

Issues of Classification of Climate Maps

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Abstract:

This paper provides a comprehensive analysis of the content of climate maps, their geographical and scientific significance, as well as the criteria for their classification. The study examines the classification of climate maps according to the elements represented on them, methods of presentation, purpose of use, territorial coverage, content, scale, and other characteristics. In addition, the scientific and technical aspects of compiling climate maps are discussed, with particular emphasis on the possibilities of effectively communicating information to users through their appropriate classification.

Keywords: climate, moisture regime, thermal regime, wind regime, atmosphere, urbanization, classification, global climate change, climatology, analytical map, climate map, complex map, synthetic map, GIS

Introduction

Today, the relationship between society and nature is becoming increasingly complex. Population growth, urbanization, the expansion of agriculture and industry, as well as global climate change, make it increasingly important for humanity to study the environment in depth. In this process, climatology plays a particularly important role. One of the practical achievements of climatology is the compilation and analysis of climate maps. These maps make it possible to represent climatic conditions on the Earth's surface spatially.

They can be used to identify, compare, and forecast the distribution of temperature, precipitation, humidity, wind, and other climatic elements in different regions.

The content and forms of climate maps vary considerably, and their proper classification is of particular importance in scientific research and practical activities. For example, some maps show only one climatic element, such as mean annual temperature, while others cover several elements or entire climatic zones. Systematic study and classification of these differences makes it possible to use cartographic materials more effectively [6, 10].

Classification of climate maps refers to a system of maps arranged according to specific characteristics. Map classification is necessary for collecting and inventorying data, compiling lists and catalogues, organizing maps into a specific system, creating climate cartographic databases, and developing cartographic information systems. Such classification enables climate maps to be used effectively in scientific research, education, and planning. Therefore, the classification of climate maps is not only a scientifically based process of systematization, but also an important practical tool that facilitates the deeper study and application of climatic knowledge.

Studies and literature reviews show that a specific characteristic of a map is selected as the basis for classification, such as scale, subject matter, period of creation, publication period, and other characteristics. However, any classification must meet certain requirements. These include:

- maps should be differentiated according to significant characteristics;
- classification should be consistent, moving systematically from the general to the specific;
- only one basis for classification should be selected at each stage of division;
- classification should be complete, with its individual components covering the entire range of maps;
- classification should be open-ended, allowing newly emerging types of maps to be incorporated into the system [4, 5].

Review of Literature

Numerous scholars, including B.P. Alisov [1, 2], W. Köppen [16, 17], R. Geiger [17], I.P. Zaruskaya [14], A.I. Kaygorodov [15], I.N. Guseva [10, 11], L.S. Berg [3], O.A. Drozdov [13], A.I. Voeikov [9], A.M. Berlyant [4, 5], A.A. Grigoriev [12], M.I. Budyko [12], E.A. Bozhilina [6, 7], and others, have classified climate maps in their studies. These authors have grouped climate maps according to the following characteristics:

- maps of major climatic elements;
- maps of the indicators used;
- climate zoning maps;

- maps classified by scale.

Maps of major climatic elements are divided into the following categories:

- **maps of climate-forming factors:** direct, diffuse, and total solar radiation; radiation balance; frequency and movement of cyclones and anticyclones; and others;
- **thermal regime maps:** mean air temperature by year and month, annual and daily air temperature amplitudes, dates of transition of mean daily air temperature through 0°C, 5°C, 10°C, and 15°C in spring and autumn, average dates of the first and last frosts, formation and disappearance of stable snow cover, and others;
- **moisture regime maps:** precipitation amount, snow depth, and others;
- **wind regime maps;**
- **maps of atmospheric phenomena:** thunderstorms, frosty days, ice thickness, and others.

According to their types, climate maps are divided into analytical, synthetic, and complex maps. Analytical maps show individual climatic elements such as air temperature, wind direction, and precipitation. In analytical maps, two or three interrelated indicators, such as pressure and wind or air temperature and precipitation, can be represented separately without taking their relationships and interdependencies into account.

