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CONTENT

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Geomagnetic activity influence on the season variations of myocardial infarction in subauroral (Yakutia) and low latitudes (Bulgaria)

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Abstract

The problem of possible influence of the solar and geomagnetic activity on the human health has been discussed during the last decades. It was established that the heart and cardiovascular system could be the main targets of this negative action. Here we present the results of the comparison of the seasonal variations of the emergency medical calls for myocardial infarction in Yakutsk (subauroral geomagnetic latitudes) with planetary geomagnetic activity near maximum (1992) and minimum (1998) solar activity and found their good agreement. However, the seasonal behaviour of deaths from myocardial infarctions at low latitudes (Bulgaria) exhibited significant differences. In Bulgaria, the maximum of infarctions was in winter without a strong correlation with magnetic activity, but controlled by Pc1 geomagnetic pulsations at periods of about 0.5–2.0 Hz. In Yakutsk, there are several maxima coincided with increase of geomagnetic activity. We suppose that, in subauroral latitudes, unlike low latitudes, a major role in the increase in the number of infarctions is played those magnetic storms which demonstrate strongest disturbances (substorms) in local (i.e. in Yakutsk) night. Typically, substorms are accompanied by irregular 0.3-4.0 Hz geomagnetic Pi1 pulsations quickly decreasing with latitude and therefore seldom observing at low latitudes. We suppose that Pi1 at subauroral latitudes like Pc1at low ones could be biotropic.

Introduction

A huge number of publications describing the influence of the solar and geomagnetic activity on the human health have appeared over last decades. Very many authors have accepted geomagnetic storms and solar flares as an important factor of hazard. It was found (e.g., Breus et al., 1995; Baevsky et al., 1997) that the main targets of the solar and geomagnetic activity influence are the heart and the cardio-vascular system.

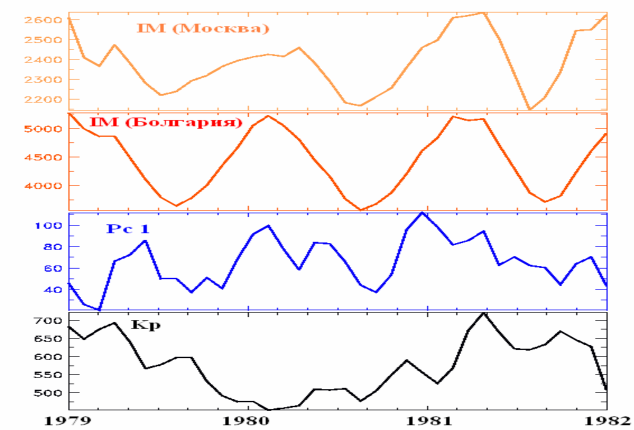

Fig.1. Infarctions (Moscow), mortality (Bulgaria), Pc1 pulsations and geomagnetic activity/

Some authors (e.g., Kleimenova and Troitskaya, 1992; Kleimenova et al., 2007) supported that geomagnetic pulsations could be one of central biotropic "agents" of magnetic storms. It was found (Kleimenova et al., 2007) the seasonal variations of the Moscow ambulance call numbers, related to diseases of the cardio-vascular system are characterized by the same seasonal regularity as it was shown by Ivanova et al. (2002) for the infarction mortality in Bulgaria. Namely, it was the profound summer minimum and the winter time maximum (Fig. 1). Very good correlation between Moscow and Bulgaria data is seen. However, they demonstrate very poor correlation with planetary geomagnetic activity.

Results of analyzing medical data

We studied the number of calls for the emergency medical care (EMC) related to myocardial infarctions in Yakutsk (subauroral geomagnetic latitudes) near the maximum (1992) and minimum (1998) of solar activity (Fig.2) and found their good correlation. The number of EMC was higher near the solar maximum than near the solar minimum.

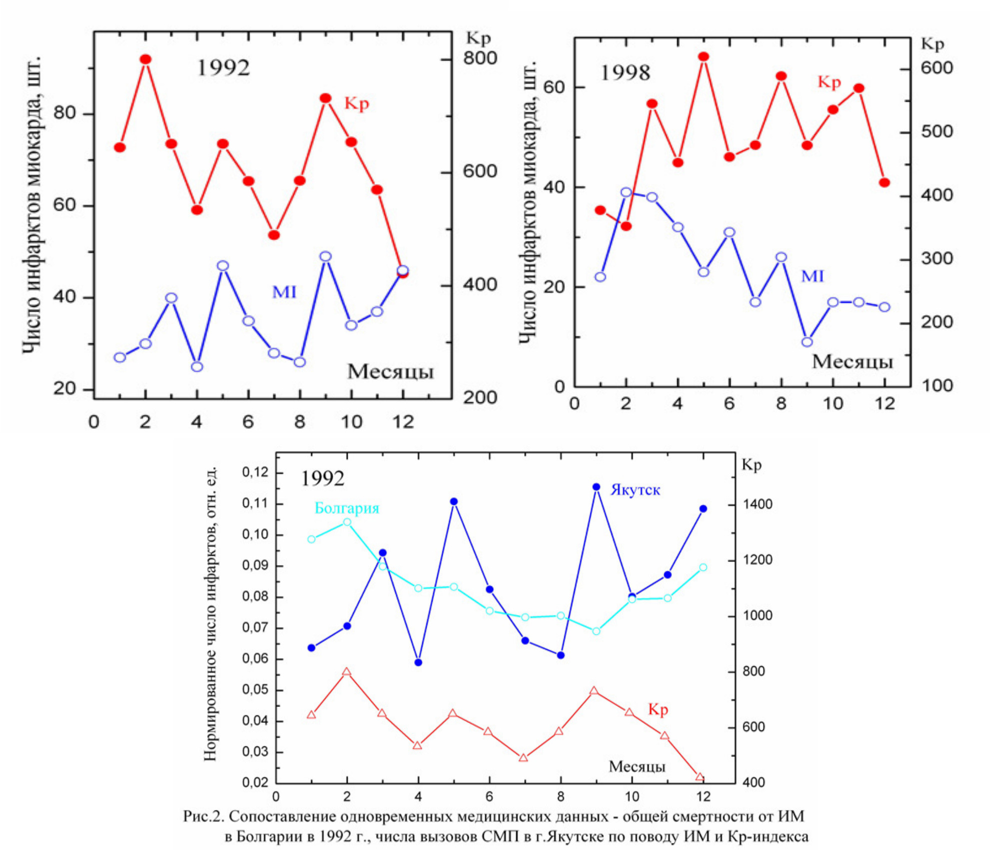

Fig. 2. The season distribution of the EMC number in Yakutsk (1992 and 1998) and their comparison with infarction mortality in Bulgaria (bottom plot).

