Central American climate is classically divided into two major seasons: rainy and dry.
- The dry season runs from January through May
- The rainy season from May to November and December

Locally, the seasons were named by the early Spanish colonizers, who compared them to their own Mediterranean climate, calling the dry months "verano" or summer, and the rainy, grey and gloomy months "invierno" or winter. Note that some of the coldest temperatures are registered during the early dry season or "summer".

Climate in the region is governed by the interaction of three factors:
- The prevailing winds
- The effect of mountains
- The Intertropical Convergence Zone, which is determined by the season/tilt of the earth

Winds
Weather in the tropics is essentially a phenomenon of solar radiation and air circulation, along with deviations caused by the earth’s rotation. Intense heat at the equator puts air in motion, and a worldwide pattern of winds is established. The most famous of these, for Costa Rica, are the north-easterly trade winds, known locally as "Alisios," in English, the Trade Winds. These winds blow with considerable force from December to March and April.

Things to notice:
- Surface winds, known as Trade Winds, move from areas of high pressure (30° latitude) to areas of low pressure (the equator). These winds blow east to west.
- Coriolis force: deflects winds and currents to the right in the Northern Hemisphere and to the left in the Southern Hemisphere (Open University 2001)
- So, the northeasterly trade winds blow from the northeast in the Northern Hemisphere and the southeasterly trade winds from the southeast in the Southern Hemisphere.
More things to notice:

- Winds that converge at the equator rise, giving rise to low pressure under them
- Winds blow downward in the temperate areas, giving rise to areas of low pressure under them
- Easterly winds meet at the equator.
- Warm air rises at the equator creating a zone of low pressure, is cooled off at high altitudes, and sinks again approximately 30º from the equator.
- The area at the equator where the easterly winds converge and rise up into the atmosphere is known as the Intertropical Convergence Zone (ITCZ).

Intertropical Convergence Zone (ITCZ)

- An area of low pressure between the north-south cycling Hadley Cell and the south-north cycling Hadley Cell (Wallace and Hobbs 1977)

The global atmospheric circulation cells. The North and South Cycling Hadley Cells meet in the tropics at the Intertropical Convergence Zone (ITCZ). Image courtesy of Barbara Summey, NASA. In Rink and Cole (2002). The ITCZ is characterized by strong upward motion, forming cumulus clouds and resulting in heavy rainfall.

- As warm, humid air rises in the ITZC, it cools, forming clouds. Hence, it usually rains heavily under the ITZC
Location, Tilt of the Earth, and Effect on ITCZ

**Tilt of the Earth**

**Things to notice:**

- The sun shines directly on the equator during the equinoxes
- The sun shines above the equator during the northern summer
- The sun shines below the equator during the northern winter
- The ITCZ forms directly under the area where the sun hits directly
- Thus, the ITCZ moves above and below the equator depending on the season:
To summarize:
The movement of the ITCZ causes the wet and dry seasons

- During Northern Summer the sun is above the equator. By the end of July the position is inverted and the sun is directly over regions north of the equator
- At the Equinoxes, the sun is directly over the equator
- During Northern Winter the sun is below the equator. By the end of December the direct sunlight has migrated south of the equator
- ITCZ will always be under the place where the sun hits Earth at a right angle
- During the transitional and dry seasons from November to April, the ITCZ is located south of Costa Rica, either at the equator or even further south
- When the ITCZ is directly over Costa Rica during July, September and October, rainfall is heaviest
- The ITCZ migrates to its northernmost boundary during July and August, resulting in reduced precipitation levels during that time.

It always rains under the ITCZ!
The role of mountains
Costa Rica has two distinct climate regions, separated by the volcanic Cordillera de Tilarán mountain range. The windward side faces the Caribbean Sea and the Atlantic Ocean, while the leeward side faces the Pacific Ocean. Easterly trade winds from the Atlantic dictate the climate variation in both regions. Whether the trade winds have a northeasterly or southeasterly origin depends on the position of the Intertropical Convergence Zone (Clark et al. 2000).

