JURNAL PENDIDIKAN GEOGRAFI

VELOCITY CHANGES ANALYSIS DISPLACEMENT DATA USING GNSS (GLOBAL NAVIGATION SATELLITE SYSTEM) IN AROUND JATI GEDE DAM

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ABSTRACT

Jati Gede Dam is located around the border of Sumedang - Majalengka region in West Java province. Jati Gede Dam provides several benefits such as for irrigation, hydropower, tourism and fish farming. Dam can also trigger the potential a disaster, especially in the water impounding process. The process of water impounding in the dam has the potential to cause earthquake disaster. The effect of water impounding potentially adds stress accumulation in the dam area so that it can cause earthquakes. Therefore, a research on strain change due to the water impounding in Jati Gede dam is needed. The method used in the research is by GPR survey. Result from GPS observation processed to generate displacement value of GPS observation point, and strain changes from the point that formed grid strain. Based on deformation analysis the effect of water impounding to the strain around Jati Gede Dam can be obtained. Development in this thesis is by using and additional method namely Kinematic PPP to see the different pattern of earth tide phenomenon around the dam which were represented by several GPS stations. These results indicate a change of velocity direction in the area around Jati Gede dam. This change can be analyzed for the station near the dam as JTG1 station, jtg2, CSUM, 0355, BDK2, CJR6, and MJLK. BDK2 campaign point leads toward the Southwestern, CJR6 displacements from the Southwest to the North, MJLK displacements from Southeast to the Northwest, and 0355 displacements from Southeast to the North. JTG1 GPS station point tends to lead toward the Southwestern and JTG2 GPS station leads toward the North with 0355 GPS station. CSUM in Sumedang displacements from Northwest to the East. This change can be analyzed for the station near the dam such as JTG1, JTG2, CSUM, 0355, BDK2, CJR6, and MJLK as result of the process of water filling in Jati Gede dam.

Keywords: *Jati Gede DAM, GPS observation, strains changes, kinematic PPP method, earth tide*

ABSTRAK

Bendungan Jati Gede memberikan beberapa manfaat sekaligus dapat memicu potensi terjadi bencana. Proses pengisian air pada bendungan memiliki potensi menimbulkan bencana gempa bumi. Oleh karena itu diperlukan penelitian perubahan regangan akibat dari pengisian air di bendungan Jati Gede. Metode yang digunakan untuk penelitian tersebut adalah dengan melakukan survey GPS. Data yang digunakan adalah data GPS tahun 2007 sampai 2016. Hasil dari pengamatan GPS diolah sehingga menghasilkan nilai pergeseran titik-titik pengamatan GPS, dan kecepatan pergerakan titik-titik stasiun GPS. Hasil penelitian ini menunjukan terjadi perubahan kecepatan di wilayah sekitar bendungan yang diwakili oleh titik-titik stasiun GPS. Perubahan ini dapat dianalisis untuk stasiun yang dekat dengan bendungan. Perubahan ini diduga akibat dari proses pengisian air di bendungan Jati Gede.

Kata kunci: Bendungan Jati Gede, pengamatan GPS, perubahan kecepatan

INTRODUCTION

Indonesia has dams, but less than compared to electricity demand by human activities and human demand in this country. Jati Gede dam is a new dam built in Sumedang regency and half of the dam includes Majalengka regency area. Development of Jati Gede dam has contributed to adding energy source for electricity and demand for electricity can be supplied for Jati Gede and the surrounding area.

Stress changes when impounding water process in this dam because increasing vertical stress caused by the weight of water and by decreasing effective stress along the major thrusts due to increased pore pressue. It causes earthquake events in the surrounding Jati Gede dam. Dam's strength and stability depends on orientation of preexisting stresses and the geometry of the dam (Baranova, et al., 2002). In Figure 1.1, it shows Wenchuan earthquake events and distribution in Zipingpu dam China.

The process of water impounding in the dam can increase the seismic effectiveness. Figure 1.2 shows that water impounding in Zipingpau Dam have a relationship in water level with event of earthquake. Water impounding in the dam has a positive correlation between volume increase and water level with earthquakes in the area around the dam.