Complex maps show several climatic elements and several of their characteristics simultaneously or in relation to one another, while each element is represented using its own indicators. To compile analytical and complex maps, long-term average values, extreme values, and amplitudes of meteorological elements calculated for a year, season, month, or other period are used. Probabilistic indicators, recurrence, reliability, standard deviation, coefficient of variation, and other statistical indicators can also be applied [13, 14].

Climate zoning maps are referred to as synthetic maps. They provide a general representation of climate by taking into account its specific characteristics, relationships between individual climatic elements, and the ways in which these elements function within particular territories. Currently, a new type of map is being developed — synthetic-analytical maps, in which climatic zoning is supplemented by analytical indicators of the major climatic elements [6, 7, 10].

The principles for compiling climate zoning maps of individual regions are determined by the methodology of climate classification. The general approaches to climate zoning developed to date can be divided into four groups according to the zoning principle:

- division of climate based on genetic characteristics (B.P. Alisov);
- zoning based on one or several climatic indicators (classifications developed by W. Köppen, A. Zupan, A.A. Kaminsky, N.N. Ivanov, and others);
- zoning according to the landscape-geographical principle (L.S. Berg, V.V. Dokuchaev);

- classification based on river systems (A.I. Voeikov, A. Penck, M.I. Lvovich, and others).

Among applied climate maps are agroclimatic, bioclimatic, medical-climatic, construction and engineering, transport, aviation, and other maps.

Agroclimatic maps contain assessments of climatic resources for growing agricultural crops or comprehensive agroclimatic characteristics of territories for agricultural purposes. Applied climate maps are also developed for recreational and medical purposes.

The scale of climate maps is selected according to the required level of detail in representing the climate of a territory. Microclimate maps compiled at scales of 1:10,000, 1:25,000 (large-scale), and 1:100,000 (medium-scale) deserve particular attention. These maps make it possible to represent the characteristics of local microclimates, relief, the presence of water bodies, and vegetation cover. Such information is important for agriculture, construction, design surveys, and other fields. In selecting suitable sites for construction in urban areas, reconstructing and expanding existing buildings, territorial planning, and environmental assessment, scales of 1:200,000 and 1:500,000 are also used [6, 11, 13].

Research Methodology

The study employed historical, geographical comparison, cartographic, scientific observation, and other research methods.

Main Part

An analysis of the classification of climate maps presented above demonstrates that existing classifications do not fully correspond to the current scientific state of modern cartography, classification principles and forms, or the requirements of all users of maps and atlases.

The growing demand for climate maps, advances in cartographic publication technologies, and the need to comprehensively represent climatic indicators demonstrate the necessity of developing a new classification based on GIS (Geographic Information System) technologies, which differs significantly from the traditional classification of climate maps.

The proposed classification of climate maps according to scale, purpose of use, content, and territorial coverage will make it possible to develop climate maps and atlases for different regions in accordance with the requirements of cartographic support. It will also contribute to ensuring the reliability and completeness of information about climate resources represented on maps.

Classification of climate maps according to scale helps determine the territory and scale at which climatic information is presented. Map scale is particularly important in

determining the level of detail, the area covered, and the accuracy of analysis of climatic conditions.

Small-scale Climate Maps

Small-scale climate maps cover large territories such as the entire globe and continents. They represent climatic zones and regions or general global climatic characteristics. These maps are usually compiled at small scales, allowing large areas to be covered, although the level of detail is limited.

Small-scale climate maps are generally compiled at scales of 1:10,000,000 and smaller. Global climate maps showing the distribution of climatic zones across the Earth, including equatorial, tropical, temperate, and other zones; maps describing the general climatic characteristics of continents; and maps depicting global climate change or the impact of anthropogenic factors on climate are generally compiled at small scales.

Medium-scale Climate Maps

Medium-scale maps provide more detailed climatic information and cover parts of continents, countries, or large geographical regions. Compared with small-scale maps, medium-scale maps provide more information, including climatic characteristics at the level of individual countries or regions.

