"Physics of Auroral Phenomena", Proc. XXVII Annual Seminar, Apatity, pp. 35-38 , 2004

Polar Geophysical Institute

CALIBRATION OF TV ALL-SKY DATA BY SIMULTANEOUS OBSERVATIONS OF SCANNING PHOTOMETER

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Abstract. Calibration of image intensity is a common problem that hampers the use of TV data in quantitative auroral studies. The availability of simultaneous photometry observations allowed us to carry out relative calibration. An example of such calibration is described in this report. The data of two instruments located at Barentsburg, Svalbard (78.1°N, 14.24°E, 75.17MLAT, 112.1MLON) are used: a TV all-sky camera and a meridian scanning photometer. The scan trajectory in the TV field of view was traced by stars crossings. The calibration procedure was based on comparison of the surrogate keogram constructed from TV data and the keograms really observed by the scanning photometer in 557.7 and 427.8. nm emission spectral bands. The calibration curve (intensity of the auroral emission as a function of TV gray level) was approximated in each 5-degrees interval of zenith angle to obtain the angle dependence. In both cases of aurora emission used, it was found that the calibrated surrogate keogram constructed from TV data reproduced reasonably well the fine small-scale structure of bright aurora observed by the scanning photometer.

Introduction

Ground-based observations of the polar aurora have very long traditions in geophysics. Now it is known that the aurora variety is a result of numerous processes occurring in the different re-gions of the magnetosphere-ionosphere system: energization due to parallel electric fields, Kelvin–Helmholtz instability, wave-particle interactions, current sheet pitch-angle scattering, field-line resonances, etc. (see, for example, reviews in Lyons et al., 1999). Investigation of these processes usually requires a separation of temporal and spatial variations. Ground-based television (TV) observations give the data which contain two-dimensional spatial and very good temporal information. However, now the images themselves are mainly used only as illustrations. One of the common problems that hampers the use of TV data in quantitative auroral studies is an absence of calibration of TV image intensity.

This paper discusses a possible procedure of calibration of image intensity in TV data by data of simultaneous photometry observations.

PGI optical observations at Barentsburg

Barentsburg Observatory (78.1°N, 14.12°E, 75.3 MLAT, 112.1 MLON) of Polar Geophysical Institute is equipped by two optical instruments: a TV all-sky camera (TVASC) and a meridian scanning photometer (MSP). The TV all-sky camera observes the auroral emission in the range of visible light with a broad maximum at blue-green wavelengths. Field of view of TVASC is shown in Fig.1. The TV data were saved by VHS recorder at the long-play type speed encoded in PAL video system, 25 images per second. We digitized the data by Acorp TV-Capture plate with the output resolution of 5 images per second, 320×288 pixels, 8 bit per pixel.

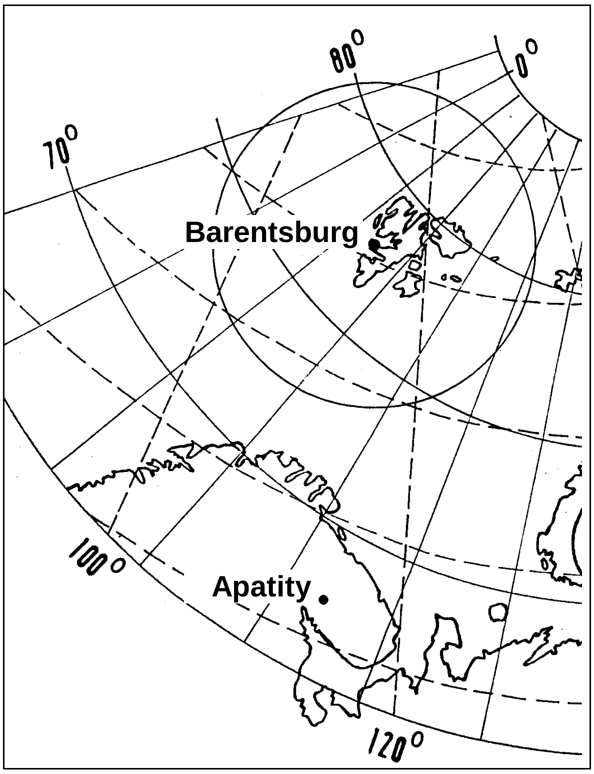

Fig.1. Kola Peninsula and Barentsburg Observatory of Polar Geophysical Institute

The MSP is a 4-channel photometer monitoring the auroral emission at the wavelengths 427.8 nm (N_2^+ 1NG), 557.7 nm (OI), 630.0 nm (OI), and 489.1 nm (Hβ). The photometer data were recorded with the angular resolution of about 0.5 degree, and the scanning time along the geographic meridian of about 12 seconds. Typically, the photometer scans the sky every 60 seconds, with even (odd) scans corresponding to south-north (north-south) scanning directions. Here we use data obtained during night of 19-20 January 2001 that was reliably documented by both instruments. The MSP data of this event in 557.7 nm emission line is shown in Fig.2.

