Seasons

Arianna Fender

First Edition, 2012

ISBN 978-81-323-1063-1

Published by:
College Publishing House
4735/22 Prakashdeep Bldg,
Ansari Road, Darya Ganj,
Delhi - 110002
Email: info@wtbooks.com

Table of Contents

Introduction

A **season** is a division of the year, marked by changes in weather, ecology, and hours of daylight.

Seasons result from the yearly revolution of the Earth around the Sun and the tilt of the Earth's axis relative to the plane of revolution. In temperate and polar regions, the seasons are marked by changes in the intensity of sunlight that reaches the Earth's surface, variations of which may cause animals to go into hibernation or to migrate, and plants to be dormant.

During May, June and July, the northern hemisphere is exposed to more direct sunlight because the hemisphere faces the sun. The same is true of the southern hemisphere in November, December and January. It is the tilt of the Earth that causes the Sun to be higher in the sky during the summer months which increases the solar flux. However, due to seasonal lag, June, July and August are the hottest months in the northern hemisphere and December, January and February are the hottest months in the southern hemisphere.

In temperate and subpolar regions generally four calendar-based seasons are recognized: *spring* (adj. vernal), *summer* (adj. estival), *autumn* (adj. autumnal), and *winter* (adj. hibernal). However, ecologists are increasingly using a six-season model for temperate climate regions that includes *pre-spring* (adj. prevernal) and *late summer* (adj. seritonal) as distinct seasons along with the traditional four.

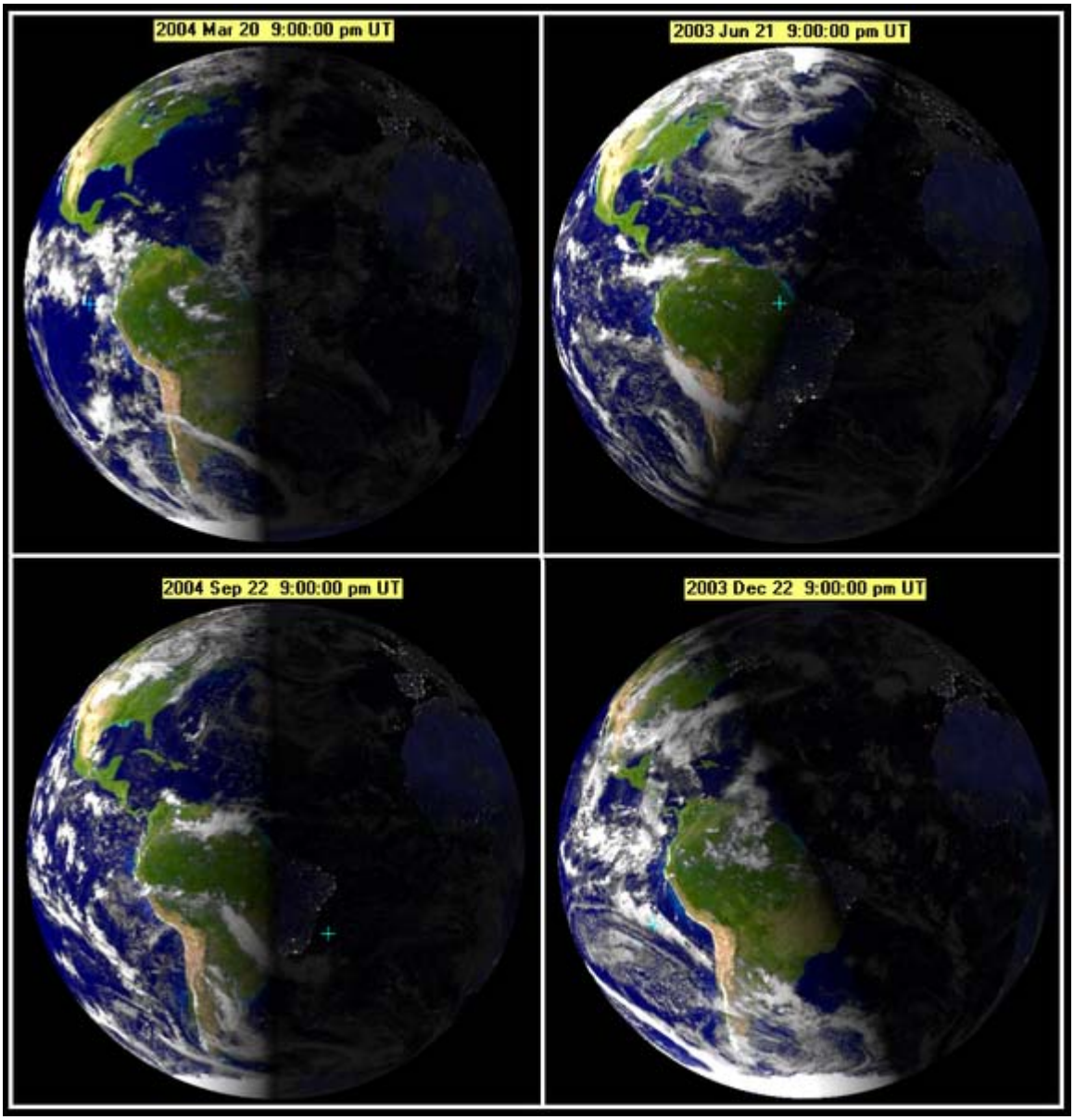
In some tropical and subtropical regions it is more common to speak of the rainy (or wet, or monsoon) season versus the dry season, because the amount of precipitation may vary more dramatically than the average temperature. For example, in Nicaragua, the dry season (October to May) is called 'summer' and the rainy season (April to November) is called 'winter', even though it is located in the northern hemisphere.

In other tropical areas a three-way division into hot, rainy and cool season is used.

In some parts of the world, special "seasons" are loosely defined based upon important events such as a hurricane season, tornado season or a wildfire season.

Chinese seasons are traditionally based on 24 periods known as solar terms, and begin at the midpoint of solstices and equinoxes.

Causes and effects



Illumination of the earth during various seasons

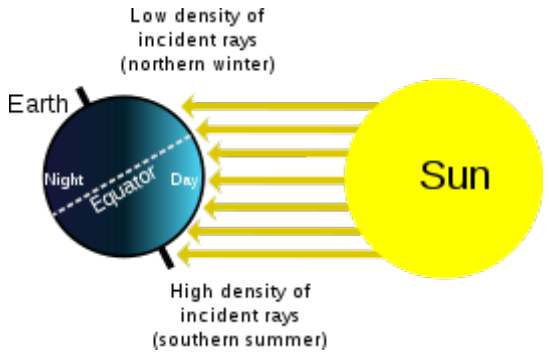


Fig. 1
This is a diagram of the seasons, regardless of the time of day (i.e. the Earth's rotation on its axis), the North Pole will be dark, and the South Pole will be illuminated; In addition to the density of incident light, the dissipation of light in the atmosphere is greater when it falls at a shallow angle.

The seasons result from the Earth's axis being tilted to its orbital plane; it deviates by an angle of approximately 23.5 degrees. Thus, at any given time during summer or winter, one part of the planet is more directly exposed to the rays of the Sun (see *Fig. 1*). This exposure alternates as the Earth revolves in its orbit. Therefore, at any given time, regardless of season, the northern and southern hemispheres experience opposite seasons.

The effect of axis tilt is observable from the change in day length, and altitude of the Sun at noon (the culmination of the Sun), during a year.

Seasonal weather differences between hemispheres are further caused by the elliptical orbit of Earth. Earth reaches perihelion (the point in its orbit closest to the Sun) in January, and it reaches aphelion (farthest point from the Sun) in July. Even though the effect this has on Earth's seasons is minor, it does noticeably soften the northern hemisphere's winters and summers. In the southern hemisphere, the opposite effect is observed.

Seasonal weather fluctuations (changes) also depend on factors such as proximity to oceans or other large bodies of water, currents in those oceans, El Niño/ENSO and other oceanic cycles, and prevailing winds.

In the temperate and polar regions, seasons are marked by changes in the amount of sunlight, which in turn often causes cycles of dormancy in plants and hibernation in animals. These effects vary with latitude and with proximity to bodies of water. For example, the South Pole is in the middle of the continent of Antarctica and therefore a considerable distance from the moderating influence of the southern oceans. The North Pole is in the Arctic Ocean, and thus its temperature extremes are buffered by the water. The result is that the South Pole is consistently colder during the southern winter than the North Pole during the northern winter.

The cycle of seasons in the polar and temperate zones of one hemisphere is opposite to that in the other. When it is summer in the Northern Hemisphere, it is winter in the Southern Hemisphere, and vice versa.

In the tropics, there is no noticeable change in the amount of sunlight. However, many regions (such as the northern Indian ocean) are subject to monsoon rain and wind cycles. A study of temperature records over the past 300 years shows that the climatic seasons, and thus the seasonal year, are governed by the anomalistic year rather than the tropical year.

In meteorological terms, the summer solstice and winter solstice (or the maximum and minimum insolation, respectively) do not fall in the middles of summer and winter. The heights of these seasons occur up to seven weeks later because of seasonal lag. Seasons, though, are not always defined in meteorological terms.

Compared to axial tilt, other factors contribute little to seasonal temperature changes. The seasons are not the result of the variation in Earth's distance to the sun because of its elliptical orbit. Orbital eccentricity can influence temperatures, but on Earth, this effect is small and is more than counteracted by other factors; research shows that the Earth as a whole is actually slightly warmer when *farther* from the sun. This is because the northern hemisphere has more land than the southern, and land warms more readily than sea. Mars however experiences wide temperature variations and violent dust storms every year at perihelion.

Polar day and night

Any point north of the Arctic Circle or south of the Antarctic Circle will have one period in the summer when the sun does not set, and one period in the winter when the sun does not rise. At progressively higher latitudes, the maximum periods of "midnight sun" and "polar night" are progressively longer. For example, at the military and weather station Alert on the northern tip of Ellesmere Island, Canada (about 450 nautical miles or 830 km from the North Pole), the sun begins to peek above the horizon in mid-February and each day it climbs higher and stays up longer; by 21 March, the sun is up for 12 hours. However, mid-February is not first light. The sky (as seen from Alert) has twilight, or at least a pre-dawn glow on the horizon, for increasing hours each day, for more than a month before the sun first appears.

In the weeks surrounding 21 June, the sun is at its highest, and it appears to circle the sky without going below the horizon. Eventually, it does go below the horizon, for progressively longer periods each day until, around the middle of November, it disappears for the last time. For a few more weeks, "day" is marked by decreasing periods of twilight. Eventually, for the weeks surrounding 21 December, it is continuously dark. In later winter, the first faint wash of light briefly touches the horizon (for just minutes per day), and then increases in duration and pre-dawn brightness each day until sunrise in February.

