Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)


STT55-P01 Room:Convention Hall Time:May 22 18:15-19:30

# Helicopter-borne EM survey over coastal areas inundated by the tsunami of March 11, 2011, in northeast Japan

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The Geological Survey of Japan, AIST conducted a helicopter-borne EM survey over inundated areas by the tsunami on March 11, 2011 in northeast Japan 15 months after the 2011 off the Pacific coast of Tohoku Earthquake. The purpose of the survey is to map the electrical resistivity of the ground intruded by seawater during the tsunami for its reutilization as farming lands and water assessment of the area.

The survey was flown in June 2012 at an altitude of 60 m above ground with a speed of 50 km/h along survey and traverse lines spaced 100 m and 1,000 m apart, respectively. The airborne EM system (Fuguro Airborne Surveys' RESOLVE system) was installed in a bird and towed 30 m below the helicopter. This is a frequency-domain system operated at five frequencies (340, 1,500, 6,900, 31,000, 140,000 Hz) in a horizontal coplanar configuration and at a frequency (3,300 Hz) in a vertical coaxial configuration.

The survey area is located at the border of Miyagi and Fukushima Prefectures along the Pacific coast in the southern part of the Sendai Plain and is divided into two sub-areas: Watari-Yamamoto-Shinchi area (area A) and Matsukawaura area (area B). The area A is known for its production of high-quality strawberries on beach ridges and much fresh groundwater has been used for irrigation of strawberries and warming of strawberry greenhouses by water curtain. However, the salinity of groundwater from shallow irrigation wells in this area increased dramatically after the tsunami (Mori et al., 2012). Since it still remains at high level, there is an urgent need to find new water resources. Whereas, the area B is characterized by a beautiful lagoon called the Matsukawaura which is preserved as one of prefectural parks of Fukushima Prefecture. Rice fields occupy the areas west of the Matsukawaura and most of them were covered by seawater during the attack of the tsunami. Desalinization of the rice fields is being conducted intensively to resume rice farming in these fields.

The observed electromagnetic data were processed and apparent resistivity maps were created for each frequencies. As for the apparent resistivity map at a frequency of 140,000Hz, very low resistivities less than 4 ohm-m are dominant over lagoons and river mouths along the coastline, indicating the existence of salt water wedge. Relatively low resistivities (8 - 22 ohm-m) range from close to the coastline up to 4km inland and are edged to the west by high resistivities (64 - 128 ohm-m), corresponding to the maximum inundated area as derived from aerial photos by the Geospatial Information Authority of Japan (2011). These low resistivities might be associated with the effect of seawater intrusions. As the frequency becomes lower, low resistivities areas ($<$ 8 ohm-m) extend to inland, indicating the existence of deep salt water wedges and/or fossil salt water. To verify the results by airborne surveys and confirm the groundwater environment, further studies will be done with shallow drillings as well as with time-domain EM and high-density electrical surveys on ground.

Keywords: airborne EM survey, resistivity, the 2011 Off the Pacific Coast of Tohoku Earthquake, tsunami, groundwater environment, salt damage

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# Three-dimensional electromagnetic modeling of topographic effects on electromagnetic field induction by GREATEM surveys

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A grounded electrical source airborne transient electromagnetics (GREATEM) survey was performed at Kujukuri beach in central Japan, where an alluvial plain is dominated by sedimentary rocks and shallow water. A reliable resistivity structure was obtained at a depth range of 300?350 m both on land and offshore, in areas where low-resistivity structures are dominant (Ito et al., 2011). Another GREATEM survey was performed at northwestern Awaji Island, where granitic rocks crop out onshore. Underground resistivity structures at depths of 1 km onshore and 500 m offshore were revealed by this survey. The absolute resistivity found onshore was much lower than existing results. To circumvent this problem and understand the reason for the inaccurate results, we used a three-dimensional (3D) electromagnetic (EM) modeling scheme based on the staggered-grid finite-difference (FD) method (Fomenko and Mogi, 2002) to study the effects of oceanic saltwater (or the sea effect) on EM field induction when conducting GREATEM surveys at coastal areas with topographic features. Topography in our model was represented as an anomaly (1E-8 S/m) in the air layer. We selected a 3D-topographic model consisting of a topographic feature (1E-2 S/m) placed on top of a uniform half-space earth medium (1E-3 S/m). The resistivity contrast was 1E+6 times between the air and the topography. In the topographic area we used X: 50 x Y: 50 x Z: 25 m cells. Outside the topographic area, irregular cells were used. The total number of nodes was 52 x 38 x 32 = 63232 cells. The computation was done for four topographic slope angles ( 90, 45, 26.5 and 14 Degree). A horizontal electric dipole source was directed along the y-axis situated at the origin (x = -1500)

The most significant effect of topography on EM field induction occurs at low flight altitudes and gradually decreases with increasing the flight altitude. The topographic effect of steep slope angles (e.g., 90 and 45 Degree) is higher than for gentler slopes (e.g., 26.5 and 14 Degree). Furthermore, the area of the topographic feature closer to the dipole source has a larger effect on EM field induction for several meters.