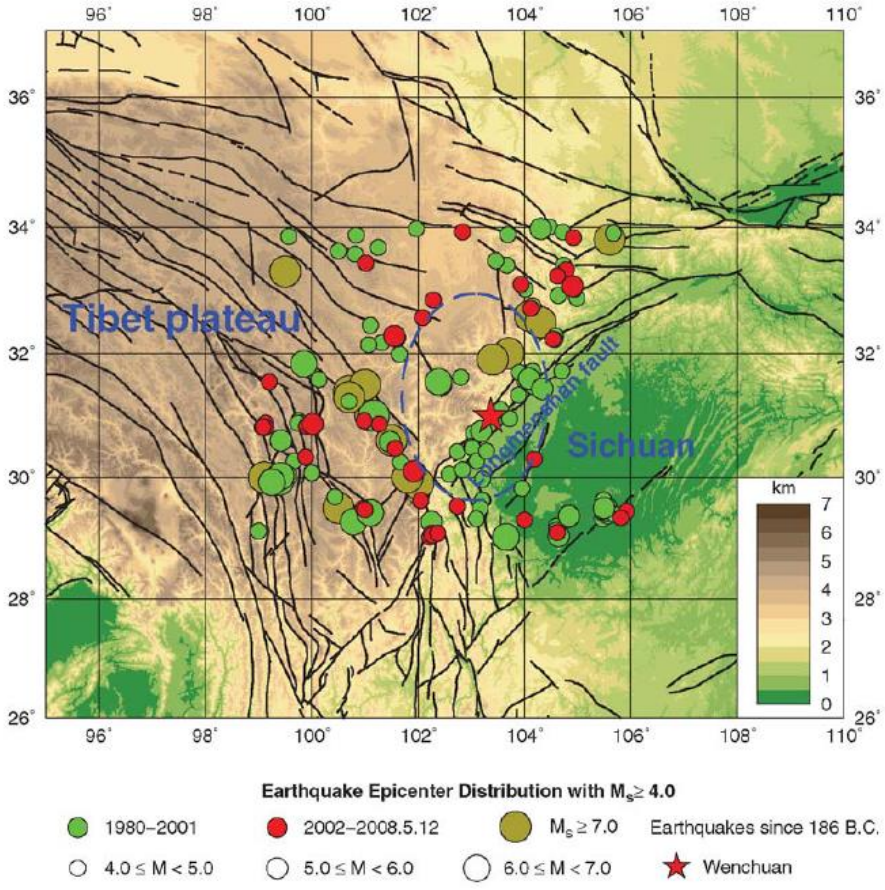

Figure 1. Earthquake events distribution in Zipingpu reservoir Wenchuan, China (Gahalaut, 2010).

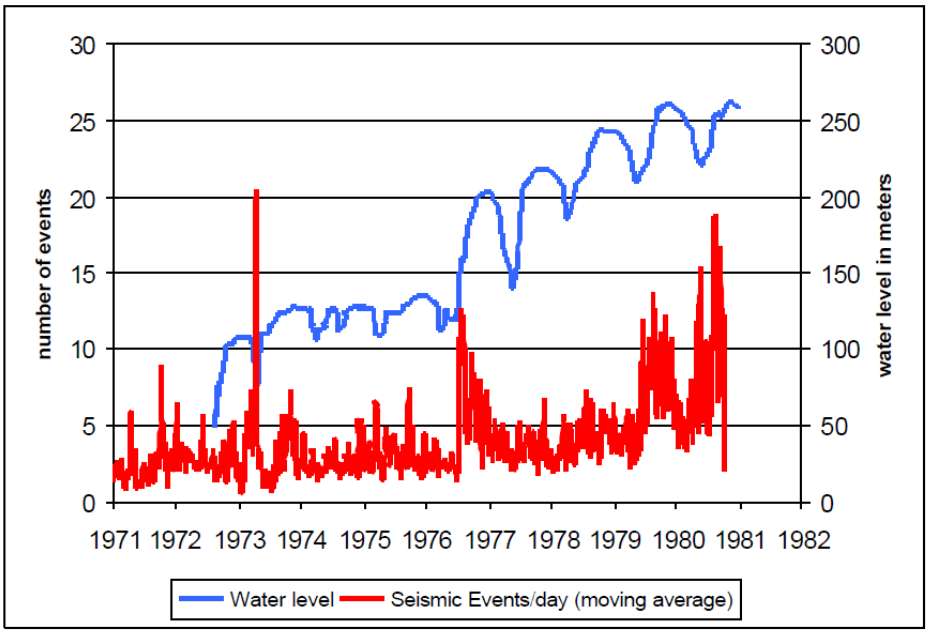

Figure 2. The Figure representation of the water level at Zipingpu dam Wenchuan China and the seismic events in the vicinity of the dam. (Gahalaut, 2010)

METHODS

A framework that object points are used located in the area of deformation observation. On relative basic framework, because the object positions used located in the observation area that is unstable, then the object points used has changed. Because every point suffers changes either in bond points or monitor points, then the calculation of this framework is relatively more complex. The stages in deformation analysis of relative basic framework are:

a. Selection of object points for single point displacement, ignoring other points or the movement modeling;
b. Deformation model design concerning the movement and deformation of rigid material into object;
c. Deformation model testing through statistic testing object.

