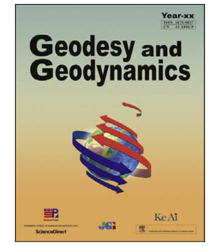
GEODESY AND GEODYNAMICS 2016, VOL X NO X, 1–7

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.keaipublishing.com/en/journals/geog; http://www.jgg09.com/jweb_ddcl_en/EN/volumn/home.shtml



Far-zone contributions of airborne gravity anomalies' upward/downward continuation

Boyang Zhou[a,*], Zhicai Luo[b], Yihao Wu[b], Yuqiao Cen[c]

[a] Department of Surveying and Mapping, Guangdong University of Technology, Guangzhou 510006, China
[b] School of Geodesy and Geomatics, Wuhan University, Wuhan 430079, China
[c] Center for Urban Science and Progress, New York University, NY 11201, USA

ARTICLE INFO

Article history:
Received 23 June 2016
Received in revised form
29 August 2016
Accepted 30 August 2016
Available online xxx

Keywords:
Airborne gravimetry
Poisson integral
Upward/downward continuation
Far-zone contributions
Remove-Compute-Restore technique

ABSTRACT

Airborne gravimetry has become a vital technique in local gravity field approximation, and upward/downward continuation of gravity data is a key process of airborne gravimetry. In these procedures, the integral domain is divided into two parts, namely the near-zone and the far-zone. The far-zone contributions are approximated by the truncation coefficients and a global geo-potential model, and their values are controlled by several issues. This paper investigates the effects of flight height, the size of near-zone cap, and Remove-Compute-Restore (RCR) technique upon far-zone contributions. Results show that at mountainous area the far-zone contributions can be ignored when EIGEN-6C of 360 degree is removed from the gravity data, together with a near-zone cap of 1° and a flight height less than 10 km, while at flat area EIGEN-6C of 180 degree is feasible.

How to cite this article: Zhou B, et al., Far-zone contributions of airborne gravity anomalies' upward/downward continuation, Geodesy and Geodynamics (2016), ■, 1–7, http://dx.doi.org/10.1016/j.geog.2016.08.001.

1. Introduction

With the development of airborne gravimetry, upward and downward continuations of gravity data are applied more frequently [1–4]. Poisson integral is a common solution for upward and downward continuations of gravity data. The integration in Poisson's integral is to be taken over the full solid angle, but for regional geoid determination, in order to use the available data at the limited survey area, a common process is the discretization of Poisson's integral equation, in which the integrating domain is divided into the near-zone cap and far-zone domain. The near-zone contributions are computed using the detailed gravity data, while the far-zone contributions are estimated from an available global geo-potential model, such as the EGM2008 [5]. A distortion will occur

* *Corresponding author.*
E-mail address: wdzbyang@163.com (B. Zhou).
Peer review under responsibility of Institute of Seismology, China Earthquake Administration.

Production and Hosting by Elsevier on behalf of KeAi

http://dx.doi.org/10.1016/j.geog.2016.08.001

in the upward/downward process if the far-zone contributions are treated inappropriately.

A number of issues must be considered for the far-zone contributions, including matters such as the computation of truncation coefficients of Poisson's integral, the resolution of the airborne gravity data, the type of the geo-potential model, the degree to extend the harmonic expansion, the flight height, and the radius of the near-zone cap. Tenzer et al. [6] computed truncation coefficients of Poisson's integral using numerical integration method; Tenzer et al. [7] applied truncation coefficients of Stokes' integral to compute far-zone contributions of Poisson's integral. For a certain block of airborne gravity data, the spatial resolution (half wavelength) depends on the low-pass filter which is applied to the measured data. Martinec [8] and Huang [9] expanded harmonic expansion to 360 degree, but their solutions are for ground observations; Jiang [10] took them as references and expanded harmonic expansion to 360 degree for airborne observations. In this paper there will be a full harmonic expansion. The goals of this paper are to analyze the influences of the flight height and the size of the near-zone cap upon the far-zone contributions, and to determine whether far-zone contributions should be considered at all.