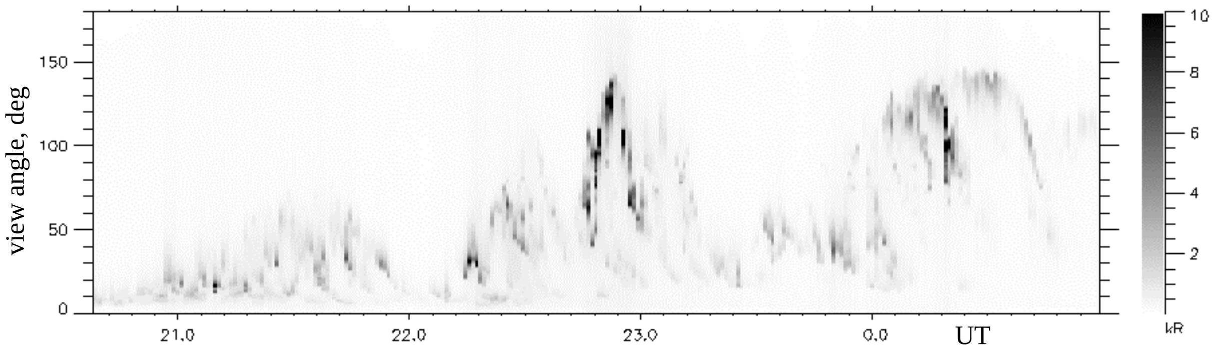

Fig.2. Meridian scanning photometer observations in 557.7 nm emission band during 19-20 January 2001 at Barentsburg Observatory. View angle is counted from south horizon

Calibration procedure

The offered calibration procedure consisted of the following basic steps:

I. The trajectory of the scanning photometer in the TV-camera field of view was traced precisely by star crossings. The results for considered events is presented in Fig.3.

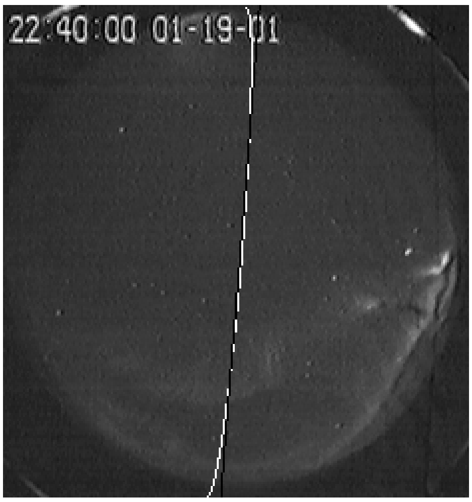

Fig.3. TV frame with MSP scanning trace. Black line - linear interpolated, white line - interpolated by second order curve

II. Taking the operational mode of the scanning photometer into account, an analogue of the keogram was constructed from the TV frames. As the time between scans is well stabilized, the adjustment of 2 parameters is required: initial time of first scan for considered event and average scanning time.

III. Based on the comparison of the observed keogram intensity and the gray-color level in the analogue keogram, the dependence of the calibration factor as a function of the zenith angle is obtained. For this we construct a dependence of intensity of the auroral emission (from MSP data in 557.7 nm emission spectral band) as a function of TV gray level for each 5-degrees view angle interval, see Fig.4. The dependencies is approximated by linear function:

$$I = a\,(L - b)\,, \qquad (1)$$

where a and b are fitted parameters, L is TV gray level, I is auroral intensity by MSP data. Then obtained values of a and b were fitted as functions of zenith angle (see Fig.5):

$$a = 67 \cos \varphi$$
$$b = 20 \cos \varphi + 30 \qquad (2)$$

From (1) and (2) we obtain:

