E3S Web of Conferences **386**, 06009 (2023) https://doi.org/10.1051/e3sconf/202338606009
GISCA 2022 and GI 2022

Some issues of geoinformatics support for agroclimatic zoning in the South Aral Sea basin

Mamanbek Reimov[1], *Nizamatdin* Mamutov[2], *Polat* Reymov[2*], *Viktor* Statov[2], *Yakhshimurad* Khudaybergenov[2], *Oralkhan* Sultashova[2], and *Bibigul* Tleumuratova[3]

[1]"Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University, K. Niyazov str., 39, 100000, Tashkent, Uzbekistan
[2]Karakalpak State University named after Berdakh, Ch.Abdirov str., 1, 230112, Nukus, Republic of Karakalpakstan, Uzbekistan
[3]Karakalpak Branch of the Uzbek Academy of sciences, Berdakh str. 41, Nukus, Republic of Karakalpakstan, Uzbekistan

Abstract. The possibility of building a regional system for assessing the climatic potential and agroclimatic zoning using geoinformation approaches and specialized description language CSML (Climate Science Modelling Language) for the Southern Aral Sea basin. Modern approaches to the construction of agroclimatic zoning systems using ground-based and space-based monitoring are discussed. The necessity of combining geo-ecological and bioclimatic zoning of the territory using spatial databases is shown.

1 Introduction

The South Aral Sea basin, being a part of the Turan lowlands, is an arid region with a continental climate [1]. Despite a large number of research works on agroclimatic zoning of Uzbekistan, global climate changes and the transformation of regional geosystems caused by the desiccation of the Aral Sea make the problem of agroclimatic zoning topical again. It should also be noted that assessment of the climatic resources of the territory is important not only for the development of irrigated agriculture but also for the optimization of measures to combat desertification and sustainable use of desert pastures [2-4]. There is an extensive state-supported initiative for Haloxylon planting on the dried seabed [5]. These afforestation measures also require assessment and prediction of climatic factors. Sustainable development of desert pastures requires long-term planning of land use and assessment of primary bio productivity, which is impossible without the combination of landscape-ecological zoning and agroclimatic zoning, taking into account climate variability and the transformation of landscapes.

Solving the above problems is impossible without extensive use of geoinformation systems, spatial databases with problem-oriented description languages, and remote sensing methods. Such a combination of tools and interdisciplinary approaches can solve both

* Corresponding author: polat1@yandex.ru

traditional tasks of ecological zoning and more complicated tasks of natural-anthropogenic ecosystems functioning forecasting.

Fast environment transformation and ecosystem changes in the South Aral Sea Basin also require a flexible innovation approach for agroclimatic prognosis and agroecological zone correction due to terrestrial ecosystem alteration. This activity is important for precise farming, water-efficient agriculture implementation, pasture management and introduction of new cultures, desertification combat as well as soil degradation prevention [6].

2 Materials and methods

For the regional climatic studies, we used various sources of climatic information, including Uzhydromet data on soil temperature, space-based land surface temperature grids in average spatial resolution, our previous schemes of geoecological regionalization of the area under investigation, and various reference data for literary sources [1-4].
Meteorological station data were interpolated using common geostatistic approaches with SAGA modules to create a continuous field of meteorological parameters (maximal and minimal diurnal temperatures, mean air humidity, aridity index, etc). We used spline interpolation with a neutral stability algorithm, and temperature Tstation (in [K] unit) was converted to potential temperatures Tpotential ([K]):

$$T_{potential} = T_{station}(P_{sea-level}/P_h)^{(R/mC_p)} \quad (1)$$

where $P_{\text{sea-level}}$ is sea-level pressure, P_h is the air pressure at elevation h (in [m] unit), R is the gas constant (8.3143 $J{\cdot}mol^{-1}{\cdot}K^{-1}$), m is the molecular weight of dry air (0.02897 $kg{\cdot}mol^{-1}$), and C_p is the specific heat of dry air at constant pressure (1005 $J{\cdot}kg^{-1}{\cdot}K^{-1}$).