Keywords: Airborne EM,, coast effect, Topography effect, 3D resistivity modeling, GREATEM surveys

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STT55-P03 Room:Convention Hall Time:May 22 18:15-19:30

# Precise formula for horizontal acceleration correction and method for its effective use

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We provide a precise formula for horizontal acceleration correction and discuss a method for its effective use in airborne gravity measurements using the SEGAWA airborne (helicopter-borne) gravimeter.

In order to determine a gravity anomaly from the observed acceleration data using a gravimeter, it is necessary to perform vertical acceleration correction, Eotvos correction, normal gravity correction, free-air reduction, and horizontal acceleration correction. These corrections (with the exception of the vertical acceleration correction and horizontal acceleration correction) each have precise individual formulas. The precise formula for the horizontal acceleration correction has not yet been presented because it is considered to be an optional correction. In fact, horizontal acceleration correction is unnecessary if the gravimeter sensor remains vertical at all times.

In previous horizontal acceleration corrections, the equations that give the component acceleration vectors acting on the gravimeter with a platform off-level angle and that give the off-level angle of the platform were linearized. Of course, the linearization of the equations is a valid technique for simplifying calculations and for finding the essence of the problem. In the present horizontal acceleration correction, the linearized equations are normally used because the off-level angle is generally kept very small using a gyroscope. However, this equation cannot deal effectively with sudden large acceleration changes caused by turning which changes the measurement profile.

In this study, we first provide the precise formula mentioned above for horizontal acceleration correction without linearization and evaluate the effects of the nonlinear terms in a new solution. In addition, we suggest a method for estimating the true values of the gravity and the off-level angle by successive iteration because our equation requires the true values to estimate the correction amount by deriving the true gravity value and the off-level angle.

Keywords: Aieborne gravity measurement, Horizontal acceleration correction, Precise formula for horizontal acceleration correction

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# Denoise of Severely Contaminated Gravity Anomaly Data Using Statistical Independence of Source and Perturbation Signals

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1.Introduction

Gravity anomaly, which is caused by the spatial distribution of stiff (heavy) layer, is used for the estimation of ground structure. For the improvement of usability and applicability, Morikawa et al.[1] has been working on the development of compact gravity observation system using force-balance (FB) accelerometer. It has a difficulty that the observed data is severely contaminated by various kinds of disturbances such as tilting motion of the carrier vessel. This report presents a scheme to extract the gravity anomaly signal from the noise-contaminated observed data, by exploiting the statistical independent property of gravity anomaly data and other perturbation signals. Although the final objective is to measure the gravity anomaly by using the air plane or some other aviation carrier, as a basic study of the research, this paper works on the results obtained by the ship in the Toyama Bay.

2.Methodology

As a scheme of considering independence of signals of source and other signals, blind source separation (BSS) techniques are used. Second Order Blind Identification method (SOBI)[2] separates signals from different sources by exploiting the statistical property of data. It separates the target source by assuming that source and unwanted data are un-correlated at various time-lags. Similar scheme is also implemented with the Independent Component Analysis (ICA), which separates the sources by maximizing the independence of linearly transformed observed signals. The method is referred to as ThinICA[3].

3.Data Observation

The presented schemes are applied to the data obtained by the field survey which was conducted at The Toyama Bay area, Japan. The carrier vessel was a middle size ship of 55 long. As the reference for comparison, we use the data generated based on the reliable data measured by AIST (National Organization of Advanced Industrial Science and Technology) by considering the Eotvos effect due to the location of the carrier and the free air anomaly, etc.

