Brief information about the project

Name of the project	AP14871838 «Study of the wave climate of the water bodies of Kazakhstan using the satellite altimetry data» (0122PK00745)
Relevance	The study of the wave climate of various water bodies is an urgent task, because gives an understanding of what changes the wave parameters undergo over a long period of time, which makes it possible to predict construction projects on the coast, prevent erosional changes in beaches and ensure the safety of navigation. In this regard, there is a need to study the wave climate. In addition to instrumental measurements of current velocities and the results of mathematical modeling, recently, Earth remote sensing data have been actively used to solve this problem. Satellite altimetry is the measurement of a satellite's height relative to the Earth's surface from the time of travel of the signal sent and received after reflection from the surface by the satellite. Altimetry data make it possible to study the wave height and wind speed, seasonal, interannual changes in the reservoir or its individual parts.
Purpose	Construction of the wave climate of the Caspian Sea, as well as lakes Alakol and Balkhash, using satellite altimetry data and the study of its influence on the state of the coast. Development of recommendations for the management of coastal zones of target water bodies, taking into account the wave climate.
Objectives	1. Analysis of existing modern methods applicable to the study of water bodies using satellite altimetry. Extraction of altimetry data for the Caspian Sea, Balkhash and Alakol lakes (data filtering). Measurable result: filtered data. Role: preparation of the base for the development of an algorithm for extracting satellite altimetry data. 2. Development of algorithms for filtering satellite altimetry data: elimination of the influence of the coast, small islands, drifting or fast ice. Measurable result: data filtering algorithm. Role: preparation of images with removed elements. 3. Development of methods for determining the typical and extreme wave heights from the satellite altimetry database. Measurable result: a method for determining typical and extreme wave heights. Role: construction of typical and extreme wave heights by seasons and basins of the Caspian Sea, Balkhash and Alakol lakes. 4. Creation of a model of wave properties in the studied regions. Measurable result: model of wave properties in the studied regions. Role: preparation of a simulation model of the upwelling process. 5. Filtering and processing cards using the SNAP program; study of the various phases of the upwelling process. Measurable result: extracted cards. Role: preparation of graphs of the distribution of heat flow over the surface of the reservoir. 6. Comparative analysis of satellite and local data. Modeling the upwelling process in the Matlab environment. Measurable result: collected local data. Role: preparation of a simulation model of the upwelling process 7. Development of a methodology for modeling the spread of pollution during accidents. Measurable Outcome: Pollution Spreading Technique. Role: preparation of a simulation model for the spread of pollution in water and coastal

	pollution processes, taking into account the wave climate of the target water bodies. 8. Study of the influence of the wave climate on the state of reservoirs and coasts. Development of recommendations for coastal management (including constructed structures) taking into account the wave climate. Measurable result: recommendations for bank management. Role: preparation of a simulation model of the wave climate of target water bodies, taking into account satellite altimetry data, recommendations were developed for coastal development, taking into account the wave climate.
Expected and achieved results	*Expected results:* algorithms for extracting satellite altimetry data, excluding the overlay of the mainland, small islands, drifting or landfast ice; methodology for determining typical and extreme wave heights by seasons and basins; model of wave properties in the studied regions; technology for comparing satellite data with local data; general features of the wave climate of target water bodies; simulation models of the upwelling process, the spread of pollution in the reservoir and the processes of pollution of coastal areas; simulation model of the wave climate of target water bodies, taking into account satellite altimetry data; recommendations for the management of coastal zones of target water bodies, taking into account the wave climate. *Achieved results:* The scientific novelty of the project lies in the use of satellite altimetry data. The research team extracted altimetric data for the reservoirs of Kazakhstan: the Caspian Sea, Lakes Balkhash and Alakol. Before extracting these data, the following checks were performed: availability of data on the Caspian Sea, Balkhash and Alakol lakes, coverage of the area under consideration, availability of wave height data, correlation coefficient, etc. from GEOSAT, ERS-1, ERS -2, TOPEX, POSEIDON, GFO-1, JASON-1, ENVISAT-1, JASON satellites-2, GRYOSAT, SARAL, JASON-3, S3A from 1990 to the current time. All these data were obtained from the RADS database (Radar Altimeter Database System http://rads.tudelft.nl/rads/rads.shtml). The satellite altimeter receives data regardless of weather conditions, time of year and time of day. During the project, algorithms for extracting and filtering satellite altimetry data for target reservoirs were developed in order to exclude data elements that may be distorted by the presence of shore, small islands, drifting or soldered ice. Regarding this, all research in the project is based on satellite altimetry data made during the implementation of various missions over the past 2-3 decades. These data are first analyzed with respect to the possible overlaying of earth and/or ice. Further, data that correspond to low wave conditions for the Caspian Sea are excluded (coefficient with backscattering coefficients >13.5 kdb) and, conversely, data with low waves for Lakes Balkhash and Alakol (backscattering coefficients <13.5 kdb) are left, since the climatic features of the Caspian Sea, Lakes Balkhash and Alakol are different. The remaining set of data will be analyzed in terms of possible offsets, time drift, and heterogeneous coverage. Methods for determining typical and extreme wave heights using altimetric data are investigated. Altimetric data from GEOSAT, ERS-1, ERS-2, TOPEX, POSEIDON, GFO-1, JASON-1, ENVISAT-1, JASON-2, GRYOSAT, SARAL, JASON-3, S3A satellites were extracted from

