

LOW-LATITUDE CLIMATE ZONES AND CLIMATE TYPES

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Summary

The description of low-latitude climates is given using the genetic Alisov classification as a framework. Three belts are differentiated in low latitudes on the basis of air mass analysis. The major climatic types - continental, oceanic and climates of western and eastern coasts - are considered in detail, with many examples.

1. Introduction

Our description of different climate types will be based on climate genesis in accordance with the Alisov classification. We shall also take notice of regional peculiarities and the place of climate zones in the Koeppen classification.

By climatic conditions of low inter-tropical latitudes we mean the climate of the zone limited by the winter location of the climatic polar front in the northern and southern hemispheres. This corresponds approximately to the latitudinal belt between 30° N and S.

The winter location of the polar front almost coincides with the boundaries of the east and west flows in the troposphere, and on that basis inter-tropical and extra-tropical latitudes are attributed to the regions with essentially different climatic conditions.

Equatorial and tropical air masses are formed within the limits of inter-tropical latitudes. Features of these masses define inter-tropical climates.

Equatorial and tropical air forms under the influence of the highest radiation balance in the world. It is natural that, as compared with other types of air masses, equatorial and tropical air masses are characterized by the highest temperatures.

Relatively small variations in radiation balance during the year, and also due to the change in latitude, are typical for the radiation regime of inter-tropical latitudes. This is one of the reasons that the annual air temperature range is very low in these latitudes. The annual range of precipitation is much more significant. In inter-tropical latitudes winter and summer are often called simply dry and rainy periods. As compared to annual mean temperatures, precipitation totals vary more in different locations.

According to the Alisov classification there are three climatic belts in inter-tropical latitudes: equatorial, subequatorial (the belt of equatorial monsoon) and tropical.

2. Equatorial belt

The equatorial climatic zone lies near the equator. It is not an unbroken belt around the globe, but actually consists of three separate parts (see *Genetic Classifications of Earth's Climate*, Figure 1).

The longest in latitudinal direction is the area in the eastern part of the Indian Ocean and western part of the Pacific Ocean. Its southern and northern boundaries lie at 5° to 7° of latitude in both hemispheres.

The next zone with equatorial climate spreads over the western part of equatorial Africa and the Gulf of Guinea, and is located mostly to the north of the equator, approximately up to 8°.

The third zone occupies the part of the South American continent close to the equator and adjacent to the eastern part of the Pacific Ocean.

In all of these three zones equatorial air masses are dominant both in winter and summer. Features of these air masses define equatorial climate, which corresponds to climate type Af (the climate of tropical forests) according to the Koeppen classification.

Formation of equatorial air from tropical air, brought to the equator by trade winds of the northern and southern hemispheres, occurs in the zone of equatorial depression with weak winds that facilitate transformation of air masses.

Radiation process has a dominant role in the genesis of equatorial climate. In equatorial latitudes radiation balance is about 3.5 GJ m^{-2} over continents and up to 4.5 to 5.0 GJ m^{-2} per year over the oceans. Large values of radiation balance and peculiarities of the surface layer (water and very moist land surface) in the equatorial zone determine the main features of equatorial air: unstable stratification and high content of heat and moisture throughout its thickness.

Equatorial regions receive almost equal insolation during the year. As a result, the annual temperature range is very low (4-5 °C), and in some regions only 1-2 °C. The

diurnal temperature range is higher than the annual range (it may be over 10 °C). This distinguishes the equatorial zone from the majority of the other world climatic zones.

To illustrate basic features of climate in different regions, so called climatic graphs are usually used. These graphs demonstrate the annual progression of long-term monthly mean values of meteorological variables. In the first place, such graphs give general annual temperature and precipitation patterns in the regions (Figures 1 to 4).

