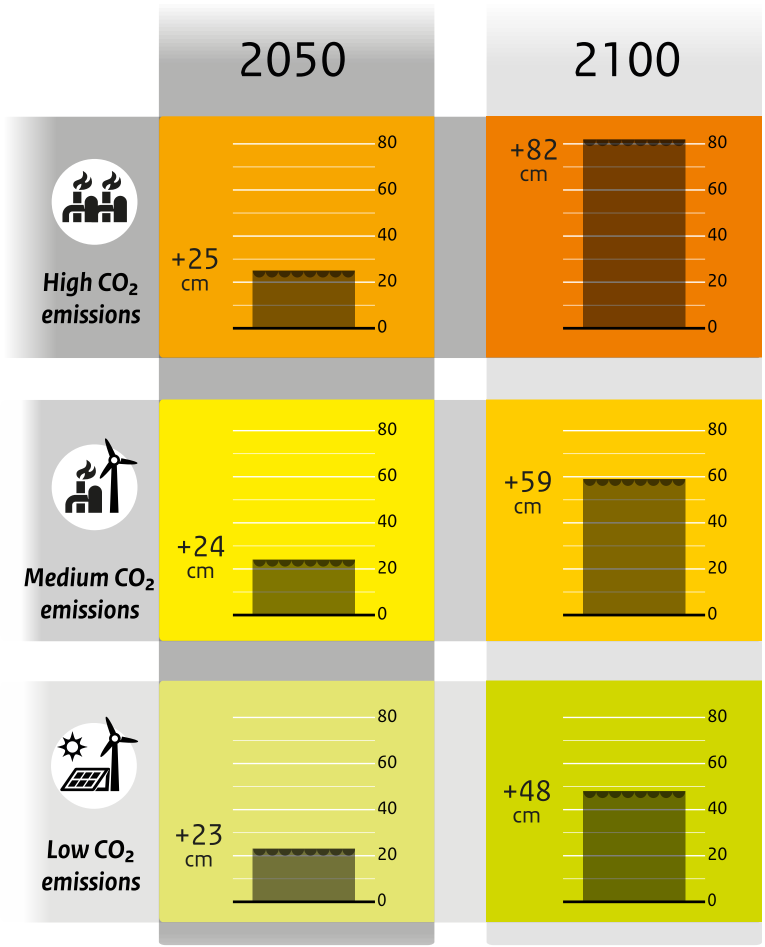
Did you know that...

... melting ice isn't the main cause of sea level rise? Although melting ice caps and glaciers do contribute, the biggest factor is actually the warming of the ocean itself. As seawater warms, it expands and takes up more space, leading to a rise in sea level. This process is known as thermal expansion.

Sea level

Sea level rise over time





Climate scenarios for 2050

	Year		Sea level	Dry season		Transition season		Wet season	
	29.8° C 423 mm 7.8 m/s	29.8° C 495 mm 7.7 m/s	+ 25 cm	29.2° C 64 mm 8.3 m/s	29.2° C 88 mm 8.2 m/s	30.5° C 55 mm 8.9 m/s	30.5° C 64 mm 8.7 m/s	29.8° C 291 mm 6.8 m/s	29.8° C 334 mm 6.8 m/s
	29.5° C 447 mm 7.8 m/s	29.5° C 499 mm 7.7 m/s	+ 24 cm	28.9° C 70 mm 8.2 m/s	28.9° C 87 mm 8.2 m/s	30.2° C 58 mm 8.8 m/s	30.2° C 65 mm 8.7 m/s	29.4° C 307 mm 6.8 m/s	29.4° C 337 mm 6.7 m/s
	29.3° C 459 mm 7.7 m/s	29.3° C 500 mm 7.7 m/s	+ 23 cm	28.8° C 73 mm 8.2 m/s	28.8° C 87 mm 8.2 m/s	30.1° C 61 mm 8.8 m/s	30.0° C 65 mm 8.7 m/s	29.3° C 315 mm 6.7 m/s	29.2° C 338 mm 6.7 m/s

	Year	Dry season	Transition season	Wet season
1991 - 2020 observations	28.5° C 498 mm 7.6 m/s	28.0° C 85 mm 8.1 m/s	29.2° C 64 mm 8.7 m/s	28.4° C 337 mm 6.7 m/s

