Guide to the Science of Climate Change in the 21st Century

Chapter 9
Climate and Seasons

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9.0 Climate and Seasons

Seasons are a description of how weather, and therefore climate, changes over a year. The seasons are a consequence of the axial tilt of the Earth and the elliptical Earth orbit. A season is a period of the year that is distinguished by special climate. Both natural and human ecosystems have developed a dependency on predictable climate variations. The predictability of the weather experienced in the different seasons is a characteristic of climate. Humans have the ability to adapt to variations of weather within a particular season. The natural ecosystems may not.

Natural ecosystems include most terrestrial life which has survived and evolved to the rhythm of climate reflected in the changing seasons. In the temperate zones this includes migrations, hibernation, breeding cycles, plant life cycle (dormancy, renewal, flowering, propagation) and more.

Human ecosystems once responded to changing seasons in a similar manner to natural ecosystems in terms of the ability to find food (terrestrial and aquatic) and provide needed shelter. Modern human ecosystems still respond to seasons relying on the expected weather patterns for agriculture activities such as crop production and animal husbandry, replenishment of water supply, availability of transportation, harvest of seafood, industry and spiritual renewal.

Human behaviour becomes accustomed to seasonal weather patterns, is aware of the variations and extremes and accommodates it to the extent possible. There has always been a need to predict the weather, particularly precipitation and temperature – climate is merely the expectation and the extremes may not be known or appreciated. Changes in the seasonal variations or characteristics of these variations can have serious negative impacts on human ecosystems, particularly if they are abrupt.

Humans may adapt to changes in climate provided the changes are not catastrophic such as failure of expected rainfall for several years or temperature extremes which inhibit agricultural activities or ability to find suitable shelter and volcanic activity. Humans are mobile and may be able to find alternative environments. It is believed that several ancient civilisations have collapsed as a consequence of serious changes in climate.

Natural ecosystems which have evolved over millions of years may not survive to what humans may consider the most gradual changes in climate.

Generally, any change in climate has a negative impact on both natural and human ecosystems.

The nature of seasonal climate changes varies with latitude. Five zones are recognized: equatorial, tropical, subtropical, temperate and polar or frigid as shown in Figure 9.1. The

Intertropical Convergence Zone or ITC lies along the Equator. The tropical zone extends from the Equator to latitude 23° 27' N and S corresponding to the Tropic of Cancer and Tropic of Capricorn. The temperate zones extend from 35° to 66° 33' N and S. The subtropical zones lie between the tropical zones and the temperate zones. The polar or frigid zone lies north and south of 66° 33' N and S respectively.

A very important seasonal climate event is the monsoon or rainy season which occurs in the tropical, subtropical and temperate zones.

A cause for climate change different from the expected annual seasons is ocean-atmosphere interactions known as a teleconnection. One of the most important of these is the El Niño-Southern Oscillation or ENSO which occurs in an irregular periodic manner and has significant global impact. ENSO is discussed in Chapter 11.