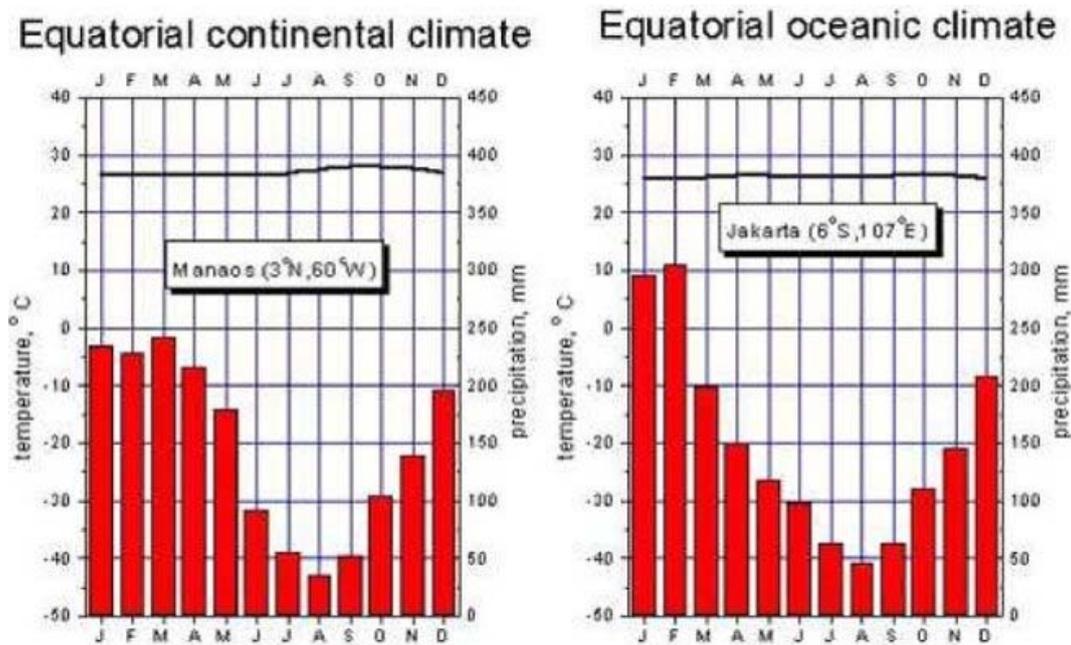


Figure 1. Monthly mean temperature and precipitation in the equatorial belt.

Thermal homogeneity of equatorial climate is apparent not only in the low variability of long-term monthly mean temperatures from month to month (Figure 1), but also in considerable stability of monthly means from year to year.

The equatorial belt as a whole is characterized by permanently high relative humidity. Even in daytime, when humidity decreases, relative humidity is not less than 70% as a rule. Annual range is very low; it rarely exceeds 10%.

The high content of moisture in equatorial air is conducive to cloud formation. Cloudiness probability, especially over the continents, is very high (Figure 2). The lower boundary of the clouds is usually at less than 1500 meters, and frequently at 300 to 1000 meters. The lower boundary of the clouds descends towards the equator. Cumulus clouds of fair weather prevail.

In this belt, the wind regime over the continents is characterized by prevalence of weak air currents, unstable in direction. Monthly mean temperatures are comparatively low in continental regions (24-28° C), due mainly to the great loss of heat by evaporation. Temperature maxima are not more than 30 to 40 °C, and minima not less than 12 to 16 °C. The annual temperature range does not fully correspond to annual ranges of the

sun's height and of solar energy income. It is influenced very much by cloudiness and precipitation regime. Temperature decline during the year corresponds to the period of precipitation and cloudiness increase, when direct insolation decreases and the loss of heat by evaporation increases.

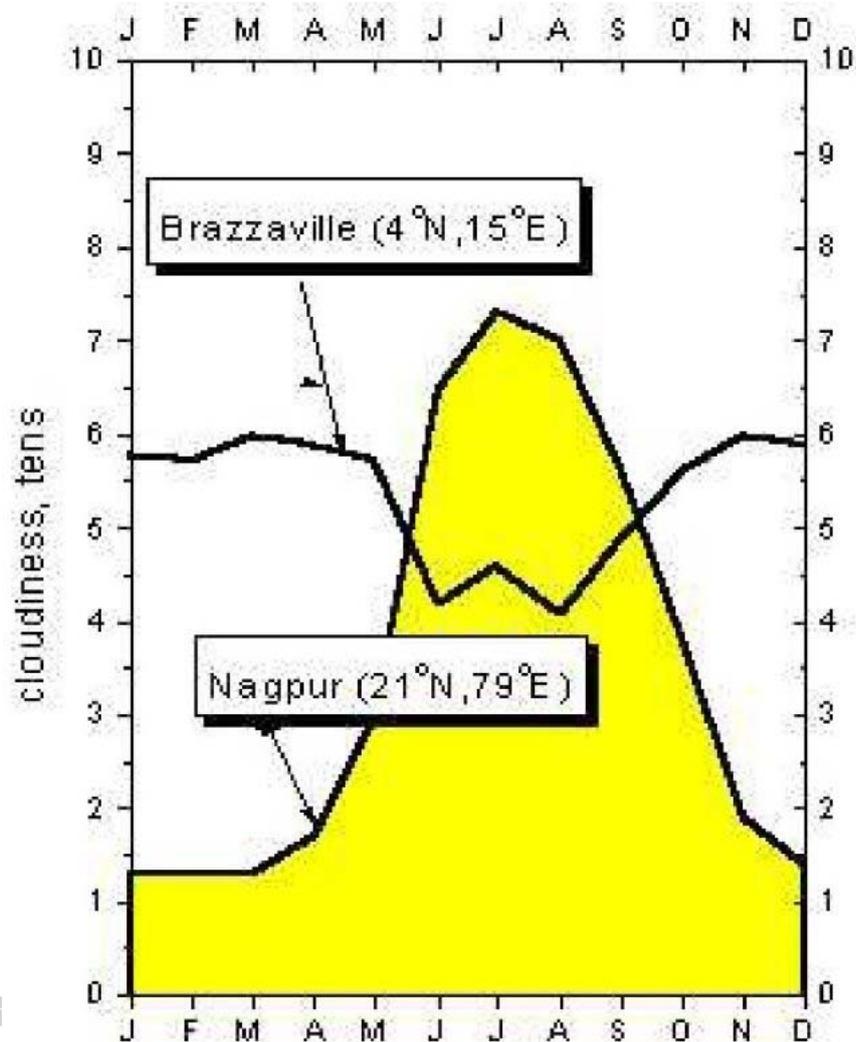


Figure 2. Monthly mean cloudiness for Brazzaville (equatorial belt) and Nagpur (subequatorial belt).