Orographic Uplift: What happens?
- An air mass ascends up the slope of a steep terrain.
- Pressure decreases with altitude, so the gases in the air mass expand.
- However, expansion is work and requires energy, which is available in the form of heat.
- This removal of heat cools the air without any heat exchange to or from the air mass.
- Any moisture in the air expands until the saturation point is reached and then condensation begins. The temperature at which this happens is known as the dew point.

Things to notice:
- As air moves up a mountain, it starts raining once it reaches the dew point.
- Hence, the air is dry by the time it reaches the other side of the mountain.
- Because the air is dry, it also is warmer by the time it reaches the other side.
- The dry, hot air that reaches leeward side of mountains causes ‘rain shadows’.

![Diagram showing oroographic uplift and climate variation](image)
Cloud Development

Two main types of cloud development relevant to the Central American highlands:

- **Orographic uplift** and **non-frontal convergence mechanisms**
- Both mechanisms require **adiabatic cooling**, which refers to the cooling of air masses without heat transfer
- Adiabatic cooling is often caused by orographic uplift, or the lifting of an air current caused by its passage up and over mountains

**Adiabatic cooling**

- As air rises up a mountain, it cools 1 degree C per 1000 m, until it reaches the dew point
- After reaching the dew point, it cools 0.5 degree C per 1000 m
- As air descends down the other side of the mountain, it heats up 10 degrees C per 1000 m

**Non-frontal convergence mechanisms: How it works**

- Hadley Cells are the major patterns of air circulation on the earth, centered on the basic principle that warm air rises and cool air sinks. At the convergence of the North and South Hadley cells, the north- and south-easterly tradewinds meet and force each other upward, producing large, cumulonimbus clouds (Blair 1965).
- Precipitation that results from this type of cloud formation is called non-frontal convergence, simplified here as NFC precipitation (Dingman 1994).

Two main types of cloud formation, non-frontal convection and orographic uplift. Adapted from Whiteman (2000).
Putting Everything Together: Why does it Rain?

• From April to October tradewinds are blowing across the Caribbean picking up moisture from the warm sea surface.

• If the warm moist air could continue unimpeded it would eventually rise as part of the ITCZ circulation pattern.
• But the mountains of Costa Rica get in the way.
• Costa Rica's backbone of peaks forces the air upwards causing the familiar rising, expanding, cooling clouds and rainfall.

• The consistent direction of the wind from the northeast creates a region of heavier rainfall on the Caribbean slopes and over the central mountains.
• The air continues to move to the southwest, but by the time it reaches Guanacaste, Nicoya and the Pacific much of the moisture has been removed.
Elevational Zones

The previous section showed how mountains affect rainfall. In addition, mountains affect temperature, and provide distinct habitats at each elevation:

**Tropical lowlands**
- Ranges from sea level to about 2,300 feet (701 meters) on the Pacific slope and 2,000 feet (610 meters) on the Caribbean slope
- Includes dry forests like those in Guanacaste as well as moist and wet forests of the southern Pacific and Caribbean lowlands

**Premontane zone**
- "Foothills", "subtropical", "middle elevation zone", "Coffee zone"
- Ranges from 2,300 feet (701 meters) to 4,900 feet (1,494 meters) on the Pacific slope and 2,000 feet (610 meters) on the Caribbean slope

**Lower Montane zone**
- "Highland"
- Ranges from 4,900 ft (1,494 m) to 8,500 ft (2,591 m) on the Pacific slope and 4,600 ft (1,402 m) to 8,200 ft (2,499 m) on the Caribbean slope
- "Cloud forest" is found here—occurs from 4,500 ft (1,372 m) to 5,500 ft (1,676 m)
- "Cloud forest" is characterized by fog, mist, and high humidity, as well as precipitation—about 120 in (305 cm) to 160 inches (406 cm) per year

**Montane zone**
- Ranges from 8,500 feet (2,591 meters) to 10,800 feet (3,292 meters) on the Pacific slope and from 8,200 feet (2,499 meters) to 10,500 feet (3,200 meters) on the Caribbean slope

**Subalpine páramo**
- Area above the treeline of the montane zone
- Above 10,800 feet (3,292 meters)

**Species Diversity**: Species diversity decreases with elevation. Out of Costa Rica's 878 species of birds, about 130 spp can be expected above 6,000 ft. About 105 can be expected above 7,000 ft; about 85 can be found above 8,000 ft; and about 70 bird spp can be expected above 9,000 ft.

