Proc. NIPR Symp. Antarct. Geosci., **10**, 26–35, 1997

APPLICABILITY OF 10 Hz SATELLITE ALTIMETRY DATA TO THE ANTARCTIC MARGIN

Kumiko TERADA and Yoichi FUKUDA

Graduate School of Science, Kyoto University, Sakyo-ku, Kyoto 606–01

Abstract: Since the declassification of the Geosat Geodetic Mission (Geosat/GM), cross-track resolution of satellite altimeter profiles has improved remarkably. Consequently, the cross-track resolution somewhat exceeds the along-track resolution. To utilize the high-density of Geosat/GM profiles, we examine whether the along-track resolution is improved by using the 10 Hz sampling data or not. For this purpose, Geosat/GM profiles in the Southern Ocean and Antarctic margin are mainly tested. Ten Hz data are converted into grids of gravity anomaly following the recipe given by D.T. SANDWELL (Geophys. J. Int., **109**, 437, 1992). The converted grids are then compared with the grids of high-cut filtered data. The result implies that the 10 Hz data can show more detailed structures than filtered data.

key words: altimetry, gravity, Geosat/GM

1. Introduction

Since the declassification of the Geosat Geodetic Mission (Geosat/GM), cross-track resolution of satellite altimeter profiles has improved remarkably. High-resolution gravity maps revised by dense satellite data are expected to provide important information over sparsely charted areas such as the Southern Ocean and Antarctic margins. These detailed maps have many applications such as charting of sea mounts, ridges, and fracture zones. However, the resolution of these gravity maps depends on both the satellite track spacing and the along-track resolution of individual profiles. The track spacing has become very dense so that it now exceeds the along-track spacing of the 1 Hz sampling data set. Geosat/GM profiles, for instance, have the track spacing of about 5 km at the equator, while the average spacing of 1 Hz sampling data is about 7 km. Accordingly, it has become necessary to handle more detailed data than the 1 Hz sampling data to obtain uniformly fine resolution.

Besides the 1 Hz data, a 10 Hz sampling data set has been provided as part of the Geosat/GM geophysical data records (GDR). In this study, we examine whether the along-track resolution of satellite altimetry is improved by using the 10 Hz sampling data or not. For this purpose, we first examine the signals included in the 10 Hz sampling data using the along-track profile method, and then we convert the 10 Hz data to the gravity anomaly grids to allow comparison with other geophysical data.

