Fractal Dimension of Tundra Lakes

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Abstract

For the first time a calculation method for fractal dimension D of the Tundra Lakes has been proposed. It has been established that for a lot in the area of Chersky settlement (Republic of Sakha-Yakutia)

Keywords: fractal dimension, Tundra Lakes

Introduction

The article describes the method of measuring the fractal dimension applied to Tundra Lakes. Fractal dimension was first introduced by Benoit B. Mandelbrot [Mandelbrot B. 2002]. Tundra Lakes occupy a vast portion of the Earth's surface. For the quantitative description of Tundra Lakes it is necessary to introduce a dimensionless quantitative index of fractal. We propose to use the fractal dimension D, which will characterize the degree of filling of the Earth's surface by the Tundra Lakes values from 1 to 2 as such index. The value D = 1 means that there are no bogs at all. The value D = 2 corresponds to the fact that the entire area of the examined lot of the Earth's surface is completely filled with Lakes, i.e. a lot is one large Lake.

Section 1. Formula George Pick

Measurement of the fractal dimension of Tundra Lakes will be carried out using the following method. The total linear dimension R of several Lakes (e.g., the sum of their transverse dimensions) is connected with the measurement scale of χ by the Mandelbrot – Richardson formula $R \sim \chi^{1-D}$. On the other hand, if S is a total area of the Lakes under consideration, then the linear size $R \sim \sqrt{S}$. If we cover bogs with a mesh, then their area will be proportional to the number K of mesh nodes that fall inside the Lakes' borders. Based on the above information we established the relationship between the number of nodes K of the mesh and cell size χ : $K \sim \chi^{-2(1-D)}$ [1]. The K number will be measured by a modified cellular method. First we calculate the nodal grid points within the contours of the Lakes (their number is M_0). Then count the number of nodes that fall in the line of contours (their number is M). Then the K number will be equal to the following expression: $K = M_0 + \dfrac{M}{2} - 1$ this formula was introduced by George Pick in 1899 [2-3].

Section 2. Fractal dimension of the measurement.

In Figure 1 presents the in lot Chersky settlement area (Republic of Sakha-Yakutia) with Tundra Lakes (Figure 2). We cover 5 Tundra Lakes with the two allocated central lots of the mesh with the equal length of cells edges. The lots have specifically been selected in such a way that the self-similar character of the 5 Lakes could clearly be seen. Figure 3 shows the results of measurements of the dependence of logarithm of the K number from the logarithm of the scales' length (in relative units). It is easy to find a power index in formula 1 by the tilt, which suggests that the fractal dimension of the Tundra Lakes. $D = 1.84 \pm 0.01$

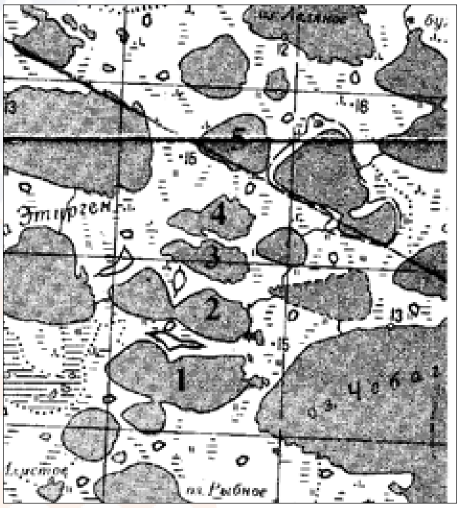

Figure 1. Tundra Lakes, $D = 1.84 \pm 0.01$ .Fractal dimension has calculated for 5 Lakes in two rectangular central sections.

This paper demonstrates how the methods of fractal analysis were for the first time applied to the system of Tundra Lakes. It is established that the Tundra Lakes are, indeed, a fractal object with the dimension equal to 1.84 ± 0.01 .

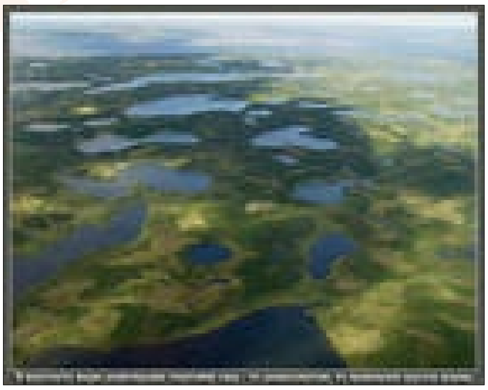

Figure 2. Photo of the Tundra Lakes.
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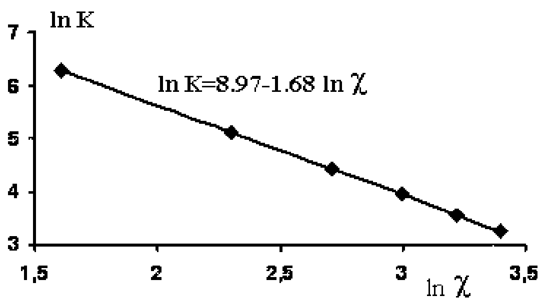

Figure 3. Dependencies of the K number of node points of the Lake area on the scale length. Linear approximation displays a practically ideal match with the measured values.

Conclusion

This paper demonstrates how the methods of fractal analysis were for the first time applied to the system of Tundra Lakes. It is established that the Tundra Lakes are, indeed, a fractal object with the dimension equal to 1.84 ± 0.01 . At the present stage of satellite technology development using the data of Earth monitoring and the aforementioned method of measuring the fractal dimension may be applied to the assessment of the condition of Tundra Lakes and, possibly, link the variability of their condition to climate variability.

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