It is seen that subauroral (Yakutsk) and low-latitude data does not correlate. In Bulgaria, the maximum of myocardial infarction was registered in winter and the minimum in summer, however, in Yakutsk there are several maxima coinciding with sharp and significant increases of planetary geomagnetic disturbances.

It is known, that with increasing planetary magnetic activity, the substorm development shifts from auroral to subauroral latitudes (so to Yakutsk latitude as well). The substorms could be important factors to medical study because they are typically accompanied by intensive Pi1 geomagnetic pulsations at the similar to Pi1 periods which could be biotropic (e.g. Kleimenova et al., 2007). A typical substorm and simultaneous subauroral Pi1 pulsations are shown in Fig. 3.

Discussion

We suggest that summer minimum of the cardio-vascular system disease could be due to availability of some physiological factors making human organisms stronger in summer than in winter. One possible reason of the infarction seasonal effects could be the seasonal variations of the pineal gland hormone (melatonin) production. The melatonin is well known as a multifunctional key regulator of the circadian rhythms.

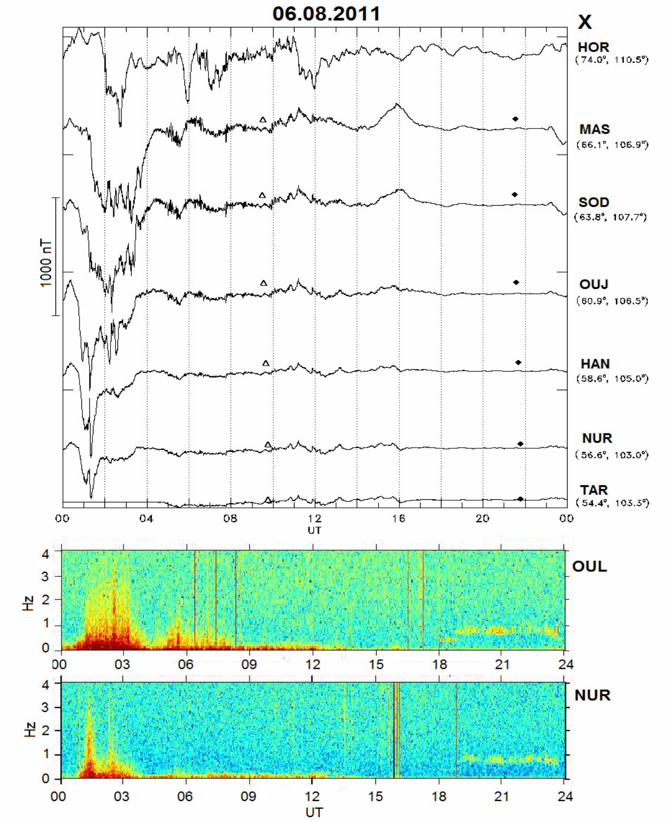

Fig.3. Magnetospheric sudstorm at different stations of IMAGE meridian chain and Pi1 irregular geomagnetic pulsations; the station geomagnetic coordinates are shown in the right.

A seasonal desynchronization of the circadian rhythms connected with the variation of the melatonin production due to long darkness periods in the winter leads to an instability of biological systems and an increase of their sensitivity to effects of other external factors. The melatonin suppressing of both day and night productions was observed during geomagnetic storms (Rapoport et al, 1995). It means, not only the solar luminosity can change the melatonin production, it has to be some other factor (or factors) related to magnetic storm.

One of such negative important factor could be the Pc1 and Pi1 geomagnetic pulsations at frequencies comparable with the human heart beat. Due to that, these pulsations can affect a human cardiovascular system.

Really, it was shown (e.g. Savitz et al., 1999) that low frequency electromagnetic pulses or oscillations can be responsible for biotropic effects. It has been shown that heart cells can became spontaneously synchronized or suddenly suppress their rhythmic oscillations under an influence of some very weak disturbances, for instance, electric impulses at the narrow range of the periods (0.18 - 0.21 s). The phase singularity in the heart rhythm following such impulse action can lead to the heart fibrillation, resulting in sudden death from arhythmia and myocardial infarction.

Summary

A comparison of seasonal distribution of the EMC related to infarction at subauroral latitudes (Yakutsk) with a simultaneous seasonal change of infarction deaths at low latitudes (Bulgaria) showed their significant difference. In Bulgaria, the maximum of myocardial infarction was registered in winter, however, in Yakutsk there are several maxima coinciding with significant increases of planetary geomagnetic activity. We assume that at subauroral latitudes, unlike low latitudes, a great role in aggravations of infarctions plays the enhancement of local geomagnetic activity, namely, the night magnetospheric substorms associated with strong magnetic planetary activity, because substorms are always accompanied by irregular geomagnetic Pi1 pulsations with similar to biotropic Pc1 periods (0.5–5.0) Hz. The Pi1 pulsations can be biotropic, as well as quasi-sinusoidal geomagnetic Pc1 pulsations.

Thus, in subauroral latitudes, could be biotropic both types of geomagnetic pulsations (Fig.4): the night and early morning irregular Pi1 pulsations during the disturbed periods (Kp=2-3) and Pc1 pulsations during the quiet periods after geomagnetic disturbances.

Kp=3-4, Pi1 pulsations **Kp=1-2, Pc1 pulsations**

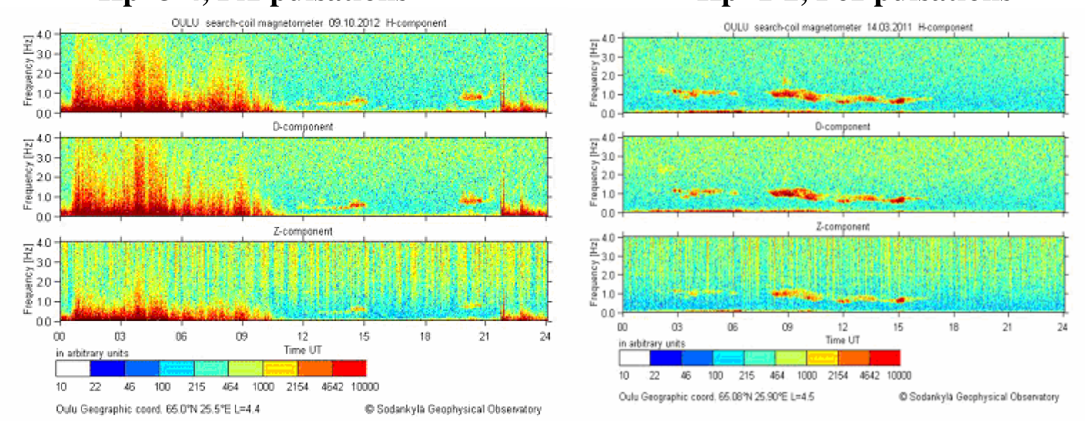

Fig. 4. Spectrograms of Pi1 and Pc1 geomagbnetic pulsations.

