AOGS 2005

The "downward continuation" of the gravity field

WenBin Shen

The Key Laboratory of Geospace Environment and Geodesy, Ministry of Education China, School of Geodesy and Geomatics, Wuhan University, 129 Luoyu Road, Wuhan, China, 430079. Tel.: 0086 27 87851163; Fax: 0086 27 87865825; e-mail: wbshen@sgg.whu.edu.cn

Given a continuous boundary value (e.g. gravitational potential on the boundary) on a simply closed surface which includes the whole Earth, how to determine the Earth's external gravity field attracts a lot of geodesists' attention. Conventionally, to solve this problem will encounter two difficulties: 1) in the line of solving this problem in a strict sense, one might solve Molodensky problem or Bjerhammar problem[1], both of which are very complicated in one aspect, and have not applied in solving the present problem in another aspect, because in the present case the boundary surface is not the Earth's surface but a more general surface such as the surface formulated by the flying satellites; 2) in the line of approximation approach, one could apply the truncated spherical harmonic expansion series, which might not be valid in the region near the Earth's surface[2−4]. In both cases, one will encounter the "downward continuation" problem. As a fact, it is well known that the "downward continuation" problem is an "improperly posed" problem, that is to say, the solution is not unique, or the solution is greatly influenced by the variation of the boundary value. Theoretically, to strictly determine the gravity field, the spherical harmonic expansion approach could not be used, because the boundary surface might not be a spherical surface.

Based on the "fictitious compress recovery" approach[5,6], the "downward continuation" problem could be satisfactorily solved. Choose a fictitious sphere K located in the interior of Earth, compress the given boundary value on the surface of the fictitious sphere, by using Poisson integral one gets the first-order regular harmonic field in the region outside the fictitious sphere. Then, one gets the difference between the original value and the first-order value on the given boundary. Repeating the above procedure, and finally one gets a fictitious field expressed by a regular harmonic series defined in the region outside the fictitious sphere, which coincides exactly with the real field to be determined in the whole region outside Earth[5,6], naturally and satisfactorily solving the "downward continuation" problem, which might be referred as the "fictitious downward continuation" approach, with which the accuracy of the gravity field determination is in the same level as the accuracy of the given boundary value[7].

Key words: fictitious compress recovery; "downward continuation" problem; "fictitious downward continuation"; gravity field determination

Acknowledgment. This study is funded in parts by Natural Science Foundation China (40374004), and in parts by Abroad Education Foundation by Ministry of Education China.

References

[1] W. A. Heiskanen and H.Moritz, Physical geodesy, Freeman and Company, San Francisco, 1967.

[2] H. Moritz, On the convergence of the spherical harmonic expansion of the geopotential at the Earth surface. Bollettino di Geodesia e Scienze Affini, 1978, 37: 363-381.

[3] L. E. Sjöberg, On the convergence problem for the spherical harmonic expansion of the geopotential at the surface of the Earth. Bollettino di Geodesia e Scienze Affini, 1980, 39: 261–272

[4] W. B. Shen, A general expression of the Earth's gravitational potentia's series expansion. Bollettino di Geodesia e Scienze Affini, 1995, 54: 361–372.

[5] W. B. Shen, The fictitious compress recovery of gravitational potential, Journal of Wuhan University (Information Science), 2004, 29, No.8, 2004.

[6] W. B. Shen, A proposed approach for determining the Earth's external gravity field. Journal of Geodesy (submitted), 2004

[7] W. B. Shen and B. Tao, The accuracy analysis of the gravity model based on the fictitious compress recuperation. Report at the 1st AOGS General Meeting, July 5-9, 2004, Singapore.