# MIDDLE-LATITUDE CLIMATE ZONES AND CLIMATE TYPES

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## Contents



## Summary

The outstanding circulation and radiation conditions of middle-latitude climates are discussed. Climatic zones and types are differentiated on the basis of the genetic classification of the Russian scientist B.P. Alisov. In both subtropical and temperate belts four main climatic types are distinguished and considered in detail: continental, oceanic, west coast and east coast.



## 1. Introduction

Subtropical, and especially temperate latitudes, are characterized by large differences between winter and summer values of radiation balance. In the temperate latitudes winter radiation balance is negative, while in summer it is positive and comparatively high. Large seasonal differences in radiation balance cause significant seasonal variation in temperature.

Changes in radiation balance and in temperature with latitude are also sharper in the middle latitudes than in the tropics. This causes marked contrasts in the temperature of air masses which prevail in the subtropical and temperate latitudes. This in turn causes an intensive cyclonic activity at polar and arctic fronts. Cyclonic activity leads to the high variability of the weather in the middle latitudes.

## 2. Subtropical belt

The subtropical belt includes all the regions where polar air masses prevail in the cold half of the year, and tropical air masses prevail in the hot half of the year. Thus, the subtropical climate is, on the whole, distinguished by seasonal change of polar and tropical air and by cyclonic activity at the polar front, which divides these air masses.

Radiation balance is still positive all the year round in all regions with subtropical climate. Annual radiation balance is high and doesn't differ much from that in the tropical belt. Over the continents annual radiation balance is from 2.5 to 3.0 GJ $m^{-2}$. Over the oceans it is higher and amounts to 3.0 to 3.5 GJ $m^{-2}$. Thus, climatic conditions of the subtropical belt are formed under the influence of the considerable amount of heat, resulting from solar energy.

Over the oceans, and in the coastal regions, the type of atmospheric circulation is determined mainly by the intensity of the development of subtropical anticyclones. In the summer, when subtropical anticyclones strengthen and spread into the higher latitudes, weather conditions in the eastern part of the oceans and on the western coasts of the continents are determined by peculiarities of circulation at the eastern periphery of subtropical anticyclones. The most typical peculiarity that influences precipitation and cloudiness is stratification of atmosphere in the eastern parts of subtropical anticyclones. Marked temperature inversion takes place there. As a result, powerful convective cloudiness, causing rain, is infrequent.

Cyclonic activity develops commonly at higher latitudes and so frontal cloudiness and precipitation also occur very rarely. For the above-mentioned reasons, in the east of the oceans, and on the western coasts of the continents, the weather in the subtropical belt is usually almost cloudless. The western parts of the oceans and eastern coasts of the continents, however, experience quite different conditions in cloud formation. The incoming air from low latitudes prevails there. Unstable stratification of atmosphere has been traced up to considerable altitudes, so there are favorable conditions for the formation of convective clouds and precipitation. Moreover, with the activation of cyclones, eastern parts of the continents have frontal cloudiness and heavy precipitation in summer. Thus, in contrast to the western parts of the continents, it often rains in the east.

In winter, the western coasts of the continents are influenced by cyclonic activity at the polar front, resulting in cloudiness and precipitation. On the eastern coasts, the polar front, being influenced by the powerful current of mid-latitudinal continental air which forms in continental weather cyclones, relatively cold air spreads to the subtropical regions. With strong prevalence of anticyclonic activity, cloudiness and precipitation decrease sharply, as compared to summer.

In the subtropical belt, atmospheric circulation over the central parts of the continents is determined by the predominance of low-pressure areas in summer, and in winter – by the predominance of high-pressure areas (continental winter anticyclones). In summer, very dry tropical air forms in the baric depressions of thermal origin, and the weather is dry and hot. Under conditions of intensive anticyclones, the winter temperature regime

depends very much on radiation. Clouds and precipitation are very rare.

The climate of the subtropical belt is greatly influenced by mountainous terrain because the continental part of the subtropics, in many parts of the world, exceeds 1000 m in altitude. The greatest mountainous systems in the subtropics (Tibet, Pamir, Tien-Shan) influence both the climate of this belt and the climate of the adjacent regions.

On the basis of the above-mentioned characteristics of atmospheric circulation, and their associated climate-forming peculiarities, four types of climate may be distinguished in the subtropical belt: continental, oceanic, climate of the western coasts of the continents and climate of the eastern coasts of the continents.

It is difficult to give a uniform description of the variety of climate forming processes in this belt. The subtropical belt, as any other climatic zone, has regions where the climate is transitive from one climatic type to another, and regions with specific climatic features, which differ markedly from those associated with characteristics common to the subtropics.

### 2.1. Subtropical continental climate

Regions with continental subtropical climate can be found in the central parts of the continents, where air masses are fully transformed to the continental type.