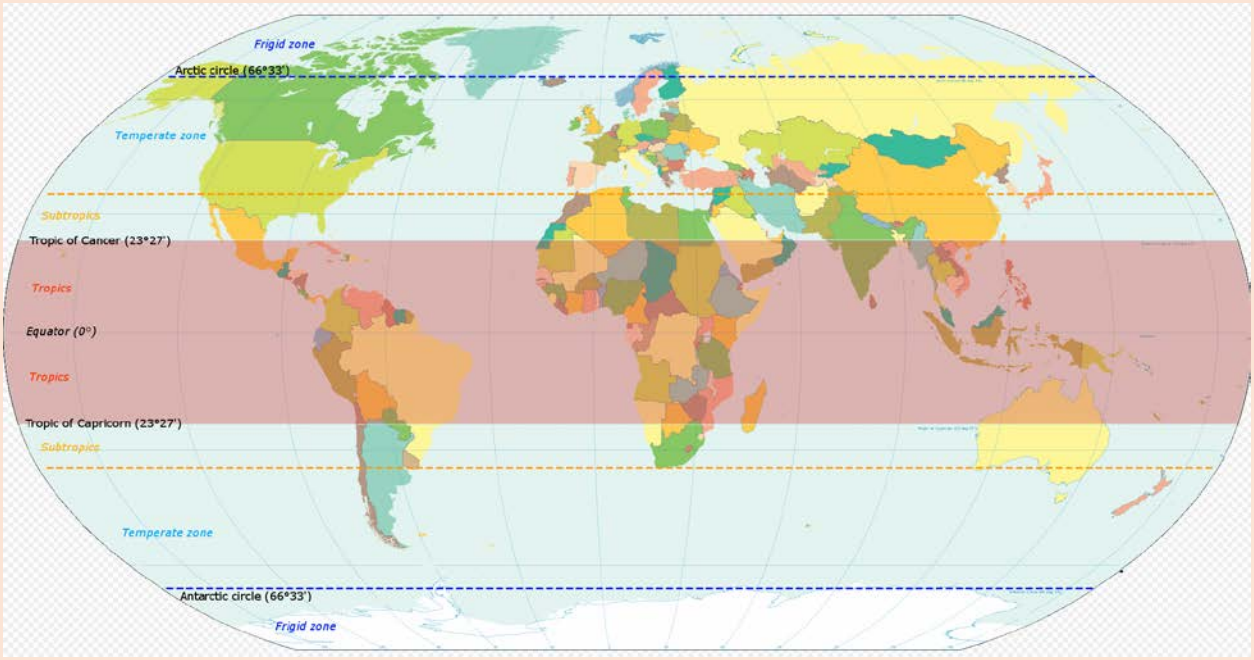


Figure 9.1 Climate zones.
https://en.wikipedia.org/wiki/Subtropics

9.1 Temperate zones – northern and southern hemispheres

The tilt of the Earth is responsible for the distinct changing seasons in the northern and southern hemispheres, north and south of the Tropic of Cancer and Tropic of Capricorn respectively. There are two types of seasons defined, astronomical seasons and meteorological seasons. The four meteorological are seasons, spring, summer, fall, and winter. The start and

end dates of the meteorological seasons are shown in Table 9.1. The astronomical seasons are also divided into spring, summer, fall and winter. The start and end dates of the astronomical seasons are shown in Table 9.2. The four seasons are characterized by changes in weather, ecology and amount of daylight. In the temperate and polar zones temperatures decrease, possibly well below freezing, depending on latitude and on proximity to open bodies of water, and precipitation type, rain or snow, and quantity.

The longest day, summer solstice, occurs when the Earth's poles have a maximum tilt toward the sun and the shortest day, winter solstice, occurs when Earth's poles have a minimum tilt toward the sun.

An equinox occurs when there is equal duration of day and night. In the northern hemisphere the vernal equinox, March 20, marks the beginning of spring and the autumnal equinox, September 22, marks the beginning of fall. In the southern hemisphere the reverse is true.

There are several ancient monuments around the world, particularly in the northern hemisphere, which mark the equinoxes and solstices because of their significance to agricultural and spiritual practices. One of the most famous monuments is Stonehenge in England. Only the astronomical seasons could be identified.

The changes in climate each year result in considerable mixing and energy exchanges between the northern and southern hemispheres.

Meteorological seasons in temperate latitudes			
Northern hemisphere	Southern hemisphere	Start date	End date
Winter	Summer	1 December	28 February
Spring	Autumn	1 March	31 May
Summer	Winter	1 June	31 August
Autumn	Spring	1 September	30 November

Table 9.1 Meteorological seasons in temperate latitudes in the northern and southern hemispheres.

Astronomical seasons in temperate latitudes			
Northern hemisphere	Southern hemisphere	Start date	End date
Winter	Summer	20 or21 December	18 or 19 March
Spring	Autumn	19 or 20 March	19 or 20 June
Summer	Winter	20 of 21 June	21 or 22 September
Autumn	Spring	22 or 23 September	19 of 20 December

Table 9.2 Astronomical seasons in temperate latitudes in the northern and southern hemispheres.