Pressure P_h was calculated as

$$P_h = P_{sea-level}\left(\frac{T_{sea-level}}{T_{sea-level}+kh}\right)^{mg/kR} \quad (2)$$

where k is the assumed lapse rate (-0.0065 $K{\cdot}m^{-1}$), h is the station elevation ([m]), and g is the acceleration due to gravity (9.80616 $m{\cdot}s^{-2}$), following [7].

These calculated fields had been compared with accessible satellite data [8] to reveal local microclimatic variability induced by terrestrial ecosystems' unsteadiness.

Information about the Climate science modeling language (CSML) standard was extracted from the OGC description and publication about this language [9,10].

3 Results and discussion

A general framework for the spatial data models is expounded in ISO TC211 (ISO 19101) international standards as a universal code for formal data description. Both internal structure and substantial content of datasets are represented as application schema using the idea of feature instances as a set of objects.

We used that formal approach to build a subject-oriented procedure to parse XML and calculate the sum of active temperatures for the area under investigation. Some results of these calculations are presented in figures 1-4.

Despite the excessively generalized description and the resulting large number of subject-oriented implementations (such as GML, Geographic Mark-up Language, or industry-oriented KML), this approach has significant advantages in terms of data portability. It also simplifies the description of the data access interface, as more attention is paid to semantic structures rather than format or hardware implementation issues. Bringing standards for the storage and processing of environmental spatial data to a common view also encourages their wide interdisciplinary use and interaction between different research areas. These advantages are especially important for regional climatic and environmental research where one need extensive instrumentation for global climatic data downscaling as well as careful consideration of local environmental features and regional specificity [11].

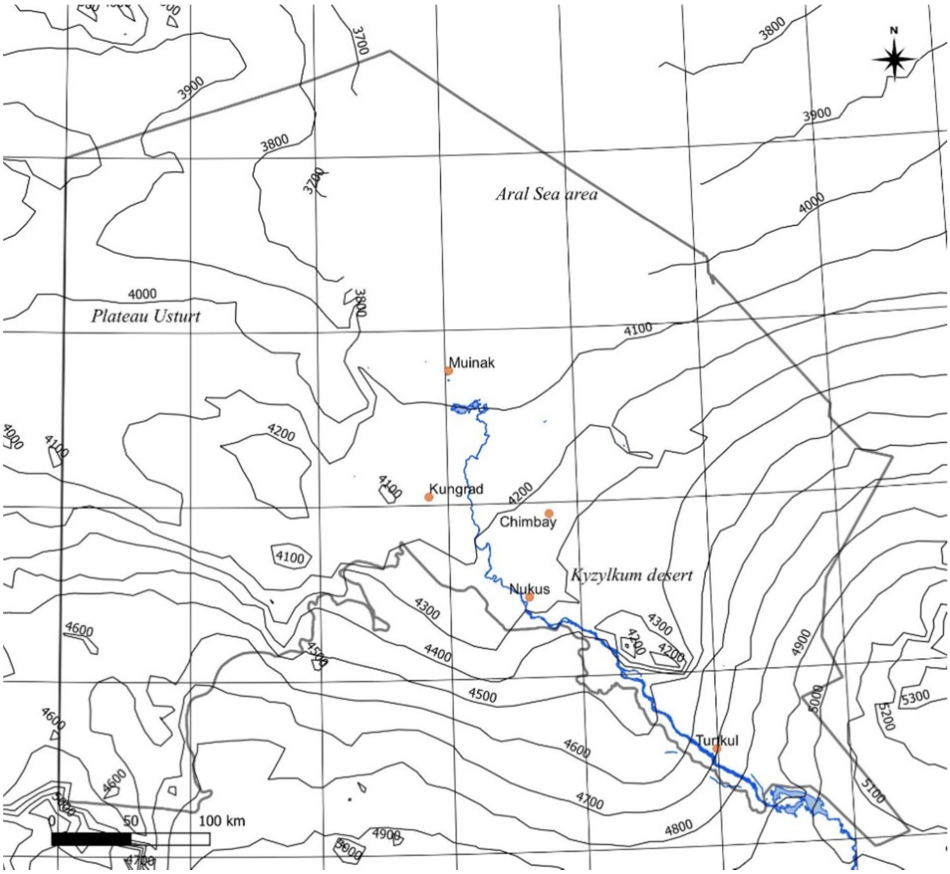

Fig. 1. The map depicts isolines of effective heat sums above 5°C for the Karakalpakstan. The spatially referenced array had been calculated using long-term average monthly air temperatures.

