SOME RESULTS OF 3-D AURORA RECONSTRUCTION BASED ON SINGLE TV IMAGE AND HEIGHT PROFILES OF BRIGHTNESS

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Abstract

An analysis of auroral brightness height profiles have shown that their form in the absence of rays is approximately stable and only their amplitude changes. This fact allows to develop iterative algorithm for tomographic reconstruction of approximate 3-D aurora using single TV image and height profiles of brightness measured by rocket-borne photometers. Some results of 3-D aurora reconstruction are presented.

1. Introduction

The problem of three-dimensional reconstruction of auroral emission on basis of ground-based TV measurements can be solved using tomographic methods [1-7]. But in contrast to medical tomography, reliable procedure for auroral tomography has not been developed. For evaluation of auroral tomography methods reliability it is necessary to have the digital model similar to real auroras. First, who used the digital model of aurora for evaluation of feasible tomographic procedure quality, was Gustavsson [7]. For simulation of aurora he used the simple analytical expression which gave the three-dimensional distribution of arc and double arc in auroras. The purpose of this report is to present another three-dimensional model of auroras calculated using real TV picture and height profiles of brightness measured by rocket-borne photometers.

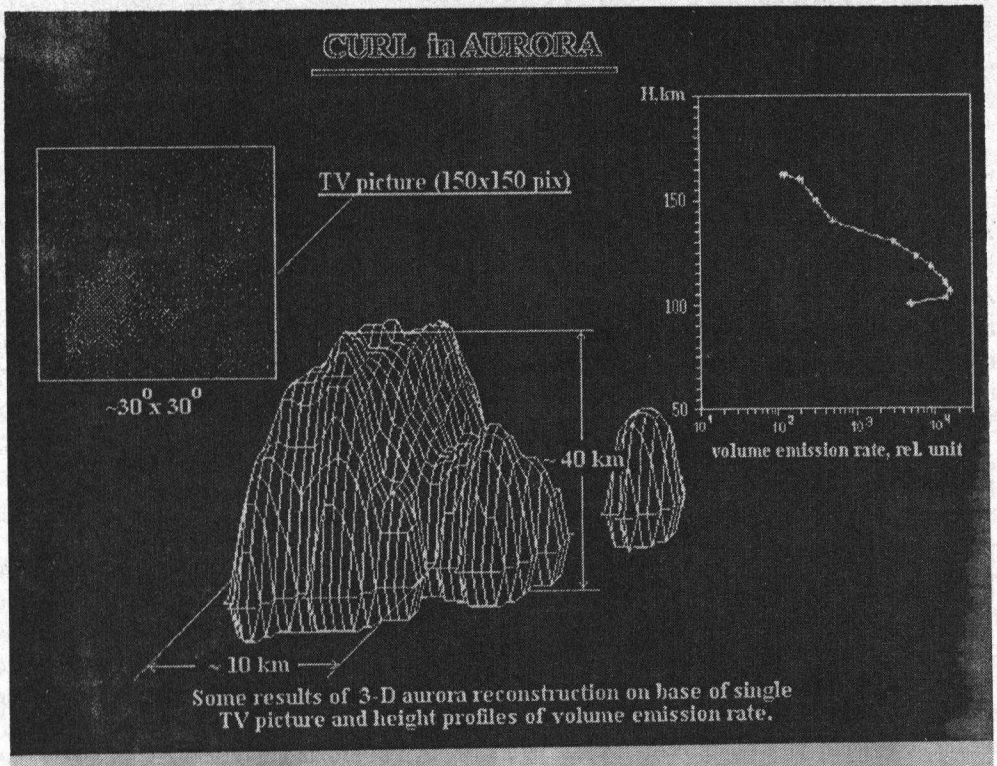
2. Three-dimensional model of aurora

Five MR-12 rockets with onboard photometers, exploring aurora at 70-170 km altitudes, were flown from the Heiss island. Two photometers were installed on each rocket [9]. Both photometers had 3^{o} field of view. One was directed along the axis of the rocket, another at angle 55^{o} to the axis which made possible to scan in the upper hemisphere using the spinning of the rocket. Measurements were made at 391.4, 427.8, 530.0, 557.7 nm and 300-600 nm. Examples of height profiles of volume emission rate at 557.7 and 391.4 nm, obtained in these experiments are presented in fig. 1 [8]. Our laboratory in cooperation with Polar Geophysical Institute have also made statistical investigations of auroral disturbances using ground based TV-cameras [10],