9.2 Tropical zones

Tropical zones are delimited by the Tropic of Cancer and Tropic of Capricorn as shown in Figure 9.1. The weather typical of this zone is shown in Table 9.2.

Meteorological Tropical seasons			
Northern Hemisphere	Southern Hemisphere	Start date	End date
Dry season	Wet season	1 November	30 April
Wet season	Dry season	1 May	31 October

Table 9.3 Meteorological tropical seasons.

9.3 Monsoons

Monsoons are large-scale seasonal weather phenomena that occur in several parts of the world as shown in Figure 9.2. They are described as large-scale sea breezes responding to the temperature of the land which may be warmer or cooler than adjacent ocean. They result in a rain season (monsoon season) and a dry season that may also be influenced by atmosphere-

ocean affects known as teleconnections (See Chapter 11 which discusses the El Niño-Southern Oscillation.) which are typically not affected by the seasons and have periodic influences that are not completely understood. The southwest Indian monsoon and African monsoon are characteristic.

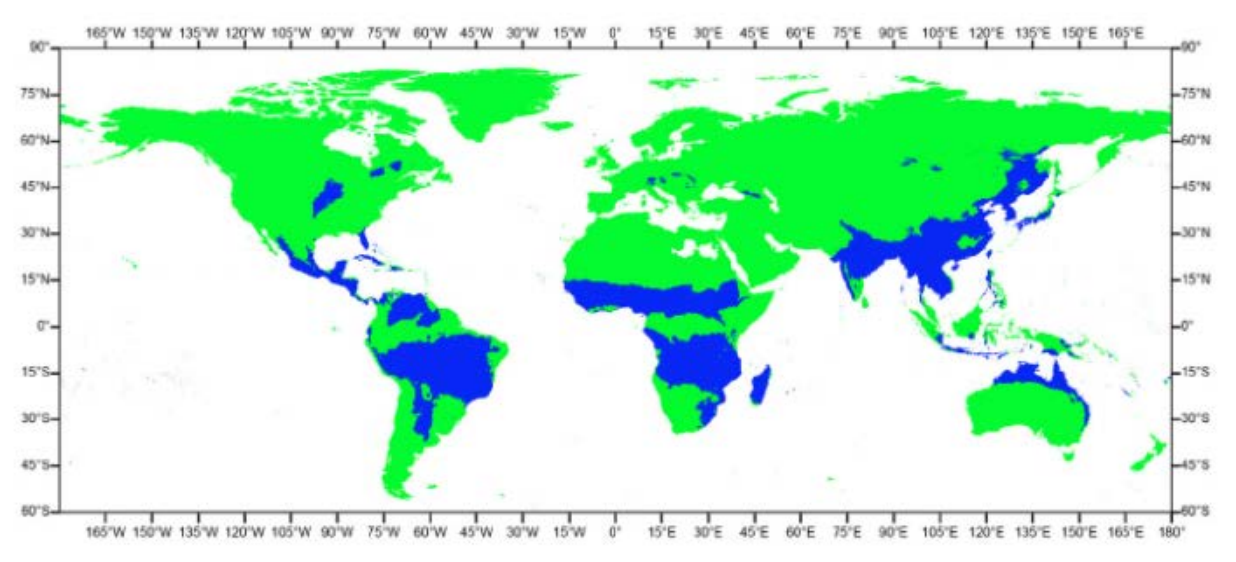


Figure 9.2 Monsoonal regions worldwide.