Reckoning

Meteorological

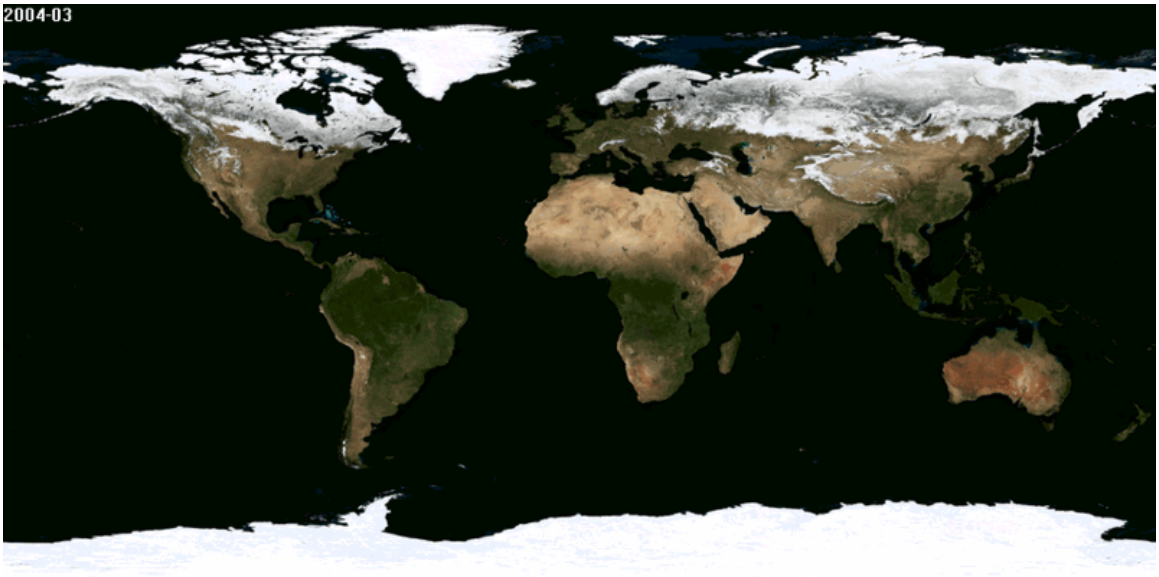


Image of seasonal differences especially snow cover through the year

Meteorological seasons are reckoned by temperature, with summer being the hottest quarter of the year and winter the coldest quarter of the year. Using this reckoning, the Roman calendar began the year and the spring season on the first of March, with each season occupying three months. In 1780 the Societas Meteorologica Palatina, an early international organization for meteorology, defined seasons as groupings of three whole months. Ever since, professional meteorologists all over the world have used this definition. So, in meteorology for the Northern hemisphere: spring begins on 1 March, summer on 1 June, autumn on 1 September, and winter on 1 December.

In Sweden and Finland, meteorologists use a different definition for the seasons, based on the temperature: spring begins when the daily averaged temperature permanently rises above 0° C, summer begins when the temperature permanently rises above +10° C, summer ends when the temperature permanently falls below +10° C and winter begins when the temperature permanently falls below 0° C. "Permanently" here means that the daily averaged temperature has remained above or below the limit for seven consecutive days. This implies two things: first, the seasons do not begin at fixed dates but must be determined by observation and are known only after the fact; and second, a new season begins at different dates in different parts of the country.

Surface air temperature

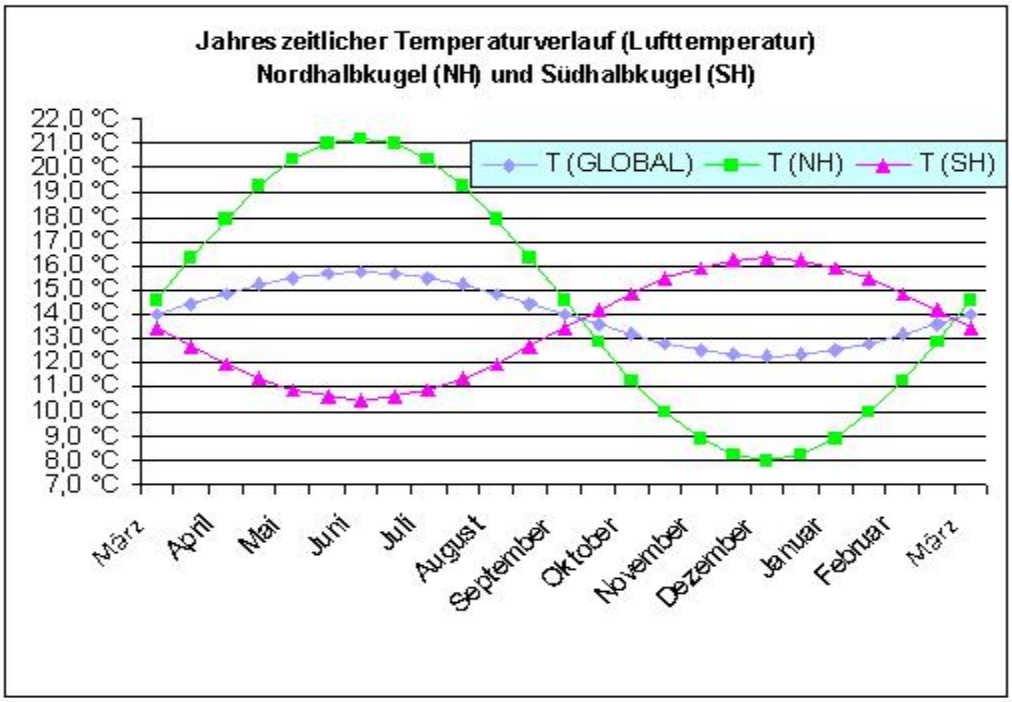
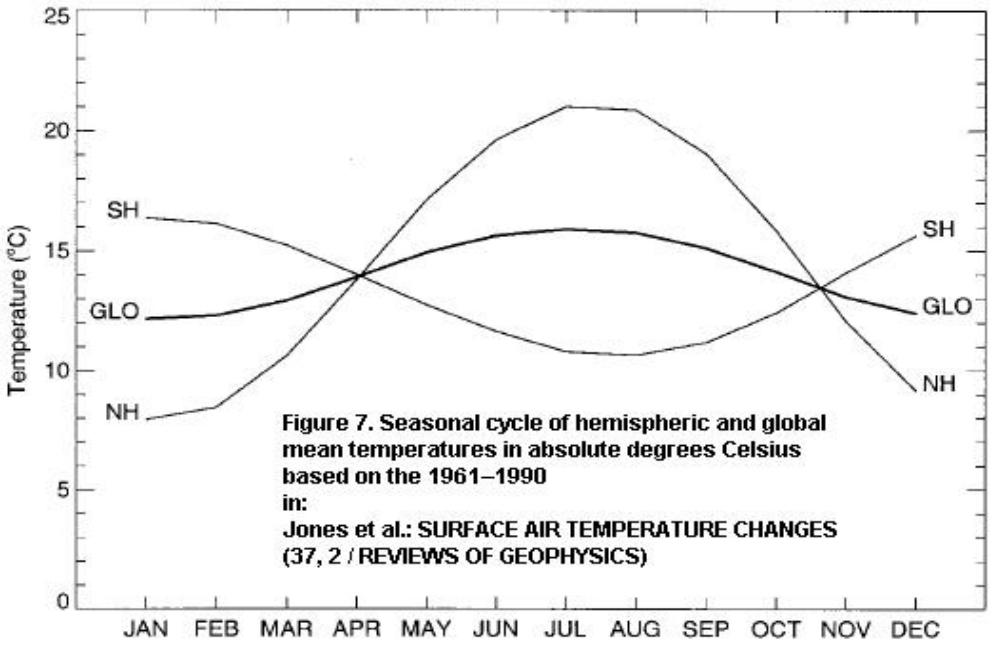


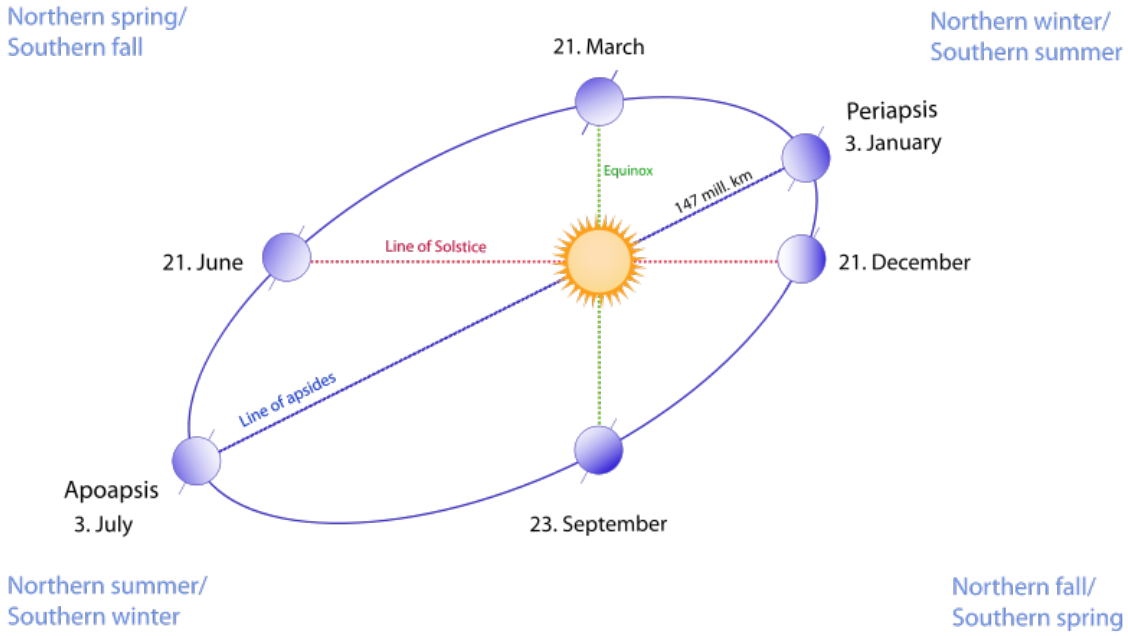
Diagram was calculated (Abscisse: 21. of each month)
Calculation based on data published by *Jones et al.*



The picture shows *Figure 7* as published by Jones et al.

Astronomical

The following diagram shows the relation between the line of solstice and the line of apsides of Earth's elliptical orbit. The orbital ellipse (with eccentricity exaggerated for effect) goes through each of the six Earth images, which are sequentially the perihelion (periapsis—nearest point to the sun) on anywhere from 2 January to 5 January, the point of March equinox on 20 or 21 March, the point of June solstice on 20 or 21 June, the aphelion (apoapsis—farthest point from the sun) on anywhere from 4 July to 7 July, the September equinox on 22 or 23 September, and the December solstice on 21 or 22 December.



