

Geographical analysis of territory in order to study of atmospheric «thermals» (scientific and applied aspects)

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SUMMARY

"Thermals" were discovered when radar technology was used in atmospheric research. In 1940, radio echoes (called angel echoes - AE) were recorded from visually invisible objects in clear weather. They are complete because they differ in the stability (coherence) of the signal and the absence of its fluctuations. It is believed that thermals cause convective thermal inhomogeneities in the atmosphere. Thermals are referred to the main structural elements of the lower layer of the troposphere, where they perform the function of material carriers of heat and moisture coming from the earth's surface. The main areas of study of thermals today are their physical nature and external factors of formation. Among them, geographical factors are important and little studied. For the first time on a broad geographical basis AE thermals were studied in 80-90 years of the 20th century at the Faculty of Geography of Taras Shevchenko National University of Kyiv within the research landfill on the South-Eastern coast of Crimea. Among the issues studied: the spatial-vertical structure of the driving layer of the atmosphere, thermal inhomogeneities of the underlying water surface, adjacent to the water physical earth's surface with its relief and rocks that make it up, soil and vegetation, anthropogenic and man-made objects on it. The zoning of the adjacent land was carried out: substantiated natural features, described morphology, morphometry, landscape and plant features, rocks of geological formations on the earth's surface, studied modern exogenous and endogenous processes, anthropogenic and man-made buildings. They create an integrated result of the removal of air flows from land to water. The conducted researches fill the problem of atmospheric thermals with concrete data.



Introduction

The existence of atmospheric "thermals" was allowed even before they were visualized. In meteorology and geography, they are envisaged theoretically as mandatory elements in circular planetary systems (water, etc.). The problem of "thermals" became practical when radar technology was used for observations in the atmosphere. Since the 40s of the 20th century, radar systems (RS) are created in the military sphere (air defense), for protection of sea borders, in civil aviation. Thanks to radar, for the first time the phenomenon of radio echo from visually invisible objects in *clear weather* was recorded, which was called *angel echo* (AE). In the following years, radio echo observations in a clean atmosphere became more frequent. For most of them, such an important feature as the absence of fluctuations and the stability (coherence) of the signal was found, which indicates that they are *complete formations*. Nowadays, AE are called radio echoes, which cannot be reliably explained and whose causes can be different. In particular, for some time it was believed that the reflections are created by insects, birds, aerosols, and other accidental causes. But systematic observations confirm this only in part. Another explanation, first expressed by A. Friend, that there are zones in the atmosphere with significant gradients of temperature and humidity, which are recorded on radar screens as AE, is more recognized. One of the main explanations of AE: they are caused by *convection thermal inhomogeneities* (KTI) or *thermals*. Currently, thermals are among the main structural elements of the lower atmosphere. Thermals here perform the function of material carriers of heat and moisture coming from the earth's surface in the ascending branch of the planetary cycle (water, etc.). Currently, thermals are among the main structural elements of the lower atmosphere. Thermals here perform the function of material carriers of heat and moisture coming from the earth's surface in the ascending branch of the planetary cycle (water, etc.). It is now established that in a saturated humid atmosphere, thermals are involved in the formation of clouds, which carry natural and man-made aerosols. The study of parameters, morphology, dynamics of AE thermals explains some fundamental issues of atmospheric physics, applied - the propagation of radio waves in the atmosphere, environmental monitoring, safety of aircraft. Nowadays, the main directions of studying thermals: their physical nature; external factors of formation, in particular little studied geographical; scientific significance, practical use.

Method and Theory

Geographical analysis of factors of formation, internal structure and dynamics of atmospheric thermals the following theories and methods were used:

- general systems theory allows you to identify integrative and study the relationships between them;
- the concept of the geographical shell allows you to systematically integrate elements of the atmosphere, earth's surface, technosphere;
- geographical analysis of natural and man-made elements of the physical earth's surface; geomorphosystem analysis of the earth's surface;
- analysis of physical indicators of the atmosphere (temperature, pressure, humidity, wind, albedo), obtained from own observations and involved;
- analysis of observations of shore radars (village of Kurortne, ARC)
- cartographic method - creation of special geographical maps, map-schemes, diagrams;

Examples

The foundations of radar at the level of theory and practice were laid by scientists and inventors D. Maxwell, G. Hertz, G. Marconi, N. Tesla etc. Since the 40s of the 20th century in the USA, the USSR, Germany, France, and Japan radar devices are being developed and radar surveillance systems (RS) are being created in various fields (military air defense, maritime border protection, civil aviation). Thanks to them, radio echoes from the *clear sky* were recorded, called *angel echo* (AE). The works of A. Friend, A. Planck, Richardson, Elder, Garner, D. Atlas, Line and Milous, Roelofs,



Button, Hay and Ryde, R. Scorer and Ludlam, Warner and Telford are devoted to the study of various mostly physical aspects of AE and thermals.