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The relative role of space weather factors in Chizhevsky-Velkhover effect

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INTRODUCTION.

The Astrobiological Chizhevsky–Velkhover effect occupies a special place among biological effects, concerned with solar activity. It's about the color change of structure elements (volyutin granules) of bacterium sells at staining by methylene blue solution (metachromasia reaction). Today the volyutin granules, consisting of inorganic polyphosphate, were observed at procaryotes, lower eukaryotes, at protozoa, and as phosphatic pellets in platelets of higher organisms (including human).

According to the discoverers, volyutin granules color change depends on solar activity. But since 1934 new data about structure of solar-earth relations were observed, and the solar dynamics changed. Cosmic weather factors having the dominating influence on etalon sell structures in 2000 – 2013 are discussed in the report.

MATERIALS and METHODS

Daily monitoring of staining of volyutin pellets of yeast Saccharomyces cerevisiae and Rhodococcus erytrhopolis from Ukrainian Microorganism Collection D.K. Zabolotny Institute of Microbiology and Virology of the NASU by methylene blue was carried out in 2000 – 2013. (E.Gromozova at all). Yeasts were cultivated on a solid medium (wort-agar) in glass tubes with cotton-gauze in a thermostat at 28oC during 24 h. Every day during the passages of cells onto fresh medium, a part of cells was resuspended in a drop of distilled water directly on the microscopy glass slide surface to form a monolayer. After drying in open air at room temperature, cells were fixed over the lab burner flame and stained with methylene blue by Leffler.Levels of metachromasia were marked: MTC=1, if no metachromatic reaction was observed (volutin granules stained in the blue color); MTC=2, if in the color of the volutin granules saturated violet color was predominant; and MTC=3, if the color of the volutin granules was red. Visual analysis was confirmed by microscopy observation using bright-field method and lens×100/1.30. Digital images of observed cells were captured with Carl Zeiss Primo Star microscope equipment with a digital camera Canon PowerSho A460 and Zeiss AxioVision image analysis microscope software [E. Gromozova,1]. Statistical treatment of the monitoring data was carried out by Solar-Terrestrial Physics department of Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, RAS.

RESULTS and DISCUSSION

Metachromasia dynamics of volyutin pellets of yeast ***Saccharomyces cerevisiae*** sells in 2002-2012 is on fig.1. From the end of 2004 to the middle 2006 the average quantity of events MTC=3 in 2 months is "0,1" instead of "5" in 2000-2003 and "21" in 2007-2012.

Anomalous dynamics of different biological systems was discussed in [2]. We suppose, that the observed charge of dynamics of different levels of organization biological objects corresponds to the adaptative response of biosphere on nonstandard geophysical singularities of 23-24 cycles of solar activity. Probably the observed process is a return of the biosphere reconstruction in anticipation of long solar activity decrease up to 4-5 next cycles[V. Obridko,2; V. Ishkov, 3].

Cosmic weather factors, able to impact considerably on the etalon sell structures, can be classified in 3 groups: terrestrial, solar, galactic. From the first group we take the ap–index of geomagnetical field variations; from the second one – solar radio waves F10,7 intensity; from the third one – galaxy cosmic rays variations. We build the statistical distributions for chosen factors in random days and in the days with the relevant type of metachromasia.

