On the choice of antennas for observation of bedrock topography below the ice sheet

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1. Introduction

In the Dome Fuji region of East Antarctica, ice core drilling is planned to reveal the history of climate change on a time scale of over one million years. The essential point in the ice core drilling plan is to understand the base topography of the ice sheet and the internal layer structure of the ice sheet, and to select the optimum drilling point. Since the deep ice core drilling plan is a large investment in terms of human resources, funds, and time, the point selection work should be done carefully.

2. Previous ice sheet radar observations and antennas

The radars used by the Japanese Antarctic Research Expedition so far are the VHF band 179MHz radar that has been used since the latter half of the 1980s, and various subsequent radars (30MHz, 60MHz, 179MHz, 434MHz). With a peak power of 1kW, we have realized the measurement of ice sheet thickness exceeding 3000m. Observations of the Dome Fuji area and its southern area (more inland) have been repeated since the early 1990s. The type and performance of the antenna have been changed according to the purpose of observation at that time. Utilizing the Yagi antenna, the number of elements was changed in the range of 3 to 16. In addition, the number of antenna stacks (the number of Yagi antennas arranged in parallel) was also changed in the range of 1 to 4. Such changes in the number of elements and the number of stacks determine the antenna gain and the directivity of the antenna beam. Specifically, the antenna gain was changed in the range of about 7 dBi to 17 dBi. When the performances of the transmitting antenna and the receiving antenna are added together, the antenna performance will change in the range of 14 dBi to 34 dBi. Also, in terms of directivity, it makes a difference that it irradiates either a very narrow range or over a relatively wide range.

3. Application in the Dome Fuji area of Antarctica

In this presentation, we will demonstrate how the selection of antennas made a difference in ice thickness measurement, using a measurement line extending about 100 km from Dome Fuji Statiom in Antarctica to the southern region of Dome Fuji (tentatively named as New Dome Fuji) as an example. The ice thickness in the southern part of Dome Fuji is about 2000-2500m, and there is a steep mountainous topography that seems to have been formed before Antarctica was covered with ice sheets. In such mountainous terrain exploration, it is not possible to accurately grasp the terrain under ice, which changes frequently, without observing with high antenna gain and high directivity. This is because the electromagnetic waves that bounce off the convex terrain of the mountainous terrain mask the electromagnetic wave signals that bounce off the valley terrain and slopes, and an error occurs when capturing the convex terrain. In this presentation, we will compare the cases of four observations from the 1990s and show the effect of the antenna on the observation results. Through this, we argue that in order to improve the accuracy of the Dome Fuji southern ice topographic map, priority should be given to observation data using a highly directional antenna.