PERFORMANCE ANALYSIS OF GPS/GLONASS PRECISE POINT POSITIONING

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Precise Point Positioning (PPP) with Global Positioning Systems (GPS) has attracted the attention of many researchers over the past decade. Recently, the Russian global navigation satellite system (GLONASS) has been modernized and restored to near full constellation status, which has made it more attractive for positioning and navigation. Having two healthy systems, namely GPS and GLONASS provides a combination of both constellations, which in turn promises to improve the availability, positioning accuracy, and reliability of PPP solutions.

This study investigates the effect of combining GPS and GLONASS dual-frequency measurements on the static PPP solution and its sensitivity to different processing strategies. Many data sets from five globally distributed International GNSS Service (IGS) tracking stations were processed using the Bernese GPS software package. The addition of GLONASS constellation improved the satellite visibility and geometry by more than 60%, and 40%, respectively, and improves the positioning convergence by up to 41%, 38%, and 19% in east, north, and up directions, respectively.

Le positionnement ponctuel précis (PPP) au moyen du système de localisation GPS a attiré l'attention d'un grand nombre de chercheurs au cours de la dernière décennie. Récemment, le système russe GLONASS (système mondial de satellites de navigation) a été modernisé et rétabli au statut de constellation presque complète, ce qui l'a rendu plus attrayant pour la navigation et le positionnement. Étant donné qu'il y a présentement deux systèmes sains en place, à savoir le système GPS et le système GLONASS, il est possible de combiner les deux constellations et d'assurer ainsi l'amélioration de la disponibilité, de la précision du positionnement et de la fiabilité des solutions du PPP.

Le présent article examine l'effet de la combinaison des mesures à double fréquence des systèmes GPS et GLONASS sur la solution statique PPP et sa sensibilité à diverses stratégies de traitement. De nombreuses séries de données recueillies à partir de cinq stations de suivi du Service international GNSS (IGS) distribuées mondialement ont été traitées en utilisant le progiciel GPS Bernese. L'ajout de la constellation GLONASS a amélioré la visibilité et la géométrie satellite de plus de 60 % et 40 % respectivement et améliore la convergence du positionnement jusqu'à 41 %, 38 % et 19 % dans les directions est, nord et ascendante respectivement.

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1. Introduction

The concept of PPP was introduced by *Zumberge et al*. in 1997 as a part of a research program at Jet Propulsion Laboratory (JPL). They analyzed daily sets of dual-frequency GPS observations and carrier phase data in PPP mode using the GIPSY/OASIS software package developed at JPL. It was found that the PPP approach is capable of providing millimetre and centimetre repeatability in the horizontal and vertical directions, respectively. It was also emphasized that in order to achieve the highest possible accuracy in PPP, precise ephemeris and their clock corrections should be used.

Subsequently, a number of researchers made further developments to the GPS-based PPP technique [e.g., *Kouba and Héroux* 2001; *Collins et al*. 2010; *Elsobeiey* 2012] and recently, the combination of GPS and GLONASS measurements for PPP was investigated [e.g., *Cai* 2009 and *Martín et al*. 2011]. However, their research included a limited number of GLONASS satellites, which may not reflect the current GLONASS status.

GLONASS has been gradually replenished since 2002 and has reached a total of 24 operational satellites. As such, to improve the availability, positioning accuracy and reliability of the PPP solution, we proposed to combine the GPS and GLONASS constellations.

The performance of the GPS/GLONASS PPP model was assessed in static mode through processing of several data sets from five globally distributed IGS stations over three consecutive days in 2011.