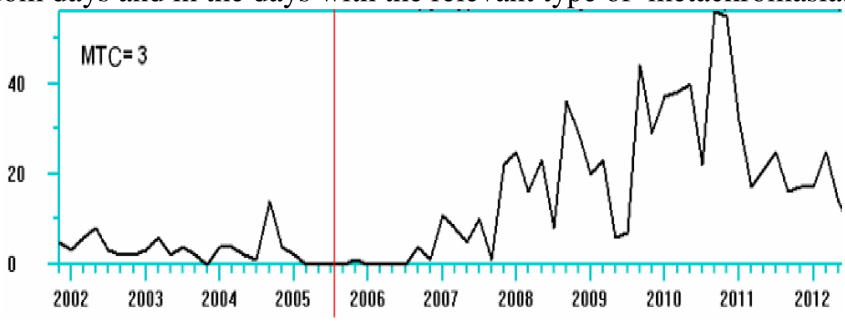

Fig.1. Average quantity of events MTC=3 in 2 months

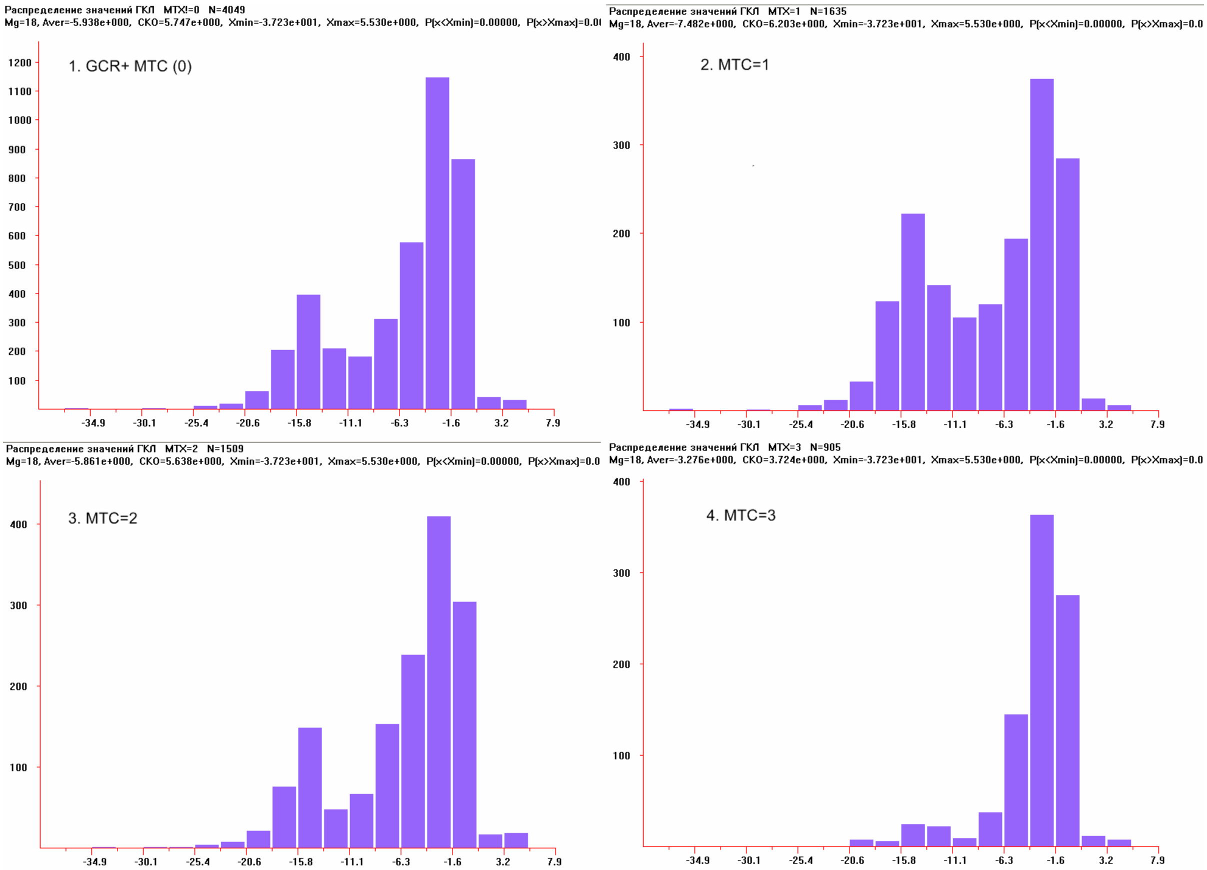

Fig. 2: Bar chart of distribution of galaxy cosmic rays intensity. 1) At Y-axis – quantity of days in the set interval of galaxy cosmic rays intensity. 2,3,4) At Y-axis - quantity of days in the set interval of galaxy cosmic rays intensity, when the metachromasia reaction of 1,2 and 3 types was accordingly observed.

RESULTS of the ANALYSIS:

1. Total statistical distribution for ap–index and MTC= (1,2,3) is random within measurement error.
2. Total statistical distribution for solar radio waves F10,7 intensity is random with MTC (1,2). Weak dependence is observed for solar radio waves F10,7 intensity with MTC= 3.
3. Distributions of galaxy cosmic rays variations in all days in 2000 – 2013 and in days, when MTC $\neq 0$ are equal within measurement error.
4. Distribution of galaxy cosmic rays variations in days with MTC =(1,2) is quite equal to the total distribution. The picture appears if one builds the distribution with random

sample of days, so the MTC= (1,2) can be considered independent from galaxy cosmic rays variations.

5. Distribution of the MTC =3 considerably depends of galaxy cosmic rays intensity variations (fig.2); it means that galaxy cosmic rays intensity variations are the main biotropical agent of the cosmic weather for sell structures.

This conclusion is confirmed by the results of E. Gromozova experiments (2010) on the shielding of the bio-objects. The metachromasy reaction of volutine granules of yeast ***Saccharomyces cerevisiae*** under shielding with the aid of different materials was studied. High likeness in a dynamics of MTC reaction with the control (non-shielded) amples was registered at cells under the permalloy, lead of a 0.1 cm thick with a permalloy layer, and steal. The likeness is much weaker at the cells shielded by the lead of a 0.55 cm thick and by the paraffin, and is about zero for the samples shielded by the water. Dynamics of MTC reaction keeps a high correlation with the control exactly for such types of screens that attenuate essential parts of electric and magnetic natural fields. It allows to presume that natural electromagnetic fields has no a major importance in the influence on the MTC reaction [3].

CONCLUSIONS

Galaxy cosmic rays intensity variations insert the main contribution on the sell structures in Chizhevsky–Velkhover effect, substantially – for MTC=3. The solar factors insert less contribution. The contribution of geomagnetic fields is indistinguishable from random.

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Development of the GPS TEC fluctuations at the high latitude ionosphere during geomagnetic storm

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Abstract

We report the result of investigations of GNSS signal phase fluctuations occurrence during the geomagnetic storm on October 2, 2013. During this space weather event the intense phase fluctuations have been registered by the permanent GNSS stations not only in the auroral and subauroral regions but even at the midlatitude stations. In combination with the optical and geomagnetic measurements this fact confirms the equaward expansion of the auroral oval.

Index Terms—ionosphere, GNSS, fluctuations.

Introduction

A trans-ionospheric radio wave propagating through the electron density irregularities may experience phase and amplitude fluctuations. Such fluctuations occur due to irregularities with different scales that present in the polar ionosphere. The ionospheric irregularities can be structured with latitude and their intensity vary at the subauroral, auroral, polar and cusp regions. In accordance with this, the fluctuation activity varies considerably with latitude and space weather's conditions. Strong TEC fluctuations can complicate phase ambiguity resolution and to increase the number of undetected and uncorrected cycle slips and loss of signal lock in GPS navigation and positioning errors [1, 2].

The low frequency GPS phase fluctuations occur due to electron density changes along the radio wave path, or the total electron content (TEC) changes. The information about TEC fluctuations may be obtained using the regular GPS observations provided by the International GPS Service (IGS). The worldwide dense network of the GPS stations is very useful for permanent monitoring of the spatial distribution of the ionospheric irregularities on a global scale [3, 4].

In this report GPS measurements of global IGS network were used to study the storm time occurrence of phase fluctuations (TEC changes) in the high latitude ionosphere during October 2, 2013 storm.

Data and geomagnetic conditions

The TEC measurements for individual satellite passes served as raw data. As a measure of fluctuations activity the rate of TEC (ROT, in the unit of TECU/min, 1 TECU=1016 electron/m2) at 1 min interval was used (5). As measure intensity fluctuations index ROTI was used (6).

$$ROTI = \sqrt{\langle ROT^2 \rangle - \langle ROT \rangle^2}$$

During the main phase of the storm we used magnetometer measurments provided by the chain of the Scandinavian network

The storm was rather moderate with the main phase started on October 2,2013 after midnight. Figure 1presents the geomagnetic conditions for September 30 - October 4, 2013.