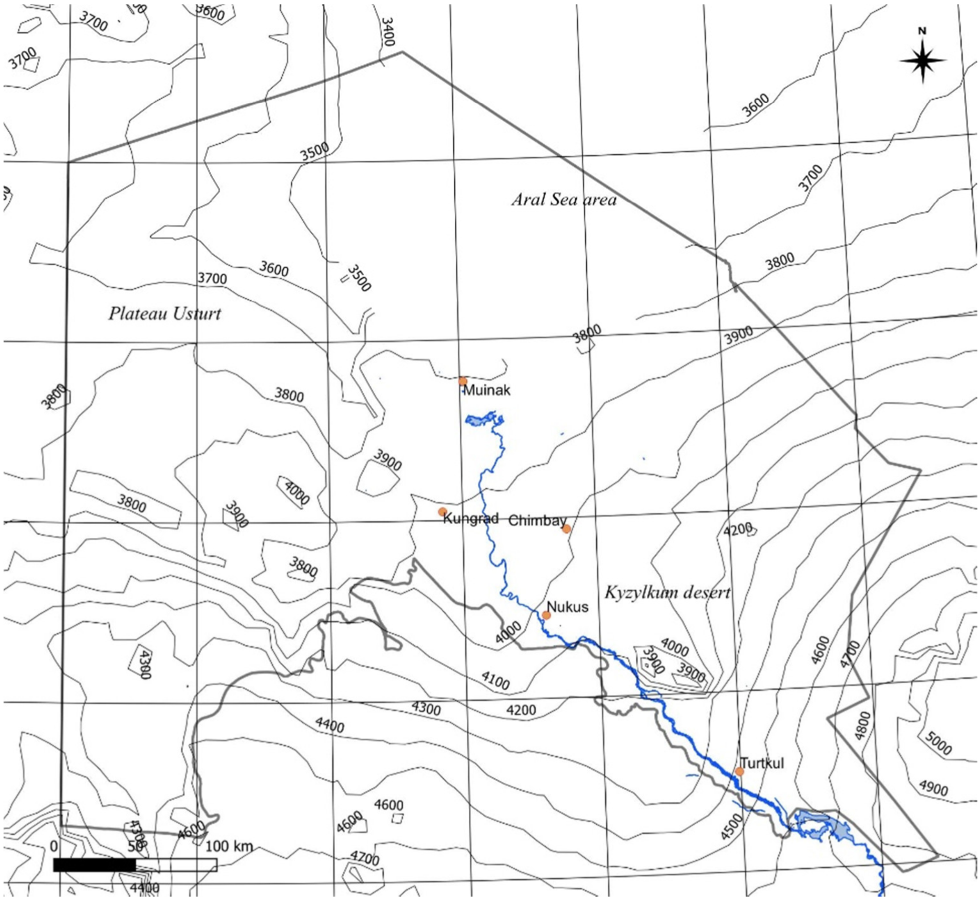

Fig. 2. The map depicts isolines of effective heat sums above 10°C for the Karakalpakstan. The spatially referenced array had been calculated using long-term average monthly air temperatures.