As mentioned already, seasonal change of prevailing baric fields is typical for the central parts of the continents. Intensity and stability of summer depressions and winter anticyclones depend very much on the spatial expanse of the continent. As a result, only in the subtropics of Asia and North America are there regions with very distinct features of continental climate. The best known of these is the continental climate in Central Asia.

Continental climate in the subtropics is characterized by comparatively low monthly mean temperatures in winter and rather high summer temperatures. Mean temperature of the coldest month is a little lower than 0 °C, and in Central Asia it is even negative at some locations. Summer temperature is very high (25 to 35 °C). The annual march of temperature is characterized by rapid changes of monthly means from month to month in spring and in autumn.

The weather is mostly clear and cloudless in the continental subtropics. Both in summer and in winter there are no favorable conditions for cloud formation causing heavy precipitation. In summer, due to thermal homogeneity of air masses, circulating in low-pressure areas, frontal activity is weak, intra-mass convective cloudiness forms very rarely, because of the high level of condensation. In winter, clouds causing precipitation are infrequent as a result of the high recurrence of anticyclones and low air humidity.

The effect of the above-mentioned conditions is low precipitation on the plains. Annual precipitation totals do not exceed 100 to 300 mm. Mountain slopes receive higher amounts of precipitation. Most of the territory has precipitation maxima at the end of winter and in early spring.

As a result of high summer temperatures and insignificant precipitation, the prevailing landscape in continental climates is arid steppes and semi-deserts.

The continental climate in Asia has the most distinctive continental features. In the north of Iran, Afghanistan, the north-west of China, and in the southernmost parts of the Central Asian republics of the former USSR, practically complete transformation of air masses to the continental type occurs: in very stable anticyclones in winter, and in blurred areas of low pressure.

Windspeed maximum is observed in spring-summer months (Figure 1, top left). All the year round weak winds of unstable direction are dominant. But along with high frequency of weak winds, hurricane winds, accompanied by dust storms and tornadoes, occur. They are especially frequent in spring, and partially in summer, when instability of the atmosphere increases, resulting from fast heating of lower air layers. For example, the northwest of China has an average of 40 days of strong winds annually, and from April to July every fourth or fifth day is a storm.

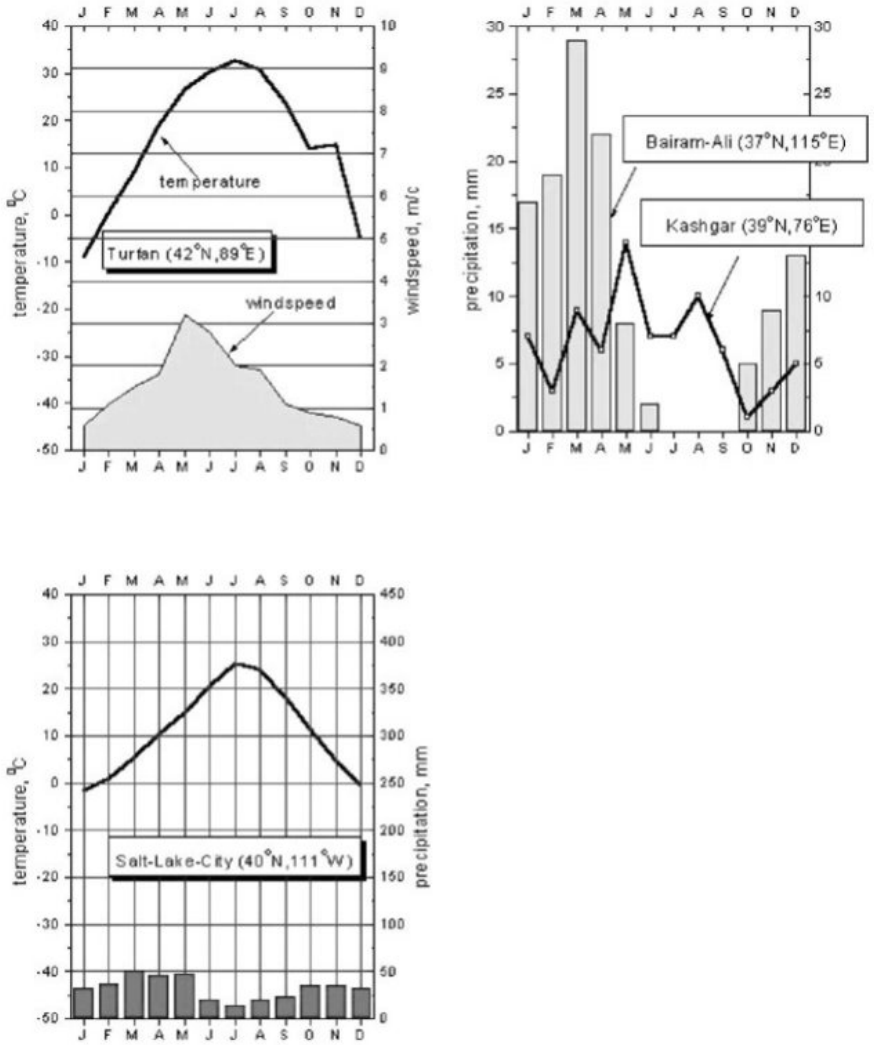


Figure 1. The subtropical continental climate. Monthly average characteristics for different areas: temperature and windspeed for Turfan, Asia (top left); precipitation for

Bairam-Ali and Kashgar, Asia (top right); temperature and precipitation for Salt-Lake City, North America (bottom).