Relative framework used for detect strain changes with input coordinate must be in millimeter level. Differential method used in this framework. This method uses GAMIT/GLOBK software in daily solution. Strain changes used to analysis impact from water impounding process in Jati Gede Dam.

Data obtained from GNSS survey method processed was using differential static methods with the processing time of 24 hours. The GPS data processing use GAMIT/GLOBK software and is a differential positioning. GAMIT/ GLOBK Algorithms system is processing data with regard the cycle ambiguity. This software is scientific software and has the accuracy until mm.

Strain changes were obtained by calculating the value of strain for the period of 2007 to 2015 data and calculate the value of strain for the data period only in 2016 except for data campaign. For data campaign, the data of 2011 and 2016 are used because there were no observations in 2015 when impounding begins.

The data used in this research was IGS station data for reference point of positioning determination of GPS observation points. IGS station point used was station point IISC, KARR, BAKO, PIMO, GUAM, DGAR, DARW, TOW2, YAR2, and COCO. Ten IGS GNSS observation stations were used to bind the observation points into the IGS framework system. In addition, there was also the observation data in the form data from continuous station and station with the observation campaign.

Listed below in Table 1 is the data obtained from continuous GNSS stations which are managed by the Geospatial Information Agency. Table 2.2 is a continuous GNSS data of new station built by ITB. Table 2.3 is a GNSS data campaign station with initial data collection in 2007 and the last data obtaining in April 2016.

Table 1. GNSS Continue Data from BIG

GPS Continue from BIG							
year	2010	2011	2012	2013	2014	2015	2016
station name	doy (%)						
CSUM	9.32	100	100	100	99.45	100	66.58
CMIS	7.122	86.85	93.97	91.23	20	99.73	66.58
CCIR	90.41	86.58	100	95.89	59.18	92.33	67.12
CRUT	7.95	98.08	99.73	100	20.55	100	64.66
CROL	6.03	100	100	100	19.73	100	66.58

Table 2. GNSS Continue Data

GPS Continue new stations							
year	2016 (%)						
station name	Feb	Mar	Apr	May	June	July	August
JTG1	37.93	70.97	70	100	96.67	50	12.90
JTG2	20.69	74.19	80	100	96.67	40	90.32

Table 3. GNSS Campaign Data

campaign															
year	2007					2009		2010		2011		2016			
station name	doy					doy		doy		doy		doy			
	121	123	124	307	309	216	219	170	171	356	357	105	106	107	108
355															
CJR6															
MJLK															
BDK2															

FINDINGS AND DISCUSSION

1. GPS Sites Times Series

Point 0355 is the campaign point close to JTG2 GPS station. This point is located in the south of Jati Gede dam. The results of data processing in the form of time series show a pretty good data accuracy. This point is used as a comparison of the direction of movement of the point prior to the water filling in the dam and when the process of water filling in the dam takes place.

Figure 4 shows the time series of point 0355. The time series of CJR6, BDK2, and MJLK points is shown in the Appendix. From the results of data processing of the campaign for period 1 and period 2, it can analyze the displacement change which occurs prior to the water filling in the dam and when the process of water filling in the dam. The change can be seen more clearly in the formed velocity.

In addition to the time series of campaign data, the time series of new station points built by ITB has also formed. Figure 5 shows the time series in JTG1 point. JTG1 point is located in the west of the dam. The results of data processing for the station show a pretty good accuracy. JTG1 and JTG2 points are local continuous GPS point to monitor the movement of Jati Gede dam. The existence of this point is very important because these two points are the closest point to Jati Gede dam. The data for JTG1 and JTG2 points newly exist in 2016. The data for JTG1 and JTG2 are included to the second period where the process of water filling has taken place in Jati Gede dam.

Figure 6 shows the time series of continuous GPS station of BIG in 2016. The CSUM point is a continuous point of BIG located in Sumedang and closest to the dam. Continuous point of BIG in this study has fairly long observation data namely from 2010 to 2016. This point is used as a comparison of local movement pattern near the dam with a region far to the dam. It is used to ensure that the change in the displacement is due the process of water filling in Jati Gede dam.