2. Along-track Deflection of Vertical

We first traced the individual profiles of the Geosat/GM 10 Hz sampling data to

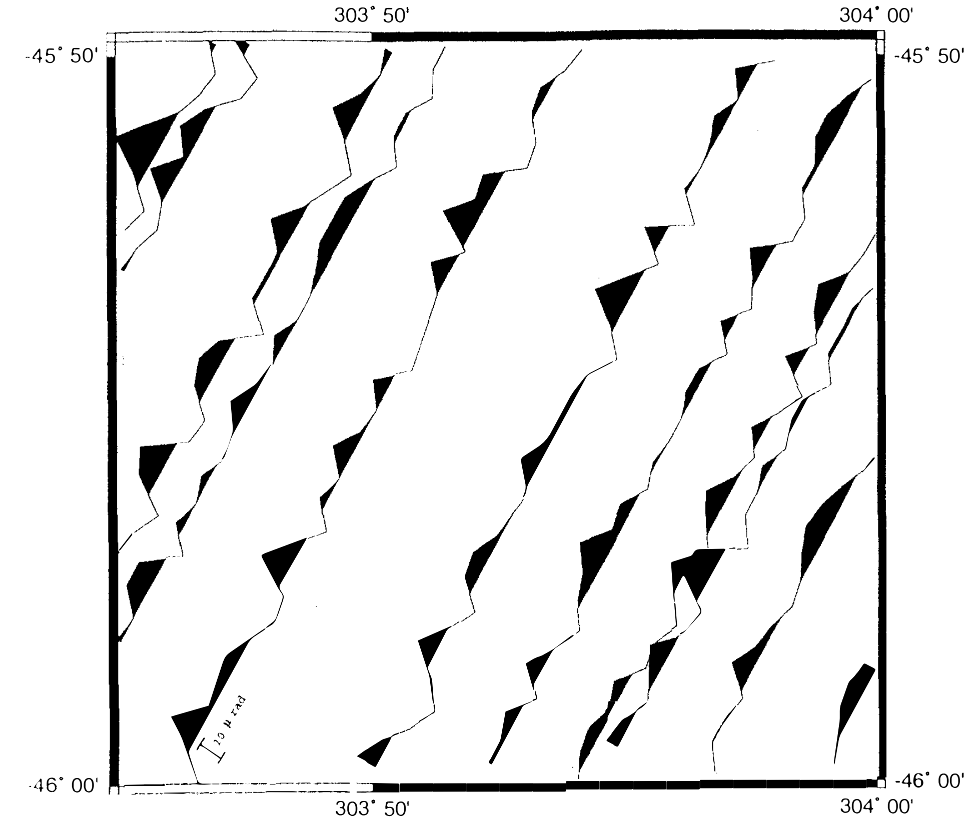

Fig. 1. Vertical deflection profiles of 10 Hz sampling data.

check the applicability of the short wavelength component of altimeter data. Figure 1 shows a plot of the so-called along-track deflection of verticals. It can be seen that adjoining profiles in the figure show the same spatial variations in short wavelength components. This fact suggests that the 10 Hz sampling data contain meaningful information.

3. Outline of Data Processing

Although the data processing procedure essentially follows the recipe given by Sandwell (1992) and Sandwell and Smith (1996), the following points are different from the original ones; 1) no high-cut filter is employed for the 10 Hz data, avoiding loss of high frequency signals; 2) a very fine grid size of 1.0 (longitude)x0.3 (latitude) minutes is adopted; and 3) corrections for long wavelength errors are omitted for the simplicity of data processing.

In the original recipe, 10 Hz data are high-cut filtered to suppress noise having wavelength shorter than 5 km and are re-sampled at the sampling rate of 5 Hz. The main purpose of this study is to use such high sampling data without distortion, so we convert the raw 10 Hz data to the gravity anomaly grids. Since our efforts are concentrated in the short wavelength signals and adopt a very fine grid size, we do not use updated values for the geophysical corrections.

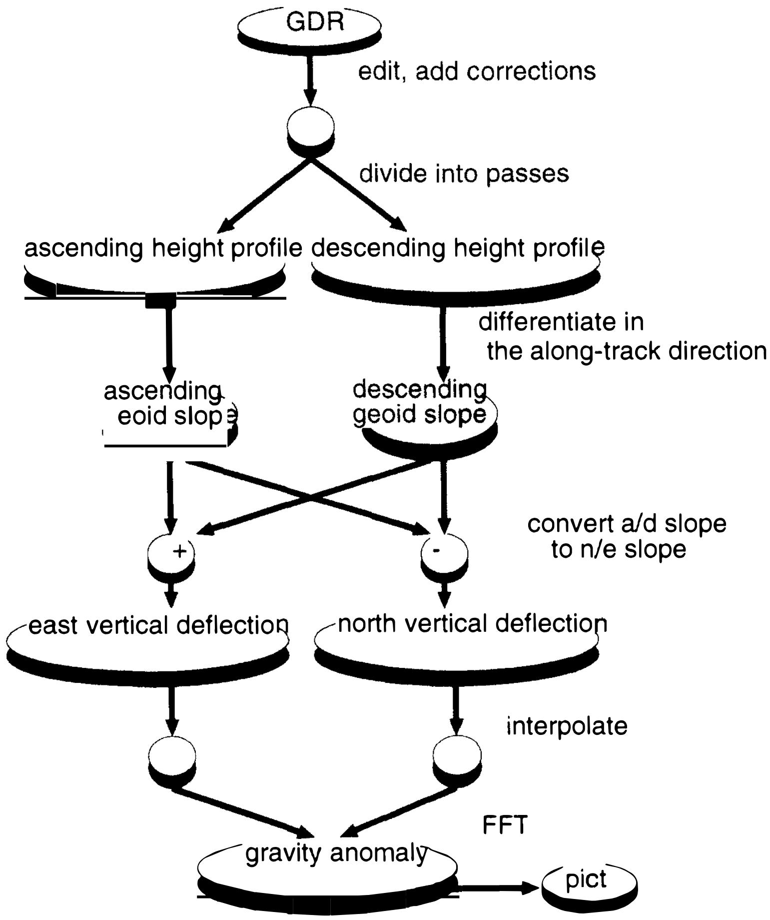

Fig. 2. Data processing.

