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Examination of various factors related to the accuracy of airborne gravity measurements

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Since 1998 we have been engaged in airborne gravimetry over the Japanese Islands. We use a helicopter as the platform of gravity measurement and achieved the flight as long as 20000km for the last 12 years. The first attempt of gravity measurement on board an airplane was made in 196 0 by Dr. Lucien LaCoste and others, but it proved to be a failure because of the inaccuracy of positioning of the airplane. Around 1985 the use of GPS for positioning became popular, so that the continuous use of GPS made it possible to get accurate 3 dimensional position of the airplane. W. Gumert of USA used a helicopter for use in mineral resourses prospectings, J. Prozena of Naval Research Laboratory of USA used a large patrol plane P3C ORION for the measurement in large unsurveyed areas such as Greenland and Antarctica. Gravity measurement at the huge/ unaccessible Greenland, the territory of Denmark, by Brozena and Rene Forsberg is a well-known story.

There seems to be three trends of study in aerial gravity measurement: 1) Measurement in the continent-scale gravity void areas (Greenland or Antarctica). 2) Measurement at gravity void zones along coastal areas. 3) Measurement above oceanic zones where there are so-called strong oceanic current. Item(1) aims at establishing regional gravity anomaly and geoid images, Item(2) aims at removing gravity void areas along the coastal zones to help construct detailed images of crustal structures and/or active seismic faults, and Item(3) aims at establishing a reliable image of geoid at the strong oceanic current zones such as Kuroshio area so that,in the later stage, we could predict the velocity of the current on the basis of the sea-surface topography measured by the oceanic satellite(Cheinway Hwang, Taiwan).

We constructed an airborne gravimeter which is typically Japanese. Using this meter we have measured gravity at 12 spots over the Japanese Islands. Our main objectives are to fill in the gravity void areas in the coastal zones to deliniate the active faults across the land-sea border lines.

There are two data flows in the airborne gravimeter. One of them is the time variation of acceleration provided by the gravity sensor. The other is position information from GPS. These data are sent at the interval from 0.01sec to 1.0 sec to the data processor. In order to reduce the effect from the large amplitude movement and/or vibration of helicopter the acceleration data have to be measured as rapidly as possible. The positioning of helicopter is conducted using the interferometric positioning method. For this purpose we establish a base station GPS site and a rover GPS site. It is important that the accuracy of positioning relies on the distance of the two GPS sites. The verticality of the gravity sensor is another problem. As for the drift of the sensor it is not a problem in the airborne gravimetry as long as the 1 mgal accuracy is aimed at. That is because the time length of a flight is usually 2 hours or so. However, if we require a better accuracy such as 0.1 mgal or so, we may have to take other way.

The spatial resolution is another problem in the airborne measurement. Since rather strong lowpass filtering is applied during the airborne gravity measurement short wave length gravity signals are likely to be smoothed out so that we may miss important gravity signals if the airplane flies too fast. Therefore it is important to select an appropriate speed of helicopter that agrees with

the objectives.
In this report, taking into account the items above, we give the results of error analysis of the gravity measurements on the basis of our past measurements, and we may propose possible ways for solving the problems.

Keywords: Airborne gravity measurement, Accuracy of measurement, Gravity sensor problem, Positioning, Verticality, Spatial rezolution