

## SOME ASPECTS OF PROCESSING OF AURORAL TV DATA

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**Abstract.** Permanently growing amount of auroral TV data obtained in various satellite and groundbased experiments requires treatment of new problems concerning mass processing of such kind of data. In this paper we deal with some programs concerning mainly mapping of auroral displays and obtaining auroral keograms. This software serves for solving contemporarily the problems of high-quality fast processing of auroral data and their comparison with data of satellite and/or ground-based experiments on investigating fast auroral processes.

### Introduction

At present auroral TV observations win more and more popularity among regular ground based observations. From occasional observations during certain campaigns they become common ones due to the main advantage of the TV observations consisting in high temporal resolution along with high sensitivity and variable field of view which is available using different types of objective lenses as an input optics. On the other side, the TV measurements have required new methods and technique for processing of data and subsequent presentation of results. The development of such methods began in PGI from the very beginning of TV observations at the end of 70th. At first it included simple photographic processing (*Chernouss et al*, 1982), then it was continued on the basis of the first generations of personal computers (*Zaitsev et al.*, 1990).

An auroral display being a very dynamic phenomenon sometimes covering global space in the sky with time variations reaching frequencies of tens of hertz required the development of special hardware and software for the data processing. New generation of personal computers and different types of digitizing cards for TV signal processing gave great opportunities for further development of the software for auroral image processing. The principal task was to use the main advantage of TV methods, i.e. high time resolution along with high spatial resolution. Such software began developing in PGI a few years ago. The basic auroral data which were used in developing of the software were those obtained during the expeditions of Polar Geophysical Institute to Heiss Island (Frantz Joseph Land) and Barentsburg (Spitzbergen) and at the stationary observational points in Loparskaya and Sodankyla (Finland). It has been permanently filling up by new programs and improved versions of older ones (*Arinin et al*, 1995a, 1995b, 1996, 1997, 1998). Digitizing of images is provided by FrameGrabber Card (FG6) which was developed and produced in Russian Federal Nuclear Center (Sarov). At present the software for image processing contains about 30 main programs for common use and enables to obtain temporal resolution as high as duration of a single TV frame (0.04s) and spatial resolution up to 720x512 pixels. It allows us to separate perfectly spatial and temporal variations in auroral luminosity by different methods of analysis, which is very important in studying dynamic auroral processes.

In this paper we deal with some new programs concerning mainly mapping of auroral displays and obtaining auroral keograms. This software serves for solving contemporarily the problems of high-quality fast processing of permanently growing amount of auroral data and their comparison with data of satellite and/or ground-based experiments on investigating fast auroral processes.

### Auroral mapping

The auroral mapping to geographic grid is important mainly with respect to the comparison of optical data with satellite ones. Several satellites such as POLAR, INTERBALL, FAST and MSX have been launched recently for investigating of auroral processes and associated phenomena in the magnetosphere and ionosphere. Comparison of ground-based and satellite data is getting more and more important because at present satellite data can be obtained with high temporal resolution reaching or even exceeding that of ground-based observations. So low-altitude satellites which earlier couldn't measure auroral irregularities with dimensions of an auroral arc width or lifetime of several seconds like that of pulsating aurora because of high speed and low temporal resolution, at present can measure them perfectly. One of such satellites is FAST which has temporal resolution of measuring particle flux and other parameters of about milliseconds.

The screen of all-sky TV camera at Loparskaya station is shown in Figure 1,a. Oval represents the field of view of fish-eye optics with auroral arc in the sky. Compass directions are northward at the top of the circle and eastward to the left. At the left side of the screen time with 0.01 s accuracy, brightness scale and name of station are given. Figure 1,b presents the geographical grid in the field of view of the TV camera with fish-eye lens calculated for Loparskaya for 100 km height. The calculations were made using the distortion curve of TV camera optical system which was derived by determining position of 80 stars (*Kaila*, 1981). The result was interpolated by a polynomial function  $h = 55.881 \cdot R +$

$24.83 \cdot R^2 + 6.36 \cdot R^3$ , where  $h$  is the elevation angle,  $R$  is the normalized radius on the frame, that can be obtained by setting the distance zenith-horizon equal to 1. Mapping of an auroral display to the contour map of the Kola peninsula and Scandinavia is shown in Figure 2. The dashed oval outlines the whole field of view of the camera whereas the dark area corresponds to the region covered by the grid in Figure 1,b. This grid was calculated for elevation angles higher than  $15^\circ$  above horizon.