9.3.1 Southwest Indian monsoon

The India Meteorological Department (IMD) designates four climatological seasons:

- **Winter**, occurring from December to February. The year's coldest months are December and January, when temperatures average around 10–15 °C (50–59 °F) in the northwest; temperatures rise as one proceeds towards the equator, peaking around 20–25 °C (68–77 °F) in mainland India's southeast.
- **Summer** or **pre-monsoon** season, lasting from March to May. In western and southern regions, the hottest month is April; for northern regions of India, the month of May is the hottest month. Temperatures average around 32–40 °C (90–104 °F) in most of the interior.
- **Monsoon** or **rainy** season, lasting from June to September. The season is dominated by the humid southwest summer monsoon, which slowly sweeps across the country beginning in late May or early June. Monsoon rains begin to recede from North India at the beginning of October. South India typically receives more rainfall.
- **Post-monsoon** or **autumn** season, lasting from October to November. In the northwest of India, October and November are usually cloudless. Tamil Nadu receives most of its annual precipitation in the northeast monsoon season.

The onset of the southwest summer monsoon in India is illustrated in Figure 9.3.

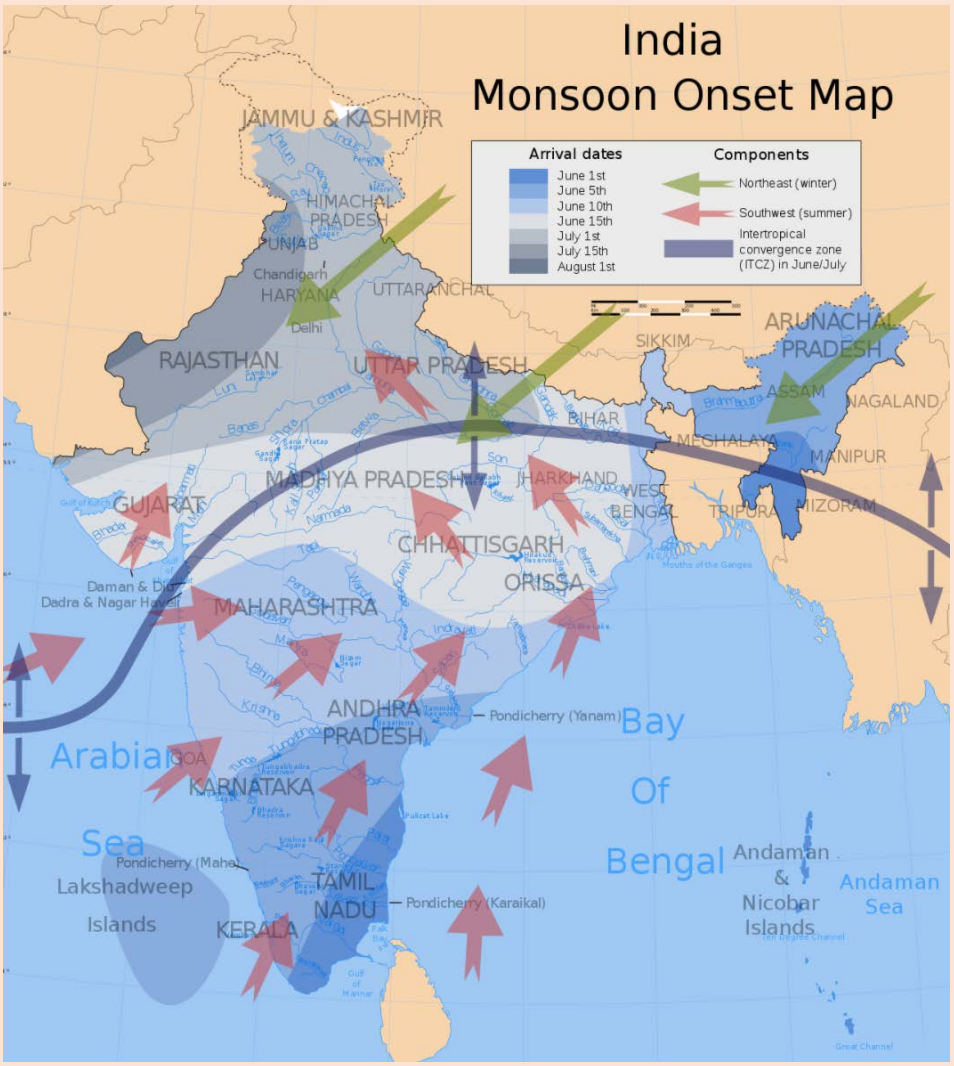
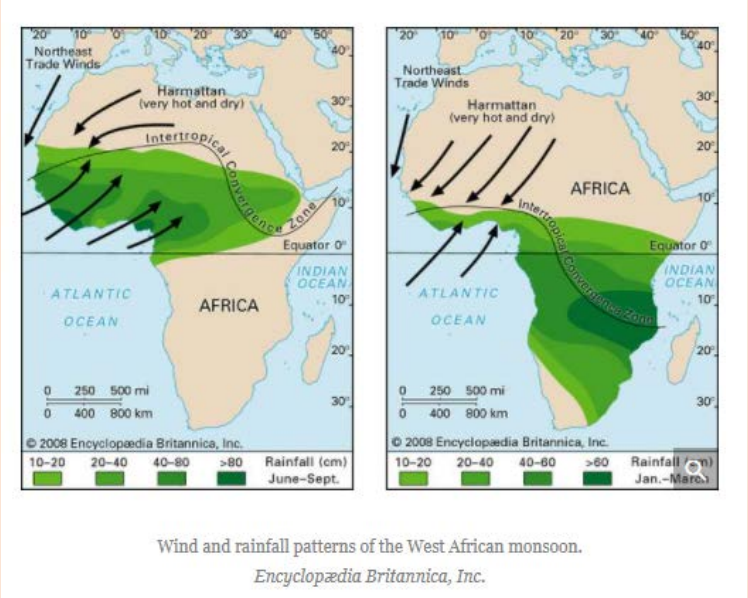


