Visualization of crustal deformations in Japan -10 years before and after the 2011 Tohoku Earthquake viewed with GNSS dates.-

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March 11, 2021 marks the 10th anniversary of the 2011 Tohoku Earthquake. The earthquake, which observed the largest magnitude in Japan's observation history, was recorded by various observation networks and recording media, and was also captured by the “GNSS Earth Observation Network System” (GEONET). GEONET has accumulated coordinate value data from 1996 to the present, and has continued to observe daily crustal deformations associated with this earthquake with an observation network of about 1,400 points. This observational data is open to the public on the Geospatial Information Authority of Japan website and can be accessed by anyone. However, since it is difficult to process a huge amount of data and visualize the observation results, it is difficult for students to grasp the appearance of Japan. On the other hand, applications and tools that can display the earth and planets in 2D or 3D, such as “Dagke Earth” (http://earth.dagik.org), are appearing as digital teaching materials and have been emphasized in recent years. These can be used for active learning, which "not only gives students knowledge and information, but also allows students to observe problems and draw conclusions." The introduction of these kinds of ICT in schools and educational institutions has begun to gradually progress, and it is expected that the number of places where these teaching materials can be used will increase in the future.

Daily observation data is stored as GEONET data from 1996 to the present, and crustal deformations during any period can be displayed as vector diagrams or baseline length graphs. In addition, the analysis coordinate values (F3 solution and F4 solution) analyzed by the Geospatial Information Authority of Japan for general use are also open to the public. However, it is difficult to intuitively grasp how Japan is fluctuating by utilizing these databases and expressing baseline length graphs and maps, and there are aspects that can only be understood by people with some specialized knowledge. In this study, we created a map that can capture the temporal fluctuations of Japan by calculating the displacement amount of each electronic reference point using the F3 solution and exaggerating the crustal deformations.

The map created by exaggerating the amount of displacement (variable topographic map) changes the shape of Japan after that depending on the reference year. In particular, the change is remarkable when the base year is before and after a relatively large earthquake. In this study, we set three periods: 1996 to 2020, when GEONET began observing Japan, 1996 to 2010, and 2011 to 2020, with the 2011 Tohoku Earthquake as the boundary. By comparing the monthly crustal deformation maps of each month, we attempted to visualize the steady movements of Japan and the aftereffect movements that are prominent after a large earthquake.

In order to capture crustal deformations, there are many aspects that must be captured by continuous observation in units of several years to several decades, so in elementary and junior high school education, it is difficult to observe during class hours, as a huge amount of data is handled. However, effectively studying the use observations that GEONET has accumulated using the new method should help us to think about the appearance of the country in which we live. In addition, if students can freely change the analysis period and exaggeration ratio of the crustal deformation map created, it will be a tool

to help students learn independently.

Keywords: crustal deformation, Japan, Digital teaching material