In astronomical reckoning, the solstices and equinoxes ought to be the middle of the respective seasons, but, because of thermal lag, regions with a continental climate often consider these four dates to be the start of the seasons as in the diagram, with the cross-quarter days considered seasonal midpoints. The length of these seasons is not uniform because of the elliptical orbit of the earth and its different speeds along that orbit.

From the March equinox it takes 92.75 days until the June solstice, then 93.65 days until the September equinox, 89.85 days until the December solstice and finally 88.99 days until the March equinox. In Canada and the United States, the mass media consider the astronomical seasons "official" over all other reckonings, but no legal basis exists for this designation.

Because of the differences in the Northern and Southern Hemispheres, it is no longer considered appropriate to use the northern-seasonal designations for the astronomical quarter days. The modern convention for them is: March Equinox, June Solstice, September Equinox and December Solstice. The oceanic climate of the Southern

Hemisphere produces a shorter temperature lag, so the start of each season is usually considered to be several weeks before the respective solstice or equinox in this hemisphere, in other countries with oceanic climates, and in cultures with Celtic roots.

Ecological seasons

Seasonal changes regarding a tree over a year

Ecologically speaking, a season is a period of the year in which only certain types of floral and animal events happen (e.g.: flowers bloom—spring; hedgehogs hibernate—winter). So, if we can observe a change in daily floral/animal events, the season is changing.

The hot regions

Here there are two seasons:

- Rainy season (winter and spring)
- Dry season (summer and autumn)

The temperate areas

Six seasons can be distinguished. Mild temperate regions tend to experience the beginning of the hibernal season up to a month later than cool temperate areas, while the prevernal and vernal seasons begin up to a month earlier. For example, prevernal crocus blooms typically appear as early as February in mild coastal areas of British Columbia, the British Isles, and western and southern Europe. The actual dates for each season vary by climate region and can shift from one year to the next. Average dates listed here are for cool temperate climate zones in the Northern Hemisphere:

- Prevernal (ca.1 March–1 May)
- Vernal (ca.1 May–15 June)
- Estival (ca.15 June–15 August)
- Serotinal (ca.15 August–15 September)
- Autumnal (ca.15 September–1 November)
- Hibernal (ca.1 November–1 March)

Cold regions

There are again only two seasons:

- Polar Day (spring and summer)
- Polar Night (autumn and winter)

Traditional season divisions

Traditional seasons are reckoned by insolation, with summer being the quarter of the year with the greatest insolation and winter the quarter with the least. These seasons begin about four weeks earlier than the meteorological seasons and 7 weeks earlier than the astronomical seasons.

In traditional reckoning, the seasons begin at the cross-quarter days. The solstices and equinoxes are the *midpoints* of these seasons. For example, the days of greatest and least insolation are considered the "midsummer" and "midwinter" respectively.

This reckoning is used by various traditional cultures in the Northern Hemisphere, including East Asian and Irish cultures. In Iran, Afghanistan and some other parts of Middle East the beginning of the astronomical spring is the beginning of the new year which is called Nowruz.

So, according to traditional reckoning, winter begins between 5 November and 10 November, Samhain, 立冬 (lìdōng or rittou); spring between 2 February and 7 February, Imbolc, 立春 (lìchūn or risshun); summer between 4 May and 10 May, Beltane, 立夏 (lìxià or rikka); and autumn between 3 August and 10 August, Lughnasadh, 立秋 (lìqiū or risshū). The middle of each season is considered Mid-winter, between 20 December and 23 December, 冬至 (dōngzhì or touji); Mid-spring, between 19 March and 22 March, 春分 (chūnfēn or shunbun); Mid-summer, between 19 June and 23 June, 夏至 (xiàzhì or geshi); and Mid-autumn, between 21 September and 24 September, 秋分 (qiūfēn or shūbun).

Australia

In Australia, the traditional aboriginal people defined the seasons by what was happening to the plants, animals and weather around them. This led to each separate tribal group having different seasons, some with up to eight seasons each year. However, most

modern Aboriginal Australians follow either four or six meteorological seasons, as do non-Aboriginal Australians.

The commonly followed dates are as follows: 1st day of March, June, September and December for the start of Autumn, Winter, Spring and Summer, respectively.

India

In India, and in the Hindu calendar, there are six seasons or Ritu: Hemant (pre-winter), Shishir (Winter), Vasanta (Spring), Greeshma (Summer), Varsha (Rainy) and Sharad (Autumn).

Ancient Celts

The ancient celtic people only recognised two seasons, that of summer and winter. These were marked by festivals, namely Samhain and Beltaine, to celebrate the death and rebirth of the sun.

Chapter-1

Spring Season

Colorful spring garden flowers

Spring is one of the four temperate seasons, the transition period between winter and summer. Spring and "springtime" refer to the season, and broadly to ideas of rebirth, renewal and regrowth. The specific definition of the exact timing of "spring" varies according to local climate, cultures and customs. At the spring equinox, days are close to 12 hours long with day length increasing as the season progresses.

Definition

Meteorologists generally define four seasons in many climatic areas, winter, spring, summer and autumn (or fall). These are demarcated by the values of their average temperatures on a monthly basis, with each season lasting three months. The three

warmest months are by definition summer, the three coldest months are winter, and the intervening gaps are spring and autumn. Spring, when defined in this manner, can start on different dates in different regions. In terms of complete months, in most North Temperate Zone locations, spring months are March, April and May (Summer is June, July, August; autumn is September, October, November; winter is December, January, February). The vast majority of South Temperate Zone locations will have opposing seasons with spring in September, October and November.

Plafond *Allegory of Spring* by Jerzy Siemiginowski, 1680s

Astronomically, the vernal equinox (usually 20 March in the Northern Hemisphere, and 22 September in the Southern Hemisphere), should be the middle of spring (based on the angle of the sun and insolation) and the summer solstice (usually 21 June in the Northern

Hemisphere and 21 December in the Southern Hemisphere) should be the middle of summer (because the sun is at its highest), but daytime temperatures lag behind insolation by several weeks because the earth and sea have thermal latency and take time to warm up.

Some cultures, such as those that devised the Celtic and East Asian calendars, call the spring equinox "mid-spring", but others (especially in the USA and sometimes in England) regard it as the "first day of spring". For most temperate regions, signs of spring appear long before the middle of March, but the folklore of 21 March being the "first day of spring" persists, and 21 June as the "first day of summer" is common in the USA. In South Africa, Australia and New Zealand, spring begins on 1 September, and has no relation to the vernal equinox.

In South America, the Tupi-Guarani calendar, from the primitive inhabitants of what is presently Brazil, counted 365 days, plus a fourth part of a day, needing no extra day every four years. The beginning of the solar year was marked by the rising of the M25 Constellation in the horizon, which occurs between June 5 and June 11 in this part of the world. For these native peoples, the four seasons were clearly identified by the solstices and equinoxes. The trajectory of the Sun throughout the year was divided into "The New Age" (Ara Pyau) and "The Old Age" (Ara Ymã). Ara Pyau was spring and summer, and Ara Ymã was autumn and winter. This calendar, which had no graphed or written form, marked activities such as hunting, fishing, planting, harvesting and religious rituals.

In East Asian Solar term, spring begins on 4 February and ends on 5 May. Similarly, according to the Celtic tradition, which is based solely on daylight and the strength of the noon sun, spring begins in early February (near Imbolc or Candlemas) and continues until early May (Beltane).

The phenological definition of spring relates to indicators, the blossoming of a range of plant species, and the activities of animals, or the special smell of soil that has reached the temperature for micro flora to flourish. It therefore varies according to the climate and according to the specific weather of a particular year.

Events

A blooming Sour Cherry in spring

In spring, the axis of the Earth is increasing its tilt toward the Sun and the length of daylight rapidly increases for the relevant hemisphere. The hemisphere begins to warm significantly causing new plant growth to "spring forth," giving the season its name. Snow, if a normal part of winter, begins to melt, and streams swell with runoff. Frosts, if a normal part of winter, become less severe. Temperate climates have no snow and rare frosts, the air and ground temperature increases more rapidly. Many flowering plants bloom this time of year, in a long succession sometimes beginning even if snow is still on the ground, continuing into early summer. In normally snowless areas "spring" may begin as early as February (Northern Hemisphere) heralded by the blooming of deciduous magnolias, cherries, and quince, or August (Southern Hemisphere) in the same way. Subtropical and tropical areas have climates better described in terms of other seasons, e.g. dry or wet, or monsoonal, or cyclonic. Often the cultures have locally defined names for seasons which have little equivalence to the terms originating in Europe. Many temperate areas have a dry spring, and wet autumn (fall), which brings about flowering in this season more consistent with the need for water as well as warmth. Subarctic areas may not experience "spring" at all until May or even June, or December in the outer Antarctic.

While spring is a result of the warmth caused by the turning of the Earth's axis, the weather in many parts of the world is overlain by events which appear very erratic taken on a year-to-year basis. The rainfall in spring (or any season) follows trends more related to longer cycles or events created by ocean currents and ocean temperatures. Good and well-researched examples are the El Niño effect and the Southern Oscillation Index.

Unstable weather may more often occur during spring, when warm air begins on occasions to invade from lower latitudes, while cold air is still pushing on occasions from the Polar regions. Flooding is also most common in and near mountainous areas during this time of year because of snowmelt, accelerated by warm rains. In the United States, Tornado Alley is most active this time of year, especially since the Rocky Mountains prevent the surging hot and cold air masses from spreading eastward and instead force them into direct conflict. Besides tornadoes, supercell thunderstorms can also produce dangerously large hail and very high winds, for which a severe thunderstorm warning or tornado warning is usually issued. Even more so than in winter, the jet streams play an important role in unstable and severe weather in the springtime in the Northern Hemisphere.

In recent decades season creep has been observed, which means that many phenological signs of spring are occurring earlier in many regions by a couple of days per decade.

Spring is seen as a time of growth, renewal, of new life (both plant and animal) being born. The term is also used more generally as a metaphor for the start of better times, as in the Prague Spring. Spring in the Southern Hemisphere is different in several significant ways to that of the Northern Hemisphere. This is because: there is no land bridge between Southern Hemisphere countries and the Antarctic zone capable of bringing in cold air without the temperature-mitigating effects of extensive tracts of water; the vastly greater amount of ocean in the Southern Hemisphere at all latitudes; at this time in Earth's geologic history the Earth has an orbit which brings it in closer to the Southern Hemisphere for its warmer seasons; there is a circumpolar flow of air (the roaring 40s and 50s) uninterrupted by large land masses; no equivalent jet streams; and the peculiarities of the reversing ocean currents in the Pacific.

