Published in the USA
Russian Journal of Astrophysical Research. Series A
Issued since 2013.
E-ISSN: 2413-7499
2024. 10(1): 13-17

DOI: 10.13187/rjar.2024.1.13
https://rjar.cherkasgu.press

Systematics of Near-Earth Space

Stanislav A. Kudzh [a], [*]

[a] Russian Technological University (RTU MIREA), Moscow, Russian Federation

Abstract

The article explores the content of near-Earth outer space. The presence of zones that create the heterogeneity of space is shown. The morphology and semantics of near-Earth space is investigated. Different approaches to estimating the boundaries of near-Earth space are described. The concept of "geocentric space" is introduced as a spherical model and a generalization of the near-Earth space. Geocentric space has floating boundaries and may include lunar space. The systematics of geocentric space up to the orbit of the Moon is given. The systematics of outer space zones is made on the basis of their distance from the center and the surface of the Earth. Eleven zones have been identified. Some zones are physical in nature, other zones are anthropogenic. The article introduces the concept of morphological and semantic modeling in space research. Morphological modeling differs from the parametric morphological analysis introduced by Zwicke. Morphological modeling in space research is proposed as a kind of geometric modeling associated with conformal transformations. A special case of morphological modeling is shown as a kind of cartographic transformations. Semantic modeling in space research is proposed as a method of parametric transformations and analysis of the similarity of models in terms of content. A graphical scheme of the systematics of near-Earth outer space is given. The features of the zones that create heterogeneity are described. The upper zone from the center of the Earth indicates the area of lunar attraction. In the proposed model, lunar space is not included in the region of near-Earth space.

Keywords: space research, near-Earth space, morphological modeling, semantic modeling, heterogeneity.

1. Introduction

Near-Earth space (NES) is associated with the geocentric model and refers to the part of spherical space relative to the Earth. The study of near-Earth space (Barmin et al., 2014), as well as the study of the Earth-Moon system (Savinych, 2022), shows that this space is heterogeneous and contains qualitatively different regions or zones. Near-Earth space is evaluated in different ways. A simple assessment includes the space between the orbit of the Earth and the Moon. This estimate sets a fixed boundary of the NES. There is no room for lunar space in this assessment. Lunar space has the same nature as near-Earth space, but has a smaller size. Near-Earth space will be considered an area that does not include lunar space. This means that the Moon's gravitational region does not enter the NES. This space is defined by (Bakulin et al., 1983) with a radius of 66,000 km centered in the center of the Moon. Since the time of Aristotle (1974), there has been another definition of the region between the Moon and the Earth – sublunary space. There is a

[*] Corresponding author
E-mail addresses: rektor@mirea.ru (S.A. Kudzh)

point of view that near-Earth space is a part of geocentric space mastered by man. This estimate gives a floating boundary and allows for the presence of lunar space. The use of the concept of geocentric space (GS) eliminates the contradiction between the definitions of NES and the presence of lunar space. Geocentric space has a fixed center in the barycenter of the Earth and a floating boundary given by a radius relative to that center. The boundary is determined by the task of the study. In a broad sense, GS includes NES. In special cases, GS may be part of the NES. For example, the space of satellite orbits or the space of space debris (Barmin et al., 2014b).

GS research technologies and methods use Earth science methods. The development of space research is characterized, on the one hand, by the emergence of a number of special sciences: space geodesy (Oznamets, Tsvetkov, 2019; Bertiger et al, 2020; Oznamets, 2023), geodetic astronomy (Gospodinov, 2022), space geoinformatics (Bondur, Tsvetkov, 2015a), space astronomy (Gospodinov, Tsvetkov, 2023) and other sciences. The development of space research, on the other hand, is characterized by an increase in the data collected and big data problem (Allam, Dhunny, 2019; Levin, Tsvetkov, 2017). The growth of GS data increases awareness of this field and reveals facts that allow us to consider NES as a heterogeneous structure (Wu et al., 2019). This article is devoted to this problem.

Morphology and semantics of cosmic information.