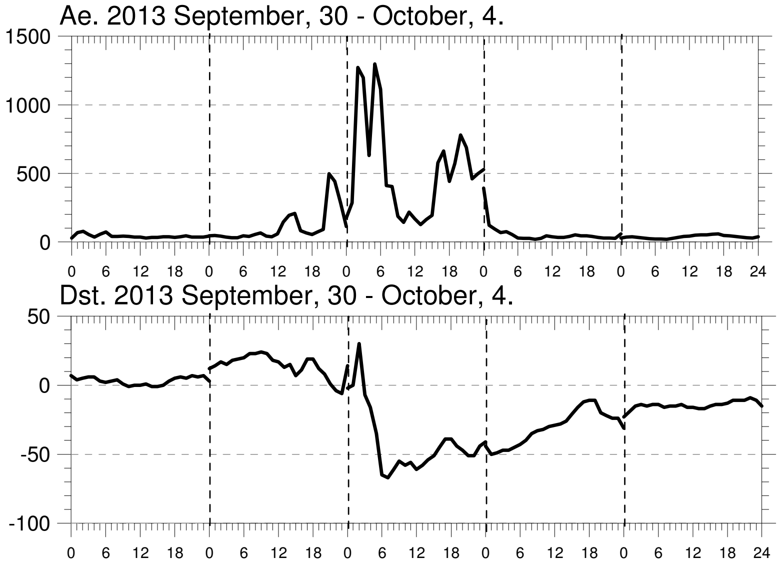

Fig1. Ae and Dst variations for September 30 - October 4, 2013.

Results

Occurrence of the TEC fluctuations can be clearly observed in the temporal variations of the dual frequency carrier phase along satellite passes. For example, the TEC variations, observed at auroral KIRO and midllatitude Kaliningrad stations for quiet and disturbed conditions are presented at Figure 2. The figure demonstrates the rates of TEC changes (ROT) along all satellite passes over 24 hour interval. At Kaliningrad stations for quiet day the fluctuations activity was very low. During geomagnetic disturbed day the intensity of fluctuations was detected in the satellite pass of PRN 14 around 05 UT.

Detailled picture of the fluctuations for PRN 14 at Kaliningrad stations for quiet and disturbed days is presented in Figure 3. The satellite trajectory in the ionosphere (cross line) is also shown on the picture.

The intensive TEC fluctuations during storm day were localized at latitudes 57-58°N when magnetic bays were occurred on magnetogram of the Scandinavian network in time interval 05-06 UT (Fig.4.).

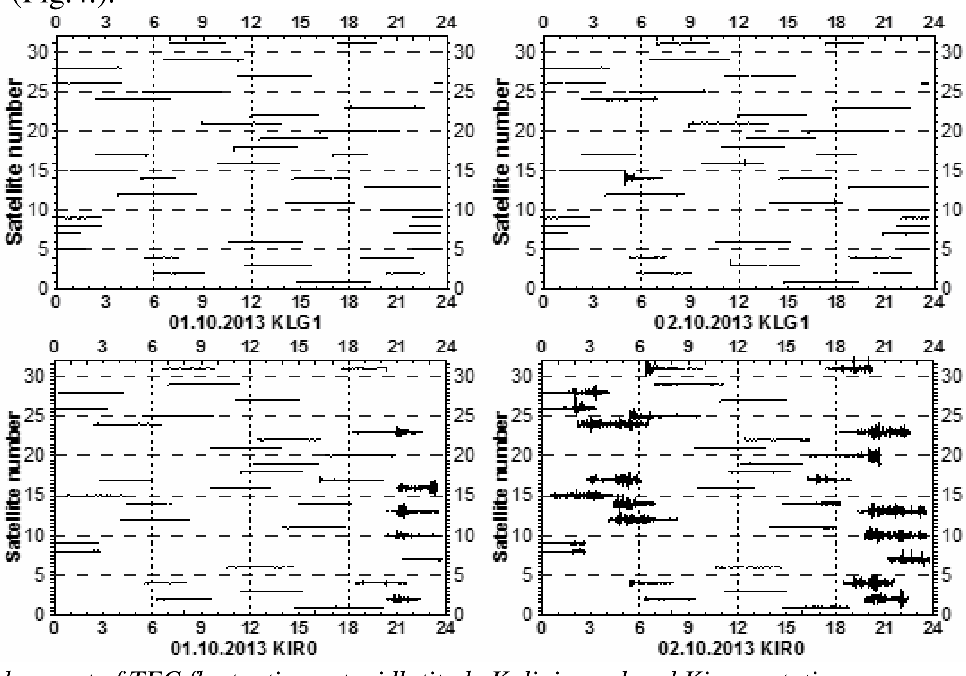

Fig.2.Development of TEC fluctuations at midlatitude Kaliningrad and Kiruna stations for quiet (1 October) and disturbed (2 October) days.

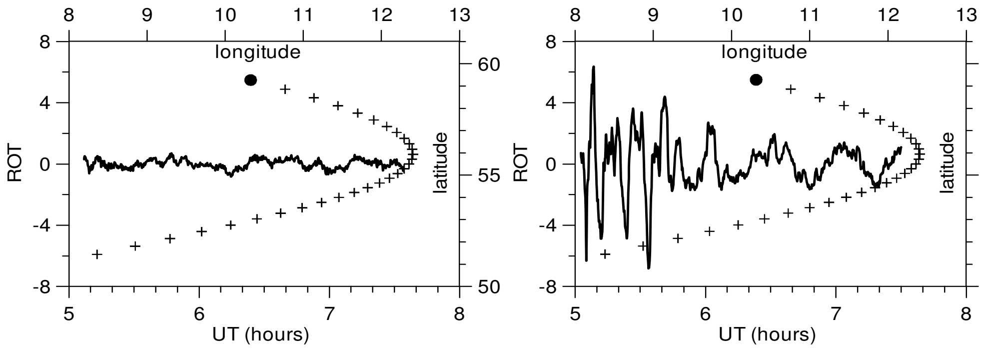

Fig. 3. TEC fluctuations along satellite pass of PRN14 at Kaliningrad station for quiet and disturbed days.

Fure 5. shows the ROT variations at different latitudes and keogram at the stations Lovozero and Sodaynkyul. Obviously, the time course of ROT coincide with the geomagnetic field at the Lovozero and Sodaynkyula stations, as well as with the variations of the geomagnetic field X-component at different stations of Scandinavian network.