Climate scenarios for 2100

	Year			Dry season		Transition season		Wet season	
	31.5°C 242 mm 8.2 m/s	31.8°C 459 mm 7.9 m/s	+ 82 cm	30.9° C 34 mm 8.6 m/s	31.1°C 91 mm 8.3 m/s	32.4° C 26 mm 9.3 m/s	32.6° C 55 mm 8.9 m/s	31.6°C 174 mm 7.3 m/s	31.9°C 310 mm 6.9 m/s
	30.1°C 395 mm 7.9 m/s	30.1°C 490 mm 7.8 m/s	+ 59 cm	29.5° C 59 mm 8.3 m/s	29.5° C 89 mm 8.2 m/s	30.8° C 50 mm 9.0 m/s	30.9° C 63 mm 8.8 m/s	30.1°C 274 mm 6.9 m/s	30.1°C 331 mm 6.8 m/s
	29.2° C 464 mm 7.7 m/s	29.2° C 500 mm 7.7 m/s	+ 48 cm	28.7° C 74 mm 8.2 m/s	28.7° C 87 mm 8.2 m/s	30.0° C 61 mm 8.8 m/s	29.9° C 65 mm 8.7 m/s	29.2° C 317 mm 6.7 m/s	29.1° C 338 mm 6.7 m/s
1991 - 2020 observations	28.5° C 498 mm 7.6 m/s			28.0° C 85 mm 8.1 m/s		29.2° C 64 mm 8.7 m/s		28.4° C 337 mm 6.7 m/s	

Background information

What is a climate scenario?

A climate scenario is a realistic and coherent picture of what the future climate could look like, it is made to study the possible consequences of climate change [2]. The current rapid changing climate is caused by humans emitting greenhouse-gases that warm the planet. It is not possible to predict future human activities. Therefore, the scenarios are not predictions and it is impossible to say which scenario is most likely.

Shared Socioeconomic Pathways (SSPs)

To compare the results of different climate models, researchers use socio-economic scenarios, known as Shared Socioeconomic Pathways (SSPs). These SSPs describe possible future developments in demographics, society, the economy, and technology. They differ in their levels of greenhouse gas and aerosol emissions, as well as in land use.

In the first part of its Sixth Assessment Report on the physical science basis of climate change [2], the IPCC presents results based on five SSPs. These scenarios cover a wide range — from one with ambitious climate policies aligned with the Paris Agreement (limiting warming to around 1.5°C, SSP1-1.9) to one where emissions continue to rise sharply (SSP5-8.5).

In this report, we also include three scenarios: a low-emission scenario (SSP1-2.6) and a high emission scenario (SSP5-8.5) to provide the range in which climate change will take place. Additionally, a moderate scenario is included (SSP2-4.5). This is important for several policy makers to use this scenario for their short-term adaptation plans in the Caribbean.

Because the amount of greenhouse gases in the atmosphere largely determines global temperature change, a low-emission scenario leads to less warming than a high-emission scenario. Which path the world follows and how much the planet warms, ultimately depend on global climate policy. The differences between these socio-economic scenarios become especially significant in the long term, after 2050.

Scientific uncertainty

In addition to uncertainty about global climate policy, there is also scientific uncertainty regarding the extent to which the climate system responds to changes in the concentration of greenhouse gases in the atmosphere. This manifests itself on a global scale as uncertainty about the average global warming. The climate sensitivity — the increase in the global average temperature associated with a doubling of the amount of CO_2 in the air — is currently estimated at +2.5 to +4.0°C and is now known more precisely than in the previous IPCC report from 2013.

On a more regional scale, uncertainties in climate processes play a large role. Climate processes related to temperature, rainfall, winds and sea-surface temperature are complex. These processes strongly influence each other. The strength of the trade winds can influence the sea-surface temperatures, which influence temperature and rainfall on the islands. Well-known climate processes influencing the Caribbean climate are El Niño and its counterpart La Niña. Uncertainties about the climate response of such regional processes are important to take into account.

In principle, uncertainty about the future climate can be reduced by conducting more research into the functioning of the climate system and by developing better climate

models. However, the climate also exhibits unpredictable behaviour. These natural variations , which result from interactions between the atmosphere, oceans, land, and ice sheets, occur on all time scales and ensure that even over a 30-year period there can be significant differences. An example of one of these processes is El Niño.
Temperature changes due to climate change (the trend) will at some point become larger than natural temperature variations (the noise) in the near future. This does not generally apply to changes in rainfall and wind. For instance, the natural variation in average wind speed over a 30-year period can be as large as 10%. This means that one 30-year period may turn out to have 10% higher or lower wind speeds.