Figure 2 shows the flow of the data processing. One of the most important parts of the data processing is to remove outliers in the original data. Besides the land and ice flags, we adopt following criteria for data rejection: 1) the RMS values of a line fitting 10 Hz samples exceeds 0.15 m, and 2) the SWH exceeds 8 m. In these cases, we reject all 10 data points. In addition to the first criterion, we reject points which deviate from the fitting line by more than 5 times the RMS value.

4. Test of the 10 Hz Data

To examine the applicability of the 10 Hz sampling data in more practical applications, we calculated gravity anomaly grids using the 10 Hz data.

The data employed for the calculation are from Geosat/GM Geophysical Data Records in the Southern Ocean (CHENEY *et al.*, 1991). The obtained gravity grids were compared with the world gravity image provided by SANDWELL and SMITH (1996). The grid size of their global data set is 2-minute and the data are high-cut filtered so that the components having wavelength shorter than 5 km are omitted. We selected two test areas as follows: 1) the plane area (A), and 2) the bumpy area (B).

4.1. *Area "A"*

As a plane area, we selected the northwest corner of the Argentine Basin, located at 300°E to 310°E, 50°S to 45°S. This area is shown as "A" in Fig. 3. In this area, the Argentine Abyssal Plain spreads at the sea floor at 5800–6100 m depth, the south of the plain is divided by the Falkland Escarpment and there the sea depth decreases rapidly. The sea floor on the plain is relatively smooth, and profiles cross some linear structures, providing a relatively low tectonic signal.

Figure 4 is the grid of filtered data and Fig. 5 is the grid of raw 10 Hz data. Figure 5 shows that raw 10 Hz data can yield clear images without noise reduction processing. Enlarged images of the west end of a valley (in the circle of Figs. 4 and 5) are shown in Figs. 6 and 7, respectively. Figure 6 is the grid of filtered data and Fig. 7 is the grid of raw 10 Hz data.

In Fig. 7, it can be seen that small linear features run across the end of the valley, while the filtered data (Fig. 6) cannot detect such small structures. Figure 7 suggests that although the overall along-track resolution is on the order of 20 to 30 km (YALE *et al.*, 1995), the along-track resolution may exceed it under some conditions. In addition, these structures run along the sea floor at about 6000 m depth. This means that the 10 Hz data set has information not only on shallow areas but also on the deep sea.

