

Spatio-temporal characteristics in GNSS time series based on robust spectral analysis

*Keisuke YANO¹, Masayuki Kano², Tetsuya Takatabatake³, Yusuke Tanaka², Yusaku Ohta²

1. The Institute of Statistical Mathematics, 2. Tohoku University, 3. Osaka University

The Global Navigation Satellite System (GNSS) is an observation system to measure the locations of observation stations by receiving radio waves transmitted from the satellites. Due to this observation principle, raw GNSS data contain various information from satellites to receivers such as the ionosphere, atmosphere, surrounding environment close to the antennas, as well as the motion of the Earth. Thus, pre-processing of raw GNSS data is required to estimate the target products by modeling the other factors using analysis software. The Geospatial Information Authority of Japan provides the daily coordinates at the GEONET stations as the F5 solution (Takamatsu et al. 2023). Because of its convenient use, the F5 solution is frequently used for a variety of geodetic, seismic, and volcanic analyses related to crustal deformation. To precisely extract the transient deformation due to tectonic or volcanic processes, it is important to understand the spatio-temporal characteristics and to accurately model them. Nonetheless, the comprehensive analysis of spatio-temporal characteristics in the F5 solution has been rarely published. Takatabatake and Yano (2023) recently proposed a method to robustly estimate the frequency-domain characteristics of observed time series. In this presentation, we introduce this robust spectral estimation and its application to the GEONET F5 solution. The method utilizes the spectral Renyi divergences, which includes the Itakura-Saito divergence as a limit. The Itakura-Saito divergence (Itakura and Saito, 1968; Whittle, 1953) is widely used in the spectral analysis and provides the foundations of the maximum likelihood method or Burg's maximum entropy method. However, the method based on the Itakura-Saito divergence is unstable in the presence of outliers in the frequency domain such as annual or semi-annual components. The spectral estimation using the spectral Renyi divergence is shown to become more stable against the presence of outliers in the frequency domain than that using the Itakura-Saito divergence, which reduces the effect due to pre-processing of observations. We then applied the method to the F5 solution from 1996 to 2023, which was then divided into four years overlapping 0.5 years to calculate power spectral densities (PSD). We modeled each PSD as the sum of the two Brune's spectral models (Brune, 1970) representing both high-frequency and low-frequency components. In this model, the amplitudes, cut-off frequencies, and slopes of the spectra for both frequencies are estimated by the proposed method. Our preliminary result indicates that, for low-frequency bands, the modeled spectral shows the colored noise with the slopes of ~ -4.0 to -1.5 , while those for high-frequency bands are close to the pink to white noise with slopes of ~ -1.5 to 0.0 . In addition, the amplitudes of high-frequency component showed a temporally gradual reduction until ~ 2003 . This may correspond to the reduction of GNSS orbits provided by International GNSS service.