In space research, models of celestial bodies have morphology and semantics. Morphology in space research is associated with the shape of celestial bodies, the trajectory of the orbits of celestial ones, and the spatial relationships between celestial bodies. Carriers of morphological properties are mathematical and information models. The global model is the information field in space research. Space monitoring is the basis for obtaining information about outer space (Kudzh, 2022; Tsvetkov, 2023). Morphology is important in the formation of spatial knowledge.

You can introduce the concept of morphological models. Mathematical models and morphological models have the important property of universality. The property of the universality of mathematical models is that different processes of the reality of the world can be described by the same formula or structure. The property of the universality of morphological models is that different objects of space research can be described by the same form. For example, the Earth, the Moon, and many planets can be roughly described by a sphere. The orbits of the planets describe mathematical models of the second-order curve.

You can introduce the concept of morphological modeling. Morphological modeling is a simulation that changes shape and allows one shape to be transformed into another. For example, a sphere can be converted to an ellipsoid. In cartography, a spherical body is transformed into a cone, a cylinder, and a plane. This leads to the creation of maps of different cartographic projections: conical. Cylindrical, azimuthal. In space photogrammetry, panoramic images are converted into a different form or create maps of a certain projection from the images. The basis of morphological transformations are conformal transformations and information morphism. Structural modeling is a type of morphological modeling. The formation of the configuration of space is an example of morphological modeling. Geocentric space or the space of the solar system are morphological models. The heliocentric system is a morphological model.

The semantics of GS space exploration is closely related to morphology. The semantics of GS is expressed through the semantics of the objects of this space. Different parts of different planets have a common characteristic area. Area can be thought of as a semantic characteristic. Different areas have different configurations. The areas of different shapes can be equal or proportionate. The shapes of the plots are different. Shapes determine morphology. The area of the shape determines the semantics.

Semantics uses a parametric description. There is semantic modeling that explores the content. Semantic modeling uses special procedures. A typical semantic procedure is semantic division. Semantic division consists in dividing the parametric description of the GS model or objects into classes according to given classification criteria. Semantic division is carried out in the parameter space, without taking into account morphology. A characteristic technique of semantic division is the method of "separating hyperplane" (Anikin et al., 1980). It divides the parameter space into two classes. Other types of semantic division are oppositional (Tsvetkov, 2014) and dichotomous division.

An important procedure for semantic analysis is the comparison of content. An example of such a procedure is correlative (Tsvetkov, 2012) semantic analysis. Semantic correlative analysis should be distinguished from statistical correlation analysis. Semantic correlative analysis reveals a qualitative relationship between content. Correlation statistical analysis provides quantitative statistical estimates without taking into account a possible relationship

2. Results and discussion

Heterogeneity of near-Earth space.

Figure 1 shows the diagrams of the boundaries of different zones in the NES (GS). The dotted line indicates the areas of satellite orbits.