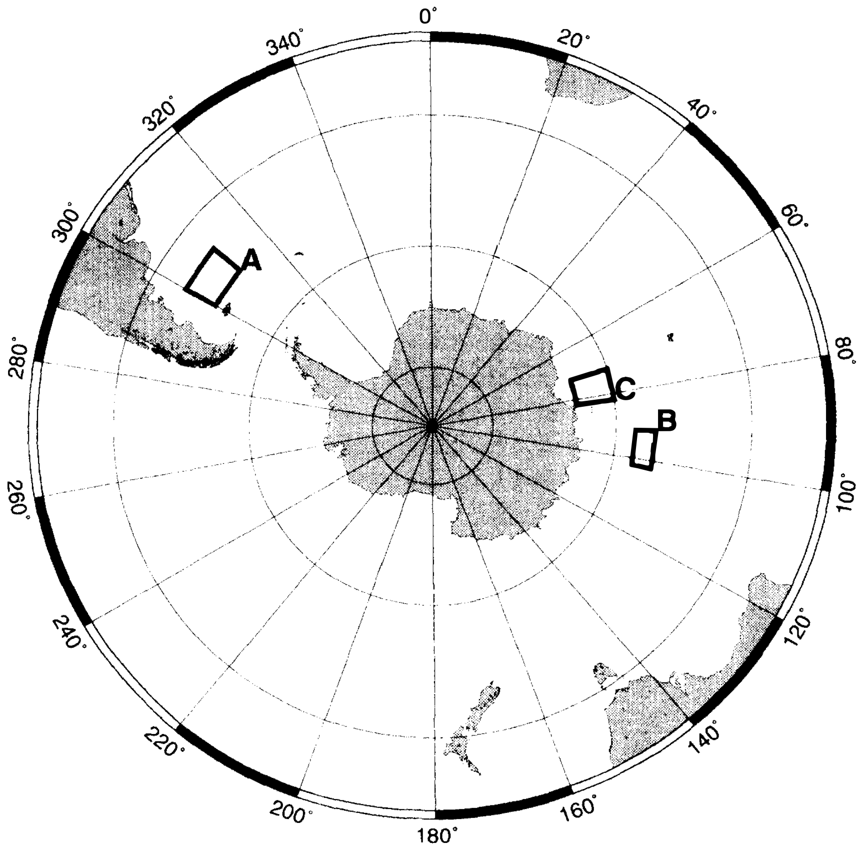

Fig. 3. Locations of test areas.

Fig. 4. Gravity anomaly images of the northwest corner of the Argentine Basin (filtered data).

Fig. 5. Gravity anomaly images of the northwest corner of the Argentine Basin (raw 10 Hz data).

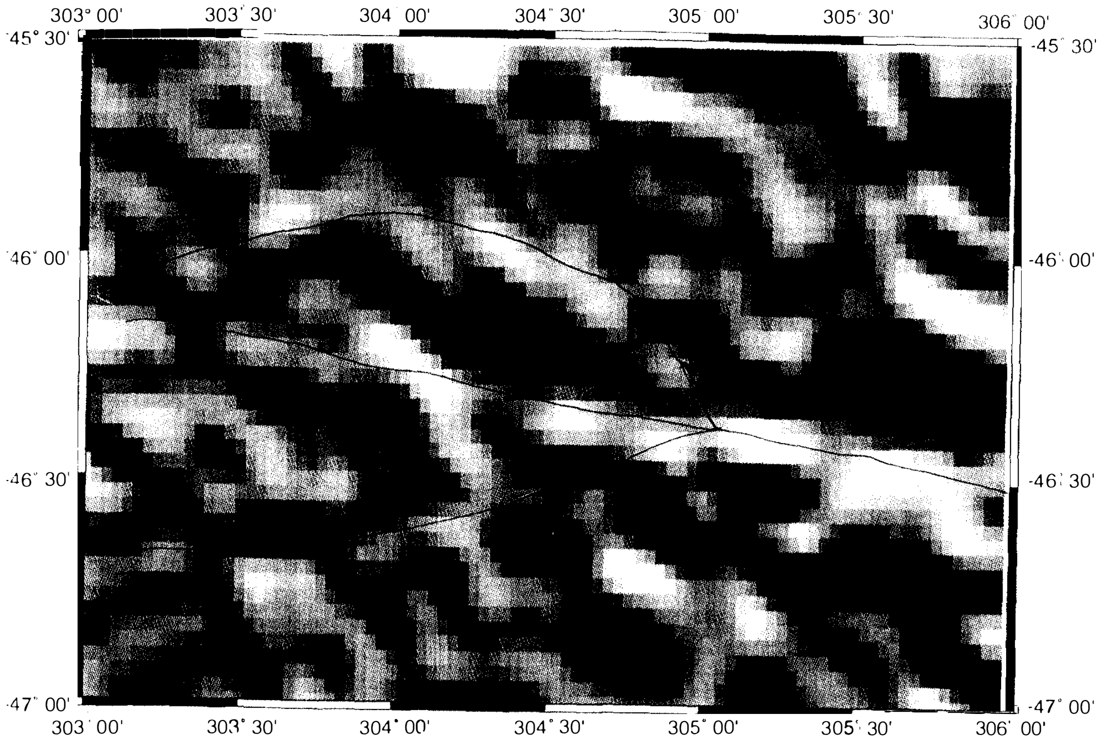

Fig. 6. Enlarged images of the end of a valley (filtered data). Solid lines indicate lineations running across the end of the valley.