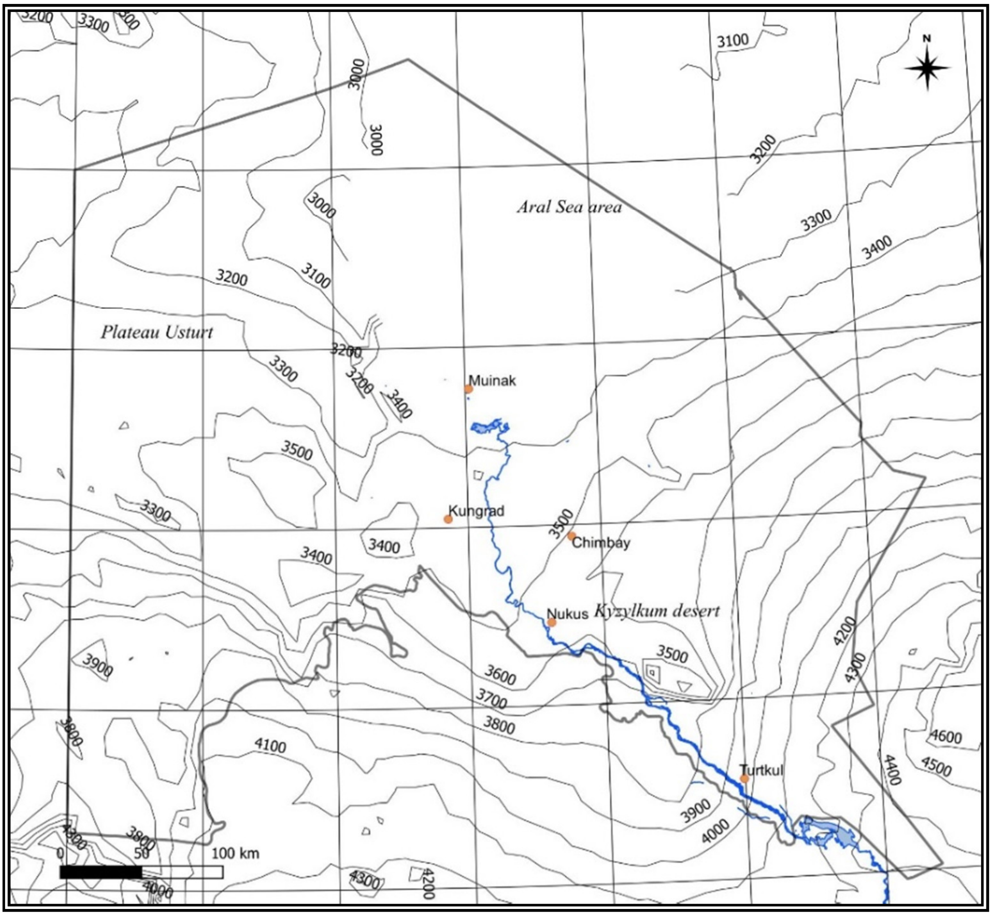

Fig. 3. The map depicts isolines of effective heat sums above 15°C for the Karakalpakstan. The spatially referenced array had been calculated using long-term average monthly air temperatures.