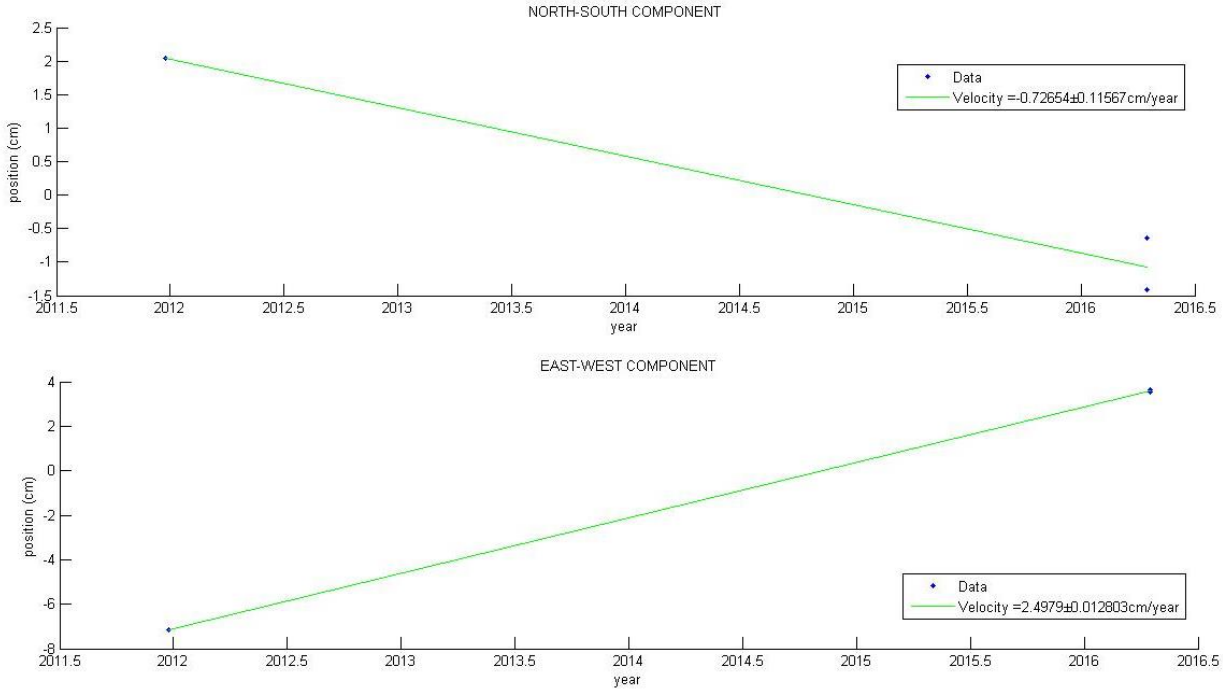

Figure 4. Time series in 0355 station for data in 2016

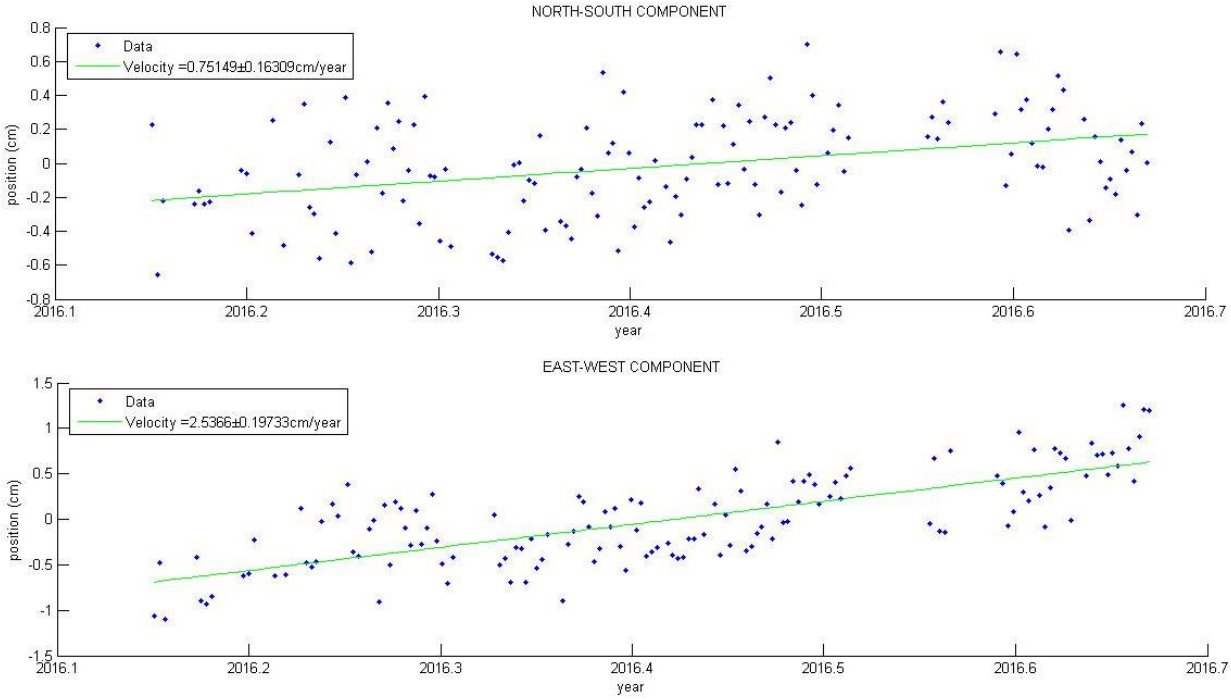

Figure 5. Time series in JTG1 station

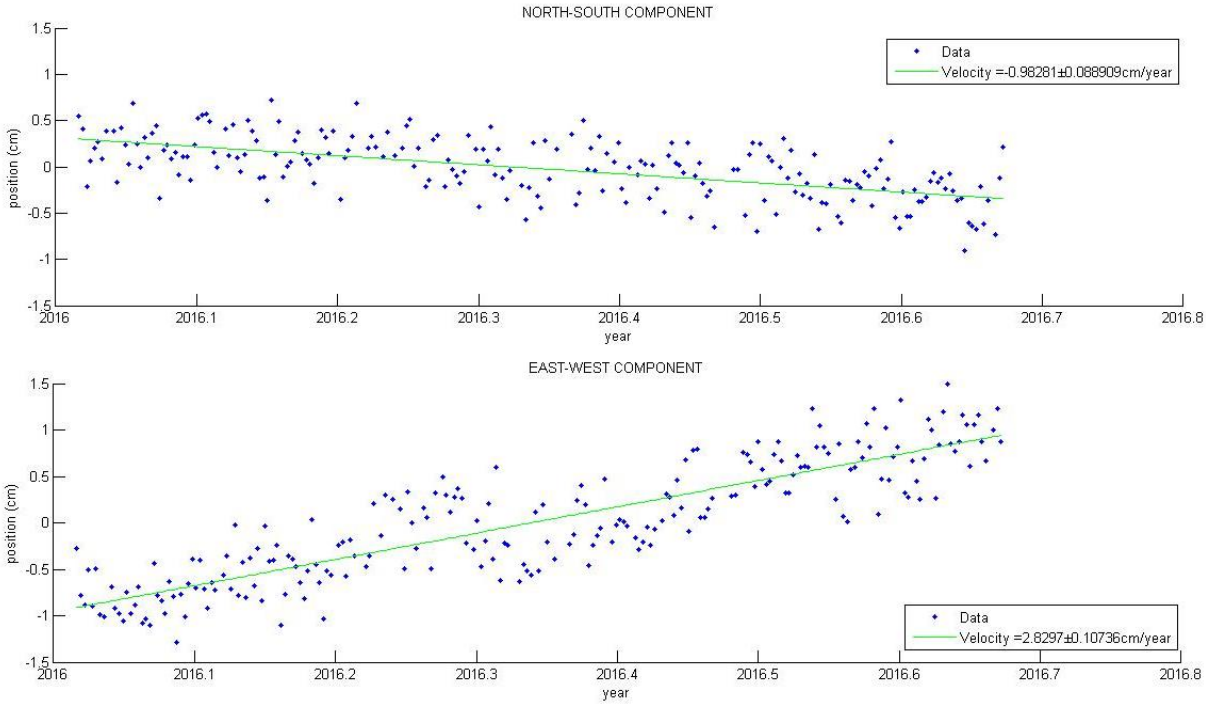

Figure 6. Time series in CSUM station for data in 2016

2. GPS Site Velocity

The calculated velocity value generates the value of velocity vector value that indicates the magnitude and direction of the displacement. Figure 7 shows the value and direction of velocity in centimeters per year for the data processing from 2007 to 2015 that still contains the effect of a displacement in the Sunda Block. There are 9 GPS stations used to form a strain in the period of 2007 to 2015. Figure 7 shows the displacement direction for the observation area to the southeast before corrected by the effect of a displacement in the Sunda Block.

