Separation Method of Anomaly Source: The Time-Lapse Microgravity Data

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Abstract. The time-lapse microgravity anomaly survey was performed in the purpose of searching the subsurface targets to discover an anomaly caused by the survey target. To isolate the source of the anomaly, an existing filter was generally used. For this certain purpose, the filter must be constructed in a way it can receive less than the maximum results. One problem is the source of the unwanted anomaly still attached to the preliminary data. As it is known, the source of time-lapse microgravity anomaly caused by the subsidence and fluid dynamics is idencated by the increases and decreases in groundwater levels. Therefore, the survey should minimize one of these anomalies sources by adjusting the filter field conditions. In this study, the constructed filter is referred as the MBF (Model Based Filter), this filter was constructed with attention-dimensional parameter source of the anomaly.

INTRODUCTON

Time-lapse microgravity data is the data obtained from the surveys of time-lapse microgravity which in principle measuring the gravity at the same point repeatedly in a certain time interval. The time interval is set on dry and rainy seasons. In the recent years, the microgravity surveys have been applied, namely for the following purposes: modeling the geothermal reservoir [1], monitoring the water injection in the geothermal reservoir [2], monitoring the volcanic activity [3], time lapse microgravity measurement which analyzed by the data of rainfall and the changes of the ground water depth level in the area of geothermal Ogumi Japan [4], monitoring the subsidence occurred in mining areas [5].

Time-lapse microgravity anomaly is defined as the difference between the value of gravity at the time (t_2) and the value of gravity at the time (t_1). Each measurement period value is a superposition of the gravity anomaly from several sources, namely the latitude, elevation, tidal, topography and variations in the mass density surface [6]. Furthermore, correction is made in order to reduce the purposes of the source anomaly using latitude correction, drift correction, tides correction, bouguer correction, and Terrain correction. Sequentially, to eliminate the source of the anomaly latitudes, the fatigue factor was applied, resulting in tidal factors within the earth and moon which change during the measurement of gravity.

Anomaly observed on the time-lapse microgravity is an anomaly in the time interval (Δt) which caused by two sources, namely subsidence and groundwater level dynamics (the increase or decrease). The problem is how to reduce one source of these anomalies. For example, in order to obtain the source of anomalous dynamics of groundwater, the source of the anomaly which generates the subsidence at each position must be eliminated and this process is difficult. An alternative method to resolve this problem is by applying a particular filter. This research will explain the filter built to separate the source anomaly on time-lapse microgravity. Filter source model is built based on anomaly

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dimensions and properties of cells and adjusted to the field conditions. Generally speaking, the filtering process is to convert the data from space and time domains to the frequency domain with FFT approach (Fast Fourier Transform) 2D.

METHODS

To build a filter based on the model of anomalous source, referred to as MBF, two points should be noticed,, the dimensions and physical properties of the model. The developed filter is different from the other filters that have been developed for this purpose [7-9]. As an illustration, the reducing of the anomaly source decreases water level to obtain resources in the case of anomalous subsidence in Semarang. The steps taken are as follows: (1) study the hydrogeology of the research area by measuring the depth of the groundwater level of the monitored wells during the time interval measurement, (2) determine the dimensions of the source model groundwater level decrease. In general, the anomalies process in the source reduction microgravity data is shown in Fig. 1. Where x (s) and X (f): input, y (s) and Y (f): output, g (s) and G (f): transfer function which is a form of linear filter. For a distance or spatial region, multiplication is performed by convolution, while the multiplicative frequency region uses an ordinary multiplication.

Based on the literature on the changes review in the groundwater level depth, the subsidence occurred during an interval of 4 years (2002-2005). In order to prepare the filter, the following data of the water level decrease during the time span of maximum 5 m or average 1.7 m/year is used. The decline in the groundwater level occurred at a depth of 25 m. Subsidence that occurred in the same time span of a maximum 48 cm or an average of 16 cm/year is the elevation measurement in the same period with the rock porosity of 30 %.