Holdridge Life Zones in Costa Rica

- The amount of rainfall, combined with temperature help determine the type of life a given geographical area will support.
- In 1947, biologist L.H. Holdridge introduced a system to classify vegetation types or "zones".
- Each zone is defined based on combinations of temperature, rainfall, and seasonal variation
- Life Zones are units that have distinct vegetation physiognomy and structure similar to bioclimatic conditions elsewhere.
- The Diagram of Holdridge Life Zones depicts thirty hexagonal Life Zones.

http://www.cieer.org/geirs/holdridge_model.html

- Costa Rica has twelve Life Zones, ranging from Tropical Dry Forests to Subalpine Rain Paramo. Transition Zones are not included in the twelve main zones, but are very important features in explaining vegetation between contrasting Life Zones.
The Holdridge Life Zones are very detailed and complicated, making them difficult to understand and distinguish.
Many of the Life Zones are similar and run together.
Hence, the twelve Life Zones of Costa Rica tend to get broken down into five specific regions.
Each region has its own climate, elevation, wildlife, and vegetation present.
These 5 zones are shown in the next page:
The 5 major ecological regions of Costa Rica:
(Simplified from the 12 Holdridge + transition zones)

Note: The sixth zone includes Pacific & Caribbean coastal beaches, islands, and mangrove lagoons.

Caribbean Lowlands

Location
- Include moist and wet lowland forests from the Caribbean coast westward to the foothills of Costa Rica’s mountains
- The Caribbean lowland fauna extends from Los Innocentes Lodge southeastward to Cahuita and the Panama border
- Elevation extends from sea level to 2,000 feet (610 meters), which is the upper limit of the tropical zone, to the premontane forest at 3,200 feet (975 meters)
- Caribbean coast is mostly flat and featureless
- Tortuguero National Park **Size:** 18,946 hectares land, 52,265 hectares marine

Climate
- Warm and humid temperature with temperatures in the 80’s (F) (27 C)
- Receives the heaviest rainfall in the country
- Averages 80 inches (203 cm) to 200 inches (508 cm) of rainfall annually
- Average chance of sunshine is 50% to 60%

Land
- Much of the region has been cleared and settled for production of cattle and banana
- Tortuguero National Park is one of the most extensive reserves and one of the best examples of rainforest in Central America.

Prevailing Vegetation
- Trees grow to heights of 150 feet (46 meters)
- Evergreen forests receive precipitation throughout the year
- Coconut palms (*Cocos*)
- Raffia palms (*Raffia*)
- Almendro (Swamp Almond, *Dipteryx panamensis*)
- The complexity of the forest canopy contributes to a high diversity of plant and animal species in the treetops

Central Plateau

Location

- Contains the human population center in Costa Rica
- The capital, San José, and adjoining suburbs are located in this relatively flat plateau at an elevation of 3,900 feet (1188 meters)
- Bordered to the north and east by major volcanoes of the Central Cordillera
- To the south is the northern end of the Talamanca Mountains

Climate

- Mild climate with a temperature of about 68 F (20 C) year round
- Rainfall averages from 40 inches (102 cm) to 80 inches (203 cm) per year
- 50-60% chance of sunshine
- Usually a very damp and misty climate

Land

- Rich volcanic soils make this an excellent region for growing coffee and sugarcane
- Also important is growing fruits, vegetables, and horticultural exports like ferns and flowers
- The original life zone in this area was premontane moist forest, but that forest has been largely cleared

