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Crustal Deformation in the Southwestern Ryukyu Arc Estimated from GNSS data

KOIKE, Toshiki[2*] ; NISHIMURA, Takuya[1] ; MIYAZAKI, Shin'ichi[2]

[1]Disaster Prevention Research Institute, Kyoto University, [2]Graduate School of Science, Kyoto University

1. Introduction

The south-western Ryukyu arc is characterized by back-arc spreading and a fast plate convergence rate (12.5 cm/year). In this region, few large earthquakes are reported though a fast plate convergence rate. Well-known large earthquake in this region is the 1771 Yaeyama earthquake (M_W 8.0) with a devastating tsunami. On the other hands, slow seismic and aseismic events are often reported. For example, biannually repeating slow slip events (SSEs) are reported by Heki and Kataoka (2008), and they reported that SSEs occur on a subducted plate interface under Iriomotejima Island. Crustal deformation during several years in this region is proposed to be expressed by rigid block rotation models by Nishimura et al. (2004), Nakamura (2004), and so on. They propose that the Ryukyu region is divided to three blocks, and each block is moving independently. But boundaries are different from each other. Nishimura et al. (2004) proposed that the Yaeyama region (Iriomotejima, Ishigakijima, and some other islands) and the Miyakojima region are moving on the same block. On the other hand, Nakamura (2004) proposed that these two are on different blocks. These studies used the GEONET GNSS data operated by Geospatial Information Authority of Japan. But this region consists of remote islands, so we can't discuss detailed internal deformation.

2. GNSS data

In this study, we use 13 stations in total. 8 stations are GEONET GNSS stations located in the Yaeyama region and the Miyakojima region. And one station is located in the south of Miyakojima Island, which is operated by the Japan Coast Guard. This station has not been used for scientific analysis. And the other 4 stations are new ones we set up, which are located in Iriomotejima Island (Funauki and Oohara), Kuroshima Island, and Kohamajima Island. We estimate daily cordinates of the GNSS stations using GIPSY 6.2 with strategy of Precise Point Positioning. Next, we calculate moving average to remove errors due to the artificial offsets and the weather condition. In time-series data of 4 new stations from 2010 to 2013, we can recognize 4 deformation episodes suggesting SSE in all station's data.

3. Rigid block rotation models

We compare displacements calculated from the model of Nishimura et al. (2004) with observed one from 2010.24 to 2012.69, and we find that they have an obvious difference. The observed displacements direct counterclockwise compared with calculated one, and displacement pattern suggests displacement direction changing counterclockwise and increasing displacement rate in western stations. This may mean that a rigid block rotation in this region changed after the previous study. Therefore, we examine how good rigid block rotation can explain the observed displacement and estimate Euler vectors for the rigid block rotation. Displacement calculated from the best-fit rotation model can reproduce the observed one. The estimated Euler pole located at (128.089^{o}E, 29.095^{o}N) with angular velocity of 6.675 rad/Myr. And we examine baseline change which is independent with rigid block rotation to study internal deformation in this region.

4. Conclusion

We analyze GNSS data in the south-western Ryukyu arc. This region is characterized by a fast plate convergence rate (12.5 cm/year) and frequent slow slip events (SSEs). Because this region consists of remote islands with a few GNSS stations, we set up new 4 GNSS stations to examine detailed crustal deformation. We compare observed and calculated displacement using the proposed rigid block rotation models and find that they have an obvious difference. We also report a result for a rigid block rotation estimated from the observed displacement and a change of baseline lengths in this region to examine internal deformation.

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Keywords: Ryukyu trench, GNSS, Rigid block rotation