Statistical downscaling

For the climate scenarios for Aruba, the same global climate models and methods are used as for the KNMI'23 scenarios for the Netherlands.
However, there is one key difference. For the Netherlands, a regional climate model is used to translate information from the global models, whereas for Aruba, this translation is done statistically. From the results of the 29 available models for the Caribbean, the 10 wettest and 10 driest models were selected — representing the largest projected increases and decreases in rainfall up to 2100, respectively. The group with the 10 wettest models is called the mild-drying scenario, for even in the wettest groups there are signs of future drying. The 10 driest models are grouped in the strong drying scenario. The relatively coarse modelled time series of temperature, rainfall, and wind were then adjusted using observational data to create regionally modelled future time series for each emission scenario and for both the mild drying and strong drying groups, this process is called statistical downscaling.
For the observational data, we used the NOAA Global Surface Summary of the Day dataset. Since this includes only one station, we compared it with (incomplete) data from the Beatrix Airport station and with ERA5 data. As a result, the models are effectively downscaled for a single station, meaning the scenarios for temperature, rainfall, and wind are optimized for Aruba Beatrix Airport.
Although climate normals for temperature, rainfall and wind might vary over the island, we expect the climate scenario values to be representative for the whole island. This implies that a location that has a current climate of 28.7 °C (while the airport has a climate of 28.5 °C) and the scenarios indicate a change of +1.6 ° in 2100, the new climates in 2100 for this location will be 30.3 °C.

Three estimates of the maximum sea-level rise

There is currently no scientific consensus on the rate at which sea level could rise to its maximum in the future under a high-emission scenario.
Three methods have been used to estimate that rate: Physical evidence discussion. This method consists of organizing an open discussion among climate scientists and sea level experts about the largest sea level rise that is still physically plausible [4].
Marine Ice Cliff Instability model. In this method, we used the result of a numerical model that simulates the physical mechanisms of Marine Ice Cliff Instability in Antarctica [5].
Structured Expert Judgement. This method uses a survey of the world's leading glaciologists. When completing the survey, they did not have to discuss their views or justify their estimates of Antarctic and Greenland contributions to sea level rise using physical mechanisms [6], which makes this method less conservative than the "Physical evidence discussion."
Each method resulted in an estimate of the highest possible sea level rise. The probability that such an estimate would be exceeded cannot be calculated but based on the characteristics of these methods and a comparison with baseline scenarios, we suspect that this probability, under the high-emission scenario,

is between 0 and 5%. Under a lower emission scenario, the probability is smaller.

Seasonal definitions

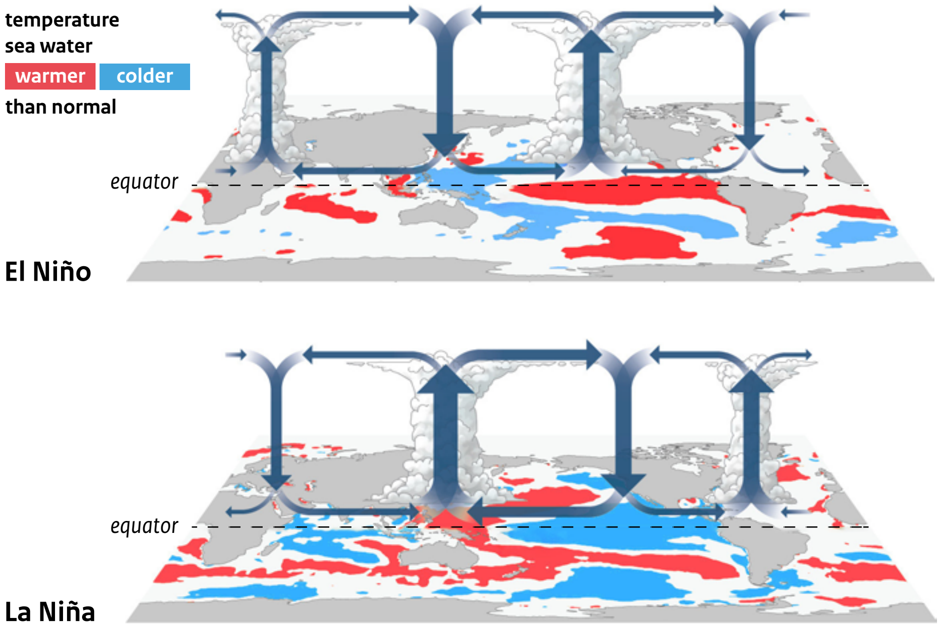
The seasons for Aruba are determined by looking at the average annual rainfall pattern. The seasons are defined in collaboration with Curaçao to create uniformity between the islands due to their proximity. The dry season is defined as the months February to May, the transitional season as the months June to August and the wet season as September to January.

Walker circulation and the El Niño bias

El Niño and La Niña are climate patterns occurring around the equator in the Pacific Ocean. They influence global air circulation, which is driven by fluctuations in sea surface temperature in the tropical Pacific Ocean.