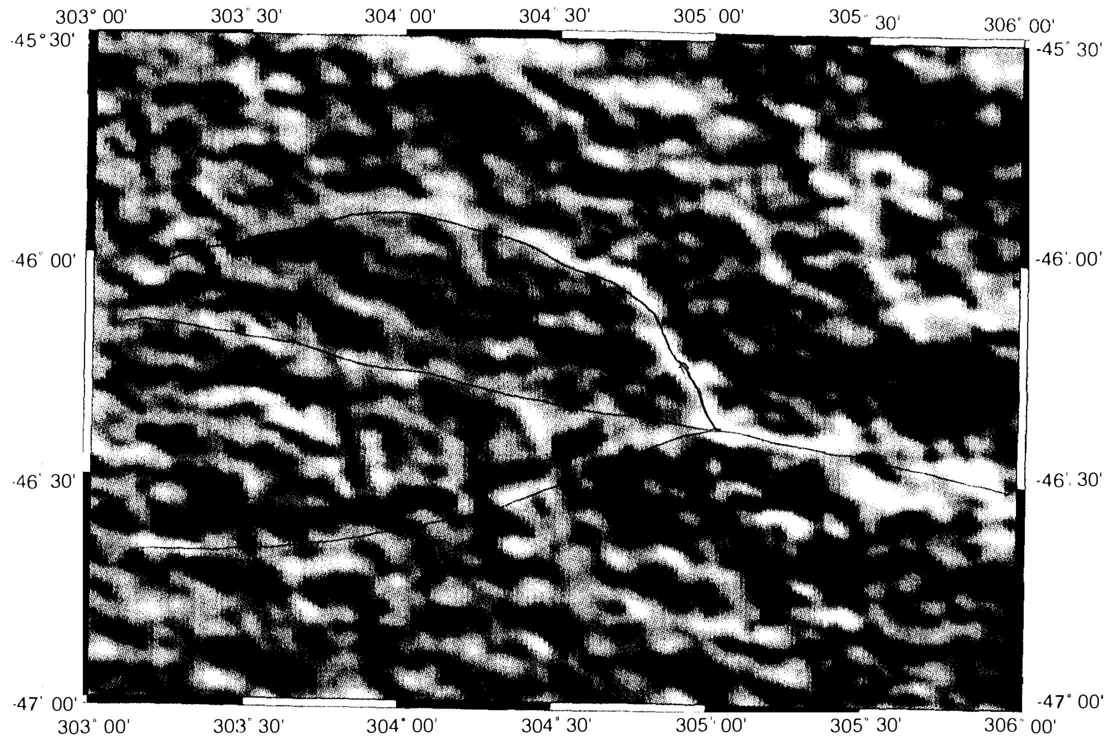

Fig. 7. Enlarged images of the end of a valley (raw 10 Hz data). Meanings of lines are the same as Fig. 6.

4.2. Area "B"

As a bumpy area, we selected the western part of the Australia-Antarctic Basin, located at 100°E, 56°S. This area is shown as "B" in Fig. 3. Profiles in this area cross several bumps providing a large signal. These bumps can be thought of as uncharted sea mounts rising from the sea floor at 3000–4000 m depth. The cause of these sea mounts is conjectured to be propagation from the Southeast Indian Ridge, but even the correct number of mounts is unknown.

Figure 8 is the grid of filtered data and Fig. 9 is the grid of raw 10 Hz data. In Fig. 9, five sea mounts are clearly distinguished from background noise, while, in Fig. 8, these sea mounts are obscured into background noise. A valley running west of these sea mounts from NW to SE barely appears among the track direction errors. If this back-