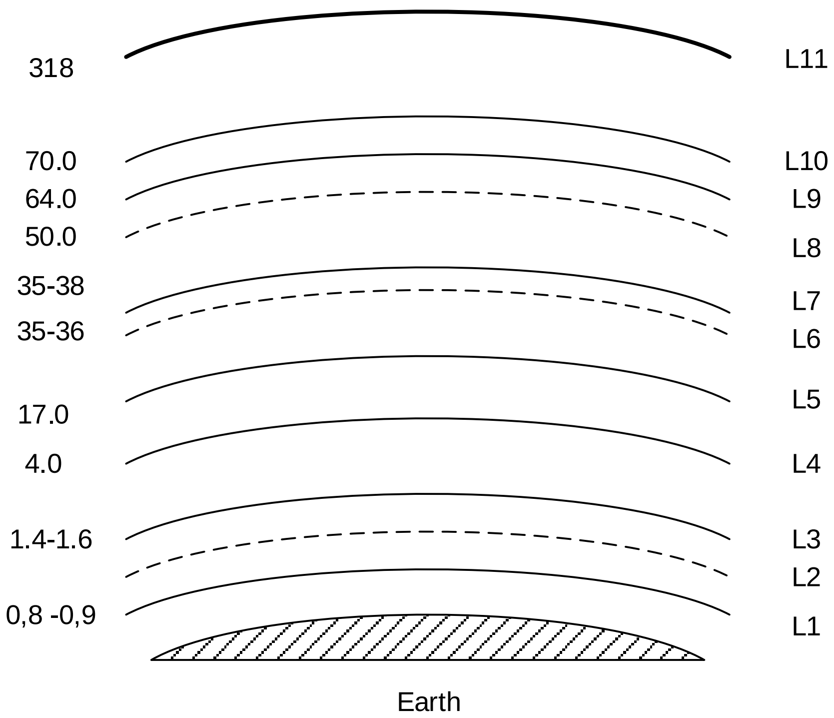

Fig. 1. Area boundaries in the NES

In Figure 1, the zone boundaries are indicated by the symbol L. Some areas may overlap. On the left, the heights from the Earth are shown in thousands of kilometers, on the right are the zone identifiers. The taxonomy of zones is given as they move away from the Earth and the earth's surface. Boundary designations have the following meanings:

L1 – denotes the first lower belt of space debris rings and corresponds to an altitude above the earth's surface of 800-900 km.

L2 – denotes the region of low satellite orbits and corresponds to an altitude above the earth's surface of 700-1500 km.

L3 – denotes the second lower belt of space debris rings and corresponds to an altitude above the earth's surface of 1400-1600 km.

Above are the radiation belts, which are toroid-shaped and form two areas.

L4 – denotes the inner radiation belt, consisting mainly of protons with an energy of tens of MeV and corresponds to an altitude above the earth's surface of about 4000 km.

L5 – denotes the outer radiation belt, consisting mainly of electrons with an energy of tens of keV and corresponds to an altitude above the earth's surface of approximately 17,000 km.

L6 – denotes the region of geostationary orbits and corresponds to an altitude above the earth's surface of 35,000-36,000 km.

L7 – denotes the upper belt of space debris rings and corresponds to an altitude above the earth's surface of 35,000-36,000 km.

Zones L 6 and L7 are almost identical, which is of interest for research.

L8 – denotes the region of high orbits and corresponds to an altitude above the earth's surface of 50,000 km.

L9 – denotes the area of the fourth and fifth libration points and corresponds to an altitude above the earth's surface of 64,000 km.

L10 – denotes the boundary of the Earth's magnetosphere and corresponds to an altitude above the earth's surface of 70,000 km

L11 denotes the actual boundary of the NES, beyond which the region of lunar attraction occurs and corresponds to a distance from the center of the Earth of approximately 318,000 km.

3. Conclusion

Near-Earth space is heterogeneous and contains different zones. The systematics of near-Earth space zones has not yet been carried out in a comprehensive manner. This is due to the significantly different physical nature of these zones and areas of use. It is possible to state a significant heterogeneity of near-Earth space. Heterogeneity is expressed in the presence of spatial areas or zones in near-Earth space. Some zones of near-Earth space are of a physical nature, others are anthropogenic. The systems approach gives reason to believe that these homogeneities are part of a general system that has not yet been investigated. The systematic approach gives reason to believe that the areas of near-Earth space are interconnected. But these connections have not yet been studied. The use of morphological and semantic modeling, according to the author, will help in the study of the heterogeneity of geocentric space. The basis for the study of the heterogeneity of near-Earth space remains space monitoring (Savinych, 2017). The systematics of the zones of outer space is made on the basis of their distance from the center and the surface of the Earth.

References

Allam, Dhunny, 2019 – *Allam, Z., Dhunny, Z.A.* (2019). On big data, artificial intelligence and smart cities. Cities. 89: 80-91.

Anikina i dr., 1980 – *Anikina, G.A., Polyakov, M.G., Romanov, L.N., Tsvetkov, V.Ya*. (1980). O vydelenii kontura izobrazheniya s pomoshch'yu lineinykh obuchaemykh modelei [On image contour extraction using linear learning models]. *Izvestiya akademii nauk SSSR*. Tekhnicheskaya kibernetika. 6: 36-43. [in Russian]

Aristotle, 1974 – *Aristotle* (1974). Ethics. P. 357.