	the RADS database, broken down by seasons and basins for 1991-2021 and local data received from Kazhydromet for Balkhash, Algazy, Saryshagan stations and from the site http://ww38.esimo.com / for Derbent, Izberg, Makhachkala stations. Using these data, namely data on intersections and slopes, the heights of typical and extreme waves of the Caspian Sea, Lakes Balkhash and Alakol were obtained, which are graphically depicted. The average significant wave heights of the Caspian Sea by seasons and basins, lakes Balkhash and Alakol by seasons were also obtained. A pairwise analysis of data from different satellites was carried out. The correction of satellite data is the reliability of the results obtained, but in order to substantiate these results of the wave climate, they were compared with local data in the area under consideration (pairwise analysis). On the website of the Center for Hydrometeorological Research of the Russian Federation (www.esimo.ru) monthly averaged wave heights of 13 stations with observations for 1977-1991 and three stations with measurements for 1977-2021 became available. This dataset, based on visual observations, allowed us to create methods for comparing the results obtained with ground-based measurements. The reproducibility of the results obtained is ensured by the correct application of these methods. In the Caspian Sea, the upwelling process is most clearly expressed near the coast of the Middle Caspian Sea. The main reason for this process is the constant north and northeast winds. We have studied the upwelling process in the period from June to August for 2017-2023. The daily rate of temperature change was calculated using SST (sea surface temperature) data obtained from the Earth Observation Satellite System (EOS). When modeling the upwelling process in the Matlab environment, 2 phases were determined: the active and the relaxation phase. Adequate information on wind data is needed to account for atmospheric effects. For this purpose, we used local wind speed and direction data measured at Fort Shevchenko, Aktau, Kuryk and Fetisovo stations. As a result, it was revealed that upwelling begins in June, but reaches its greatest intensity in July and August. The wind speed and direction were visualized using the Matlab application package. In the same way, the upwelling process is modeled for lakes Balkhash and Alakol.
Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles	1. Rakisheva Zaure, Associate Professor, Hirsch Index – 2, Researcher ID: N-4332-2014, ORCID: 0000-0003-2745-7775 , https://www.scopus.com/authid/detail.uri?authorId=56449239900 2. Soomere Tarmo, Professor of Coastal Engineering, Hirsch Index – 35, ORCID: 0000-0003-2900-0840 https://www.scopus.com/authid/detail.uri?authorId=6602843214 3. Kalieva Nazgul, PhD, Hirsch Index – 0, ORCID: 0000-0002-8629-0023 https://www.scopus.com/authid/detail.uri?authorId=57191632932 4. Sakhayeva Aigerim, Master, Hirsch Index – 1, ORCID: 0009-0003-6240-6938 https://www.scopus.com/authid/detail.uri?authorId=58141961800 5. Nogaibayeva Makpal, Master, Hirsch Index – 0, ORCID: 0000-0003-1205-2564 https://www.scopus.com/authid/detail.uri?authorId=57202786707 6. Mayemerova Gulnara, PhD, Hirsch Index – 4, ORCID: 0000-0003-2878-580X

	https://www.scopus.com/authid/detail.uri?authorId=55899282100 7. Lyazat Zhanbolat, Master, Hirsch Index – 0, ORCID: 0000-0002-8022-6143, Researcher ID Web of Science P-5622-2017 8. Kussembayeva Kuanysh, Master, Hirsch Index – 1, ORCID: 0009-0006-6651-0291 https://www.scopus.com/authid/detail.uri?authorId=57212082055
List of publications with links to them	D. Nurbekuly, M.K. Beisembekova, G.M. Mayemerova, Z.B. Rakisheva. Modeling of changes in the volume of water of Lake Alakol using polynomial regression // Bulletin of KazNPU named after Abaya, series "Physical and mathematical sciences". – 2023. – vol. 84, issue 4. – pp. 101-108. https://bulletin-phmath.kaznpu.kz/index.php/ped/article/view/1720/915
Patents	-