$$I = 67\, L \cos \varphi + 2010 \cos \varphi + 1340 \cos^2 \varphi \qquad (3)$$

IV. The expression (3) has been extrapolated to full TV frame to calibrate auroral intensity level.

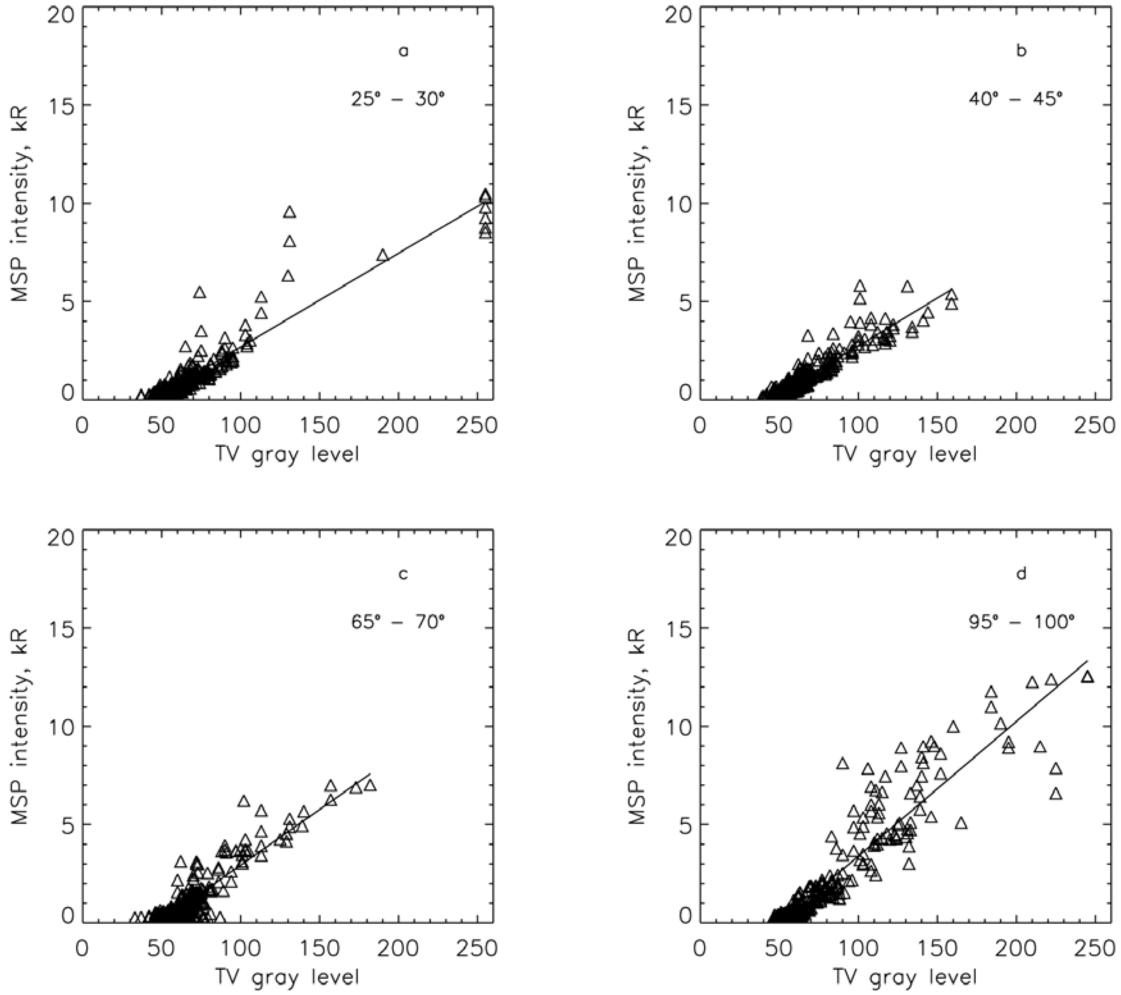

Fig.4. Examples of dependence of intensity of the 557.7 nm auroral emission (from MSP data) as a function of TV gray level for 5-degrees view angle interval. Lines are approximations by (1).