Medium-scale climate maps are compiled at scales of 1:1,000,000 and smaller. Maps of the climatic characteristics of countries or large regions, climatic zones of major geographical regions such as Central Asia and East Asia, and maps showing precipitation and temperature data are examples of medium-scale climate maps.

Large-scale Climate Maps

Large-scale maps provide detailed climatic characteristics and cover geographical areas, valleys, provinces, and large cities. They contain climatic indicators by month or season, as well as data from individual meteorological stations.

Large-scale climate maps are compiled at scales of 1:500,000 and larger. They represent climatic characteristics at the level of geographical regions, valleys, provinces, or cities, including precipitation, monthly air temperature, humidity, and other climatic information useful for agronomists, ecologists, and meteorologists. Maps showing microclimatic characteristics for agricultural purposes, such as crop planning, are also compiled at large scales.

Very Large-scale Climate Maps

Very large-scale maps provide highly detailed climatic information and cover individual parts of large cities, such as urban environments and microclimatic zones, as well as localized areas. They are particularly important for studying urban ecology and the impact of climate on buildings and infrastructure.

Very large-scale climate maps are compiled at scales of 1:50,000 and larger. They are widely used to represent the microclimate of large cities, including the spatial distribution of temperature and precipitation within urban areas, as well as for planning and developing green zones in urban environments.

Classification According to Purpose of Use

Classification of climate maps according to their purpose of use makes it possible to distinguish them based on their intended users and applications. The purpose of a map has a significant influence on its scale, content, and methods of design. According to their purpose, climate maps can be divided into educational maps, scientific reference maps, cartographic materials for practical use, cartographic materials for specialized research, and other types.

Educational Maps

Educational maps are published for use in educational institutions. They provide information on climatic zones and regions, climate types, and major climatic characteristics necessary for the comprehensive study of climatology and geography in accordance with educational curricula.

Popular Science and Public Information Maps

Popular science and public information climate maps are published to provide a deeper understanding of climatic processes and are intended for a broad audience, including students, researchers, and specialists in related fields. Compared with educational maps, they contain more detailed information, but are less specialized than scientific reference maps.

Such maps provide detailed information on climatic parameters, including seasonal temperature changes, precipitation, and characteristics of climate change in different regions. They may also present information on the dynamics of climate change and the risks associated with climatic phenomena.

Scientific Reference Maps

Scientific reference maps are more specialized and are developed on the basis of more detailed information than popular science maps. They are intended for researchers, climatologists, geographers, and ecologists. Such maps usually contain detailed data and graphical materials for scientific research.

They provide detailed climatic information, including seasonal variations in climate and various climatic parameters such as precipitation, temperature, atmospheric pressure, and humidity. They also include specialized information for climate analysis, maps for studying climate change, maps assessing the impact of climatic factors on ecosystems, and maps used for climate modelling and forecasting.

Planning and Applied Project Maps

Planning and applied project maps are designed for practical use in agriculture, ecology, urbanization, and other fields. They are often used for decision-making in natural resource management, agricultural planning, and risk assessment.

These maps are useful in addressing ecological, agricultural, and urban planning issues. In particular, they can be used to determine climatic suitability for agriculture, forecast risks such as droughts and floods, estimate energy costs for heating and cooling buildings, predict crop yields according to climatic conditions, develop green areas, urban greening strategies, and create agroclimatic zoning maps for agriculture.

Special-purpose Maps

Special-purpose maps are widely used in highly specialized research in climatology, ecology, agronomy, and other scientific fields. They contain information necessary for conducting research, modelling, and preventing or mitigating large-scale problems.

Examples include maps for studying climatic phenomena and climate change, ecosystem-related climate maps, climate model and forecast maps, maps assessing the impact of climate change on ecosystems, and maps for planning measures to reduce climate-related risks.

Documentary Maps

According to the objectivity and practical orientation of information, documentary maps are intended to provide a broad audience with information about current climate conditions, climate change, environmental conditions, and other ecological issues. They are widely used by mass media, public organizations, and educational projects.

