USE OF DIFFERENTIAL CORRECTIONS FOR CALCULATING GEODETIC LATITUDES ON SPATIAL RECTANGULAR COORDINATES

Konstantin F. Afonin

Siberian State University of Geosystems and Technologies, 10, Plakhotnogo St., Novosibirsk, 630108, Russia, Ph. D., Associate Professor, Department of Space and Physical Geodesy, phone: (383)343-29-11

Currently, GNSS technologies are the main ones for coordinate support of territories, which can be used almost everywhere. However, they allow to get only the spatial rectangular coordinates of the defined points. Most users, as a rule, need other coordinates – flat rectangular Gauss-Kruger coordinates. The Gauss–Kruger coordinates can only be calculated from geodetic latitudes and longitudes. The special literature describes more than a dozen ways to calculate geodetic latitude using spatial rectangular coordinates. Some iterative or non-iterative methods are usually used to solve this problem. Both have their advantages and disadvantages. The paper uses the third way of solving the problem, which was popular in the 60s of the last century. It is proposed to calculate and use a differential correction to the initial (approximate) value of the geodetic latitude. Working formulas that implement this idea are obtained. They differ from previously published formulas in that they allow to get the geodetic latitude with greater accuracy. Numerical examples are given showing the possibility of practical application of the proposed method at any heights of ground points.

Key words: coordinate systems, geodesic latitude and altitude, spatial geodesic rectangular coordinates, differential corrections to geodesic latitude.

REFERENCES

1. Afonin, K. F. (2011). *Vysshaya geodeziya. Sistemy koordinat i preobrazovaniya mezhdu nimi [Higher Surveying. Coordinate systems and transformations between them]*. Novosibirsk: SSGA Publ., 66 p. [in Russian].

2. GOST R 32453-2017. (2017). Coordinate systems. Methods of transforming coordinates of defined points. Interstate standard (Enter. 2018-01-07.). Moscow: Stadartinform, 19 p. [in Russian].

3. Teleganov, N. A., & Elagin, A. V. (2004). *Vysshaya geodeziya i osnovy koordinatno-vremennykh system [Higher geodesy and the basics of coordinate-time systems]*. Novosibirsk: SSGA Publ., 238 p. [in Russian].

4. Laping, K. A. (1962). Calculation of coordinates and heights from the measured azimuths of normal sections and the angles of inclination of the chords at two starting points. *Izvestiya vuzov. Geodeziya i aerofotos"emka [Izvestiya vuzov. Geodesy and Aerophotography]*, 1, 3–8 [in Russian].

5. Lipatnikov, L. A. (2016). An experiment on the formation of a geocentric earth coordinate system on the territory of Russia and neighboring countries. *Vestnik SGUGiT [Vestnik SSUGT]*, 3(35), 16–26 [in Russian].

6. Medvedev, P. A. (2016). Research on methods for calculating the geodetic latitude and height of points on the earth's surface in rectangular coordinates. *Izvestiya vuzov. Geodeziya i aerofotos"emka [Izvestiya vuzov. Geodesy and Aerophotography]*, 3, 24–28 [in Russian].

7. Medvedev, P. A., & Mazurov, B. T. (2016). Algorithms for the direct calculation of geodesic latitude and geodesic height from rectangular coordinates. *Vestnik SGUGiT [Vestnik SSUGT]*, 3(34), 5–13 [in Russian].

8. Medvedev P. A., & Kenzheguzinova M. M. (2016). Calculation of the geodetic height from the rectangular spatial coordinates of the points on the earth's surface. *Vestnik Omskogo gosudarstvennogo agrarnogo universiteta [Bulletin of the Omsk State Agrarian University]*, 3(23), p. 146.

9. Medvedev, P. A. (2016). Mathematical models of transformations of spatial coordinates. *Geodeziya i kartografiya [Geodesy and Cartography]*, 3, 2–7 [in Russian].