Festivals

Mesopotamia

Akitu (Sumerian *Akiti-šekinku* "cutting of barley", *Akiti-šununum* "sowing of barley", Babylonian *rêš-šattim* "head of the year") was a spring festival in ancient Mesopotamia. The name is from the Sumerian for "barley", originally marking two festivals celebrating the beginning of each of the two half-years of the Sumerian calendar, marking the sowing of barley in autumn and the cutting of barley in spring, in the month of Nisannu (Aries). In Babylonian religion it came to be dedicated to Marduk's victory over Tiamat.

Afghanistan

The first day of spring is the beginning of the new year, Nowruz, in the Solar Hijri Calendar. Nowruz (also Naw-Rúz, Norooz, Newroz, Navroj, and many other variants) which means "New Day" in Persian, marks an important traditional holiday festival celebrated in Afghanistan as well as in many other countries such as Azerbaijan, Iran and Tajikistan.

Persia (Iran)

The first day of spring (celebrated on the day of the astronomical vernal equinox, which usually occurs on 21 March or the previous or following day depending on where it is observed) is the beginning of the new year, Nowruz, in the Iranian calendar. Nowruz (also Naw-Rúz, Norooz, Newroz, Navroj, and many other variants)which means "New Day" in Persian language, marks an important traditional holiday festival celebrated in Iran as well as in many other countries with a significant population from one of various Iranian peoples, such as Azerbaijan, Afghanistan and Tajikistan, and by Kurdish communities in Turkey and Iraq and elsewhere.

May Day

1 May is the date of several public holidays. In many countries, May Day is synonymous with International Workers' Day, or Labour Day, which celebrates the social and economic achievements of the labour movement. As a day of celebration the holiday has ancient origins, and it can relate to many customs that have survived into modern times. Many of these customs are due to May Day being a cross-quarter day, meaning that (in the Northern Hemisphere where it is almost exclusively celebrated) it falls approximately halfway between the spring equinox and summer solstice. In the Celtic tradition, this date marked the end of Spring and the beginning of Summer.

Easter

Easter is the most important religious feast in the Christian liturgical year. Christians believe that Jesus was resurrected from the dead on the "third day" (two days *after* his crucifixion), and celebrate this resurrection on Easter Day, two days after Good Friday. The date of Easter varies between 22 March and 25 April in Western tradition, and between 4 April and 8 May in Eastern Christianity.

Chapter-2

Summer

A field in summer

Summer is the warmest of the four temperate seasons, between spring and autumn. At the summer solstice, the days are longest and the nights are shortest, with day-length decreasing as the season progresses after the solstice. The date of the beginning of summer varies according to climate, culture and tradition, but when it is summer in the

southern hemisphere it is winter in the northern hemisphere, and vice versa. In areas of the tropics and subtropics, the wet season occurs during the summer. Tropical cyclones develop and roam the tropical and subtropical oceans during the summer. In the interior of continents, thunderstorms can produce hail during the afternoon and evening. Schools and universities have a summer break to take advantage of the warmer weather and longer days.

Timing

From an astronomical view, the equinoxes and solstices would be the middle of the respective seasons, but a variable seasonal lag means that the meteorological start of the season, which is based on average temperature patterns, occurs several weeks later than the start of the astronomical season. According to meteorologists, summer extends for the whole months of June, July and August in the northern hemisphere and the whole months of December, January and February in the southern hemisphere. This meteorological definition of summer also aligns with the commonly viewed notion of summer as the season with the longest (and warmest) days of the year, in which daylight predominates. From the astronomical perspective, days continue to lengthen from equinox to solstice and summer days progressively shorten after the solstice, so meteorological summer encompasses the build-up to the longest day and a diminishing thereafter, with summer having many more hours of daylight than spring.

The meteorological reckoning of seasons is used in Austria, Denmark and the former USSR; it is also used by many in the United Kingdom, where summer is thought of as extending from mid-May to mid-August. The definition based on equinox to solstice is more frequently used in the United States where a temperature lag of up to half a season is common.

Summer in Fethiye, Turkey

Elsewhere, however, Solstices and equinoxes are taken to mark the mid-points, not the beginnings, of the seasons. In Chinese astronomy, for example, summer starts on or around 5 May, with the *jiéqì* (solar term) known as lìxià (立夏), i.e. "establishment of summer", and it ends on or around 6 August. An example of Western usage would be William Shakespeare's *A Midsummer Night's Dream*, where the play takes place over the shortest night of the year, which is the summer solstice.

In Ireland, the summer months according to the national meteorological service, Met Eireann, are June, July and August. However, according to the Irish Calendar summer begins 1 May and ends 1 August. School textbooks in Ireland follow the cultural norm of summer commencing on 1 May rather than the meteorological definition of 1 June.

In southern and southeast Asia, where the monsoon occurs, summer is more generally defined as lasting from March to May/early June, their warmest time of the year, ending with the onset of the monsoon rains.

In the United States, summer is often fixed as the period from the summer solstice (June 20 or 21, depending on the year) to the fall equinox (September 22 or 23, again depending on the year). Unofficially, the U.S. summer season is commonly regarded as beginning on Memorial Day weekend and ending on Labor Day weekend. Likewise, another set of pop-cultural reference points for summer in the USA is the time when

elementary and secondary schools close down for the "summer vacation". This period usually lasts from around early to mid June until around late August to early September, depending on where the school is located.

The Southern Hemisphere (Australia, Brazil, South Africa, etc) uses the meteorological definition with summer starting on December 1 and ending at the end of February or sometimes early March.

Weather

Wet season thunderstorm at night in Darwin, Australia

Summer is traditionally associated with hot dry weather, but this does not occur in all regions. The wet season occurs during summer across many parts of the tropics and subtropics. Where the wet season is associated with a seasonal shift in the prevailing winds, it is known as a monsoon. The wet season is the main period of vegetation growth within the savanna climate regime. However, this also means that wet season is a time for food shortages before crops reach their full maturity. This causes seasonal weight changes for people in developing countries, with a drop occurring during the wet season until the time of the first harvest, when weights rebound. Malaria incidence increases during periods of high temperature and heavy rainfall.

The onset of the rainy season signals the departure of the Monarch butterfly from Mexico. Tropical species of butterflies show larger dot markings on their wings to fend off possible predators and are more active during the wet season than the dry season. Within the tropics and warmer areas of the subtropics, decreased salinity of near shore wetlands due to the rains causes an increase in crocodile nesting. Other species, such as the arroyo toad, spawn within the couple months after the seasonal rains. Armadillos and rattlesnakes seek higher ground.

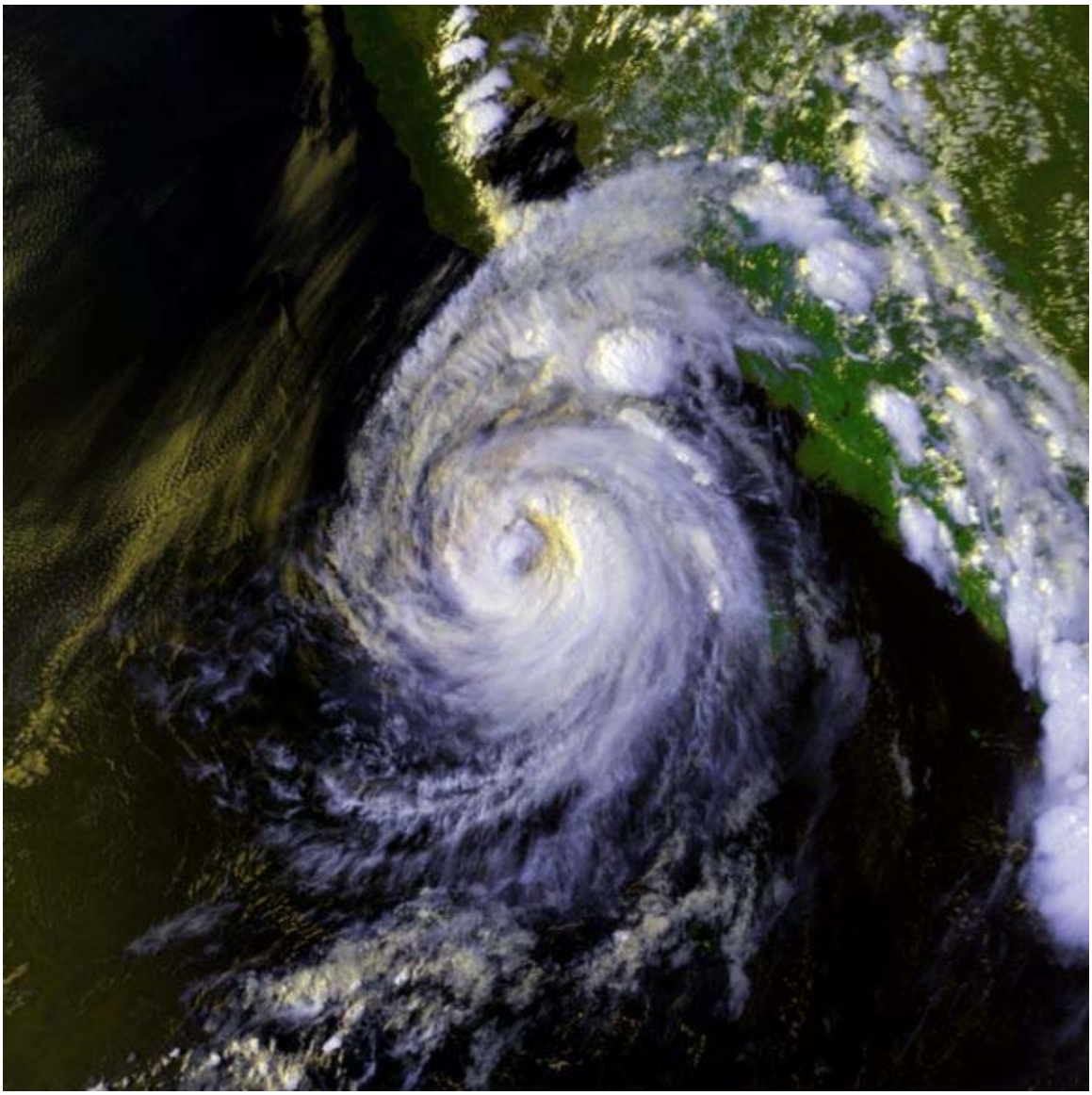


Image of Hurricane Lester from late August 1992.

In the Northern Atlantic Ocean, a distinct tropical cyclone season occurs from 1 June to 30 November, sharply peaking from late August through September. The statistical peak of the Atlantic hurricane season is 10 September. The Northeast Pacific Ocean has a broader period of activity, but in a similar time frame to the Atlantic. The Northwest

Pacific sees tropical cyclones year-round, with a minimum in February and March and a peak in early September. In the North Indian basin, storms are most common from April to December, with peaks in May and November. In the Southern Hemisphere, the tropical cyclone season runs from 1 November until the end of April with peaks in mid-February to early March.