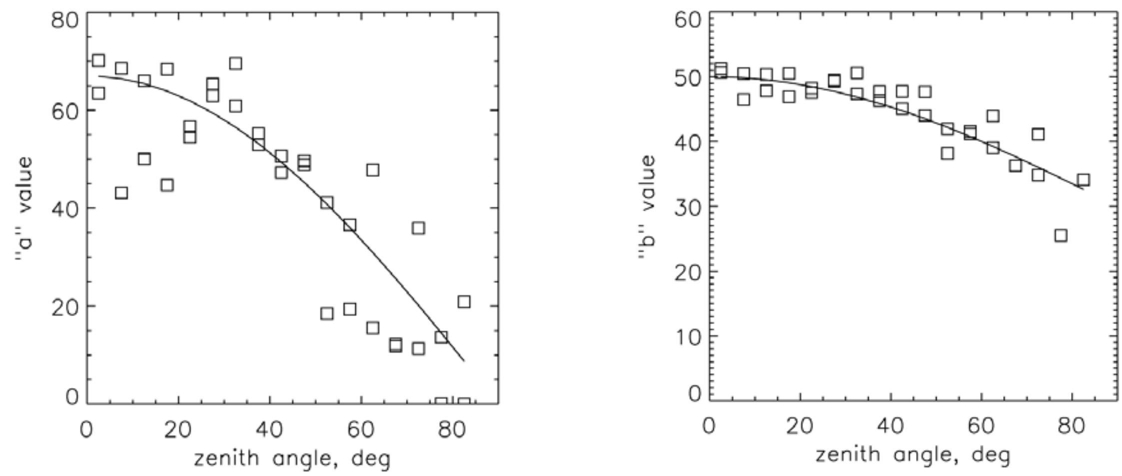

Fig.5. Approximation of zenith angle dependency. Symbols - parameters of *a* and *b* in (1) as functions of zenith angle; lines – fitted functions by (2).

Discussion

A comparison of MSP keogram and surrogate keogram constructed from calibrated TV data is presented in Fig.6 to demonstrate a quality of the offered calibration procedure. One can see that the calibrated surrogate keogram constructed from TV data reproduced reasonably well the fine small-scale structure of bright aurora observed by the scanning photometer. However, background noise in the surrogate keogram is much higher than in MSP data.

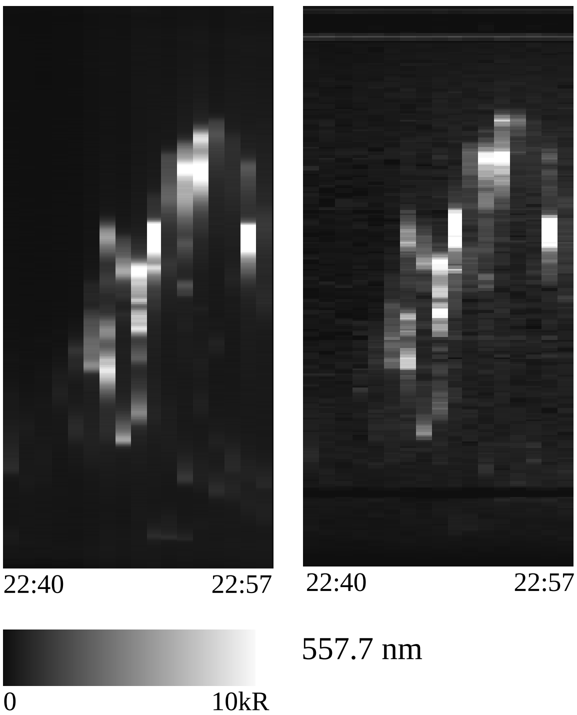

Fig.6. A comparison of MSP keogram (left panel) and surrogate keogram (right panel) constructed from calibrated TV data

The same calibration procedure was carried out by 427.8 nm emission spectral band. It was found that in bright aurora the relation between calibrated intensity levels for case 557.7 nm and 427.8 nm is ~5 that corresponds well to theoretical value of these relation.

Conclusions

1. A procedure of calibration of image intensity in TV data by data of simultaneous photometry observations is presented.
2. An example of such calibration by data of PGI instruments located at Barentsburg (Svalbard) is described.
3. It was found that the calibrated surrogate keogram constructed from TV data reproduced reasonably well the fine small-scale structure of bright aurora observed by the scanning photometer.

Acknowledgements. The author is thankful to the Polar Geophysical Institute for data of optical observations at Barentsburg Observatory and program DPS-18 of Russian Academy of Sciences for financial support.

References

Lyons, L. R., Koskinen, H. E. J., Blake, J. B., Egeland, A., Hirahara, M., Oieroset, M., Sandholt, P. E., and Shiokawa, K.: Processes leading to plasma losses into the high-latitude atmosphere, in: Magnetospheric plasma sources and losses, Space Science Series of ISSI, vol.6, edited by Hultqvist, B., Oieroset, M., Paschmann, G., and Teumann, R., Kluwer, Dordrecht, 85–136, 1999.