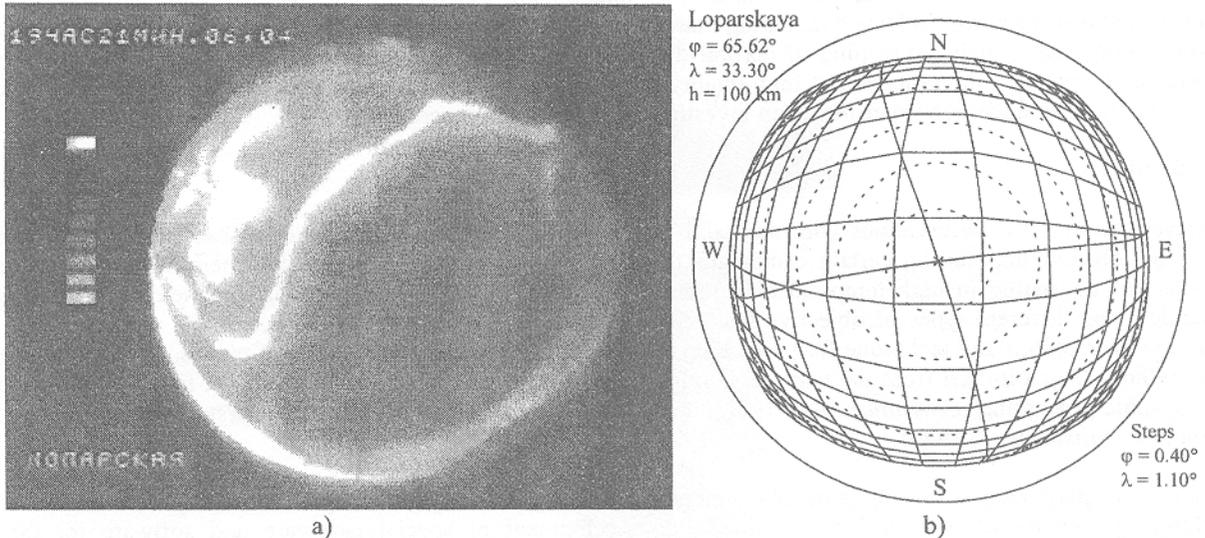


Fig.1. a) The screen of Loparskaya all-sky camera with auroral display on 09 February 1997. North is at the top of the image and west is to the right. At the left side of the screen universal time, brightness wedge and the name of station are shown; b) Geographical grid in the field of view of Loparskaya TV camera with fish-eye lens calculated for 100 km height. Two lines passing the center represent geomagnetic latitude and longitude crossing the zenith of the station. Dashed circles are drawn with 15 degrees interval of elevation angle.

### Keograms

Building of keograms (or auroragrams) using ground-based TV observations can be considered as one of the basic tasks of primary processing and presentation of this kind of observations. They represent spatial-temporal variations of auroral intensity along any direction in the field of view of a camera. Popularity of keograms is caused by their relative compactness and imposing view of dynamic character of auroral displays, easy treatment and perception. They are very convenient as quick-look data and compared to temporal characteristics of other geophysical parameters.

The dynamic range of auroras is very wide and varies from less than 1 kR for diffuse and pulsating auroral forms to 1000 kR for discrete bright and active auroral arcs and bands. The dynamic range of TV tubes is much less. That's why it is necessary sometimes to involve automatic brightness regulation inside the TV channel or when the brightness of aurora is very high to change the sensitivity manually. This causes dropouts of brightness on keograms like that shown in Figure 3 (the first and third panels). To avoid this disadvantage we used a so-called "brightness wedge", which is shown at the left side of TV screen in Figure 1,a, as a basic light source for correction the brightness during building keogram.