4. Results

It was found that application of low pass filtering (LPF) is efficient as a pre-process of observed data. Both SOBI and ICA worked well after the data is processed by low pass filter (LPF). As for the applicability of devices, combination of VSE data and vertical component of accelerometer Titan (Taurus-Z) were found to be suitable for our data set. It was also discussed that the motion of the carrier vessel influences the performance of noise removing algorithm. Under certain conditions, the proposed method was not able to salvage the gravity anomaly data from the observed data with the accuracy sufficient for the purpose of identification of gravity anomaly distribution. It was difficult, for example, to salvage the gravity data from the data obtained during the ship is stopped. Comparison of the LPFed observed data and the data extracted by the presented method using SOBI and ThinICA show that they are at acceptable level for the purpose of subsurface modeling. It would require, however, improvement for the application for the data obtained by the aviation carrier devices such as unmanned helicopter.

5. Conclusion

The noise removal method for the highly contaminated data to salvage the target data is discussed. The method is applied to the observed data from Toyama. It requires the condition for the mobility of carrier vessel. For the purpose of data obtained using the aviation device, considerable improvement of performance is required.

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Keywords: Gravity Anomaly, Independent Component Analysis

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# Regularization of the aeromagnetic data using eigen-function expansion in Cartesian coordinate system

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The dominant upward- and downward-continuation technique used in the potential-field is the fast Fourier transform (FFT) technique. However, this technique is, in principle, only applicable to the regularized data obtained on a flat plane. So, for the data on irregular grid on an uneven surface, the inversion technique based on the equivalent sources is commonly used.

For the equivalent sources, dipole source is often used. In this case, the computational cost of inversion becomes large because the observation equation is represented by a dense matrix.

In this study, we design a continuation operator used for the direct continuation of the geomagnetic field data on irregular and uneven surface and developed an algorithm for calculating upward- or downward-continuation using the eigen function expansion based on the basic solutions of the Laplace equation defined on the Cartesian-coordinates. We apply the eigen function expansion to each rows of the coefficient matrix of the observation equation and subsequently threshold the matrix to generate a sparse representation in the wave number domain.

Keywords: aeromagnetic observation, upward continuation, downward continuation, regularization

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# Analysis of the magnetization intensity in Mt. Unzen using an air-borne magnetic survey data

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We carried out airborne geophysical and LiDAR survey around the lava dome of Mt. Unzen, under a contract with Kyushu distinct Maintenance-and-Repair Offfice, Ministry of Land, Infrastructure and Transport.

Aeromagnetic and electromagnetic data was colleted during airborne geophysical surveys. The former was analysed by means of three-dimensional inversion techniques, and subsurface magnetic sutructure (magnetic-intensity distribution) to the depth of 1000m was derived. In addition, comapring with aeromagnetic data obtained at 1999 by the Shimabara Development and Protection Bureau, Nagasaki Prefecture, clearly showed the temporal change in the pattern of magnetic anomalies, which was also analysed by time-lapse inversion technique.

In this study, we reported the results of the above survey and analysis, with special attention to three-dimensional magnetic strsucture and its temporal change for about a decade.

Keywords: Airborne magnetic survey, Airborne geophysics, Three-dimensional inversion, Mt. Unzen, Lava dome, slope failure

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# The airborne electromagnetic survey to the slope with high risk of deep catastrophic landslide in the Himekawa basin

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Including the collapse of Hiedayama, Himekawa basin has caused a number of deep catastrophic landslides in the past, and many landslides and large-scale collapse scars are distributed. Investigated based on the manual ”Extraction method of Mountain Stream trending to cause deep catastrophic landslide”, in the Ministry of Land, Infrastructure, Transport and Tourism, we announced the results of the evaluation level mountain stream. Relatively high risk streams are extracted in the Himekawa basin.

The technique evaluated from stereoscopic examination of aerial photographs or digital elevation models, and the evaluation technique using LiDAR data and etc. are studied to extraction of the slope with risk of deep catastrophic landslide. In order to acquire subsurface structure broadly and to acquire the information on the depth direction of deep collapse, the evaluation technique which used the airborne electromagnetic survey is effective.

In this research, airborne electromagnetic survey was performed as a target in the Urakawa up-stream basin and Otokorogawa middle-stream basin especially with high risk of deep catastrophic landslide among Himekawa valleys. We have carried out an understanding of three-dimensional resistivity distribution. Then, the drilling survey and borehole test were done to a certain specific slope, and it verified about the extraction technique of layer thickness with risk of depths collapse by comparing with the specific resistance distribution map by an airborne electromagnetic survey result.

Keywords: deep catastrophic landslide, airborne electromagnetic survey, resistibility, microtopography, saturation