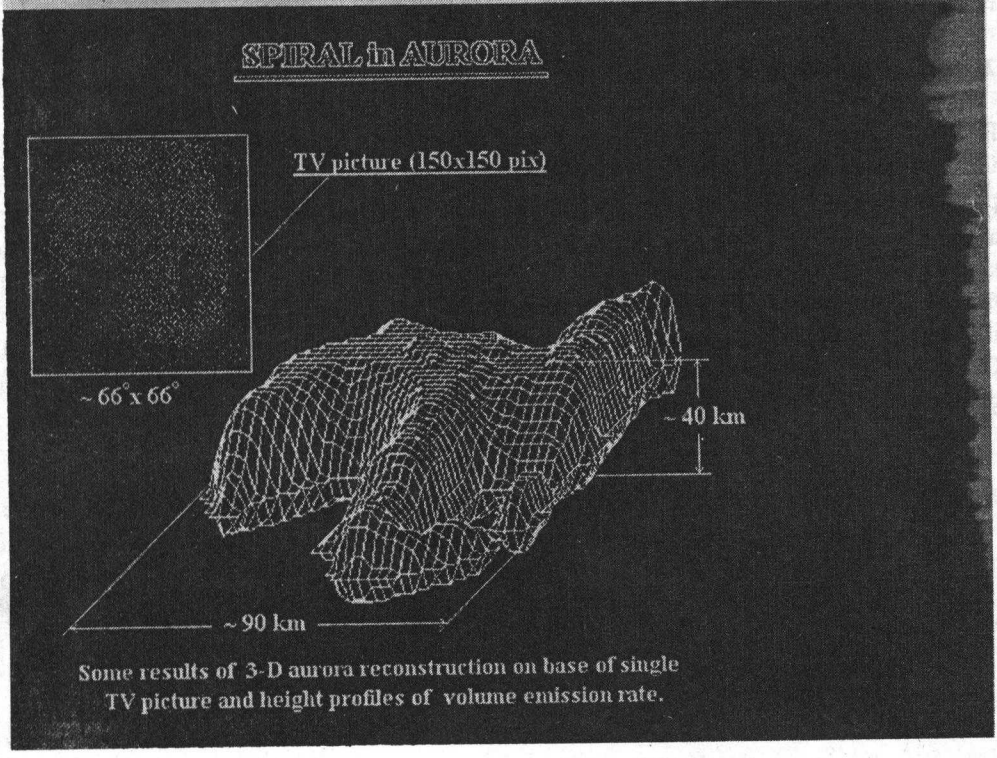
An analysis of auroral brightness height profiles have shown that their form in the absence of rays is approximately stable and only their amplitude changes. This fact allows to develop a method of tomographic reconstruction of approximate 3-D aurora image using single 2-D TV image and height brightness profiles obtained by geophysical rockets. The simple iterative methods similar to Gordon's ART [1] method have been developed.

If B(h,x,y) is 3-D array of volume emission rate then the TV image pixel intensity is:

$$P_{\varphi,\theta} = \sum B(h,x,y) \cdot \exp[\, -c \cdot |r_{h,x,y}| \,] \,/\, |r_{h,x,y}|^2, \qquad (1)$$



Some results of 3-D aurora reconstruction on base of single TV picture and height profiles of volume emission rate.



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where (h,x,y) are all points that lie within the solid angle which is projected on the pixel (φ,θ), c - atmospheric attenuation, $r_{h,x,y}$ - spatial coordinates corresponding to point (h,x,y) of 3-D array B.

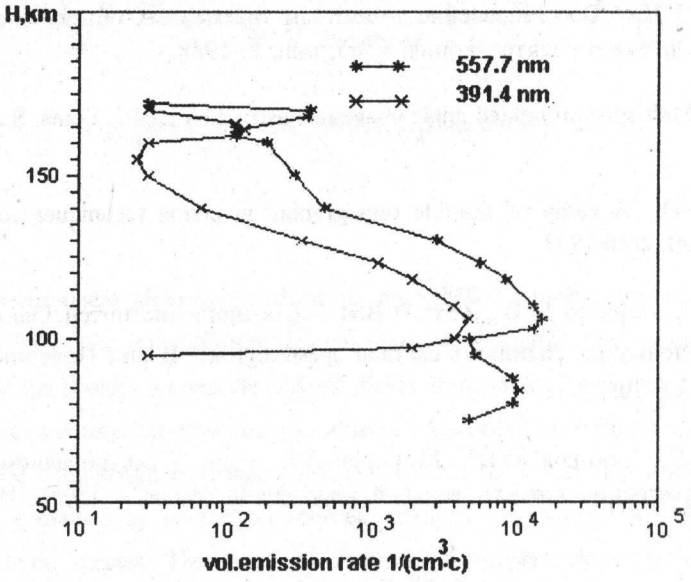

Fig. 1 Height profiles of volume emission rate .

Intensity in the m-th iteration step is given by:

$$B^{m+1}(h',x',y') = \max \{B^m(h',x',y') + \xi \cdot (P_{\varphi,\theta} - P^m_{\varphi,\theta}) \cdot B^m(h'=h_0,x',y') \cdot B_R(h')/N_{\varphi,\theta},0\}, \quad (2)$$

where (h',x',y') is all points on the ray parallel to magnetic field line, $B_R(h')$-averaged relative rocket height profiles of volume emission rate, $N_{\varphi,\theta}$ - is the number of points in the solid angle (φ,θ), ξ- empirical constant. As a start approximation for the iterative procedure 3-D arrays calculated by a simple multiplication of pixel intensity in TV image on height profiles of volume emission rate have been used. The numerical experiments have shown the good convergence of this method after 20-30 iterations. Three-dimensional models of auroras based on fragments (150x150 pixel, 8 bit/pixel) of TV frames containing images of auroral curl and spiral have been developed by means of this method . To remove the influence of noise on quality of reconstruction fragments of TV image were smoothed before processing. Axonometric viewes of three-dimensional models drawn for boundary level corresponding to 0.1 of maximal intensity are shown in fig. 2 and fig. 3.

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