Such maps primarily inform society about current climatic phenomena and trends. They may show current climate data or forecasts, including possible extreme weather events, levels of air and water pollution, and other environmental indicators. Examples include weather forecast maps, current extreme weather maps, storm and flood maps, and air pollution maps.

Classification According to Content

Classification of climate maps according to their content is based on the type of information represented. Depending on which climatic characteristics or phenomena are important for analysis, maps can be divided into different categories.

Temperature Maps

Temperature maps show temperature characteristics across territories, including mean annual temperatures, maximum and minimum temperatures, temperature ranges, and seasonal temperature variations.

Temperature maps are important for analysing temperature regimes, identifying zones with extreme temperatures, and assessing the impact of temperature on ecosystems and human activities. Examples include maps of mean annual temperature, temperature

amplitude maps representing the difference between maximum and minimum temperatures, and maps of temperature anomalies.

Precipitation Maps

Precipitation maps show the distribution of precipitation across a territory, including mean annual or monthly precipitation and seasonal patterns. They represent mean annual precipitation, seasonal distribution of precipitation, precipitation amounts in millimetres per square metre, types of precipitation such as rain, snow, and fog, and other characteristics.

These maps are used to analyse water resources, identify areas experiencing water scarcity, and forecast drought or flood risks. Examples include monthly precipitation maps and maps showing the distribution of precipitation in different climatic zones, such as tropical forests and deserts.

Atmospheric Pressure Maps

Atmospheric pressure maps show variations in atmospheric pressure at the Earth's surface depending on season, latitude, and elevation. They provide information on mean atmospheric pressure, the seasonal and spatial distribution of pressure, and areas of high and low pressure.

Atmospheric pressure maps are important for studying weather phenomena such as cyclones and anticyclones and for forecasting weather conditions. Examples include isobar maps, which show lines of equal atmospheric pressure, and pressure maps of climatic zones.

Wind Maps

Wind maps show wind directions and speeds, as well as their seasonal variations and regional characteristics. They provide detailed information on prevailing winds, including trade winds, monsoons, westerlies, and easterlies; wind speed; wind direction; and seasonal wind patterns.

These maps are particularly important for analysing climatic conditions such as drought and desertification, as well as for navigation and agricultural planning. Global wind maps, mean annual wind speed maps, seasonal wind direction maps, and maps showing the distribution of wind direction and intensity across different continents can be distinguished.

Climate Maps of Local Areas

Climate maps of local areas represent climatic conditions in smaller territories, cities, and their surroundings, including atmospheric pressure, precipitation, temperature, and other climatic indicators.

These maps generally cover cities, districts, or local geographical areas. Local climate maps are not limited to depicting general climatic phenomena; rather, they focus on

specific and complex climatic conditions within individual small areas and provide detailed information.

Such maps are particularly important for infrastructure development, agriculture, construction, transport systems, and the planning and implementation of other socio-economic activities.

Conclusion

Climate maps are important cartographic sources that spatially represent various climatic elements and phenomena in geographical space. They enable the analysis of climatic conditions on the Earth's surface, monitoring of climatic changes, and effective planning of natural resource use and environmental protection processes. These maps are widely used not only in scientific research but also in various practical sectors of the economy, including agriculture, urban planning, transport, healthcare, ecology, and tourism.

The classification of climate maps serves to scientifically systematize maps and clearly define their types, functions, and methods of representation. Classification criteria are based on the climatic elements represented, cartographic methods, and the spatial scale of the mapped territory. These criteria help users fully understand the content of maps, analyse them, and present information in a form appropriate for different user groups.

In conclusion, the proper classification of climate maps not only facilitates their effective analysis but also strengthens the interrelationships among climatology, cartography, and physical geography. In the future, interactive forms of climate maps, their integration into digital platforms, and real-time updating will contribute to more reliable climate monitoring and forecasting.

Therefore, the comprehensive study of climate map types, methods of their compilation, and classification systems is of significant importance for modern science and practical activities.

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