10. Obidenko, V. I. (2017). About the change of coordinates on the territory of the Russian Federation during the transition from SK-95 to GSK-2011. *Vestnik SGUGiT [Vestnik SSUGT]*, 22(2), 5–21 [in Russian].

11. Obidenko, V. I. (2018). Determination of the metric parameters of the territory of the Russian Federation by means of geographic information systems. *Vestnik SGUGiT [Vestnik SSUGT]*, 23(2), 18–33 [in Russian].

12. Maksimova, M. V. (2013). Century Transformations of coordinates in engineering and geodetic surveys. *Inzhenernye izyskaniya [Engineering Surveys]*, 2, 18–21 [in Russian].

13. Balandin, V. N., Bryn, M. Ya., Imshenetskiy, S. P., Matveev, A. Yu., & Yuskevich, A. V. (2006). Algorithm for calculating the geodetic height from spatial rectangular coordinates. *Geodeziya i kartografiya [Geodesy and Cartography]*, 6, 15–16 [in Russian].

14. Kurchenko, L. A., Taran, V. V., & Shlapak, V. V. (2016). On the question of the transformation of geodesic rectangular coordinates into curved. *Izvestiya vuzov. Geodeziya i aerofotos"emka [Izvestiya vuzov. Geodesy and Aerophotography]*, 3, 29–33 [in Russian].

15. Shanurov G. A., Manilova A. D. (2017). On the recalculation of spatial Cartesian coordinates into geodesics. *Izvestiya vuzov. Geodeziya i aerofotos"emka [Izvestiya vuzov. Geodesy and Aerophotography]*, 1, 13–17 [in Russian].

16. Shanurov, G. A., Polovnev, O. V., & Manilova, A. D. (2015). Transformations of spatial coordinates during geodetic support of the scanning complex. *Izvestiya vuzov. Geodeziya i aerofotos"emka [Izvestiya vuzov. Geodesy and Aerophotography]*, 1, 15–18 [in Russian].

17. Ogorodova, L. V. (2011). Joint calculation of the geodetic latitude and height of points on the surface of the earth. *Izvestiya vuzov. Geodeziya i aerofotos"emka [Izvestiya vuzov. Geodesy and Aerophotography]*, 9, 11–15 [in Russian].

18. Gafiatulin, Kh. G., & Novoselov, O. G. (2017). Solutions of the geodesic problem of the inverse transformation of plane rectangular and polar coordinates, determined by a system of numbers from one network to another through the projection of a conditionally auxiliary coordinate system. *Internet-zhurnal Naukovedenie [Internet Journal of Science]*, 3, 1–8 [in Russian].

19. Bowring, B. R. (1985). The accuracy of geodetic latitude and height equations. *Surv. Rev.*, 38, 200–206.

20. Bowring, B. R. (1976). Transformation from spatial to geodetic coordinates. *Surv. Rev.*, 23, 323–327.

21. Medvedev, P. A., Novorodskaya, M. V., & Sharov, S. A. (2017). Non-iterative algorithm for calculating geodetic latitude using spatial rectangular coordinates. *Vestnik Omskogo gosudarstvennogo agrarnogo universiteta [Bulletin of the Omsk State Agrarian University]*, 2(26), 60–64.

22. Butkevich, A. V. (1967). On the transition from spatial rectangular coordinates to geodesic. *Geodeziya i kartografiya [Geodesy and Cartography]*, 5, 6–7 [in Russian].

23. Afonin, K. F., & Trifonova, Yu. S. (2019). Determination of geodetic latitude by spatial rectangular coordinates using differential correction. In *Sbornik materialov Interekspo GEO-Sibir'-2019: Mezhdunarodnoy nauchnoy konferentsii: T. 1, No, 2 Geodeziya, geoinformatika, kartografiya i marksheyderiya [Proceedings of Interexpo GEO-Siberia-2015: International Scientific Conference: Vol. 1, No. 2. Surveying, Geoinformatics, Cartography and Surveying]* (pp. 3–8). Novosibirsk: SSUGT Publ. [in Russian].