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Review

The Multi-GNSS Experiment (MGEX) of the International GNSS Service (IGS) – Achievements, prospects and challenges

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Abstract

Over the past five years, the International GNSS Service (IGS) has made continuous efforts to extend its service from GPS and GLONASS to the variety of newly established global and regional navigation satellite systems. This report summarizes the achievements and progress made in this period by the IGS Multi-GNSS Experiment (MGEX). The status and tracking capabilities of the IGS monitoring station network are presented and the multi-GNSS products derived from this resource are discussed. The achieved performance is assessed and related to the current level of space segment and user equipment characterization. While the performance of orbit and clock products for BeiDou, Galileo, and QZSS still lags behind the legacy GPS and GLONASS products, continued progress has been made since launch of the MGEX project and already enables use of the new constellations for precise point positioning, atmospheric research and other applications. Directions for further research are identified to fully integrate the new constellations into routine GNSS processing. Furthermore, the active support of GNSS providers is encouraged to assist the scientific community in the generation of fully competitive products for the new constellations.

Keywords: IGS; MGEX; BeiDou; Galileo; QZSS; Orbit and clock

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Contents

1. Introduction

The International GNSS Service (IGS; Dow et al., 2009; Johnston et al., 2017) is a volunteer association formed by numerous universities, research institutions, as well as geodetic and space agencies around the globe, which work together to provide highest-quality GNSS data and products on a freely accessible basis for scientific advancement and public benefit. Over the twenty years of its existence, the IGS has continuously advanced the quality of GPS, and later GLONASS, orbit and clock products, thus enabling cutting-edge research and engineering applications.

While one or two global navigation systems may well be considered sufficient for common users, a growing interest in the build-up of independent national positioning, navigation, and timing (PNT) capabilities has triggered a race for new global and regional navigation satellite systems (GNSSs/RNSSs) at the turn of the millennium. The launches of the first Galileo In-Orbit Validation Element (GIOVE) satellite in 2005 and the first test satellite of the Chinese BeiDou-2 constellation (Compass-M1) in 2007 marked the start of a new era in satellite navigation.

Even though remarkable scientific progress has been made (and continues to be made) with legacy GPS and GLONASS observations, the ongoing modernization and the build-up of new constellations offers exciting prospects for further improvement:

- The larger number of satellites and signals-in-space benefits positioning through a reduced dilution of precision (DOP) and offers an improved sky coverage for atmospheric remote sensing from ground (Li et al., 2015a) and space (Harnisch et al., 2013). It also helps to improve the reliability and convergence time for precise point positioning applications (PPP; Tegedor et al., 2014; Li et al., 2015b,c; Ge et al., 2016).
- The availability of unencrypted signals on at least two frequencies and the advanced signal structure of the new GNSSs (Betz, 2016) enables improved tracking performance in terms of precision and robustness with an overall benefit for the availability of measurements. This is of great interest for tracking under severe scintillation but likewise for spaceborne radio occultation (Anthes, 2011) and reflectometry observations (Foti et al., 2015) that are collected at extremely low signal power levels.