2. Far-zone contribution of Poisson's integral

The domain of Poisson's integral may be divided to two parts: the near-zone and the far-zone. Thus, the Poisson's integral can be expressed as

$$\Delta g(r,\Omega)=\frac{R}{4\pi r}\int\limits_{\Omega_S}\Delta g(R,\Omega')K(r,\psi_0,R)d\Omega'+F_{\Delta g}(r,\Omega) \tag{1}$$

where the first part on the right of Equation (1) are the near-zone contributions; $F_{\Delta g}(r,\Omega)$ are the far-zone contributions, which can be expressed as

$$F_{\Delta g}(r,\Omega)=\frac{R}{4\pi r}\int\limits_{\Omega-\Omega_S}\Delta g(r',\Omega')K(r,\psi_0,r')d\Omega' \tag{2}$$

With the Poisson kernel

$$K(r,\psi,R)=\frac{R(r^2-R^2)}{(r^2+R^2-2Rr\cos\psi)^{3/2}}=\sum_{l=0}^{\infty}(2l+1)\left(\frac{R}{r}\right)^{l+1}P_l(\cos\psi) \tag{3}$$

where Δg are gravity anomalies; (r,Ω) and (R,Ω') are the computing point and running point respectively; Ω represents co-latitude and longitude (ϕ,λ); R is the Earth's mean radius, and $R = 6371$ km is adopted in this paper; r is the geocentric radius of the running point; Ω_S and $\Omega{-}\Omega_S$ indicate the near-zone and far-zone; $P_l(\cos\psi)$ is the nth degree Legendre polynomial.

Theoretically, global gravity data is needed for Poisson's integral. In fact, airborne gravity data can only be obtained in a limited domain. Remove-Compute-Restore (SoRCR) technique is always applied, modeling the influence of the gravity data beyond the survey area upon the computing point using a low degree geo-potential model. This paper uses the geo-potential model EIGEN-6C [11] in RCR process; furthermore, the treatment of topographical and atmospheric effects is out of the scope of this study.

As shown in Equation (3), $K(r,\psi_0,R)$ is described as an infinite summation, but for an airborne solution, and meanwhile the RCR technique is applied, the Poisson kernel $K(r,\psi_0,R)$ should be modified as

$$K(r,\psi,R)=\sum_{l=N_S}^{N}(2l+1)\left(\frac{R}{r}\right)^{l+1}P_l(\cos\psi) \tag{4}$$

where N is the max degree of airborne gravity; N_S-1 is the max degree of the low-degree geo-potential model in the RCR process.

The far-zone contributions $F_{\Delta g}(r,\Omega)$ can be approximated by using the Molodensky-type harmonic expansion technique

$$F_{\Delta g}(r,\Omega)=\frac{GM}{2Rr}\sum_{n=N_S}^{N}(n-1)Q_n(H,\psi_0)\sum_{m=0}^{n}(dC_{nm}\cos(m\lambda)+dS_{nm}\sin(m\lambda))P_{nm}(\phi) \tag{5}$$

where $\Delta g_n(\Omega)$ is the nth surface harmonics of $\Delta g(\Omega)$; dC_{nm} and dS_{nm} is the fully normalized disturbing potential coefficients; γ is the normal gravity; $P_{nm}(\phi)$ are the fully-normalized associated Legendre functions; GM is the geocentric gravitational constant; $Q_n(H,\psi_0)$ is the nth truncation coefficient which is a function of the kernel $K(r,\psi_0,r')$ and the angular radius of the near-zone cap ψ_0.

$$Q_n(H,\psi_0)=\int\limits_{\psi_0}^{\pi}K(r,\psi,R)P_n(\cos\psi)\sin\psi d\psi \tag{6}$$

As shown in Equation (6), $Q_n(H,\psi_0)$ could be computed using numerical integration method. It is worth mentioning that the above expressions assume an Earth-fixed reference frame.

3. Results and discussions

The far-zone contributions to quantities of the Earth's gravity field are numerically investigated at the area of study

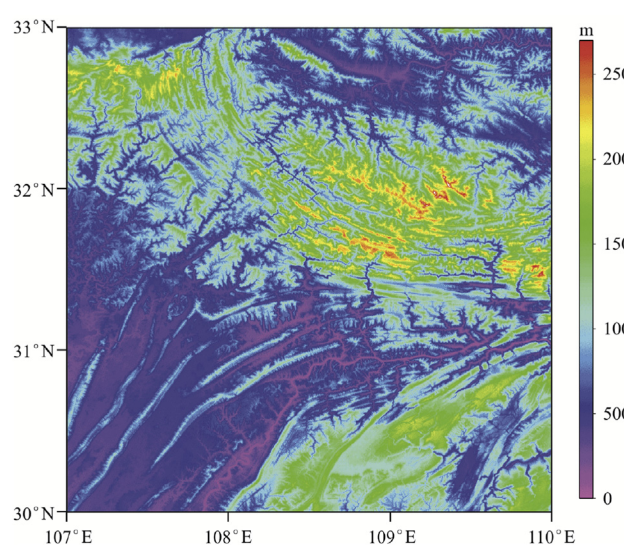


Fig. 1 – DEM of the test area.