Across interior North America, cumulonimbus clouds produce hail between the months of March and October during the afternoon and evening hours, with the bulk of the occurrences from May through September. Cheyenne, Wyoming is North America's most hail-prone city with an average of nine to ten hailstorms per season.

Construction

In higher latitude locations, summer is the time for road resurfacing, as winter ice and snow leaves potholes behind in the pavement due to the expansion and contraction of ice and snow during the winter months. Construction jobs tend to have minimum temperature requirements in order for work to be accomplished, such as the laying of concrete. This is because materials like concrete take increasingly longer to dry within cold temperature regimes. Also, working within warmer weather regimes is done to prevent expansion of ice within the new material, which decreases its potential strength and integrity.

School break

In most countries children are out of school during this time of year for summer holidays, although dates vary. In the Northern hemisphere, some begin as early as mid-May, although in England and Wales, school ends in mid- to late July. In the Southern hemisphere, school holiday dates include the major holidays of Christmas and New Year's Day. Summer school holidays in Australia begin a few weeks before Christmas and end in late January to mid-February, with the dates varying in different states.

Activities

People take advantage of the warmer temperatures by spending more time outdoors during the summer. Activities such as traveling to the beach and picnics occur during summer months. Sports such as cricket, volleyball, skateboarding, baseball, softball, soccer, tennis, water polo, and football are played. Water skiing is a uniquely summer sport, which is done when waters approach their warmest of the year.

Boys cycling during summer

Barefoot skiing

Summer, a fresco by Ambrogio Lorenzetti

Chapter-3

Autumn

An autumn vineyard in Napa Valley, California

Autumn or **fall** is one of the four temperate seasons. Autumn marks the transition from summer into winter usually in March (Southern Hemisphere) or September (Northern Hemisphere) when the arrival of night becomes noticeably earlier.

The equinoxes might be expected to be in the middle of their respective seasons, but temperature lag (caused by the thermal latency of the ground and sea) means that seasons appear later than dates calculated from a purely astronomical perspective. The actual lag varies with region, so some cultures regard the autumnal equinox as "mid-autumn" whilst others with a longer lag treat it as the start of autumn. Meteorologists (and most of the temperate countries in the southern hemisphere) use a definition based on months, with autumn being September, October and November in the northern hemisphere, and March, April and May in the southern hemisphere.

In North America, autumn is usually considered to start with the September equinox. In traditional East Asian solar term, Autumn starts on or around 8 August and ends on about 7 November. In Ireland, the autumn months according to the national meteorological service, Met Éireann, are September, October and November. However, according to the Irish Calendar which is based on ancient Celtic traditions, autumn lasts throughout the months of August, September, and October, or possibly a few days later, depending on tradition. In Australia, autumn officially begins on 1 March and ends 31 May. The vast diversity of the ecological zones of the South American, African and Australian continents renders the rigid European, North Asian and North American seasonal calendar an imposed cultural concept rather than relevant to climactic conditions. The seasonal cycles as named and described by the various indigenous Aboriginal peoples of Australia differ substantially from one another according to their local geographical and ecological environment and are intricately dependent on local environmental events and resources.

Personification of Autumn (Currier & Ives lithograph, 1871).

Etymology

The word *autumn* comes from the Old French word *autompne* (*automne* in modern French), and was later normalised to the original Latin word *autumnus*. There are rare examples of its use as early as the 12th century, but it became common by the 16th century.

Before the 16th century, *harvest* was the term usually used to refer to the season. However, as more people gradually moved from working the land to living in towns (especially those who could read and write, the only people whose use of language we

now know), the word *harvest* lost its reference to the time of year and came to refer only to the actual activity of reaping, and *autumn*, as well as *fall*, began to replace it as a reference to the season.

The alternative word *fall* is now mostly a North American English word for the season. It traces its origins to old Germanic languages. The exact derivation is unclear, the Old English *fiæll* or *feallan* and the Old Norse *fall* all being possible candidates. However, these words all have the meaning "to fall from a height" and are clearly derived either from a common root or from each other. The term came to denote the season in 16th century England, a contraction of Middle English expressions like "fall of the leaf" and "fall of the year".

During the 17th century, English emigration to the British colonies in North America was at its peak, and the new settlers took the English language with them. While the term *fall* gradually became obsolete in Britain, it became the more common term in North America, where *autumn* is nonetheless preferred in scientific and often in literary contexts.

Harvest association

Association with the transition from warm to cold weather, and its related status as the season of the primary harvest, has dominated its themes and popular images. In Western cultures, personifications of autumn are usually pretty, well-fed females adorned with fruits, vegetables and grains that ripen at this time. Most ancient cultures featured autumnal celebrations of the harvest, often the most important on their calendars. Still extant echoes of these celebrations are found in the mid-autumn Thanksgiving holiday of the United States and Canada, and the Jewish Sukkot holiday with its roots as a full moon harvest festival of "tabernacles" (huts wherein the harvest was processed and which later gained religious significance). There are also the many North American Indian festivals tied to harvest of autumnally ripe foods gathered in the wild, the Chinese Mid-Autumn or Moon festival, and many others. The predominant mood of these autumnal celebrations is a gladness for the fruits of the earth mixed with a certain melancholy linked to the imminent arrival of harsh weather.

This view is presented in English poet John Keats' poem *To Autumn*, where he describes the season as a time of bounteous fecundity, a time of 'mellow fruitfulness'.

Melancholy association

A brightly colored tree contrasts the green foliage which surrounds it

Autumn in poetry has often been associated with melancholy. The possibilities of summer are gone, and the chill of winter is on the horizon. Skies turn grey, and people turn inward, both physically and mentally. Rainer Maria Rilke, a German poet, has expressed such sentiments in one of his most famous poems, *Herbsttag* (*Autumn Day*), which reads

> *Who now has no house, will not build one (anymore).*
> *Who now is alone, will remain so for long,*

will wake, and read, and write long letters
and back and forth on the boulevards
will restlessly wander, while the leaves blow.

Similar examples may be found in Irish poet William Butler Yeats' poem *The Wild Swans at Coole* where the maturing season that the poet observes symbolically represents his own aging self. Like the natural world that he observes he too has reached his prime and now must look forward to the inevitability of old age and death. French poet Paul Verlaine's "*Chanson d'automne*" ("Autumn Song") is likewise characterized by strong, painful feelings of sorrow. Keats' *To Autumn*, written in September 1819, echoes this sense of melancholic reflection, but also emphasises the lush abundance of the season.

Season of mists and mellow fruitfulness,
Close bosom-friend of the maturing sun;
Conspiring with him how to load and bless
With fruit the vines that round the thatch-eves run;
To bend with apples the moss'd cottage-trees,
And fill all fruit with ripeness to the core;'

Other associations

Halloween pumpkins

Autumn is also associated with the Halloween season (which in turn was influenced by Samhain, a Celtic autumn festival), and with it a widespread marketing campaign that promotes it. The television, film, book, costume, home decoration, and confectionery industries use this time of year to promote products closely associated with such holiday,

with promotions going from early September to 31 October, since their themes rapidly lose strength once the holiday ends, and advertising starts concentrating on Christmas.

Since 1997, Autumn has been one of the top 100 names for girls in the United States.

In Indian mythology, autumn is considered to be the preferred season for the goddess of learning Saraswati, who is also known by the name of "goddess of autumn" (Sharada).

Tourism

Although color change in leaves occurs wherever deciduous trees are found, colored autumn foliage is most famously noted in three regions of the world: most of Canada and the United States, Eastern Asia (including China, Korea, and Japan), and Europe.

Eastern Canada and the New England region of the United States are famous for the brilliance of their autumnal foliage, and this attracts major tourism (worth billions of US$) for the regions.

Paintings

Otoño, Frederic Edwin Church, 1875. Museo Thyssen-Bornemisza

John Everett Millais, "Autumn Leaves".

Cherry trees in autumn

Oak tree in autumn

Leaf.

Chapter-4

Winter

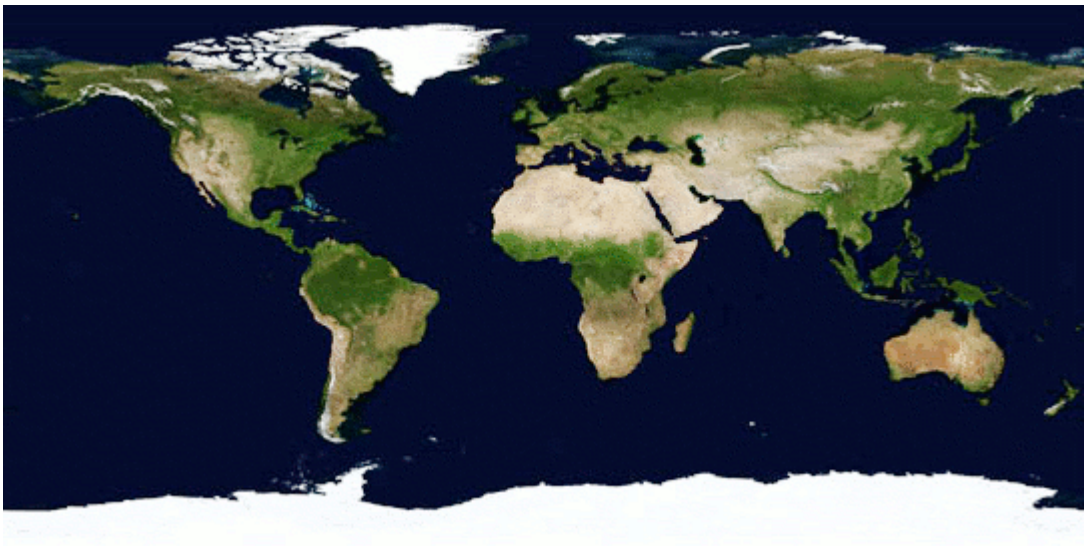


Image of snow cover changing with the seasons.

Winter is the coldest season of the year in temperate climate, between autumn and spring. At the winter solstice, the days are shortest and the nights are longest, with days lengthening as the season progresses after the solstice.

Meteorology

Meteorological winter is the season having the shortest days and the lowest average temperatures, which have the coldest weather. This corresponds to the months of December, January and February in the Northern Hemisphere, and June, July and August in the Southern Hemisphere. The coldest average temperatures of the season are typically experienced in January in the Northern hemisphere and in June or July in the Southern hemisphere. Nighttime predominates the winter season, and in some regions it has the highest rate of precipitation as well as prolonged dampness because of permanent snow cover or high precipitation rates coupled with low temperatures, precluding evaporation. Blizzards often develop and cause many transportation delays. A rare meteorological phenomenon encountered during winter is ice fog, which comprises ice crystals suspended in the air; it occurs only at very low temperatures, below about –30°C (–22°F).