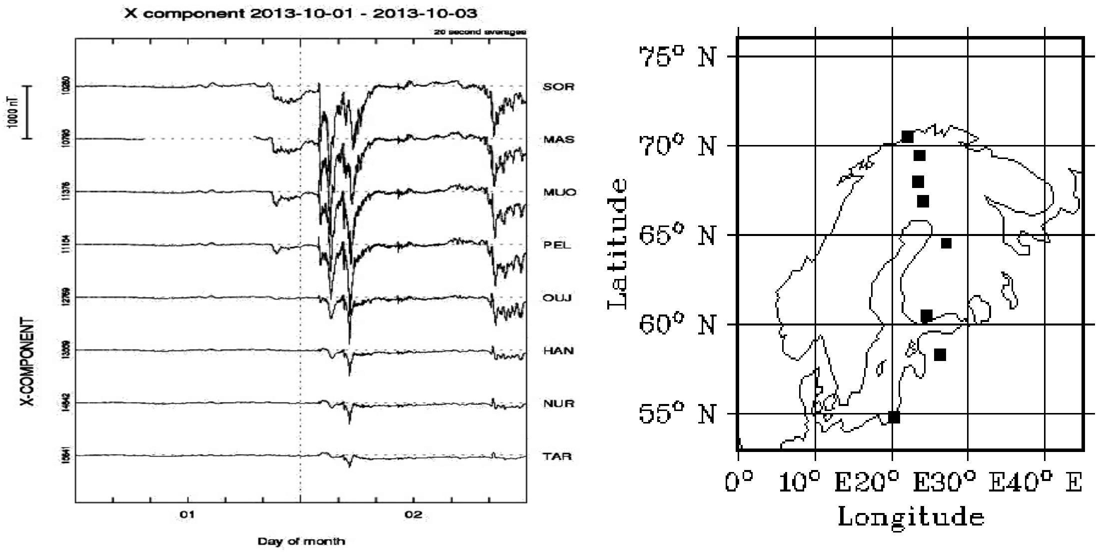

Fig.4. The variations of the geomagnetic field X-component at different stations (left panel) and map of Scandinavian network (right panel).

It appears that according to evidance of the maximum TEC variations as well as the pulsations of the geomagnetic field we can determine the source which affect a destruction of the navigation signal in the ionosphere in the presence of auroral disturbances. This is particularly noticeable in the intervals of the substorm intensification.

For example, a small perturbation around 01.10.2013 21:00 UT, localized in the polar region, had little effect on variations of ROT in Kaliningrad. On the other hand, the strong disturbance about 02/10/2013 05:00 UT as reflected in magnetic observations at the latitude of Kaliningrad and in the values of ROT on this point. This result suggests the possibility of a diagnostics and prognosis the conditions of the navigation signals receiving using measurements of geomagnetic field variations.

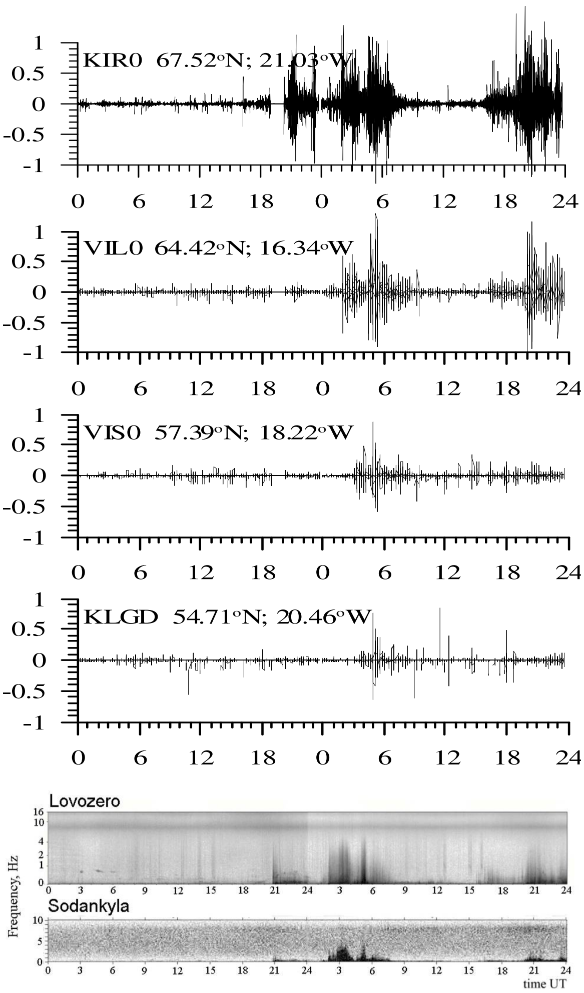

Fig. 5. Latitudinal occurrence of TEC fluctuations and keogram at the stations Lovozero and Sodaynkyula

Irregularity oval

Based on the daily GPS measurements from 130-150 selected stations, the images of spatial distribution TEC fluctuations (index ROTI) in CGC and MLT coordinates was formed. Similarly to the auroral oval, these images demonstrate the irregularity oval. The occurrence of the irregularity oval relates with the auroral oval, cusp and polar cap. The irregularity oval expands equatorward with increase of the magnetic activity.
As an example, Figure 6, presents the dynamics of the irregularity oval in dependece on geomagnetic activity. As seen at Figure 6, the activity and intensity of the TEC fluctuations relate weakly with the behouver of Kp and mostly depend on the auroral activity.

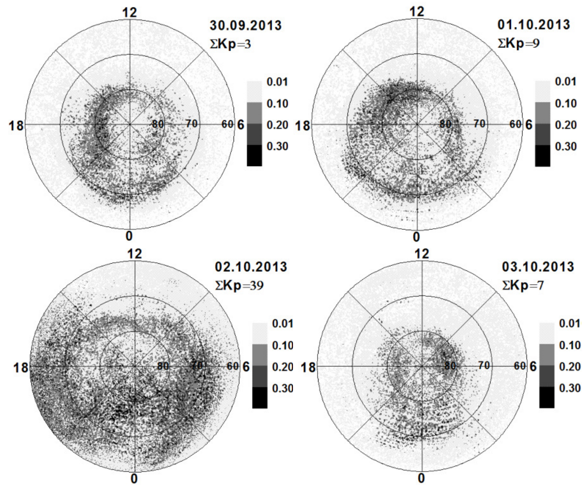

Fig. 6. Dynamics of the irregularity oval.

Conclusions

During October 2, 2013 geomagnetic storm the intense TEC fluctuations were observed at the auroral and subauroral ionosphere. Joint analysis of observed phase fluctuations of GPS signals, and fluctuations of the geomagnetic field demonstrated rather good agreement during intensification of the auroral activity. During the peaks of the aurora activity the intense GPS phase fluctuations were registered even at midlatitude station Kaliningrad. In combination with optical and geomagnetical measurements this fact confirms the equatorward expansion of the auroral oval. The analysis is shown that the irregularity oval is very sensitive to variations of the auroral activity and can be used as an indicator the space weather conditions.