While in Figure 8 shows the direction of power value changes in domain frequency on earth tide phenomenon corrected by Sunda Block effect on the observation area represented by 9 GPS stations with the data in 2007 to 2015. BDK2 and CJR6 campaign points lead toward the Southwestern and MJLK and 0355 points lead toward the Southeast of the Jati Gede dam. BDK2, CJR6, and MJLK GPS station points are located in the north of Jati Gede dam. Continuous GPS stations of BIG have different directions.

CROL GPS point in Indramayu leads toward the Southeast, CCIR in Cirebon leads toward Southwestern, CMIS in Ciamis leads toward the South, CRUT in Garut leads toward the East and CSUM in Sumedang leads towards the Northwest.

The velocity change between period 1 and period 2 can be seen by comparing the results of velocity of the data from 2007 to 2015 with a velocity from the results of data processing in 2016. In the second period data, there are additional data namely JTG1 and JTG2 station points. There is velocity change in both direction and magnitude between

the velocity formed from the data of 2007 to 2015 with the velocity formed in 2016.

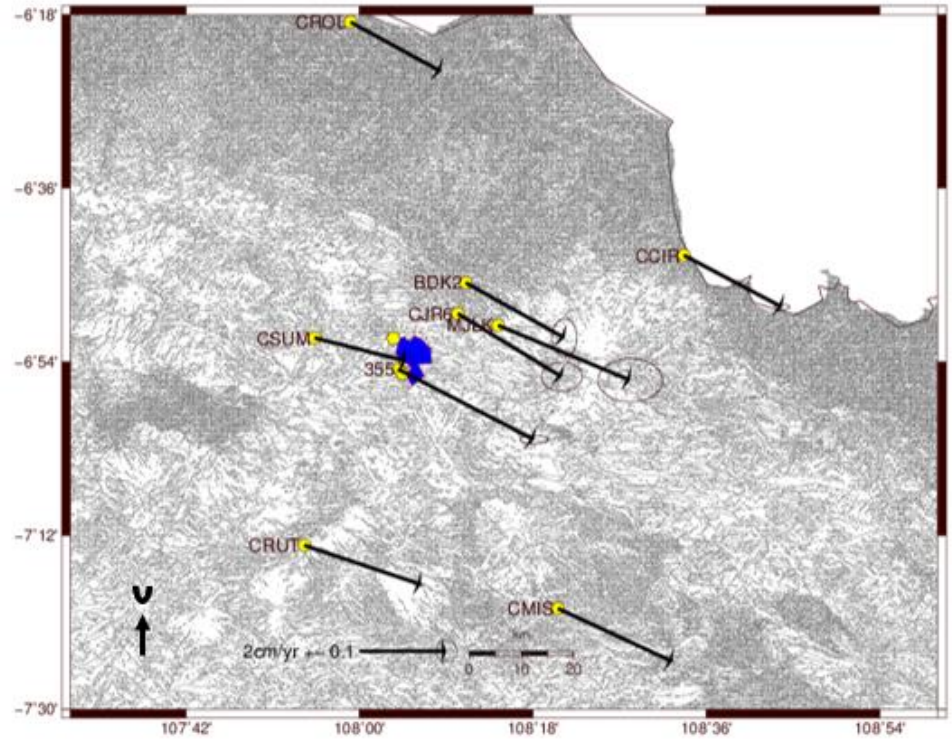

Figure 7. Velocity with Sunda block effect for data 2007 until 2015

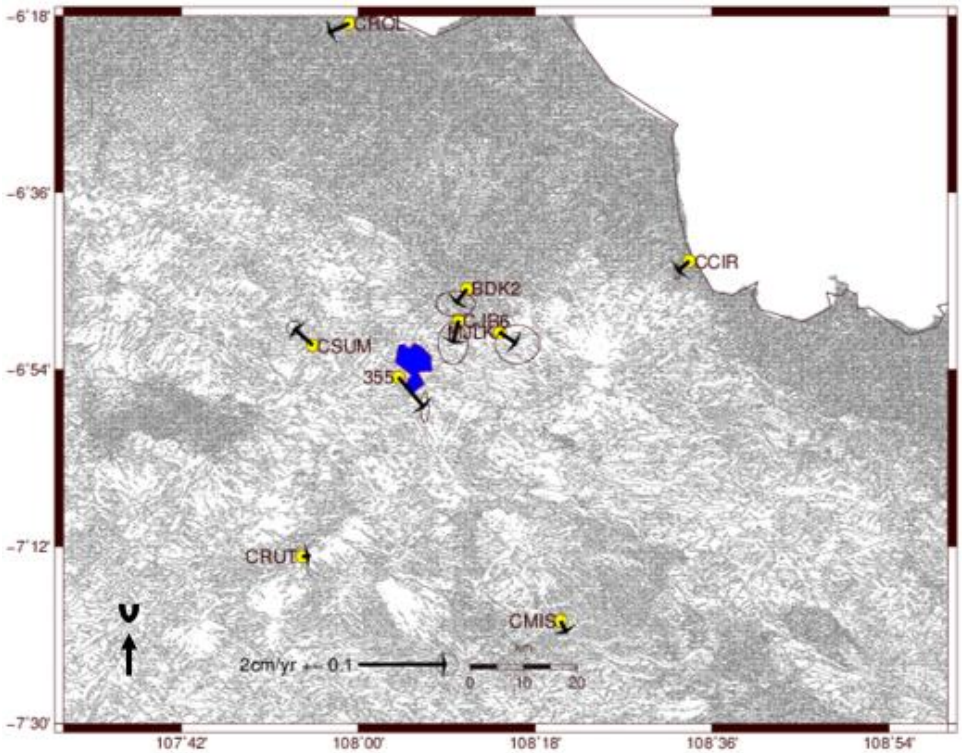

Figure 8. Velocity reduced Sunda block effect for data 2007 until 2015

This change is clearly seen on the local station near the dam namely JTG1 and JTG2 stations. Figure 9 shows the velocity for the data in 2016 before corrected by the effect of a displacement in the Sunda Block. 9 GPS points other than JTG1 and JTG2 have the same velocity pattern with direction to the Southeast. However, there is a change of direction in JTG1 and JTG2 GPS points that tends to lead toward the East. The direction of the 9 points is similar to the direction of the velocity with the data from 2007 to 2015. This shows that there is a change in velocity as a result of local phenomena namely a displacement as a result of water filling in the Jati Gede dam.

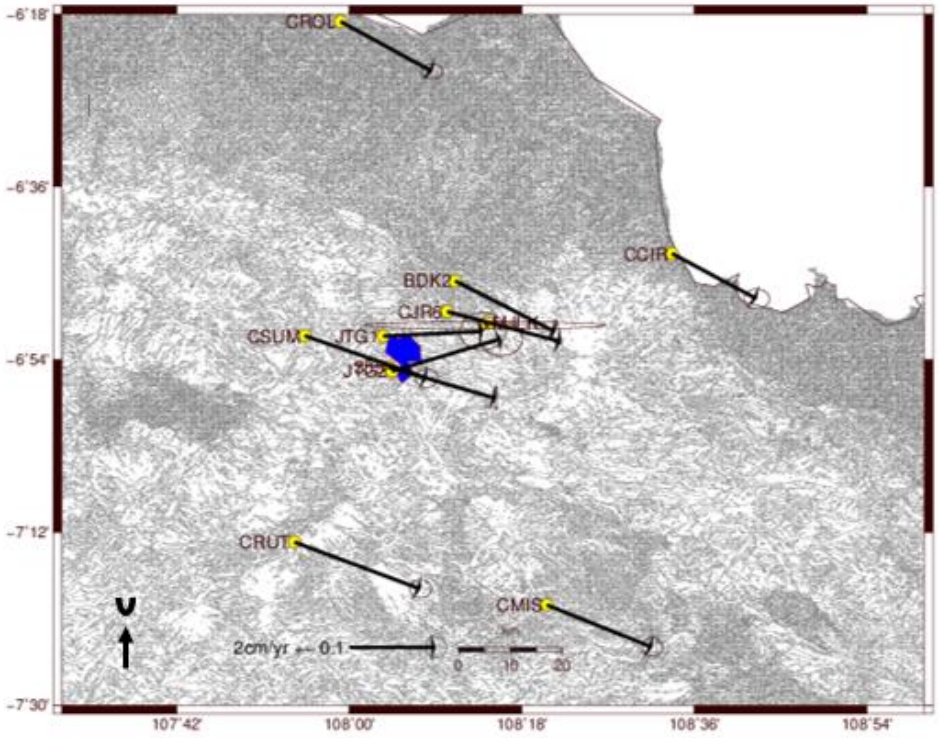

Figure 9. Velocity with Sunda block effect for data 2016.

