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For satellite gravimetry to work as a global precise earth sensor of large earthquakes and water resources and beyond: solutions to problems incorrectly solved for 100 years

Peiliang Xu

Disaster Prevention Research Institute, Kyoto University, Uji, Kyoto 611-0011, Japan

Abstract: Satellite geodesy such as GNSS and InSAR has been playing an essential role in Earth Sciences. As a new important component of space geodesy, satellite gravimetry has been becoming more and more important in global precise sensing of water resource and large earthquakes, which some earthquake workers are obviously still not able to understand.

Earth's gravitational products have been routinely made from satellite tracking measurements of CHAMP and/or GRACE types by major institutions worldwide, for example, NASA Goddard Space Flight Center and German Research Center for Geosciences (GFZ). These global gravitational models have found widest possible multidisciplinary applications in Earth Sciences. The mathematical foundation used by these major institutions worldwide is essentially implemented by solving the differential equations of the partial derivatives of the orbit of a satellite with respect to the unknown harmonic coefficients under the conditions of zero initial values, which has been best known as the dynamical numerical integration method in geodesy and aerospace engineering. I prove that the method, originating from Gronwall on Ann Math almost 100 years ago and currently implemented and used in statistics, chemical engineering and satellite gravimetry and many other areas of science and engineering, is mathematically erroneous and physically not permitted.

I present three different methods to derive local solutions to the Newton's nonlinear differential equations of motion of satellites, given unknown initial values and unknown force parameters. They are mathematically correct and can be used to estimate unknown differential equation parameters, with applications in gravitational modelling from satellite tracking measurements. These solution methods are generally applicable to any differential equations with unknown parameters;

I develop the measurement-based perturbation theory and construct global uniformly convergent solutions to the Newton's nonlinear differential equations of motion of satellites, given unknown initial values and unknown force parameters. From the physical point of view, the global uniform convergence of the solutions implies that they are able to exploit the complete/full advantages of unprecedented high accuracy and continuity of satellite orbits of arbitrary length and thus will automatically guarantee theoretically the production of a high-precision high-resolution global standard gravitational models from satellite tracking measurements of any types; and finally,

I develop an alternative method by reformulating the problem of estimating unknown differential equation parameters, or the mixed initial-boundary value problem of satellite gravimetry with unknown initial values and unknown force parameters as a standard condition adjustment model with unknown parameters.

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