THE CARTOGRAPHIC METHOD FOR STUDYING GLACIATION DYNAMICS IN ANTARCTICA

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Abstract

The investigated area is located in the East Antarctic and includes Lambert outlet and Amery ice shelf. The digital models for the ice surface relief and rock surfaces are determined by computation (using the Pericolor AM System of image processing). By transforming these two digital models, a digital model for ice thickness is obtained (by extraction), according to which the ice volume within the region under investigation can be calculated.

A digital model for the velocity of motion of ice mass is also developed. Using the cartographic methods, the dependence of ice velocity on its thickness is established, and three characteristic types of such combination within the investigated region are isolated.

Based on similar relationships, one may predict, with a certain degree of probability, the dynamics of ice for other poorly explored regions of the Antarctic.

1 Preface

The ice sheet of the Antarctic is presented by about 25 583 thous. km cubed of ice, including the ice shelves. If fully melted, the Antarctic ice sheet may raise the level of the World Ocean by more than 60 meters.

The calving of icebergs accounts for the most of the snow-ice wastage in the Antarctic, amounting to not less than 6% of the total run-off from the Earth surface to the World Ocean and the South Ocean, making about 15 thous. km cubed of the run-off ice (as calculated for water). For the correct evaluation of the effect of the continental Antarctic ice on the hydrological conditions of the World Ocean and global climate of the Earth, it is very important to determine the ice volume contributed annually by the Antarctic continent to the sea.

2 Cartographic Sources

Much data have been obtained by now by the world science in the study of the dynamics of glaciation. The investigations carried out for a number of years led to the development of the maps of relief of the Antarctic ice sheet, rock surface, and ice thickness. The investigated

area, covering about 310 000 square km , is located in the East Antarctic between McRobertson Land and Princess Elizabeth Land and includes Lambert outlet and Amery ice shelf.

Cartographic materials used in this study:

1. A set of maps the "Antarctic" at the scale of 1 : 2 500 000, Main Administration of Geodesy and Cartography under the Council of Ministers of the USSR, Moscow (1975);
2. The author's original copy of map (I. Souetova) "Subglacial Relief of the Antarctic" at the scale of 1 : 2 500 000 prepared for a new version of the Atlas of Antarctica (1990);
3. The authors' original copy of map (W.F. Budd et al.) "The Balance of Velocity Distribution", 1971 (Glaciers, ice sheets, and Sea level: Effect of a CO_2 -induced climatic change. Report at a workshop, Seattle, Washington, Sept. 13 - 15, 1984).

3 Research Methods

The method of digitizing consists in introducing the contour parts of a map (isolines) from the graphic table into the memory device of the computer with the recording of the coordinates X and Y for all kinds of lines and points, for example, the individual measurements of heights or some quantitative indices. The "Pericolor-2000" graphic system operative in the raster format is used. The obtained system of lines is written to be further treated by the special program, "Marker".

The next important step is the editing of these lines in the interactive or automatic modes. This procedure is called for to reduce the size of the lines to one pixel and to check and correct the mistakes of digitizing. Finally, the system of marker lines is formed. Any "point" of these lines or, to be more correct, any element of the raster has the two coordinates X and Y in space.

In order to solve the set problems, third dimension, corresponding to the height of each pixel with respect to the sea level, is to be introduced. This procedure is performed in two stages, however, before starting its description, it is relevant to make some remarks.

It is of prime importance that the maps would be compatible, that is, in our case, they should correspond in view of two aspects. First the mathematic-cartographical processing of a series of maps envisages their full agreement in scale, projection, and coordinates. If they fail to agree, the geometrical correction, scaling, and other relevant procedures are to be carried out. Second, as applied to the set problem of evaluation of ice thickness, the compatibility of the volumetric digital models for third dimension, that is, with respect to the vertical scale, is to be observed.

The maximum amplitude of heights is calculated for all of the maps used. The relationship between this quantity and the brilliancy interval making 256 units for the "PERICOLOR" system is determined to yield the specific value of height (m) per one unit of brilliancy.

At the subsequent stage, the parameters of third dimension for the isolines reflected in the system of marker lines are recorded. Each marker line is assigned a value of an altitude

level corresponding to the obtained gradation. As a result, at the screen, we get a discrete image which is recorded into a special storage block, "IMAGE".

In order to obtain the digital models of relief of ice and rock surfaces, a special block of derivative images is used. The method of interpolation is used to calculate, under the automatic conditions, the digital models of relief. Similarly to the marker lines, the obtained digital model must be edited.

Subtraction from the digital model of ice surface the digital model of relief yields the digital model of ice thickness. Knowing the specific volume of ice per unit of brilliancy for each pixel, one may calculate the ice volume within the limits of the region under investigation. Similar calculations can be automatically carried out for any closed contours.

The obtained map of the ice thickness is an essential though insufficient material for predicting the volumes of the ice transformed to icebergs, because we must know the dynamics of the Antarctic ice sheet. For this purpose, a map (and a digital model developed on its basis) of the velocity of ice motion is used. The method of making the digital model is similar to that described above.

4 The Analysis of the Obtained Results

Even visually compared, these two maps show certain regularities in the combinations of the regions of different ice thickness with the sections with different velocities of motion of ice. For example, considerable velocities are characteristic of the sections with a relatively small ice thickness. Under these conditions, this ice is pressed out by the ice mass surrounding it.

Based on the digital models of these two maps, in separate fixed points of a regular coordinate grid taken at random (with a mesh width of 20 pixel along the axes X and Y), the values of the ice thickness and its velocity are calculated. Graphically, the relationship between these two parameters is established. In the plot, two boundary conditions dividing the combinations in three types are isolated. The first type is characterized by considerable variations of ice thickness at small velocity gradients; the third type is characterized by the opposite regularity; and second, occupies an intermediate position.

5 The Problems to Be Solved in the Future

In future, it is planned to make a summary of the latest data available on the velocity of motion of ice masses. The specified data are to be put in the computer, get more specific data on spatial regularities of variation of the ice dynamics depending on its thickness and morphology of the surface, and finally, regionalize the coastal sections with the indication of their specific features. The proposed method makes it possible to predict the possible velocities of ice motion, possible variants of catastrophic calving of icebergs, and give recommendations on the locations of future research stations.