During La Niña, sea surface temperatures in the eastern Pacific are lower than normal. Air rises over the western Pacific and the Caribbean region, while it descends over the central Pacific. Between these areas, there are easterly and westerly winds in the lower and upper atmospheric layers. This so-called Walker circulation shifts westward during La Niña. Where air rises — such as over the Caribbean — there is heavy rainfall; where air descends, there is little rainfall.

During El Niño, the eastern Pacific warms up, causing the Walker circulation to shift eastward. Air then rises over the central Pacific and descends over the Caribbean region. As a result, the Caribbean receives less rainfall during El Niño than during La Niña. There is currently scientific uncertainty about the future El Niño and La Niña cycle. The CMIP6 models point towards an El Niño dominated future, where the observations show a trend more towards La Niña. If the models are incorrect about El Nino, the extreme dry models are less likely. However, we do not yet know how the El Niño and La Niña cycle will behave in the future.



Climate change impact on extreme weather and hurricanes

The present set of climate scenarios do not show all possible effects of climate change on Aruba. Some important topics, like extreme rainfall and hurricanes, are not discussed because they require different scientific methods and climate models that were not part of this study. Still, we can describe what science currently says about these risks in general while studies for Aruba lack.
Even though total yearly rainfall may decrease, extreme rain events could become heavier, because a warmer atmosphere can hold more moisture and release more rain in short, intense downpours [7].

Hurricanes are expected to become stronger as the climate warms

They draw their energy from warm ocean waters, and as sea surface temperatures rise, storms can intensify more rapidly and reach higher peak wind speeds. The Caribbean has already experienced this in recent decades with several devastating hurricanes. Stronger storms also produce higher waves and more dangerous storm surges. In addition, hurricanes are projected to become wetter, delivering heavier rainfall as a warmer atmosphere can hold more moisture. While the number of the most intense hurricanes is expected to increase, it remains uncertain whether the total number of tropical storms in the region will change [1, 7].

KNMI'23 examined Hurricane Irma (2017) in a warmer climate and

found that the most severe hurricanes are likely to produce even stronger winds and significantly more rainfall. This means that the strongest hurricanes of the future could have even greater impacts than those observed today [8, p. 40].

Glossary

Anomalies are values that deviate from what is standard, normal or expected.

The **climate** is the average weather for about thirty years.

Climate change is the long-term change in regional or global climate patterns.

A **climate scenario** is a realistic picture of the future climate that makes scientific sense. They are made using historical data and assumptions on how much greenhouse gas the world emits and how the climate will respond to these emissions. Climate scenarios are important for planning and adaptation.

The **dry Season** is the period of the year with the least rain on average, from February to May.

El Niño is a natural climate pattern where the surface of the Pacific Ocean becomes warmer than usual, changing temperature, wind and rain patterns around the world. In the Caribbean, El Niño causes drier conditions and suppresses hurricane activity. El Niño is the opposite from La Niña.

Emissions are gases or particles released into the air, often from burning fuels like coal, oil, or gas. Some emissions, such as carbon dioxide (CO_2), trap heat in the atmosphere and contribute to climate change.

Extremely hot days are days with a temperature at least as high as the top 5% warmest days in 1991-2020.

IPCC stands for Intergovernmental Panel on Climate Change. It's a science collaboration from around the world that studies climate change and provides reports to help governments understand its causes, impacts, and possible solutions.

IPDC stands for The International Panel on Deltas and Coastal Areas and helps deltas, coasts, and islands adapt to climate change. It supports them in protecting their ecosystems, communities, and economies while dealing with other social challenges.

La Niña is a natural climate pattern where the surface of the Pacific Ocean becomes cooler than usual, changing wind and rain patterns around the world. In the Caribbean, La Niña causes wetter conditions and enhances hurricane activity. La Niña is the opposite from El Niño.

Marine Heat Waves are defined by IPCC as a period of 5 days or more where the ocean temperature exceeds the 90th percentile in SST from 1982 to 2016.

Observations are a measurement of a weather variable, such as temperature, amount of rain and wind speed.

SSP stands for Shared Socioeconomic Pathways (SSPs), have a number followed by a value that (approximately) represents the radiative forcing in W/m^2 by the year 2100. The numbering ranges from 1, the sustainable pathway, to 5, the pathway with high greenhouse gas emissions. In this report, SSP1-2.6 is referred to as the low scenario, SSP2-4.5 as the moderate scenario, and SSP5-8.5 as the high scenario.

The **transitional season** is the period of the year between the dry and wet season, from June to August.

The **wet season** is the period of the year with the most rain on average, from September to January.

A **wind reversal** is an event where the normally eastern trade winds temporarily die down or the wind changes direction. This is often caused by storm system passing the island.

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