Figure 10 shows the velocity generated from data processing in 2016. Some of the GPS station points has a changed velocity in 2016. BDK2 campaign point leads toward the Southwestern, CJR6 displacements from the Southwest to the North, MJLK displacements from Southeast to the Northwest, and 0355 displacements from Southeast to the North. JTG1 GPS station point tends to lead toward the Southwestern and JTG2 GPS station leads toward the North with 0355 GPS station.

Some continuous GPS station points of BIG have changed direction. CROL GPS point in Indramayu displacements from East to the Southwestern, CCIR in Cirebon displacements from Northwest to the

West, CMIS in Ciamis leads toward the South, CRUT in Garut displacements from East to the Southeast and CSUM in Sumedang displacements from Northwest to the East. This change can be analyzed for the station near the dam such as JTG1, JTG2, CSUM, 0355, BDK2, CJR6, and MJLK as result of the process of water filling in Jati Gede dam.

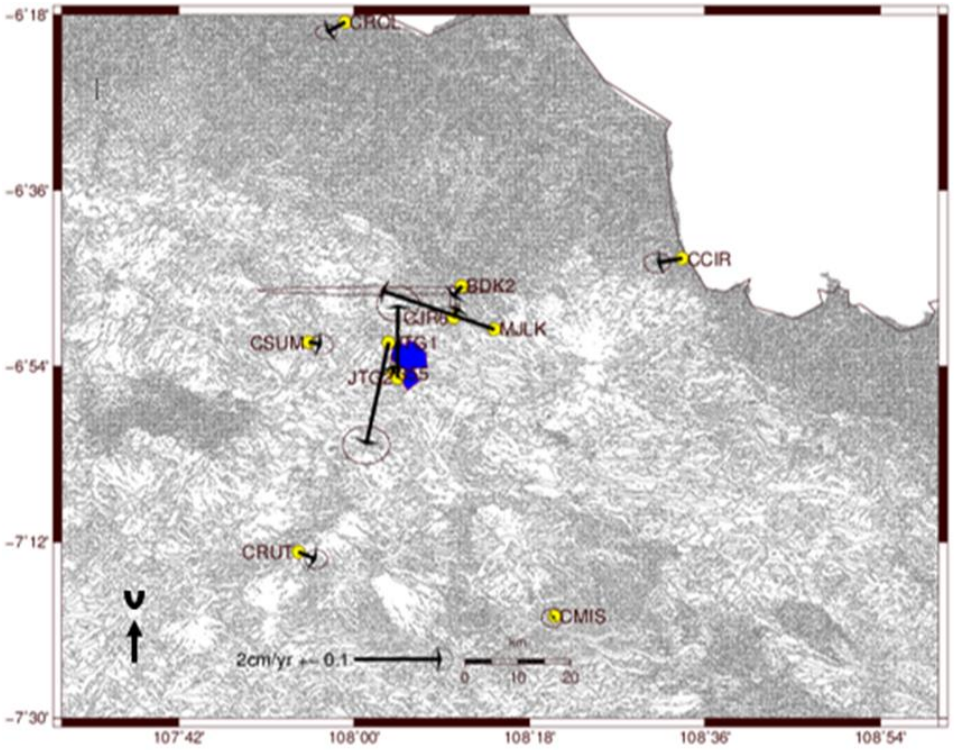

Figure 10. Velocity reduced Sunda block effect for data 2016.

CONCLUSIONS

There is a change in strain that is formed from the data processing in 2007 and 2015 with a strain that is formed from the data processing in 2016. In August 2015 to December 2016, there is a process of water filling in the Jati Gede dam. For the strains generated for the data processing from 2007 to 2015 obtain the maximum value of extension by 0.145901 microstrain and the maximum value of shortening by 0.1014 microstrain. In the strains generated for the data processing in 2016 obtain the maximum value of extension by 0.405937 microstrain and the maximum value of shortening by 0.57023 microstrain. A change in strain for the extension and shortening by 0.260036 microstrain and 0.46883 microstrain respectively. The change in strain is allegedly due to the process of water filling in the Jati Gede dam.

RECOMMENDATIONS

Of experience and processing of this study, there are some suggestions to improve both this study and further studies.

a. Continuous data observation in JTG1 and JTG2 GPS stations is extended so

that monitoring Jati Gede dam keeps going on.

b. Better modelling is required to clarify the change in strain occurred in the area around the Jati Gede dam.

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