Figure 9.3 Onset dates for the southwest summer monsoon in India taken from: https://en.wikipedia.org/wiki/Monsoon#Process

9.3.2 West African monsoon

The West African monsoon is a major wind system that affects West African regions between latitudes 9° and 20° N and is characterized by winds that blow southwesterly during warmer months and north-easterly during cooler months of the year. See Figure 9.4. Although areas just outside of this region also experience wind reversals, the influence of the monsoon declines with increasing distance.



Wind and rainfall patterns of the West African monsoon.
Encyclopædia Britannica, Inc.

Figure 9.4 West African monsoon
https://www.britannica.com/science/West-African-monsoon

9.3.3 West coast North America monsoon

The North American monsoon is a pattern significant increase in thunderstorms and rainfall over areas of southwestern United States and Northwestern Mexico as shown in Figure 9.5. The storm events occur between July and mid-September.

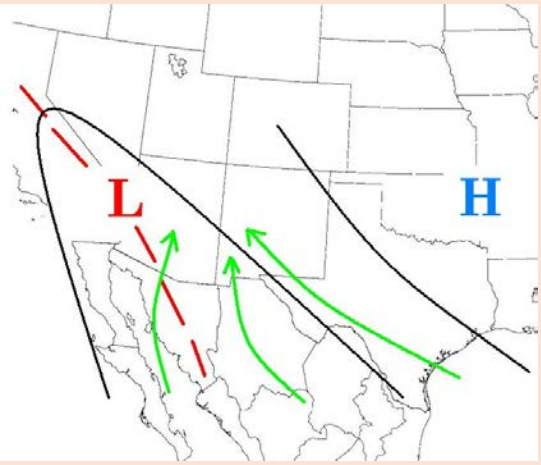


Figure 9.5 Extent of the North American monsoon.
https://en.wikipedia.org/wiki/North_American_monsoon

9.4 Intertropical Convergence Zone (ICZ)

In the tropics and subtropics there is very little fluctuation in amount of daylight. Season shifts occur along a rainy, low-pressure belt called the Intertropical Convergence Zone or ICZ. See Figure 9.6. The amount of precipitation, all rain, will vary more significantly than temperature. When the ICZ is north of the Equator, the northern tropics experience their wet or rainy season and the southern tropics their dry season. The pattern reverses when the ICZ migrates to a position south of the Equator. The position of the ICZ gradually varies with the seasons.

