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基于BFGS法融合InSAR和GPS技术监测地表三维形变

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Measuring three-dimensional surface displacements from combined InSAR and GPS data based on BFGS method

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摘要

虽然InSAR技术具有高精度、大范围和高空间分辨率等优点,但只能监测雷达视线方向上的一维地表形变;而GPS技术虽可以监测地表的三维形变,但其空间分辨率很低.本文针对融合InSAR和GPS技术监测地表高空间分辨率三维形变展开研究.首先证明了简单的局部最优化迭代算法就能求得综合InSAR和GPS监测地表形变速率的能量函数模型的全局最优估值.随后提出了利用BFGS局部最优算法反演最优的地表三维形变速率.该方法既能避免全局最优化算法计算复杂且难以收敛的问题,又能克服传统的解析法中数值计算不稳定的缺点.最后,通过模拟实验和美国南加州真实数据实验表明,该方法能够得到高精度的地表三维形变速率场.而且当观测或插值误差导致解析法误差较大时,BFGS方法仍能得到高精度、稳定的全局最优解.

关键词 InSAR, GPS, 三维形变监测, 凸函数, BFGS方法

Abstract:

InSAR has the advantages of wide spatial coverage, high spatial resolution and high precision, but it can only measure one-dimensional surface displacements in line-of-sight (LOS). While GPS can monitor three-dimensional surface displacements, it is generally with very low spatial resolution. In this paper, the method of combining InSAR and GPS to measure three-dimensional surface displacements with high spatial resolution is studied. Firstly, it is proved that a local optimization method is sufficient to achieve the global optimization solutions of the objective function model, which is used to optimize the InSAR and GPS integration. Then the BFGS method is introduced in this study to estimate the optimal value of the three-dimensional surface displacement velocities. Compared to the global optimization method or the analytical optimization method, the BFGS method is very simple in computing and easy to converge, and has good resistance to numerical instability. In the last of the paper, the results of numerical simulations and real data experiments over Southern California are presented. They show a great improvement of accuracy when the proposed methods are used. Especially, when the observation or interpolation errors lead to ill-condition in the coefficient matrix of normal equations, the analytical optimization method can result in great errors, while the BFGS method works very well.

Keywords InSAR, GPS, 3D displacements monitoring, Convex function, BFGS method

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