ACKNOWLEDGMENT

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GUV 2511 instrument installation in Stara Zagora and first results

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Abstract.

In February 2015 a Ground-based Ultraviolet Radiometer (GUV) 2511 was installed in Stara Zagora. The GUV 2511 instrument is designed for measurements of the downwelling global irradiances at 305, 313, 320, 340, 380, 395 nm and of the irradiance in the visible range of 400-700 nm. The instrument allows obtaining of the total column ozone (TCO) in the atmosphere, the determination of the UV-index and the retrieval of cloud optical thickness. In the paper the first results of the measurements are presented and the methodology to derive TOC is described.

Introduction

Routinely total column ozone (TCO) observations began with the design of the Dobson-spectrometer in 1924 (see Dobson, 1968). After the International Geophysical Year 1957 a global network of ground-based ozone measurements was established mainly consisting of Dobson and Brewer spectrophotometers with a typical spectral resolution of approximately 1 nm. Stamnes et al. (1991) have shown that by the help of spectrometers with high resolution of about 0.5 nm TCO and the cloud transmission can be determined very accurately. In the 90-ties broadband filter instruments were developed to increase the global coverage of the measurements. Broadband instruments with only a few filters allow also determining of the biologically UV dose, the total ozone abundances, and the cloud optical depths (Dahlbeck, 1996).In February 2015 a Ground-based Ultraviolet Radiometer (GUV) 2511 was installed in Stara Zagora. The GUV 2511 instrument is designed for measurements of the downwelling global irradiances in six broadband channels and of the irradiance in the visible range from 400 to 700 nm. The instrument allows obtaining of the total column ozone (TCO) in the atmosphere, the determination of the UV-index and the retrieval of cloud optical thickness. In the paper the first results in respect of the measurements are presented and the methodology to derive TOC is described.

Methodology of TCO determination

By GUV instruments the global, the diffuse and the direct components of the downwelling irradiation are measured. The ratio of the irradiances at different wavelengths depends on the scattering properties of the air particles and molecules and also on the solar elevation, e.g. on the absorbing path length through the atmosphere. Therefore TCO cannot be determined directly by the observed irradiance ratios as it is possible for Dobson and Brewer spectrophotometers for direct solar measurements. To determine TCO from UVA/UVB ratios simulations by radiation transfer models including the UV spectral range are necessary. Here we used Tropospheric Ultraviolet and Visible (TUV) model, version 4.1., developed by Madronich (1993), where the Rayleigh scattering parameters were calculated through an improved algorithm for standard atmospheric conditions (Thomasi et al., 2005). The spectra were calculated for the Stara Zagora location (Lat=42.4°N, Long=25.6°E, alt = 0.43 km) for different TCO from 0 up to 700 DU with a step of 20 DU and zenith angels from 20° up to 90° with a step of 1°. A ground albedo of 0.05 was used as input parameter. The obtained spectra were multiplied with the relative filter response functions, approximated by a Gaussian with 10 nm Full Width at the Half-Maximum (FWHM). The irradiance ratios for wavelengths 340 nm and 313 nm were calculated for the mentioned above TCO and zenith angles (Stamnes table, see Fig.1). The ozone content values are determined by interpolation of the calculated tables for the measured ratios and the zenith angles for the time moments, when the measurements were performed.

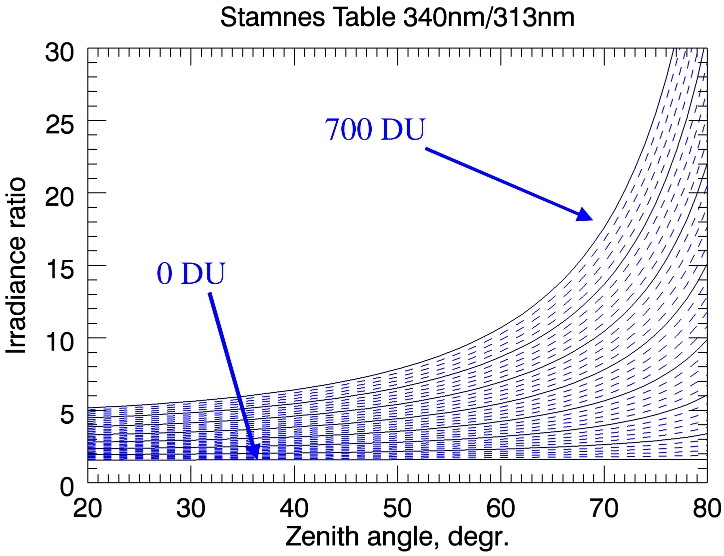

Fig.1. Calculated Stamnes table (ground albedo of 0.05) for Stara Zagora.

Brief description of GUV 2511 instrument

The GUV instrument measures the global irradiances at 305, 313, 320, 340, 380, 395 nm with a bandwidth of 10 nm FWHM as well as the Photosynthetically Available Radiation (PAR) irradiance in the visible spectral range from 400 to 700 nm. The 313 nm filter was added in the GUV 2511 type instrument unlike the previous GUV 511 type instrument to ensure ozone determinations at greater zenith angles (of about 80°) where the absorption at 305 nm is very high. The entrance instrument window consists of a teflon diffusor on a quarz base. A heater blanket placed in the instrument head stabilizes the photodiodes and filters at the temperature of 50°C. A portion of the heat is used to warm the diffuser and to keep it free from ice and snow. Melt water or rain on the diffuser and occluding ring is led outside by drain holes.

The instrument functioning is operated by a controller including the power management, the temperature control and the data transfer via the interface RS232.

The main advantage of the GUV instrument series is that they have not moving components. Moreover the measurements are carried out very fast.

GUV 2511 instrument installation

Fig.2. View of the GUV 2511 instrument on the roof of the observatory.

The GUV instrument was installed in February 2015 on the roof of the Stara Zagora observatory (Fig.2). The observatory is located at 3 km from the City Stara Zagora at an altitude of 430 m, about 250 m higher than the city. Near the observatory there aren't other high buildings, thus a free view to the sky is ensured. The instrument is connected with the computer via RS232 by a 50 m long cable. Fig.3 shows the instrument controller and the monitor displaying the measurement progress in the control room.

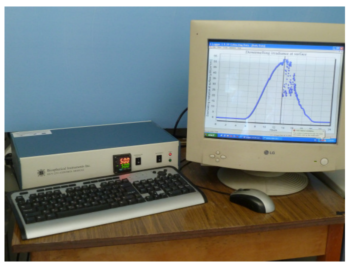

Fig.3. The instrument controller and the monitor in the control room.