The next step is to determine the dimensions of X, Y (width, length) model of subsidence and water level decrease to be used as a filter (Fig. 2). Given the research area of 10 km x 10 km, the two models are arranged at 6 km x 6 km to subsidence and 8 km x 8 km to water level decrease. This size is assumed to represent the subsidence and groundwater level decline that occurred in the studied area. Using this filter, the model is expected to have good results when compared to other models. On the previously performed modeling, the position of subsidence and water level decrease do not affect the calculation results. In this study, a model position of subsidence and groundwater level decline made eligible dimensional symmetry with the water level decrease which is greater than the dimensions of subsidence.

Further action is to create a model subsidence and groundwater level decrease in 3D with the parameters specified above. Filter that will be created adapted to periods of time-lapse microgravity anomaly. The filter parameters are listed in Table 1. The software used for the preparation of the filter is Matlab. The following parameters are used: subsidence (50.5 cm), groundwater level decrease (5 m) and a porosity of 30 %. The 3D filter model form is depicted in Fig. 3.

2D FFT is to create a component data of 64 x 64 spaced 200 m using gravity anomaly data from the modeling. The reason for the selection of 2D FFT dimension is that the point of origin at (0.0), the path length is 63 x 200 m = 12,600 m for the X and Y. These dimensions are larger than the dimensions of the model subsidence and groundwater level decline. This is in accordance with the provisions that the dimensions of the filter must be larger than the dimensions of the object to be filtered.

RESULTS DAN DISCUSSION

Spacing is arranged in 200 m in order to balance the length and width of the prism on the model of subsidence and groundwater level decline. Model subsidence created at 6 x 6 km composed of 30 prisms. To model the decrease in groundwater level the size of 8 x 8 km model is arranged which composed of 40 prisms. The combined model of subsidence and water level decrease using the second model The anomalies data generated from these models are further gridded to obtain the component of 64 on the X axis and Y with the same space. The gravity anomalies due to subsidence, water level decrease and the combination of both are further gridded in 2D FFT to create the desired filter. The filter shape of each period is used to minimize the effects of water level decrease as shown in Fig. 4.

For example, the gravity anomaly separation between the times in Semarang is performed to obtain the anomalous subsidence. Inputs used are micro-gravity data between the time periods of 2002-2005 (Fig. 5a). This data source of the anomaly is a superposition of two sources, namely subsidence anomalies and dynamics of groundwater level decrease. So, the filtering process is to find the source of anomalous subsidence by reducing the

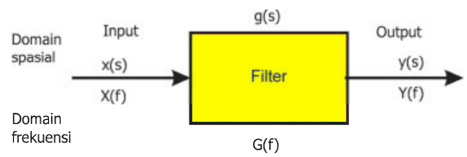


FIGURE 1. Filtering scheme in the area of spatial and frequency

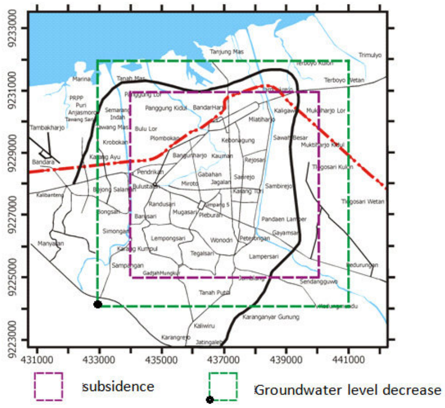


FIGURE 2. Dimension X, Y (width, length) subsidence and decreased water level is used as a filter