Results

Nowadays, the physical nature and internal structure of thermals are much more studied and much less the external factors that influenced their occurrence and which can be generalized as a geographical factor.

Analysis of open publications allows us to conclude that AE has not been studied on a broad geographical basis. Therefore, it should be of interest to study AE thermals, which were conducted in the 80-90 years of the 20th century at the Faculty of Geography (together with the departments of Geomorphology and meteorology and climatology) of the Taras Shevchenko National University of Kyiv. Their customer was the defense complex of the USSR. After the collapse of the USSR, they were suspended. (Kobzisty et al., 1995; Kobzisty and Komliev, 2001; Komliev, 2017a, 2017b, 2018, 2019).

These studies were conducted on the Black Sea coast of Crimea at a research site within the coastal zone of the South-Eastern coast of Crimea between the cities of Sudak and Feodosia, where there was all the necessary infrastructure for complex stationary and field work. The aim of this work was to investigate the spatial-vertical structure of the driving layer of the atmosphere, thermal inhomogeneities of the underlying water surface, the physical earth surface adjacent to the water area with its relief, composed of various rocks, covered with soil and vegetation, complicated by anthropogenic and man-made superstructure. To perform the work it was necessary to: 1) study the meteorological and actinometric parameters of the atmosphere, favorable for the emergence of objects AE - thermals; 2) to check the reflective characteristics of surfaces, their connection with the inhomogeneities of the atmosphere through the study of meteorological indicators; 3) to investigate the spatio-temporal dynamics of the temperature field of the water surface of the water area within the study area; 4) to carry out zoning of the adjacent land: to substantiate natural allocations, to describe morphology, morphometry, landscape and vegetative features, rocks of the geological formations exposed here on a terrestrial surface, modern exogenous and endogenous processes, anthropogenic and technogenic buildings influencing wine air from land to water.

Thus, the following provisions were taken into account when performing this work: the main reason for the appearance of AE in the drive layer of the troposphere in the coastal zones is convective thermal inhomogeneities (thermals); breeze circulation, which is developed here, is a factor that enhances the formation of thermals; geographical factor of land adjacent to the water at the local and regional levels, which is manifested through elements of natural-territorial complexes (NTC), which are part of the Earth's crust, the largest NTC on the planet, where systemic links between atmosphere, hydrosphere, lithosphere, biosphere also the anthroposphere, especially such an important part of it as the technosphere. The work consists of 2 complementary parts: 1) meteorological, the content of which was to obtain data devices, their analysis, correction (synchronization) with the data of the radar located here, which covers the sea within the landfill, the establishment of space-time dynamics of AE thermals; 2) geographical, the content of which was to study the elements (components) of the natural complex of the adjacent land and assess their impact on the formation of thermals.

In our opinion, the conducted researches fill the problem of atmospheric *thermals* with concrete data. According to the results of *meteorological* studies, the following results were obtained. In the drive layer of the troposphere within the research site during the passage of electromagnetic waves there are reflections of the radio signal (radio echo), which are identified as angel echo (AE). Analysis of previous results and published data confirm in their dynamics a clear annual and daily course.

The drive layer of the troposphere is dominated by spot lights on the radar screen, which have spatial and temporal features. Most often AE are installed in clear weather 10-15 km from the water's edge. AEs develop over the water surface in whole families, and in the form of single targets. AEs are detected at different values of the sensitivity of the radar receiver. This indicates their internal morphological heterogeneity.



The appearance and dynamics of AE is clearly consistent with the diurnal features of the developed here breeze circulation, which causes convection processes, the appearance of thermals and AE from them. Most AE thermals are observed directly near the water surface, but some formations here reach a height of 200 m. In the daily course of AE, the maximum of their development occurs at 18 hours.

In the end, we note some differences in the thermal regime of the atmosphere above the earth's surface and in the drive layer: in the morning over the water is an unstable state, which is favorable for the development of convection and the formation of thermals. From 18 o'clock the temperature begins to decrease sharply, the thermal regime of the water surface becomes quite inhomogeneous, and the daily course of its temperature has little contrast, with a maximum of oscillations at 18 o'clock.

The humidity regime above the water surface is characterized by a significant saturation of water vapor, especially at the end of the day, approaching full saturation.

