Preliminary Investigation of Applications of Kinematic KSA-GRF in Saudi Arabia

Saad AlQahtani, Sultan Alshahrani, Rossen Grebenitcharsky, Othman M. Alrubayyi and Tariq Alqrni (Saudi Arabia)

Key words: GNSS/GPS; Reference frames; Reference systems; Temporal Geodetic Reference System; Kinematic Geodetic Reference Frame (KGRF); Crustal Motion and Velocity Field; Saudi Arabia National Spatial Reference System; SANSRS; Geodynamics Monitoring

SUMMARY

The General Authority for Survey and Geospatial Information (GEOSA) of Saudi Arabia developed a concept for Temporal Saudi Arabia National Spatial Reference System (T-SANSRS) which consists of three integrated components, i.e., a Kinematic Geodetic Reference System (KGRS), a Time-varying Vertical Reference System (TVRS) and a Dynamic Geoid (DGEOID), as part of the country's National Temporal Geodetic Infrastructure (NTGI).

The KGRS aims to provide a highly precise and sustainable 4D geodetic reference frame reflecting crustal motions on regional and local scales. The Kinematic Geodetic Reference Frame (KGRF) as realization of KGRS will be based on a robust fully operational active national geodetic infrastructure (KSA-CORS) for continuous data collection and online monitoring with a Core Collocated Station, combining advanced space satellite and gravity techniques (VLBI SLR, DORIS, and GNSS absolute/superconducting/quantum gravimeter) and integrated into the Global Geodetic Observing System.

The preliminary research of the KGRF was performed based on the long-term continuous (more than five years) GNSS data collected at 209 permanent stations of the KSA-CORS network. The time series analysis of daily solitons allowed the detection of annual and semi-annual fluctuations as well as motions of various periods of unknown nature. In addition, the analysis recovered some stations affected by co-seismic and post-seismic motions due to two earthquakes that occurred on 2017-11-12 with a magnitude of 7.3 and on 2023-02-06 with a magnitude of 7.8. As a result of the combination of daily solutions, the Arabian tectonic plate rotation parameters were computed, which allowed us to determine the model of the KSA intraplate velocities utilizing the Least Square Collocation technique in the form of regular

grid.

Employing the model of KSA intraplate velocities, we calculated such parameters of crustal deformations as principal strain rates, dilatation rates, rotation rates, and maximum shear strain rates.

The results of this preliminary study confirmed that internal kinematics of the Arabian plate is not uniform, and could be caused by activity of local faults, volcanoes, etc. or anthropogenic (minerals or water extraction, etc.) activities and requires further detailed interdisciplinary investigation. The study demonstrates that the major case studies of geospatial applications, i.e., the Earth's surface, undergo dynamic changes, which must be considered in the geospatial area, not only for geodetic/surveying applications but also for other areas such as cadastre, precise farming, autonomous driving, and civil engineering.

Moreover, a consideration of intraplate motions, caused by local geodynamic or anthropogenic activity, is crucial for accurate positioning in geodesy and surveying.

The Kinematic Geodetic Reference Frame (KGRF) will enhance national surveying and mapping applications by providing time-dependent reference coordinates, supporting deformation monitoring, infrastructure stability assessment, and improving the accuracy of GNSS-based positioning services for land and engineering surveys. Practical applications include monitoring subsidence in urban areas, ensuring stability of large infrastructure such as bridges and pipelines, and improving control in high-precision construction and cadastral projects.