Bakulin i dr., 1983 – *Bakulin. P.I., Kononovich. E.V., Moroz. V.I.* (1983). Kurs obshchei astronomii [Course of general astronomy.]. 5-e izd. M.: Nauka. P. 110. [in Russian]

Barmin et al., 2014b – *Barmin, I.V., Dunham, D.W., Kulagin, V.P., Savinykh, V.P., Tsvetkov, V.Ya.* (2014). Rings of Debris in Near_Earth Space. *Solar System Research*. 48(7):. 592-599. DOI: 10.1134/S0038094614070041

Barmin, et al., 2014a – *Barmin, I.V., Kulagin, V.P., Savinykh, V.P., Tsvetkov, V.Ya*. (2014). Near_Earth Space as an Object of Global Monitoring. *Solar System Research*. 48(7): 531-535.

Bertiger et al., 2020 – *Bertiger, W. et al.* (2020). GipsyX/RTGx, a new tool set for space geodetic operations and research. *Advances in space research*. 66(3): 469-489.

Bondur, Tsvetkov, 2015 – *Bondur, V.G., Tsvetkov, V.Ya*. (2015). New Scientific Direction of Space Geoinformatics. *European Journal of Technology and Design*. 4(10): 118-126.

Gospodinov, 2022 – *Gospodinov, S.G.* (2022). Evolution of geodetic astronomy. *Russian Journal of Astrophysical Research. Series A*. 8(1): 3-11.

Gospodinov, Tsvetkov, 2023 – *Gospodinov, S.G, Tsvetkov, V.Ya*. (2023). Nekotorye teoreticheskie aspekty instrumental'nykh metodov kosmicheskoi astronomii [Some theoretical aspects of instrumental methods of space astronomy]. Sofiya. Art Eternal Cinema. 92 p. [in Russian]

Kudzh, 2022 – *Kudzh, S.A.* (2022). Development of space monitoring. *Russian Journal of Astrophysical Research. Series A*. 8(1): 12-22.

Levin, Tsvetkov, 2017 – *Levin, B.A., Tsvetkov, V.Ya.* (2017). Informatsionnye protsessy v prostranstve «bol'shikh dannykh» [Information processes in the space of "big data"]. *Mir transporta*. 15. 6(73): 20-30. [in Russian]

Oznamets, 2023 – *Oznamets. V.V.* (2023). The Evolution of Space Geodesy. *Russian Journal of Astrophysical Research. Series A*. 9(1): 14-19.

Oznamets, Tsvetkov, 2019 – Oznamets, V.V., Tsvetkov, V.Ya. (2019). Space Geodesy of Small Celestial Bodies. *Russian Journal of Astrophysical Research. Series A*. 5(1): 30-40.

Savinych, 2022 – *Savinych, V.P.* (2022). Study of the "earth-moon" system. *Russian Journal of Astrophysical Research. Series A*. 8(1): 32-39.

Tsvetkov, 2012 – *Tsvetkov, V.Ya*. (2012). Framework of Correlative Analysis. *European researcher*. 6-1(23): 839-844.

Tsvetkov, 2014 – *Tsvetkov, V. Ya*. (2014) Opposition information analysis. European Journal of Technology and Design. – 2014. № 4(6). P.189-196 DOI: 10.13187/ejtd.2014.6.18

Tsvetkov, 2023 – *Tsvetkov, V.Ya*. (2023). Satellite Monitoring. *Russian Journal of Astrophysical Research. Series A*. 9(1): 24-27.

Wu et al., 2019 – *Wu, S.W., Wang, G., Wang, Q., Jia, Y.D., Yi, J., Zhai, Q.J., … , Zhang, T.Y.* (2019). Enhancement of strength-ductility trade-off in a high-entropy alloy through a heterogeneous structure. *Acta Materialia*. 165: 444-458.