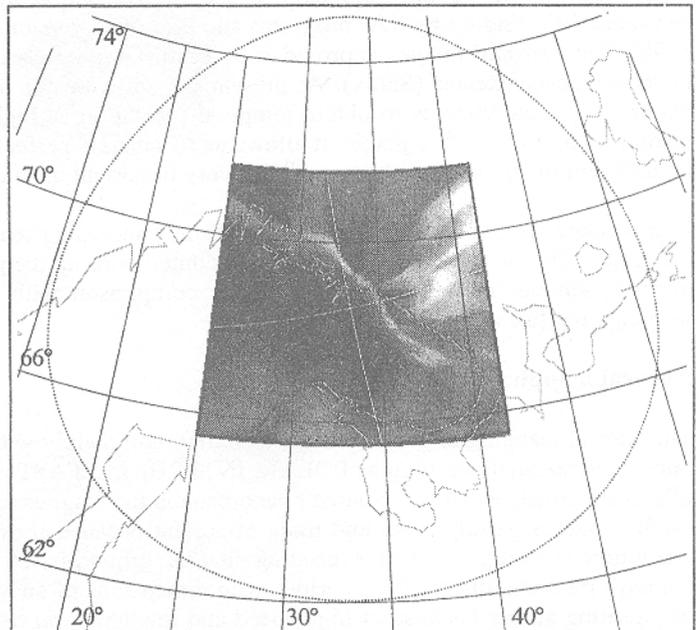


Fig.2. The result of the mapping of auroral display to the contour map of Kola peninsula and Scandinavia. The dashed oval outlines the whole field of view of the camera whereas the dark area corresponds to the region covered by the grid in Figure 1,b.

This was performed in a special computer software named AUG. The development of the software was not simple. We had to take into account the nonlinear transmission characteristics of TV camera channel and approximate it by the third order polynomial function. Because of a very noisy character of TV signal we used summarizing and averaging of different

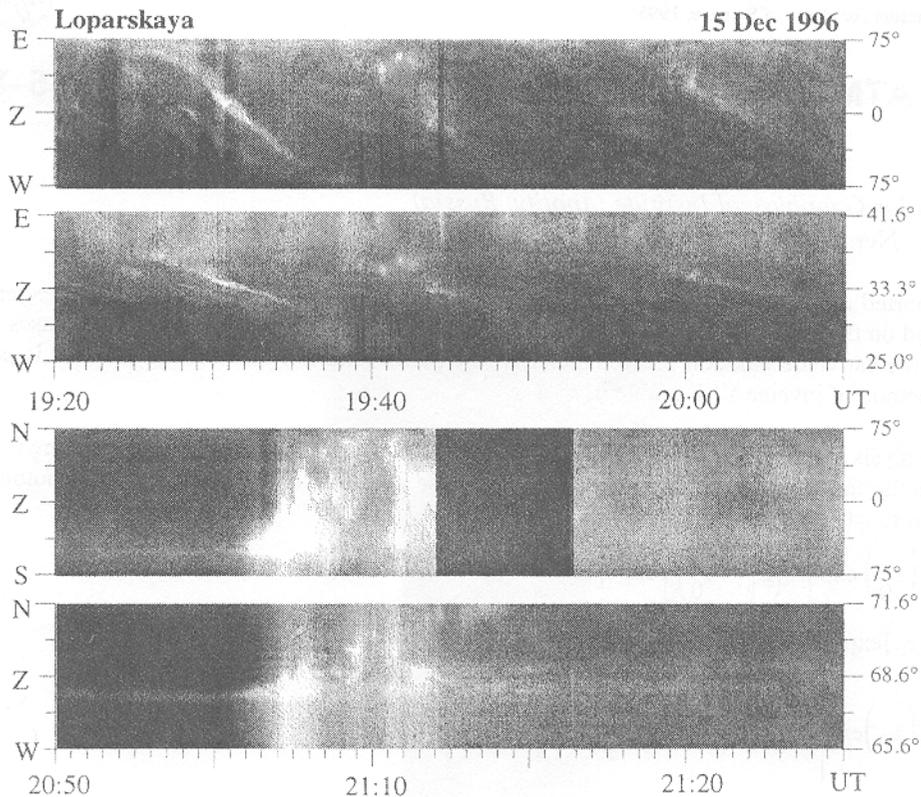


Fig.3. The first panel presents the keogram obtained with automatic brightness regulator and without correction of geometrical and optical distortion factors. The second panel shows the same keogram after the correction for the both factors. The third keogram contains the interval with the sensitivity switched down. The fourth one is the same keogram with corrected brightness and geometry. Elevation angles and geographic coordinates are shown on the right axis.

zones of “brightness wedge” basic light source. Keograms can be build along any curved or straight direction. The software makes correction of geometrical distortion due to both optical and geometry factors. At present during play of record in real time the keograms can be obtained with temporal resolution as high as 0.08 s. The results of using the software are shown in Figure 3 (the second and fourth panels).

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