Most regions with equatorial climate receive from 1000 to 3000 mm of precipitation. Due to the local relief annual totals of precipitation are even higher in some locations. For example, in the west of Africa annual precipitation amount is more than 3000 mm.

Annual precipitation (and also relative humidity at many equatorial stations) has two maxima, which are generally associated with the days of equinox, and two minima, close to the solstices. Annual variations of precipitation and temperature are influenced by local conditions. Two minima and two maxima of cloudiness don't occur at every station, and the annual temperature range is small.

Precipitation at the equator falls mostly due to in-mass convective processes. With high air humidity (up to 30 g m^{-3}) and unstable stratification of atmosphere, increase in incoming solar radiation causes increase in convection, and, as a result, increase in convective cloudiness and precipitation.

Being mostly convective, precipitation falls mainly in the second part of the day in the form of showers and is accompanied by powerful thermal thunderstorms. As a rule, in the first half of a day the weather is fair with development of cumulus clouds. At night fogs may occur, as with high atmospheric humidity even a very small drop of temperature is enough for super-saturation. Fogs are also formed due to adiabatic cooling of air masses rising up slopes.

The equatorial zone has occasional brief invasions of air masses from middle latitudes when the weather has characteristics of the passage of cold fronts.

Climatic conditions in equatorial regions of America and Africa differ little from each other. Both are characterized by moderately hot and very humid climate with a lot of precipitation. As precipitation is higher than evaporation, considerable territories are marshy. Luxuriant rain forests grow around such areas. The equatorial type of climate is unfavorable for people because of high relative and absolute humidity, accompanied by high temperature and weak wind. The climate over the oceans in the equatorial belt does not differ much from that of the continents. The annual temperature range is even lower and the winds are a little bit stronger over the oceans.

In equatorial regions of the Indian and Pacific Oceans the difference between temperatures of the hottest and coolest months does not exceed $1.5 \text{ }^\circ\text{C}$ (Figure 1, right). Over the Atlantic Ocean this difference is a little higher (up to 3 to $4 \text{ }^\circ\text{C}$). The Atlantic equatorial zone is the least warm, because air masses on coming here meet the cold Benguela Current and thus cooled. In the Gulf of Guinea July temperatures are about $24 \text{ }^\circ\text{C}$, due to increase in inflow of relatively cold air masses from the south. In January temperature increases up to 26 to $27 \text{ }^\circ\text{C}$. The equatorial zone in the east of the Pacific Ocean has a little higher monthly mean temperature (temperature of the coolest month is $24.5 \text{ }^\circ\text{C}$). This also results from the cooling of southern hemisphere trade winds over the cold Peruvian current.

The Indian Ocean and the west of the Pacific have no cold currents at equatorial latitudes, so the equatorial zone of these regions is characterized by higher air temperature: from $27.5 \text{ }^\circ\text{C}$ to $29 \text{ }^\circ\text{C}$. Though intra-annual variations are insignificant, the winter-autumn period may be considered as relatively cool in northern regions. At this time of year, air masses that are brought by the southern hemisphere trade winds, form equatorial air. Spring has a temperature maximum resulting from an increase of incoming solar radiation and from weakening of southern hemisphere cold air advection. Since in equatorial oceanic zones air temperature is on an average $1 \text{ }^\circ\text{C}$ colder than water surface temperature, convection develops intensely and promotes cloudiness, high probabilities of showers and thunderstorms. Maximum precipitation falls in the summer-autumn period. Thunder rains over the oceans occur usually at night, as a result of rise in atmospheric instability during night hours. The annual precipitation total is about 2000 mm .

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Biographical Sketch

E.I. Khlebnikova was born in 1945 in Leningrad, USSR. In 1963 she entered Leningrad State University, Mathematics and Mechanics Faculty, and in 1968 graduated from the Dept. of Theory of Probabilities and Mathematical Statistics of this University. In 1968 she began to work at the Main Geophysical Observatory in the Dept. of Climatology and in 1975, after postgraduate studies in meteorology and climatology, received a scientific degree of Candidate in Math & Physics. Since 1998 she has been a leading scientist in the Dept. of Applied Climatology. Dr. Khlebnikova has thirty years of experience in climatology including research on statistical modeling of meteorological processes, methodology of climate monitoring and different aspects of statistical interpretation of meteorological and other observations. She has more than 50 publications in these fields.