# Climate

Climate provides the broad framework for the exogenic geomorphological processes, soil formation, plant growth and land use potential and is of fundamental importance in helping to define the character of an ecozone. Solar radiation and the length of the growing season are of particular importance for vegetation because radiation is the energy source for photosynthesis and determines the growing season length and therefore also the annual primary production of the vegetation.

The mean values of climatic data have only a limited usefulness for interpreting the effects of climate in an area. At least as important are the data on extreme events and their frequency, for example, data on precipitation intensities, the frequencies of extended periods of drought, strong winds, periods of intense cold and freeze thaw cycles. Also the micro climatic conditions within a small area and even within a plant cover may differ considerably from the climate for the ecozone as a whole.

## 2.1 Solar radiation

*Global radiation* is defined as the radiation with a shortwave range from about 290 to 3,000 nm that reaches the earth's surface as direct or diffused radiation (Fig. 2.1). The *photosynthetic active radiation (PAR)*, the radiation usable by plants, lies between 400 and 700 nm, the range for visible light. About half the energy from global radiation lies within these wave lengths.

The peak mean monthly radiation is similar in all ecozones (Fig. 2.2). Differences in annual growing season totals are caused by variations in the duration of the peak radiation and by variations in the time span within which plants can make use of the radiation energy they receive which, in turn, depends on their requirements for moisture and heat.

The *length of day* and its pattern of change throughout the year also affects the duration of the daily radiation. Ecozones in the middle and high latitudes are characterized by long hours of daylight and warmth in summer and by cold and darkness for long periods in winter. The low latitudes, by contrast, show little or no seasonal radiation and thermal differences. Energy transfers at the surface are shown in Box 1.

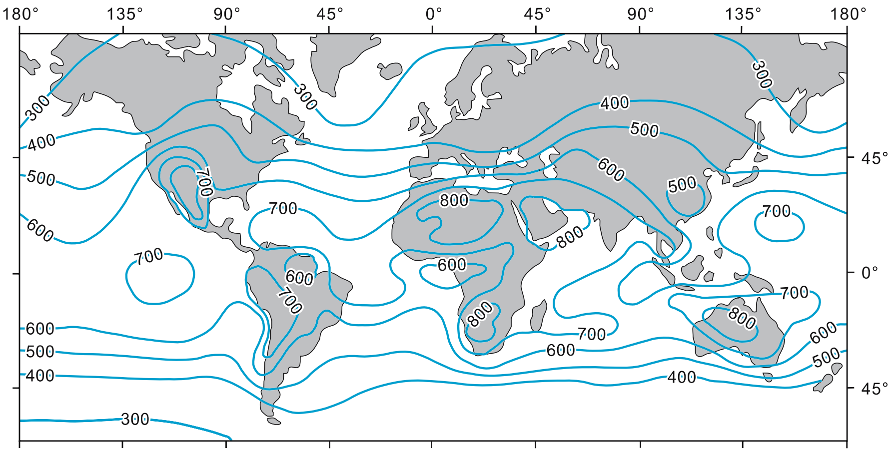


**Fig. 2.1.** Annual global radiation $10^8$ kJ ha$^{-1}$. Source: De Jong 1973. Based on the uptake of this radiation it is possible to approximate primary production in the individual ecozones (Tab. 5.2)

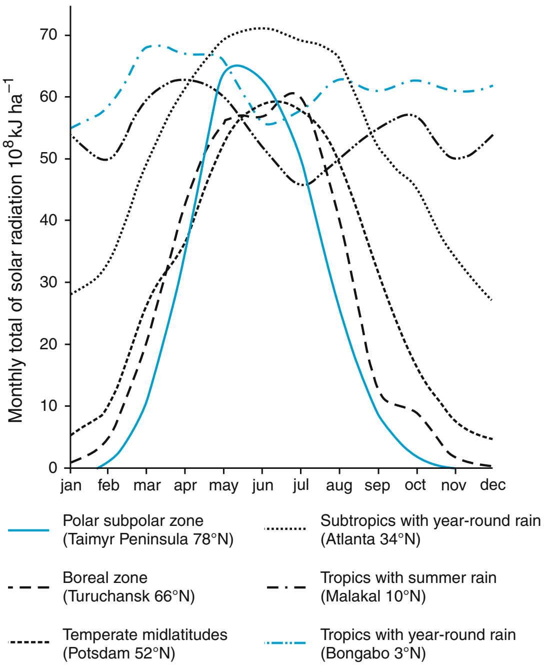


**Fig. 2.2.** Annual distribution of global radiation at weather stations in six ecozones

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## Simplified radiation (or energy) balance.[a]

$$(Q + q) \times (1 - \alpha) - A + G = LE + H$$

$(Q + q) \times (1 - \alpha) - A + G$ = radiation balance (net radiation):

- $Q$ = direct solar radiation
- $q$ = diffuse radiation (downscatter)
  - $Q + q$ = global radiation of which < 50% in photosynthetically active radiation (PAR)
- $\alpha$ = reflected radiation as % of global radiation = albedo
  - $(Q + q) \times (1 - \alpha)$ = absorbed short wave radiation (= net insolation)
- $A$ = outgoing radiation (longwave)
- $G$ = counter radiation from within atmosphere (longwave)
  - = temperature or heat radiation
  - $A - G$ = effective longwave outgoing radiation (= net outgoing radiation)