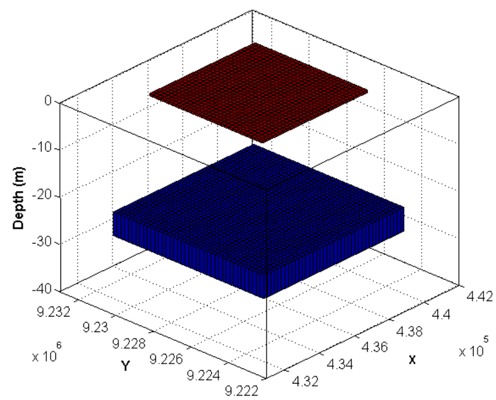


FIGURE 3. Subsidence and groundwater level decrease model is used as a filter

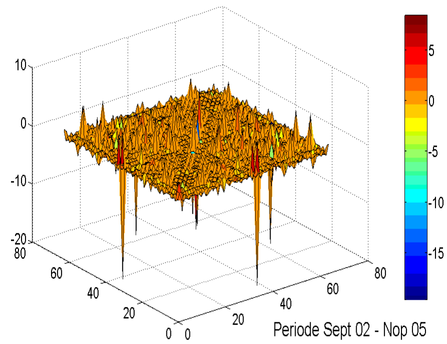
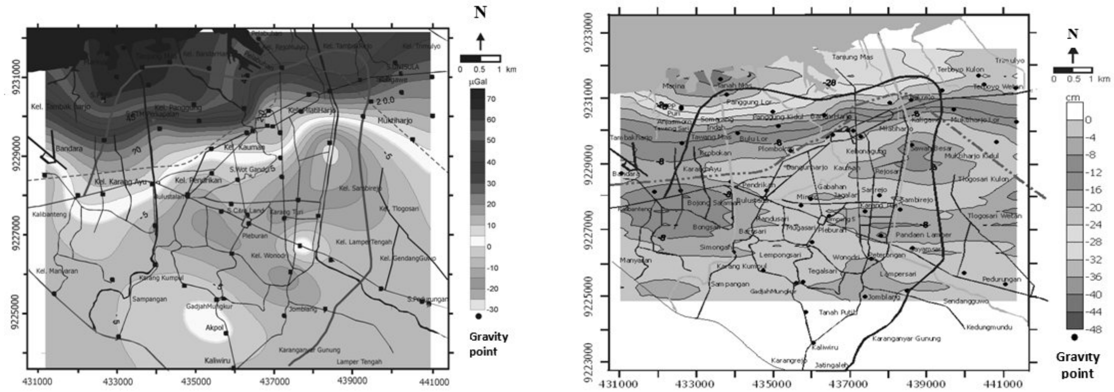


FIGURE 4. Filter to minimize the effects of decreased water level in the microgravity of data across time with the axis X-Y (frequency space) and Z axis (amplitude)

source of anomalous groundwater levels decrease. The subsidence of the filtering process is depicted with a contour map (Fig. 5b).

The result of subsidence associated with changes in the depth of the groundwater level at the same time interval shows that the water level decrease on the monitored wells have occurred during that time. The lowest water level in the monitored wells is found in Simpang Lima and Plampitan due to the extraction of the ground since the Ciputra Hotel is located in the region as well as the routine use for households. As known, Plampitan monitored wells is located in a residential location which is one of the dense settlements in Semarang. To observe the correlation time lapse microgravity anomalies, subsidence and water level decrease on the monitored wells, the correlation map based on data made for the period 2002-2005 (Fig. 6) is used.

Based on Fig. 6, it shows that the subsidence is observed in the northern city of Semarang, covering the residential area of Tanah Mas, PRPP, housing Puri Anjasmoro, port of Tanjung Mas, Stage villages, urban villages and Trimulyo Terboyo. These areas have microgravity anomaly between positive times. Thus, it can be stated that in the northern region of the studied area there is a correlation between time lapse microgravity anomaly positive values with



(a) (b)

FIGURE 5. (a) microgravity data input between time and (b) filtering results in the form of subsidence in the form of a contour map

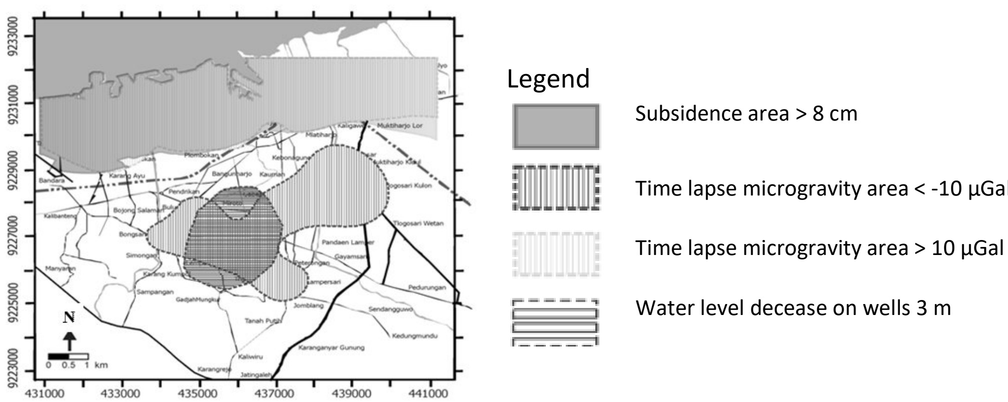


FIGURE 6. Map of the correlation between micro gravity anomaly between time, subsidence with decreased water level period 2002-2005

