地球物理学报 » 2011, Vol. 54 » Issue (1) :14-21
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引用本文:
郑伟, 许厚泽, 钟敏, 员美娟, 周旭华.基于时空域混合法利用Kaula正则化精确和快速解算GOCE地球重力场[J] 地球物理学报, 2011,V54(1): 14-21,DOI: 10.3969/j.issn.0001-5733.2011.01.003

ZHENG Wei, HSU Hou-Tse, ZHONG Min, YUN Mei-Juan, ZHOU Xu-Hua.Accurate and rapid determination of GOCE Earth's gravitational field using time-space domain method associated with Kaula regularization.Chinese J.Geophys. (in Chinese),2011,V54(1): 14-21,DOI: 10.3969/j.issn.0001-5733.2011.01.003

基于时空域混合法利用Kaula正则化精确和快速解算GOCE地球重力场

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Accurate and rapid determination of GOCE Earth's gravitational field using time-space domain method associated with Kaula regularization

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摘要 为了研究卫星重力梯度技术对中高频地球重力场反演精度的影响,本文基于时空域混合法,利用Kaula正则化反演了250阶GOCE地球重力场. 模拟结果表明:第一,时空域混合法是精确和快速求解高阶地球重力场的有效方法;第二,Kaula正则化是降低正规阵病态性的重要方法;第三,基于改进的预处理共轭梯度迭代法可快速求解大型线性方程组,计算时间较直接最小二乘法至少降低1000倍;第四,基于卫星轨道误差1 cm和卫星重力梯度误差3×10^{-12} /s^2,在250阶处反演累计大地水准面和重力异常的精度分别为9.295 cm和0.204 mGal. 第五,论证了基于国际GRACE和GOCE卫星计划反演高精度和高空间分辨率地球重力场的互补性.

关键词: GOCE 时空域混合法 Kaula正则化 卫星重力梯度 地球重力场

Abstract: The GOCE Earth's gravitational field complete up to degree and order 250 is recovered based on the time-space domain method associated with Kaula regularization in order to study the influences of satellite gravity gradiometry on the accuracy of medium-high frequency Earth's gravitational field recovery. The simulated results show: Firstly, the time-space domain method is an effective way to accurately and rapidly determine the high-degree Earth's gravitational field; Secondly, the Kaula regularization is one of the key processes to reduce ill condition of normal matrix; Thirdly, the large-scale linear system of equations is solved quickly using the improved pre-conditioned conjugate-gradient iterative approach, and the computing time can be reduced at least 1000 times as compared to the direct least-squares approach; Fourthly, at the degree 250, cumulative geoid height and gravity anomaly errors are 9.295 cm and 0.204 mGal with orbital error 1 cm and gravity gradient error 3×10^{-12}/s^2, respectively. Finally, the complementarity of high-accuracy and high-resolution Earth's gravitational field recovery between international GRACE and GOCE missions is demonstrated.

Keywords: GOCE Time-space domain method Kaula regularization Satellite gravity gradiometry Earth's gravitational field

Received 2009-04-20;

Fund:

中国科学院知识创新工程青年人才重要方向项目(KZCX2-EW-QN114), 国家自然科学青年基金(41004006), 湖北省自然科学基金(2010CDB05301), 中国测绘科学研究院地理空间信息工程国家测绘局重点实验室开放基金(201031), 中科院动力大地测量学重点实验室开放基金(L09-14),中国科学院测量与地球物理研究所知识创新工程领域前沿项目和湖北省耐火材料与高温陶瓷重点实验室-省部共建国家重点实验室培育基地开放基金(G201009)联合资助.

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