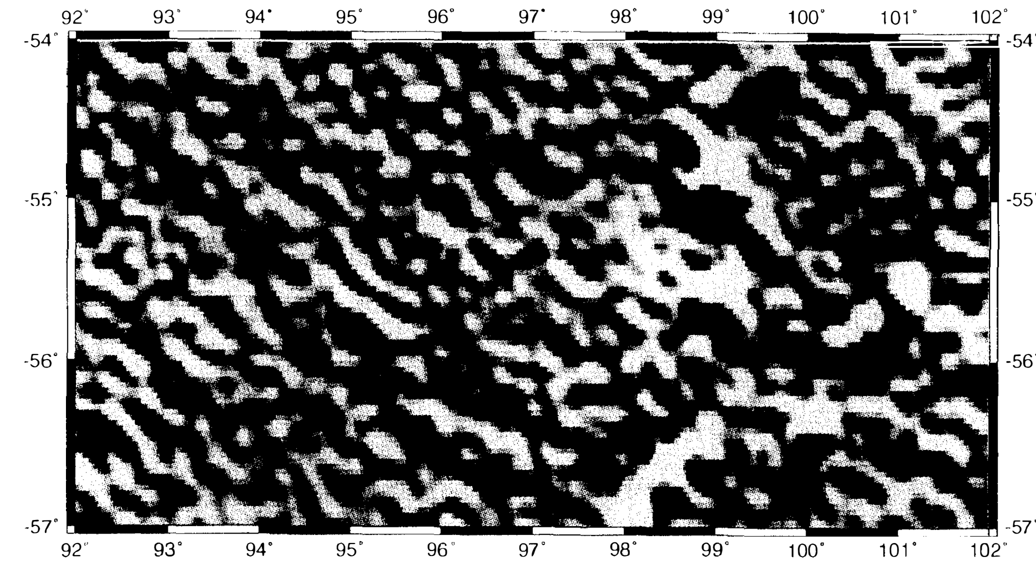

Fig. 8. Gravity anomaly images of sea mounts located at 100°E, 55°S (filtered data).

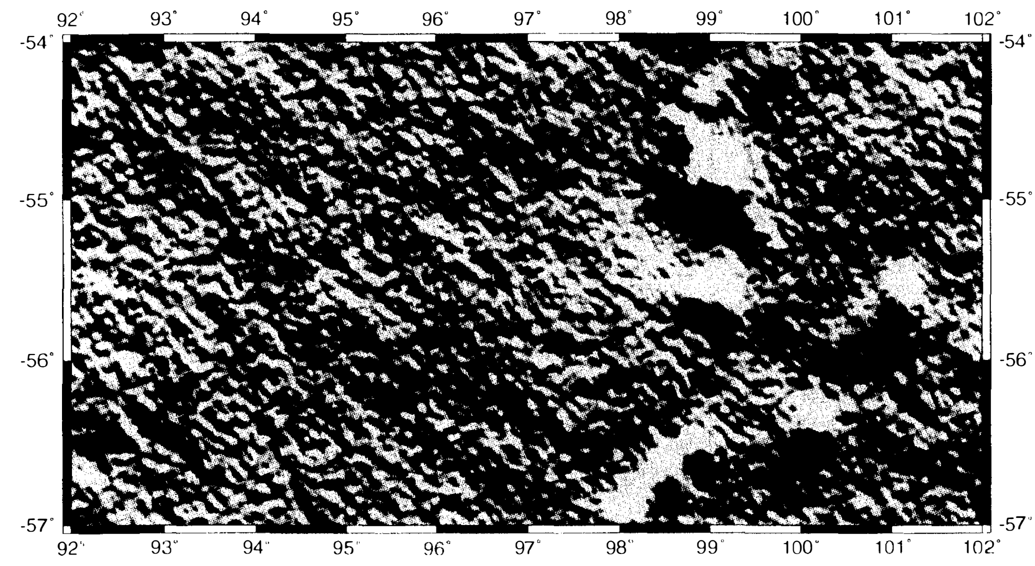

Fig. 9. Gravity anomaly images of sea mounts located at 100°E, 55°S (raw 10 Hz data).

