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插值公式、相关系数和采样间隔对GRACE Follow-On 星间加速度精度的影响

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Impacts of interpolation formula, correlation coefficient and sampling interval on the accuracy of GRACE Follow-On intersatellite range-acceleration

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摘要

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摘要 本文基于星间加速度法开展了插值公式、相关系数和采样间隔对GRACE Follow-On星间加速度精度影响的研究。模拟结果表明: 1)适当增加数值微分公式的插值点数可有效提高插值精度。基于9点Newton插值公式,星间加速度的插值误差为 $4.401 \times 10^{-13} \text{ m} \cdot \text{s}^{-2}$,分别基于7点、5点和3点插值公式,插值误差增加了1.192倍、6.912倍和274.029倍。2)适当增大相关系数可有效降低星间加速度的误差。基于相关系数0.99,星间加速度方差为 $3.777 \times 10^{-24} \text{ m}^2 \cdot \text{s}^{-4}$,分别基于相关系数0.90、0.70、0.50和0.00,方差增加了9.780倍、22.404倍、26.217倍和26.820倍。3)随着采样间隔增大,星间加速度方差逐渐降低,但卫星观测值的空间分辨率也同时降低,因此合理选取采样间隔有利于地球重力场精度的提高。4)基于9点Newton插值公式、相关系数(K波段测量系统星间距离和星间速度0.85、GPS轨道位置和轨道速度0.95、星载加速度计非保守力0.90)和采样间隔10 s,利用预处理共轭梯度迭代法,精确和快速反演了120阶GRACE Follow-On地球重力场,在120阶处累计大地水准面精度为 $4.602 \times 10^{-4} \text{ m}$ 。

关键词: GRACE Follow-On 星间加速度法 插值公式 相关系数 采样间隔 地球重力场

Abstract: The studies of the impacts of the interpolation formula, correlation coefficient and sampling interval on the accuracies of the GRACE Follow-On intersatellite range-acceleration are developed using the Intersatellite Range-Acceleration Method (IRAM). The results of numerical simulation show: Firstly, the interpolation accuracy can be efficiently improved with appropriately increasing the number of the interpolation points from the numerical differential formula. The interpolation error of intersatellite range-acceleration is $4.401 \times 10^{-13} \text{ m} \cdot \text{s}^{-2}$ using the nine-point Newton's interpolation formula, and errors are enhanced 1.192 times, 6.912 times and 274.029 times based on the seven-point, five-point, three-point interpolation formulas, respectively. Secondly, the error of intersatellite range-acceleration is observably decreased with the proper increase of the correlation coefficients. The variance of intersatellite range-acceleration is $3.777 \times 10^{-24} \text{ m}^2 \cdot \text{s}^{-4}$ using a correlation coefficient of 0.99, and the variances are respectively increased 9.780 times, 22.404 times, 26.217 times and 26.820 times based on the correlation coefficients 0.90, 0.70, 0.50 and 0.00. Thirdly, with increasing sampling intervals, the variances of intersatellite range-acceleration are gradually decreased, however, the spatial resolution of satellite observations will be simultaneously reduced. Therefore, the accuracy of the Earth's gravitational field can be improved due to an preferred selection of sampling intervals. Finally, the Earth's gravitational field from GRACE Follow-On complete up to degree and order 120 is accurately and rapidly recovered using the nine-point Newton's interpolation formula, correlation coefficients (0.85 in intersatellite range and intersatellite range-rate, 0.95 in orbital position and orbital velocity, and 0.90 in non-conservative force) and a sampling interval of 10 s based on the Pre-Conditioned Conjugate-Gradient (PCCG) approach, and the cumulative geoid height error is $4.602 \times 10^{-4} \text{ m}$ at degree 120.

Keywords: GRACE Follow-On Intersatellite range-acceleration method Newton's interpolation formula Correlation coefficient Sampling interval Earth's gravitational field

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