subsidence. In the areas of Simpang Lima, Miroto, Gabahan, the declining groundwater level is greater than other areas. Water level decrease is correlated with time lapse microgravity anomaly that is negative.

Research shows that the area of north of Semarang experiences the most subsidence. These results are confirmed by the previous research results [10] which stated that the existence of clay layer beneath the surface in Semarang accelerates the consolidation process of Holocene sediment in the east and north of Semarang that increases the potential for land subsidence.

The similar point is appointed [11], that the subsidence in nothern part of Semarang is believed to be caused by combination of natural consolidation, groundwater extraction and load of buildings and constructions. Due to this coastal land subsidence, part of the north coast area of Semarang city has been showing a growth of sea water inundation since almost the last three decades.

CONCLUSIONS

Time-lapse microgravity anomaly caused by subsidence and groundwater dynamics in the form of an increase or decrease in groundwater level. For the purpose of the anomaly source separation, the particular filter is constructed. These filters are constructed differently from the existing filter. The different approach is used, i.e. the source of the anomaly model approach is related to the dimensions and physical properties of the model. The application of the time lapse microgravity data in Semarang is observed in the period of 2002-2005 by reducing the source of anomalous groundwater level decrease to obtain the subsidence. The greatest subsidence occurred in the northern city of Tanjung Mas Semarang port area and its surroundings.

MBF filter that has been built to separate the source of time-lapse microgravity anomaly generates a good result and has been validated by the results of other studies from the related research. It can be concluded that MBF filter used for other locations should be accompanied by the dimensions and physical properties information of the resource model micro gravity anomaly between the times for the region.

REFERENCES

1. S. C. P Pearson, P. Franz, and J. Clearwater, *Calibrating A Geothermal Reservoir Model Using Microgravity Data* (European Geosciences Union, Vienna, 2014), pp.153.
2. J. Nishijima, Y. Fujimitsu, S. Ehara, and M. Yamauchi, "Reservoir Monitoring by Observation of Gravity Changes at Some Geothermal Fields in Kyushu, Japan", in *Proceeding of World Geothermal Congress*, ed. E. Iglesias (International Geothermal Association, Japan, 2000).
3. P. Jousset, S. Dwipa, F. Beauducel, T. Duquesnov, and M. Diament, Journal of Volcanology and Geothermal Research **100**, 289-320 (2000).
4. C. Akasaka and S. Nakanishi, "Evaluation of the Background Noise for Microgravity Monitoring in the Oguni Field, Japan", in *Proceedings of the 25th Workshop on Geothermal Reservoir Engineering* (Standford Geothermal Program, California, 2000)
5. M. W. Branston, and P. Style, Quarterly Journal of Engeneering Geology and Hydrogeology **36**, 231-244 (2003).
6. W. M. Telford, L. P. Geldart, and R. P. Sheriff, *Applied Geophysics* (Cambridge University Press, New York, 1990)
7. R. S. Palowski and R. O. Hansen, Geophysics **55**, 539-548 (1990).
8. L. Cordell, *A Striping Filter for Potential-Field Data* (Society of Exploration Geophysicist, Tulsa, 1985), pp. 217-218.
9. A. Aina, Geophysics **59**, 488-490 (1994).
10. A. Yuliyanti, D. Sarah, and E. Soebowo, Jurnal Riset Geologi dan Pertambangan **22**, 91-103 (2012).
11. H. Z. Abidin *et al*., "Studying Land Subsidence in Semarang (Indonesia) Using Geodetics Methods", in *Proceedings of FIG Congress Facing the Challeanges Building the Capacity* (International Federation of Surveyors, Sydney, 2010).