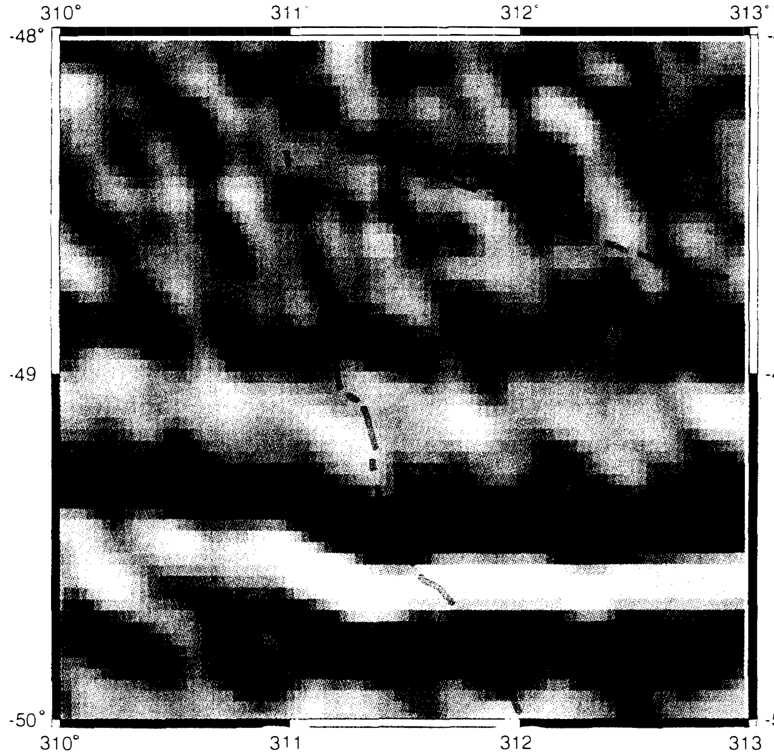

Fig. 10. *Track direction errors of filtered data. The solid line shows track direction, and dashed lines show structures.*

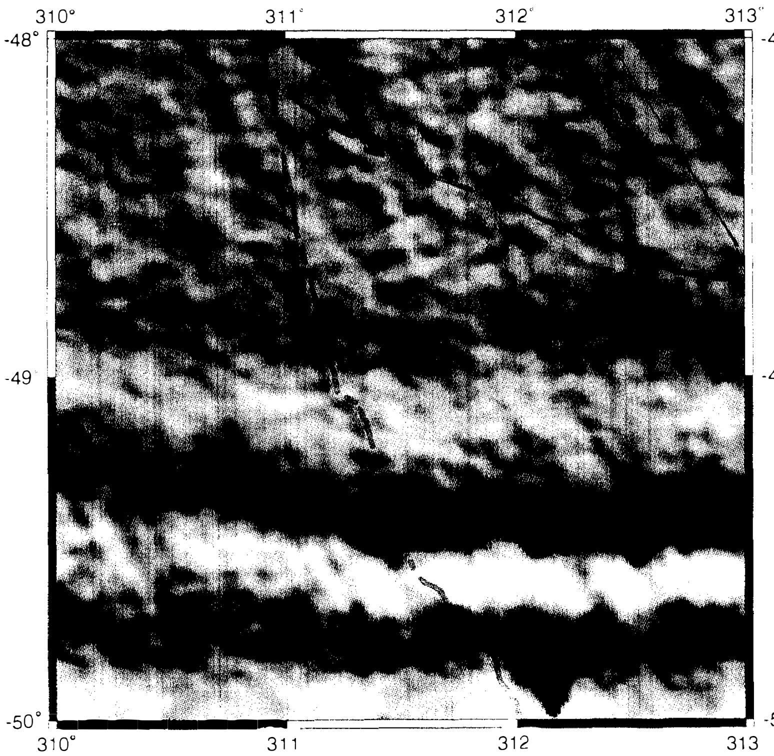

Fig. 11. *Track direction errors of raw 10 Hz data. Meanings of lines are the same as Fig. 10.*

ground noise is mainly caused by the offsets between orbits, it may be possible to suppress them by some kind of orbit correction and to detect the more precise direction of this valley.

Figures 10 and 11 show the offsets between orbits still remain in both the filtered and the non-filtered grids. These offsets in the filtered grids (Fig. 11) are hardly distinguishable from true diagonal structures, and they blur the lineaments recognized in the not-filtered grid (Fig. 10). Processing which simply regards the 10 Hz data as noise masks visible structures behind the track direction errors.

Regarding the data editing, these track-direction errors become noticeable near the coast where the sea surface variability is large. This is partly because we do not employ a new ocean tide model as correction values. To utilize the high frequency signals, we also pay much attention to the ocean signals themselves.