Accumulations of snow and ice are mostly associated with winter in the Northern Hemisphere, due to the large land masses there. In the Southern Hemisphere, the more maritime climate and the relative lack of land south of 40°S makes the winters milder; thus, snow and ice are less common in inhabited regions of the Southern Hemisphere. In this region, snow occurs every year in elevated regions such as the Andes, the Great Dividing Range in Australia, and the mountains of New Zealand, and also occurs in the southerly Patagonia region of South America. Snow occurs year-round in Antarctica.

Period

The road from Dornbirn, Austria to the mountain village of Ebnit in winter.

Astronomically, the winter solstice, being the day of the year which has fewest hours of daylight, ought to be the middle of the season, but temperature lag means that the coldest period normally follows the solstice, so the season is sometimes regarded (in the USA and Britain) as beginning at the solstice and ending on the following equinox. In the Northern Hemisphere, depending on the year, this corresponds to the period between 21 or 22 December and 20 or 21 March. Meteorologists in the UK consider winter to be the three coldest months of December, January and February. In Scandinavia, winter traditionally begins on 14 October and ends on the last day of February. In many countries in the Southern Hemisphere, including Australia, New Zealand and South Africa, winter begins on 1 June and ends on 31 August. In Brazil the winter begins on June 21 and ends on September 23. In Celtic nations such as Ireland (using the Irish calendar) and in Scandinavia, the winter solstice is traditionally considered as midwinter,

with the winter season beginning 1 November, on All Hallows, or Samhain. Winter ends and spring begins on Imbolc, or Candlemas, which is 1 or 2 February. This system of seasons is based on the length of days exclusively. (The three-month period of the shortest days and weakest solar radiation occurs during November, December, and January in the Northern Hemisphere and May through July in the Southern Hemisphere.)

In the mid-latitudes and arctic, winter is associated with snow and ice.

Also, many mainland European countries tend to recognize Martinmas or St. Martin's Day (11 November), as the first calendar day of winter. The day falls at midpoint between the old Julian equinox and solstice dates. Also, Valentine's Day (14 February) is recognized by some countries as heralding the first rites of spring, such as flowers blooming.

In Chinese astronomy and other East Asian calendars, winter is taken to commence on or around 7 November, with the *Jiéqì* (known as 立冬 *lì dōng*—literally, "establishment of winter").

The three-month period associated with the coldest average temperatures typically begins somewhere in late November or early December in the Northern Hemisphere and lasts through late February or early March. This "thermological winter" is earlier than the solstice delimited definition, but later than the daylight (Celtic) definition. Depending on seasonal lag, this period will vary between climatic regions.

Cultural influences such as Christmas creep may have led to the winter season being perceived as beginning earlier in recent years, although high latitude countries like Canada and Russia are usually well into their real winters before the December solstice.

Causes

Snow frozen onto a tree in Germany

A winter day

The tilt of the Earth's axis relative to its orbital plane has a dramatic effect on the weather. The Earth is tilted at an angle of 23.44° to the plane of its orbit, and this causes different latitudes on the Earth to directly face the Sun as the Earth moves through its orbit. It is this variation that primarily brings about the seasons. When it is winter in the Northern Hemisphere, the Southern Hemisphere faces the Sun more directly and thus experiences warmer temperatures than the Northern Hemisphere. Conversely, winter in the Southern Hemisphere occurs when the Northern hemisphere is tilted more toward the Sun. From the perspective of an observer on the Earth, the winter Sun has a lower maximum altitude in the sky than the summer Sun.

During winter in either hemisphere, the lower altitude of the Sun in winter causes the sunlight to hit that hemisphere at an oblique angle. In regions experiencing winter, the same amount of solar radiation is spread out over a larger area. This effect is compounded by the larger distance that the light must travel through the atmosphere,

allowing the atmosphere to dissipate more heat. Compared with these effects, the changes in the distance of the earth from the sun are negligible.

Exceptionally cold winters

- 1684, when the Thames was frozen solid, hosting one of many River Thames frost fairs, and the sea froze up to two miles out around the coast.
- Year Without a Summer was the name for the northern summer of 1816, because the weather was so cold that it reminded people of winter all year.
- In Europe, the winters of early 1947, 1962–63, 1981–82 and 2009–10 were considered abnormally cold.

Winter in Córdoba, Argentina

Ecology

The snowshoe hare is one animal that changes color in winter.

To survive the harshness of winter, many animals have developed different behavioral and morphological adaptations for overwintering:

- Migration is a common effect of winter upon animals, notably birds. However, the majority of birds do not migrate—the cardinal and European Robin, for example. Some butterflies also migrate seasonally.
- Hibernation is a state of reduced metabolic activity during the winter. Some animals "sleep" during winter and only come out when the warm weather returns; e.g., gophers, frogs, snakes, and bats.
- Some animals store food for the winter and live on it instead of hibernating completely. This is the case for squirrels, beavers, skunks, badgers, and raccoons.
- Resistance is observed when an animal endures winter but changes in ways such as color and musculature. The color of the fur or plumage changes to white (in order to be confused with snow) and thus retains its cryptic coloration year-round. Examples are the ptarmigan, arctic fox, weasel, white-tailed jackrabbit, and mountain hare.
- Some fur-coated mammals grow a heavier coat during the winter; this improves the heat-retention qualities of the fur. The coat is then shed following the winter season to allow better cooling. The heavier coat in winter made it a favorite season for trappers, who sought more profitable skins.
- Snow also affects the ways animals behave; many take advantage of the insulating properties of snow by burrowing in it. Mice and voles typically live under the snow layer.

Some annual plants never survive the winter. Other annual plants require winter cold to complete their life cycle, this is known as vernalization. As for perennials, many small ones profit from the insulating effects of snow by being buried in it. Larger plants, particularly deciduous trees, usually let their upper part go dormant, but their roots are still protected by the snow layer. Few plants bloom in the winter, one exception being the flowering plum, which flowers in time for Chinese New Year. The process by which plants become acclimated to cold weather is called hardening.

Mankind and winter

Humans evolved in tropical climate, and met cold weather as they migrated into Eurasia. Micro-evolution in Caucasian, Asiatic and Inuit people show some adaptation to the climate.

Winter and human health

Humans are sensitive to cold. Snowblindness, norovirus, seasonal depression and falling icicles are other health concerns associated with cold and snowy weather.

Activities

Snowboarder in the halfpipe.

Snow activities

Many winter activities involve the use of snow in some form (which sometimes is man-made, using snow cannons):

- Bobsledding — a winter sport in which teams make timed runs down narrow, twisting, banked, purpose-built ice-covered tracks in a steerable sled.
- Skiing — the activity of gliding over snow using fiberglass planks called *skis* that are strapped to the skiers' feet with ski bindings.
- Sledding — a gravity-powered activity using a sled to glide downhill.
- Snow castle building — for example, constructions such as the SnowCastle of Kemi, the largest in the world.
- Snowball fight — a physical game in which snowballs are thrown with the intention of hitting someone else.
- Snowboarding — an increasingly common sport in which participants strap a composite board to their feet and slide down a snow-covered mountain.
- Snowman building — creating a manlike model out of snow.
- Snowmobiling — driving snowmobiles in snow, across frozen lakes, on public trails, or around mountains.
- Snowshoeing — a means of travel on top of the snow by increasing the surface area of the feet by wearing snowshoes.
- Winter camping - cooking, eating and sleeping outside in the snow during the winter. Those who winter camp build a shelter from evergreen tree boughs, dig a snow cave, create a quinzhee or sleep in a tent for shelter overnight.

Ice activities

Bandy, an early form of ice hockey.

Many other winter activities and sports focus on ice, which may be contained in an ice rink.

- Curling — a team sport using brooms and stones. The object of the game is to slide your stones in a bullseye and get your opponent's stones out of it.
- Ice biking — the continuation of regular cycling activities in the winter and cold weather.
- Ice boating — a means of travel in a specialized boat similar in appearance to a sailboat but fitted with skis or runners (skates) and designed to run over ice instead of (liquid) water.
- Ice climbing — the recreational activity of climbing ice formations such as icefalls and frozen waterfalls.
- Ice diving — a type of penetration diving where the dive takes place under ice.
- Ice fishing — the sport of catching fish with lines and hooks through an opening in the ice on a frozen body of water.
- Ice hockey — a team sport played on the ice with skates, sticks, and a puck. The goal is to send the puck into the opposing team's net.
- Ice racing — automobile racing on ice surfaces.
- Ice sculpture — elaborate sculptures are carved out of blocks of ice.
- Ice skating — a means of travelling on ice with skates, narrow (and sometimes parabolic) bladelike devices molded into special boots.

Symbolism

Some use winter to suggest death, as in Robert Frost's "Stopping by Woods on a Snowy Evening". Some use it to suggest the absence of hope, as in C.S. Lewis' *The Lion, the Witch and the Wardrobe,* where it was always winter but never Christmas. Winter is one concerto in Antonio Vivaldi's "The Four Seasons," and there are many examples of four paintings all showing the same scene in different seasons. Ursula K. LeGuin's novel *The Left Hand of Darkness* is set on a planet named Winter. In Alex Raymond's comic strip *Flash Gordon*, there is a land called Frigia, where it is always winter. The land of Frigia is also featured in the serial *Flash Gordon Conquers the Universe*. Other uses of winter in the graphic arts occur in Winsor McCay's *Little Nemo in Slumberland*. There are many films in which a winter setting plays an important role, *Fargo* being an example. Novels such as *Ethan Frome* also use a winter setting to mirror the bleak, frozen feelings that the characters harbor. The film *Requiem for a Dream* concludes with "Act III: Winter," in which the movie reaches its chilling climax. The final vignette in James Joyce's Dubliners, 'The Dead', employs a winter motif in conjunction with themes of regret and isolation.

Mythology

In various cultures

In Persian culture the night starting winter is called Yalda (meaning: birth) and it is celebrated for thousands of years. It is referred as the eve of the birth of Mithra, the Sun

God, who symbolised light, goodness and strength on earth. By the whiteness of Winter, the Sun (the white) rises again to fade away the darkness of the long night (Yalda). It is also believed that the last day of Winter (the white), which is the first day of Spring (also known as Nowrouz), is the day that all the "Good"s will over come all the "Bad"s for ever.

In Greek mythology, Hades kidnapped Persephone to be his wife. Zeus ordered Hades to return her to Demeter, the goddess of the Earth and her mother. However, Hades tricked Persephone into eating the food of the dead, so Zeus decreed that Persephone would spend six months with Demeter and six months with Hades. During the time her daughter is with Hades, Demeter became depressed and caused winter. In Welsh mythology, Gwyn ap Nudd abducted a maiden named Creiddylad. On May Day, her lover, Gwythr ap Greidawl, fought Gwyn to win her back. The battle between them represented the contest between summer and winter.