Preliminary results

From February to May 2015 were carried out daily measurements with an integration time of 10 sec. with some interrupts for technical reasons. In Fig.4 an example is given

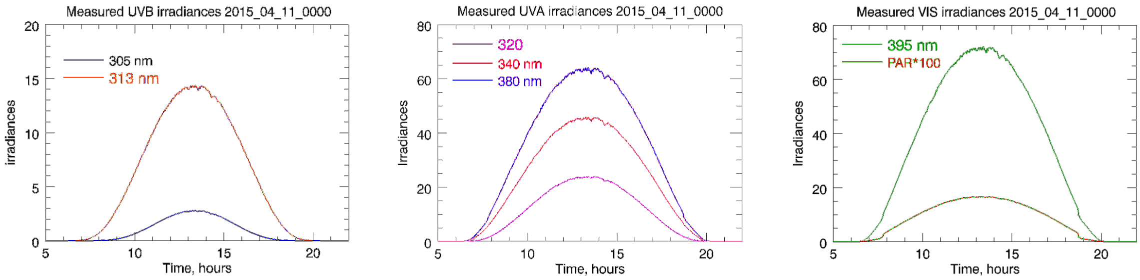

Fig.4. Measured irradiances (given in µmW/(cm^{2}nm) *by all GUV 2511 channels.*

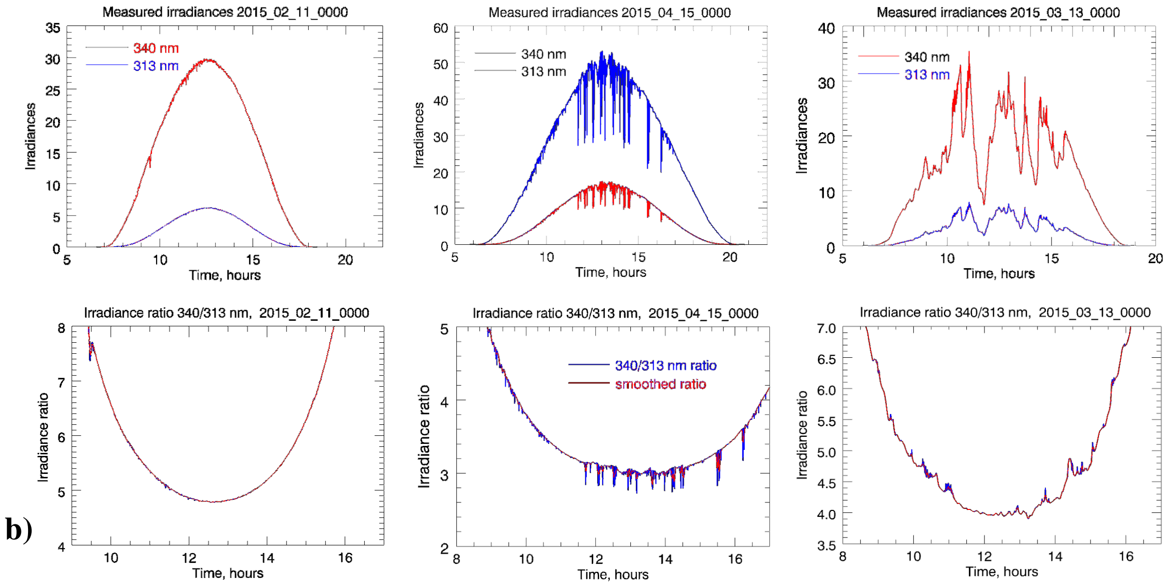

Fig.5. a) Measured irradiances, given in µmW/(cm^{2}nm), *for days with different cloudiness and b) the irradiance rations (see text).*

for the measured irradiances in all GUV 2511 channels during a clear day (11 April 2015). The irradiance maxima are observed at noon about 12:30 Local time.

Fig.5a shows the observed irradiances during days with different cloudiness: for an almost clear day (left), for a day with fast changing of the solar disc cloud cover (middle) and for a day with large cloud fraction (right). Fig.5b presents the irradiances ratios for the same days. The obtained ratios are much more insensitive against changes of the overhead cloudiness in comparison with the observed irradiations. To reduce the cloudiness influence on the ratios even more, the ratios were additionally smoothed by a running boxcar over 13 values, e.g. over 130 sec., and the result is drawn by red lines in figures 5b.

The TCO densities for the obtained irradiance ratios retrieved by interpolation of the Stamnes table for the corresponding zenith angles are shown in Fig.6. For comparison the TOMS long time annual mean variations are shown, too (the blue line in Fig.6). It is evident, that our ozone data would be much better fitted if the TOMS data are shifted by approximately 20 DU downwards (the red line in Fig.6). Consequently our data values are about 20 DU lower. The main reason is that the location of the central filter wavelength and the response function of the individual filters are not exactly known. However the variations of the individual daily values from the TOMS yearly mean are typical for ozone.

Conclusions

More detailed analyses about the filter choice and the determination of more accurate filter functions are necessary to improve the quality of the TCO data. The instrument has to be calibrated by the help of standard ozone spectrometers. However the preliminary results show, that in the future ozone data with high quality are to be expected for the Stara Zagora location.

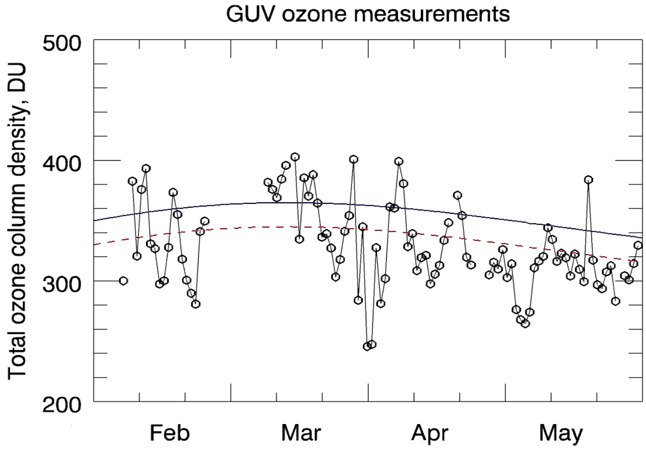

Fig.6. TCO for Stara Zagora determined for the observation period February-May 2015 (black line) and the TOMS annual means (thick and dashed line, see text).

Acknowledgements

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