5. An Application to the Sea Floor Survey

In 1990, the RV HAKURYO MARU found a channel-like structure located at 78°E, 64°S, off the Amery Ice Shelf. The width of the channel is about 5 km, and the height is

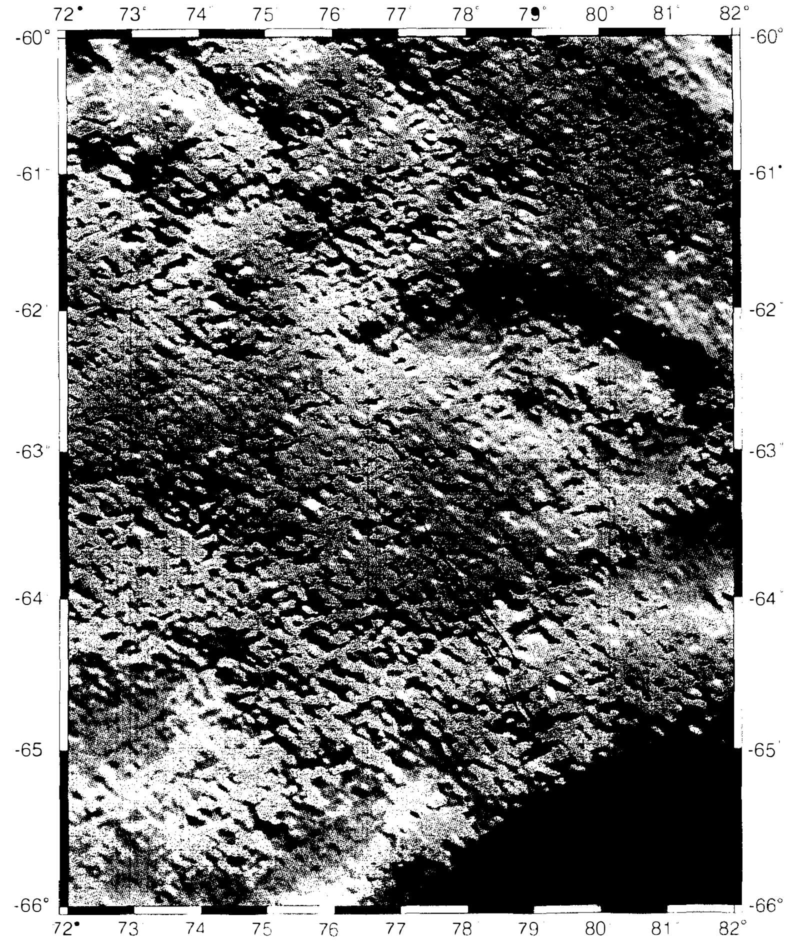

Fig. 12. Gravity anomaly images of a channel located at 78°E, 64°S. Solid lines indicate channels. The no data area in the SE corner is blacked out.

about 150 m at the sea floor at about 3700 m depth. No fault corresponding to the channel has been found, and the cause of this structure is unknown. Although this channel is thought to run at least 18 km, we have no more detailed data in this area. We thus tried to reveal this channel by our method. This area is shown as "C" in Fig. 3.

In Fig. 12, a lineation is observed where the existence of the channel is expected. This lineation can be regarded as continuing further, although the overlapping by a valley structure running from ENE to WSW reduces the certainty. Another lineation seems to run almost parallel to the west of this channel. The direction of these patterns running in Fig. 12 from NNW to SSE is oblique to the direction of satellite tracks. Moreover, these patterns are shown even in the changed grid intervals. Hence they are neither track errors nor aliases.

For this area, we tried to re-edit profiles manually, expecting a more precise outcome. Despite this, bad data located on the edge of profiles are not completely removed yet so that results leave ambiguity. There still remains room for improvement in processing in areas of sea ice.

6. Conclusions

We examined whether the along-track resolution of satellite altimetry is improved by using the 10 Hz sampling data or not. The result implies that the 10 Hz data can show more detailed structures and that there still remains some room for improvement in the processing method in areas of sea ice. It is now necessary to compromise with the sea surface change to recover the true gravity field near coasts, and to distinguish true structures from short wavelength errors. To detect local structures, suppression of the offsets between each orbits is needed, and a kind of crossover technique can be considered. Through this examination, as pointed out in previous studies, problems seemed to be accumulated in shallow areas near the coast of large sea surface variability. We will therefore concentrate on the recovery of the short-wavelength component of altimetry data near coasts in the next step of our studies.

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(Received February 10, 1997; Revised manuscript accepted May 22, 1997)