Prevailing Vegetation

- Shrubs, flowers, fruiting and flowering trees

Highlands

Location
- Comprised of Costa Rica’s four mountain ranges
- This zone includes lower montane, montane, and subalpine elevations generally above 4,200 feet (1280 meters) to 4,500 feet (1372 meters)
- Cerro Chirripó-15,526 feet (4,732 meters) is the highest point in Costa Rica

Climate
- The forest grows lusher and the air cools with increases in the elevation. The middle elevations of these mountains receive the brunt of the weather off the Pacific and are typically swaddled in clouds by midday, even in the dry season. As a result, it is very soggy. On the western side of the mountains, there is a “rain shadow” effect. The high mountains of the Cordillera sweep the moisture out of the clouds, leaving little for the land to the west.
- Usually a mild climate, due to the rain, with temperatures ranging from the 60’s (F) (16 C) to the low 80’s (F) (27 C)
- Receives anywhere from 120 inches (305 cm) to 240 inches (610 cm) of rainfall annually
- No distinct dry season
- 50% chance of sunshine

Land
- Five volcanoes near the Nicaraguan border form the Cordillera of Guanacaste: Orosí, Rincón de la Vieja, Santa María, Miravalles, and Tenorio
- The second group of mountains is the Cordillera of Tilarán. This includes the still-active Arenal Volcano, which erupted in 1968
- The third group is the Cordillera Central that includes three large volcanoes: Poás, Irazú, and Barva
- The fourth highland region is composed of the Talamanca Mountains and the Cerro de la Muerte, from Cartago to the Panama border, which are tectonic rather than volcanic

Southern Pacific Lowlands

Location
- Include the moist and wet forested region from Carara National Park through the General Valley, Osa Peninsula, and Golfo Dulce lowlands to the Panama border and inland to the premontane forest zone at San Vito
- Less than a generation ago the coast was uninhabited
- 400 species of birds found here
- 6000 species of insects

Climate
- Warm and dry with temperatures averaging from the mid 80’s (F) (27 C) to the 90’s (F) (32 C)
- Average chance of sunshine is 80% and up
- Rainfall is between 80 inches (203 cm) to 200 inches (508 cm)
- Dry season from December through March

Land
- Much of this region has been converted to pastureland and plantations of pineapple, coconut, and African oil palm
- Carara, Manuel Antonio and Corcovado National Parks
- Corcovado is one of the best examples of a lowland wet forest in Central America
- Wilson Botanical Garden at San Vito is an example of premontane wet forests

Prevailing Vegetation
- Kapok (Ceiba)
- Purpleheart (Peltogyne purpurea)
- Garlic tree (Caryocar costaricense)
- Tabebuia
- Spundias
- Some trees maintain their foliage throughout the year

Tropical Dry Forests

Location
- In northwest Costa Rica, a lowland region, that extends eastward to the Cordilleras of Guanacaste and Tilarán, southeast to Carara National Park, and north to the Nicaragua border.
- Elevation extends from sea level to approximately 2,000 feet (610 meters)

Climate
- Warm and dry with average temperatures from 80 F (27 C) to 90 F (32 C)
- Average chance of sunshine is between 50% to more than 80%
- Rainfall ranges from 40 inches (102 cm) to 80 inches (203 cm) per year
- Dry season from December through March

Land
- This is cattle and rice country
- Unfortunately, raising cattle has destroyed much of the dry forest
- The deciduous trees lose their leaves during the dry season and flower during that leafless period
- The ease with which the forest can be burned and cleared for agricultural purposes has made the tropical dry forest the most endangered habitat in the country

Prevailing Vegetation
- Bullhorn acacia (*Acacia*)
- Strangler fig (*Ficus*)
- Guanacaste tree (*Enterolobium cyclocarpum*) National Tree of Costa Rica
- Riparian forests (gallery forests)-an important habitat that exists along the rivers. They maintain more persistent foliage during the dry season.

Sources:


• http://www.geog.ucsb.edu/~joel/g110_w05/lecture_notes/lifting_mechanisms/fig_07_19.jpg