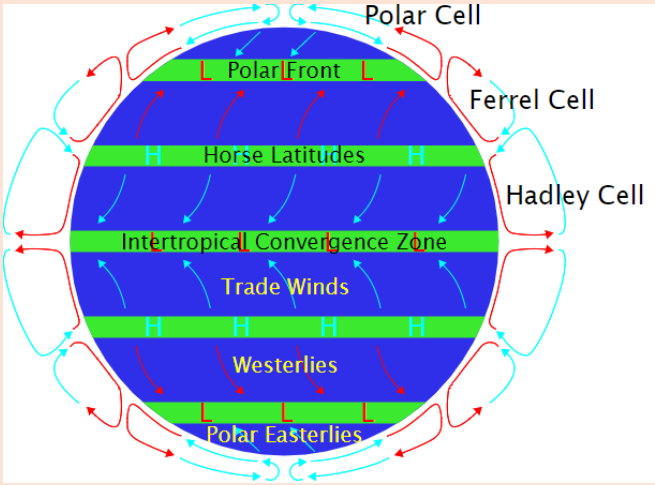


Figure 9.6 Location of the Intertropical Convergence Zone and Horse Latitudes.
https://en.wikipedia.org/wiki/Horse_latitudes

9.5 Predictability

The relationship between humans and climate is very important. We depend on our ability to forecast climatic events and predict potential climatic behaviour.

'Forecasting' is a term used to 'predict' what will happen in the near future. Weather forecasting is a very good example where the timing and magnitude of precipitation, temperature, wind and other weather elements are predicted. River flow, lake level, storm surge and tides can be forecast. This information is used to guide human activities in the near future.

'Prediction' is a term used provide answers to questions such as:

- What is maximum amount of rain that can be expected to fall in a twenty-four-hour period in the next ten years? (So, one can design a storm sewer.)
- What is the highest wind speed that can be expected to occur once in a one-hundred-year time period? (So, one can design for wind loading on a building.)

- What is earliest date we can expect freezing temperatures with fifty per cent chance of occurrence? (So, one selects crop type or harvest times.)
- What is the maximum depth of river flow that can be expected to occur once every one hundred years? (So, one can determine how far away a cottage needs to be from the river edge.)

Other questions might refer to height of dykes, spillway capacity on a dam, and water supply.

These questions are statistical in nature. The quality of the answers depends on having sufficient quality historical information on the parameters being queried. The validity of the answers relies on the information being used in the determinations is describing a phenomenon that is only being influenced by forces that have not changed during the period in which the information was collected. It follows that the utility of the prediction depends on the implication that the forces that influence the phenomena will not change in the future.

If new forces emerge or disappear it is possible that maximum rainfall estimates might be low or too high, predicted river depths too low, predicted maximum temperatures too low, etc.

The forces being alluded to are those that determine weather and climate. Until recently these could not be imagined. Examination of the energy budget or the carbon cycle clearly suggests that human influence is introducing new elements or modifying existing elements in such a way that historical experience is not as reliable as it was before human, anthropogenic, influence. Statistical analysis is no longer valid yet answers to the questions posed are still required.

The solution is to gain a better more thorough understanding of the science and develop deterministic methods which require an understanding of the science and have data to support it. Statistical methods may still be used but not in such a direct way.

The science of climate change may not be necessary for forecasting weather but is absolutely critical in being able to predict the impact of anthropogenic influences.

9.6 Information support

Key web sites:

1. Season. https://en.wikipedia.org/wiki/Season
2. Subtropics. https://en.wikipedia.org/wiki/Subtropics
3. Tropics. https://www.nationalgeographic.org/encyclopedia/tropics/
4. Tropics. https://en.wikipedia.org/wiki/Tropics
5. West African monsoon. https://www.britannica.com/science/West-African-monsoon
6. Monsoon of South Asia. https://en.wikipedia.org/wiki/Monsoon_of_South_Asia
7. North American monsoon. https://en.wikipedia.org/wiki/North_American_monsoon
8. Monsoon. https://en.wikipedia.org/wiki/Monsoon#Process