$LE$ = latent heat fluxes, LE is the transfer of heat energy connected with the state of water without changing the temperature, that is energy required for evaporation[b], melting[c], and/or release of heat by condensation and freezing (in immediate transition from solid to gaseous or solid state or vice versa: heat of sublimation)

$H$ = sensible heat fluxes $H$ is the temperature effective transfer of heat energy by molecular conduction at interfaces, includes heat transfers to and from the soil or snow cover to or from the atmosphere

[a] Lateral advective transport of energy, reflection of longwave counter radiation and photosynthetic energy fixed by plants are excluded. The latter ranges in terrestial areas from near zero in deserts to 0.8% in tropical rainforests of the global radiation.

[b] Energy required for evaporation or energy released by condensation of 1 g $H_2O$ at 20 °C and normal pressure at sea level is 2.45 kJ

[c] Energy required to melt 1 g of ice or the energy released by freezing of 1 g $H_2O$ is 0.17 kJ.

## 2.2 The growing season and conditions for plant growth

The *growing season* is defined as the annual total of months with a mean temperature of $t_{mon} \geq 5\,°C$ and precipitation ($p$) in millimeters of double the monthly mean value of the temperature in centigrade (C). This can be expressed as $p[mm] > 2t_{mon}[°C]$. Figure 2.1 shows the growing season in the ecozones derived from climatic diagrams in Walter and Lieth (1960–1967) and climatic tables in Müller (1996) and Landsberg (1970–86).

In the middle and high latitudes the plant growth is interrupted when the air temperature in winter falls low enough for one month or more to have a mean of $t_{mon} < 5\,°C$. In these areas a thermal seasonal climate dominates and the length of the cold period determines the length of the growing season. In tropical and subtropical ecozones temperatures do not fall low enough to limit growth, the annual range is in fact smaller than the diurnal range, but variability in the supply of moisture causes periods of drought which interrupt growth and affect the length of the growing season.

**Table 2.1.** Thermal and moisture conditions for growth in the ecozones

| **Ecozones** | **Growing season** Months with $p$(mm) > $2t_{mon}$(°C) and $t_{mon} \geq 5\,°C$ | **Months with** $t_{mon} \geq 10\,°C$ | $t_{mon} \geq 18\,°C$ | **Annual** precipitation **(mm)** |
|---|---|---|---|---|
| Polar<br>subpolar | 0–3<br>(4) | 0<br>(1) | – | < 250 |
| Boreal | 4–5<br>(3–6) | 2–3<br>(1–4) | 0<br>(1) | 250–500 |
| Temperate<br>midlatitudes | 6–12<br>(5) | 5–7<br>(4) | 1–3<br>0–5 | 500–1000 |
| Dry<br>midlatitudes | 0–4<br>(5) | 5–7 | ≤ 4<br>(5) | < 400<br>< 200 (250)<br>(summer) |
| Subtropics with<br>winter rain | 6–9<br>(5–10) | 8–12 | 4–6 | 500–1000 |
| Subtropics with<br>year-round rain | 12 | 8–12 | 4–7<br>(up to 12) | 1000–1500 |
| Dry tropics<br>and subtropics | 0–4<br>(5) | 12<br>(9–11) | 5–12 | < 300 polewards<br>< 500<br>equatorwards |
| Tropics with<br>summer rain | 6–9<br>(5) | – | 12 | 500–1500 |
| Tropics with<br>year-round rain | 12 | – | 12 | 2000–4000 |

Values in parenthesis are regional exceptions due to continental, maritime or latitudinal differences

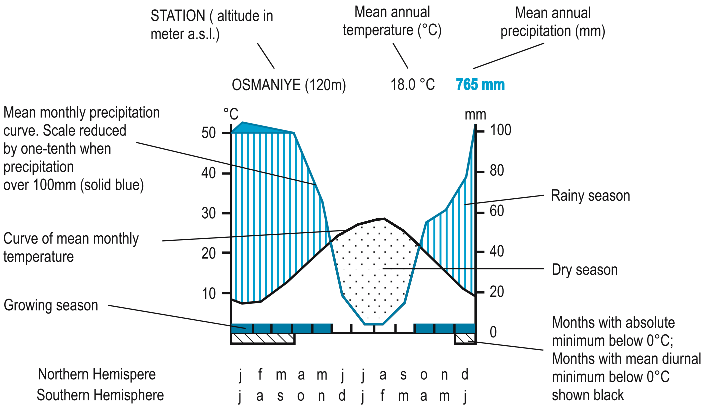


**Fig. 2.3.** Climatic diagram for a weather station in Turkey in the Subtropics with winter rain. The mean monthly precipitation in mm and the mean monthly temperature in °C are shown in a relationship of 1:2 i. e., 20 °C is equated with 40 mm precipitation. When the precipitation curve is above the temperature curve, the months are moist, when below, arid.

In addition to the length of the growing season, the available radiation energy and the level of the air temperature are significant for plant growth. The mean monthly temperature in the tropics is over 18 °C in all months and in the subtropics in at least four months. On the polar boundary of the Boreal zone, a mean of 10 °C is reached in only one month (Tab. 2.1).