On days with intense downward movements in the drive and surface layers AE does not develop. AE do not develop at wind speeds greater than 7 m/s.

Geographical analysis of territories usually begins with the most conservative element of TTC (landscape) - *relief*. Other elements (components) are largely determined by them - soils, vegetation, modern exogenous processes. Relief is an important planetary climatic factor that manifests itself at both the regional and local levels. In the physical and geographical works of previous years, the term *orography* was often used as a synonym instead of *relief*. "Orography" is used in the original sense as an "obstacle to the movement of air masses", "determines the movement of air masses" and so on. Currently, the leading morphodynamic paradigm in geomorphology is accompanied by a tendency to detail the study of relief. In studies of AE and thermals, "orography" is used traditionally, but here it is necessary to take into account the small details of the terrain, to use the considerable experience of studying which is accumulated within the morphodynamic concept.

The general orographic features of coastal land, which form the flow of air masses from land to sea and affect the distribution in the driving layer of the troposphere of the zone of high moisture concentration and temperature contrasts. A more detailed analysis of the relief shows that the greatest climatic value is played by the negative valleys of the form, which form the trajectories of air masses in both the surface and in the drive layers of the coastal troposphere. Our analysis of orography and some details of the relief showed that the greatest climatic value is played by the negative valleys of the form, which form the trajectories of air masses in both the surface and drive layers of the coastal troposphere. It was found that the concentration of jets and air masses, as well as the time of change of directions of the breeze "rings" are influenced by the following properties of the earth's surface: symmetry of the structure of the coast as a whole and individual valley (basin) systems; area and shape of the pool; horizontal and vertical dismemberment of land by valley forms; the number and density of order-forming points of the valley grid in the basins; morphology and morphometry of valley slopes; exposition of slopes in pools; morphology of the bottom of the valleys; orographic isolation of pools.

Climatic factors of relief create a certain integral effect, which is manifested in the formation, concentration, power of laminar air flows from land to water. This action can occur in both directions. The structure of the land surface relief is differentiated by a single static thermobaric field of the atmosphere, transformed into a dynamic system. It highlights specific pools that differ in their ability to carry laminar flows.

Within the studied landfill, occupied by the objects of the resort recreational complex, the formation of laminar flows is also influenced by the numerous anthropogenic and man-made objects developed here (buildings, roads, overpasses, fortifications, piers, greenhouses, gardens). They significantly affect these flows: strengthen them (tunnels, overpasses) or, conversely, weaken.

In the future, it is necessary to deepen the study of geographical factors in the formation of thermals, and the indication of AE to carry out by analyzing the dynamics of each individual formation.

Conclusions

"Thermals" were discovered when radar technology was used in atmospheric research. In 1940, radio echoes (called angel echoes - AE) were recorded from visually invisible objects in clear weather.



They are complete because they differ in the stability (coherence) of the signal and the absence of its fluctuations. It is believed that thermals cause convective thermal inhomogeneities in the atmosphere. Thermals are referred to the main structural elements of the lower layer of the troposphere, where they perform the function of material carriers of heat and moisture coming from the earth's surface. Thermals are involved in the formation of clouds, which carry at a distance natural and man-made aerosols. Thermals make it possible to solve fundamental questions of the physics of the atmosphere, to study the propagation of radio waves in the atmosphere, to ensure ecological monitoring, and the safety of the movement of aircraft. The main areas of study of thermals today are their physical nature and external factors of formation. Among them, geographical factors are important and little studied. For the first time on a broad geographical basis AE thermals were studied in 80-90 years of the 20th century. At the Faculty of Geography of Taras Shevchenko National University of Kyiv within the research landfill on the South-Eastern coast of Crimea. Among the issues studied: the spatial-vertical structure of the driving layer of the atmosphere, thermal inhomogeneities of the underlying water surface, adjacent to the water physical earth's surface with its relief and rocks that make it up, soil and vegetation, anthropogenic and man-made objects on it . In the course of the work, meteorological weather parameters were found to be favorable for the occurrence of thermals; the reflective characteristics of surfaces and their connection with atmospheric inhomogeneities, spatio-temporal dynamics of the temperature field of the water surface of the water area were studied. The zoning of the adjacent land was carried out: substantiated natural features, described morphology, morphometry, landscape and plant features, rocks of geological formations on the earth's surface, studied modern exogenous and endogenous processes, anthropogenic and man-made buildings. They create an integrated result of the removal of air flows from land to water. The conducted researches fill the problem of atmospheric thermals with concrete data.

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