Personifications

- Old Man Winter, also known as Father Winter
- Jack Frost
- Ded Moroz
- Snegurochka
- Vetr
- Sinterklaas

Chapter-5

Monsoon and Wet Season

Monsoon

Monsoon is traditionally defined as a seasonal reversing wind accompanied by corresponding changes in precipitation, but is now used to describe seasonal changes in atmospheric circulation and precipitation associated with the asymmetric heating of land and sea. Usually, the term monsoon is used to refer to the rainy phase of a seasonally-changing pattern, although technically there is also a dry phase.

The major monsoon systems of the world consist of the West African and Asia-Australian monsoons. The inclusion of the North and South American monsoons with incomplete wind reversal may be debated.

The term was first used in English in British India (now India, Bangladesh and Pakistan) and neighbouring countries to refer to the big seasonal winds blowing from the Bay of Bengal and Arabian Sea in the southwest bringing heavy rainfall to the area.

Etymology

Monsoon clouds over Lucknow, Uttar Pradesh.

The English *monsoon* came from Portuguese *monção*, ultimately from Arabic *mawsim* (موسم "season"), "perhaps partly via early modern Dutch *monsun*". The Arabic-origin

word *mausam* is also the word for "weather" in Hindi, Urdu, and several other North Indian languages.

History

Strengthening of the Asian monsoon has been linked to the uplift of the Tibetan Plateau after the collision of the Indian sub-continent and Asia around 50 million years ago. Many geologists believe the monsoon first became strong around 8 million years ago based on records from the Arabian Sea and the record of wind-blown dust in the Loess Plateau of China. More recently, plant fossils in China and new long-duration sediment records from the South China Sea led to a timing of the monsoon starting 15-20 million years ago and linked to early Tibetan uplift. Testing of this hypothesis awaits deep ocean sampling by the Integrated Ocean Drilling Program. The monsoon has varied significantly in strength since this time, largely linked to global climate change, especially the cycle of the Pleistocene ice ages. Timing of the monsoon strengthening of the Indian Monsoon of around 5 million years ago was suggested due to an interval of closing of the Indonesian Seaway to cold thermocline waters passage from the Pacific to the Indian Ocean which is believed to have resulted in an increased sea surface temperature in the Indian Ocean, which increased gyral circulation and then caused an increased intensity of the monsoon.

Five episodes during the Quaternary at 2.22 Ma (PL-1), 1.83 Ma (PL-2), 0.68 Ma (PL-3), 0.45 Ma (PL-4) and 0.04 Ma (PL-5) were identified which showed a weakening of Leeuwin Current (LC). The weakening of the LC would have an effect on the sea surface temperature (SST) field in the Indian Ocean, as the Indonesian through flow generally warms the Indian Ocean. Thus these five intervals could probably be those of considerable lowering of SST in the Indian Ocean and would have influenced Indian monsoon intensity. During the weak LC, there is the possibility of reduced intensity of the Indian winter monsoon and strong summer monsoon, because of change in the Indian Ocean dipole due to reduction in net heat input to the Indian Ocean through the Indonesian through flow. Thus a better understanding of the possible links between El Niño, Western Pacific Warm Pool, Indonesian Throughflow, wind pattern off western Australia, and ice volume expansion and contraction can be obtained by studying the behaviour of the LC during Quaternary at close stratigraphic intervals.

Process

View of the Indian Ocean Monsoon clouds over Howrah Bridge, Calcutta.

Monsoons may be considered as large-scale sea breezes, due to seasonal heating and the resulting development of a thermal low over a continental landmass. They are caused by the larger amplitude of the seasonal cycle of land temperature compared to that of nearby oceans. This differential warming happens because heat in the ocean is mixed vertically through a "mixed layer" that may be fifty metres deep, through the action of wind and buoyancy-generated turbulence, whereas the land surface conducts heat slowly, with the seasonal signal penetrating perhaps a metre or so. Additionally, the specific heat capacity of liquid water is significantly higher than that of most materials that make up land. Together, these factors mean that the heat capacity of the layer participating in the seasonal cycle is much larger over the oceans than over land, with the consequence that the air over the land warms faster and reaches a higher temperature than the air over the ocean. The hot air over the land tends to rise, creating an area of low pressure. This creates a steady wind blowing toward the land, bringing the moist near-surface air over the oceans with it. Similar rainfall is caused by the moist ocean air being lifted upwards by mountains, surface heating, convergence at the surface, divergence aloft, or from storm-produced outflows at the surface. However the lifting occurs, the air cools due to expansion in lower pressure, which in turn produces condensation.

In winter, the land cools off quickly, but the ocean retains heat longer. The cold air over the land creates a high pressure area which produces a breeze from land to ocean. Monsoons are similar to sea and land breezes, a term usually referring to the localized, diurnal (daily) cycle of circulation near coastlines, but they are much larger in scale, stronger and seasonal.

Most summer monsoons have a dominant westerly component and a strong tendency to ascend and produce copious amounts of rain (because of the condensation of water vapor in the rising air). The intensity and duration, however, are not uniform from year to year. Winter monsoons, by contrast, have a dominant easterly component and a strong tendency to diverge, subside and cause drought.

Even more broadly, it is now understood that in the geological past, monsoon systems likely accompanied the formation of supercontinents such as Pangaea, with their extreme continental climates.

Global monsoons

Africa

The monsoon of western Sub-Saharan Africa is the result of the seasonal shifts of the Intertropical Convergence Zone and the great seasonal temperature and humidity differences between the Sahara and the equatorial Atlantic Ocean. It migrates northward from the equatorial Atlantic in February, reaches western Africa on June 22, then moves back to the south by October. The dry, northeasterly trade winds, and their more extreme form, the harmattan, are interrupted by the northern shift in the ITCZ and resultant southerly, rain-bearing winds during the summer. The semiarid Sahel and Sudan depend upon this pattern for most of their precipitation.

North America

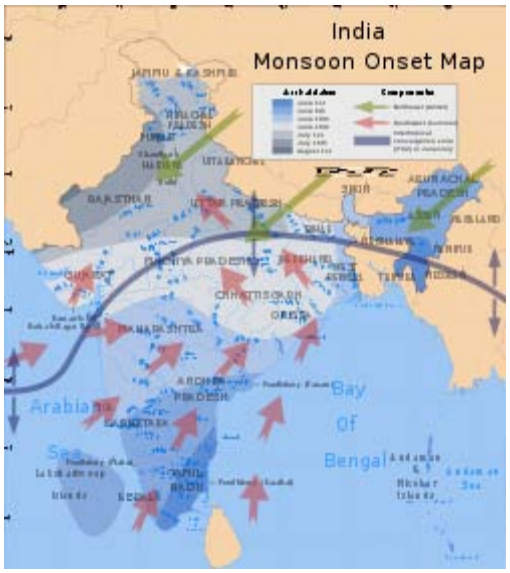
The **North American Monsoon** (also abbreviated as **NAM**) occurs from late June or early July into September, originating over Mexico and spreading into the southwest United States by mid-July. It affects Mexico along the Sierra Madre Occidental as well as Arizona, New Mexico, Nevada, Utah, Colorado, West Texas and California. It pushes as far west as the Peninsular Ranges and Transverse Ranges of Southern California, but rarely reaches the coastal strip (a wall of desert thunderstorms only a half-hour's drive away is a common summer sight from the sunny skies along the coast during the monsoon). The North American monsoon is known to many as the *Summer*, *Southwest*, *Mexican* or *Arizona* monsoon. It is also sometimes called the *Desert Monsoon* as a large part of the affected area are the Mojave and Sonoran deserts.

Asia

The Asian monsoons may be classified into a few sub-systems, such as the South Asian Monsoon which affects the Indian subcontinent and surrounding regions, and the East Asian Monsoon which affects southern China, Korea and parts of Japan.

South Asian Monsoon

Southwest Monsoon



Onset dates and prevailing wind currents of the southwest summer monsoons in India.

The southwestern summer monsoons occur from June through September. The Thar Desert and adjoining areas of the northern and central Indian subcontinent heats up considerably during the hot summers, which causes a low pressure area over the northern and central Indian subcontinent. To fill this void, the moisture-laden winds from the Indian Ocean rush in to the subcontinent. These winds, rich in moisture, are drawn towards the Himalayas, creating winds blowing storm clouds towards the subcontinent. The Himalayas act like a high wall, blocking the winds from passing into Central Asia, thus forcing them to rise. With the gain in altitude of the clouds, the temperature drops and precipitation occurs. Some areas of the subcontinent receive up to 10,000 mm (390 in) of rain.

The southwest monsoon is generally expected to begin around the start of June and fade down by the end of September. The moisture-laden winds on reaching the southernmost point of the Indian Peninsula, due to its topography, become divided into two parts: the *Arabian Sea Branch* and the *Bay of Bengal Branch*.

The *Arabian Sea Branch* of the Southwest Monsoon first hits the Western Ghats of the coastal state of Kerala, India, thus making the area the first state in India to receive rain from the Southwest Monsoon. This branch of the monsoon moves northwards along the Western Ghats with precipitation on coastal areas, west of the Western Ghats. The eastern areas of the Western Ghats do not receive much rain from this monsoon as the wind does not cross the Western Ghats.

The *Bay of Bengal Branch* of Southwest Monsoon flows over the Bay of Bengal heading towards North-East India and Bengal, picking up more moisture from the Bay of Bengal. The winds arrive at the Eastern Himalayas with large amounts of rain. Mawsynram, situated on the southern slopes of the Eastern Himalayas in Shillong, India, is one of the wettest places on Earth. After the arrival at the Eastern Himalayas, the winds turns towards the west, travelling over the Indo-Gangetic Plain at a rate of roughly 1–2 weeks per state, pouring rain all along its way. June 1 is regarded as the date of onset of the monsoon in India, as indicated by the arrival of the monsoon in the southernmost state of Kerala.

The monsoon accounts for 80% of the rainfall in India. Indian agriculture (which accounts for 25% of the GDP and employs 70% of the population) is heavily dependent on the rains, for growing crops especially like cotton, rice, oilseeds and coarse grains. A delay of a few days in the arrival of the monsoon can badly affect the economy, as evidenced in the numerous droughts in India in the 1990s.

The monsoon is widely welcomed and appreciated by city-dwellers as well, for it provides relief from the climax of summer heat in June. However, the condition of the roads take a battering each year. Often houses and streets are waterlogged and the slums are flooded in spite of having a drainage system. This lack of city infrastructure coupled with changing climate patterns causes severe economical loss including damage to property and loss of lives, as evidenced in the Bombay floods of 2005. Bangladesh and certain regions of India like Assam and West Bengal, also frequently experience heavy floods during this season. And in the recent past, areas in India that used to receive scanty rainfall throughout the year, like the Thar Desert, have surprisingly ended up receiving floods due to the prolonged monsoon season.

