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利用精密单点定位求解电离层延迟

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Determination of ionospheric observables with precise point positioning

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摘要 近年来,高时空分辨率的全球导航卫星系统(GNSS)观测信号已成为电离层研究的重要资源.利用GNSS研究电离层,需首先将观测资料转换成包含电离层信息的可观测量(Ionospheric Observables,称之为"电离层观测值").目前,最常用的电离层观测值一般采用联合无几何影响组合的码和相位观测,利用相位平滑伪距方法计算得到(称之为"平滑电离层观测值"),但该过程易受平滑弧段长度和与测站有关的误差(如多路径效应和观测噪声)的影响.本文提出利用精密单点定位(Precise Point Positioning, PPP)提取电离层观测值(称之为"PPP电离层观测值",形式与平滑电离层观测值相同).与相位平滑伪距相比,IGS发布的卫星轨道、钟差产品可被PPP合理利用,从而有效减少了待估参数,使得电离层观测值的估计精度得到改善.基于短基线和零基线实验,通过考察两类电离层观测值的站间单差结果在各卫星弧段间的离散程度,验证了PPP电离层观测值的可靠性:以某两天的短基线实验结果为例,与测站有关的误差对PPP电离层观测值的影响分别为对平滑电离层观测值影响的44.4%和35.7%,表明PPP电离层观测值更利于高精度电离层建模、预报等研究.

关键词: 全球导航卫星系统 相位平滑伪距 精密单点定位 站间单差 电离层观测值

Abstract: In recent years, the Global Navigation Satellite System (GNSS) signals with extensive spatial coverage and temporal continuity have become an important source for ionosphere study. Determination of the ionospheric observables is the first step for GNSS-based ionosphere study, which is commonly done by combining the geometry-free linear combinations of carrier phase and code observations with leveling process to generate the so-called Leveled Ionospheric Observables (LIOs). However, the leveling process is vulnerable to the length of continuous satellite arc and receiver dependent model errors (e.g. multipath effects and measurement noise). In this paper, a strategy for determining the ionospheric observable with Precise Point Positioning (PPP) is proposed, and the resulted PPP Ionospheric Observables (PIOs) have coincidently identical forms with the LIOs. Different from the leveling process, the available IGS satellite orbits/clocks can be utilized by the PPP to effectively reduce the unknowns that have to be estimated, thus improving the accuracy of generation of ionospheric observables. Based on the short- and zero-baseline experiments, the improving reliability of PIOs with respect to LIOs is verified from comparing the spread of the between-receiver single difference of both ionospheric observables corresponding to different satellite arcs: in the cases of two representative days, the effect of receiver dependent model errors on the LIOs is respectively reduced to 44.4% and 35.7% of that on PIOs, which reveals that the PIOs would be more beneficial for ionosphere modeling and prediction.

Keywords: Global Navigation Satellite System (GNSS) Leveling process Precise point positioning (PPP) Single difference between receivers Ionospheric observable

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