Continental subtropics in Asia have very low (for this latitudinal zone) winter temperatures and very high summer temperatures. As a rule, the mean temperature of the coldest month is about 0 °C, while in the north-east of China it is even lower, about –5 °C to –10 °C (Figure 1). The mean temperature of the hottest month is about 23 to 25 °C. Daily maxima may exceed 40 °C.

Conditions for cloud formation to cause precipitation are unfavorable both during the cold half-year and the hot half-year; annual precipitation amounts are about 100 to 300 mm (in the north-west of China even less than 100 mm).

Precipitation maximum occurs in spring, when there are significant contrasts in temperature between mid-latitude air and continental tropical air, resulting in intensification of cyclonic activity (Figure 1, top right).

In winter precipitation falls mostly in the form of snow, but there is no stable snow cover in the plains, as a result of frequent thaws and evaporation of snow, which is very intensive here, because of lack of humidity.

Due to the lack of humidity, fog is rare in the plains and does not occur every year, but there is considerable recurrence of days with low visibility (2 to 4 km). This is because of frequent haze (dry fogs), especially in Central Asia, where haze occurs 100 to 200 times per year. That is, almost every second or third day visibility worsens.

Thunderstorms and humid fogs do not occur every year in the plains. In the mountains, thunderstorms do happen every year. Eastern regions with this climatic type have thunderstorms in the summer, and in western regions, in the winter.

In North America the regions with continental climate are northern Mexico, Nevada and the eastern part of the state of California. As in Asia, there are typical features of continental climate here: dry and hot summer and relatively cold winter (Figure 1, bottom). But since the North American continent is smaller than Asia, winter anticyclones are not stable enough, and this affects climatic elements, especially precipitation. Annual precipitation is 200 to 400 mm commonly, and that is more than in Central Asia. But it should be mentioned that North America as well as Asia has arid regions with desert landscape. The most arid area is along the lower parts of the Colorado River and the tablelands of South Nevada, where the annual precipitation amount is less than 100 mm. The extreme aridity of this region is influenced to a marked degree by orography. Mountain chains, stretching almost in the meridian direction, block these regions from the influence of the Pacific Ocean in the west and the Atlantic in the east.

Summer monthly mean temperatures are about 30 to 35 °C. In many regions air temperatures may exceed 50 °C. In Death Valley air temperature has reached 56.7 °C (10 July 1913).

The size of the South American continent is not great, and therefore there are no proper conditions for considerable cooling in winter and intensive heating in summer. This is why in the continental region of South America, the winter is not as cold and summers are not as hot, as continental Asia. Monthly temperature means in July are 12 to 18 °C; in January they are –24 to –28 °C. In addition, there is sufficient precipitation here. Arid regions occupy a small territory near the eastern slopes of the Andes and are mainly conditioned by orography.

### 2.2. Subtropical oceanic climate

In summer an anticyclonic weather regime prevails in the subtropical latitudes over the oceans. In winter cyclonic activity is observed at the polar front. In this climate, the thermal regimes of the eastern and western parts of the ocean of the northern hemisphere have essential differences. On the east of the oceans, where air transfer from higher latitudes prevails and cold sea currents pass, summer is relatively cool. Mean temperature of the hottest month is about 18 to 20 °C. In the western part of the oceans, the temperature is considerably higher, as the air masses travel considerable distances over the oceans in low latitudes, prior to reaching land. The mean temperature of the hottest month is about 22 to 26 °C. In the colder periods, temperature distribution in the east and the west of the oceans changes to the opposite, as compared to the summer months. That is, the eastern parts of the oceans become warmer. This is especially typical of the Atlantic and Pacific Oceans in the northern hemisphere. It is caused by frequent incoming air from the cooled continents of North America and Asia, to the western parts of the oceans in the colder half of the year.

Along with atmospheric circulation, sea currents, and the relationship between water surface temperature and adjacent air layers, also influence the distribution of cloudiness and precipitation. Over the oceans of the subtropics, there is a marked anticyclonic weather regime in summer and conditions for the formation of both frontal and in-mass cloudiness are unfavorable. Therefore in summer the weather is mostly cloudless and precipitation amounts are insignificant. In winter, along with the occurrence and intensity of cyclonic activity, recurring cloudy, rainy weather with frequent storms is common.

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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 studyies 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.