The influence of the Southwest Monsoon is felt as far north as in China's Xinjiang. It is estimated that about 70% of all precipitation in the central part of the Tian Shan Mountains falls during the three summer months, when the region is under the monsoon influence; about 70% of that is directly of "cyclonic" (i.e., monsoon-driven) origin (as opposed to "local convection").

Northeast Monsoon

Monsoon clouds in Calcutta

Around September, with the sun fast retreating south, the northern land mass of the Indian subcontinent begins to cool off rapidly. With this air pressure begins to build over northern India, the Indian Ocean and its surrounding atmosphere still holds its heat. This causes the cold wind to sweep down from the Himalayas and Indo-Gangetic Plain towards the vast spans of the Indian Ocean south of the Deccan peninsula. This is known as the **Northeast Monsoon** or **Retreating Monsoon**.

While travelling towards the Indian Ocean, the dry cold wind picks up some moisture from the Bay of Bengal and pours it over peninsular India and parts of Sri Lanka. Cities like Madras, which get less rain from the Southwest Monsoon, receives rain from this Monsoon. About 50% to 60% of the rain received by the state of Tamil Nadu is from the Northeast Monsoon. In Southern Asia, the northeastern monsoons take place from December to early March when the surface high-pressure system is strongest. The jet stream in this region splits into the southern subtropical jet and the polar jet. The subtropical flow directs northeasterly winds to blow across southern Asia, creating dry air streams which produce clear skies over India. Meanwhile, a low pressure system develops over South-East Asia and Australasia and winds are directed toward Australia known as a monsoon trough.

East Asian Monsoon

The East Asian monsoon affects large parts of Indo-China, Philippines, China, Korea and Japan. It is characterised by a warm, rainy summer monsoon and a cold, dry winter monsoon. The rain occurs in a concentrated belt that stretches east-west except in East China where it is tilted east-northeast over Korea and Japan. The seasonal rain is known as *Meiyu* in China, *Changma* in Korea, and *Bai-u* in Japan, with the latter two resembling frontal rain.

The onset of the summer monsoon is marked by a period of premonsoonal rain over South China and Taiwan in early May. From May through August, the summer monsoon shifts through a series of dry and rainy phases as the rain belt moves northward, beginning over Indochina and the South China Sea (May), to the Yangtze River Basin and Japan (June) and finally to North China and Korea (July). When the monsoon ends in August, the rain belt moves back to South China.

Australia

Monsoonal squall nears Darwin, Northern Territory, Australia.

Also known as the **Indo-Australian Monsoon**. The rainy season occurs from September to February and it is a major source of energy for the Hadley circulation during boreal winter. The *Maritime Continent Monsoon* and the *Australian Monsoon* may be considered to be the same system, the Indo-Australian Monsoon.

It is associated with the development of the Siberian High and the movement of the heating maxima from the Northern Hemisphere to the Southern Hemisphere. North-easterly winds flow down Southeast Asia, are turned north-westerly/westerly by Borneo topography towards Australia. This forms a cyclonic circulation vortex over Borneo, which together with descending cold surges of winter air from higher latitudes, cause significant weather phenomena in the region. Examples are the formation of a rare low-latitude tropical storm in 2001, Tropical Storm Vamei, and the devastating flood of Jakarta in 2007.

The onset of the monsoon over the Maritime Continent tends to follow the heating maxima down Vietnam and the Malay Peninsula (September), to Sumatra, Borneo and the Philippines (October), to Java, Sulawesi (November), Irian Jaya and Northern Australia (December, January). However, the monsoon is not a simple response to heating but a more complex interaction topography, wind and sea, as demonstrated by its abrupt rather than gradual withdrawal from the region. The Australian monsoon or rainy season occurs in the austral summer when the monsoon trough develops over Northern Australia. Over three-quarters of annual rainfall in Northern Australia fall during this time.

Europe

The **European Monsoon** (more commonly known as the **Return of the Westerlies**) is the result of a resurgence of westerly winds from the Atlantic, where they become loaded with wind and rain. These Westerly winds are a common phenomenon during the European winter, but they ease as Spring approaches in late March and through April and May. The winds pick up again in June, which is why this phenomenon is also referred to as "the return of the westerlies".

The rain usually arrives in two waves, at the beginning of June and again in mid to late June. The European monsoon is not a monsoon in the traditional sense in that it doesn't meet all the requirements to be classified as such. Instead the Return of the Westerlies is more regarded as a conveyor belt that delivers a series of low pressure centres to Western Europe where they create unseasonable weather. These storms generally feature significantly lower than average temperatures, fierce rain or hail, thunder and strong winds.

The Return of the Westerlies affects Europe's Northern Atlantic coastline, more precisely Ireland, Great Britain, the Benelux countries, Western Germany, Northern France and parts of Scandinavia.

Wet season

Rainfall distribution by month in Cairns, Australia

The **wet season**, or **rainy season**, is the time of year, covering one or more months, when most of the average annual rainfall in a region falls. The term *green season* is also sometimes used as a euphemism by tourist authorities. Areas with wet seasons are dispersed across portions of the tropics and subtropics. Under the Koppen climate classification, for tropical climates, a wet season month is defined as a month where average precipitation is 60 millimetres (2.4 in) or more. In contrast to areas with savanna climates and monsoon regimes, mediterranean climates have wet winters and dry summers. Tropical rainforests technically do not have dry or wet seasons, since their rainfall is equally distributed through the year. Some areas with pronounced rainy seasons will see a break in rainfall mid-season when the intertropical convergence zone or monsoon trough move poleward of their location during the middle of the warm season.

When the wet season occurs during the warm season, or summer, precipitation falls mainly during the late afternoon and early evening hours. The wet season is a time when air quality improves, freshwater quality improves, and vegetation grows significantly, leading to crop yields late in the season. Floods cause rivers to overflow their banks, and some animals to retreat to higher ground. Soil nutrients diminish and erosion increases. The incidence of malaria increases in areas where the rainy season coincides with high temperatures. Animals have adaptation and survival strategies for the wetter regime. Unfortunately, the previous dry season leads to food shortages into the wet season, as the crops have yet to mature.

Character of the rainfall

Wet season storm at night in Darwin, Australia

The wet, or rainy, season covers one or more months when most of the average annual rainfall in a region falls. The term *green season* is also sometimes used by those in tourism. In areas where the heavy rainfall is associated with a wind shift, the wet season becomes known as the monsoon. Since rainfall during the wet season is predominantly due to daytime heating which leads to diurnal thunderstorm activity within a pre-existing moist airmass, rainfall is mainly focused during the late afternoon and early evening hours within savannah and monsoon regimes. This also leads to much of the total rainfall each day falling during the initial minutes of the downpour, before the storms mature into their stratiform stage. While most locations have only one wet season, areas of the tropics can experience two wet seasons as the monsoon trough, or Intertropical Convergence Zone, can pass over locations in the tropics twice per year. Since rain forests have equitable rainfall throughout the year, they do not technically have a wet season.

The situation is different for locations within the Mediterranean climate regime. In the western United States, during the cold season from September through May, extratropical cyclones from the Pacific ocean move inland into the region due to a southward migration of the jet stream during the cold season. This shift in the jet stream brings much of the annual precipitation to the region, and also brings the potential for heavy rain and strong low pressure systems. The peninsula of Italy experiences very similar weather to the western United States in this regard.

Areas impacted

Areas with a savanna climate in Sub-Saharan Africa, such as Ghana, Burkina Faso, Darfur, Eritrea, Ethiopia, and Botswana have a distinct rainy season. Also within the savannah climate regime, Florida and East Texas have a rainy season. Monsoon regions include southeast Asia (including Indonesia), northern sections of Australia's North, Polynesia, Central America, western and southern Mexico, the Desert Southwest of the United States, southern Guyana, portions of northeast Brazil.

Northern Guyana experiences two wet seasons: one in late spring and the other in early winter. In western Africa, there are two rainy seasons across southern sections with only

one across the north. Within the Mediterranean climate regime, the west coast of the United States and the Mediterranean coastline of Italy, Greece, and Turkey experience a wet season in the winter months. Similarly, the wet season in the Negev desert of Israel extends from October through May. At the boundary between the Mediterranean and monsoon climates lies the Sonoran desert, which receives the two rainy seasons associated with each climate regime.

Effects

Monsoon in the Vindhya mountain range, central India

In tropical areas, when the monsoon arrives daytime high temperatures drop and overnight low temperatures increase. During the wet season, a combination of heavy rainfall and in some areas, such as Hong Kong, a wind more off the ocean, significantly improve air quality. In Brazil, the wet season is correlated to weaker trade winds off the ocean. The pH level of water becomes more balanced due to the charging of local aquifers during the wet season. Water also softens, as dissolved materials lower in concentration during the rainy season. Erosion is also increased during rainy periods. Arroyos that are dry at other times of the year fill with runoff, in some cases with water as deep as 10 feet (3.0 m). Leaching of soils during periods of heavy rainfall depletes nutrients. The excessive runoff from land masses significantly impacts nearby ocean areas, which are more stratified, or less mixed, due to stronger surface currents forced by the heavy rainfall runoff.

Floods

Widespread flooding can occur if rainfall becomes excessive, which can lead to landslides and mudflows in mountainous areas. Such floods cause rivers to leave their banks and homes to go underwater. Floods can be exacerbated by fires during the previous dry season, which cause soils which are sandy or composed of loam to become hydrophobic, or repellent of water. There are various ways government organizations help their residents deal with wet season floods. Flood plain mapping is conducted, which helps diagnose what areas are more prone to flooding. Instructions on how to control erosion through outreach is also done via telephone or the internet.

Life adaptations

Equatorial savanna in the East Province of Cameroon

Humans

The wet season is the main period of vegetation growth within the Savanna climate regime. However, this also means that wet season is a time for food shortages before crops reach their full maturity. This causes seasonal weight changes for people in developing countries, with a drop occurring during the wet season until the time of the first harvest, when weights rebound. Malaria incidence increases during periods of high temperature and heavy rainfall.

Animals

Cows calve, or give birth, at the beginning of the wet season. The onset of the rainy season signals the departure of the Monarch butterfly from Mexico. Tropical species of butterflies show larger dot markings on their wings to fend off possible predators and are more active during the wet season than the dry season. Within the tropics and warmer areas of the subtropics, decreased salinity of near shore wetlands due to the rains causes an increase in crocodile nesting. Other species, such as the arroyo toad, spawn within the couple of months after the seasonal rains. Armadillos and rattlesnakes seek higher ground.