Statistical property of the GNSS carrier phase observations and the related hypothesis testing with the bootstrap methods

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ABSTRACT

High accuracy GPS relative positioning is usually based on the double-differenced (DD) carrier phase observables. When considering short baseline (less than 20 km), the linear model for DD phase may be simplified to a mixed integer linear model, where the central problem of the determination of the integer phase ambiguities must be first solved. This topic has therefore been a rich source of GPS geodesy research over the last decades and more than 300 papers related to the method and application are published. Until now most of the existed validation and hypothesis tests (e.g. χ^2-test, *F*-test, *t*-test, and *ratio test* etc.) about the float solution and the fixed solution within *Least Squares Ambiguity Search* (LSAS) or "*Integer Least Squares*" approaches are performed under the assumption that the measured phases or phase differences are approximately *Gauss-Laplace* normally distributed. But based on our new research results (Cai, et al., 2007), the GPS carrier phase observables that are actually measured on the unit circle have been statistically validated to have a *von Mises* normal distribution. The existed validation and hypothesis testing procedures must therefore be improved accordingly. Since the distributions of the statistics commonly used for inference on directional distributions are more complex than those arising in standard normal theory, *bootstrap methods* are particularly useful in the directional context. In statistics the phase '*bootstrap method*' refers to a class of computer-intensive statistical procedures which can often be helpful for carrying out a statistical test or for assessing the variability of a point estimate in situations where more usual statistical procedures are not valid and /or not available (e.g. the sampling distribution of a statistic is not known). In this paper we will 1) study these technological and methodological aspects of the bootstrap methods, and 2) develop and investigate new efficient bootstrap algorithms for the confidence domains/hypothesis tests on the parameters of the GPS mixed integer linear models.

Key words: GPS mixed integer linear model; Validation and hypothesis tests; *Gauss-Laplace* normal distribution; *von Mises* normal distribution; *Bootstrap methods*