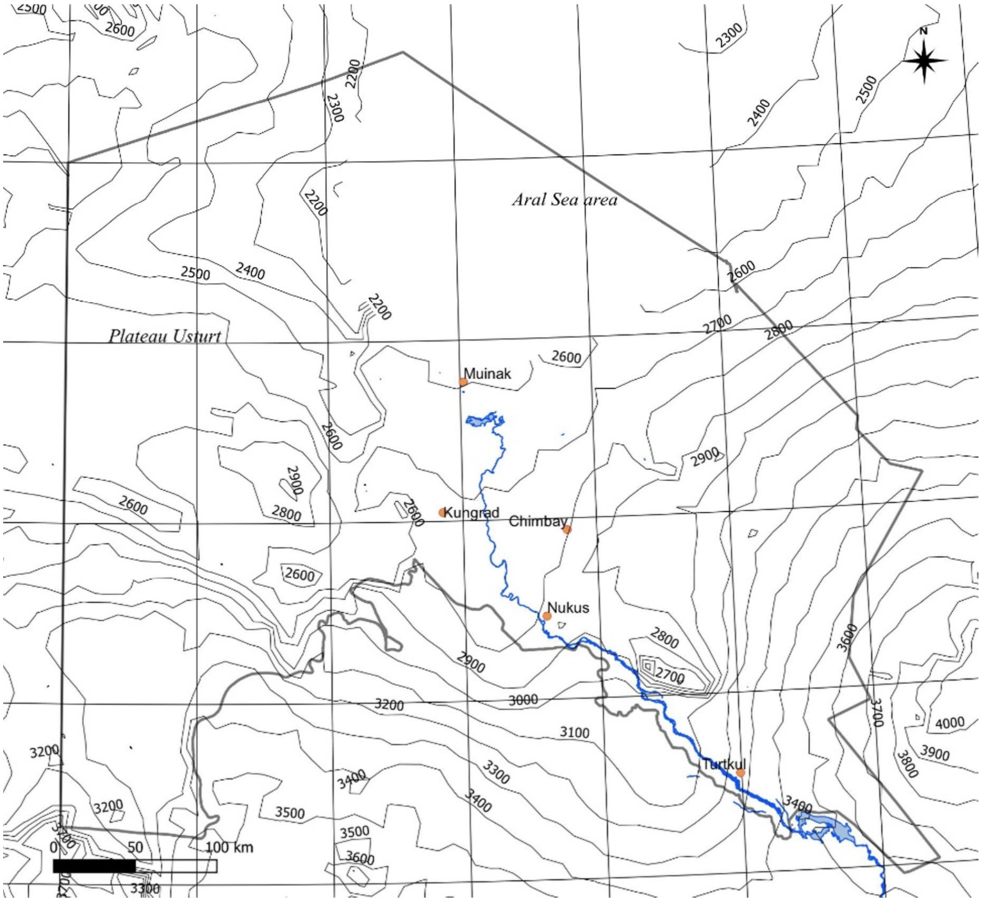

Fig. 4. The map depicts isolines of effective heat sums above 20°C for the Karakalpakstan. The spatially referenced array had been calculated using long-term average monthly air temperatures.

4 Conclusions

Application of the subject-oriented XML-like meta-languages is a prospective approach in agroclimatic studies and regional bioclimatic zoning. These methods are easily integrated with various representations of spatial and Spatio-temporal information to build a consistent system of regional climatic monitoring and prognosis even for non-stable and transformed ecosystems in arid regions. We had concentrated on the sum of the effective temperatures is a key agroclimatic parameter for agroclimatic zoning and our Spatio-temporal framework demonstrated the ability for reliable and flexible superposition of interpolated geo fields derived from sparse point data and coarse-resolution land surface temperatures satellite measures.

Despite we had used only spline interpolation in our study, Climate science modeling language easily integrates with various interpolation techniques such as kriging, residual kriging, IDW, etc., depending on input data peculiarities and specific model requirements.

References

1. V.E. Chub, Climate change and its influence on the natural resources potential of Republic of Uzbekistan (Tashkent) SANIGMI, 252 (2000)

2. T.Yu. Spektorman and E.V. Petrova, Agrolimatic changes estimation with climate scenarios data for the territory of Uzbekistan// Climatic scenarios, climate change impact estimation, (Bulletin 6. - Tashkent: NIGMI), 28-37 (2007)
3. F.A. Muminov and H.M. Abdullaev, Agroclimatic resources of Uzbekistan (Tashkent: SANIGMI) 178 (1997)
4. D.Zh. Matmuradov, *Agroclimatic conditions of the North-West Uzbekistan*. (Nukus, Karakalpakstan) 255 (1989)
5. Government Decree 4204 of February 22, 2019 *"On measures to improve the efficiency of work to combat desertification and drought in the Republic of Uzbekistan"*
6. A.R. Babajanov, M. Suleymanova and Kh.A. Abdivaitov, *Organization of irrigated land use of Uzbekistan on the basis of anti-erosion measures,* International Journal of Advances in Science Engineering and Technology 8, 76-80 (2020)
7. R. Dodson and D. Marks, *Daily air temperature interpolated at high spatial resolution over a large mountainous region,* Climate research, Vol.8, 1-20 (1997)
8. Yu.P. Zhao and T.J. Shi et al., *Global spatiotemporally continuous MODIS land surface temperature dataset,* Sci Data 9, 143 (2022)
9. A. Woolf and B. Lawrence et al., *Data integration with the Climate Science Modelling Language,* Advances in geosciences 8, 83-90 (2006)
10. Climate Science Modelling Language (CSML) - OGC Portal, see https://portal.ogc.org/files/?artifact_id=42894&version=1
11. T. Bauer, M. Immitzer and R. Mansberger et al., *The Making of a Joint E-Learning Platform for Remote Sensing Education: Experiences and Lessons Learned,* Remote Sensing 13(9), 1718 (2021)